chromatography, so direct comparison with out electron microprobe data should be made with caution.

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A new mantle xenolith locality from southern Ethiopia

ULTRAMAFIC xenoliths are found in basanite and nephelinite lava flows and pyroclastic rocks of probable late Pleistocene age south of Mega, in the Sidamo Region of southern Ethiopia, close to the Kenya–Ethiopia border line (Lat. 3°55′N, Long. 38°15′E) in the Anza graben (Fig. 1). The xenoliths, first reported by Jelenc (1966), comprise crustal granite and gneiss, and abundant ultramafic inclusions, up to 40 cm in diameter, and are sub-rounded ovoidal to angular. The host rocks also carry rarer feldspathic and pyroxenitic nodules as well as megacrysts, mainly of anorthoclase, clinopyroxene and amphibole. The first chemical data of the ultramafic xenoliths and host rocks are presented here.

Host rocks

The nephelinite and basanite host rocks show a porphyritic texture of olivine phenocrysts and Ti-augite microphenocrysts set in a groundmass of olivine, Ti-augite, plagioclase, opaques, subordinate nepheline and glass. Elongate vesicles with a maximum diameter up to 2.5 cm are common. Table 1 shows the chemical composition and CIPW norms of two rock samples representing the dominant host compositions, i.e. basanitic (ET 73) and nephelinitic (ET 13).

Mantle xenoliths

The ultramafic inclusions are mainly spinel lherzolite (SL) (the most abundant type), spinel harzburgite (SH) and spinel dunite with subordi-

