to 1300°C and pressures of 10 kb to 25 kb within the upper mantle. The phlogopite-rich 'kelyphitic' material rimming garnets in eclogite xenoliths from kimberlite is considered to have formed in the region of the lower crust by the action of alkalies and volatiles associated with the hydrous phase of kimberlite emplacement.

(Preliminary Abstract)

E10

COARSE AND VEINED PERIDOTITES FROM N. TANZANIA TUFF CONES

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Lherzolite, harzburgite and wehrlite blocks from two Neogene tuff-rings in the Tanzania rift valley comprise olivine (mg.93), enstatite, Cr-diopside ($Ca_{44}Mg_{52}Fe_4$, Cr_2O_3 2.3., TiO_2,0.12) and chromite (MgO 13.1, Cr_2O_3 59.4 wt%); texture is coarse though strain and evidence of grain-boundary migration is common. Some blocks are cut by planar or anastomising veins of combinations of olivine (mg.82), Ti-diopside ($Ca_{47}Mg_{45}Fe_8$, Cr_2O_3 0.06, TiO_2 1.04%), Tiphlogopite (TiO_2 4.18, Na_2O 1.14, mg.83) Tipargasitic hornblende (TiO_2 3.5., Al_2O_3 10.3, mg.80) and magnesian ilmenite (mg O 13.1%). Compared with non-veined peridotite, in peridotite adjacent to veins the olivine is more Fe-rich (mg.86 - .89) and cpx (being replaced by pargasitic hornblende) contains more Fe, Ti and Ca; the replacing amphibole contains less Ti, Fe, Al, K, and Ca, but more Mg and Cr, than vein amphibole. Bulk analysis of one vein resembles ugandite. Some non-veined peridotites also contain metasomatic mica and amphiboles and it appears some parts of the mantle below the Rift Valley are metasomatised and enriched in LIL-elements.

E11

DEPLETED MANTLE ROCKS AND METASOMATICALLY ALTERED PERIDOTITE INCLUSIONS IN TERTIARY BASALTS FROM THE HESSIAN DEPRESSION (NW-GERMANY)

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During Miocene basaltic magmas ranging from quartz tholeiites to melilite containing olivine nephelinites have been generated in the area north of the Vogelsberg volcanoe. They are exposed in about 2000 partly eroded necks, flows and beds of pyroclastics. About 73 percent of the basaltic coverage consists of alkali olivine basalts, about 12 percent of nepheline basanites and limburgites and 9 percent of olivine nephelinites. The majority of the latter species but less than 40 percent of the alkali olivine basalts contain spinel lherzolite and spinel harzburgite inclusions. At a few localities upper mantle rocks (spinel lherzolites, spinel harzburgites, griquaite and websterite) and xenoliths from the lower crust (granulites, pyriclasites etc) occur in pyroclastics.

The average modal composition of 30 equigranular lherzolite and harzburgite xenoliths is : 74 vol% olivine, 10 vol% orthopyroxene, 7 vol% clinopyroxene and 1-2 vol% spinel. Estimates of temperature of equilibration according the the Wells geothermometer range from 870 to 1110°C for these samples. Spinels with 40 mol.% $MgCr_2O_4$ are stable up to about 30 kb at 1100°C (O'Neill, 1981). The abundant peridotites are depleted in numerous elements relative to the primary upper mantle composition. The primary upper mantle composition has been estimated by Wedepohl (1981) after redistribution of the compatible elements from the earth's crust into a 200 km mantle layer and of the incompatible and volatile elements into a 900 km mantle layer. Because of their abundance the depleted equigranular spinel peridotites are expected to represent large volumes of the upper mantle down to about 100 km depth.

Distinct indications of a metasomatic imprint on certain spinel lherzolites have been observed in several xenoliths from pyroclastics of our area. They are deformed into a fine grained reequilibrated groundmass and coarse relicts of olivine and orthopyroxene. These so called porphyroclastic spinel lherzolites usually contain a few percent phlogopite. Their fine grained groundmass has been equilibrated at temperatures from 800 to 1000°C (Wells geothermometer). Crustal granulite xenoliths from the same area have been equilibrated at temperatures from 800 to 900°C and indicate an origin from layers close to the Moho (32 km depth). Some coarse orthopyroxenes of porphyroclastic lherzolites contain exsolved clinopyroxene lamellae. Taking their bulk opx + cpx composition as the primary opx composition two stages of equilibration can be discriminated. The difference in temperature between the two stages ranges from 80 to 200°C (Sachtleben and Seck, 1981, opx-thermometer). Reequilibration is assumed to be due to diapiric uprise of mantle material. Phlogopite has been formed during or after reequilibration of the groundmass of porphyroclastic peridotites probably from metasomatic fluids.

