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27. *DATA REPORT:* MINERALOGY AND Sr- AND Nd-ISOTOPIC COMPOSITION OF GABBROIC OCEANIC CRUST RECOVERED FROM HOLES 923A AND 921E IN THE MARK AREA[1]

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ABSTRACT

Gabbroic rocks recovered from Holes 923A and 921E in the MARK area include troctolite, clinopyroxene-olivine gabbro, olivine-clinopyroxene gabbro, gabbro, gabbronorite, oxide gabbro, and quartz diorite. Clinopyroxene and plagioclase occur in all rock types, whereas olivine is supplanted by orthopyroxene in the evolved rock types and in the intercumulus stage. Forsterite (Fo) content of olivine, magnesium number (Mg#) of pyroxenes, and anorthite (An) content of plagioclase systematically decrease with decreasing modal olivine content, and plagioclase is most sodic in the quartz diorite. Sr- and Nd-isotopic compositions are characteristic of N-type MORB.

INTRODUCTION

Gabbroic oceanic crust was drilled at the Mid-Atlantic Ridge near the Kane Fracture Zone (MARK, 23°N) during Leg 153. The rock types obtained span a wide range, including troctolite, olivine gabbro, gabbro, gabbronorite, oxide gabbro, and quartz diorite. Petrography, mineralogy, and Sr- and Nd-isotopes are reported for a suite of 27 gabbroic rocks from Holes 923A (23°32.55′N, 45°01.90′W) and 921E (23°32.40′N, 45°01.85′W) on the western median valley wall of the Mid-Atlantic Ridge about 10 km south of the Kane Transform Fault (Table 1).

PETROGRAPHY

Troctolite

Troctolites occur as thin (a few centimeters) layers or as dikes emplaced in gabbro, clinopyroxene-olivine gabbro, and olivine-clinopyroxene gabbro. Sample 153-923A-8R-2, Piece 1, is a thin dike. Sample 153-923A-12R-1, Piece 4B, is composed of layered troctolite and clinopyroxene-olivine gabbro; the troctolite part is labeled 153-923A-12R-1, Piece 4B-Tr. These troctolites have large, tabular but anhedral, plagioclase, and anhedral olivine with less than 5% interstitial clinopyroxene and rare orthopyroxene. Orthopyroxene occurs partly rimming olivine grains.

Clinopyroxene-Olivine Gabbro

Clinopyroxene-olivine gabbro is a subtype of olivine gabbro after the IUGS classification scheme (Streckeisen, 1976), as is olivine-clinopyroxene gabbro, which is distinguished by a modal olivine/clinopyroxene ratio less than 1.

Clinopyroxene-olivine gabbro is composed of olivine, clinopyroxene, plagioclase, and occasional small amounts of ilmenite and Ni-Fe sulfide. Samples 153-923A-13R-1, Piece 6, and 153-923A-7R-2, Piece 1, have large olivine and plagioclase crystals (average length 2–4 mm, up to 6 mm) and fine interstitial clinopyroxene. Some olivine grains include partly subhedral to anhedral plagioclase laths.

Samples 153-923A-7R-1, Piece 2B, 7R-2, Piece 8, 8R-2, Piece 6, and 9R-2, Piece 8A, contain oikocrystic olivine. In these rocks, large oikocrystic olivine (up to 6–10 mm across) encloses plagioclase laths. Plagioclase and clinopyroxene crystals tend to be smaller (average 1 mm) than olivine grains, and clinopyroxene usually occurs interstitially. Some plagioclase grains are large, as much as 6 mm in length.

Sample 153-923A-12R-1, Piece 4B-COGb, is characterized by poikilitic clinopyroxene that encloses rounded olivine and plagioclase laths. The grain size of poikilitic clinopyroxene is as much as a few centimeters across.

Olivine-Clinopyroxene Gabbro

Most of the olivine-clinopyroxene gabbros are primarily equigranular, and are often modified into a porphyroclastic texture. Samples 153-923A-5R-1, Piece 2A, 9R-1, Piece 3D, 9R-2, Piece 9A, 10R-3, Piece 1, 153-921E-2R-1, Piece 6, and 4R-1, Piece 5, show primary equigranular texture, and are composed of plagioclase, clinopyroxene, olivine, and ilmenite. Samples 153-923A-2R-1, Piece 3, 9R-3, Piece 3B (sheared), 10R-2, Piece 2A, 11R-1, Piece 12, and 11R-2, Piece 3, are somewhat sheared and show porphyroclastic textures.

An olivine-clinopyroxene gabbro, Sample 153-921E-7R-1, Piece B, is characterized by poikilitic clinopyroxene. The poikilitic clinopyroxene is up to 2–3 cm across and encloses anhedral olivine and plagioclase crystals. Orthopyroxene rarely rims olivine grains.

Gabbro

Gabbro is composed of clinopyroxene, plagioclase, and minor amounts of olivine (<5%), orthopyroxene (<1%), and opaque minerals (1%–2%). Opaque minerals are ilmenite and iron sulfide, and the total amount is high, up to a few percent. Some of these gabbros are called microgabbros because of their highly recrystallized, fine-grained texture.

Samples 153-923A-5R-1, Piece 2A, and 5R-3, Piece 1, are typical coarse-grained gabbro without deformation texture. They are composed of equigranular, anhedral plagioclase, olivine, clinopyroxene, and interstitial orthopyroxene and opaque minerals. Modal olivine is less than 5%.

Sample 153-923A-3R-2, Piece 1B, is highly sheared gabbro, having porphyroclasts of olivine, clinopyroxene, and plagioclase.

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Table 1. List of gabbroic rocks studied, Holes 921E and 923A.

Hole, core, section	Piece no.	Interval (cm)	Rock name	Texture	Lithologic name	Unit
153-923A-						
2R-1	3	16–19	Microgabbro	Lineated	Variably deformed gabbro and olivine gabbro	1
3R-2	1B	22–26	Gabbro	Gneissic	Variably deformed gabbro and olivine gabbro	1
5R-1	2A	4–10	Gabbro	Equigranular	Variably deformed gabbro and olivine gabbro	1
5R-3	1	19–29	Gabbro	Equigranular	Variably deformed gabbro and olivine gabbro	1
7R-1	2B	17–21	Cpx-ol gabbro	Ol oikocryst	Variably deformed gabbro and olivine gabbro	1
7R-2	1	12–17	Cpx-ol gabbro	Ol oikocryst	Interlayered troctolite and olivine gabbro	2
7R-2	8	84–92	Cpx-ol gabbro	Ol oikocryst	Interlayered troctolite and olivine gabbro	2
8R-2	1	3–7	Troctolite	Equigranular	Interlayered troctolite and olivine gabbro	2
8R-2	6	61–67	Cpx-ol gabbro	Ol oikocryst	Interlayered troctolite and olivine gabbro	2
9R-1	3D	113–119	Ol-cpx gabbro	Equigranular	Interlayered troctolite and olivine gabbro	2
9R-2	8A	65–70	Cpx-ol gabbro	Ol oikocryst	Interlayered troctolite and olivine gabbro	2
9R-2	9A	109–114	Ol-cpx gabbro	Equigranular	Interlayered troctolite and olivine gabbro	2
9R-3	3B	33–42	Ol-cpx gabbro	Sheared	Interlayered troctolite and olivine gabbro	2
10R-2	2A	70–76	Ol-cpx gabbro	Sheared	Interlayered troctolite and olivine gabbro	2
10R-3	1	7–13	Ol-cpx gabbro	Equigranular	Interlayered troctolite and olivine gabbro	2
11R-1	12	119–123	Ol-cpx gabbro	Sheared	Interlayered troctolite and olivine gabbro	2
11R-2	3	34–38	Ol-cpx gabbro	Sheared	Interlayered troctolite and olivine gabbro	2
12R-1	4B	38–43	Troctolite	Equigranular	Poikilitic olivine gabbro and troctolite	3
12R-1	4B	38–43	Cpx-ol gabbro	Poikilitic	Poikilitic olivine gabbro and troctolite	3
13R-1	6	33–38	Cpx-ol gabbro	Ol oikocryst	Troctolite and poikilitic olivine gabbro	4
153-921E-						
2R-1	6	77–84	Ol-cpx gabbro	Equigranular	Very coarse -grained to pegmatitic gabbro	1
3R-1	5	37–41	Oxide gabbro	Sheared	Heterogeneous poikilitic olivine gabbro	2
4R-1	5	39–44	Ol-cpx gabbro	Equigranular	Heterogeneous poikilitic olivine gabbro	2
7R-1	4	25–30	Quartz diorite	Orthocumulate	Heterogeneous poikilitic olivine gabbro	2
7R-1	9B	119–123	Ol-cpx gabbro	Poikilitic	Heterogeneous poikilitic olivine gabbro	2
8R-1	1	0–6	Quartz diorite	Orthocumulate	Varitextured gabbro/olivine gabbro	3
8R-1	7B	52-55	Gabbronorite	Sheared	Varitextured gabbro/olivine gabbro	3

Notes: Cpx = clinopyroxene; Ol = olivine.

Microgabbro consists of a foliated fine-grained equigranular aggregate of clinopyroxene, plagoiclase, and brown hornblende, sometimes associated with olivine. Sample 153-923A-2R-1, Piece 3, is a typical microgabbro. Olivine and clinopyroxene occur rarely as porphyroclasts (1–2 mm across). Brown hornblende substitutes at the margins of clinopyroxene grains.

Gabbronorite

Gabbronorite generally occurs as a porphyroclastic dike intruded into the olivine gabbro. Gabbronorite (Sample 153-921E-8R-1, Piece 7B) was collected from such a dike, whose thickness is around 1 or 2 m. The sample is composed of plagioclase, clinopyroxene, orthopyroxene, and opaque oxides. Pyroxenes show exsolution texture, and are elongated by shear stress.

Oxide Gabbro

Oxide gabbro usually forms thin veins in olivine gabbro. Sample 153-921E-3R-1, Piece 5, is a small vein (a few cm thick) intruded into the shear zone formed at the boundary between Units 1 (pegmatitic gabbro) and 2 (olivine gabbro). The anhedral plagioclase, clinopyroxene, and orthopyroxene grains are primarily cemented by ilmenite and titanomagnetite, and are deformed into a porphyroclastic texture.

Quartz Diorite

Only two discrete samples of quartz diorite were recovered during Leg 153, both from Hole 921E: Samples 153-921E-7R-1, Piece 4, and 8R-1, Piece 1. These specimens are composed of plagioclase, clinopyroxene, orthopyroxene, ilmenite, titanomagnetite, and quartz. Plagioclase grains are large and euhedral to subhedral in shape. Clinopyroxene, orthopyroxene, ilmenite, titanomagnetite, and quartz are the intergranular minerals. Pyroxenes are relict minerals and occur in the center part of the hornblendes and clay minerals. Clinopyroxene is surrounded by brown hornblende. Orthopyroxene is replaced by muscovite, chlorite, green hornblende, and so forth, at the margins.

MINERALOGY

Mineral compositions of plagioclase, olivine, and pyroxenes in gabbroic rocks from Holes 923A and 921E were determined using the JEOL JXA-8600 Electron Microprobe at Niigata University. Standard silicate analyses were performed at an accelerating potential of 15 kV, a beam current of 1.3×10^{-8} A, and a spot size of 10 μm. The standards used for calibration were diopside (Si, Ca), synthetic TiO_2, Al_2O_3, Cr_2O_3, Fe_2O_3, NiO, periclase (Mg), jadeite (Na), and adularia (K). Consistency of the data was checked by daily analyses of a kaersutite standard. Representative analyses are listed in Tables 2, 3, 4, and 5.

Plagioclase

Plagioclases in troctolite and clinopyroxene-olivine gabbro have high maximum anorthite (An) contents, typically >72 (Fig. 1, Table 2). Plagioclases in olivine-clinopyroxene gabbro are less calcic, but still have maximum An contents >60. The maximum An contents of plagioclases in gabbro are less than 60. Porphyroclastic grains in gabbronorite have homogeneous An ranges between 45 and 47. In oxide gabbro, some grains have calcic cores with An of 69–71, and the others have sodic cores with An of 45. Plagioclase grains in quartz diorite are sodic, having homogeneous cores characterized by An of 26–27, rimmed by a more sodic solution, whose An equals 7.

