ECLOGITE XENOLITHS: SAMPLES OF ARCHEAN OCEAN FLOOR

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The origin of eclogite xenoliths carried by kimberlitic magmas continues to be controversial. There are basically two schools of thought: 1) eclogites represent crystal cumulates from basaltic magmas formed at high pressures within the mantle, and 2) eclogites represent fragments of oceanic lithosphere that were subducted or otherwise buried to great depths within the lithospheric mantle.

The non-mantle-like values for carbon, oxygen and sulfur isotopes found associated with some eclogite xenoliths suggest they formed as recycled oceanic crust. However, other eclogites have mantle-like stable isotopic signatures (e.g., many eclogites or eclogitic diamonds & inclusions from Udachnaya, (Jacob et al., 1994; Jerde et al., 1995; Rudnick et al., 1993)) and the origin of these samples is less clear.

Major, trace element and isotope geochemistry provide additional constraints on eclogite genesis, but should be used with the following provisos in mind.

1) The presence of secondary phases on grain boundaries and particularly replacing omphacites in most kimberlite-borne eclogite xenoliths greatly alters the incompatible trace element (hence isotopic) composition of the rocks, making whole rock data of little use in deciphering eclogite petrogenesis.

2) Recent measurements of garnet and omphacite included in diamonds from eclogite xenoliths shows that, in comparison to the rock phases, these inclusions are more depleted in incompatible trace elements (Ireland et al., 1994). This suggests that the incompatible trace element concentrations and isotopic ratios of purified mineral separates from eclogite xenoliths may yet reflect metasomatic overprints rather than the original composition of the eclogite minerals.

Major elements are less susceptible to metasomatic alteration in eclogites than incompatible trace elements and thus provide a better opportunity to interpret whole rock data. Eclogite xenoliths are distinct from MORB, having significantly lower TiO_2 and Na_2O and higher MgO contents (Fig. 1). In contrast, massif eclogites have major element compositions identical to MORB, consistent with their inferred origin as obducted fragments of metamorphosed ocean floor (e.g. (Stosch and Lugmair, 1990)). In addition, the recasting of average MORB or altered MORB into eclogite mineralogy predicts a lower garnet to clinopyroxene ratio and lower Na_2O content in omphacite than observed in typical xenolithic eclogites. Other significant differences include the absence of a silica phase (coesite) and higher Mg# in most xenolithic eclogites compared to MORB or their eclogitic equivalents.