E12

ULTRAMAFIC XENOLITHS FROM LAKE BULLEN MERRI AND MT. LEURA, S.E. AUSTRALIA, AND THEIR BEARING ON THE EVOLUTION OF THE CONTINENTAL UPPER MANTLE

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Some 48 ultramafic xenoliths from two neighbouring locations within the Newer Volcanics of Victoria, Australia have been investigated in terms of petrography, mineral chemistry and partly for bulk rock chemistry.

The xenoliths include lherzolites with and without hydrous phases (such as amphibole and phlogopite), wehrlites, pyroxenites, and hornblendites, and include cumulates and composite xenoliths.

Mineral chemistry provides evidence for equilibrium crystallization for individual nodules over a small range of depths (app. 45 km) but a range of temperature. Anhydrous assemblages yield temperatures of 1015 - 1065 C, phlogopite bearing assemblages yield 975 -1025 C and amphibole bearing assemblages yield temperatures of 820 - 1010 C with most in the 925 -975 C range.

Among the harzburgites and lherzolites there is a wide variation of MgO, CaO, Al_2O_3, and compatible elements, which can be modelled as an early partial melting event, giving rise to various degrees of depletion.

Amphiboles in lherzolites are developed independently and postdate the partial melting event, as a response to near-isochemical metamorphic reaction, consequent on addition of water. Possibly Na and K, but no Ti were mobile components during the hydration event. The relationships of incompatible elements to the partial melting event and the hydration remain uncertain.

The metasomatic (hydration) events predate but are not precursor conditions for production of basanite. Metasomatism is present in the uppermost mantle above the LVZ, but this is most probably not the region of formation of the alkaline magmas. The emplacement and passage of alkaline magmas through the lithosphere/upper mantle may be the cause of local metasomatism and of hydration.

Wehrlites, pyroxenites, some lherzolites and hornblendites are regarded as precipitates from magmas fractionating and/or crystallizing at mantle depths. Observable wallrock-reaction is extremely restricted (about 1 cm) as evidenced by composite xenoliths.

A liquidus phase diagram for a hydrous basanite provides constraints on precipitation at high pressures and offers an internally consistent model for the genesis of the wehrlite, pyroxenite and hornblendite suite.

E13

NATURE OF THE CONTINENTAL MANTLE BELOW THE GERONIMO VOLCANIC FIELD ARIZONA, U.S.A.

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Trace element and isotopic analysis of hydrous and anhydrous peridotites and their host lavas, from the Geronimo volcanic field Arizona, U.S.A., have helped compile a chronology of enrichment and depletion events in the mantle. Host lavas have low $^{87}Sr/^{86}Sr$ = 0.70289 - 0.70327 and uniformly high $^{143}Nd/^{144}Nd$ = 0.513021 - 0.513037. The time-integrated light REE depleted character of the basaltic source region requires some form of enrichment to permit extraction of light REE enriched lavas at moderate degrees of melting.

Fragments of "veined mantle" have been analysed for REE, Nd and Sr isotopes. Co-existing kaersutite and diopside give an "age" of 169 ± 21 MA (1σ) (MSWD = 0.63) with an $(^{143}Nd/^{144}Nd)_I$ = 0.51287. Clinopyroxenes separated from five petrographically distinct peridotites exhibit an extreme range in $^{143}Nd/^{144}Nd$ = 0.512983 - 0.512603 and $^{87}Sr/^{86}Sr$ = 0.70272 - 0.704697, that overlaps the "mantle array". If the linear arrays on trace element and isotope diagrams represent "mixing lines" then we can define the enriched (E) and depleted (D) components in the mantle. First, the kaersutite veined Type I lherzolites from Geronimo and Dish Hill comprise a MORB residue (D) and an enriched component identical to Basin and Range lavas. Clearly kaersutite veins represent frozen conduits of basanitic magma. Second the anhydrous Type I and Type II lherzolites at Geronimo and San Carlos comprise a MORB residue (D) and an enriched component with $\Sigma_{Nd} \approx 0$. Mantle below the southwestern U.S.A. has experienced a multi-stage history comprising a major widespread depletion event (> 1 b.y.) and enrichment events caused by migration and infiltration of LIL element rich fluids. (Σ_{Nd} = 0 to 8.)

