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7. Data Report: Physical Properties of Sediment, Basalt, and Massive Sulfide Samples from Holes 856H, 1035D, 1035E, 1035F, and 1035H, Middle Valley, Northern Juan de Fuca Ridge, and Holes 1037B and 1038I, Escanaba Trough, Gorda Ridge[1]

Henrike M. Gröschel-Becker[2]

ABSTRACT

The results of 72 index properties analyses and 29 high-pressure velocity experiments on samples of sediment, basalt, and sulfide rocks recovered during Leg 169 of the Ocean Drilling Program are presented. The large sample set was subjected to shore-based index properties measurements from which wet bulk densities (ρ_b), grain densities (ρ_g), and porosities (ϕ) were calculated. The majority of samples are from Sites 856 and 1035 in the Bent Hill area of Middle Valley, part of the northern Juan de Fuca Ridge. Four basalts are from Holes 1037B and 1038I drilled in the Escanaba Trough of the Gorda Ridge.

Reentry drilling of Hole 856H below 93.8 meters below seafloor (mbsf) resulted in penetration of a complete Bent Hill Massive Sulfide (BHMS) area reference section below the massive sulfide deposit drilled during Leg 139. Physical properties samples were obtained from the underlying sulfide feeder zone section of mineralized sediments (Unit VI), a deeper interbedded hemipelagic and turbiditic sediment interval (Unit II), the intercalated sills and sediment of "hydrothermal basement" (Unit VII), and the basaltic flows of interpreted oceanic basement (Unit VIII). Elevated-pressure velocity measurements of sediments

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[2]Division of Marine Geology and Geophysics, Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami FL 33149-1098, USA.
hgroschel@rsmas.miami.edu

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from Units II and VI, sediment interbeds of Unit VII, and basalts of Unit VIII were made for the first time. The presence of sulfide minerals as disseminations, blebs, and vein infillings affects the velocity and density signatures of sediment samples from cores in the vicinity of the BHMS (Site 1035). Densities, velocities, and porosities of massive sulfides (Unit V; Holes 1035F and 1035H) and basaltic sills (Hole 856H) are comparable to Leg 139 data for sulfides from 0.0 to 93.8 mbsf in Hole 856H and Hole 857D sills.

INTRODUCTION

The results of 72 index properties analyses and 29 high-pressure velocity experiments on samples of sediment, basalt, and sulfide rocks recovered during Leg 169 of the Ocean Drilling Program (ODP) are presented (Tables T1, T2, T3). The minicores obtained from cores recovered from Holes 856H, 1035D, 1035F, 1035H, 1037B, and 1038I included 27 minicores sampled for shore-based use by Dr. Gerardo Iturrino. Wet bulk densities (ρ_b), grain densities (ρ_g), and porosities (ϕ) were calculated from shore-based index properties measurements of wet weight, dry weight, and dry volume. Compressional (V_p) and shear (V_s) wave velocities of 29 oriented minicores were measured at varying confining pressures using a pulse-transmission technique similar to that of Birch (1960, 1961).

T1. Shore-based physical properties experiments, p. 14.

T2. Index properties measurements, p. 15.

T3. Elevated-pressure velocity experiments, p. 17.

The following synopsis of principal lithostratigraphic results at Site 1035, included to provide an overview of the samples analyzed for this paper (Table T1), is taken from Shipboard Scientific Party (1998d) and Zierenberg et al. (1998). The reader is referred to Shipboard Scientific Party (1998a, 1998b) for a discussion of the petrology of basalts recovered at Sites 1037 and 1038 in the Escanaba Trough.

The Bent Hill Massive Sulfide (BHMS) deposit in Middle Valley was first drilled during ODP Leg 139 in 1991. Hole 856H, located at the bathymetric high point of the deposit, penetrated 93 m of massive sulfide that was mostly precipitated above the seafloor and had experienced extensive hydrothermal recrystallization. This hole was revisited during Leg 169 and deepened to 500 meters below seafloor (mbsf); it is considered a reference section of all major lithologies drilled in the area. Massive sulfide (Unit V) was cored from 93.8 to 103.6 mbsf. Three subunits of a sulfide feeder zone with mineralized sediment (Unit VI) were then encountered from 103.6 to 210.6 mbsf. Unit II, a section of lithified and unaltered to slightly mineralized turbidites, is in sharp, perhaps faulted, contact with a copper-rich sandstone, termed the Deep Copper Zone at the base of Unit VI. Unit II extends from 210.6 to 307.7 mbsf, and is underlain by Unit VII, a section of "hydrothermal basement" first described during Leg 139 as altered, richly veined basaltic sills interbedded with sediment, from 431.7 to 471.3 mbsf. Drilling was terminated after successful coring of 30 m of altered pillow basalts (Unit VIII; 471.4–500.0 mbsf), interpreted as the top of normal oceanic crust (Shipboard Scientific Party, 1998d).

A series of holes was drilled along east-west (Holes 1035A, 1035D, and 1035G) and north-south (Holes 1035B, 1035C, 1035E, and 1035F) transects to assess the size of the BHMS deposit. Hole 1035D, drilled 75 m east of Hole 856H, penetrated more than 40 m of massive to semimassive sulfide and underlying hydrothermally altered sediment. Hole 1035F, located 60 m south of Hole 856H, penetrated more than 70 m of massive sulfide below a surficial layer of clastic sulfide and is characterized by a greater extent of feeder zone mineralization than observed in Hole 1035D. The only known active venting in the Bent Hill area before Leg 169 was observed 50 m away from Hole 1035H at the northern end of the mound. In fact, drilling reactivated venting once more, as at Hole 1035F. Analysis of 210 m of recovered core from Hole 1035F shows three stacked sequences of massive sulfide above a section of feeder zone mineralization, indicating repeated episodes of hydrothermal discharge.

METHODS

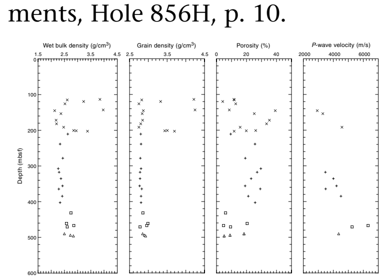
Velocity experiments were performed on oriented minicores of sediment, basalt, and sulfide rock in the Rosenstiel School of Marine and Atmospheric Science (RSMAS) Petrophysics Laboratory at hydrostatic pressures from 3 to 100 MPa (Table T1). Wet bulk densities and porosities were also obtained. Sample preparation and experimental methods for igneous and sulfide samples were generally the same as those described in Gröschel-Becker et al. (1994a, 1994b). Sediment samples required different treatment in sampling, preparation, and experimental stages.

Horizontally and vertically oriented sediment and rock minicores were drilled perpendicular and parallel, respectively, to the axis of the core on board ship. The 2.54-cm-diameter samples were stored in vials filled with seawater. Shore-based samples collected by the author were offered to the shipboard Physical Properties Laboratory scientists and subjected to routine analyses. Measurements performed on these discrete samples during Leg 169 consisted of wet and dry weights and dry volumes, and ultrasonic velocity experiments at atmospheric pressures. Initially, the Hamilton Frame and the GEOTEK Multisensor Split Core Logger (MSSCL) both were used; the MSSCL was used preferentially after comparison trials and calibration tests (Shipboard Scientific Party, 1998c).

Index properties measurements for all samples were performed at RSMAS. The masses of both the saturated and dry minicores were determined with a Thomas Scientific T2000S electronic balance (±0.010 g accuracy), and dry volumes were obtained with a single cell Micromeritics AccuPyc 1330 helium pycnometer (±0.03% accuracy). Resultant densities are good to 0.2% (±0.006 g/cm³). The equations used to calculate porosity, wet bulk density, grain density, dry water content, and void ratio are given in Shipboard Scientific Party (1992a), and are those recommended by the ODP Shipboard Measurements Panel (1991). Salinity-corrected wet bulk densities and porosities were recalculated from shipboard data and standard ODP formulas that utilize dry volumes in order to be consistent with the shore-based data set (Davis, Mottl, Fisher, et al., 1992).

A velocimeter with a l-MHz transducer system was used at RSMAS for measurements at confining pressures from 3 to 100 MPa and a constant pore pressure of 3 MPa (Fig. F1). A unique feature of this l-MHz transducer system is that two orthogonal shear waves (S1 and S2) are propagated through the sample along with a single compressional wave. The minicores were aligned so that the S2 wave propagated in the plane defined by the orientation marks, whereas the S1 wave propagated in a plane oriented 90° from the S2 plane. The precision of V_p and V_s measurements for intact rock samples is ~1%–2%.

