

Sanidine and Orthopyroxene Bearing Eclogite Xenoliths from the Zero Kimberlite Pipe

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Eclogite xenoliths brought up from mantle depths occur in most kimberlite pipes, though a generalised model for the origin of all eclogite environments cannot be applied yet. Two different models are still debated, postulating an origin either as melt cumulates directly from the upper mantle (MacGregor & Carter, 1970) or as relics of subducted oceanic crust (MacGregor & Manton, 1986). To get better insights into eclogite sources, we focused on eclogite xenoliths sampled by the Zero kimberlite pipe. The Zero kimberlite intruded the Kaapvaal craton 1.6 Ga ago and occurs as a member of 12 oldest and non-diamond bearing kimberlite pipes, located in the Kuruman Province, South Africa (Shee et al., 1986). Here we present petrography, major and trace element chemistry of the constituent minerals of the Zero eclogites.

Significantly, the opx- and sanidine bearing eclogites (Smith et al., 1991) occur together with kyanite- and abundant biminer- alic eclogite xenoliths. Clinopyroxenes contain exsolved sili- cates, garnets show coesite and rutile inclusions. The sanidine bearing eclogites consisting of pyrope-rich garnet and omphacitic cpx with garnet, opx and sanidine exsolving from the cpx has a key position considering the K content of recon- structed clinopyroxene and might provide important constraints on the origin of eclogite xenoliths.

Considerable amounts of exsolved garnet from cpx occur in all eclogite types as subsolidus exsolution textures frozen in clinopyroxene hosts. The absence of diffusion gradients in the major elements argues for equilibration following exsolution under high temperatures or for long mantle residence times. These exsolutions themselves may be caused either by tempera- ture decrease or pressure increase, according to the P/T depen- dent Al-solubility (Ca-tschermakite) in clinopyroxene.

The solubility of enstatite in clinopyroxene is mainly temper- ature dependent and decreases with decreasing temperature, implying that opx exsolved under decreasing temperature condi- tions. Al-content in opx from the samples is low (0.8 wt%) consistent with decreased Al content for opx under the prevailing conditions due to the Al-exchange between opx and garnet at high pressure.

Generally, the partitioning of K in cpx is assumed to be a function of pressure. Harlow (1999) could show that K-solu- bility is also affected by chemical composition of cpx and, thus, is also temperature dependent. Hence exsolution of sanidine from cpx is not compellingly affected by pressure release alone.

The re-equilibration stage prior to kimberlite eruption, has been estimated and indicate a temperature range of 950-990 °C at 4 GPa pressure.

Trace element abundance of gt, cpx, opx and san, have been analysed by LA ICP-MS at the Memorial University, St. John's Newfoundland. Trace element patterns of the reconstructed bulk composition normalised to primitive mantle indicate that metaso- matism has affected the rocks, judging from enriched LREE. Some of the opx- and non-sanidine bearing eclogites show a slight negative slope in LREE and might be affected by low degree partial melting at a late stage. No significant Eu-anomaly occur in the eclogites, indicating that their precursor may not have crys- tallised in the plagioclase stability field. Generally the eclogites show MREE to HREE abundance close to primitive mantle not comparable with modern MOR basalts.

The oxygen isotope composition, performed on cpx and gt of the sanidine eclogite show values close to unchanged Earth's mantle. However, the occurrence of coesite inclusions in garnet cores seems to exclude a mantle source and might be evidence for a recycled precursor. Coesite and sanidine inclusions associated with high K-contents of reconstructed cpx could imply relatively cold subduction without considerable melt loss. Interestingly, the coesite inclusions within the garnet cores are euhedral crystals, which is uncommon for relict metamorphic coesites from eclog- ites and might have crystallised from a fluid which was lost during ascent with the kimberlite.

Although the Zero eclogites do not originate from a precursor comparable to typical oceanic crust they must have been brought into great depth prior to equilibration and kimberlite eruption. Hence, an origin as a cumulate which was subducted seems possible.

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