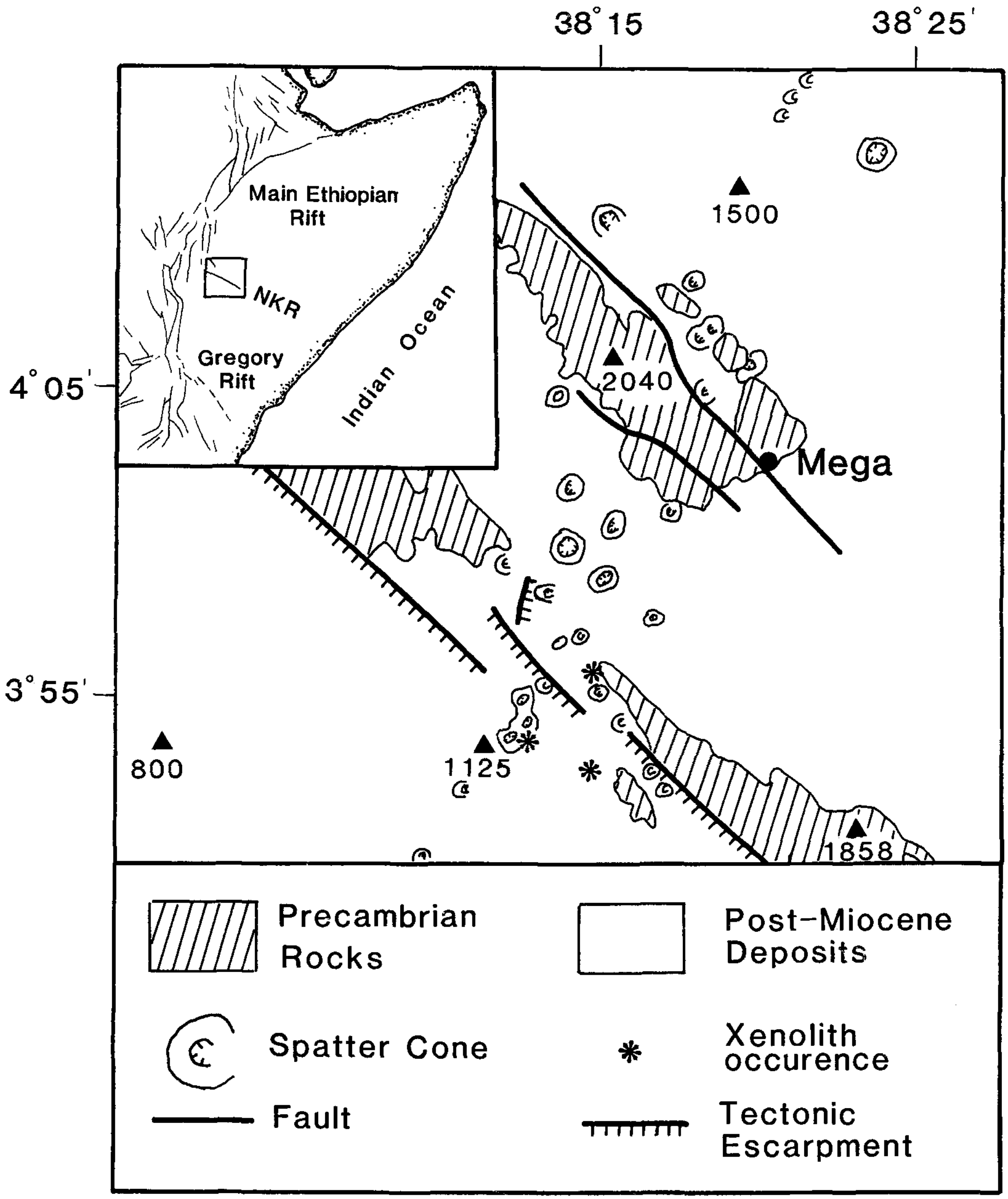

FIG. 1 Geological and structural sketch map of the study area showing the location of main xenolith occurrences (asterisks). NKR—North Kenyan Rift. The Precambrian rocks are mainly K-feldspar (±amphibole) gneisses, intruded locally by granites, now orthogneisses, with a NW–SE foliation which dips gently towards NE. The rest of the area is covered by basaltic lava flows, pyroclastic rocks and agglutinates, and by recent sedimentary rocks.

Table 1. Chemical analyses of representative host rocks.

	ET 13	ET 73	Norm+		
SiO_2	43.44	43.67	Or	9.9	8.5
TiO_2	2.02	1.99	Ab	3.3	6.2
Al_2O_3	15.35	12.24	An	10.9	14.6
Fe_2O_3*	11.82	12.22	Ne	24.8	11.5
MnO	0.18	0.18	Wo	11.5	11.0
MgO	10.28	14.84	En	7.2	7.4
CaO	8.70	8.98	Fs	3.7	2.8
Na_2O	5.81	3.25	Fo	12.9	20.6
K_2O	1.67	1.44	Fa	7.3	8.4
P_2O_5	0.72	0.54	Mt	2.0	2.1
L.O.I.	0.01	0.65	Il	3.8	3.8
Total	100.00	100.00	Ap	1.7	1.3

* Total iron as Fe_2O_3. + The C.I.P.W. norms are calculated assuming the Fe_2O_3/FeO ratio of 0.15.

nate wehrlites and clinopyroxenites. The SL and SH inclusions show a wide range of textures, i.e. coarse, coarse–equant, granuloblastic and mosaic porphyroclastic (Harte, 1977). A few nodules show a pyrometamorphic texture (Pike and Schwarzmann, 1977). The dunite nodules generally have a porphyroclastic texture with occasional spectacular large olivine crystals (up to 2.5 cm in diameter) of gem quality (Du Bois, 1976). The wehrlite and clinopyroxenite nodules show a granuloblastic texture but are of varied grain size. Under the microscope the SL and SH xenoliths show signs of post-crystalline deformation (e.g. kink-banded olivines, strained pyroxenes), subsolidus reactions (e.g. exsolution in pyroxenes), and melting episodes (e.g. interstitial glass veinlets and small glassy blebs within clinopyroxenes).

The results of electron microprobe analyses of minerals from a range of ultramafic xenoliths are presented in Table 2. The olivines are highly magnesian in SL and in SH xenoliths, i.e. Fo_{90} and Fo_{91} respectively, but less so in the wehrlites, i.e. Fo_{84}–Fo_{79}. The clinopyroxenes in the SL and SH xenoliths are Al- and Cr-rich diopsides with Ca/(Ca + Mg) ratios from 0.49 to 0.47, respectively. The clinopyroxenes from the SH xenoliths have higher Cr/(Cr + Al) ratios than those from SL xenoliths and still higher than those from wehrlite xenoliths. The relatively high 'fertility' of the SL xenoliths is indicated by high TiO_2, Na_2O and Al_2O_3, and low Cr/(Cr + Al) ratio. The spinels in the SL and SH xenoliths are quite different, i.e. their Cr/(Cr + Al) ratios are 0.09 and 0.92, respectively. The temperatures of equilibration, using the two pyroxene geother-

Table 2. Mineral chemistry of ultramafic xenoliths, Sidamo Region, southern Ethiopia.