Olivine

Olivine grains in troctolite and clinopyroxene-olivine gabbro have magnesian compositions with a forsterite (Fo) content >76, up to 86 (Fig. 2, Table 3). Olivines in Samples 153-923A-12R-1, Piece 4B-Tr, 12R-1, Piece 4B-COGb, 13R-1, Piece 6, and 7R-2, Piece 1, are magnesian, and have NiO contents greater than 0.24 wt% (Figs. 2, 3). Maximum Fo contents of olivine in olivine-clinopyroxene gabbro generally range from 72 to 74, except in Samples 153-921E-4R-1, Piece 5, and 153-921E-7R-1, Piece 9B, which equal 75 and 78, respectively. Olivines in gabbro samples (Samples 153-923A-2R-1, Piece 3, and 5R-1, Piece 2A) have maximum Fo values of 73 and 74,

Table 2. Representative microprobe analyses of plagioclase for gabbroic rocks from Holes 921E and 923A.

Hole:	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A
Core, section:	2R-3	3R-2	3R-2	3R-2	5R-1	5R-1	5R-3	5R-3	7R-1	7R-1	7R-1	7R-2	7R-2
Piece no.:	1	1	1	1	2A	2A	1	1	2B	2B	2B	1	1
Rock name:	Gb	Gb	Gb	Gb	Gb	Gb	Gb	Gb	COGb	COGb	COGb	COGb	COGb
SiO_2	54.21	53.60	55.23	56.95	53.31	54.47	53.53	55.71	49.18	53.30	52.93	49.75	52.66
TiO_2	0.00	0.05	0.04	0.01	0.04	0.04	0.07	0.13	0.07	0.06	0.05	0.02	0.02
Al_2O_3	28.38	29.12	28.33	27.15	29.70	28.90	29.06	27.77	31.69	29.14	29.60	31.24	29.90
FeO	0.10	0.36	0.20	0.22	0.21	0.31	0.32	0.31	0.31	0.18	0.25	0.22	0.29
MnO	0.00	0.10	0.03	0.11	0.05	0.00	0.00	0.00	0.02	0.05	0.05	0.10	0.09
MgO	0.02	0.02	0.02	0.00	0.03	0.04	0.02	0.01	0.04	0.03	0.03	0.04	0.03
CaO	11.09	11.63	10.35	9.21	11.89	10.95	11.54	10.04	14.93	11.54	12.23	14.63	12.76
Na_2O	5.04	4.72	5.75	6.28	4.69	5.00	4.71	5.68	2.88	4.74	4.41	3.13	4.27
K_2O	0.00	0.07	0.10	0.11	0.05	0.06	0.06	0.09	0.02	0.04	0.03	0.03	0.05
Total	98.83	99.68	100.04	100.03	99.97	99.76	99.31	99.74	99.12	99.08	99.59	99.15	100.06
Atomic no.	(O = 32)												
Si	9.886	9.731	9.954	10.226	9.651	9.846	9.7425	10.055	9.064	9.722	9.625	9.160	9.552
Ti	0.000	0.007	0.005	0.002	0.006	0.005	0.010	0.017	0.009	0.008	0.007	0.003	0.003
Al	6.100	6.231	6.017	5.746	6.337	6.156	6.234	5.907	6.885	6.265	6.343	6.778	6.391
Fe	0.014	0.054	0.029	0.033	0.031	0.047	0.049	0.047	0.047	0.027	0.038	0.034	0.044
Mn	0.000	0.016	0.005	0.016	0.007	0.001	0.000	0.000	0.002	0.008	0.008	0.015	0.014
Mg	0.005	0.005	0.006	0.001	0.008	0.010	0.005	0.003	0.010	0.008	0.009	0.010	0.009
Ca	2.167	2.263	2.001	1.772	2.308	2.122	2.252	1.942	2.949	2.257	2.384	2.887	2.481
Na	1.781	1.663	2.009	2.186	1.647	1.753	1.661	1.989	1.029	1.675	1.555	1.117	1.500
K	0.000	0.016	0.022	0.024	0.011	0.014	0.015	0.020	0.005	0.008	0.008	0.008	0.012
Total	19.954	19.986	20.048	20.005	20.004	19.954	19.968	19.979	20.001	19.979	19.978	20.011	20.005
An	54.9	57.4	49.6	44.5	58.2	54.6	57.3	49.2	74.0	57.3	60.4	72.0	62.1
Ab	45.1	42.2	49.8	54.9	41.5	45.1	42.3	50.3	25.8	42.5	39.4	27.8	37.6
Or	0.0	0.4	0.5	0.6	0.3	0.4	0.4	0.5	0.1	0.2	0.2	0.2	0.3

Notes: Tr = troctolite, COGb = clinopyroxene-olivine gabbro, OCGb = olivine-clinopyroxene gabbro, Gb = gabbro, GbN = gabbronorite, OxGb = oxide gabbro, QzDi = quartz diorite. Oxide and elemental analyses are reported in weight percent; An, Ab, and Or are reported in mole percent.

Table 2 (continued).

Hole:	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A
Core, section:	7R-2	7R-2	7R-2	8R-2	8R-2	8R-2	9R-1	9R-1	9R-2	9R-2	9R-2	9R-2	9R-2
Piece no.:	8	8	8	1	1	6	3D	3D	8	8	8	9	9
Rock name:	COGb	COGb	COGb	Tr	Tr	COGb	OCGb	OCGb	COGb	COGb	COGb	OCGb	OCGb
SiO_2	49.84	51.53	52.52	50.37	53.46	48.71	52.50	51.52	49.45	51.23	53.36	53.62	51.47
TiO_2	0.04	0.06	0.08	0.04	0.05	0.01	0.02	0.03	0.05	0.07	0.07	0.03	0.06
Al_2O_3	31.91	30.40	29.89	31.39	29.54	31.28	29.42	29.61	32.01	30.97	29.76	28.66	29.61
FeO	0.39	0.38	0.34	0.37	0.25	0.24	0.28	0.30	0.21	0.24	0.24	0.18	0.32
MnO	0.00	0.05	0.00	0.02	0.00	0.00	0.00	0.02	0.01	0.03	0.08	0.00	0.00
MgO	0.05	0.02	0.04	0.06	0.04	0.03	0.00	0.01	0.04	0.02	0.04	0.02	0.06
CaO	14.81	13.24	12.50	14.33	12.24	14.37	11.86	12.54	15.06	13.74	12.49	11.40	12.79
Na_2O	2.96	3.70	4.23	2.80	4.00	2.84	4.38	4.07	2.83	3.67	4.42	4.81	4.01
K_2O	0.04	0.05	0.07	0.03	0.03	0.03	0.04	0.03	0.01	0.00	0.04	0.00	0.00
Total	100.05	99.43	99.67	99.41	99.60	97.52	98.50	98.13	99.67	99.97	100.50	98.72	98.32
Atomic no.						(O = 32)							
Si	9.097	9.418	9.555	9.222	9.693	9.107	9.641	9.523	9.057	9.322	9.623	9.804	9.502
Ti	0.006	0.008	0.011	0.006	0.007	0.001	0.002	0.003	0.007	0.009	0.010	0.004	0.008
Al	6.863	6.548	6.409	6.772	6.311	6.892	6.367	6.451	6.911	6.641	6.324	6.176	6.442
Fe	0.060	0.058	0.052	0.057	0.037	0.038	0.043	0.047	0.032	0.037	0.036	0.028	0.049
Mn	0.000	0.008	0.000	0.003	0.000	0.000	0.000	0.003	0.001	0.005	0.011	0.000	0.000
Mg	0.013	0.006	0.010	0.015	0.010	0.009	0.001	0.002	0.010	0.006	0.009	0.005	0.017
Ca	2.899	2.594	2.438	2.812	2.379	2.880	2.334	2.486	2.957	2.680	2.415	2.235	2.532
Na	1.049	1.311	1.493	0.993	1.405	1.030	1.559	1.457	1.005	1.294	1.546	1.705	1.435
K	0.010	0.011	0.017	0.007	0.008	0.008	0.010	0.008	0.002	0.000	0.008	0.000	0.000
Total	19.995	19.961	19.984	19.886	19.851	19.965	19.958	19.980	19.984	19.995	19.983	19.957	19.986
An	73.3	66.2	61.8	73.8	62.7	73.5	59.8	62.9	74.6	67.4	60.8	56.7	63.8
Ab	26.5	33.5	37.8	26.1	37.1	26.3	39.9	36.9	25.4	32.6	39.0	43.3	36.2
Or	0.2	0.3	0.4	0.2	0.2	0.2	0.3	0.2	0.1	0.0	0.2	0.0	0.0

respectively, and those in Samples 153-923A-5R-3, Piece 1, and 3R-2, Piece 1, have maximum Fo contents of 71 and 66, respectively.

Clinopyroxene

Clinopyroxenes in troctolite, clinopyroxene-olivine gabbro, olivine-clinopyroxene gabbro, and gabbro have a significant range in diopside, endiopside, and augite contents (Fig. 4). Clinopyroxenes in primitive samples, such as troctolite (Samples 153-923A-12R-1, Piece 4B-Tr), and clinopyroxene-olivine gabbros (Samples 153-923A-7R-2, Piece 1, 12R-1, Piece 4B-COGb, and 13R-1, Piece 6), plot entirely in the diopside and endiopside fields. The maximum magnesium numbers (Mg#) of clinopyroxenes in these four samples are high (88 and 89) (Table 4). Clinopyroxenes in clinopyroxene-olivine gabbro (Samples 153-923A-7R-2, Piece 1, and 153-923A-12R-1, Piece 4B-COGb) also have high Cr_2O_3 contents, up to 1.3 (wt%) (Fig. 5). Clinopyroxenes in gabbronorite, oxide gabbro, and quartz diorite have low maximum Mg# values, ranging from 64 to 74, and plot along the boundary between the salite and augite fields (Fig. 4).

Orthopyroxene

Orthopyroxenes in troctolite, clinopyroxene-olivine gabbro, and olivine-clinopyroxene gabbro are classified as bronzite (Fig. 4).

Table 2 (continued).

Hole:	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A
Core, section:	9R-3	9R-3	10R-2	10R-2	10R-3	10R-3	11R-1	11R-1	11R-2	11R-2	12R-1	12R-1	12R-1
Piece no.:	3	3B	2	2	1	1	12	12	3	3	4B	4B	4B
Rock name:	OCGb	OCGb	OCGb	OCGb	OCGb	OCGb	OCGb	OCGb	OCGb	OCGb	Tr	Tr	Tr
SiO_2	53.03	54.24	52.75	54.86	52.61	54.04	52.84	54.23	53.13	54.50	48.78	50.49	51.01
TiO_2	0.09	0.02	0.05	0.03	0.06	0.04	0.07	0.07	0.01	0.05	0.00	0.07	0.08
Al_2O_3	29.46	29.03	29.78	28.59	29.79	28.79	29.45	28.23	28.81	28.16	32.27	30.92	30.40
FeO	0.34	0.25	0.33	0.26	0.35	0.35	0.28	0.35	0.30	0.34	0.25	0.27	0.31
MnO	0.02	0.00	0.06	0.08	0.02	0.01	0.00	0.00	0.03	0.04	0.01	0.00	0.03
MgO	0.04	0.03	0.03	0.03	0.13	0.03	0.03	0.02	0.02	0.04	0.01	0.03	0.01
CaO	12.43	11.67	12.49	10.79	12.43	11.37	12.58	11.11	11.72	11.01	15.56	14.29	13.54
Na_2O	4.25	4.80	4.40	5.38	4.31	5.03	4.32	5.03	4.51	4.81	2.58	3.29	3.75
K_2O	0.04	0.05	0.03	0.05	0.07	0.05	0.04	0.06	0.06	0.05	0.00	0.00	0.00
Total	99.68	100.09	99.92	100.06	99.77	99.70	99.59	99.09	98.57	98.98	99.47	99.37	99.13
Atomic no.											(O = 32)		
Si	9.637	9.790	9.577	9.894	9.565	9.799	9.618	9.882	9.744	9.925	8.970	9.257	9.363
Ti	0.012	0.003	0.007	0.004	0.008	0.005	0.009	0.009	0.001	0.006	0.000	0.010	0.011
Al	6.310	6.176	6.372	6.077	6.383	6.152	6.317	6.063	6.227	6.043	6.992	6.680	6.576
Fe	0.052	0.037	0.050	0.040	0.053	0.053	0.043	0.054	0.046	0.051	0.038	0.042	0.047
Mn	0.002	0.000	0.010	0.011	0.003	0.001	0.000	0.000	0.004	0.006	0.002	0.000	0.005
Mg	0.011	0.009	0.007	0.008	0.034	0.009	0.007	0.006	0.006	0.010	0.003	0.009	0.004
Ca	2.421	2.259	2.430	2.085	2.422	2.210	2.455	2.170	2.305	2.150	3.068	2.809	2.664
Na	1.497	1.679	1.548	1.880	1.519	1.768	1.523	1.776	1.603	1.699	0.921	1.171	1.335
K	0.009	0.011	0.007	0.011	0.016	0.012	0.010	0.013	0.014	0.012	0.000	0.000	0.000
Total	19.950	19.964	20.008	20.009	20.003	20.009	19.981	19.972	19.950	19.903	19.994	19.978	20.005
An	61.7	57.2	61.0	52.4	61.2	55.4	61.6	54.8	58.8	55.7	76.9	70.6	66.6
Ab	38.1	42.5	38.8	47.3	38.4	44.3	38.2	44.9	40.9	44.0	23.1	29.4	33.4
Or	0.2	0.3	0.2	0.3	0.4	0.3	0.2	0.3	0.3	0.3	0.0	0.0	0.0

Table 2 (continued).

