

30 kilobars. Normative bulk compositions of the eclogites are equivalent to picrite, olivine tholeiite, alkali olivine basalt, basanite and basaltic anorthosite. Compared to equivalent phases precipitated from laboratory melts, eclogite clinopyroxenes contain higher jadeite and SiO_2 and lower Ca-Tschermak molecule, whereas garnets contain higher grossular. Eclogite bulk compositions are dissimilar to those of mafic liquids derived by partial melting of mantle peridotites. Eclogites contain higher Al_2O_3 , Na_2O and locally K_2O , and lower MgO and Cr_2O_3 . Such compositions are similar to those of clinopyroxene + garnet + kyanite + feldspar cumulates precipitated from tholeiitic and calc-alkaline laboratory melts. Chemical compositions support the hypothesis of Green and Ringwood (1967) that the eclogites may be metamorphosed residua and cumulates from partially melted subducted oceanic crust.
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D17**ILMENITE IN UPPER MANTLE POLYMICT XENOLITHS FROM BULTFONTEIN**

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Four polymict deformed xenoliths from Bulfontein, each of which have a strong disequilibrium garnet lherzolitic mineralogy, also contain abundant ilmenite. The ilmenite occurs either as transgressive veins or as isolated patches and 'blebs' and is closely associated with phlogopite and often rutile as well as occasional sulphides. The ilmenite in the various xenoliths broadly have similar compositions being characterised by high but variable Cr_2O_3 (1-5 wt.%) contents and relatively constant and high MgO (14-15 wt.%) contents, while the rutile is also often enriched in Cr_2O_3 (3-4 wt.%). Where the ilmenite occurs as veins, which are clearly intrusive into the xenoliths, the smaller veins and the edges of the larger veins invariably have the higher Cr_2O_3 contents, perhaps in response to temperature variation during crystallisation. No armalcolite has been found which is suggestive of a high pressure (more than 20 kb) paragenesis for the ilmenite. The mineral chemistry of the ilmenite and rutile is described in detail and is also compared to xenocrystal material and available experimental data. This information is used to develop a possible phenocrystal model of formation for the majority of the ilmenite which occurs in kimberlite.

D18**PETROLOGY AND GEOCHEMISTRY OF ULTRAMAFIC XENOLITHS FROM THE GERONIMO VOLCANIC FIELD**

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Ultramafic xenoliths included in Plio/Pleistocene alkali basalts from the Geronimo Volcanic Field (GVF) record a multistage evolution for the

mantle beneath SE Arizona. The dominance of unfoliated, granuloblastic, Type I harzburgites and clinopyroxene-depleted spinel lherzolites at GVF supports the occurrence of a major depletion event in the mantle followed by a period of re-equilibration. The coherence of major element mineral chemistry data indicates that variation in bulk rock major element chemistry among the xenoliths is a function of modal mineral abundances and that equilibration conditions were relatively uniform. Variation in Fe/Mg and REE abundances indicates different degrees of depletion among the xenoliths. INAA analyses of REE in cpx from cpx-rich spinel lherzolites have high, LREE-enriched patterns while cpx from depleted (cpx-poor) spinel lherzolites and harzburgites may be as much as an order of magnitude lower in REE.

Composite xenoliths are abundant and of two types: 1) websterite or diopside veins in spinel lherzolite, and 2) Type II clinopyroxenite cross-cutting wehrlite or spinel lherzolite. Chemically, the Type II clinopyroxenites are distinguished from the Type I xenoliths by higher Al, Ti, Ca and Na, but lower Mg. They typically possess igneous textures in which cpx subpoikilitically to poikilitically encloses olivines and probably formed as the crystallization of magma in dikes or conduits under mantle conditions.

Kaersutite peridotites, similar to the Type II spinel-bearing clinopyroxenites, are locally abundant. The kaersutite commonly forms large, cm-sized, optically continuous crystals which partially replace clinopyroxenes of varying crystallographic orientations. The origin of the amphibole is enigmatic, but may represent the final, fluid-rich stage of crystallization of magma trapped at depth.

