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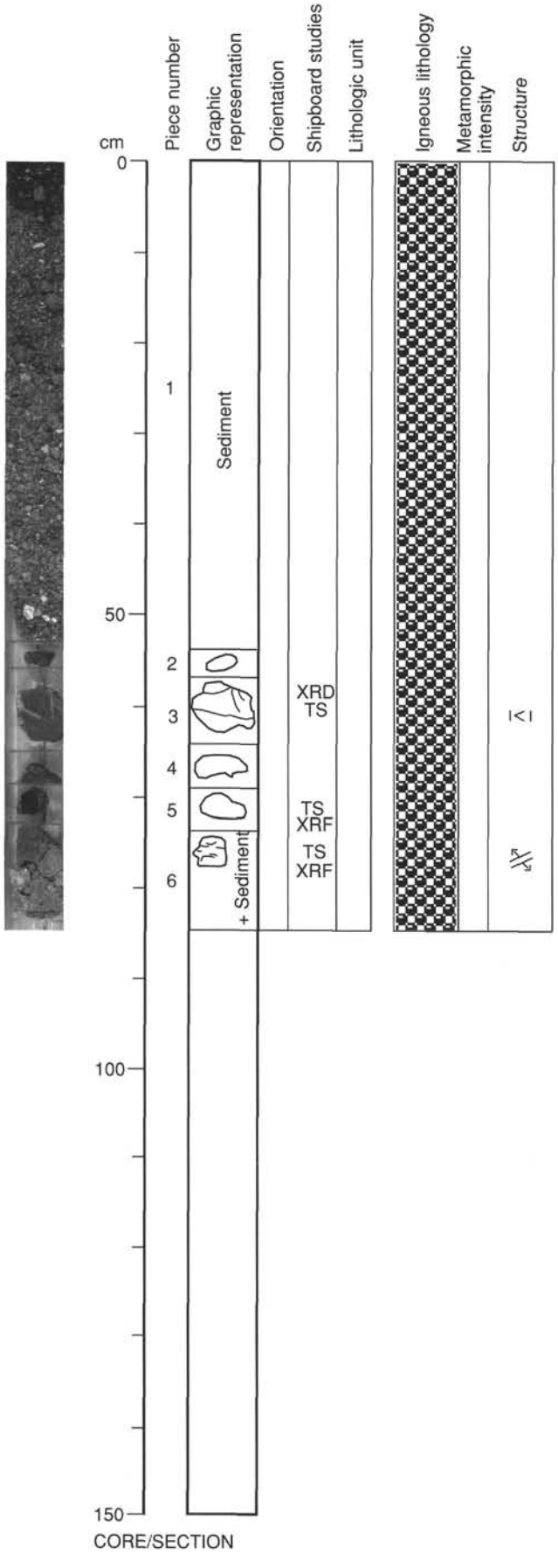
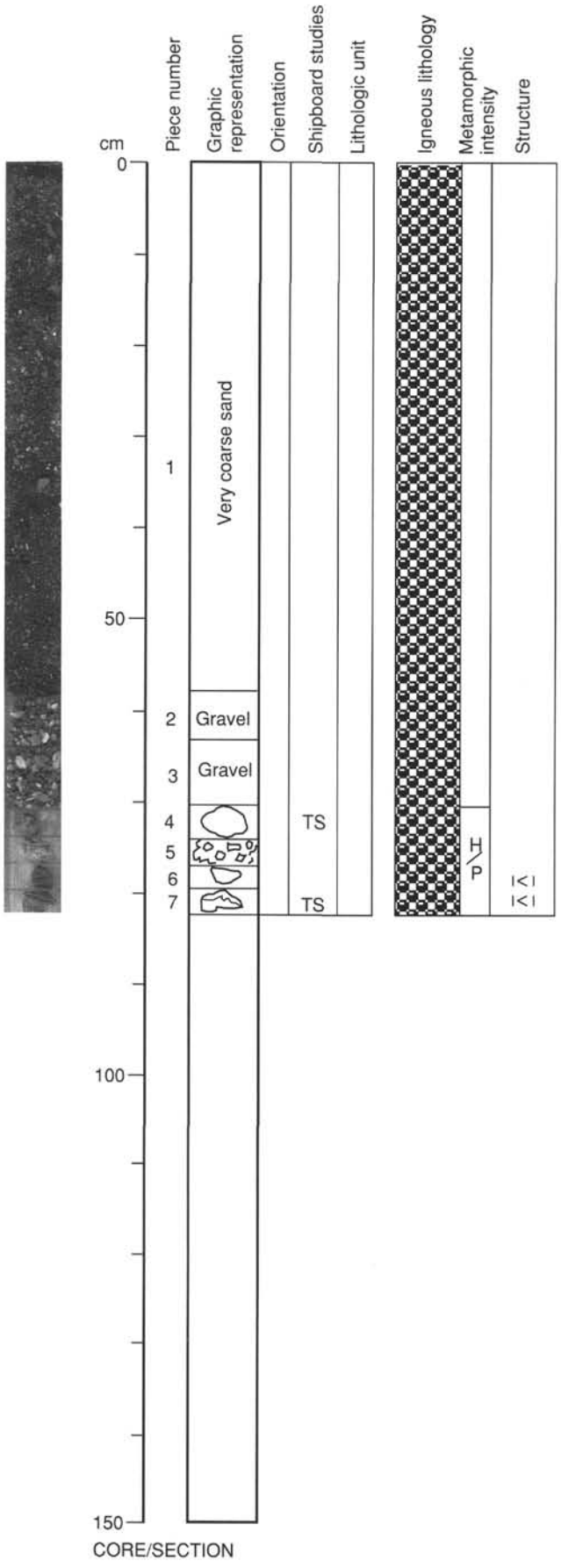


UNIT 0: SERPENTINIZED HARZBURGITE AND POLYGENETIC GRAVEL

Pieces 1–6

COLOR: Green-black.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Spaced cleavage and crosscutting veins at high angle. Development of en echelon vein arrays at a low angle to the parting cleavage.
PRIMARY MINERALOGY:
Spinel - Mode: <1%.
Crystal Size: <1 mm.
Orthopyroxene - Mode: 15%.
Crystal Size: 5–10 mm.
Crystal Shape: Elongate.
Crystal orientation: Tectonic.
Olivine - Mode: 85%.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 98%.
Mode of Occurrence: After olivine and orthopyroxene.
Comments: After olivine and orthopyroxene.
Comments: Piece 3 exhibits an alteration halo diffusing away from fractures; light colored filling mineral scratched for XRD (brucite?).
VEIN/FRACTURE FILLING:
Serpentine, brucite?, iron oxide minerals.
Percent: <1%
Size: <1 or 2 mm.
Orientation: n/a
ADDITIONAL COMMENTS: POLYGENETIC GRAVEL
Clast size: 1–25 mm. Clast shape: angular. Clasts: (1) Serpentinized peridotite (dominant clast lithology). Networked by syntaxial fractures filled with serpentine, chlorite, amphibole, dispersed oxide and hydroxide minerals; two different zeolites (with acicular and radiating habits) occur on the surfaces. (2) Serpentinitic carbonate-bearing breccia. (3) Coarse- and fine-grained metagabbro. (4) Fresh volcanic glass (black). Fragments of serpentine, clinopyroxene, brucite?, silica, plagioclase, and foraminifers.
SERPENTINIZED HARZBURGITE FRAGMENTS
Some pieces show faint parting that may be a spaced cleavage of transitional brittle-ductile fabric. None of the pieces exhibit evidence of having been cut by the bit and are, therefore, likely to represent rubble. Relict orthopyroxene is commonly elongate with preferred alignment and pull-apart cracks. Veins occur as conjugate and single sets, commonly at high angles to parting cleavage (e.g. Piece 3).
Structure
Pieces are not oriented. Anastomosing vein fabric common.

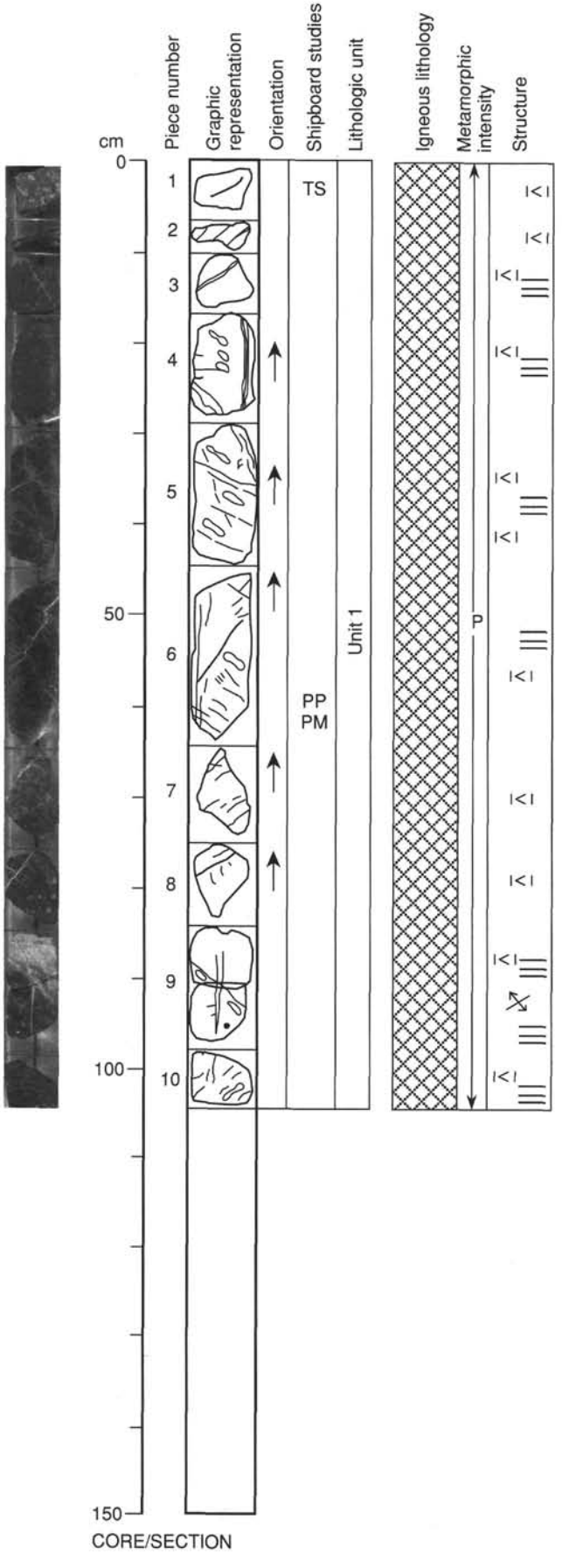


153-920A-2M-1

UNIT 0: POLYGENETIC GRAVEL AND SERPENTINIZED HARZBURGITE

Pieces 1–7

COLOR: Greenish black.
PRIMARY STRUCTURE: Elongate porphyroclastic texture in Piece 7. Not evident in Piece 6.
SECONDARY STRUCTURE: Serpentine veins.
PRIMARY MINERALOGY:
Olivine - Mode: 75%–80%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 20%.
Crystal Size: 6–8 mm.
Crystal Shape: Subhedral to anhedral.
Clinopyroxene - Mode: 0–5%.
Crystal Size: 5–10 mm.
Crystal Shape: Anhedral.
Comments: Primary mineral description based on Pieces 4, 6, and 7. Piece 4 is the least altered containing some fresh olivine and orthopyroxene; other pieces are totally altered. Polygenetic gravel consists of assorted serpentine fragments, glass, and serpentine vein fragments. Black and light green chrysotile vein materials, some basaltic glass (highly weathered and altered), occasional fresh pyroxene grains, and pelagic ooze. Particle sizes 1–15 mm. Orthopyroxene forms elongate diffuse grains pseudomorphically replaced (100%) by pale blue-green serpentine and iron oxide minerals, commonly rimmed by light pale green serpentine ± clay. Olivine is completely replaced by serpentine ± clay and in Piece 6; brucite is common. Serpentine forms a pale green to almost black mesh network enclosing pervasively altered olivine kernels.
SECONDARY MINERALOGY:
Brucite.
Mode of Occurrence: After olivine.
Comments: Fine-grained brown mineral with a luster in hand sample.
Clay minerals.
Mode of Occurrence: After olivine and orthopyroxene.
Serpentine.
Texture: Mesh
Mode of Occurrence: After orthopyroxene and olivine.
Comments: Orthopyroxene is pseudomorphically replaced (100%) by pale blue-green serpentine and iron oxide minerals, which are commonly rimmed by light pale green serpentine ± clay minerals. Olivine is completely replaced by serpentine ± clay minerals, where it forms a pale green to almost black mesh network enclosing replaced olivine kernels.
Iron oxide minerals.
Mode of Occurrence: After sulfide minerals.
Comments: Bounds thin white vein in Piece 7.
Amphibole.
Mode of Occurrence: After clinopyroxene.
Comments: Total alteration is ≈98% except in Piece 4 which is ≈60% altered and contains relict olivine (50% altered), fairly fresh orthopyroxene, (40% altered), and minor clinopyroxene (30% altered). Rare irregular shaped "pods" of a moderately soft dark colored mineral(s) may be altered spinel grains. Piece 7 is cut by a thin white veinlet (magnesite) which is bounded by fine sulfide mineral grains altered to iron oxide minerals and which cuts a chrysotile microveinlet.
VEIN/FRACTURE FILLING:
Chrysotile.
Percent: <10%
Size: <2 mm.
Orientation: n/a
Magnesite.
Percent: <10%
Size: <2 mm.
Orientation: n/a
Comments: Thin white veinlet cuts Piece 7 and fizzes under hot HCl. Vein cuts chrysotile microveinlet.
ADDITIONAL COMMENTS: STRUCTURE
Pieces are not oriented. Anastomosing vein fabric and two discrete vein sets occur in most pieces.

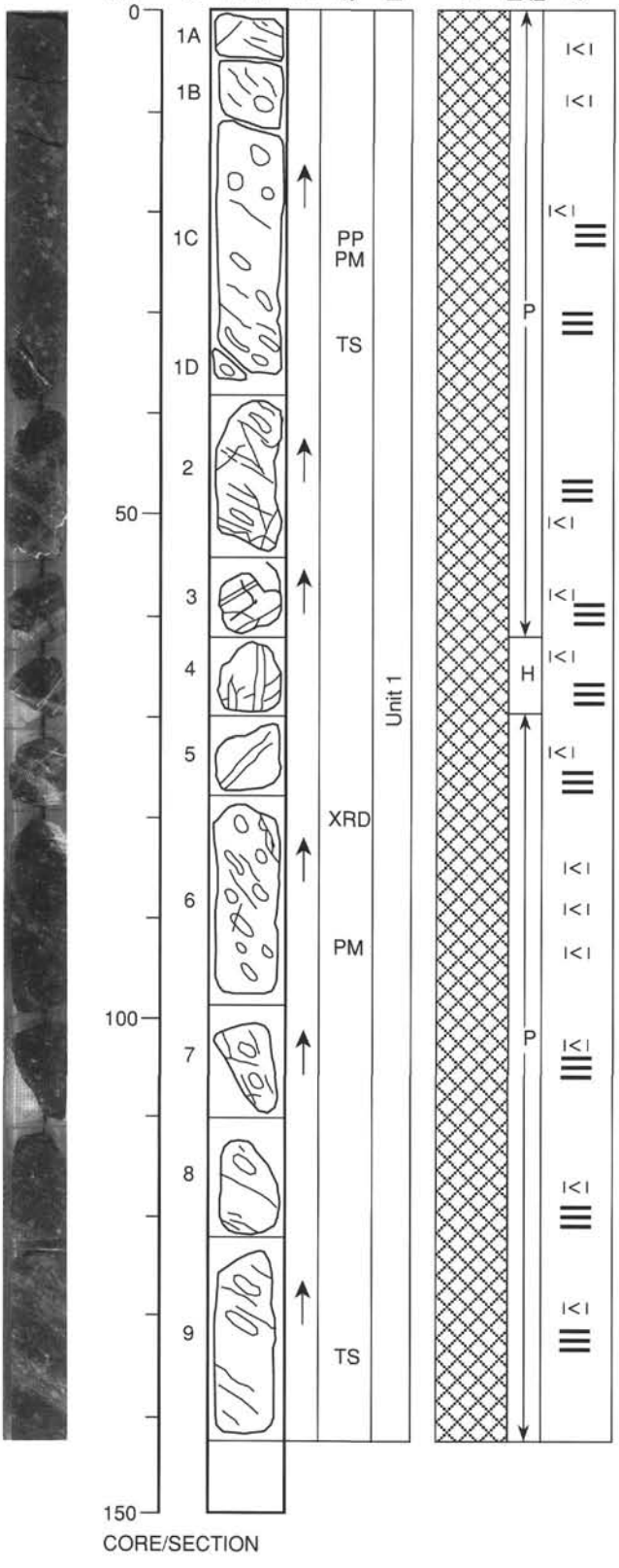


153-920B-1W-1

UNIT 1: SERPENTINIZED HARZBURGITE

Pieces 1–10

COLOR: Black-green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: *En echelon serpentine microveins.*
PRIMARY MINERALOGY:
Olivine - Mode: 85%.
Spinel - Mode: 1%.
Crystal Size: 1–2 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 3%.
Crystal Size: 2–7 mm.
Orthopyroxene - Mode: 11%.
Crystal Size: 3–15 mm.
Comments: This section consists of serpentinized harzburgite. Generally, the total modal pyroxene content is less than 20% and clinopyroxene is less than 3%. Chrome spinel is present as isolated or clusters of grains. The texture of these peridotites is coarse-grained porphyroclastic. There is also variation in the modal abundance of pyroxene from piece to piece. Pieces 1 and 3 contain altered pyroxenite vein material and Piece 9 contains an altered (chlorite, tremolite, and serpentine) gabbroic vein. The large gabbroic vein in Piece 9 cuts a very pyroxene-poor harzburgite to dunite. Piece 10 is a harzburgite with low modal pyroxene (i.e., relative to the remainder of the section which is harzburgite more enriched in pyroxene).
SECONDARY MINERALOGY:
Serpentine
Total Percent: 45
Mode of Occurrence: Replacing olivine.
Amphibole
Total Percent: 7
Mode of Occurrence: Rimming pyroxene.
Comments: Olivine shows diffuse alteration to serpentine (5%–100%), and generally preserves mesh texture, except in high strain domains; clinopyroxene porphyroclasts are rimmed by serpentine (alteration 30%–60%), as well as orthopyroxene grains (alteration 30%–60%), with fresh spinel. Crosscutting veining is diffuse; vein filling minerals include: 1) serpentine 2) serpentine and hematite 3) hematite 4) serpentine, hematite, and sulfide minerals 5) sulfide minerals. Serpentine-bearing veins are polyphasic syntaxial. Piece 3 contains a 12 mm wide magmatic vein witn amphibole and chlorite. Pieces 9A and 9B contain a cm wide tremolite, chlorite, and possibly prehnite vein cut by a composite serpentine vein.
VEIN/FRACTURE FILLING:
Serpentine, pyrite, and hematite
Percent: 3%
Size: 1 mm.
Orientation: See description.
Comments: Veins are both parallel to and crosscutting the foliation.
Tremolite
Percent: 1%
Size: 20 mm.
Orientation: See description.
Comments: Veins are both parallel to and crosscutting the foliation.
ADDITIONAL COMMENTS: Structure
A foliation is defined by aligned pyroxene porphyroclasts which show aspect ratios as high as 4:1. The pyroxene porphyroclasts are also extended by intracrystalline fractures, oriented at a high angle to the foliation plane. Dark serpentine veins define an anastomosing foliation that is generally parallel to the pyroxene grain elongation. Fabric orientations are relatively homogeneous throughout the core. Both the foliations have weak to moderate intensities. Two vein arrays are present. The most abundant vein array lies parallel to the foliations and contains cross-fibers of serpentine. The second, less abundant vein array comprises steeply dipping green serpentine veins (1–3 mm wide) that crosscut the foliation-parallel set. The foliation-parallel veins cut the veins at a high angle to the foliation. The metapyroxenite band in Piece 9 dips at about 45°, subparallel to the orthopyroxene foliation.



153-920B-1W-2

UNIT 1: SERPENTINIZED HARZBURGITE

Pieces 1A–9

COLOR: Black-green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Veins of serpentine.
PRIMARY MINERALOGY:
Olivine - Mode: 85%.
Orthopyroxene - Mode: 14%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 3%.
Crystal Size: 1–10 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: 1–2 mm.
Crystal Shape: Anhedral.
Comments: This section consists of serpentinized harzburgite. Generally, the total modal pyroxene content is less than 20% and clinopyroxene is less than 3%. Chrome spinel is present as isolated or clusters of grains. The texture of these peridotites is coarse-grained porphyroclastic. There is some variation in modal pyroxene within the section. Pieces 2 and 9 contain compositional banding defined by varying modal pyroxene content (pyroxene poor to pyroxene rich). Banding is best defined between 40–55 and 112–142 cm in the section, each showing two prominent pyroxene-rich bands subparallel to the high-temperature foliation. Pyroxene-rich layers contain pyroxene porphyroclasts up to 18 mm in length. Piece 3 contains a large altered clinopyroxenite band or vein (15 cm thick) within a pyroxene depleted harzburgite. Pieces 4 and 5 contain similar altered pyroxenite veins.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 45
Mode of Occurrence: Replacing olivine.
Amphibole.
Total Percent: 7
Mode of Occurrence: Rimming pyroxene.
Prehnite?
Total Percent: <1
Mode of Occurrence: See description.
Comments: Occurs replacing feldspar in thin basic dikes.
Comments: Olivine shows diffuse alteration to serpentine (50%–100%) and generally preserves a mesh texture, except for high strain domains; clinopyroxene porphyroclasts are rimmed by serpentine (alteration 30%–60%), as are orthopyroxene grains (alteration 30%–60%), with fresh spinel. Vein filling minerals include: 1) serpentine 2) serpentine and hematite 3) hematite 4) serpentine, hematite, and sulfide minerals 5) sulfide minerals (chalcopyrite?). Serpentine-bearing veins are polyphasic syntaxial. A metapyroxenite band is extensively replaced by tremolitic amphibole with a radiating, fibrous texture. Pieces 3–5 are cut by 1–5 mm wide gabbroic and pyroxenitic veinlets altered to serpentine and chlorite. This vein set in Piece 5 cuts a 1.2 cm wide tremolite vein, and both of these are cut by a late, 2 mm wide aqua-colored serpentine vein.
VEIN/FRACTURE FILLING:
Serpentine, pyrite, and hematite.
Percent: 1%
Size: <2 mm.
Orientation: See description.
Comments: Veins occur both parallel to and croscutting the foliation.
Serpentine.
Percent: 1%
Size: <2 mm.
Orientation: See description.
Comments: Veins occur both parallel to and crosscutting the foliation.
Tremolite.
Percent: 1%
Size: 50 mm.
Orientation: See description.
Comments: Veins crosscut foliation.

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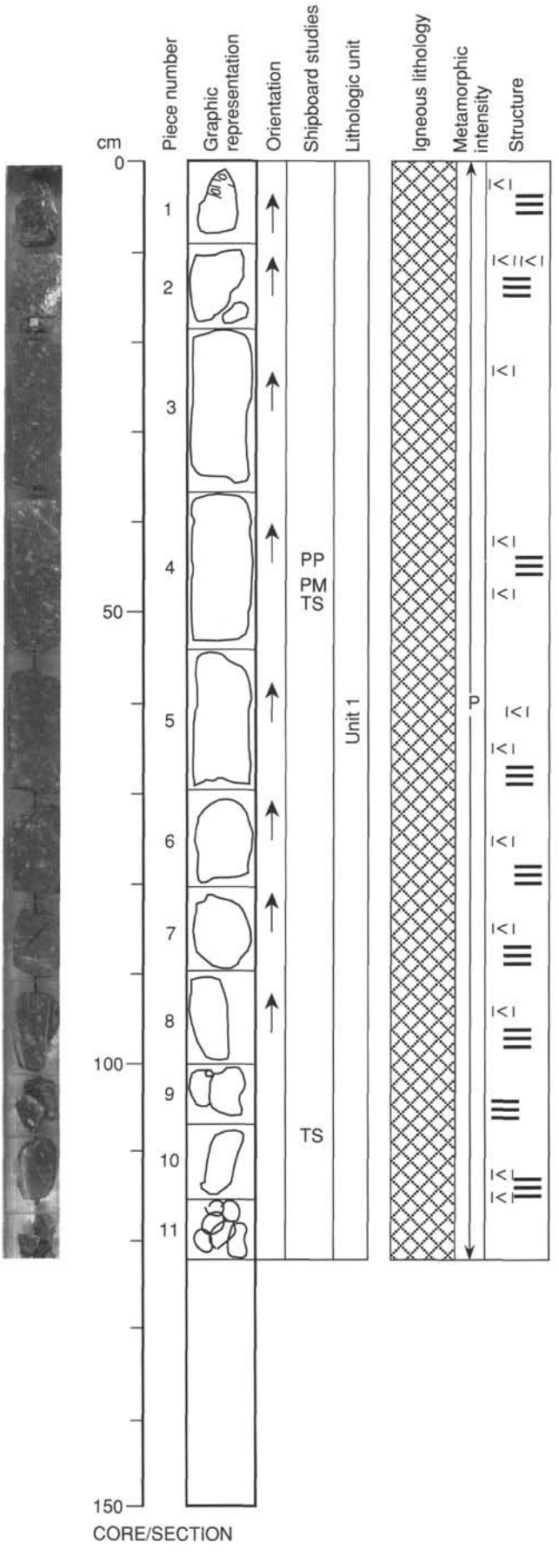
ADDITIONAL COMMENTS: Structure

A penetrative foliation is defined by the preferred dimensional orientation of elongate orthopyroxene porphyroclasts. Dark serpentine veins form an anastomosing foliation that is generally parallel to the pyroxene grain elongation. Compositional banding (Pieces 2 and 9) is oriented subparallel to the foliation. The intensity of the porphyroclast foliation decreases through the first five pieces. Some foliation-parallel veins of white serpentine occur as en echelon arrays. These white veins cut dark green serpentine veins that are oriented at a high angle to the foliation. A less abundant vein array comprises steeply dipping green serpentine veins (1–3 mm wide) that crosscut the white serpentine veins.

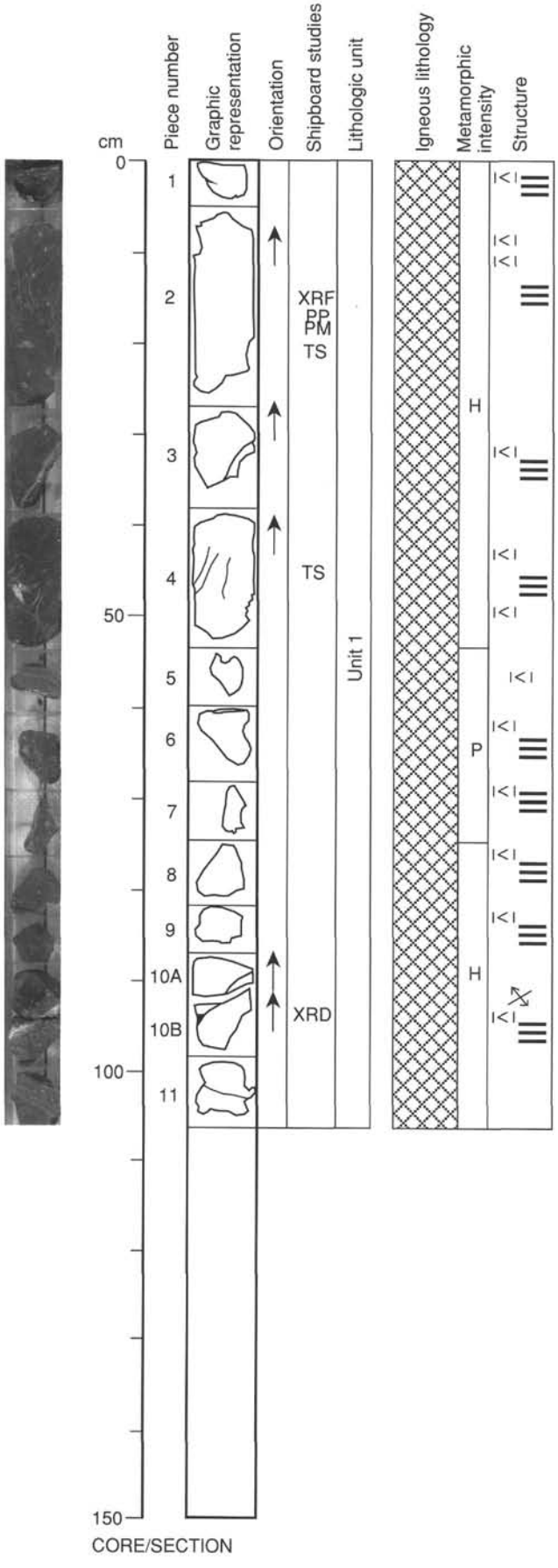


153-920B-1W-3

UNIT 1: SERPENTINIZED HARZBURGITE

Pieces 1–11

COLOR: Black-green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Veins of serpentine.
PRIMARY MINERALOGY:
Olivine - Mode: 85%.
Orthopyroxene - Mode: 12%.
Crystal Size: 1–15 mm.
Crystal orientation: Tectonic.
Clinopyroxene - Mode: 3%.
Crystal Size: 1–8 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: This section consists of serpentinized harzburgite. Generally, the total modal pyroxene content is less than 20% and clinopyroxene is less than 3%. Harzburgite Pieces 2, 6, 7, and 10 are very depleted in pyroxene content and Piece 5 verges on being a dunite. Piece 4 contains prominent serpentine veins (upper right). Chrome spinel is present as isolated grains or clusters of grains. Pieces 8, 9, 10, and 11 contain small gabbroic veins (≈10 mm in thickness). Sulfide mineral veins were noted in Pieces 2 and 5. The texture of these peridotites is coarse-grained porphyroclastic.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 40
Mode of Occurrence: Replacing olivine.
Amphibole.
Total Percent: 5
Mode of Occurrence: Rimming pyroxene.
Comments: Olivine is replaced by serpentine up to 50%. In most cases primary mesh textures are preserved; clinopyroxene (altered 0–60%) and orthopyroxene (altered 20%–60%) porphyroclasts are rimmed by serpentine and clay minerals; clinopyroxene cleavages are deformed. Crosscutting veins are diffuse: the filling is 1) serpentine 2) serpentine and sulfide minerals; 3) serpentine, hematite, and sulfide minerals. Pieces 8–10 are cut by a 5–7 mm wide, near vertically oriented (with respect to the core axis) gabbroic vein, pervasively altered to amphibole, prehnite, serpentine, and chlorite.
VEIN/FRACTURE FILLING:
Serpentine, pyrite, and hematite.
Percent: 1%
Size: <2 mm.
Orientation: See description.
Comments: Veins occur parallel to and crosscutting the foliation.
Serpentine.
Percent: 1%
Size: <3 mm.
Orientation: See description.
Comments: Parallel to foliation.
Amphibole, chlorite, prehnite, and serpentine.
Percent: 10%
Size: 5–7 mm.
Orientation: See description.
ADDITIONAL COMMENTS: Structure
A weak foliation is defined by aligned pyroxene porphyroclasts, intensifying within Piece 8. Most of the pieces contain two vein arrays. The dominant array contains thin white discontinuous serpentine veins that overprint an anastomosing foliation, defined by thin green serpentine veins. The second vein array contains dark green serpentine veins that are cut by the thin white serpentine veins. Many of the dark green serpentine veins are perpendicular to the anastomosing foliation. Small gabbroic veins (≈10 mm in thickness) dip steeply in Pieces 8 and 10. It is not possible to orient the veins in rubble Pieces 9 and 11.



153-920B-2R-1

UNIT 1: SERPENTINIZED HARZBURGITE

Pieces 1–11

COLOR: Black-green.
PRIMARY STRUCTURE: Elongated porphyroclastic.
SECONDARY STRUCTURE: Serpentine veins.
PRIMARY MINERALOGY:
Olivine - Mode: 64–91%.
Orthopyroxene - Mode: 21%–34%.
Crystal Size: 1–17 mm.
Crystal Shape: Elongate.
Crystal orientation: Strong.
Clinopyroxene - Mode: 1%.
Crystal Size: 2–10 mm.
Crystal Shape: Subrounded.
Crystal orientation: Weak.
Spinel - Mode: 1%–2%.
Crystal Size: <1 mm.
Crystal Shape: Holly leaf.
Crystal orientation: Weak to strong.
Comments: Section 1 consists largely of serpentinized harzburgite with coarse porphyroclastic texture. Generally the total modal pyroxene is less than 20%, except for one piece where a pyroxenite vein (2–3 cm thick) cuts the section (seen as a light band on the edges of Pieces 13A and 13B). In Piece 4 a butterfly-shaped white patch in the piece is a highly altered gabbroic patch that contains relict apatite and zircon suggesting that this altered gabbroic rock was highly fractionated. Piece 4 is also the most depleted in pyroxene content verging on dunite. The entire section appears to be highly depleted in pyroxene content. The orthopyroxene-clinopyroxene ratio is generally high throughout the section, except in veins. Piece 6 contains spinel "trains" characterized by linear clusters (continuous or discontinuous) of spinel. Piece 3 contains composite serpentine, (magnesite) and sulfide mineral veins. Pieces 1, 3, 6, 7, 8, 10, and 11 contain sulfide mineral veins.
SECONDARY MINERALOGY:
Serpentine.
Mode of Occurrence: After orthopyroxene and olivine.
Amphibole/tremolite.
Mode of Occurrence: After orthopyroxene.
Brucite.
Iron oxide minerals.
Mode of Occurrence: After pyrite.
Clay minerals.
Mode of Occurrence: After orthopyroxene.
Actinolite.
Mode of Occurrence: After clinopyroxene.
Chlorite?
Mode of Occurrence: After clinopyroxene.
Prehnite?
Mode of Occurrence: In patches.
Comments: Relict olivine forms very fine-grained and rounded, high-relief islands enclosed in a dark black to olive green colored (when wet) serpentinized matrix. [Olivine is commonly pervasively altered, and alteration ranges from (60%–95%).] Small kernels of white colored serpentine after olivine are common in some samples. Rounded to elongate, highly to more rarely pervasively altered (50%–80%) porphyroclasts of orthopyroxene exhibit apple green cores when fresh, darker cores when more highly altered, and are commonly rimmed by well-developed alteration halos of serpentine and clay minerals, with rare brucite. Pale gray blue microveinlets of serpentine cutting orthopyroxenes are uncommon, as are more highly altered partings and kink bands. The outermost alteration halos are commonly discontinuously rimmed by spinel. Clinopyroxene is generally less altered (≈50%) to actinolite and serpentine and exhibits less well-developed halos. Piece 4 contains a butterfly-shaped alteration patch which contains amphibole, chlorite, calcite, clay minerals, apatite, and zircon. This patch is cut by a serpentine veinlet. Piece 9 is cut by a 1cm wide, pervasively altered gabbroic vein. Alteration minerals include tremolite, actinolite, chlorite, and possibly prehnite.
VEIN/FRACTURE FILLING:
Magnesite.
Percent: <1%
Size: 0.1–2 mm.

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Orientation: See comments.

Chrysotile.

Percent: <1%

Size: 0.1–2 mm.

Orientation: See comments.

Sulfide minerals.

Percent: <1%

Size: 0.1–2 mm.

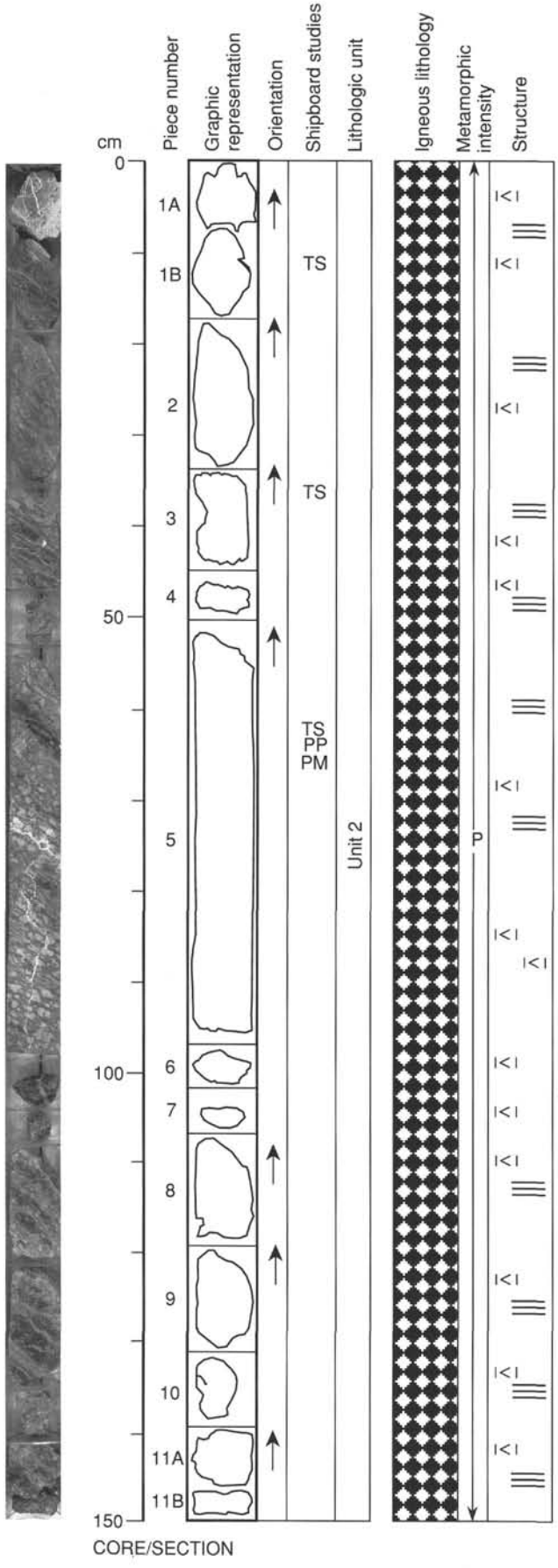
Brucite.

Percent: <1%

Size: 0.1–2 mm.

ADDITIONAL COMMENTS: Structure

Elongated orthopyroxene porphyroclasts form a weak foliation. Two sets of veins are present. One array consists of thin white discontinuous serpentine veins that lie parallel to an anastomosing foliation. These are cut by irregular, branching veins of "chalky," pale green serpentine. The butterfly-shaped alteration patch in Piece 4 is due to an offset created by a serpentinized, mylonitic shear zone (see metamorphic comments). Spinel trails are oriented subparallel to the foliation plane in Piece 6.



CORE/SECTION

153-920B-3R-1

UNIT 2: SERPENTINIZED PYROXENE-RICH HARZBURGITE

Pieces 1A–11B

COLOR: Black/green.
PRIMARY STRUCTURE: Elongated porphyroclastic.
SECONDARY STRUCTURE: Anastomosing foliated with parallel veining and second generation of core-axis parallel veining.
PRIMARY MINERALOGY:
Orthopyroxene - Mode: 18%–45%.
Crystal Size: 2–25 mm.
Crystal Shape: Anhedral.
Olivine - Mode: 54%–81%.
Clinopyroxene - Mode: 1%.
Crystal Shape: Anhedral.
Spinel. - Mode: 0.5%–1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Unit 2 consist of coarse porphyroclastic to coarse elongate porphyroclastic, highly serpentinized pyroxene-rich harzburgite. The top of the unit is defined by a highly altered (calcium metasomitzed peridotite—Piece 1) that is strongly veined with serpentine and sulfide minerals. Across this unit boundary the average modal abundances of pyroxene has increased dramatically approaching 50% in places along the section, but normally between 20% and 40% which is higher than the previous section. Because most of the section was so highly altered it is impossible to accurately distinguish altered orthopyroxene and clinopyroxene. Rough estimates are based on the shape habits typical of fresh orthopyroxene and clinopyroxene, and spatial associations of orthopyroxene with spinel. Orthopyroxene is usually highly kinked (noticeable even in pseudomorphs). Clinopyroxene tends to be blocky and less than 1%–2% of the mode. Sulfide mineral veins were noted in Pieces 1, 5, and 9. Pieces 5, 8, 9, and 11 are characterized by the strongest layering defined by variations in modal pyroxene content. The new unit was defined because of the marked increase in average pyroxene modal abundances.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine and orthopyroxene.
Brucite.
Mode of Occurrence: After olivine.
Amphibole.
Mode of Occurrence: After orthopyroxene.
Comments: Forms coronas after orthopyroxene.
Green amphibole.
Mode of Occurrence: After clinopyroxene.
Comments: Forms coronas after clinopyroxene.
Chlorite(?)
Mode of Occurrence: After clinopyroxene.
Comments: Forms coronas after clinopyroxene.
Iron oxide minerals.
Mode of Occurrence: After pyrite.
Comments: Disseminated and as vein fillings.
Comments: Total alteration from 90% to 100%. Olivine is highly to pervasively (85%–100%) altered to serpentine and iron oxide and clay minerals, and is enclosed in a dark black to white mesh of serpentine and disseminated sulfide minerals, with rare brucite. Porphyroclastic elongate grains of orthopyroxene, which form up to 50 modal%, exhibit moderate to well-developed alteration halos (up to 0.5 cm in width) and are generally pervasively altered (90%–100%). Rare, slightly altered, small, yellow green cores of orthopyroxene are enclosed by disseminated spinel, and from the center outward are rimmed by a dark green corona of serpentine and a lighter colored rim of serpentine and chlorite, which is in turn enclosed by the matrix mesh serpentine. halos after orthopyroxene in the most highly altered samples are crosscut by serpentine microveinlets. Relict cores are completely replaced by intergrowths of serpentine and clay, and iron oxide minerals. Replaced grains are pale green to light gray green in color. Clinopyroxene is highly to pervasively altered to serpentine (80%–100%).
Veins
Piece 1 is a heterogeneously altered, highly calcium-metasomatized sample, in which primary mineralogy in the top portion of the sample is almost completely obscured by intergrowths of tremolite, talc, and prehnite(?).

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Calcite veins cut spinel and postdate veins of talc. Disseminated fine-grained sulfide minerals are enclosed in the calcite matrix and also occur as discontinuous lenses associated with composite calcite and talc veins.

1. Composite wisps of white serpentine and dark serpentine veins are abundant in the section.
2. Piece 6 is cut by an irregular shaped vein, 3 mm wide, which is oriented at a high angle to the foliation. It includes white serpentine, pyrite, and calcite.

VEIN/FRACTURE FILLING:

Calcite, talc, and sulfide minerals.

Percent: <10%
Size: Irregular, 20 mm.
Orientation: See description.

Talc and calcite.

Percent: <10%
Size: 20 mm.
Orientation: See description.

ADDITIONAL COMMENTS: Contact

The contact between Unit 1 and 2 was not recovered. The new unit is based a significant increase in modal pyroxene in the section.

Structure

A strong foliation, defined by the orthopyroxene porphyroclast elongation, is present in Piece 1B, diminishing in intensity toward the base of the piece. Axial ratios of porphyroclasts on the cut face reach 7:1. A moderate to strong plastic fabric intensity persists through the rest of the core. Compositional layering is parallel to the orthopyroxene fabric. The strong plastic fabric is mirrored by the intensity of the anastomosing foliation, defined by thin green serpentine veins. Thin white discontinuous veins are oriented parallel to, and overprint, the anastomosing foliation. Both fabrics dip between 40° to 50°.

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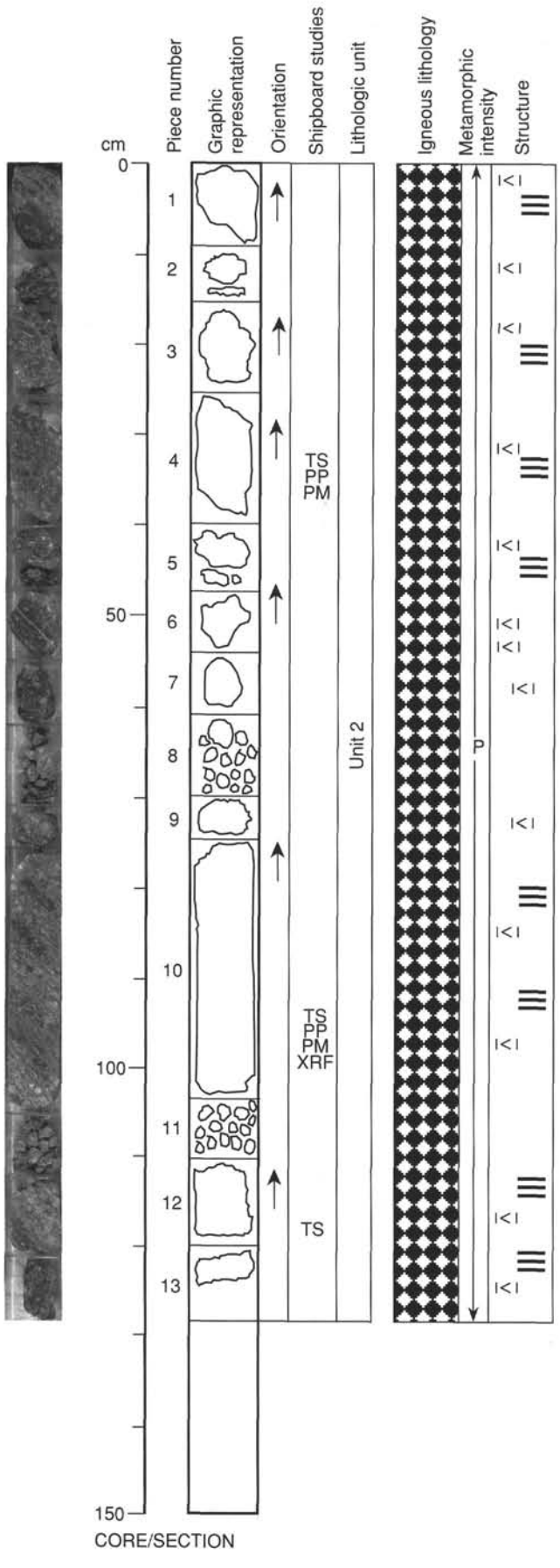
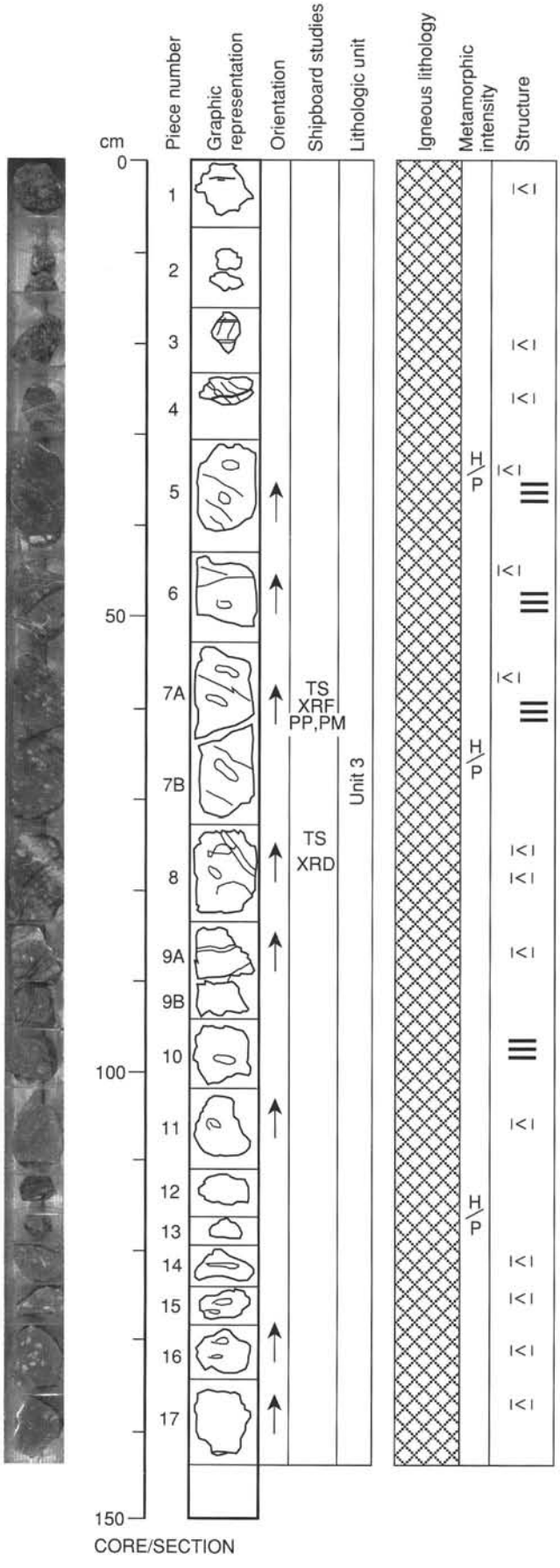


UNIT 2: SERPENTINIZED PYROXENE-RICH HARZBURGITE

Pieces 1–13

COLOR: Green-gray.
PRIMARY STRUCTURE: Elongated porphyroclastic.
SECONDARY STRUCTURE: Anastomosing foliation with parallel veining.
PRIMARY MINERALOGY:
Olivine - Mode: 69%–85%.
Orthopyroxene - Mode: 15%–30%.
Crystal Size: 3–30 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 1%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: 1–2 mm.
Crystal Shape: Anhedral.
Comments: Interlayed coarse porphroclastic lherzolite and harzburgite. Layer contacts observed in Pieces 1, 5, and 12. Layer contacts are marked by increases or decreases in the modal pyroxene content. Dominant lithology has high modal pyroxene and with orthpyroxene between 20% and 30% of the mode. The degree of alteration is extreme in most samples (95%–100%). Pieces 6 and 8 contain pyroxenite veins. Primary mineralogy is preserved in some of the samples, but alteration exceeds 90% in all samples examined. Fresh olivine, orthopyroxene, clinopyroxene, and spinel were observed in the section, but in minor abundances. Piece 16 contains the least altered relicts of the primary mineralogy. Sulfide mineral veins were not observed in the pieces examined.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After orthopyroxene, olivine, clinopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine, clinopyroxene.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Comments: Olivine is in general highly to pervasively altered to mesh textured white, black to olivine green-colored serpentine, clay(?), and iron oxide minerals. Localized areas contain fresh clear olivine kernels enclosed in the serpentine matrix. Orthopyroxene is highly to pervasively altered with fresh yellow green cores in color which are rimmed by moderate to well-developed coronas (up to 0.9 cm in width) of disseminated spinel, serpentine, and clay minerals. Porphyroclasts exhibit a bastite texture and are cut by serpentine veinlets. Rare iron oxide mineral veinlets are also present. Piece 6 is cut by a narrow pyroxenite vein, 2 mm in width, which is pervasively altered to serpentine with a chloritic(?) core. A ≈1 cm wide depletion zone (orthopyoxene poor) systematically bounds the vein.
VEIN/FRACTURE FILLING:
White, green and black serpentine.
Percent: <10%
Size: <2 mm.
Orientation: See description.
Serpentine
Percent: <10%
Size: <10 mm
ADDITIONAL COMMENTS: Structure
A weakly developed elongate porphyroclastic fabric defines a foliation throughout the section, intensifying in Piece 10, where axial ratios of porphyroclasts reach values of 4:1. An anastomosing foliation defined by cross-fibered, thin white serpentine veins (<1 mm) pervades the serpentine matrix. Compositional layering in Piece 1 dips at about 17°, a lower angle than the foliation or plastic fabric. In Pieces 6, 10, and 12 the compositional layering dips at about 45°.



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UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–17

COLOR: Dark green.
PRIMARY STRUCTURE: Coarse-grained porphyroclastic.
SECONDARY STRUCTURE: Anastomosing foliation with thin white veins.
PRIMARY MINERALOGY:
Olivine - Mode: 75%–80%.
Orthopyroxene - Mode: 18%–20%.
Crystal Size: 3–20 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 1%.
Crystal Shape: Anhedral.
Spinel. - Mode: <1.5%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: The section represents a return to more depleted serpentinized porphyroclastic harzburgite. This is marked by an obvious reduction in pyroxene modal abundance and a more subtle layering in the core. In general, modal abundance of pyroxene appears to decrease to near a minimum at the base of the section described, but averages about 15%. Pieces 9, 10, 11, and 17 are very depleted in pyroxene and verge locally in parts of these pieces to dunite compositions. Piece 8 contains a pyroxenite vein 12 mm thick. Piece 9 contains a pyroxenite vein 10 mm thick. Composite sulfide mineral and chrysotile cross-fiber veins are in lower abundances except locally (e.g. Piece 8 and 17). In general, the primary mineralogy is better preserved in the section with fresh olivine, clinopyroxene, orthopyroxene, and spinel abundant in many samples. Piece 11 contains a high concentrations of spinel locally within the piece.
SECONDARY MINERALOGY:
Serpentine.
Texture: Fibrous-mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Brucite.
Mode of Occurrence: After olivine.
Amphibole.
Texture: Fibrous.
Mode of Occurrence: After orthopyroxene.
Green amphibole.
Mode of Occurrence: After clinopyroxene.
Chlorite.
Mode of Occurrence: After clinopyroxene.
Iron oxide minerals.
Mode of Occurrence: After pyrite.
Clay minerals.
Mode of Occurrence: After olivine and orthopyroxene.
Comments: Total alteration is 60%–98%. Olivine is highly to pervasively altered (50%–100%); when fresh it forms clear, high-relief islands enclosed in a brown to olive green serpentine mesh, with rare brucite and talc. Orthopyroxene is highly to pervasively altered exhibiting poorly developed alteration halos of fine-grained cummingtonite, talc, and serpentine. When fresh it exhibits apple green grains, which are locally cut by serpentine veinlets. Spinels occur around olivine and pyroxene grain boundaries. Clinopyroxene alteration is highly variable, ranging from 30%–100%. It is altered to chlorite(?) and serpentine.
Veins
Piece 8 is cut by a 1-cm-wide pyroxenite vein, now pervasively altered to tremolite-actinolite, chlorite, and serpentine. It is bounded by a seam of sulfide minerals. Piece 17 contains abundant sulfide mineral grains in a serpentine vein on broken surface. White to aqua green-colored serpentine veins <1 to 1 mm wide are common in Pieces 5, 6, and 8.
VEIN/FRACTURE FILLING:
White green and black serpentine, minor pyrite.
Percent: <10%
Size: <1 to 6 mm.
Orientation: See comments.
ADDITIONAL COMMENTS: Contact Unit 2 and Unit 3. The contact between Unit 2 and 3 is not exposed, but there is a marked reduction in the modal pyroxene at the start of section 4R1. Unit 3 is a pyroxene depleted harzburgite.
Structure
A weak foliation delineated by orthopyroxene porphyroclast elongation is oriented

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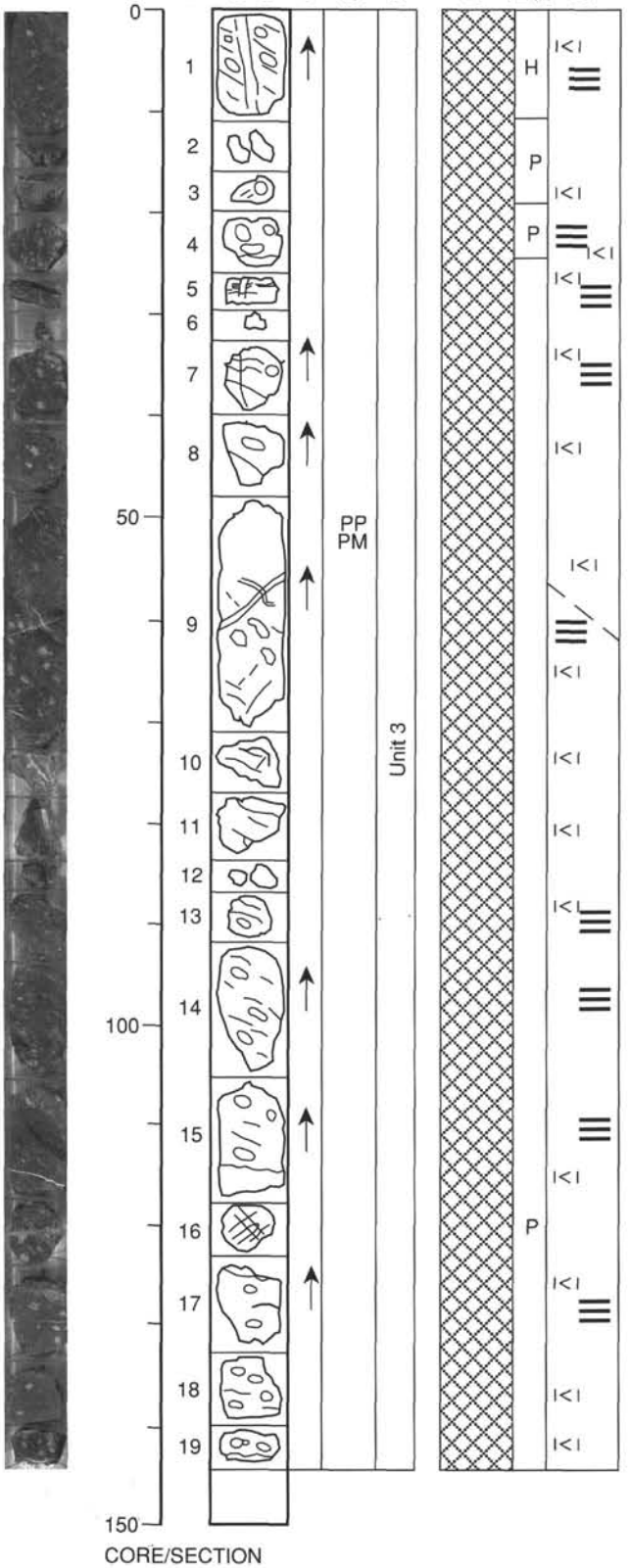
consistently at a 30°–35° dip. The foliation intensifies in Pieces 5, 7, 14, and 15. Altered pyroxenite veins in Pieces 8 and 9 are oriented subperpendicular to orthopyroxene fabric. Light green serpentine veins cut thin white discontinuous serpentine veins that overprint the anastomosing foliation.



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UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–19

COLOR: Black green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Two vein sets parallel and perpendicular to the foliation.
PRIMARY MINERALOGY:
Olivine - Mode: 68%–90%.
Orthopyroxene - Mode: 8%–30%.
Crystal Size: 1–20 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 1%.
Crystal Size: 1–6 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <2%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: Unit 3 (serpentinized porphyroclastic harzburgite) continues in this section. Subtle interlayering defined by pyroxene abundance continues downsection. In general, the primary mineralogy is well preserved in the section with significant amounts of remnant fresh olivine, orthopyroxene, clinopyroxene, and spinel. Modal abundance of partially serpentinized olivine is generally more than 70%. Total pyroxene abundance is highly variable; orthopyroxene (10% to 30%), clinopyroxene (from less than 1% to 5%). Modal abundance of spinel is less than 1%. Pieces 8, 9, 10, 11, 13, and 15 are the most depleted in pyroxene content. Pieces 5 and 9 contain thin gabbroic veins (2 mm in thickness). Piece 16 contains a composite pyroxenite-gabbro vein with pyroxenite lining the walls of the vein and gabbro forming its center. Maximum grain size of porphyroclastic orthopyroxene grains is commonly less than 2 cm. Pyroxene-rich and -poor layers are observed (e.g. Pieces 4 and 9). In the pyroxene-rich layers of Piece 4 modal abundance of clinopyroxene higher. Clinopyroxene grains are commonly in association with large grains of orthopyroxene. Piece 19 contains a composite carbonate and sulfide mineral vein.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 75
Texture: Mesh
Mode of Occurrence: Replacing olivine.
Amphibole(s).
Total Percent: 15
Mode of Occurrence: See description.
Comments: Pseudomorphs and rims pyroxenes.
Iron oxide minerals.
Total Percent: Trace.
Comments: Product of serpentinization.
Bastite.
Total Percent: <10
Mode of Occurrence: Replacing orthopyroxene.
Comments: Olivine is replaced by serpentine up to 100%. Clinopyroxene and orthopyroxene porphyroclasts are rimmed by serpentine.
Veins
Piece 9 is cut by a 2 mm wide gabbroic(?) vein now altered to serpentine, chlorite, and pale green amphibole. The vein is oriented at a high angle to the fabric defined by the elongation of orthopyroxene porpyroclasts and is itself cut by a discontinuous aqua green serpentine vein which is subparallel to the orthopyroxene foliation. Piece 10 is net veined with fine white- to cream-colored serpentine. Piece 11 is an olivine-rich (dunitic) sample that is bounded on one side by a 5 mm wide composite vein consisting of tremolite, bounded by chlorite, prehnite, and serpentine. Piece 16 is crosscut by 2 veins, one 2 mm and the other 5 mm wide. They are composed of amphibole, chlorite, serpentine, and minor prehnite(?). These veins are crosscut at a high angle by discontinuous aqua green veins. Piece 19 is bounded on one side by a 4 mm wide aragonite and sulfide mineralized vein.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 98%
Size: <10 mm.
Orientation: See comments.

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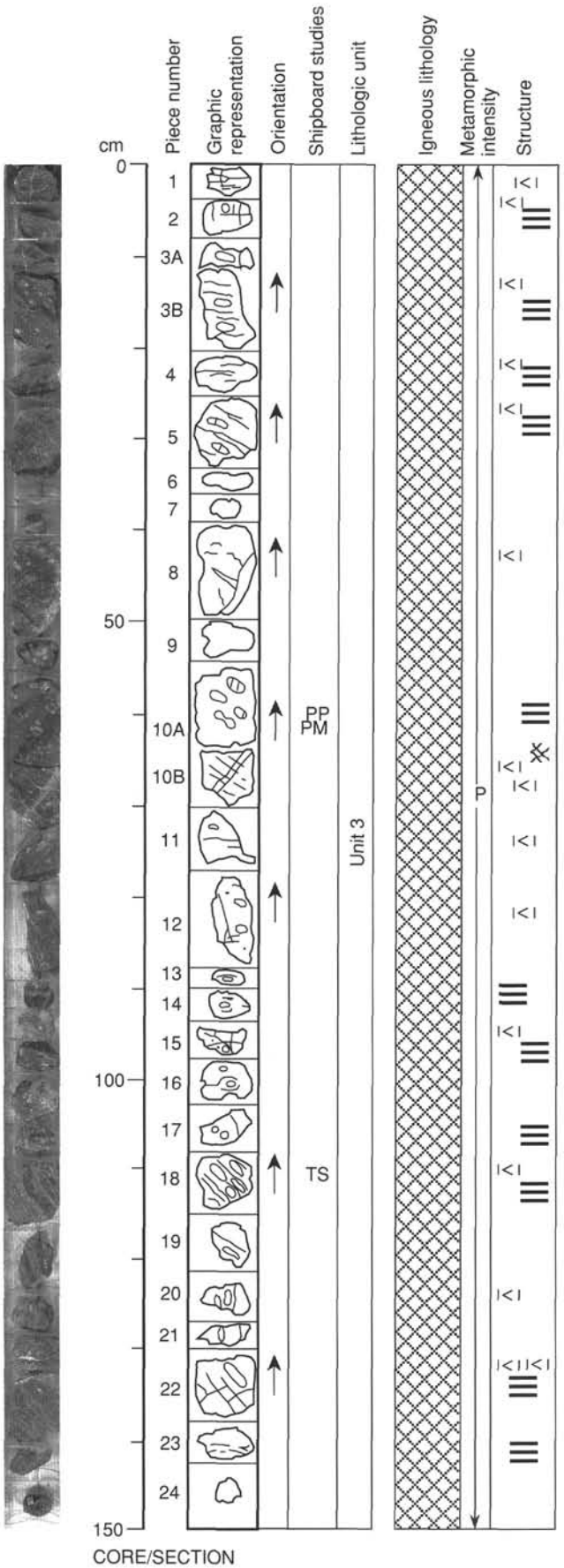
Hematite.
Percent: 1%
Orientation: See comments.
Sulfide minerals.
Percent: 1%

ADDITIONAL COMMENTS: Structure

This section has a moderately intense and relatively uniform foliation defined by orthopyroxene porphyroclast elongation. The porphyroclasts are also deformed by irregular intracrystalline cracks. The foliation dips at approximately 35°. An anastomosing foliation composed of thin green serpentine veins also has a moderate intensity and overprints the porphyroclast deformation. Compositional layering in Piece 9 dips more steeply than foliation at about 40°. The dunitic horizon in Piece 9 is more strongly deformed than the adjacent pyroxene rich layers. The abundance of vein material reaches greater than 10% in Pieces 10, 11, and 19. The pyroxenite-gabbro dike in Piece 16 is oriented at a high angle to the foliation but no true dip could be measured.



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UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–24

COLOR: Black green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Two vein sets parallel and perpendicular to the foliation.
PRIMARY MINERALOGY:
Olivine - Mode: 79%–99%.
Orthopyroxene - Mode: 1%–20%.
Crystal Size: 3–12 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 1%.
Crystal Size: 3–5 mm.
Crystal Shape: Anhedral.
Crystal orientation:
Spinel. - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized and depleted porphyroclastic harzburgite and dunite are the predominant rock types near the top of the section and harzburgite more enriched in pyroxene dominates the base of the section. Pyroxene content is generally less than 15% in Pieces 1–16. Pieces 1, 2, 6, 7, 10, and 11 are most depleted, in places verging to dunite within the pieces (e.g., Piece 7). Pieces 8 and 10 contain pyroxene-rich veins. Pieces 18, 20, 21, and 22 are more "enriched" in pyroxene content (>20%). Pieces 23 and 24 also contain altered pyroxenite veins.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 85
Texture: Mesh to ribbon.
Mode of Occurrence: Replacing olivine.
Amphibole(s).
Total Percent: 13
Mode of Occurrence: See description.
Comments: Pseudomorphs and rims pyroxene.
Iron oxide minerals.
Total Percent: 2
Comments: Product of serpentinization.
Bastite.
Total Percent: <10
Mode of Occurrence: Replacing orthopyroxene.
Comments: The main texture is porphyroclastic, with a weak foliation defined by the elongation of orthopyroxene porphyroclasts. A set of 10 to 20 mm thick serpentine veins cut the orthopyroxene foliation at a high angle and are themselves cut by thin, radiating crystalline serpentine veins with low, but variable, abundance. The later veins are typically <2 mm thick, and in some places occur in en echelon sets. Piece 10B is cut by a 7 mm wide tremolite, serpentine, and oxide minerals vein which is cut by abundant thin aqua green serpentine and tremolite veins which are oriented at a high angle to the thick vein. The larger vein appears to have been derived from a gabbroic protolith. Pieces 16–23 have abundant, composite white, wispy veins of white serpentine and black serpentine and iron oxide minerals.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 97%
Size: 1–2 mm.
Orientation: See comments.
Magnetite.
Percent: 1%
Size: 1–2 mm.
Orientation: See comments.
Hematite.
Percent: 1%
Sulfide minerals.
Percent: 1%

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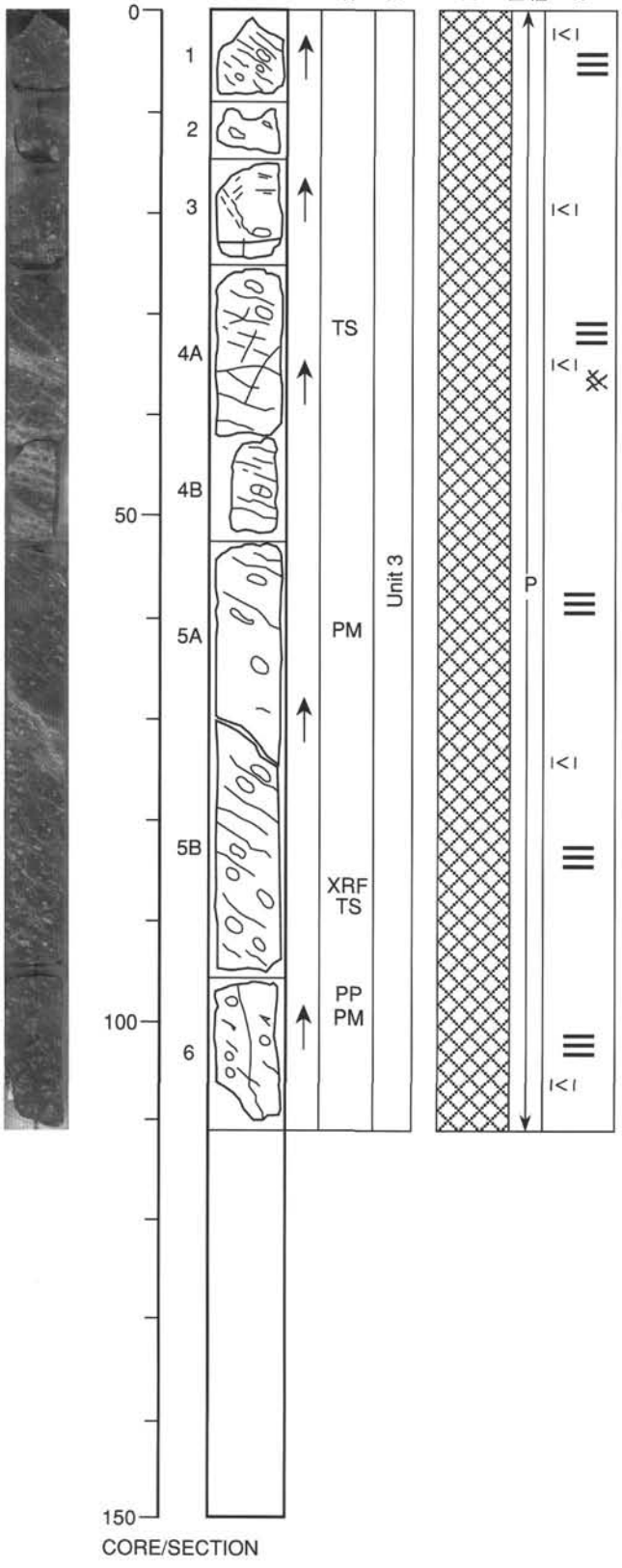
ADDITIONAL COMMENTS: Structure

A penetrative foliation, defined by elongate orthopyroxenes, has a weak to moderate intensity over Pieces 1–19. The fabric intensifies over Pieces 20 to 24, to the end of the section and steepens to a dip of about 60°. An anastomosing foliation composed of thin green serpentine veins also intensifies toward the base of the section. Pale green serpentine veins cut the thin white discontinuous veins that overprint the anastomosing foliation. Pyroxene-rich veins in Pieces 8 and 10 are oriented obliquely to the orthopyroxene fabric.



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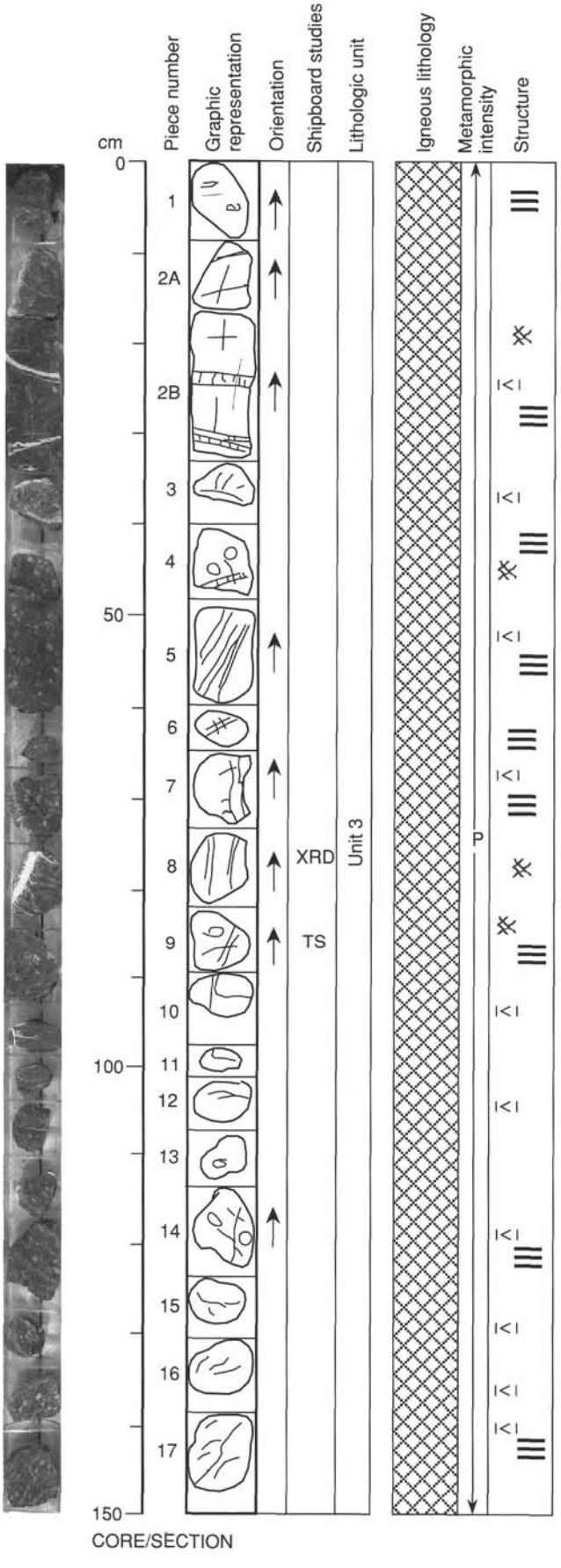
UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–6

COLOR: Dark green/black.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Two vein sets parallel and perpendicular to the foliation.
PRIMARY MINERALOGY:
Olivine - Mode: 79%–84%.
Orthopyroxene - Mode: 15%–20%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 1%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: The serpentinized depleted harzburgite of Unit 3 continues in this section. Total pyroxene abundance is usually <20%, but is locally more abundant. For example, Piece 4 contains strongly interlayered pyroxene-rich harzburgite and pyroxene-poor harzburgite. Six layers can be observed in this piece. A little altered pyroxenite vein 1 cm thick cuts Piece 2. A 1–2 mm thick gabbroic vein cuts Piece 6. Unaltered relics of the primary phases (olivine, orthopyroxene, and clinopyroxene) are abundant in the section. Spinel is an ubiquitous accessory.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 75
Mode of Occurrence: Replacing olivine.
Amphibole(s).
Total Percent: 23
Mode of Occurrence: See description.
Comments: Pseudomorphs and rims pyroxenes.
Iron oxide minerals.
Total Percent: 2
Comments: Product of serpentinization.
Bastite.
Total Percent: <10
Mode of Occurrence: Replacing orthopyroxene.
Comments: There is a ubiquitous tectonic alignment of the pyroxene porphyroclasts. Extensive replacement of olivine (up to 100% in most cases) by serpentine, iron oxide minerals, and clay minerals are common. Clinopyroxene and orthopyroxene porphyroclasts are rimmed by serpentine with traces of amphibole(?) and chlorite. Secondary sulfide minerals (up to 2%) occur in Piece 8. Vein filling is comprised of:
1) serpentine
2) a second generation of serpentine with carbonate minerals, and
3) serpentine, aragonite, and sulfide minerals.
Early veins of serpentine, magnetite, and pyrite cut the pyroxene-rich harzburgite. Later thin white anastomosing veinlets of radiating and fibrous serpentine cut the thicker serpentine veins, and lie subparallel to the foliation.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 97%
Orientation: See comments.
Magnetite.
Percent: 1%
Orientation: See comments.
Hematite.
Percent: 1%
Sulfide minerals.
Percent: 1%
ADDITIONAL COMMENTS: Structure
Deformation is characterized by a moderate to strong foliation formed by the shape preferred orientation of elongate orthopyroxene porphyroclasts. The fabric development intensifies downward over Pieces 3, 4, and 5 becoming strongest at the base of Piece 5. The layering in Piece 4 is subparallel to the crystal plastic fabric. An increase in the intensity of white serpentine veins corresponds to the increase in the orthpyroxene content. A thick gabbroic vein in Piece 6 cuts the anastomosing foliation and plastic fabric at a high angle.



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UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–17

COLOR: Gray/black.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Two vein sets parallel and perpendicular to the foliation.
PRIMARY MINERALOGY:
Olivine - Mode: 80%–90%.
Orthopyroxene - Mode: 9%–20%.
Crystal Size: 2–18 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 0–3%.
Crystal Size: 1–4 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: Unit 3 continues in this section (serpentinized pyroxene-poor harzburgite). Pyroxene abundance is fairly constant with typical values of 0–3% and 10%–20% for clinopyroxene and orthopyroxene, respectively. The variation in modal composition is local without the development of any compositional layering parallel to the high-temperature foliation. For example, Pieces 2, 7, and 8 contain altered clinopyroxenite or gabbro veins that show halos adjacent and parallel to the vein that represents regions of the peridotite that are significantly depleted in pyroxene (dunitic halos), probably as the result of melt wall-rock interaction associated with the vein. Piece 3 appears, in part, to represent altered pyroxenite vein material (small piece). The section is highly altered, but the primary mineralogy is preserved locally. Spinel is a ubiquitous accessory.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 80
Mode of Occurrence: Replacing olivine.
Amphibole(s).
Total Percent: 12
Mode of Occurrence: See description.
Comments: Pseudomorphs and rims pyroxenes.
Iron oxide minerals.
Total Percent: 3
Comments: Product of serpentinization.
Bastite.
Total Percent: <10
Mode of Occurrence: Replacing orthopyroxene.
Comments: Pervasive alteration of olivine to serpentine occurs in this section (Pieces 2B, 5, 8, and 13). Orthopyroxene porphyroclasts are flattened and elongated, with extensive replacement and rimming of serpentine. Serpentine (lizardite) and magnetite veins crosscut earlier serpentine (chrysotile) veins. Both brittle episodes show polyphase evolution. In Piece 11 magnesite veins are crosscut by later veins of magnetite and sulfide minerals. Pieces 2A and 2B are rimmed on one side by a vertical, 6 mm wide vein with tremolite/actinolite, magnetite, serpentine, chlorite, and minor prehnite. Tapering aqua-colored serpentine veins cut the composite vein and change to prehnite at the margin of the main vein. Massive white serpentine veins with cores of cream-colored zeolite also cut the first-generation veins. Similar veins are observed in Piece 8. Piece 3 is net veined by abundant serpentine, tremolite, and oxide mineral veins. Piece 5 has diffuse, tapering, dark green blue serpentine veins that are 2 mm to 4 mm in width and rimmed by chlorite. They are cut by later aqua-colored serpentine veins.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 99%
Size: <1 to >10 mm.
Orientation: See comments.
Magnetite.
Percent: 1%
Size: <1 to >10 mm.
Orientation: See comments.

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ADDITIONAL COMMENTS: Structure

An weak anastomosing foliation represented by thin green serpentine veins dips steeply (up to 75°) through most of the section. In Pieces 3, 8, and 9, elongated porphyroclasts of orthopyroxene are oriented perpendicular to a moderate to strong anastomosing foliation. The altered gabbroic/pyroxenite vein in Piece 7 dips steeply, oriented subparallel to the anastomosing foliation. White, segmented serpentine veins that overprint the anastomosing foliation reach thicknesses of up to 1 cm. They are deflected to high angles (>60°) away from the dominant foliation plane in pyroxene-rich horizons. The thin white serpentine veins cut an earlier generation of green serpentine veins with cross fibers. Pale white/green massive serpentine veins, with irregular, branching geometries cut the white serpentine veins.

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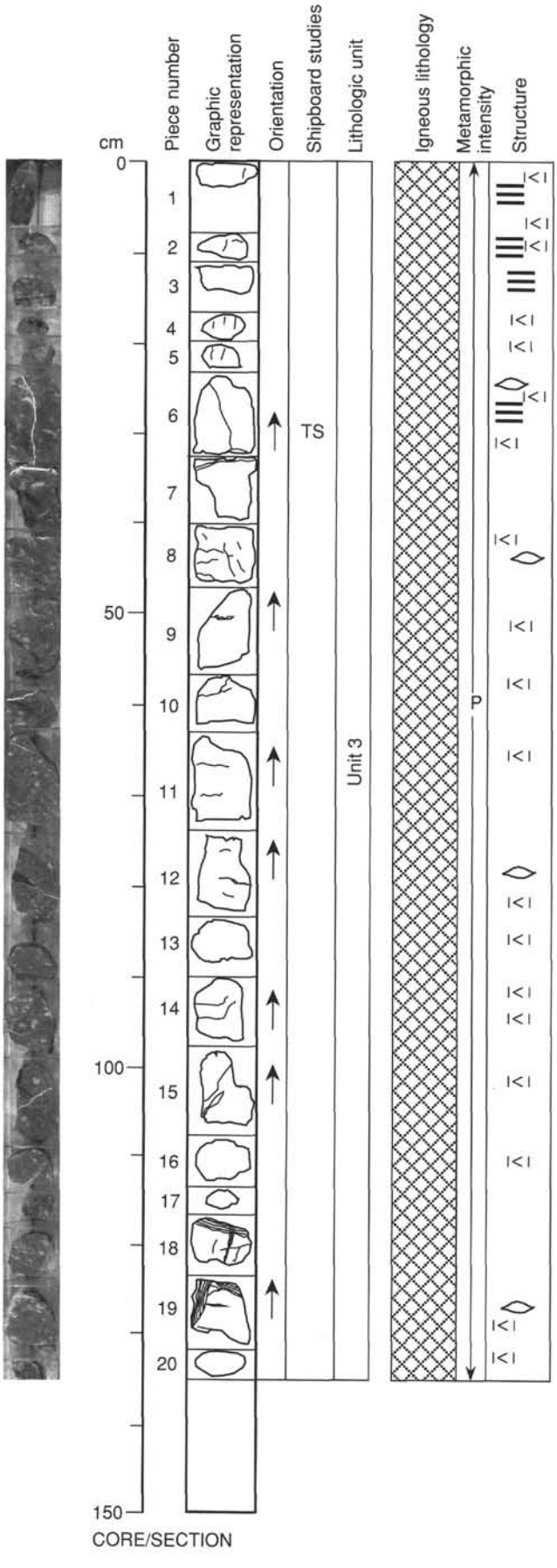
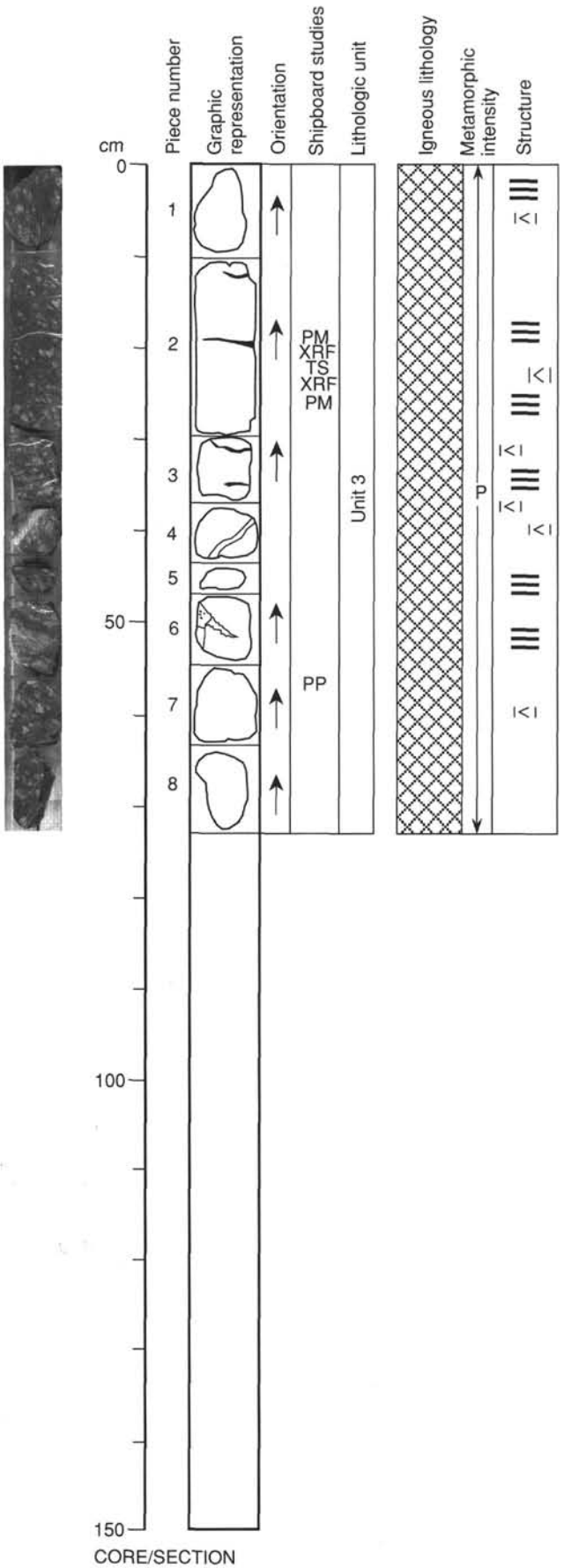


UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–20

COLOR: Green/gray-black.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Two vein sets parallel and perpendicular to the foliation.
PRIMARY MINERALOGY:
Olivine - Mode: 80%.
Orthopyroxene - Mode: 17%–19%.
Crystal Size: 2–18 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 0–2%.
Crystal Size: 1–4 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: This section consists of porphyroclastic serpentinized harzburgite that ranges from depleted (<20%) to very depleted (<10%–15%) in pyroxene content. The section is associated with several pyroxenite veins. For example, Pieces 1, 2, and 16 contain pyroxenite vein material. Pieces 18 and 19 appear to contain pyroxenite veins cut at their centers by later serpentine veins (on edges of piece). Pieces 7, 8, 10, 11, 12, 14, and 15, consist of harzburgite that is very depleted in pyroxene. The interval from 110–131 cm contains highly altered large grains of clinopyroxene aligned in trains across the core. The variation in modal composition is always very local without any presence of compositional layering concordant to the high-temperature foliation. It is usually associated with proximity to vein pyroxenite or gabbroic vein material. The section is highly altered and scarce unaltered primary phases are observed. Spinel is a ubiquitous accessory.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 80
Mode of Occurrence: Replacing olivine.
Amphibole(s)
Total Percent: 10
Mode of Occurrence: See description.
Comments: Pseudomorphs and rims pyroxenes.
Iron oxide minerals.
Total Percent: 2
Comments: Product of serpentinization.
Bastite.
Total Percent: <5
Mode of Occurrence: Replacing orthopyroxene.
Comments: Extensive alteration of olivine to serpentine is observed in Piece 6A; ribbon textures are widely developed. Clinopyroxene and orthopyroxene porphyroclasts are elongated; alteration to serpentine is pervasive. Millimeter-sized serpentine (chrysotile) and magnetite veins crosscut the main foliation at low angle.
Veins
White veins typically <1 to 2 mm wide and composed of serpentine, and oxide and sulfide minerals occur in Pieces 6, 7, 9, 11, 13, 14, and 18. Wispy white serpentine veins commonly observed in serpentinized harzburgites that are rich in pyroxene porphyroclasts are absent in this section.
VEIN/FRACTURE FILLING:
Serpentine.
Magnetite.
Sulfide minerals.
ADDITIONAL COMMENTS: Structure
A weak anastomosing foliation defined by thin green serpentine veins, dips at 60°–70°. The anastomosing foliation reaches its highest intensity in Piece 6. Light green serpentine veins cut thin white serpentine veins that overprint the anastomosing foliation. Dark green serpentine veins cut the foliation at a high angle but also trend parallel to it. A weak fabric defined by the shape preferred orientation of pyroxene porphyroclasts is present in Pieces 7, 11, 12, 18, and 19. Other pieces show no shape preferred orientation.



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UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–8

COLOR: Green/gray-black.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Two vein sets parallel and perpendicular to the foliation.
PRIMARY MINERALOGY:
Olivine - Mode: 75%–80%.
Orthopyroxene - Mode: 16%–20%.
Crystal Size: 2–20 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 2%–3%.
Crystal Size: 2–8 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%–2%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: The section is composed dominantly of depleted pyroxene-poor serpentinized harzburgite (pyroxene <20%). Pyroxene abundance is generally between 15%–20%, but locally becomes lower. The extent of alteration is high, but the primary phases are preserved as relict grains. Piece 4 contains a thin (2 mm) concordant gabbroic vein. The harzburgite is highly depleted in pyroxene along the vein. Likewise, Piece 6 contains a pyroxenite band concordant with the high-temperature foliation. Sharp variations in modal composition are seen across layers a few cm thick in Piece 8.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 81
Mode of Occurrence: Replacing olivine.
Comments: Pseudomorhs and rims.
Amphibole(s).
Total Percent: 18
Mode of Occurrence: Replacing pyroxene.
Comments: Pseudomorhic.
Iron oxide minerals.
Total Percent: 1
Comments: Product of serpentinization.
Bastite.
Total Percent: <5
Mode of Occurrence: Replacing orthopyroxene.
Comments: Intense alteration of olivine to serpentine is common. Clinopyroxene and orthopyroxene porphyroclasts are altered to serpentine. Serpentine veins crosscut clinopyroxene porphyroclasts. Diffuse, serpentine-bearing veins crosscut the foliation at high angle. Tapering white to cream-colored serpentine and cream-colored zeolite veins 1–2 mm wide occur in Pieces 2 and 3. Piece 4 contains a 9 mm wide tremolite/actinolite and prehnite vein with serpentine and chlorite-rich margins. This assemblage may replace a gabbroic protolith.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 99%
Magnetite.
Percent: 1%
ADDITIONAL COMMENTS: Structure
A weak to moderate plastic foliation defined by orthopyroxene porphyroclast elongation dips between 20° to 30° in Pieces 3, 4, 5, and 6. A weak anastomosing foliation represented by thin (<1 mm) green serpentine veins has only sparse white serpentine veins overprinting it. Irregular, branching, light green serpentine veins with sulfide minerals cut the anastomosing foliation. In Piece 2 one of these veins intersects the pyroxene fabric at about 38°. An altered gabbroic vein in Piece 4 is oriented subparallel to the foliation.

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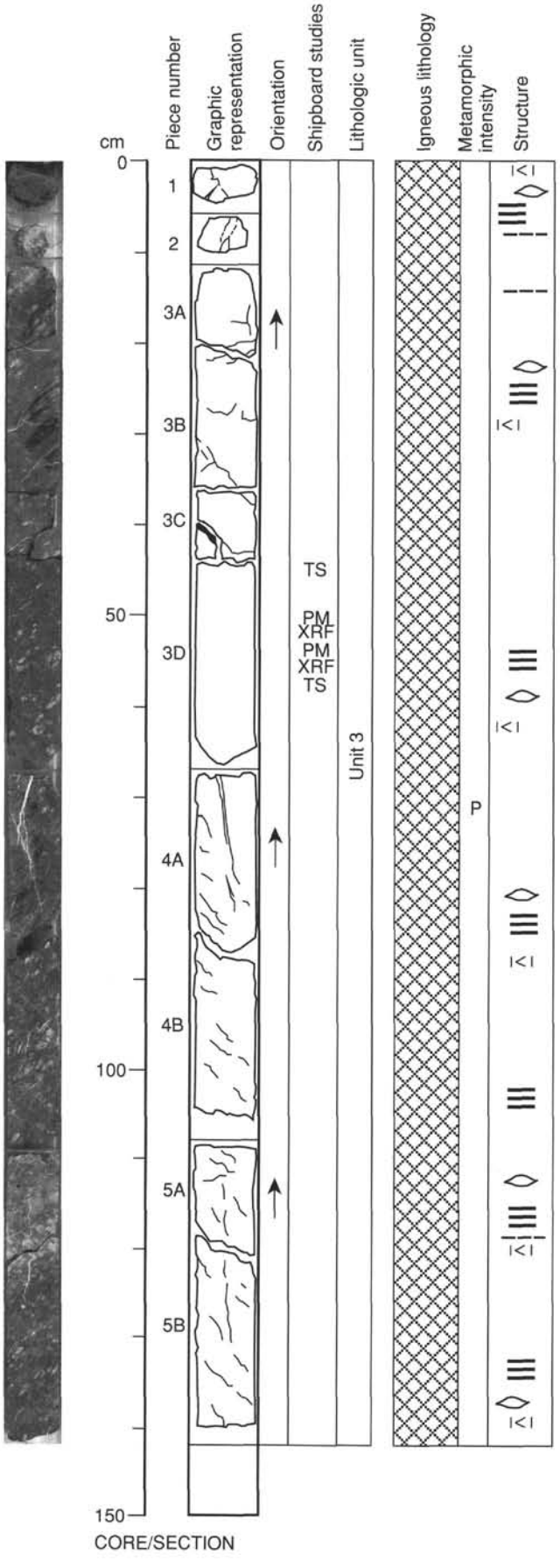

UNIT 3: SERPENTINIZED HARZBURGITE WITH PYROXENITE VEIN

Pieces 1–5B

COLOR: Dark gray/green.
PRIMARY STRUCTURE: Elongated porphyroclastic.
SECONDARY STRUCTURE: Anastomosing foliation with parallel veining.
PRIMARY MINERALOGY:
Olivine - Mode: 25%–80%.
Orthopyroxene - Mode: 15%–74%.
Crystal Size: 2–12 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 0–4%.
Crystal Size: 1– 3 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: The section consists of predominantly porphyroclastic serpentinized harzburgite. Modal proporations of pyroxene vary throughout the section from as low as 10% at ≈117 cm, to as high as 75% at a pyroxene vein/segregation in Piece 2. Piece 3 contains an altered clinopyroxenite at the top (3 cm wide) which is associated with a zone of pyroxene depletion in the adjacent harzburgite. This vein is not exactly concordant to the high-temperature foliation and its irregular shape indicates that it is unaffected by the deformation. This indicates that it is a late stage magmatic/metasomatic phase post-dating the deformation. The depletion halo along the vein margin is strong and follows a general and broader trend to increased pyroxene depletion from the base of the core section to the pyroxenite vein. The original size of the vein is unknown because the recovery is not complete over this interval but based on the wide zone showing depletion it is probably larger than sampled. The primary assemblages are preserved as relicts locally although the alteration generally exceeds 90% throughout the section.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh-fibrous.
Mode of Occurrence: After orthopyroxene, olivine.
Brucite.
Mode of Occurrence: After orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Comments: Forms anastomosing networks after pyrite.
Spinel.
Mode of Occurrence: Exsolution lamellae.
Comments: From orthopyroxene.
Amphibole.
Total Percent: Minor.
Mode of Occurrence: After orthopyroxene and clinopyroxene.
Chlorite?
Mode of Occurrence: After clinopyroxene.
Clay minerals.
Mode of Occurrence: After orthopyroxene, clinopyroxene, olivine.
Pyrite.
Mode of Occurrence: Associated with clinopyroxene.
Comments: The primary mineralogy is highly to pervasively altered with total alteration reaching approximately 98%–100%. Olivine grains are generally pervasively altered to serpentine, iron oxide minerals, and clay minerals, however in localized zones, relict clear olivine kernels remain. Serpentine forms an olive green to brown mesh network with very fine anastomosing microveinlets of iron oxide minerals. Relict cores of orthopyroxene are pale green, and altered from 50% to 75%. Porphyroclastic grains in some cases are extremely elongated with poorly to moderately developed halos of amphibole, serpentine, spinel, and brucite. Spinel occurs along exsolution lamellae. Clinopyroxene is commonly pervasively altered, and chlorite, amphibole, and clay minerals(?) commonly form pseudomorphs. Pyrite is commonly associated with these grains and is disseminated throughout the core. Piece 2 and the top of Piece 3A contains a pyroxenite vein running parallel to the fabric defined by orthopyroxene [which is ≈30% altered with amphibole and sulfide minerals common] (altered to iron oxide minerals on broken surfaces). An amphibole vein? cuts pegmatitic pyroxene in this vein.

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Veins

1. Fibrous white serpentine veinlets which form an anastomosing network generally parallel to the foliation defined by orthopyroxene elongation.
2. Serpentine veinlets which are generally wider than vein set 1, which run ≈perpendicular to the anastomosing network.
3. Fine microveinlets of sulfide minerals (Piece 3B).
4. Early tremolite veins 2 mm across which have outer margins of white serpentine and which cut a composite vein of calcite, magnesite, and sulfide minerals.

VEIN/FRACTURE FILLING:

White serpentine.

Orientation:

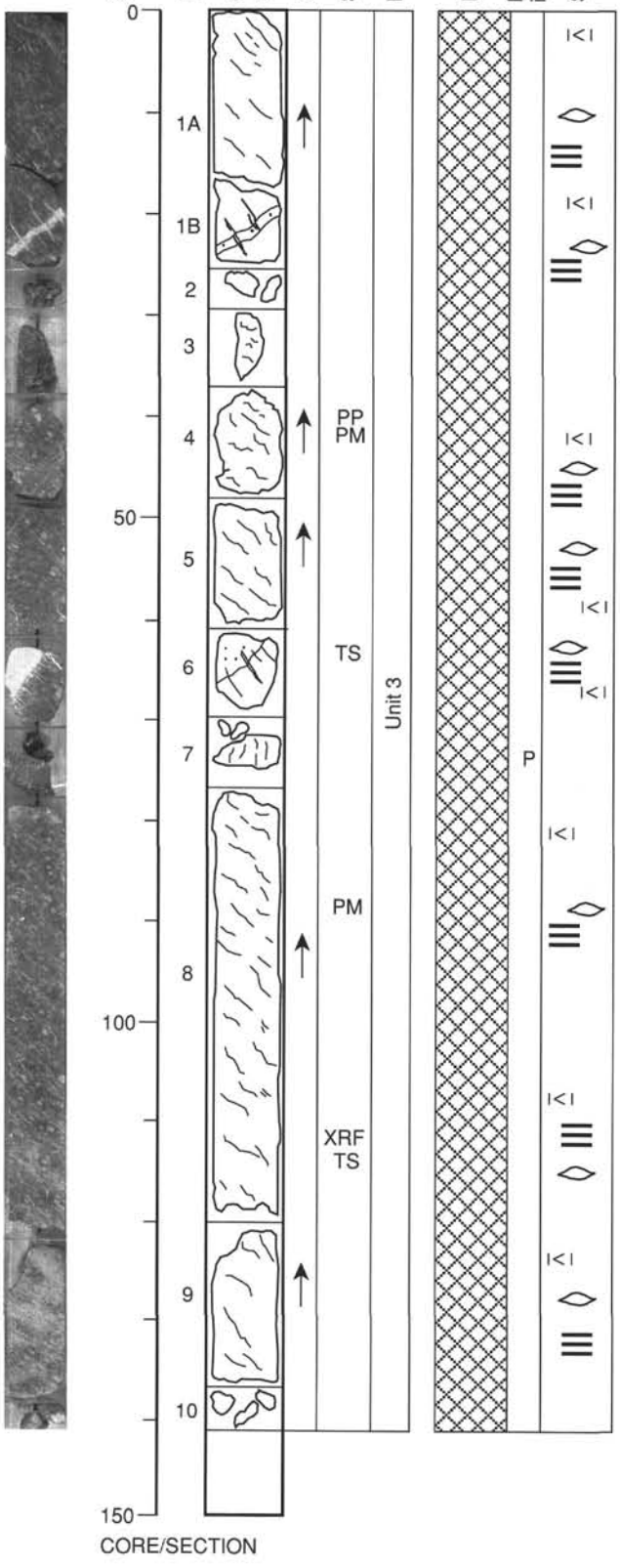
Comments: Two generations, one parallel to orthopyroxene fabric the other perpendicular.

