F Crust-mantle transition

F1

THE NATURE OF THE LOWER CRUST/UPPER MANTLE TRANSITION IN EASTERN AUSTRALIA – EVIDENCE FROM ECLOGITE AND GRANULITE XENOLITHS IN BASALTIC ROCKS

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Lower crustal xenoliths occurring in basaltic rocks range from garnet-bearing granulites and eclogites, through pyroxenites, amphibole-rich metagabbros to felsic metamorphic rocks. Contact relationships between different rock types suggest a complex petrogenesis including multiple intrusive, metasomatic and metamorphic events. Unaltered spinel therzolite, typical of "normal" eastern Australian upper mantle, is interleaved with or veined by eclogitic and granulitic rocks. Geobarometry using a variety of methods yields equilibration pressures for different xenoliths ranging from 12-18 kb. Geothermometry gives ranges of different xenoliths from 850° to 950°c. These physical parameters suggest the eastern Australian crust may be up to 60 km thick and has sustained a high geothermal gradient.

The nature of the mineral assemblages and the contact relationships suggest that the Moho is not a discrete feature, but is represented by a transition zone over approximately 20 km. This is in agreement with geophysical parameters (mainly seismic velocities) determined for this region.

The geochemistry of the lower crustal xenoliths suggests they originated as underplating of the crust by continental-type basaltic magmas. It is postulated that such addition of basaltic magma to the lower crust may represent an important alternative or additional mechanism to the conventional andesite model for crustal accretion.

F2

PERIDOTITE NODULES FROM THE NOGPETSEU AND LIPELANENG KIMBERLITES, LESOTHO: A CRUSTAL OR MANTLE ORIGIN.

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Observed variations in both whole rock and mineral chemistries have lead to the recognition of four groups of peridotite nodule samples in these kimberlites, which overall contain an unusually high proportion of spinel bearing garnet free peridotites. Equilibration temperatures estimated from various mineral equilibria, together with general geochemical considerations, strongly suggest that Group 1 (dunitic spinel wehrlite/lherzolite) and Group 2 (more 'fertile' spinel lherzolite) nodules are of lower crustal origin. However, Group 3 ('depleted' spinel lherzolite/harzburgite) and Group 4 ('depleted' garnet harzburgite) nodules are considered to have had progressively deeper upper mantle origins. The implication is therefore of a Cr-spinel (Y_{Cr}^{Sp} = 0.25-0.48) peridotite zone at the top of the mantle section sampled by these kimberlites. Such rocks mostly show subsolidus deformation and recrystallisation effects leading to the development of mosaic and symplektite textures. Element partition considerations indicate that such textures have developed during cooling from an earlier temperature maximum.

F3

MANTLE AND LOWER CRUSTAL XENOLITHS FROM KIMBERLITES OF THE CENTRAL CAPE PROVINCE, R.S.A.

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In the central Cape Province Cretaceous-age kimberlites are intruded on a regional scale through postulated Namaqua mobile belt basement (1000 m.y.), that forms the southern fringes to the Kaapvaal craton. These kimberlites are non-diamondiferous. Mantle-derived peridotite and pyroxenite xenoliths are found together with lower crustal eclogites and garnet granulites in these kimberlites. The peridotites are inferred to have equilibrated at lower P,T's than similar xenoliths in kimberlites of the Kaapvaal craton. The lower crustal suite is believed to have equilibrated during high grade metamorphism accompanying Namaqua tectogenesis. Geochemical data are presented for the different xenolith suites.

F4

Nd- AND Sr-ISOTOPE STUDIES ON CRUSTAL XENOLITHS FROM SOUTHERN AFRICA

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The presence of crustal xenoliths in kimberlite pipes across much of southern Africa offers a unique opportunity to determine the horizontal, and, in some areas, the vertical dimensions of segments of continental crust of different ages. Particular questions include the balance between new and reworked crustal material in the Proterozoic mobile belts, whether the Archaean cratonic nucleii are underplated by a younger lower crust, and possible relationships between stabilisation of the crust and events in the uppermost continental mantle.