	ET 2				ET 19				ET 6		ET 18	
	ol	opx	cpx	sp	ol	opx	cpx	sp	ol	cpx	ol	cpx
SiO_2	41.05	55.75	52.40	-	40.89	56.29	53.30	-	39.75	49.23	38.83	48.53
TiO_2	-	-	0.35	-	-	0.02	0.08	-	-	1.21	-	1.10
Al_2O_3	-	4.09	6.34	60.09	-	2.63	4.43	24.60	-	8.03	-	8.06
Cr_2O_3	-	0.23	0.73	8.50	-	0.52	1.64	45.19	-	0.35	-	0.52
FeO*	10.14	6.41	2.36	9.96	8.49	5.32	2.27	13.31	15.22	4.19	20.14	5.48
MnO	0.23	0.19	0.12	0.06	0.11	0.15	0.08	-	0.26	0.03	0.25	0.08
MgO	49.52	33.58	15.51	21.97	50.88	34.77	16.05	17.26	45.08	14.55	41.73	14.56
CaO	-	0.44	21.30	-	-	0.57	20.02	-	-	21.94	0.02	20.05
Na_2O	-	0.41	1.60	-	-	0.47	1.77	-	-	0.75	-	1.07
K_2O	-	-	-	-	-	-	0.03	-	-	-	-	-
Total	100.94	101.10	100.71	100.58	100.37	100.74	99.67	100.36	100.31	100.28	100.97	99.45
Atom %												
Ca		1	49			1	46			50		48
Mg	90	92	50		91	95	52		84	46	79	48
Fe	10	7	1		9	4	2		16	4	21	4
Ca/(Ca+Mg)			0.49				0.47			0.52		0.50
Cr/(Cr+Al)			0.07	0.09			0.20	0.92		0.03		0.04

ET2: spinel lherzolite. ET19: spinel harzburgite. ET6: coarse-grained wehrlite. ET18: fine-grained wehrlite. * Total iron as FeO.

mometers (Wood and Banno, 1973; Wells, 1977; Lindsley and Anderson, 1983) range from 900–1100 °C.

Comparison with Kenyan occurrences

Fig. 1 shows the regional structure. Precambrian rocks are bounded by a system of NW-trending faults and dissected by a NNE-trending volcanic belt. Faulting separates the Ethiopian plateau to the north from the Main Kenyan Rift to the south. From Landsat MSS images the volcanic belt is seen to extend southward as far as equatorial latitudes, and links with the Ndonyuo Olnchoro xenolith occurrence.

As with many other occurrences of mantle xenoliths all over the world (Nixon, 1987), the Sidamo nodules range in composition from spinel lherzolite to spinel dunie via spinel harzburgite. This may indicate different degrees of fertility of the mantle as suggested also by the varying Cr/(Cr + Al) ratios of the spinels (Morten *et al.*, 1989). In comparison with xenoliths in alkaline rocks from a similar graben-related area, i.e. Ndonyuo Olnchoro, Central Kenya (Suwa *et al.*, 1975), the Ethiopian suite of xenoliths consists of a wider variety of nodule-types. The former is composed only of spinel lherzolite, spinel harzburgite and websterite xenoliths. In both suites, the spinel lherzolite and harzburgite nodules have suffered similar postcrytalline and subsolidus history. A comparison of the mineral chemistry of the spinel lherzolite and harzburgite xenoliths, shows that the Kenyan samples contain olivines with higher Fo content, orthopyroxenes more depleted in Al_2O_3 and Cr_2O_3, and clinopyroxenes relatively depleted in Al_2O_3, Na_2O, TiO_2 and Cr_2O_3 with lower Ca/(Ca + Mg) ratios. The spinels have higher Cr/(Cr + Al) ratios. From the small number of Ethiopian xenoliths so far analysed, this suggests that the Kenyan lherzolite and harzburgite xenoliths are relatively more depleted than the Ethiopian ones.

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