Tremolite.

Calcite, magnesite, and sulfide minerals.

ADDITIONAL COMMENTS: Structure

This section has a weak to moderately intense foliation defined by an elongate pyroxene porphyroclastic fabric. An anastomosing foliation defined by thin green serpentine veins is oriented parallel to the pyroxene foliation and is deflected around the porphyroclasts. Thin white serpentine veins overprint the anastomosing foliation and form small (up to 5 cm) en echelon arrays. Where pyroxene contents are higher the thickness of serpentine veins increases and the spacing decreases. Compositional banding is present at the top of Piece 3 and at the top of Piece 6 and dips subparallel to the planar deformation fabrics (about 40°–50°). In Piece 2 a pyroxenite vein cuts the plastic fabric at a lower angle (about 45°) than the 50°–60° dip of the foliations. Irregular branching veins of pale green serpentine cut the thin white serpentine veins.



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UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1A–10

COLOR: Black/gray to green.
PRIMARY STRUCTURE: Elongated porphyroclastic.
SECONDARY STRUCTURE: Anastomosing foliation with parallel veining.
PRIMARY MINERALOGY:
Olivine - Mode: 69%–79%.
Orthopyroxene - Mode: 20%–30%.
Crystal Size: 3–20 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 1%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Shape: Anhedral.
Comments: Dominant lithology consists of serpentinized harzburgite, with some zones of increased pyroxene content (possibly lherzolites) toward the base of the section. Most of the primary mineralogy is altered, except locally within some pieces. Generally, relict orthopyroxene and spinel are preserved, although alteration is generally in excess of 85%–90% for all samples examined. Clinopyroxene relics and pseudomorph outlines are sometimes embayed with long axes of grains highly oblique to the orthopyroxene foliation. This may indicate that some clinopyroxenes represent late synkinematic to post-kinematic products of melt impreganation or channelization in some samples. The top of the core is comprised of a calcium-metasomitzed zone, which may have been a small pyroxenitic or gabbroic dikelet prior to alteration. Pieces 1–8 are depleted harzburgite, whereas Piece 9 is enriched in pyroxene (>20%). Pieces 1, 2, and 5 contain altered gabbroic dikes or veins. In Piece 3 the completely altered gabbroic vein is a minimum of 3 cm wide. The gabbroic vein in Piece 1 is a composite vein with pyroxenite, later cut and modified by serpentine veins.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Amphibole.
Total Percent: Trace.
Mode of Occurrence: After orthopyroxene, clinopyroxene.
Chlorite?
Mode of Occurrence: After clinopyroxene.
Brucite.
Mode of Occurrence: After orthopyroxene.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Comments: Pervasively altered (80%–95%). Olivine is pervasively replaced by (90%–100%) olive green to brown serpentine with local areas of white to white green altered olivine kernels. Orthopyroxene is generally pervasively altered (80%–95%), although some grains contain relatively fresh cores of apple green orthopyroxene. Altered orthopyroxene exhibits moderately to well-developed alteration halos (up to 0.5 cm across) dominated by serpentine and clay minerals, brucite, disseminated spinel, and rare amphibole along edges and exsolution lamellae. Serpentine veins cut some porphyroclasts. Clinopyroxene is moderately to pervasively altered to amphibole(?) and chlorite(?) forming small, dark colored patches.
Veins
Piece 1B is cut by a Ca-metasomatized vein approximately 1 cm in width, which is cut by white to pale gray green complex serpentine veinlets that are aligned subparallel to the fabric defined by orthopyroxene. The vein, which consists of tremolite, disseminated iron oxide minerals, spinel, prehnite(?), and talc, is oriented perpendicular to the main fabric defined by elongate orthopyroxene porphyroclasts. Piece 6 contains a 2.9 cm wide incipiently Ca-metasomatized zone which is altered to tremolite, serpentine, and talc(?), and fine-grained spinel. The piece is cut by white serpentine veinlets. Anastomosing, composite veinlets of white serpentine and iron oxide minerals, which run subparallel to the fabric defined by orthopyroxene, are common.
VEIN/FRACTURE FILLING:
White, black, and green serpentine.

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Percent: <10%
Size: <1 to 9
Orientation: See comments.

ADDITIONAL COMMENTS: Structure

A weak to moderate elongation of pyroxene porphyroclasts forms the dominant foliation. The porphyroclast elongation increases toward the base of the section. Thin (<1 mm) white serpentine veins overprint a weak anastomosing foliation defined by thin (<1 mm) green/black serpentine veins. The anastomosing foliation also increases in intensity toward the base of the section. An altered pyroxenite vein in Piece 1B dips at about 50°. Similar veins in Pieces 2 and 5 could not be oriented. A pale green serpentine vein in Piece 6 cuts the white, foliation-parallel serpentine veins.

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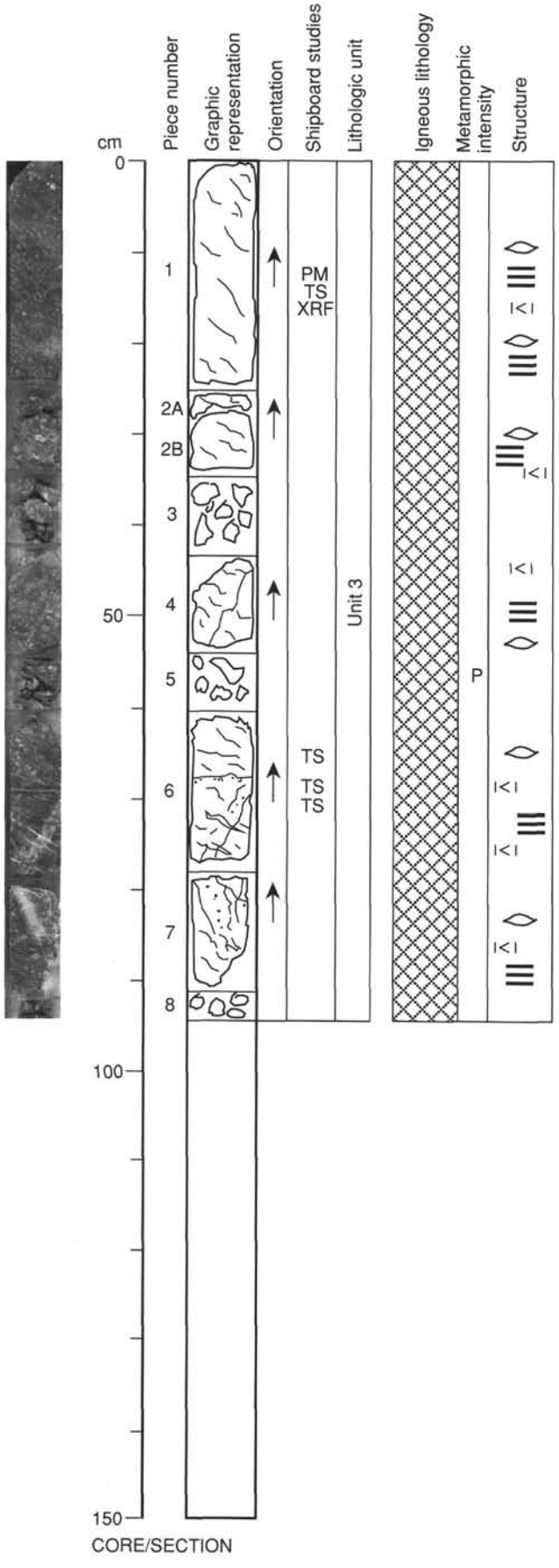
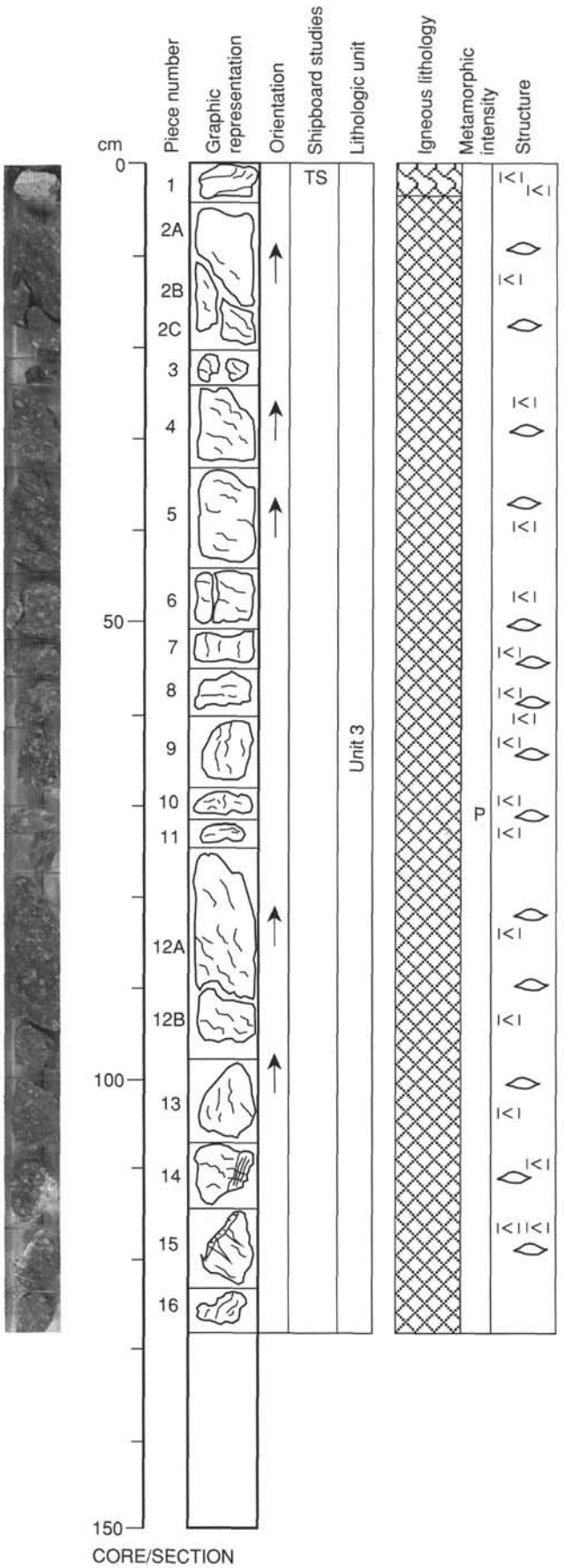


UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–8

COLOR: Green to dark gray.
PRIMARY STRUCTURE: Elongated porphyroclastic.
SECONDARY STRUCTURE: Anastomosing foliation with parallel veining.
PRIMARY MINERALOGY:
Olivine - Mode: 70%–84%.
Orthopyroxene - Mode: 15%–29%.
Crystal Size: 1–13 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 1%.
Crystal Size: 1–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Shape: Anhedral.
Comments: The section comprises pyroxene-rich to pyroxene-poor serpentinized harzburgite with a porphyroclastic texture. Modal pyroxene in Pieces 1–5 generally ranges between 24% and 30%, whereas Pieces 6–8 range from 15%–19%. Piece 7 contains a 15 mm thick altered pyroxenite vein with abundant oxide minerals and a thin gabbroic vein. The pyroxenite is cut at right angles by serpentine veins. Piece 8 contains a 2-cm-thick serpentine vein. The upper part of the section is characterized by patchy alteration. All the primary phases are preserved as relics within the section.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh
Mode of Occurrence: After olivine, orthopyroxene.
Amphibole.
Total Percent: Trace
Texture: Fibrous.
Mode of Occurrence: After orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After orthopyroxene, sulfide minerals
Brucite.
Mode of Occurrence: After orthopyroxene.
Comments: Total alteration = 80% to 100%. Olivine is pervasively altered (95%–100%), to brown green serpentine with localized areas of white to pale yellow green kernels. Very fine-grained iron oxide minerals define an anastomosing vein network in the serpentine mesh. Orthopyroxene exhibits very well-developed halos and is commonly pervasively altered (80%–100%), though some halos contain apple green relatively fresh orthopyroxene cores. Halos include trace amphibole, serpentine, and spinel which also occurs along exsoltuion lamallae.
Veins
Piece 6 is cut by two relatively large veins and numerous smaller veins. One of the larger veins is 1.5 mm wide. It is composed of amphibole after pyroxene and a trace of sulfide minerals. This vein is cut by fine, white, serpentine veinlets. A second vein is a 1.5 cm wide pyroxene-rich vein, now pervasively altered to amphibole that is brown to green, chlorite, prehnite(?), and minor sulfide and oxide minerals. This vein is oriented perpendicular to the orthopyroxene fabric and is cut by serpentine veinlets, and contains sulfide minerals and magnetite(?). Piece 7 is cut by a diffuse 1.5 cm wide tremolite, talc(?), and chlorite vein with feathery edges and traces of spinel and orange iron oxide minerals. Fine, white, serpentine veinlets parallel to the orthopyroxene fabric are common; larger (1–2 mm), perpendicular, white- to aqua-colored serpentine veins are more rare and are associated with increased percentages of brucite along vein margins.
VEIN/FRACTURE FILLING:
White, black, and green serpentine.
Percent: <10%
Size: <1 to 9 mm.
Orientation: See comments.
ADDITIONAL COMMENTS: Structure
Weak to moderately elongated pyroxene porphyroclasts define a foliation throughout the section. The pyroxene fabric intensifies toward the base of Piece 7. An anastomosing foliation, defined by thin green serpentine veins overprints the shape preferred orientation fabric of the porphyroclasts. Thin white serpentine veins (1 mm) overprint the anastomosing foliation. The spacing of these veins reduces toward the base of Piece 8. An altered pyroxenite vein, 15 mm thick, in Piece 6 dips at about 60°. This vein, and another steeply dipping pyroxenite vein in Piece 7 (70°) is cut by pale green/white serpentine veins that dip at about 50°.



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UNIT 3: SERPENTINIZED HARZBURGITE WITH PYROXENITE

Pieces 1–16

COLOR: Black/green.
PRIMARY STRUCTURE: Elongated porphyroclastic.
SECONDARY STRUCTURE: Anastomosing foliation with parallel veining.
Intermittant crosscutting veins at high angle to foliation.
PRIMARY MINERALOGY:
Olivine - Mode: 70%–80%.
Orthopyroxene - Mode: 16%–25%.
Crystal Size: 4–21 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 2%–5%.
Crystal Size: 2–6 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Comments: Lithology continues to be dominantly serpentinized porphyroclastic harzburgite. Pieces 2–7 and 10–16 are typical depleted harzburgites with 15%–20% modal pyroxene content. Pieces 8 and 9 have higher modal pyroxene content ≈25%). Piece 1 is a pyroxenite that is ≈5 cm thick. This piece is marked by strong calcium metasomitism which completely obliterates the textural relationships and original mineralogy in most of the samples, but some of the pyroxenite has been preserved locally. Piece 7 contains a small vein which is highly altered. This may have been a pyroxenite based on the pseudomorphs present. Relics of orthopyroxene and spinel are, in places, well preserved in the section, but in general olivine and clinopyroxene are highly altered. They are completely replaced in most samples. Alteration exceeds 90% in all samples examined.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh
Mode of Occurrence: After olivine, orthopyroxene.
Amphibole.
Total Percent: Trace
Pyrite.
Mode of Occurrence: After clinopyroxene.
Brucite.
Mode of Occurrence: After orthopyroxene, olivine.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Comments: Pervasively altered with total alteration of approximately 95%–100%, and dominated by serpentinization. Olivine grains are pervasively altered (90%–98%) to serpentine, iron oxide minerals, and clay minerals. Serpentine forms an olive green to brown mesh network with very fine anastomosing microveinlets of iron oxide minerals, and localized zones of pale white to green serpentine kernels after olivine. Orthopyroxene grains exhibit very well-developed halos with apple green relatively fresh cores in some grains, bounded by thin dark green rims and gray green outer rims composed of trace amphibole, serpentine, spinel, and brucite. White anastomosing serpentine veinlets commonly wrap around and enclose porphyroclasts. Iron oxide minerals occurs along exsolution lamellae. Clinopyroxene is commonly pervasively altered (85%–100%) to chlorite, amphibole, and clay minerals(?). Some samples contain disseminated pyrite after clinopyroxene(?). Piece 1 is highly calcium-metasomatized and primary mineralogy is completely obscured by tremolite, talc(?), chlorite, and hydrogrossular. Sample is cut by a mm-wide calcite veinlet which crosscuts a veinlet of tremolite. Pieces 14 and 15 have shear zones composed of white to gray green serpentine, 5–10 mm wide bounding the edges of the pieces. The shear zones are cut by discontinuous, aqua to white serpentine veins (<1 to 1 mm wide.)
Veins
Tremolite veinlet and later calcite veinlet in Piece 1.
Anastomosing, wispy, white serpentine veinlets are common.
VEIN/FRACTURE FILLING:
White, black, and green serpentine.
Percent: <10%
Size: <1 to 10 mm.
Orientation: See comments.

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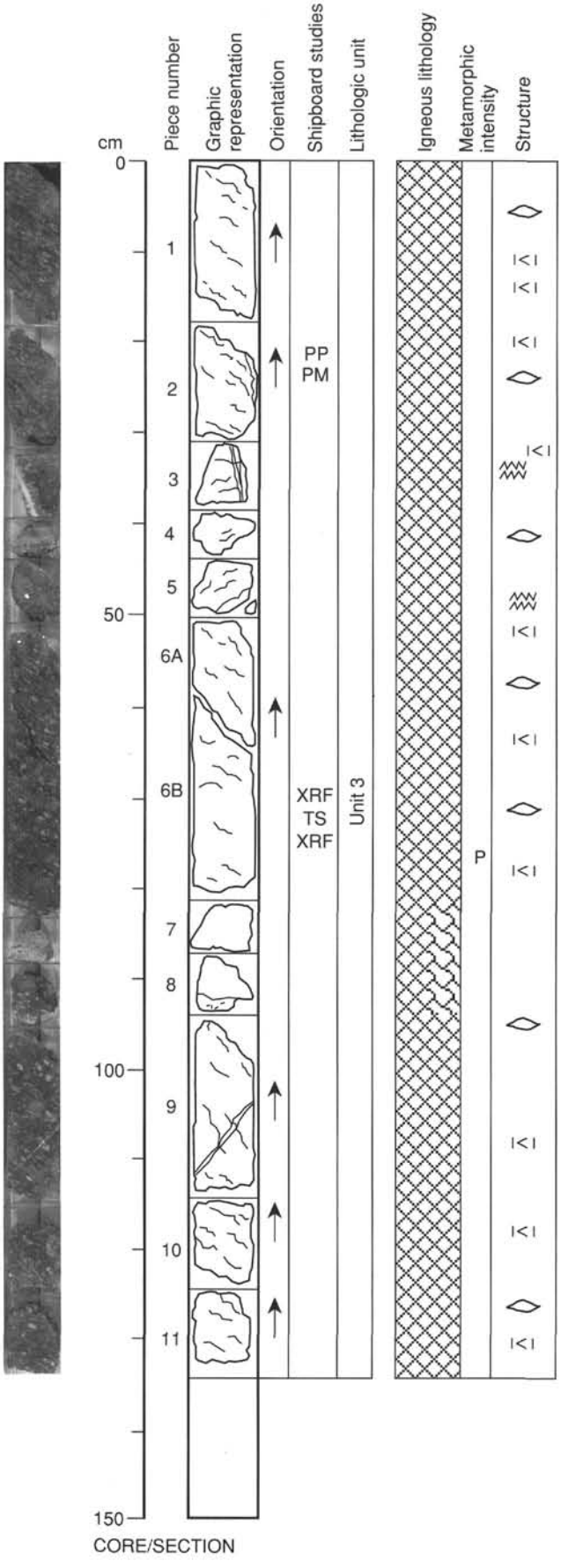
ADDITIONAL COMMENTS: Structure

A moderately intense elongate porphyroclastic texture is present throughout the section, overprinted by a weak anastomosing foliation, defined by thin green/black serpentine veins. The anastomosing foliation intensifies within Piece 12 and dips more steeply than the porphyroclast foliation. Thick veins (3–10 mm), filled primarily with greenish blue serpentine veins are oriented parallel and perpendicular to the porphyroclast foliation. These are cut by thin white serpentine veins that overprint the anastomosing foliation. Fibrous, green serpentine veins with normal shear sense (> 0.5 cm) inclined at about 50°, cut both of these vein sets in Pieces 14 and 15. These minor shear zones offset white/green serpentine veins, oriented perpendicular to the shear zone margin but are also cut by similar serpentine veins.



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UNIT 3: SERPENTINIZED HARZBURGITE WITH PYROXENITE VEIN

Pieces 1–11

COLOR: Dark gray to green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Thick (>2 mm) veins of green-blue serpentine cut foliation and later thin foliation parallel veins.
PRIMARY MINERALOGY:
Olivine - Mode: 10%–90%.
Orthopyroxene - Mode: 8%–20%.
Crystal Size: 2–20 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 1%–90%.
Crystal Size: 1–10 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Shape: Anhedral.
Comments: This section consists of predominantly serpentinized porphyroclastic harzburgite crosscut by highly altered pyroxenite veins (Pieces 7 and 8). Pieces 1, 2, 4, 8, 9, 10, and 11 are depleted harzburgite with 15%–20% modal pyroxene, whereas harzburgite Pieces 3, 5, and in part Piece 6 are more enriched in pyroxene. Pieces 7 and 8 include an oxide-rich pyroxenite with space filling oxide and sulfide minerals interstitial to large clinopyroxene grains. The vein or band appears nearly concordant with the high-temperature foliation. Piece 8 preserves the contact between harzburgite and pyroxenite and shows a mark reduction in pyroxene content in the harzburgite toward the edge of the pyroxenite vein. A similar reduction in pyroxene content can be observed in Piece 5 in which pyroxene abundances decay from the top of the piece.Total alteration of the serpentinized harzburgite is greater than 95%, but the pyroxenite vein is only about 50% altered. Piece 3 is cut by a large serpentine vein (5 mm) and is associated with sulfide minerals. Piece 6 shows some modal layering. There is possibly a thin clinopyroxene-rich layer in the pyroxene-poor portion of the piece, near 68 cm. This relationship also occurs in Piece 9, near 100 cm.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh
Mode of Occurrence: After olivine, orthopyroxene.
Amphibole.
Total Percent: Trace.
Mode of Occurrence: After orthopyroxene, clinopyroxene(?)
Iron oxide minerals.
Mode of Occurrence: After olivine.
Pyrite.
Mode of Occurrence: After clinopyroxene(?)
Chlorite.
Mode of Occurrence: After clinopyroxene.
Comments: Pervasively altered with total alteration of about 95%–99%, except for Piece 7 which is comprised predominantly of a pyroxene-rich vein. Olivine grains are pervasively altered (95%–99%) to serpentine, iron oxide minerals, and clay minerals. Serpentine forms an olive green to brown mesh network with very fine anastomosing microveinlets of iron oxide minerals, and localized pods, up to 2.5 cm across, of pale white green serpentine kernels after olivine (very common in Piece 4 which fine, white, serpentine veinlets). Elongated to rounded orthopyroxene porphyroclasts are generally highly altered and exhibit very well-developed halos with relatively fresh apple green cores in some grains, bounded by thin dark green rims and gray green outer rims composed of traces of amphibole, serpentine, spinel, and brucite. White anastomosing serpentine veinlets commonly wrap around and enclose the orthopyroxene porphyroclasts. Iron oxide minerals occurs along exsolution lamellae. Clinopyroxene is pervasively altered (85%–100%) to chlorite, amphibole, and clay minerals(?).
Veins
Piece 3 is cut by a 0.6 cm wide serpentine vein oriented perpendicular to fabric defined by orthopyroxene porphyroclasts and is cut by fabric-parallel white serpentine veinlets <1 to 1 mm wide. Pieces 7 and 8 are cut by a pyroxene-rich vein, altered to amphibole tremolite/actinolite, chlorite, and zeolites with traces of sulfide minerals. Serpentine veinlets cut the pyroxene vein. Piece 9 contains a diffuse, 1–2 mm wide, white green veinlet of prehnite(?),

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amphibole, chlorite.

VEIN/FRACTURE FILLING:

Pyroxene and amphibole.

Size: 20 mm.

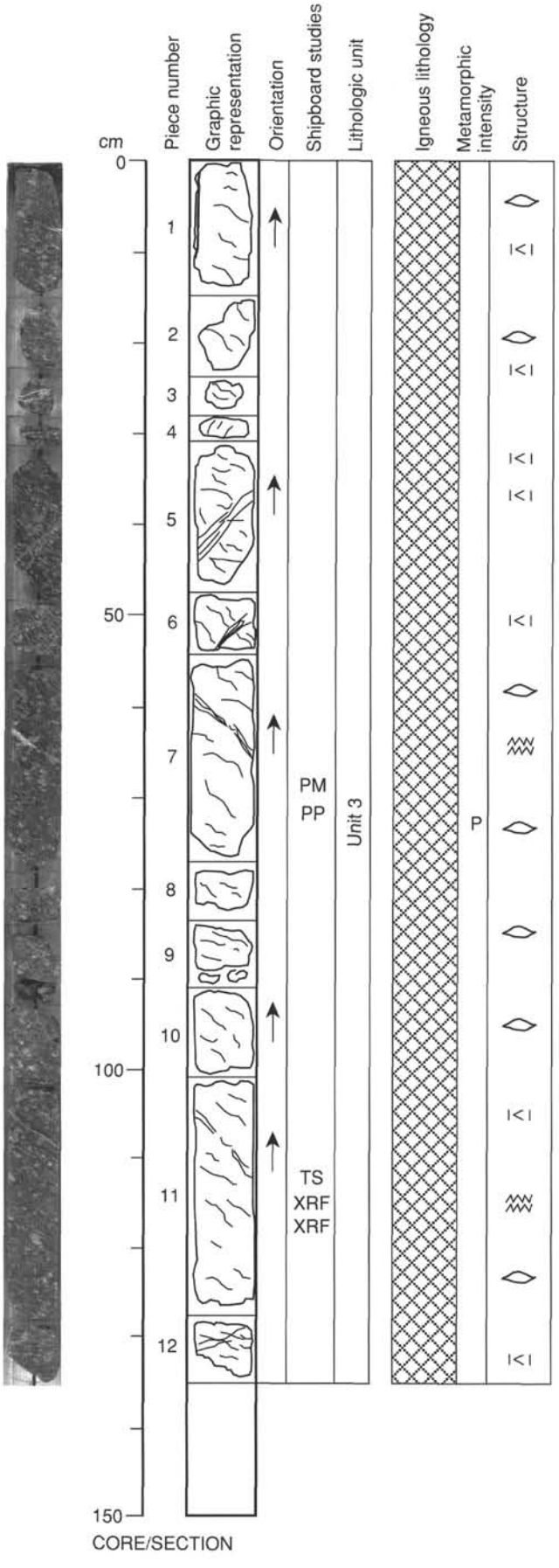
Serpentine.

Size: 6 mm.

Comments: One set of veins perpendicular to fabric define by orthopyroxene. Another set of hairline fractures form parallel to the fabric.

ADDITIONAL COMMENTS: Structure

A weak to moderate elongate porphyroclastic texture is present through the section but is stronger in Piece 3. An anastomosing foliation that dips about 40° to 50° is formed by thin green/black serpentine veins, and is oriented subparallel to the shape preferred orientation of the orthopyroxene porphyroclasts. A dark green serpentine vein cuts the anastomosing foliation in Piece 3. This vein is cut by thin white serpentine veins that follow the trace of the anastomosing foliation. Altered magmatic veins in Pieces 7 and 8 cut the foliation at a high angle.



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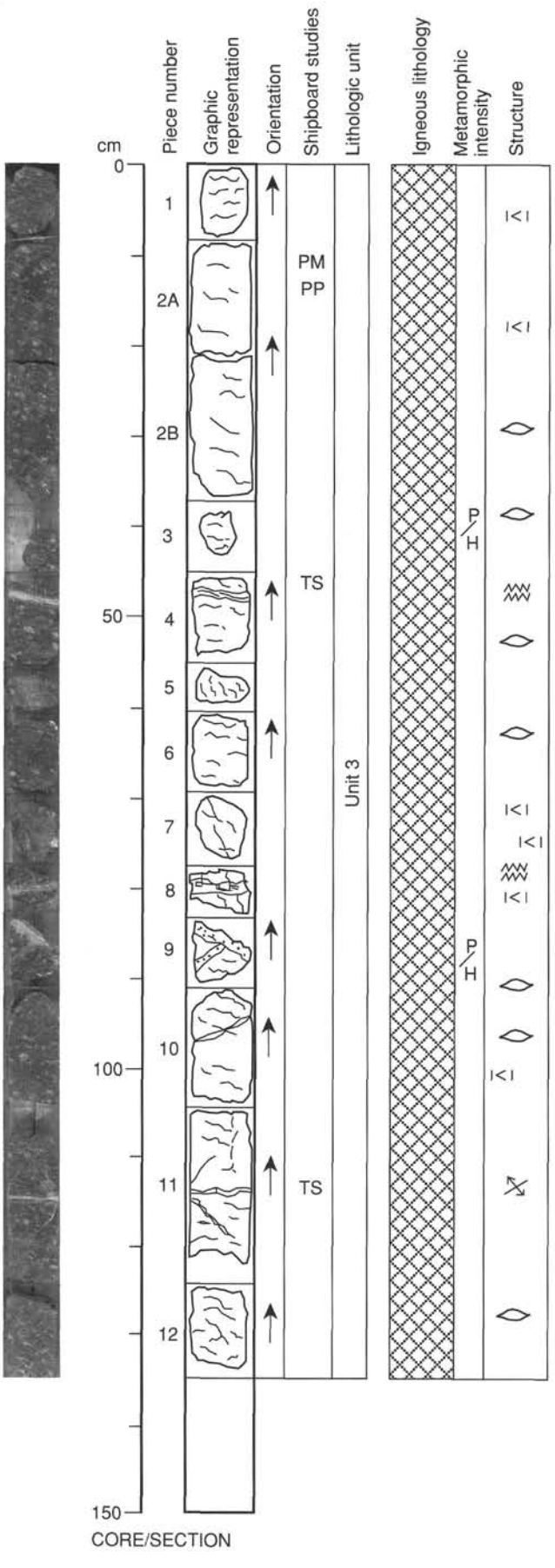
UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–12

COLOR: Black/gray.
PRIMARY STRUCTURE: Elongate porphyroclastic.
SECONDARY STRUCTURE: Vein networks.
PRIMARY MINERALOGY:
Olivine - Mode: 78%–85%.
Orthopyroxene - Mode: 16%–25%.
Crystal Size: 4–21 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 2%–5%.
Crystal Size: 2–6 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Shape: Anhedral.
Comments: Still in pyroxene-depleted harzburgite with 3%–5% clinopyroxene and between 13%–30% orthopyroxene. The section is still highly altered (85%–95%). Relict olivine is scarce. Orthopyroxene relicts perist as cores to strongly altered outer parts of grains. Clinopyroxene is still present as scarce relicts. Modal abundances of pyroxene varies from about 25% to 15%. Spinel is well preserved in all pieces examined.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Amphibole.
Texture: Fibrous.
Mode of Occurrence: After orthopyroxene, clinopyroxene(?).
Brucite.
Total Percent: Trace.
Mode of Occurrence: After orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Comments: Pervasively altered with total alteration of about 87%–96%. Olivine grains are altered 90%–98%. They include relict, clear islands of olivine, that are enclosed in an olive green to brown mesh-textured serpentine network, with filled hairline veinlets of iron oxide and clay minerals. Elongated to rounded orthopyroxene porphyroclasts (60% to 80% altered) in some places contain very fresh cores up to 1.5 cm long, which exhibit very well to poorly developed alteration halos of trace amounts of amphibole, with serpentine, spinel, and brucite. White anastomosing serpentine veinlets commonly wrap around, enclose, and cut porphyroclasts. Clinopyroxene is commonly pervasively altered (97%–100%) to chlorite, amphibole, and clay minerals(?).
Veins
Piece 7 contains a tapering, 0.5 cm wide tremolite/actinolite, talc, and serpentine vein which is cut by fine, wispy, aqua green serpentine veinlets.
Pieces 11 and 12 contain pale green serpentine veins.
VEIN/FRACTURE FILLING:
Gray/green serpentine.
Size: 30–50 mm.
Comments: Parallel to orthopyroxene fabric.
ADDITIONAL COMMENTS: Structure
A weak to moderate elongation of orthopyroxene porphyroclasts defines the dominant fabric in this section. This fabric is overprinted by an anastomosing foliation that is defined by thin green/black serpentine veins, cut by all other veins in the section. A shear zone with oblique serpentine fibers cuts Piece 7. The shear zone is cut by syn- to post-kinematic light green serpentine serpentine veins oriented subperpendicular to the shear zone margin. A minimum displacement is estimated to be about 1 cm based on the right lateral offset of serpentine veins. Pale green serpentine veins in Pieces 11 and 12 are oriented subparallel to fabric defined by elongated orthopyroxene porphyroclasts. Thin cross-fibered serpentine veins are also abundant in all samples parallel to the foliation.



153-920B-8R-4

UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–12

COLOR: Gray/black.
PRIMARY STRUCTURE: Elongate porphyroclastic.
SECONDARY STRUCTURE: Several sets of veins.
PRIMARY MINERALOGY:
Olivine - Mode: 75%–80%.
Orthopyroxene - Mode: 18%–20%.
Crystal Size: 3–13 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 2%–4%.
Crystal Size: 2–9 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Comments: The section consists of serpentinized black gray porphyroclastic harzburgite. Fresh olivine, orthopyroxene, clinopyroxene, and spinel can be observed in most pieces. Pyroxene tends to be especially well preserved in some pieces (e.g., Piece 11). Some subtle modal layering in the core can be observed parallel to the foliation. Layering is defined by increases and decreases in pyroxene samples. Several samples contain chains of several spinel grains elongated in the plane of the high-temperature foliation. Thin white serpentine veins are oriented subparallel to the high-temperature foliation. Piece 11 contains a good example of serpentine shear zones which appear as common features in this core section.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After orthopyroxene, olivine.
Brucite.
Mode of Occurrence: After orthopyroxene, olivine.
Clay minerals.
Mode of Occurrence: After orthopyroxene, olivine.
Amphibole.
Mode of Occurrence: After clinopyroxene, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Comments: Highly to pervasively altered (75% to 84%). Alteration is generally somewhat less in this section than in the sections above. Relict clear islands of olivine, altered 85%–90%, are enlosed in an olive green to brown mesh-textured serpentine network, with filled hairline veinlets of iron oxide and clay minerals. Elongate to rounded orthopyroxene porphyroclasts are highly altered (50%) with slighty altered to fresh apple yellow green cores. Well to poorly developed alteration halos up to 0.2 mm wide are composed of trace amphibole, serpentine, spinel and locally moderately abundant brucite. White anastomosing serpentine veinlets commonly wrap around, enclose, and cut the orthopyroxene porphyroclasts. Clinopyroxene is moderately to pervasively altered (60%–80%) to amphibole(?) and clay minerals(?).
Veins
White serpentine veinlets parallel to orthopyroxene elongation are common. Piece 2A is cut by a conjugate set of pale blue serpentine veins approximately 0.1 mm wide. Pieces 5, 8, and 11 contain serpentinite shear zones with anastomosing, cream-colored, and green serpentine in a 6–10 mm wide zone bounded by a diffuse, blue gray halo about 5 mm wide. Fine, tapering aqua serpentine veins are oriented subparallel to the shear zones but are offset across them. Piece 9 has a 1cm wide pervasively altered pyroxenite vein. It is replaced by tremolite/actinolite, chlorite, prehnite(?), serpentine, and zeolites.
VEIN/FRACTURE FILLING:
White, fine serpentine
Percent: <10%
Size: Hairline to 2 mm.
Orientation: See comments.
Comments: Parallel to fabric.
Blue serpentine.
Percent: <10%
Size: 2–6 mm.
Orientation: See comments.
Comments: Subparallel and at high angle to main fabric; cut by white serpentine vein.

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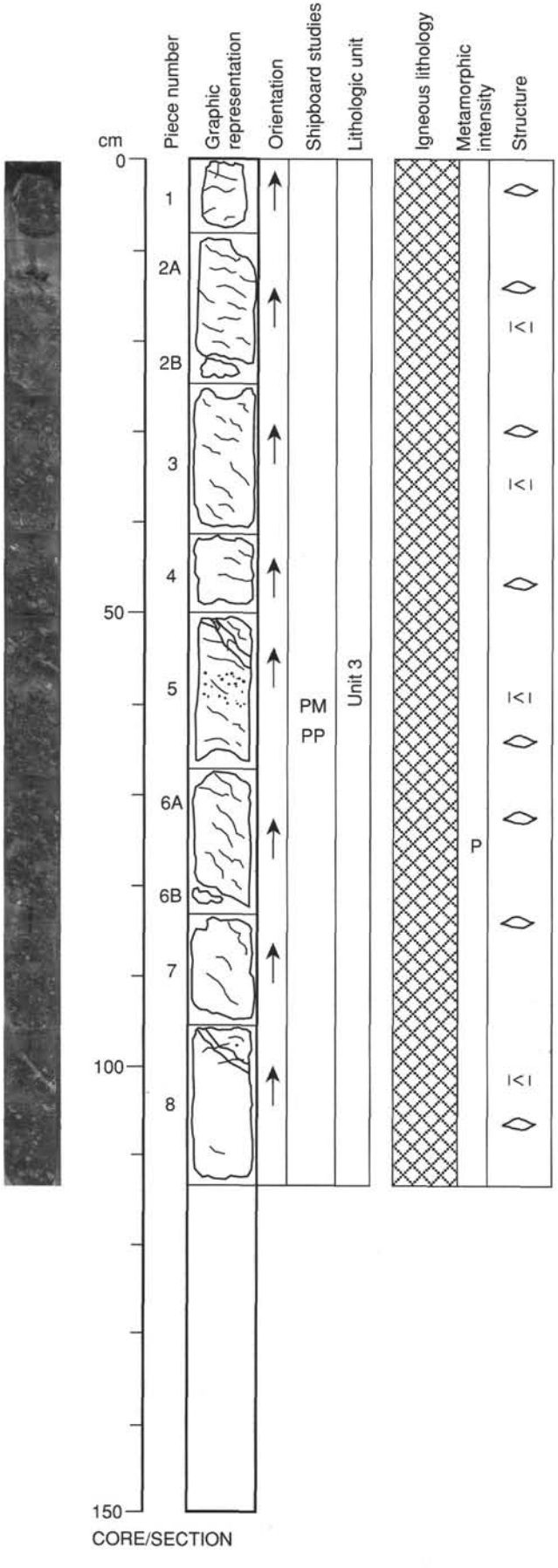
ADDITIONAL COMMENTS: Structure

A weak to moderate attenuation of orthopyroxene porphyroclasts defines a foliation that dips at about 30°. Several generations of serpentine veins and shear zones can be observed in the section. Pieces 1, 4, 8, 9, and 11 all contain serpentine shear zones. Instead of cross-fiber orientations, the chrysotile fibers are oriented generally in a direction parallel or subparallel to the margins of the shear zone. These shear zones are generally oriented in a subhorizontal plane or planes that have 30° dips. These shear zones are cut by syn-kinematic and post-kinematic extensional veins composed of syntaxial cross-fibered serpentine.

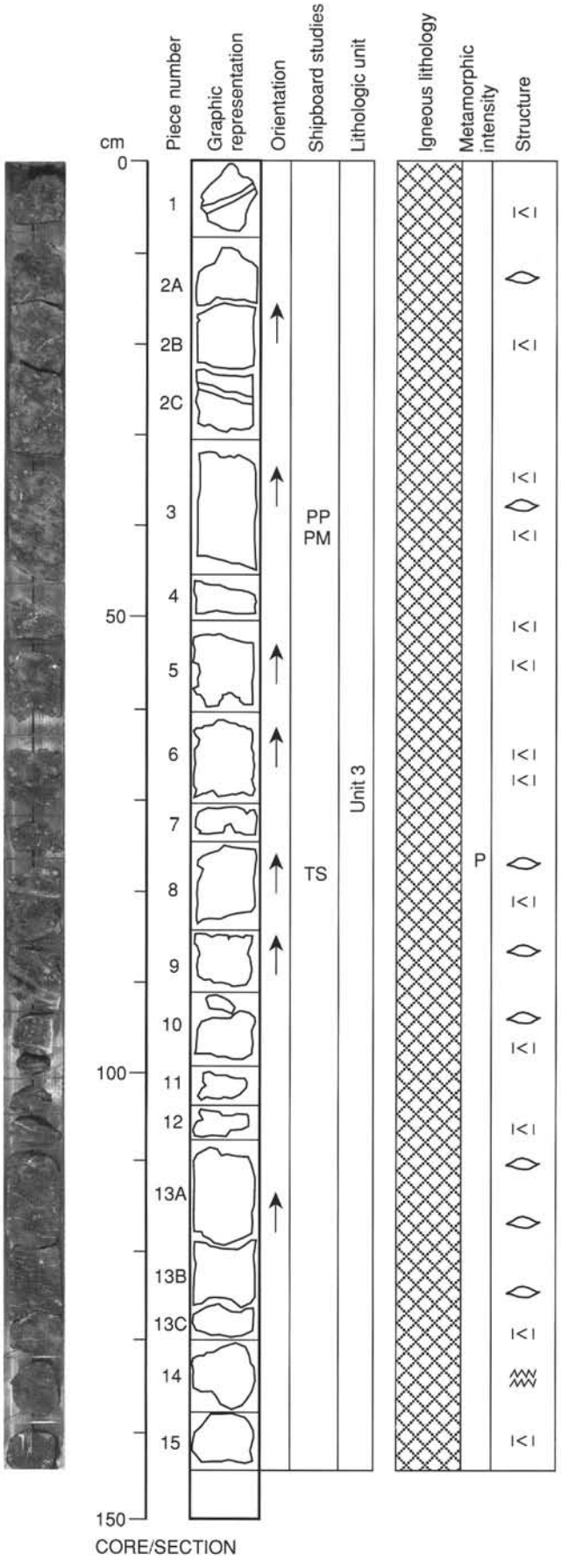


153-920B-8R-5

UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–8

COLOR: Dark gray/green.
PRIMARY STRUCTURE: Elongate porphyroclastic.
SECONDARY STRUCTURE: Several vein networks.
PRIMARY MINERALOGY:
Olivine - Mode: 60%–90%.
Orthopyroxene - Mode: 10%–40%.
Crystal Size: 1–17 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: <1%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: The section consists of serpentinized black green porphyroclastic harzburgite. The percentage of total alteration is 80%. Fresh olivine, orthopyroxene, clinopyroxene, and spinel can be observed in most pieces. Pyroxene tends to be especially well preserved in some pieces (e.g., Pieces 6 and 8). Some samples (Pieces 6 and 8) contain more elongate orthopyroxene within the plane of the foliation. Patchy alteration is common within olivine. There is a large serpentine vein in Piece 5.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After orthopyroxene, olivine.
Amphibole.
Total Percent: Trace
Mode of Occurrence: After orthopyroxene, clinopyroxene(?).
Iron oxide minerals.
Comments: Associated with serpentine after olivine.
Clay.
Texture: After orthopyroxene, olivine.
Comments: This core is generally less altered (80%) than sections above. The core is characterized by discontinuous and heterogeneous pods of pale white green serpentine kernels after olivine in which cores of "kernels" are generally white and are rimmed by pale green serpentine. These zones are bounded by olive green brown mesh serpentine. Orthopyroxene in these zones is pervasively altered, and is less altered away from these pods. Elongate to rounded orthopyroxene porphyroclasts in these less altered areas are generally moderately to highly altered and exhibit well-developed halos around apple green cores in some grains, bounded by thin dark green rims and gray green outer rims composed of trace amphibole, serpentine, spinel, and brucite. Clinopyroxene is 50% to 100% altered to chlorite(?), and clay minerals(?).
Pieces 5 and 8 are cut by green serpentine veins, 3–4 mm wide, which are in turn cut by wispy, white to aqua-colored veins.
VEIN/FRACTURE FILLING:
Green serpentine.
Percent: <10%
Size: <1 mm.
Orientation: See comments.
White serpentine.
Percent: <10%
Size: 2–6 mm.
Orientation: See comments.
ADDITIONAL COMMENTS: STRUCTURE
The deformation in this section is variable with textures ranging from coarse-grained prophyroclastic textures to an elongate porphyroclastic texture. Dark green serpentine veins (3–10 mm wide) and thin white serpentine veins (1–2 mm), are oriented parallel and perpendicular to the main foliation defined by the porphyroclast elongation. Pale green serpentine veins cut both of these vein types. Two serpentine veins have been reactivated by shearing. Their oblique fibers, combined with the offsets of veins crossing the shear zone suggests a normal shear sense. The displacement occurred during formation of short (1–2 cm long) green-white serpentine veins as these veins cut the shear fabric but some are offset by shearing.



153-920B-9R-1

UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–15

COLOR: Black/gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Several vein networks.
PRIMARY MINERALOGY:
Olivine - Mode: 78%–82%.
Orthopyroxene - Mode: 14%–20%.
Crystal Size: 3–14 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 2%–4%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: Porphyroclastic serpentinized harzburgite. The upper and lower parts of the section are highly altered >90%. Primary olivine is scarce to absent, although scarce partially altered relicts of orthopyroxene, clinopyroxene are preserved. Spinel is well preserved throughout the core. The section is made up of depleted harzburgite with 15%–20% pyroxene content. The central part of the core is less altered (≈70%), although the alteration is highly variable locally, even on a piece scale. Pyroxene is well preserved throughout the central part of the section (e.g. Piece 7). Piece 7 contains highly strained mildly altered clinopyroxne and orthopyroxene. Piece 7 contains an altered clinopyroxenite vein.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Brucite.
Mode of Occurrence: After orthopyroxene.
Amphibole.
Total Percent: Trace
Mode of Occurrence: After orthopyroxene, clinopyroxene(?).
Clay.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Comments: Pieces 1–5 (total alteration is about 85%) are characterized by discontinuous and heterogeneous pods of pale white-green serpentine kernels after olivine in which cores of "kernels" are generally white and are rimmed by pale green serpentine (similar to those of the previous core). These zones are bounded by olive-green brown mesh serpentine. Orthopyroxene in these zones is pervasively altered, and is less altered away from these pods. Pieces 6–15 have fewer and less well-developed pods and are less altered (70%) with clear olivine islands enclosed by a brown serpentine matrix with hairline, iron oxide mineral-filled microveinlets. Orthopyroxene porphyroclasts in these less altered areas are generally moderately to pervasively altered to trace amphibole, serpentine, spinel, and locally abundant brucite. Clinopyroxene is 50% to 96% altered to chlorite(?), and clay minerals(?).
Piece 8 is cut by 3 veins: 1) a 0.4 cm wide composite serpentine vein with a pale green core, white inner rim and yellow white outer rim; 2) a 0.2 mm wide serpentine vein cut by hairline iron oxide filled veins; and 3) vein 2 is cut by vein 3 which is a branching serpentine mineral. Irregular, fine calcite veins commonly cut the orthopyroxene foliation. Rare white wispy serpentine veins occur throughout the section.
VEIN/FRACTURE FILLING:
Pale green serpentine.
Percent: <10%
Size: 2–4 mm.
Orientation: See comments.
White serpentine.
Percent: <10%
Size: <1 mm.
Orientation: See comments.

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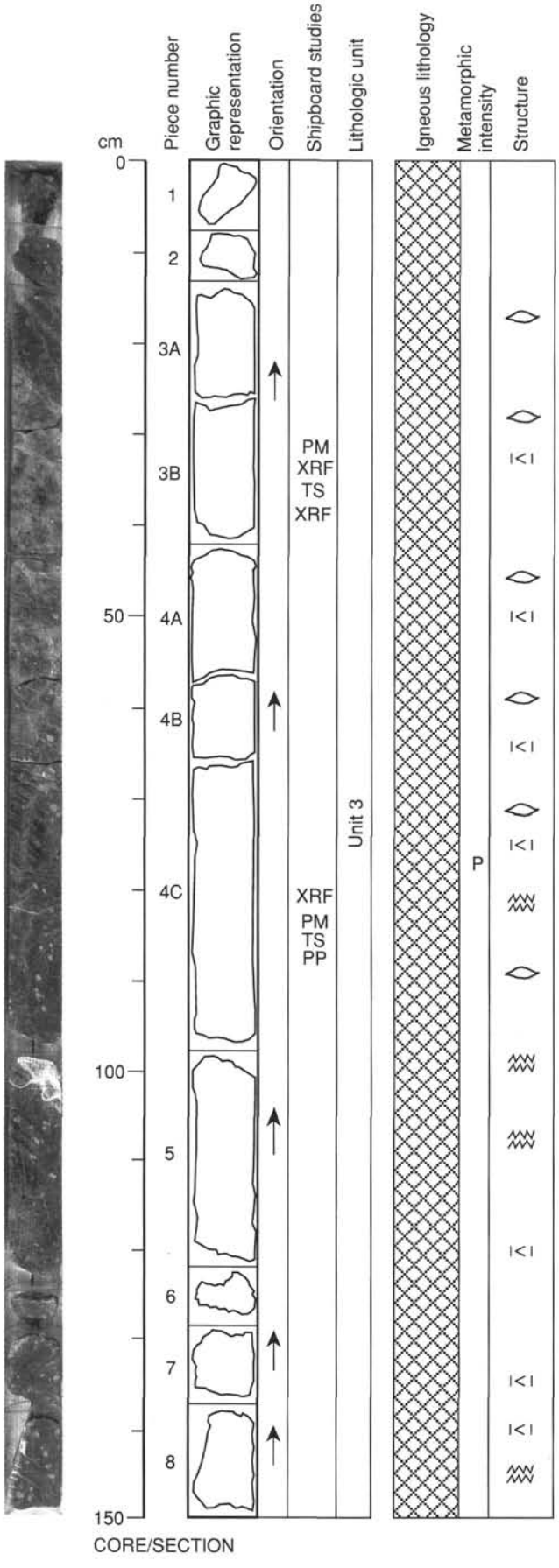
ADDITIONAL COMMENTS: Structure

Only a weak fabric is present in this section with very minor or no porphyroclast elongation and a weak anastomosing foliation defined by dark serpentine veins. Discrete serpentine veins (2–5 mm wide) are oriented perpendicular and subparallel to the foliation. Thin white serpentine veins, parallel to the foliation are ubiquitous. Many of these veins still preserve open void spaces where syntaxial cross-fiber serpentine which started growing on the walls of the vein terminate at the void space (e.g. Piece 17). Several large green chrysotile veins cut across the section (Piece 8 and 9) and a dark green serpentine vein in Piece 5 contains shear fibers. Bent exsolution lamellae and cleavages can be readily observed in clinopyroxene in hand samples under magnification.

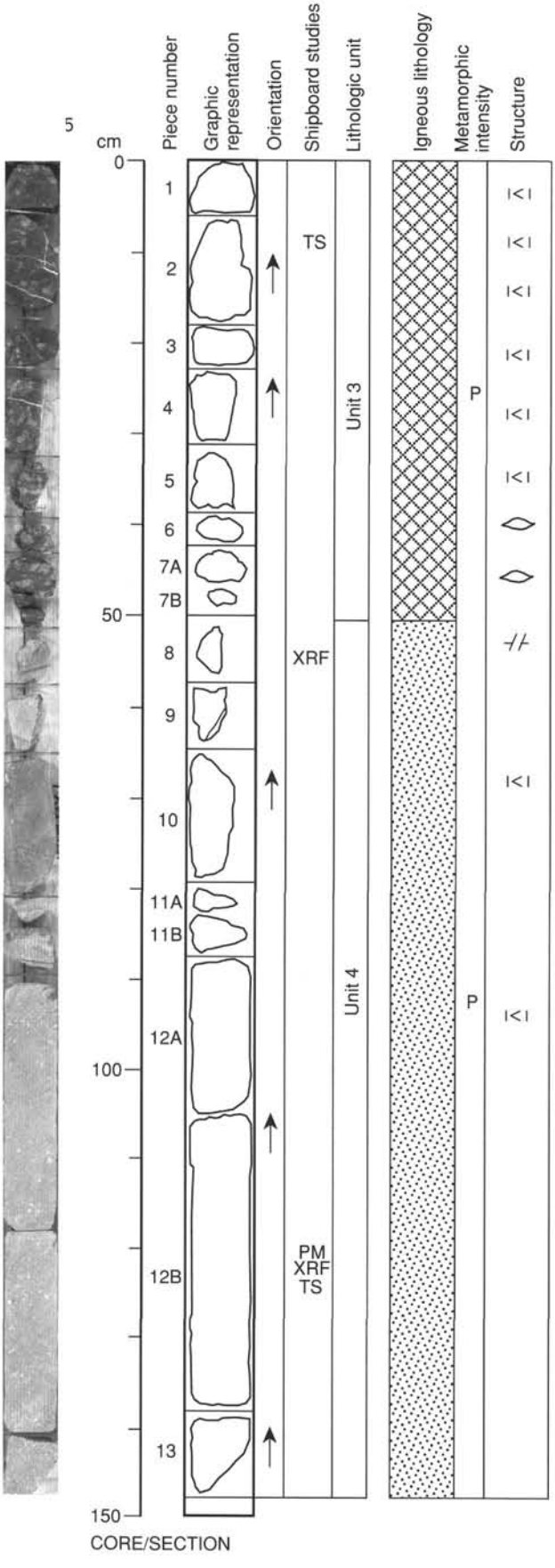


153-920B-9R-2

UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–8

COLOR: Dark green-gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Vein networks.
PRIMARY MINERALOGY:
Olivine - Mode: 69%–77%.
Orthopyroxene - Mode: 20%–30%.
Crystal Size: 3–10 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 1%.
Crystal Size: 2–10 mm.
Crystal Shape: Anhedral.
Chrome-spinel - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Porphyroclastic to coarse granular serpentinized harzburgite. The upper and lower parts of the section are highly altered (>90%). Primary olivine is scarce to absent, although scarce partially altered relics of orthopyroxene, clinopyroxene are preserved. Spinel is well preserved throughout the core. The central part of the core is less altered (~80%), although the alteration is highly variable locally, even on a piece scale. The harzburgite is very depleted with between 10% and 20% pyroxene. Pyroxene is well preserved here in Piece 4. Pieces 1, 2, 4, 6, 7, and 8 contain very depleted harzburgite. The green chrysotile veins of Piece 8 are lined with altered pyroxene and may have been one edge of a pyroxene vein prior to formation of the serpentine vein.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 70–80
Texture: Mesh
Mode of Occurrence: After olivine and orthopyroxene.
Comments: Alteration is similar to Core 153-920B-9R-1 with heterogeneous alteration patches downcore (total alteration 80%–100%). Piece 1 to bottom part of Piece 3A, and Pieces 4C to 8 lack alteration pods. Clear olivine islands in less altered zones are enclosed by a brown serpentine matrix with hairline iron oxide mineral-filled microveinlets after olivine. Orthopyroxene porphyroclasts are generally highly to pervasively altered (70%–80%) to a trace of amphibole, with serpentine, spinel and locally abundant brucite. Clinopyroxene is 50% to 96% altered to chlorite(?), and clay minerals(?). Pieces 3A–4B are characterized by discontinuous and heterogeneous pods of pale white-green serpentine kernels after olivine in which cores of "kernels" are generally white and rimmed by pale green serpentine. Orthopyroxene in these zones is pervasively altered (80%–100%), although rare, relict cores remain in some porphyroclasts. Clinopyroxene is highly to pervasively altered to amphibole(?) chlorite(?)
Veins
1) Composite black serpentine veins with discontinuous stringers of white serpentine are common, which are oriented at high angles to fabric defined by orthopyroxene porphyroclasts.
2) Fabric parallel thin white serpetine veinlets.
3) Composite light gray-green and white, 0.3 mm wide, serpentine veins at high angle to fabric, and which are cut by wide white serpetine veins.
4) A 1 mm wide composite white serpentine vein with sulfide minerals in the core.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: <10%
Size: 1 mm.
Orientation: See comments.
ADDITIONAL COMMENTS: Structure
The top of the section contains a well-developed foliation defined by the preferred dimensional orientation of orthopyroxene, whereas toward the base of the section (Pieces 7 and 8) the porphyroclasts in the serpentinized harzburgite show no shape preferred orientation. An anastomosing foliation defined by thin black serpentine veins is present from Piece 5 where it dips steeply. A large green chrysotile shear zone cuts the top of Piece 5 at a low angle and Piece 8 at a high dip angle. In Piece 4 a dark green serpentine vein (2 mm) cuts the foliation at a high angle and is, in turn, cut by a light green serpentine vein oriented obliquely to the foliation. Another dark green serpentine vein (0.5 cm wide) is present in Piece 8.



153-920B-9R-3

UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–7B

COLOR: Dark gray to green
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE:
PRIMARY MINERALOGY:
Spinel. - Mode: 1%.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 2%–4%.
Crystal Size: 2–11 mm.
Crystal Shape: Anhedral.
Olivine. - Mode: 75%.
Orthopyroxene. - Mode: 20%–23%.
Crystal Size: 5–12 mm.
Crystal Shape: Anhedral.
Comments: Unit 3/4 contact
Porphyclastic harzburgite which, at its base (Piece 7), is intruded by a fine-grained diabasic dike or sill. The top of the section consists of residual harzburgite with variable alteration, but olivine, clinopyroxene, and orthopyroxene relicts are well preserved. Most spinel is well preserved. The harzburgite section is *cut by serpentine and sulfide mineral composite veins (e.g., Pieces 1 and 7).* Piece 7 is the lowest harzburgite in the section. Pieces 1, 2, and 3 are highly depleted and Pieces 5, 6, and 7 are enriched in pyroxene content (20%).
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 73–90
Texture: Mesh texture.
Iron oxide minerals.
Total Percent: <4
Comments: Total alteration 90% to 100%. Olivine grains are generally pervasively altered to serpentine, iron oxide minerals, and clay minerals, however, in localized zones relict clear olivine kernels remain (70%–90%). Serpentine forms an olive green to brown mesh network with very fine anastomosing microveinlets of iron oxide minerals. Relict cores of orthopyroxene are pale green, and alteration is from 60%–70%, with developed halos of amphibole (trace), serpentine, spinel and brucite. Clinopyroxene is commonly altered 70%–80%, to chlorite(?), amphibole, serpentine, and clay minerals.
Veins
1) Composite white serpentine and sulfide mineral veins at high angle to fabric, 2 mm wide.
2) Thin white serpentine veins.
3) Hairline sulfide mineral vein altered to iron oxide minerals.
VEIN/FRACTURE FILLING:
ADDITIONAL COMMENTS: Structure
In the serpentinized harzburgite, overlying the diabase, the orthopyroxene porphyroclasts show a weak shape preferred orientation. No anastomosing foliation is present but arrays of thin (1 mm) white serpentine veins are oriented parallel to the porphyroclast elongation. A few 2 mm wide white serpentine veins are oriented at a high angle to the porphyroclast foliation (70°–90°).
Unit 3/4 Contact
Piece 8 is a very fine-grained aphyric diabase that represents an obvious chill margin of a dike or sill against the peridotite. The contact is not exposed in any piece within the section, but the lower pieces of the diabase (Pieces 9–13) in the section become progressively coarser grained with distance downward from Piece 8, suggesting that Piece 8 represents the strongly chilled margin of the pluton. Both phenocrysts and the groundmass coarsen with depth. We have defined the pluton as Unit 4 and placed its contact with the overlying harzburgite of Unit 3 in the unsampled interval between Pieces 7 and 8.

UNIT 4: APHYRIC TO MODERATELY PORPYRITIC DIABASE

Pieces 8–13

CONTACTS: Inferred intrusive.
PHENOCRYSTS:
Olivine - 0–5%; <2 mm; Anhedral.
Plagioclase - 0–15%; <7 mm; Subhedral.

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Iron oxide minerals - <1%; <1 mm; Anhedral.
Clinopyroxene(?) - 0–1%; <4 mm; Anhedral.

GROUNDMASS: Intergranular; fine-grained intergrown plagioclase, pyroxene, and spinel. Partially altered to chlorite.

COLOR: Light gray.

ALTERATION: The rock is partially altered to clay, serpentine, secondary plagioclase, green amphibole, and chlorite. Prehnite veins cut the samples. Alteration includes clay, zeolites(?), actinolite, chlorite, and secondary plagioclase after plagioclase. Serpentine after olivine.

VEIN/FRACTURES:

Prehnite.

Size: 20–30 mm.

ADDITIONAL COMMENTS: Unit 3/4 Contact

Piece 8 is a very fine-grained aphyric diabase or diorite that represents an obvious chill margin of a dike or sill against the peridotite. The contact is not exposed in any piece within the section, but the lower pieces of the diabase/diorite (Pieces 9–13) in the section become progressively coarser grained with distance from Piece 8, suggesting that Piece 8 represents the strongly chilled margin of the pluton. We have defined the pluton as Unit 4 and placed its contact with the overlying harzburgite of Unit 3 in the unknown interval between Pieces 7 and 8.

Unit 4

The definition of the rock type for Unit 4 was problematical at first in hand sample because of its fine-grained size and unusual color. The color of the rock is light gray, and has a bleached appearance relative to other diabases of basaltic composition which normally are dark gray in color. Some samples are so thoroughly altered that the primary mineralogy of the phenocrysts is no longer present in the pluton's margin. Altered phenocrysts of plagioclase, and altered olivine phenocrysts or xenocrysts and small unaltered spinel grains were recognized. Altered phenocrysts of plagioclase are obvious from pseudomorphs in Pieces 11–13 and phenocrysts or xenocrysts of completely serpentinized olivine are also present. Some of the altered plagioclase is within glomeropophyritic clusters. Clay minerals, serpentine, secondary plagioclase, green amphibole, and chlorite are secondary. Prehnite veins cut the samples. The altered olivine, which is subrounded, and unaltered spinel within the samples suggested a mafic composition, but they could have represented xenocrystic olivine and spinel from the ultramafic section included within a dioritic magma. However, bulk rock chemistry acquired by the shipboard XRF shows that the composition is diabasic and very primitive with 13% MgO. Thin sections show parts of the diabase are slightly altered with much of the phenocryst and groundmass phases preserved. The anorthite content of the plagioclase phenocrysts was optically determined to be $An_{65–75}$. Olivine grains are altered but have euhedral outlines suggesting they are of igneous origin, rather than xenocrystal. Clinopyroxene is groundmass phase. The texture is intergranular to subophitic, typical of diabase.

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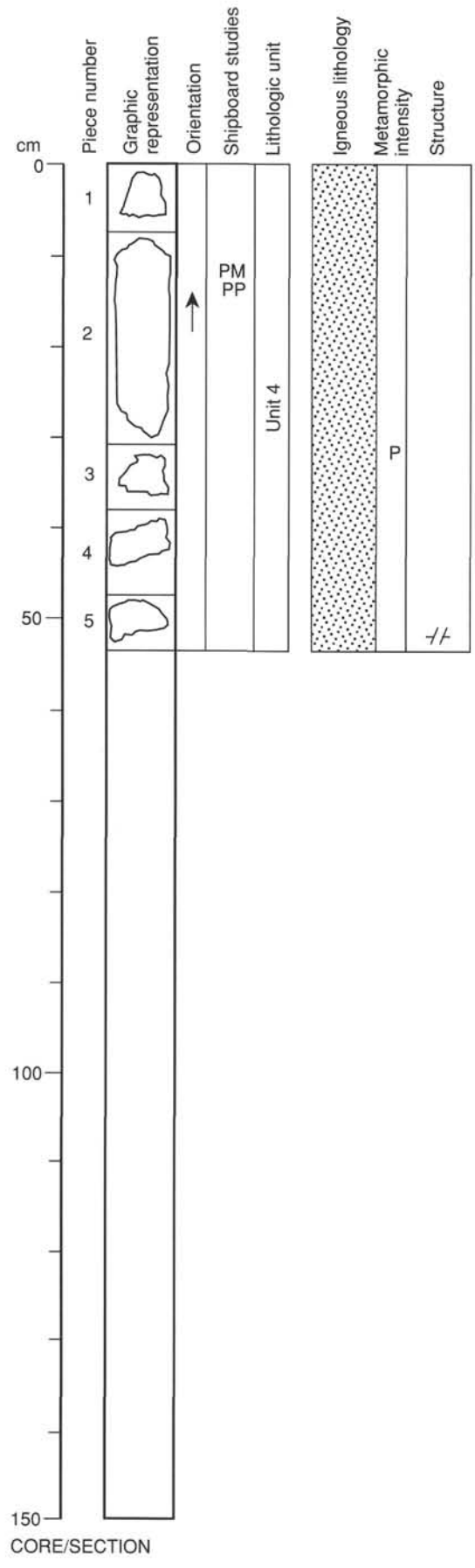


UNIT 4: MODERATELY PORPHYRITIC DIABASE

Pieces 1–5

CONTACTS: None observed.

PHENOCRYSTS:

Clinopyroxene. - 1%–2%; 2–4 mm; Anhedral.

Olivine. - 5%; 1–2 mm; Anhedral.

Plagioclase. - 15%; 1–7 mm; Anhedral.

GROUNDMASS: Intergranular; fine-grained intergrown plagioclase, pyroxene, and spinel. Partially altered to chlorite.

COLOR: Light gray.

ALTERATION: Alteration consists of clay, zoisite, and secondary plagioclase after plagioclase; amphibole and chlorite after plagioclase and clinopyroxene(?).

VEIN/FRACTURES:

Thin white serpentine.

Percent: <10%.

Size: <1 mm.

Orientation: See comments.

Sulfide minerals altering to iron oxide minerals.

Size: <1 mm.

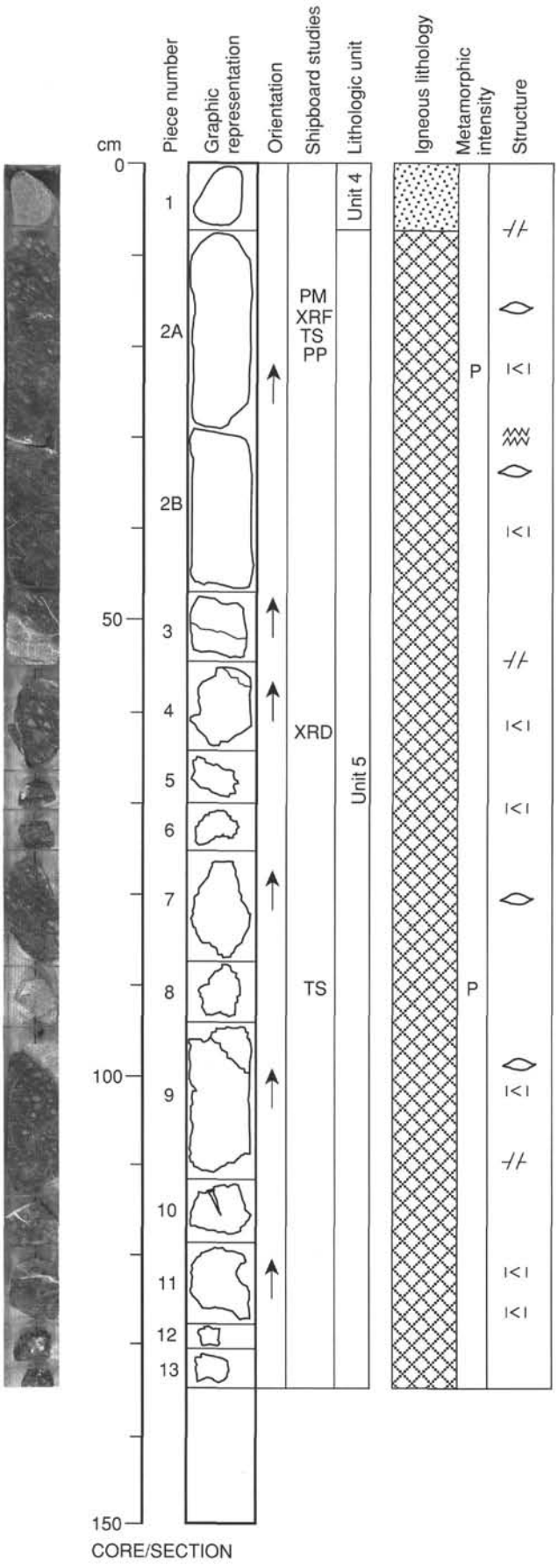
Composite sulfide and white serpentine

Size: 20 mm.

ADDITIONAL COMMENTS: The rock type is the same as in the base of section 153-920B-9R-3, fine-grained plagiclase-olivine phyric diabase. The samples are phenocryst rich (highly altered), suggesting samples are from the interior of the intrusion and so do not show any progression of coarsening or fining along the core section. The rock is light gray. Fresh hornblende phenocrysts and small spinel grains are also common. The rock is highly altered in places to clay minerals, serpentine, secondary plagioclase, green amphibole, and chlorite. Samples are cut by a network of 1–2 mm wide prehnite and zeolite veinlets.

Structure

No plastic deformation is evident in the diabase but the prehnite and zeolite veins can be broadly divided into two main arrays in individual pieces. No orientations could be measured for these veins.



153-920B-10R-1

UNIT 4: MODERATELY PORPHYRITIC DIABASE

Piece 1

CONTACTS: Not observed.
PHENOCRYSTS:
Spinel - <1%; <1 mm; euhedral.
Plagioclase - 2%–3%; 1–3 mm; prismatic.
Olivine - 1%; 1–3 mm; resorbed.
GROUNDMASS: Fine-grained intergrown plagioclase, pyroxene, and spinel. Partially altered to chlorite.
COLOR: Light gray/green.
VEIN/FRACTURES:
White, green, and black serpentine. Prehnite.
Percent: <10%.
Size: <1 to10 mm.
Orientation: See comments.
Ca-metasomatized after pyroxenite dike.
Percent: <10%.
Size: >30 mm.
Orientation: 180, 40
ADDITIONAL COMMENTS: Contact: The contact between diabase above (Unit 4) and harzburgite below (Unit 5) is not exposed in the section. The grain-size reduction is not as significant here as the upper contact region and the interval is not recovered. Based on the upper contact, we also assume that the lower contact is intrusive.
Piece 1 is the last piece of dike continued from Core 153-920B-9R. The dike is *composed of diabase to metadiabase, comprising phenocrysts of resorbed* olivine (containing spinel inclusions, 2–3 mm), plagioclase (1–3 mm) and spinel (<1 mm). The groundmass is a crystalline aggregate of partially altered pyroxene and plagioclase. This piece does not have the strongly chilled appearance of the first piece of diabase sampled, but the recovery is uncertain between Pieces 1 and 2.
Metamorphic
End of Unit 4. Alteration of the basaltic chilled margin in Piece 1 includes serpentinization and chloritization of corroded olivine phenocrysts, and chloritization of plagioclase phenocrysts. The core is cut by prehnite and *zeolite veinlets 1–2 mm wide.*
Structure
No plastic deformation fabrics are evident in the diabase but zeolite and prehnite veins are present.

UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 2A–13

COLOR: Black/gray.
PRIMARY STRUCTURE: Elongated porphyroclastic.
PRIMARY MINERALOGY:
Olivine. - Mode: 75%.
Clinopyroxene. - Mode: 2%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Orthopyroxene. - Mode: 20%.
Crystal Size: 2–20 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak textonic alignment.
Spinel. - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Crystal orientation: None.
Comments: Porphyroclastic serpentinized harzburgite. Olivine is generally strongly serpentinized, few relics remain. Orthopyroxene and clinopyroxene are relatively less altered and cores of pyroxene rimmed by serpentine and amphibole are common. The grain-size range of porphyroclasts is consistently 2–5 mm for clinopyroxene and 2–20 mm for orthopyroxene. The degree of porphyroclast alignment (and foliation development) is weak, except as noted below. Pieces 2, 4, 5, 6, 7, and 9 are highly depleted in pyroxene content (<15%); Pieces 7, 10, and 11 are even more highly depleted pyroxene-bearing dunite (<10% pyroxene). Pieces 12 and 13 are more normal pyroxene-depleted harzburgite (15%–20% pyroxene). Piece 3

153-920B-10R-1

is a highly metasomitized oxide pyroxenite/gabbro band or vein that is 50 mm thick and concordant to the high-temperature foliation which is usually defined by the preferred dimensional orinetation of orthopyroxene in the adjacent pieces. The fabric is well defined in the adjacent pieces. Piece 8 consists of a highly altered pyroxenite/gabbro band or vein that is also ≈50 mm thick and concordant with the high-temperature foliation plane. The adjacent pieces, Piece 7 above and Piece 9 below, are essentially pyroxene-bearing dunite at the contact and both show a gradation to lower pyroxene content as the contact with pyroxenite is approached. Piece 9 preserves the lower contact of an altered pyroxenite with the adjacent harzburgite and Pieces 8 and 9 are interpreted to be formerly contiguous based on their similar lithology and alteration products. Pieces 10 and 11 are dunite and show a stronger fabric and a closely spaced less undulatory and nearly planar-parallel serpentine vein fabric. It appears under the binocular microscope to be mylonitic with highly strained orthopyroxene porphyroclasts and is subparallel to the high-temperature foliation plane.

SECONDARY MINERALOGY:

Serpentine.
Total Percent: 76
Mode of Occurrence: Replacement

Comments: Replacement of olivine and orthopyroxene.

Amphibole.
Total Percent: 5

Comments: Replacement of orthopyroxene and clinopyroxene.

Chlorite.
Total Percent: 2

Comments: Rimming clinopyroxene.

Magnetite.
Total Percent: 2

Comments: Breakdown product of serpentinization of olivine.

Comments: In representative samples, olivine exhibits extensive replacement by serpentine which shows ribbon textures and diffuse veining of serpentine. Iron oxide minerals occur after olivine and along fractures or veins, which also crosscut pyroxene porphyroclasts. The replacement of clinopyroxene and orthopyroxene ranges from 10% to 70%. They are altered to amphibole and serpentine.

A vein of rodingitized metagabbro (4 cm in width) occurs in Pieces 3 and 9. The rock is coarse grained, and the primary mineralogy is replaced by epidote, tremolite/actinolite, chlorite, and prehnite. The dikelet and related magmatic fractures occur also in Section 153-920B-10R-3, Piece 1.

The most common vein filling mineral is serpentine, also occurring in open cracks. In Piece 2 and 3 thin magnetite veins were observed.

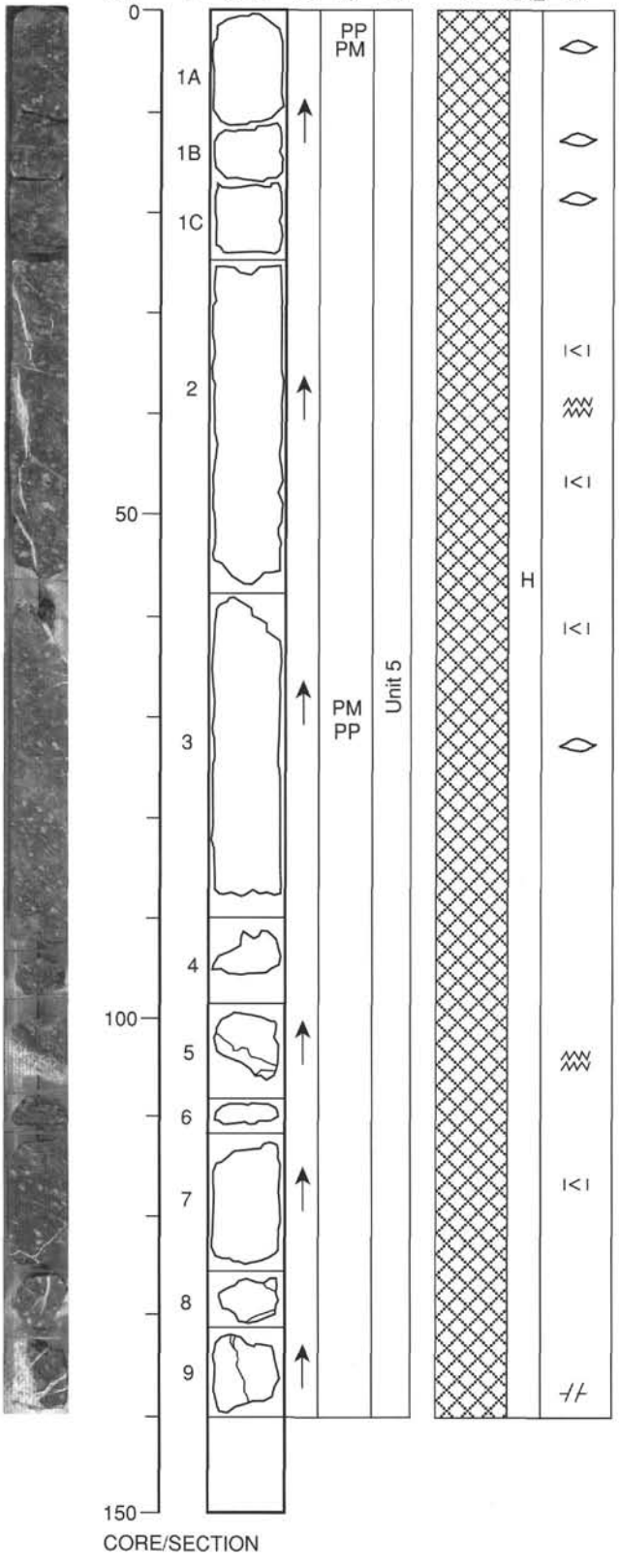
VEIN/FRACTURE FILLING:

White, black, and green serpentine .
Percent: <10%
Size: <1 to 10 mm.
Orientation: See comments.

Ca-metasomatited after pyroxenite dike.
Percent: 1%
Size: 30 mm.
Orientation: 090,40

ADDITIONAL COMMENTS: Structure

Most of the section is made of highly deformed serpentinized peridotite displaying a strongly elongated porphyroclastic texture. The foliation dips range between 40° to 50°. Lower in the section, the porphyroclast elongation diminishes overall and the dip decreases to about 35°. In Piece 3 an altered gabbroic vein (50 mm thick) is oriented parallel to the porphyroclast elongation. A similar, concordant vein is present in Piece 8. In Pieces 10 and 11 a strong localized foliation defined by aligned serpentine veins in pyroxene-bearing dunite. The few orthopyroxene porphyroclasts evident in this interval appear to be highly strained and may be mylonitic.

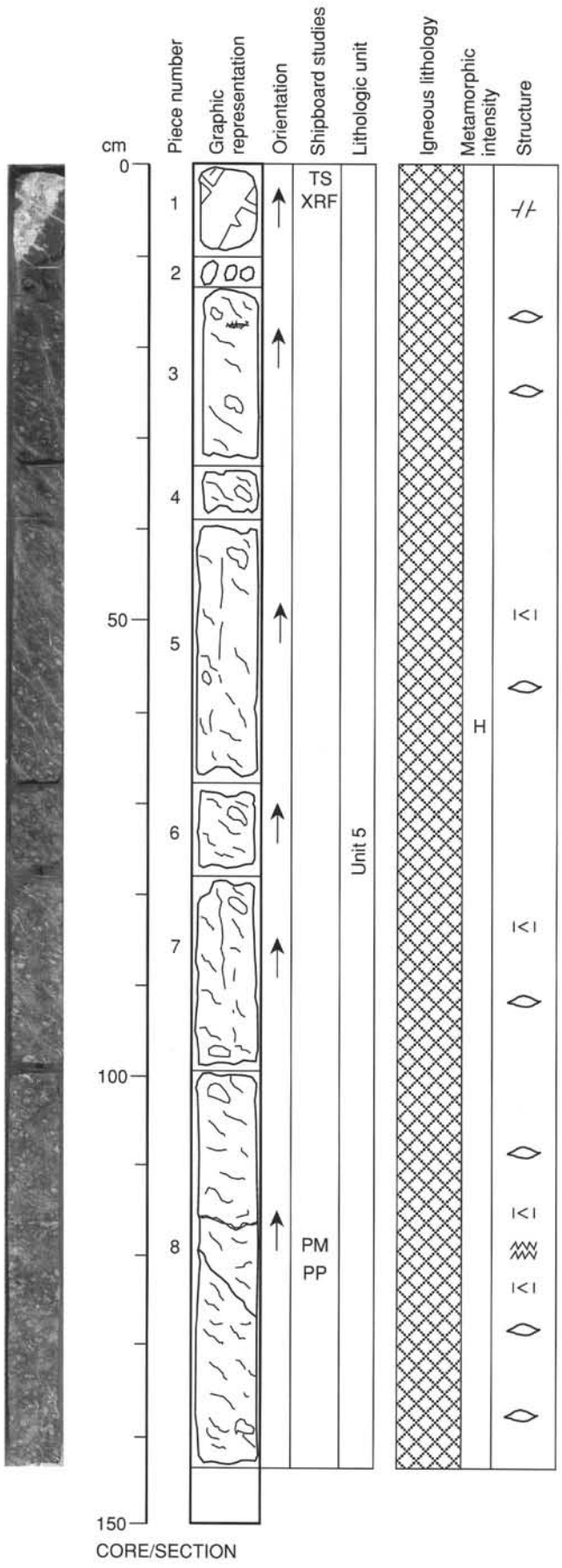


153-920B-10R-2

UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1A–9

COLOR: Green/black.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Vein networks.
PRIMARY MINERALOGY:
Olivine - Mode: 76%.
Clinopyroxene - Mode: 3%.
Crystal Size: 3–5 mm.
Crystal Shape: Weakly elongate.
Orthopyroxene - Mode: 20%.
Crystal Size: 5–10 mm.
Crystal Shape: Weakly elongate.
Crystal orientation: Weak tectonic.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Subhedral.
Crystal orientation:
Comments: This section consists of porphyroclastic serpentinized harzburgite and minor dunite. Pieces 1, 2, 3, and 4 are depleted harzburgite with 15%–20% pyroxene content. Piece 5 is a highly altered oxide pyroxenite that is oriented concordant with the foliation plane. Depleted dunite marks either side of the pyroxenitic band, as in previous sections. Pieces 2 and 3 are relatively pyroxene rich (≈25%).
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 70
Texture: Ribbon.
Mode of Occurrence: Replacement.
Comments: Replaces olivine and orthopyroxene.
Amphibole.
Total Percent: 6
Mode of Occurrence: After pyroxene.
Comments: Rimming and replacing pyroxene.
Magnetite.
Total Percent: 2
Comments: Segregations from serpentinization.
Comments: The alteration of the peridotitic assemblage is comprised of serpentine (70%) after primary olivine, and amphibole and serpentine extensively replacing clinopyroxene (60%) and orthopyroxene (up to 90%). In Piece 5 the peridotite foliation is crosscut by a veins up to several mm wide composed of serpentine and chlorite which could represent a metamorphic pyroxenitic layer. In Piece 9, a rodingitized metagabbro vein cuts the peridotite; the primary assemblage is replaced by tremolite/actinolite, chlorite, and minor prehnite. Serpentine is the only vein-filling material. Serpentine is also on open crack surfaces.
Piece 2 is cut by an en echelon series of cream to light green tremolite veins which form diffuse, 1 to 10 mm wide bands that are braided and offset by 1–2 cm.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: <10%
Size: 1 mm.
Orientation: See comments.
Comments: Two types:
Thick pale green veins that are generally oriented at a high angle to the foliation.
Thin white veinlets subparallel to the foliation.
Magnetite.
Comments: Filling microfractures.
ADDITIONAL COMMENTS: Structure
A weak elongation of orthopyroxene porphyroclasts defines the foliation in this serpentinized harzburgite. In Piece 2 there are two serpentine shear zones. One is oriented subparallel to the foliation and a few mm in thickness and one is nearly vertical and several mm in thickness that is at a high angle to the foliation. This near vertical serpentine shear zone continues into the top of Piece 3 in an en echelon pattern downsection. A highly altered pyroxenite in Piece 5 is oriented concordantly with the foliation plane.

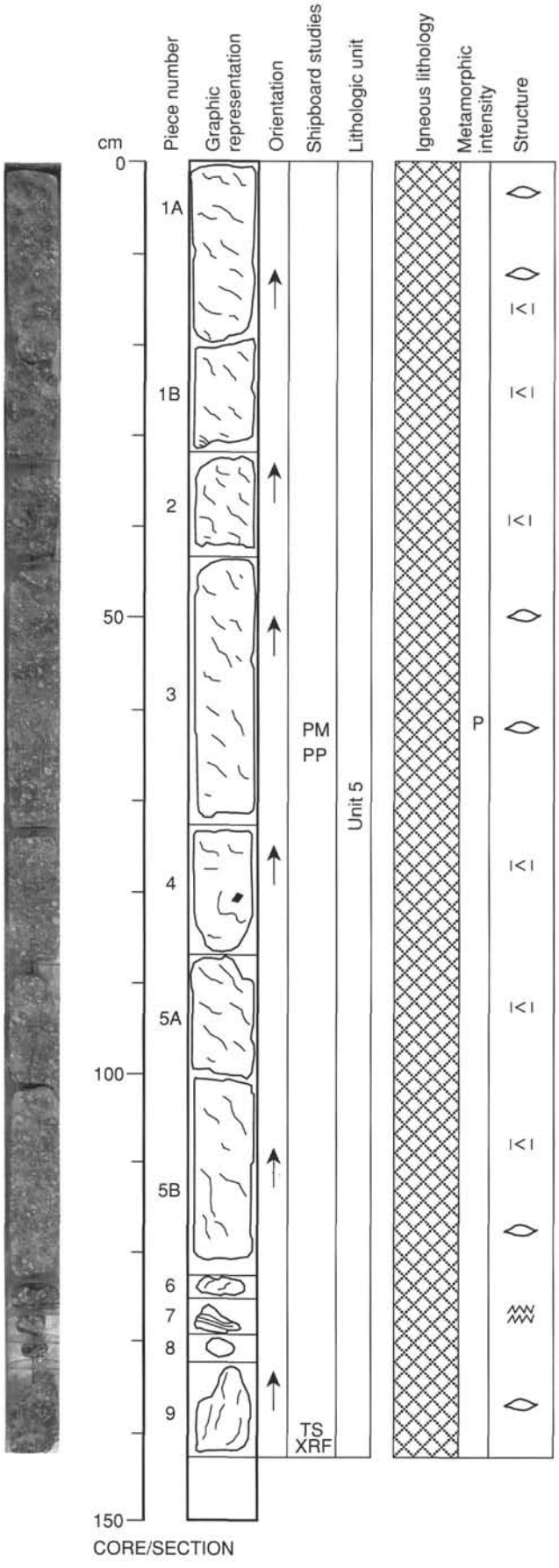


153-920B-10R-3

UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1–8

COLOR: Black/gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Vein networks.
PRIMARY MINERALOGY:
Olivine - Mode: 70%.
Clinopyroxene - Mode: 3%.
Crystal Size: 1–5 mm.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 26%.
Crystal Size: 2–20 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic alignment.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: Igneous rocks comprise porphyroclastic serpentinized olivine-orthopyroxene-clinopyroxene-spinel harzburgite. Primary olivine is rarely preserved. Orthopyroxene and clinopyroxene survive as fresh grains rimmed by serpentine and amphibole. The grain-size range of porphyroclasts is consistently 2–5 mm for clinopyroxene and 2–20 mm for orthopyroxene. The degree of porphyroclast alignment (and foliation development) is weak. Below Piece 6, there is a consistent increase in the proportion of porphyroclasts from 25% to 30% and this continues at least beyond Core 153-920B-12R.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 70
Comments: Replacing olivine and orthopyroxene.
Amphibole.
Total Percent: 10
Comments: Rimming and replacing pyroxene.
Magnetite.
Total Percent: 5
Comments: Breakdown product of serpentinization of olivine.
Comments: The peridotite is less altered than in the previous sections. Olivine is up to 70% replaced by serpentine and generally shows ribbon textures; pyroxene alteration reaches 40%. Vein filling minerals are mainly serpentine and minor magnetite, after breakdown of olivine.
Piece 1 contains a 4.5 cm wide Ca-metasomatized gabbroic vein composed of recrystallized and relict clinopyroxene, with alteration to tremolite/actinolite. Plagioclase is pervasively altered to secondary plagioclase, prehnite, zoisite, zeolite, and pods of amphibole and chlorite. The vein is cut by 2–4 mm wide, white, prehnite veins which progressively become more serpentine rich away from the gabbroic vein.
VEIN/FRACTURE FILLING:
White, black, and green serpentine.
Percent: <10%
Size: <2 mm.
Orientation: See comments.
Metagabbro
Percent: <10%
Size: 45 mm.
Orientation: 000,75
ADDITIONAL COMMENTS: Structure
A weak elongation of orthopyroxene porphyroclasts defines the main foliation in this section. The foliation dips at about 45°. The metagabbro in Piece 1 dips at about 75°. In Piece 8 three different generations of veins are present. A dark green serpentine vein (2 mm) is cut by thin white serpentine veins that are, in turn, cut by light green serpentine veins. Minor shear displacements (1–2 mm) are evident on the youngest veins that dip at about 35°.



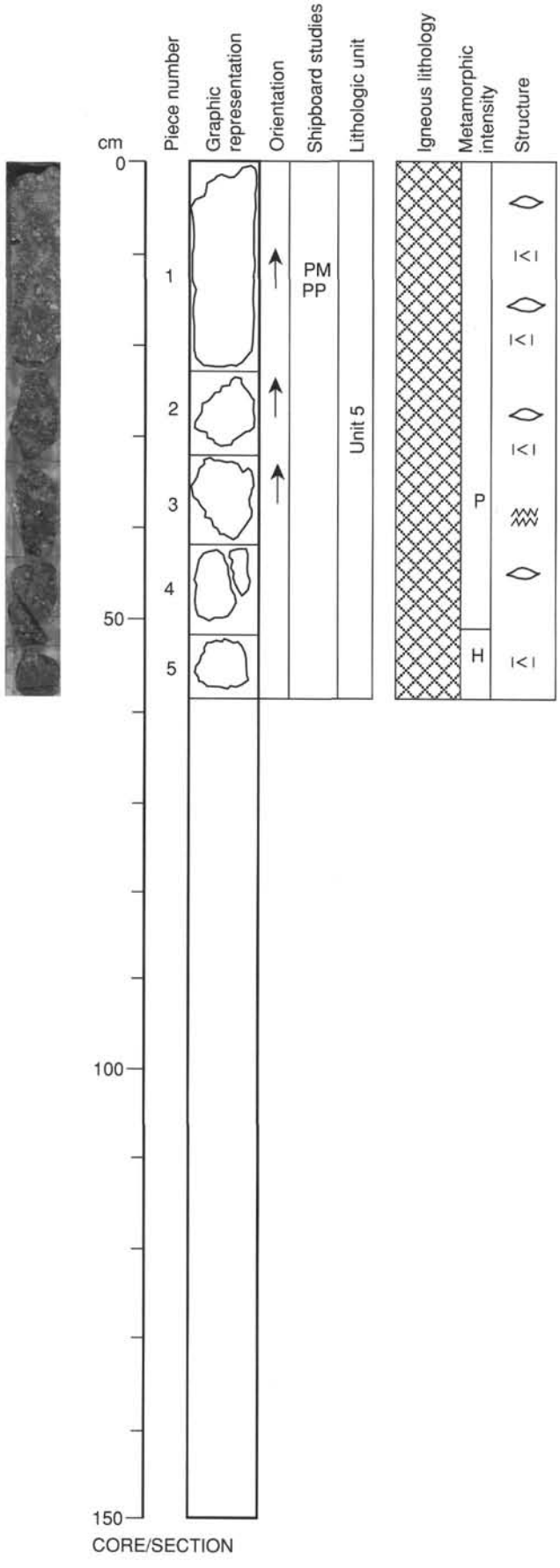
153-920B-10R-4

UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1A–9

COLOR: Dark gray-green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Two vein networks.
PRIMARY MINERALOGY:
Olivine - Mode: 80%–90%.
Orthopyroxene - Mode: 10%–20%.
Crystal Size: 1–16 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 1%–3%.
Crystal Size: <1–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral
Comments: The section is comprised of porphyroclastic serpentinized olivine, orthopyroxene, clinopyroxene, and spinel harzburgite. Few relict olivine cores remain. Orthopyroxene and particularly clinopyroxene are generally less altered and cores of pyroxene rimmed by serpentine and amphibole are common. The grain-size range of porphyroclasts is consistently 1–5 mm for clinopyroxene and 1–16 mm for orthopyroxene. The degree of porphyroclast alignment (and foliation development) is weak. Two styles of serpentinization are developed in the matrix giving it a patchy appearance. The section is dominatly composed of depleted harzburgite with 18%–25% pyroxene content. Piece 7 is cut a serpentine shear zone (small piece).
SECONDARY MINERALOGY:
Serpentine.
Total Percent: >89
Texture: Ribbon and mesh.
Mode of Occurrence: Replacing olivine/orthopyroxene.
Amphibole.
Total Percent: <10
Mode of Occurrence: Replacing pyroxene.
Oxide minerals.
Total Percent: 1
Comments: Product of serpentinization.
Comments: Olivine is extensively replaced, whereas clinopyroxene and orthopyroxene are altered up to 80% and 70% respectively, mainly exhibited as reaction rims. As a product of olivine breakdown, large quantities of oxide minerals occur, and crosscut porphyroclasts. The main vein filling minerals are serpentine and magnetite. In Piece 7, a serpentine vein (>1 mm) occurs.
VEIN/FRACTURE FILLING:
White, black serpentine.
Percent: <10%
Size: <1 mm.
Orientation: See Comments.
ADDITIONAL COMMENTS: Structure
Orthopyroxene porphyroclasts are slightly elongate, defining a weak foliation that dips at about 45°. A weak anastomosing foliation overprints the elongated porphyroclastic textures defined by dense arrays of dark green serpentine veins (<1 mm). In Pieces 2 and 5 the veins that define the foliation are cut by a discrete green serpentine vein (2 mm) that is cut by thin white discontinuous serpentine veins. The thin white serpentine veins are oriented parallel to the anastomosing foliation.

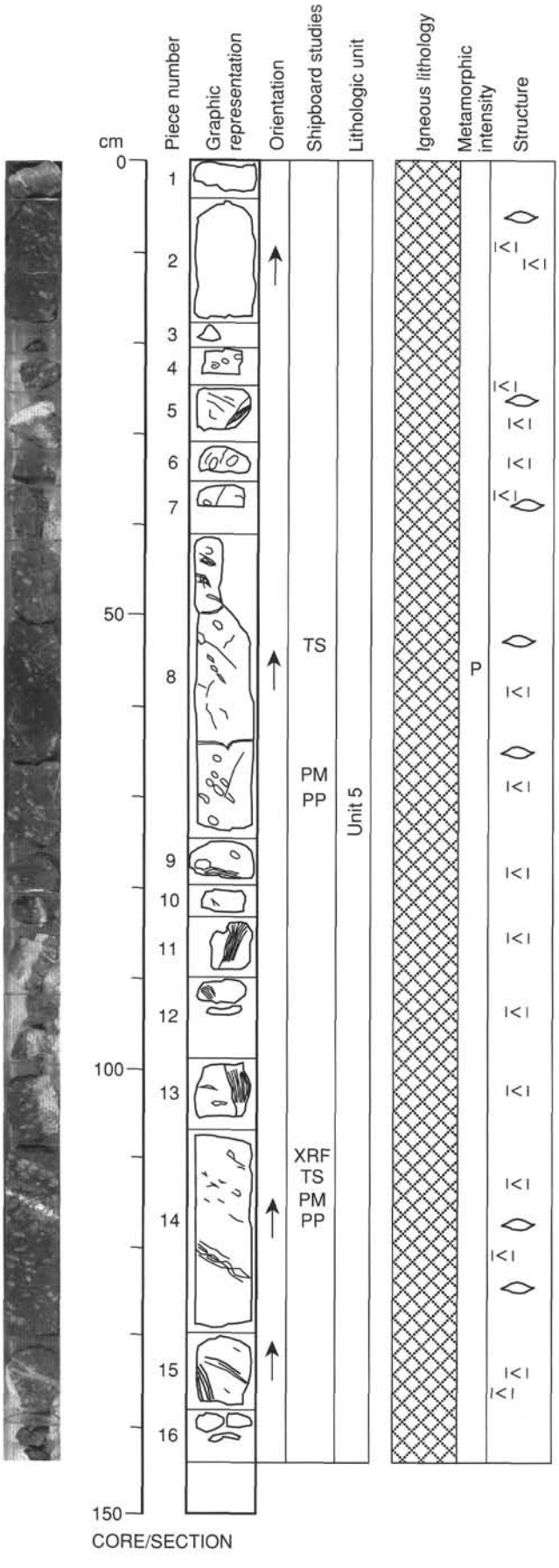
153-920B-10R-5



UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1–5

COLOR: Dark gray-green.
PRIMARY STRUCTURE: Poorly developed porphyroclastic.
SECONDARY STRUCTURE: Vein networks with normal-sense shear on foliation-parallel veins.
PRIMARY MINERALOGY:
Olivine - Mode: 80%–90%.
Orthopyroxene - Mode: 10%–15%.
Crystal Size: 2–17 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 1%–3%.
Crystal Size: 1–6 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: Piece 1 is porphyroclastic serpentinized olivine, orthopyroxene, clinopyroxene, and spinel harzburgite. Olivine is strongly serpentinized. Orthopyroxene and clinopyroxene are generally less altered and cores of pyroxene rimmed by serpentine and amphibole are common. Pieces 1–4 consists of depleted harzburgite 15%–20% modal pyroxene, whereas Piece 5 is a more highly depleted harzburgite (10%–15% pyroxene). The top of Core 153-920B-11R is a pyroxenite so that the highly depleted harzburgite in Piece 5 may be adjacent this pyroxneite. The grain-size range of porphyroclasts is consistently 1–6 mm for clinopyroxene and 2–17 mm for orthopyroxene. The degree of porphyroclast alignment (and foliation development) is weak. In the rest of the section (Pieces 2–5) the porphyroclastic serpentinized harzburgite has small areas (<10 cm) where almost pure serpentinite is developed. In Piece 5, only a small percentage (<5%) of fresh orthopyroxene remains.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: >80
Mode of Occurrence: Replacing olivine and orthopyroxene.
Amphibole.
Total Percent: <5
Mode of Occurrence: Replacing pyroxene.
Oxide minerals.
Total Percent: 1
Comments: Product of serpentinization.
Comments: Olivine is largely replaced by serpentine, and clinopyroxene and orthopyroxene replacement reaches 90% and 60% respectively, exhibited as reaction rims. Scarce veining is developed; the main vein filling mineral is fibrous and radiating serpentine. Magnetite veins occur in Pieces 1 and 2.
VEIN/FRACTURE FILLING:
White, green, and black serpentine.
Percent: <10%
Size: <1 mm.
Orientation: See Comments.
ADDITIONAL COMMENTS: Structure
A foliation defined by a very weak elongation of orthopyroxene porphyroclasts dips at about 50°. A weak anatomosing foliation overprints the porphyroclast foliation, defined by thin green/black serpentine veins that is emphasized by thin white discontinous serpentine veins. In Piece 3, a pale green serpentine vein cuts the anastomosing foliation. This vein contains fibers oblique to the vein walls, suggesting a displacment along the vein. Neither the displacement nor the orientation of the vein could be measured.



