

Olivine-hosted melt inclusions in Belingwe komatiites: Implications for cooling history, parental magma composition and its H₂O content

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We present the compositions of melt inclusions hosted by fresh olivine phenocrysts Fo_{90.5-92.9} in the cumulate zone of 2.7 Ga komatiites lavas from Belingwe, Zimbabwe. Olivines have large homogenous cores surrounded by thin normally zoned rims. Melt inclusions are recrystallised to a fine-grain aggregate and has been rehomogenised before analysis by reheating to 1300 °C in 30 s. and quenching after a maximum of 90 s. The quenching temperature is below that of trapping, and thus glass compositions are depleted in olivine that remained on the inclusion walls. Glass FeO* contents (4.8-6.6 wt%) correlate negatively with Fo and are lower than in komatiites (~12 wt%) of similar MgO contents, a result of post-entrapment reequilibration with the hosts. Fe-Mg diffusion profiles in olivine around melt inclusions show that this reequilibration occurred during cooling to ~1050 °C in a cumulate layer at a rate of 4-5 °/day. Calculated trapped compositions of the inclusions form a trend consistent with olivine fractionation, which overlaps the field of rock samples but displays lower Na₂O and K₂O. The coherent trend displayed by all major elements is an evidence that Fe-loss was the only factor affecting bulk inclusion compositions after trapping. The well-defined olivine fractionation trend recorded by melt inclusion major and trace element compositions implies that a single parental melt existed for the suite. This melt was in equilibrium with olivine Fo_{93.5}, had 25-28 wt% MgO and 1450-1480 °C liquidus temperature. The lack of chemical variations in melt inclusions, and their good agreement with the wholerock compositions, distinguishes Belingwe komatiites from modern mantle-derived magmatic suites, which normally show a great variety of inclusion compositions significantly exceeding the range recorded by rock samples. The H₂O contents of melt inclusions determined by FTIR in Fo₉₁₋₉₂ are 0.18-0.26 wt% and likely represent magmatic values, as fast cooling rates rule out diffusion of molecular H₂O after trapping, and normal Fe³⁺ contents in the inclusions (~ 10% of total Fe) argue against significant diffusion of H out of or into the inclusions. H₂O contents and correlate positively with host Fo, indicating degassing during crystallisation. Implications for H₂O contents of primary komatiite magmas are discussed.

Causal relationship among magmatism, BIFs and glaciation during the earliest Paleoproterozoic

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The beginning of the Paleoproterozoic period was marked by a global mafic magmatic event (2.48 to 2.45 Ga), banded iron-formation (BIF) deposition (2.47 to 2.43 Ga), and glaciation (2.45 to 2.33/2.22 Ga). The magmatic event was suggested to be responsible for intensification of hydrothermal activity leading to deposition of world's largest BIF deposits. The earliest glacial deposits of the Paleoproterozoic directly overlie the BIFs in the Hamersley Group of Western Australia and the Transvaal Supergroup of South Africa. In the Huronian successions of North America, the magmatic event is followed by presence of paleosols and glacial deposits. Based on this intrinsic lithological association, here we explore the possibility of the earliest glaciation of earth history being caused by the magmatism-BIF deposition induced changes in the carbon cycle. We have estimated the total amount of CO₂ sequestered from the atmosphere for deposition of Fe, present in Hamersley and Transvaal basins (1.2 × 10²⁰ g), completely in either oxide or carbonate facies, which range from 1.35 × 10¹⁸ to 2.15 × 10¹⁸ moles, respectively. Since these BIFs were deposited at a very rapid rate (Barley et al., 1997), substantial draw down of CO₂ within a short span of geological time would have triggered global cooling ultimately leading to the earliest glaciation during the Paleoproterozoic.

Carbonates associated with the Paleoproterozoic BIFs show consistent enrichment in light carbon (¹³C) having δ¹³C values up to -12 ‰ PDB, which have been attributed to diagenesis. However, a strong linkage between magmatism and BIF deposition does not preclude the possibility of light mantle input carbon (δ¹³C ~ -25 ‰), different from normal MORB/upper mantle input (δ¹³C ~ -5 ‰), being responsible for ¹³C depletion in BIF carbonates. This proposition is based on three observations: (a) linear trend between δ¹³C values of coexisting carbonate and organic carbon, (b) D'' layer disturbance causing Paleoproterozoic magmatism and (c) deep mantle reservoir characterized by depleted ¹³C composition (Deines et al., 1993). Under such condition, negative δ¹³C compositions of BIF carbonates represent enhanced organic carbon burial (calculated maximum f_{org} = 0.54). It is thus possible that these Paleoproterozoic BIFs deposited predominantly in oxide facies. Incidentally a drastic rise in iron retainment in paleosol of this time interval also suggest oxygen enrichment in the atmosphere (Sreenivas and Das Sharma, this volume).

References

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