F1. Index properties measurements, Hole 856H, p. 10.



All samples were saturated under vacuum in a bell jar for 24–48 hr prior to measurement. The ends were trimmed flat and parallel to within 0.05 mm. The “flatness” of the minicore ends was checked with a comparator stand, and the lengths of the right-circular cylinders were measured with a digital caliper micrometer.

EXPERIMENTAL LIMITATIONS

Many of the author’s minicores sampled for shore-based velocity experiments were erroneously cut by a physical properties scientist during Leg 169 to fit into the shipboard Penta-Pycnometer. Some were too short to use in the RSMAS velocimeter and were not analyzed. Ideally, minicores should be at least 2.54 cm (1 in) in length. This minimal length is especially important to the measurement of representative velocities for medium- to coarse-grained or phenocryst-rich igneous rocks and conglomeratic or brecciated sedimentary samples.

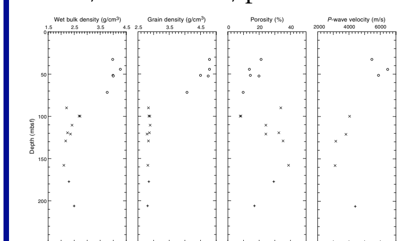
Relatively soft, fine-grained sediment samples often collapsed between 30 and 40 MPa confining pressure and intruded into the stainless steel pore pressure tubing in the upper part of the velocimeter’s sample assembly. Disassembly and extraction of the liquefied sediment from the pore pressure fluid delivery system was time consuming, tedious, and delicate work. This happened most commonly with hemipelagic and turbiditic sediments of Unit II and also occurred with Unit VI claystone and siltstone samples with rare to <10% disseminated sulfide. Experiments on similar samples were performed up to 35 MPa and were eventually discontinued to protect the analytical equipment. Unit VI sediment samples with higher percentages of sulfide, present as blebs, bands, or disseminations, and coarser grained turbiditic samples (Unit II) did not fail at lower pressures. Experiments were stopped at 60 MPa, and only selected intact igneous, sulfide, and sulfide-dominated coarser sediment samples were measured to 90 and 100 MPa. The problems encountered with massive sulfide samples in high-pressure velocity experiments are discussed in Gröschel-Becker et al. (1994b). In general, velocities of intact igneous and sedimentary rocks are good to 1%; sulfide results are good to 1%–2% up to 80 MPa.

RESULTS

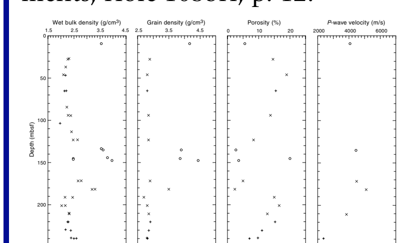
Density and Porosity

The results of shore-based Leg 169 index properties measurements and calculations are shown in tabular form in Table T2. Figures F1, F2, and F3 are graphical representations of wet bulk density, grain density, porosity, and compressional wave velocity results for samples from Hole 856H (Fig. F1), Hole 1035F (Fig. F2), and Hole 1035H (Fig. F3), the three deepest holes drilled in the vicinity of the BHMS deposit. Figure F4 is a compilation plot for Hole 856H that includes both shipboard and shore-based index properties data from Leg 169 and the massive sulfide section, to 93.8 mbsf, drilled during Leg 139. Identical symbols, defined in Figure F1, are used in all four figures to represent sample lithologies encountered at different depths in each hole. Characteristics of each lithologic unit and subunit used in Leg 169 core descriptions are summarized in Table T1.

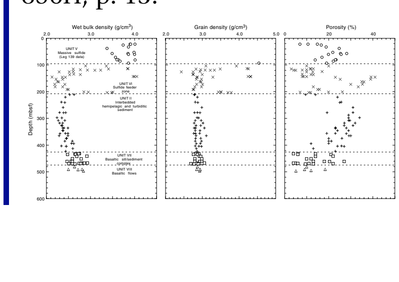
F2. Index properties measurements, Hole 1035F, p. 11.



F3. Index properties measurements, Hole 1035H, p. 12.



F4. Shore-based and shipboard index properties data plots, Hole 856H, p. 13.



Hemipelagic and Turbiditic Sediment (Unit II)

Shore-based index properties analyses were performed on 20 Unit II samples from Holes 856H, 1035D, 1035E, 1035F, and 1035H (Tables T1, T2; Figs. F1, F2, F3, F4). The average grain density (ρ_g) is 2.32 g/cm^3, and the average wet bulk density (ρ_b) is 2.81 g/cm^3. The average porosity (ϕ) of all Unit II samples is 27.1%.

Thirteen samples are from Subunit IIA, described as interbedded, laminated hemipelagic claystone and turbiditic siltstone and sandstone with generally <2% sulfide (Shipboard Scientific Party, 1998d). These rocks have an average wet bulk density of 2.29 g/cm^3, an average grain density of 2.80 g/cm^3, and an average porosity of 28.4%. Seven samples are from Subunit IID. These sediments are, in general, finer grained than those of Subunit IIA and mainly consist of chloritic siltstone and mudstone with occasional interbeds of fine-grained sandstone (Shipboard Scientific Party, 1998d). The rocks are characterized by a slightly higher average wet bulk density of 2.37 g/cm^3, an average grain density of 2.83 g/cm^3, and an average porosity of 24.9%.

Sulfide Feeder Zone Sediment (Unit VI)

Shore-based index properties analyses were performed on 31 Unit VI samples from Holes 856H, 1035D, 1035F, and 1035H (Tables T1, T2; Figs. F1, F2, F3, F4). The average grain density is high (3.03 g/cm^3), as is the average wet bulk density (2.57 g/cm^3). The average porosity of all Unit VI samples is 23.2%.

Ten samples are from Subunit VIA, which is described as moderately to intensely indurated and hydrothermally altered mudstone, siltstone, and sandstone with 10%–50% sulfide, commonly present in veins (Shipboard Scientific Party, 1998d). These rocks are characterized by a high average wet bulk density of 2.86 g/cm^3 and average grain density of 3.17 g/cm^3, and an average porosity of 14.9%. Sixteen samples are from Subunit VIB, described as siltstone with 2%–10% disseminated and vein-hosted sulfide (Shipboard Scientific Party, 1998d). These sulfide-poor rocks have a lower average wet bulk density of 2.28 g/cm^3 and average grain density of 2.82 g/cm^3. The average porosity is 29.5%. Five samples are from Subunit VIC, characterized by sulfide-banded sandstone with 10%–50% sulfide (Shipboard Scientific Party, 1998d). Subunit VIC rocks have a lower average wet bulk density of 2.77 g/cm^3, and a higher average grain density of 3.40 g/cm^3 than Subunit VIA samples. The average porosity is 19.9%.

Basaltic Sill/Sediment Interbeds (Unit VII) and Basaltic Flows (Unit VIII)

Shore-based index properties analyses were performed on four Unit VII samples from Hole 856H (Tables T1, T2; Fig. F1). This unit, also penetrated in Hole 857D during Leg 139 and interpreted as "hydrothermal basement," consists of slightly to intensely altered fine-grained basaltic sills alternating with highly indurated hemipelagic and turbiditic sediment (Shipboard Scientific Party, 1992c). Two samples are from veined, fractured sill rock, and two samples are from silty claystone to siltstone interbeds. The average grain density is 2.90 g/cm^3, and the average wet bulk density is 2.70 g/cm^3. The average porosity is 10.2%.

Three Unit VIII samples from Hole 856H were measured. The highly altered and veined fine-grained pillow basalts are characterized by an average wet bulk density of 2.69 g/cm³, an average grain density of 2.89 g/cm³, and an average porosity of 10.8%.

Massive to Semimassive Sulfides (Unit V)

Shore-based index properties analyses were performed on 10 Unit VII samples from Hole 1035H (Tables T1, T2). These sulfides were described according to the sulfide classification scheme originally defined aboard ship during Leg 139 (Shipboard Scientific Party, 1992b). The average grain density of these 10 samples is high (4.31 g/cm³), as is the average wet bulk density (3.69 g/cm³). The average porosity of all Unit V samples is 18.7%.

Five samples from Hole 1035F are from Subunit VD, which corresponds to the Type 5 sulfide classification of massive colloform and vuggy pyrite (Table T2). These rocks are characterized by higher average wet bulk density (4.00 g/cm³), higher average grain density (4.56 g/cm³), and an average porosity of 13.9%. Variable proportions of pyrite (ρ_g = 4.92 g/cm³), pyrrhotite (ρ_g = 4.55 g/cm³), and magnetite (ρ_g = 5.15 g/cm³) (Horai, 1971), 10%–25% of which are present in Type 4 and 5 rocks, result in high grain density and wet bulk density values.