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UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1–16

COLOR: Black-green/gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Vein network.
PRIMARY MINERALOGY:
Olivine - Mode: 90%.
Clinopyroxene - Mode: 2%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral.
Crystal orientation:
Orthopyroxene - Mode: 17%.
Crystal Size: 5–15 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Spinel - Mode: <1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: The section consists dominantly of porphyroclastic harzburgite variably depleted in pyroxene. Piece 1 contains composite pyroxenite-gabbroic vein material which is somewhat altered, but contains unaltered clinopyroxene. Piece 2 adjacent to this vein material is harzburgite to dunite and highly depleted in pyroxene content. The sample contains trains of spinel that are up to ≈5 cm in length. Pieces 3 and 4 are depleted harzburgite (15%–20% pyroxene). Piece 5 contains a small (1-cm-thick) altered pyroxenite/gabbro composite vein within pyroxene-bearing dunite. Piece 6 is pyroxene-bearing dunite. Piece 7 is a highly depleted harzburgite with a 2 cm thick pyroxenite vein. Piece 8 is highly depleted harzburgite and pyroxene-bearing dunite. Pieces 9–16 are pyroxene bearing dunite to highly depleted harzburgite that are heavily veined with composite pyroxneite/gabbro. Piece 10 contains a composite gabbro/pyroxenite vein 1 cm thick; Piece 11 contains a similar near vertical vein 4 cm thick. Piece 13 contains a 2.5 cm thick near-vertical vein of pyroxenite, with some gabbro. The margin of this vein in the harzburgite is very depleted in pyroxene. These veins cut the high-temperature foliation at a high angle. Piece 14 contains a composite gabbro/pyroxenite vein that is 8 mm thick and parallel to the high-temperature foliation. The gabbro contains sulfide and opaque oxide minerals as primary phases. The vein is strongly zoned with dunite at the margin, followed inward by pyroxenite and gabbro at the center. Piece 16 contains two composite gabbro/pyroxenite veins 2 cm and 1 cm thick. Piece 16 is a small piece of dunite. All veins are highly altered to some degree, but several veins preserve fresh clinopyroxene. In general, the primary mineralogy is partially preserved throughout the section, although altered.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 80
Mode of Occurrence: Metamorphic.
Comments: Replaces olivine and orthopyroxene.
Amphibole.
Total Percent: 7–10
Mode of Occurrence: Metamorphic.
Comments: Replaces pyroxene.
Comments: The peridotite is extensively altered and olivine is replaced by serpentine (90%–100%) showing mesh and ribbon textures. Clinopyroxene porphyroclasts are relatively fresh (10% altered) to actinolitic amphibole; orthopyroxene is relatively fresh (generally 20%, maximum 50% in Piece 1) replaced by amphibole and serpentine. In Piece 1, a fine-grained amphibole-rich zone occurs. A 1 cm wide prehnite, tremolite, chlorite, and epidote vein appears to have replaced a gabbroic protolith. In Pieces 2–4, the serpentine is schistose. In Pieces 5–8, carbonate mineral and serpentine veins occur. In Pieces 9–13, veins or pockets or rodingitized metagabbros are altered to calcite and zoisite/prehnite(?) with actinolite. In Pieces 14 and 15, a large amount of sulfide minerals occurs in the gabbroic pockets. Piece 16 contains a rodingitized gabbroic vein with abundant secondary sulfide minerals. In Pieces 1, 3, 5, 11, and 13, 10 to 30 mm wide veins of pervasively altered gabbroic material are present. These veins are composed of abundant prehnite after plagioclase, secondary clinopyroxene and amphibole after clinopyroxene(?), as well as chlorite, zeolite, and serpentine.
VEIN/FRACTURE FILLING:
Serpentine.

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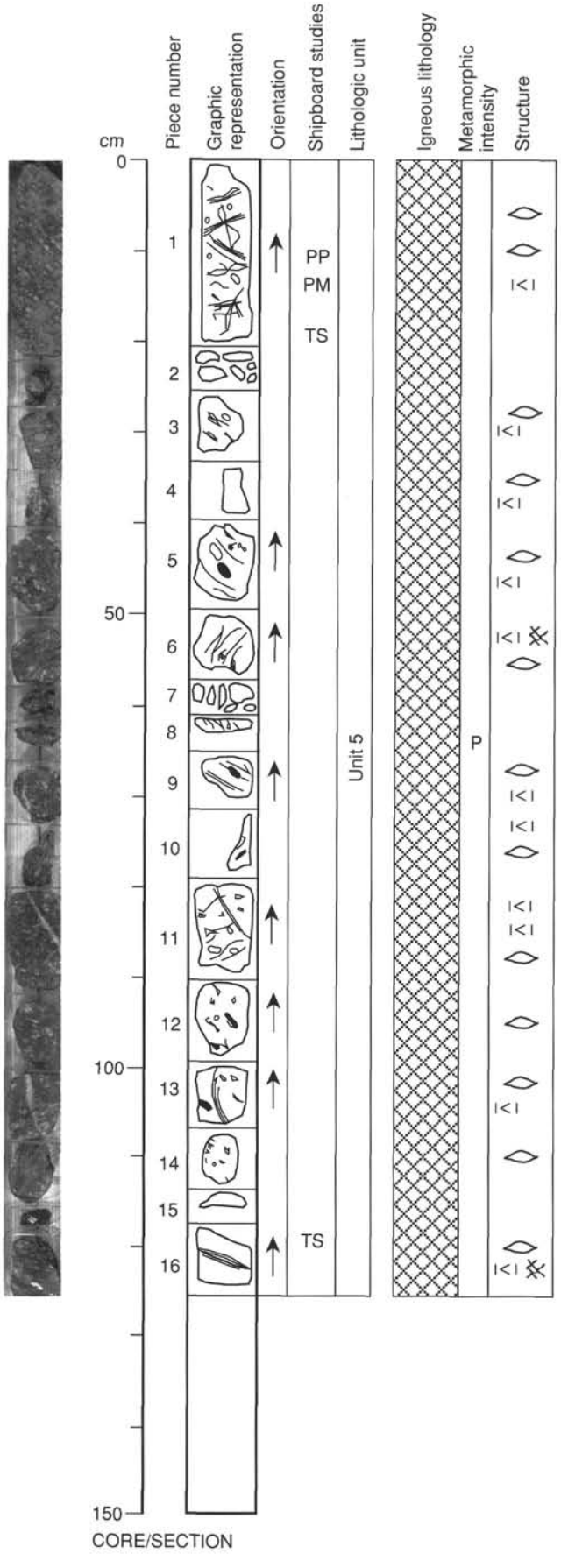
Percent: 3%
Size: 1 mm.
Orientation: See comments.

ADDITIONAL COMMENTS: Structure

Pyroxene crystals have a weak shape preferred orientation, forming a penetrative foliation that dips at about 45°. Some pyroxene grains are boudinaged (e.g. Piece 8B). The grain size of olivine is strongly reduced relative to the orthopyroxene crystals. The anastomosing foliation evident in many other core sections is only present in Piece 8. Foliation-concordant magmatic veins are present in Pieces 14 and 15. In Pieces 10, 11, and 13 they are discordant to the foliation. In Piece 2, a thin dark green vein cuts the porphyroclastic fabric. This vein is cut by sparse, thin white serpentine veins that are oriented subparallel to the foliation. An altered gabbroic vein in Piece 11 is cut by a light green serpentine vein.



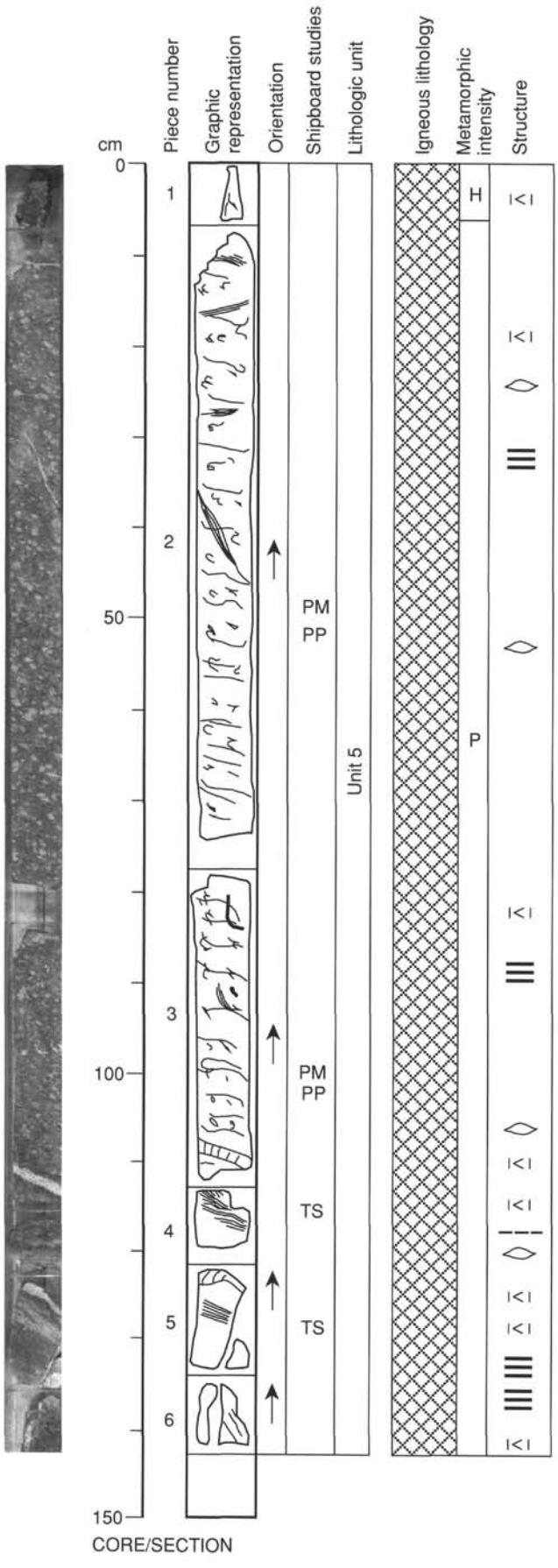
153-920B-11R-2

UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1–16

COLOR: Black/gray.
PRIMARY STRUCTURE: Elongate porphyroclastic.
SECONDARY STRUCTURE: Vein network.
PRIMARY MINERALOGY:
Olivine - Mode: 80%.
Clinopyroxene - Mode: 2%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Crystal orientation:
Orthopyroxene - Mode: 16%.
Crystal Size: 2–20 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Spinel - Mode: 1%–2%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: Section consists largely of serpentinized harzburgite. The modal pyroxene content is variable in the section. Chrome spinel is present as isolated grains. Pieces 1–5, 9, 10, and 12 are typical depleted harzburgite with 15%–25% pyroxene, whereas Pieces 6–7, 11, and 14, are highly depleted in pyroxene (10%–15%) and Piece 15 is a dunite. Piece 11 contains an altered gabbroic vein 5 cm in thickness that is highly oblique to the foliation. Piece 13 contains a clinopyroxenite and gabbro vein intruding parallel and perpendicular to the high-temperature foliation plane, respectively. Piece 16 contains a composite pyroxenite/gabbro vein with primary sulfide and opaque oxide minerals. The vein is ≈5 mm in thickness and gnereally highly altered.
SECONDARY MINERALOGY:
Serpentinite.
Total Percent: 70
Mode of Occurrence: Metamorphic
Comments: Replaces olivine and orthopyroxene.
Amphibole.
Total Percent: 7
Mode of Occurrence: Metamorphic.
Comments: Replaces orthopyroxene and clinopyroxene.
Comments: Olivine is altered to serpentine (about 90%); clinopyroxene and orthopyroxene are slightly to moderately altered (10% and 20% respectively). In Piece 2, the alteration is patchy. In Pieces 11 and 13, the veins are serpentine, brown amphibole, chlorite, tremolite(?) or zeolites, and clay minerals. In Piece 16, an altered metagabbro veinlet crosscuts the peridotite. Plagioclase in this vein has a zoned corona of serpentine, chlorite, and prehnite (outward from plagioclase) at the contact with peridotite.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 2%
Size: <1–3 mm.
Orientation: See comments.
Magnetite.
Percent: 0.1%
ADDITIONAL COMMENTS: Structure
A moderately intense elongate porphyroclastic fabric forms the dominant foliation in this section, dipping at about 40°. Pieces 1–4 are less deformed but show moderate alignment of porphyroclasts. The grain size of olivine in the surrounding matrix is strongly reduced relative to the orthopyroxene porphyroclasts. This fabric is overprinted by a weak anastomosing foliation but this is not evident in Pieces 8, 9, and 10. Thin white discontinuous serpentine veins overprint the foliation. In Pieces 11 and 13, altered gabbroic veins are oriented at high angles to the foliation. In Piece 16, another metagabbro vein is oriented slightly oblique to the foliation (10°).

153-920B-12R-1



UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1–6

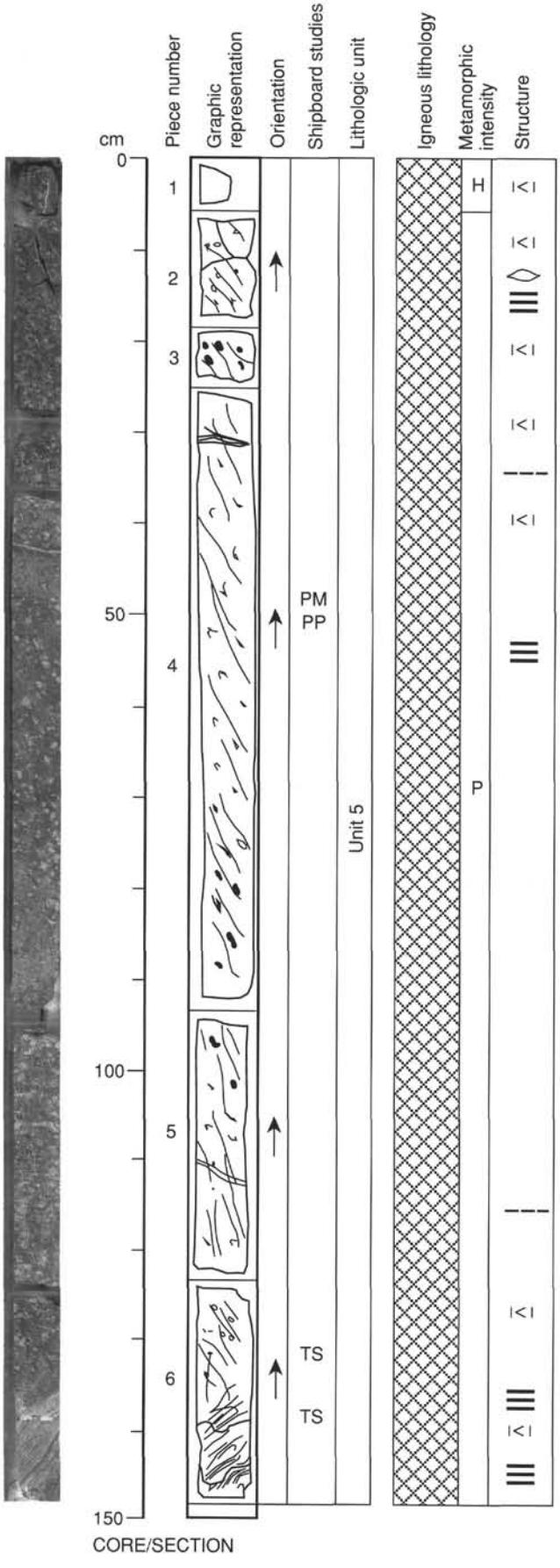
COLOR: Dark gray/green.
PRIMARY STRUCTURE: Weakly elongated porphyroclastic.
SECONDARY STRUCTURE: Two sets of veins, one subparallel to the foliation, second set at 40°–60° to foliation.
PRIMARY MINERALOGY:
Olivine - Mode: 75%–95%.
Clinopyroxene - Mode: 4%.
Crystal Size: 2–8 mm.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 20%.
Crystal Size: 2–12 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: This section is composed of moderately porphyroclastic serpentinized harzburgite containing variable percentages of pyroxene (15%–25%) to pyroxene-bearing dunite (<10%). The harzburgite in this section is notable for the relatively low degrees of alteration in parts of the section; as little as 70% of primary olivine and 20% of primary pyroxene have been replaced in some samples. Piece 1 consists of a depleted harzburgite; Piece 2 is a pyroxene-rich harzburgite with two 2–3 mm wide gabbroic veinlets. Piece 3 is also a pyroxene-rich harzburgite and contains a pyroxene-depleted zone centered by a 15 mm thick gabbroic dike at its base. The halo at the margin of the dike is dunitic in composition. Piece 4 is a dunite with a concordant (foliation parallel) pyroxenite band (10 mm thick). Piece 5 is dunite with a gabbroic vein. The adjacent wall rock to the gabbro is a highly depleted dunite. The dunite in Piece 5 appears also to be mylonitized in places with the usually anastomosing white serpentine veins nearly planar and parallel to a strong high-temperature foliation. The veins appear highly altered.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 70
Mode of Occurrence: Metamorphic.
Comments: Replaces olivine and orthopyroxene in bastite.
Amphibole.
Total Percent: 10
Mode of Occurrence: Metamorphic.
Comments: Replacement on orthopyroxene rims.
Comments: This section is pervasively serpentinized (90%–100%) and commonly cut by wispy white asbestiform serpentine veinlets. Olivine is highly to pervasively altered (70%–100%) to iron oxide minerals, and mesh-textured serpentine. Clinopyroxene is heterogeneously altered (40% to 100%) with overprinting by serpentine and fine-grained iron oxide minerals. Porphyroclasts of elongate orthopyroxene are replaced by serpentine 20%–50% and commonly wrapped by fine, wispy white asbestiform serpentine veinlets.
Veins
Wispy white serpentine and magnetite-bearing veins are common throughout the section. Piece 2 contains two, 2–3 mm wide gabbroic veinlets which are altered to actinolite, chlorite, and prehnite(?). A high angle serpentine vein, ≈8 mm wide cuts near the top of Piece 2. Piece 3 contains an incipently Ca-metosomatized gabbroic vein (≈10 mm wide), which cuts the bottom of the piece, and which is cut at a high angle by serpentine veins. Alteration minerals include tremolite, epidote, and zeolites. A similar vein occurs in Piece 5. Piece 4 is cut by a serpentinized pyroxenite vein, 4 mm wide, which exhibits a 1–2 mm wide alteration halo of chlorite and serpentine, and which is altered to tremolite, actinolite, and chlorite.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 2%
Size: 1 mm.
Orientation: See comments.
Magnetite.
Percent: 0.5%
MnO.
Percent: .01%

153-920B-12R-1

ADDITIONAL COMMENTS: *Structure*

Serpentinized harzburgite is deformed by a weak elongated porphyroclastic fabric overprinted by weak to moderately intense anastomosing foliation. Thin white wispy serpentine veins overprint the foliation. The elongation of porphyroclasts is subparallel to foliation, both dipping at about 40°–50°. An intensification of the anastomosing foliation at base of core coincides with a gradational boundary to a pyroxene-poor layer (Pieces 4, 5, and 6). An array of serpentine veins (1–2 mm wide) is oriented at 40°–60° to the anastomosing foliation. In Piece 3, a pale green serpentine vein cuts the white serpentine veins that are oriented parallel to the foliation.

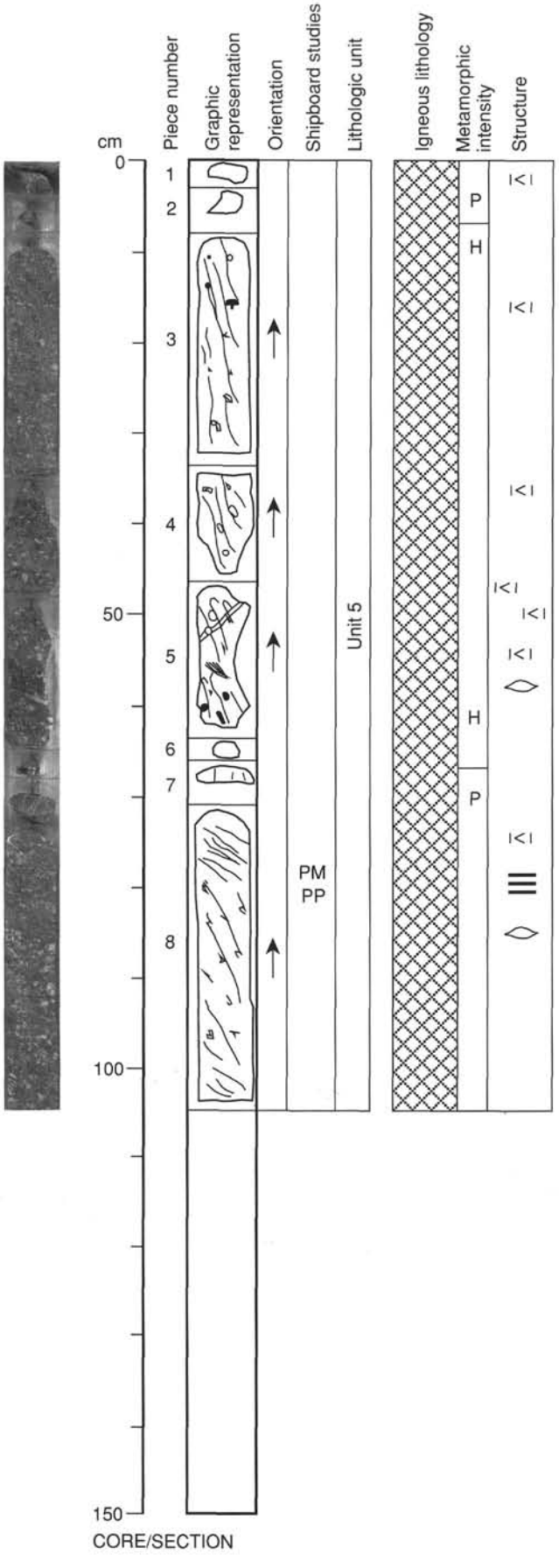
153-920B-12R-2



UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1–6

COLOR: Gray/green
PRIMARY STRUCTURE: Weakly elongate porphyroclastic.
SECONDARY STRUCTURE: A shear zone, perpendicular to the dominant foliation and cut by two faults is located in Piece 6. Strong serpentine alteration within the shear zone.
PRIMARY MINERALOGY:
Olivine - Mode: 80%.
Orthopyroxene - Mode: 16%.
Crystal Size: 2–12 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 3%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: This section is composed of moderately porphyroclastic serpentinized harzburgite containing high orthopyroxene abundances (≈15%–21%) and clinoyproxene abundances that are consistently about 4%. Pieces 1 and 2 are pyroxene-rich harzburgite/lherzolite, whereas Pieces 3–5 are depleted harzburgite. Piece 6 is a depleted harzburgite to dunite at the base. Piece 4 contains a gabbroic veinlet about 3 mm in thickness. The alteration of the section ranges from 70%–100%, but the primary mineralogy is generally well preserved as relict grains. The lower half of Piece 6 is strongly sheared and is mylonitized dunite. Note that the presence of sheared rocks at the base of Sections 153-920B-1R, -2R, and -3R in this core suggests that shear zones are repeated in this interval.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 70
Mode of Occurrence: Metamorphic.
Amphibole.
Total Percent: 10
Mode of Occurrence: Metamorphic.
Comments: Alteration in this section varies from 85%–100%, with olivine alteration ranging from 70% to 100%. Olivine is highly to pervasively replaced by serpentine and fine-grained iron oxide minerals. The pervasive background mesh textured serpentine is cut at a high angle by fine white serpentine veinlets <1 mm in width. Orthopyroxene is moderately to locally pervasively replaced by serpentine and is cut by high angle fine white serpentine veinlets. Minor clinopyroxene may be only slightly to moderately altered, locally (10%). Pieces 1 and 4 are cut by <1 to 1 mm wide serpentine veins, respectively.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 1%
ADDITIONAL COMMENTS: Structure
Weak elongated porphyroclastic texture with a weak to moderately intense anastomosing foliation, emphasized by thin white wispy serpentine veins. The elongation of porphyroclasts is subparallel to the foliation, both dipping 40°–50°. Serpentine veins with fibers oblique to margins of vein cross foliation at about 60°. A shear zone is located in Piece 6, with a dunitic margin. Strong serpentine alteration has localized within the shear zone. The shear zone is cut by two faults, filled with serpentine. The displacement and shear sense however are undetermined. The shear zone is oriented perpendicular to dominant foliation but the foliation steepens as it approaches the shear zone. Just above the shear zone in Piece 6, the porphyroclast foliation is oriented at about 60° relative to the anastomosing foliation. Gradational boundaries of alteration intensity are subparallel to foliation.



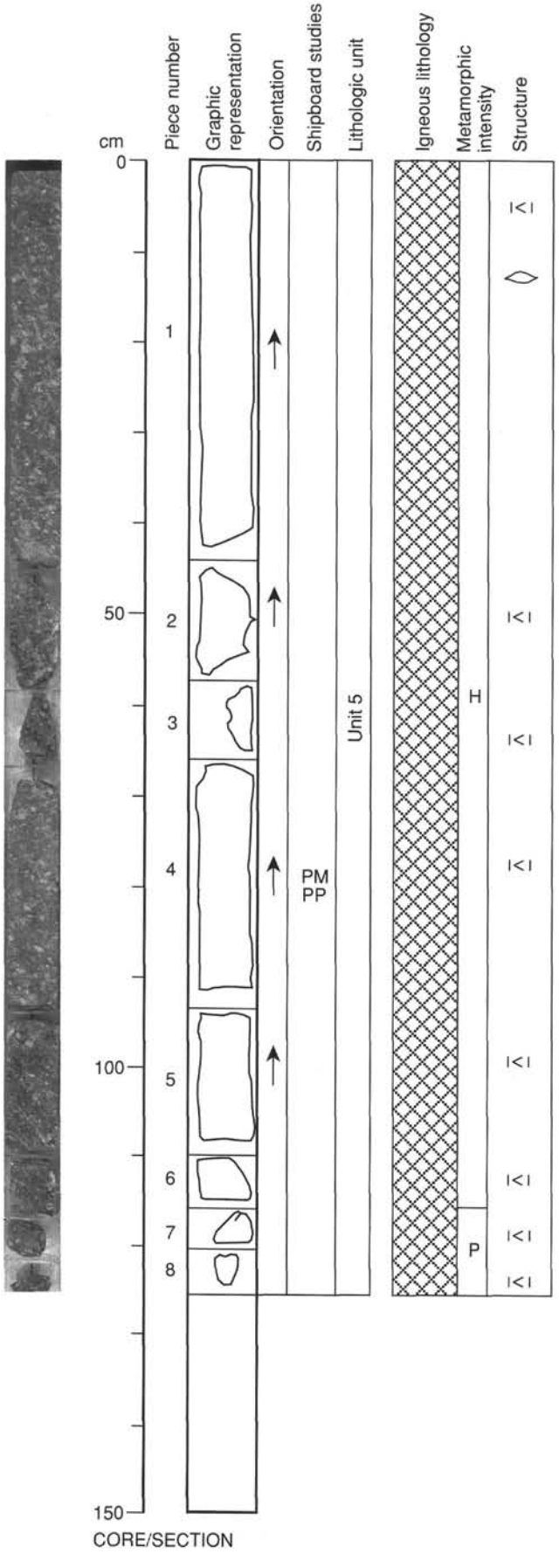
153-920B-12R-3

UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1–8

COLOR: Dark gray/green
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE:
PRIMARY MINERALOGY:
Spinel - Mode: 1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Orthpyroxene - Mode: 15%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 4%.
Crystal Size: 2–6 mm.
Crystal Shape: Anhedral.
Olivine - Mode: 80%.
Comments: This section consists of variably depleted harzburgite. Pieces 1–4 and 7 are depleted harzburgite (≈15–20 pyroxene) and dunite in Pieces 5 and 6. Alteration varies from 50%–100%. Piece 6 contains large blocky spinel grains. Piece 4 contains a serpentine vein.
SECONDARY MINERALOGY:
Amphibole.
Total Percent: 4
Mode of Occurrence: Metamorphic.
Comments: Repalces orthopyroxene and clinopyroxene.
Serpentine.
Total Percent: 45
Mode of Occurrence: Metamorphic.
Comments: Repalces olivine and orthopyroxene.
Comments: Alteration of this section is pervasive (90%–100%) with olivine pervasively replaced by mesh textured serpentine and fine-grained iron oxide minerals. Olivine alteration is heterogeneous ranging from 50% to 100%, with pervasive alteration common. Orthopyroxene alteration is highly variable ranging from 20% in Pieces 3 and 8, to 100% in Piece 7. Orthopyroxene is variably replaced by serpentine and bastite and is wrapped and cut by fine, white asbestiform serpentine and magnetite veinlets.
Veins
Fine serpentine veinlets, white in color which cut the core subvertically are pervasive. Piece 5 is cut by a tapering serpentine(?) vein (10 mm wide), which is cut by <1 mm wide serpentine veinlets.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 2%
Magnetite.
Percent: 0.5%
ADDITIONAL COMMENTS: Structure
Pyroxene porphyroclasts are weakly to moderately elongated parallel to an anastomosing foliation. The foliation is defined by thin, green/black serpentine veins that are overprinted by white, wispy serpentine veins. The foliation dips at about 55° to 60° and is locally oblique to the weak elongation direction of porphyroclasts, (e.g., Piece 8, about 15° difference).

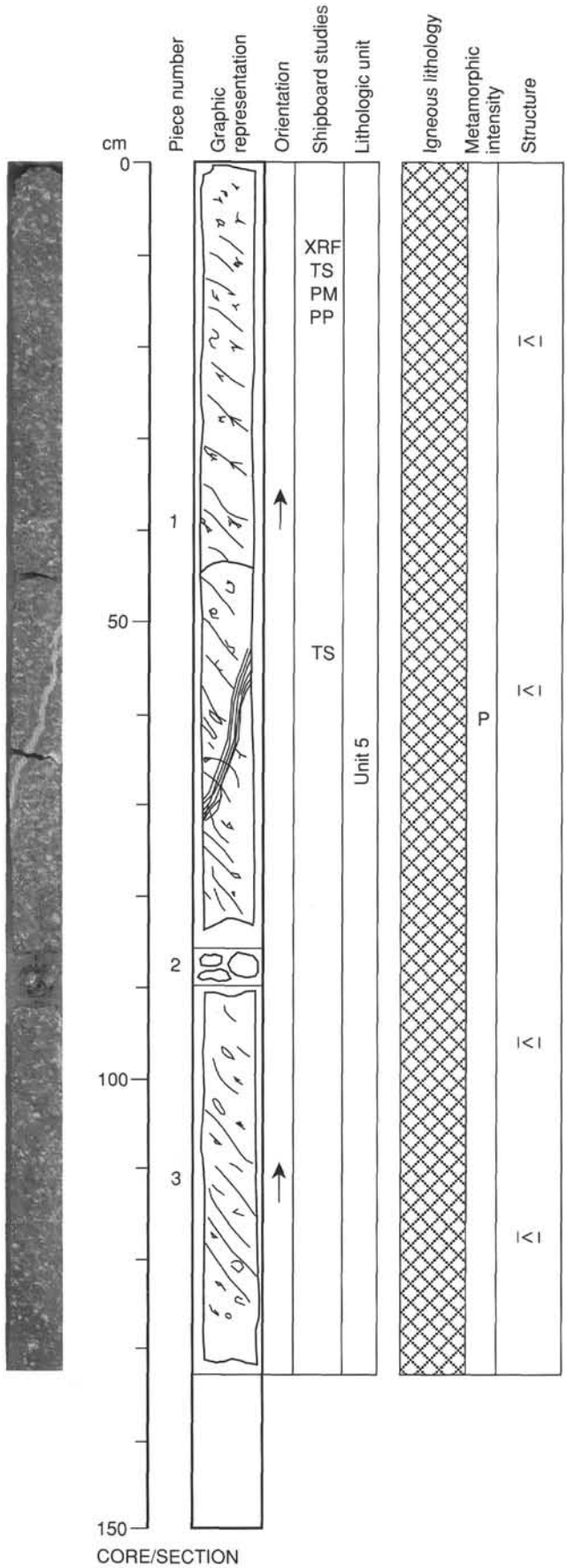
153-920B-12R-4



UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1–8

COLOR: Dark gray/black
PRIMARY STRUCTURE: Weak elongated porphyroclastic.
SECONDARY STRUCTURE: Anastomosing foliation and thin white discontinuous serpentine veins intensify toward the lower half of the section, dipping about 50°. Kink bands evident in orthopyroxene porphyroclasts.
PRIMARY MINERALOGY:
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 15%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 4%.
Crystal Size: 2–6 mm.
Crystal Shape: Anhedral.
Olivine - Mode: 60%.
Comments: This section is composed of porphyroclastic serpentinized harzburgite. Pyroxene abundances vary between approximately 18% and 23%. The average pyroxene content in this section is somewhat higher the average of previous sections. No magmatic veins are observed in the section.
SECONDARY MINERALOGY:
Magnetite
Total Percent: 3
Mode of Occurrence: Metamorphic.
Comments: Breakdown of olivine.
Amphibole.
Total Percent: 8
Mode of Occurrence: Metamorphic.
Serpentine.
Total Percent: 60
Mode of Occurrence: Metamorphic.
Comments: Alteration of this core is pervasive (95%–98%) with olivine alteration varying from 60% to 100%. Serpentine after olivine forms a fine, dark gray-green mesh textured fabric which is cut by <1 mm wide white serpentine veinlets. Clinopyroxene is only moderately altered (20%–30%) and overprinted by the serpentine mesh. Orthopyroxene alteration is highly variable from 20% to 100%. In pervasively altered areas bastite after the porphyroclasts is common. Fine, white serpentine veinlets are common.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 2%
Magnetite.
Percent: 0.5%
ADDITIONAL COMMENTS: STRUCTURE
A weak elongated porphyroclastic fabric with a shape preferred orientation of orthopyroxene is evident throughout the section. An anastomosing foliation of a dense meshwork of black serpentine veins dips as high as 70°. This foliation orientation is locally oblique to the weak elongation direction of pyroxene porphyroclasts, intersecting up to a maximum angle of 60°. Thin white wispy serpentine veins overprint the foliation.



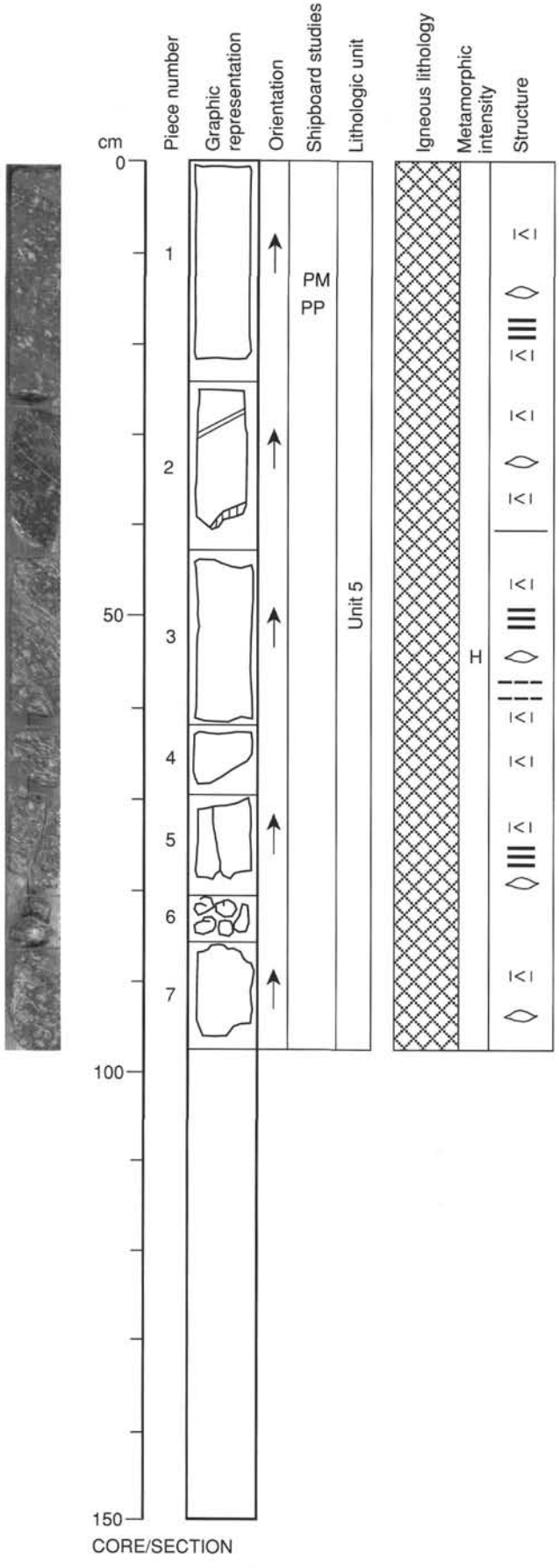
153-920B-12R-5

UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1–3

COLOR: Dark gray/black
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: A serpentine vein with blue green alteration parallel to margins, intersects foliation at a high angle in Piece 1B.
PRIMARY MINERALOGY:
Olivine - Mode: 80%.
Clinopyroxene - Mode: 4%.
Crystal Size: 4–8 mm.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 15%.
Crystal Size: 2–12 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: This section is composed of porphyroclastic serpentinized harzburgite. Pyroxene abundances are estimated at 15%–19%. Piece 1 contains an 8 mm thick subvertical veinlet of serpentine with syntaxial cross fibers. Piece 2 is harzburgite rubble.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 60
Mode of Occurrence: Metamorphic.
Comments: Replaces olivine and orthopyroxene.
Amphibole.
Total Percent: 5
Mode of Occurrence: Metamorphic.
Comments: Replaces and rims clinopyroxene.
Comments: Alteration of this section is pervasive (90%–95%) with olivine alteration to mesh textured serpentine varying from (70%–100%). Sparse clinopyroxene is altered moderately (20%) with overprinting by serpentine. Orthopyroxene porphyroclasts are replaced 30% to 100% by serpentine and are cut by fine veinets of serpentine. In pervasively altered areas, orthopyroxene is pseudomorphed by bastite with minor chlorite. Piece 1B is cut by a subvertical, 2 cm wide, cross-fibered green chrysotile vein, which exhibits a symmetrical 1 cm wide light blue gray-colored alteration halo of serpentine and chlorite. The section is cut by abundant fine, white serpentine veinlets (1 mm wide).
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 2%
ADDITIONAL COMMENTS: STRUCTURE
The pyroxene porphyroclasts show no shape preferred orientation in this section. A weak to moderate anastomosing foliation comprising a dense meshwork of green/black serpentine veins dips at about 50° to 60°. A serpentine vein with blue-green alteration parallel to margins, intersects foliation at a high angle in Piece 1B.

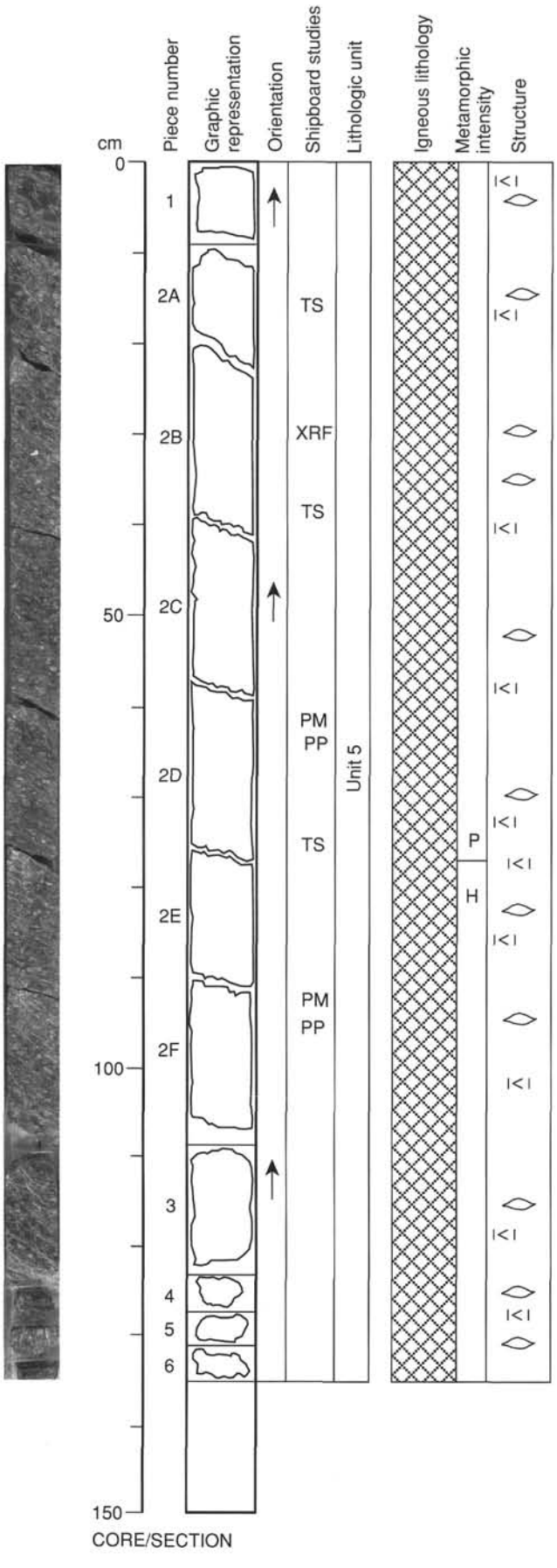
153-920B-12R-6



UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1–7

COLOR: Dark gray/black.
PRIMARY STRUCTURE: Elongated porphyroclastic.
SECONDARY STRUCTURE: Anastomosing foliation with thin white serpentine veins.
PRIMARY MINERALOGY:
Olivine - Mode: 80%.
Clinopyroxene - Mode: 4%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 15%.
Crystal Size: 2–23 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: The section is composed of serpentinized porphyroclastic harzburgite that ranges between 15% and 28% pyroxene. Pieces 1 and 2 contain depleted harzburgite (<20% pyroxene); Pieces 3–7 contain harzburgite more enriched in pyroxene(>20%). There are two small gabbroic veinlets in Piece 2. The pyroxene-enriched harzburgite of Pieces 3–7 is characterized by a more pronounced anastomosing serpentine vein foliation subparallel to the high-temperature foliation, but the increase in pyroxene content corresponds with an increase amplitude in the sinuousity of the foliation.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 60
Mode of Occurrence: Metamorphic.
Comments: Replaces olivine.
Amphibole.
Total Percent: 5
Mode of Occurrence: Metamorphic.
Comments: Replaces and rims orthopyroxene and clinopyroxene.
Iron oxide minerals.
Total Percent: 2
Comments: Alteration of this section is pervasive (95%–98%) and is dominated by replacement of olivine by mesh textured serpentine and fine-grained, iron oxide minerals (85%–100%). Othopyroxene porphyroclasts are highly to pervasively (50%–100%) replaced by serpentine, with average alteration of ≈65%. Clinopyroxene is moderately to highly altered to minor amphibole, and rimmed by the serpentine matrix. Piece 2 is cut by a pervasively altered gabbroic vein, 2 mm wide, which is oriented concordant to the foliation. Alteration minerals include chlorite, actinolite, and prehnite(?) after plagioclase. Pieces 3 and 4 are cut by a fine, anastomosing network of serpentine and serpentine and magnetite veinlets which parallel the anastomosing foliation.
VEIN/FRACTURE FILLING:
Serpentine.
Magnetite.
ADDITIONAL COMMENTS: Structure
An elongated porphyroclastic texture, defined by the shape preferred orientation of oprthopyroxene porphyroclasts is strongest in this section of Core 153-920B-12R. The thin white serpentine veins that follow an anastomosing foliation are deflected to high angles around porphyroclasts. Both the porphyroclastic fabric and the foliation dip at 50°–60°. In Piece 3 there is a local intensification of the anastomosing foliation. Elliptical ratios of porphyroclasts on cut face attain values of up to 1:3. A pyroxene-poor horizon about 10 cm thick lies subparallel to the foliation. Note: An increase in the modal pyroxene abundance correlates with an increase in the deflection of the wispy white veins.



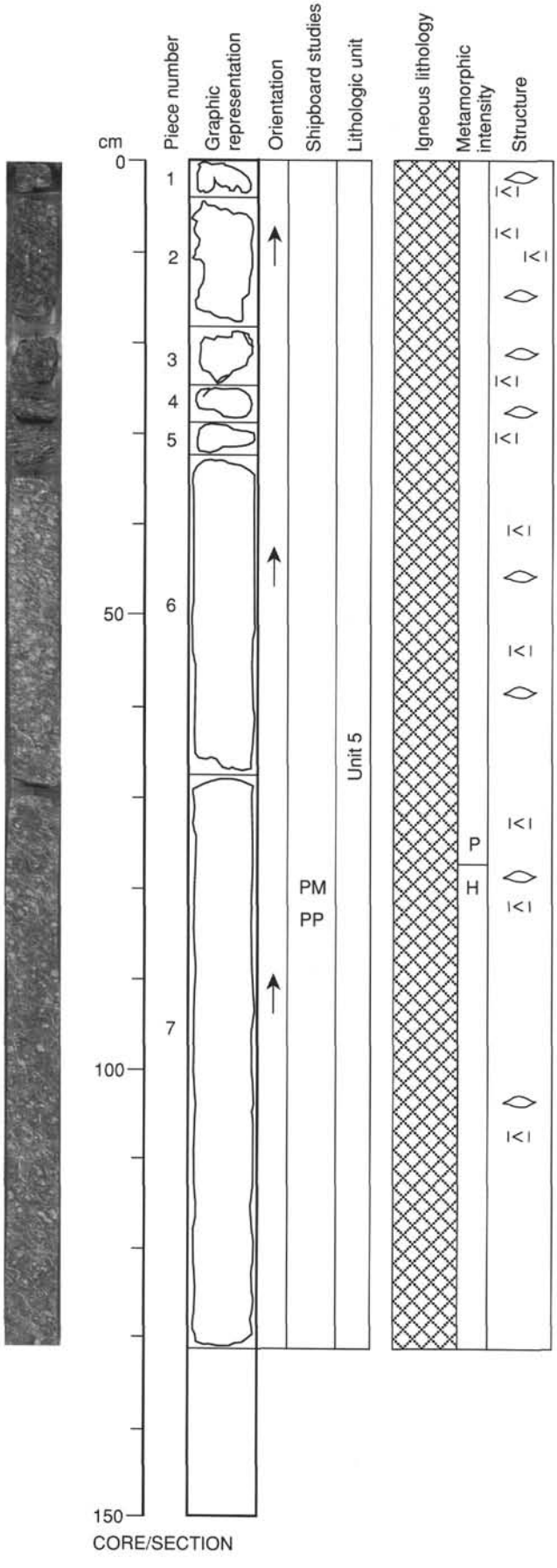
153-920B-13R-1

UNIT 5: SERPENTINIZED LHERZOLITE

Pieces 1–6

COLOR: Dark green/black.
PRIMARY STRUCTURE: Elongate porpyhroclastic.
SECONDARY STRUCTURE: Moderate to strong anastomosing fabric with thin white serpentine veins.
PRIMARY MINERALOGY:
Clinopyroxene - Mode: 10%.
Crystal Size: 3–15 mm.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 19%–29%.
Crystal Size: 3–30 mm.
Crystal Shape: Anhedral.
Olivine - Mode: 60%–70%.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: The section is dominated by porphyroclastic serpentinized harzburgite and lherzolite that is pyroxene-rich similar to Pieces 3–7 in Section 153-920B-12R-6, with 25%–30% total pyroxene content. Primary olivine is preserved within serpentine mesh structures, and primary orthopyroxene is preserved in some cores of porphyroclasts. Clinopyroxene grains are largely altered, but locally preserved. Spinel is well preserved throughout the core. Alteration tends to increase downsection. Common thin white serpentine veins bend around porphyroclasts, lending a distinctive appearance to the core. Magmatic veins are not present and tend to be uncommon in sections where the pyroxene content is high.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Amphibole.
Mode of Occurrence: After orthopyroxene, clinopyroxene.
Clay.
Mode of Occurrence: After olivine, amphibole, clinopyroxene.
Comments: Highly to pervasively altered (75%–90%). Olivine grains are pervasively altered (85%–100%) to serpentine, iron oxide minerals, and clay minerals. Pervasive alteration of olivine to white kernels with green rims, which are enclosed in an olive green to brown mesh serpentine network is common. Elongate orthopyroxene porphyroclasts are generally highly altered, although some contain relatively fresh cores. Well-developed alteration halos defined by thin dark green rims and gray green outer rims composed of a trace of amphibole, with serpentine, spinel and brucite. White anastomosing serpentine veinlets commonly wrap around and enclose porphyroclasts. Clinopyroxene is commonly pervasively altered (85%–100%) to chlorite, amphibole, and clay minerals(?). Clinopyroxene is pervasively altered to rare dark pods, replaced by serpentine and clay minerals.
Veins
1) Anastomosing fine white serpentine veinlets parallel to fabric are common.
2) <1 mm wide dark serpentine vein cuts fabric defined by elongate pyroxene at high angle.
VEIN/FRACTURE FILLING:
Anastomosing white serpentine.
ADDITIONAL COMMENTS: Structure
A strong elongated porphyroclastic texture is defined by the shape preferred orientation of orthopyroxene porphyroclasts. A strong anastomosing foliation wraps around the porphyroclasts, defined by a dense meshwork of green/black serpentine veins (<1 mm). Thin white serpentine veins overprint the trace of the anastomosing foliation and are strongly deflected around porphyroclasts. The porphyroclastic fabric and the anastomosing foliation dip at 50°. Elliptical ratios of porphyroclasts on cut face attain values of up to 1:3.

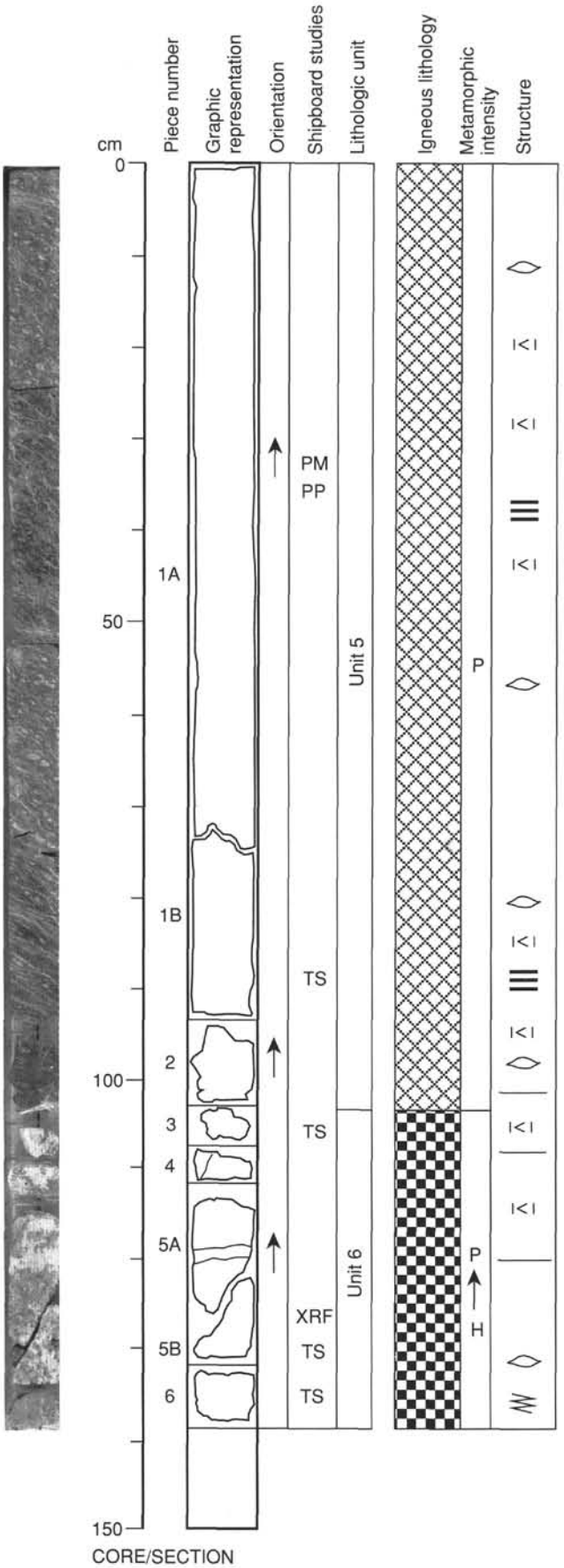
153-920B-13R-2



UNIT 5: SERPENTINIZED HARZBURGITE AND LHERZOLITE

Pieces 1–7

COLOR: Green/black.
PRIMARY STRUCTURE: Elongate porphyroclastic.
SECONDARY STRUCTURE: Strong–moderate anastomosing fabric, emphasized by thin white discontinuous serpentine veins.
PRIMARY MINERALOGY:
Olivine - Mode: 69%–73%.
Orthopyroxene - Mode: 25%–27%.
Crystal Size: 2–22 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 1%–3%.
Crystal Size: 1–4 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Porphyroclastic serpentinized harzburgite to lherzolite with 25%–30% total pyroxene content. Primary olivine is preserved within serpentine mesh structures, and primary orthopyroxene is preserved in some cores of porphyroclasts. Clinopyroxene is significantly altered at the top of the section but is significantly fresher toward the bottom (25% alteration). Spinel is well preserved throughout the core. Alteration texture changes between Pieces 5 and 6. Patches formed by mesh texture replacement of olivine create a speckled appearance toward the bottom. Common thin white serpentine veins are deflected around porphyroclasts, lending a distinctive appearance to the core, as in the two previous sections. There are no magmatic veins in the section.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh, fibrous.
Mode of Occurrence: After orthopyroxene, olivine.
Iron oxide minerals.
Texture: Granular.
Mode of Occurrence: After olivine.
Amphibole.
Mode of Occurrence: After orthopyroxene.
Clay.
Mode of Occurrence: After orthopyroxene, olivine, clinopyroxene.
Comments: Highly to pervasively altered (75%–85%). Pervasive alteration of olivine (85%–90%) to white kernels with green rims, which are enclosed in an olive green to brown mesh serpentine network is common. Elongate orthopyroxene porphyroclasts are generally highly altered, although some contain relatively fresh cores. Alteration halos defined by thin dark green rims and gray green outer rims composed of a trace of amphibole, with serpentine, spinel, and brucite are very well developed in some grains. White anastomosing serpentine veinlets commonly wrap around and enclose porphyroclasts. Clinopyroxene is commonly moderately altered (25%–40%) to amphibole and clay minerals(?).
VEIN/FRACTURE FILLING:
White thin serpentine.
Orientation: Parallel to fabric.
Dark serpentine.
Size: <1 mm.
Orientation: High angle to fabric.
ADDITIONAL COMMENTS: Structure
A moderate-strong, elongated porphyroclastic fabric is defined by a shape preferred orientation of orthopyroxene porphyroclasts. A moderate to strong anastomosing fabric, overprinted by thin white discontinuous serpentine veins overprints the porphyroclastic texture. The anastomosing fabric becomes more planar in upper five pieces where less orthopyroxene is present. Both the porphyroclast foliation and the anastomosing foliation dip at about 40° to 50°. Some orthopyroxene porphyroclasts have fractures perpendicular to elongation that are filled with serpentine.



153-920B-13R-3

UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1A–2

COLOR: Green/black.
PRIMARY STRUCTURE: Elongate porphyroclastic.
SECONDARY STRUCTURE: Moderately intense anastomosing fabric emphasized by white discontinuous veins.
PRIMARY MINERALOGY:
Olivine - Mode: 72%–85%.
Orthopyroxene - Mode: 12%–21%.
Crystal Size: 4–28 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 1%–3%.
Crystal Size: 1–4 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Porphyroclastic serpentinized harzburgite. There is a progression from high pyroxene content (20%–25%) in Pieces 1A and 1B to more depleted in pyroxene contents in Pieces 1C and 1D (15%–20%). Piece 2 is a highly depleted harzburgite (10%–15% pyroxene) with an altered gabbroic vein near its base. Primary olivine is preserved within serpentine mesh structures, and primary orthopyroxene is preserved in some cores of porphyroclasts. Clinopyroxene alteration is variable, ranging from 90% at the top to ≈50% at the bottom. Spinel is well preserved throughout the core and occurs in rounded clusters rather rather than strung out parallel to folation. Piece 2 is the last ultramafic piece in Hole 920B and is underlain by an oxide gabbro (Pieces 3–5).The progressive depletion of the harzburgite in pyroxene content as the contact with the underlying gabbro is approached is similar to the progessive depletions observed at the edges of smaller pyroxenitic and gabbroic veins in several previous sections of the core.
SECONDARY MINERALOGY:
Serpentine.
Mode of Occurrence: After olivine, orthopyroxene, clinopyroxene.
Brucite.
Mode of Occurrence: After olivine, orthopyroxene.
Amphibole(?).
Mode of Occurrence: After orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Pyrite.
Mode of Occurrence: After clinopyroxene.
Comments: Highly to pervasively altered (75%–90%), increasing in intensity downsection. Pervasive alteration of olivine (85%–90%) to white kernels with green rims, which are enclosed in an olive green to brown mesh serpentine network is common. Elongate orthopyroxene porphyroclasts are generally highly altered, although rare grains contain relatively fresh cores. Alteration halos defined by thin dark green rims and gray green outer rims composed of a trace of amphibole, with serpentine, spinel, and brucite are very well developed in some grains. White anastomosing serpentine veinlets commonly wrap around and enclose porphyroclasts. Small dark patches of chlorite and amphibole after clinopyroxene(?) are present. These patches are associated with disseminated pyrite. Some clinopyroxene grains have recrystallized into small elogate aggregates, now pervasively altered.
VEIN/FRACTURE FILLING:
Serpentine.
Orientation: Parallel to fabric.
Calcite, serpentine, and talc.
Comments: At sheared zone contact with serpentinized harzburgite.
ADDITIONAL COMMENTS: STRUCTURE
The shape preferred orientation of orthopyroxene porphyroclasts defines a moderately strong foliation. This is overprinted by a strong anastomosing foliation which, in turn, is overprinted by white, wispy serpentine veins.
The bottom of Piece 2 contains a serpentine shear zone filled later by serpentine and carbonate. Veins are truncated against the top edge of the shear zone but their offset cannot be determined.

153-920B-13R-3

UNIT 6: OXIDE GABBRO

Pieces 3–6

COLOR: Gray/brown/white.
PRIMARY STRUCTURE: Magmatic.
SECONDARY STRUCTURE: Coarse-grained quartz veins with vugs cut gabbro. Local development of shear zones.
PRIMARY MINERALOGY:
Plagioclase - Mode: 40%–67%.
Crystal Size: 3–15 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 37%–55%.
Crystal Size: 2–20 mm.
Crystal Shape: Anhedral.
Iron oxide minerals - Mode: 3%–5%.
Crystal Shape: Anhedral.
Comments: Piece 3 begins a 34 cm long section of iron oxide-rich gabbro (Pieces 3–6). The upper contact with the serpentinzed harzburgite is not sampled, but the bottom piece is porphyroclastic to mylonitic (Piece 6) and is interpreted as evidence for a sheared lower contact for this unit. The gabbro is highly variable in texture and grain size, being pegmatitic at the bottom of Piece 5 and finer grained in Pieces 3 and 4 and the top of Piece 5. Piece 5 also shows an apparent igneous contact between these two different grain sizes; the boundary is accentuated by the presence of amphibole. Piece 5 also contains a vuggy prehnite vein which crosscuts the sample at a high angle to the apparent magmatic contact. Clinopyroxene is rimmed by amphibole, particularly near the prehnite vein. The mineralogy consists of plagioclase, clinopyroxene, and iron oxide and sulfide minerals. The texture is magmatic (except in Piece 6) and varies from intergranular to subophitic relationships between plagioclase and clinopyroxene with clinopyroxene as the space-filling phase. Piece 6 has the same mineralogy as the succeeding pieces, but is now a highly deformed porphyroclastic-textured gabbroic gneiss with strongly recrystallized plagioclase (fine-grained) surrounding large highly strained porphyroclasts of plagioclase and clinopyroxene. The piece contains abundant oxide minerals as do the pieces above suggesting that the protolith was the same as the undeformed gabbro above.
SECONDARY MINERALOGY:
Amphibole.
Mode of Occurrence: After pyroxene.
Chlorite.
Mode of Occurrence: After pyroxene.
Secondary plagioclase(?).
Mode of Occurrence: After plagioclase.
Hydrogarnet.
Mode of Occurrence: After plagioclase.
Serpentine + talc.
Texture: Pseudomorphic.
Mode of Occurrence: After olivine.
Comments: Piece 6 is a mylonite with an oxide gabbro protolith, as defined by elongate augen of highly deformed, coarse-grained plagioclase porphyroclasts, rounded aggregates and isolated grains of amphibolitized clinopyroxene and orthopyroxene, abundant primary oxide minerals, and apatite and zircon as accessory phases. Alteration in the mylonite sample is heterogeneous ranging from 60% to 100%, and includes secondary minerals of clinopyroxene, olive green to pale green amphibole ± chlorite, and magnetite, with trace blebs of brown amphibole as inclusions after clinopyroxene. Orthopyroxene is altered to colorless, to pale green amphibole, which forms concentrated pods and fine narrow rims around grain boundaries. Plagioclase augen exhibit undulose and patchy extinction, sutured grain boundaries, and extensive subgrain development. They are commonly rimmed by anastomosing ilmenite-rich stringers. Plagioclase subgrain development has proceeded in at least two stages as evidenced by medium-grained, recrystallized plagioclase in aggregates of clinopyroxene, plagioclase, and apatite that are enclosed in a matrix of fine to very fine-grained, neoblastic plagioclase. The mylonite is dominated by secondary mineral assemblages formed under greenschist facies conditions.
VEIN/FRACTURE FILLING:
Prehnite.
Size: 1–15 mm.
Orientation: Cutting gabbro.

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Calcite and serpentine.
Comments: At sheared zone contact with harzburgite.
ADDITIONAL COMMENTS: Contact relationships (Units 5 and 6).
The contact between harzburgite above and oxide gabbro is not exposed, but is placed between Pieces 2 and 3. The gabbroic intrusive vein at the base of Unit 5 may indicate that the contact is intrusive (gabbro into harzburgite). Above the contact, the progressive depletion of the harzburgite in pyroxene as a gabbroic contact is approached has been observed several times in the preceeding sections at well-preserved intrusive contacts, again possibly indicating an intrusive relationship between gabbro and the the overlying harzburgite.
Structure
A weakly deformed metagabbro in lower half of section is cut by coarse-grained veins with vugs. Piece 6 contains a shear zone, represented by porphyroclastic mylonite. This mylonite contains porphyroclasts of plagioclase and clinopyroxene and is thought to have been derived from the gabbro.

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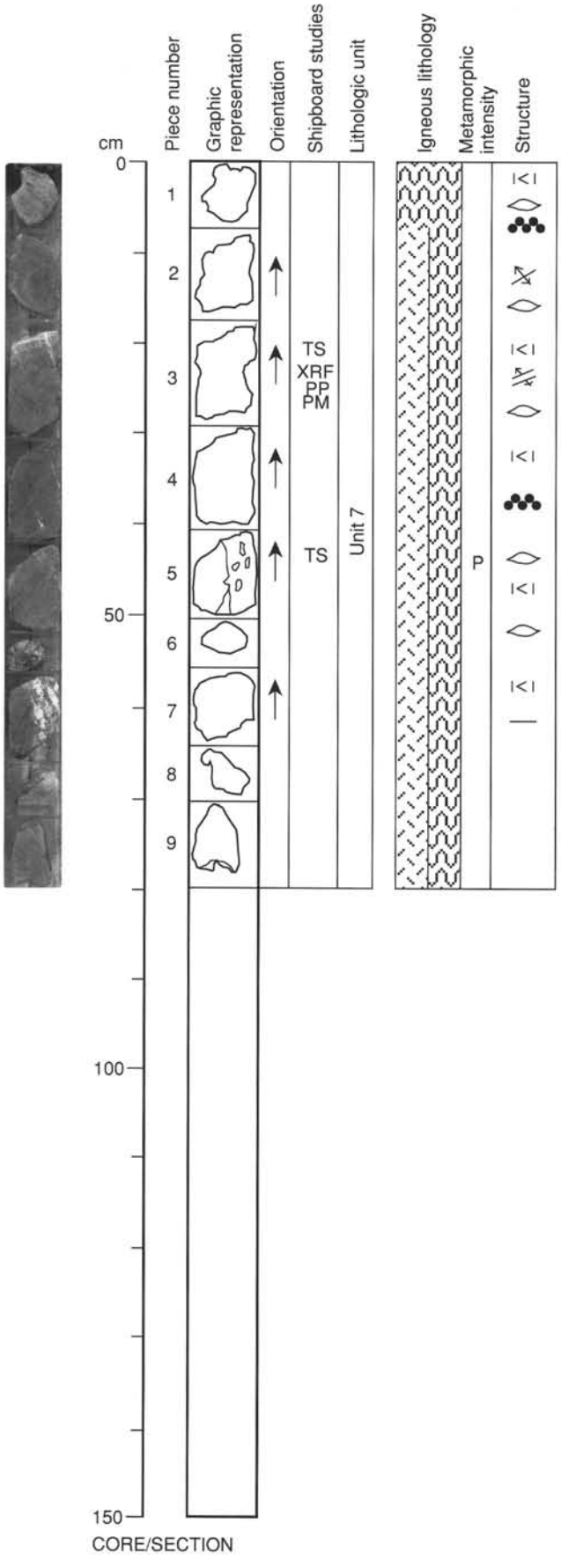

UNIT 7: GNEISSIC AMPHIBOLITE WITH GNEISSIC GABBRO

Pieces 1–9

COLOR: Green black.
PRIMARY STRUCTURE: Gneissic.
SECONDARY STRUCTURE: Late quartz veins cut boundary between amphibolite and gabbro.
PRIMARY MINERALOGY:
Plagioclase - Mode: 45%–60%.
Crystal Size: 2–30 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 30%–35%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 10%.
Crystal Size: 1–6 mm.
Crystal Shape: Anhedral.
Comments: Piece 1, a fine-grained gneissic amphibolite is a mixture of hornblende, clinopyroxene, olivine, and plagioclase with minor opaque oxide minerals, suggesting uppermost amphibolite facies. There is minor retrograde actinolitic alteration of brown amphibole along rare veins. A strong linear fabric is defined by amphibole in the plane of foliation (LS Fabric). The foliation is described by a fine layering between recrystallized mafic aggregates and felsic aggregates. The rock has been labeled a gneiss because of this layering and because the rock is characterized by a high-temperature dynamically recrystallized texture, although the grain size is not coarse. Grain size varies across the pieces from medium to fine. Quartz veins 2 mm and 8 mm in width cut one end of the sample. Pieces 2–9 are fine-grained gneissic amphibolite in near-vertical contact with coarse-grained gneissic (porphyroclastic textured) gabbro on the back side of the core. The fine-grained gabbro appears similar to the coarse-grained gabbro in the pieces below (Pieces 5, 7, 8, and 9). A contact is exposed in Piece 5 on the front cut face of the core. The gneissic gabbro is characterized by highly strained porphyroclasts of plagioclase with recrystallized plagioclase and clinopyroxene neoblasts. In the amphibolite, there is a strong lineation and foliation defined by the preferred orientation of brown hornblende, olivine, and pyroxene or their recrystallized aggregates. The foliations in both are parallel and the contact is marked by a oxide mineral-rich zone a few mm wide that is subparallel to the foliation. This oxide-rich zone marks a contact between hyrdrous mineralogies and largely anhydrous mineralogies. The plagioclase in the gneissic gabbro is recrystallized to the same grain size as in the amphibolite and shows marked grain-size reduction from the original porphyroclastic grain sizes. The plagioclase porphroclasts are highly elongate. As in previous samples actinolite partially replaces the rims of pyroxene along veins. Piece 3 is cut by a branching 0.2 mm wide quartz vein which cuts a 3 mm wide lens of plagioclase, and a subparallel 1 mm wide diffuse vein of amphibole. In this zone, grain size is generally coarser than in the rest of the sample.
SECONDARY MINERALOGY:
Actinolite.
Mode of Occurrence: After hornblende + plagioclase.
Chlorite.
Mode of Occurrence: After hornblende + plagioclase.
Comments: Pieces 1–5 and 8–9 are amphibolite gneiss with well-developed neoblastic brown amphibole after clinopyroxene, which form fine-grained, mm-wide anastomosing and discontinuous bands. The bands contain porphyroclasts of medium- to fine-grained strained olivine, clinopyroxene with inclusions of brown amphibole, and magnetite stringers. They are bounded by segregations and layers of neoblastic plagioclase, which is fine- to medium-grained equigranular, and commonly exhibits a mosaic texture. The alternating bands define a moderately developed foliation and a well-developed lineation. The association of olivine, clinopyroxene, and brown amphibole, in near textural equilibrium with plagioclase, indicates formation at temperatures of ≈ 600°–800°C under low pressure conditions. Subsequent interaction with lower temperature fluids in these rocks was rare, as alteration phases indicating retrograde reactions are absent. The amphibolite gneiss is in contact with a porphyroclastic gabbro gneiss (exposed in Piece 5), which exhibits minor to moderate retrograde alteration under greenschist facies conditions. The contact is subparallel to the foliation both in the porphyroclastic gneiss and amphibolite and is defined by a narrow, magnetite-ilmenite-rich ribbon. Extensive recrystallization of

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minerals along this zone indicates that deformation along the contact occurred at elevated temperatures of 700°–800°C.

VEIN/FRACTURE FILLING:

Prehnite.

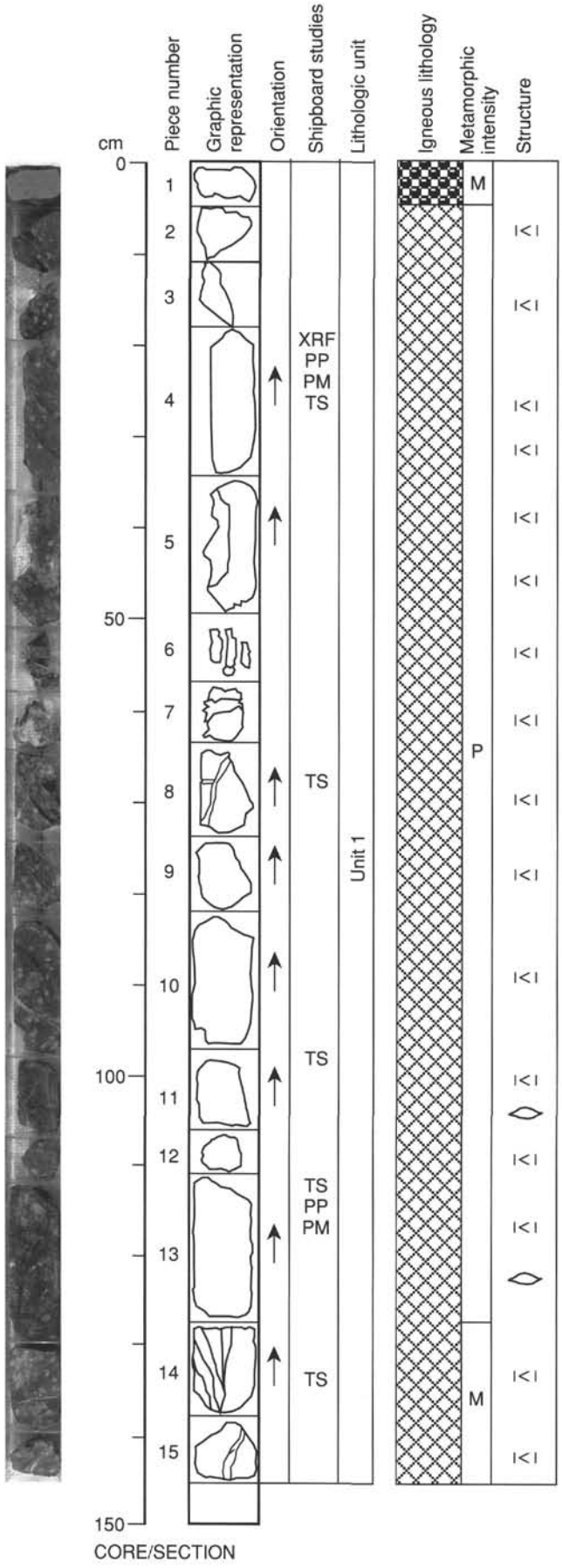
Size: 2 mm.

ADDITIONAL COMMENTS: Contact between Unit 6 and 7

The contact is not exposed. However, there would appear to be a marked structural discordance between undeformed gabbro of Unit 6 and highly deformed amphibolite and gabbro of Unit 7. The base of Unit 6 is also marked by a strongly deformed gneissic gabbro lending support to a tectonic contact between the two units.

STRUCTURE

A strong L-S fabric in the amphibolite gneiss has steeply plunging lineation (70°–80°) throughout the section. A very weak foliation in the gneiss is subparallel to the boundary with the gneissic gabbro that contains plagioclase augen (Pieces 2–4). The boundary is cut by a prehnite vein in Piece 3. A gradational boundary to an amphibole vein perpendicular to the contact and lineation reflects a grain-size variation (Piece 3). Thin, deformed prehnite veins lie parallel to lineation. A steeply dipping contact with gabbroic gneiss may represent original intrusive contact but it is now strongly tectonized with minor cracks overprinting the gneissic fabrics (Piece 5).



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UNIT 0: SPARSELY PORPHYRITIC BASALT

Piece 1

CONTACTS: None observed.
PHENOCRYSTS:
Plagioclase - 1%; 2–3 mm; Anhedral.
GROUNDMASS: Fine-grained, composed of olivine and plagioclase, probably includes clinopyroxene as well.
VESICLES: 1 % Size: <0.5 mm. Shape: Irregular.
Distribution: Even.
COLOR: Gray.
ALTERATION: *Alteration intesity is difficult to estimate in this sample due to the fine-*grain size, but is likely 15%–20% and includes secondary plagioclase, clay, smectite(?), amphibole, and chlorite replacing clinopyroxene.

UNIT 1: SERPENTINIZED HARZBURGITE

Pieces 2–15

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Veins and shear zones.
PRIMARY MINERALOGY:
Olivine. - Mode: 60%–85%.
Crystal Shape: Anhedral.
Orthopyroxene. - Mode: 10%–27%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 1%-2%.
Crystal Size: 1–2 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%–2%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: The section consists predominantly of serpentinized porphyroclastic harzburgite with about 85% olivine, 15% orthopyroxene and 1%–2% clinopyroxene. Most pieces are crosscut by at least two types of veins; one type is igneous and the other is hydrothermal in origin. The first type appears to "stream" through the rock in a subvertical orientation and are either highly altered gabbroic or pyroxenitic in composition. Subhedral to euhedral terminations to pyroxene crystals can be observed associated with these veins in Pieces 13 and 14. Pyroxenitic veins were observed in Pieces 7, 8, 13, and 14. The altered gabbroic veins are in Pieces 5, 11, and 15 and are crosscut by a later set of pale green chrysotile serpentine veins. Most pieces in the section contain sulfide minerals (<1%), and Piece 11, which is an oxide pyroxenite/gabbro, contains approximately 17% iron oxide minerals and 13% sulfide minerals. This may also represent an igneous vein, but contacts were not observed. Based on the fact that Piece 2 has rim of carbonate-cemented sediment including clasts of serpentine and olivine, basalt in Piece 1 may have been rubble within a pelagic carbonate matrix just above peridotite basement. *Pieces 2, 3, 4,10, and 12, are highly depleted harzburgite with* <15% pyroxene. Pieces 7, 8, 9, and 13 are a typical depleted harzburgite with 15%–20% pyroxene. Pieces 14 and 15 are pyroxene-rich harzburgite with 24–27% pyroxene. The most depleted regions of the core are associated with high densities of magmatic veins.
SECONDARY MINERALOGY:
Pyrite.
Clay minerals.
Mode of Occurrence: Replacing orthopyroxene, olivine.
Talc.
Total Percent: Trace
Mode of Occurrence: Replacing olivine.
Serpentine.
Texture: Mesh.
Mode of Occurrence: Replacing orthopyroxene, olivine.
Amphibole.
Total Percent: Trace.
Mode of Occurrence: Replacing orthopyroxene.
Comments: Alteration of the harburgite is heterogeneous throughout the section but is dominated by formation of serpentine after olivine and orthopyroxene.

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Although total alteration is about 80%, pyroxene is fresh in some pieces (orthopyroxene less than 25% altered). Olivine minerals are commonly altered 90%–100%, although local pods containing clear kernels enclosed in mesh serpentine are present in some samples. Microveinlets of serpentine and iron oxide minerals are common. Clinopyroxene is altered 50% to 100% to serpentine, clay minerals, and a trace of pyrite. Amphibole after clinopyroxene is abundant in Piece 11. Pervasively altered grains form dark green-black patches enclosed by serpentine. Orthopyroxene is altered 50% to 100%, with apple green cores rimmed by poorly developed alteration halos of serpentine. Alteration of the gabbro and clinopyroxenite veins and pods, which are abundant throughout the section, is pervasive with amphibole, chlorite, and pyrite after pyroxene common. Plagioclase is altered to prehnite(?). These veins, which reach up to 2 cm in width, commonly contain fine offshooting veinlets which have thin alteration halos of amphibole, chlorite ± serpentine (Pieces 5, 7, 8, 9, 10, and 15). The veins and pods are cut by 1–2 mm wide aqua-green colored serpentine veinlets.

Veins

Aqua blue green serpentine ± pyrite veins (1–2 mm in width), commonly rimmed by dark green serpentine ± chlorite(?) form one of the latest veining events. In some samples these veins are cut by fine wispy white serpentine veinlets.

Dark green serpentine ± amphibole ± chlorite(?) veinlets crosscut gabbro and clinopyroxenite veins in some samples.

VEIN/FRACTURE FILLING:

Abundant gabbro-pyroxenite veins and veinlets.

Aqua blue serpentine.

Size: 2 mm.

Orientation: See comments.

White serpentine.

Size: 1 mm.

Dark green serpentine and sulfide minerals.

Size: 2–3 mm.

ADDITIONAL COMMENTS: Structure

The serpentinized harzburgite has a coarse porphyroclastic texture with localized zones of elongated porphyroclasts. The foliation has a moderate to shallow dip. Several pyroxenite and gabbroic veins are oriented discordantly to the foliation and many are steeply dipping (Pieces 5, 7, 8, 11, 13, 14, and 15, see igneous section). Grain-size reduction and a strong, localized preferred alignment occur in Pieces 13 and 15 and resemble mylonitic shear zones. Piece 8 also contains a similar zone that is cut by a pyroxenite vein. Dark green serpentine veins cut some of the gabbroic and pyroxenite veins. Piece 11 comprises a recrystallized, foliated oxide-gabbro. In Piece 4, a dark green serpentine vein is cut by thin white serpentine veins. The white serpentine veins are cut by light green serpentine veins (1–2 mm).

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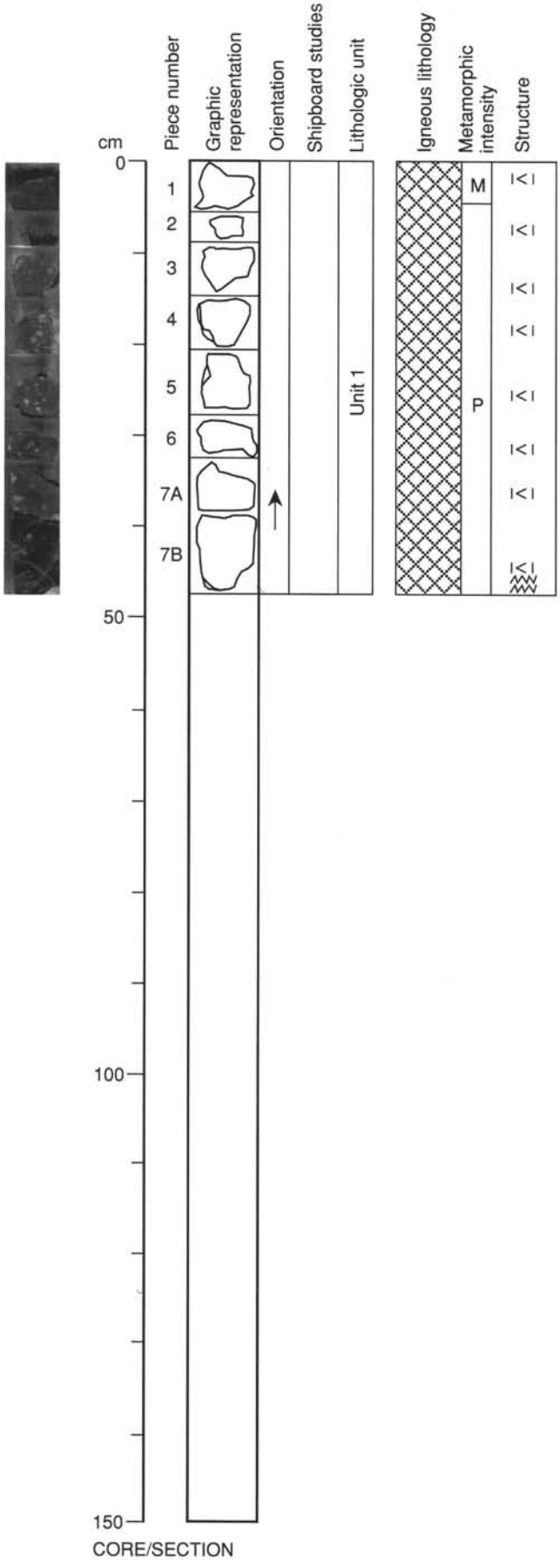
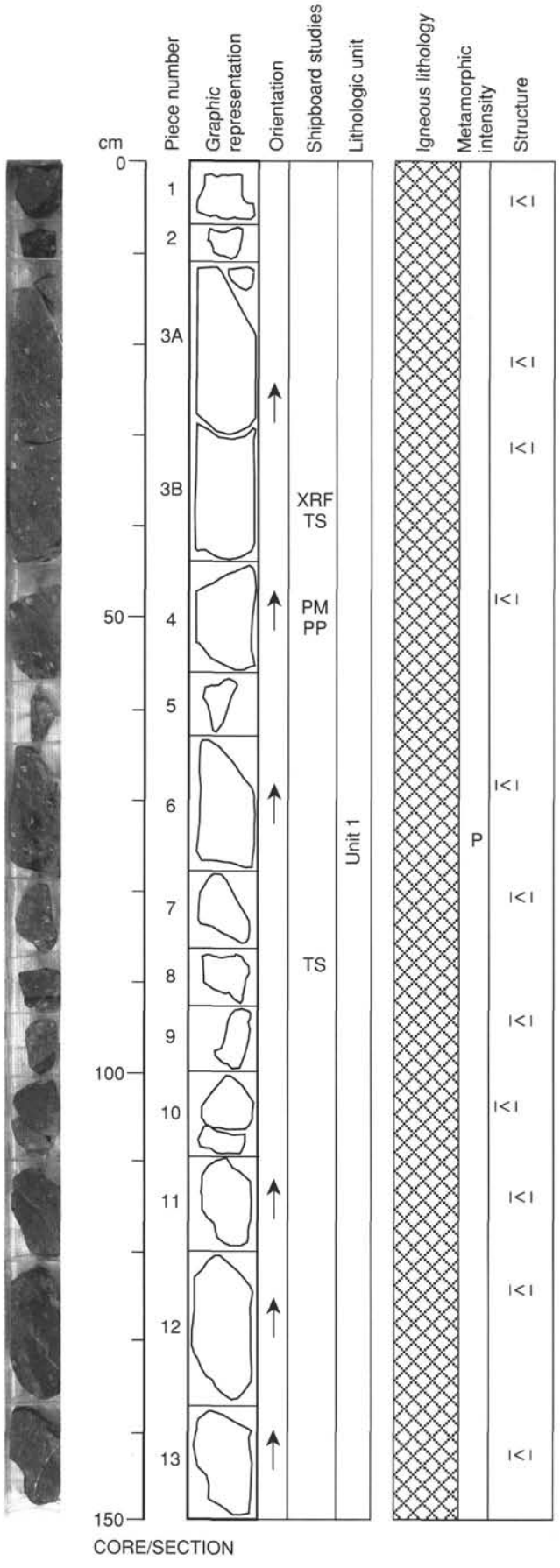


UNIT 1: SERPENTINIZED HARZBURGITE

Pieces 1–7B

COLOR: Black-gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Veins; shear zone in the bottom of Piece 7.
PRIMARY MINERALOGY:
Olivine - Mode: 86%.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 13%.
Crystal Size: 2–30 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: <1%.
Crystal Size: 3–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Shape: Anhedral.
Comments: Serpentinized black-gray porphyroclastic harzburgite. Pieces 2, 4, 5, 6, and 7 are highly depleted pyroxene-poor (10%–16%) harzburgite. Pieces 1 and 3 are pyroxene-bearing dunite. Relict primary olivine and orthopyroxene are present in small abundances in most samples (except Piece 7). Large spinel grains and clots are present in some samples (Pieces 1, 3, and 7). Clinopyroxene is generally present in small quantities throughout the section. Disseminated sulfide minerals and composite veins of serpentine and sulfide minerals are present in the section (e.g., Piece 7). Orthopyroxene or its pseudomorphs are strongly kinked in Pieces 3, 4, and 7. There are no magmatic veins in the section.
SECONDARY MINERALOGY:
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene, clinopyroxene.
Serpentine.
Texture: Mesh
Mode of Occurrence: After olivine, orthopyroxene, clinopyroxene.
Pyrite.
Mode of Occurrence: After clinopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Comments: This section is highly to pervasively altered with total alteration ranging from 65%–98%. Alteration is dominated by olivine alteration to serpentine (70%–95%), forming a dark brown-black mesh with microveinlets of iron oxide minerals. Orthopyroxene is replaced by bastite (60%–85%) and exhibits thin, moderately developed coronas of dark green serpentine. Rare clinopyroxene is overprinted by serpentine (50%), forming small dark patches associated with trace pyrite. Several pieces are cut by <1–2 mm wide, aqua-colored tapering serpentine veinlets, and dark green microveinlets of serpentine (Pieces 1, 2, 3, 4, and 7B).
VEIN/FRACTURE FILLING:
Aqua blue serpentine veins.
Size: 2 mm.
Orientation: See comments.
White serpentine veins.
Size: 0.5 mm.
Dark green serpentine veins.
Size: 2 mm.
ADDITIONAL COMMENTS: Structure
This section displays a porphyroclastic texture with no anastomosing foliation, minor porphyroclast elongation, and very sparse distribution of wispy white serpentine veins (Pieces 2–6). Orthopyroxene or its pseudomorphs are strongly kinked in Pieces 3, 4, and 7. Pieces 1 and 7 display an intense foliation and a strong attenuation of porphyroclasts. A shear zone in Piece 7 truncates and deflects the porphyroclasts along its margin in the center of the piece. In Pieces 1, 2, and 4 dark green serpentine veins (1–3 mm) are cut by thin white serpentine veins. In Piece 3, a light green serpentine vein cuts a dark green serpentine vein.



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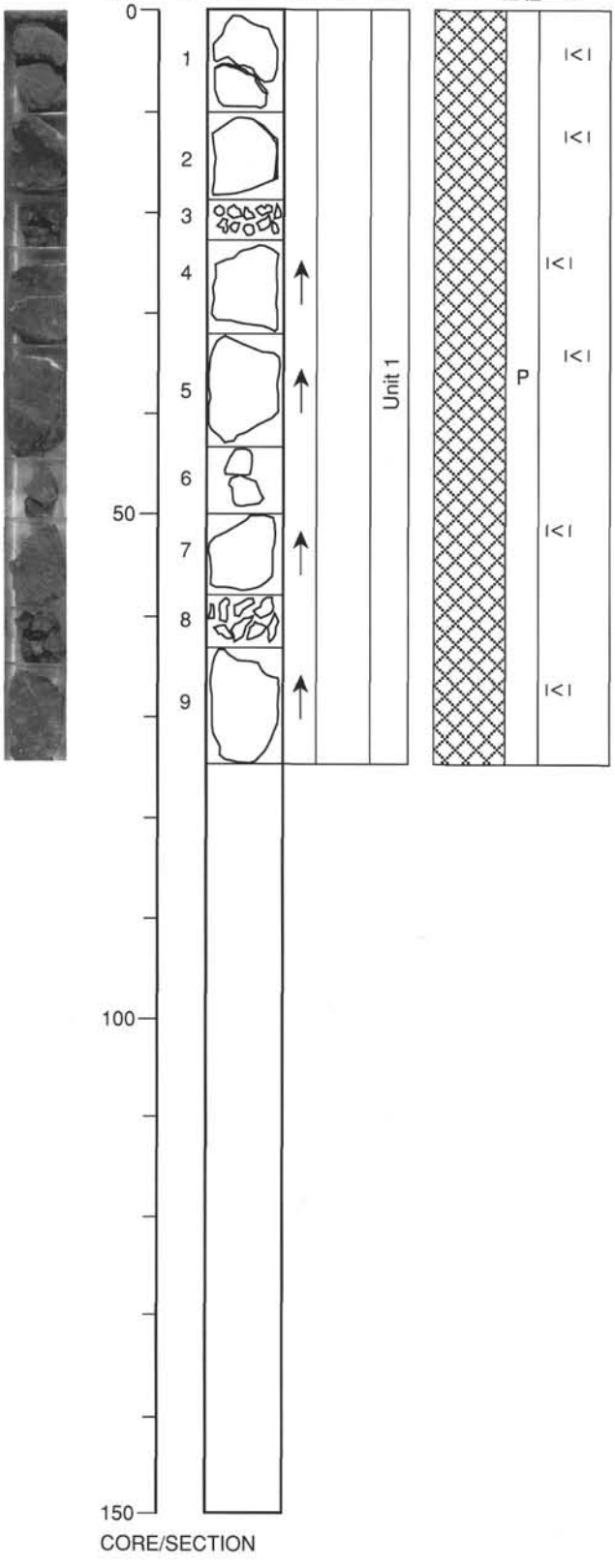
UNIT 1: SERPENTINIZED HARZBURGITE

Pieces 1–13

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE:
PRIMARY MINERALOGY:
Clinopyroxene. - Mode: <2%.
Crystal Size: 1–4 mm.
Crystal Shape: Anhedral.
Orthopyroxene. - Mode: 12%–20%.
Crystal Size: 2–10 mm.
Crystal Shape: Anhedral.
Olivine. - Mode: 79%–85%.
Spinel. - Mode: 1%–2%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: The section consists of very highly altered, green-black, porphyroclastic serpentinized harzburgite. Sulfide minerals, disseminated and in veins, are common. These sulfide mineralized veins are generally filled with pyrite, and often are somewhat oxidized. Sulfide minerals also appear to be associated with bright orange hematite as a consequence of oxidation (e.g. Piece 8). All samples appear to be depleted in pyroxene. In general, olivine and orthopyroxene are completely altered with only minor spinel preserved. Piece 2 contains a thin clinopyroxenite vein. Piece 7 contains a 1 mm thick gabbroic vein. Piece 8 contains a 2 mm wide vein of little altered clinopyroxenite and a white mineral (possibly altered plagioclase), with chlorite and hematite, which is possibly magmatic in origin. Piece 1 is a pyroxene-bearing dunite. Piece 2 is a typical depleted harzburgite (≈21% pyroxene). Pieces 2–13 are harzburgite more highly depleted in pyroxene (<15% on average).
SECONDARY MINERALOGY:
Clay minerals.
Mode of Occurrence: After orthopyroxene, olivine, clinopyroxene.
Serpentine.
Texture: Mesh.
Mode of Occurrence: After orthopyroxene, olivine, clinopyroxene.
Pyrite.
Mode of Occurrence: After clinopyroxene.
Hematite.
Mode of Occurrence: After pyrite.
Comments: Alteration is pervasive in this section with total alteration reaching 100% in many samples. Alteration is heterogeneous in some samples, with localized zones containing clear islands of olivine kernels. Olivine is pervasively altered to mesh serpentine, kernels of white serpentine, clay minerals, and abundant serpentine and iron oxide minerals, microveinlets (85%). Mottled olive-green serpentine forms cores of pseudomorphed orthopyroxene; dark serpentine cores are rimmed by pale green serpentine. Iron oxide minerals replacing the exsolution lamellae in orthopyroxene are common. Elongate aggregates of dark green serpentine associated with pyrite may be pseudomorphs after clinopyroxene.
Veins
2 mm wide, pervasively altered gabbroic veinlets cut Piece 8. Alteration minerals include prehnite(?) after plagioclase, amphibole and chlorite(?) after pyroxene, and hematite after pyrite. Carbonate minerals, and pyrite and hematite coat the backsides of some samples. Wispy, anastomosing thin white serpentine veinlets wrapping around altered porphyroclasts of orthopyroxene are moderately common throughout the section.
VEIN/FRACTURE FILLING:
Carbonate minerals, pyrite, hematite, amphibole, and prehnite.
Size: 2 mm.
Comments: After gabbroic vein material, crosscutting harzburgite.
Wispy white anastomosing serpentine veinlets.
ADDITIONAL COMMENTS: Structure
A weak to moderate elongation of pyroxene porphyroclasts forms the dominant foliation in this section. This foliation is overprinted by a weak anastomosing foliation formed by branching arrays of dark green-black serpentine veins. Both fabrics generally have a low to moderate dip, but in Piece 12, the anastomosing foliation is perpendicular to the preferred orientation of orthopyroxene elongation. At the base of Pieces 1, 4, 5, 6, and 7, the pyroxene fabric intensifies. In Piece 8, a 2 mm wide gabbroic veinlet is oreinted parallel to the orthopyroxene elongation direction.



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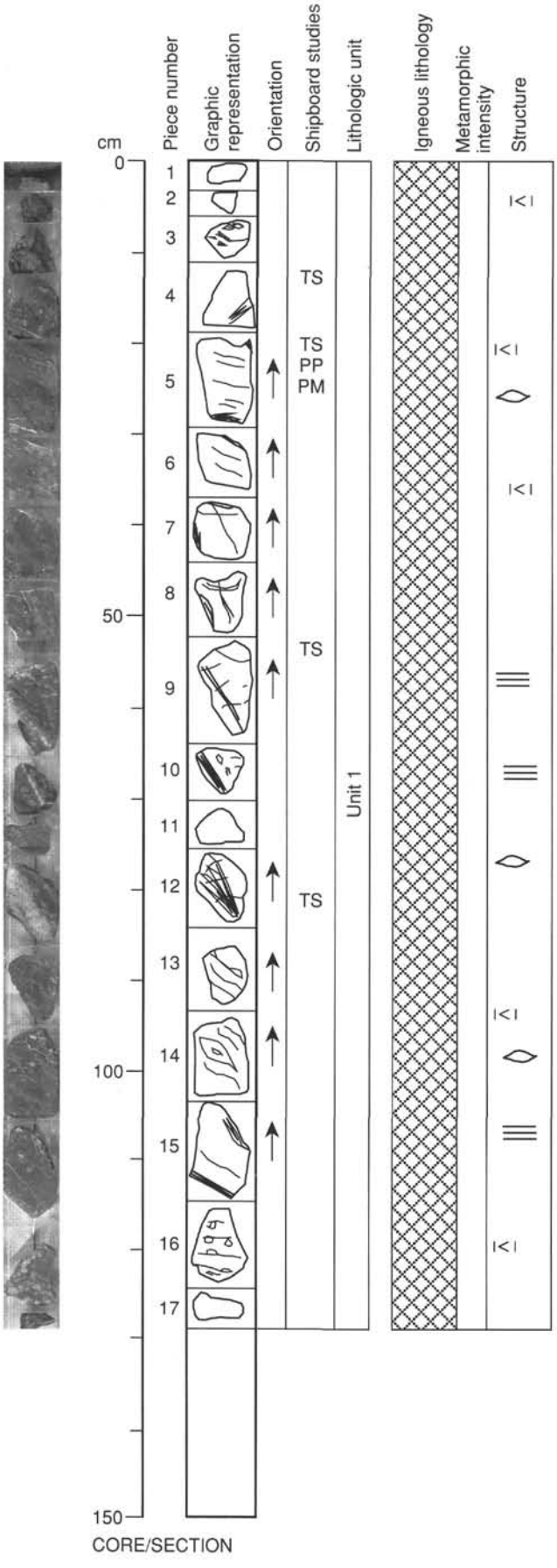
UNIT 1: SERPENTINIZED HARZBURGITE

Pieces 1–9

COLOR: Green to dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE:
PRIMARY MINERALOGY:
Olivine. - Mode: 80%–85%.
Orthopyroxene. - Mode: 14%–19%.
Crystal Size: 3–10 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Shape: Anhedral.
Comments: The section consists of very highly altered, green-black, porphyroclastic serpentinized harzburgite, riddled with composite asbestiform white serpentine and sulfide mineral veins, as well as veins comprised of only sulfide minerals. These sulfide mineral veins are generally filled with pyrite, and often are somewhat oxidized. The sulfide mineral veins resemble stockwork veins and are pervasive throughout most samples, with very high vein densities in some samples (e.g., Pieces 1, 2, and 5). Sulfide minerals also appear to be associated with bright orange hematite as a consequence of oxidation. Estimates of the primary mineralogy are difficult, but except for Piece 9, all samples appear to be very depleted in pyroxene. Pieces 1 and 3 are highly depleted harzburgite (11%–13% pyroxene), Pieces 2, 3, 5, 6, 7, and 8 are less depleted (≈15% pyroxene). Piece 9 is more enriched with ≈20% pyroxene. In general, olivine and orthopyroxene are completely altered with only minor spinel preserved.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene, clinopyroxene.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene, clinopyroxene.
Pyrite.
Mode of Occurrence: After clinopyroxene.
Comments: Alteration is pervasive in this section with total alteration reaching 100% in many samples. Olivine is pervasively (100%) altered to mesh serpentine, kernels of white serpentine, and clay minerals, with abundant microveinlets containing iron oxide minerals. Mottled olive green to dark green serpentine and clay minerals pseudomorphs orthopyroxene (65%–100%). Clinopyroxene is pervasively (100%) altered to serpentine and a trace of pyrite. Orthopyroxene has iron oxide minerals replacing the exsolution lamellae.
Veins
Samples are cut by mm wide green serpentine veinlets and composite thin white and black serpentine veinlets, which form small subparallel swarms. Very fine wispy white serpentine veinlets cut the mm wide green serpentine veins. Composite serpentine and pyrite veins and pyrite stringers are abundant (Pieces 1, 4, and 5).
VEIN/FRACTURE FILLING:
Serpentine.
Comments: Occurs as composite white and black, hairline thickness subparallel swarms.
Green serpentine.
Size: 1
Composite serpentine and pyrite.
Pyrite stringers.
Anastomosing white veins.
Comments: Hairline thickness, wrapping around porphyroclasts.
ADDITIONAL COMMENTS: Structure
The serpentinzed harzburgite has a porphyroclastic texture, but pyroxene porphyroclasts show only a weak to nonexistant shape preferred orientation. In Piece 5, there is slight strengthening of the pyroxene fabric. Sparse arrays of thin white; discontinuous serpentine veins (1–2 mm) that overprint the porphyroclasts also form a weak foliation. Both foliations have a low to moderate dip (20°–50°).



