

The search for organic biomarkers in >3700 Ma metasedimentary rocks from Isua, West Greenland

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Although carbon isotopic evidence seems fairly robust, supporting evidence based on other biogenic signals is needed to settle the case for the presence of life >3700 Ma. We have undertaken a study of >3700 Ma metasedimentary rocks from Isua, West Greenland, which contain high abundances of graphite ($\delta^{13}\text{C} = -19$ to -27 per mil) derived from a reduced carbon component of the original sediment. The metasediment contains mm-size garnet porphyroblasts, which contain abundant inclusions of carbonaceous material. This material has supposedly been isolated from the environment since growth of the garnets during the early Archaean. This isolation might have provided a local environment that allowed the preservation of organic molecules during metamorphism. We have separated such garnet crystals and removed matrix and the outermost crystal surfaces by air-flow abrasion. Single abraded garnet crystals were heated in vacuum to 400 C in a mass spectrometer and mass spectra were collected for reference. Subsequently, the garnets were crushed while still in the sample holder, and new mass spectra were obtained during heating of the now crushed sample. The garnet interiors contain heavy organic components not detected from their exteriors. We have not yet identified the molecular composition or structure of these components, but we feel confident that we have identified the presence of heavy organic molecules that have been isolated within mineral grains since the early Archaean. The exact identity of these organic components and their possible biogenic origin remains to be established.

Source variability and flux melting in the Cascadia subduction zone

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Mafic melts in continental arcs provide direct constraints on the composition, thermal structure and melting of the underlying mantle wedge. However, crustal processes such as volatile degassing, fractionation and crustal assimilation often obscure important compositional variations. One means by which these can potentially be circumvented is by examining phenocrysts and contained melt inclusions within the most primitive lava samples available.

We present the results of a study of lava, phenocryst and melt inclusion compositions from mafic basalts in the Oregon High Cascades. Four distinct mafic endmember compositions have been identified within the Oregon Cascades: 1) OIB-like (high incompatible element concentrations, low LILE/HFSE) basalts, 2) MORB-like (low incompatible element concentrations) basalts, 3) Calc-Alkaline (high LILE/HFSE) basalts, and 4) Shoshonitic (very high LILE/HFSE) basalts. The origins of these are still unclear and contentious, and different studies have emphasized the possible roles of mantle heterogeneity and flux melting. Melt inclusions hosted within primitive phenocrysts in these lavas provide direct constraints on the diversity of primitive magma compositions, and inclusion compositions, particularly where volatile information is available, allowing us to directly test these conflicting hypotheses.

Melt inclusions show a high degree of compositional variability. K_2O and TiO_2 both vary by a factor of ~ 5 in inclusions from a given sample. In addition, melt inclusions from calc-alkaline basalts have $\text{K}_2\text{O}/\text{TiO}_2$ ratios which vary from 0.75 to 2.25 whereas more depleted inclusions range from 0.75 to 0.9, with individual samples varying by less than 0.25. $\text{Cl}/\text{K}_2\text{O}$ ratios vary greatly between samples and range from primitive mantle values (0.05) to 0.30 in the most Cl enriched inclusions. Sulfur concentrations (up to 0.3 wt%) also vary greatly both within, and between samples. The highest S concentrations occur in shoshonitic samples, probably as a result of higher oxygen fugacity than the other basalt types. LILE concentrations fluctuate by over an order of magnitude in calc-alkaline samples with observed Ba concentrations up to 7000ppm, greater than values reported for the most enriched Cascade basalts. While LILE concentrations appear to vary greatly, other incompatible elements display little variation, with a consistent depletion in HREE and HFSE evident in all samples.