Four samples from Hole 1035H cores are described as Subunit VC. A lithologic summary for this subunit is presented in Table T1; this category does not correspond to the Leg 139 classification scheme for Hole 856H sulfides. These rocks have an average wet bulk density of 3.40 g/cm³, an average grain density of 4.09 g/cm³, and an average porosity of 22.8%.

Velocity

The results of 29 elevated-pressure velocity experiments conducted on minicores from Holes 856H, 1035D, 1035F, 1035H, and 1037B are presented in Table T3. Compressional wave velocities vs. depth are shown with index properties data in the multiplots of Figure F1 for Hole 856H, Figure F2 for Hole 1035F, and Figure F3 for Hole 1035H. The symbols used to represent different lithologies are defined in Figure F1; the units and subunits used in Leg 169 core descriptions are summarized in Table T1.

Sediment and Sediment + Sulfide Samples (Units II and VI)

Velocities at elevated pressures were measured for 11 Unit VI samples obtained from a sulfide feeder zone and mineralized sediment interval beneath the massive sulfide deposit at Site 1035, and seven Unit II samples of hemipelagic and turbiditic sediment encountered beneath Unit VI sediments in Holes 856H, 1035F, and 1035H. Results are given in Table T3 and graphically shown in Figure F1 (Hole 856H), Figure F2 (Hole 1035F), and Figure F3 (Hole 1035H). Descriptions of lithologic subunits are summarized in Table T1 (Shipboard Scientific Party, 1998d). Two samples represent Subunit VIA, eight samples are from Subunit VIB, one sample is from Subunit VIC, five samples represent Subunit IIA, and two samples are from Subunit IID.

Variations in compressional wave velocities among Subunit IIA samples may be linked to the presence or absence of thinly bedded, coarser grained turbidite layers with minor sulfide (Samples 169-856H-45R-1, 16–18 cm, and 47R-1, 118–120 cm) and parallel laminae in siltstone samples (Sample 169-856H-50R-1, 132–134 cm). Velocity differences between samples from Subunits VIA, VIB, and VIC are likely related to percentages of sulfide minerals present in the mudstone, siltstone, and sandstone. The fastest velocities, including V_p of 5114 m/s at 90 MPa, are observed in Sample 169-1035H-21R-1, 88–91 cm, of Subunit VIC (Fig. F3). This altered, laminated sandstone contains 50%–70% bed-parallel sulfide. In contrast, Sample 169-856H-26R-1, 91–93 cm, a siltstone of Subunit VIB with small sulfide blebs comprising <10% of the sample, has a V_p of 3603 m/s at 90 MPa (Fig. F1).

Basaltic Sill/Sediment Complex Samples (Unit VII)

Two "hydrothermal basement" (Unit VII) samples from Hole 856H were measured. One is a basalt/diabase recovered from near the base of sill VIIE, the fifth and last sill drilled above oceanic basement, and the other was sampled from the interbed of indurated sediment immediately above oceanic basement (Shipboard Scientific Party, 1998d).

Unit VII in the vicinity of Sample 169-856H-60R-2, 26–28 cm, is described as altered, fine- to medium-grained greenish gray pyroxene-phyric basalt/diabase. A thin section made from a sample 20 cm downcore (58–60 cm) from this physical properties sample is described as a medium-grained, "spectacularly fresh," subophitic to ophitic diabase with 40% plagioclase phenocrysts, 35% clinopyroxene phenocrysts, and 15% olivine(?) phenocrysts (Shipboard Scientific Party, 1998d). The sample is slightly altered, with quartz, chlorite, and titanite alteration minerals; pyrrhotite and ilmenite are opaque constituents. V_p at 90 MPa was 6319 m/s (Table T3; Fig. F1). This is comparable with velocities measured for slightly altered diabase samples, with similar densities and porosities, obtained from cores below 762.5 mbsf in Hole 857D during Leg 139 (Gröschel-Becker et al., 1994b).

Sample 169-856H-62R-1, 72–74 cm, is an interbedded mudstone/siltstone with ilmenite, quartz, and pyrrhotite mineralization along bedding planes and fractures that result from its proximity to the sediment/sill contact zone. The V_p at 50 MPa of 5255 m/s (Table T3; Fig. F1) is fast for a sedimentary rock and is likely caused by thermal alteration and mineralization.

Basaltic Flow Samples (Hole 856H Unit VIII; Hole 1037B)

Velocity data for four flow samples of basalt interpreted as oceanic basement from Hole 856H in Middle Valley and Hole 1037B, Escanaba Trough, are given in Table T3. The V_p at 90 MPa of 4358 m/s for Sample 169-856H-64R-1, 91–93 cm, is also shown graphically in Figure F1.

This sample was described as a fine-grained, greenish gray pillow basalt with chlorite-filled variolites and populated with veins and blebs of chlorite and quartz with chalcopyrite. The slowness of the velocity data when compared to fresh basalts is explained by the high degree of alteration observed in the pillow basalt and by the presence of low-velocity chlorite.

The fine- to medium-grained, relatively unaltered basalts sampled from Hole 1037B cores have higher velocities at 80 and 90 MPa than the Hole 856H sample (Table T3). The lower velocity at 80 MPa of 5953 m/s of Sample 169-1037B-58R-1, 105–108 cm, compared to velocities of 6360 and 6365 m/s, respectively, for the two deeper samples, can be linked to the extent of alteration and the resulting differences in mineralogy. Sample 169-1037B-58R-1, 105–108 cm, is a fine-grained basalt with plagioclase and pyroxene phenocrysts altered to actinolite and cut by a <1-mm-wide vein of calcite with some chlorite (Shipboard Scientific Party, 1998b). In contrast, Sample 169-1037B-61R-1, 75–77 cm, is only slightly vesicular with vesicles filled with smectite/chlorite, and Sample 169-1037B-62R-1, 75–77 cm, is similarly homogenous except for a few irregular veins of chlorite and zeolite.

Sulfide Samples (Unit V)

Shore-based velocity measurements were conducted on three Hole 1035F samples assigned to Unit VD and equivalent to Leg 139 Type 5 massive colloform and vuggy pyrite (Table T2). The minicores taken for velocity measurements from Hole 1035H cores are both assigned to Subunit VC. Sample 169-1035H-2R-1, 50–53 cm, was described as a sulfide breccia with moderately indurated, pyrite-dominated clasts in a fine-grained matrix of pyrite, marcasite, and sphalerite. Sample 169-1035H-16R-2, 109–111 cm, was described as a fine- to medium-grained massive to semimassive, pyrite- and magnetite-rich sulfide with a partly oxidized, mottled texture caused by neoblastic pyrite.

V_p at 40 MPa for Samples 169-1035F-4R-1, 70–72 cm, 5R-2, 126–128 cm, and 6R-1, 16–18 cm, are 5467, 6478, and 5892 m/s, respectively (Table T3; Fig. F2). These data are comparable with velocities measured for four Type 5 massive sulfide samples, with similar densities and porosities, obtained from cores above 93.8 mbsf in Hole 856H, and from nearby Hole 856G, during Leg 139 (Gröschel-Becker et al., 1994a). The variability in velocities is likely caused by textural variations in the samples (i.e., the ratio of pore spaces, or vugs, to pyrite).

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Figure F1. Results of index properties measurements performed on 30 Leg 169 samples from Hole 856H. Elevated-pressure compressional wave velocity data for a subset of 11 samples are shown in the far right panel. Velocities are reported at 50 MPa for sulfide-rich, medium-grained sediment (Unit VI), sandy turbidite (Unit II) samples, and the altered siltstone interbed sample from Unit VII; 30 MPa for fine-grained samples from Units VI and II; and 90 MPa for basaltic sill (Unit VII) and altered basaltic flow (Unit VIII) samples. Results for Section 169-856H-25R-2 (Subunit VIA) are given at 20 MPa because the sample failed at 30 MPa. × = Unit VI (feeder zone sediment + sulfide) samples; + = Unit II (hemipelagic/turbidite sediments); squares = Unit VII (basalt sill/sediment complex); and triangles = Unit VIII (basaltic flows, or oceanic basement).