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UNIT 1: SERPENTINIZED HARZBURGITE

Pieces 1–17

COLOR: Dark green/black.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Late shear movements related to altered veins.
PRIMARY MINERALOGY:
Orthopyroxene - Mode: 10%–15%.
Crystal Size: 1–18 mm.
Crystal Shape: Anhedral.
Olivine. - Mode: 83%–89%.
Clinopyroxene. - Mode: <2%.
Crystal Size: <5 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: <3%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: The bulk of this section consists of gray-black serpentinized harzburgite, highly depleted in orthopyroxene, harzburgite enriched in pyroxene, and dunite. Orthopyroxene ranges from 10%–15% of the mode in Pieces 1–10 and 13–15. Piece 2 contains dense linear trains of spinel. Piece 3 contains a pyroxene-rich band that is parallel to the foliation. Pieces 6 and 7 are stongly foliated and contain a possible mylonite zone. Piece 9 is cut by an altered gabbroic vein (5 mm thick), a pyroxenite vein (2 mm thick), and two serpentine veins parallel to the margins of the gabbroic vein. Piece 10 is cut by a small altered gabbroic vein. Pieces 11 and 12 are pyroxene-bearing dunite. Piece 12 is cut by a pervasively altered pyroxenitic/gabbro composite vein a few cm in thickness. Piece 13 has low modal pyroxene (≈10%). Pieces 15 and 16 are serpentinized harzburgite more enriched in pyroxene (≈20% modal pyroxene). The section is pervasively altered (95%–100%). Partially altered clinopyroxene and spinel are present in minor amounts (<2%). Primary mineralogy is locally preserved throughout the section. The texture is porphyroclastic with a weak elongation of orthopyroxene porphyroclasts.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 90
Mode of Occurrence: Replacing all phases.
Comments: Alteration is pervasive (95%–97%) with serpentine as the dominant alteration phase. Serpentine mimics the foliation and encloses pyroxene (Piece 4). Serpentine alteration rims are present around the elongated pyroxene porphyroclasts, which only rarely preserve an unaltered core. Olivine is heterogeneously altered with alteration ranging from 50%–100%. Serpentine, magnetite, and clay minerals comprise the dominant alteration assemblage. Piece 9 contains a 7 mm wide composite vein comprised of an inner, dark green serpentine core intergrown with tremolite, chlorite, and prehnite?, which is symmetrically rimmed by a 1 mm wide band of pale green serpentine. The vein protolith may have been gabbroic. The vein is cut by dark green, tapering serpentine veins. A similar set of veins is in Piece 10. Piece 12 is cut by a 5 cm wide Ca-metasomatized gabbroic or pyroxenite vein. From the rim of the vein inward, the vein filling minerals include: 1) radiating aggregates of chlorite, 2) fine serpentine fibers 3) intergrowths of chlorite and serpentine, with abundant tremolite. Wispy white serpentine veinlets are common downsection and form anastomosing arrays wrapping around orthopyroxene porphyroclasts. Piece 15 contains a thin vein of serpentine, zeolites, and carbonate and sulfide minerals which are exposed on a broken surface.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 100%
Orientation: Wispy white veins.
Serpentine, clay minerals, pyrite, ± zeolites.
Comments: Open fractures.
Fibrous serpentine and amphibole.
Size: 5–15 mm.
Comments: Thick veins at various angles to foliation.
ADDITIONAL COMMENTS: Structure
The serpentinized harzburgite displays a moderately developed elongated porphyroclastic fabric at the top of the section (Pieces 1–4). In Pieces 5 and 6, this foliation intensifies. An anastomosing foliation defined by submillimeter green-black serpentine veins overprints the pyroxene-defined foliation and shows similar intensification in Pieces 5 and 6. The

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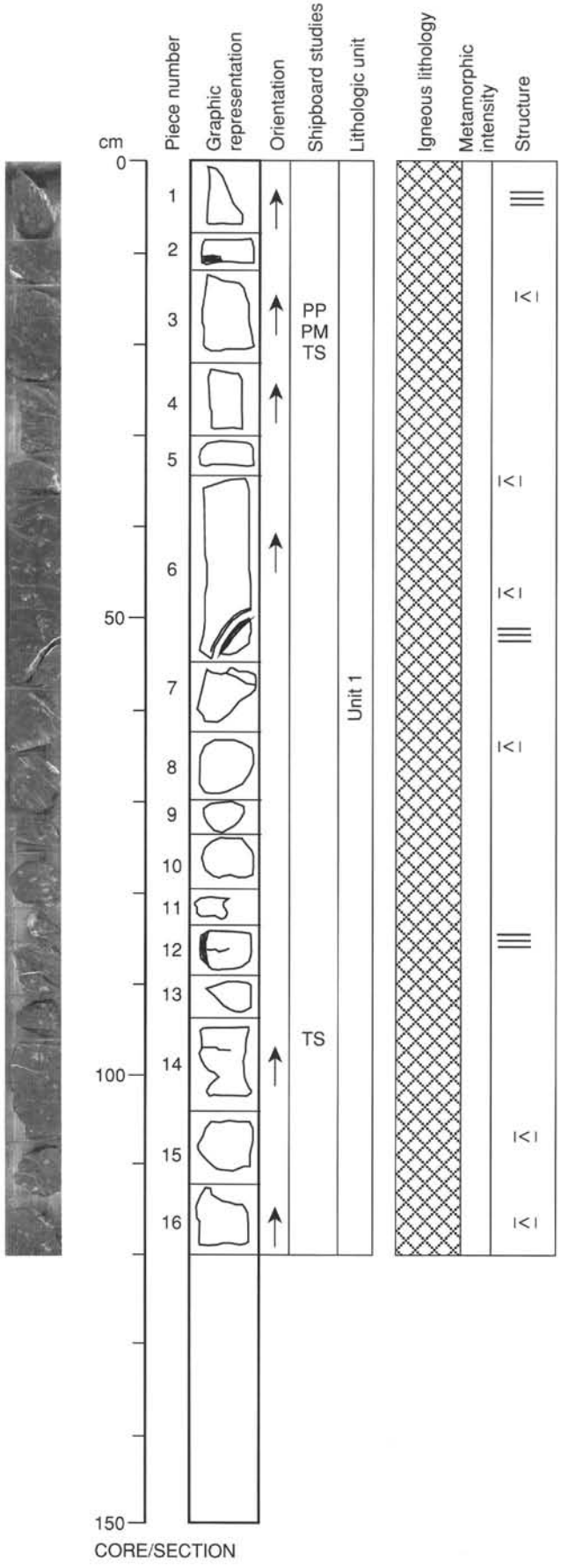
anastomosing foliation is overprinted by thin white serpentine veins. Altered gabbroic veins are found in Pieces 9, 10, and 12. In Piece 12, there is a mylonitic shear zone that has formed on the margin of the altered gabbro dike in Piece 12. Both foliations steepen in this piece (about 65°). Below this piece the pyroxene fabric strengthens relative to the upper part of the section. Pale green serpentine veins cut the anastomosing foliation.



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UNIT 1: SERPENTINIZED HARZBURGITE

Pieces 1–16

COLOR: Dark gray-green.
PRIMARY STRUCTURE: Elongated porphyroclastic.
SECONDARY STRUCTURE: Vein networks.
PRIMARY MINERALOGY:
Olivine. - Mode: 83%–95%.
Orthopyroxene. - Mode: 4%–13%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene. - Mode: <1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: <2%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: This section consists of strongly altered serpentinized porphyroclastic harzburgite and dunite. Orthopyroxene contents range from 4%–18% with most pieces ranging from harzburgite highly depleted in pyroxene to dunite. Pieces 1–2, 5–8, and 10–16 are harzburgite highly depleted in pyroxene; Pieces 3 and 4 are more enriched in pyroxene and Piece 9 is a dunite that contains a small pyroxenite vein. Pieces 4 and 7 contain small highly altered gabbroic veins. Two pieces (14 and 16) are in part dunite. Orthopyroxene porpyroclasts range from from 2–15 mm in size. Clinopyroxene and spinel are minor phases in the section. Serpentine alteration is pervasive (>93%), but all the primary minerals are in part preserved in the section.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 93–100
Mode of Occurrence: Replaces major phases.
Comments: Pieces 1–8 are pervasively serpentinized (95%), with only rare kernels of fresh olivine or orthopyroxene. Fresh kernels are more common in Pieces 9–16 (90% serpentinized). Throughout this section, olivine is 95%–97% altered to a dark colored serpentine and magnetite mesh. Orthopyroxene alteration (70%–95%) produces green bastite. Anastomosing serpentine microveinlets are weakly developed in Pieces 1–5, and almost absent in the rest of the section. Pieces 1, 2, 4, 6–8, 11, 14, and 15 contain later, irregular, 1 mm wide veins of serpentine and carbonate minerals with rare sulfide minerals, some of which are sheared. Pieces 3 and 7 each contain a 2–5 mm wide vein of serpentine and magnetite. Pieces 4, 11, 12, and 15 each contain an amphibole- and chlorite-filled vein (2–5 mm wide), which also contains a white alteration phase (zeolite?).
VEIN/FRACTURE FILLING:
Serpentine, clay minerals, pyrite, and radiating zeolite(?)
Size: 2 mm.
Comments: Open fractures both parallel and at a high angle to foliation.
ADDITIONAL COMMENTS: Structure
A weak elongated porphyroclastic fabric is present, defined by elongated pyroxene grains. In the upper half of the section (Pieces 1 to 6), arrays of thin white serpentine veins overprint a weak anastomosing foliation of dark green serpentine veins. In Piece 14, the anastomosing foliation dips at about 65° and is oriented obliquely to the pyroxene porphyroclast foliation (about 20°). Overall the dips of the foliations are low (40°). Below Piece 7, the arrays of white serpentine veins diminish with pale green serpentine veins cutting them. Some of these green serpentine veins (1 mm wide) have fibers oblique to their margins.

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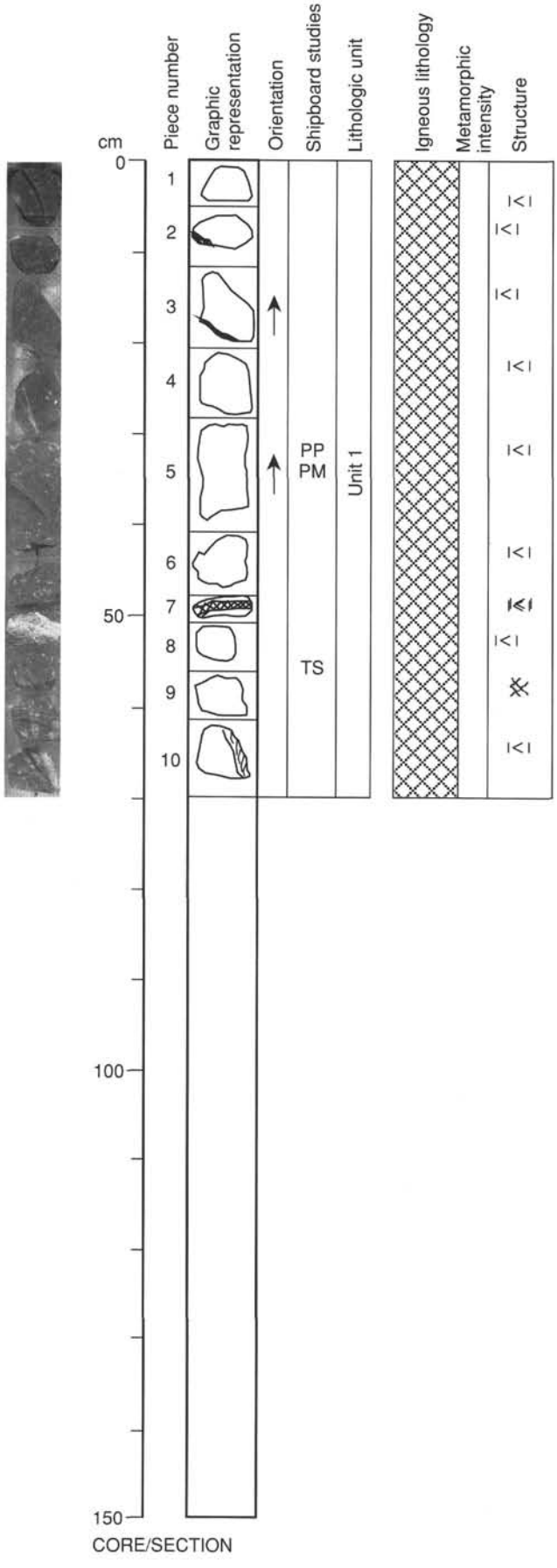

UNIT 1: SERPENTINIZED HARZBURGITE

Pieces 1–10

COLOR: Dark gray/black.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Weak development of vein arrays, generally not pervasive.
PRIMARY MINERALOGY:
Olivine. - Mode: 82%–93%.
Orthopyroxene. - Mode: 5%–15%.
Crystal Size: 2–8 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene. - Mode: 1%–3%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: <1%.
Crystal Size: <2 mm.
Comments: This section consists of serpentinized pyroxene-poor harzburgite and dunite. Orthopyroxene contents range from 5% to approximately 15%, and are lowest in Pieces 1, 7, and 8 which are pyroxene-bearing dunite. All other pieces are pyroxene-poor (10%–15%) harzburgite. Piece 5 contains elongate trains of spinel grains. Piece 7 contains a highly metasomatized and altered gabbroic vein with pyroxene altered to amphibole and with plagioclase completely altered to low-temperature mineral assemblages. Alteration affects the adjacent wall rock as well. Piece 10 contains an altered composite pyroxenite/gabbro, cut by several serpentine veins. Pyroxene content is progressively depleted away from the vein margin. Alteration is extensive (95%–100%). Clinopyroxene abundances are generally low in the section and it is generally altered. Fresh clinopyroxene is, however, present in Piece 6. Olivine is preserved as rims and in shadows around orthopyroxene. The texture is porphyroclastic, weakly elongate within the anastomosing serpentine foliation in Pieces 1–6.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 95
Mode of Occurrence: Replaces major phase.
Comments: Pieces 1–5 are pervasively serpentinized (95%–100%); Piece 3 is 100% serpentinized. Serpentinization is a bit less intense in Pieces 6–10 (85%). Olivine is altered to a dark green, serpentine and magnetite mesh, and pyroxene is 85%–100% altered to gray and pale green bastite. Relics of olivine and pyroxene form centimeter-sized kernels. The net of anastomosing serpentine microveinlets is only clearly evident in Pieces 3, 8, and 9. Veins are present in most pieces. They comprise serpentine, clay minerals, and pyrite on open fractures, typically with radiating clusters of zeolites? and possibly tremolite (Pieces 7 and 10). Piece 7 is cut by a pervasively altered pyroxenite/gabbro vein, which is composed of serpentine, tremolite, pyrite, radiating zeolite? and exhibits an alteration halo. Pyrite occurs as disseminated grains in Piece 1, and as a composite set of thin (<1 mm) irregular and sharp veins. Piece 10 contains a linear, 1.5 cm wide, pervasively altered composite gabbro-pyroxenite vein comprised of zoned serpentine, radiating amphibole, clay minerals, and chlorite. The vein cuts at a low angle to the apparent elongation of relict kernels of olivine and pyroxene. Serpentine in the selvage of veins is recrystallized to a radiating habit. Generally, this section exhibits sulfide mineralization along veins, which is also concentrated in small patches.
VEIN/FRACTURE FILLING:
Serpentine, clay minerals, pyrite, and radiating zeolite?
Size: Open fractures
Serpentine, amphibole, pyrite, ± clay minerals.
Size: 1–15
Orientation:
Serpentine and pyrite.
Size: <2
Comments: Thin irregular composite veinlets.
ADDITIONAL COMMENTS: Structure
Elongation of pyroxene porphyroclasts is weak to nonexistant in this section. White serpentine veins are sparse but follow the trace of a weak anastomosing foliation. This foliation is defined by closely spaced, submillimeter, green black serpentine veins. In Piece 5, the dip of the foliation is about 35°, subparallel to the pyroxene foliation. In several pieces (e.g., Piece 5) there is

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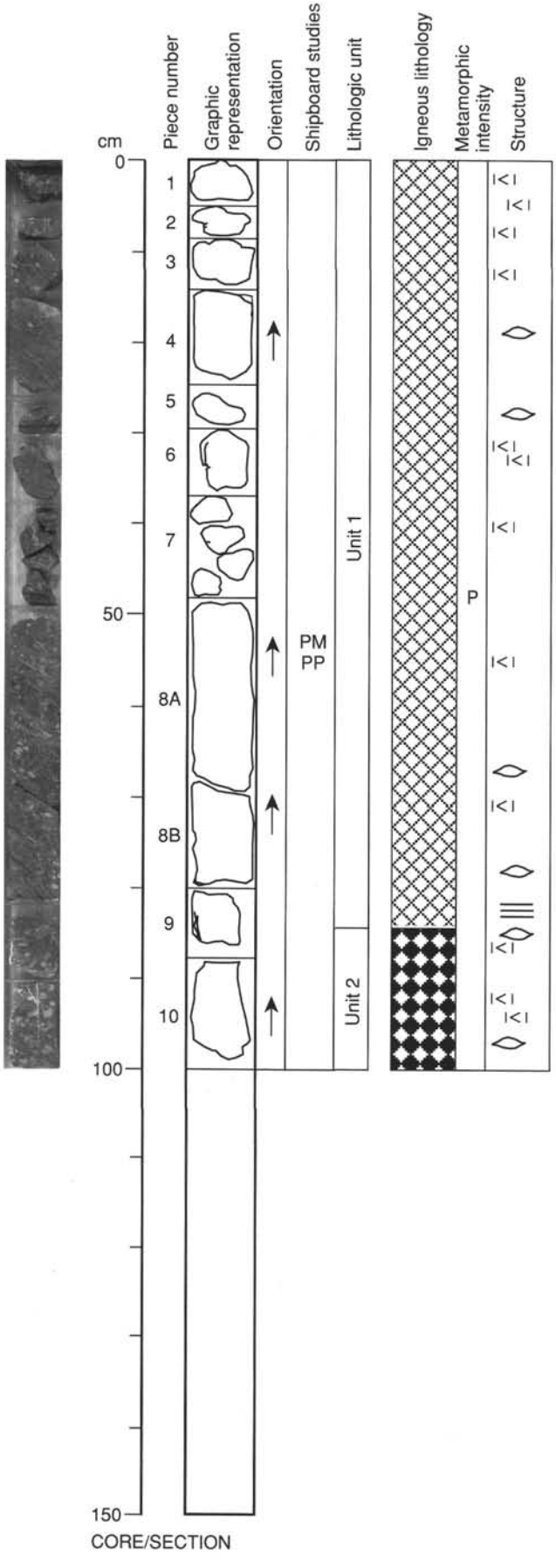
a weak development of two thin (<1 mm) sets of white fibrous serpentinite veins that are perpendicular to each other. Occasional dark green serpentine veins are subhorizontal and commonly contain associated sulfide minerals. In Piece 4, a dark green serpentine vein is oriented perpendicuar to the foliation. Piece 7 includes a complex composite braching vein composed of serpentine, aragonite(?), and sulfide minerals.



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UNIT 1: SERPENTINIZED HARZBURGITE

Pieces 1–9

COLOR: Dark gray.
PRIMARY STRUCTURE: Elongate porphyroclastic.
SECONDARY STRUCTURE: Several generations of serpentine dominated veins generally not defining any distinct foliation.
PRIMARY MINERALOGY:
Olivine. - Mode: 88%–92%.
Crystal Size: - mm.
Crystal Shape: -
Crystal orientation: -
Orthopyroxene. - Mode: 6%–10%.
Crystal Size: 2–10 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 1%.
Crystal Size: 1–5 mm.
Crystal Shape: Anhedral
Comments: From 0 to 87 cm, the section is composed of pyroxene-poor (10% –15%) serpentinized harzburgite (Pieces 1–2, 4–5, and 7), pyroxene-bearing dunite (Pieces 3 and 6), and harzburgite more enriched (15%–20%) in pyroxene content (Piece 7-lower and 8). Modal clinopyroxene is low (1%–3%). Spinel contents are generally high (in excess of 1%). Relict orthopyroxne is present in most pieces and spinel is well preserved overall. Sulfide minerals are common, both in veins and disseminated in the rock. Pyroxene abundance increases in the bottom of Piece 7 and Piece 8 to Piece 10 (>15%) and the gradational contact with Unit 2 is defined between Piece 8 and 9. Unit 2 is best developed in Section 153-920D-5R-2. The anastomosing serpentine vein sets are weakly developed in pyroxene-poor harzburgite and dunite, but better developed as the unit boundary is crossed.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 95.
Texture: Mesh.
Comments: After olivine, orthopyroxene, and clinopyroxene.
Magnetite.
Total Percent: 2–3
Mode of Occurrence: In serpentine.
Comments: After olivine and orthopyroxene.
Pyrite.
Total Percent: <1
Clay minerals.
Comments: Alteration is pervasive (95%) and is dominated by olivine alteration to serpentine (99%–100%). Serpentine forms a dark brown black mesh with microveinlets of iron oxide minerals which are associated with composite veinlets of dark serpentine. Pieces 1–3 are relatively less serpentinized (90%) with more abundant kernels of relict olivine, orthopyroxene, and clinopyroxene. Orthopyroxene is highly to pervasively altered (70%–95%). It is replaced by bastite forming mottled gray green-colored grains with iron oxide minerals along exsolution lamellae. Pale, gray-green cores of pyroxene are enclosed by a brown green serpentine mesh matrix. Rare clinopyroxene is replaced by serpentine (99%–100%), forming small dark patches associated with a trace of pyrite.
Veins
Development of wispy white serpentine veinlets is heterogeneous, but generally increases downsection. Anastomosing swarms of black serpentine veinlets are common.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 4%–50%
Size: 4–8 mm.
Orientation: No preferred.
Comments: Five generations of veins, the earliest and last are thicker and longer, generally cutting completely across the core, while the others are sparsely developed and short.
White serpentine.
Size: 1 mm.
Orientation: See comments.
Dark green serpentine.
Size: 4 mm.

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Light green serpentine.
Size: 5 mm
ADDITIONAL COMMENTS: Structure
Pyroxene porphyroclasts display a weak to nonexistant elongation in Pieces 1 to 8. Thin white discontinuous serpentine veins are present throughout the core, but they are significantly reduced in the pyroxene-poor interval (Pieces 1 to 8). The porphyroclast fabric dips as low as 30° in Piece 8. An anastomosing foliation formed by dense arrays of thin green serpentine veins is present in Pieces 9 and 10 (see next section) but is virtually nonexistent in Pieces 1 to 8. This absence of veining corresponds to the pyroxene-poor interval of the section. In Piece 8, a shallow-dipping, dark green serpentine vein (1 mm wide) is cut by thin white serpentine veins.

UNIT 2: PYROXENE-RICH SERPENTINIZED HARZBURGITE

Pieces 9–10

COLOR: Gray-green.
PRIMARY STRUCTURE: Porphyroclastic to elongate porphyroclastic.
SECONDARY STRUCTURE: Anastomosing white serpentine veins.
PRIMARY MINERALOGY:
Olivine. - Mode: 75%–80%.
Orthopyroxene. - Mode: 18%–22%.
Crystal Size: 3–12 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 1%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: 0.5–2 mm.
Crystal Shape: Anhedral
Comments: Pyroxene-rich serpentinized harzburgite with porphyroclastic texture, resembling Unit 2 of Hole 920B. Orthopyroxene content averages about 15% in this section but tends to increase gradually until the next section where higher modal orthopyroxene is present (≈25%). Modal clinopyroxene is low in Section 153-920D-1R (1%–3%). Spinel content is generally <1%. The anastomosing low-temperature white serpentine veins are commonly nearly planar. Pieces 9 and 10 have fragments of white veins of serpentine and carbonate minerals on one side; the carbonate minerals also have a radiating growth pattern suggesting growth into an open void. Piece 10 is also cut by several <1 mm wide white veins oblique to foliation. Relict orthopyroxene is present in some pieces and spinel is well preserved overall. Olivine is strongly altered (≈100%).
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 98
Texture: Mesh.
Comments: After olivine and orthopyroxene.
Iron oxide minerals.
Total Percent: 2
Comments: After olivine and orthopyroxene.
Clay minerals.
Comments: After olivine and orthopyroxene.
Comments: This section of harzburgite is 100% serpentinized. Olivine is replaced by a dull green mesh of serpentine and magnetite. Pyroxene is altered to pale green bastite. The anastomosing net of serpentine microveinlets is well developed. Piece 10 contains a 1–2 mm thick coating of aragonite(?), forming radiating sprays and intergrown with serpentine. Pieces 9 and 10 are cut by sparse, ≈1 mm wide, subvertical serpentine veinlets.
VEIN/FRACTURE FILLING:
White serpentine.
Size: 0.5–1 mm
Dark green serpentine.
Size: 1 mm.
Orientation: See comments.
Comments: Development of wispy white veinlets is heterogeneous, but generally increases downsection where they become more abundant in Pieces 8–10. Anastomosing swarms of back serpenitine veinlets are common. Piece 10 contains a 1–2 mm thick coating of aragonite? forming radiating sprays and intergrown with serpentine.
Pale green serpentine/melt channels(?).

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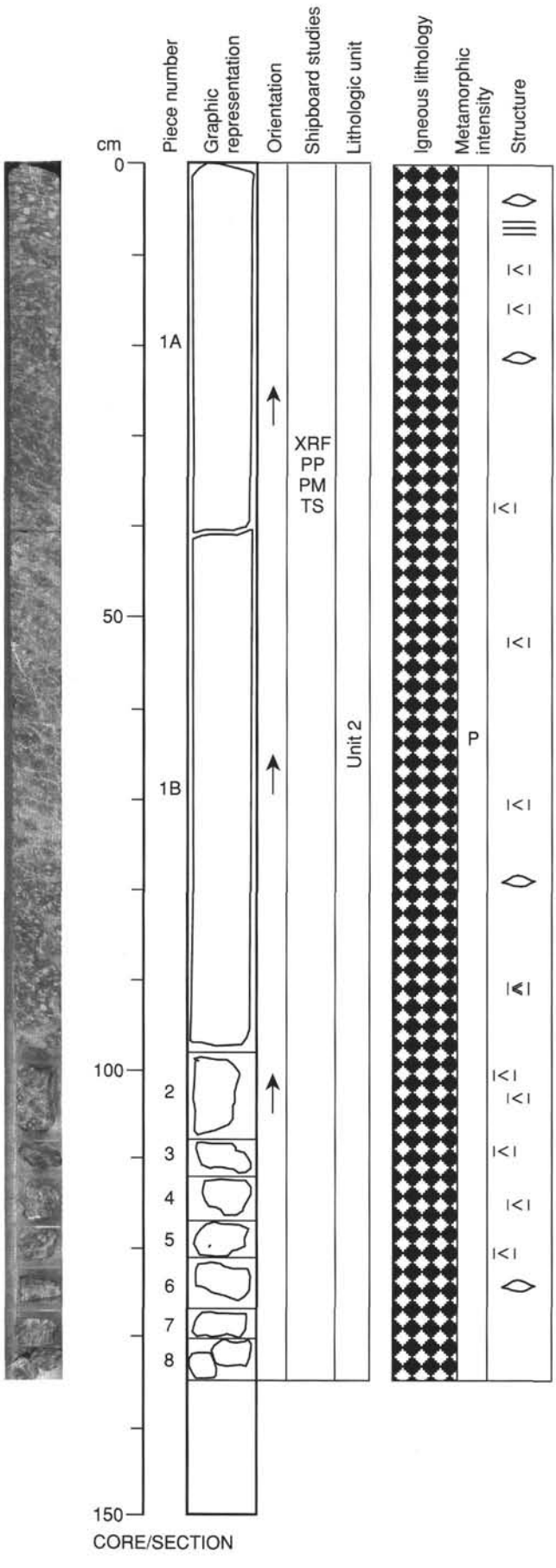
Size: up to 5 mm.

ADDITIONAL COMMENTS: Structure

A weak to moderate elongate porphyroclastic fabric in pyroxene increases in intensity toward the base of this section. An anastomosing foliation formed by thin (<1 mm) dark green serpentine veins intensifies at the top of Piece 10 and also at the base of Piece 9, becoming more planar, where the gradational contact with Unit 2 begins. Both foliations have a moderate dip (40°–50°), except at the junction between Pieces 9 and 10 where they become horizontal. The intense fabric at this junction resembles a shear zone but no shear sense could be determined. The fabric intensity diminishes toward the base of Piece 10. In Piece 10, a pale green, subvertical, serpentine vein (2–3 mm wide) cuts the thin white serpentine veins that overprint the anastomosing foliation and also cuts the intense fabric at the top of the piece.



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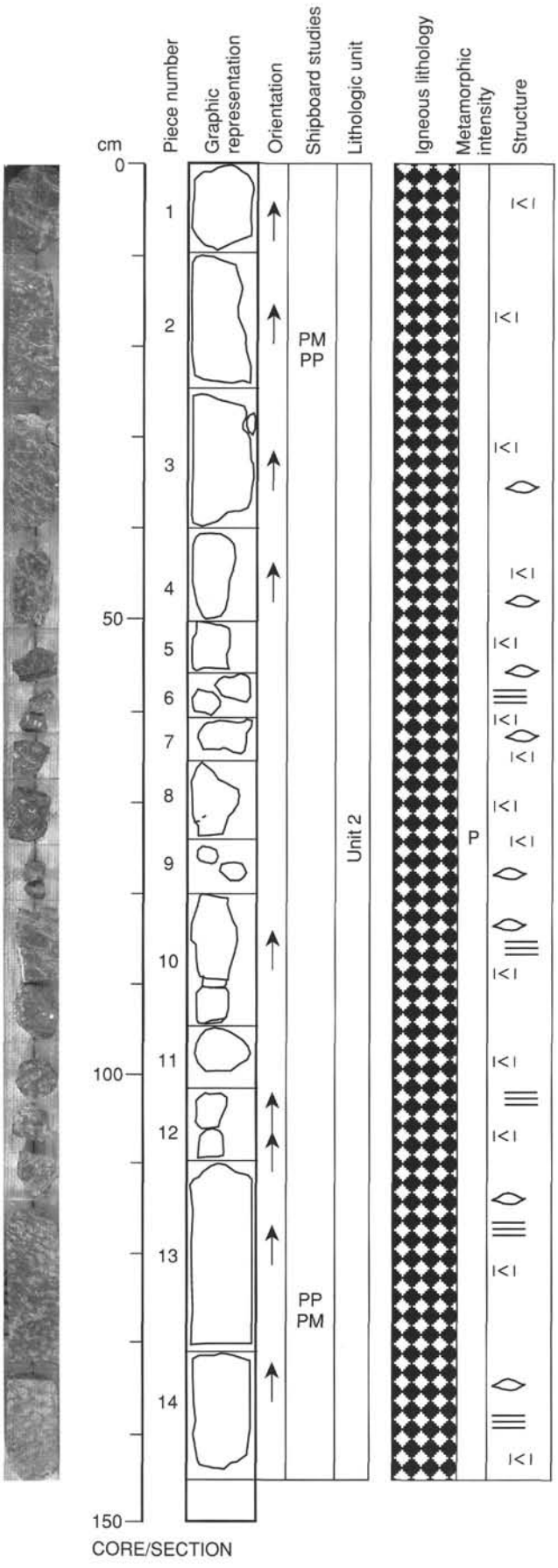
UNIT 2: PYROXENE-RICH SERPENTINIZED HARZBURGITE

Pieces 1A–8

COLOR: Gray-green.
PRIMARY STRUCTURE: Strongly elongated porphyroclastic.
SECONDARY STRUCTURE: White fibrous serpentine veins outline the rounded orthopyroxene porphyroclasts.
PRIMARY MINERALOGY:
Olivine. - Mode: 70%–74%.
Orthopyroxene. - Mode: 25%–29%.
Crystal Size: 3–15 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 1.%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1.0%.
Crystal Size: 1–2 mm.
Crystal Shape: Anhedral.
Comments: Pyroxene-rich serpentinized harzburgite with porphyroclastic texture. Pyroxene content averages about 25%, modal clinopyroxene is low (1%–3%). Orthopyroxene porphyroclasts range in size from 5 to 25 mm. All pieces within the section consist of pyroxene-rich harzburgite. Spinel content is generally high (in excess of 1%). Discontinuous white cross-fiber veins are formed in orientations subparallel to the elongation direction of orthopyroxene porphyroclasts, defining an anastomosing foliation that in part mimics the high-temperature foliation. Larger white serpentine veins also crosscut this foliation. The pieces are generally highly altered (>90%) and olivine is completely altered in most pieces, except for the top of Piece 1. Relict orthopyroxene is present in most pieces and spinel is well preserved overall. There are no magmatic veins in the section.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 80–90
Texture: Mesh.
Comments: After olivine, orthopyroxene (bastite pseudomorphs), and clinopyroxene.
Iron oxide minerals.
Total Percent: 3
Clay minerals.
Total Percent: Trace.
Pyrite.
Total Percent: Trace.
Comments: This section is pervasively serpentinized with total alteration ranging from 90%–93%, and generally increasing downsection. Alteration is dominated by serpentine replacement of olivine (90%–95%), forming a dark brown-black mesh with microveinlets of iron oxide minerals. Pods of white serpentine kernels rimmed by lighter green serpentine after olivine are rare. Bastite, iron oxide minerals along exsolution lamellae, and spinel inclusions along grain boundaries are common after orthopyroxene. Alteration of the porphyroclasts ranges from 80%–100%. Porphyroclasts exhibit well-developed coronas with apple green cores enclosed by a thin dark serpentine rim, and are enclosed in the mesh serpentine matrix. Rare clinopyroxene(?) is replaced by serpentine (100%), forming small dark patches associated with a trace of pyrite.
Veins
This section is cut by abundant composite wispy white and black serpentine and iron-oxide-bearing veinlets, which parallel the fabric defined by orthopyroxene porphyroclasts. These veins are cut by irregular, white branching serpentine veins, ≈1 mm wide, which are oriented perpendicular to the composite wispy white veins. Radiating sprays of aragonite, serpentine, and a trace of pyrite coatings are common on broken surfaces, indicating precipitation in open voids. Piece 4 contains abundant composite black and white serpentine veins, which are cut by a vein composed of radiating sprays of carbonate minerals and serpentine.
VEIN/FRACTURE FILLING:
Serpentine.
Aragonite.
ADDITIONAL COMMENTS: Structure
A strongly elongated porphyroclastic texture has developed at the top of this section where the foliation has a low dip (25°–30°). From Piece 2 the fabric intensity diminishes and is overprinted by an anastomosing serpentine foliation that is highlighted by thin white serpentine veins. From Piece 2 downward the white

veins are strongly deflected around the margins of the porphyroclasts and thicken toward the base of the section (up to 2 mm). Veins of a similar composition are also oriented perpendicular to the foliation, (e.g., Piece 2).



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UNIT 2: PYROXENE-RICH SERPENTINIZED HARZBURGITE

Pieces 1–14

COLOR: Gray-green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Several generations of crosscutting veins.
PRIMARY MINERALOGY:
Olivine. - Mode: 62%–76%.
Orthopyroxene. - Mode: 22%–37%.
Crystal Size: 4–14 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 1%.
Crystal Size: 2–4 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: 1–2 mm.
Crystal Shape: Anhedral.
Comments: Porphyroclstic pyroxene-rich serpentinized harzburgite. Orthopyroxene content averages about 22%–37%, modal clinopyroxene is low (<1%). In some cases orthopyroxene and clinopyroxene porphyroclasts are recrystallized to finer grained aggregates, but still roughly preserve the original porphyroclast size isolated in a matrix of serpentinized olivine. Spinel content is generally low (<1%). Discontinuous white cross-fiber veins are formed in orientations subparallel to the elongation direction of orthopyroxene defining an anastomosing foliation. Piece 14 has very high modal pyroxene (up to 37%). Piece 10 contains a 2 mm thick altered gabbroic vein. Piece 10 also contains an elongate train of isolated or aggregate spinel that cuts the piece approximately parallel to the high-temperature foliation plane. Larger white to green chrysotile serpentine veins also crosscut this foliation. In one case (Piece 10), a late composite serpentine, sulfide mineral, and aragonite vein cuts the sample. The aragonite appears intergrown with the sulfide minerals. The aragaonite also has a radiating growth pattern suggesting growth into an open void. The pieces are generally highly altered (>90%) and olivine is completely altered in most pieces. Relict orthopyroxne is present in most pieces as large porphyroclasts and spinel is well preserved overall.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 85–95
Texture: Mesh.
Comments: After olivine and bastite pseudomorphs after orthopyroxene.
Iron oxide minerals.
Total Percent: 1–2
Comments: After olivine and orthopyroxene.
Pyrite.
Clay minerals.
Comments: Pervasively serpentinized with total alteration ranging from 87%–98%. Olivine is replaced by serpentine, iron oxide minerals, and clay minerals (90%–100%). Swarms of black serpentine veinlets and black mesh serpentine microveinlets with iron oxide minerals give the rock a patchy, dark color. Pods of white serpentine kernels rimmed by lighter green serpentine after olivine are rare. Orthopyroxene with spinel inclusions is altered to bastite, with iron oxide minerals along exsolution lamellae and along grain boundaries. Alteration of the porphyroclasts ranges from 70%–100%. Some porphyroclasts exhibit well-developed coronas with very elongate gray green cores enclosed by a 1–2 mm wide rim of pale green serpentine, which is enclosed in the mesh serpentine matrix. Rare clinopyroxene(?) is replaced by serpentine (60%–80%), forming small dark patches associated with a trace of pyrite.
Veins
Pieces are cut by abundant composite black serpentine and iron oxide mineral veinlets which parallel the fabric defined by relict orthopyroxene, clinopyroxene, and olivine porphyroclasts. Wispy white serpentine veinlets are conspicuously absent in Piece 14 through to the top of Core 153-920D-5R-4. Radiating sprays of aragonite, serpentine, and a trace of pyrite coatings are common on broken surfaces and indicate precipitation in voids (e.g. Pieces 10A and 10B). Pieces 11 and 12A contain an early, 1 mm wide, gray green and white serpentine vein after gabbro, which is cut by later wispy white serpentine veinlets.
VEIN/FRACTURE FILLING:
Serpentine.

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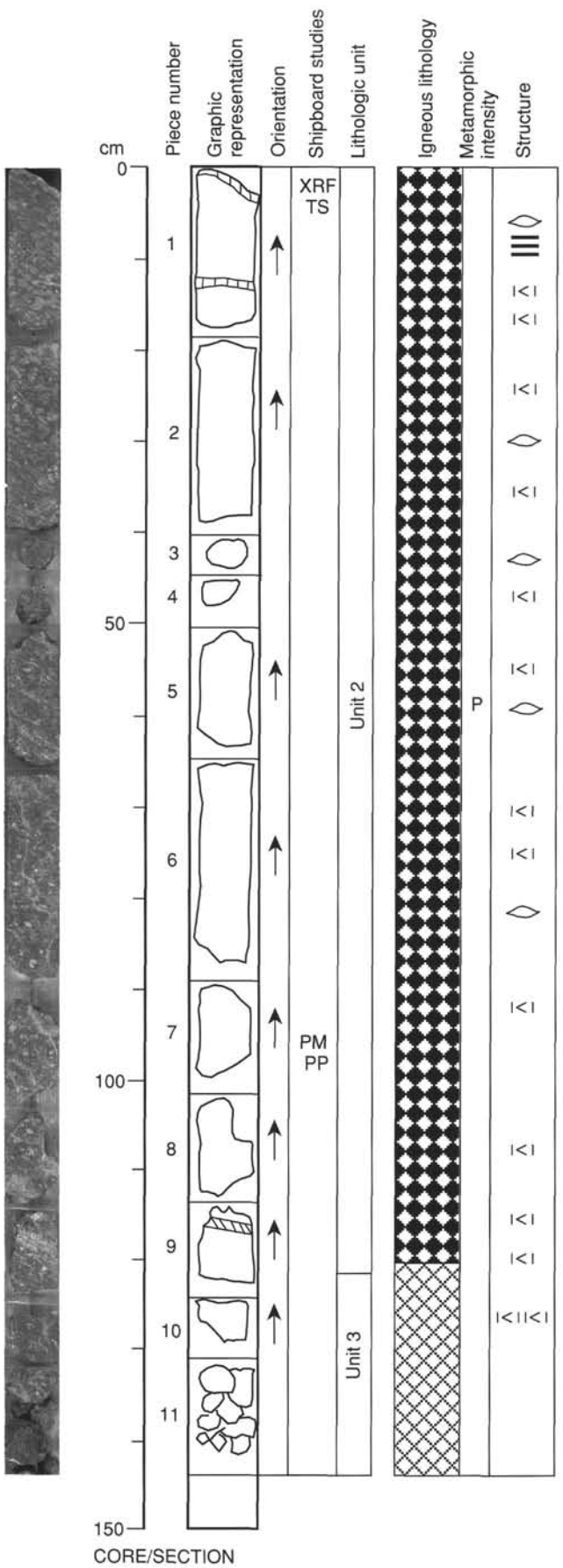
Size: <1 mm.

Aragonite.

Pyrite.

ADDITIONAL COMMENTS: Structure

A weakly developed elongated porphyroclastic fabric exists from Piece 1 to Piece 11. A moderately elongated porphyroclastic fabric has formed in Pieces 11 to 14. The foliation orientation varies between about 15° and 40°. Anastomosing white serpentine veins predominate throughout the section and increase in intensity toward the base of the section (Pieces 12 to 14). Serpentine fibers are subperpendicular to the vein walls. The veins commonly wrap around the orthopyroxene porphyroclasts. In some pieces, anastomosing low-temperature veins are nearly planar (e.g. Piece 14). Sparse green serpentine veins are cut by the thin white serpentine veins.



153-920D-5R-4

UNIT 2: PYROXENE-RICH SERPENTINIZED HARZBURGITE

Pieces 1–9

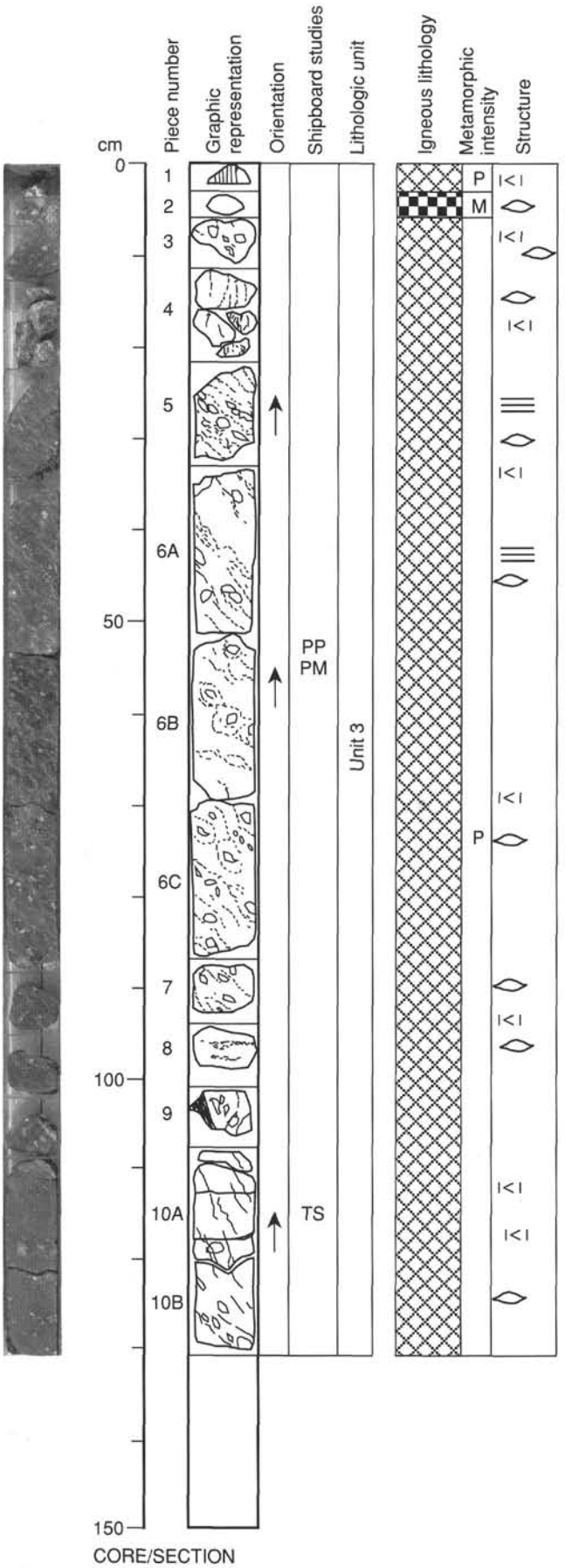
COLOR: Gray green.
PRIMARY STRUCTURE: Strongly developed elongate porphyroclastic.
SECONDARY STRUCTURE: Thin white fibrous serpentine veins are more pronounced and ring the rounded orthopyroxene in the lower pieces rather than define a planar foliation.
PRIMARY MINERALOGY:
Olivine. - Mode: 68%–78%.
Orthopyroxene. - Mode: 20%–30%.
Crystal Size: 2–23. mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 1%.
Crystal Size: 2–3. mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: 1–2. mm.
Crystal Shape: Anhedral.
Comments: This section consists of pyroxene-rich serpentinized harzburgite in Pieces 1–9. Orthopyroxene content averages about 25%; modal clinopyroxene is low (<1%). Orthopyroxene is elongate in shape, having aspect ratios of about 3:1. Spinel, which tends to occur in clusters or trails, is generally present in excess of 1%. Sulfide minerals occur in veins in Piece 5. All pieces are generally highly altered (>90%) and olivine is completely altered in most pieces, except for Piece 6. Relict fresh orthopyroxene is present in some pieces and spinel is well preserved overall. No magmatic veins were observed.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 85–90.
Texture: Mesh.
Comments: After olivine and orthopyroxene.
Iron oxide minerals.
Clay minerals.
Comments: Pervasively serpentinized with total alteration ranging from 90%–99%. Wispy white serpentine veins are rare in Piece 1 and increase in abundance downsection. In porphyroclastic-rich areas, elongate orthopyroxene is replaced by bastite, with iron oxide minerals along exsolution lamellae. Spinel inclusions in orthopyroxene and along grain boundaries are common. Alteration of orthopyroxene is high to perasive from 50%–100%, with the abundance of less altered pieces increasing midway downsection. Some porphyroclasts exhibit well-developed coronas with very elongate, gray green cores enclosed by a 1–2 mm wide rim of pale green serpentine enclosed in a mesh serpentine matrix. Olivine is pervasively replaced by serpentine, iron oxide minerals, and clay minerals (90%–100%). Swarms of black serpentine veinlets and black mesh serpentine microveinlets with iron oxide minerals give the rock a dark color. Patches of white serpentine kernels rimmed by lighter green serpentine after olivine occur at the base of the section. Rare clinopyroxene(?) is replaced by serpentine (80%–100%), forming small dark patches.
Veins
Pieces are cut by abundant composite black serpentine and iron oxide mineral veinlets, which parallel the fabric defined by orthopyroxene porphyroclasts. Coatings of radiating sprays of aragonite, serpentine, and a trace of pyrite are common on broken surfaces and indicate precipitation in voids. Piece 1 is cut by a 2 mm wide green serpentine and chlorite ± actinolite(?) veinlet. Piece 6 is cut by abundant anastomosing, composite wispy white and black serpentine veinlets. These veinlets are cut by a subvertical composite white serpentine vein.
VEIN/FRACTURE FILLING:
Composite black and white serpentine veinlets.
Orientation: Parallel to fabric.
ADDITIONAL COMMENTS: Structure
A strong elongated porphyroclastic fabric is present in Pieces 1 to 3 with the strongest fabric intensity in Piece 1. This fabric is overprinted by a weak anastomosing foliation of serpentine veins that, in turn, is overprinted by discontinuous, thin white serpentine veins. Steeply dipping, sparse, white serpentine veins crosscut this foliation. A pale green serpentine vein in Piece 1 has a shallow dip and fiber orientations within the vein suggest a normal displacement component.

153-920D-5R-4

UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 9–11

COLOR: Gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE:
PRIMARY MINERALOGY:
Olivine. - Mode: 90%.
Orthopyroxene. - Mode: 5%–10%.
Crystal Size: 2–20 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: <1%.
Crystal Size: <5 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: The contact between Units 2 and 3 has been placed within Piece 9 where a significant orthopyroxene modal reduction is observed. At a depth of 120 cm in this section, the pyroxene content is approximately 35%, but below this pyroxene contents drops to approximately 10%. The pyroxene-rich layer in Piece 9 is accentuated by serpentine veins which wrap around the pyroxene porphyroclasts. Below 120 cm the section is composed of pyroxene-poor (6%–10%) serpentinized harzburgite and dunite, having low modal clinopyroxene (<1%). Spinel contents is generally high (in excess of 1%). The pieces are generally pervasively altered (>95%) and olivine is completely altered in most pieces. Relict orthopyroxene is present in most pieces and spinel is well preserved overall. A pyroxenite vein was observed in Piece 11 rubble, together with highly depleted harzburgite. The association of pyroxene-depleted harzburgite with the introduction of magmatic veins is common.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Comments: Olivine is pervasively replaced by serpentine, iron oxide minerals, and clay minerals (90%–100%). Swarms of black serpentine veinlets and black mesh serpentine microveinlets with iron oxide minerals impart a dark color to the rock. Rare clinopyroxene(?) is replaced by serpentine (80%–100%), forming small dark patches.
Veins
Pieces are cut by abundant composite black serpentine and iron oxide mineral veinlets which parallel the fabric defined by orthopyroxene porphyroclasts. Pieces 9 and 10 contain <1 mm wide carbonate mineral veinlets which crosscut wispy white serpentine veinlets. Piece 10 contains early dark serpentine veins cut by later wipsy white veinlets.
VEIN/FRACTURE FILLING:
Composite serpentine and oxide minerals.
Aragonite(?), serpentine, and pyrite on open surfaces.
ADDITIONAL COMMENTS: Structure
A weak elongated porphyroclastic texture is defined by pyroxene porphyroclasts. In Piece 10 an early dark green serpentine vein is cut by thin white serpentine veins that overprint an anastomosing foliation. Thin (<1 mm) carbonate mineral veins cut the anastomosing white veins. A drop in the intensity of serpentine veining coincides with the reduction in pyroxene content of the harzburgite at the lithological Unit 2–3 boundary (Piece 9).



153-920D-6R-1

UNIT 3: SERPENTINIZED HARZBURGITE WITH OLIVINE METAGABBRO

Pieces 1–10B

COLOR: Black-gray
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Anastomosing white serpentine veins.
PRIMARY MINERALOGY:
Olivine. - Mode: 85%–89%.
Crystal Shape: Anhedral.
Orthopyroxene. - Mode: 9%–13%.
Crystal Size: 2–10 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 1%–2%.
Crystal Size: 2–10 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: <1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: This section consists dominantly of pyroxene-depleted serpentinized harzburgite with a porphyroclastic texture and with modal pyroxene ranging from 6%–13%. Pieces 7–10 are very pyroxene-depleted dunite and harzburgite (6%–10% orthopyroxene). Several igneous veins cross the section. Piece 2 consists of an altered oxide-rich olivine gabbro with magmatic textures which was probably intrusive into the peridotite. The contact with the peridotite is not preserved, but an intrusive contact is inferred based on the lack of deformation and preserved igneous textures. The gabbro is highly altered, but under static conditions. Mineral modes for Piece 2 are as follows: plagioclase (55%), clinopyroxene (36%), olivine (4%), oxide minerals (4%). Crystal shapes range from anhedral to subhedral. Grain sizes are: plagioclase 5–15 mm, clinopyroxene 5–10 mm, olivine 2–3 mm. Percent replacement by secondary phases are: plagioclase 30%, clinopyroxene 60%, and olivine 60%. Piece 10A and 10B each preserve horizontal clinopyroxene-rich veins which appear igneous in origin and cut the high-temperature ductile foliation plane which is more steeply inclined than the veins. Pieces 7–10 are the most pyroxene-depleted rocks in the section and are associated with magmatic vein occurrences.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine and orthopyroxene.
Clay minerals.
Mode of Occurrence: After olivine and orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine and clinopyroxene.
Pyrite.
Mode of Occurrence: After clinopyroxene(?).
Comments: The extent of alteration varies from ≈85%–90% with minor preservation of all primary phases. In orthopyroxene-poor zones, wispy white late veinlets of serpentine are not abundant, but increase with increasing orthopyroxene content. Alteration is dominated by serpentine after olivine (90%–100%), and bastite after orthopyroxene. Disseminated pyrite and sulfide mineral veins are common. In orthopyroxene-rich areas, porphyroclasts are gray-green in color with iron oxide minerals common along lamellae. Some grains are rimmed by dark green serpentine, with lighter serpentine rims adjacent to a brown-green serpentine matrix. Piece 2 is a highly altered (60%), oxide-rich olivine metagabbro in which olivine is pervasively altered to serpentine, plagioclase is moderately to highly altered to secondary plagioclase, prehnite, and a trace of epidote and zeolite. Altered grains exhibit a thin white alteration halo when adjacent to pyroxene. Clinopyroxene is pervasively to highly altered to amphibole, chlorite, secondary clinopyroxene, and iron oxide minerals.
Veins
Composite white and black anastomosing, wispy serpentine veins are common in zones of abundant porphyroclasts (Pieces 5 and 6). Rare white serpentine and sulfide mineral veinlets cut fabric parallel veins (1 mm in width) in Pieces 5 and 6. Sulfide minerals are common on the backs of some pieces (e.g. Piece 9). Magmatic veins(?), 2 mm wide in Piece 10 are pervasively altered to serpentine with minor amphibole, and chlorite, and pyrite. Adjacent pyroxene are pervasively altered to amphibole, chlorite, and serpentine.

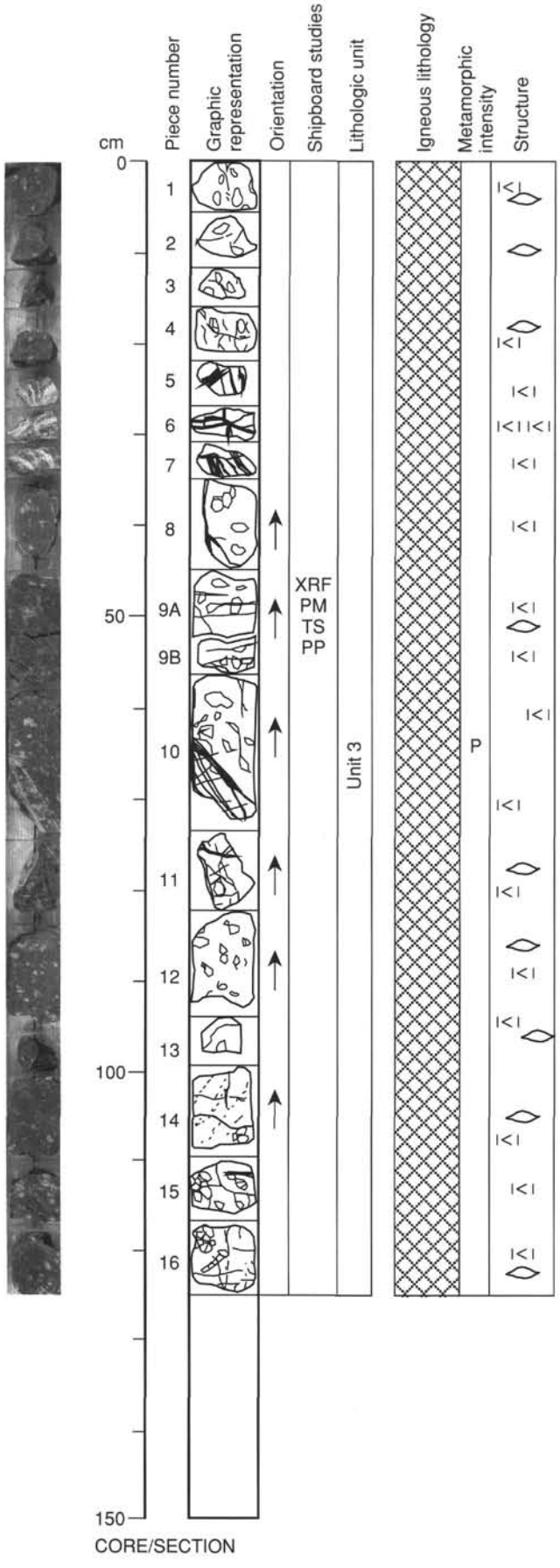
153-920D-6R-1

VEIN/FRACTURE FILLING:

Wispy white serpentine.
Orientation: Parallel to fabric.
Sulfide minerals and carbonate minerals.
Orientation: On broken surfaces.
White serpentine.
Size: 1 mm.
Orientation: Oblique to fabric.
Light green serpentine veins.
Size: 2 mm.
Orientation: Shallow dips (10–20)

ADDITIONAL COMMENTS: Structure

A weak to moderate elongated porphyroclastic fabric defined by orthopyroxene porphyroclasts forms the dominant fabric. This foliation is overprinted by a weak to moderate anastomosing foliation comprising dense arrays of serpentine veins (<1 mm). Both foliations dip between 50° and 60°. The oxide-rich olivine gabbro in Piece 2 is weakly deformed and cutting across the pyroxene fabric in the adjacent harzburgite. Thin white serpentine veins overprint the anastomosing foliation. Trails of steel gray pyroxene are found in Pieces 10A and 10B and resemble melt channels. They are oriented obliquely to the foliation and are cut by the thin white serpentine veins.

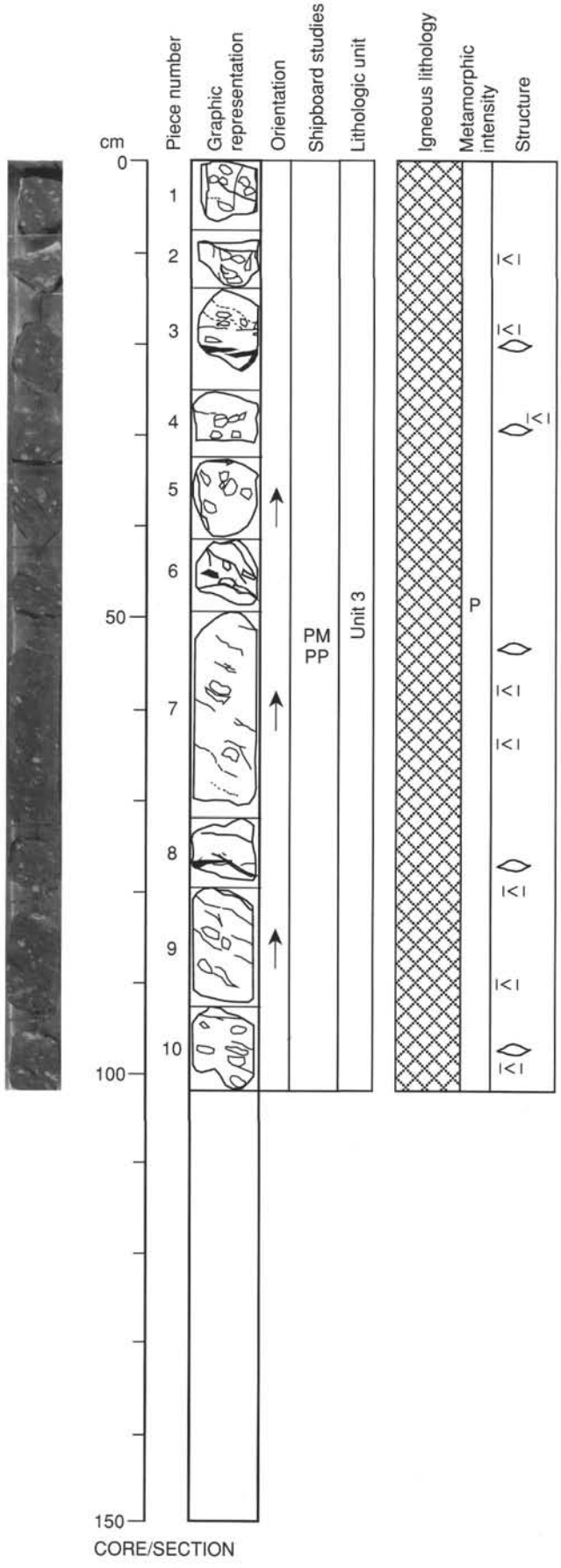


153-920D-6R-2

UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–16

COLOR: Gray black.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE:
PRIMARY MINERALOGY:
Olivine. - Mode: 90%–94%.
Orthopyroxene. - Mode: 5%–8%.
Crystal Size: 2–11 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 1%–4%.
Crystal Size: 1–4 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: This section consists dominantly of pyroxene-depleted, serpentinized harzburgite in which modal orthopyroxene ranges from 5%–13%. Pieces 1–4 and 14 are pyroxene-bearing dunite. All other pieces are pyroxene-poor (<13%) harzburgite. Pieces 5–7 are highly fractured and veined harzburgite. They are small pieces of serpentinite that have been heavily veined by prehnite, amphibole, and sulfide and carbonate minerals. Veins range from 1 to 8 mm wide. The primary mineralogy is no longer recognizable in these pieces. Pieces 8, 9, 11, and 16 preserve horizontal clinopyroxene-rich melt channels or veins which cut oblique to the foliation; clinopyroxene abundance reaches 2%–3% in these rocks. In Piece 10, clinopyroxene abundance is about 4% and the veins are subvertical. Piece 10 contains two highly altered gabbroic veins that are both discordant with respect to the high-temperature crystal-plastic fabric. Piece 11 contains a continuation of one of these veins. Piece 15 contains a highly altered composite gabbro/pyroxenite vein. These features probably represent crystallization from infiltrating silicate melts. Sulfide minerals are common throughout the section.
SECONDARY MINERALOGY:
Serpentine.
Mode of Occurrence: After olivine, orthopyroxene, clinopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Clay minerals.
Mode of Occurrence: After orthopyroxene, clinopyroxene, olivine.
Pyrite.
Mode of Occurrence: After clinopyroxene.
Comments: This section of harzburgite is pervasively serpentinized (85%–99%). Alteration is dominated by alteration of olivine to mesh textured serpentine, clay and iron oxide minerals (90%–95%). Orthopyroxene forms gray green to olive green patches and when pervasively altered is pseudomorphically replaced by bastite. Spinel and iron oxide minerals form along exsolution lamellae. Orthopyroxene alteration ranges from 60%–99%. Rare dark green serpentine clots associated with disseminated pyrite may be altered clinopyroxene.
Veins
Pieces 10, 11, and 15 contain composite veins (1–2 mm wide) of actinolite, tremolite, and chlorite after a gabbroic protolith. These veins are discordant to the foliation defined by othopyroxene porphyroclasts. Thinner veinlets of a similar alteration assemblage are in Pieces 9 and 11. Crosscutting serpentine veins, some with sulfide mineralization, ≤ 1 mm wide are in Pieces 8 and 11.
Wispy white serpentine veins are common. Pieces 5–7 are strongly net veined by prehnite(?), serpentine, and sulfide minerals.
VEIN/FRACTURE FILLING:
Serpentine and chlorite(?).
White serpentine.
Pyrite, serpentine, and carbonate minerals.
ADDITIONAL COMMENTS: Structure
The upper part of this section is weakly deformed with a weak elongated porphyroclastic texture defined by pyroxene porphyroclasts. A weak anastomosing foliation wraps around the porphyroclasts, defined by a dense network of serpentine veins. An intensely veined section dominates through Pieces 4 through 7 with pale green sepentinite veins and sulfide minerals. White serpentine veins are otherwise very sparse through the section. The foliations dip at about 60°. Subhorizontal melt channels in Pieces 8, 9, 11, and 16 cut obliquely to the foliation.



153-920D-6R-3

UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–10

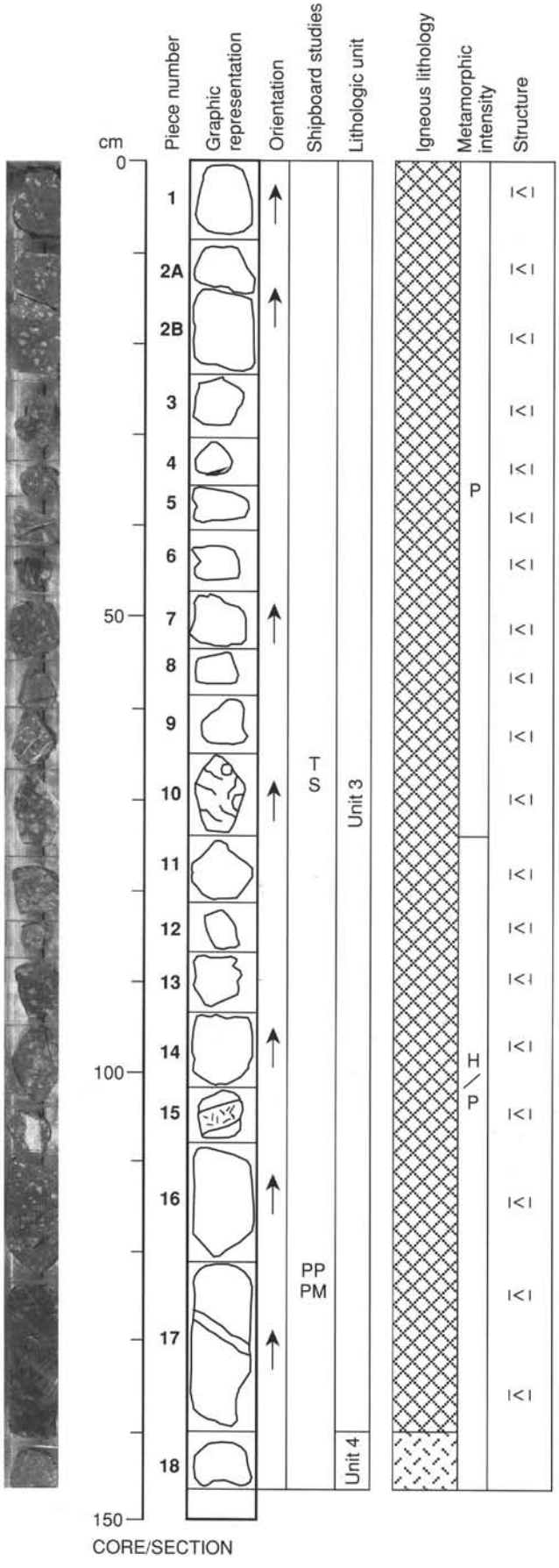
COLOR: Black/green.
PRIMARY STRUCTURE: Weakly elongate porphyroclastic.
SECONDARY STRUCTURE: Veins.
PRIMARY MINERALOGY:
Olivine. - Mode: 82%–89%.
Orthopyroxene. - Mode: 9%–12%.
Crystal Size: 2–10 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 1%–8%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: This section consists dominantly of porphyroclastic pyroxene-depleted, serpentinized harzburgite in which modal orthopyroxene ranges from 9%–12%. Clinopyroxene is abundant in some samples (e.g., Pieces 2, 9, and 10) which contain altered clinopyroxenite or composite gabbro/clinopyroxenite vein material. Other pieces appear impregnated by clinopyroxene trails that cut across the foliation plane, generally they are horizontal. Piece 2 contains a composite gabbroic/pyroxenitic vein (very altered) with a clinopyroxenite-rich halo. The composite veins in Pieces 9 and 10 are nearly concordant with the high-temperature foliation, but cross at a low angle. These veins are interpreted as subhorizontal clinopyroxene-rich melt channels which cut oblique to the foliation; clinopyroxene abundance reach 2%–8% in these rocks as a consequence of these melt channels, even though the rock is depleted in total pyroxene content. The channels are on the scale of veins a few mm wide or on the scale of individual linear trains of clinopyroxene grains. Sulfide minerals are common throughout the section. All primary phases are partially preserved. Magmatic veins are commonly developed through the section.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Pyrite.
Mode of Occurrence: After clinopyroxene(?).
Comments: This section is highly to pervasively altered (85%–95%). Alteration is dominated by alteration of olivine to serpentine, and clay and iron oxide minerals (85%–93%). Othopyroxene is highly altered (70%–90%) to bastite and serpentine and forms gray green to olive green patches replaced by serpentine; iron oxide minerals form along exsolution lamellae. Rare, dark green serpentine clots associated with disseminated pyrite may be altered clinopyroxene. Clinopyroxene alteration ranges from 40%–80%.
Veins
1–3 mm wide amphibole, chlorite, and possibly zeolite minerals occur in Pieces 3 and 4. Anastomosing white serpentine microveinlets occur in Pieces 3, 7, and 8. In Pieces 8–10, pervasively altered 1 mm wide gabbroic veinlets are replaced by amphibole, chlorite and a white colored mineral (prehnite?) that may be replacing plagioclase. Serpentine and/or serpentine and carbonate mineral veins (1 mm wide) occur in Pieces 1, 5, 8, and 9. There are a number of different types of hydrothermal veins that form after the melt impregnation events. These veins, best displayed in Piece 9, include from youngest to oldest: sulfide minerals, sulfide mineral and serpentine composites, chrysotile-filled tension gashes, and asbestiform white serpentine veins subparallel to the high-temperature foliation. The relative age relationships are based on crosscutting relationships.
VEIN/FRACTURE FILLING:
Sulfide minerals and serpentine.
Wispy white serpentine.
Sulfide and carbonate minerals.
Serpentine, amphibole, chlorite(?)
Size: 4 mm.

153-920D-6R-3

ADDITIONAL COMMENTS: Structure

A weak to moderate, elongated porphyroclastic texture is formed by orthopyroxene porphyroclasts. Pieces 7 and 8 have a slightly stronger fabric than the upper pieces of the section. Kink bands are evident in the orthopyroxene crystals in Piece 1 in hand specimen. No anastomosing foliation is present and white serpentine veins are sparse in the pyroxene-poor intervals. In Pieces 8 to 10, clinopyroxene trails cut across the foliation plane and have a shallow dip (<15°). In Piece 10, a pale green serpentine vein cuts across a metagabbroic vein.

153-920D-7R-1



UNIT 3: SERPENTINIZED HARZBURGITE

Pieces 1–17

COLOR: Black/green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE:
PRIMARY MINERALOGY:
Olivine. - Mode: 80%.
Crystal Shape: Anhedral.
Orthopyroxene. - Mode: 15%.
Crystal Size: 3–10 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 5%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: <1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: The section consists of porphyroclastic serpentinized harzburgite both depleted and enriched in pyroxene and intruded by gabbroic and pyroxenitic veins. Pieces 1–9 and 14–15 are depleted harzburgite with between 15% and 20% pyroxene. Pieces 10 and 11 are enriched harzburgite (20%–50% pyroxene). Pieces 16 and 17 are highly depleted in pyroxene content (≈10%–13%). Clinopyroxene is scarce in the harzburgite (<1%), except near altered vein or gabbroic material, such as in Pieces 10 and 11 where it can become quite abundant. Piece 10 preserves the edge of an altered pyroxenite vein at least 4 cm in thickness. Likewise, Piece 11 preserves part of a pyroxenite vein 4 cm in minimum width. Piece 12 is an altered clinopyroxenite (probably vein material) cut by a serpentine vein. Piece 14 contains an altered pyroxenite vein 1.5 cm wide. Gabbroic veins are highly altered. Piece 15 contains an altered gabbro/hornblende gabbro vein. The clinopyroxene-rich regions in the section appear to have been localized along melt infiltration zones. Clinopyroxene is generally coarse grained in these regions (e.g., Piece 11) and pyroxene halos around veins are common. There is generally a rapid dissipation in clinopyroxene and increase in olivine content away from the vein. Pieces in the section generally contain well-preserved olivine (some very large kernels of fresh olivine isolated by serpentine veins), orthopyroxene, clinopyroxene, and spinel. Olivine seems well preserved adjacent to magmatic veins even though the vein itself is highly altered. The pieces are, however, riddled by numerous veins of sulfide minerals, composite green chrysotile serpentine and sulfide minerals, as well as green chrysotile serpentine veins. Tension gashes are present locally and filled with syntaxial cross-fibered serpentine. Sulfide minerals are very abundant in most pieces. The sulfide mineralization increases downward to a gabbroic intusion which may have acted as a heat source that caused local hydrothermal alteration and the elemental mobilization necessary for the network of sulfide minerals observed in the overlying sections. Piece 17 contains a tremolite vein with an unrecognizable protolith. Piece 17 is a serpentinized harzburgite and is the last piece in Unit 3; but it is underlain by a metagabbro (Piece 18) defining a new unit (Unit 4, see description for Section 153-920D-7R-2).
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Clay minerals.
Mode of Occurrence: After olivine.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Comments: Alteration of harzburgite in this section is around 80%, however, Pieces 10–12 are only 60% altered. Clear relict olivine grains form islands enclosed in a dark brown mesh-texutred serpentine matix. Olivine is well preserved around orthopyroxene prophyroclasts, but may be partially altered to a trace of talc and amphibole. Pyroxene in these zones is relatively fresh but is replaced by amphibole (brown after clinopyroxene? and colorless to green after orthopyroxene). Bastite after orthopyroxene is common in the most pervasively altered samples. Dark green patches associated with pyrite may be after clinopyroxene. Disseminated sulfide minerals are common, where they occur in association with altered clinopyroxene and in small pods they replace kernels of olivine. The sulfide minerals are most abundant adjacent veins near the base of this unit.

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Veins

Veins containing sulfide minerals are extremely abundant in this section. They occur in composite veins with serpentine, serpentine and carbonate minerals, and are especially abundant in Piece 17 where they form crosscutting arrays. In this sample a 5 mm wide amphibole and chlorite vein, possibly an altered clinopyroxenite vein, is cut by sulfide mineral stringers. This vein is also cut by a composite vein of dark and light green serpentine which contains sulfide minerals and which also cuts a zoned dark green and light green serpentine vein oriented at an oblique angle to the clinpyroxenite vein. These veins are then cut by light gray green serpentine veins. The veins are bounded by an alteration halo of brown serpentine which contains abundant sulfide minerals. Thin, anastomosing serpentine microveinlets are present in Pieces 2, 5, and 7. Thin (<1 mm) veinlets containing chlorite, amphibole, and serpentine occur in Pieces 5, 11, and 16. Pervasively altered pyroxenite and gabbroic veins include amphibole, chlorite, ± serpentine as secondary phases in Pieces 10, 14, 15, and 17. These are crosscut by irregular (1 mm wide) serpentine ± carbonate mineral veins that are also in Pieces 1, 2, 7, and 9.

VEIN/FRACTURE FILLING:

Gabbro/clinopyroxenite.

Comments: Altered to amphibole, serpentine, and chlorite.

Wispy white serpentine.

Size: <1 mm.

Serpentine, with clay and sulfide minerals.

Size: 1–2 mm.

Sulfide and carbonate minerals.

Size: <1 mm.

Comments: Stringers crosscut serpentine veins.

ADDITIONAL COMMENTS: Structure

The serpentinized harzburgite and clinopyroxene-rich lherzolite have a weakly developed elongate porphyroclastic texture. An anastomosing foliation, overprinted by white serpentine veins wraps around the pyroxene porphyroclasts. The foliation comprises dense arrays of green/black serpentine veins and dips at about 50°. In Piece 17, an altered clinopyroxenite is oriented subparallel to the foliation.

Contact Unit 3/ Unit 4.

The contact is not exposed in the core and placed between Pieces 17 and 18. In general, the harzburgite at the base on Unit 3 becomes more highly depleted in pyroxene content as the contact is approached (compare top of section 7R-1 to lowermost pieces). This is a similar to the trend found in many other sections of Holes 920B and 920D where a gabbroic contact is approached.

UNIT 4: METAGABBRO

Piece 18

COLOR: Yellow-green to brown.

PRIMARY STRUCTURE: Altered magmatic.

SECONDARY STRUCTURE:

PRIMARY MINERALOGY:

Plagioclase. - Mode: 36%.

Clinopyroxene. - Mode: 60%.

Crystal Size: 2–4 mm.

Crystal Shape: Anhedral.

Spinel. - Mode: <1%.

Crystal Size: <1 mm.

Iron oxide minerals. - Mode: 4%.

Crystal Size: <1 mm.

SECONDARY MINERALOGY:

Actinolite.

Mode of Occurrence: After clinopyroxene, plagioclase.

Chlorite.

Mode of Occurrence: After clinopyroxene, plagioclase

Prehnite.

Mode of Occurrence: After plagioclase.

Epidote.

Mode of Occurrence: After plagioclase.

Zeolite.

Mode of Occurrence: After plagioclase.

ADDITIONAL COMMENTS: Small isolated piece of altered basic rock. No macroscopic evidence of deformation, but is pervasively altered under static conditions to clay minerals, zeolite, amphibole, and chlorite after pyroxene.

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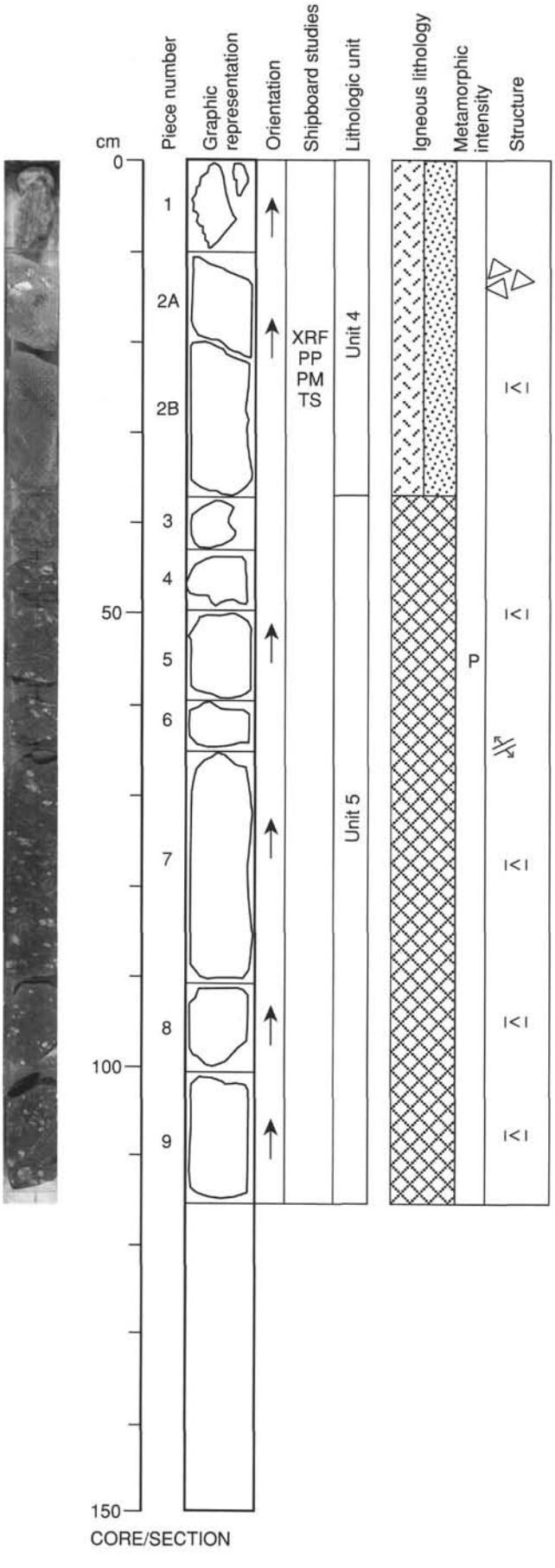

UNIT 4: METAGABBRO AND METADIABASE

Pieces 1–2B

COLOR: Yellow-green to gray.
PRIMARY STRUCTURE: Magmatic.
PRIMARY MINERALOGY:
Plagioclase - Mode: 54%.
Clinopyroxene. - Mode: 45%.
Crystal Size: 4–15 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: Unit 4 consists of two lithologies, a metagabbro in Piece 1 (also seen as Piece 18 in Section 153-920D-7R-1) and a metadiorite in Piece 2. The metagabbro is almost totally altered, but is largely undeformed so that it still retains evidence of magmatic textures. The amphibolitized microgabbro which underlies the metagabbro is fine to medium grained and aphyric. The primary mineral proportions are difficult to estimate due to the degree of alteration, but roughly equal proportions of mafic primary and secondary minerals vs. plagioclase are observed and may therefore reflect a similar proportion in the unaltered diabase protolith. Clinopyroxene, brown amphibole, and possibly olivine are the principal mafic phases. Clinopyroxene appears partially to, in places, fully replaced by brown amphibole indicating amphibolite facies hydration. The textures are magmatic and the metamorphic replacement has been static. Piece 2A has a 5 cm wide zone at the top which includes numerous large xenocrysts of altered plagioclase, pyroxene, and olivine (up to 18 mm in size). The grain size of the metadiabase increases downward, suggesting that this may be a chilled margin against the overlying gabbro.
SECONDARY MINERALOGY:
Brown amphibole.
Mode of Occurrence: After clinopyroxene.
Plagioclase.
Mode of Occurrence: After plagioclase.
Actinolite(?).
Mode of Occurrence: After amphibole and clinopyroxene.
Prehnite.
Mode of Occurrence: See description.
Comments: After plagioclase xenocrysts.
Epidote.
Mode of Occurrence: See description.
Comments: After plagioclase xenocrysts.
Serpentine.
Mode of Occurrence: See description.
Comments: After olivine xenocrysts.
Comments: Piece 1 is a pervasively altered metagabbro which contains a clay mineral matrix with rounded amphibolitized and chloritized pods after pyroxene. Piece 2 is a medium-grained amphibolite which contains abundant brown hornblende, actinolite, plagioclase, and olivine. Xenoliths of an oxide gabbro and serpentinite within the amphibolite are pervasively altered. Pegmatitic plagioclase grains are replaced by prehnite, epidote, ampibole, and hydrogrossular(?). Disseminated pyrite is abundant and occurs as rare stringers. Diffuse zones of dark green amphibole occur throughout the section. Secondary minerals do not exhibit a preferred orientation.
VEIN/FRACTURE FILLING:
Quartz and prehnite.
Size: 1–2 mm.
ADDITIONAL COMMENTS: Structure
The metagabbro in Piece 1 is strongly altered but mainly undeformed. Only veins deform the metadiorite. Branching prehnite veins (1–3 mm) in the metadiorite show no preferred orientation.

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UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 3–9

COLOR: Green/black.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE:
PRIMARY MINERALOGY:
Olivine. - Mode: 87%–93%.
Orthopyroxene. - Mode: 6%–10%.
Crystal Size: 2–12 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: <2%.
Crystal Size: 1–4 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: <1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Below 37 cm, Pieces 3–9, the lithology returns to porphyroclastic serpentinized harzburgite (pyroxene-poor) and dunite (pyroxene content ranges between 6%–12%). Pieces range from 90%–100% altered. The samples are highly depleted relative most harzburgite sections in the core with most pieces containing regions that require a rock name of pyroxene-bearing dunite. The anastomosing white serpentine vein foliation is poorly developed and more planar, probably as a function of the low pyroxene content. The pieces are riddled by numerous sulfide minerals, composite veins of green chrysotile serpentine ± sulfide minerals, and some tension gashes. Sulfide minerals are very abundant in most pieces, especially Piece 3 adjacent to last piece of amphibolitized microgabbro.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene, clinopyroxene.
Pyrite.
Mode of Occurrence: After clinopyroxene.
Amphibole(?).
Mode of Occurrence: After clinopyroxene.
Comments: Piece 3 is a serpentinite in which all primary minerals have been replaced by serpentine. This section contains abundant crosscutting sulfide mineral stringers. Pieces 4–9 are pervasively altered (90%) harzburgite in which olivine is altered 95%–99% to serpentine, and clay and iron oxide minerals and is enclosed in a dark brown mesh-textured serpenitine matrix. Iron oxide mineral microveinlets associated with serpentine are abundant. Orthopyroxene porphyroclasts exhibit poorly developed alteration halos and are altered 50%–95%. In the most pervasively altered areas bastite forms gray green pseudomorphs. Clinopyroxene-rich zones are moderately altered to amphibole? and serpentine, with a trace of pyrite.
Veins
An anastomosing net of thin serpentine microveins is evident in Pieces 5–7 and 9. Piece 7 is cut by a 2 mm wide green serpentine vein, and by thin (<<1 mm) irregular amphibole and chlorite veinlets. Piece 9 contains a ≈1 mm wide sulfide mineralized serpentine veinlet.
VEIN/FRACTURE FILLING:
Sulfide minerals and serpentine.
Size: <1 mm.
Sulfide mineral stringers.
Size: <1 mm.
Amphibole, serpentine, and chlorite.
ADDITIONAL COMMENTS: Contact Unit 4/ Unit 5
The contact is not exposed and is placed between Pieces 2 and 3. It may be intrusive.
Structure
The harzburgite has a moderate to strongly developed elongated porphyroclastic texture formed by pyroxene elongation. The dips of this foliation cluster around about 30° with a subhorizontal dip in Piece 5. The intensity of the foliation decreases markedly toward the base of the section. An anastomosing foliation, defined by fine (<1 mm) serpentine veins overprints the pyroxene fabric. A pale green serpentine vein in Piece 7 cuts thin white serpentine veins. These white serpentine veins overprint the anastomosing foliation.

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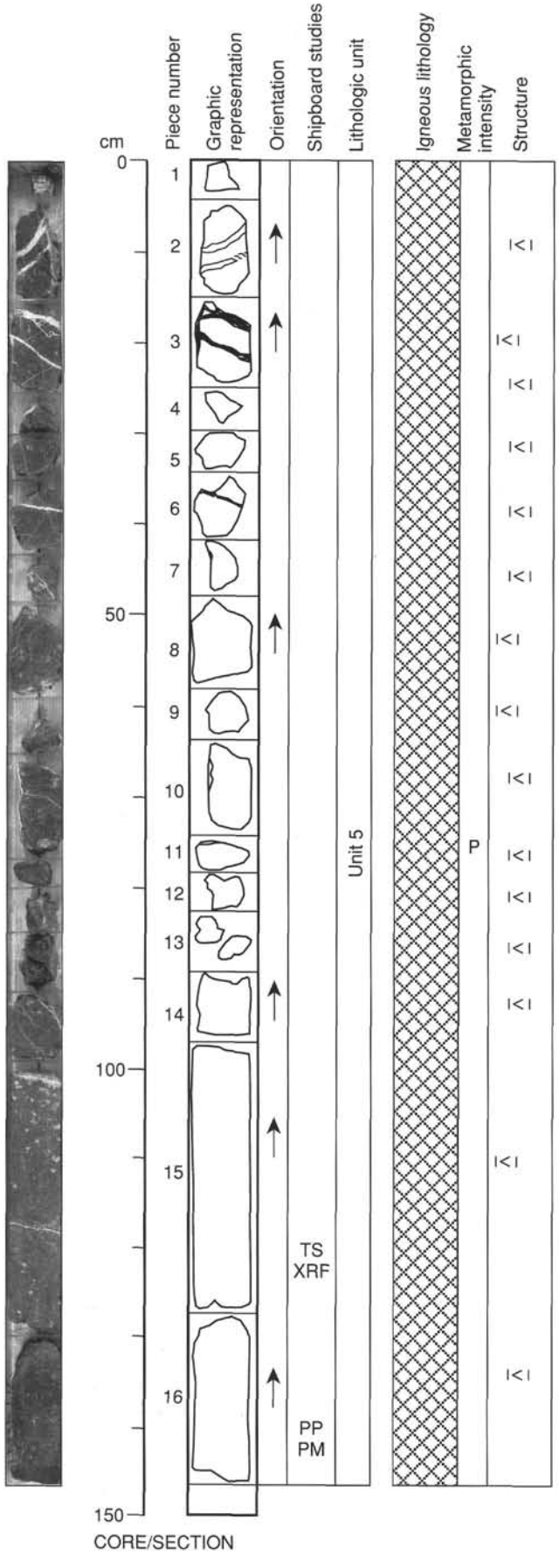

UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1–16

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclatic.
SECONDARY STRUCTURE: Abundant and thick serpentine veins, locally sheared.
PRIMARY MINERALOGY:
Olivine. - Mode: 86%–95%
Orthopyroxene. - Mode: 2%–10%.
Crystal Size: 1–8 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene. - Mode: 0–2%.
Crystal Size: 0.2–2 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 0–1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: The section consists dominantly of porphyroclastic serpentinized *harzburgite highly depleted in pyroxene* (10%–15%), *as well as pyroxene*-bearing dunite. Pieces 1 and 16 contain pyroxene-bearing dunite, all other pieces are pyroxene-depleted harzburgite. Piece 16 contains a dunite band between upper and lower harzburgite bands and appears layered parallel to the high-temperature foliation plane. Orthopyroxene content is relatively low in most samples. Clinopyroxene and spinel are minor phases (<2%). The section is characterized by almost complete alteration and replacement of the primary phases, except for Piece 2, which is relatively fresh (70% altered). Pieces 1, 2, 10, and 15 contain several generations of white-*asbestiform serpentine veins 2 mm to 8 mm thick. Piece 10 contains a* composite serpentine and sulfide minerals vein. There are no magmatic veins obvious in the section.
SECONDARY MINERALOGY:
Magnetite.
Total Percent: 2–3
Mode of Occurrence: Replaces olivine and orthopyroxene.
Serpentine.
Total Percent: 90
Mode of Occurrence: Replaces olivine and orthopyroxene.
Comments: Orthopyroxene-poor zones in Pieces 1–14 are pervasively altered (95%–100%) with complete replacement of olivine by serpentine, which forms a dark mesh-textured matrix. Orthopyroxene is pervasively altered to bastite and brucite?. Clinopyroxene is pervasively altered to serpentine. Disseminated pyrite is common in Pieces 1–10.
Veins
Pieces 2–4, 6, 7,10, and 14 contain 8 mm to <1 mm wide composite veins of carbonate minerals, serpentine, sulfide minerals, chlorite, and minor amphibole which form complex, anastomosing bands within the veins. Some veins contain elongate selvages of the host serpentine. These wide, white, complex veins postdate earlier wispy white and aqua green serpentine veins, and are cut by later <1 mm wide carbonate mineral veins. The top of Piece 15 is bounded by a 2 mm wide, pervasively altered pyroxenite(?) vein now replaced by amphibole and serpentine. Sulfide mineral stringers <<1 mm wide are common in Pieces 2 and 3. Wispy white serpentine veins become more abundant in orthopyroxene-rich zones in Piece 15.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 2%–3%
Size: <2 mm.
Orientation: Foliation parallel.
Comments: Wispy.
Serpentine, carbonate minerals, ± chlorite, ± pyrite.
Percent: <1%
Size: 3–10 mm.
Orientation: Crosscuts foliation.
ADDITIONAL COMMENTS: Structure
A weak, elongated porphyroclastic texture is formed by the shape preferred orientation of pyroxene porphyroclasts. The foliation dips at about 30°. No anastomosing foliation is present. Thin white serpentine veins increase in

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abundance toward the base of the section where there is a corresponding increase in pyroxene content (Pieces 15 and 16). The white serpentine veins are cut by pale green serpentine veins that are, in turn cut by veins of carbonate minerals, serpentine, and sulfide minerals. Veins that overprint the white serpentine veins are mainly discordant to the deformation fabric.

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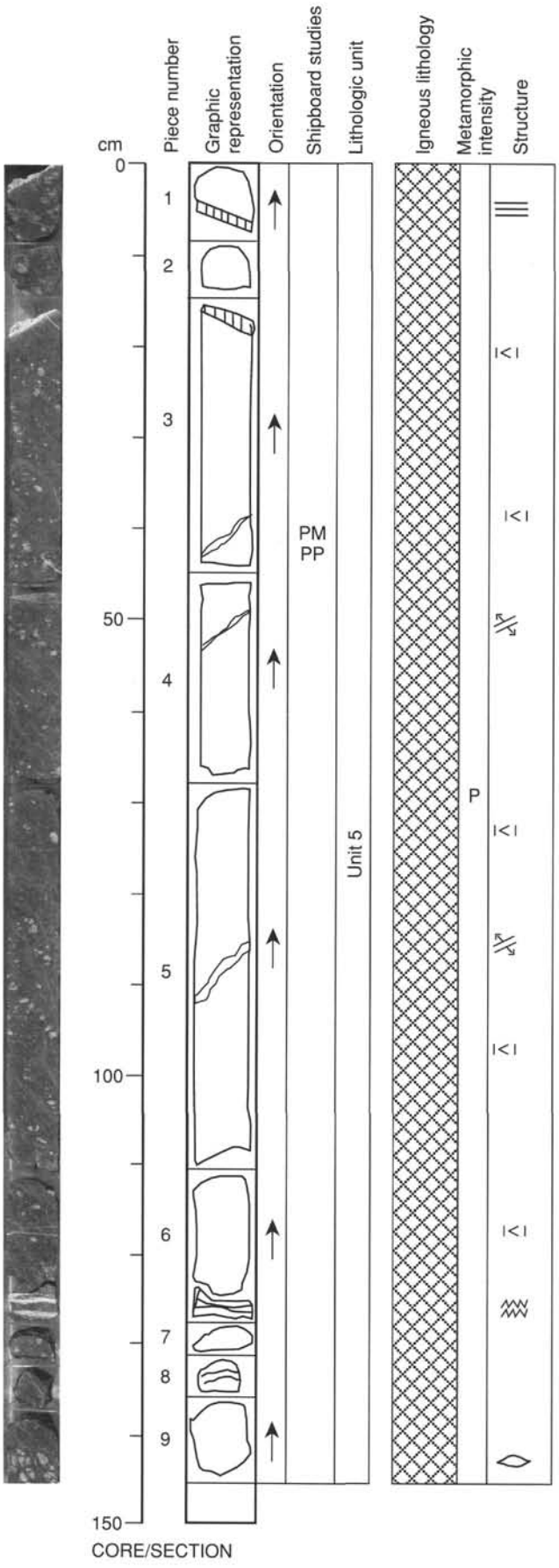
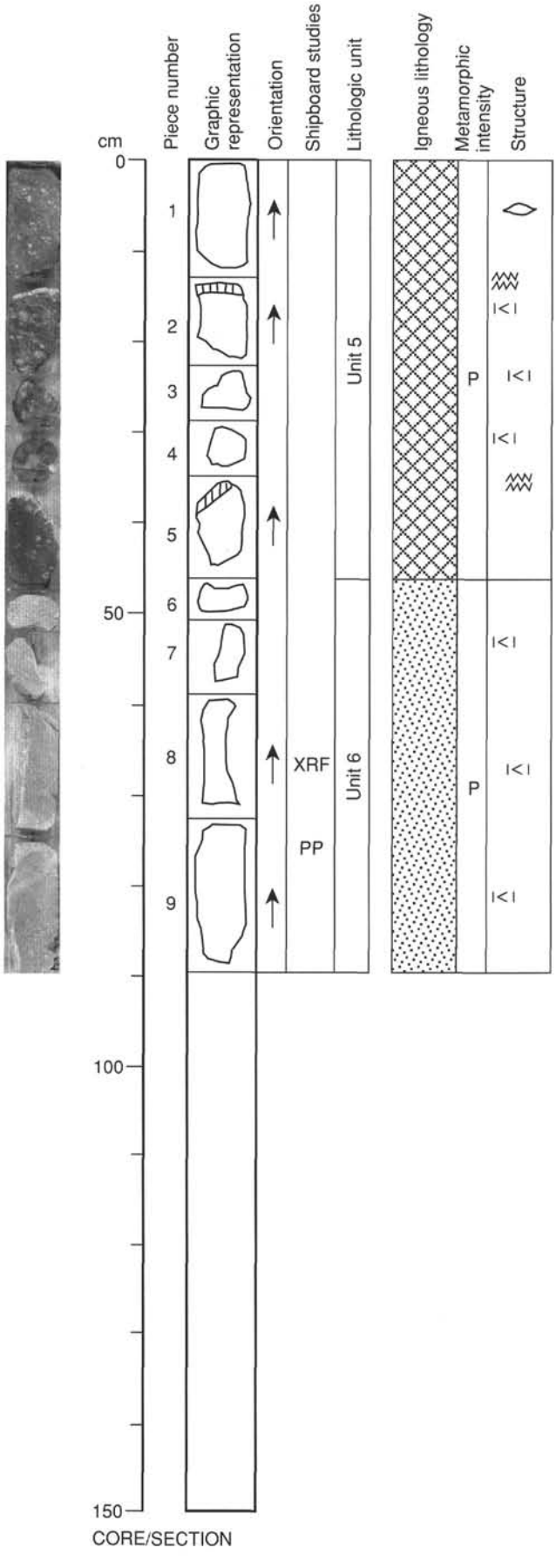


UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1–9

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Abundant and thick serpentine vein network.
PRIMARY MINERALOGY:
Olivine. - Mode: 77%–80%.
Orthopyroxene. - Mode: 11%–16%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene. - Mode: 0–7%.
Crystal Size: 1–10 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: <2%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: The section consists dominantly of porphyroclastic serpentinized harzburgite depleted in pyroxene (15%–20% modal percent), harzburgite highly depleted in pyroxene (10%–15%) as well as pyroxene-bearing dunite. Pieces 1–6 contain 15%–20% pyroxene. Pieces 7–8 contain 10%–15% pyroxene and Pieces 8 and 9 are dunite. Piece 1 contains an altered composite pyroxenite/gabbro vein 1–2 mm thick. The top of Piece 2 contains an altered gabbro vein. Piece 9 contains interbanded pyroxenite and dunite. Total alteration reaches approximately (85%). Fresh orthopyroxene is abundant (50% altered) throughout the section.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 85
Mode of Occurrence: Replaces olivine and orthopyroxene.
Magnetite.
Total Percent: 2–3
Mode of Occurrence: Replaces olivine and orthopyroxene.
Comments: Alteration is heterogeneous downsection, but it is generally pervasive (85%) due to alteration of olivine to serpentine. Serpentine forms a dark, olive green to brown mesh network cut by abundant microveinlets of serpentine and iron oxide minerals. Complex porphyroclastic aggregates of orthopyroxene are highly to pervasively altered (50%–100%) with apple green- to cream-colored cores which are rimmed by serpentine. Dark green pods may be pseudomorphed clinopyroxene which has been replaced by serpentine and chlorite. Large aggregates (10–12 mm long) of fresh clinopyroxene, orthopyroxene, and olivine form rounded, elongate pods in Piece 9.
Veins
Narrow, 1–2 mm wide, dark green patches of amphibole and chlorite are present in Piece 1. Pieces 1 and 3 are bounded by veins of serpentine, prehnite, tremolite, and calcite (after pyroxenite/gabbro), which are cut by narrow, aqua serpentine veins. Piece 5 contains a narrow discontinuous amphibole and chlorite vein, adjacent to which pyroxene grains are pervasively altered to amphibole(?), chlorite, and serpentine. Piece 6 contains a vein network of subparallel, 5–6 mm wide veins of tremolite, serpentine, chlorite, and zeolites. Anastomosing black and white composite serpentine veinlets which wrap around porphyroclasts are abundant.
VEIN/FRACTURE FILLING:
Serpentine, carbonate minerals, and pyrite.
Percent: 1%–2%
Size: 8–15 mm.
Comments: Pieces: 1, 3, and 6.
Tremolite and clinopyroxene.
Percent: 1%
Comments: Alteration around fracture. Pieces: 3 and 4.
ADDITIONAL COMMENTS: Structure
The section is deformed by a weak elongated porphyroclastic texture that intensifies locally within Piece 6. A weak anastomosing foliation is present at the top of the section but is not evident in Pieces 7, 8, and 9. The foliations dip at about 45°. Thin white serpentine veins overprint the anastomosing foliation. An altered gabbroic(?) vein is oriented concordantly to the fabric in Piece 6. Carbonate mineral and prehnite veins cut thin white serpentine veins in Piece 5.