Ten samples of predominantly basic granulites from Lesotho kimberlites scatter about a whole rock Sm-Nd errorchron corresponding to an age of 1.4±.1 Ga, with an initial $^{143}Nd/^{144}Nd$ ratio slightly higher than CHUR at that time. The remaining five samples plot above that errorchron suggesting that they either represent younger material, or they were derived from a more depleted source region. In either case 1.4 Ga is the best estimate for the maximum age of the lower crust beneath Lesotho. Granite- and paragneiss xenoliths from Kimberley and two granulite facies metasediments from near Kroonstadt yield model Nd (T^{Nd}_{CHUR}) ages of 2.9-2.4 Ga, consistent with their position on the Archaean craton. However, seven of the eight samples analysed of both upper and lower crustal material from pipes in the Namagua Mobile Belt have Proterozoic model Nd ages (1.0-1.5 Ga) and only one contains any indication of a longer crustal residence time. The available evidence suggests that a considerable volume of new crust was generated in the Late Proterozoic, and that upper mantle heterogeneities of that age were subsequently sampled both by Karoo magmatism and kimberlite emplacement.

F5

BASAL CRUST (?) FROM LASHAINE, E. AFRICA.

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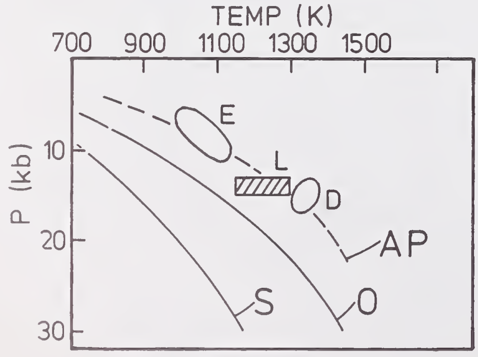
Detailed petrographic and mineralogical studies of a suite of basic garnet-plagioclase-clinopyroxenites, websterites and garnet anorthosite,



indicate equilibration under P-T conditions of 1150-1300 K and 1.3-1.5 GPa. Within the uncertainties of the thermometers and barometers, all of the xenoliths may have come from the same restricted zone in the lithosphere; resembling a suite of olivine-normative metagabbros. The pressure estimates are consistent with the presence of kyanite needles in every sample bearing plagioclase, and indicate derivation from the deepest parts of the crust; assumed to be 35-40 km in this part of Africa.

The calculated temperature (1200 K) for the Lashaine granulites lies well above temperatures at ∿1.4 GPa predicted from a standard shield (S) geotherm (850 K) and even an oceanic (O) geotherm (1060 K). A new "alkaline province" (AP) geotherm is proposed, based on well constrained P-T estimates for granulite xenoliths from Delegate (D), Engeln (E) and Lashaine (L).

F6

LOWER CRUSTAL XENOLITHS FROM COLORADO-WYOMING STATE LINE KIMBERLITES

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Granulite facies xenoliths recovered from kimberlite in the state line district of northern Colorado and southern Wyoming are primarily anorthosite, leuconorite, norite, gabbronorite, hypersthene, granulite, two pyroxene granulite, two pyroxene garnet granulite, and clinopyroxene garnet granulite. No known granulite facies rocks are exposed in this area and the entire nodule population is interpreted as lower crustal in origin. The most abundant groups of lower crustal xenoliths are mafic garnet granulites in which allotriomorphic granular and cumulate textures are obscured by symplectites and coronas produced by late subsolidus reactions and exsolution. Continuous modal variation occurs between the garnet granulites and garnet clinopyroxenite or eclogite as orthopyroxene and plagioclase are eliminated.

Garnet-clinopyroxene equilibration temperatures of 570 - 690°C were obtained for the garnet granulites using the method of Raheim and Green (1974). Based on experimental work of Green and Ringwood (1972), equilibration pressures for the garnet granulites are estimated to fall in a range of 10-18 Kb. suggesting depths of approximately 30-55 km. Normative compositions of the mafic granulites are mostly equivalent to quartz tholeiite and olivine tholeiite. The mineralogy of the nodule suite suggests that the lower crust in the Colorado-Wyoming state line region is a predominantly mafic igneous-metamorphic complex. (Study supported by Earth Sciences Section of NSF, Contract EAR-7810775)

F7

THE IVREA ZONE, AN EXAMPLE OF THE EVOLUTION OF DEEP CONTINENTAL CRUST

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Seismic and gravimetric studies have shown that the MOHO-discontinuity rises from a depth of about 30 km up to 3 km in the Ivrea