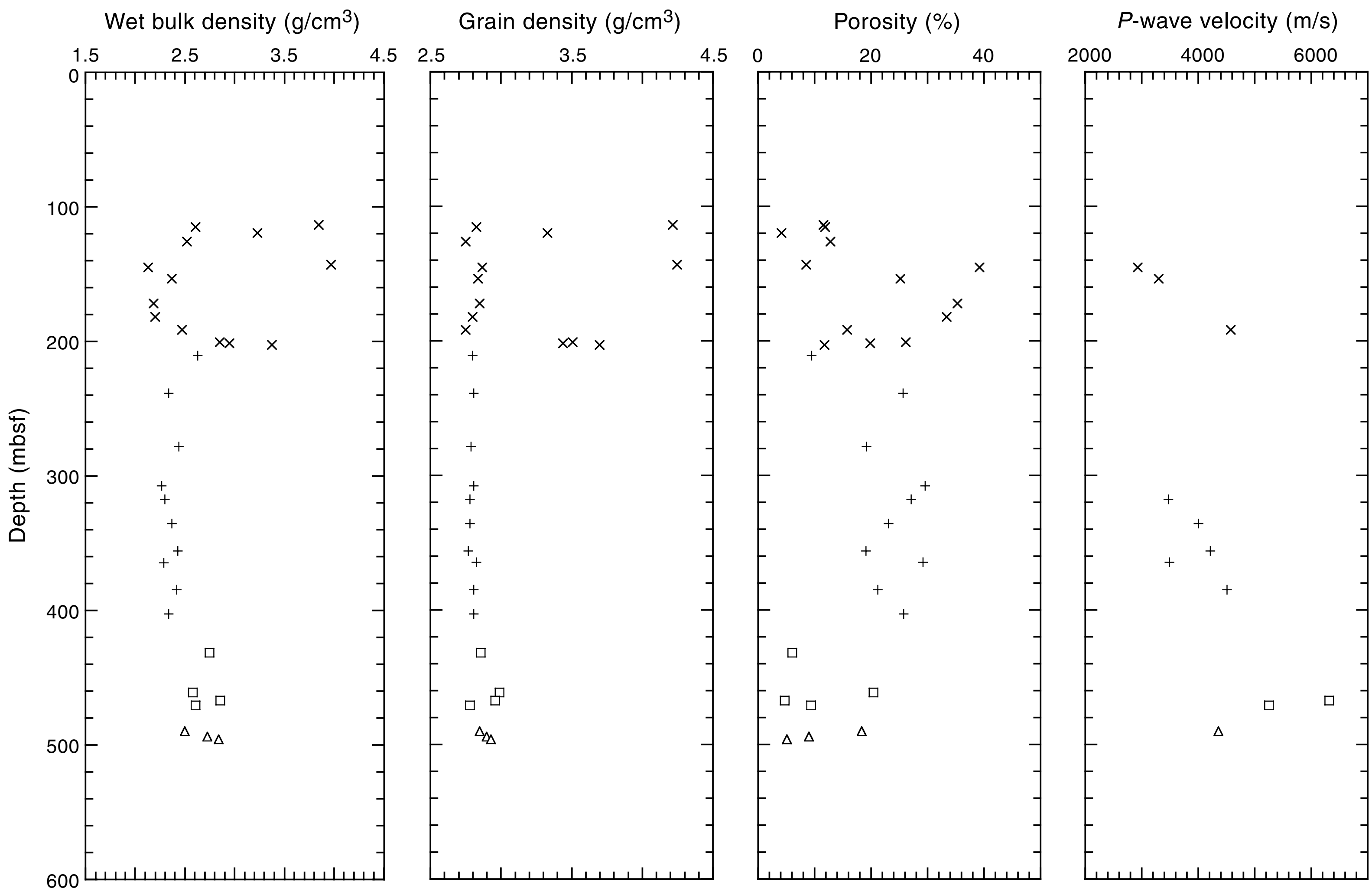

Figure F2. Results of index properties measurements performed on 15 Leg 169 samples from Hole 1035F. Elevated-pressure compressional wave velocity data for a subset of eight samples are shown in the far right panel. Velocities are reported at 40 MPa for all samples except Section 169-1035F-17R-1 (Subunit VIB); the velocity value at 25 MPa is reported because this sample failed at 30 Mpa. Circles = Unit V (massive sulfide) samples; × = Unit VI (feeder zone sediment + sulfide) samples; and + = Unit II (hemipelagic/turbidite sediments).

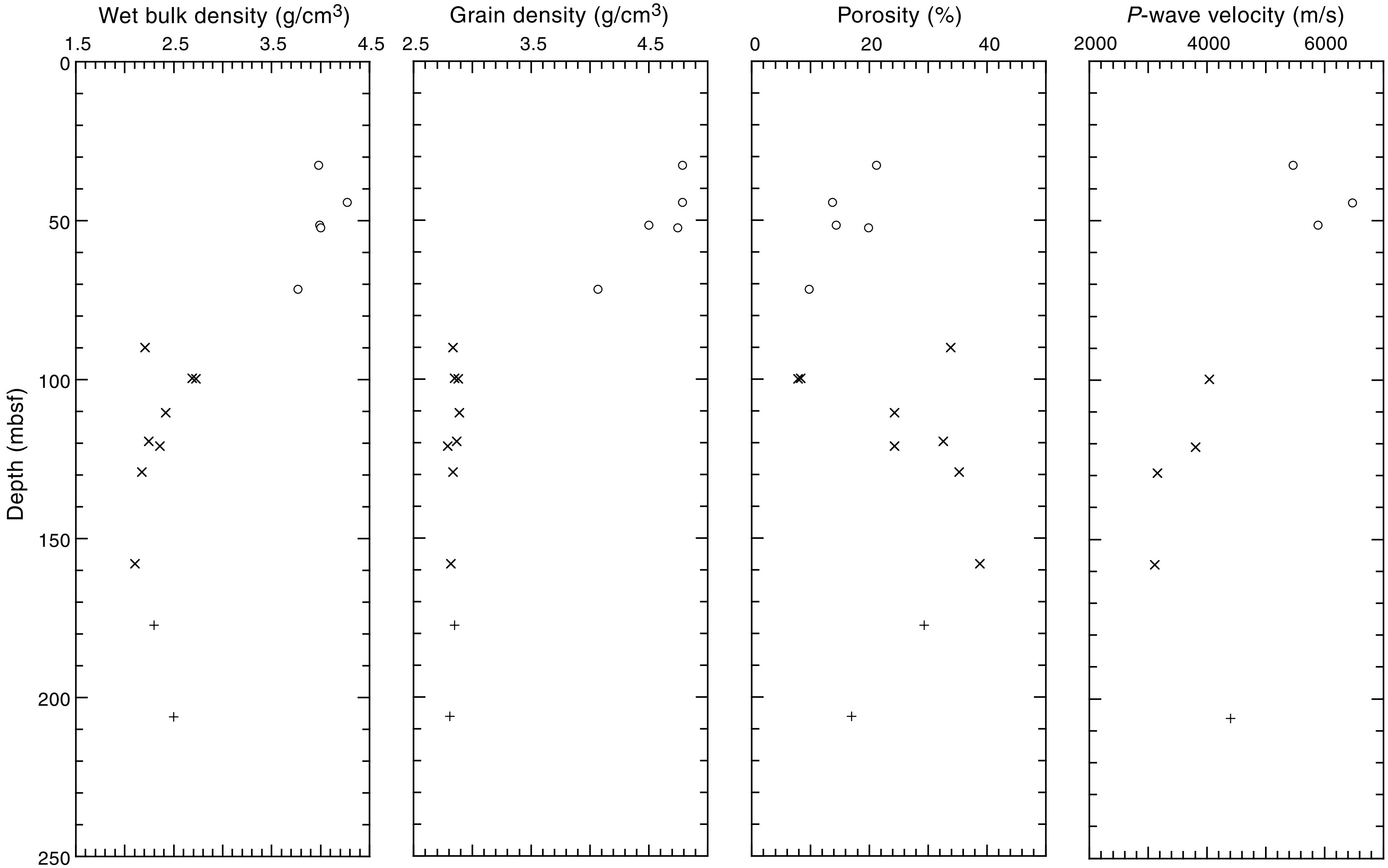

Figure F3. Results of index properties measurements performed on 18 Leg 169 samples from Hole 1035H. Elevated-pressure compressional wave velocity data for a subset of six samples are shown in the far right panel. Velocities are reported at 50 MPa for sulfide-rich, medium-grained sediment (Unit VI) and sandy turbidite (Unit II) samples and at 90 MPa for the sulfide-dominated siltstone (Subunit VIC) and the massive sulfide (Unit V) samples. Results for the sample from Section 169-1035H-2R-1 (Subunit VC), a sulfide breccia, are given at 30 MPa because the sample failed at 40 MPa. Circles = Unit V (massive sulfide) samples; × = Unit VI (feeder zone sediment + sulfide) samples; and + = Unit II (hemipelagic/turbidite sediments).

