Tholeiitic vs. Calc-Alkaline Igneous Trends on the Moon: Lunar Meteorite Northwest Africa 773 vs. Apollo 15 Quartz Monzodiorite

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Terrestrial igneous rocks exhibit a wide variety of compositions, but many can be linked together as stages of magmatic evolution along chemical trends. Two of the main trends are the tholeiitic (or FeO-enrichment or Fenner) trend and the calc-alkaline (or SiO2-enrichment or Bowen) trend. Lunar igneous rocks also show a wide range of compositions, even if only basalts are considered. Linking lunar rocks together along magmatic trends has proven difficult though, in part due to impact disruption of the surface wreaking havoc on igneous field relations.

However, impact processing can work in our favor by assembling breccias of magmatically related clasts. We use textures, pyroxene compositions (Fe# = Fe/(Fe+Mg)x100 and Ti# = Ti/(Ti+Cr)x100) and zoning relationships to argue that this is precisely what has happened during the formation of lunar meteorite Northwest Africa 773 (NWA 773). Clasts of olivine cumulate (OC) are characterized by pyroxene with low Fe# (20-30) and variable Ti# (10-75). Pyroxene Ti# correlates with proximity to intercumulate pockets with K,Ba-feldspar and Ca-phosphates. This increasing Ti-trend is interpreted as a product of fractional crystallization where the Fe# was buffered by abundant surrounding mafic silicates.

Pyroxenes from other types of clasts in the breccia show a trend of Ti# and Fe# both increasing to nearly 100. Clasts with the highest Fe# and Ti# include fayalite+hedenbergite+ silica symplectites and K,Ba-feldspar+fayalite+silica ±hedenbergite FeO-alkali-rich clasts. These are interpreted as the alkali-poor and alkali-rich products of silicate liquid immiscibility (SLI) after the liquid evolved to ferroan compositions. Igneous (crystallized from liquid) silica occurs only in the FeO-alkali clasts, suggesting that SiO2-enrichment occurred only after extreme FeO-enrichment, comparable to the terrestrial tholeiitic trend.

Igneous silica also occurs in Apollo 15 quartz monzodiorite (QMD), but coexists with pyroxene having moderate Fe# (60-70), more akin to the calc-alkaline trend. Whole-rock compositions of QMD fall on a mixing line between immiscible liquids produced during experiments on a KREEP basalt composition [1], suggesting a role of SLI during formation of QMD.

[1] Rutherford et al (1976) Proc. LSC 7, p. 1723-1740.

Late quaternary sedimentary provenances in the Central Arctic Ocean inferred by Nd and Pb isotopes of fine detrital fraction

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Nd and Pb isotope signatures of sediments from Central Arctic were analysed to trace detrital particle provenance. Changes in relative contribution of different source-areas were used to reconstruct paleoceanographical changes over the last 250 kyr. Temporal changes in Nd and Pb isotopic composition confirm that sediment supply is controlled by the glacial/interglacial-deglacial variability. Pb mixing calculations suggest a major contribution from Mackenzie and Lena river areas. All intergacial-deglacial samples show isotopic values shifted towards the signature of Mackenzie end-member. Such source is consistent with their carbonate-rich lithology, detrital carbonates being mainly originated from this area and the Canadian channels. Nd mixing signature reports contribution from a third volcanic source; A compilation of trace element content of regional geological sources suggests that the most probable candidate is the Okhotsh-Chutoka province (Eastern border of Siberian platform). Our geochemical data confirm that the sediment provenances in Central Arctic remain close to the Present conditions during the earlier interglacials. Glacial stage 4 and 6 are characterised by the lowest supplies from the American margin, suggesting reduced particle supplies coming from the Beaufort Gyre to the Mendeleeiv Ridge.

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