Hole:	923A	923A	923A	923A	923A	923A	921E	921E	921E	921E	921E	921E	921E
Core, section:	12R-1	12R-1	12R-1	13R-1	13R-1	13R-1	2R-1	2R-1	2R-1	3R-1	3R-1	3R-1	4R-1
Piece no.:	4B	4B	4B	6	6	6	6	6	6	5	5	5	5
Rock name:	COGb	COGb	COGb	COGb	COGb	COGb	OCGb	OCGb	OCGb	OxGb	OxGb	OxGb	OCGb
SiO_2	48.95	50.11	53.05	49.97	51.21	52.34	53.10	53.78	54.95	53.30	57.93	59.66	51.38
TiO_2	0.00	0.05	0.03	0.04	0.06	0.06	0.01	0.01	0.01	0.03	0.00	0.00	0.03
Al_2O_3	32.26	31.48	30.01	31.88	30.95	30.24	29.38	28.90	28.20	30.91	28.04	26.25	29.89
FeO	0.20	0.14	0.18	0.29	0.14	0.23	0.29	0.17	0.22	0.23	0.13	0.20	0.36
MnO	0.05	0.07	0.05	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
MgO	0.13	0.04	0.11	0.03	0.03	0.02	0.04	0.04	0.03	0.03	0.01	0.03	0.06
CaO	15.70	14.45	12.84	14.97	13.85	13.13	12.15	11.39	10.39	13.39	9.84	8.25	13.17
Na_2O	2.36	2.97	4.00	3.01	3.66	4.11	4.83	5.19	5.82	3.08	4.82	5.45	4.21
K_2O	0.03	0.04	0.04	0.01	0.02	0.02	0.05	0.08	0.07	0.01	0.07	0.06	0.04
Total	99.69	99.33	100.32	100.20	99.90	100.15	99.85	99.56	99.69	100.96	100.84	99.89	99.14
Atomic no.						(O = 32)							
Si	8.978	9.186	9.579	9.106	9.323	9.488	9.645	9.769	9.944	9.536	10.253	10.601	9.434
Ti	0.000	0.007	0.004	0.005	0.008	0.007	0.001	0.002	0.001	0.005	0.000	0.000	0.005
Al	6.973	6.800	6.385	6.846	6.640	6.460	6.288	6.188	6.015	6.517	5.848	5.497	6.470
Fe	0.031	0.021	0.028	0.045	0.021	0.035	0.045	0.026	0.034	0.034	0.019	0.030	0.055
Mn	0.007	0.010	0.008	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000
Mg	0.035	0.011	0.031	0.007	0.007	0.006	0.009	0.010	0.009	0.007	0.002	0.007	0.016
Ca	3.088	2.840	2.485	2.925	2.703	2.551	2.366	2.217	2.015	2.568	1.868	1.571	2.593
Na	0.841	1.055	1.400	1.064	1.290	1.445	1.701	1.828	2.043	1.067	1.652	1.876	1.498
K	0.007	0.008	0.009	0.003	0.004	0.006	0.012	0.019	0.016	0.001	0.015	0.013	0.009
Total	19.959	19.939	19.928	20.000	19.997	19.999	20.067	20.058	20.077	19.735	19.657	19.595	20.080
An	78.5	72.8	63.8	73.3	67.6	63.8	58.0	54.6	49.5	70.6	52.8	45.4	63.2
Ab	21.4	27.0	36.0	26.7	32.3	36.1	41.7	45.0	50.1	29.3	46.7	54.2	36.5
Or	0.2	0.2	0.2	0.1	0.1	0.1	0.3	0.5	0.4	0.0	0.4	0.4	0.2

Among those, crystals in Samples 153-923A-12R-1, Piece 4B-COGb and -Tr, have the highest Mg# (76–77). Orthopyroxenes in most gabbro samples also plot in the bronzite field, whereas those in gabbronorite plot near the boundary between bronzite and hypersthene. Orthopyroxenes in oxide gabbro and quartz diorite are classified as hypersthene. Neither pigeonite nor inverted pigeonite occur in the examined samples.

Sr- AND Nd-ISOTOPIC COMPOSITION

Six samples of various rock types were selected for isotopic analyses. Samples were crushed in a tungsten carbide mill to a few millimeters in size, and then warmed on a hot plate and washed ultrasonically in distilled water until no AgCl was produced by reaction with 2% $AgNO_3$. The sample for bulk analysis was segregated at this stage and ground in a tungsten carbide mill. The washed chips were again crushed for mineral separates to the 60 mesh size, and then warmed in 6-N HCl for 30 min to obtain fresh mineral separates by dissolving clay minerals. Samples then were cleaned ultrasonically and rinsed in distilled water. Plagioclase and pyroxene were separated using isodynamic magnetic separators.

Sr- and Nd-isotope analyses were performed using a Finnigan MAT 261 multicollector mass spectrometer at the Institute of Study for Earth's Interior, Okayama University. The Sr and Nd extractions followed the procedures described by Kagami et al. (1987, 1989).

Table 2 (continued).

Hole:	921E	921E	921E	921E	921E	921E	921E	921E	921E	921E	921E
Core, section:	4R-1	7R-1	7R-1	7R-1	7R-1	7R-1	8R-1	8R-1	8R-1	8R-1	8R-1
Piece no.:	5	4	4	4	9B	9B	1	1	1	7B	7B
Rock name:	OCGb	QzDi	QzDi	QzDi	OCGb	OCGb	QzDi	QzDi	QzDi	GbN	GbN
SiO_2	54.49	61.49	63.48	65.97	52.06	54.25	60.78	64.63	67.23	55.51	56.69
TiO_2	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.02
Al_2O_3	27.93	23.68	22.90	21.15	30.80	29.48	23.90	21.50	20.56	27.11	27.22
FeO	0.28	0.28	0.20	0.07	0.17	0.10	0.24	0.12	0.03	1.32	0.22
MnO	0.03	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.01	0.00
MgO	0.03	0.02	0.01	0.00	0.00	0.00	0.02	0.00	0.00	0.03	0.02
CaO	11.15	5.80	4.59	2.43	13.52	12.00	5.83	3.17	1.66	9.75	9.46
Na_2O	5.54	8.71	9.28	10.94	3.75	4.96	8.82	10.03	11.27	6.11	6.24
K_2O	0.04	0.17	0.43	0.27	0.02	0.03	0.16	0.33	0.37	0.07	0.06
Total	99.56	100.15	100.88	100.83	100.36	100.84	99.74	99.79	101.11	100.01	99.92
Atomic no.			(O = 32)								
Si	9.901	10.939	11.173	11.550	9.418	9.731	10.870	11.445	11.707	10.053	10.194
Ti	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.002
Al	5.982	4.964	4.751	4.365	6.567	6.232	5.037	4.487	4.219	5.788	5.769
Fe	0.043	0.042	0.029	0.010	0.026	0.016	0.036	0.017	0.005	0.200	0.032
Mn	0.004	0.000	0.000	0.000	0.003	0.003	0.000	0.000	0.000	0.001	0.000
Mg	0.007	0.005	0.003	0.001	0.001	0.000	0.005	0.000	0.000	0.009	0.006
Ca	2.173	1.107	0.865	0.457	2.623	2.307	1.117	0.603	0.310	1.893	1.823
Na	1.951	3.005	3.166	3.713	1.316	1.724	3.057	3.443	3.804	2.144	2.174
K	0.010	0.038	0.096	0.061	0.005	0.007	0.036	0.074	0.081	0.016	0.014
Total	20.080	20.100	20.083	20.155	19.959	20.019	20.159	20.070	20.126	20.119	20.014
An	52.6	26.7	21.0	10.8	66.5	57.1	26.5	14.6	7.4	46.7	45.4
Ab	47.2	72.4	76.7	87.8	33.4	42.7	72.6	83.6	90.7	52.9	54.2
Or	0.2	0.9	2.3	1.4	0.1	0.2	0.9	1.8	1.9	0.4	0.4

The extracted elements were loaded on Ta-filament in a double filament mode. Blanks for both Sr and Nd were less than 1 ng. The average $^{87}Sr/^{86}Sr$ ratio for the NBS987 standard was 0.710258 ± 14 (± represents an analytical reproducibility in terms of 2σ) and the average $^{143}Nd/^{144}Nd$ for the BCR-1 was 0.512612 ± 11. $^{87}Sr/^{86}Sr$ was normalized to $^{86}Sr/^{88}Sr = 0.1194$; $^{143}Nd/^{144}Nd$ was normalized to a value of $^{146}Nd/^{144}Nd = 0.7219$. The results are listed in Table 6. The $^{143}Nd/^{144}Nd$ ratios are reported relative to $^{143}Nd/^{144}Nd = 0.512640$ for BCR-1 (Wasserburg et al., 1981).

The $^{87}Sr/^{86}Sr$ ratio ranges from 0.70232 to 0.70260, and $^{143}Nd/^{144}Nd$ ranges from 0.513243 to 0.513252. All the $^{87}Sr/^{86}Sr$ of analyzed samples are less than 0.7030 and in the range of N-type MORB (Wilson, 1989).

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Table 3. Representative microprobe analyses of olivine for gabbroic rocks from Holes 921E and 923A.

Hole:	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A
Core, section:	2R-1	2R-1	3R-2	3R-2	5R-1	5R-3	5R-3	7R-1	7R-1	7R-1	7R-2	7R-2	7R-2
Piece no.:	3	3	1	1	2A	1	1	2B	2B	2B	1	1	8
Rock name:	Gb	Gb	Gb	Gb	Gb	Gb	Gb	COGb	COGb	COGb	COGb	COGb	COGb
SiO_2	37.94	37.65	37.05	36.68	38.44	37.70	37.68	38.63	38.13	37.23	39.73	39.79	38.40
Al_2O_3	0.00	0.00	0.02	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00
TiO_2	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.00	0.04	0.04	0.01	0.01	0.02
FeO	24.99	26.17	30.10	31.72	24.88	26.56	27.85	20.73	22.49	24.29	15.79	17.41	22.38
MnO	0.45	0.36	0.54	0.54	0.38	0.44	0.44	0.31	0.41	0.33	0.25	0.31	0.46
NiO	0.10	0.11	0.05	0.11	0.06	0.15	0.09	0.12	0.14	0.15	0.24	0.17	0.23
MgO	36.33	35.51	32.07	31.85	37.83	35.27	34.70	40.07	38.26	38.39	43.71	43.24	39.13
CaO	0.09	0.06	0.04	0.05	0.02	0.07	0.05	0.08	0.04	0.05	0.05	0.03	0.04
Total	99.88	99.85	99.87	100.99	101.61	100.21	100.82	99.94	99.51	100.48	99.78	100.95	100.64
Atomic no.	(O = 4)												
Si	1.003	1.001	1.004	0.992	0.996	1.001	1.000	0.999	1.000	0.977	1.005	1.002	0.996
Al	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ti	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000
Fe	0.552	0.582	0.682	0.717	0.539	0.590	0.618	0.448	0.493	0.533	0.334	0.366	0.485
Mn	0.010	0.008	0.012	0.012	0.008	0.010	0.010	0.007	0.009	0.007	0.005	0.007	0.010
Mg	1.430	1.406	1.295	1.283	1.460	1.396	1.371	1.544	1.495	1.502	1.648	1.622	1.512
Ca	0.002	0.002	0.001	0.002	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001
Total	2.997	2.999	2.996	3.007	3.004	2.999	3.000	3.001	2.999	3.022	2.994	2.998	3.004
Fo	72.1	70.7	65.5	64.1	73.0	70.3	68.9	77.5	75.2	73.8	83.1	81.6	75.7

Notes: Tr = troctolite, COGb = clinopyroxene-olivine gabbro, OCGb = olivine-clinopyroxene gabbro, and Gb = gabbro. Analyses are reported in weight percent.