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UNIT 5: SERPENTINIZED HARZBURGITE

Pieces 1–5

COLOR: Dark gray black.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Thick serpentine veins, locally sheared.
PRIMARY MINERALOGY:
Spinel. - Mode: <1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 0–3%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Orthopyroxene. - Mode: 3%–14%.
Crystal Size: 2–10 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Olivine. - Mode: 83%–93%.
Comments: The section consists dominantly of porphyroclastic serpentinized harzburgite depleted in pyroxene (15%–20% modal pyroxene, Pieces 1–4), as well as harzburgite highly depleted in pyroxene (10%–15%, Piece 5). Pieces 2 contains a part of a gabbro vein at the top of the piece and Piece 3 contains part of a pyroxenite vein. Piece 5 contains a serpentine shear zone dipping at ≈45° and Piece 1 contains pyroxene-bearing dunite, all other pieces are pyroxene-depleted harzburgite.
SECONDARY MINERALOGY:
Magnetite.
Total Percent: 2–3
Mode of Occurrence: Replaces olivine and orthopyroxene.
Serpentine.
Total Percent: 90–95
Mode of Occurrence: Repalces olivine and orthopyroxene.
Comments: Alteration intensity is pervasive (90%) due to abundant serpentinization of olivine. Serpentine forms a dark, olive green to brown mesh network cut by abundant microveinlets of serpentine and iron oxide minerals. Complex porphyroclastic aggregates of orthopyroxene, olivine, and clinopyroxene are moderately to pervasively altered (50%–100%) with apple green- to cream-colored cores. Alteration halos are poorly developed and aggregates are commonly rimmed by a dark brown serpentine mesh textured matrix. Dark green pods may be pseudomorphed clinopyroxene which has been replaced by serpentine and chlorite. Large diffuse aggregates (10–20 mm long) of moderately fresh clinopyroxene, orthopyroxene, and olivine form rounded, elongate pods in Pieces 1 and 2 and are crosscut by serpentine veinlets.
Veins
Pieces 2 and 5 contain altered gabbroic veins of serpentine, ± sulfide minerals, ± amphibole, 2–3 mm wide, which are cut by tapering white to green serpentine veinlets. Anastomosing black and white composite serpentine veinlets which wrap around porphyroclasts are common.
VEIN/FRACTURE FILLING:
Serpentine, pyrite, and clay minerals.
Percent: 2%–3%
Size: 3–8 mm.
Pyrite.
Percent: <1%
Size: <1 mm.
ADDITIONAL COMMENTS: Structure
In Pieces 1 to 5 there is a weakly elongated porphyroclastic texture present in the serpentinized harzburgite. No anastomosing foliation is present but thin white discontinuous serpentine veins overprint the porphyroclast foliation and are deflected around the pyroxene prophryoclasts. The foliation dips at about 45°. A reduction in the intensity of white serpentine veins in Pieces 4 through 5 corresponds to a decrease in the pyroxene content. Pale green serpentine veins in Pieces 2 and 5 cut the thin white discontinuous serpentine veins.

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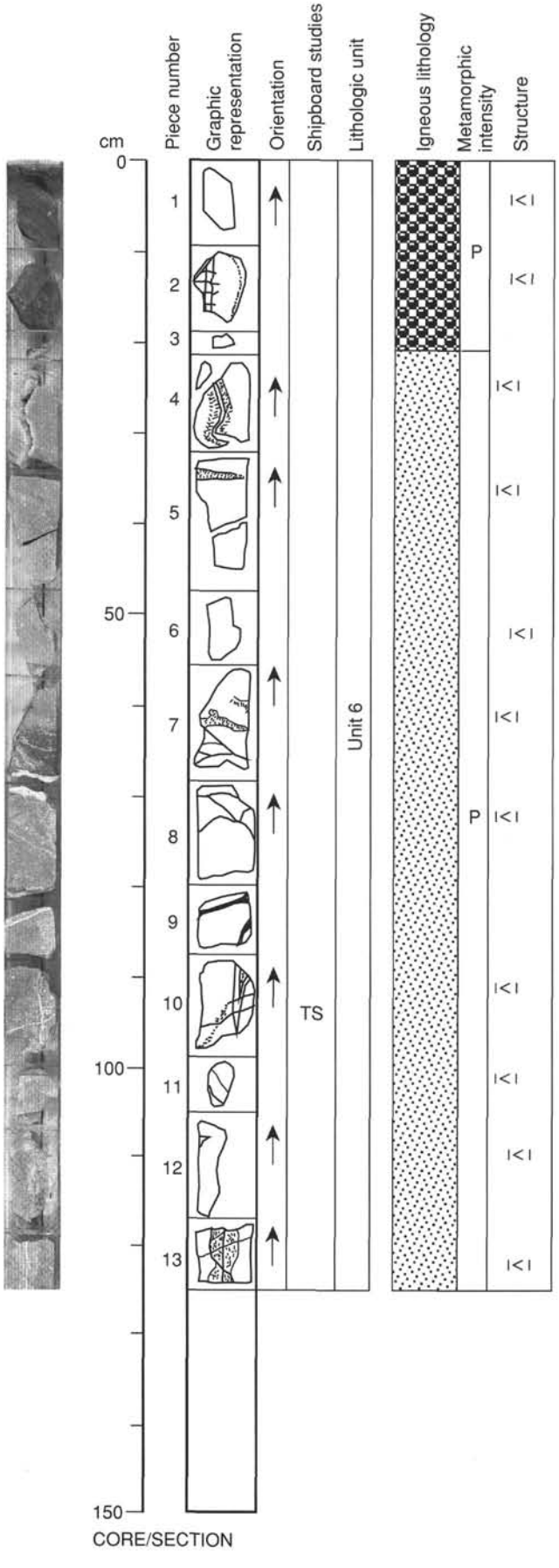
UNIT 6: MODERATELY PORPHYRITIC DIABASE

Pieces 6–9

CONTACTS: Top contact not preserved but chilled margin evident.
PHENOCRYSTS:
Plagioclase. - 0–4%; 1–4 mm; Subhedral.
Olivine. - 1%–2%; 1–2 mm; Euhedral.
GROUNDMASS: Clinpyroxene/plagioclase/magnetite(and ilmenite), 35/60/2%–3%
COLOR: Light gray.
ALTERATION: Olivine completely replaced by chlorite and serpentine?
VEIN/FRACTURES:
Plagioclase, clinopyroxene, amphibole, and chalcopyrite?
Size: 2–3 mm.
Description: Has an 8 mm alteration halo.
ADDITIONAL COMMENTS: CONTACT Units 4/5 : The contact is placed between Pieces 5 and 6 and is not exposed in the core. Piece 6 is a strongly chilled diabase suggesting an igneous chilled contact with the overlying harzburgite.
The lower part of the section (Pieces 6–9) is gray sparsely porphyritic diabase (Unit 6). A strongly chilled margin is preserved in Piece 6. The grain size of the groundmass increases downsection in subsequent pieces from Piece 6 to 9. Altered olivine and plagioclase form the major phenocryst phases which progressively become more abundant and larger in size downsection from Pieces 6–9. The groundmass consists of clinopyroxene, plagioclase, and ilmenite/magnetite in ophitic to subophitic relation. Spinel appears also as a minor phenocryst phase.
Metamorphic
Alteration of the diabase is moderate to high with the groundmass altered to zeolite, chlorite, and a trace of amphibole. Plagioclase phenocrysts are replaced by secondary plagioclase, clay minerals, and prehnite? adjacent to veins. Olivine phenocrysts are pervasively replaced by chlorite and serpentine with fine amphibole rims. Prehnite and zeolites occur in narrow ≤1 mm crosscutting veinlets.
Structure
The only structures found in the diabase are thin (<1 mm), irregular veins of prehnite and zeolites that show no preferred orientation.



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UNIT 6: SERPENTINIZED HARZBURGITE RUBBLE

Pieces 1–3

COLOR: Black.
PRIMARY STRUCTURE:
SECONDARY STRUCTURE:
PRIMARY MINERALOGY:
Olivine. - Mode: 90%–95%.
Orthopyroxene. - Mode: 5% –10%.
Crystal Size: 1–10 mm.
Crystal Shape: Anhedral.
Comments: Pieces 1 and 2 are highly serpentinized pyroxene-bearing dunite and depleted harzburgite. Olivine and orthopyroxene are 100% replaced by serpentine. No unaltered or pseudomorphed clinopyroxene was identified. Piece 3 is a highly altered and metasomitized piece of a gabbroic vein within serpentinized harzburgite. These pieces are believed to be wash that has fallen in during core retrieval.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 95
Mode of Occurrence: Replaces olivine and orthopyroxene.
Magnetite.
Total Percent: 3–4
Mode of Occurrence: Replaces olivine and orthopyroxene.
Sulfide minerals.
Total Percent: <1
Mode of Occurrence: See description.
Comments: Disseminated adjacent to veins.
Comments: Pieces 1 and 2 are pervasively serpentinized (100%) harzburgite, with abundant sulfide minerals along the foliation. Piece 2 contains a 5 mm wide green serpentine vein and a parallel vein (1 mm wide) of white serpentine and sulfide minerals. Piece 3 is pervasively altered and metasomatized gabbroic vein which is replaced by abundant serpentine. The bounding wall rock is serpentinized harzburgite.
VEIN/FRACTURE FILLING:
Serpentine and sulfide minerals.
Percent: <1%
Size: 8 mm.
Sulfide minerals.
Percent: <1%
Size: <1 mm.
Green serpentine.
Percent: <1%
Size: 1 mm.
Orientation: See description.
ADDITIONAL COMMENTS: These pieces are probably rubble washed down when previous core was retrieved.
Structure
No elongate porphyroclastic texture or anastomosing foliation is evident in the serpentinized harzburgite. In Piece 2 a green serpentine vein is cut by a thin (1 mm) white serpentine vein. The serpentine vein fragment in Piece 3 preserves aligned serpentine fibers.

UNIT 6: PORPHYRITIC DIABASE

Pieces 4–13

CONTACTS: Not preserved in core, but chilled margin continues (from Core 8R-3) in Piece 4.
PHENOCRYSTS:
Olivine. - 2%–7%; 0.5–3 mm; Euhedral.
Plagioclase. - 2%–10%; 1–5 mm; Euhedral.
GROUNDMASS: Subophitic and intergranular. Minerals: plagioclase, olivine(?, clinopyroxene, magnetite, and ilmenite. Proportions: 30%–40%, 30%–40%, 20%–25%, 1%–2%. Grain size: 0.1–1, 0.2–0.5, 0.1–1, 0.1 mm.
COLOR: Pale gray.
ALTERATION: Olivine phenocrysts are 100% pseudomorphed by chlorite and a white mineral (?clay/serpentine). Groundmass olivine is replaced by chlorite. Plagioclase and clinopyroxene are only 5%–10% altered.

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VEIN/FRACTURES:

Quartz, epidote, and clay minerals.

Size: 1 mm.

Description: Open fracture fillings.

Quartz

Percent: 2%–3%.

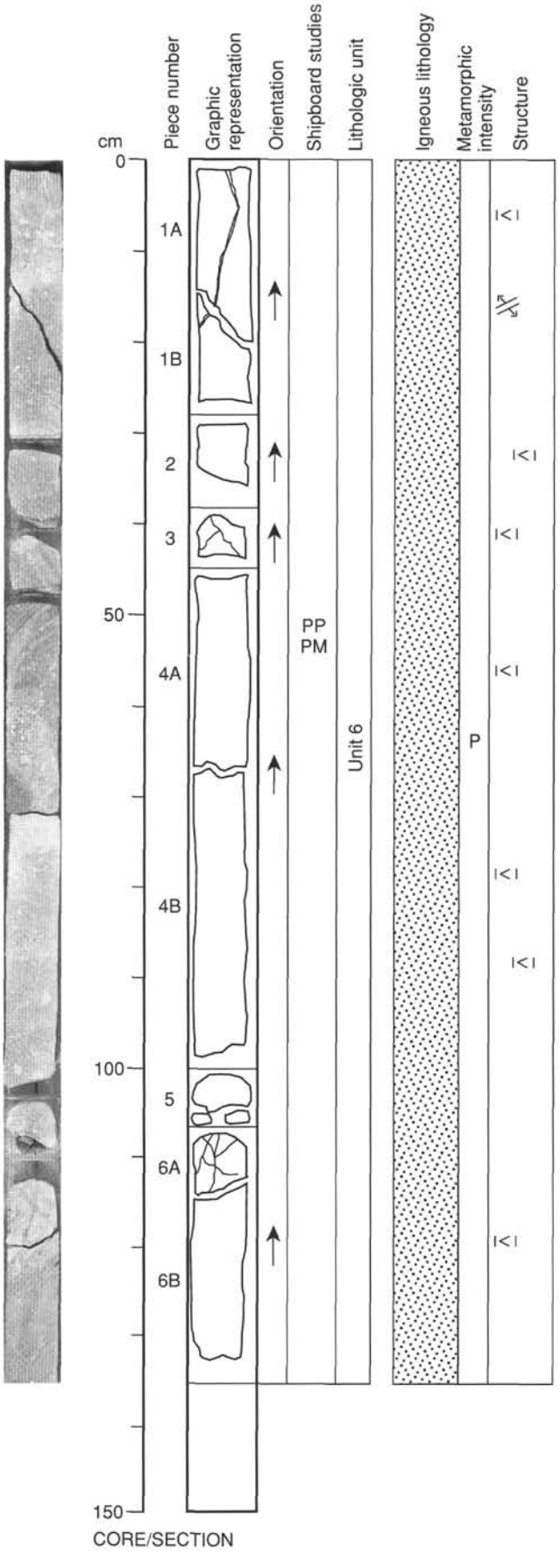
Size: 1–10 mm.

Description: Two main sets. Have alteration halos in diabase up to 15 mm wide.

ADDITIONAL COMMENTS: Pieces 4–13 are relatively fresh, moderately to highly (5%–15%) plagioclase-olivine phyric diabase (Unit 6). Plagioclase phenocrysts (euhedral laths; 5%–10% altered) are more abundant than olivine and range in size from 1– 5 mm; olivine phenocrysts (euhedral but 100% pseudomorphed by chlorite and an unidentified white (?clay/serpentine) mineral) are 0.5–3 mm in size. The groundmass is composed of plagioclase laths (0.1–1 mm) subophitically enclosed by brown clinopyroxene (0.1–1 mm) and intergranular brown clinopyroxene and olivine (0.2–0.5 mm; replaced by chlorite). Piece 4 is slightly finer grained and less porphyritic (5%) than Pieces 5–13, suggesting that it lay closer to the chilled margin of the dike than the subsequent pieces of the section. The grain size of Piece 4 is similar to that of the last piece (Piece 9) recovered in Core 153-920D-8R-3 with which it is believed to have been contiguous.

Metamorphic

The diabase (Pieces 4–13) shows moderate (less than 30%) alteration. Alteration minerals after groundmass mesostasis include clay minerals, chlorite, and actinolite. Prehnite, secondary plagioclase, granular epidote, chlorite, clay and zeolite minerals moderately to pervasively replace plagioclase phenocrysts and clinopyroxene is commonly replaced by actinolite. Olivine phenocrysts are pseudomorphed by zoned, euhedral pods containing cores of serpentine(?), chlorite, and clay minerals that are rimmed by fine-grained fibrous amphibole. Prehnite and zeolite veins crosscut Pieces 4, 7, 8, 12, and 13; some induce lighter gray alteration halos in the diabase (Pieces 12 and 13).



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UNIT 6: MODERATELY TO HIGHLY PHYRIC DIABASE

Pieces 1A–6B

CONTACTS: Not observed.
PHENOCRYSTS:
Olivine. - 3%–5%; 1–4 mm; Subhedral.
Plagioclase. - 8%–15%; 1–6 mm; Euhedral.
GROUNDMASS: Clinopyroxene-40%, plagioclase-60%, ilmenite and magnetite-1% with subophitic texture.
VESICLES: <1 % Size: 1–3 mm. Shape: Rounded
Distribution: Rare
COLOR: Pale gray.
ALTERATION: Moderate (50%) prehnite alteration of groundmass in Piece 1. Serpentine after olivine.
VEIN/FRACTURES:
Prehnite? and quartz.
Percent: 1%–2%.
Size: 1–15 mm.
Description: Alteration selvage proportional in width to vein width.
ADDITIONAL COMMENTS: Moderately to highly-phyric diabase (Unit 6) comprising olivine (3%–5%) and plagioclase (8%–15%) phenocrysts in an ophitic textured groundmass of 40% clinopyroxene, 60% plagioclase, and 1% ilmenite/magnetite. Amygdules filled with prehnite, chlorite, and serpentine are distributed irreglarly throughout the core. A xenocryst of fresh olivine is present in Piece 1A. A decrease in the density of phenocrysts and grain size of the groundmass in Piece 6B suggests that the lower contact of the dike was approached.

Metamorphic
The diabase is moderately altered (30%). Secondary minerals after groundmass mesostasis include clay minerals, chlorite, and actinolite-tremolite. Prehnite, secondary plagioclase, chlorite, clay and zeolite minerals moderately to pervasively replace plagioclase phenocrysts. Clinopyroxene is commonly replaced by actinolite. Olivine phenocrysts are pseudomorphed by zoned, euhedral pods containing cores of serpentine, chlorite, and clay minerals that are rimmed by fine-grained fibrous amphibole.

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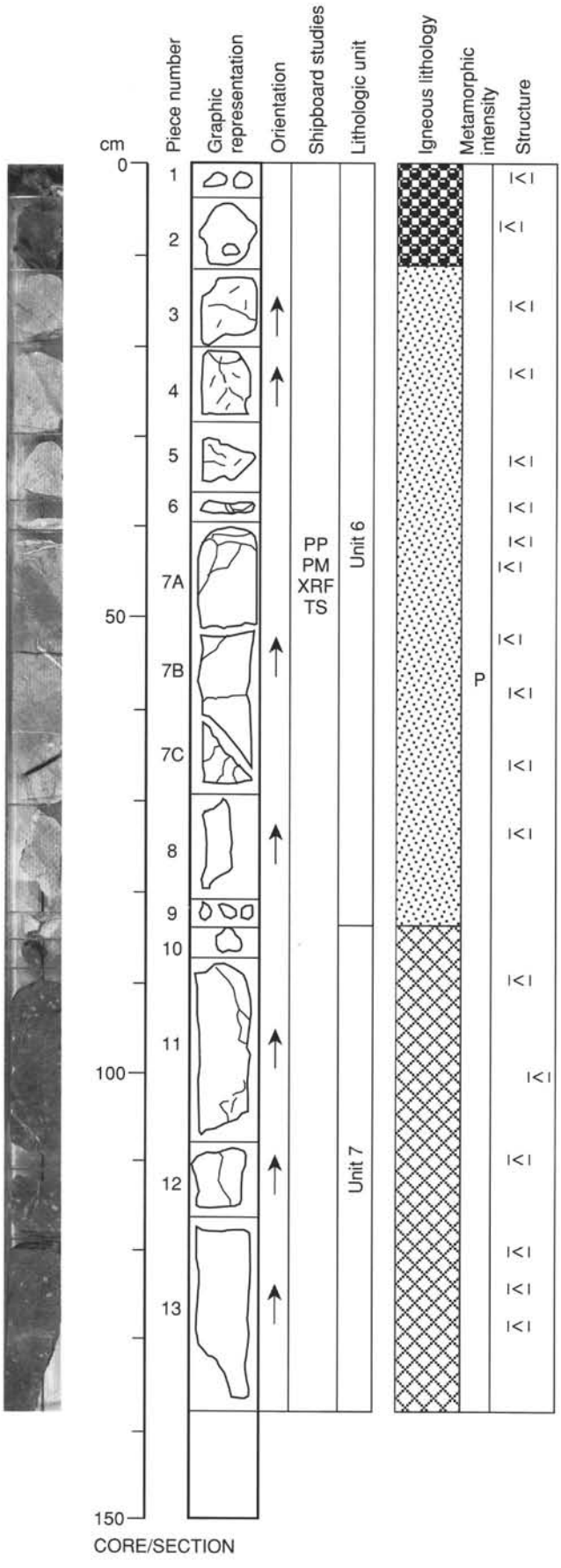

UNIT 6: MODERATELY PORPHYRITIC DIABASE

Pieces 1–9

CONTACTS: Not observed, middle part of dike.
PHENOCRYSTS:
Plagioclase. - 3%; 1–4 mm; Euhedral.
Olivine - 1%; 1–5 mm; Anhedral.
GROUNDMASS: Fine grained (<1 mm) with an intergranular texture. Minerals: plagioclase(laths), clinopyroxene or amphibole, magnetite and ilmenite(laths).
Distribution:
COLOR: Light gray.
ALTERATION: Patchy chlorite alteration (after olivine?).
VEIN/FRACTURES:
Quartz, prehnite, epidote.
Percent: 1%–2%.
Size: 2–3 mm.
Orientation: See description.
Description: Several horizontal, some steep but varying.
ADDITIONAL COMMENTS: Pieces 1 and 2 consists of pyroxene-depleted, serpentinized porphyroclastic harzburgite that appears to represent wash at the top of the core. Below these two pieces, a sparsely to moderately phyric diabase (Unit 6) comprising olivine (3%–5%) and plagioclase (8%–15%) phenocrysts in an ophitic textured groundmass of 40% clinopyroxene, 60% plagioclase, and 1% ilmenite/magnetite is present within Pieces 2–8. A decrease in the density of phenocrysts and grain size of the groundmass in Pieces 7B through 9 suggests that the lower contact of the dike was approached. Piece 2 is approximately the same grain size as the last piece in 153-920D-9R2 (Piece 13) suggesting that they may have been nearly contiguous and further supporting the suggestion that the upper two pieces of this section are wash pieces that interupt the cored interval. Piece 7B preserves a 5 mm thick zone of spotted diabase inclined at approximately 50°. The spotting (≈0.3 mm) is due to small clots of slender radiating accicular feldspar. The diabase in this piece appears to have intruded later than, but soon after, the host dike because the chilled margin continues across the narrow zone suggesting that the intrusions were nearly contemperaneous.
Metamorphic
Pieces 1 and 2 are pervasively replaced by mesh textured serpentine after olivine. Olivine is commonly replaced 90%–100%, with netveins of fine-grained iron oxide minerals common. Rare orthopyroxene is moderately to pervasively altered to serpentine and bastite. In Pieces 2–9, alteration of the diabase is moderate with alteration dominated by clay minerals, amphbiole, and zeolite(?) after groundmass mesostasis. Plagioclase phenocrysts are slightly altered to secondary plagioclase along microfractures and minor chlorite and amphibole along grain boundaries. Clinopyroxene is slightly altered to actinolite. The diabase is cut by irregular, branching network of prehnite and zeolite veins (0.6 to 1 mm wide) that show no preferred orientation.

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UNIT 6: MODERATELY PORPHYRITIC DIABASE

Pieces 10–13

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Several generations of serpentine veins.
PRIMARY MINERALOGY:
Spinel. - Mode: <1%.
Crystal Size: 2 mm.
Crystal Shape: Anhedral.
Crystal orientation: Tectonic.
Clinopyroxene. - Mode: 2%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Orthopyroxene. - Mode: 7%.
Crystal Size: 2–10 mm.
Crystal Shape: Anhedral.
Crystal orientation: Tectonic.
Olivine. - Mode: 80%–90%.
Comments: Pieces 10–13 consist of serpentinized porphyroclastic harzburgite depleted in pyroxene content (10%–15% modal percent) and makes up the base of this section. Piece 13 contains pyroxene-bearing dunite intervals. A thin (<2 mm) magnetite-sulfide mineral vein cuts the core in Piece 13.
SECONDARY MINERALOGY:
Magnetite.
Total Percent: 3
Mode of Occurrence: Replaces olivine and orthopyroxene.
Serpentine.
Total Percent: 82
Mode of Occurrence: Replaces olivine and orthopyroxene.
Comments: The harzburgite in Pieces 10–13 is 95%–98% altered. Olivine is (95%–100%) altered to a dark green mesh of serpenitne and iron oxide minerals. Pyroxene is 95%–98% altered to gray bastite. The anastomosing serpentine fabric is well developed in Piece 11, less in the other pieces. Later discontinuous whitish serpentine veins (<1mm wide) are present in Pieces 11 and 12. In Piece 13, there is a 2 mm wide serpentine and magnetite vein, which may be contemporaneous with the anastomosing serpentine fabric, and is surrounded by a dull green halo.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: <1%
Size: 0.2 mm.
Orientation: Foliation parallel.
Serpentine, chlorite, and sulfide minerals.
Percent: 1%
Size: 6 mm.
Orientation: See description.
Comments: At an angle to foliation (Piece 13).
ADDITIONAL COMMENTS: Contact Unit 6/Unit 7
The contact between diabase (Unit 6) and harzburgite (Unit 7) is not exposed and placed between Pieces 9 and 10. Piece 9 is strongly chilled diabase suggesting that the diabase is intrusive into the subadjacent harzburgite. The upper contact showed the same relationship.
Structure
A very weak elongated porphyroclastic texture is present, defined by the shape preferred orientation pyroxene porphyroclasts. The fabric is strongest in Piece 11. No penetrative anastomosing foliation of serpentine veins is present but sparse arrays of thin white discontinuous veins overprint the porphyroclastic texture. Three generations of veins are evident in Piece 11. A dark green serpentine vein (4 mm) is cut by the thin white serpentine veins. A pale green serpentine vein cuts across the white serpentine veins orthogonally.

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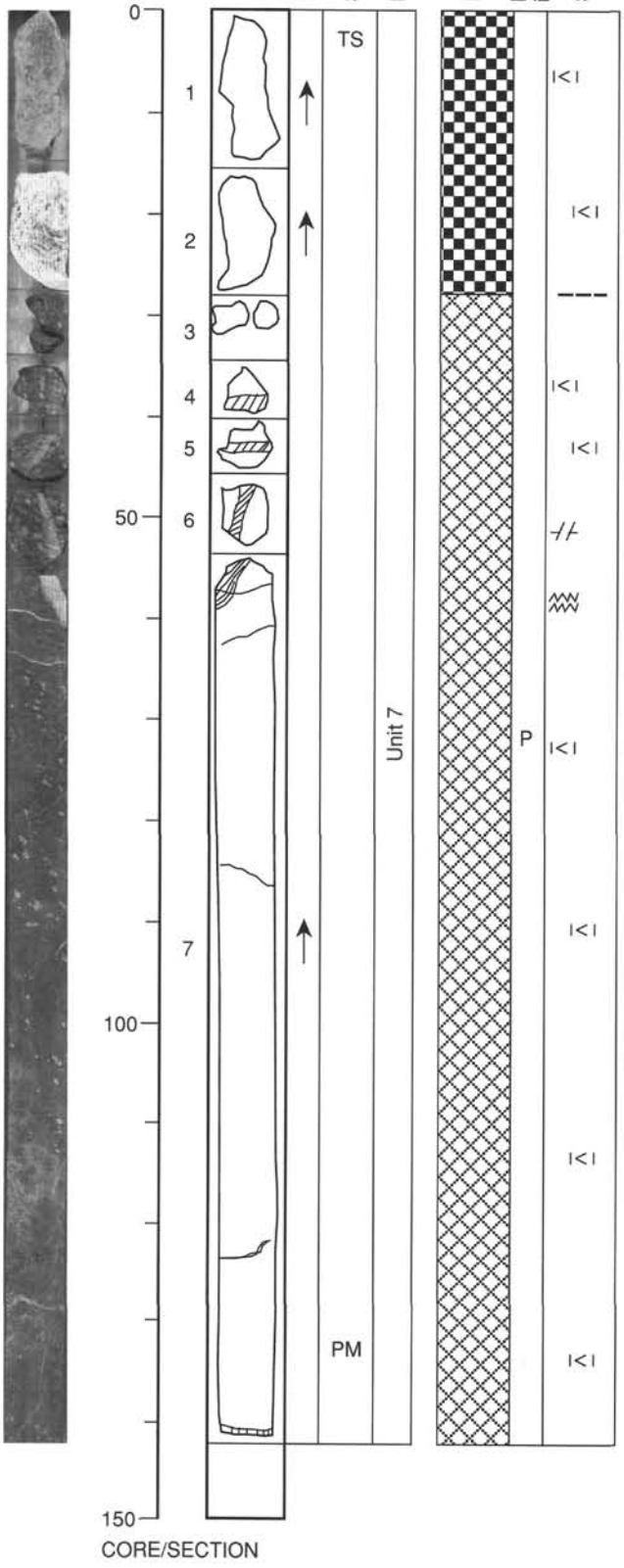
UNIT 7: SERPENTINIZED HARZBURGITE

Pieces 1–7



COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Several generations of serpentine veining, weakly developed.
PRIMARY MINERALOGY:
Olivine. - Mode: 90%.
Orthopyroxene. - Mode: 6%–10%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral.
Crystal orientation: Tectonic.
Spinel. - Mode: 0–1%.
Crystal Size: 2 mm.
Crystal Shape: Anhedral.
Comments: Piece 1, is a chlorite, actinolite, and iron oxide mineral-bearing rock containing 15% iron oxide minerals. Its protolith is probably an oxide metagabbro. The texture of opaque oxide minerals is fine grained, anhedral and appears to have a space filling relationship to altered pyroxene. Piece 2 is a fibrous, white to pale green, strongly serpentinized rock containing chlorite and talc, plus relatively high spinel abundances (2%). The altered primary minerals are strongly lineated and tectonized. The origin of this rock is unclear, but it may represent a sheared and rodingitized metagabbro. Pieces 3–7 are dark gray serpentinized harzburgite to dunite containing 6%–14% orthopyroxene. They are characterized by porphyroclastic textures. Only a trace amount of clinopyroxene is present except near clinopyroxenite veins. Pieces 4, 5, and 6 contain altered pyroxenite veins (1–2 cm in thickness) that cut across the high-temperatures cystal-plastic fabric at high angles. These veins appear undeformed. The upper part of Piece 7 is a harzburgite, but the base of the piece is largely pyroxene-bearing dunite.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 90–93
Mode of Occurrence: Replaces olivine and orthopyroxene.
Magnetite.
Total Percent: 5
Mode of Occurrence: Replaces olivine and orthopyroxene.
Comments: The silicates in Piece 1 are pervasively altered (100%) to chlorite, actinolite-tremolite, and iron oxide minerals. The primary mineralogy is obscurred by the formation of secondary phases, though the presence of oxide minerals and abundant actinolite indicate it was probably an oxide metagabbro. This piece is also cut by a 3 mm prehnite vein. Piece 2 is a sheared serpentinite containing dark streaks that may have been spinel, now iron oxide minerals, and a green serpentine matrix containing vaguely discernable relics, possibly of pyroxene. The matrix is cut by sheared veins of pale green to white serpentine. Pieces 3 to 6 are 60%–75% serpentinized harzburgite. Olivine is replaced (80%–90%) by a dark green mesh of serpentine and iron oxide minerals and pyroxene is 60%–80% replaced by serpentine with lesser actinolite and chlorite. These pieces contain an oxide-bearing, amphibole and chlorite vein, 2–5 mm thick, with a halo of amphibole ± talc(?) alteration. This vein is cut by serpentine filled cracks. Piece 7 exhibits patchy alteration (90%) by a dark green or gray green mesh of serpentine and iron oxide minerals. Orthopyroxene is altered to dull green bastite (80%–90%). This piece has a weakly developed network of anastomosing serpentine veins (<<1 mm) and 2 thin (1–2 mm) amphibole and chlorite veins.
VEIN/FRACTURE FILLING:
Serpentine and sulfide minerals.
Size: 0.2 mm.
Orientation: Foliation parallel.
Serpentine.
Size: 0.2 mm.
Orientation: See description.
Comments: High angle to foliation.
Serpentine, magnetite, sulfide minerals, and tremolite?.
Size: 5–15 mm.
Orientation: See description.
Comments: High angle to foliation.

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ADDITIONAL COMMENTS: Structure

The first piece of the section contains a metagabbro but no deformation fabrics are evident. In Piece 2, a strongly sheared and veined serpentinite contains crenulated and microfaulted serpentine fibers. Dark streaks within this piece may represent deformed spinels. A well-developed elongate porphyroclastic fabric is present in Pieces 3 to 7 but there is only a weak anastomosing foliation and thin white serpentine veins are sparse. The foliation dips at about 60° to 70°. These veins cut across amphibole and chlorite veins (metagabbro?) in Pieces 4, 5, 6, and 7.

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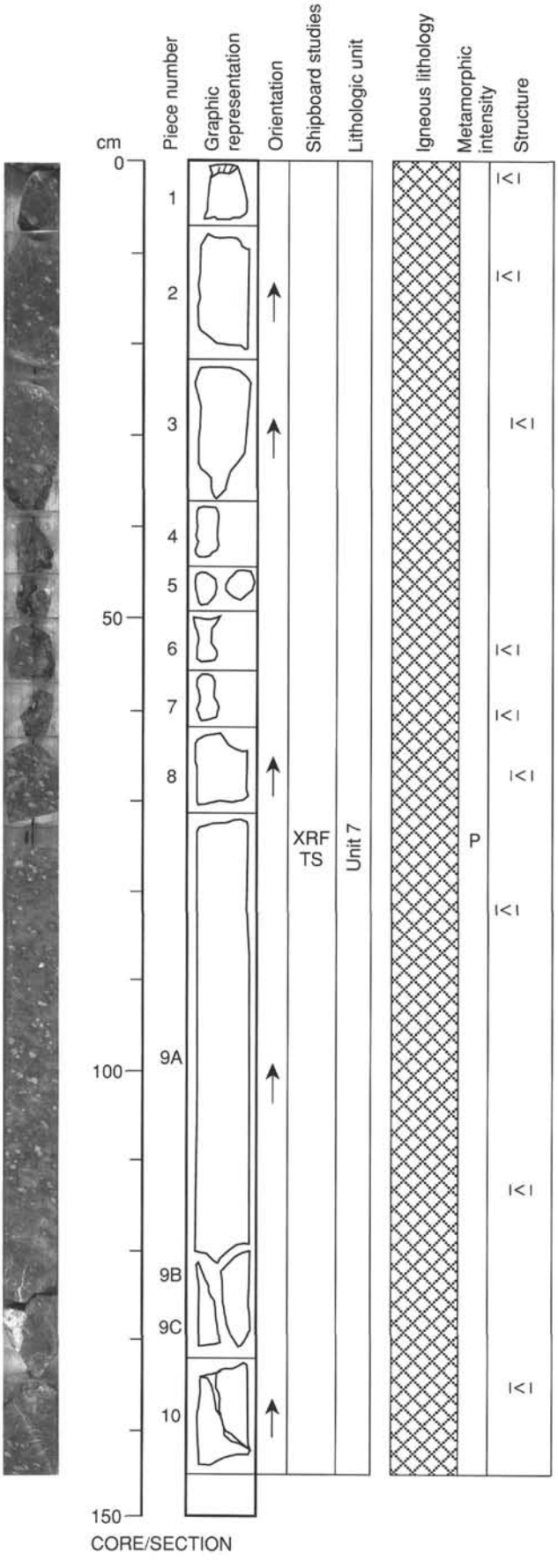
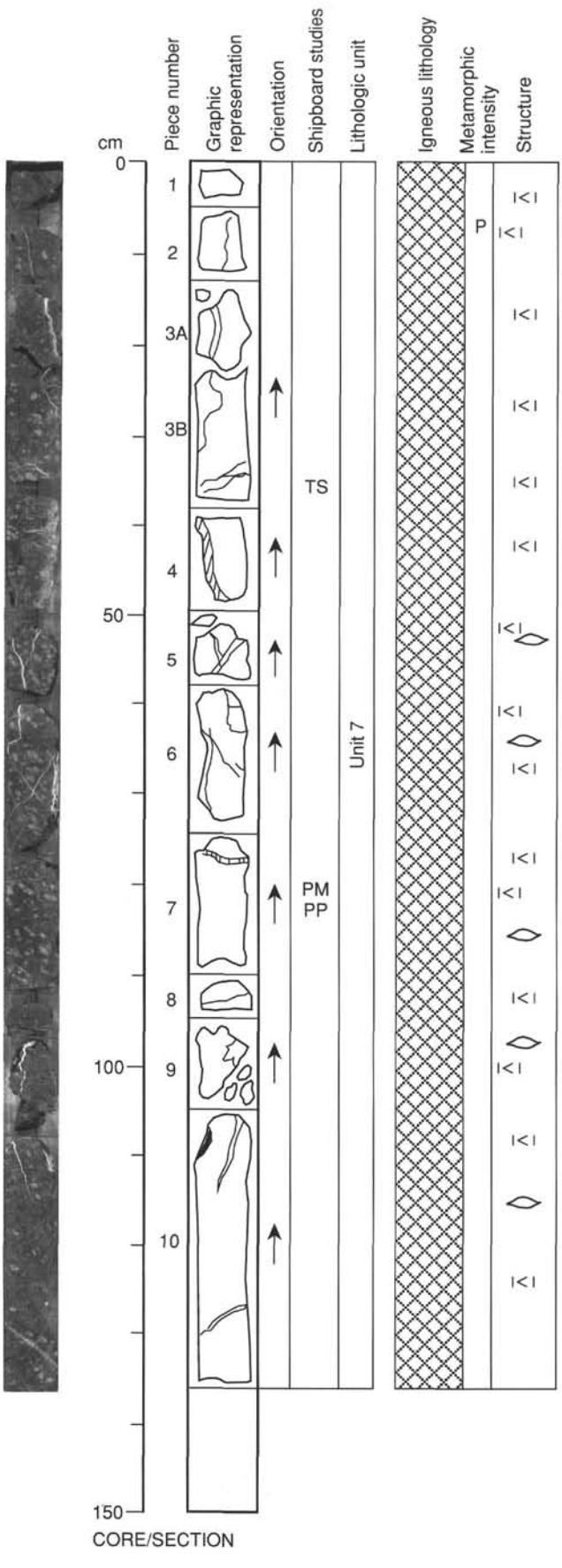


UNIT 7: SERPENTINIZED HARZBURGITE

Pieces 1–10

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Weak vein development.
PRIMARY MINERALOGY:
Olivine. - Mode: 85%–88%.
Orthopyroxene. - Mode: 10%–12%.
Crystal Size: 2–12 mm.
Crystal Shape: Anhedral.
Crystal orientation: Tectonic.
Clinopyroxene. - Mode: 1%–2%.
Crystal Size: 1–6 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: The section consists of gray black, serpentinized porphyroclastic harzburgite highly depleted in pyroxene (only 10–15 modal percent). There are no magmatic veins in the section and the anastomosing white serpentine vein set is not developed, consistent with the low pyroxene content. Piece 9 and 10 contain two serpentine and sulfide mineral composite veins that cut the high-temperature cystal-plastic fabric at high angles. Clinopyroxene is generally <1% of the pyroxene content. Alteration of the primary phases reaches 80%–90% in most pieces.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 90
Mode of Occurrence: Replaces olivine and orthopyroxene.
Comments:
Magnetite.
Total Percent: 3
Mode of Occurrence: Replaces olivine and orthopyroxene.
Comments: This section of harzburgite is 80%–90% altered to a dark green mesh serpentine and iron oxide minerals. Pieces 8 and 9 are a lighter shade of green. Pyroxene is 70%–90% altered to bastite. Dark spots of unknown origin or affinity are in the lower part of Piece 9A. The anastomosing serpentine fabric is well developed in Pieces 2 and 9. Pieces 1, 9B, and 10 contain brown to dark green serpentine, magnetite, ± sulfide mineral-bearing veins. In Piece 10, this vein is 0.5 cm across and is surrounded by a pervasively serpentinized halo. This vein set is cut by irregular serpentine, ± carbonate mineral, ± sulfide mineralized veins in Pieces 1, 6, 9, and 10.
VEIN/FRACTURE FILLING:
Serpentine and sulfide minerals.
Percent: <1%
Size: 0.2 mm.
Orientation: See description.
Comments: From parallel to, to high angle to foliation.
Serpentine and magnetite.
Percent: < 1%
Size: 6–8 mm.
Comments: Piece 10.
ADDITIONAL COMMENTS: Structure
A moderately strong elongated porphyroclastic texture, defined by pyroxene porphyroclast elongation intensifies toward the base of the section. An anastomosing foliation overprints the pyroxene fabric and is highlighted by sparse white serpentine veins that are deflected around porphyroclasts. Aspect ratios of orthopyroxene porphyroclasts vary from 1.4 to 2.5. Increases in the intensity of the anastomosing vein fabric broadly correspond to increases in intensity of the orthopyroxene grain elongations. The foliations dip at about 40° to 45°. The white serpentine veins are cut by pale green serpentine veins, containing carbonate and sulfide minerals.



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UNIT 7: SERPENTINIZED HARZBURGITE

Pieces 1–10

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Crosscutting green serpentine veins.
PRIMARY MINERALOGY:
Olivine. - Mode: 83%–94%.
Orthopyroxene. - Mode: 5%–15%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Crystal orientation: Tectonic.
Clinopyroxene. - Mode: 0–3%.
Crystal Size: 1–5 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: <1%–1%.
Crystal Size: 2 mm.
Crystal Shape: Anhedral.
Comments: The section consists of dark gray serpentinized porphyroclastic harzburgite and dunite highly depleted in pyroxene (range 6%–15%). Pieces 1–7 and 9–10 are harzburgite and Piece 8 is a pyroxene-bearing dunite. Steeply inclined white serpentine veins a few mm to 1 cm wide are contained within Pieces 1, 2, 5, and 6. Pieces 4 and 10 contain altered clinopyroxenite veins 5 mm wide that are discordant with respect to the high-temperature crystal-plastic fabric.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 82
Mode of Occurrence: Replaces olivine and orthopyroxene.
Magnetite.
Total Percent: 3
Mode of Occurrence: Replaces olivine and orthopyroxene.
Comments: This section comprises 70%–100% serpentinized harzburgite. Olivine is replaced (80%–90%) by a dark green mesh of serpentine and iron oxide minerals and pyroxene is 60%–80% replaced by bastite. Pieces 5–7 are less altered (70%), with abundant gray patches containing relict olivine and pyroxene. Pieces 8 and are 100% altered. The anastomosing serpentine fabric is well developed in Pieces 5–10. This fabric is cut by serpentine and sulfide mineral-bearing veins. A 1–5 mm thick white to gray branching serpentine vein with minor sulfide minerals runs for the length of most of the section (Pieces 2, 3, 5, 6, 9, and 10). In Piece 4, a zone of amphibole (actinolite) and chlorite after pyroxenite, occurs as a selvage around a later serpentine vein. This later vein is pale green, carries minor sulfide minerals, and has secondary veinlets running at 90°, as is typical for these veins. The alteration zone appears to passively replace the earlier porphyroclastic harzburgite texture, and thus is a low-temperature hydration zone rather than a melt migration vein. In Piece 10, a 1 mm wide clinopyroxenite vein, pervasively replaced by amphibole and chlorite, is surrounded by a dull green halo of pervasively serpentinized harzburgite.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 1%
Size: 0.2 mm.
Orientation: Foliation parallel.
Serpentine, amphibole, and magnetite.
Percent: < 1%
Size: 4 mm.
Orientation: Angle to foliation.
Serpentine and sulfide minerals.
Percent: < 1%
Size: 0.3 mm.
ADDITIONAL COMMENTS: Structure
The shape preferred orientation and elongation of orthpyroxene porphyroclasts increases downsection from a nonexistent fabric at the top of the section to a moderate intensity in Pieces 6 to 8. The fabric has a moderate to shallow dip. Four distinct generations of veins are evident. The earliest generation is represented by an amphibole and chlorite vein (metagabbro?) that is cut by pale green, sulfide mineral-bearing veins that are typically irregular and branching (e.g. Piece 4 and Piece 10). In Piece 10, serpentine fibers are oriented obliquely to the margins of 5 mm wide vein.

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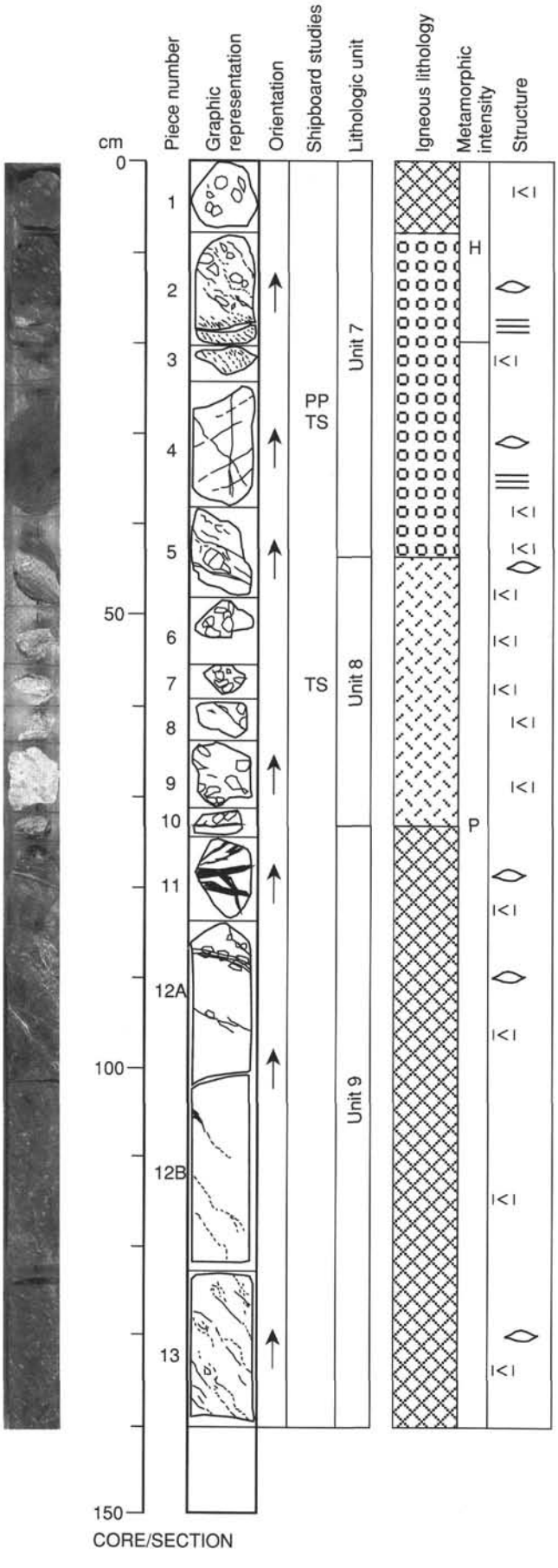

UNIT 7: SERPENTINIZED HARZBURGITE

Pieces 1–5

COLOR: Black green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Cm-scale zones of elongated porphyroclastic texture and serpentine veins.
PRIMARY MINERALOGY:
Spinel. - Mode: 1%–2%.
Clinopyroxene. - Mode: 0–2%.
Crystal Size: 2–4 mm.
Crystal Shape: Anhedral.
Orthopyroxene. - Mode: 0–21%.
Crystal Size: 2–6 mm.
Crystal Shape: Anhedral.
Olivine. - Mode: 74%–99%.
Comments: Porphyroclastic serpentinized harzburgite and dunite (Pieces 1–5). The top of Piece 1 is a harzburgite (with 21% orthopyroxene), in which the pyroxene content rapidly decreases downward through the piece and into Piece 2, which is a dunite. Pieces 2, 3, 4, and 5 are dunite. Piece 5 contains a large single clinopyroxene grain 25 mm in length. An igneous gabbroic contact occurs within Piece 5 and defines the upper contact of Unit 8. The gradation suggests that the gabbroic dike is associated with the depletion of the harzburgite in pyroxene toward the contact. Spinel concentrations are also higher in the dunite as compared to the harzburgite, reaching up to 2% in places. Disseminated sulfide minerals are present in all of these pieces. Alteration is generally low as the gabbroic contact is approached, but is high within the gabbro.
SECONDARY MINERALOGY:
Iron oxide minerals.
Mode of Occurrence: After olivine.
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Amphibole(?).
Mode of Occurrence: After clinopyroxene.
Pyrite.
Mode of Occurrence: After clinopyroxene.
Comments: Piece 1 is a pervasively altered harzburgite, with alteration dominated by formation of mesh-textured serpentine. Dunite Pieces 2–4 is 100% serpentinized. In Piece 5, the alteration is only 60%–70%. Olivine is replaced by a dark green to green gray serpentine and iron oxide mineral mesh. Relict olivine and pyroxene are preserved in gray patches. In Pieces 2 and 3, these aggregates are bounded by well-developed anastomosing serpentine veins. In Piece 5, there is a 3 cm wide metagabbroic vein, altered to amphibole and chlorite.
Veins
Dunite section is dominated by composite wispy white and black serpentine and oxide mineral veinlets. Dark green serpentine and amphibole? veins, <1 mm in width, are cut by anastomosing serpenitne veinlets. Rare sulfide mineral stringers are <<1 mm wide. Wispy white serpentine veins cut aqua green serpentine veins.
VEIN/FRACTURE FILLING:
See comments.
ADDITIONAL COMMENTS: Structure
A strongly elongated porphyroclastic fabric is present in the dunitic horizons that border the metagabbro (Pieces 5 to 7). Sparse, thin (<1 mm) white serpentine veins overprint the strong foliation. The foliation dips between 30° to 40°.

UNIT 8: RODINGITIZED GABBRO

Pieces 5–10

COLOR: Green white.
PRIMARY STRUCTURE: Magmatic.
SECONDARY STRUCTURE: Weakly developed plastic fabric.
PRIMARY MINERALOGY:
Plagioclase. - Mode: 60%.

Crystal Size: 3–6 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 40%
Crystal Size: 2–10 mm.
Crystal Shape: Anhedral.
Comments: Rodingitized metagabbro with highly altered plagioclase (60%–70%) and altered clinopyroxene (≈30%–40%). Igneous textures are well preserved in places although there does not appear to be any primary mineralogy remaining in the pieces examined. Clinopyroxene is altered to amphibole and serpentine(?) and exhibits thin alteration halos of green amphibole and chlorite. Plagioclase is pervasively replaced by prehnite, secondary plagioclase and a trace of epidote.
Piece 10
Contact (Units 8–9)
Contact between rodingitized gabbro and ultramafic rocks. Contact appears intrusive with igneous textured gabbro intruding dunite. However, directly adjacent to the contact the peridotite is enriched in clinopyroxene which decreases in abundance rapidly downward into the peridotite below. The peridotite is altered to chlorite and serpentine(?) at the contact, and away from the contact is dominated by serpentine after olivine.

SECONDARY MINERALOGY:

Amphibole.
Texture: Fibrous.
Mode of Occurrence: After clinopyroxene.
Comments: Alteration halos around clinopyroxene.
Chlorite.
Mode of Occurrence: After clinopyroxene, plagioclase.
Comments: Alteration halos around clinopyroxene.
Prehnite.
Mode of Occurrence: After plagioclase.
Secondary plagioclase.
Mode of Occurrence: After plagioclase.
Epidote(?).
Mode of Occurrence: After plagioclase.
Comments: Veins
A prehnite vein, 1.5 mm wide, cuts Piece 9 and where in contact with pyroxene contains possible brown amphibole.

VEIN/FRACTURE FILLING:

Actinolite and chlorite.
Size: <1 mm.
Prehnite.
Size: 1.5 mm.

ADDITIONAL COMMENTS: Contact (Unit 7/8)

Unit 8 consists of a highly altered gabbro with igneous textures, thus the contact in Piece 5 is between residual dunite and intrusive gabbro. A thin dark green alteration halo at the contact is probably due to amphibole and chlorite replacment. The piece is cut by a few wispy white serpentine veinlets. Pyroxene in this zone is pervasively altered to amphbiole, serpentine, talc(?), and chlorite. Prehnite replaces fine-grained plagioclase.
Structure
Pieces 6 to 10 contain metagabbro that is strongly altered but only weakly deformed, suggested by kink bands in clinopyroxene and distortions of plagioclase grains.

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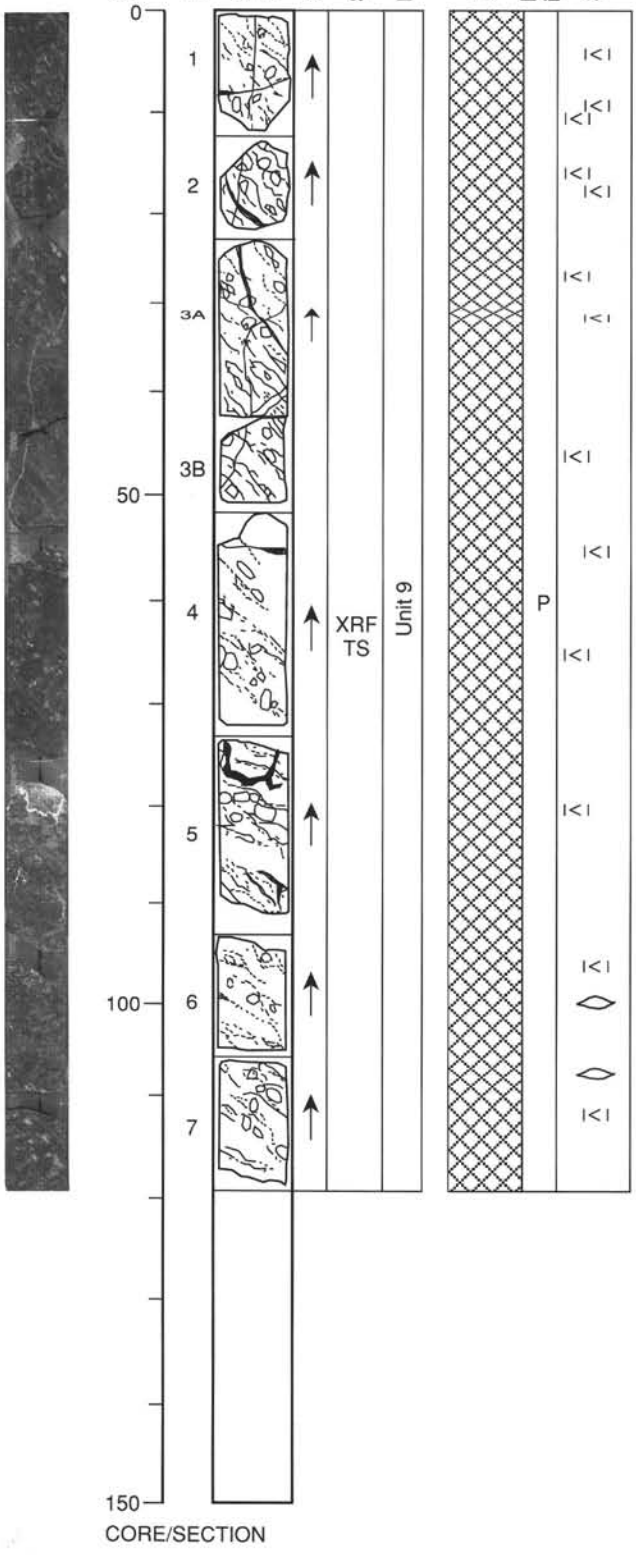
UNIT 9: SERPENTINIZED HARBURGITE

Pieces 10–13

COLOR: Black/green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine. - Mode: 60%–94%.
Orthopyroxene. - Mode: 12%–15%.
Crystal Size: 3–10 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized lherzolite, dunite, and harzburgite. Piece 10 is a lherzolite at the contact due to the enrichment in clinopyroxene content. This is followed downward by dunite again (Piece 11) and then grades into harzburgite (Pieces 12 and 13). This again suggests that the pyroxene depletion around the gabbroic intrusion is due to some sort of wall-rock reaction or melt depletion zone around the gabbroic intrusion (Unit 8). Pyroxene content climbs from the dunite in Pieces 10 and 11 to approximately 12%–15% in Pieces 12 and 13 which are pyroxene-depleted harzburgite. Pieces are generally highly altered away from the gabbroic contact, but less altered right adjacent to the gabbroic contact. Piece 11 contains a small highly altered gabbroic vein that is several mm thick. Disseminated sulfide minerals are common in all of these pieces.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene, clinopyroxene.
Chlorite
Mode of Occurrence: After olivine.
Amphibole.
Mode of Occurrence: After olivine.
Iron oxide minerals.
Mode of Occurrence: After olivine, clinopyroxene, orthopyroxene.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Pyrite.
Mode of Occurrence: After clinopyroxene.
Comments: Dunite in Piece 11 appears to be entirely serpentinized (100%). Harzburgite in Pieces 12 and 13 is also very altered (99%). Olivine is altered (99%–100%) to a dark mesh of serpentine and iron oxide mineral veins. Pyroxene is replaced by dull green serpentine. A net of anastomosing serpentine veins is well developed in all pieces. Wispy white serpentine veins are also abundant. Piece 11 contains two veins, one discontinuous and thin (<1 mm), composed of serpentine and chlorite, and the other, 3–6 mm wide, contains a chlorite and amphibole assemblage after a gabbroic protolith.
VEIN/FRACTURE FILLING:
Composite wispy white serpentine.
Comments: 6 mm wide band of thin veins.
Serpentine.
Size: 2–3 mm.
Orientation: Green.
Actinolite and chlorite.
Size: <1 mm.
ADDITIONAL COMMENTS: Contact (Unit 8–9)
Contact between rodingitized gabbro and ultramafic rocks. Contact appears intrusive with igneous textured gabbro intruding dunite. However, directly adjacent to the contact the peridotite is enriched in clinopyroxene which decreases in abundance rapidly downward into the peridotite below. The peridotite is altered to chlorite and serpentine(?) at the contact, and away from the contact is dominated by serpentine after olivine.
Structure
A strong elongated porphyroclastic fabric occurs below the contact with the metagabbro diminishing toward Pieces 12 and 13. The fabric is locally stronger at the top of Piece 13. A moderately strong anastomosing foliation, defined by a dense meshwork of serpentine veins overprints the elongated porphyroclastic texture. Thin (<1 mm) white serpentine veins overprint the anastomosing foliation. In Piece 12, strongly aligned serpentine fibers on the upper surface of the core piece suggest a shear surface. In Pieces 11 and 12, thin veins of amphibole and chlorite are cut by thin white serpentine veins. A pale green serpentine vein in Piece 12 crosses all other vein types in the piece. There are melt channels in last two pieces.



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UNIT 9: SERPENTINIZED HARZBURGITE

Pieces 1–7

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine. - Mode: 81%–96%.
Orthopyroxene. - Mode: 4%–25%.
Crystal Size: 3–16 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: <1%.
Crystal Size: 1–2 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: <1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: This section consists of porphyroclastic serpentinized harzburgite and dunite. Pieces 1–4 have less than 8–12 modal % pyroxene, but Piece 5 is more pyroxene-rich (orthopyroxene 18%–35%, higher in the top of the piece). Piece 5 contains a 3 cm wide zone or band of pyroxene enrichment where its modal abundance reaches 35%; below this, however, abundance drops rapidly back to about 10%–15%. Spinel concentrations are higher in the pyroxene-poor sections of the core as compared to the harzburgite. Disseminated sulfide minerals are also more abundant in these pieces. Total alteration is high, ranging from 95% to 100%. Serpentine veins are common in Piece 5 and the anastomosing serpentine vein set is present throughout the section. This anastomsing vein set is inclined steeply in the section.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene, clinopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Clay minerals.
Mode of Occurrence: After orthopyroxene, olivine, clinopyroxene.
Comments: Total alteration varies from about 90%–100%. Olivine is altered 90%–100% to serpentine, iron oxide minerals, and clay minerals. Orthopyroxene is highly to pervasively altered to serpentine and iron oxide minerals along exsolution lamellae. Clinopyroxene is highly to pervasively altered to serpentine and a trace of pyrite.
Veins
All pieces are cut by an anastomosing net of composite wispy white and dark serpentine veins forming 6 mm wide branching sets. Diffuse fibrous serpentine veins, 2–3 mm wide, are green and cut by aqua serpentine veins. Pieces 1, 2, and 3 contain thin (<1 mm) subvertical green veins that contain chlorite and are cut by wispy white serpentine veins. In Piece 4, a similar veinlet is subhorizontal. Piece 5 contains discontinuous, white, serpentine veins, about 1 mm wide, that crosscut all the previously described veins.
VEIN/FRACTURE FILLING:
Gray green serpentine.
Size: <1 mm.
Comments: Cut by wispy white serpentine veins at angle to foliation.
Wispy white serpentine.
Size: <1 mm.
Orientation: Parallel to fabric.
Carbonate and sulfide minerals.
Size: 1–2 mm.
Comments: Cut by whispy white veins.
Irregular serpentine (white).
Size: 3 mm.
Comments: Cuts carbonate veins.
Composite black and white serpentine.
ADDITIONAL COMMENTS: Structure
An elongated porphyroclastic texture, defined by pyroxene porphyroclasts, is best developed toward the base of the section. No anastomosing foliation of serpentine veins is present but thin (<1 mm) white serpentine veins follow the trace of the pyroxene foliation. The foliation dips at about 55°. In Piece 6 a few orthopyroxene porphyroclasts are oriented at a high angle (about 60°) to the arrays of thin white veins. Dark green serpentine veins with chlorite in Pieces 1, 2, and 3 are cut by the thin white serpentine veins.

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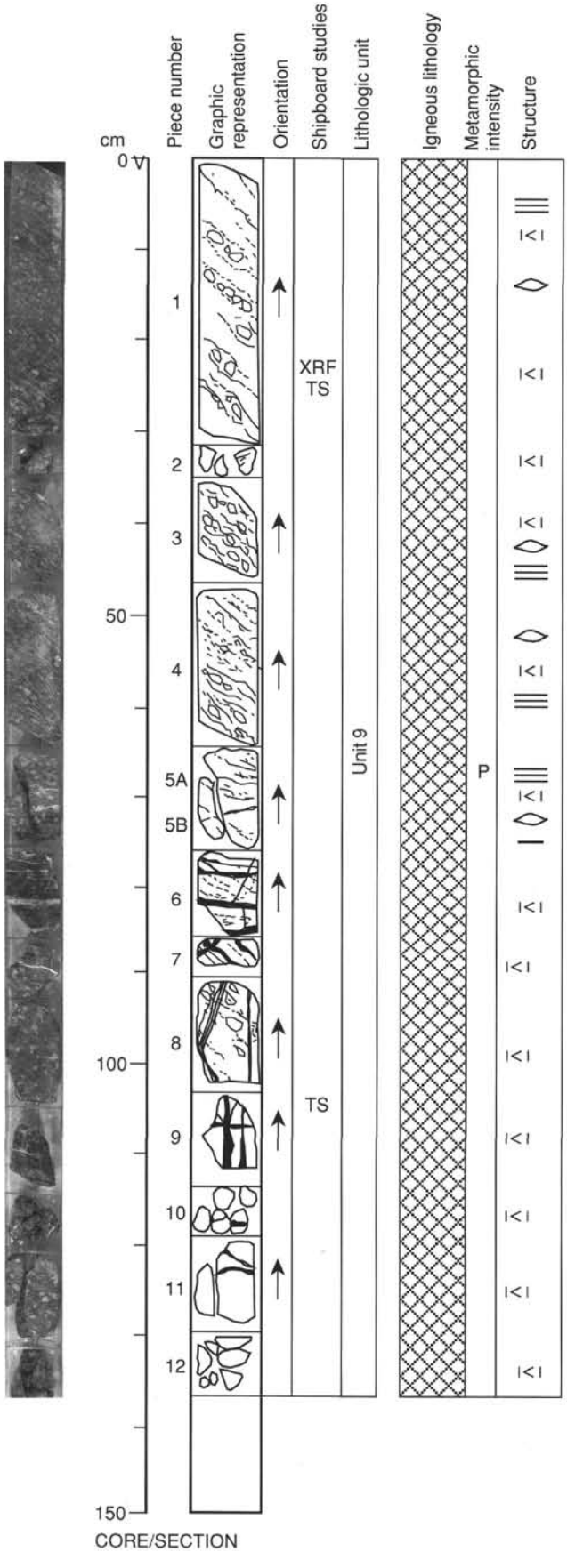
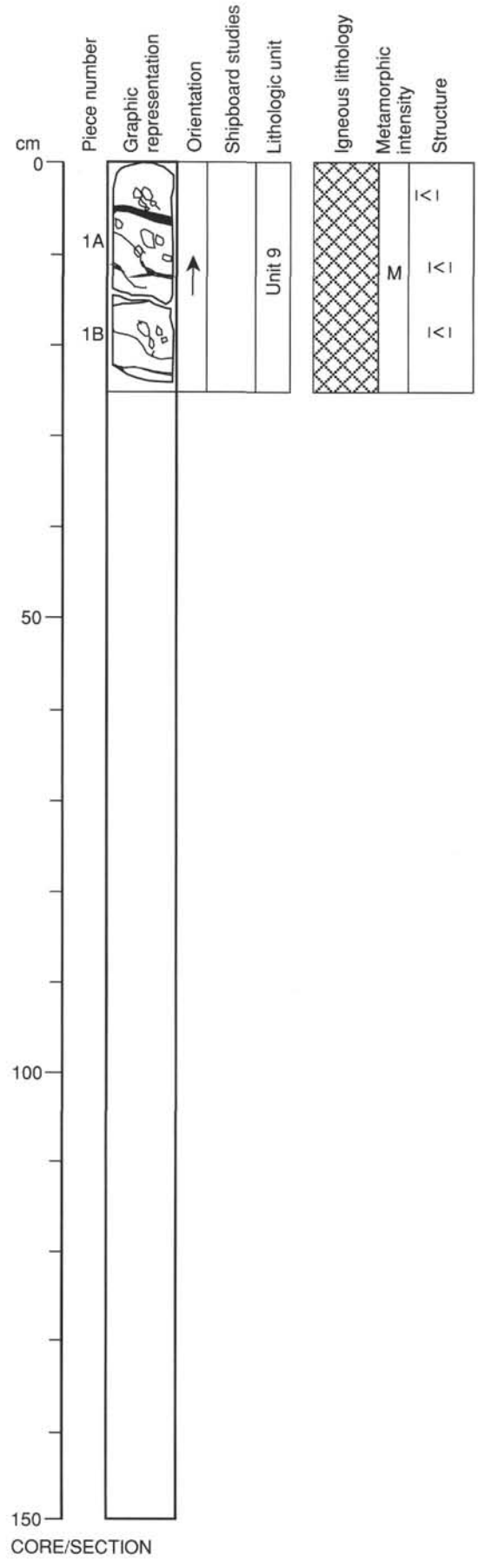


UNIT 9: SERPENTINIZED HARZBURGITE

Pieces 1–12

COLOR: Black gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Anastomozing network of white serpentine veins and other vein generations.
PRIMARY MINERALOGY:
Orthopyroxene. - Mode: 24%–25%.
Crystal Size: 3–20 mm.
Crystal Shape: Anhedral.
Olivine. - Mode: 73%–75%.
Spinel. - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Porphyroclastic serpentinized harzburgite that is more enriched in pyroxene content in Pieces 1–5 than previous sections with between 24% and 27% total pyroxene content, however, clinopyroxene appears to be absent or a minor component of the pyroxene content in the section. Pieces 6–12 are more depleted in pyroxene content (15%–20%). Piece 9 contains a thin, altered pyroxenite vein that cuts across the high-temperature foliation.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Amphibole.
Mode of Occurrence: After orthopyroxene.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Comments: Pervasively altered serpentinized harburgite (85%–96%) with serpentine after olivine and orthopyroxene as the dominant alteration phase. Alteration characteristics are patchy downsection due to pods and patches of olivine altering to kernels with pale white cores and light green serpentine rims, which are enclosed in olive brown to green mesh-textured serpentine. Olivine is altered 80%–98% to serpentine, iron oxide minerals, and clay minerals. Rounded to elongate gray green- to cream-colored orthopyroxene porpyroclasts are altered to serpentine and a trace amount of amphibole and oxide minerals along exsolution lamellae (85%–98%).
Veins
Pieces 6 and 9 contain veins (2 to 6 mm) that contain or have contained brown prismatic hornblende. These veins also contain chlorite and actinolite which may have replaced plagioclase near some of the prismatic amphibole. Piece 6 also contains thin amphibole and chlorite veins (1 mm) that branch out of the thicker euhedral amphibole-bearing veins. Both types of veins are crosscut by pale green serpentine veins, then by white anastomosing serpentine filled veins. Other veins throughout the section include carbonate mineral veins <1 mm wide, serpentine and chlorite veins, and white, wispy serpentine veins <1 mm wide. There are also very rare, irregular patches of carbonate minerals.
VEIN/FRACTURE FILLING:
Carbonate minerals.
Size: <1 mm.
Serpentine and chlorite.
Wispy white serpentine.
Size: <1 mm.
Brown amphibole, green amphibole, chlorite, serpentine, and prehnite(?).
ADDITIONAL COMMENTS: Structure
The first five pieces of the section display a well-developed elongated porphyroclastic fabric defined by moderately elongated oprthopyroxene porphyroclasts with an aspect ratio of about 3:1. Although an anastomosing foliation of dense serpentine veins is not evident the white serpentine veins that commonly overprint it are present. The fabric diminishes in intensity below Piece 5. A compositonal boundary near the base of Piece 5 separates an orthopyroxene-rich harzburgite from an orthopyroxene-poor harzburgite. Pieces 7 and 9 contain veins with amphibole and altered pyroxene that are crosscut by the thin white serpentine veins and a later generation pale green serpentine veins.



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UNIT 9: SERPENTINIZED HARZBURGITE

Pieces 1A and 1B

COLOR: Black to green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine. - Mode: 69%.
Clinopyroxene. - Mode: 5%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral.
Orthopyroxene. - Mode: 25%.
Crystal Size: 3–15 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 2%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic harzburgite enriched in pyroxene (25%–29%). Pyroxene content varies from top to bottom of Piece 1. A cross-fibered serpentine vein with curved fibers crosses the top of the piece. The anastomosing serpentine vein sets are weakly developed.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Talc(?).
Mode of Occurrence: After olivine.
Amphibole.
Mode of Occurrence: After orthopyroxene, olivine(?).
Actinolite.
Mode of Occurrence: After clinopyroxene.
Comments: This piece is generally less altered than previous sections (60% total alteration). Olivine is 80% altered to serpentine, clay minerals, iron oxide minerals, and a trace of talc? Orthopyroxene porphyroclasts contain apple green cores, and are altered 20%–50% to serpentine and amphibole, with minor alteration halos. Clinopyroxene is moderately altered.
Veins
Piece 1 contains a 1–2 mm wide pervasively altered gabbroic(?) vein composed of chlorite, amphibole, serpentine, and prehnite(?). It is rimmed by a dark halo of serpentine. This piece also contains composite wispy white and dark serpentine veins.
VEIN/FRACTURE FILLING:
Serpentine, prehnite, and amphibole.
Size: 1–2
Comments: After melt infiltration zones?
Wispy white and dark serpentine.
ADDITIONAL COMMENTS: Structure
A very weak shape preferred orientation defines an elongate porphyroclastic texture in orthopyroxene porphyroclasts. Vein arrays are restricted to zones of en echelon segments of white serpentine veins (≈2 mm wide) in both Pieces 1A and 1B.

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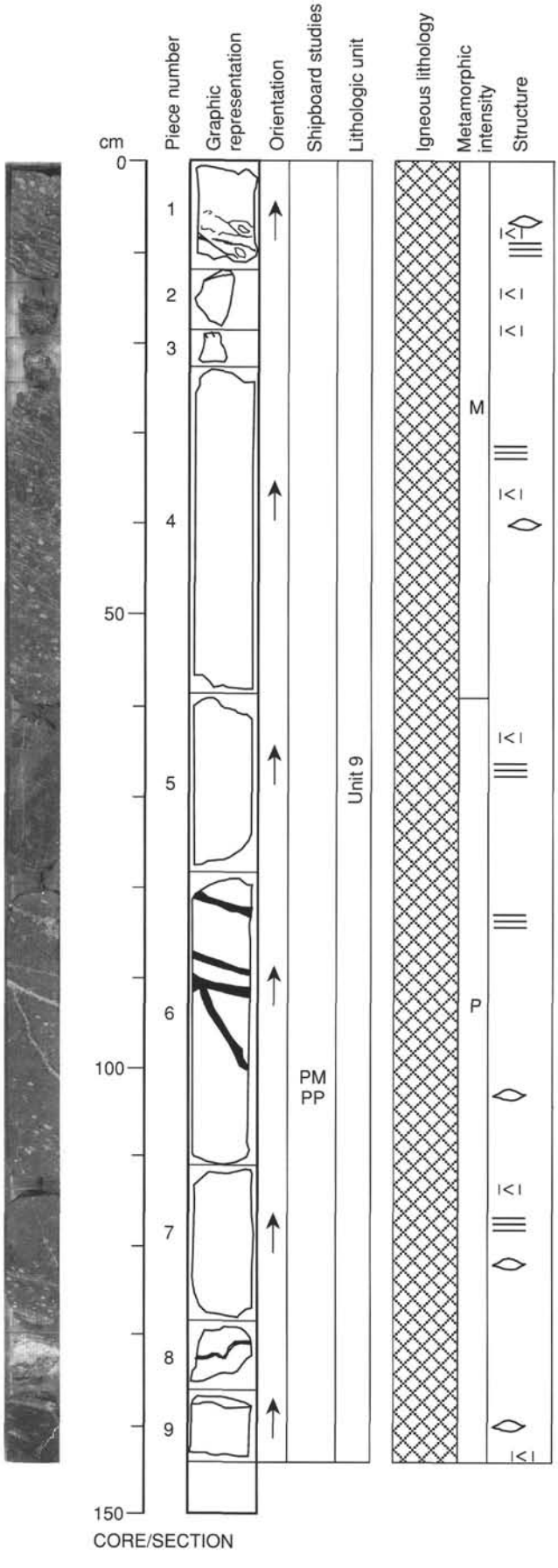

UNIT 9: SERPENTINIZED HARZBURGITE AND DUNITE WITH HORNBLENDITE VEIN

Pieces 1–9

COLOR: Gray-black to green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Magmatic veins and serpentine veins.
PRIMARY MINERALOGY:
Olivine. - Mode: 82%–95%.
Clinopyroxene. - Mode: 0%–2%.
Crystal Size: 1–8 mm.
Crystal Shape: Anhedral.
Orthopyroxene. - Mode: 4–15%.
Crystal Size: 2–14 mm.
Crystal Shape: Anhedral.
Comments: This section consists of porphyroclastic serpentinized harzburgite and dunite crosscut by altered composite gabbroic-hornblendeblendite and pyroxenite/gabbro veins. Pieces 1–4 are serpentinized harzburgite, slightly less altered than observed in nearby cores (≈70%–80% total alteration). The top of Piece 1 contains up to 25% pyroxene. The remainder of these pieces contain about 15% orthopyroxene and 1%–2% clinopyroxene. Pieces 4 and 6 contain evidence for melt infiltration: clinopyroxene is concentrated in trails subparallel to foliation. In these zones of melt infiltration, clinopyroxene very locally (mm to cm scale) forms about 30% of the mode. Pieces 5, 6, 7, and 9 are significantly more altered (97%–100%) and have lower modal proportions of pyroxene (<8%) and are pyroxene-bearing dunite. Piece 6 contains two altered composite pyroxenite/gabbro veins. Piece 7 is texturally and mineralogically variable with dunite at the top and a pyroxene-rich band (10% pyroxene) at the base of the piece. Piece 7 also contains a thin discordant altered gabbroic vein. The top 8 cm are pervasively altered. The bottom 6 cm of this piece is only about 50% altered. Olivine, although serpentinized and forming mesh textures, has abundant fresh kernels remaining between the mesh structures at the bottom of the piece. Piece 8 has two distinct parts and consists of altered composite gabbroic-pyroxenite vein material now dominated by hornblende replacing pyroxene (or it is original magmatic amphibole) on its margin and prehnite replacing plagioclase in the central part of the vein. Piece 9 retains a contact between the hornblendeblendite and the underlying serpentinized harzburgite. The piece is highly altered and there appears to be an alteration halo at the edge of the vein in Piece 9. The vein must have been in excess of 5 cm thick. The vein margin is horizonatal and oblique to the high-temperature crystal-plastic foliation. Disseminated sulfide minerals occur in Pieces 5, 6, and 7 and in a thin vein in Pieces 5 and 9.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine, clinopyroxene.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Pyrite.
Mode of Occurrence: After clinopyroxene(?).
Amphibole(?).
Mode of Occurrence: After clinopyroxene.
Comments: Total alteration ranges from 80%–100%. Olivine is pervasively altered 80%–99%, with zones of fresh kernels enclosed in mesh-textured serpentine and microveinlets of serpentine and iron oxide minerals. Orthopyroxene alteration includes serpentine and a trace of amphibole? (25%–99%). Least altered samples occur at the top of the core. Clinopyroxene is altered 25% to 100% and exhibits similar alteration relationships as orthopyroxene. Amphibole ± chlorite? replace clinopyroxene.
Veins
Composite black and white wispy serpentine veinlets are abundant in Pieces 1–4. Large sulfide mineral grains occur on broken surfaces of Pieces 4 and 5.
Piece 4 contains veins of sulfide minerals ± hematite, carbonate minerals, and serpentine, <1 mm to 1 mm wide, which cut wispy white veins at a high angle.
Piece 6 is cut by 2–10 mm wide veins which are oriented at a high angle to the dominant fabric and are now composed of brown and green amphibole, chlorite, and serpentine. Piece 7 is crosscut by a vein of serpentine,

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amphibole, chlorite, sulfide minerals, and serpentine in tear fractures. The vein is cut by white to green, 6 mm long, serpentinite veinlets. Piece 8 is an amphibole-rich interval composed of 3 distinct bands. A zone 15–20 mm wide of brown amphibole, chlorite, zeolite and clay minerals is bounded by a 10–15 mm wide band that is blue gray and composed of cholrite(?) and serpentine(?) and which abuts a white tremolite-rich band. The original protolith for this pervasively altered zone was likely pyroxenite/gabbro. Piece 9 is highly deformed and pervasively replaced by serpentine. It is cut by an irregular, <1 to 1 mm wide, tapering, white, serpentine veinlet which cuts the deformation fabric defined by elongated pyroxene. The top of the piece is bounded by a 8 mm wide, brown hornblende-rich zone which is altered to chlorite and actinolite.

VEIN/FRACTURE FILLING:

Composite black and white serpentine.

Sulfide mineral stringers.

Size: <1 mm.

Sulfide minerals, hematite, carbonate minerals, and serpentine.

Size: 1 mm.

Comments: Cuts whispy white veins.

Green and brown amphibole, chlorite, and serpentine.

Size: 2–10 mm.

Sulfide minerals and serpentine.

Comments: In tear fractures.

ADDITIONAL COMMENTS: Structure

A moderate to strong elongation of porphyroclasts defines a foliation emphasized by wispy white serpentine veins. The strongest crystal-plastic fabric is located in Piece 9 which is pyroxene poor. A weak shape preferred orientation of alignment of spinels lies oblique to the foliation. The intensity of veining reduces in Pieces 5, 6, and 7 where clinopyroxene is concentrated in trails, subparallel to the foliation. In Piece 6, an amphibole-bearing vein is oriented subperpendicular to the foliation. A strong foliation is present at the contact in Piece 9 between hornblendite and the underlying harzburgite.

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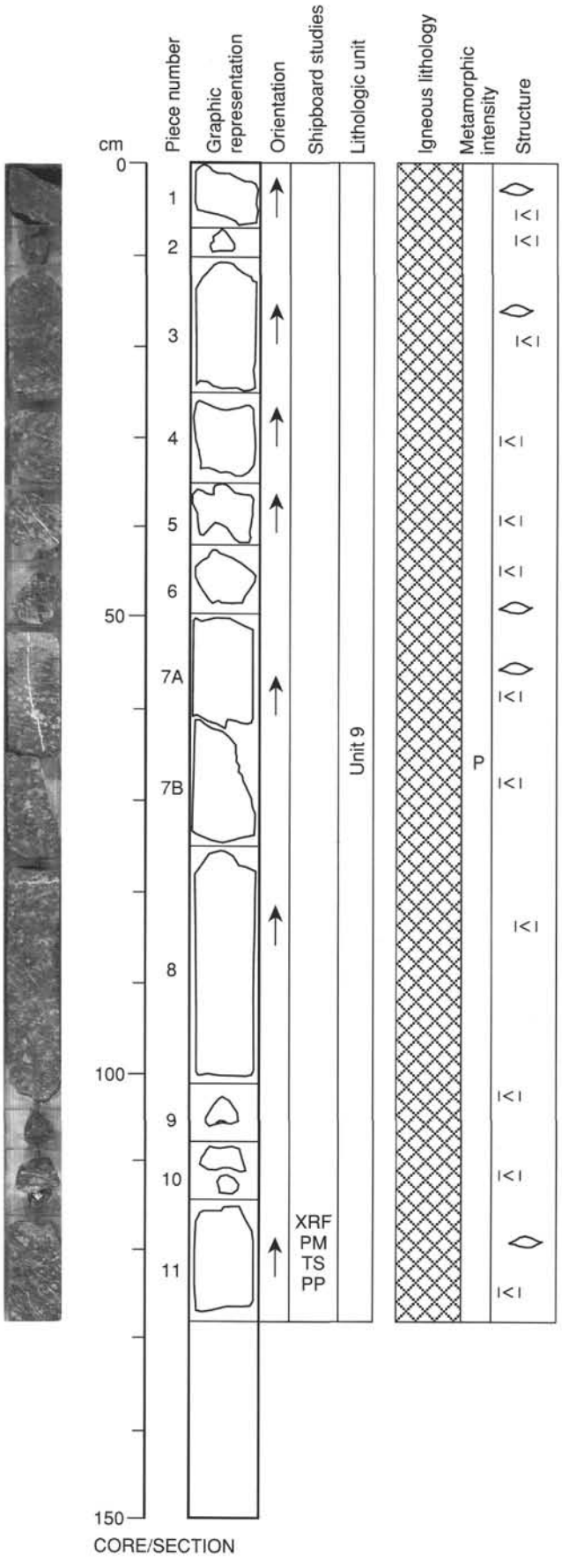
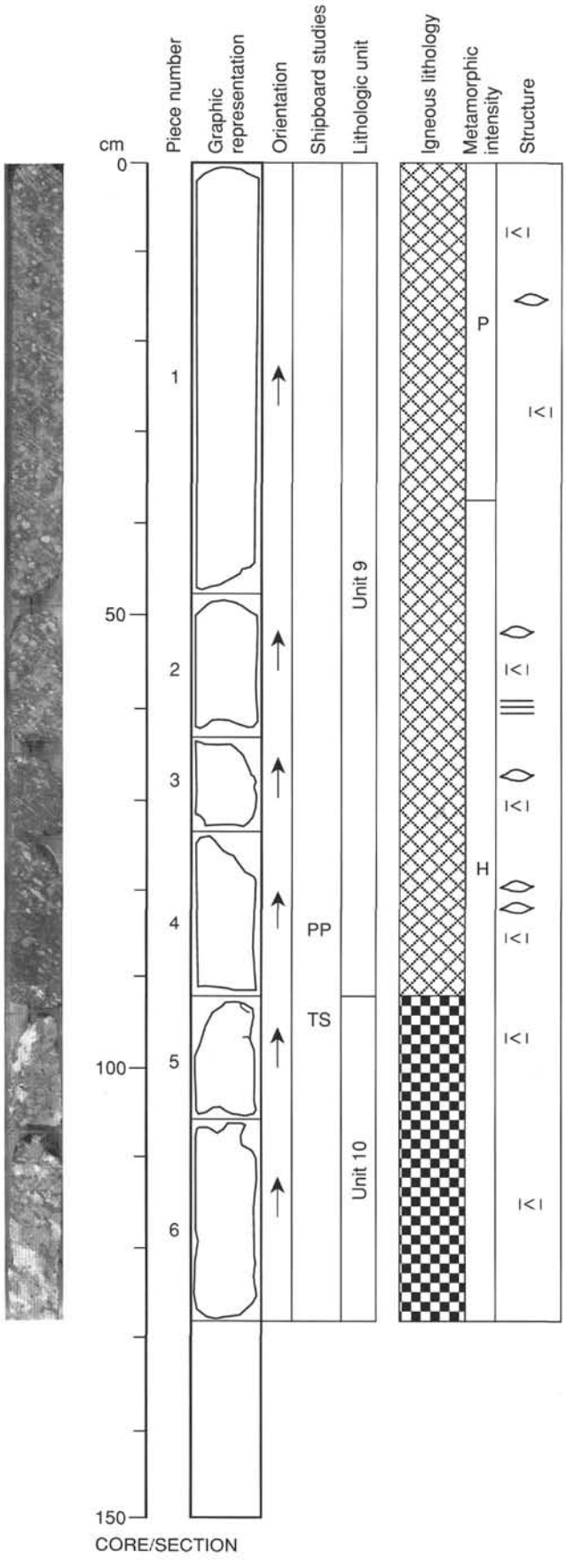


UNIT 9: SERPENTINIZED HARZBURGITE

Pieces 1–11

COLOR: Black/gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Multiple vein generations.
PRIMARY MINERALOGY:
Olivine. - Mode: 74%–84%.
Clinopyroxene. - Mode: 2%–3%.
Crystal Size: 1–8 mm.
Crystal Shape: Anhedral.
Orthopyroxene. - Mode: 11%–25%.
Crystal Size: 2–4 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic harzburgite with 11% to 25% orthopyroxene and 1%–3% clinopyroxene. Piece 1 contains two clinopyroxenite veins that are oriented nearly horizontal having a lower dip than the foliation plane. Piece 1 also contains very elongate orthopyroxene. Pieces 1 and 2 are strongly depleted in pyroxene (14%), whereas Pieces 3–11 are relatively enriched in pyroxene with between 20 and 25 modal percent. There are no magmatic veins in the section. White serpentine veins define an anastomosing foliation parallel to the high-temperature foliation. Piece 1 contains a thin sulfide mineral vein, but in general the core is devoid of sulfide mineral veins. Piece 7 contains a near vertical white asbestiform serpentine vein.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Comments: Replacing orthopyroxene along exsolution lamellae.
Brown amphibole.
Mode of Occurrence: After orthopyroxene.
Comments: Replacing orthopyroxene along exsolution lamellae.
Amphibole.
Mode of Occurrence: After orthopyroxene, clinopyroxene.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Comments: Alteration is patchy in appearance due to pods of olivine-rich zones altering to white serpentine kernels with light green rims, enclosed in an olive green to light green serpentinized matrix. Total alteration ranges from 87%–99%. Alteration of olivine is generally pervasive (90%), however in less altered zones clear olivine kernels are enlcosed in a mesh serpentine matrix. Clinopyroxene is highly to pervasively altered (70%–95%) to serpentine, amphibole(?), and minor chlorite. Brown amphibole occurs along exsolutiuon lamellae in Piece 3. Orthopyroxene is moderately to pervasively altered (75%–85%) with apple green to cream-colored cores which are rimmed by amphibole(?) and serpentine.
Veins
Composite wispy white and dark serpenitine and iron oxide mineral veinlets are common where the abundance of porphyroclasts increases. Serpentine, and carbonate and sulfide minerals occur in a vein 1–2 mm wide in Pieces 7A and 7B. It cuts the pyroxene foliation and wispy white serpentine veins at a high angle. White serpentine veins 1–2 mm wide cut wispy white vein in Piece 8.
VEIN/FRACTURE FILLING:
Composite wispy white and dark serpentine and iron oxide minerals.
Serpentine, and carbonate and sulfide minerals.
Size: 1–2 mm.
White serpentine.
Size: 1–2 mm.
Comments: Cuts wispy white veins.
ADDITIONAL COMMENTS: Structure
A weak elongated porphyroclastic texture is defined by orthopyroxene porphyroclasts. This foliation is overprinted by thin (<1 mm) anastomosing white serpentine veins. The foliation dips at about 35° to 40° consistently through the section. Pale green serpentine veins cut the foliations at a high angle. Two clinopyroxenite veins in Piece 1 dip at a lower angle than the foliation with a subhorizontal orientation.



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UNIT 9: SERPENTINIZED HARZBURGITE

Pieces 1–4

COLOR: Black/green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE:
PRIMARY MINERALOGY:
Olivine. - Mode: 78%–85%.
Orthopyroxene. - Mode: 12%–20%.
Crystal Size: 3–20 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 2%–3%.
Crystal Size: 1–4 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: The section is made up of pyroxene depleted porphyroclastic harzburgite and pegmatitic oxide gabbronorite or oxide gabbro (Unit 10). Pieces 1, 2, 3, and 4 constitute the lowest part of Unit 9 and show a pyroxene depletion trend toward the contact with the oxide gabbro (Unit 10) with modal pyroxene dropping from a high in Piece 1 of ≈22% to a low in Piece 4 of ≈10%. Piece 3 contains a clinpopyroxenite vein a few mm wide. There is a strong orthopyroxene lineation in Piece 3 and brown amphibole appears to replace clinopyroxene lamellae in this piece. Piece 4 contains an altered gabbroic vein that may be associated with a gabbroic intrusion below (Piece 5). Piece 4 also contains markedly elongate orthopyroxene and an apparent increase in shape fabric intensity (elongation). There seems to be a general depletion of pyroxene toward the margins of a gabbroic intrusion (Unit 10).
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Amphibole.
Mode of Occurrence: After orthopyroxene, clinopyroxene.
Chlorite.
Mode of Occurrence: After clinopyroxene(?).
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Comments: Alteration is patchy in appearance due to pods of olivine-rich zones altering to white serpentine kernels with light green rims, enclosed in an olive-green to light green serpentinized matrix. Patches decrease downsection. Total alteration ranges from 82%–95%. Alteration of olivine is generally pervasive (80%–98%), however in less altered zones clear olivine kernels are enclosed in a mesh serpentine matrix. Clinopyroxene is highly to pervasively altered (60%–80%) to serpentine and minor chlorite. Orthopyroxene is highly to pervasively altered (50%–80%) with apple green to cream-colored cores which are rimmed by serpentine. A diffuse vein occurs at the base of Piece 4 and is interpreted to be a melt impregnation zone as evidenced by plagioclase altered to prehnite, which encloses sulfide minerals, amphibole, chlorite, and serpentine. Pyroxene is altered to amphibole, chlorite, and serpentine.
VEIN/FRACTURE FILLING:
Prehnite, sulfide minerals, amphibole, chlorite, and serpentine.
Comments: Diffuse appearance, probably after a melt infiltration zone.
ADDITIONAL COMMENTS: Structure
The first four pieces consist of serpentinized harzburgite with a weakly developed elongated porphyroclastic fabric of elongated orthopyroxene grains. A weak anastomosing foliation, defined by thin green serpentine veins overprints the porphyroclastic texture. Both foliations dip at about 35°. A clinopyroxenite vein in Piece 3 has a subhorizontal orientation and is slightly oblique to the foliation. The white serpentine veins that overprint the anastomsing foliation tend to cluster in 5–10 mm bands (Piece 1).

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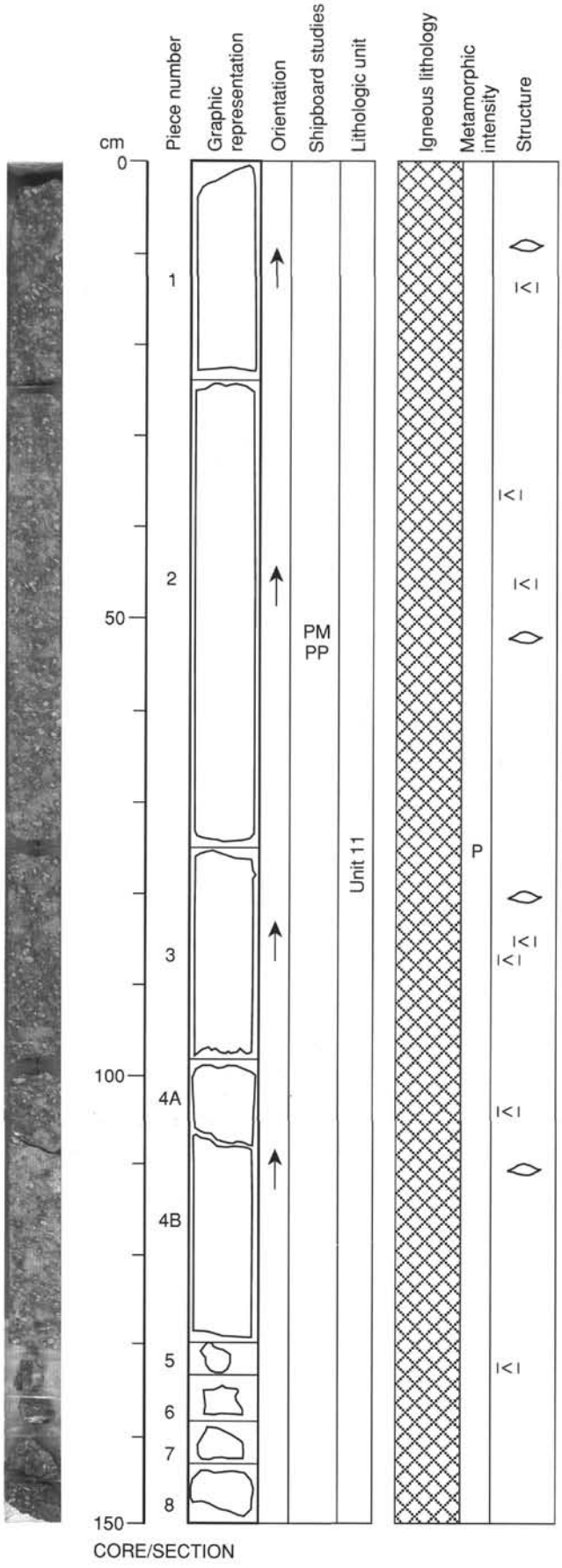
UNIT 10: PEGMATITIC OXIDE GABBRO

Pieces 5–6

COLOR: Rose, green, and white.
PRIMARY STRUCTURE: Magmatic.
PRIMARY MINERALOGY:
Clinopyroxene. - Mode: 25%–30%.
Crystal Size: 2–11 mm.
Crystal Shape: Subhedral.
Orthopyroxene. - Mode: 10%.
Crystal Size: 3–7 mm.
Crystal Shape: Anhedral.
Plagioclase. - Mode: 20%.
Crystal Size: 10–30 mm.
Crystal Shape: Anhedral.
Iron oxide minerals. - Mode: 5%.
Sulfide minerals. - Mode: <1%.
Comments: Altered pegmatitic oxide melanogabbro or gabbronorite. Clinopyroxene appears to be the primocryst phase and plagioclase, pyroxene, and oxide and sulfide minerals are space filling, intergranular phases. Pyroxene makes up about 75% of Pieces 5–6 and plagioclase ≈20%. It is not clear whether orthopyroxene is present in the sample; there appears to be two populations of pyroxene, one a primocryst phase (clinopyroxene), the other a space filling phase (possibly orthopyroxene). Sulfide minerals rarely appear to be primary space filling phases. Primary opaque oxide minerals are also abundant (≈5%). The grain size is very coarse, up to 30 mm for pyroxene.
SECONDARY MINERALOGY:
Prehnite.
Mode of Occurrence: After plagioclase.
Secondary plagioclase.
Mode of Occurrence: After plagioclase.
Actinolite.
Mode of Occurrence: After clinopyroxene.
Comments: Thin alteration rims on clinopyroxene.
Chlorite.
Mode of Occurrence: After clinopyroxene.
Comments: Total alteration is moderate (30%). Plagioclase is extensively altered to prehnite, secondary plagioclase, and actinolite and chlorite when in contact with pyroxene. Clinopyroxene is altered to secondary clinopyroxene, amphibole and chlorite 20%–25%, and commonly exhibits a thin dark alteration rim of actionlite ± chlorite. Cummingtonite and talc(?) replaces orthopyroxene (25%). The core is cut by a mm-wide amphibole and prehnite vein.
VEIN/FRACTURE FILLING:
Amphibole and prehnite.
Size: 1 mm.
ADDITIONAL COMMENTS: Contact Unit 9/ Unit 10: The contact is not exposed in the core, however, a gabbroic vein within harzburgite of Piece 4 and the magmatic textures in Unit 10 indicates that the gabbro is likely to have intruded the harzburgite.
Structure
The only deformation evident in the pegmatitic oxide gabbronorite is represented by steeply dipping amphibole and prehnite veins (Pieces 5 and 6).



