MANTLE XENOLITHS FROM SOUTHEASTERN NEW ENGLAND

B.D. LEAVY (Department of Geology, University of Rhode Island, Kingston, Rhode Island, 02881).
O.D. HERMES (Department of Geology, University of Rhode Island, Kingston, Rhode Island, 02881).

We have identified a suite of ultramafic nodules that are enclosed in mafic dikes that intrude granites near Westerly, Rhode Island. Xenoliths include lherzolites, harzburgites, and wehrlites, all of which are rock types that are believed to represent accidental samples of the upper mantle. In addition, there are megacrysts of olivine, pyroxenes, and several types of presumed crustal fragments. To our knowledge, this is the first documented occurrence of such rocks in southeastern New England.

The dikes dip vertically and appear to follow a prominent regional joint trend (N25E). They cross-cut both the Narragansett Pier and Westerly Granites, both generally accepted to be of late Paleozoic Age. Xenolith abundance appears to be controlled both by dike width and by position within the dikes; they are sparse at dike margins and in constricted areas, but where dike width is greatest they may comprise up to 70 percent of the rock.

Alteration of the host dikes is common. Relict primary phases include titaniferous augite, kaersutitic amphibole, biotite, and opaque minerals (Table 1). The presence of the secondary minerals serpentine, calcite, and chlorite makes it difficult to determine the primary chemical composition. However, whole-rock and mineral compositions (Table 1) indicate affinites to alkalic basaltic rocks, lamprophyres, monchiquites, or even kimberlites. The titaniferous augite and kaersutitic amphibole present in the Westerly dikes is similar to that common to alkalic basalts or basanites (MacDonald and Katsura, 1964).

The ultramafic xenoliths enclosed in these dikes are subrounded, and up to 8 cm. in longest dimension. At least two major textural varieties are present; 1) a coarse granular type, and 2) a tectonite type. Both varieties display foliation similar to the metamorphic textures common to xenolith suites of presumed mantle origin (Pike and Schwarzman, 1977).

The granular types include spinel lherzolites and spinel harzburgites; major minerals include olivine, orthopyroxene, clinopyroxene, and a Cr-rich spinel (Table 1). Pargasitic amphibole is also present, but not common. The tectonite types are wehrlites, composed of large porphyroclasts of olivine and clinopyroxene surrounded by a fine-grained recrystallized matrix of the same minerals. Spinel grains are elongated, but appear to have resisted recrystallization. A red-stain, probably iddingsite, coats grain margins in the wehrlites.

Bulk chemistry of these nodules (Table 1) is comparable with that of mantle xenoliths worldwide, and the range of nodule types contained in the Westerly suite is likewise similar to that reported for other localities. A $MgO/\Sigma Fe = FeO$ of 5.20 is within the range (6.57 - 2.28) reported for most periodite nodules from basalts (Kuno and Aoki, 1970); this ratio is somewhat lower than that for continental peridotites, but is comparable to nodule suites from oceanic rocks (Suwa, et al., 1975).

Representative microprobe analyses of minerals from the lherzolite nodules are shown in Table 1. Mineral chemistry is simmilar to published data for comparable peridotite xenoliths from other regions. Compositions are relatively homogeneous from nodule to nodule, grain to grain, and within grains, as well as between rock types. Only spinel displays significant chemical variation (Cr_2O_3 11-35%, Al_2O_3 20-35%). Based on the chemistry of coexistent pyroxenes, preliminary estimates of temperatures and pressures of final equilibration are within the range 1000-1200 °C, 15-20 kb. This places them slightly above the estimated P-T conditions for an oceanic geotherm (Mercier and Carter, 1975), and may reflect the disturbance of such a gradient by a period of epeirogenic doming following a tectonic episode, such as the Allegheny orogeny. Dikes similar to the host rocks are associated with major granitic intrusions elsewhere, such as the Appinite-Newer Granites association of Northern Ireland and Scotland (Carmichael, et al., 1974); this sort of cogenetic relationship may exist between the Westerly dikes and the Narragansett Pier Granite.

The possible relationship of these dikes with a major tectonic episode is also suggested by the coincidence of the trend of the dikes with that of regional jointing and faulting, and that of the Mesozoic diabase dikes which are common in this part of New England. The trend of these diabase dikes has been attributed to a stress field associated with the last opening of the Atlantic Ocean (May, 1971). It is possible that such a deep-seated stress field could have mobilized upper mantle as represented by the nodule suite.

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TABLE 1: REPRESENTATIVE CHEMICAL ANALYSES OF ROCKS AND MINERALS FROM THE WESTERLY DIKES.

Wt. %	1	2	3	4	5	6	7	8	9	10
SiO_2	37.99	43.45	41.11	39.30	37.94	40.49	55.64	52.44	0.00	42.07
TiO_2	1.90	0.03	0.00	6.98	7.50	0.03	0.07	0.30	0.18	2.17
Al_2O_3	4.67	1.66	0.00	11.50	13.86	0.03	3.46	5.46	47.83	12.71
Cr_2O_3	0.11	0.11	0.00	0.01	0.01	0.03	0.29	0.39	20.35	7.22
Fe_2O_3	5.44	1.37	*	*	*	*	*	*	*	*
FeO	8.05	6.44	7.43	8.07	10.65	8.89	5.48	2.99	11.99	3.56
MnO	0.19	0.13	0.09	0.10	0.20	0.16	0.12	0.11	0.18	0.21
MgO	28.91	42.27	50.70	9.96	12.20	50.01	34.16	15.78	18.93	18.07
CaO	5.75	1.75	0.02	23.04	12.12	0.04	0.63	20.37	0.02	11.20
Na_2O	1.15	0.33	0.01	0.61	2.08	0.02	0.07	1.54	0.04	3.65
K_2O	0.46	0.11	0.00	0.07	1.68	0.32	0.00	0.00	0.00	0.14
NiO	0.18	0.38	0.00	0.00	0.00	0.27	n.d.	n.d.	0.29	n.d.
H_2O+	3.69	0.39	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
H_2O-	0.52	0.05	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
P_2O_5	0.30	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CO_2	0.57	1.36	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
TOTAL	99.89	99.84	99.36	99.64	98.24	100.19	99.96	99.93	99.81	96.00
$\Sigma Fe = FeO$	12.06	8.13	7.43	8.07	10.65	8.89	5.48	2.99	11.99	3.56
$MgO/\Sigma FeO$	2.48	5.20	6.82	1.23	1.20	5.63	6.23	5.28	1.58	5.03

*ΣFe = FeO

1.) Representative bulk composition of dike groundmass
2.) Representative bulk composition of ultramafic xenoliths
3.) Representative mineral microprobe analysis, groundmass olivine megacryst
4.) " groundmass clinopyroxene
5.) " groundmass amphibole
6.) " nodule olivine
7.) " nodule orthopyroxene
8.) " nodule clinopyroxene
9.) " nodule spinel
10.) " nodule amphibole