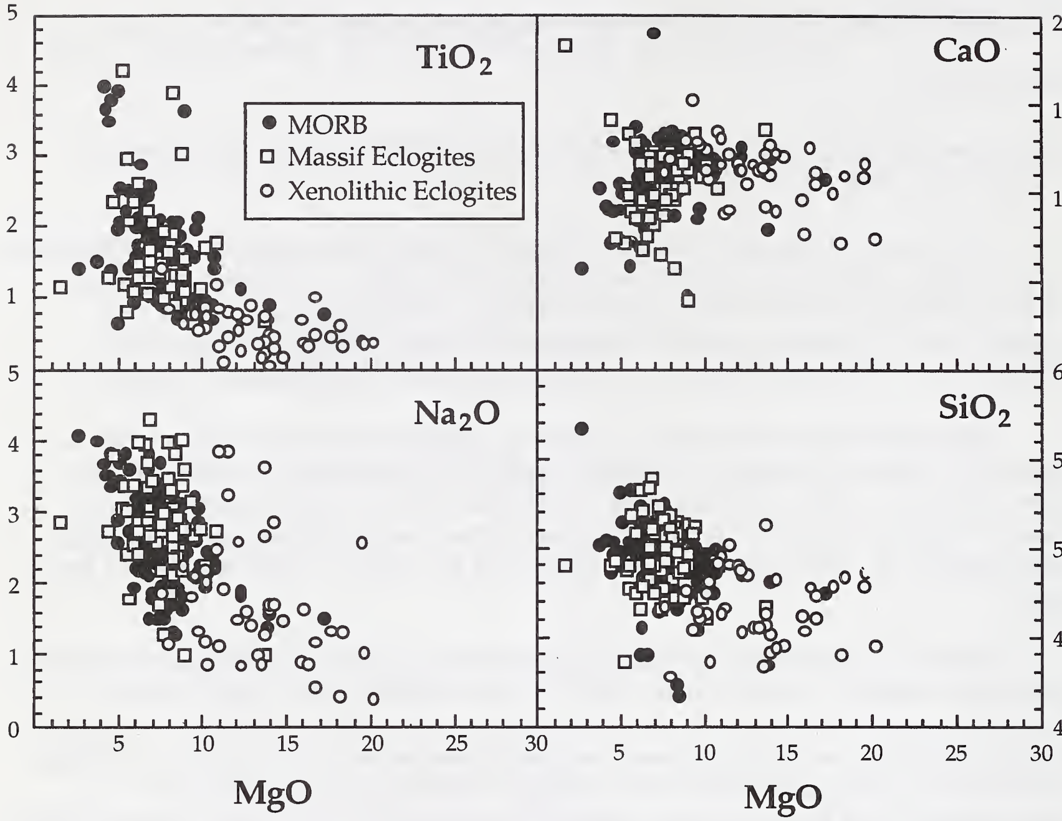

Figure 1. Plots of MgO vs. TiO_2, CaO, Na_2O and SiO_2 for MORB, massif eclogites and xenolithic eclogites (bi-mineralic only). Massif eclogite data are from the following locations: Münchberg massif, Bohemian Massif, D'Entrecasteaux Island. Xenolithic eclogite data are from the following: Udachnaya, Obnazhennya, Mir, Koidu, Bellsbank and Roberts Victor.

The above discrepancies are explicable if xenolithic eclogites represent subducted Archean oceanic crust that has lost a partial melt at high pressures. Melting in the 3-6 GPa range to produce a tonalitic melt increases the proportion of garnet to clinopyroxene in the residue, eliminates the SiO_2-phase (and any primary K-phase) and, since Na_2O partitions into clinopyroxene over melt at high pressures, will result in jadeite-rich clinopyroxene.

The similarity between xenolithic eclogites and Archean basalts/komatiites is striking (Fig. 2). The lower SiO_2 in xenolithic eclogites compared with Archean basalts is consistent with the loss of a silicic melt from the eclogitic residue. Thus the major element compositions of eclogite xenoliths support their origin as subducted (and melted) Archean oceanic crust (Jacob et al., 1994).

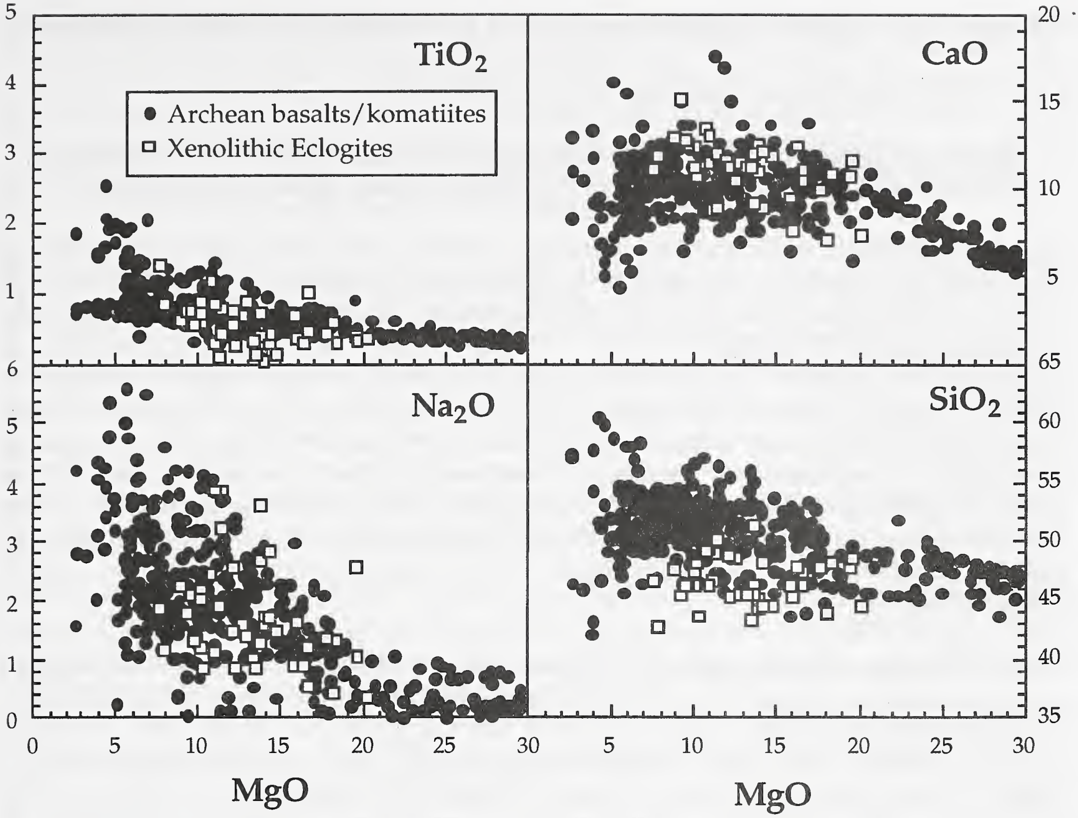

Figure 2. Plots of MgO vs. TiO_2, CaO, Na_2O and SiO_2 for Archean basalts and komatiites compared with xenolithic eclogites. Data sources as in Fig. 1.

References

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