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UNIT 11: SERPENTINIZED HARZBURGITE

Pieces 1–8

COLOR: Black to green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine. - Mode: 78%–86%.
Orthopyroxene. - Mode: 10%–18%.
Crystal Size: 3–13 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 2%–3%.
Crystal Size: 1–4 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%–2%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: The section consists of relatively homogeneous serpentinized harzburgite with porphyroclastic texture. Pieces 1–10 are remarkably similar in appearance, modal proportions, and style of alteration. Pyroxene content ranges from 18%–22% with the clinopyroxene component between 1%–3%. The most obvious feature is the patchy alteration appearance that results from formation of a coarse serpentine mesh texture after olivine. Pyroxene is relatively fresh compared with other sections of the core (50%–60%). There are no magmatic veins in the section. This appears to correlate with increases in modal pyroxene abundances in this section. The increase in pyroxene content also appears to correlate with a better development of the anastomosing white serpentine vein foliation wrapping around the orthopyroxene porphyroclasts.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Amphibole(?).
Mode of Occurrence: After clinopyroxene.
Amphibole.
Mode of Occurrence: After orthopyroxene.
Talc(?).
Mode of Occurrence: After olivine.
Comments: Alteration is patchy in appearance due to pods of olivine-rich zones altering to white serpentine kernels with light green rims, enclosed in an olive green to light green serpentinized matrix. Patches decrease in abundance downsection. Total alteration ranges from 85%–95%. Alteration of olivine is generally pervasive (88%–95%), however in less altered zones clear olivine kernels are enlcosed in a mesh serpentine matrix. Clinopyroxene is highly to pervasively altered (50%–100%) to serpentine and minor chlorite. Orthopyroxene is highly altered (50%–60%) with relatively homogeneous, apple green- to cream-colored cores which are rimmed by amphibole(?) and serpentine.
Veins
Composite veins composed of wispy white serpentine and iron oxide mineral-rich black serpentine, commonly wrap around orthopyroxene porphyroclasts and are subparallel to the pyroxene fabric. Dark serpentine and chlorite(?) veins, <1–1 mm wide, cut the pyroxene foliation at a high angle in Pieces 2 and 3.
VEIN/FRACTURE FILLING:
Wispy white serpentine and black serpentine (oxide mineral-rich).
Orientation: Parallel to fabric.
ADDITIONAL COMMENTS: Structure
This section has a weak elongate porphyroclastic fabric defined by orthopyroxene porphyroclasts. No anastomosing foliation is present and thin white serpentine veins are aligned, but sparse, and are deflected by pyroxene porphyroclasts. The foliation dips at about 45° to 50°. Steeply dipping, dark serpentine veins (1–3 mm) are cut by the thin white serpentine veins in Pieces 2 and 3.

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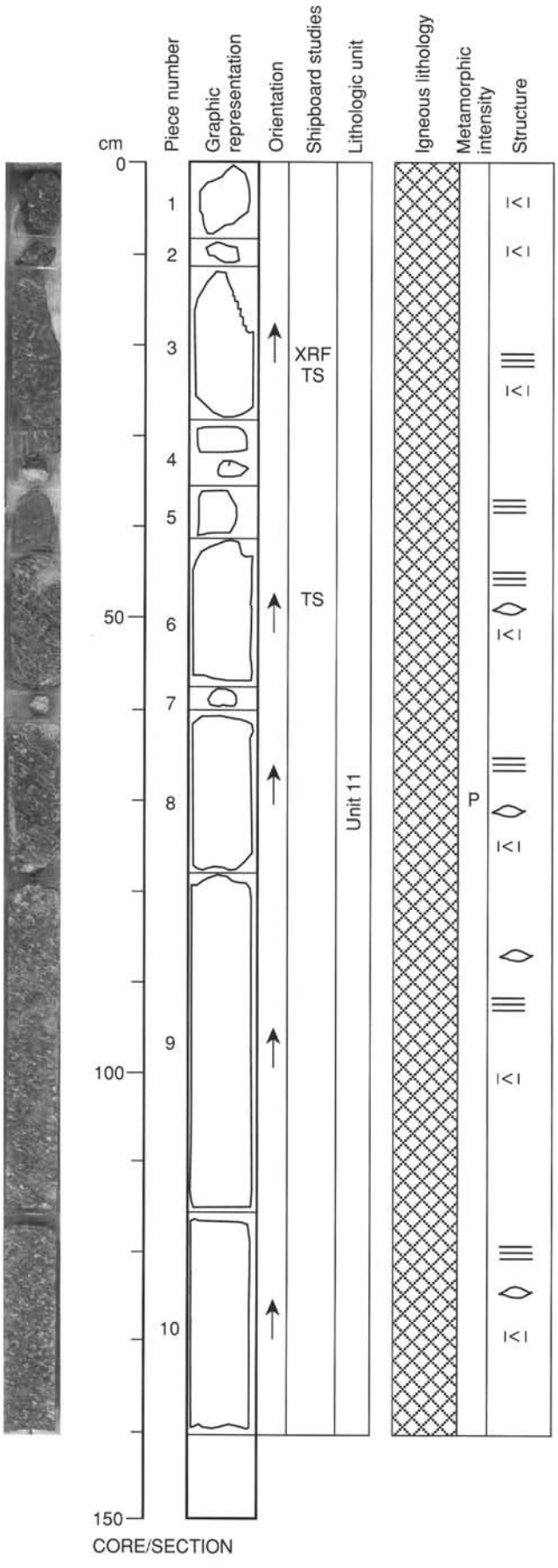
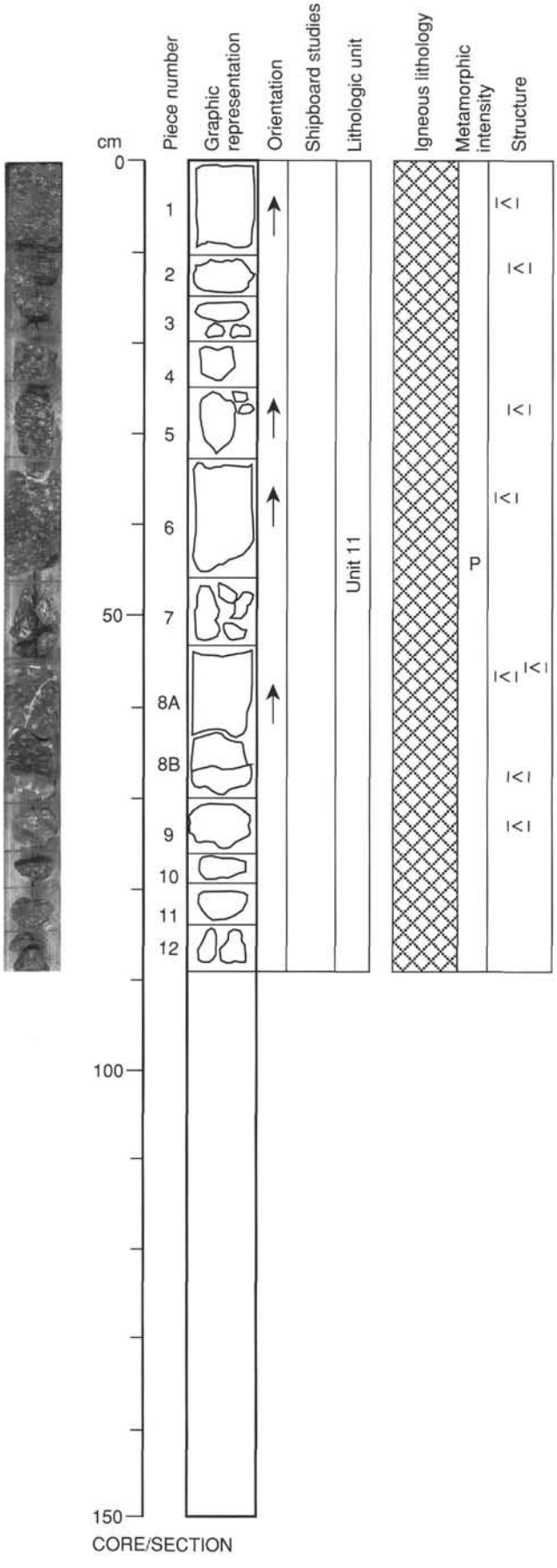


UNIT 11: SERPENTINIZED HARZBURGITE

Pieces 1–10

COLOR: Gray/green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine. - Mode: 83%–97%.
Orthopyroxene. - Mode: 11%–15%.
Crystal Size: 2–12 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene. - Mode: 1%–3%.
Crystal Size: 0.5–4 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: <1%.
Crystal Size: 0.2–2 mm.
Crystal Shape: Anhedral.
Comments: This section comprises moderately to strongly serpentinized porphyroclastic harzburgite. Orthopyroxene abundances range from 11%–15%, and clinopyroxene from 1%–3% in Pieces 1–3, 6, and 8–10. Pieces 4, 5, and 7 are pyroxene-bearing dunite (orthpyroxene <10%). Alteration is variable, and is least 85% in Piece 8, where both orthopyroxene and olivine are well preserved. Traces of disseminated pyrite occur throughout the section. The patchy alteration and coarse mesh structure continues through the section.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 85–98
Mode of Occurrence: Replacement.
Magnetite.
Total Percent: <2
Mode of Occurrence: Metamorphic.
Comments: Formed from the serpentinization of olivine.
Comments: The upper-middle to lower part of this section is similar to section 153-920D-12R-4. Pieces 1–3 lack the well-developed foliaton and development of wispy white serpentine veinlets which are present in the previous section and which occur below this interval starting in Piece 6. Alteration in this zone is pervasive with olivine altered to serpentine. Orthopyroxene grains contain rare apple green cores whch are enclosed by a halo of dark green serpentine. Orthopyroxene is altered to gray green bastite. Pieces 5 and 6 pervasively altered and green due to abundance of serpentine. The samples are crosscut by abundant fine, subparallel, iron oxide mineral-bearing serpentine veinlets. In Pieces 7–10, alteration is patchy in appearance due to pods of olivine-rich zones altering to white serpentine kernels with light-green rims, enclosed in an olive green to light green serpentinized matrix. Alteraton is pervasive and ranges from 85%–98%. Alteration of olivine is generally pervasive, however, in rare less altered zones, clear olivine kernels are enclosed in a mesh serpentine matrix. Clinopyroxene is highly to pervasively altered to serpentine and minor chlorite. Orthopyroxene is highly to pervasively altered with apple green to cream-colored cores which are rimmed by serpentine and a trace of amphibole(?). Composite wispy white serpentine veinlets with iron oxide minerals are abundant in Pieces 7–10.
VEIN/FRACTURE FILLING:
Serpentine.
Percent: 100%
Size: <2 mm thick.
Orientation: Foliation parallel.
Comments: Thin, white, foliation-parallel.
ADDITIONAL COMMENTS: Structure
The section is dominated by a moderately elongate porphyroclastic texture with thin white foliation-parallel serpentine veinlets. In Pieces 1 and 3, the foliation is weak and thin white serpentine veins are very sparse, corresponding to a pyroxene-poor horizon. In Pieces 4 and 5, an extremely intense foliation occurs in a serpentinized dunite. This zone is parallel to the foliation throughout the section that dips between 40° and 50°. A steeply dipping clinopyroxene trail crosses the orthopyroxene foliation in Piece 12B.



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UNIT 11: SERPENTINIZED HARZBURGITE WITH PYROXENITE

Pieces 1–12

COLOR: Black/green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine. - Mode: 75%–77%.
Orthopyroxene. - Mode: 20%–24%.
Crystal Size: 3–12 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: The section consists of serpentinized porphyroclastic harzburgite relatively enriched in pyroxene and pegmatitic gabbro to feldspathic clinopyroxenite. Pieces 1–7 and Piece 8 (top only) consist of serpentinized harzburgite, relatively enriched in pyroxene content (22%–26%). It is generally highly altered (95%–98%) and there is very little primary mineralogy remaining. The base of Piece 8 is more depleted in pyroxene. The section is cut by a feldspathic clinopyroxenite-gabbro pegmatite exposed at the base of Piece 8 and in Piece 9. The igneous contact between the clinopyroxenite and harzburgite is exposed in Piece 8. The feldspathic clinopyroxenite at the contact contains 8–15 modal % space-filling plagioclase between large clinopyroxene grains up to about 25 mm in diameter. The contact is igneous with the gabbro intruding a previously deformed residual mantle section at high temperature. Pyroxene along the contact exhibits comb-like structure with subhedral clinopyroxene terminations toward the interior of the intrusion. The clinopyroxene-rich gabbro of Piece 8 grades into a feldspathic clinopyroxenite in Piece 9. The primary mineralogy in Pieces 8 and 9 is largely unaltered, especially clinopyroxene. Magmatic sulfide minerals and opaque oxide minerals are present in Piece 9, probably indicating increased fractionation away from the peridotite contact. The lower contact is not exposed between Pieces 9 and 10. Pieces 10–12 are serpentinized harzburgite more depleted in pyroxene content (15%–20%).
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Texture: After olivine.
Comments: Mesh serpentine.
Cummingtonite(?)
Texture: After orthopyroxene.
Clay minerals.
Texture: After orthopyroxene, olivine.
Comments: Alteration is patchy in appearance in Piece 1 due to pods of olivine-rich zones altering to white serpentine kernels with light green rims. The kernels are enclosed in an olive green to light green serpentinized matrix. Patches are generally absent downsection. Total alteration is pervasive throughout the peridotite section 95%–98%. Alteration of olivine is pervasive (98%–100%), with clear olivine kernels rare. Serpentine forms a dark olive green brown mesh network cut by abundant microveinets of serpentine and iron oxide minerals. Orthopyroxene is pervasively altered (92%–95%) with apple green to cream-colored cores which are rimmed by amphibole(?) and serpentine. Pieces 8B–9 are moderately altered (10%–35%) and are dominated by alteration of plagioclase to prehnite and hydrogrossular (Piece 8B). Actinolite and chlorite form a fine rim around plagioclase grains in contact with moderately altered pyroxene (10%–50%). Piece 9 is slightly to moderately altered. Clinopyroxene is slightly altered to amphibole and a trace of chlorite. Piece 8B is cut by prehnite, amphibole, vein with a trace of carbonate minerals (1–2 mm wide).
Veins
Anastomosing black and white composite serpentine veinlets. Piece 8 in the pyroxenite is cut by a <1–2 mm wide serpentine, and carbonate and sulfide mineral veins.
VEIN/FRACTURE FILLING:
Black and white composite serpentine.

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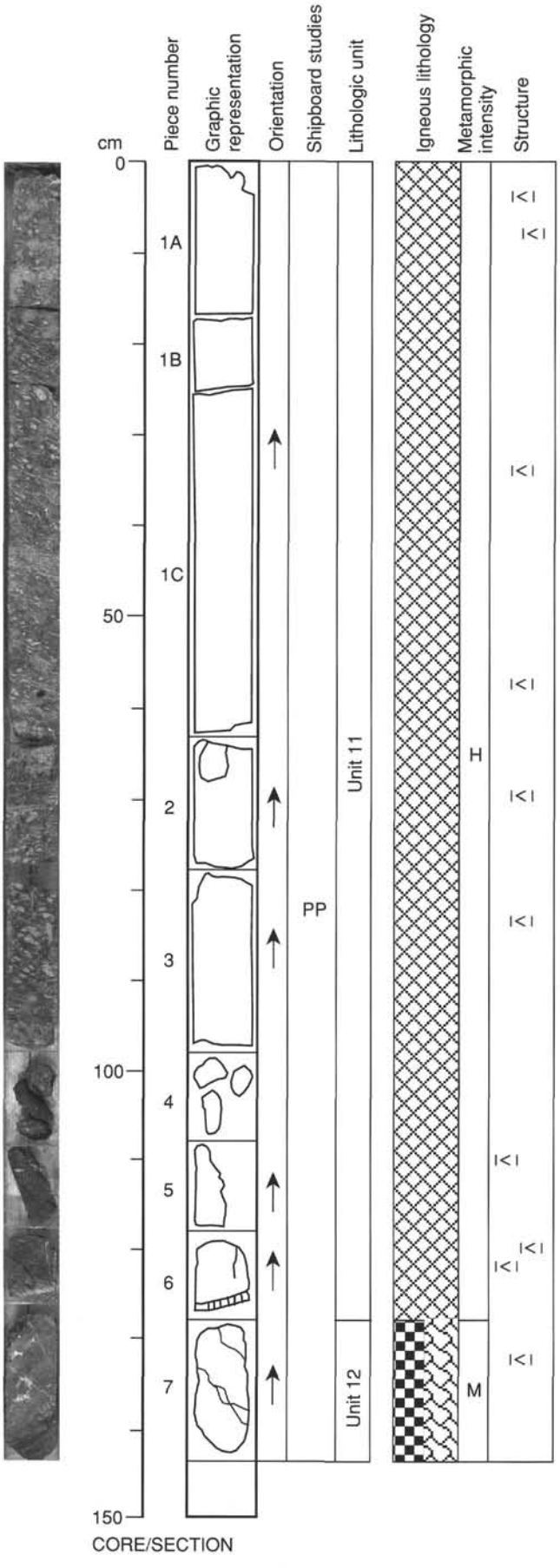
Serpentine , and carbonate and sulfide minerals.
Size: 1–2 mm.
Comments: Cuts pyroxenite.
ADDITIONAL COMMENTS: Structure
A shape preferred orientation of orthopyroxene porphyroclasts defines a moderately elongated porphyroclastic texture. A weak anastomosing foliation formed by a dense meshwork of green black serpentine veins overprints the porphyroclastic fabric. The predominant dip for both foliations is about 30°. Thin (1 mm), white serpentine veins overprint the foliation. A pyroxenite vein in Pieces 8B and 9 dips at about 25° and is cut by a pale green serpentine, and carbonate and sulfide mineral vein that also cuts the thin white serpentine veins.



153-920D-13R-2

UNIT 11: SERPENTINIZED HARZBURGITE AND DUNITE

Pieces 1A–6

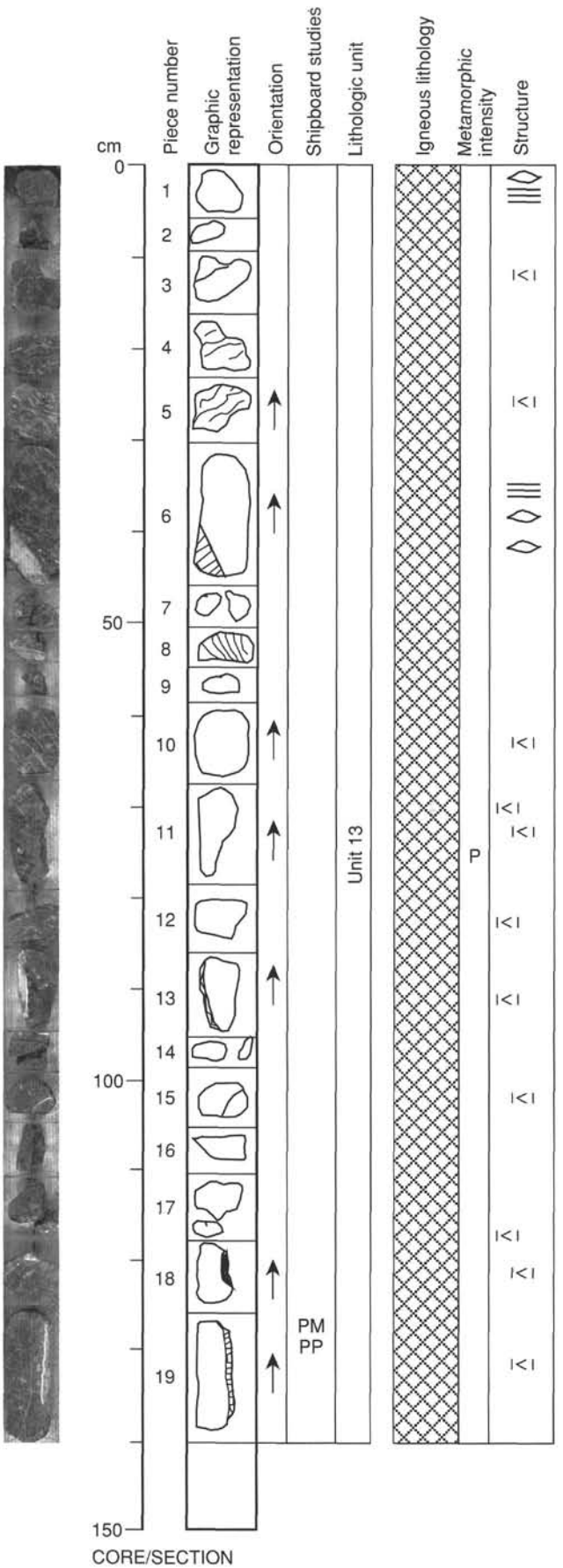
COLOR: Black to green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine. - Mode: 75%–98%.
Orthopyroxene. - Mode: 2%–23%.
Crystal Size: 3–18 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 0–1%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Pieces 1–6 are porphyroclastic serpentinized harzburgite to dunite. The proportion of pyroxene decreases downsection from 18%–23% in Pieces 1–3 to 2%–3% in Pieces 5 and 6. Total alteration increases with decreasing pyroxene content from 70% to greater than 95%. Piece 1 contains a dunite band at the base of the piece that appears to be mylonitic. Piece 2 contains an oval-shaped inclusion (3 x 4 cm) or band of olivine websterite in which modal proportions are as follows: clinopyroxene - 30%, orthopyroxene - 57%, olivine - 10%, spinel - 3% and a trace amount of sulfide minerals. The origin of this pod is uncertain, but may either be a xenolith or a vein. Alteration is minimal, except for the olivine which is partially altered by serpentine in mesh texture. Pieces 5 and 6 are dunite adjacent to an intrusive contact. Piece 6 retains a 0.5 cm wide fragment of an intrusive contact between the serpentinized dunite above and an oxide-rich metagabbro to feldpathic clinopyroxenite of Unit 12 below.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene, clinopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene, clinopyroxene.
Amphibole(?).
Mode of Occurrence: After orthopyroxene.
Talc(?).
Mode of Occurrence: After olivine.
Comments: Alteration is patchy in appearance due to pods of olivine-rich zones altering to white serpentine kernels with light green rims, enclosed in an olive green to light green serpentinized matrix. Total alteration is high in the harzburgitic sections (70%–75%) and pervasive in dunite zones. Alteration of olivine is pervasive (80%–100%), with clear olivine kernels present in less altered areas. Serpentine forms a dark olive green brown mesh network cut by abundant microveinets of serpentine and iron oxide minerals. Orthopyroxene is moderately to highly altered (40%–50%) with apple green to cream-colored cores which are rimmed by amphibole(?), a trace of talc when bounded by olivine, and serpentine. Clinopyroxene is generally moderately altered to amphibole, serpentine, and pyrite. A 3–4 mm wide zone of tremolite, chlorite, and serpentine marks the contact with the underlying gabbro.
Veins
Composite wispy white and iron oxide mineral and serpentine veinlets are abundant in porphyroclastic-rich zones. Sulfide stringers are present.There is a 1 mm wide tapering serpentine vein in Piece 6.
VEIN/FRACTURE FILLING:
Composite wispy white and black serpentine.
Sulfide mineral stringers.
Size: <1 mm.
Tapering serpentine vein.
Size: 1 mm.
ADDITIONAL COMMENTS: Structure
In the upper half of the section an elongate porphyroclastic texture is weakly developed. Below a piece comprising several pebbles of harzburgite (Piece 3) an extremely strong foliation with the possible local development of mylonite. An anastomosing foliation of serpentine veins overprints the porphyroclast fabric and is overprinted by thin white serpentine veins. The

fabric dips at about 40°. There is a slight strengthening of the fabric in Pieces 2 and 3.

UNIT 12: OXIDE METAGABBRO-PYROXENITE

Piece 7

COLOR: Brown, white and black.
PRIMARY STRUCTURE: Magmatic textures.
SECONDARY STRUCTURE:
PRIMARY MINERALOGY:
Clinopyroxene. - Mode: 85%.
Crystal Size: 7–25 mm.
Crystal Shape: Subhedral.
Plagioclase. - Mode: 10%.
Crystal Size: <5 mm.
Crystal Shape: Anhedral.
Iron oxide minerals. - Mode: 2%.
Crystal Shape: Anhedral.
Sulfide minerals. - Mode: 1%.
Crystal Shape: Anhedral.
Comments: Piece 7 is a very coarse-grained oxide metagabbro/pyroxenite. Plagioclase occurs in the interstitial areas created by the framework of large clinopyroxene crystals. Sulfide and iron oxide minerals also appear to be interstitial and are probably magmatic in origin. The lower intrusive contact is preserved in Piece 7 against dunite depleted in pyroxene. As along the upper contact in Piece 6, olivine is well preserved adjacent to the pyroxenite along the lower contact.
SECONDARY MINERALOGY:
Prehnite.
Mode of Occurrence: After plagioclase.
Zoisite.
Mode of Occurrence: After plagioclase.
Secondary plagioclase.
Mode of Occurrence: After plagioclase.
Actinolite.
Mode of Occurrence: After clinopyroxene.
Chlorite.
Mode of Occurrence: After clinopyroxene.
Comments: The gabbro is moderately to highly altered (25%). Plagiocase is commonly highly altered to prehnite, secondary plagioclase, zoisite, and rimmed by amphibole and chlorite when adjacent to pyroxene. Pyroxene is moderately amphibolitized to actinolite and cummingtonite?; chlorite forms a dark rim adjacent to plagioclase. The piece is cut by carbonate mineral veinlets and a 1.5 mm wide vein of prehnite and epidote.
VEIN/FRACTURE FILLING:
Carbonate minerals.
Size: <1 mm.
Prehnite and epidote(?).
Size: 1.5 mm.
ADDITIONAL COMMENTS: Structure
The lowermost part of the section is intruded by a coarse-grained pyroxenite-gabbro dike. The peridotite is strongly deformed along the margins of the dike but the dike is only very weakly deformed with minor kinking and distortion of clinopyroxene grains that may also be associated with their alteration. A shear zone is located in Piece 6 above the pyroxenite dike. The lower contact with the dunite is highlighted by numerous wispy white serpentine veins roughly parallel to the contact.



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UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–19

COLOR: Black/green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine. - Mode: 84%–88%.
Orthopyroxene. - Mode: 11%–13%.
Crystal Size: 2–10 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 0–1%.
Crystal Size: 3–10 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%–2%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Sulfide minerals. - Mode: <1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic harzburgite that is generally depleted in pyroxene content (11%–16%). Pieces 1–12 contain 14%–16% pyroxene, whereas Pieces 13–19 are more highly depleted in pyroxene (11%–13%). There is a general trend of decreasing pyroxene content downward in the section. The degree of alteration is high in most samples, although olivine is well preserved in Piece 1 where the alteration is only about 80% for olivine. Spinel in the section can either be disseminated (the normal case) or concentrated along seams that are either horizontal or at a high angle to the foliation and appear to cut across the high-temperature fabric. In some cases these spinel seams appear to track through the sample in a random manner. The seams can be deceptive in the sense that they can be misinterpreted to define a foliation or lineation where they are straight. They are generally comprised of discontinous elongate spinels (elongate parallel to the seam) that can define an aggregate lineation on the surface of inspection. In general, they can be recognized easily because they are zones of concentrated spinel, where spinel is in much higher abundance than in the bulk rock. The seams may be interpreted as melt pathways through which melts have migrated through interconnected pore spaces and precipitated spinel, and possibly in some cases depleted the wall of pyroxene. Generally, these channels are small and the spinel trails are very thin. Piece 6 contains good examples of these types of features. They are most abundant in zones where the pyroxene content of the harzburgite is low. In addition, a highly altered gabbroic vein is also contained at the base of Piece 6 (few cm thick) and is discordant to the foliation. Small clinopyroxenite veinlets can be found in some samples (e.g., Piece 19) that represent further evidence of melt migration. These melt migration seams are generally undeformed and cut across the foliation plane, suggesting that they are post-kinematic with respect to the deformation of the peridotite. They are also common in zones of pyroxene depleted harzburgite.
Brown amphibole occurs in Pieces 1 and 6. It replaces clinopyroxene lamellae and is retrograded to chlorite. In Piece 6, a vein of hornblendite intrudes the sample (≈20 mm wide). The hornblendite has retrograded in places to tremolite and talc mixtures. Piece 19 contains a vein cutting the sample that contains serpentine, calcite, and chalcopyrite.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene, clinopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Amphibole(?).
Mode of Occurrence: After orthopyroxene.
Talc(?).
Mode of Occurrence: After olivine.

Comments: Alteration is patchy in appearance due to pods of olivine-rich zones altering to white serpentine kernels with light green rims, enclosed in an olive green to light green serpentinized matrix. Total alteration is heterogeneous but is commonly pervasive (80%–95%). Alteration of olivine is pervasive (80%–95%), with clear olivine kernels present in less altered areas, which

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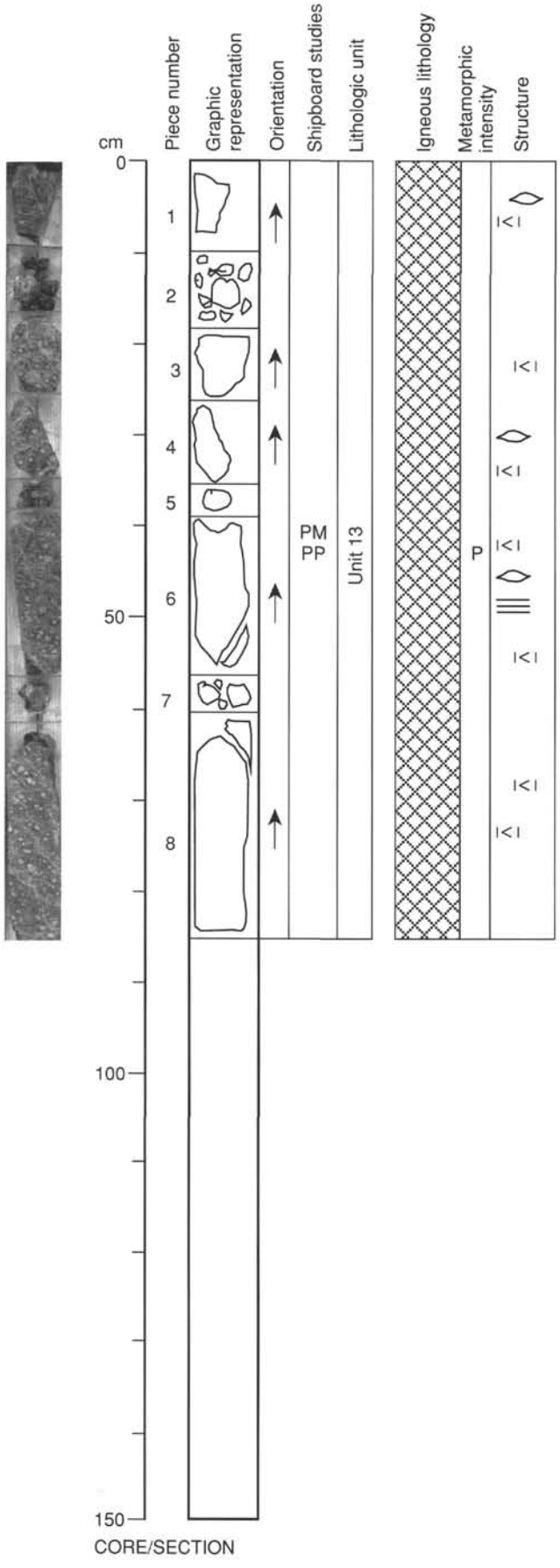
are generally associated with porphyroclasts of orthopyroxene. Serpentine forms a dark olive green brown mesh network cut by abundant microveinets of serpentine and iron oxide minerals. Orthopyroxene is pervasively altered (85%–98%) with apple green to cream-colored cores which are rimmed by amphibole?, and a trace of talc(?) when bounded by olivine. Iron oxide minerals along lamellae are common. Clinopyroxene rarely contains blebs of brown amphibole and is associated with disseminated pyrite.

Veins

Piece 3 has carbonate minerals and serpentine on outer margins and discontinous pods of pyrite which locally is altered to hematite. Black, tapering, mm wide, high relief veins may be amphibole. Serpentine and chlorite mm-wide veinlets and sulfide mineral stringers are present. Piece 6 contains abundant composite black and white anastomosing veinlets of serpentine. At the bottom of the piece there is a 2.5 cm wide hornblendeblendite vein of tremolite and talc(?), brown hornblende, and chlorite. Piece 15 contains a serpentine, and carbonate and sulfide mineral vein 1 mm wide. Piece 18 contains abundant, subparallel, aqua, tapering serpentine veins <1 to 1 mm wide, and serpentine, amphbiole, and chlorite veins (after gabbro/pyroxenite vein). Piece 19 has vertically oriented carbonate mineral and serpentine veinlets, which run parallel to dark amphibole filled veins (1 mm wide). The amphibole veins are cut by wispy white serpentine veins.

ADDITIONAL COMMENTS: Structure

A moderate to strong elongated porphyroclastic texture deforms orthopyroxene grains that show a maximum aspect ratio of about 4. The foliation dips at about 45° to 50°. An anastomosing foliation formed by dark green serpentine veins overprints the orthopyroxene fabric and is highlighted by thin (1–2 mm) serpentine veins. The percentage of veining is low in Pieces 1 to 3 in a pyroxene poor interval. Toward the base of the section the orthopyroxene content decreases and the clinopyroxene trails increase in abundance. Some trails of spinels cut across the pyroxene foliation following wandering paths, but some also run subparallel to it on linear trails. Some spinels show a weak shape preferred orientation, subparallel to the linear trails (e.g., Piece 6). Clinopyroxenite veins also cut across the foliation (e.g., Piece 18).



153-920D-13R-4

UNIT 13: SERPENTINIZED PYROXENE-RICH HARZBURGITE

Pieces 1–8

COLOR: Dark gray green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE:
PRIMARY MINERALOGY:
Olivine - Mode: 81%–93%.
Orthopyroxene. - Mode: 5%–15%.
Crystal Size: 2–18 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene. - Mode: 1%–4%.
Crystal Size: 1–7 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: <1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized pyroxene-rich porphyroclastic harzburgite and dunite. Pyroxene abundances are relatively high, averaging ≈22% below Piece 2. Piece 1 is strictly a serpentinized dunite, containing only 5% orthopyroxene and 1% clinopyroxene. It also contains a small 3 mm wide altered clinopyroxenite vein that is highly discordant with repect to the high-temperature crystal-plastic foliation. Piece 2 is depleted harzburgite with ≈15% pyroxene. Pieces 3–8 contain serpentinized harzburgite more enriched in pyroxene (>20%) and again lack magmatic veins. Clinopyroxene abundances are low (1%–3%), but along with orthopyroxene are well preserved due to the generally low degrees of alteration (80%). Anastamosing white serpentine veins become prominent again from Piece 3 to 8 where pyroxene content is high.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 80–95
Mode of Occurrence: Replacement.
Comments: Replaces olivine and orthopyroxene.
Magnetite.
Total Percent: <1
Mode of Occurrence: Mineral breakdown.
Comments: Produced during serpentinization.
Comments: Alteration is patchy in appearance in Piece 2 to the bottom of the section due to pods of olivine-rich zones altering to white serpentine kernels with light green rims, enclosed in an olive green to light green serpentinized matrix. Total alteration is heterogeneous, but is commonly pervasive (85%–95%). Alteration is most intense in the olivine-rich zones of Piece 1. Alteration of olivine is pervasive (90%–99%), with clear olivine kernels present in less altered areas, which are generally associated with porphyroclasts of orthopyroxene. Serpentine forms a dark, olive green brown mesh network cut by abundant microveinlets of serpentine and iron oxide minerals. Orthopyroxene exhibits heterogeneous alteration which decreases downsection from 80% to 20% with apple green to cream-colored cores rimmed by amphibole, and a trace of talc(?) when bounded by olivine. Iron oxide minerals along lamallae are common.
Veins
Piece 1 contains a 1 mm-wide, amphibole, serpentine, chlorite, and sulfide mineral-bearing vein. This vein is cut by tapering, aqua green serpentine veins which run parallel to thin wispy white veinlets. Piece 5 is cut by a 1 mm wide amphibole, chlorite, serpentine vein. Piece 6 is cut by dark green serpentine veins with dark brown serpentine halos about 1 mm wide. Black and white serpentine composite veinlets cut the dark serpentine vein.
VEIN/FRACTURE FILLING:
Amphibole and pyrite.
Size: <2 mm.
Orientation: Along core.
Comments: Piece 1.
Serpentine and pyrite.
Comments: Coating on outer surface of Piece 1.
ADDITIONAL COMMENTS: Structure
A weak elongated porphyroclastic texture deforms the pyroxene-rich harzburgite. The increase in abundance and grain size of the orthopyroxene correspond to a stronger anastomosing foliation of green serpentine veins and strong deflections of white serpentine veins around the porphyroclasts. The

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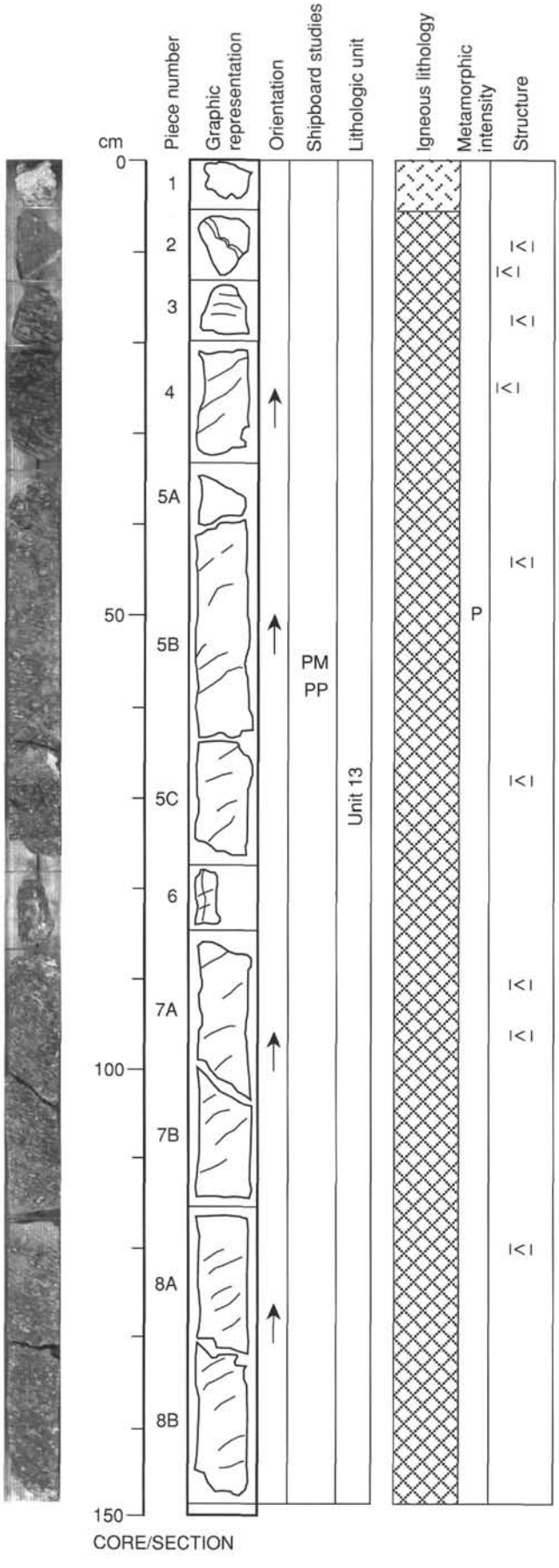
average dip of the foliation is about 45°. Piece 1 contains a metagabbro(?) vein that is cut by a pale green serpentine vein that, in turn, overprints white serpentine veins. A dark green serpentine vein, oriented at a high angle to the foliation is cut by white, foliation parallel serpentine veins.



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UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–8B

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 82%–93%.
Orthopyroxene - Mode: 7%–12%.
Crystal Size: 15–25 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 0%–5%.
Crystal Size: 0.5–1 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 2%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: Piece 1 is a metagabbro comprising a coarse crystalline aggregate of amphibole (<1.5 cm), vuggy prehnite replacing original plagioclase, and radiating zeolite grains. Pieces 2–7 are serpentinized porphyroclastic harzburgite. Pieces 2 and 8 are highly depleted harzburgite to dunite with 6%–10% pyroxene. They contain a clinopyroxenite vein boundary on one edge. The orthopyroxene content ranges from 12%–18% below Piece 3 and above Piece 8, and clinopyroxene is relatively abundant, in places up to 5%. The degree of alteration is relatively low; 70% below Piece 3. The anastomosing serpentine foliation is well developed.
SECONDARY MINERALOGY:
Serpentine
Total Percent: 57–93
Mode of Occurrence: Replaces primary minerals.
Magnetite.
Total Percent: 1–2
Comments: Product of serpentinization.
Comments: Piece 1 is a pocket of incipiently Ca-metasomatized pegmatoid gabbro, altered to actinolite after clinopyroxene(?) and prehnite, epidote, zeolite, ± hydrogrossular(?) after plagioclase. Piece 2 is extensively serpentinized. The piece is crosscut by a 1 mm wide metagabbroic vein composed of chlorite, actinolite(?), brown amphibole, and serpentine. This vein is cut by short, dark green serpentine veins. Below Piece 3, the rock contains fresh clinopyroxene, orthopyroxene, and olivine; <1 mm veins are parallel to the foliation.
VEIN/FRACTURE FILLING:
Serpentine and brucite(?).
Size: 0.05–0.1 mm.
Orientation: Foliation parallel.
Serpentine.
Size: 3 mm.
Orientation: Normal to foliation.
ADDITIONAL COMMENTS: Structure
A weak, elongated porphyroclastic texture is present, defined by orthpyroxene porphyroclasts. The structure is dominated by moderate development of wispy serpentine veinlets parallel to weak to moderately developed anastomosing foliation. The dip of the foliation ranges from about 20° to 30°. Piece 2 is an orthopyroxene-poor interval cut by a metagabbro vein that is cut by dark green serpentine veins. In Piece 7, a dark green serpentine vein (3 mm wide) is cut by the thin white anastomosing serpentine veins.

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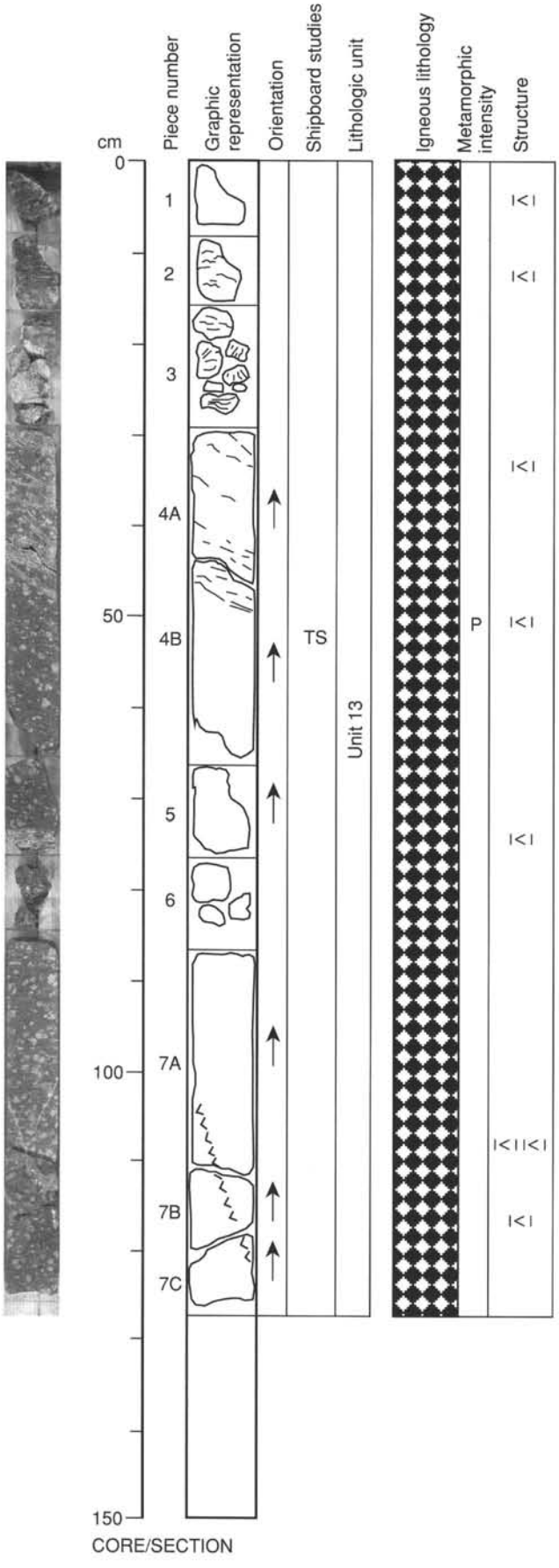
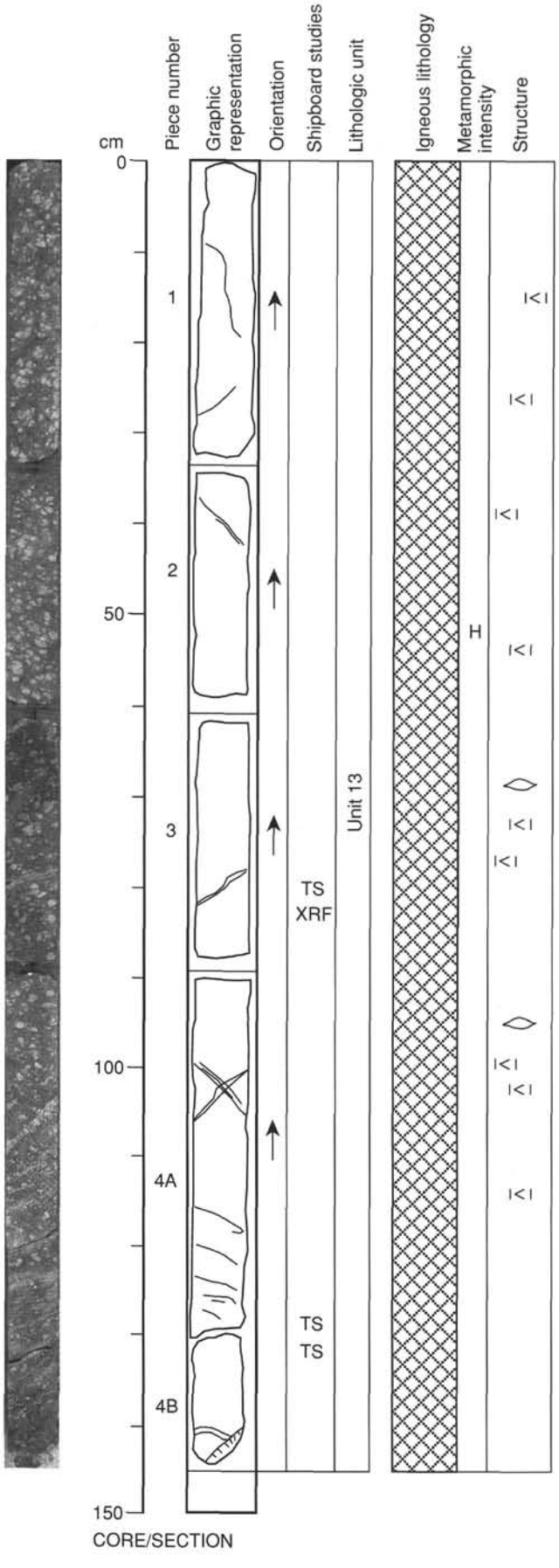


UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–7C

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Serpentinized broken zone in Piece 3 associated with strong adjacent folition development.
PRIMARY MINERALOGY:
Olivine - Mode: 79%–93%.
Orthopyroxene - Mode: 6%–15%.
Crystal Size: 2–16 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 0%–5%.
Crystal Size: 1–9 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic harzburgite. Pieces 1 through 4A are small intervals of more strongly altered harzburgite containing dense serpentine veinlet development. Piece 2 contains a 10 mm dunite layer, and Piece 3 is a rubbly zone of altered serpentinite. Below Piece 4A, the harzburgite is relatively fresh and shows little or no elongation of orthopyroxene porphyroclasts. Pyroxene content tends to decrease somewhat to the base of Piece 4. Pyroxene content is between 15% and 20%. Orthopyroxene abundances are moderate (13%–16%) and clinopyroxene is abundant and fresh (up to 5%). Olivine is also relatively fresh (<65% altered). Piece 7 contains an altered gabbro/pyroxenite composite vein several mm wide.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 60–95
Comments: Replaces olivine and orthopyroxene.
Magnetite.
Total Percent: <2
Comments: Product of serpentinization.
Comments: Pieces 1–3 are strongly serpentinized with 98%–100% alteration. Below Piece 4B an anastomosing fabric is defined by dark serpentine veinlets in a very broad wavy network. A 1.5 to 5 mm wide vein of metagabbroic composition (altered plagioclase, amphibole, and chlorite) dips steeply through Pieces 7A, 7B, and 7C. In Piece 7A it branches with a thinner vein (1 mm) composed of amphibole and chlorite.
VEIN/FRACTURE FILLING:
White mineral-amphibole vein cuts Pieces 7A–7C
Size: 50 mm.
Wispy serpentine.
Orientation: Foliation parallel.
Comments: Pieces 1–5.
ADDITIONAL COMMENTS: Structure
A weak foliation is defined by a weak ellipticity of orthopyroxene porphyroclasts. This section is distinct from most other sections in Hole 920D as it contains very few white serpentine veins. The white serpentine veins at the top of the section are subplanar thin (<1 mm) veins forming closely spaced arrays. The few white veins that are present from Piece 3 downsection are characterized by wavelengths of >10 cm and amplitudes of about 1 cm. Their trace does not appear to be directly controlled by the pyroxene porphyroclasts. The most abundant veins are dark green serpentine veins that form irregular, branching network through most of the section. Below Piece 5, the white serpentine veins are absent. In Piece 7, a steeply dipping metagabbro vein has intruded the harzburgite.



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UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–4B

COLOR: Gray/green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 80%–85%.
Crystal Size: 0.8–1 mm.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 13%–16%.
Crystal Size: 1–13 mm.
Crystal Shape: Anhedral-euhedral.
Clinopyroxene - Mode: 3%–4%.
Crystal Size: 1–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Sulfide minerals - Mode: <<1%.
Crystal Size: 0.2 mm.
Crystal Shape: Subhedral.
Comments: Unit 13, serpentinized porphyroclastic harzburgite continues in this section. It is remarkably fresh (as little as 55% altered); the top 100 cm of the section are also almost undeformed. It contains approximately 15%–22% pyroxene with orthopyroxene/clinopyroxene estimated as at least 4 or 5. Orthopyroxene ranges in size from 1–13 mm and is fairly fresh except when cut by serpentine veinlets. Clinopyroxene ranges in size from 1–5 mm and is fresh. Olivine in the matrix occurs as fresh rounded relics (0.1–0.5 mm) within the serpentine and magnetite network. The development of serpentinization is patchy. In places there is only a trail of magnetite grains along grain boundaries, whereas in other areas, in particular near abundant serpentine veinlets, olivine grains are totaly replaced. Spinel (up to 2 mm) is quite prominant, occurring both interstitially in orthopyroxene ± clinopyroxene ± olivine aggregates and as trails up to 4 mm long paralleling the development of the serpentine veinlets in the matrix. Sulfide minerals are also present. The lower 45 cm (below the green serpentine vein in Piece 4A) has a lower pyroxene content (10% pyroxene with less than 1% clinopyroxene) and it is more altered than the upper part of the section. There are no magmatic veins in the section.
SECONDARY MINERALOGY:
Serpentine.
Comments: Replaces olivine and orthopyroxene.
Magnetite.
Comments: Product of serpentinization.
Comments: The degree of alteration is low (as little as 55%) in Pieces 1–3 and the top of Piece 4. It increases in the bottom of Piece 4 (to about 85%–90%) as anastomosing nets of dark and wispy serpentine veins become well developed. Olivine is partially altered to a mesh of serpentine and iron oxide minerals that bound kernels of fresh olivine. Orthopyroxene is only marginally serpentinized and clinopyroxene is fresh. The more altered part of the section is more gray. It contains very little fresh olivine (<5%), but still at least 40% fresh pyroxene.
Veins
At the bottom of Piece 4 are two veins of amphibole and chlorite, 0.4–1 mm wide. Piece 4 also contains an 0.5 mm wide, dull green serpentine vein.
VEIN/FRACTURE FILLING:
Serpentine (white).
Percent: <<1%
Orientation: Foliation parallel.
Serpentine (green).
Percent: <1%
Size: 5 mm.
Orientation: Low angle to foliation.
ADDITIONAL COMMENTS: Structure
The section is characterized by an extremely weak foliation defined by the elongation of orthopyroxene porphyroclasts. At the top of the core the foliation is weak to nonexistent, but toward the bottom of Piece 4, the matrix olivine is evident as "lozenges" and as elongated, aligned lenses of neoblasts outlined by the serpentine and magnetite alteration. There is a local intensification of this fabric at the base of Pieces 3 and 4. Green black serpentine veins form the dominant veins but they show no preferred orientation, having a wavy,

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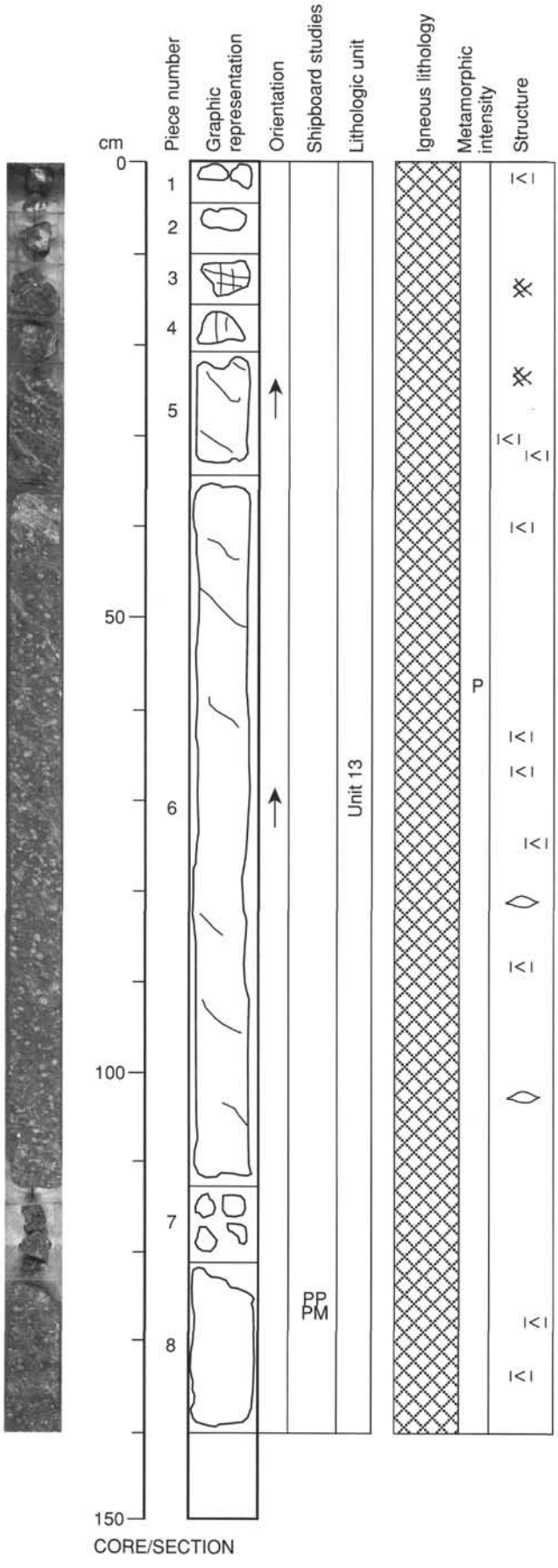
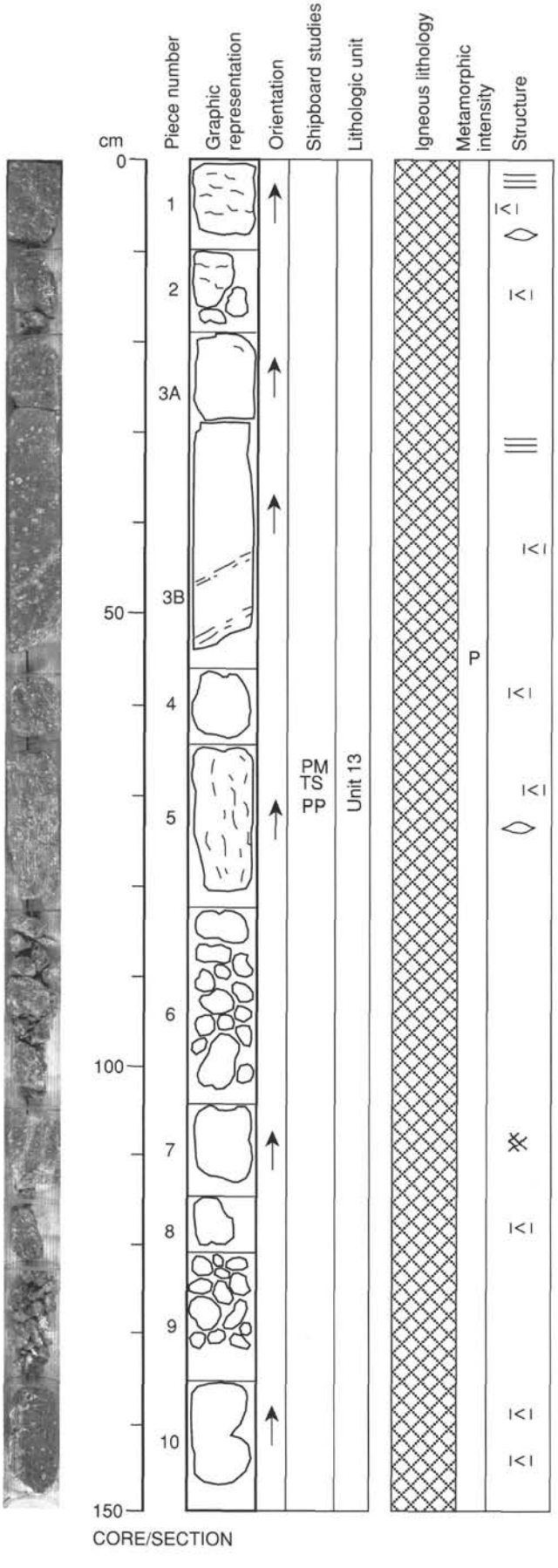


UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–8

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 86%–89%.
Orthopyroxene - Mode: 10%–12%.
Crystal Size: 2–18 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 1%–3%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: Pieces 1 and 2 are small chips of strongly altered harzburgite containing serpentine-pyrite veinlets. Pieces 1–5 are pyroxene depleted harzburgite with between 14% and 18% modal pyroxene. Clinopyroxene ranges between 2% and 3%. Pieces 6–8 are more enriched in pyroxene with ≈20% total pyroxene content. No magmatic veins were observed in the section.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 85–100
Comments: Replaces primary minerals.
Magnetite.
Total Percent: <2
Comments: Product of serpentinization.
Sulfide minerals.
Total Percent: <<1
Comments: Disseminated.
Comments: Harzburgite in this section is 60%–90% altered with the freshest material in Piece 6, which is somewhat lighter in color. Pieces 1–4 are more strongly altered. Olivine is altered to mesh textured serpentine and iron oxide minerals. In Piece 6 olivine alteration is 60%–70%. In the rest of the section it is 80%–95% altered. Pyroxene is altered (40% in piece 6, 70%–80% in the rest of the section), with formation of bastite in pervasively altered samples. Anastomosing nets of serpentine veins are well developed in Pieces 3–5 and the top of Piece 6. In most of Piece 6 and in Piece 8, the serpentine vein network has a weaker preferred orientation, but is still well developed. In Pieces 1–4 and the top of Piece 6, there is a late set of narrow (<1 mm) serpentine and iron oxide veins that define a network characterized by relatively high angle intersections.
VEIN/FRACTURE FILLING:
Talc and serpentine.
Comments: Within foliation.
Serpentine and chlorite.
Orientation: Crosscutting foliation.
ADDITIONAL COMMENTS: Structure
The structure is dominated by a weak to moderate development of an elongated porphyroclastic fabric developed in orthopyroxene. There is a weak alignment of porphyroclasts, particularly below Piece 5. A spaced anastomosing foliation is present toward the base of the core section, defined by thin dark green serpentine veins. A dark green serpentine vein (1.5 mm) in Piece 5 is cut by a thin white serpentine vein (1 mm wide) (also seen in Piece 8). A later, pale green serpentine vein cuts the white serpentine veins.



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UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–10

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 80%–90%.
Orthopyroxene - Mode: 9%–13%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 0%–5%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: The section consists of relatively homogeneous serpentinized porphyroclastic harzburgite with between 15% and 20% modal pyroxene content. Orthopyroxene abundances decrease from 14%–18% on the top of the section to 13% below Piece 6. Clinopyroxene ranges from 3%–4%. Clinopyroxene abundances are consistently high. Pieces 5–10 contain a near vertical anastomosing serpentine vein set. Pieces 6 and 9 are rubble zones. Piece 10 contains a large vertical serpentine vein. There are no magmatic veins in the section.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 54–90
Comments: Replacement.
Magnetite.
Total Percent: 1–5
Comments: Serpentine breakdown product.
Comments: Harzburgite in this section is 70%–90% altered. There are lower degrees of alteration in Pieces 3–5, which are lighter gray green. Rubbly material in Piece 6 is similar in color and degree of alteration. Olivine is altered (85%–100%) to a serpentine and iron oxide mineral mesh. Orthopyroxene is altered (60%–90%) to gray to pale green bastite, clinopyroxene is altered to amphibole. Anastomosing nets of dark and light colored serpentine and iron oxide mineral-bearing veins are well developed in Pieces 4–9, and at the bottom of Piece 3. In Piece 7, these anastomosing serpentine veins are crosscut by discontinuous serpentine veins. A 0.8 cm wide white, serpentine vein cuts Piece 10. It is subvertical, dark gray and cut by later pale green serpentine veins <1 to 1 mm in width.
VEIN/FRACTURE FILLING:
Serpentine, talc, and brucite(?).
Size: <1 mm.
Orientation: Normal to foliation.
ADDITIONAL COMMENTS: Structure
A weak to moderate elongated porphyroclastic fabric is much steeper (60°–8°) than in most of the other core sections. The fabric runs almost vertically down the core below Piece 4. An anastomosing foliation is defined by thin (1–2 mm) serpentine veins and overprints the porphyroclastic fabric. Veining is partitioned into discrete zones in the section that correspond in several places to zones of slightly stronger porphyroclastic fabric (e.g. Piece 3). Some portions of the section show no veining at all (e.g. Piece 3). Pieces 6 and 9 contain several open, oxidized joint surfaces on small pieces. At the top of the section closely spaced (0.5 cm) orthogonal joint sets cross Piece 1.

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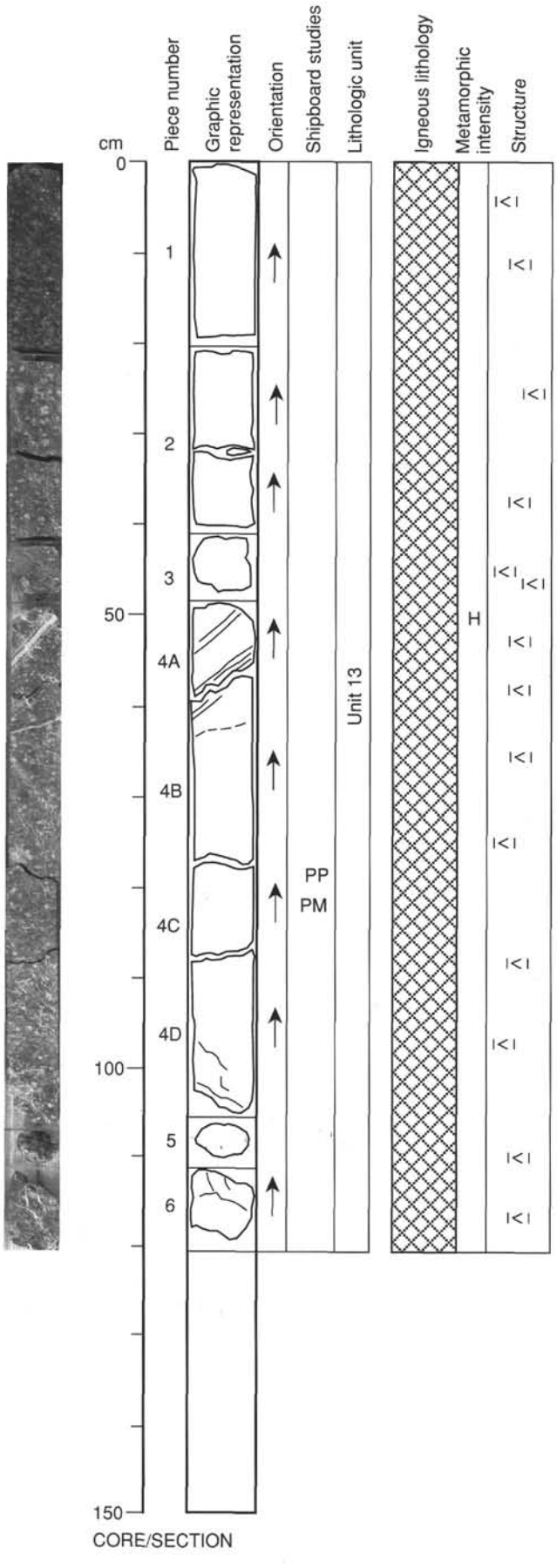
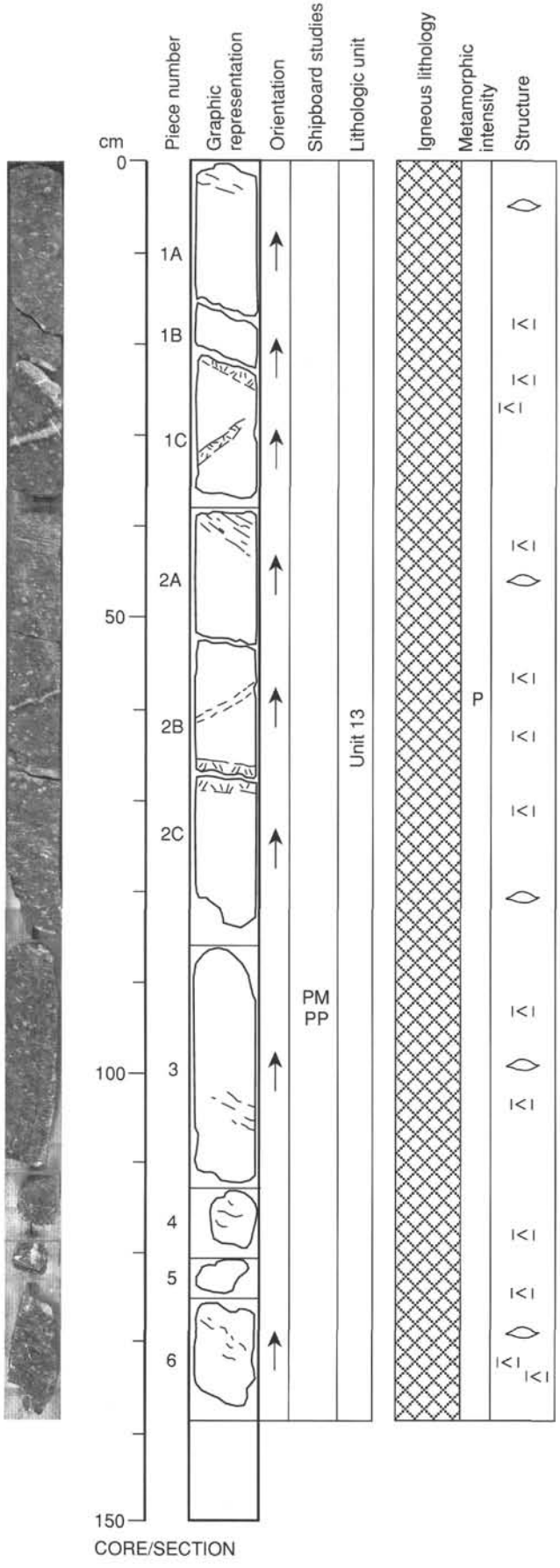


UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–6

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 86%–88%.
Orthopyroxene - Mode: 7%–12%.
Crystal Size: 2–6 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 3%–5%.
Crystal Size: 1–4 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: <1%–1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: The section is composed of serpentinized porphyroclastic harzburgite with 15% to 20% total pyroxene in Pieces 1–4. Piece 4 contains a large green chrysotile and chlorite composite vein 1.5 cm thick and a thin (mm scale) altered gabbroic vein. Pieces 5 and 6 show an increase in pyroxene content to 20%–23%. Some orthopyroxene grains show a weak elongation, but are typically somewhat rounded in shape. Only one thin magmatic vein was observed.
SECONDARY MINERALOGY:
Magnetite.
Total Percent: <2
Comments: Breakdown product of serpentinization.
Serpentine.
Total Percent: 70
Comments: Replaces primary phases.
Comments: The harzburgite in this section is about 70%–80% altered with light gray green patches of relict olivine and pyroxenes in a darker, more serpenintized matrix. Olivine is 70%–80% altered to a serpentine and iron oxide mineral mesh. Pyroxene is typically replaced by dull green bastite and are 40%–70% altered. Nets of anastomosing serpentine veins are relatively well developed. Two parallel, 8 mm wide, metagabbroic veins of serpentite, magnetite, and a trace of sulfide minerals cut Pieces 4A and 4B. White wispy veining becomes thicker downsection, and in the last piece (Piece 6) forms a branching mass with veinlets up to 5 mm thick.
VEIN/FRACTURE FILLING:
Pyroxenite veinlets
Size: 2 mm.
Orientation: Normal to core.
Serpentine, tremolite, and chlorite.
Size: 2–20 mm.
ADDITIONAL COMMENTS: Structure
A moderately strong elongated porphyroclastic texture of orthopyroxene porphyroclasts is overprinted by an anastomosing foliation. The foliation is formed by thin white serpentine veins (<1 mm). The white serpentine vein foliation dips relatively steeply in Piece 2; approximately 60°, although the main foliation has a shallow dip (24°). In Piece 4, several dark green serpentine veins (1–7 mm wide) are cut by the thin white serpentine veins.



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UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–6

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Anastomosing crystal-plastic fabric.
PRIMARY MINERALOGY:
Olivine - Mode: 85%–86%.
Orthopyroxene - Mode: 10%.
Crystal Size: 2–14 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 3%–4%.
Crystal Size: 1–8 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic harzburgite with pyroxene content between 15%–20%. Piece 1 contains 6–8 mm thick altered clinopyroxenite/gabbro composite veins, both of which are highly discordant with respect to the high-temperature foliation. Piece 2 is also cut by two altered pyroxenite veins, one concordant and one discordant to the foliation. Clinopyroxene is relatively abundant and only slightly altered in the section (2%–5%).
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 85
Comments: Replaces primary phases.
Magnetite.
Total Percent: 5
Comments: Product of serpentinization.
Comments: Alteration is pervasive and somewhat patchy in appearance due to pods of olivine-rich zones altering to white serpentine kernels with light green rims, enclosed in an olive green to light green serpentinized matrix. Alteration of olivine is pervasive (98%–100%), with clear olivine kernels rare. Serpentine forms a dark olive green brown mesh network cut by abundant microveinets of serpentine and iron oxide minerals. Aggregates of orthopyroxene, olivine, and minor clinopyroxene are moderately to pervasively altered and exhibit apple green- to cream-colored cores, which are rimmed by serpentine and a trace of amphibole.
Veins
Pieces 1C, 2B, and 2C contain 4 to 12 mm wide, metagabbroic and pyroxenitic veins which both cross at a high angle, and lie parallel to the fabric defined by porphyroclastic aggregates. Alteration minerals include tremolite-actinolite after clinopyroxene, prehnite, zeolite, and clay minerals after plagioclase, and well-developed to diffuse alteration halos of intergrown serpentine, chlorite, and amphibole (3–5 mm wide). The magmatic veins are cut by 1 mm wide thick white, discontinuous serpentine veins oriented subperpendicular to the magmatic veins. Pieces 3, 4, and 6 are cut by subvertical <1 to1 mm wide dark veinlets which contain a narrow core of pale green serpentine and a dark green colored rim composed of serpentine, chlorite, and amphibole(?). Wispy composite white and iron oxide mineral-bearing veinlets are common, forming an anastomosing network parallel to the foliation.
VEIN/FRACTURE FILLING:
Serpentine and amphibole.
Size: 0.5–4 mm.
Orientation: Subparallel to foliation.
ADDITIONAL COMMENTS: Structure
A moderate to strong elongated porphyroclastic fabric is mesoscopically defined by orthopyroxene porphyroclasts. Thin (1 mm) white serpentine veins overprint the porphyroclastic foliation but no anastomosing foliation of dark green serpentine veins is evident. The strongest fabric development is seen at the top and bottom of Pieces 2 and also in Pieces 3 and 6. In Piece 1, four generations of veins are evident: An early amphibole-bearing vein is cut by the white serpentine veins that form the foliation. These are cut by a pale green serpentine vein that is cut by a later generation of white to pale green serpentine vein that is cut by a later generation of white to pale green serpentine veins.

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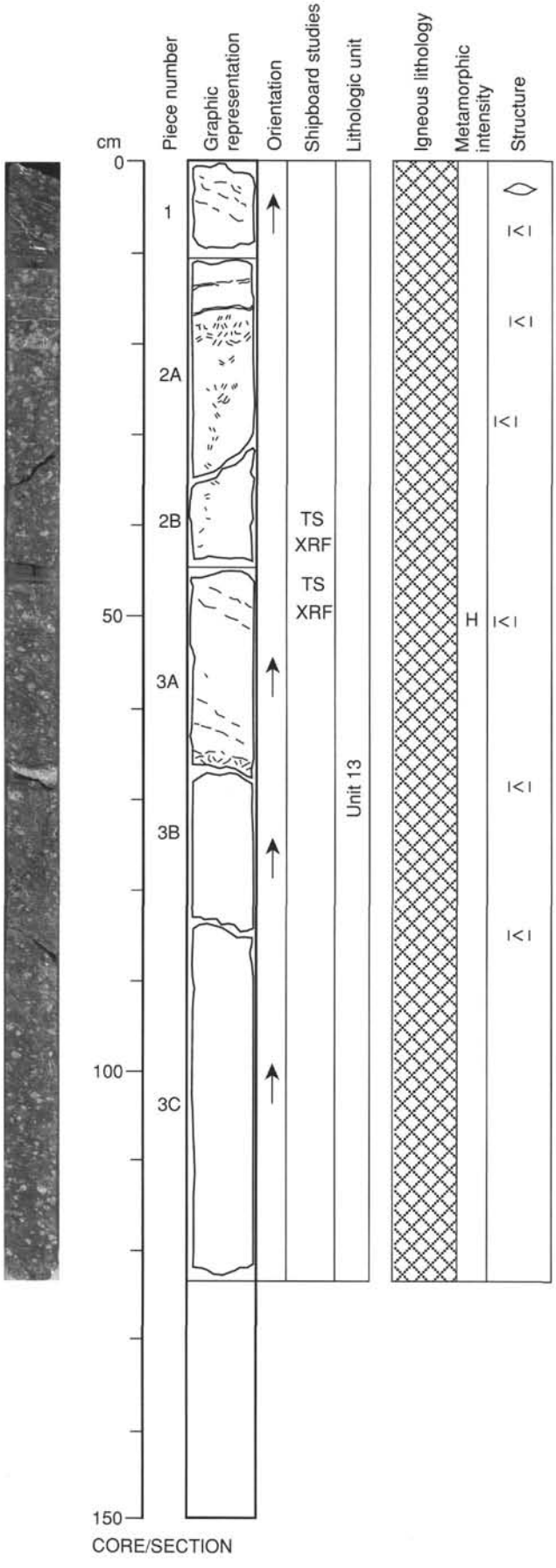

UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–3C

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 80%.
Orthopyroxene - Mode: 14%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 5%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: >2 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic harzburgite. Orthopyroxene is strongly elongate and pyroxene abundance is slightly higher than the previous section. Total pyroxene content is 15% in Piece 1 and 20%–23% in Pieces 2 and 3. Clinopyroxene is only slightly altered and abundances are consistently 4%–5%. 6–8 mm wide concordant bands of altered pyroxenite cut Pieces 2 and 3. In Piece 2, the vein has developed around a nodule of clinopyroxenite that is almost certainly mantle derived. A second trail of secondary pyroxene crystals branches from this vein and runs along the length of Piece 2. These crystals appear to have developed along a channel through which melt or fluid has migrated, but did not form an extensional vein fill. An alteration halo occurs around pyroxenitic veins on the contact of Pieces 3A and 3B.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 60
Comments: Replaces primary phases.
Magnetite.
Total Percent: 5
Comments: Product of serpentinization.
Comments: Alteration is similar in character to Core 153-920B-15R-4. Formation of secondary minerals is pervasive (80%–98%) and patchy in appearance due to pods of olivine-rich zones altering to white serpentine kernels with light green rims, enclosed in an olive green to light green serpentinized matrix. Alteration of olivine is pervasive (80%–100%), with clear olivine kernels most commonly adjacent to porphyroclastic aggregates of olivine, orthopyroxene, and minor clinopyroxene. Serpentine forms a dark olive green brown mesh network cut by abundant microveinets of dark brown-green serpentine and iron oxide minerals. Aggregates of orthopyroxene, olivine, and minor clinopyroxene are moderately to pervasively altered and exhibit apple green cores, which are cut by fine microveinlets of serpentine and rimmed by trace amphibole and serpentine. Elongation of porphyroclasts is most pronounced in Piece 1.
Veins
Piece 2A is cut by an irregular shaped 15–18 mm wide pyroxene-rich zone in which coarse-grained pyroxene has grown adjacent to and within a pyroxenite vein. Both the rimming pyroxene and vein pyroxene are altered to actinolite and chlorite with serpentine becoming more abundant near vein margins. A 2 mm wide actinolitic vein subparallels the wide pyroxenite vein. The magmatic veins are cut by 1 mm wide, white discontinuous serpentine veins oriented subperpendicular to the magmatic veins. Piece 3B is cut by subvertical <1 to 1 mm wide dark veinlets which contain a narrow core of pale green serpentine and a dark green rim composed of serpentine, chlorite, and amphibole(?). Wispy composite white and iron oxide mineral-bearing serpentine veinlets are common, forming an anastomosing network parallel to the foliation.
VEIN/FRACTURE FILLING:
Clinopyroxene.
Percent: 100%
Size: 20 mm.
Amphibole, serpentine, and chlorite.
Size: 20 mm.
ADDITIONAL COMMENTS: Structure
An elongated porphyroclastic texture, defined by orthopyroxene porphyroclasts is very well developed at the top of the section but decreases rapidly in intensity

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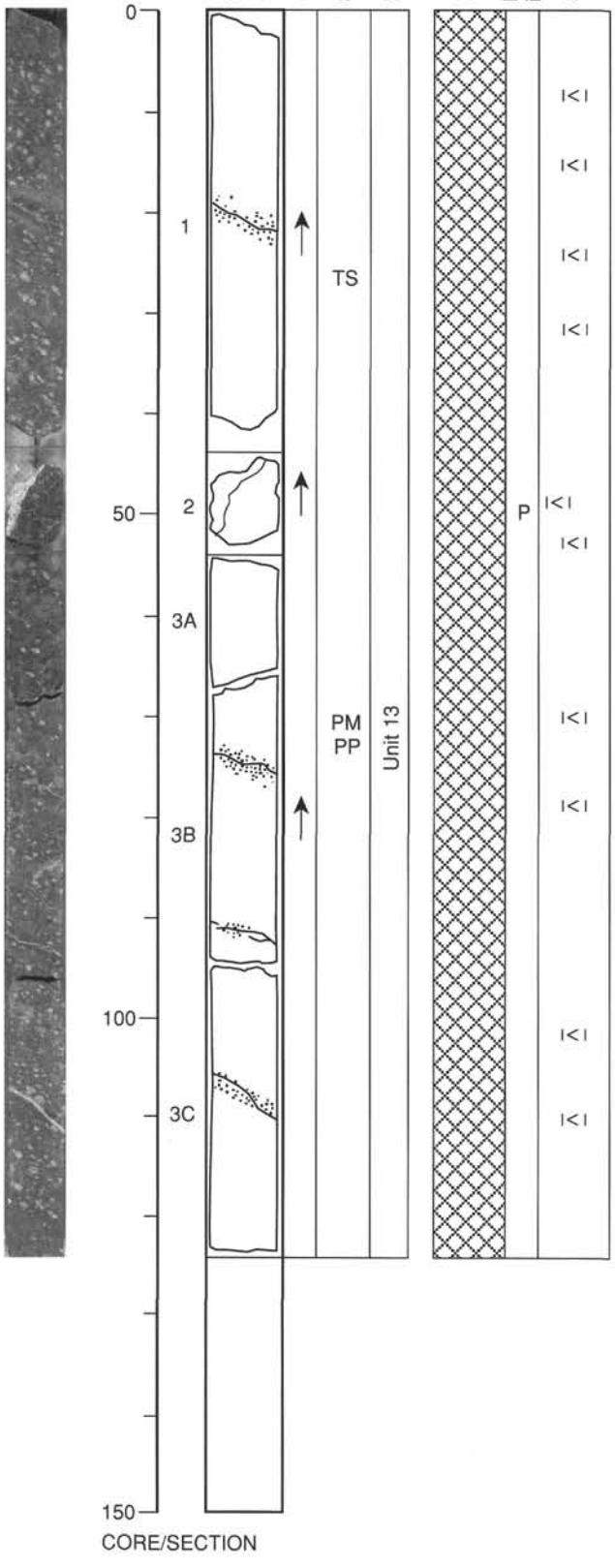
down the section (after Piece 3). The porphyroclast foliation has a moderate dip (<30°) and is even subhorizontal in a 30 cm thick interval in Piece 3. Sparse, thin, white serpentine veins have a preferred orientation subparallel to the porphyroclast foliation. A magmatic vein in Piece 3 is oriented subhorizontally, slightly oblique to the shallow-dipping foliation. A dark green serpentine vein (2–3 mm) is cut by white serpentine veins in Piece 3. Two pale green serpentine veins that cut the white serpentine veins are found in Pieces 2 and 3.

153-920D-15R-4

UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–3C



COLOR: Gray green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 85%–95%.
Crystal Size: 0.1–1 mm.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 4%–12%.
Crystal Size: 1–10 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: <1%–3%.
Crystal Size: 1–12 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <<1%.
Crystal Size: 0.1 mm.
Crystal Shape: Anhedral.
Comments: This section is composed of serpentinized harzburgite and is distinguished by the presence of rounded elongate patches of *orthopyroxene, clinopyroxene, olivine, ± spinel, all of which are fresh.* The proportion of clinopyroxene in these patches is greater than in the rock as a whole. These patches are up to 25 mm long. The percentage of pyroxene is estimated at 16% at the top of the section and decreases to 10% at the bottom. The ratio of orthopyroxene to clinopyroxene is estimated to be at least four or five. The distribution of kernels of fresh olivine within the serpentine and magnetite network is patchy, with fresh olivine varying between 0 and 25% of the matrix. Piece 3 is cut by two thin magmatic gabbroic veins concordant with the foliation and Piece 2 is in part pegmatitic gabbro, now strongly altered.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 78
Comments: Replaces primary phases.
Magnetite.
Total Percent: 5
Comments: Product of serpentinization.
Amphibole?.
Total Percent: <<1
Comments: Rimming orthopyroxene adjacent clinopyroxene.
Comments: Alteration is similar in character to the previous three sections in this core. Formation of secondary minerals is pervasive (80%–95%) and patchy in appearance due to pods of olivine-rich zones altering to white serpentine kernels with light green rims, enclosed in an olive green to light green serpentinized matrix. Patchiness is best developed in Piece 3A, which contains abundant relict olivine kernels, and orthopyroxene with spinel abundant near porphyroclast boundaries. Alteration of olivine is pervasive (80%–100%), with clear olivine kernels most common adjacent to porphyroclastic orthopyroxene and aggregates of olivine, orthopyroxene, and minor clinopyroxene. Serpentine forms a dark olive green brown mesh network cut by abundant microveinets of dark brown green serpentine and iron oxide minerals. Aggregates of orthopyroxene, olivine, and minor clinopyroxene are moderately to pervasively altered and exhibit apple green cores, which are rimmed cut by fine microveinlets of serpentine and which are rimmed by trace amphibole and serpentine.

Veins

Piece 1 is cut by an apple green-colored serpentine and chlorite vein which pervasively alters adjacent clinopyroxene in the host rock to serpentine and chlorite. This vein is 3 mm wide and is cut by near vertical wispy white serpentine veins. Piece 2 is cut by a wide metagabbroic vein, which is pervasively altered to brown amphibole, tremolite/actinolite after clinopyroxene, and zeolite with minor prehnite after plagioclase. Only one contact is present. The vein exhibits a narrow alteration halo which includes serpentine, actinolite, and chlorite and is oriented at a high angle to the foliation. The metagabbro is cut by abundant <1 mm wide aqua green serpentine veins which change composition and become whiter upon cutting the metagabbroic vein. Piece 3B contains a 2 mm wide vein subparallel to the foliation which contains serpentine, chlorite, and zeolite and a second vein, 2 mm wide which contains tremolite/actinolite after pyroxene(?), chlorite, and serpentine. Piece 3C is cut by a 2–3 mm wide vein containing

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brown amphibole, tremolite/actinolite after pyroxene(?), chlorite, and zeolite. Wispy, composite white and iron oxide mineral-bearing serpentine veinlets are common, forming an anastomosing network parallel to the foliation.

VEIN/FRACTURE FILLING:

Tremolite and chlorite.

Size: 30 mm.

Orientation: Oblique to foliation

Amphibole and chlorite.

Size: 20 mm.

Orientation: Oblique to foliation

ADDITIONAL COMMENTS: Structure

A weak to moderately elongated porphyroclastic texture deforms the serpentinized harzburgite with a fairly consistent dip throughout the core of about 30°. This foliation is overprinted by an anastomosing foliation formed by dense arrays of dark green serpentine veins, overprinted by thin (<1 mm) white serpentine veins. The serpentinized peridotite is crosscut by an altered coarse-grained gabbro dike (Piece 2) that dips steeply. In Piece 3 an amphibole bearing vein (2–3 mm wide) is oriented subparallel to the foliation.

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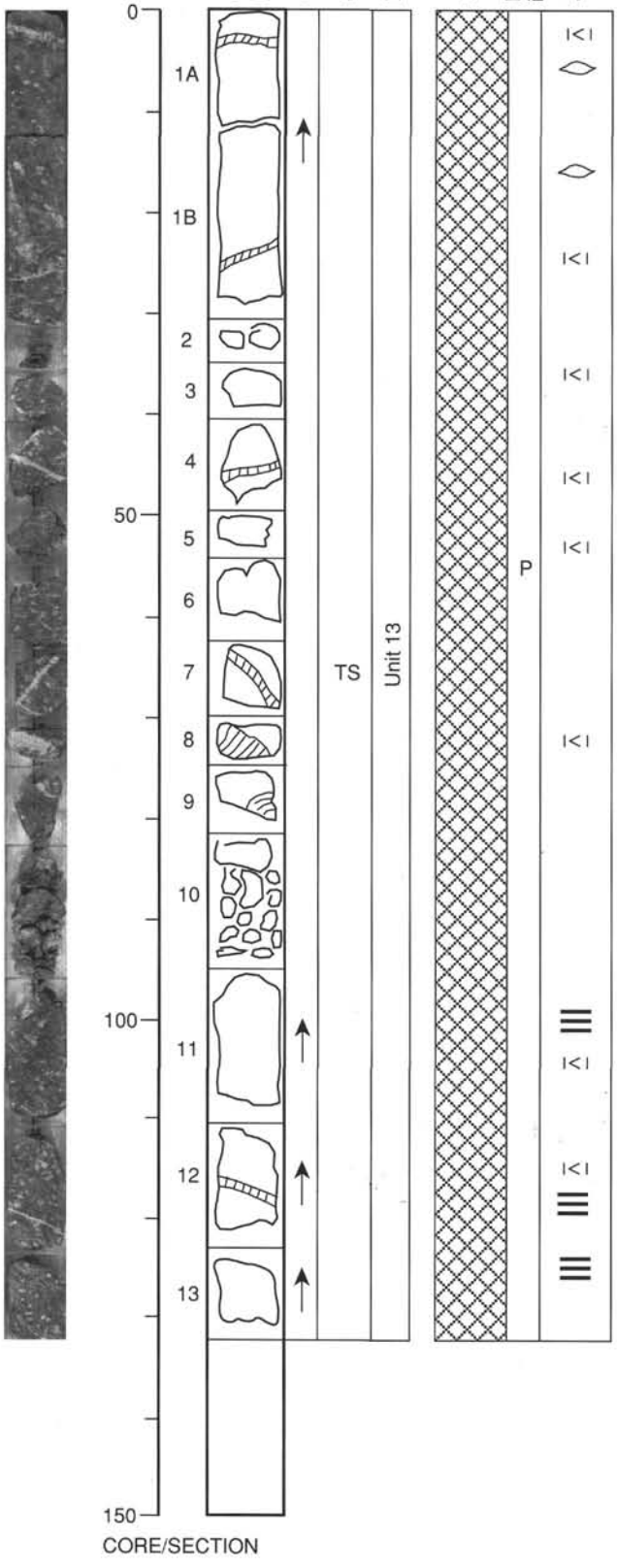
UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–13



COLOR: Dark gray.
PRIMARY STRUCTURE: Elongate porphyroclastic.
SECONDARY STRUCTURE: Serpentine veins and magmatic veins.
PRIMARY MINERALOGY:
Olivine - Mode: 90%–95%.
Orthopyroxene - Mode: 5%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Crystal orientation: Tectonic.
Clinopyroxene - Mode: 0–4%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <1 mm.
Comments: Serpentinized porphyroclastic harzburgite with variable pyroxene content. Pieces 1–4 and 10–13 contain 15%–20% pyroxene; Pieces 5–9 contain between 10% and 15% pyroxene. Pieces 2 and 10 are harzburgite rubble. Two highly altered gabbroic veins occur in Piece 1; they are both nearly concordant to the high-temperature crystal-plastic foliation plane. Pieces 4, 8, and 12 contain altered clinopyroxenite veins. Piece 7 contains an altered composite pyroxenite/gabbro vein. Orthopyroxene forms rounded to elongate porphyroclasts with the greatest elongation evident in Pieces 1A, 1B, 11, and 12.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 85
Comments: Replaces primary phases.
Magnetite.
Total Percent: 5
Comments: Product of serpentinization.
Comments: This section of core generally lacks the patchy alteration observed in previous sections and is poorer in porphyroclasts. Total alteration is 85%. Alteration of olivine is pervasive (80%–100%), with local areas containing abundant fresh olivine kernels. This is especially well developed adjacent to a metagabbroic vein in an olivine-rich section, Piece 7, in which bands of fresh olivine kernels are adjacent to the vein. Serpentine forms a dark olive green brown mesh network cut by abundant microveinets of dark brown green serpentine and iron oxide minerals. Aggregates of orthopyroxene, olivine, and minor clinopyroxene are moderately to pervasively altered and exhibit apple green cores, which are cut by fine microveinlets of serpentine and which are rimmed by trace amphibole and serpentine. These are especially abundant in Piece 1B, where compound aggregates reach 1–3 cm in size. Piece 1 is cut by a 5 mm wide, tremolite/actinolite, chlorite, serpentine, and prehnite(?) composite vein which is cut by white serpentine and oxide mineral-bearing veins. Piece 1B is cut by a 2–3 mm wide vein similar to that in Core 153-920B-15R-3, Piece 2A, and is characterized by growth of clinopyroxene adjacent to a narrow tremolite/actinolite and chlorite vein. Piece 4 contains a 4 mm wide tremolite vine cut by white serpentine veinlets. Piece 7 is cut by a an actinolite/tremolite, chlorite, and serpentine vein with a white serpentine and zeolite core and an amphibole-chlorite-rich margin. Piece 8 contains a metagabbro vein (1.8 cm in width) in which only 1 contact is present. Tremolite/actinolite and chlorite after pyroxene, and zoisite and prehnite after plagioclase form the dominant vein minerals. In Piece 12, a 3 mm wide vein of chlorite and serpentine with a dark green core rimmed by tremolite(?) actinolite is oriented at a slgiht angle to the poorly developed foliation. Wispy white veins are present, but less well oriented and abundant than in previous sections.
VEIN/FRACTURE FILLING:
Serpentine and chlorite.
Percent: 2–6
Amphibole, epidote, and chlorite.
Percent: 20
ADDITIONAL COMMENTS: Structure
The principal fabric is an elongated porphyroclastic fabric defined by moderate to intense porphyroclast elongation (aspect ratios up to 3). Stronger crystal-plastic fabric at top of core, again with only sparse white serpentine veins. Pieces 2 to 10 are only weakly deformed with sparse white serpentine veins that overprint the foliation. Amphibole-bearing veins and metagabbroic veins.

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up to 0.5 cm wide, are found in Pieces 1B, 4, and 7 (discordant to the fabric) and 8 (concordant). Orthogonal sets of white serpentine veins are found in Pieces 11, 12, and 13 with only weak elongation of orthopyroxene. Piece 10 contains several pieces of rubble.

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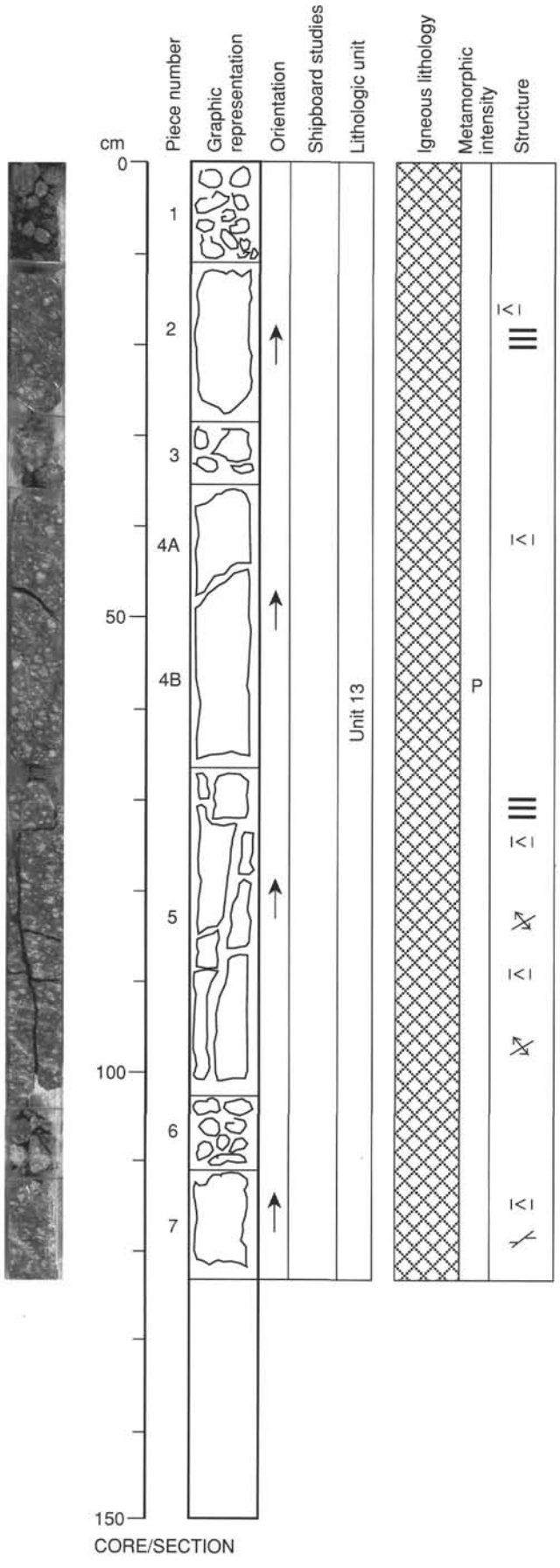
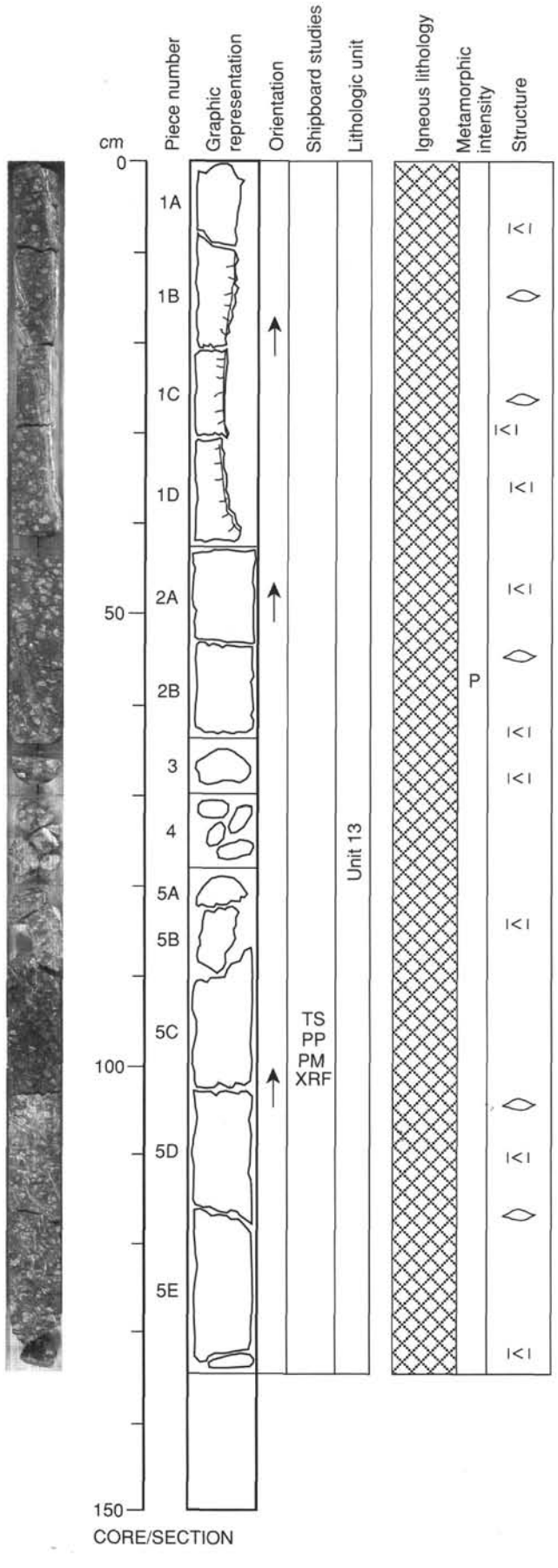


UNIT 13: SERPENTINIZED CRYSTAL-RICH HARZBURGITE

Pieces 1–7

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Serpentine veins and open joints.
PRIMARY MINERALOGY:
Olivine - Mode: 78%–84%.
Orthopyroxene - Mode: 15%–17%.
Crystal Size: 10–18 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 0–4%.
Crystal Size: 1–8 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Comments: Serpentinized porphyroclastic pyroxene-rich harzburgite. Pyroxene forms rounded to elongate porphyroclasts with abundances in the range 20%–25%, higher than in the previous sections. Clinopyroxene abundance is variable (0–4%) and spinel is accessory. Alteration is strongly developed, averaging 90%–95%. No magmatic veins were observed. The lack of magmatic veins correlates with an increase in pyroxene content.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 80–98
Comments: Replaces primary phases.
Magnetite.
Total Percent: <2
Comments: Product of serpentinization.
Comments: Alteration in this section is high to pervasive and is characterized by high to pervasive serpentinization of olivine (80%–100%) and bastite after orthopyroxene. Local areas containing abundant fresh olivine kernels are common in this section, which form adjacent to well developed and abundant porphyroclastic aggregates of orthopyroxene, olivine, and minor clinopyroxene(?). These aggregates are only slightly altered in their cores and get progressively more altered to serpentine away from the composite pods. They are commonly cut by fine microveinlets of serpentine and are rimmed by trace amphibole and serpentine after orthopyroxene, with a trace of talc after olivine. Composite asbestiform wispy white serpentine and black iron oxide mineral-rich serpenitine veinlets are abundant throughout the section. The veins are oriented both at a high angle and parallel to the poorly developed fabric forming an anastomosing network.
VEIN/FRACTURE FILLING:
White serpentine.
Size: 0.2–1 mm.
Dark green serpentine.
Size: 0.25 mm.
ADDITIONAL COMMENTS: Structure
Very weak to nonexistant development of elongate oprthopyroxene texture. Recovery is poor in Pieces 1, 3, and 6 which are small pebbles. Several *pieces of rubble display fresh fracture surfaces but no evidence of shear* displacements. An anastomosing foliation formed by a dense meshwork of serpentine veins cuts the core at a low angle, but thin white serpentine veins that overprint the foliation are typically steeper and tend to aggregate into better defined, but distinct, zones. Jointing in Piece 6 forms two orthogonal sets. A subhorizontal joint in this piece reactivates a serpentine vein. Fibrous talc and serpentine occur in a vein in Piece 7 with a strong preferred orientation.