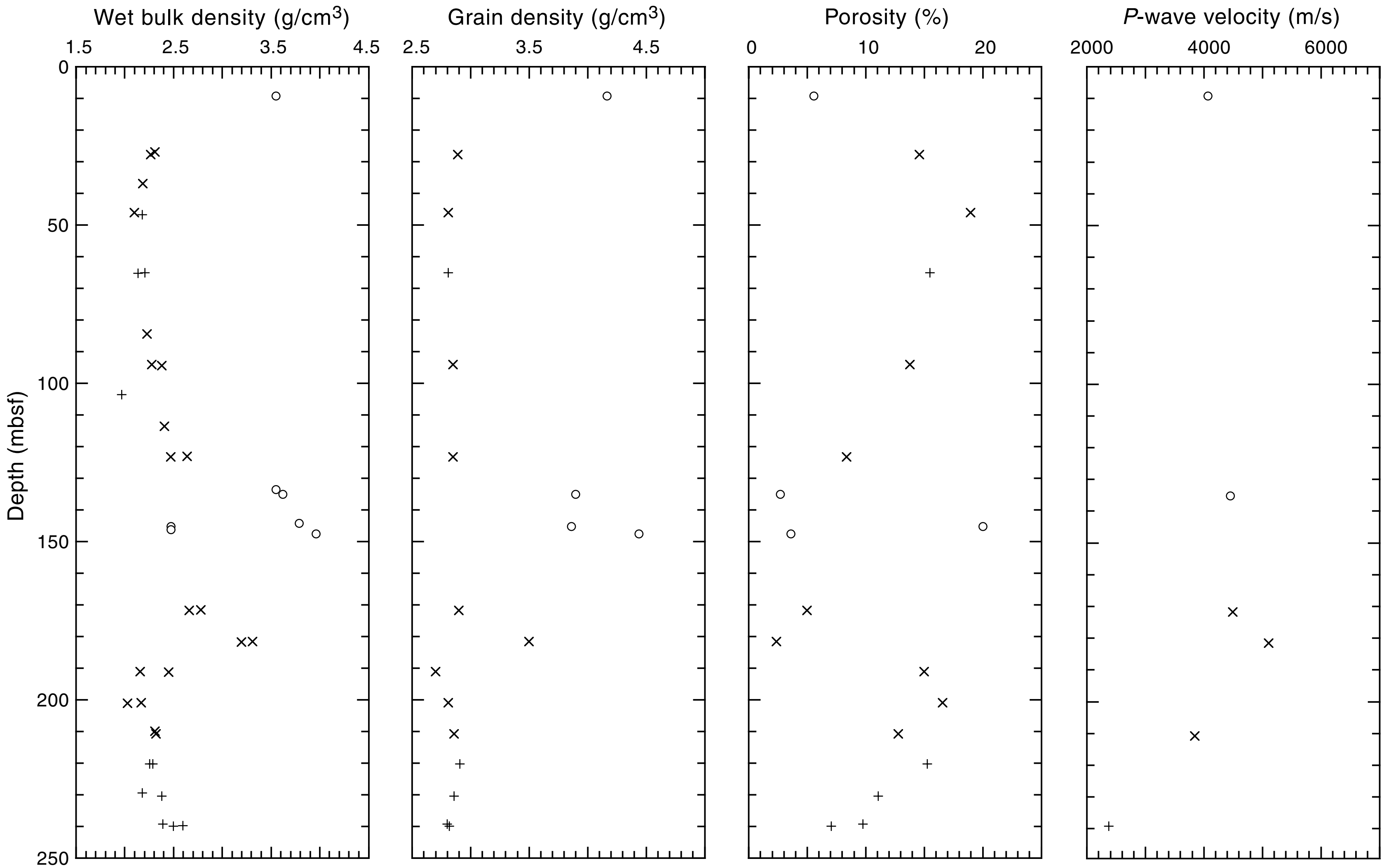

Figure F4. Compilation plots of shore-based and shipboard index properties data for Hole 856H. Data for Unit V (massive sulfide) above 93.8 mbsf are from Leg 139 analyses (Shipboard Scientific Party, 1992b; Gröschel-Becker et al., 1994a). Data deeper than 93.8 mbsf are from Leg 169 analyses (Shipboard Scientific Party, 1998d) and work reported here. Circles = Unit V (massive sulfide) samples; × = Unit VI (feeder zone sediment + sulfide) samples; + = Unit II (hemipelagic/turbidite sediments); squares = Unit VII (basalt sill/sediment complex); and triangles = Unit VIII (basaltic flows, or oceanic basement).

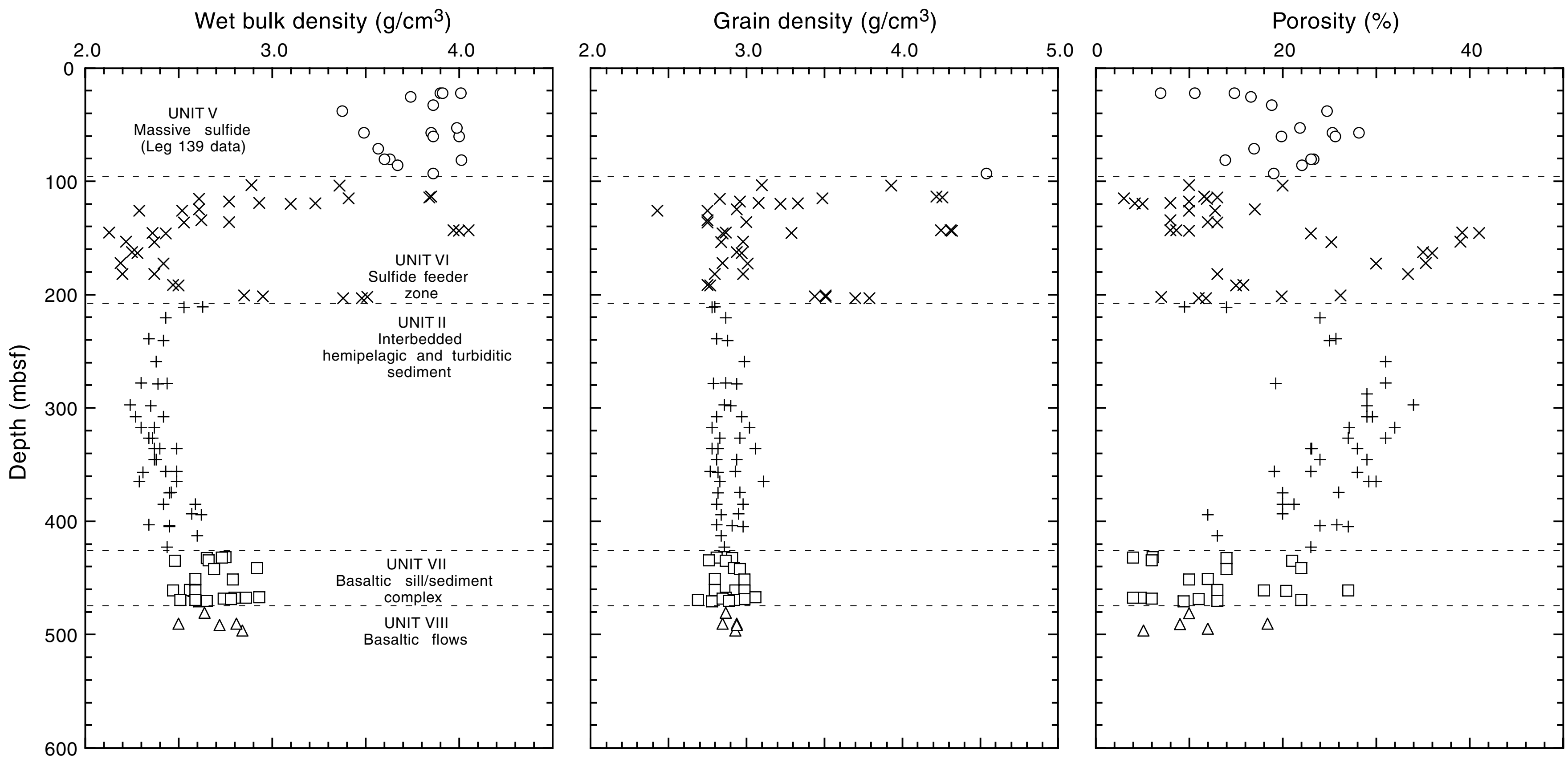

Table T1. Summary of shore-based experiments conducted on Leg 169 physical properties samples.

