

xenoliths from several localities to determine local geotherms, after making assumptions about the activities of various components in the natural solid solutions. Results on southern African peridotites compare favorably with pressure estimates made by independent geobarometers and with calculated continental conduction geotherms. Results from southwestern United States, however, indicate that the geotherm is elevated, though not to the extent of mid-ocean ridge convection geotherms. This may be due to an intermediate thermal state, involving both convection and conduction, resulting from the slow rate of spreading occurring along the Rio Grande Rift.

D4

GARNET LHERZOLITES FROM THE HANAUS-I AND LOUWRENSIA KIMBERLITES, NAMIBIA

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The Gibeon cluster of Namibian kimberlites is emplaced into the Orange River Belt which has accreted to the Transvaal craton. These "off-craton" kimberlites are non-diamondiferous and are younger than the diamond bearing "on-craton" kimberlites. The Hanaus-I and Louwrensia kimberlites each contain a bimodal suite of upper mantle-derived garnet lherzolite xenoliths characterized by a coarse granular or a porphyroclastic-mosaic texture. The Louwrensia pipe in addition contains garnet harzburgites in which the orthopyroxenes have exsolved lamellar clinopyroxenes. Deformed lherzolites are not iron-enriched relative to the deformation-free types. Temperatures and pressures of equilibration calculated by the Wells-Wood method are from 915-1050°C at 27-36 kb and 915-1010°C at 29-41 kb for coarse lherzolites from Hanaus and Louwrensia respectively, and from 1000-1225°C at 26-39 kb and 1010-1125°C at 33-34 kb for porphyroclastic-mosaic types from Hanaus and Louwrensia respectively. The coarse types from both localities have similar equilibration P and T's to coarse lherzolites from on-craton kimberlites and plot on the lower non-inflected limb of the South African continental shield "paleogeotherm" defined by such lherzolites. The deformed lherzolites plot randomly above this geotherm and do not define an inflected limb. These higher equilibration temperatures are considered to be due to heating, shearing and recrystallization of mantle during kimberlite formation. The lherzolite mineral compositions and equilibration conditions indicate that the Namibian kimberlites have been derived from similar depths to on-craton kimberlites and have incorporated similar mantle material. The lack of diamonds is not a consequence of derivation from atypical mantle or from regions with an unusual geothermal gradient.

D5

GARNET PERIDOTITES FROM WILLIAMS KIMBERLITES, NORTH-CENTRAL MONTANA, USA

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Two Williams kimberlites, 250x350m and 37x390m, in the eastern part of a swarm of 30 middle Eo-

cene alnoitic diatremes, contain xenoliths of garnet-bearing lherzolites, harzburgites and dunites. Temperatures were calculated by the Lindsley-Dixon 20 kb method for lherzolites and by the O'Neill-Wood method for harzburgites and dunites and pressures were calculated by the MacGregor method, or were assumed to be 50 kb for dunites. Most peridotites equilibrated at 1220-1350°C and 50-60 kb, well above a 44 mW/m² shield geotherm and on or at higher P than the graphite-diamond boundary. Three lherzolites show low T-P (830-940°C, 23-42 kb) and are close to the shield geotherm. All three low T-P lherzolites have coarse texture whereas the high T-P cluster has both coarse and porphyroclastic textures, indicating a range of conditions of deformation and recrystallization in a restricted high T-P range. Maximum size of large strained olivines is as much as 2 cm. The tiny size (0.1-0.2 mm) of granulated and euhedral olivines in several xenoliths shows that deformation was occurring just prior to incorporation in kimberlite and that ascent was rapid enough to retard further coarsening of fine-grained olivine. For other high T-P peridotites, cessation of deformation before inclusion in kimberlite is suggested by larger (2mm) euhedral olivines in a matrix of fine granulated olivine or by optical continuity of large and nearby small olivines. Two low T-P lherzolites contain 5-8mm clots of moderate-Cr garnet + Cr-spinel + Cr-diopside inferred to form by reaction of an initial high-Cr garnet brought into the garnet-spinel stability field. This suggests a slower ascent or pause in ascent, compared with other peridotites containing inclusion-free, high-Cr garnets. Textural and compositional variations of peridotites are compatible with kimberlite generation and ascent during dynamic diapiric perturbation of the upper mantle.

D6

MANTLE GARNET-SPINEL TRANSITION ZONE DEMONSTRATED BY XENOLITHS FROM COLORADO-WYOMING KIMBERLITES

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Two groups of xenoliths containing coexisting garnet and spinel have been recovered from Colorado-Wyoming kimberlites. The first group consists of pyroxenites with coarse-grained, pale green, aluminous spinel that is relatively Mg-rich and Cr-poor. Garnet in these xenoliths appears to be exsolved from aluminous pyroxene, and occurs as lamellae and as grain boundary rims surrounding pyroxenes and spinels. Xenoliths of the second group are peridotites containing fine-grained vermicular, reddish-brown spinel that is more enriched in Fe and Cr relative to Al. Some garnet in these nodules also occurs as exsolution lamellae in pyroxene, but most engulfs spinel and probably formed by the reaction *orthopyroxene + clinopyroxene + spinel = olivine + garnet* as suggested by MacGregor (1970). Utilizing MacGregor's (1974) orthopyroxene geobarometer, mineral equilibration depths of 50-100 km and 25-60 km have been calculated for the peridotite and pyroxenite xenoliths, respectively. Temperature estimates range between 590-800°C. Garnet in both xenolith groups apparently formed during or immediately prior to kimberlite emplacement and the

resulting metastable textures probably owe their preservation to the relatively rapid transport of nodules to the surface in kimberlite magma. Garnet exsolution from pyroxene could have been facilitated by decreased temperatures accompanying kimberlite cooling. Formation of peridotite suite garnet by the above pyroxene-spinel reaction also may have been induced by decreasing temperatures; however, locally higher pressures possibly associated with tectonic adjustments related to intrusion of kimberlite may have perturbed the garnet-spinel phase boundary triggering crystallization of garnet at shallower mantle depths. (Study supported by Earth Sciences Section of NSF, Contract EAR-7810775)

D7

GARNET-PYROXENITES ASSOCIATED WITH THE ULTRAMAFIC ROCKS: ECLOGITES, ARIEGITES, GRIQUAITES OR GROSPYDITES?