D19**TWO-PYROXENE INTERGROWTHS FROM SOUTH AFRICA**

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Megacrysts consisting of two-pyroxene intergrowths in which one of the phases has obviously exsolved from the other have been investigated. These megacrysts were obtained from Koffiefontein, and the Bellbank area kimberlites. All previous studies of megacrysts to date have been for the most part on discrete mineral grains. Conclusions made from such studies are based on the assumption that the discrete megacrysts may have formed in equilibrium. In the case of the 2-pyroxene intergrowths no assumption is necessary as it is a fact that the two phases have equilibrated together.

The pyroxenes forming the intergrowths are typically diopside-enstatite. In some instances minor garnet either as lamella or rounded blebs is present. Either enstatite or diopside may be the host with the other mineral occurring as the exsolved phase. All analyses of the clinopyroxenes and orthopyroxene pairs were used in determining pressures and temperatures of equilibration via the computer program TEMPEST. Temperature (Lindsley and Dixon, 1976) versus pressure (Wells, 1977) plot for the Bellbank intergrowths define a geotherm generally similar to ones suggested for other kimberlites in the region. It appears that most of the intergrowths have cooled to the geotherm and there is little evidence for abnormal temperature environ-

ments. Samples at the extreme ends of the geotherm differ by 220°C and reflect depth differences of the order of 60km. These results together with those of Koffiefontein and Frank Smith suggest that many megacrysts may have come from widely differing depths and environments in the mantle.

D20

SINGLE-CRYSTAL STRUCTURE REFINEMENTS OF SUPER-SILICIC CLINOPYROXENES FROM THE ZAGADOCHNAYA KIMBERLITE PIPE, YAKUTIA, USSR.

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It has often been suggested that supersilicic (cation-deficient) clinopyroxenes contain vacant sites, probably in the form of solid-solution of the CaEs end-member ($\text{Ca}_{0.5}\text{Al}_{1.5}\text{Si}_2\text{O}_6$), but full structure refinements by X-ray diffraction have not previously been made. Refinements are now presented for optically-clear supersilicic clinopyroxenes from two gospodite nodules from the Zagadochnaya kimberlite pipe.

In sample Zaga/0, both refinements and electron microprobe analysis indicate inter-grain inhomogeneity but intragrain homogeneity. The refinements are compatible with vacancies in M2 and with the microprobe analysis (Jd.45 Di.38CaTs.07CaEs.10), but they do not prove the existence of vacancies in M2. The space group is C2/c such that this is the only confirmed disordered omphacite with around 50 % Jd. This primary clinopyroxene co-existed with garnet, kyanite and corundum, but has been partially replaced by secondary clinopyroxene (Jd.17Di.66 CaTs.17), clinoamphibole, plagioclase, quartz and zoisite. This rock thus displays the simultaneous expulsion of excess SiO_2 and breakdown to an amphibolite-facies paragenesis.

Sample Zaga/8 differs in containing secondary clinopyroxene in an exsolution texture. Both samples share some features in common with certain supersilicic clinopyroxenes from the Roberts Victor kimberlite pipe, S. Africa, though direct exsolution of SiO_2 has not been observed in these Zagadochnaya samples.

D21

ON THE CHARACTERISATION AND CREDIBILITY OF SUPERSILICIC, STOICHIOMETRIC, AND SUBSILICIC PYROXENES

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$X_{n-s} = 100 \frac{(S-(N+D))}{(S+N+D)} \%$ in the natural chemical system SAND (where $S = \text{Si} + \text{Ti}$, $A = \text{Al} + \text{Fe}3 + \text{Cr} - \text{Na} - \text{K}$, $N = 2\text{Na} + 2\text{K}$, and D (divalent) = $\text{Ca} + \text{Mg} + \text{Ni} + \text{Fe}2 + \text{Mn}$, all in cation proportions) is proposed as a useful indicator of pyroxene non-stoichiometry. The S : A : (N+D) diagram conveniently demonstrates : 1. supersilicic, stoichiometric, or subsilicic pyroxenes for which X_{n-s} is positive, zero or negative, respectively ; 2. the irrelevance of trivalent cations to pyroxene stoichiometry (since their oxides also have 4 cations (C) per 6 oxygens (O), such that X_{n-s} isopleths radiate from the A apex ; 3. that supersilicic pyroxene is most simply considered as a solid solution of stoichiometric pyroxene with SiO_2 rather than with any A-bearing end-member ; 4. the im-