Table 3 (continued).

Hole:	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A
Core, section:	7R-2	8R-2	8R-2	8R-2	8R-2	9R-1	9R-1	9R-2	9R-2	9R-2	9R-2	9R-3	9R-3
Piece no.:	8	1	1	6	6	3	3	8	8	9	9	3	3B
Rock name:	COGb	Tr	Tr	COGb	COGb	OCGb	OCGb	COGb	COGb	OCGb	OCGb	OCGb	OCGb
SiO_2	37.65	39.33	39.50	38.30	38.03	38.19	37.89	39.78	38.51	38.09	38.11	37.99	37.59
Al_2O_3	0.00	0.01	0.01	0.00	0.00	0.03	0.02	0.03	0.00	0.00	0.00	0.00	0.00
TiO_2	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.11	0.00	0.08	0.02	0.00	0.00
FeO	23.48	19.90	21.20	20.54	21.65	21.91	22.60	20.72	21.32	24.06	24.97	24.56	25.92
MnO	0.39	0.27	0.34	0.45	0.36	0.31	0.33	0.29	0.30	0.31	0.38	0.40	0.35
NiO	0.22	0.09	0.10	0.06	0.07	0.01	0.03	0.05	0.12	0.10	0.08	0.11	0.12
MgO	38.14	41.31	40.24	39.66	39.52	39.39	38.97	40.80	39.87	37.63	36.91	37.27	36.13
CaO	0.03	0.04	0.04	0.06	0.07	0.04	0.01	0.01	0.05	0.01	0.03	0.04	0.05
Total	99.94	100.94	101.44	99.07	99.68	99.88	99.86	101.79	100.18	100.28	100.50	100.36	100.17
Atomic no.						(O = 4)							
Si	0.990	1.001	1.006	0.999	0.991	0.994	0.990	1.006	0.997	0.997	1.000	0.997	0.995
Al	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
Ti	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.002	0.000	0.000	0.000
Fe	0.516	0.424	0.452	0.448	0.472	0.477	0.494	0.438	0.461	0.527	0.548	0.539	0.574
Mn	0.009	0.006	0.007	0.010	0.008	0.007	0.007	0.006	0.007	0.007	0.008	0.009	0.008
Mg	1.494	1.567	1.527	1.542	1.535	1.527	1.517	1.538	1.537	1.468	1.443	1.457	1.426
Ca	0.001	0.001	0.001	0.002	0.002	0.001	0.000	0.000	0.001	0.000	0.001	0.001	0.001
Total	3.010	2.999	2.994	3.001	3.009	3.006	3.010	2.992	3.003	3.001	3.000	3.003	3.005
Fo	74.3	78.72	77.18	77.5	76.5	76.2	75.4	77.82	76.92	73.6	72.5	73.0	71.3

Table 3 (continued).

Hole:	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	921E	921E
Core, section:	10R-2	10R-3	10R-3	11R-1	11R-2	11R-2	12R-1	12R-1	12R-1	12R-1	13R-1	2R-1	2R-1
Piece no.:	2	1	1	12	3	3	4B	4B	4B	4B	6	6	6
Rock name:	OCGb	OCGb	OCGb	OCGb	OCGb	OCGb	Tr	Tr	COGb	COGb	COGb	OCGb	OCGb
SiO_2	38.59	37.62	37.15	37.25	38.10	37.70	39.67	39.86	39.76	39.68	39.43	38.14	37.70
Al_2O_3	0.01	0.00	0.02	0.03	0.02	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00
TiO_2	0.01	0.01	0.01	0.01	0.04	0.00	0.07	0.05	0.07	0.06	0.02	0.03	0.02
FeO	24.67	25.35	30.76	23.86	23.83	26.67	14.83	15.39	14.03	14.24	17.76	25.20	26.11
MnO	0.29	0.47	0.49	0.32	0.45	0.43	0.29	0.22	0.19	0.28	0.29	0.41	0.31
NiO	0.12	0.10	0.07	0.07	0.01	0.00	0.28	0.11	0.24	0.17	0.22	0.07	0.05
MgO	37.83	36.58	32.40	37.36	37.50	35.48	44.32	44.71	45.34	45.19	42.54	36.78	36.05
CaO	0.05	0.03	0.02	0.06	0.04	0.05	0.06	0.05	0.07	0.04	0.06	0.05	0.07
Total	101.57	100.15	100.93	98.96	99.99	100.32	99.52	100.41	99.70	99.66	100.33	100.67	100.30
Atomic no.											(O = 4)		
Si	0.999	0.994	0.999	0.990	0.999	0.999	1.003	0.999	0.999	0.998	1.002	1.000	0.997
Al	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
Ti	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.001	0.001	0.001	0.000	0.001	0.000
Fe	0.534	0.560	0.692	0.530	0.523	0.591	0.314	0.323	0.295	0.300	0.377	0.552	0.577
Mn	0.006	0.010	0.011	0.007	0.010	0.010	0.006	0.005	0.004	0.006	0.006	0.009	0.007
Mg	1.459	1.440	1.298	1.479	1.465	1.400	1.670	1.670	1.698	1.694	1.610	1.437	1.420
Ca	0.001	0.001	0.001	0.002	0.001	0.001	0.002	0.001	0.002	0.001	0.002	0.001	0.002
Total	3.000	3.006	3.001	3.010	3.000	3.001	2.996	3.000	2.999	3.000	2.998	3.000	3.003
Fo	73.2	72.0	65.2	73.6	73.7	70.3	84.19	83.81	85.20	84.97	81.0	72.2	71.1

Table 3 (continued).

Hole:	921E	921E	921E
Core, section:	4R-1	7R-1	7R-1
Piece no.:	5	9B	9B
Rock name:	OCGb	OCGb	OCGb
SiO_2	38.47	38.63	38.50
Al_2O_3	0.00	0.00	0.01
TiO_2	0.03	0.03	0.06
FeO	23.92	21.13	24.01
MnO	0.26	0.29	0.41
NiO	0.06	0.16	0.11
MgO	37.87	40.08	37.47
CaO	0.04	0.03	0.04
Total	100.64	100.36	100.59
Atomic no.			
Si	1.001	0.997	1.004
Al	0.000	0.000	0.000
Ti	0.001	0.001	0.001
Fe	0.521	0.456	0.524
Mn	0.006	0.006	0.009
Mg	1.469	1.541	1.456
Ca	0.001	0.001	0.001
Total	2.998	3.002	2.995
Fo	73.8	77.2	73.5

Table 4. Representative microprobe analyses of primary clinopyroxene for gabbroic rocks from Holes 921E and 923A.

Hole:	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A
Core, section:	2R-1	2R-1	3R-2	3R-2	5R-1	5R-1	5R-3	5R-3	7R-1	7R-1	7R-2	7R-2	7R-2	8R-2
Piece no.:	3	3	1	1	2A	2A	1	1	2B	2B	1	1	8	1
Rock name:	Gb	Gb	Gb	Gb	Gb	Gb	Gb	Gb	COGb	COGb	COGb	COGb	COGb	Tr
SiO_2	51.61	51.64	52.30	51.85	52.80	52.57	51.84	51.59	51.49	51.53	50.81	51.09	51.62	52.76
TiO_2	0.83	0.93	0.57	0.80	0.57	0.61	0.66	0.96	0.60	0.96	0.54	1.31	0.68	0.69
Al_2O_3	2.57	2.60	1.79	2.36	2.51	2.53	2.20	2.53	3.12	2.61	3.88	3.47	2.62	2.49
Cr_2O_3	0.19	0.15	0.00	0.00	0.00	0.00	0.04	0.06	0.56	0.13	1.30	0.60	0.38	0.11
FeO	6.86	7.71	7.33	7.98	6.30	7.58	7.76	7.44	5.87	7.20	4.62	5.29	6.85	5.98
MnO	0.13	0.23	0.16	0.17	0.21	0.32	0.21	0.22	0.22	0.21	0.07	0.25	0.21	0.14
NiO	0.18	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.06	0.08	0.00	0.04	0.19
MgO	15.28	15.57	15.04	14.84	16.12	16.97	15.21	15.14	15.81	15.03	16.00	15.50	15.04	15.47
CaO	20.74	20.13	20.84	20.52	21.17	19.16	20.64	20.32	20.79	20.59	20.78	21.65	20.99	21.68
Na_2O	0.47	0.41	0.36	0.44	0.31	0.31	0.35	0.38	0.44	0.44	0.45	0.41	0.40	0.41
K_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Total	98.85	99.48	98.40	98.95	99.98	100.05	98.92	98.62	99.00	98.76	98.52	99.57	98.83	99.90
Atomic no.	(O = 6)													
Si	1.932	1.923	1.961	1.939	1.939	1.932	1.940	1.932	1.921	1.930	1.908	1.897	1.934	1.945
Ti	0.023	0.026	0.016	0.022	0.016	0.017	0.019	0.027	0.017	0.027	0.015	0.037	0.019	0.019
Al	0.113	0.114	0.079	0.104	0.109	0.110	0.097	0.111	0.137	0.115	0.172	0.152	0.116	0.108
Cr	0.006	0.004	0.000	0.000	0.000	0.000	0.001	0.002	0.017	0.004	0.039	0.018	0.011	0.003
Fe	0.215	0.240	0.230	0.249	0.194	0.233	0.243	0.233	0.183	0.225	0.145	0.164	0.215	0.184
Mn	0.004	0.007	0.005	0.005	0.006	0.010	0.007	0.007	0.007	0.007	0.002	0.008	0.007	0.004
Mg	0.852	0.864	0.841	0.827	0.882	0.929	0.848	0.845	0.880	0.839	0.895	0.858	0.840	0.850
Ca	0.832	0.804	0.838	0.823	0.834	0.755	0.828	0.816	0.832	0.827	0.837	0.862	0.843	0.857
Na	0.034	0.030	0.026	0.032	0.022	0.022	0.026	0.028	0.032	0.032	0.033	0.030	0.029	0.029
K	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	4.011	4.013	3.996	4.002	4.002	4.007	4.007	4.001	4.026	4.005	4.046	4.024	4.014	4.000
Mg#	79.9	78.3	78.5	76.8	82.0	80.0	77.7	78.4	82.8	78.8	86.0	83.9	79.7	82.2
Ca/(Ca + Mg + Fe)	43.8	42.1	43.9	43.3	43.7	39.4	43.1	43.1	43.9	43.7	44.6	45.7	44.4	45.3
Mg/(Ca + Mg + Fe)	44.9	45.3	44.1	43.6	46.2	48.5	44.2	44.6	46.4	44.4	47.7	45.5	44.3	44.9
Fe/(Ca + Mg + Fe)	11.3	12.6	12.0	13.1	10.1	12.2	12.7	12.3	9.7	11.9	7.7	8.7	11.3	9.8

Notes: Tr = troctolite, COGb = clinopyroxene-olivine gabbro, OCGb = olivine-clinopyroxene gabbro, Gb = gabbro, GbN = gabbronorite, OxGb = oxide gabbro, and QzDi = quartz diorite. Analyses are reported in weight percent.

Table 4 (continued).

