sions within olivine. This is presumably magnesite generated during: Forsterite + CO_2 Magnesite + Enstatite. By varying the p,T path followed during quenching one can study either the degree of incorporation of CO_2 into olivine under conditions stabilizing the carbonate or the development of features related to the generation of free CO_2. Analysis of these samples is in progress. In addition, several samples have been deformed and have developed shear zones containing mylonitic material. Thus application of pressures up to 3.0 GPa has not precluded shear zone formation.

E7

FLUID ACTIVITY IN THE MANTLE - EVIDENCE FROM LARGE LHERZOLITE XENOLITHS

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Lherzolite xenoliths in a breccia pipe from northeastern N.S.W., Australia attain diameters of up to 60 cm. They record, approximately concentric with xenolith margins, zones of alteration by hydrous and carbonic fluids which may represent metasomatism by primary mantle volatiles. Successive zones (each about five cm. wide) decrease in alteration intensity from the outside inward. The simplified sequence of mineral assemblages is: (1) quartz /talc/Mg-Fe-Ca carbonates, (2) talc/Mg-Fe-Ca carbonates, (3) fresh spinel lherzolites. Crosscutting this concentric alteration pattern are discrete carbonate veins, rarely radial with the xenolith shape, but commonly en echelon.

The zonal nature of the alteration suggests that fluid invasion occurred either (a) after entrainment in the host basaltic liquid or (2) within the mantle prior to entrainment and possibly resulting from fluid activity genetically linked with the production of the host magma. If the major alteration event took place in the mantle, this implies that brecciation associated with volatile movement can occur within the mantle. This may provide a mechanism for xenolith entrainment which commonly takes place within a vertically limited horizon.

Abundant carbonate of light isotopic character is present in the host basalt and may be of primary mantle origin. This evidence of a high CO_2 content may be significant in carrying such large xenoliths to the surface.

E8

MAGNESITE AND OTHER MINERALS IN FLUID INCLUSIONS IN A LHERZOLITE XENOLITH FROM AN ALKALI BASALT

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Magnesite has been observed in CO_2-rich fluid inclusions in a typical Cr-diopside and spinel-bearing lherzolite recovered from the 1824 eruption of Lanzarote volcano, Canary Islands. The carbonate, which exists as 2-4 μm diameter crystals on inclusion walls, was identified by its rhombohedral form and electron beam-generated EDS and WDS characteristic x-ray spectra in which C and Mg are major elements. The carbonate occurs as the sole phase in individual inclusions and has only been found in those inclusions enclosed in olivine. Phases present in other inclusions in olivine include Fe-oxide (probably pure magnetite), Fe- and Cu-Fe-sulfides, and silica. Although sulfides and magnetite may exist together in the same inclusion, most magnetite-bearing inclusions contain no other phases.

Regardless of the phases in them, mineral-bearing inclusions tend to possess irregular shapes, are relatively large (10-30 μm) and exist together in arrays which define non-crystallographic surfaces. These features distinguish them as a group from all other inclusion populations in which daughter minerals are absent.

The production of carbonate by reaction of olivine and CO_2-rich fluid requires only that CO_2 fugacities be sufficiently high for any set of assumed conditions, i.e., the mere presence of magnesite yields no information on the T and P at which it formed. However, the apparent lack of phases more siliceous than olivine, e.g., enstatite or glass, in association with magnesite (or magnetite) means that either olivine in the immediate vicinity of the inclusion is non-stoichiometric, or the carbonate crystallized in a microfracture before annealing of olivine and formation of the inclusion, presumably at mantle P-T conditions.

E9

THE MINERALOGY, STRUCTURE AND MODE OF FORMATION OF KELYPHITE AND ASSOCIATED SUB-KELYPHITIC SURFACES ON PYROPE FROM KIMBERLITE.

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The mineralogy, structure and mode of formation of kelyphite shells surrounding garnet is discussed in relation to kimberlite emplacement. Pyrope encrusted by kelyphite is commonly found in most garnet peridotites, some eclogite xenoliths from kimberlites, as well as a few garnet-bearing serpentinites.Observations made with the aid of a scanning electron miscroscope on 858 kelyphite-encrusted garnet grains from 30 kimberlite occurrences and petrological examinations of kelyphite rims enclosing garnet in ultrabasic nodules from kimberlite are discussed.

Although the relative abundance of kelyphite-encrusted garnet varies from one kimberlite to another, kelyphite shells are most commonly developed on mauve garnets which are most probably derived from peridotite and are least commonly found on orange varieties from eclogites. The underlying sub-kelyphitic surfaces formed on pyrope as a result of kelyphitization are described. There is a direct relationship between the different types of surface features found on the sub-kelyphitic surfaces and the structure and mineralogy of the kelyphite shells surrounding garnet and filling cracks within garnet.

During the ascent of kimberlite magma garnet lherzolite nodules are moved upwards from depths of approximately 150 km within the upper mantle resulting in the kelyphitization of pyrope within the peridotite nodules, forming shells consisting of a spinel-two pyroxene assemblage. The proposed zone of kelyphitization of pyrope lies within the spinel lherzolite stability field and is most likely to occur at temperatures of 900°C 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