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UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–5E

COLOR: Black, gray, green.
PRIMARY STRUCTURE:
Porphyroclastic.
PRIMARY MINERALOGY:
Clinopyroxene - Mode: 2%–3%.
Crystal Size: 2–11 mm.
Crystal Shape: Anhedral.
Olivine - Mode: 70%.
Crystal Size: ? mm.
Crystal Shape: ?
Orthopyroxene - Mode: 13%–27%.
Crystal Size: 3–15 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Pyroxene-rich porphyroclastic harzburgite (25%–29% pyroxene). Some pieces contain very fresh and large cores of olivine (e.g., Pieces 1 and 2). Generally, clinopyroxene and orthopyroxene are fresh. There are good examples of zones of highly concentrated spinel "trains" in Pieces 1 and 5. Anastamosing veins of asbestiform white serpentine, rimmed by chlorite, are subparallel to the foliation in Piece 1, but rotate to near vertical in Piece 5. Piece 5 is associated with rubble zones above and subvertical serpentine veins may lead to the core's destruction and the development of rubble. Large serpentine and chlorite veins run the length of Piece 1 and the adjacent regions of the piece have usually suffered the highest degrees of alteration. Alteration appears to increase downward from the top to the bottom of the core. There were no magmatic veins observed.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: Replacing olivine, orthopyroxene, clinopyroxene.
Iron oxide minerals.
Mode of Occurrence: Replacing olivine.
Clay minerals.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Talc.
Mode of Occurrence: Replacing olivine.
Cummingtonite?
Mode of Occurrence: Replacing orthopyroxene.
Comments: Total alteration in section varies from 65% to 87%, with alteration increasing downsection and most pervasive in Pieces 3–5B, where abundant net veining of serpentine is common. Olivine is altered 70%–95%, with fresh olivine kernels relatively abundant in Pieces 1 and 2. Olivine kernels are enclosed in a brown serpentine mesh with abundant serpentine and oxide mineral microveinlets forming a mesh texture. Rare pods exhibit white and light green kernels of serpentine after olivine. Orthopyroxene is moderately to pervasively altered (40%–70%) to serpenitine, clay minerals, amphibole, and a trace of talc when in contact with olivine in the least altered areas. Composite porpyroclasts composed of olivine, orthopyroxene, and clinopyroxene which are associated with abundant fresh olivine kernels have apple green- to cream-colored cores and exhibit poorly developed alteration halos of serpentine. Highly altered aggregates of pyroxene are mottled in appearance due to pervasive alteration by serpentine. Clinopyroxene is 50% to 80% altered to serpentine.
Veins
Piece 1 is cut by a 1 cm wide, near vertical, highly serpentinized zone with talc on broken surfaces. Composite black and wispy white serpentine with asbestiform serpentine are oriented both near vertical and subparallel to the poorly developed fabric and are common throughout the section. Discontinuous tapering agua serpentine veins are also present.
VEIN/FRACTURE FILLING:
Asbestiform serpentine and talc.
Size: 10 mm.
Composite black and white wispy veinlets.
Discontinuous tapering aqua serpentine veins.
ADDITIONAL COMMENTS: Structure
A very weak elongated porphyroclastic fabric characterizes the deformation of this

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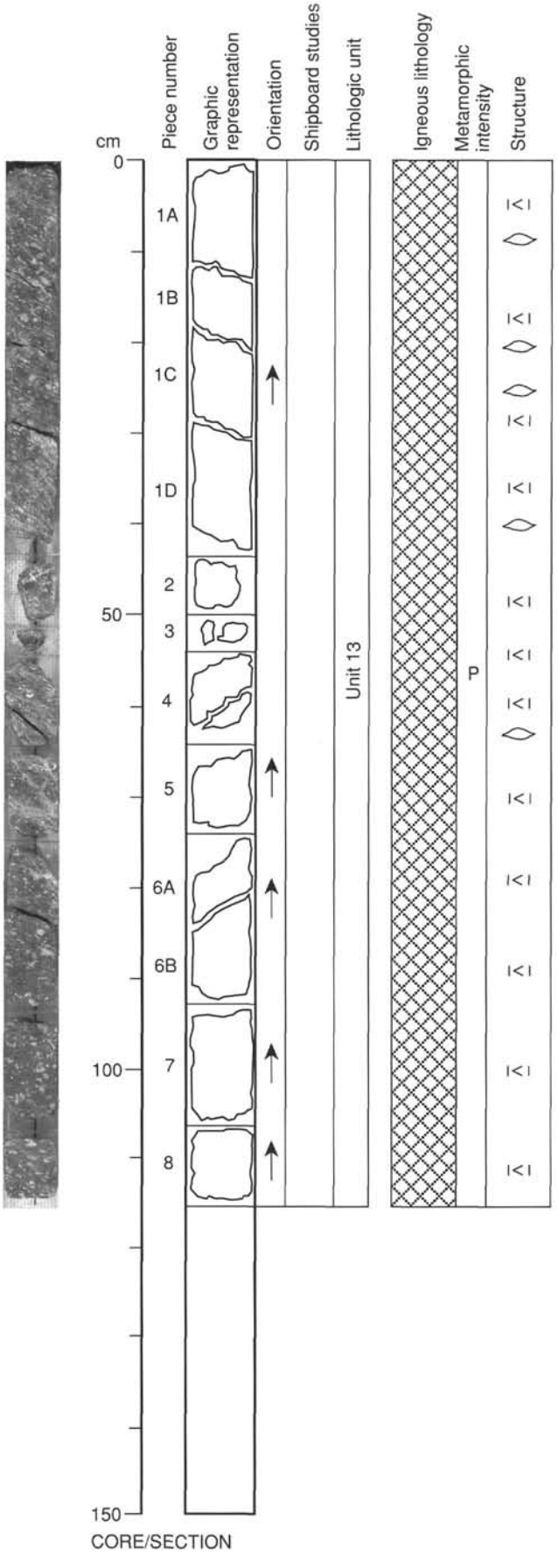
section. In some places the orthopyroxene porphyroclasts show no shape preferred orientation. Anastomosing veins of white serpentine, rimmed by chlorite are oriented subparallel foliation in Piece 1, but rotate to near vertical in Piece 5. Piece 5 is associated with rubble zones. Discrete trails of spinel occur in Pieces 1 and 5. Pale green serpentine veins with talc occur in Pieces 1 and 3 and cut the white serpentine veins. Piece 4 comprises several small pieces, one of which preserves strongly linear talc and serpentine fibers.



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UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–8

COLOR: Black, gray.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 77%–81%.
Orthopyroxene - Mode: 17%–21%.
Crystal Size: 4–20 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 1%.
Crystal Size: 2–6 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Comments: Serpentinized porphyroclastic harzburgite. Pyroxene content is approximately 24% in Pieces 1–3 and decreases to 15%–20% in Pieces 4–8. Pyroxene alteration (≈60%–70%) is low in comparison to olivine which tends to be highly altered in the section (≈90%). Disseminated sulfide minerals occur in Piece 1. There are good examples of spinel trains in Pieces 1 and 6. The anastomosing serpentine foliation is strong in Pieces 1–5, but becomes weak in Pieces 6–9 where the pyroxene content drops. There were no magmatic veins observed in the section.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: Replacing olivine, orthopyroxene, clinopyroxene
Iron oxide minerals.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Talc(?)
Mode of Occurrence: Replacing olivine.
Clay minerals.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Bastite.
Mode of Occurrence: Replacing orthopyroxene.
Comments: Total alteration in section varies from 86%–90% and is somewhat patchy in appearance due to small zones in which olivine kernels are altered to white serpentine enclosed in a rim of pale-green serpentine. Olivine alteration is pervasive (88%–90%), except in aureoles around composite (orthopyroxene, olivine, and clinopyroxene) aggregates and orthopyroxene porhyroclasts, where fresh olivine kernels are abundant. Porphyroclasts and olivine kernels are enclosed in a dark brown to olive green serpentine mesh with abundant serpentine and oxide mineral microveinlets. Orthopyroxene is highly to pervasively altered (60%–70%) away from aggregates to serpentine and clay minerals. When enclosed in aggregates they are commonly fresher and are rimmed by a trace of amphbiole. Porphyroclasts have apple green- to cream-colored cores and are gray green when altered to bastite. Clinopyroxene is 80%–100% altered to serpentine.
Veins
Veining is heterogeneous downsection with composite wispy white and black serpentine veins common in Pieces 1–4. Piece 2 is cut by a 10 mm wide tapering diffuse vein with an aqua green serpentine core and light green serpentine rim. The vein is cut by a wide white serpentine vein. Piece 7 contains <1 to 1 mm wide aqua green serpentine veins. Poor development of wispy white serpentine veinlets occurs in Pieces 6–8.
VEIN/FRACTURE FILLING:
Composite wispy white serpentine and iron oxide minerals.
Size: <1 mm.
Pale green serpentine.
White serepntine.
Aqua serpentine.
ADDITIONAL COMMENTS: Structure
The first four pieces are characterized by a weakly developed porphyroclastic texture with an anastomosing network of white serpentine veins. The last four pieces are devoid of an elongate porphyroclastic texture and the percentage of veins correspondingly decreases (<1%). In Pieces 1 and 6, there are several spinel trains that are oriented parallel and oblique to the porphyroclastic foliation described by the preferred dimensional orientation of orthopyroxene. In Piece 7, a pale green serpentine vein contains serpentine fibers oriented at about 30° to the walls of vein. This vein is cut by thin white serpentine veins and is oriented at a high angle to the fabric.

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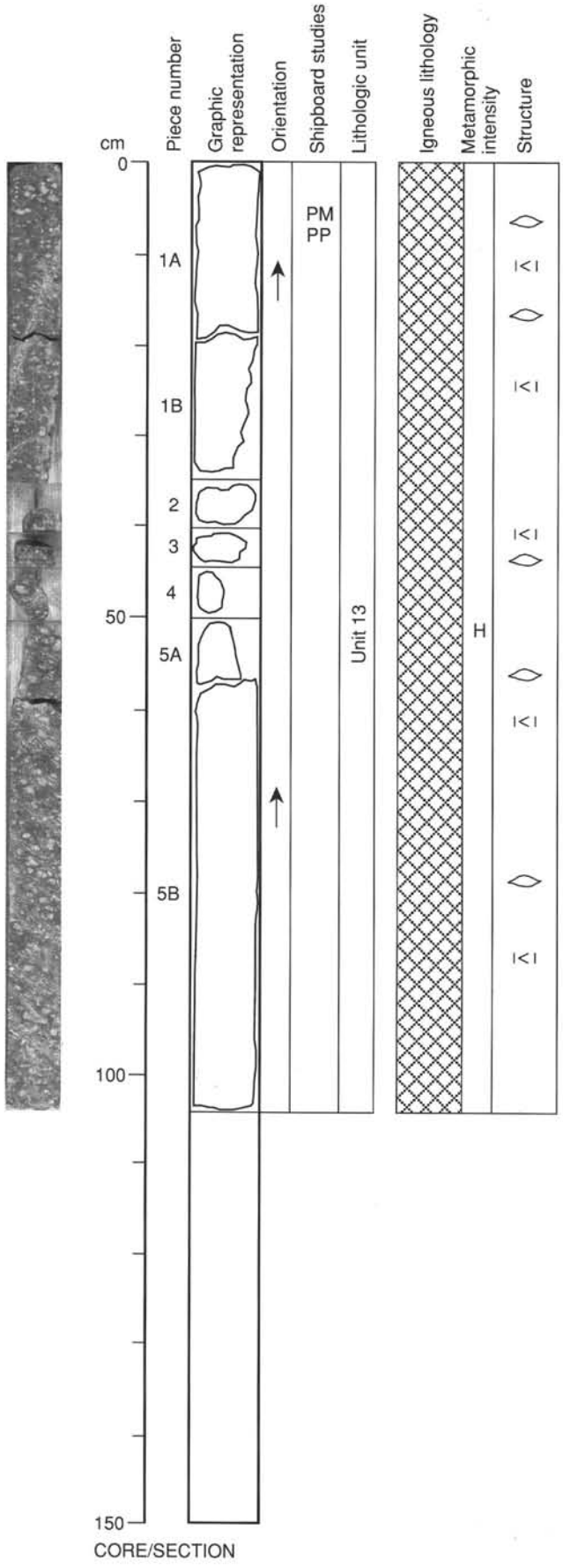
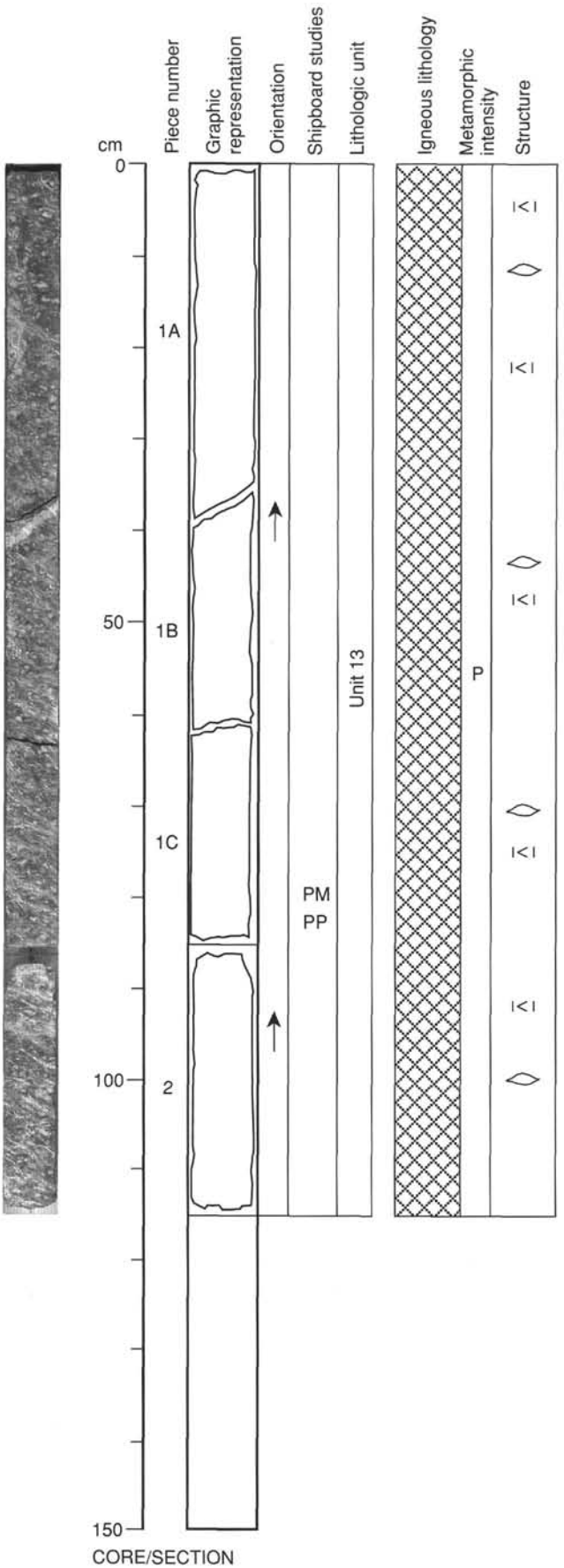


UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–5B

COLOR: Black, gray.
PRIMARY STRUCTURE: Porphyroclastic
PRIMARY MINERALOGY:
Olivine - Mode: 76%–79%.
Orthopyroxene - Mode: 18%–21%.
Crystal Size: 5–20 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 2%.
Crystal Size: 2–6 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic harzburgite. Longest Pieces 1 and 2 were charcterized by primary modes of 76%–79% olivine, 18%–21% orthopyroxene, and 2% clinpyroxene. Wormy spinel "trains" are observed in Pieces 1 and 5. These are observed to cut across pyroxene grains in some places, in others they wrap around pyroxene porphyroclasts. Most of these are subhorizontal. The alteration is low in the core and good preservation of all the primary phases is a characteristic of the core section. Piece 1 contains an altered gabbroic vein lined with serpentine at its margin.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Amphibole.
Mode of Occurrence: Replacing clinopyroxene, orthopyroxene.
Clay minerals.
Mode of Occurrence: Replacing olivine.
Comments: Total alteration in this core is somewhat less than previous sections, commonly ranging around 72%–73%. Olivine is altered 78%–80%, with fresh olivine kernels in pockets around orthopyroxene porphyroclasts and along elongate zones between composite serpentine veins common. In composite aggregates of orthopyroxene, clinopyroxene, and olivine, a trace of talc after olivine is rarely present. Olivine kernels are enclosed in a dark brown to olive green serpentine mesh with abundant serpentine and oxide mineral microveinlets. Orthopyroxene is highly altered (50%–60%) to serpentine with fine amphibole rims. Porpyroclasts have apple green cores in less altered areas and are cream-colored when pervasively altered. They commonly exhibit poorly developed serpentine alteration halos. Clinopyroxene is 30% altered to serpentine.
Veins
Composite black and white wispy serpentine veins and abundant serpentine and iron oxide mineral microveinlets are common throughout the section. Piece 1 is cut by a 2 mm wide, steeply oriented metagabbroic vein which contains a core of green and white serpentine and is rimmed by dark green amphbiole and chlorite. The vein is cut by fine white discontinuous serpentine veins.
VEIN/FRACTURE FILLING:
White and black serpentine.
Green serpentine with brown alteration halo.
Size: Vein 2 mm; halo 1 mm.
ADDITIONAL COMMENTS: Structure
The section is deformed by a weakly elongated porphyroclastic texture defined by the orthopyroxene porphyroclasts. Thin white anastomosing serpentine veins with cross fibers overprint the porphyroclastic fabric. Most of these are subhorizontal. The foliations dip at about 35° to 40°. A green serpentine vein in Piece 1 is oriented subperpendicular to the foliation and cuts the white serpentine veins. In Piece 3 a dark green serpentine vein is oriented subparallel to the foliation but overprints the serpentine meshwork.



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UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–2

COLOR: Black, gray.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 78%.
Orthopyroxene - Mode: 19%–20%.
Crystal Size: 4–20 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 2%.
Crystal Size: 2–8 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic harzburgite. Two pieces (Pieces 1 and 2) are characterized by primary modes of ≈78% olivine, 19%–20% orthopyroxene, and 2% clinopyroxene. At the top margin of Piece 2A, a sheared serpentine vein with an associated alteration halo is present. The anastomosing white serpentine foliation is strongly developed in the section.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh
Mode of Occurrence: Replacing olivine, orthopyroxene, clinopyroxene.
Iron oxide minerals.
Mode of Occurrence: Replacing orthopyroxene.
Clay minerals.
Mode of Occurrence: Replacing orthopyroxene, olivine.
Amphibole.
Mode of Occurrence: Replacing clinopyroxene.
Comments: As rare dark thin rims around clinopyroxene.
Talc.
Mode of Occurrence: Replacing olivine(?).
Comments: Total alteration in this core is somewhat less than previous sections, commonly ranging around 85%–88%. Olivine is altered 88%–92%. Serpentinized olivine kernels are enclosed in a dark brown to olive green serpentine mesh with abundant serpentine and oxide mineral microveinlets. Orthopyroxene is highly to pervasively altered (60%–85 %) to serpentine and amphibole. Porphyroclasts have apple green- to cream-colored cores. Clinopyroxene is 70% altered to serpentine and amphibole. Anastomosing veins of white asbestiform serpentine are prominent throughout the core, increasing in abundance near the base of the section. A single 10 mm wide chlorite, amphibole, and serpentine vein occurs at the top of Piece 1B.
VEIN/FRACTURE FILLING:
Composite wispy white and black serpentine with iron oxide minerals.
Serpentine, tremolite, brown amphibole, and chlorite.
Comments: Piece 1B has this type vein, 1.4 cm wide, cut by a wispy white vein. Where a wispy white vein cuts the large vein a halo of aqua serpentine is present.
ADDITIONAL COMMENTS: Structure
The moderately elongated porphyroclastic texture defined by orthopyroxene porphyroclasts is evenly distributed throughout the section. The foliation dips at about 45° and is overprinted by thin white serpentine veins (1–2 mm wide). The top of the section has more widely spaced serpentine veins. In Piece 1, a pale green serpentine vein (3 mm wide) cuts a dark green serpentine vein at a high angle (>70°). A similar dark green serpentine vein is present in Piece 1C, where it is cut by the foliation-parallel white serpentine veins.

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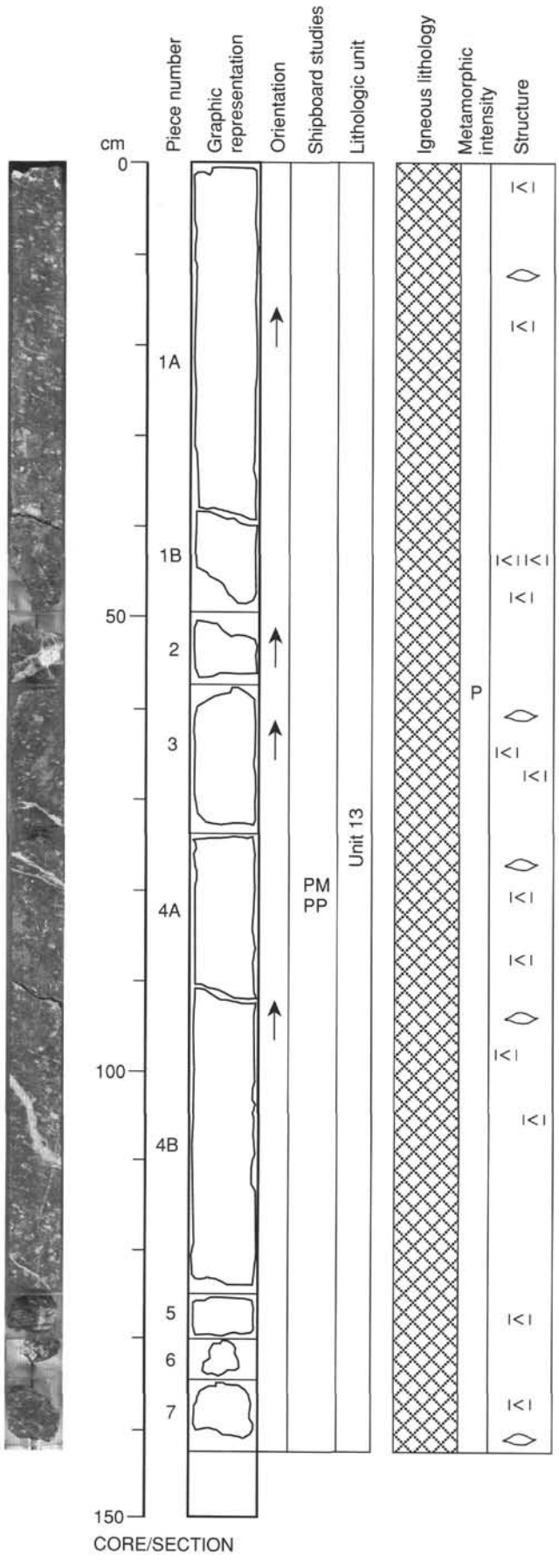
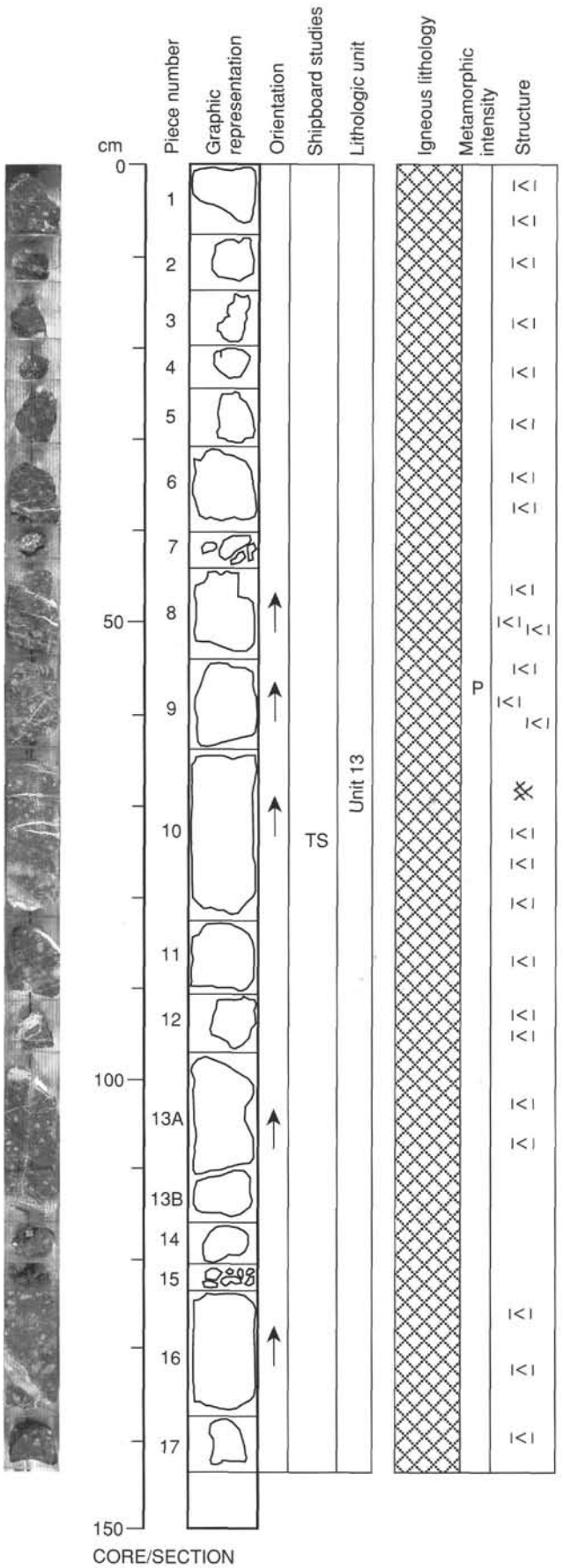


UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–7

COLOR: Black, gray.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 84%–95%.
Clinopyroxene - Mode: 1%–3%.
Crystal Size: 2–7 mm.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 3%–15%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <<1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: Porphyroclastic sepentinized harzburgite with low pyroxene content ranging to a dunite in composition near altered gabbroic veins. Pyroxene content varies between 3% and 18% in the section (10%–12%), but is generally low throughout. The section is cut by gabbroic veins of varying sizes between a few mm and 20 mm, that have been strongly altered. The primary mineralogy is completely altered in most pieces. The widest altered gabbroic vein (2 cm) is rimmed on both sides by dunite (Piece 2). Gabbroic veins cut Pieces 2 and 3 (1 vein = 2 mm thick), Piece 4 (3 veins = 1 cm, 2 mm, 2 mm thick). Piece 5 contains a green chrysotile serpentine vein 4 mm thick.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: Replacing olivine, clinopyroxene, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Actinolite.
Mode of Occurrence: Replacing clinopyroxene.
Cummingtonite(?).
Mode of Occurrence: Replacing orthopyroxene.
Chlorite.
Mode of Occurrence: Replacing clinopyroxene.
Talc(?).
Mode of Occurrence: Replacing olivine.
Clay minerals.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Comments: Alteration is patchy, but highest in dunitic intervals; it varies from 85%–95%. Olivine is altered 90%–95% to a brown mesh serpentine network. Orthopyroxene porpyhyroclasts are altered 60%–95% and are apple green to pale gray green where pervasively replaced by bastite. Cummingtonite may be present after some orthopyroxene. Clinopyroxene is altered 50%–95% and exhibits well-developed dark thin alteration rims of amphibole and amphibole along exsolution lamellae.
Veins
This section contains abundant melt veins now altered to tremolite, brown amphibole, chlorite, talc, and serpentine (2–8 mm in size; Pieces 2, 3, and 4). These veins are comonly cut by aqua green serpentine veins which are cut by wispy white serpentine veinlets. Rare milky white irregular veins may be talc?. Piece 2 has a large branching butterfly shaped composite vein which is composed of prehnite, talc, serpentine, minor carbonate minerals, and a trace of sulfide minerals. Pseudomorphs after clinopyroxene(?) include dark amphibole and chlorite thin rims which enclose pods of tremolite and prehnite. The vein is cut by aqua green serpentine veins and has small serpentine offshoots which contain sulfide minerals. Large green chrysotile serpentine veins are present locally and cut gabbroic veins (Pieces 2 and 4).
ADDITIONAL COMMENTS: Structure
A moderate to strong elongate porphyroclastic texture diminishes in intensity down the core. The porphyroclast foliation is overprinted by arrays of thin white serpentine veins. They dip at about 35°. The section is dissected by several melt veins that show no preferred orientation and are oriented both concordantly and discordantly to the foliation (e.g., Pieces 2, 3, and 4). Pale green serpentine veins cut the white serpentine veins and the melt veins. (e.g., Pieces 2 and 5).



153-920D-16R-6

UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–17

COLOR: Black, gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Serpentine veins and magmatic veins.
PRIMARY MINERALOGY:
Olivine - Mode: 85%–97%.
Orthopyroxene - Mode: 3%–12%.
Crystal Size: 2–14 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 1%–3%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: Porphyroclastic serpentinized harzburgite with low pyroxene content ranging to a dunite in composition. Orthopyroxene content varies between 3% and 12% in the section, but is generally low throughout. Pieces 3–7 have the lowest modal pyroxene and are nearly dunitic. Clinopyroxene is relatively fresh when preserved adjacent to orthopyroxene, but its abundance is usually less than 3%. Pieces 9, 11, 12, 13-top, 13-bottom, and 16 contain highly altered thin (2 mm thick) pyroxenite veins that cut the core at a wide variety of angles with respect to the high-temperature foliation (nearly concordant to highly discordant).
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: Replacing olivine., orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: Replacing olivine., orthopyroxene.
Amphibole (act).
Mode of Occurrence: Replacing clinopyroxene.
Cummingtonite(?)
Mode of Occurrence: Replacing orthopyroxene.
Talc(?)
Mode of Occurrence: Replacing olivine.
Comments: Total alteration in this core ranges from 93%–98%. Olivine is altered 90%–99%. Serpentinized olivine kernels are enclosed in a dark brown to olive green serpentine mesh with abundant serpentine and oxide mineral microveinlets. Apple green- to cream-colored orthopyroxene porphyroclasts exhibit heterogeneous alteration ranging from moderate to pervasive (40%–75 %). Alteration minerals include serpentine, amphibole (cummingtonite), and clay minerals. Clinopyroxene is altered 40%–60% with dark actinolite and chlorite rims.
Veins
This section of core is cut by abundant melt veins now highly amphibolitized. Veins occur in Pieces 2, 6, 7, and 8 to 16 and range from 1 mm to 23 mm in size, with diffuse boundaries common in larger veins. Alteration minerals include talc, tremolite, and brown amphibole in the cores with rims of actinolite and chlorite. Veins are commonly cut by aqua serpentine veins, and milky white, fine veins of talc. These veins are prominent in Pieces 8, 10, 11, 12, and 13 (1–5 mm thick). Other veins include white serpentine veins with sulfide minerals going to hematite, 1 mm wide, wispy asbestiform serpentine veinlets <1 mm wide, which are present in all pieces. The anastomosing serpentine fabric is poorly developed to absent in this section.
VEIN/FRACTURE FILLING:
White serpentine and talc.
Size: 1 mm.
Light green serpentine.
Size: 1 mm.
Dark green serpentine.
Size: 2 mm.
ADDITIONAL COMMENTS: Structure
This section contains a porphyroclastic texture with very weak to no elongation of the pyroxene porphyroclasts. No anastomosing foliation is present, but thin white serpentine veins wrap around the porphyroclasts. There are fewer veins in this section where the modal orthopyroxene abundance drops significantly. Several light green serpentine veins cut the white serpentine veins (Pieces 1, 6, 8, and 10). Thick magmatic veins are located toward base of section (Pieces 2, 6, 7, and 8).

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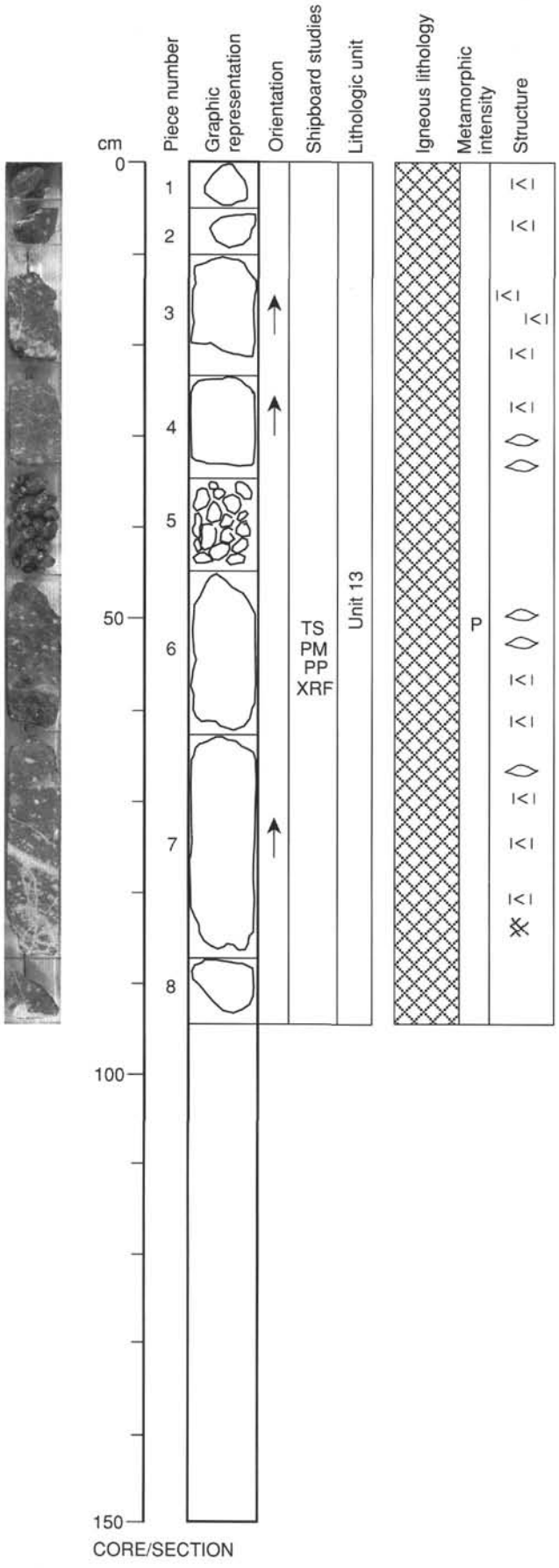
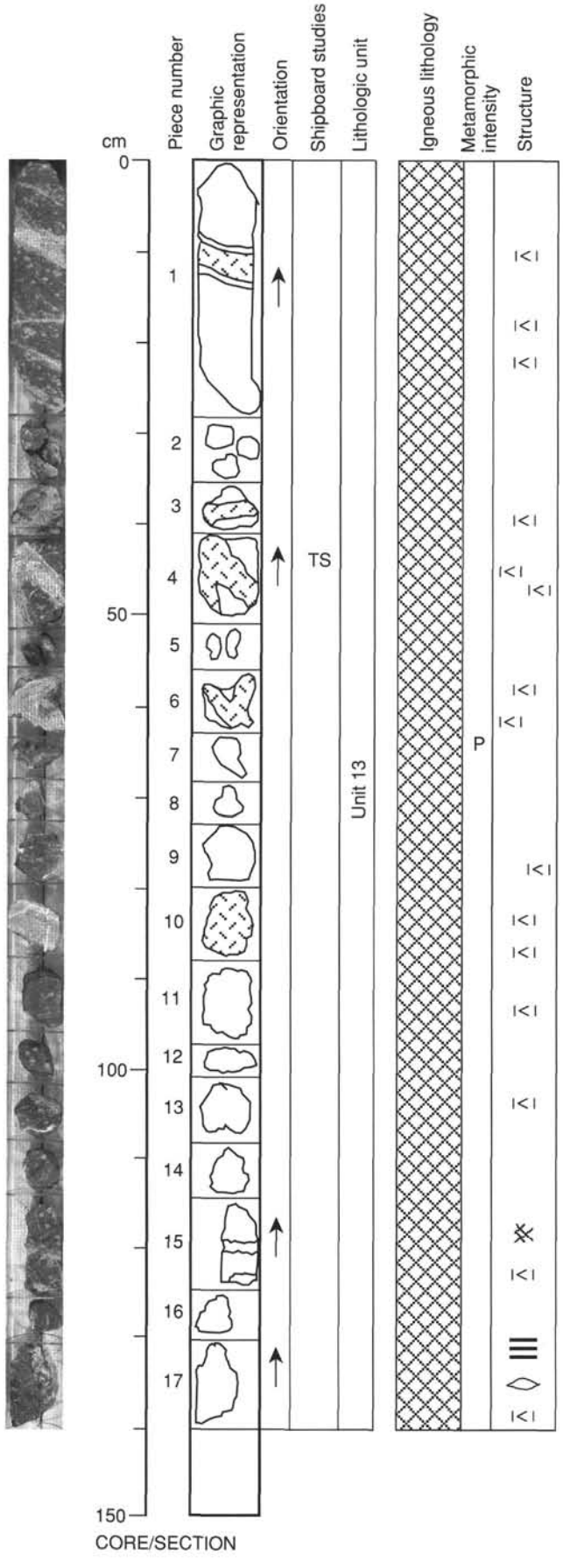


UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–8

COLOR: Black green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 82%–90%.
Orthopyroxene - Mode: 3%–4%.
Crystal Size: 2–8 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 6%–14%.
Crystal Size: 2–10 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: This section consists of pyroxene-poor harzburgite riddled by strongly altered clinopyroxenite and gabbroic veins (Pieces 3, 6, 7, and 8). The harzburgite contains 10% to 17% pyroxene. A small degree of pyroxene depletion in the adjacent wall rock is associated with the magmatic veins. Clinopyroxene is abundant adjacent to and within gabbroic and pyroxenite dikes. Pieces 3, 6, 7, and 8 contain either highly altered composite pyroxenite/gabbro or pyroxenite veins that are both discordant and concordant with respect to the high-temperature crystal-plastic foliation. At the base of Piece 7, these veins form a vein network that is, in general, highly discordant. Harzburgite contains linear clusters of spinel in long trains oriented subhorizontally. They are abundant in the section.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: Replacing olivine, orthopyroxene, clinopyroxene.
Iron oxide minerals.
Mode of Occurrence: Replacing olivine, clinopyroxene.
Clay minerals.
Mode of Occurrence: Replacing olivine.
Amphibole.
Mode of Occurrence: Replacing clinopyroxene, orthopyroxene.
Chlorite.
Mode of Occurrence: Replacing clinopyroxene.
Sulfide minerals.
Comments: Harzburgite in this section is 90%–95% altered, except in the bottom 10 cm of Piece 7 (85%) where altered gabbroic veins are most abundant. These veins form a complex network cutting Pieces 7 and 8. The gabbro veins are almost completely replaced by actinolite and chlorite mixtures on their outer edges and tremolite a talc mixtures in their cores. They are 2 mm (Piece 6) to over 10 mm wide (Pieces 3, 7, and 8). Fresh olivine and clinopyroxene are usually preserved along the margins of the gabbroic and pyroxenite veinlets even though the veinlet itself is completely altered. Steeply inclined asbestiform white serpentine and green chrysotile veins cut the altered magmatic veins. Disseminated sulfide minerals in Piece 3 occur near green serpentine veins.
VEIN/FRACTURE FILLING:
Actinolite, chlorite, tremolite, and talc.
Comments: Replacing gabbroic and pyroxenitic veins.
White serpentine (asbestiform).
Size: <1 mm.
Chrysotile.
Size: <1 mm.
Comments: Pale green
ADDITIONAL COMMENTS: Structure
A weak to moderate elongate porphyroclastic texture formed by orthopyroxene porphyroclasts. No anastomosing foliation evident. In Piece 3, the foliation is subhorizontal and elsewhere has a shallow dip of about 20° to 30°. Sparse white serpentine veins with only weak preferred orientation. Spinel trails that cut across the foliation are evident in several pieces (e.g., Pieces 6 and 7). Several discordant metagabbroic veins are located in Pieces 3, 6, 7, and 8 that thicken toward the base of the core.



153-920D-17R-1

UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–17

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 90%–95%.
Orthopyroxene - Mode: 5%–10%.
Crystal Size: 1–10 mm.
Crystal Shape: Anhedral.
Crystal orientation: Tectonic.
Spinel - Mode: <1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: The rock comprises serpentinized weakly porphyroclastic harzburgite cut by numerous 10–50 mm gabbroic to pyroxenitic veins (now strongly altered). Orthopyroxene abundance is consistently around 8%–12%, and clinopyroxene is absent or accessory, except as associated with veins. Metagabbro/pyroxenite veins are developed in Pieces 1, 4, 6, and 10, while thinner tremolite-rich veins along zones of pyroxene recrystallization/growth are present in Pieces 1, 3, 13, 15, and 17. Piece 1 contains five altered pyroxenite/gabbro composite veins that range in orienation from parallel to highly oblique to the foliation plane defined by the preferred dimensional orientation of orthopyroxene porphyroclasts. Piece 2 is harzburgite rubble with pyroxenite vein material. Piece 3 contains a strongly altered pyroxenite vein 4 cm thick. Piece 4 contains a strongly altered 2.5 cm thick branching and highly altered gabbroic vein. Pieces 6 and 10 are composed of thick (>4 cm thick) composite pyroxenite/gabbro veins that are highly altered. In general, there is a high density of vein material in the section and this is correlated with generally low total pyroxene content in the harzburgite.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 95
Comments: Replaces primary phases.
Magnetite.
Total Percent: <1
Comments: Product of serpentinization.
Comments: Harzburgite in this section is variably altered. Pieces 1 and 3 are less than 70% altered. In Piece 3, this less altered interval occurs near a metagabbroic/pyroxenite vein now replaced by amphibole and chlorite. In the other pieces, alteration is 90%– 98%. Olivine is 70%–99% altered to a gray, dark gray serpentine and iron oxide mineral-rich mesh. Talc may be present near altered magmatic veins. Pyroxene is 60%–95% serpentinized, and marginally replaced by amphibole, chlorite, and talc, also near the altered magmatic veins. The gabbroic and pyroxenitic veins (up to 50 mm wide, Pieces 1, 4, 6, and 10) are characterized by early brown amphibole replaced by actinolite, epidote, chlorite, and late zeolite. They typically show chloritic rims. Late serpentine and sulfide mineral veins cut the metagabbro. Veins, and coarse impregnations along fractures, of clinopyroxenite are altered to actinolite/tremolite in Pieces 1, 2, 3, 13, 15, and 17. These veins are typically <1 to 10 mm in width. Later serpentine-bearing veins (2–4 mm wide) are found in Pieces 10 and 11. Thin white to pale green discontinuous serpentine veins occur in most pieces. This sections lacks development of anastomosing wispy serpentine vein networks.
VEIN/FRACTURE FILLING:
Metagabbro (brown amphibole, actinolite, chlorite, and zeolite?).
Size: 10–50 mm.
Serpentine and pyrite.
Size: <2 mm.
Orientation: Crosscutting.
ADDITIONAL COMMENTS: Structure
A moderately elongated porphyroclastic fabric is present in the upper part of the section, particularly Piece 1. This fabric diminishes in the lower part of the section. No orientation could be measured for the foliation. Metagabbro veins and altered clinopyroxenite veins commonly display bifurcating branches and show no preferred orientation (e.g., Pieces 4 and 15). In Piece 15 an altered clinopyroxenite is cut by a thin, white serpentine vein that parallels the foliation. In Piece 4, a pale green serpentine vein cuts across a metagabbro vein.

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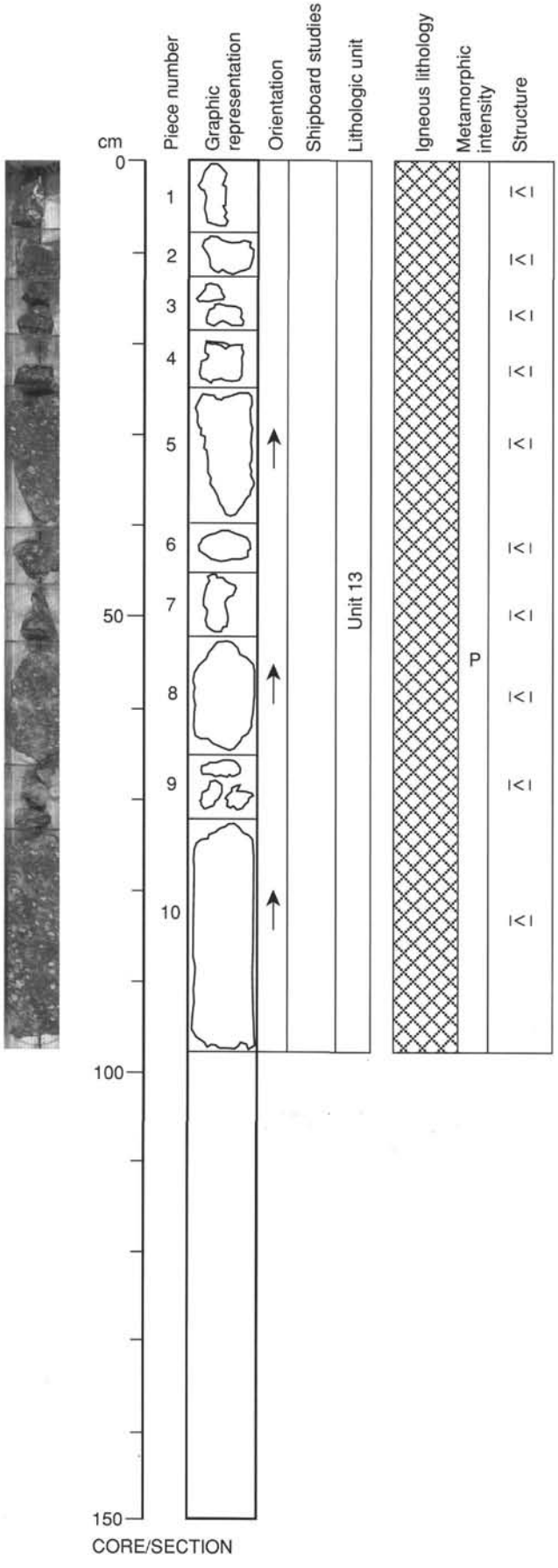
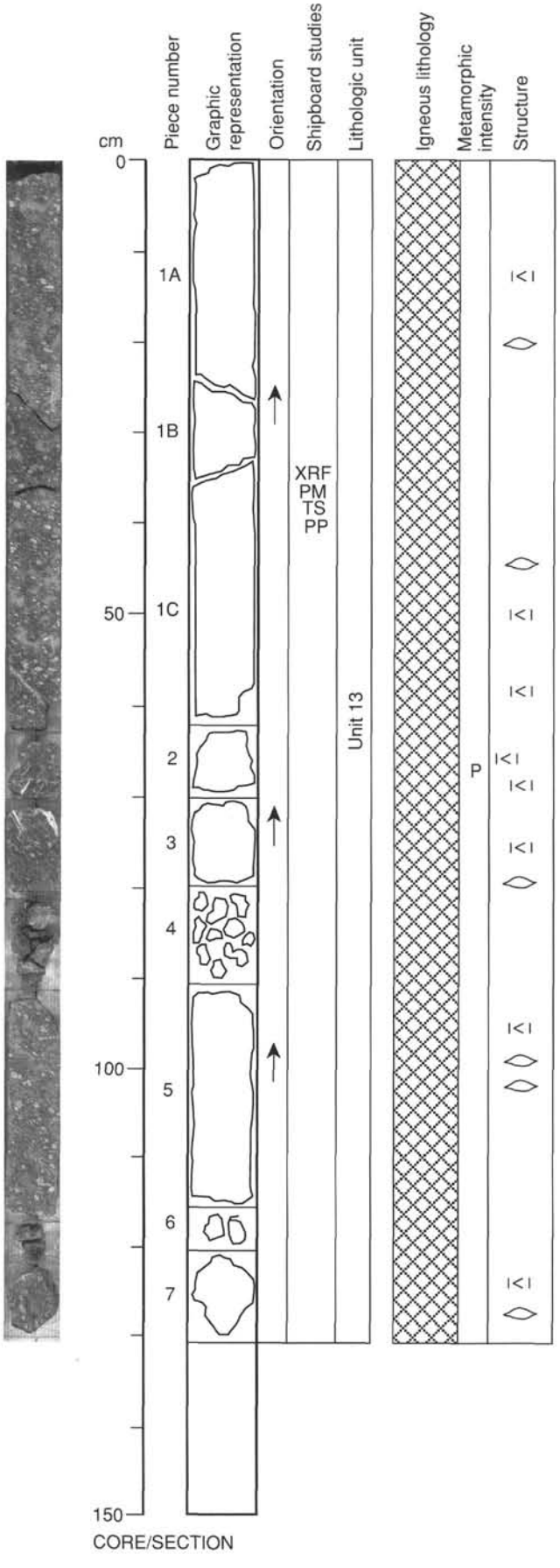


UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–10

COLOR: Dark gray to green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 82%–95%.
Orthopyroxene - Mode: 5%–15%.
Crystal Size: 2–10 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 0%–2%.
Crystal Size: 1–2 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: This section consists of serpentinized harzburgite in which the modal proportions of phases and degree of alteration vary downsection. Pieces 1–4 are similar, being very pyroxene poor (≈10%–12%). Pieces 5–10 are similar to each other, but differ from the overlying pieces in being more pyroxene rich (up to 15%–18%). Clinopyroxene is common in the less altered pieces. Linear clusters of spinel form long trains with subhorizontal orientations, crosscutting the metamorphic fabric in Piece 8. Evidence for melt infiltration and crystallization of magmatic clinopyroxene (now totally altered) occurs in Pieces 3, 6, 8, and 10. These form linear trains of discrete clinopyroxene in the rock. They are more subtle in appearance and smaller in scale than the pyroxenitic veins. They can generally be observed under the binocular microscope. The anastomosing serpentine foliation is well developed and inclined at ≈45°.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: Replacing olivine, orthopyroxene, clinopyroxene.
Clay minerals.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: Replacing olivine.
Chlorite(?).
Mode of Occurrence: Replacing clinopyroxene(?).
Amphibole.
Mode of Occurrence: Replacing orthopyroxene, clinopyroxene.
Comments: Alteration is patchy in appearance due to concentrated pods of serpentinized olivine kernels with white serpentine cores and green rims, which are enclosed in a dark brown mesh serpentine matrix. The section is pervasively altered with alteration ranging from 85% to 100%. Pieces 1 to 4 are 100% altered. Olivine is pervasively altered (98% to 100%). Rare clinopyroxene is altered to serpentine ± amphibole and chlorite(?). Orthopyroxene porphyroclasts, apple green to mottled gray green, exhibit highly varible alteration intensity ranging from 35% to 100%. Alteration minerals include cummingtonite and serpentine.
Veins
Thin amphibole and chlorite veins (1 mm wide) occur in Pieces 3 and 10. Composite white wispy and serpentine and iron oxide mineral veins form an anastomosing set in Pieces 6 and 10. Dark green, 1 mm wide serpentine veins occur in Pieces 2 and 4.
VEIN/FRACTURE FILLING:
White wispy and dark serpentine and iron oxide minerals.
Size: <1 mm.
Green serpentine.
Size: 1 mm.
Comments: Occur in Pieces 2 and 4.
ADDITIONAL COMMENTS: Structure
Only a weakly developed elongated porphyroclastic fabric exists in this section. A stronger preferred orientation is evident from Piece 8 that corresponds to an increase in the modal abundance of pyroxene. Thin (1–2 mm) white serpentine veins overprint the porphyroclastic foliation. Alteration patches are common throughout the section. Piece 8 has several, gently dipping spinel trails with spinel grains displaying a shape preferred orientation parallel to the trace of the trail. The trails are oriented obliquely to the foliation (about 30°). Amphibole-bearing veins in Pieces 3 and 4 are cut by thin (1–2 mm) white serpentine veins.



153-920D-17R-3

UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–7

COLOR: Gray green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 85%–89%.
Orthopyroxene - Mode: 9%–12%.
Crystal Size: 2–16 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 1%–2%.
Crystal Size: 1–7 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1–1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: The rock comprises serpentinized moderately porphyroclastic harzburgite. Orthopyroxene shows moderate elongation. Orthopyroxene abundance is consistently around 14%–17%, and clinopyroxene 1%–3%. Piece 4 is harzburgite rubble. No magmatic veins were observed in the section, again correlated with the higher pyroxene content of the harzburgite. The anastomosing foliation is well developed and is inclined at 45°.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 90–95
Comments: Replaces primary phases.
Magnetite.
Total Percent: 1–2
Comments: Product of serpentinization.
Comments: Harzburgite in this section is 75%–95% altered. Alteration is highest in Pieces 2, 3, and 4; and lowest in Pieces 1 and 5. Olivine is altered into a net of serpentine and iron oxide minerals. In Pieces 1 and 5, this alteration (75%–85%) *produces dark or light green patches. In the other pieces, altered* domains are dark green. Pyroxene is relatively fresh; 10%–20% and 30%–80% altered for clinopryoxene and orthopyroxene respectively. Amphibole and chlorite veins, 1–2 mm wide, occur in Piece 1. Pieces 1, 2, 3, and 5 have *a well-developed anastomosing set of wispy composite serpentine veins.* White serpentine veins, 1–2 mm wide, occur in Pieces 2 and 3.
ADDITIONAL COMMENTS: Structure
A weak ellipticity of orthopyroxene grains defines a weakly elongated porphyroclastic *texture throughout this section. The dip of this foliation clusters around 30°.* Homogeneously distributed arrays of thin (1–2 mm) white serpentine veins overprint the porphyroclastic fabric but no anastomosing foliation defined by dark green serpentine veins is present. In Pieces 2 and 3, the wispy white *serpentine veins dip steeply and crosscut the flat-lying pyroxene fabric.* In Pieces 1B and 1C, amphibole and chlorite veins are cut by thin white serpentine veins. Thin (<3 mm) serpentine veins with fibers oblique to the vein walls crosscut the porphyroclastic fabric in Pieces 1B, 1C, and 3.

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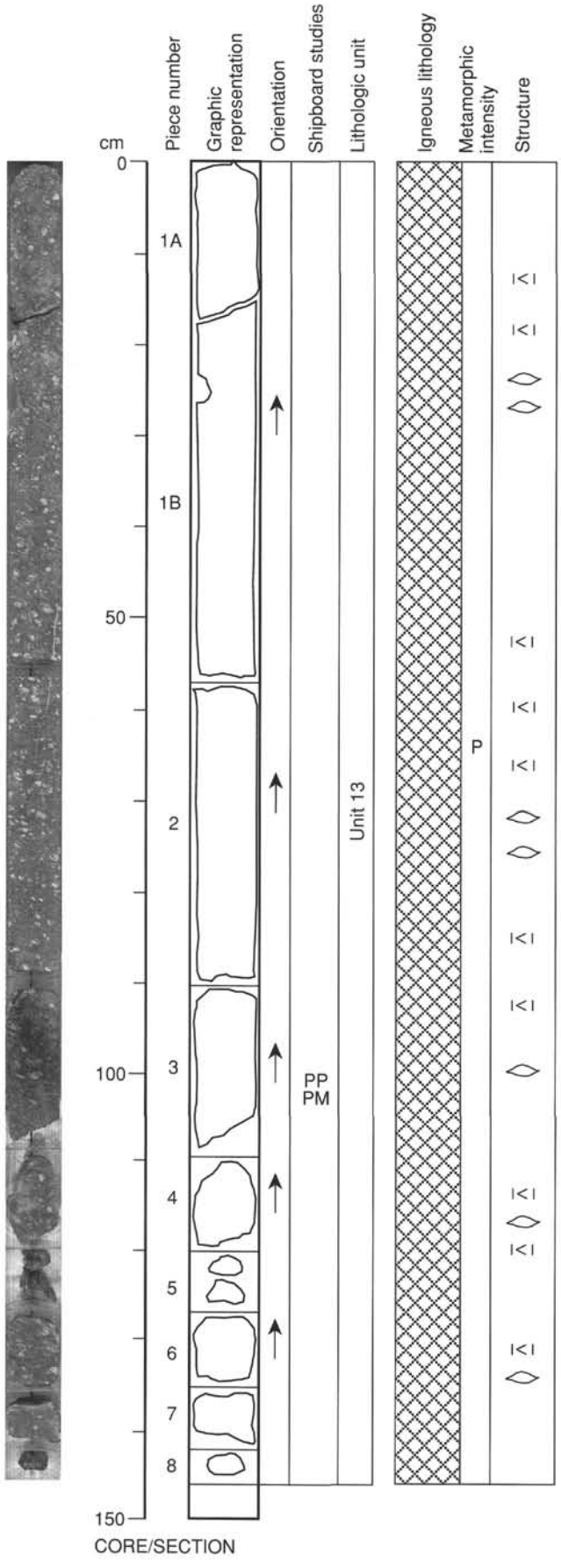
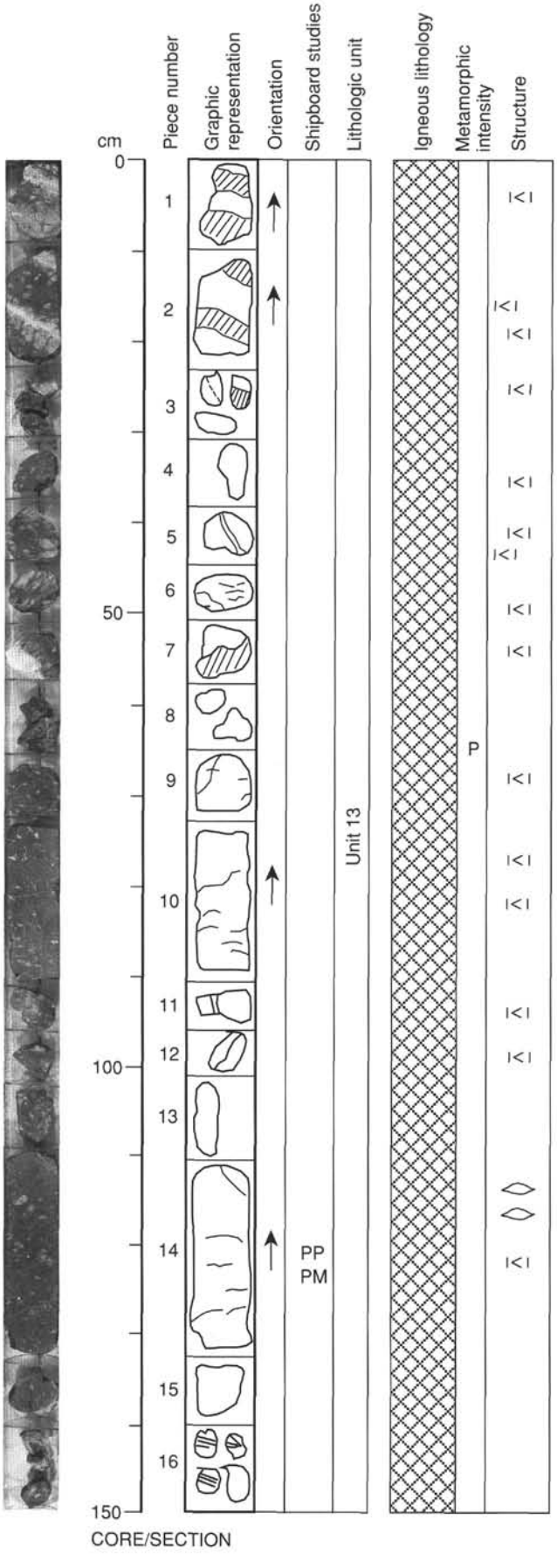


UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–8

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 82%–90%.
Orthopyroxene - Mode: 3%–12%.
Crystal Size: 3–8 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 1%–5%.
Crystal Size: 1–4 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1–1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: The rock comprises serpentinized porphyroclastic harzburgite. Pyroxene abundance varies from 15%–18% in Pieces 1 and 2 to 10%–15% downsection in Pieces 3–8. No magmatic veins were observed in the section. The anastomosing serpentine foliation becomes weak in the section.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 95–98
Comments: Replaces primary phases.
Magnetite.
Total Percent: 1–2
Comments: Breakdown product from serpentinization.
Comments: Harzburgite in this section is 70% to 95% altered. Alteration is lowest in Pieces 1 and 2, and highest in Pieces 4 to 8. Olivine is altered (75%–99%) into a mesh of serpentine and iron oxide minerals that is light gray green in the least altered pieces, and darker in the more altered intervals. Pyroxene is 70% to 95% replaced by bastite. Composite wispy serpentine veinlets form an anastomosing net in this section. A 1–2 mm wide, amphibole and chlorite vein cuts the bottom of Piece 1 and the top of Piece 2. A 2 mm wide, dull green serpentine vein cuts Piece 1.
VEIN/FRACTURE FILLING:
Serpentine ± sulfide minerals.
Size: 2–8 mm.
Orientation: Irregular.
ADDITIONAL COMMENTS: Structure
The effects of deformation in this section are exhibited by a weakly developed elongate porphyroclastic texture. The dip of the foliation is about 30° overall and is overprinted by an anastomosing foliation defined by a green black serpentine vein meshwork. In the lowermost part of the section, the anastomosing serpentine network shows an increase in preferred orientation, becoming more planar. The white serpentine vein array that overprints the anastomosing foliation is homogeneously distributed throughout the core. The white, cross-fibered serpentine veins are 1–2 mm wide.



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UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–16

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 84%–96%.
Orthopyroxene - Mode: %.
Crystal Size: 3–15 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 1%–3%.
Crystal Size: 2–4 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%–1%.
Crystal Size: <1.5 mm.
Comments: The rock comprises serpentinized porphyroclastic harzburgite highly depleted in pyroxene (10%–13%) to pyroxene bearing-dunite (5%–10% modal pyroxene-Pieces 9–15) and altered gabbro and pyroxenite in some pieces. There are several magmatic veins or bands in the section. Piece 1 contains a relatively fresh pyroxenite vein or band 4–7 cm in thickness that appears concordant with the high-temperature foliation plane. Piece 2 contains a pyroxenite band that is also concordant with the foliation that contains comb-like margins that finger into the depleted harzburgite country rock. Piece 3 is harzburgite rubble. Piece 6 contains a band of olivine websterite. Piece 7 contains a highly altered pyroxenite/gabbroic composite vein. The zone around the vein is strongly depleted in pyroxene and is essentilally a dunite. Pieces 3–11 contains an altered pyroxenite vein. Orthopyroxene shows moderate to strong elongation parallel to the crystal-plastic fabric.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 94–96
Comments: Replaces primary phases.
Magnetite.
Total Percent: <2
Sulfide minerals.
Total Percent: <1
Mode of Occurrence: In veins and disseminated.
Comments: Alteration in this section is very heterogeneous and is related to abundant metagabbroic-pyroxenitic veins which occur in Pieces 1, 2, 7, and 11. Adjacent to these veins, wide bands in which alteration is only moderate is common with abundant fresh olivine and pyroxene. Away from these areas, alteration is pervasive (85%–95%), with serpentine and iron oxide minerals after olivine dominating the alteration. Porphyroclasts of orthopyroxene are highly to pervasively altered to bastite.
Veins
Wispy white veins are very sparse in occurrence in this section correlating with the low abundance of porphyroclasts. Piece 1 contains two 14–20 mm wide metagabbroic veins which include clinopyroxene altered to actinolite and chlorite, light brown amphibole, minor prehnite after plagioclase, and sulfide minerals. The veins are cut by apple-green serpentine veinlets. Piece 2 is cut by two 7–15 mm wide composite veins after clinopyroxenite/gabbro which include talc, tremolite/actinolite, serpentine, iron oxide minerals. The vein is symetrically rimmed by an alteration halo 3 mm wide of green serpentine, chlorite, and green amphibole. The metagabbro is cut by discontinuous <1–1 mm wide green serpentine veins which change to a yellow color when hosted in the metagabbro. Pieces 5–6 are cut by 1 mm wide dark blue gray veins which contain amphibole, chlorite, and serpentine as vein-filling minerals. Sample also contain <1 mm wide pale green serpentine, sulfide mineral, and hematite veins. Piece 7 is cut by a 20 mm wide vein in which only one contact is preserved and includes a core of talc, tremolite, and brown amphibole which is rimmed by actinolite/tremolite, chlorite, and serpentine. Piece 11 is cut by a 4 mm wide chlorite, pyrite, serpentine, and zeolite filled vein, which is cut at a high angle by dark green serpentine veinlets.
VEIN/FRACTURE FILLING:
Brown amphibole, tremolite, chlorite, sulfide minerals, and zeolite(?).
Size: 20 mm.
Orientation: Normal to foliation.
Serpentine and sulfide minerals.
Size: <6 mm.

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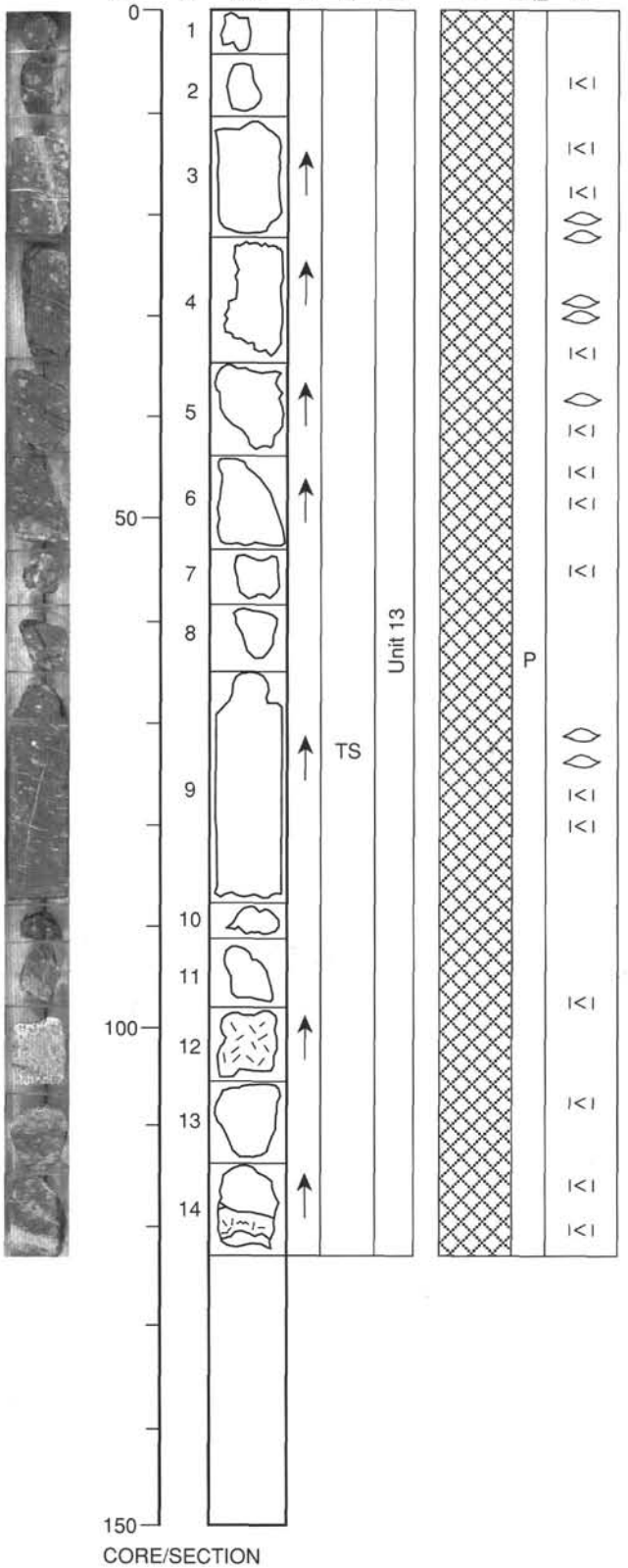
Orientation: Irregular.

ADDITIONAL COMMENTS: Structure

A weak elongated porphyroclastic fabric dominates the structure in this section but is generally absent in Pieces 3, 7, 8, 11, and 12. Where evident, the foliation defined by the orthopyroxene porphyroclasts dips at about 30° (Pieces 9,10, and 11). An anastomosing foliation defined by green serpentine veins is generally absent except for a weak development in Pieces 5 and 6. There is only a sparse overprint of the foliation by white serpentine veins, corresponding to the relatively low pyroxene content. Several discordant metagabbroic veins disseminated the core (Pieces 1, 2, 7, and 11). The orientations of these veins range from shallow to steeply dipping. The metagabbro vein is cut by a pale green serpentine vein in Piece 2.



153-920D-18R-2

UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–14

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 85%–95%.
Orthopyroxene - Mode: 3%–10%.
Crystal Size: 1–12 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 1%–4%.
Crystal Size: 2–6 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1–1%.
Crystal Size: <2 mm.
Comments: The section consists of serpentinized porphyroclastic harzburgite highly depleted in pyroxene content (7–15%) which is strongly veined by gabbroic and pyroxenitic intrusions. Marked depletion in pyroxene is commonly associated with the margins of the largest veins. Orthopyroxene abundance ranges to as little as 3% at the margins of these veins. Piece 3 contains a sheared serpentine vein inclined at about 70°. Piece 6 contains the edge of a concordant pyroxenite band at its lower edge. Piece 7 is a pyroxenite (and possibly the same vein as in Piece 6. Piece 8 also contains part of a pyroxenite band. Pieces 11,12,13, and 14 contain a sequence illustrating the zoned nature of many of the intrusions and the marked depletion of the wall rock in pyroxene content directly adjacent to the intrusion. Piece 11 contains a highly pyroxene-depleted harzburgite grading to dunite at the margins of a pyroxenite (2 cm thick). The next piece downward is a medium-grained altered gabbro, which contains fresh pyroxene and plagioclase. The gabbro piece is ≈7 cm in length. Piece 13 is a nearly identical to Piece 11 with a 2.5 cm thick pyroxenite adjacent to harzburgite highly depleted in pyroxene. The distribution of rock types about the gabbro intrusion is symmetrical. Piece 14 contains 2 pyroxenite veins. Orthopyroxene shows moderate to strong elongation parallel to the crystal-plastic fabric.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 85–95
Comments: Replaces primary phases.
Magnetite.
Total Percent: 1–3
Comments: Product of serpentinization.
Sulfide minerals.
Total Percent: <1
Mode of Occurrence: Veins and disseminated.
Comments: Alteration in this section is pervasive ranging from 85%–95%. Alteration is dominated by formation of serpentine after olivine and orthopyroxene. Olivine is pervasively altered to mesh serpentine and iron oxide minerals with rare fresh kernels associated with orthopyroxene porphyroclasts. Orthopyroxene porphyroclasts are not as common as in previous cores and are highly to pervasively altered to serpentine. Rare composite aggregates of orthopyroxene, clinopyroxene, and olivine are pervasively altered to a trace of amphibole and talc with abundant serpentine, resulting in a mottled appearance. Piece 12 is a pervasively altered gabbro. Plagioclase is highly to pervasively altered to secondary plagioclase and prehnite, and minor chlorite and actinolite. Clinopyroxene grains are commonly rimmed by actinolite, chlorite, and oxide minerals. Rare grains are completely pseudomorphed by talc(?) and rimmed by actinolite, chlorite, and oxide minerals and commonly rimmed by amphibole and chlorite. An thin actinolite rim marks a contact(?) between the metagabbro and a more pyroxene-rich metagabbro which exhibits the same alteration assemblage.
Veins
Piece 2 is cut by a 5 mm wide green serpentine and chlorite vein which is then cut by a 1 mm wide yellow green serpentine vein. Piece 3 contains a 9 mm wide composite sheared serpentine vein composed of subparallel bands of pale gray green serpentine intergrown with amphibole and dark green serpentine intergrown with white sepentine bands. The vein is cut by discontinuous and tapering white to gray green serpentine veins <1 to 1.5 mm in width. Pieces 6–7 are cut by a metapyroxenite vein altered to tremolite, actinolite, chlorite, and serpentine at the vein margins. Piece 9 contains moderately abundant wispy white asbestiform serpentine veinlets which cut a near vertical 1–2 mm

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wide vein of amphibole, serpentine, chlorite, and prehnite(?). The top of this piece contains a 4–5 mm wide band of composite white serpentine and magnetite stringers in serpentine. Piece 13 contains a metagabbro vein in which only one contact is preserved. It is pervasively altered to actinolite and chlorite after pyroxene, and prehnite and zeolite after plagioclase. Piece 14 is cut by a low angle metapyroxenite vein altered to tremolitic and pale brown amphibole with an outer rim of chlorite, amphibole, and talc (9 mm in width).

VEIN/FRACTURE FILLING:

Serpentine and sulfide minerals.

Size: <8 mm.

Orientation: Irregular.

Amphibole.

Size: 5–15 mm.

Orientation: Irregular, linear.

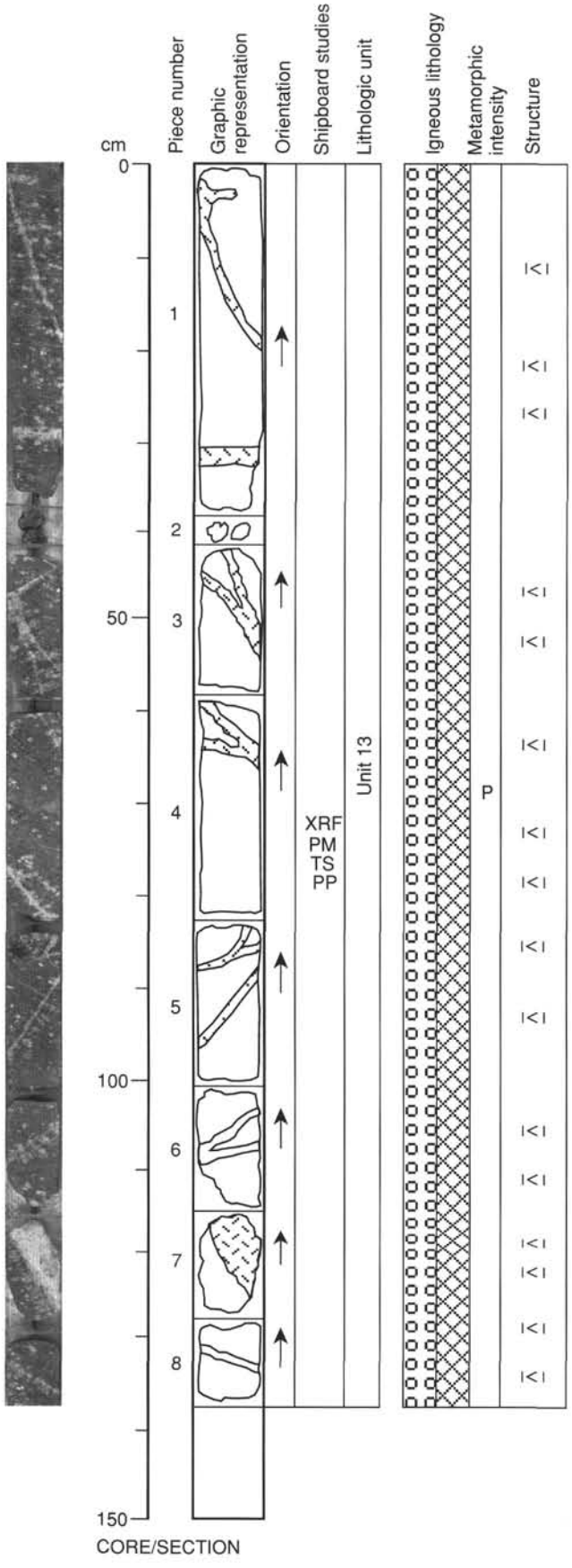
Pegmatitic gabbro.

Size: 6 mm.

Orientation: High angle to foliation.

ADDITIONAL COMMENTS: Structure

Orthopyroxene porphyroclasts have aspect ratios of up to 1:4 or 5, defining an elongated porphyroclastic texture. The foliation dips as low as 30° (Piece 3). The strongest foliation is present in Piece 9. A weak anastomosing fabric is present in some pieces (Pieces 3 and 9), defined by a dense meshwork of dark green serpentine veins. Thin white serpentine veins (1–2 mm) overprint the anastomosing foliation but are widely spaced (1–2 cm). Pieces 3, 6, 7, 9, and 13 are cut by altered pyroxenite veins. These veins are cut by dark green serpentine veins but both are oriented at high or low angles to the pyroxene elongation fabric.



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UNIT 13: SERPENTINIZED HARZBURGITE-DUNITE

Pieces 1–8

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 87%–91%.
Orthopyroxene - Mode: 7%–10%.
Crystal Size: 2–18 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 1%–2%.
Crystal Size: 1–7 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: <1 mm.
Comments: The section continues to be highly serpentinized porphyroclastic harzburgite strongly depleted in orthopyroxene content (10%–14%). Locally within pieces pyroxene content <10% (e.g., center of Piece 4). The abundance of orthopyroxene porphyroclasts and degree of elongation vary both within, and between, pieces. Modal orthopyroxene varies from 7%–13%, and clinopyroxene from 1%–2%. Generally, the section is moderately altered (90%). The section is notable for the frequency of crosscutting altered pyroxenite veins. Pyroxene adjacent to these veins tends to be larger, suggesting that some recrystallization or grain growth has occurred adjacent to the veins. The pyroxene and olivine adjacent to these veins are also less altered than pyroxene away from the veins. Piece 1 contains two pyroxenite veins 1 cm thick. One cuts the foliation at a high angle and is inclined at about 70°, the other cuts the foliation at a lower angle and is horizontal on the core face. Piece 2 is harzburgite rubble. Piece 3 contains two highly discordant and branching pyroxenite veins (1–2 cm thick). Piece 4 contains two 10 mm wide discordant pyroxenite veins at its base. Piece 5 contains two altered pyroxenite veins, one with comb-like structure adjacent to the vein with pyroxene growth within the wall rock adjacent to the vein. Piece 6 contains a 2 cm thick altered pyroxenite vein with a similar comb-like structure adjacent to the vein. Piece 7 contains a 4 cm thick (minimum thickness-one side only) altered pyroxenite vein with a halo of pyroxene-rich harzburgite and comb-structure adjacent to the vein. Piece 8 contains the same type of pyroxenite vein with the same comb-like structure.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 85–95
Comments: Replaces primary phases.
Magnetite.
Total Percent: <2
Comments: Serpentinization product.
Tremolite.
Mode of Occurrence: In veins after clinopyroxene.
Comments: Harzburgite in this section is 85% to 95% altered and dark green. Olivine is altered (75%–99%) into a mesh of serpentine and iron oxide minerals. Pyroxene is 90%–95% replaced by bastite and possibly minor amounts of amphibole. Metagabbro to metapyroxenite veins are common throughout this section. The metagabbro veins are largely altered to secondary amphibole (actinolite/tremolite) and vary from 2–50 mm in width. All pieces contain at least one such vein. Generally the veins contain brown amphibole after clinopyroxene, set in a tremolitic matrix. Piece 7 contains a metapyroxenite vein (≈40 mm in width) which contains coarse-grained amphibole crystals. Several magmatic veins altered to amphibole and chlorite crosscut the foliation at a low angle (Pieces 1, 3, 4, 5, 7, and 8). They contain brown amphibole and tremolite. In Piece 3, the vein contains grains preserving magmatic (?) intergranular relations.
VEIN/FRACTURE FILLING:
Serpentine.
Size: <6 mm.
Orientation: Subparallel to foliation.
Brown amphibole, clinopyroxene, actinolite?, chlorite, and iron oxide minerals.
Size: <6 mm.
Orientation: Irregular.
Tremolite/actinolite, chlorite, and serpentine.
Size: <15 mm.
ADDITIONAL COMMENTS: Structure

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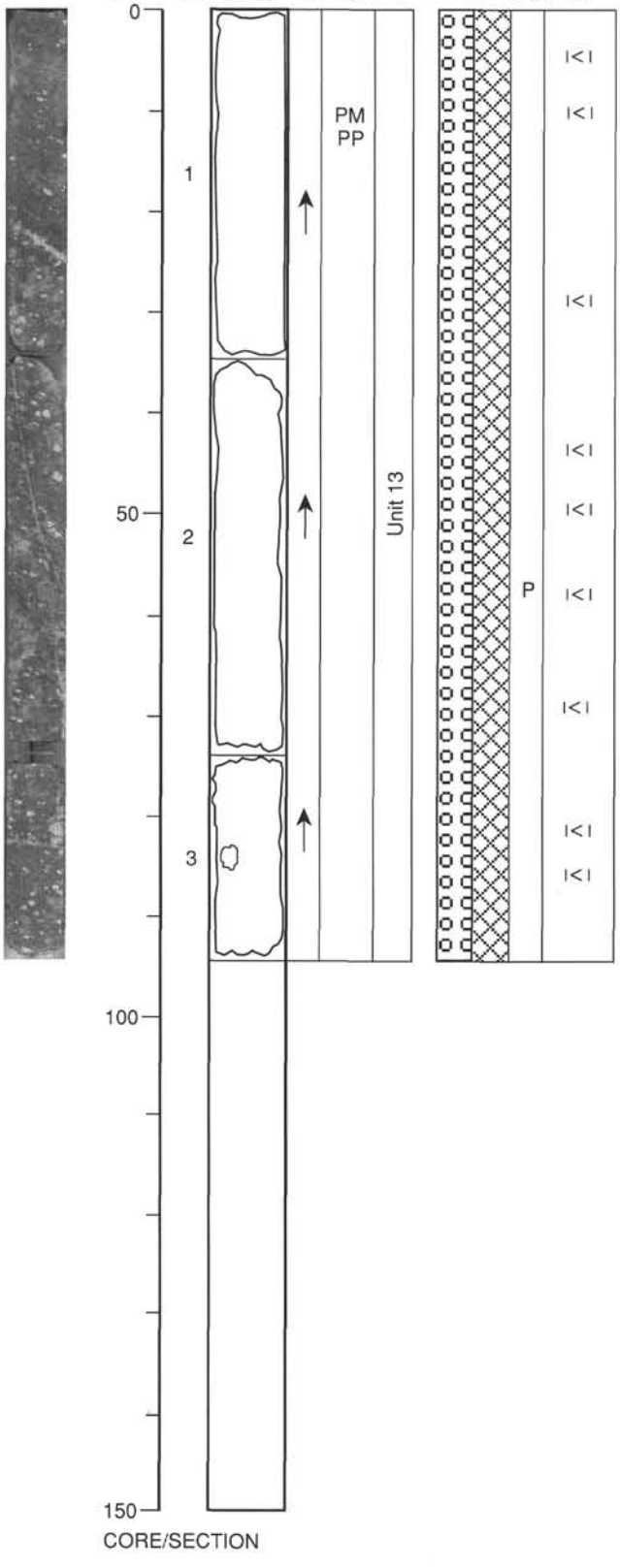
In this section, the elongated porphyroclastic foliation is weakly developed and the dip of the foliation is less than 30° (15° in Piece 1). There is no anastomosing foliation defined by dark serpentine veins but thin white serpentine veins are present throughout the section. In Piece 5, a pale green serpentine vein contains fibers oblique to the vein margin. The shear sense indicated by the fibers is compatible with normal faulting and an altered pyroxenite dike is offset across the vein. The metagabbro(?) vein in Piece 7 is deformed displaying dynamic recrystallization textures in tremolite and fracturing in amphibole. Slightly discordant metagabbro veins cross the pyroxene fabric in Pieces 1, 3, 5, and 7.



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UNIT 13: SERPENTINIZED DUNITE-HARZBURGITE

Pieces 1–3

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 88%–92%.
Orthopyroxene - Mode: 6%–10%.
Crystal Size: 2–13 mm.
Crystal Shape: Anhedral.
Crystal orientation: Tectonic.
Clinopyroxene - Mode: 0.5%–1%.
Crystal Size: 1–2 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <1 mm.
Comments: Serpentinized porphyroclastic dunite/harzburgite. This section contains relatively fresh primary phases (≈85% altered) with fresh orthopyroxene up to 13 mm in size and minor clinopyroxene (0.5%–1%). Pyroxene content ranges from 8%–12% and the section is generally highly depleted. Piece 1 contains a 0.5 cm thick concordant pyroxenite vein. Piece 2 contains three thin (3 mm) altered pyroxenite veins that are discordant, one is steeply inclined. Piece 3 contains one thin altered pyroxenite vein cutting the section horizontally. Porphyroclasts are only weakly elongated and aligned. It is common for pyroxene grains along the margins of these veins to be larger than the porphyroclasts in the harzburgite. The thicker pyroxenite vein of Piece 1 shows a narrow pyroxene-depletion zone in the adjacent wall rock (dunitic band on either side).
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 80–95
Comments: Replaces primary phases.
Magnetite.
Total Percent: <2
Comments: Harzburgite in this section is 85% altered. Olivine is 85%–90% altered to a serpentine and magnetite mesh with patchy green and gray colors. Pyroxene is 60%–85% altered to serpentine, and possibly also minor amphibole, chlorite, and talc. The wispy white serpentine network is poorly developed in Pieces 1 and 2 and it is absent in Piece 3. Pyroxenite veins which are pervasively altered to tremolite, actinolite, and chlorite (<1–5 mm wide) occur in all pieces. A black, flat-lying serpentine vein cuts Piece 1.
VEIN/FRACTURE FILLING:
Tremolite, serpentine, and chlorite.
Size: <8 mm.
Orientation: Irregular.
Serpentine.
Size: <5 mm.
ADDITIONAL COMMENTS: Structure
A weak elongated porphyroclastic fabric deforms this section, dipping less than 30°. No anastomosing foliation formed by the serpentinite meshwork veins is evident. Thin white serpentine veins (1 mm) are present, aligning closely with the pyroxene foliation. The veins are sparse, however, compared to more pyroxene-rich sections of this hole. Several altered pyroxenite veins crosscut the peridotite (Pieces 1, 2, and 3). Most of these veins are concordant or slightly discordant to the pyroxene foliation. One vein in Piece 2 is more steeply dipping than the foliation.

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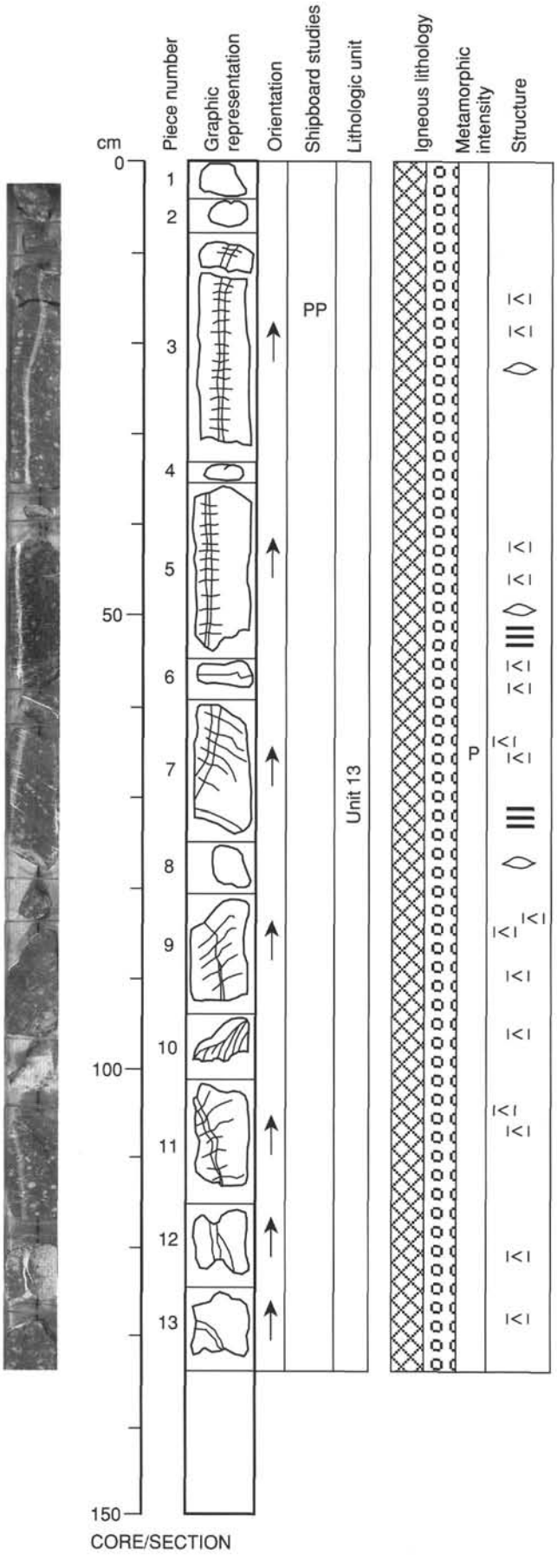
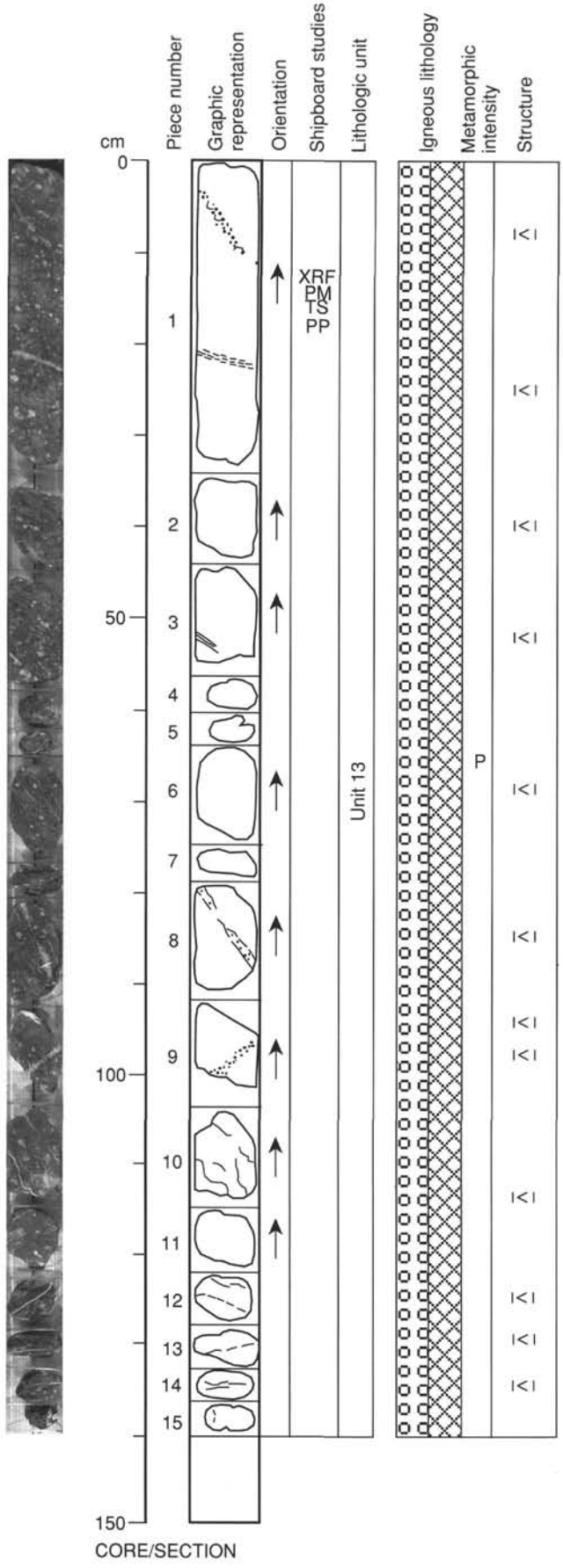


UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–13

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 90%–98%.
Orthopyroxene - Mode: 2%–10%.
Crystal Size: 1–10 mm.
Crystal Shape: Anhedral.
Crystal orientation: Tectonic.
Clinopyroxene - Mode: 1%.
Crystal Size: 1–2 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic harzburgite. The section consists of moderately altered harzburgite and dunite containing 2%–18% pyroxene. Pieces 1–3 and 11 contain 15%–18% pyroxene, Pieces 5–9 and 12–13 contain 10%–13% pyroxene, but the top of Piece 5 is in part a dunite. Piece 4 is an altered pyroxenite pebble. Piece 10 is part of an altered composite pyroxenite/gabbro vein. Piece 12 contains a similar altered vein 3–4 cm wide and one of the contact zones with a pyroxene depleted harzburgite. Piece 13 contains two thin altered pyroxenite veins. Orthopyroxene is most strongly elongated in Pieces 7–9. Pieces 3, 5, and 7 contain a long zoned (green to white) cross-fibered serpentine vein that is inclined at ≈85°; the same vein is in each piece. The vein is at least 60 cm in length and is associated with a series of short tension gashes filled with cross-fibered serpentine that are developed subperpendicular to the margin of the long vein.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 90–98
Comments: Replaces primary phases.
Magnetite.
Total Percent: <2
Comments: Harzburgite in this section is 85% to 95% altered. Olivine is altered (85%–95%) into a mesh of serpentine and iron oxide minerals. Orthopyroxene is 75% to 95% replaced by bastite and serpentine, and also possibly by small quantities of amphibole. Metapyroxenite veins altered to amphibole and chlorite, 0.4 to 40 mm wide, occur in Pieces 4, 7, 10, and 12. A thinner set of similar veins (2 mm) occurs in Pieces 5 and 12. A 1 cm wide *serpentine, carbonate mineral, and sulfide mineral-bearing vein* cuts subvertically throughout Pieces 3, 5, 6, 7, 11, and 12. A parallel vein of similar composition probably bounded Piece 7 on one side. Thinner, less steep white discontinuous serpentine and sulfide mineral veins occur in Pieces 3, 5, 6, 7, 9, and 11. The wispy white composite serpentine vein network is poorly developed in this section.
VEIN/FRACTURE FILLING:
Serpentine and pyrite.
Size: 3–5 mm.
Orientation: Irregular.
Amphibole, magnetite, and chlorite.
Size: 2–6 mm.
Orientation: Irregular.
ADDITIONAL COMMENTS: Structure
Orthopyroxene grain elongation is weakly developed. The anastomosing fabric is variably developed. A weak anastomosing foliation, defined by dark green serpentine veins overprints the pyroxene foliation and is highlighted by thin white serpentine veins. The reduction in the percentage of white veins corresponds to a reduction in the orthopyroxene content as seen in other core sections. The dip of the foliations varies but ranges mainly between 30 and 50°. A single dark green serpentine vein can be seen in all but two pieces of the section. It is vertically dipping and is cut by thin white serpentine veins (1–3 mm). In Piece 13, pyroxenite veins are concordant to the anastomosing foliation.