Unit/Subunit description	Hole 856H		Hole 1035D		Hole 1035E		Hole 1035F		Hole 1035H	
	IP	V	IP	V	IP	V	IP	V	IP	V
Turbidites and hemipelagic sediment										
Subunit IIA: interbedded gray laminated hemipelagic claystone, and turbiditic bedded and cross-bedded siltstone and sandstone; sulfide disseminations and veins can occur but generally are <2% of the rock	9	5			2		1		1	
Subunit IID: greenish gray, chloritic siltstone and mudstone with rare interbeds of fine-grained sandstone	1		1				1	1	4	1
Sulfide feeder zone and mineralized sediments										
Subunit VIA: sulfide (pyrrhotite/chalcopyrite/isocubanite/pyrite)-veined, moderately to intensely indurated and hydrothermally altered mudstone, siltstone, sandstone (10%-50% sulfide)	6	1					3	1	1	
Subunit VIB: siltstone with sulfide (pyrrhotite/chalcopyrite/isocubanite/pyrite) veins and disseminations (2%-10% sulfide)	4	2	1	1			4	3	7	2
Subunit VIC: sulfide (pyrrhotite/chalcopyrite/isocubanite/pyrite)-banded sandstone (10%-50% sulfide)	3						1		1	1
Massive and semimassive sulfide (>50% sulfide)										
Subunit VA (Type 1 of Leg 139): fine-grained, homogeneous pyrrhotite/sphalerite/isocubanite/chalcopyrite			1							
Subunit VC: clast-supported massive sulfide breccia composed of pyrite-dominant clasts in fine-grained matrix of marcasite, black iron-rich sphalerite with minor chalcopyrite, isocubanite, pyrrhotite; also neoplastic pyrite infilled and replaced by black sphaleritic, magnetitic clays, minor chalcopyrite with sediment altered to chlorite and minor epidote									4	2
Subunit VD (Type 5 of Leg 139): colloform and vuggy pyrite							5	3		
Basaltic sills and flows										
Unit VII: slightly to intensely altered cryptocrystalline basaltic sills intercalated with highly indurated gray hemipelagic and turbiditic sediment	4	2								
Unit VIII: pale to medium green, fine-grained, slightly to highly altered pillow lavas and hyaloclastic basalts with quartz-chlorite-Cu-Fe sulfide/pyrrhotite veins	3	1								
Total samples:	30	11	3	1	2	0	15	8	18	6

Notes: Brief lithologic descriptions and site/hole information for each sample from Shipboard Scientific Party (1998b). IP = index properties measurements, V = velocity measurements.

Table T2. Results of index properties measurements performed on 72 samples from cores recovered from Holes 856H, 1035D, 1035E, 1035F, 1035H, 1037B, and 1038I during Leg 169. (**See table note.** Continued on next page.)

Core, section, interval (cm)	Piece number	Lithologic subunit	Orientation	Water content (%)	Wet bulk density (g/cm³)	Grain density (g/cm³)	Porosity (%)	Sample description
Middle Valley, Juan de Fuca Ridge								
169-856H-								
21R-1, 34-36	4A	VIA	h	3.18	3.85	4.22	11.6	Sulfide-veined, altered siltstone
21R-2, 65-67	10	VIA	h	4.92	2.61	2.83	11.9	Siltstone with minor veins and disseminated sulfide
22R-2, 124-130	15	VIA	v	1.36	3.23	3.33	4.2	Sulfide-veined siltstone and silty claystone; large sulfide vein with disseminated pyrrhotite, chalcopyrite
23R-2, 62-64	9	VIA	h	5.49	2.52	2.75	12.8	Sulfide-veined, altered mudstone
25R-01, 19-21		VIA	h	2.26	3.97	4.25	8.6	Sulfide-veined siltstone and mudstone with anhydrite vein
25R-2, 62-64		VIA	h	23.26	2.13	2.87	39.2	Laminated siltstone
26R-1, 91-93		VIB	h	12.23	2.37	2.84	25.2	Silty claystone with small sulfide blebs
28R-1, 28-30		VIB	h	19.77	2.19	2.85	35.3	Broken; siltstone with minor sulfide blebs
29R-1, 55-57	9	VIB	h	18.44	2.20	2.80	33.4	Silicified, indurated, laminated siltstone with pyrrhotite/quartz in thin veins and vugs
30R-1, 43-45	8	VIB	h	7.00	2.47	2.75	15.8	Siltstone to fine sandstone with disseminated sulfide
31R-1, 9-11	2	VIC	h	10.40	2.85	3.51	26.2	Sulfide-banded fine-grained sandstone to siltstone
31R-1, 74-79	10	VIC	v	7.45	2.95	3.44	19.9	Sulfide-banded fine-grained sandstone to siltstone
31R-2, 74-76	10	VIC	h	3.72	3.38	3.70	11.8	Sulfide-banded sandstone to siltstone
32R-1, 53-55	9A	IIA	h	3.84	2.63	2.80	9.5	Indurated sandstone to siltstone; trace sulfide in silicified laminae and quartz veinlets
35R-1, 42-44	8	IIA	h	12.63	2.34	2.81	25.7	Broken; clayey siltstone with minor disseminated sulfide
39R-1, 69-71	8	IID	h	8.91	2.44	2.79	19.5	Finely laminated, fine- to medium-grained sandstone with anhydrite veinlets
42R-1,101-103	14	IIA	h	15.40	2.27	2.81	29.6	Laminated, interbedded siltstone and silty claystone with minor quartz, anhydrite veins
43R-1, 122-124	12	IIA	h	13.74	2.30	2.78	27.1	Siltstone to fine sandstone (fine turbidite sequence)
45R-1, 16-18	3	IIA	h	11.09	2.37	2.78	23.1	Siltstone to fine sandstone (thin-bedded turbidite)
47R-1, 118-120	15	IIA	h	8.74	2.43	2.77	19.1	Sandstone with thinly bedded turbidite
48R-1, 36-38	7	IIA	h	15.04	2.29	2.83	29.2	Finely laminated silty claystone
50R-1, 132-134	18	IIA	h	9.85	2.42	2.81	21.2	Finely laminated silty claystone
52R-1, 14-16	2	IIA	h	12.68	2.34	2.81	25.8	Laminated silty claystone
55R-1, 28-30	5A	VII	h	2.32	2.75	2.86	6.1	Fine-grained plagioclase-pyrite basalt with veins of chlorite and minor quartz, epidote, chalcopyrite
59R-1, 83-85	12	VII	h	8.81	2.58	2.99	20.4	Indurated silty claystone with veins of quartz-pyrrhotite-epidote-zeolite?; abuts basalt sill
60R-2,26-28	3	VII	h	1.76	2.86	2.96	4.8	Fine- to medium-grained basalt with up to 3-mm clinopyroxene phenocrysts; thin veins, fractures
62R-1, 72-74	13	VII	h	3.84	2.61	2.78	9.4	Laminated siltstone
64R-1, 91-93	15	VIII	h	8.16	2.50	2.85	18.4	Fine-grained altered pillow basalt with chlorite/quartz veins and blebs
65R-1, 28-30	4	VIII	h	3.51	2.73	2.90	9.0	Highly altered fine-grained basalt with two wide chlorite-haloed sulfide veins
65R-2, 75-77	9B	VIII	h	1.87	2.84	2.93	5.1	Highly altered fine-grained basalt with thin vein
169-1035D-								
10X-1, 34-36	6	VA	h	5.52	3.31	3.78	16.9	Sulfide (semimassive and veins) with highly altered silty claystone
17X-1, 16-18	3	VIB	h	9.34	2.40	2.75	20.0	Medium-grained, faintly laminated, altered sandstone
20X-1, 81-83	10	IID	h	22.37	2.14	2.85	38.2	Hydrothermally altered siltstone with disseminated sulfide blebs
169-1035E-								
2H-6, 22-24		IIA	h	81.01	1.56	2.76	68.0	Silty clay
4H-4, 48-49		IIA	h					Silty clay (disintegrated)
169-1035F-								
4R-1, 70-72	7	VD	h	5.79	3.98	4.79	21.3	Vuggy, pyritic massive sulfide with anhydrite vug infill
5R-2,126-128	21	VD	h	3.41	4.27	4.79	13.8	Colloform and vuggy, pyritic massive sulfide with anhydrite infill
6R-1,16-18	3	VD	h	3.83	3.99	4.50	14.4	Colloform pyritic massive sulfide with anhydrite cavity infill
6R-1, 109-113	20	VD	v	5.37	4.00	4.75	19.9	Massive to spongy, recrystallized, colloform massive sulfide with anhydrite in cavities
8R-1,116-118	19	VD	h	2.75	3.77	4.07	9.8	Vuggy pyrite with clay infill; altered sediment clasts (?)
10R-1, 25-27		VIC	h	18.61	2.21	2.84	33.9	Pyrite, pyrrhotite and sphalerite interbanded with moderately indurated siltstone and sandstone
11R-1, 6-13	2	VIA	v	3.30	2.69	2.85	8.4	Altered, sulfide-veined silty claystone and siltstone; pyrrhotite/chalcopyrite veins and pyrrhotite blebs
11R-1, 20-23	3	VIA	h	3.060	2.73	2.88	7.9	Altered, sulfide-veined silty claystone and siltstone; pyrrhotite/chalcopyrite veins and pyrrhotite blebs
12R-1, 132-134	14	VIA	h	11.45	2.42	2.89	24.3	Fine-grained, altered sulfide-veined sandstone to siltstone; 15%–20% of core is pyrrhotite, chalcopyrite, sphalerite, anhydrite

Table T2 (continued).