Hole:	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A
Core, section:	8R-2	9R-1	9R-2	9R-2	9R-2	9R-2	9R-3	9R-3	10R-2	10R-2	10R-3	11R-1	11R-1	11R-1
Piece no.:	1	3D	8	8	9	9	3B	3B	2	2	1	12	12	12
Rock name:	Tr	OCGb	COGb	COGb	OCGb	OCGb	OCGb	OCGb	OCGb	OCGb	OCGb	OCGb	OCGb	OCGb
SiO_2	52.57	51.60	51.94	52.21	52.22	52.09	52.51	52.74	52.50	51.99	52.52	52.56	52.74	52.17
TiO_2	0.86	0.58	1.26	0.70	0.51	0.89	0.49	0.49	0.39	0.78	0.59	0.52	0.48	0.48
Al_2O_3	2.54	2.65	3.46	2.29	2.85	2.66	2.79	3.16	2.20	1.89	2.16	2.69	2.91	2.62
Cr_2O_3	0.18	0.12	0.14	0.06	0.21	0.06	0.14	0.28	0.03	0.09	0.05	0.14	0.18	0.17
FeO	6.51	6.23	5.71	5.50	5.67	6.58	5.80	6.93	7.26	7.63	6.98	5.61	6.63	7.83
MnO	0.11	0.22	0.13	0.17	0.13	0.15	0.16	0.17	0.13	0.26	0.17	0.18	0.17	0.18
NiO	0.13	0.00	0.07	0.00	0.05	0.09	0.00	0.00	0.00	0.03	0.06	0.05	0.03	0.02
MgO	15.85	15.72	15.30	15.63	16.92	15.30	16.60	16.55	16.55	16.20	17.17	16.20	16.74	17.74
CaO	21.29	21.31	22.47	22.45	19.70	20.92	20.22	19.01	20.61	19.85	19.02	21.19	19.98	18.14
Na_2O	0.39	0.36	0.42	0.40	0.36	0.42	0.37	0.37	0.31	0.33	0.35	0.42	0.42	0.27
K_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.42	98.79	100.90	99.40	98.60	99.18	99.07	99.71	99.98	99.05	99.07	99.56	100.28	99.62
Atomic no.						(O = 6)								
Si	1.932	1.926	1.899	1.934	1.937	1.935	1.940	1.940	1.936	1.939	1.945	1.938	1.932	1.926
Ti	0.024	0.016	0.035	0.019	0.014	0.025	0.014	0.014	0.011	0.022	0.016	0.014	0.013	0.013
Al	0.110	0.116	0.149	0.100	0.125	0.117	0.121	0.137	0.096	0.083	0.094	0.117	0.125	0.114
Cr	0.005	0.004	0.004	0.002	0.006	0.002	0.004	0.008	0.001	0.003	0.001	0.004	0.005	0.005
Fe	0.200	0.194	0.175	0.170	0.176	0.205	0.179	0.213	0.224	0.238	0.216	0.173	0.203	0.242
Mn	0.003	0.007	0.004	0.005	0.004	0.005	0.005	0.005	0.004	0.008	0.005	0.006	0.005	0.006
Mg	0.868	0.874	0.834	0.863	0.935	0.847	0.914	0.907	0.909	0.901	0.948	0.890	0.914	0.976
Ca	0.839	0.853	0.881	0.892	0.783	0.833	0.801	0.750	0.815	0.794	0.755	0.837	0.785	0.718
Na	0.028	0.026	0.030	0.028	0.026	0.030	0.026	0.027	0.022	0.024	0.025	0.030	0.030	0.020
K	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	4.009	4.016	4.010	4.013	4.006	3.999	4.003	4.000	4.018	4.012	4.006	4.009	4.012	4.019
Mg#	81.3	81.8	82.7	83.5	84.2	80.5	83.6	81.0	80.2	79.1	81.4	83.7	81.8	80.1
Ca/(Ca + Mg + Fe)	44.0	44.4	46.6	46.3	41.4	44.2	42.3	40.1	41.8	41.1	39.3	44.1	41.3	37.1
Mg/(Ca + Mg + Fe)	45.5	45.5	44.1	44.8	49.4	44.9	48.3	48.5	46.7	46.6	49.4	46.8	48.1	50.4
Fe/(Ca + Mg + Fe)	10.5	10.1	9.2	8.8	9.3	10.9	9.5	11.4	11.5	12.3	11.3	9.1	10.7	12.5

Table 4 (continued).

Hole:	923A	923A	923A	923A	923A	923A	923A	923A	923A	921E	921E	921E	921E	921E
Core, section:	11R-2	11R-2	11R-2	12R-1	12R-1	12R-1	12R-1	13R-1	13R-1	2R-1	2R-1	3R-1	3R-1	4R-1
Piece no.:	3	3	3	4B	4B	4B	4B	6	6	6	6	5	5	5
Rock name:	OCGb	OCGb	OCGb	Tr	Tr	COGb	COGb	COGb	COGb	OCGb	OCGb	OxGb	OxGb	OCGb
SiO_2	52.59	52.92	51.99	51.35	51.88	52.26	51.86	52.98	52.12	51.89	52.28	51.80	51.91	52.73
TiO_2	0.46	0.40	0.78	1.27	1.11	0.26	0.52	0.72	0.70	0.47	0.46	0.76	0.69	0.49
Al_2O_3	2.90	2.34	2.60	3.37	3.20	3.20	3.82	1.89	2.99	2.66	2.59	2.33	1.88	2.70
Cr_2O_3	0.19	0.11	0.00	0.25	0.20	1.15	1.16	0.08	0.13	0.11	0.10	0.14	0.09	0.16
FeO	5.32	6.49	7.58	3.69	4.48	3.76	3.87	4.18	5.23	5.52	5.53	10.02	10.51	4.96
MnO	0.16	0.17	0.17	0.11	0.13	0.16	0.17	0.07	0.09	0.09	0.14	0.39	0.30	0.10
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.19	0.03	0.00	0.00	0.00	0.05
MgO	16.47	17.96	15.06	15.95	15.89	17.56	16.11	16.43	15.62	16.74	16.62	12.73	12.47	16.29
CaO	20.91	18.65	20.53	23.09	21.98	20.36	21.71	22.14	21.34	20.89	20.71	20.52	20.75	21.08
Na_2O	0.37	0.36	0.40	0.38	0.43	0.41	0.50	0.28	0.41	0.42	0.33	0.46	0.48	0.39
K_2O	0.00	0.00	0.00	0.02	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	99.38	99.41	99.11	99.47	99.32	99.14	99.74	98.93	98.84	98.81	98.76	99.14	99.06	98.95
Atomic no.											(O = 6)			
Si	1.937	1.945	1.937	1.894	1.914	1.933	1.916	1.957	1.935	1.926	1.938	1.955	1.965	1.948
Ti	0.013	0.011	0.022	0.035	0.031	0.007	0.014	0.020	0.020	0.013	0.013	0.021	0.020	0.014
Al	0.126	0.101	0.114	0.146	0.139	0.139	0.166	0.082	0.131	0.116	0.113	0.104	0.084	0.118
Cr	0.006	0.003	0.000	0.007	0.006	0.034	0.034	0.002	0.004	0.003	0.003	0.004	0.003	0.005
Fe	0.164	0.200	0.236	0.114	0.138	0.116	0.120	0.129	0.163	0.171	0.171	0.316	0.333	0.153
Mn	0.005	0.005	0.005	0.003	0.004	0.005	0.005	0.002	0.003	0.003	0.004	0.012	0.010	0.003
Mg	0.904	0.983	0.836	0.877	0.874	0.968	0.887	0.904	0.864	0.926	0.918	0.716	0.704	0.897
Ca	0.826	0.735	0.820	0.913	0.869	0.807	0.860	0.877	0.850	0.831	0.823	0.830	0.842	0.835
Na	0.026	0.026	0.029	0.027	0.031	0.030	0.036	0.020	0.030	0.030	0.024	0.033	0.035	0.028
K	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	4.006	4.009	3.999	4.019	4.007	4.039	4.039	3.994	3.999	4.021	4.007	3.993	3.994	3.998
Mg#	84.7	83.1	78.0	88.5	86.3	89.3	88.1	87.5	84.2	84.4	84.3	69.4	67.9	85.4
Ca/(Ca + Mg + Fe)	43.6	38.3	43.3	48.0	46.2	42.7	46.1	45.9	45.3	43.1	43.0	44.6	44.8	44.3
Mg/(Ca + Mg + Fe)	47.8	51.3	44.2	46.1	46.4	51.2	47.5	47.3	46.1	48.0	48.0	38.4	37.5	47.6
Fe/(Ca + Mg + Fe)	8.6	10.4	12.5	6.0	7.3	6.2	6.4	6.8	8.7	8.9	9.0	17.0	17.7	8.1

Table 5. Representative microprobe analyses of primary orthopyroxene for gabbroic rocks from Holes 921E and 923A.

Hole:	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	923A	921E	921E	921E	921E	921E	921E	921E
Core, section:	3R-2	3R-2	5R-1	5R-3	5R-3	8R-2	8R-2	9R-1	9R-2	12R-1	12R-1	3R-1	7R-1	7R-1	8R-1	8R-1	8R-1	8R-1
Piece no.:	1	1	2A	1	1	1	1	3D	9	4B	4B	5	4	9B	1	1	7B	7B
Rock name:	Gb	Gb	Gb	Gb	Gb	Tr	Tr	OCGb	OCGb	Tr	COGb	OxGb	QzDi	OCGb	QzDi	QzDi	QzDi	GbN
SiO_2	53.58	53.12	54.79	53.36	54.17	55.26	55.17	53.85	54.20	56.23	56.13	51.94	53.38	55.30	54.44	54.36	53.92	53.45
TiO_2	0.28	0.41	0.24	0.23	0.34	0.24	0.38	0.33	0.34	0.12	0.17	0.37	0.31	0.25	0.19	0.17	0.36	0.36
Al_2O_3	1.06	1.19	0.98	1.15	0.89	1.09	1.36	1.25	1.27	0.84	1.09	0.77	1.21	1.21	1.03	1.11	1.29	1.22
Cr_2O_3	0.00	0.00	0.00	0.00	0.02	0.00	0.07	0.02	0.01	0.00	0.14	0.02	0.00	0.04	0.05	0.04	0.04	0.06
FeO	18.35	19.92	15.20	16.21	16.73	12.72	12.42	14.12	14.71	9.45	9.23	22.35	24.05	14.74	25.11	25.51	18.57	20.06
MnO	0.49	0.46	0.45	0.38	0.45	0.23	0.33	0.37	0.37	0.30	0.31	0.61	0.80	0.26	0.86	0.89	0.42	0.49
NiO	0.00	0.00	0.01	0.00	0.00	0.12	0.05	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	25.13	23.71	28.09	26.99	26.49	29.44	29.17	28.55	27.25	31.45	31.73	20.06	15.86	27.64	16.46	16.25	24.67	23.23
CaO	1.15	1.08	0.89	0.97	1.02	0.71	1.04	0.90	1.22	0.76	0.80	1.68	1.80	0.90	1.41	1.80	1.19	1.37
Na_2O	0.03	0.03	0.01	0.02	0.02	0.00	0.02	0.00	0.04	0.03	0.03	0.02	0.43	0.01	0.29	0.36	0.04	0.04
K_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.06	99.91	100.66	99.31	100.12	99.82	100.01	99.37	99.46	99.20	99.63	97.82	97.84	100.35	99.82	100.49	100.50	100.28
Atomic no.	(O = 6)																	
Si	1.961	1.961	1.961	1.949	1.965	1.970	1.964	1.946	1.962	1.984	1.974	1.988	2.051	1.977	2.054	2.045	1.965	1.969
Ti	0.008	0.011	0.007	0.006	0.009	0.006	0.010	0.009	0.009	0.003	0.004	0.011	0.009	0.007	0.005	0.005	0.010	0.010
Al	0.046	0.052	0.041	0.050	0.038	0.046	0.057	0.053	0.054	0.035	0.045	0.035	0.055	0.051	0.046	0.049	0.056	0.053
Cr	0.000	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.000	0.000	0.004	0.001	0.000	0.001	0.001	0.001	0.001	0.002
Fe	0.562	0.615	0.455	0.495	0.507	0.379	0.370	0.427	0.445	0.279	0.272	0.715	0.773	0.441	0.792	0.802	0.566	0.618
Mn	0.015	0.014	0.014	0.012	0.014	0.007	0.010	0.011	0.011	0.009	0.009	0.020	0.026	0.008	0.028	0.028	0.013	0.015
Mg	1.371	1.304	1.499	1.469	1.432	1.564	1.547	1.538	1.470	1.654	1.663	1.145	0.908	1.473	0.925	0.911	1.340	1.275
Ca	0.045	0.043	0.034	0.038	0.040	0.027	0.040	0.035	0.047	0.029	0.030	0.069	0.074	0.034	0.057	0.073	0.047	0.054
Na	0.002	0.002	0.001	0.001	0.001	0.000	0.002	0.000	0.003	0.002	0.002	0.002	0.032	0.001	0.021	0.026	0.003	0.003
K	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	4.009	4.003	4.012	4.020	4.008	4.000	4.000	4.019	4.003	3.996	4.004	3.985	3.929	3.993	3.930	3.940	4.000	3.998
Mg#	70.9	68.0	76.7	74.8	73.8	80.5	80.7	78.3	76.8	85.6	86.0	61.5	54.0	77.0	53.9	53.2	70.3	67.4
Ca/(Ca + Mg + Fe)	2.3	2.2	1.7	1.9	2.0	1.4	2.0	1.7	2.4	1.5	1.5	3.6	4.2	1.8	3.2	4.1	2.4	2.8
Mg/(Ca + Mg + Fe)	69.3	66.5	75.4	73.4	72.4	79.4	79.1	76.9	74.9	84.3	84.6	59.3	51.8	75.6	52.2	51.0	68.6	65.5
Fe/(Ca + Mg + Fe)	28.4	31.3	22.9	24.7	25.6	19.2	18.9	21.3	22.7	14.2	13.8	37.1	44.0	22.6	44.6	44.9	29.0	31.7

Notes: Tr = troctolite, COGb = clinopyroxene-olivine gabbro, OCGb = olivine-clinopyroxene gabbro, Gb = gabbro, GbN = gabbronorite, OxGb = oxide gabbro, and QzDi = quartz diorite. Analyses are reported in weight percent.

