F4

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

*C.J. HAWKESWORTH*, N.W ROGERS, P W. VAN CALSTEREN, M A. MENZIES, D.L. REID
Department of earth Sciences Open University, Walton Hall, Milton Keynes, MK7 6AA, U.K.

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 ($T_{CHUR}^{Nd}$) 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.

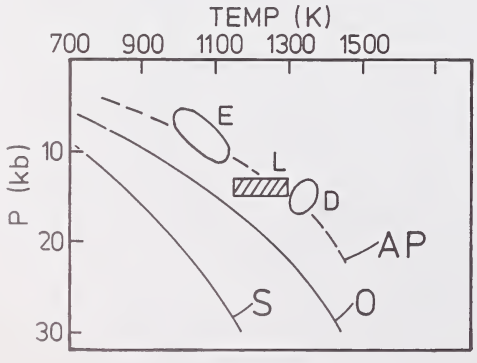
F5

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

*A.P. JONES*, J.V. SMITH, E.C. HANSEN, J.B. DAWSON
Department of Geophysical Sciences, University of Chicago, Chicago IL 60637 U.S.A.

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

*S.D. BRADLEY* and M.E. McCALLUM,
Department of Earth Resources, Colorado State University, Fort Collins, Colorado 80523

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

*A. ZINGG* and J.C. HUNZIKER
Geologisches Institut, Bernoullistr. 32 CH-4056 Basel, Switzerland

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

zone region (e.g.Berckhemer 1968), giving us the opportunity to study a segment of deepest continental crust. The Ivrea zone consists mainly of amphibolite to granulite facies pelitic and mafic rocks. Spinel-peridotites are restricted to the highest grade part adjacent to the Insubric Line. The peak of metamorphism is considered to be due to the advective heat associated with these mafic-ultramafic intrusions. The metapelites show a considerable amount of partial melting and the so-called stronalithes (=granulite facies metapelites) are regarded as restites produced by "degranitization" of the metapelites (Schmid 1978). Rb-Sr determinations on restites and neosome, 30-50kg samples, give a 478±20 m.y. age, dating approximatly the peak of metamorphism (Hunziker and Zingg 1980). During this thermal event at least two phases of deformation can be discerned. Subsequent, cooling was very slow (≤2°C/m.y.) and high-T conditions lasted into Hercynian time as can be demonstrated in the phlogopite-peridotite of Finero (Hunziker and others, this conference). During this period of slow cooling, few retrograde, discontinuos reactions occur. However considerable retrograde cation exchange between neighbouring mineral grains is observed. Using T-estimates, the end of this retrograde cation exchange might be correlated with Rb-Sr data. Band isochrons yielding ages of approximately 350 m.y. give the end of Sr exchange at the cm scale.

## F8

## EMPLACEMENT AND CRUSTAL CONTAMINATION OF THE PERIDOTITES IN THE IVREA-ZONE

J.C. HUNZIKER, A. STECK, G. RIVALENTI, I. MERCOLLI and A. ZINGG
Min.-Petr. Institut, 1. Baltzerstr. 3012 Bern

Based on structural work combined with Rb-Sr, K-Ar, as well as main and trace element analysis on basic and ultrabasic rocks of the Ivrea zone, a multistage emplacement history of the peridotites must be postulated. A first granulite facies episode with at least 3 deformation phases is followed by a second amphibolite facies episode ending with a mylonisation; followed by a third episode of green schist facies deformation of presumably Alpine age.