Core, section, interval (cm)	Piece number	Lithologic subunit	Orientation	Water content (%)	Wet bulk density (g/cm^3)	Grain density (g/cm^3)	Porosity (%)	Sample description
13R-1, 63-65	1	VIB	h	17.49	2.25	2.87	32.7	Altered silty claystone with disseminated sulfide blebs
13R-2, 68-70	1	VIB	h	11.82	2.36	2.79	24.3	Fine- to medium-grained altered sandstone with sulfide (veins, disseminations)
14R-1, 74-80	1	VIB	h	19.95	2.18	2.84	35.4	Siltstone with sandstone interbeds and minor bed-parallel sulfide
17R-1, 56-58	9	VIB	h	23.33	2.11	2.82	38.9	Fine-grained, laminated, turbidite sandstone with disseminated sulfide
19R-1, 76-78	13	IIA	h	15.05	2.30	2.85	29.4	Fine- to medium-grained sandstone interbedded with siltstone laminae; minor (<1%) sulfide
22R-1, 63-75	8	IID	h	7.46	2.50	2.81	17.0	Altered, laminated silty claystone with disseminated sulfide and quartz
169-1035H-								
2R-1, 50-53	8	VC	h	5.91	3.55	4.17	19.3	Sulfide breccia: irregular, pyrite-dominated clasts in fine-grained matrix
4R-1, 147-150		VIB	h	17.07	2.27	2.89	32.4	Turbiditic fine-grained sandstone with some silty claystone clasts and 2%–10% pyrite, sphalerite as veins, disseminations
6R-1, 62-64		VIB	h	23.40	2.10	2.81	38.9	Siltstone impregnated with pyrrhotite, few pyrite veins (sulfide 5% of core)
8R-1, 17-20	3	IIA	h	18.30	2.21	2.81	33.3	Laminated, very fine to fine-grained sandstone
11R-1, 7-10	2	VIB	h	15.98	2.28	2.85	30.6	Fine- to medium-grained laminated sandstone with slump folding
14R-1, 27-29	5	VIA	h	9.14	2.47	2.85	20.2	Locally laminated siltstone with pyrrhotite veins and veinlets, small blebs of soft zeolite?, clay?
16R-2, 109-111	17	VC	h	2.79	3.62	3.90	9.6	Partially oxidized, mottled, magnetite-rich massive sulfide
17R-3, 6-8	2	VC	h	25.00	2.47	3.86	48.3	Section 2: semimassive, variably silicified sulfide (pyrite, magnetite + sphalerite, pyrrhotite) amid clay-altered sediment
17R-4, 84-89	12	VC	v	3.74	3.96	4.44	13.9	Section 3: massive sulfide in high-grade sphalerite zone with 4%–40% sphalerite, wurtzite and up to 8% magnetite
20R-1, 69-72	16	VIB	h	5.29	2.66	2.90	13.0	Silicified sedimentary breccia with Cu-Fe sulfide in anhydrite molds
21R-1, 88-91	18	VIC	h	2.44	3.31	3.50	7.7	Altered, laminated siltstone with 50%–70% bedding-parallel sulfide
22R-1, 84-87	16	VIB	h	17.67	2.16	2.70	31.7	Interbedded silty claystone, siltstone and laminated fine-grained sandstone with <1% disseminated sulfide
23R-1, 110-113	18	VIB	h	19.88	2.17	2.81	35.2	Strongly altered, vuggy (silica, chlorite?) siltstone with minor silty claystone interbeds
24R-1, 135-138	19	VIB	h	14.70	2.32	2.86	29.0	Turbiditic siltstone and sandstone with <2% disseminated sulfide
25R-1, 120-123	19	IID	h	18.11	2.26	2.91	33.9	Highly distorted siltstone with silty claystone and fine-grained sandstone interbeds; rare sulfide
26R-2, 23-26	4	IID	h	12.45	2.38	2.86	25.7	Fine-grained sandstone, probably chlorite altered; no sulfide
27R-1, 102-105	14	IID	h	10.82	2.39	2.80	22.8	Altered turbiditic, laminated fine-grained sandstone interbedded with siltstone
27R-2, 26-29	3	IID	h	7.62	2.50	2.82	17.3	Laminated, bioturbated interbeds of silty claystone and siltstone
Escanaba Trough, Gorda Ridge								
169-1037B-								
58R-1, 105-108	7C	N/A	h	0.94	2.86	2.91	2.6	Altered fine-grained basalt with <1-mm-thick calcite + chlorite selvage vein
61R-1, 75-77	2	N/A	h	0.98	2.91	2.97	2.8	Fine- to medium-grained altered basalt; vesicles filled with smectite/chlorite
62R-1, 75-77	5B	N/A	h	1.18	2.93	2.99	3.3	Altered. medium-grained, plagioclase-phyric basalt with few thin chlorite/zeolite veins
169-1038I-								
43X-3, 58-61	8	N/A	h	0.94	2.87	2.92	2.6	Massive, fine-grained, aphyric (flow?) basalt

Note: h = horizontal minicore oriented perpendicular to core axis; v = vertical minicore oriented parallel to core axis.

Table T3. Results of velocity experiments made at elevated pressures for a subset of 29 samples from Leg 169 Holes 856H, 1035D, 1035E, 1035H, and 1037B. (**See table notes.** Continued on next two pages.)

Core, section, interval (cm)	Orientation	Lithologic unit/subunit	Density (g/cm^3)	Porosity (%)	Mode	Velocity (m/s)														Comments
						5 MPa	10 MPa	15 MPa	20 MPa	25 MPa	30 MPa	35 MPa	40 MPa	50 MPa	60 MPa	70 MPa	80 MPa	90 MPa	100 MPa	
169-856H-																				
25R-2, 62-64	h	VIA	3.97	39.2	P	2891	2910		2930		Sample									Laminated
					S1	1619	1663		1628		failure at									
					S2	1971	1684		1668		30 MPa									
26R-1, 91-93	h	VIB	2.37	25.2	P	3411	3512		3433		3368		3286	3306	3325	3424	3509	3603	3729	Small sulfide blebs
					S1	2034	2050		2066		2042		1836	1814	1826	1869	1955	2006	2105	
					S2	2017	2032		2048		2029		1837	1818	1835	1881	1960	2023	2098	
30R-1, 43-45	h	VIB	2.47	15.8	P	4485	4523	4582	4523	4562	4582	4582								Disseminated sulfide
					S1	2760	2804	2819	2834	2841	2849	2865								
					S2	2735	2763	2771	2771	2800	2793	2807								
43R-1, 122-124	h	IIA	2.30	27.1	P	3445	3474	3468	3492	3500	3480	3431								Deformed sandstone laminae
					S1	2005	2015	2031	2037	2038	2022	1993								
					S2	1889	1924	1933	1943	1943	1927	1880								
45R-1, 16-18	h	IIA	2.37	23.1	P	4023	4037		4065		4079		4107	4010	4051	3996				Thinly bedded turbidite, pyrite spots
					S1	2281	2299		2321		2340		2339	2317	2290	2231				
					S2	2342	2385		2424		2434		2439	2424	2414	2370				
47R-1, 118-120	h	IIA	2.43	19.1	P	4085	4091		4119		4160		4174	4216	4065	4039	4025			Thinly bedded turbidite
					S1	2454	2484		2524		2539		2529	2513	2484	2454	2430			
					S2	2355	2391		2433		2452		2457	2438	2391	2368	2333			
48R-1, 36-38	h	IIA	2.29	29.2	P	3467	3503	3502	3511	3510	3499	3493								Finely laminated
					S1	1869	1883	1889	1889	1891	1887	1868								
					S2	2143	2161	2164	2163	2159	2153	2137								
50R-1, 132-134	h	IIA	2.42	21.2	P	4195	4374	4393	4430	4450	4508									Thin-bedded, parallel laminae
					S1	2504	2516	2529	2560	2593	2612									
					S2	2320	2402	2419	2453	2465	2483									
60R-2, 26-28	h	VII	2.86	4.8	P	5865	5958		5988		6028		6087	6112	6121	6243	6276	6319		Phenocrysts, veins, and fractures
					S1	3315	3289		3298		3321		3329	3332	3348	3363	3375	3396		
					S2	3267	3282		3302		3321		3329	3352	3363	3392	3406	3422		
62R-1, 72-74	h	VII	2.61	9.4	P	5015	5085	5133	5206	5230	5255	5281	5230	5255	5255					Laminated
					S1	3343	3375	3324	3344	3427	3438	3449	3364	3426	3244					
					S2	3165	3175	3212	3240	3240	3279	4301	3309	3328	3328					
64R-1, 91-93	h	VIII	2.50	18.4	P	4187	4268	4276	4310	4284	4310	4344	4369	4335	4323	4333	4351	4358	4386	Veins and blebs of chlorite, quartz
					S1	2431	2440	2443	2457	2456	2460	2453	2460	2450	2447	2450	2450	2444	2444	
					S2	2406	2421	2426	2437	2442	2451	2453	2456	2451	2461	2458	2248	2453	2447	
169-1035D-																				
17X-1, 16-18	h	VIB	2.40	20.0	P	3619	3664	3680	3704	3714	3726	3732	3774	3788	3793		3678			Faintly laminated; altered
					S1	2186	2193	2209	2226	2225	2224	2214	2214	2195	2162		2140			
					S2	2259	2262	2284	2292	2306	2306	2310	2321	2321	2305		2280			
169-1035F-																				
4R-1, 70-72	h	VD	3.98	21.3	P	5166	5236		5273		5337		5467	5952	6883	Sample				Pyrite rich; vuggy
					S1	6034	3029		3065		3095		3103	3149	3170	failure after				
					S2	3153	3157		3143		3152		3161	3181	3187	60 MPa				