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UNIT 13: SERPENTINIZED DUNITE-HARZBURGITE

Pieces 1–15

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE:
PRIMARY MINERALOGY:
Olivine - Mode: 90%–95%.
Crystal Size: 0.1–0.4 mm.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 4%–8%.
Crystal Size: 1–15 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: <1%.
Crystal Size: 1–5 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 0.5%–1%.
Crystal Size: <5 mm.
Crystal Shape: Anhedral.
Comments: The section consists of serpentinized porphyroclastic harzburgite. Pieces 1–2, 6, and 8–15 are highly depleted in pyroxene content averaging only 10%–12%. Pieces 3–5 and 7 contain 15%–18% pyroxene. In general, the section is strongly depleted in pyroxene content. The clinopyroxene content is locally high near pyroxenite veins and along trains of clinopyroxene grains that cut the pieces. Pieces 1, 8, and 9 contain thin 1–4 mm thick altered pyroxenite veins that are discordant with respect to the high-temperature crystal-plastic fabric. Pieces 10 and 12 contain several cross-fibered serpentine veins and they are generally highly altered. It is not uncommon for the pyroxenite veins to be preferred sites of serpentine veining as well (e.g., Piece 9).
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 90
Comments: Replaces olivine and orthopyroxene.
Magnetite.
Total Percent: 2–3
Comments: Product of serpentinization.
Amphibole.
Total Percent: <1
Comments: Replaces clinopyroxene.
Comments: Harzburgite in this section is 85% to 98% altered. Alteration is lowest in Piece 1, which is gray green, and highest in Pieces 2 to 6. Olivine is altered (85%–99%) into a mesh of serpentine and iron oxide minerals that is organized into an anastomosing fabric in the extensively altered interval of Pieces 2 to 7. Clinopyroxene is 80% to 95% replaced by serpentine. Altered pyroxenite veins, 1 to 3 mm thick, composed of chlorite, actinolite, and tremolite occur in Pieces 1, 8, 9, 10, and 12. Crosscutting discontinuous veins of serpentine and carbonate minerals occur in Pieces 9 to 15. 1–2 mm thick serpentine and sulfide mineral veins occur in Pieces 6, 10, and 12.
VEIN/FRACTURE FILLING:
Serpentine.
Size: <0.5 mm.
Orientation: Subparallel to foliation.
Serpentine, sulfide minerals, and carbonate minerals.
Size: 3–8 mm.
Orientation: Subparallel to foliation.
Serpentine and talc.
Size: <0.5 mm.
Orientation: Subparallel to foliation.
Serpentine, chlorite, carbonate minerals, epidote.
Orientation: Irregular.
ADDITIONAL COMMENTS: Structure
No mesoscopic preferred orientation of pyroxene porphyroclasts is evident in this section so no fabric orientations could be measured. Thin, white discontinuous serpentine veins however are present and form sparse arrays dipping at about 45°. The white serpentine veins are cut by pale green serpentine veins in Pieces 1 and 10. Fibers in pale green serpentine veins in Pieces 1 and 8 are oriented obliquely to the vein margins but no offsets could be determined. Several gabbroic intrusions, now totally transformed into chlorite, serpentine, and actinolite assemblages (Pieces 1, 8, 9, and 12) are cut by the white, foliation-parallel serpentine veins.

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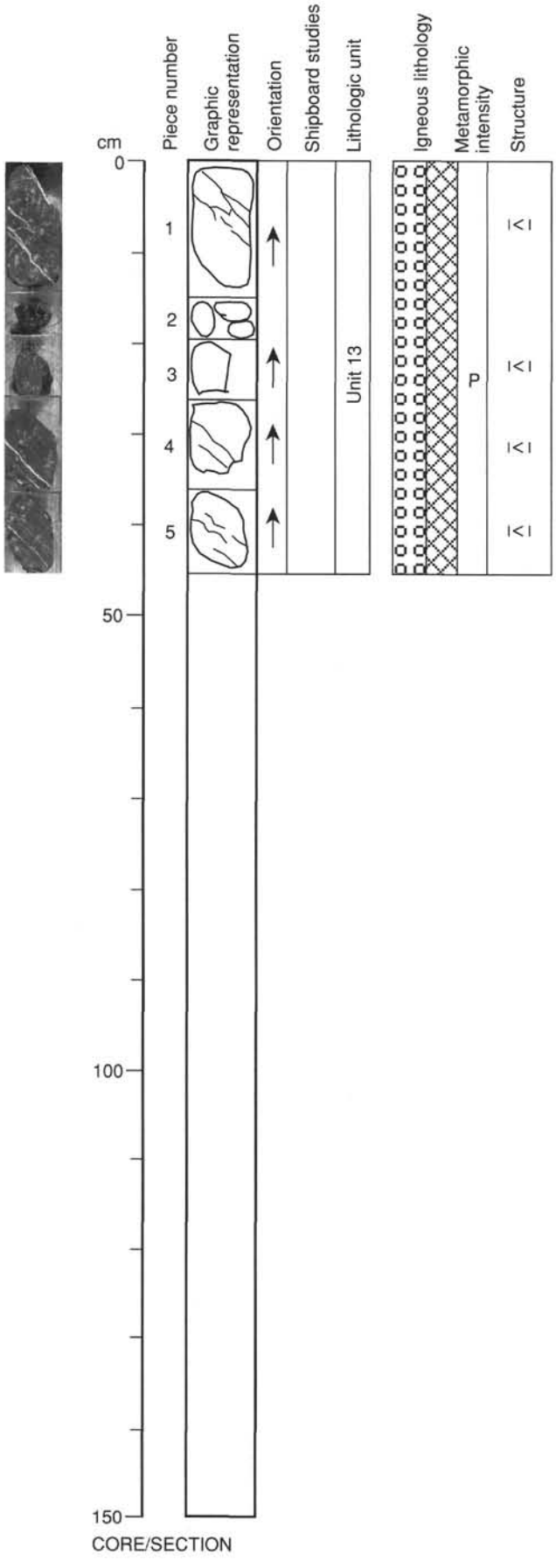
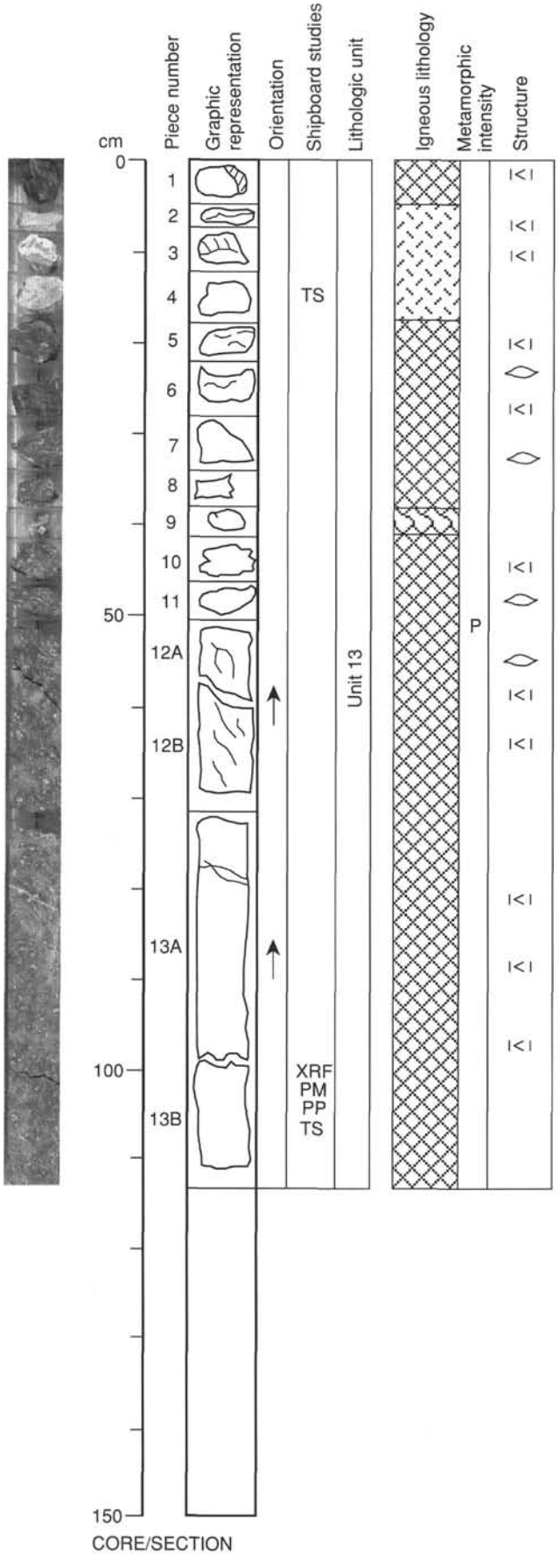


UNIT 13: SERPENTINIZED HARZBURGITE-DUNITE

Pieces 1–5

COLOR: Gray black.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 85%–92%.
Orthopyroxene - Mode: 5%–12%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Crystal orientation: Subangular.
Clinopyroxene. - Mode: 1%–2%.
Crystal Size: 1–5 mm.
Crystal Shape: Anhedral.
Crystal orientation: Irregular.
Spinel - Mode: 0.5%–1%.
Comments: Serpentinized porphyroclastic harzburgite. Pyroxene abundance ranges from 15%–18% in Pieces 1 and 2 and from 9%–12% in Pieces 3–5. Orthohpyroxene porphyroclasts show a weak to moderate elongation and define the high-temperature crystal-plastic fabric. Clinopyroxene and spinel are minor phases (<2%). Several large white cross-fibered serpentine veins are present in Pieces 1, 4, and 5 and are inclined at about 45°.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 80–98
Comments: Replaces olivine and orthopyroxene.
Magnetite.
Total Percent: <2
Comments: Harzburgite in this section is 85% to 95% altered and dark green. Alteration is lowest in Piece 1. Olivine is altered (85%–99%) into a mesh of serpentine and iron oxide minerals. Clinopyroxene is 80% to 95% replaced by serpentine.
Pieces 1, 4 and 5 are cut by a subparallel set of serpentine, carbonate mineral, and iron oxide mineral-bearing veins, less than 3 mm wide, and by a lesser developed crosscutting set of serpentine veins.
VEIN/FRACTURE FILLING:
Serpentine, and carbonate and sulfide minerals.
Size: <5 mm.
Orientation: Vein set parallel to foliation.
ADDITIONAL COMMENTS: Structure
No elongation of porphyroclasts is evident. An anastomosing foliation is evident in all pieces (Pieces 1 through 5), defined by a dense network of dark green serpentine veins. Sparse, thin (1–3 mm) white serpentine veins are steeply dipping, subparallel to the anastomosing foliation. Discrete, pale green serpentine veins cut across the steeply dipping white serpentine veins at an angle of about 45°.



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UNIT 13: SERPENTINIZED HARZBURGITE AND DUNITE

Pieces 1–13B

COLOR: Gray, green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 89%–96%.
Crystal Size: 3–10 mm.
Crystal Shape: Anhedral.
Orthopyroxene - Mode: 3%–10%.
Crystal Size: 3–10 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 0%–2%.
Crystal Size: 1–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: 1 mm.
Crystal Shape: Anhedral.
Comments: The section consists of predominantly serpentinized harzburgite with minor dunite (Pieces 5 and 6) and some zoisite, prehnite, tremolite, actinolite, chlorite, and talc vein fragments (Pieces 2, 3, 4, and 9) which had gabbroic to pyroxenitic protoliths (see description of alteration). Pieces 5–9 are highly depleted harzburgite (10%–12% pyroxene) to pyroxene-bearing dunite (e.g., Piece 5). Pieces 1 and 10–13 contain a higher percentage of pyroxene (≈15%). Piece 1 also has a remnant of one side of a pyroxenite magmatic vein (now altered) with a comb-like pyroxene edge to the vein. Pieces 2 and 3 are thoroughly altered and rodingitized gabbroic lithologies. Piece 4 is a less altered gabbro. Spinel occurs either concentrated in stringers subparallel to foliation or as clusters around relict orthopyroxene. Piece 9 is an altered pyroxenite. Clinopyroxene was only positively identified in Piece 1 and in the bottom 5 cm of Piece 13 where it occurs adjacent to relict orthopyroxene. Olivine is also less altered in these areas of Piece 13. Pieces 12 and 13 have the commonly observed speckled or patchy appearance due to alteration of olivine by serpentine in mesh textures. The thin white serpentine veins tend to wrap around the porphyroclasts in Pieces 12 and 13.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: Replacing olivine, clinopyroxene.
Amphibole.
Mode of Occurrence: Replacing orthopyroxene, clinopyroxene.
Chlorite.
Mode of Occurrence: Replacing clinopyroxene.
Clay minerals.
Mode of Occurrence: Replacing orthopyroxene, olivine.
Comments: Alteration is patchy in appearance due to concentrated pods of serpentinized olivine kernels with white serpentine cores and green rims, which are enclosed in a dark brown mesh serpentine matrix. The section is pervasively altered with alteration ranging 70%–100%. Olivine is pervasively altered (78% to 99%), with fresh clear kernels commonly clustering near orthopyroxene porphyroclasts. Clinopyroxene is highly altered to serpentine ± amphibole and chlorite (45%–100%). Orthopyroxene porphyroclasts, apple green to mottled gray green, exhibit variable alteration intensity ranging from 25% to 80%. Alteration minerals include cummingtonite, serpentine and traces of disseminatedeminated pyrite. Pieces 2–4 are rodingitized gabbroic samples, which are pervasively replaced by zoisite, prehnite, tremolite, actinolite, chlorite, and minor talc. Piece 3 contains minor amounts of brown amphibole as well.
Veins
Piece 3 contains a 6 mm wide vein of zoisite and prehnite. Serpentitine, chlorite, and actinolite veins <1 to 2 mm wide are in Piece 13. Aragonite forms fine veins in the dunitic samples <1 mm wide. The anastomosing set of composite wispy dark and light serpentine veins is poorly developed.
VEIN/FRACTURE FILLING:
ADDITIONAL COMMENTS: Structure
The fabrics in the first 11 small pieces of this section suggest the development of a strong elongate porphyroclastic fabric, overprinted by intensive veining, including thin white serpentine veins. Piece 12 marks a change in the style

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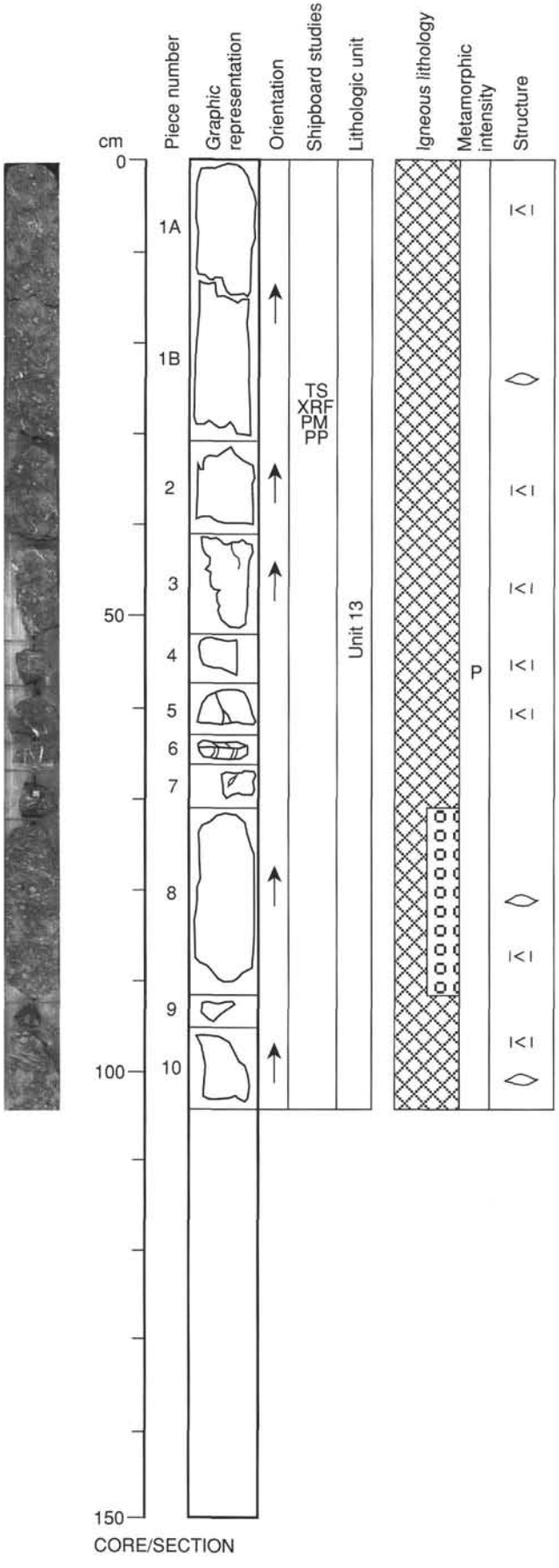
of deformation. The lower two pieces of the core (Pieces 12 and 13) have a weakly developed elongate porphyroclastic texture with no anastomosing foliation evident. The white serpentine veins at the base of Pieces 12 and 13 become less planar and form arcs around the porphyroclasts. Some spinel trails are oriented subparallel to the foliation. In Piece 1, a metagabbro vein is present and cuts the porphyroclastic texture. In Pieces 5 and 7, pale green serpentine veins with irregular traces, cut a few white serpentine veins.



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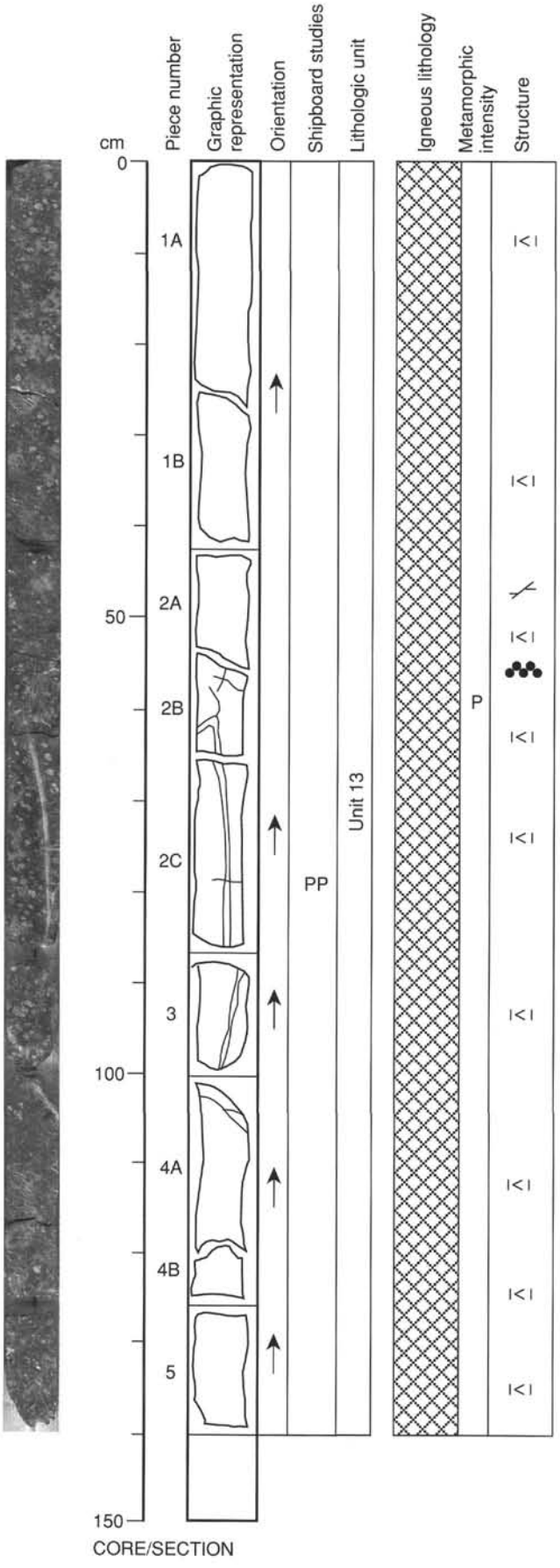
UNIT 13: SERPENTINIZED HARZBURGITE AND DUNITE

Pieces 1A–10

COLOR: Black, gray.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 82%–94%.
Orthopyroxene - Mode: 6%–16%.
Crystal Size: 2–15 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 0%–1%.
Crystal Size: 3–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: This section consists of interlayered serpentinized pyroxene-poor harzburgite (11%–18% pyroxene) and more pyroxene-poor dunite (≈5% pyroxene). Orthopyroxene tends to be well preserved in most pieces, but olivine is highly altered in dunite (within Pieces 4 and 9). It tends to be preserved only around orthopyroxene porphyroclasts in more pyroxene-rich harzburgite. Piece 8 shows the interlayered nature of dunite and harzburgite. There are many good examples of spinel trains that cut samples both subparallel to the foliation and at random high angles to the foliation. Piece 5 contains a concordant pyroxenite band.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene, clinopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Comments: Alteration is patchy in appearance due to concentrated pods of serpentinized olivine kernels with white serpentine cores and green rims, which are enclosed in a dark brown mesh serpentine matrix. The section is *pervasively altered with alteration ranging* 80%–86%. *Olivine is pevasively* altered (90% to 100%), with fresh clear kernels commonly clustering near orthopyroxene porphyroclasts. Dark gray green patches are likely to be pervasively altered clinopyroxene which is altered to serpentine ± amphbiole and chlorite (70%–100%). Orthopyroxene porphyroclasts, apple green to mottled gray green, exhibit varible alteration intensity ranging from 50% to 80%. Alteration minerals include cummingtonite and serpentine.
Veins
Piece 6 contains a pervasively altered gabbroic vein, which is altered to zoisite, prehnite, actinolite/tremolite, minor chlorite, and magnetite.
It is cut by a green, cross-fibered chrysotile vein. Hydrothermal veins include 1) composite chlorite and green chrysotile serpentine veins, 2) green chrysotile veins, 3) composite green chrysotile and sulfide mineral veins, 4) anastomosing and discontinuous white asbestiform veins (listed in sequence of formation - oldest to youngest). The anastomosing set of composite white wispy and serpentine and iron oxide mineral veins is poorly developed in this section.
VEIN/FRACTURE FILLING:
Dark amphibole, chlorite, and sulfide minerals.
Size: 4 mm.
Orientation: Tapering veins.
Composite wispy white serpentine and iron oxide minerals.
Orientation: Veinlets.
Serpenntine, actinolite, and zoisite.
ADDITIONAL COMMENTS: Structure
No elongated porphyroclastic fabric is evident in the upper part of the section (Piece 1A). In piece 1B, a weak elongated porphyroclastic texture is present, it then diminishes until Pieces 8 and 10 where it is evident again. The strongest fabric occurs in the center of Piece 8. Overall the porphyroclastic fabric dips at about 45° to 50°. White serpentine veins that overprint the porphyroclast foliation are more irregular and branching in Piece 1B. Both steeply dipping and foliation subparallel sets of white serpentine veins are present in Pieces 1 to 3. In Piece 6, a metagabbro vein is cut by a pale green serpentine vein.

153-920D-20R-3



UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–5

COLOR: Dark gray to green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine. - Mode: 77%–96%.
Orthopyroxene. - Mode: 3%–18%.
Crystal Size: 3–19 mm.
Crystal Shape: Anhedral.
Clinopyroxene. - Mode: 2%–4%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: 1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: This section consists predominantly of serpentinized harzburgite (Pieces 1, 2, 3, 4B, and 5) which contains two pyroxenes and a total pyroxene content of 12% to 22%, but is generally between 10%–15%. Clinopyroxene is generally 2%–3%. Piece 4A is more depleted than the others (dunitic composition) in the section, having less than 3% orthopyroxene and no identifiable clinopyroxene. Spinel is localized in trails, generally parallel to the foliation, but also occurs in clusters around relict orthopyroxene porphyroclasts. Piece 3 has a long serpentine vein and part of a highly altered pyroxenite vein at its base.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: Replacing olivine, orthopyroxene, clinopyroxene.
Iron oxide minerals.
Mode of Occurrence: Replacing olivine, clinopyroxene.
Amphibole.
Mode of Occurrence: Replacing clinopyroxene(?), orthopyroxene(?).
Chlorite.
Mode of Occurrence: Replacing clinopyroxene.
Clay minerals.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Comments: The section is pervasively altered with alteration ranging 86%–97%. Alteration is patchy in appearance due to concentrated pods of serpentinized olivine kernels with white serpentine cores and green rims which are enclosed in a dark brown mesh serpentine matrix. Olivine is pevasively altered (98%–99%), with fresh clear kernels commonly clustering near orthopyroxene porphyroclasts. Clinopyroxene is moderately altered to serpentine ± amphbiole and chlorite (25%). Near veins, clinopyroxene may be altered to brown amphibole, chlorite, and pyrite. Orthopyroxene porphyroclasts, apple green to mottled gray green, exhibit varible alteration intensity ranging from 25% to 50%. Alteration minerals include cummingtonite(?) and serpentine.
Veins
Piece 2 contains netveins of yellow green to dark green serpentine and a 6 mm wide tremolite/actinolite vein with a trace of pyrite which is rimmed by chlorite. Piece 3 is cut by a metagabbro/pyroxenite vein of tremolite, actinolite, and serpentine with chlorite rims. This vein is cut by a later generation of green white serpentine veinlets which are cut by wispy asbestiform veinlets. Composite wispy white iron oxide mineral and serpentine veinlets do not have a preferred orientation (no anastomosing serpentine fabric in this section). Piece 4A contains a sheared serpentine vein, 4 mm thick.
VEIN/FRACTURE FILLING:
Amphibole, chlorite, and serpentine.
Size: <1 to 5 mm.
Composite wispy white and black serpentine.
Comments: Cuts white serpentine veins.
White serpentine.
Comments: Cuts amphibole vein.
ADDITIONAL COMMENTS: Structure
There is no preferred orientation of the orthopyroxene porphyroclasts in this section. Thin white serpentine veins are weakly developed and have no well-defined orientation. Piece 2A contains (on the curved surface) a fault plane with oblique slickenline fibers; the fault surface cuts across a pale green

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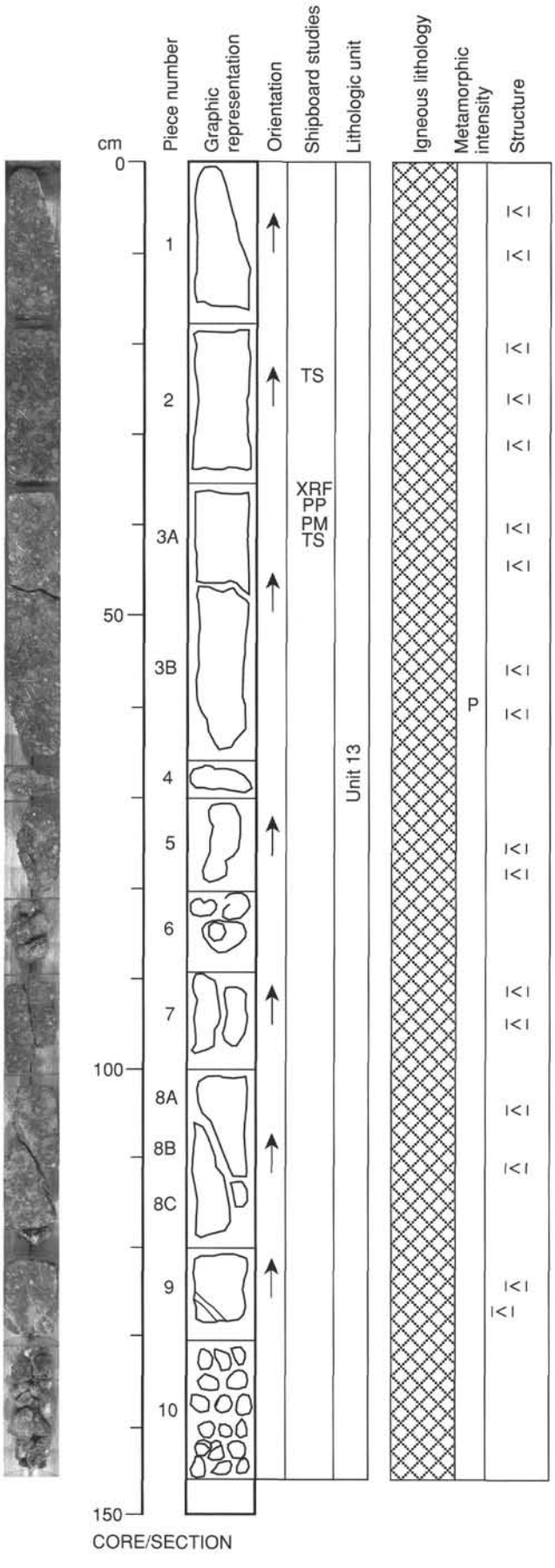
serpentine vein. Piece 4A also contains a serpentine vein with fibers oblique to its margins. Pieces 3 and 4 contain altered metagabbro veins. In Piece 3, one of these veins is cut by a later pale green serpentine vein. Similar pale green veins occur in Pieces 2A, 2C, 3, 4A, and 5. In Piece 4, one of these veins cuts the thin white serpentine veins. Spinel trails are evident, concentrated around orthpyroxene porphyroclasts.

153-920D-20R-4



UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–10

COLOR: Dark gray green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivive - Mode: 82%–93%.
Orthopyroxene - Mode: 6%–16%.
Crystal Size: 3–12 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 0%–1%.
Crystal Size: 3–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized pyroxene-poor harzburgite (10%–15% total pyroxene content) with minor dunite in some pieces (e.g. Pieces 8, 9, and 10). Modal abundance of pyroxene is generally low (6%–15%) throughout the section. All primary phases are preserved to some degree although alteration is high (≈85%) throughout the section. Orthopyroxene is usually best preserved, but olivine is commonly preserved adjacent to orthopyroxene porphyroclasts. The section contains excellent examples of spinel trains that cut the core either in a subhorizontal orientation or at a high angle to the high-temperature foliation. The center of Piece 2 preserves a spinel train ≈50 mm long consisting of a series of bleb-like spinel sometimes interconnected with thin films of spinel which appear to represent an interconnected melt channelway along which spinel (and possibly) olivine was being precipitated. The spinel grains often have channel-like extensions that link one spinel grain to another. Piece 3 contains another example in which the zone of spinel is oriented at 20° to the high-temperature foliation in the section. Likewise Piece 8B contains another good subhorizontal example. Piece 9 contains a small gabbroic dikelet.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Talc?
Mode of Occurrence: After olivine.
Amphibole.
Mode of Occurrence: After orthopyroxene, clinopyroxene.
Chlorite.
Mode of Occurrence: After clinopyroxene.
Comments: Alteration is patchy in appearance due to concentrated pods of serpentinized olivine kernels with white serpentine cores and green rims which are enclosed in a dark brown mesh serpentine matrix. The section is pervasively altered with average alteration reaching ≈85%. Olivine is pervasively altered (89%–92%), with fresh clear kernels commonly clustering near orthopyroxene porphyroclasts. Clinopyroxene is pervasively altered to serpentine (80%–85%). Orthopyroxene porphyroclasts, apple green to mottled gray green, are moderately altered to cummingtonite(?) and serpentine.
Veins
Composite wispy white and iron oxide mineral and serpentine veinlets form a weak anastomosing net in Pieces 2 and 3. Piece 9 is cut by pervasively altered gabbroic veinlets (1–2 mm wide). Alteration minerals include brown amphibole, tremolite/actinolite, chlorite, and serpentine. Pyroxene grains adjacent to the veins are highly altered to chlorite and actinolite. Fragments of veins with similar mineralogy are present in Piece 10. Piece 2 has a set of thin (<1 mm) subparallel dark veins, possibly of serpentine and chlorite(?), which are crosscut by the wispy serpentine veins.
VEIN/FRACTURE FILLING:
Dark amphibole and chlorite veins.
Size: 1–2 mm.
Composite wispy white and dark serpentine veinlets.
ADDITIONAL COMMENTS: Structure
There is no preferred orientation of the pyroxene porphyroclasts in this section. Thin

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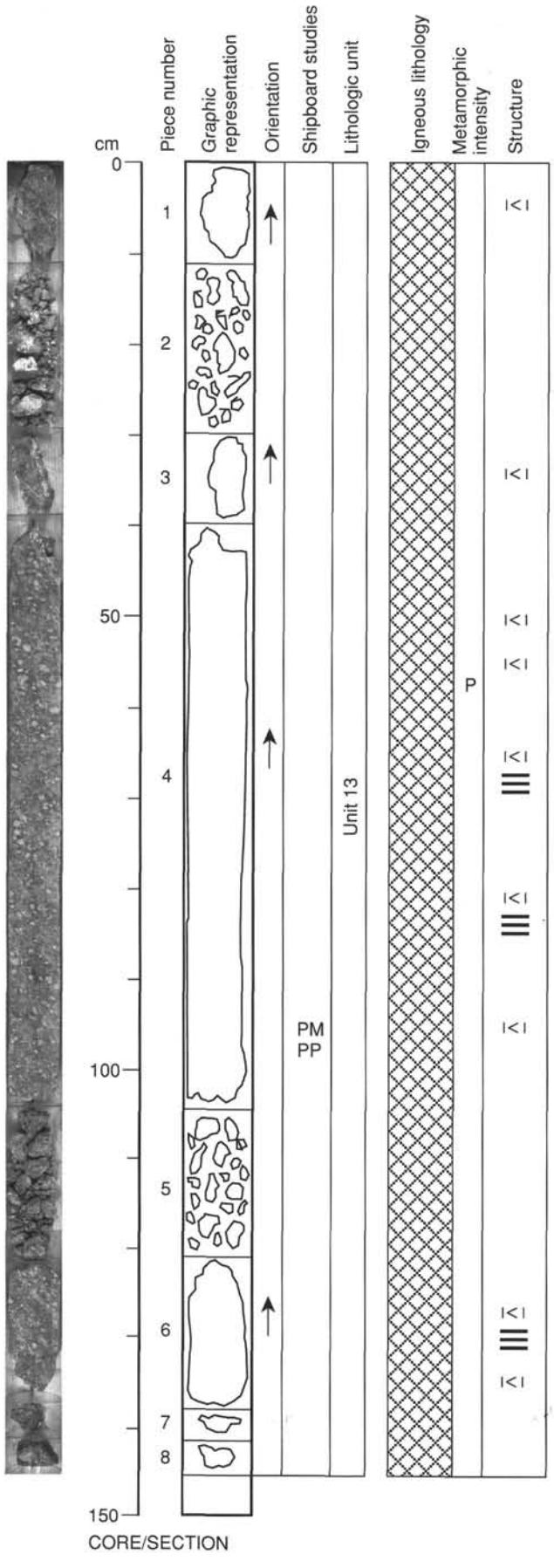
white serpentine veins are steeply dipping and define locally well-developed foliation zones (e.g., Pieces 2 and 3A) that are cut across by gently dipping veins (chalky white serpentine). The relatively oldest veins are filled with chlorite (e.g., Pieces 2, 3A and 3B). In Piece 3B, a pale green serpentine vein cuts both the chlorite filled vein and the white serpentine veins. Spinel trails are evident in several locations following paths perpendicular or subparallel to the foliation. The spinel grains have a weak shape preferred orientation, parallel to the trail (e.g., Piece 3).

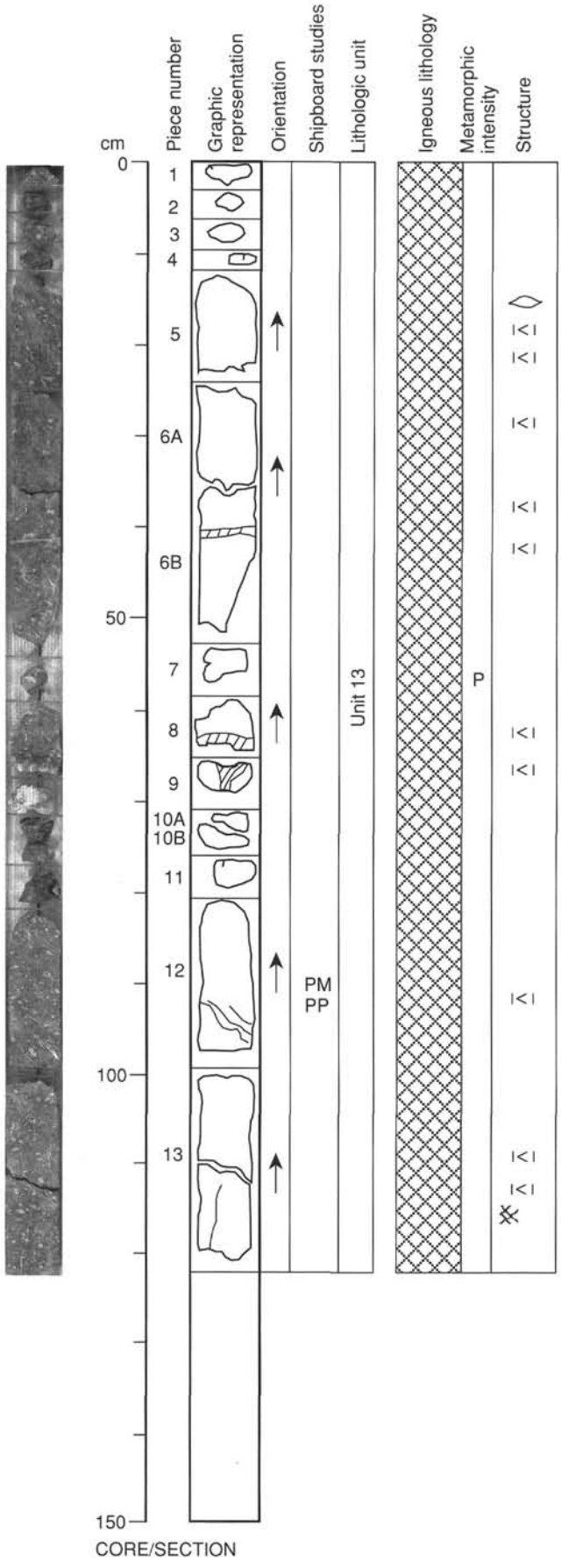
153-920D-20R-5



UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–8

COLOR: Black, gray.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 80%–88%.
Orthopyroxene - Mode: 11%–18%.
Crystal Size: 4–8 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 0%–3%.
Crystal Size: 4–8 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized harzburgite with minor serpentinized pyroxene-poor dunite bands that are a few cm thick. All primary phases are preserved as relics, especially orthopyroxene and spinel. Average pyroxene content is about 16%–18%. Piece 2 is harzburgite rubble. Piece 4 is very long, about 60 cm. It contains minor spinel, relative to most pieces examined in the core. There are no magmatic veins in the section, but some spinel trains observed.
SECONDARY MINERALOGY:
Serpentine.
Texture: Mesh.
Mode of Occurrence: After olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: After olivine.
Clay minerals.
Mode of Occurrence: After olivine, orthopyroxene.
Amphibole?
Mode of Occurrence: After clinopyroxene(?)
Comments: The section is pervasively altered with average alteration reaching ≈86%. Olivine is pervasively altered (88%–92%) with fresh clear kernels commonly clustering near orthopyroxene porphyroclasts. Clinopyroxene is moderately altered to serpentine (70%–75 %). Orthopyroxene porphyroclasts, apple green to mottled gray green, are moderately altered (50%–70%) to cummingtonite(?) and serpentine. Alteration is patchy in appearance due to concentrated pods of serpentinized olivine kernels with white serpentine cores and green rims which are enclosed in a dark brown mesh serpentine matrix.
Veins
Pieces 4 and 6 contain a set of 1–2 mm wide, dark subparallel veins filled with chlorite ± amphibole and serpentine. The net of composite iron oxide minerals and serpentine and wispy white asbestiform serpentine postdates the chlorite and serpentine veinlets and shows a weak preferred orientation (anastomosing serpentine fabric) in Pieces 1, 4, and 6. Pieces 3 and 4 also contain white serpentine veins, 1 mm wide, some with slickensides fibers of serpentine.
VEIN/FRACTURE FILLING:
Composite white and black wispy serpentine veins.
Amphibole and chlorite veins.
Size: 1–2 mm.
Comments: Before composite serpentine veins.
ADDITIONAL COMMENTS: Structure
A weak elongated porphyroclastic fabric is present, defined by the shape preferred orientation of pyroxene. This fabric is overprinted by a weak to moderate anastomosing foliation that dips at about 45°. Thin (1 mm) white veins overprint the anastomosing foliation, wrapping around pyroxene grains. In Piece 4 the veins develop longer wavelengths (5–10 cm) and become more planar. Chlorite veins (1–2 mm) are oriented at high angles to white serpentine veins (Pieces 3, 4, and 6). Pieces 2 and 5 comprise rubble fragments. One vein surface contains fibrous serpentine and talc in Piece 3.



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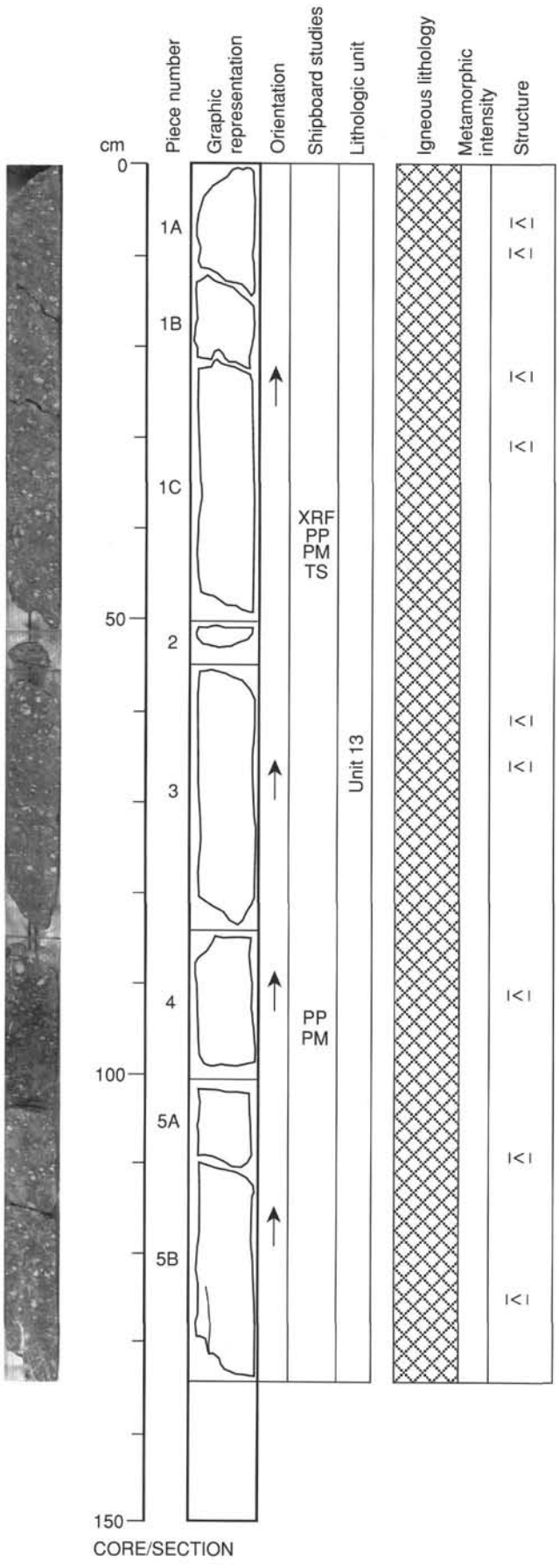
UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–13

COLOR: Dark green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 87%–90%.
Orthopyroxene - Mode: 8%–15%.
Crystal Size: 2–16 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 1%–3%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic harzburgite. The section contains relatively fresh harzburgite in which clinopyroxene is only partially altered and is better preserved, relative to orthopyroxene. Clinopyroxene is, nonetheless, still present in minor abundances (1%–3%), with higher abundances toward the base of the section (Piece 13). Pyroxene content ranges from 15%–20%. A conspicuous feature of harzburgite in the base of the section is the appearance of lensoidal aggregates of fresh olivine. Spinel forms <2 mm grains that are commonly aligned in trains across the apparent elongation of orthopyroxene porphyroclasts. This is also a common form in recrystallized porphyroclastic lenses, however, suggesting that spinel is recording the same fabric within and outside the porphyroclastic aggregates. Piece 5 contains an altered gabbroic vein. Piece 7 is altered pyroxenite vein material, and Piece 9 is amphibolitized gabbro.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 85–100
Comments: Replaces olivine and orthopyroxene.
Magnetite.
Total Percent: <2
Comments: Product of serpentinization.
Comments: This section is 85%–98% altered, alteration being lowest in Pieces 6B, 12, and 13, and highest in Pieces 1, 2, and 4. Olivine is 85%–100% altered into a mesh of serpentine and magnetite. Pyroxene is 80%– 95% altered to serpentine, possibly with minor amounts of amphibole, chlorite, and talc. The veining of wispy white serpentine is present in Pieces 1, 5, 4, 6B, 7, 8, 12, and 13. Piece 6A contains iron oxide mineral patches after spinel. Piece 9 is composed entirely of an actinolite/tremolite and sulfide mineral-bearing vein after gabbro, with a core of later zoisite and prehnite veining (<3 mm wide). In Piece 11, serpentine and sulfide minerals are present in a 1 mm wide vein. Piece 12 is cut by a single steep tremolite/actinolite vein (<3 mm) at a high angle to the ductile foliation.
VEIN/FRACTURE FILLING:
Tremolite/actinolite ± epidote./
Size: 3–>20 mm.
Orientation: Crosscutting foliation.
Serpentine.
Orientation: Anastomosing foliation.
ADDITIONAL COMMENTS: Structure
A weak elongated porphyroclastic texture deforms this section, dipping at about 35°. An anastomosing foliation is also weakly developed, defined by a dense meshwork of serpentine veins. Although the foliation is generally parallel to the porphyroclast fabric it is also locally oriented at high angles. The vertical white serpentine vein set is more developed than the one which dips parallel to the foliation (e.g., Piece 5). Both concordant and discordant metagabbroic veins are present. In Piece 12, a dark green serpentine vein contains oblique fibers. Spinel grains displaying a weak shape preferred orientation form trails that are subparallel to the porphyroclast foliation.



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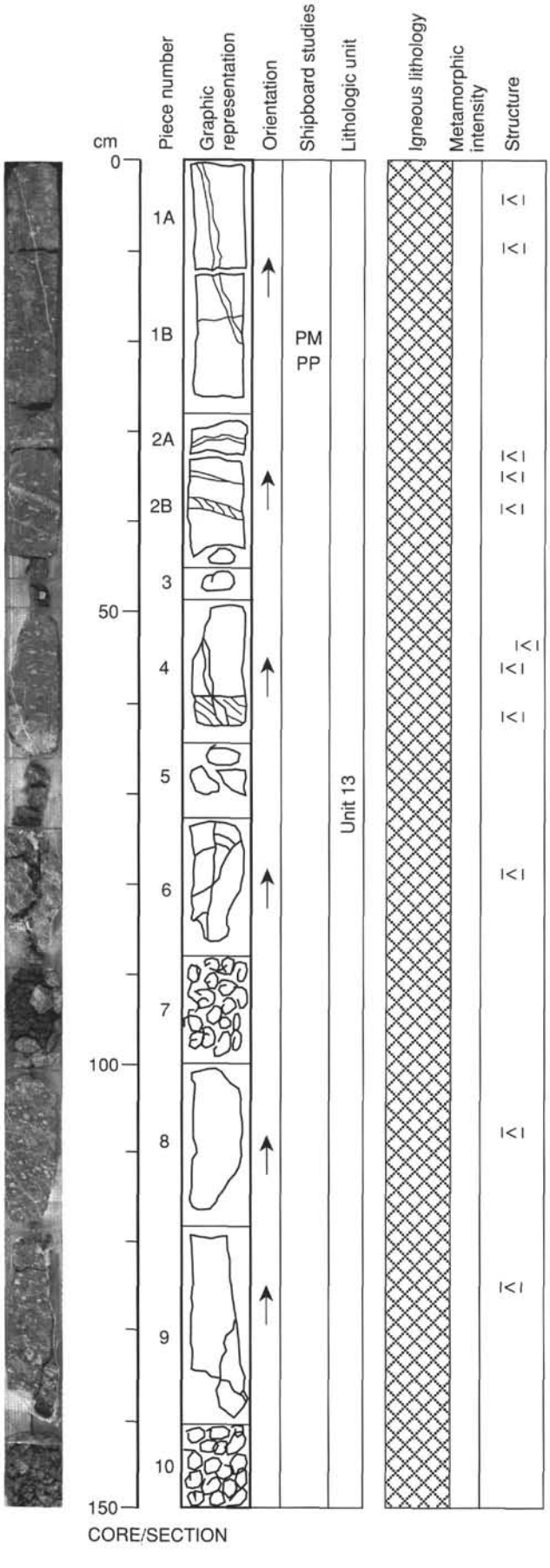
UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–5B

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic; weak crystal-plastic fabric.
PRIMARY MINERALOGY:
Olivine - Mode: 88%.
Orthopyroxene - Mode: 15%.
Crystal Size: 4–12 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 5%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 2%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic pyroxene-rich harzburgite. The section contains relatively fresh harzburgite in which clinopyroxene is preserved and relatively abundant. Total pyroxene abundances are between 15 %–20%, with clinopyroxene as high as 5%. There is a moderate elongation of the porphyroclasts throughout the section. Thin subhorizontal clinopyroxene lenses are abundant in Piece 1. There are no larger magmatic veins in the section.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 80
Comments: Replaces primary phases.
Magnetite.
Total Percent: 2
Comments: Product of serpentinization.
Comments: Harzburgite in this section is 80% altered, with a patchy distribution of gray green and darker domains. Olivine is 85%–90% altered into serpentine and iron oxide minerals. Orthopyroxene is 30%–70% serpentinized. In Pieces 1A and 1B, there is a thin (1 mm) amphibole and chlorite vein. The net of wispy serpentine veins is poorly developed in this section. Piece 5B contains a 2 mm wide vein of white serpentine and minor carbonate minerals.
VEIN/FRACTURE FILLING:
ADDITIONAL COMMENTS: Structure
A weak shape preferred orientation of orthopyroxene porphyroclasts defines a weak elongated porphyroclastic texture in this section. The associated foliation dips at about 35° and is best developed in Piece 1. No anastomosing foliation, formed by dark green serpentine veins is present. Sparse, white, discontinuous serpentine veins (1–2 mm) are present but they do not have a strong preferred orientation. Dark green chlorite and amphibole veins are steeply dipping in Piece 1 and are crosscut by the thin white serpentine veins.



153-920D-21R-3

UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–10

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 82%–93%.
Orthopyroxene - Mode: 5%–15%.
Crystal Size: 2–13 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode:0 .5%–3%.
Crystal Size: 1–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Comments: Serpentinized porphyroclastic harzburgite/dunite with pyroxene content ranging from 10%–15% in Pieces 16, up to 20% in Pieces 7 and 9, and 5%–13% in Piece 4. This section is similar in overall appearance to Sections 153-920D-21R-1 and 2, but is pyroxene poor in the top half (Pieces 1–6). Piece 1 contains a 1 mm wide altered pyroxenite vein. Piece 2 contains two pyroxenite/gabbro veins (1 cm and 3 mm thick) that cut across the core parallel to the direction of orthopyroxene elongation. A 50 mm, very coarse-grained sulfide mineral-rich metapyroxenite/gabbro composite vein forms the bottom contact of Piece 4. A marked depletion in pyroxene in the harzburgite takes place as the vein margin is approached. A notable feature of this core is the presence of 1–2 mm wide rims of fresh olivine common on porphyroclasts, particularly below Piece 8.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 90
Comments: Replaces primary phases.
Magnetite.
Total Percent: <2
Comments: Product of serpentinization.
Talc.
Total Percent: <1
Comments: The section is 80%–90% altered. Alteration intensity is lowest (80%) in Piece 8. Olivine is altered to a mesh of serpentine and oxide minerals, with a patchy dark and light gray green color. Orthopyroxene is altered to serpentine, with minor amphibole, chlorite, and talc. In Piece 1A, a 1 mm wide metapyroxenite vein includes chlorite, tremolite, and serpentine with associated hematization of pyroxene grains. This vein is crosscut by green serpentine veins. Wispy white serpentine veins are developed in Pieces 1, 2A, 4, 6, 8, and 9. In Piece 2B, a 10 mm wide serpentine and amphibole vein occurs parallel to a 5 mm wide serpentine vein. In Piece 4, a 30 mm wide vein of pegmatoid gabbro is altered to brown amphibole and green amphibole. This magmatic vein is cut by an amphibole, chlorite, and serpentine vein similar to that of Piece 1. Irregular (up to 1 mm wide) serpentine veins also cut this section. Poor recovery, possibly caused by fracturing induced by high density of serpentine veining appears in Pieces 6, 7, 9, and 10. Thin serpentine veins are present running down the length of Piece 1 and across Piece 2.
ADDITIONAL COMMENTS: Structure
An elongated porphyroclastic fabric is moderately to strongly developed. In the upper part of this section, clasts show sharp rectangular boundaries. In the lower part of the section, porphyroclasts are often composite clumps of more coarsely crystalline orthopyroxene, clinopyroxene, and olivine. The foliation dips at about 10° to 25° in the upper part of the section, steepening to about 40° in Piece 7. Thin (1–2 mm) white serpentine veins are strongly anastomosing where two orthogonal vein sets appear to have linked (e.g., Piece 2). Below piece 8 the spacing between the white serpentine veins decreases. In Piece 2, a metagabbro vein is oriented concordantly to the pyroxene-defined foliation. In Piece 8, there are several pieces of fractured rubble.

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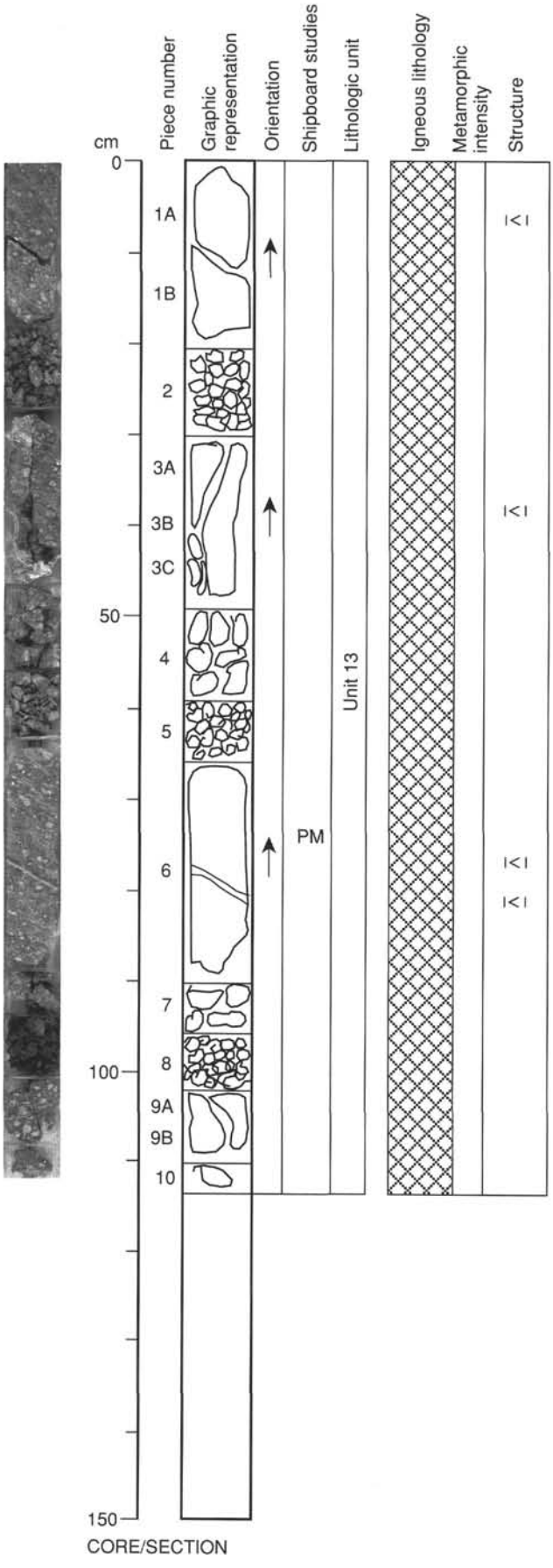
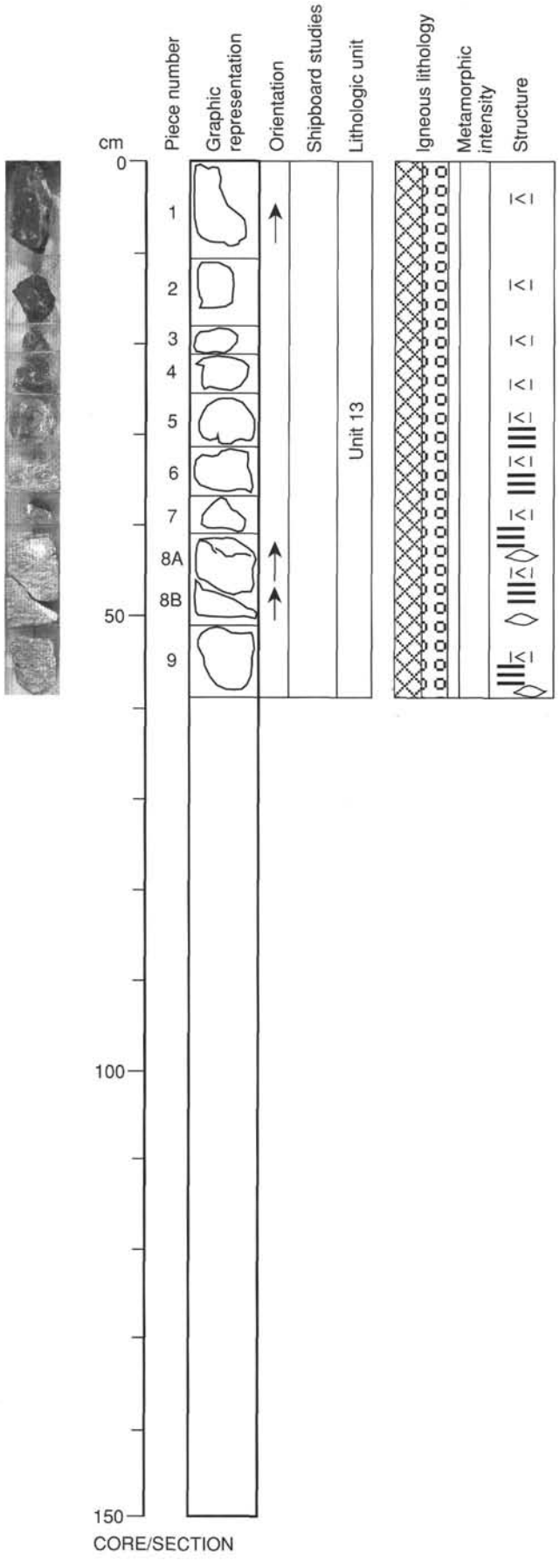


UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–10

COLOR: Gray.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 82%–85%.
Orthopyroxene - Mode: 13%–15%.
Crystal Size: 1–13 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 2%–4%.
Crystal Size: 5–10 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: <2 mm.
Comments: Serpentinized harzburgite. Although rubbly in some pieces (Pieces 2, 4, 5, 7, and 8) the rock is relatively fresh. The total modal abundance of pyroxene is 15%–22% with clinopyroxene increasing downsection. There is a concordant altered pyroxenite vein in Piece 6.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 78–83
Comments: Replaces primary phases.
Magnetite.
Total Percent: 2–4
Comments: Product of serpentinization.
Comments: Harzburgite in this section is 80% altered. Olivine is altered (80%) to serpentine and iron oxide minerals. Both pyroxenes are relatively fresh, orthopyroxene is 15%–40% altered and clinopyroxene ranges from 5%–10%. Anastomosing sets of wispy white and dark serpentine veins are well developed. Pieces 2, 4, 5, 7, and 8 are made of fragments broken along these anastomosing set of veins. In Piece 6, a 2 mm wide, metapyroxenite vein composed of actinolite-tremolite, chlorite, and serpentine develops at a low angle to the anastomosing serpentine fabric. In Piece 10, a 0.5 cm composite vein of dark green and white serpentine occurs.
ADDITIONAL COMMENTS: Structure
A moderate pyroxene porphyroclast elongation forms the dominant deformation fabric in this section. The associated foliation dips at about 30° to 45°. A moderately intense anastomosing foliation overprints the porphyroclastic fabric. The foliation is defined by a meshwork of serpentine veins that wraps around and transects the porphryoclasts. This foliation is overprinted by thin white serpentine veins that are abundant through the section. An amphibole, chlorite, serpentine vein in Piece 6 is oriented at about 20° to the serpentine foliation. Several pieces of rubble occur through this section (Pieces 2, 4, 5, 7, and 8).



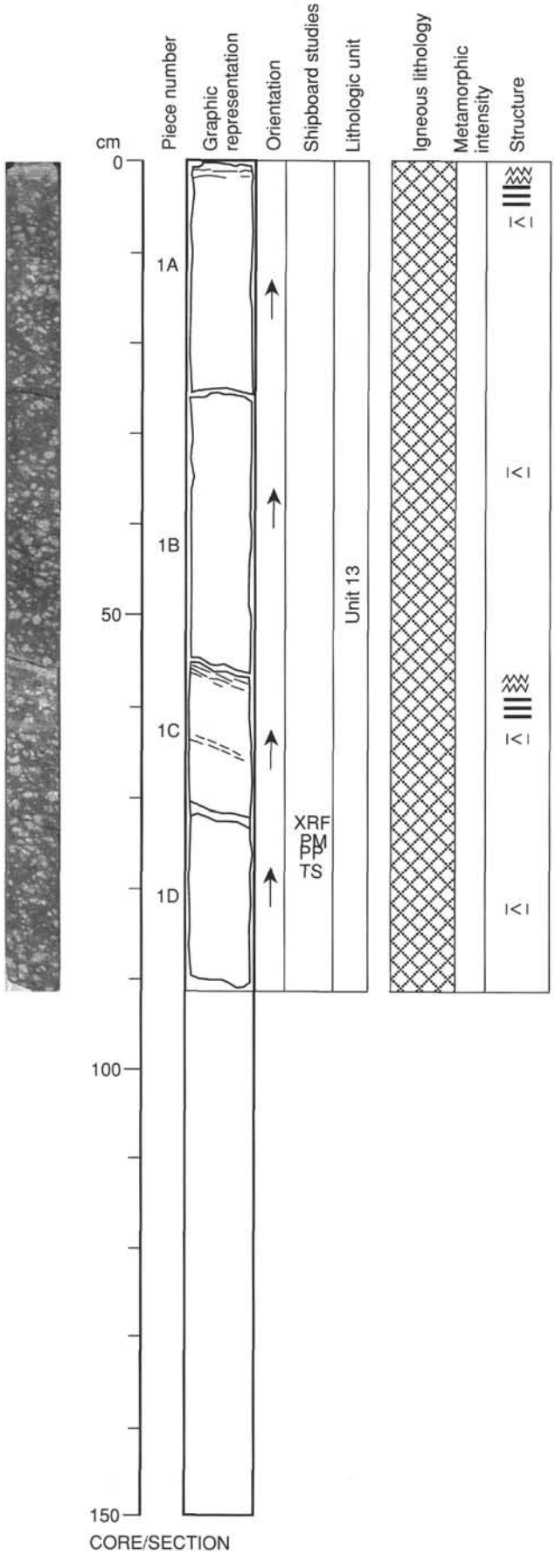
153-920D-22R-1

UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–9

COLOR: Green gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Veins.
PRIMARY MINERALOGY:
Olivine - Mode: 90%.
Orthopyroxene - Mode: 10%.
Crystal Size: 4–6 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Comments: Serpentinized porphyroclastic harzburgite that is highly variable in pyroxene content would appear to be interlayed on a fine scale (although contacts are not preserved). Pieces 1, 2, and 4 contain 10%–15% total pyroxene, Piece 3 contains ≈23% pyroxene, and Pieces 6–9 contain 15%–20% pyroxene. Piece 1 contains a thin (10 mm wide) altered pyroxenite vein cutting the foliation at high angles. Both olivine and pyroxene are completely altered.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 99
Comments: Replaces primary phases.
Magnetite.
Total Percent: <2
Comments: Product of serpentinization.
Comments: This section is 99%–100% altered. Olivine is 100% replaced by a dark serpentine, iron oxide mineral-rich mesh, and pyroxene is almost entirely replaced by serpentine. Intensity of anastomosing wispy serpentine veining increases downsection, with veining absent in Piece 1, and quite intense in Piece 5. In Piece 1, a 10 mm wide, brown amphibole and serpentine vein after pyroxenite is irregularly developed. On the opposite side of Piece 1, a 4 mm wide serpentine vein occurs. Piece 8 also contains a thin sheared fracture, coated with serpentine fibers.
VEIN/FRACTURE FILLING:
Amphibole.
Size: 10 mm.
Orientation: Subparallel to foliation.
ADDITIONAL COMMENTS: Structure
The first three pieces in this section are relatively orthopyroxene poor and undeformed. Veins are scarce. An increase in orthopyroxene content in Piece 5 coincides with the development of an elongated porphyroclastic fabric. In Piece 6, the aspect ratios reach 1:3, and in Piece 7, they reach 1:5. Kinked orthopyroxene porphyroclasts are evident in Piece 2. Pieces 1 and 4 contain metagabbro(?) veins. This vein is subparallel to subvertical thin white serpentine veins. In Piece 4 a metagabbro(?) vein is oriented perpendicuar to the white serpentine veins. In Piece 8, there is fault surface coated with aligned serpentine fibers. No offset could be determined for this slip surface. The porphyroclast-defined foliation dips at a bout 25° in Piece 8.

153-920D-22R-2

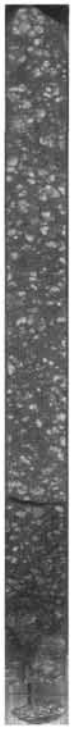


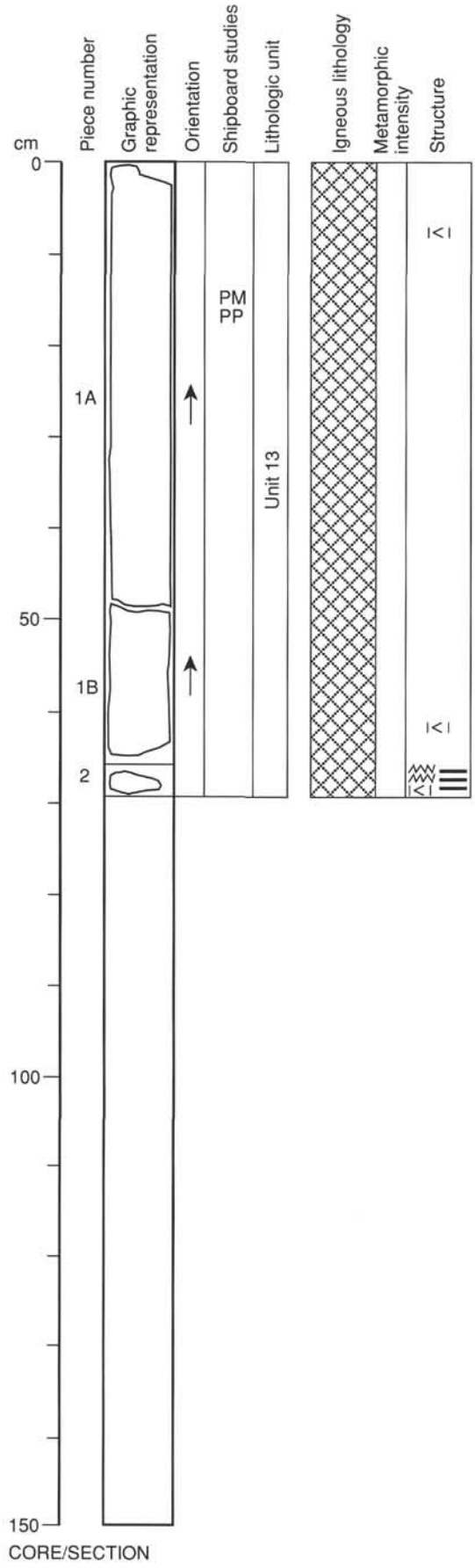
UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–1D

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic.
SECONDARY STRUCTURE: Veins.
PRIMARY MINERALOGY:
Olivine - Mode: 77%.
Orthopyroxene - Mode: 18%.
Crystal Size: 2%–22 mm.
Crystal Shape: Subhedral.
Clinopyroxene - Mode: 4%.
Crystal Size: 1–10 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic pyroxene-rich harzburgite. This section is notable for both the freshness of harzburgite, and for the relatively large grain size. The top of Piece 1 is marked by a <1 cm thick zone of intensely serpentine veined harzburgite similar to that in the last piece of the preceeding section. Alteration intensity within the section is moderate (60%). Orthopyroxene (18%) forms single grains up to 22 mm in size. Clinopyroxene abundance is ≈4%. Long (2 cm) trails of interstitial clinopyroxene grains that crosscut the foliation and cut orthopyroxene porphyroclasts may mark melt migration paths. Clinopyroxene locally forms subhorizontal elongated lenses. Fresh olivine rims on porphyroclasts are common. No magmatic veins were observed in the section.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 60
Comments: Replaces primary phases.
Comments: Harzburgite in this section is 60%–70% altered. Olivine is 70% altered to a gray mesh of serpentine and iron oxide minerals. Pyroxene is 20%–40% altered to serpentine. Scarce veins are present as wispy white serpentine in Piece 1A, 2 cm from the top; Piece 1B, bottom of the piece; and Piece 1C, interval 57–74 cm.
VEIN/FRACTURE FILLING:
Brown amphibole.
Size: 10 mm.
Orientation: Normal to core length.

Serpentine
Size: 4 mm.
Orientation: Normal to core length.
ADDITIONAL COMMENTS: Structure
A weakly elongated porphyroclastic fabric is defined by orthpyroxene porphyroclasts. A weak anastomosing foliation formed thin white serpentine veins that wrap around the orthopyroxene porphyroclasts. The anastomosing foliation in Piece 1 dips at about 10°. In Piece 1C, there is an intensification of the anastomosing foliation in two 2 cm wide bands that resemble shear zones. In Piece 1B, a dark green chlorite and serpentine vein is oriented at a high angles to the weak elongation direction of the porphyroclasts. The vein is cut by a white serpentine vein. Trails of clinopyroxene grains cut across the foliation.





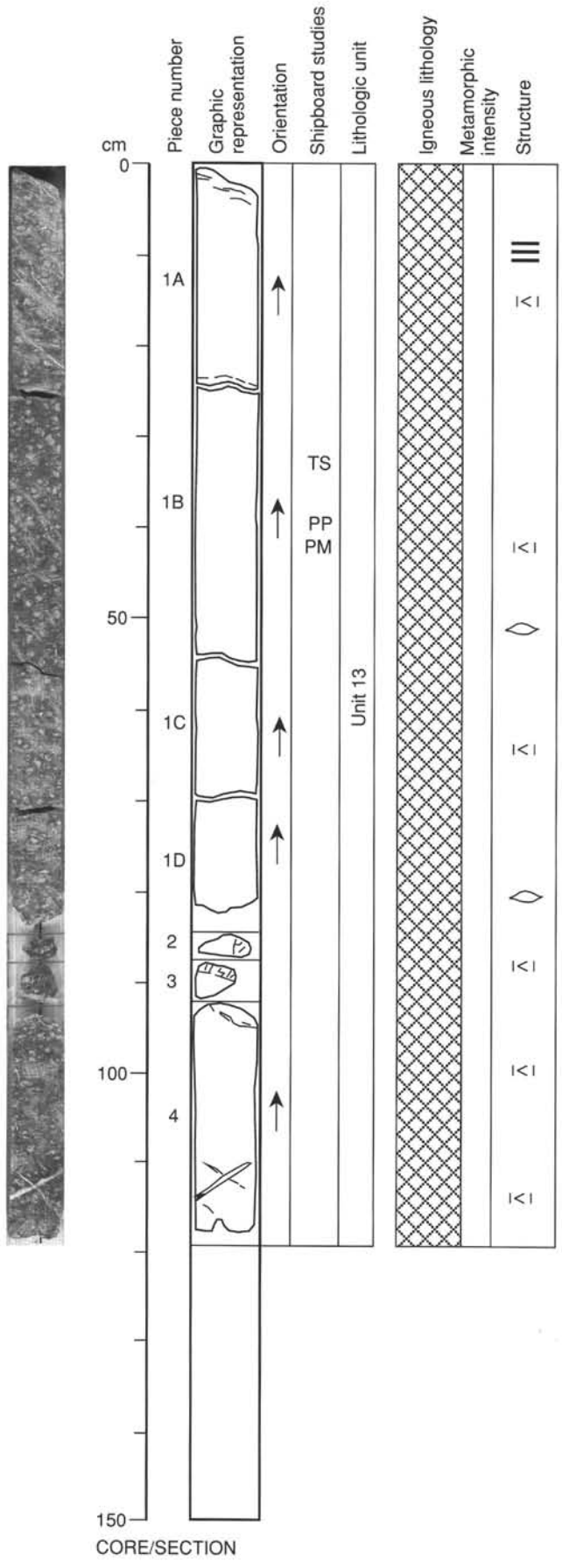
153-920D-22R-3

UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–2

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic
SECONDARY STRUCTURE: Veins.
PRIMARY MINERALOGY:
Olivine.- Mode: 77%–80%.
Orthopyroxene - Mode: 15%–18%.
Crystal Size: 2–20 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 4%.
Crystal Size: 1–8 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic pyroxene-rich harzburgite. This section is notable for the relatively large grain size as in Section 153-920D-2R. Orthopyroxene (15%–20%) forms single grains up to 20 mm in size. Clinopyroxene is very fresh and moderate in abundance (1%–4%). Fresh olivine rims on porphyroclasts are common. Total pyroxene is usually 20%–25% in the section. Long (2 cm) trails of interstitial clinopyroxene grains that crosscut the foliation and cut orthopyroxene porphyroclasts may mark melt migration paths. No larger magmatic veins are present
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 65–90
Comments: Serpentinization of primary phases.
Magnetite.
Total Percent: 1–2
Comments: Product of serpentinization.
Comments: Harzburgite in Piece 1A and at the top of Piece 1B is 50%–60% altered. The bottom of Piece 1B, and Piece 2, are more pervasively altered (95%–99%) and have a well-developed anastomosing set of wispy dark and light serpentine veins. Olivine is replaced by serpentine and iron oxide minerals forming a mesh texture. Pyroxene is moderately altered (20%–40%) in the upper part of this section, and highly (70%–80%) serpentinized in the lower 15 cm of the section. In Pieces 1A and 1B, no veining is observed. In Piece 2, only the anastomosing wispy white serpentine veins are present.
ADDITIONAL COMMENTS: Structure
A compositional boundary in the middle of Piece 1B separates a relatively orthopyroxene-rich harzburgite from the base of the section. There is a very weak to nonexistant elongated porphyroclastic fabric in the upper part, whereas in Piece 2 there is a well-defined foliation and a foliation parallel shear zone. Minor offsets on this shear zone suggest a sinistral component of motion on the cut face of the archive half of the core. At the base of Piece 1B a pale green serpentine vein cuts across the thin white serpentine veins. Vein density increases toward the base of the core section.

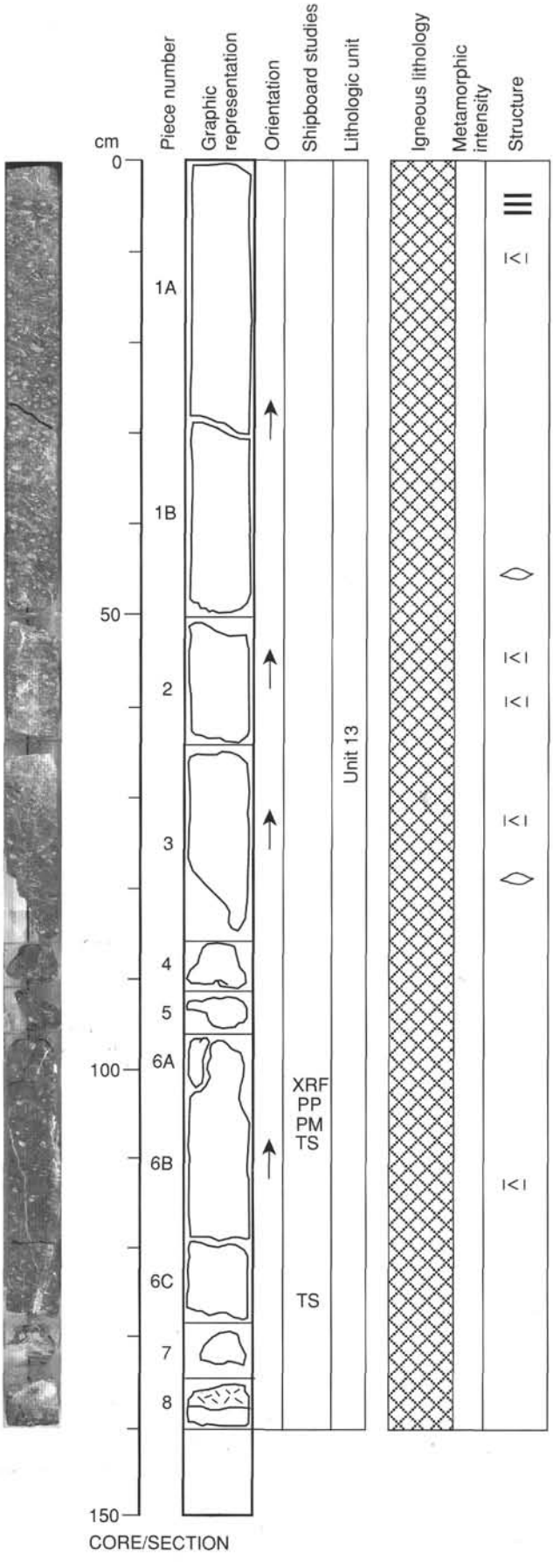
153-920D-22R-4



UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–4

COLOR: Dark gray.
PRIMARY STRUCTURE: Porphyroclastic - weak elongated porphyroclastic .
SECONDARY STRUCTURE: Veins.
PRIMARY MINERALOGY:
Olivine - Mode: 77%–82%.
Orthopyroxene - Mode: 15%–18%.
Crystal Size: 2–25 mm.
Crystal Shape: Anhedral.
Crystal orientation: Weak tectonic.
Clinopyroxene - Mode: 2%–4%.
Crystal Size: 1-8 mm.
Crystal Shape: Anhedral.
Spinel - Mode: 1%.
Crystal Size: <2 mm.
Comments: Serpentinized porphyroclastic pyroxene-rich harzburgite. This section comprises relatively fresh (78%–95% altered) harzburgite similar to Sections 153-920D-2R and -3R. Orthopyroxene (17%–18%, up to 25 mm) shows no elongation within a ductile fabric. Clinopyroxene is fresh and present in minor abundances (2%–4%). Total pyroxene is generally in excess of 20%. Trails of clinopyroxene grains across the core may record the passage or crystallization products from a melt. Piece 4 is depleted in pyroxene content 10%–15% and contains a 0.5 cm altered pyroxenite vein. Piece 5 is also more depleted and contains two thin altered gabbroic veins.
SECONDARY MINERALOGY:
Serpentine.
Total Percent: 78–95
Comments: Replaces olivine and orthopyroxene.
Magnetite.
Total Percent: 1–2
Comments: Product of serpentinization.
Talc.
Total Percent: <1
Comments: Harzburgite in this section is 70%–80% altered, except Piece 3, which is 90% replaced. Olivine is 80% to 95% altered to mesh textured serpentine and iron oxide minerals. Pyroxene is 30% to 80% altered to serpentine. Wispy dark and white serpentine veins exhibit a well-developed preferred orientation (anastomosing serpentine fabric) in the upper part of Piece 1. This fabric becomes more random in the bottom of Piece 1, and in Pieces 3 and 4. In Piece 3, there is a 5 mm wide amphibole vein, which is crossut by a 1 mm wide vein of green serpentine. In Piece 4, a 5 mm wide serpentine vein is crosscut by a later green and white serpentine vein.
VEIN/FRACTURE FILLING:
White serpentine.
Size: 1 mm.
Orientation: See comments.
Green and white serpentine.
Size: 2 mm.
ADDITIONAL COMMENTS: Structure
A weakly elongate porphyroclastic fabric is present throughout the section but varies in intensity. The fabric strengthens overall toward the base of Piece 1. At the top of the section the fabric dips about 45°. After steepening through Piece 1B the foliation dips at <10° in the region of the highest fabric intensity. A spaced, anastomosing foliation is highlighted by by white serpentine veins in Piece 1. Zones of orthogonal sets of white serpentine veins occur in Pieces 1D and 4. In Piece 4, a white serpentine vein is crossed by a pale green serpentine vein that also cuts the anastomosing foliation.



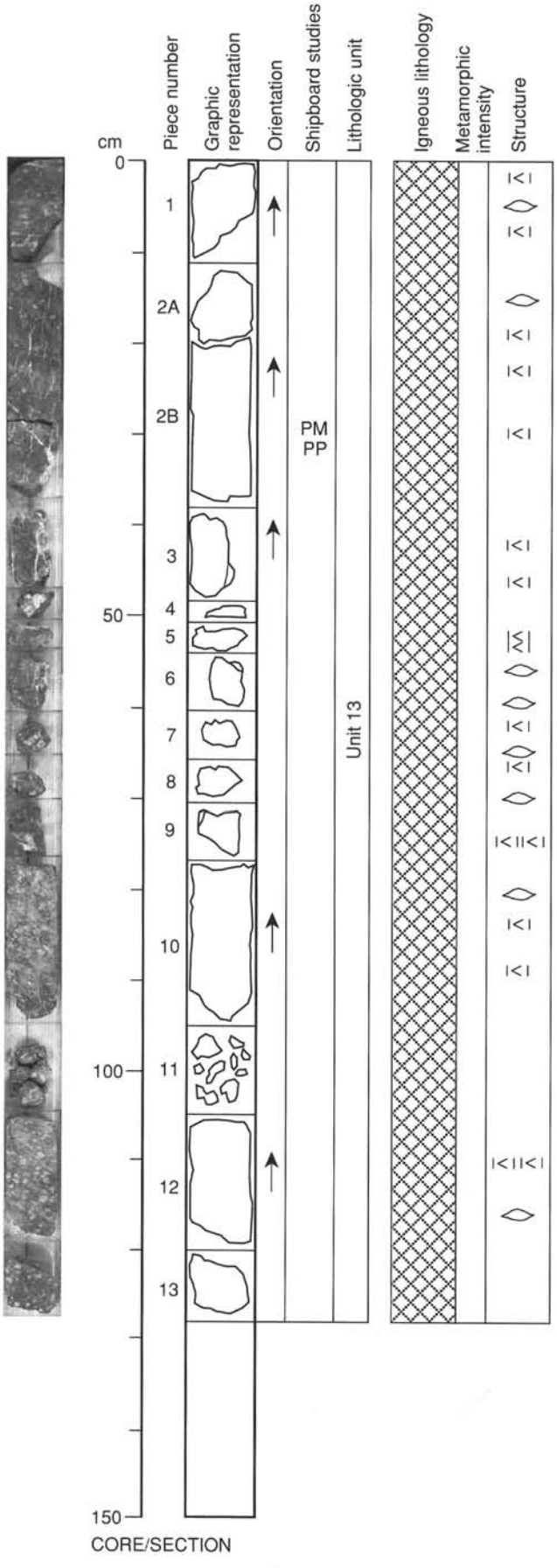
153-920D-22R-5

UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1A–8

COLOR: Dark gray to green.
PRIMARY STRUCTURE: Weak to moderate elongated porphyroclastic.
SECONDARY STRUCTURE: Veins.
PRIMARY MINERALOGY:
Olivine - Mode: 82%–92%.
Orthopyroxene - Mode: 6%–15%.
Crystal Size: 4–10 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 1%–3%.
Crystal Size: 2–5 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: The section consists predominantly of serpentinized harzburgite (Pieces 1–6) with minor amounts of pegmatitic composite altered pyroxenite/gabbro vein (Pieces 7–8) and dunite. Alteration and modal mineralogy are variable downsection. Piece 1 is the most pyroxene rich (≈18%–20% total pyroxene) and has a patchy appearance due to serpentinization similar to that seen in previous cores with a coarse mesh texture; anastomosing white veins wrap around porphyroclasts. Pieces 2–6 are lower modal pyroxene (<13%) and more altered than Piece 1. Trace amounts of sulfide minerals were observed in Pieces 2, 3, and 7. Spinel occurs in minor amounts throughout and occurs both as clusters and as subhorizontal trails (Piece 1). Piece 7 is a pegmatitic oxide-rich metagabbro and Piece 8 is a pegmatitic feldspathic oxide pyroxenite that is now partially altered to secondary plagioclase, actinolite, and chlorite. Acicular crystals growing into a fracture may be tremolite. Pieces 6B and 8 show marked pyroxene depletion of the harzburgite toward the contact with the pegmatitic vein. Piece 8 also has a crosscutting serpentine vein ≈3 mm wide.
SECONDARY MINERALOGY:
Serpentine.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: Replacing olivine, spinel.
Comments: The harzburgite in this section is 80% to 98% altered. Alteration is lowest in Piece 1, and higher downsection. Olivine is 90% to 99% altered into serpentine and iron oxide minerals. Orthopyroxene is 60% to 95% replaced by serpentine. Anastomosing sets of wispy dark and white serpentine veins is present in Pieces 1 and 2. In the rest of the section, these wispy veins are less conspicuous, and more randomly oriented. Piece 6 contains a 10 mm wide serpentine and iron oxide mineral-bearing vein, which is crosscut by later serpentine veins. The pegmatitic metagabbro in Pieces 7 and 8 is pervasively altered. Plagioclase is altered into zeolites, prehnite, and secondary plagioclase with thin actinolite and chlorite veinlets. Clinopyroxene is altered to secondary clinopyroxene, actinolite, chlorite. and iron oxide minerals.
VEIN/FRACTURE FILLING:
White serpentine.
Size: 1 mm.
Chlorite.
Size: 1–2 mm.
Orientation: See comments.
Green and black serpentine.
Size: 0.5 mm.
ADDITIONAL COMMENTS: Structure
Orthopyroxene porphyroclast elongation defines a weak to moderate elongated porphyroclastic fabric that varies in intensity through the section. No anastomosing foliation of dark serpentine veins is present but numerous thin white serpentine veins overprint the porphyroclastic fabric. In Pieces 2 and 3 the white veins become subhorizontal, switching back to a subvertical orientation in Piece 6. The orthopyroxene porphyroclasts are locally elongated horizontally in Piece 6, orthogonal to the white serpentine veins. In Pieces 2, 6, and 8, there are pale green serpentine veins that cut the white serpentine veins. Metagabbro veins are located in Pieces 7 and 8, both oriented discordantly with respect to the foliation.

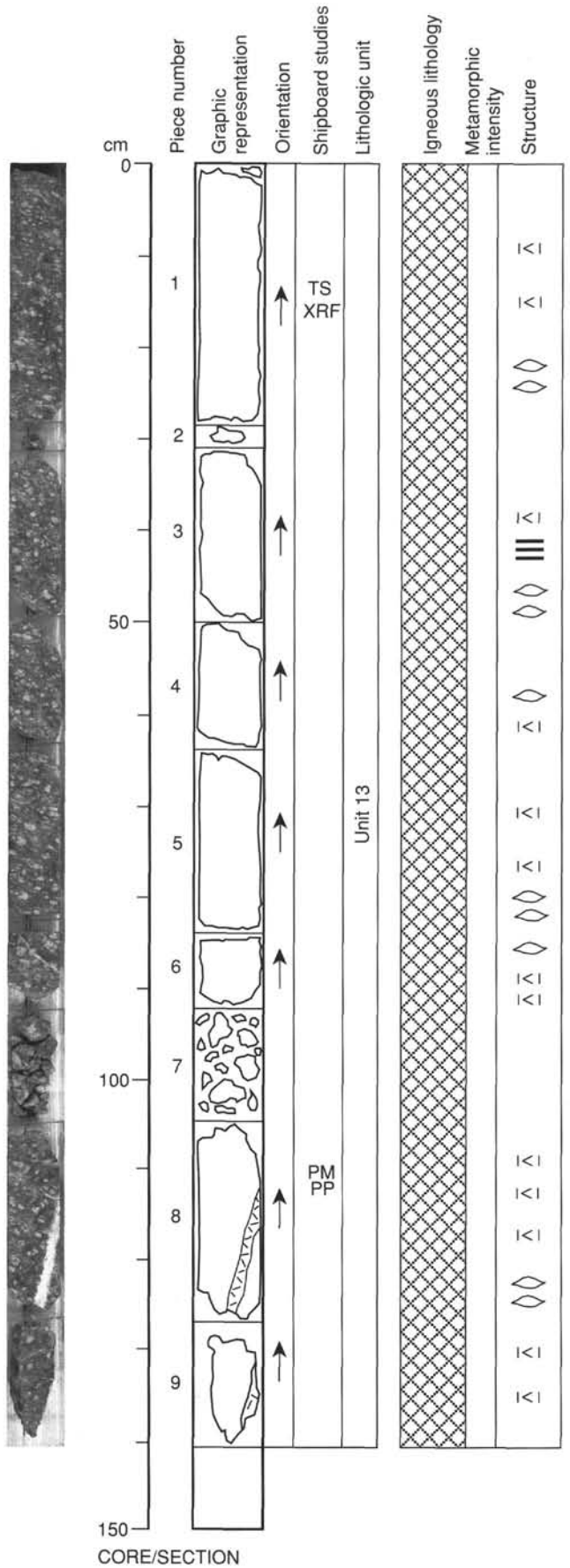
153-920D-22R-6



UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–13

COLOR: Black, gray.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 82%–95%.
Orthopyroxene - Mode: 3%–16%.
Crystal Size: 3–15 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: 2%.
Crystal Size: 1–4 mm.
Crystal Shape: Anhedral.
Spinel. - Mode: <1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: Serpentinized porphyroclastic dunite and harzburgite. The top of the section is pyroxene depleted and is dunitic in composition with only 5%–6% pyroxene. The orthopyroxene in these Pieces (1, 2, and 3) is evenly distributed throughout the core, but clinopyroxene is found along melt infiltration zones as continuous veins or discontinuous trains. Three altered veins that may have been clinopyroxenite veins ≈2 mm thick are within Piece 1. A metagabbroic vein (0.5 cm) is also observed in Piece 2. At the base of the section, pyroxene is more enriched (15%–20%) and Pieces 4–12 are harzburgitic in composition. Fresh olivine is abundant in Piece 10. Spinel and clinopyroxene trains are well preserved in Pieces 10 and 12. There are more magmatic veins at the top of the section where pyroxene depletion is highest.
SECONDARY MINERALOGY:
Serpentine.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: Replacing olivine, spinel.
Comments: The alteration on average is 95%, except in Piece 12 which is only about 80% altered. Olivine is 80%–99% altered into serpentine and iron oxide minerals. Orthopyroxene is 80% to 95% altered to serpentine, bastite, and possibly minor amounts of chlorite, amphibole, and talc. Altered clinopyroxenite veins, 1 to 5 mm wide, are pervasively altered to actinolite/tremolite, and cummingtonite(?) and chlorite occur in Pieces 1 and 2. White serpentine veins, 1 mm wide, are common in Pieces 2, 3, 4, 5, and 6. Wispy white to dark serpentine vein sets are poorly developed. Sulfide mineral-bearing veins are present in Pieces 1 and 2 as composite veins with serpentine. Sulfide minerals are commonly concentated at the center of these veins.
VEIN/FRACTURE FILLING:
Serpentine.
Size: 0.4–1 mm.
ADDITIONAL COMMENTS: Structure
A strong elongate porphyroclastic texture is present, defined by orthopyroxene porphyroclasts, at the top of the section reducing to moderate intensity from Piece 2. Sparse thin white serpentine veins form orthogonal arrays in Pieces 1 and 2 with the steeply dipping veins being more continuous and more widely spaced. Piece 11 consists of small rubble fragments with fresh fractured surfaces. In Pieces 3, 6, and 9 pale green serpentine veins (3 mm) cut an earlier generation of dark green serpentine veins (1–2 mm).



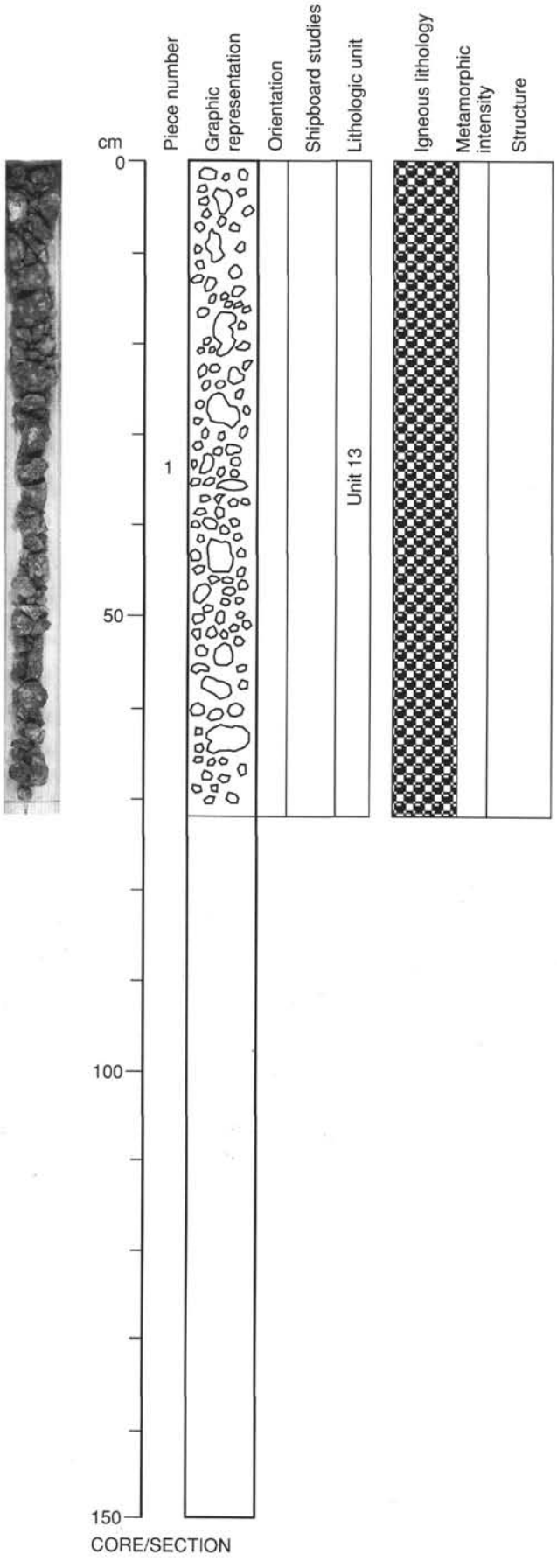
153-920D-22R-7

UNIT 13: SERPENTINIZED HARZBURGITE

Pieces 1–9

COLOR: Dark gray to green.
PRIMARY STRUCTURE: Porphyroclastic.
PRIMARY MINERALOGY:
Olivine - Mode: 81%–83%.
Orthopyroxene - Mode: 11%–13%.
Crystal Size: 3–14 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: ~5%.
Crystal Size: 1–6 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: The section consists predominantly of serpentinized lherzolite (borderline harzburgite). Clinopyroxene content averages 4%–5% and orthopyroxene 15%–17% throughout. Total pyroxene is generally 20%–22%. Alteration of pyroxene is low to moderate (30%–60%). Clinopyroxene occurs concentrated in layers parallel or subparallel to the fabric. Orthopyroxene is more equant than elongate. Spinels occur in trails, subparallel to the layering defined by the pyroxene. Most fresh olivine kernels are preserved adjacent to pyroxene porphyroclasts. Alteration has a patchy appearance due to replacement of olivine by serpentine in mesh texture. Piece 6 contains a thin altered gabbroic vein. Pieces 7 and 8 are crosscut by a 10 mm wide metagabbro vein, now altered to secondary plagioclase and amphibole (after clinopyroxene). Primary modal proportions in the gabbro were approximately 65% plagioclase and 35% clinopyroxene.
SECONDARY MINERALOGY:
Serpentine.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: Replacing olivine, spinel.
Comments: Harzburgite in this section is 80%–90% altered. Olivine is 80%–95% replaced by mesh textured serpentine and iron oxide minerals. Pyroxene is 60%–85% altered into serpentine, minor amphibole, and chlorite. Anastomosing networks of wispy dark and white serpentine veinlets are well developed in Pieces 1 and 2, but poorly developed in Pieces 3, 4, 5, 6, and 7. Pieces 6, 8, and 9 contain metagabbroic veins. In Piece 8, a 12 mm wide metagabbroic vein crosscuts the harzburgite; clinopyroxene is replaced by brown amphibole and plagioclase is altered to epidote, actinolite, prehnite, and zeolite minerals. Fractures in this metagabbro are filled with zeolites.
VEIN/FRACTURE FILLING:
Gabbroic vein (amphibole + epidote)
Size: 12 mm.
Serpentine.
Size: 1 mm.
ADDITIONAL COMMENTS: Structure
A moderately elongate porphyroclastic texture is present through the section. Foliation parallel white serpentine veins are weakly developed and deflected by the pyroxene porphyroclasts. They overprint an anastomosing foliation in Piece 2, formed by a dense network of dark green serpentine veins. The anastomosing foliation is not present elsewhere in the section. In Piece 8, there is a discordant vein of metagabbro that is cut by a thin (1 mm) vein of serpentine, chlorite, and amphibole. A similar serpentine vein in Piece 1 is cut by one of the thin white serpentine veins. Spinel trails align closely to the foliation associated with the orthopyroxene porphyroclasts.

153-920D-22R-8



UNIT 13: SERPENTINIZED HARZBURGITE RUBBLE

Pieces 1

COLOR: Dark gray to green.
PRIMARY MINERALOGY:
Olivine - Mode: ~80%.
Orthopyroxene - Mode: ~10%.
Crystal Size: 3–8 mm.
Crystal Shape: Anhedral.
Clinopyroxene - Mode: <5%.
Crystal Size: 1–3 mm.
Crystal Shape: Anhedral.
Spinel - Mode: <1%.
Crystal Size: <1 mm.
Crystal Shape: Anhedral.
Comments: The section consists entirely of rubble; all pieces are less than 4 cm in size. The small clast size makes modal estimates and average assessments of alteration difficult, but the pieces appear to be very similar to that recovered in Core 153-920D-22R-7. Most are fragments of serpentinized lherzolite/harzburgite; a few are from the metagabbro dike seen in Core 153-920D-22R-7, Pieces 7 and 8.
SECONDARY MINERALOGY:
Serpentine.
Mode of Occurrence: Replacing olivine, orthopyroxene.
Iron oxide minerals.
Mode of Occurrence: Replacing olivine, spinel.
Comments: The section shows extensive alteration; the harzburgite is largely serpentinized and records a high density of thin (<1 mm wide) white and dark serpentine vein network.
VEIN/FRACTURE FILLING:
Serpentine.
Size: 1 mm.
ADDITIONAL COMMENTS: Structure
No polished surfaces or striations were evident on the surfaces of the rubble pieces.