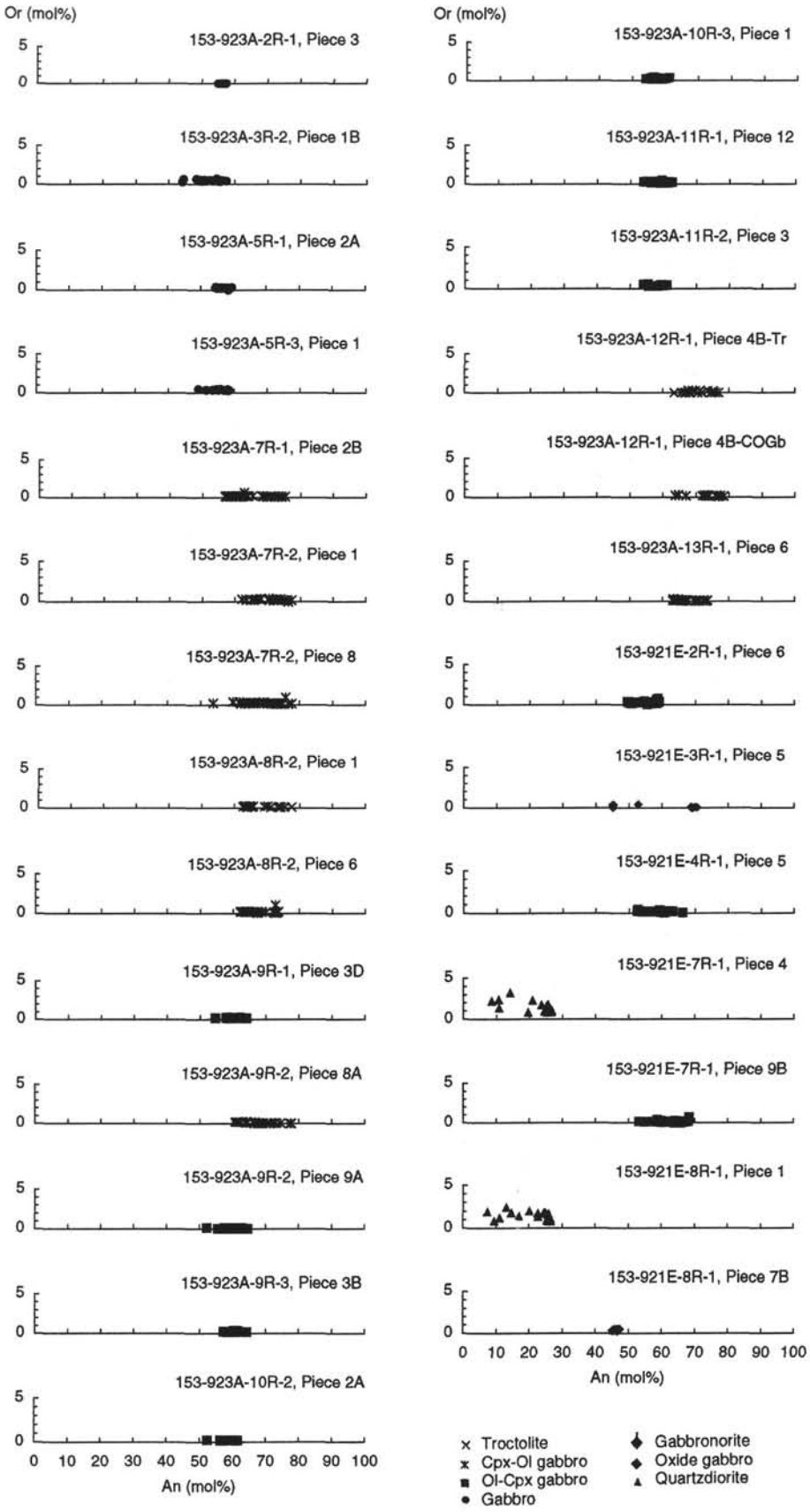

Figure 1. An-Or (mol%) plot of plagioclase in gabbroic rocks from Holes 921E and 923A. Cpx = clinopyroxene, Ol = olivine.

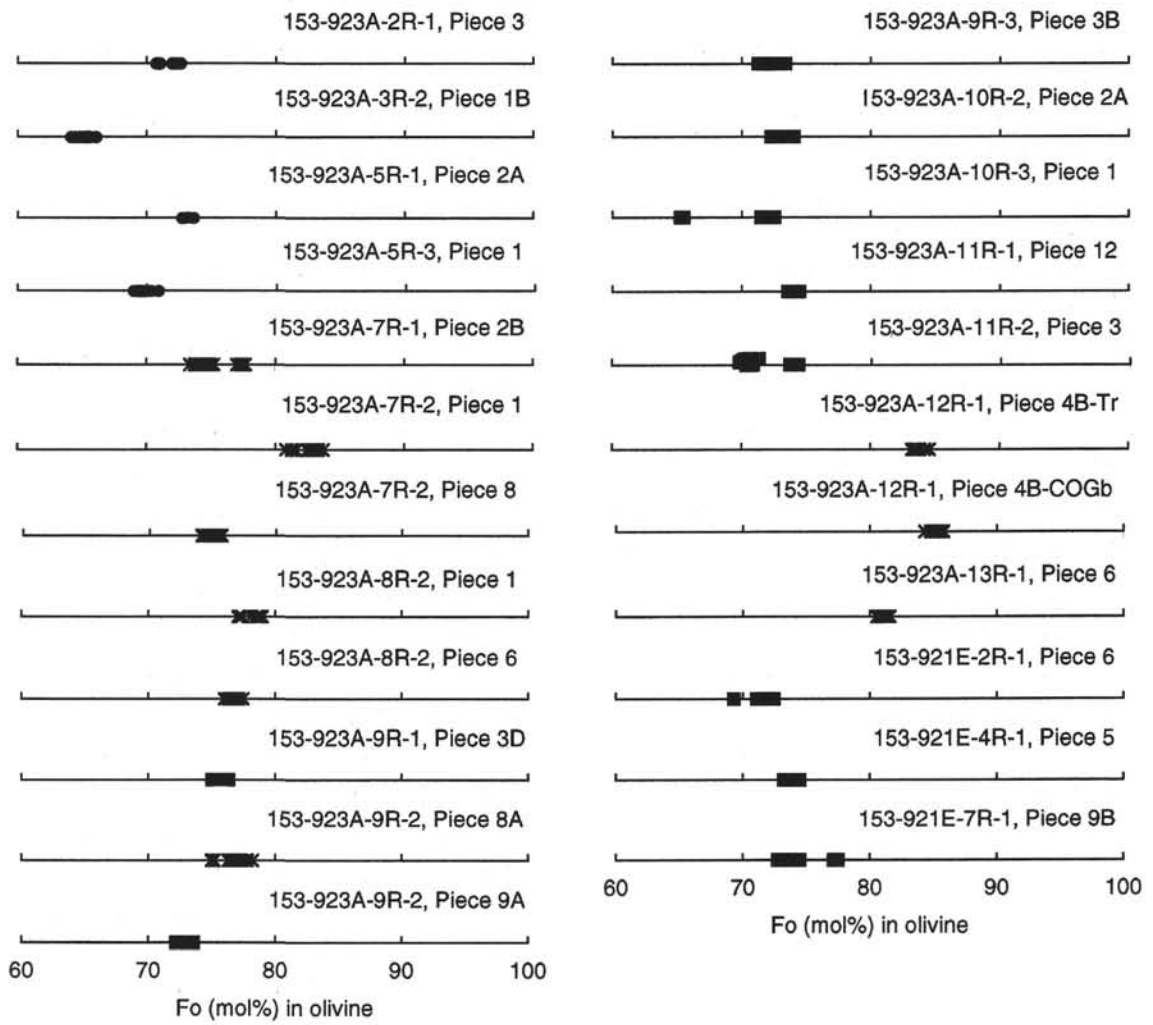

Figure 2. Fo (mol%) in olivine in troctolite, clinopyroxene-olivine gabbro, olivine-clinopyroxene gabbro, and gabbro from Holes 921E and 923A. Symbols are the same as in Figure 1.

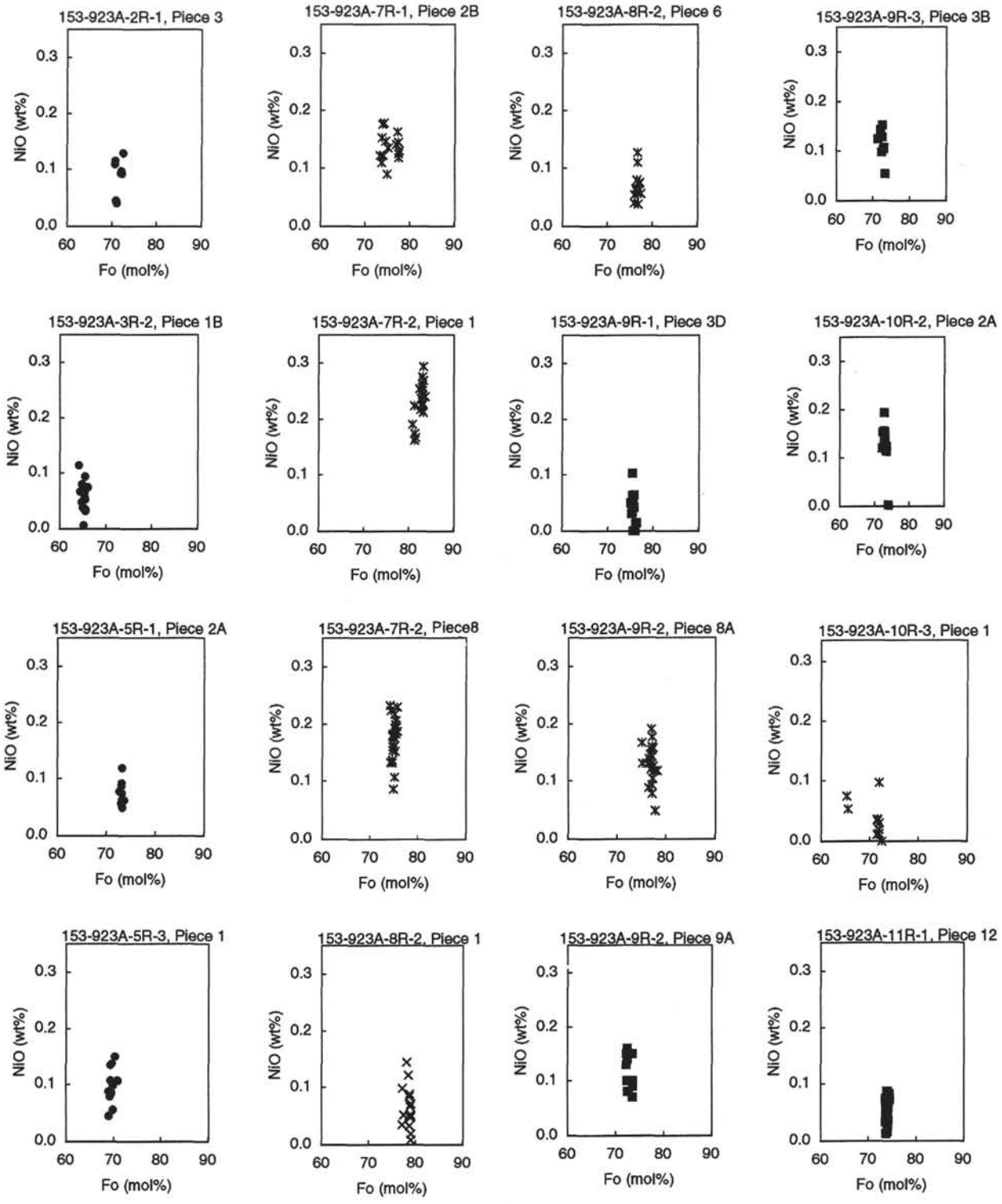

Figure 3. NiO (wt%) in olivine in troctolite, clinopyroxene-olivine gabbro, olivine-clinopyroxene gabbro, and gabbro from Holes 921E and 923A. Symbols are the same as in Figure 1.