E14
MANTLE HETEROGENEITY: ISOTOPIC AND TRACE ELEMENT EVIDENCE FROM NUNIVAK ISLAND ALASKA

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A diverse suite of ultramafic and mafic nodules occurs in Quaternary basanites on Nunivak Island (166°W, 60°N), including granuloblastic-equant (GE), coarse-equant (CE), and coarse-tabular (CT) lherzolites, amphibole-pyroxenites, and pyroxene granulites. GE nodules have La/Yb ratios less than chondrites, and clinopyroxenes from these nodules have $^{87}Sr/^{86}Sr$ (0.70203-0.70264) and $^{143}Nd/^{144}Nd$ (0.51321-0.51330) ratios similar to those of oceanic-ridge basalts. We interpret these nodules to be petrogenetically related to oceanic-ridge basalts however, very low bulk rock K contents (9-17 ppm) complicate simple models. The CT and CE peridotites, some of which contain hydrous minerals, all have La/Yb ratios greater than chondrites, and have high concentrations of K (80-1065 ppm), Rb (0.058-2.83 ppm), Ba (3.7-42 ppm), and Sr (11-82 ppm) relative to the GE nodules (0.01-0.11 ppm Rb, 0.56-0.83 ppm Ba, 12-16 ppm Sr). These CE and CT nodules are similar to metasomatized peridotites from other localities. Isotopic data indicate that some of the amphibole-bearing peridotites ($^{87}Sr/^{86}Sr$= 0.70289-0.70313; clinopyroxene $^{143}Nd/^{144}Nd$ = 0.51309) are petrogenetically related to the amphibole-pyroxenites ($^{87}Sr/^{86}Sr$=0.70288-0.70297; 2 whole rocks $^{143}Nd/^{144}Nd$ = 0.51310). These pyroxenites have trace element characteristics consistent with an origin as crystal accumulates. We infer that this example of metasomatism is the result of the infiltration of a H-C-O-rich fluid and/or residual silicate melt which originated in the pyroxenites. Based on consideration of isotopic data, we concur with Menzies and Murthy (1980) that the metasomatism occurred recently, and that it is petrogenetically related to the basaltic volcanism on Nunivak. Metamorphic textures in the pyroxenites preclude a direct relationship with the host basalts.

E15
METASOMATISM AND CHEMICAL HETEROGENEITY IN THE SUB-CONTINENTAL MANTLE: Sr and Nd ISOTOPIC ANALYSIS OF APATITE RICH XENOLITHS AND ALKALINE MAGMAS FROM EASTERN AUSTRALIA

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Cenozoic volcanic rocks from E. Australia are relatively uncontaminated (viz. high Mg values, high Ni, Cr, Co and Sc) and offer a unique opportunity to study mantle isotopic heterogeneities. Most of the magmas in the S. Highlands province are geochemically distinct and reached the surface as isolated flows of limited volume. Consequently the considerable range in $^{87}Sr/^{86}Sr$ = 0.70289 - 0.70444 and $^{143}Nd/^{144}Nd$ = 0.512965 - 0.512611 (13 rocks) can best be reconciled by melt extraction from a geochemically and mineralogically inhomogeneous mantle. Trace element and isotopic analyses of Al-augite series xenoliths reveal the following: (1) Apatite-rich pyroxenites have a narrow $^{143}Nd/^{144}Nd$ = 0.51257 - 0.51266 and $^{87}Sr/^{86}Sr$ = 0.70368 - 0.70397, similar to that of the host dike rocks (i.e. $^{143}Nd/^{144}Nd$ = 0.512611 - 0.512663 and $^{87}Sr/^{86}Sr$ = 0.70405 - 0.70414). (2) Whole rock pyroxenites have slightly higher $^{87}Sr/^{86}Sr$ ratios than constituent minerals perhaps due to the presence of mica. (3) Minerals separated from the xenoliths (viz. apatite, amph. and cpx.) exhibit an extremely narrow range in $^{87}Sr/^{86}Sr$ = 0.703543 - 0.703665 and a wide range in $^{143}Nd/^{144}Nd$ = 0.51252 - 0.51276, with the exception of spinel which has a higher $^{87}Sr/^{86}Sr$ = 0.704139. The minerals and whole rocks plot to the left of the mantle array. (4) Co-existing spinel, apatite and clinopyroxene exhibit a narrow range in Sm/Nd that does not permit accurate dating of pyroxenite formation (≈500 m.y.). The pyroxenites are believed to represent the products of infiltration and crystallisation of a kimberlitic liquid into the mantle. The mantle heterogeneities produced by such metasomatism may be widespread in the Southern Highlands and may explain the diverse nature of the volcanic rocks.

E16
Nd ISOTOPIC DISEQUILIBRIUM IN GARNET PERIDOTITES FROM THE BULTFONTEIN KIMBERLITE AND IMPLICATIONS FOR MANTLE METASOMATIC COMPONENT ADDITION

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The Sm-Nd and Rb-Sr isotopic systematics of garnet, diopside and phlogopite from coarse granular peridotite xenoliths in the southern African Bultfontein kimberlite pipe indicate addition of a mantle metasomatic component. $^{147}Sm/^{144}Nd$ and $^{143}Nd/^{144}Nd$ ratios of garnet, diopside and phlogopite (major REE carrier phases), corrected back to the time of kimberlite emplacement (90 m.y.), are negatively correlated precluding conventional Nd isochron relationships and requiring exotic component addition without reequilibration. On a Nd-Sr correlation diagram these phases lie on an extension of the mantle array defined by mantle derived volcanics, at lower Nd and higher Sr isotopic ratios, as pre-