probable existence of subsilicic pyroxene which requires $C > 4$ per O=6 ; 5. the "bimimetic eclogite line" between A and $(\text{N}+\text{D})_2\text{Si}_2$ upon which lie all stoichiometric pyroxenes and garnets.

All theoretical supersilicic pyroxene end-members (e.g. $\text{D}_{0.5}\text{AS}_{2.0}\text{O}_6$, $\text{DA}_{0.67}\text{S}_{2.0}\text{O}_6$) have no N, since in alkali pyroxene all other cation sites already have the highest-valent cation possible. However, Jd solution aids the stability of M-site vacancies, more so than Di solution, by providing more similarly-charged M-sites and a smaller volume. Exsolution of the excess Si as quartz (e.g. in Norway, Greenland and S. Africa) can create Al(iv) at lower T than if the CaTs proportion was in equilibrium with garnet.

The recent suggestion of O⁻stability allows the not too remote possibility of new high-density supersilicic "pyroxene" end-members (e.g. $\text{AS}_{2.0}\text{O}_{5.0}$, $\text{D}_{1.5}\text{S}_{2.0}\text{O}_{5.0}$) at high P.

Supersilicic pyroxenes are thus to be expected in Na-, Ca-, Al- & Si-rich systems at high P (blueschists, eclogites, experiments).

D22

GARNET AND Cpx MEGACRYS FROM KASAI.

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Eastern Kasai xeno-tuff breccia kimberlite include a long set of megacrysts:garnet,cpx ilmenite,rutile,kyanite, corundum,zircon and baddeleyite. Neither olivine nor enstatite have been found. We are only concerned with garnet and cpx. About 200 specimen each have been sampled from Mbuji Mayi and Tshibua pipes, eastern Kasai.

All the garnets from Tshibua are Cr pyropes. They tend to have relatively low Ca O contents (~ 4.0 wt%) and Cr_2O_3 values in the range 0.95-6.5 wt%. Two Cr pyropes show a particular zonation affecting only octahedral diadocitic ions Al^{3+} and Cr^{3+} . All the cpx from Tshibua are diopsides. Except for one specimen the Cr_2O_3 contents are below 0.9 Wt% and Al_2O_3 values below 1.90 Wt%. Na_2O ranges between 1.40 and 2.0 wt%. Garnets and cpx from Tshibua are all ranged in the lherzolitic suite.

Several garnet and cpx megacrysts from Mbuji Mayi resemble those from Tshibua and are ranged in the lherzolitic suite yet an important part of analysed minerals are quite different. Cpx have considerable contents of Na_2O and Al_2O_3 in the ranges 4.0-6.8 and 6.9-11.4 wt% respectively. Cr_2O_3 contents do not exceed 0.2 wt%. These cpx are omphacitic. Some garnets belong to the pyrope-almandine-grossular serie. Both these latter minerals have been ranged in an eclogitic suite.

Using enstatite-diopside thermometers, the lherzolitic cpx show a possible equilibration range from 950 to 1350°C. Isotopic ratios $^{87}\text{Sr}/^{86}\text{Sr}$ of cpx are quite different of kimberlitic matrix. Garnet and cpx megacrysts show a reaction rim with the kimberlitic matrix. Thus a xenocrystal origin is proposed for garnet and cpx megacrysts.

D23

Mg-ILMENITES IN ALKALI BASALTS FROM THE VOLCANIC HOGGAR AREA

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