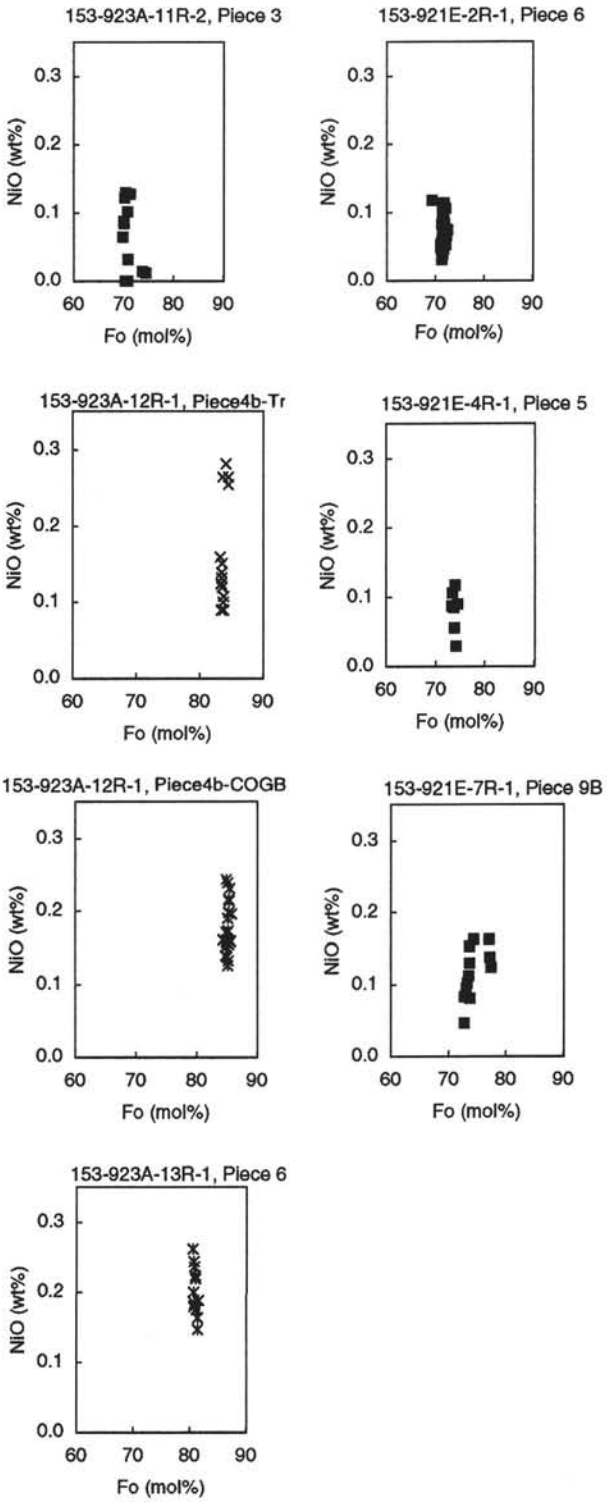

Figure 3 (continued).

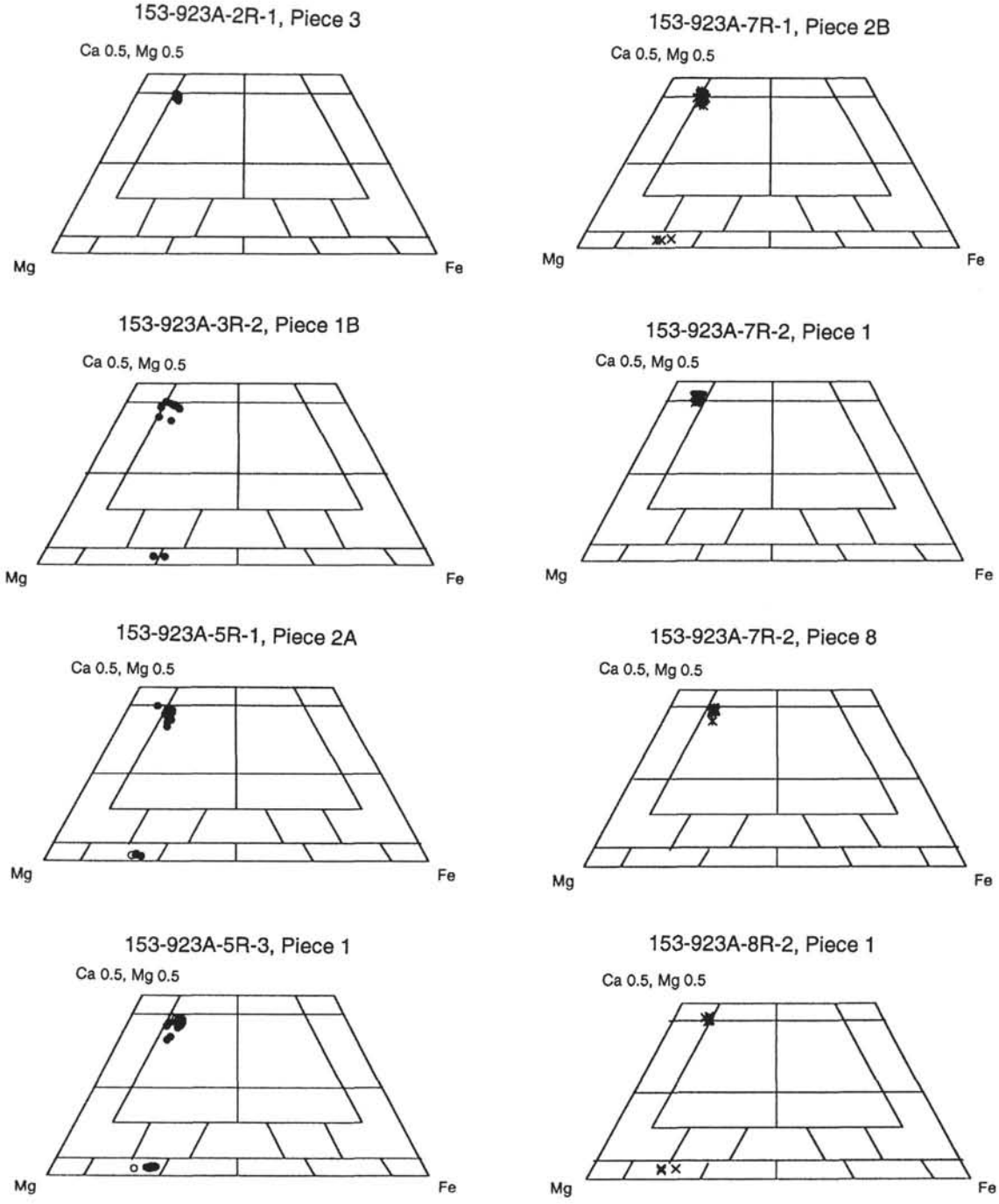

Figure 4. Ca-Mg-Fe (atomic ratio) plot of pyroxenes in gabbroic rocks from Holes 921E and 923A. Symbols are the same as in Figure 1. Open symbols are for exsolution lamellae and host.

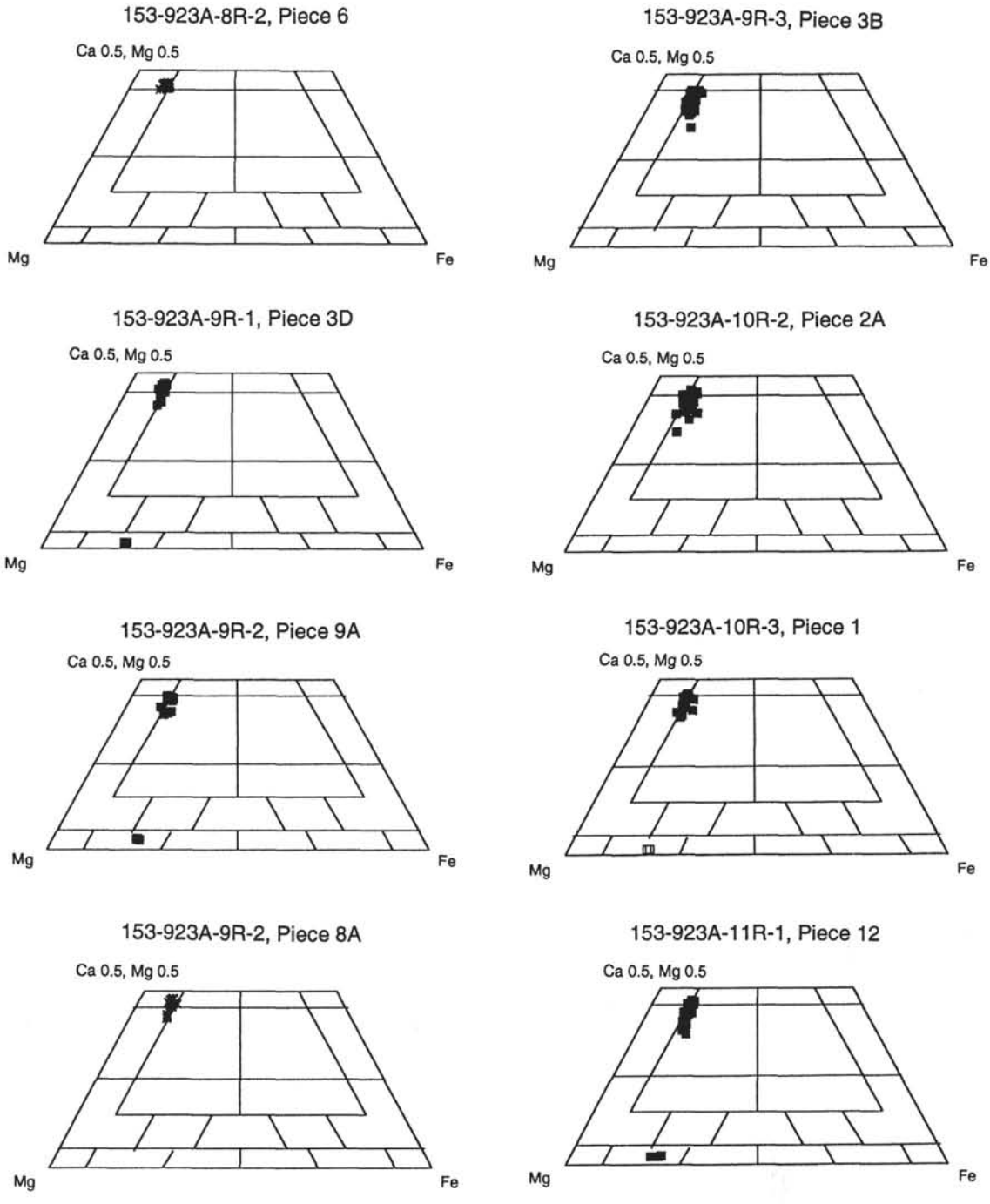

Figure 4 (continued).