Structural work shows that the peridotites already underwent a first deformation of lower Paleozoic age under granulite facies conditions, together with the surrounding metapelites. 2 different peridotites occuring in one and the same body can be distinguished. Hornblende peridotites and the different peridotites containing no phlogopite are characterized by low $^{87}Sr/^{86}Sr$ initial values around .7025 -.7035. (The same lOw87/86 ratios are found for the cogenetic gabbros), by Rb/Sr ratios lower than .02 and by high K/Rb ratios above 1000. On the other hand phlogopite peridotites have crustal Rb/Sr ratios between .2 and 2.0 and crustal K/Rb ratios around 250. These rocks revealed a Rb-Sr whole rock isochron with an age of 305± 10 m.y. and an initial $^{87}Sr/^{86}Sr$ ratio of .7062±5 (cogenetic gabbros show even higher Sr ratios). The analytical data of the phlogopite peridotite so far point to a crustal contamination, that according to structural criteria must have taken place at the end of the granulite facies episode.

Combining our Rb/Sr data on phlogopites as well as whole rocks, we can extrapolate from the present day $^{87}Sr/^{86}Sr$ ratio of the phlogopites over the initial ratio of the peridotite isochron 305 m.y. ago to the assumed Sr evolution curve of the mantle and the intersection of the two evolution curves, marks the time of the Sr contamination around 350 m.y. ago. This time mark coincides with the end of the small scale Sr homogenisation in the surrounding metapelites.

## F9

## PRE-ALPINE AMPHIBOLITE-FACIES METAMORPHISM IN SHEARED GABBROS OF THE ULTRAMAFIC LANZO MASSIF (INTERNAL WESTERN ALPS)

R. COMPAGNONI, *F. RADICATI di BROZOLO*, R. SANDRONE
Centro Studio Orogeno Alpi Occidentali, CNR, Via Accademia Scienze 5, 10123 Torino, Italy

The Lanzo Massif, one of the largest ultramafic bodies of the Alps, consists of a spinel/plagioclase lherzolitic core, with minor harzburgite and dunite, surrounded by serpentinized lherzolite and antigorite serpentinite (1). This massif, commonly considered as deriving from the upper mantle originally underlying the Insubric Plate, is now considered, due to the discovery of widespread early-Alpine H-P eclogitic parageneses, as part of the Western Alps ophiolitic belt (2). Within the peridotitic core, besides the well described gabbro and diabase dykes (3), a special type of mylonitic gabbro has been found, which is characterized by the presence of dark brown hornblende. The gabbro shows a polyphase pattern of HT deformation, and consists of olivine, clinopyroxene, orthopyroxene, plagioclase, ilmenite, apatite and brown hornblende (kaersutite to Mg-hornblende). Locally plagioclase is converted to jadeitic pyroxene + zoisite + quartz assemblage. Reconnaissance K-Ar dating was attempted on brown hornblende separates from the mylonitic bands. The apparent ages obtained range from 440 m.y. to 1650 m.y. and are most probably due to variable amounts of excess 40 Ar. The data do not fit on an isochron and no reliable age for the hornblendes can therefore be calculated. It is interesting to note that model Sm-Nd and Rb-Sr ages for Lanzo (4) fall in the same range. New dating experiments are needed to solve this problem.

Refs.: (1) NICOLAS, Thesis, Nantes, 299 p., 1966; (2) COMPAGNONI & SANDRONE, Rend. S.I.M.P., 35, 842, 1979; (3) BOUDIER, Thesis, Nantes, 163 p., 1976; (4) RICHARD & ALLEGRE, E.P.S.L., 47, 65-74, 1980.

## F10

## OROGENIC LHERZOLITES AS WITNESS OF MANTLE CONVECTION

*M. POLVE* and C.J. ALLEGRE
Laboratoire de Géochimie-Cosmochimie, Institut de Physique du Globe, 4 Place Jussieu, 75230 Paris 5

Orogenic lherzolite bodies are key places to study mantle heterogeneities and to try to understand these heterogeneities, as it is possible to have indications about geometric position of one sample compared to one another.

Our study has been done on the massif of Lherz (France), Beni Bousera (Morocco) and Lanzo (Alps).

Our results show important isotopic heterogeneities on the initial $^{87}Sr/^{86}Sr$ ratios of the lherzolites, even at small scale.

These heterogeneities are comparable to the one found on MORB.