Table T3 (continued).

Core, section, interval (cm)	Orientation	Lithologic unit/subunit	Density (g/cm³)	Porosity (%)	Mode	Velocity (m/s) 5 MPa	10 MPa	15 MPa	20 MPa	25 MPa	30 MPa	35 MPa	40 MPa	50 MPa	60 MPa	70 MPa	80 MPa	90 MPa	100 MPa	Comments
5R-2, 126-128	h	VD	4.27	13.8	P	6276	6307		6390		6444		6478	6217	6095	6080				Pyrite rich; vuggy and colloform
					S1	3667	3785		3832		3842		3859	3822	3825	3828				
					S2	3782	3839		3847		3854		3860	3870	3871	3876				
6R-1, 16-18	h	VD	3.99	14.4	P	5747	5743		5792		5857		5892	5792	5809	5858	5859	5809		Pyrite rich; colloform
					S1	3425	3477		3489		3506		3512	3518	3513	3531	3525	3519		
					S2	3501	3507		3531		3549		3549	3556	3555	3556	3562	3568		
11R-1, 20-23	h	VIA	2.73	8.4	P	4204	4261		4238		4260		4048	3927	3942					Sulfide blebs, disseminated sulfide; altered
					S1	2401	2406		2417		2368		2365	2104	2124					
					S2	2330	2342		2353		2296		2147	2093	2119					
13R-2, 68-70	h	VIB	2.36	24.3	P	3758	3778	3769	3784	3809	3834	3833	3814	3869	Sample					Sulfide blebs, disseminated sulfide; altered
					S1	2093	2115	2124	2125	2164	2129	2127	2145	2069	failure at					
					S2	2231	2248	2262	2266	2275	2275	2281	2279	2277	60 MPa					
14R-1, 74-80	h	VIB	2.18	35.4	P	3180	3259		3277		3288		3163		2947					Minor bed-parallel sulfide
					S1	1678	1667		1667		1654		1659		Sample					
					S2	1841	1881		1898		1874		1727		failure					
17R-1, 56-58	h	VIB	2.11	38.9	P	2997	3024	3066	3075	3118	2992	2561	Sample							Laminated, turbidite; disseminated sulfide
					S1	1619	1596	1593	1580	1524	1523	1452	failure after							
					S2	1611	1625	1640	1618	1582	1317	1323	35 MPa							
22R-1, 63-65	h	IID	2.50	17.0	P	4247			4340		4399		4410	4425	4446					Laminated; altered; with quartz and disseminated sulfide
					S1	2394			2509		2558		2601	2624	2645					
					S2	2408			2465		2473		2489	2649	2731					
169-1035H-																				
2R-1, 50-53	h	VC	3.55	19.3	P	4061	4262		4192		4072	Sample								Pyrite-dominant clasts in fine-grained matrix
					S1	2834	2834		2889		2856	failure after								
					S2	2818	2199		2277		2297	35 MPa								
16R-2, 109-111	h	VC	3.62	9.6	P	3975	4118		4130		4139		4150	4159	4276	4218	4343	4455		Partly oxidized, mottled, magnetite rich
					S1	2561	2207		2268		2359		2345	2373	2402	2408	2243	2450		
					S2	2646	2209		2286		2364		2386	2449	2484	2520	2549	2561		
20R-1, 69-72	h	VIB	2.66	13.0	P	4398	4407	4417	4427	4455	4445	4474	4473	4502	4513	4523	4523			Silicified; Cu-Fe sulfide in anhydrite molds
					S1	2616	2636	2657	2678	2684	2698	2713	2719	2733	2734	2741	2741			
					S2	2593	2613	2633	2647	2667	2674	2688	2694	2715	2723	2738	2738			
21R-1, 88-91	h	VIC	3.31	7.7	P	4685	4694		4711		4720		4763	4807	4959	5001	5020	5114		Laminated; altered; 50%–70% bed-parallel sulfide
					S1	2532	2556		2549		2554		2557	2558	2560	2562	2563	2566		
					S2	2551	2569		2573		2583		2586	2592	2595	2597	2596	2602		
24R-1, 135-138	h	VIB	2.32	29.0	P	3674	3703	3750	3793	3774	3804	3810	3829	3847						Turbidite; <2% disseminated sulfide
					S1	1929	2088	2122	2141	2149	2164	2168	2174	2180						
					S2	2071	2217	2251	2268	2286	2295	2308	2308	2307						
27R-1, 102-105	h	IID	2.39	22.8	P	3900	3904	3909	3917	3922	3920	3929	3921	3922						Laminated; altered; turbidite
					S1	2339	2351	2364	2377	2379	2383	2388	2389	2374						
					S2	2261	2278	2295	2310	2318	2326	2326	2327	2308						
169-1037B-																				
58R-1, 105-108	h	Fine-grained basalt	2.86	2.6	P	5934	5935		5948		5969		5942	5985	5900	5953				Altered; <1-mm-thick calcite + chlorite vein
					S1	3798	3892		3856		3805		3753	3768	3760	3784				
					S2	3528	3538		3539		3500		3525	3515	3515	3500				

Table T3 (continued).

Core, section, interval (cm)	Orientation	Lithologic unit/subunit	Density (g/cm^3)	Porosity (%)	Mode	Velocity (m/s) 5 MPa	10 MPa	15 MPa	20 MPa	25 MPa	30 MPa	35 MPa	40 MPa	50 MPa	60 MPa	70 MPa	80 MPa	90 MPa	100 MPa	Comments
61R-1, 75-77	h	Fine- to medium-grained basalt	2.91	2.8	P	6166	6164		6170		6243		6275	6308	6307	6360	6376	6391		Altered; vesicles filled with smectite, chlorite
					S1	3355	3326		3311		3319		3347	3352	3357	3360	3381	3390		
					S2	3272	3284		3306		3338		3352	3381	3393	3400	3419	3434		
62R-1, 75-77	h	Medium-grained basalt	2.93	3.3	P	6050	6114		6130		6163		6209	6293	6349	6365	6372	6371		Altered; few thin chlorite/zeolite veins
					S1	3194	3265		3314		3346		3370	3392	3397	3409	3423	3430		
					S2	3241	3310		3358		3403		3418	3440	3446	3451	3471	3467		

Notes: h = horizontal minicore oriented perpendicular to core axis; v = vertical minicore oriented parallel to core axis; P = compressional wave; S1 = shear wave propagating perpendicular to minicore alignment direction; S2 = shear wave propagating parallel to minicore alignment direction. Elevated pressures set at 5–100 megapascals (MPa).