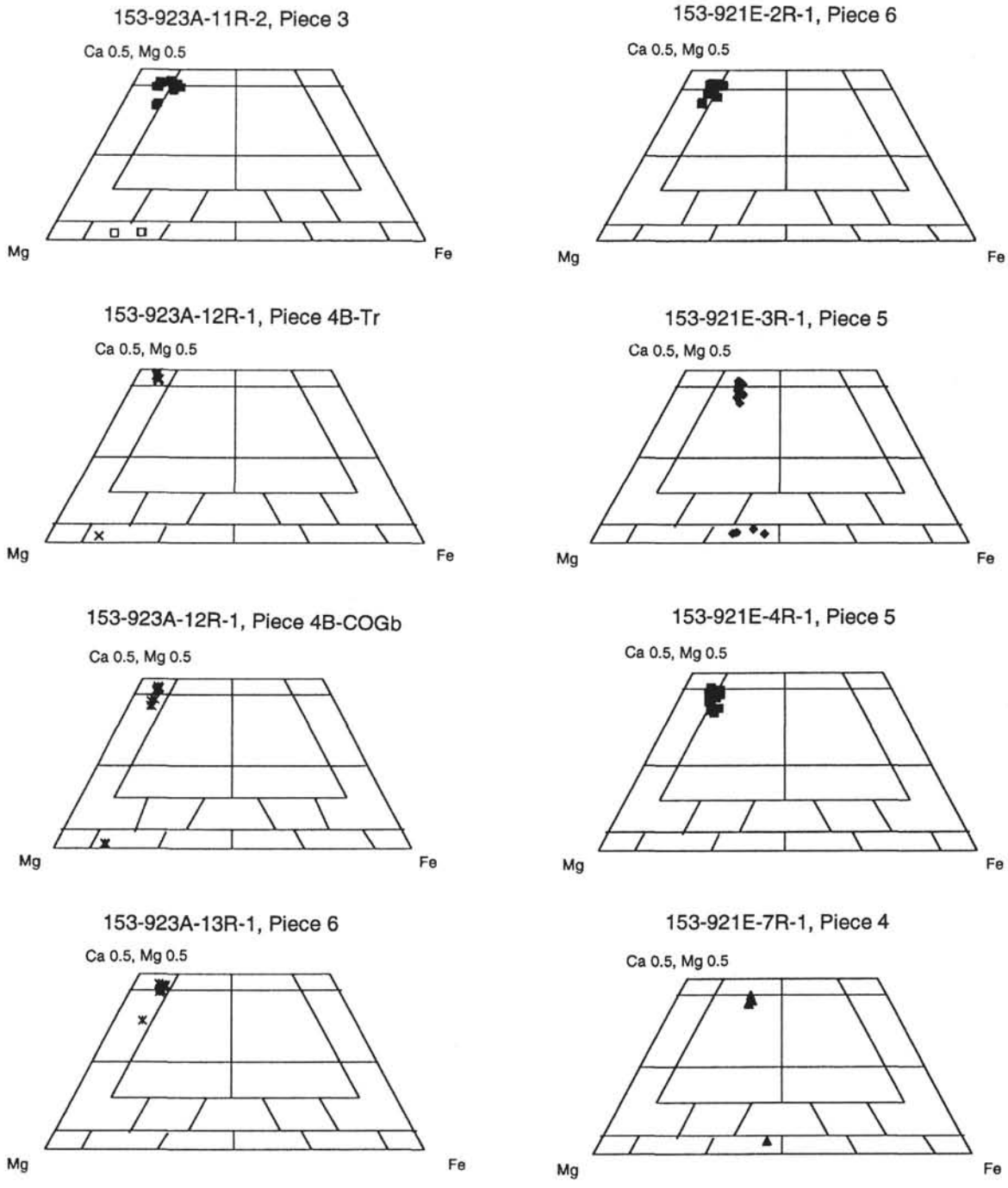

Figure 4 (continued).

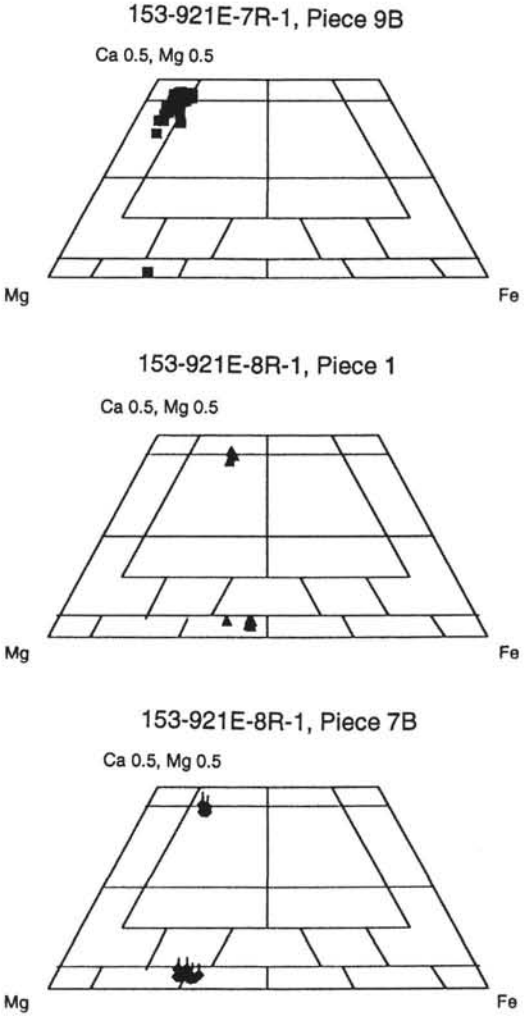

Figure 4 (continued).

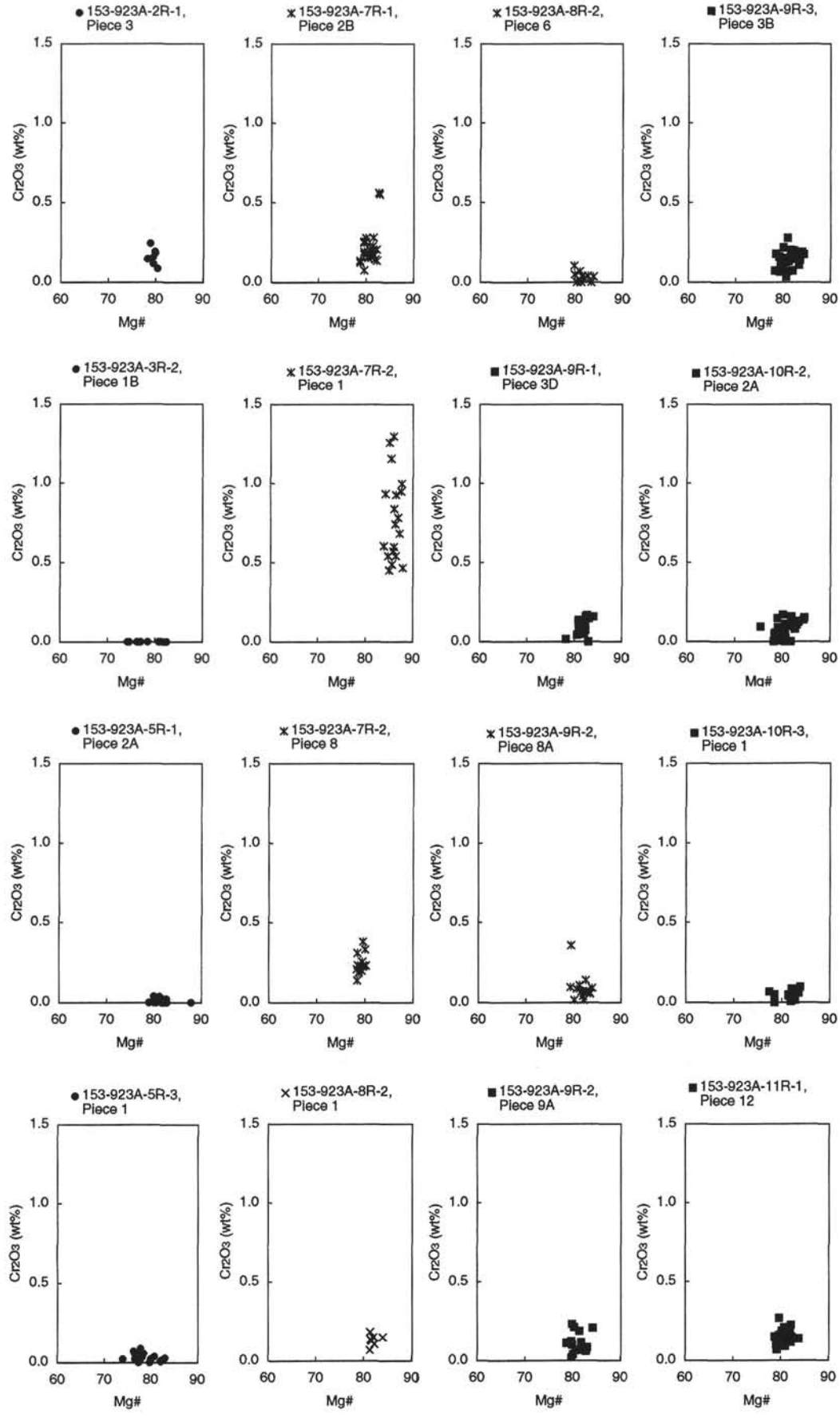

Figure 5. Cr_2O_3 (wt%) in clinopyroxene in gabbroic rocks from Holes 921E and 923A. Symbols are the same as in Figure 1.

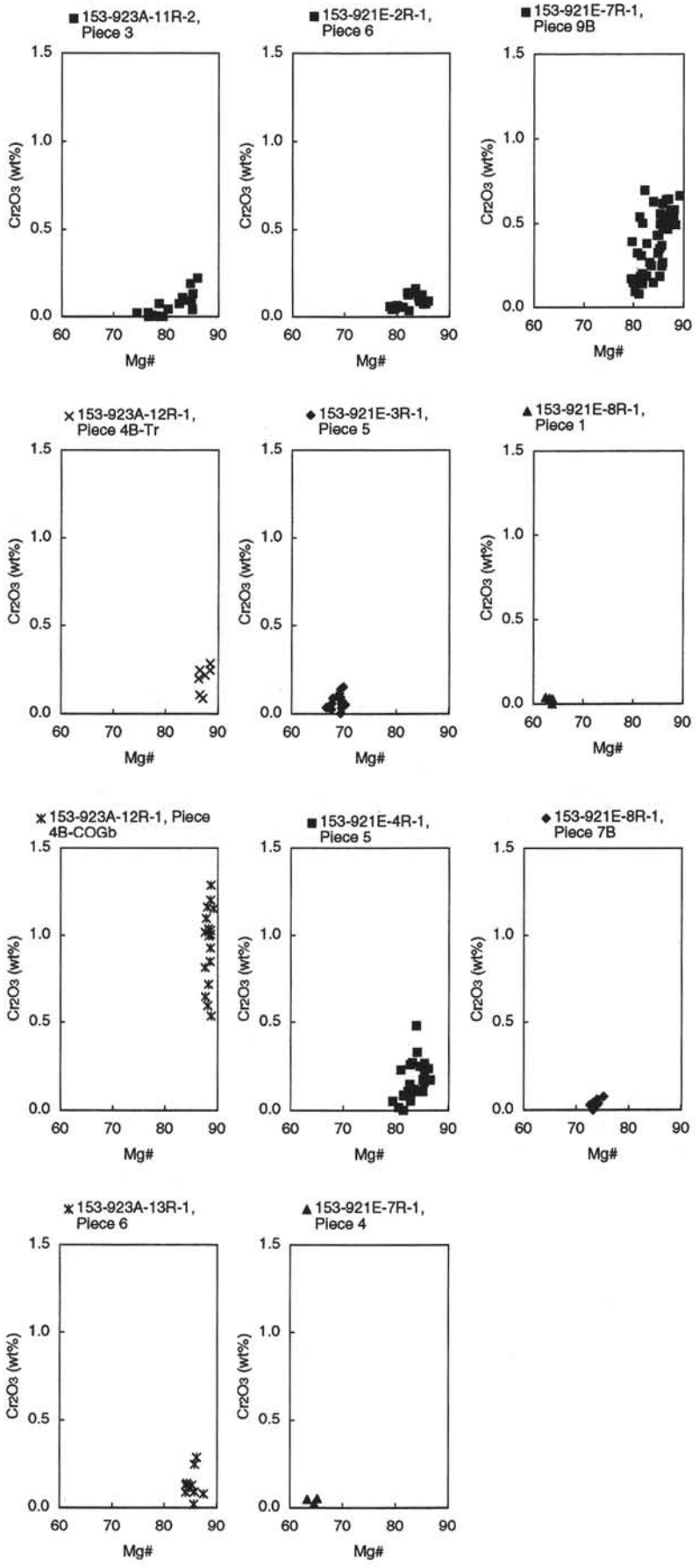

Figure 5 (continued).

Table 6. Sr- and Nd-isotope compositions for gabbroic rocks from Holes 921E and 923A.

Hole, core, section, piece no.	Rock name	Mineral	$^{87}Sr/^{86}Sr$	2σ	$^{143}Nd/^{144}Nd$	2σ
921E-8R-1, Piece 1	Quartz diorite	Pl	0.702452	9		
		Px			0.513252	29
921E-8R-1, Piece 7B	Gabbronorite	Px	0.702445	25		
923A-8R-2, Piece 1	Troctolite	Px	0.702542	22		
923A-9R-2, Piece 8A	Cpx-ol gabbro	Pl	0.702316	14		
		Px			0.513243	26
		Bulk	0.702599	16		
923A-10R-2, Piece 2A	Ol-cpx gabbro	Px	0.702403	16		
923A-10R-3, Piece 1A	Ol-cpx gabbro	Px	0.702338	13		

Notes: Cpx = clinopyroxene, Ol = olivine, Pl = plagioclase, Px = pyroxene.