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Garnet(py-al) + clinopyroxene associations related to metamorphic rocks were termed "eclogites" by Hauy (1822). This appellation designates also various gt-cpx assemblages related to ultramafic bodies or xenoliths. So the same appellation classifies different types of gt-cpx bearing rocks whereas different names are still used to qualify the same class of rocks. It is suggested:

1- To keep "eclogite" for rocks associated with high-pressure/low-temperature metamorphic units. Most of them are saturated in silica and the clinopyroxene is Jd-rich and Ca-Ts-poor. Silica undersaturated compositions may involve corundum in their parageneses.

2- To consider the high pressure/ high temperature gt-cpx rocks:

a) As "ariegites" when orthopyroxene and spinel are also abundant phases. The ariegites, characterizing the high pressure subfacies of spinel-lherzolite facies (O'Hara, 1967), would breakdown at higher pressure to give gt-harzburgerites or -wehrlites.

b) As "griquaites" when clinopyroxene and garnet are the main phases (plus or minus spinel). The griquaites equilibrated in the ariegite subfacies as well as in the garnet-lherzolite facies.

c) As "grosphydites" when garnet and clinopyroxene are associated with kyanite and/or corundum. Such rocks are characterized by Ca-rich garnet with Ca-Ts and Jd-rich clinopyroxene; giving a larger acceptance to this word than previously defined by Bobriyevich et al. (1960), the grosphydites would involve most of corundum and kyanite eclogites associated with kimberlites. They crystallized at very high pressure in the ariegite subfacies or in the garnet-lherzolite facies.

D8

PETROLOGY OF A SUITE OF ECLOGITE INCLUSIONS FROM THE BOBBEJAAN MINE, SOUTH AFRICA:

I. MAJOR PHASE CHEMISTRY

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A suite of more than forty eclogite samples from the Bobbejaan kimberlite, near Bellsbank, South Africa, has been examined in thin section and major phases have been analysed by electron microprobe. Most samples are biminerallitic eclogites, although a few contain up to 20% apparently primary phlogopite. Primary accessory phases include sulfides (pyrrhotite, pentlandite, chalcopyrite), kyanite, rutile, and graphite. Also, two corundum grosphydites are described in a companion paper.

Some systematic trends are observed in the major-element chemistry of the principal phases.

1) The more calcic garnets occur with the more aluminous clinopyroxenes, and conversely, the more Fe- and Mg-rich garnets occur with the more aluminum-poor clinopyroxenes.

2) When temperatures are estimated from the Fe-Mg distribution between garnet and clinopyroxene, the highest apparent temperatures correlate with the highest Fe contents of both clinopyroxene and garnet, and the lowest temperatures correlate with the most calcic garnets and aluminous clinopyroxenes.

It is postulated that these inclusions are a suite (or suites) of igneous eclogites derived by magmatic differentiation at pressures between 25 and 40 Kbar. If this is true, the generalized chemical trends observed may be representative of high pressure differentiation within the alkali basalt system.

D9

PETROLOGY OF A SUITE OF ECLOGITE INCLUSIONS FROM THE BOBBEJAAN MINE, SOUTH AFRICA:

II. TWO UNIQUE CORUNDUM GROSPYDITES

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Two small corundum grosphydite inclusions from the Bobbejaan kimberlite, near Bellsbank South Africa, have been observed in thin section and analyzed by electron microprobe. One sample (SBB-2H) contains approximately 60% garnet ($\text{Gr}_{48}\text{Py}_{37}\text{Alm}_{15}$), 35% clinopyroxene ($\text{Jd}_{52}\text{Di}_{39}\text{CaTs}_7$), 5% kyanite, and less than one percent corundum. The second (SBB-3P) contains 58% garnet ($\text{Gr}_{48}\text{Py}_{37}\text{Alm}_{16}$), 25% clinopyroxene ($\text{Jd}_{55}\text{Di}_{36}\text{CaTs}_9$), 14% kyanite, and 3% corundum. In both samples most corundum is observed as inclusions in kyanite, but in the second sample it is also observed as inclusions in garnet. In neither sample is corundum observed in contact with pyroxene.

In this second sample clinopyroxenes are observed to include lamellae of both kyanite and garnet in an apparent exsolution texture. If the kyanite and garnet lamellae in this clinopyroxene were once a single pyroxene, it would have a composition of approximately 30% $\text{CaAl}_2\text{Si}_4\text{O}_{12}$, 40% jadeite, and 20% diopside. Such pyroxene compositions have not been reported in kimberlite eclogites but may be stable at pressures in excess of 40 Kbar.

It is postulated that these two grosphydites formed by magmatic differentiation within the eclogite system at pressures between 40 and 60 Kbar and subsequently re-equilibrated at pressures between 25 and 35 Kbar. The initial phases were garnet, clinopyroxene, and corundum, plus possible kyanite. Breakdown of the $\text{CaAl}_2\text{Si}_4\text{O}_{12}$ -rich pyroxene to form clino-