Hydromagmatic amphibole in high-Mg rocks of the Abitibi greenstone belt, Canada: Evidence for Archaean wet ultramafic magmas

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Detailed petrographic, electron microprobe and ion probe studies of Archaean hydromagmatic amphiboles from the Abitibi greenstone belt yield new insights into the origin of komatiitic, ferropicritic and tholeiitic melts. The amphiboles occur in minor to major amounts in peridotite layers and basal chill zones of ultramafic sills and flows, and can be grouped into two petrographic types: (1) groundmass amphibole and (2) melt inclusion amphibole. The groundmass amphiboles are mm-size intercumulus grains of pargasite-hastingsite, which host small, rounded and embayed cumulus olivine grains. The amphibole-bearing melt inclusions are within the cumulus olivine, rounded in shape, 50-500 µm in size, and modally dominated by amphibole. In-situ ion probe analyses indicate the amphiboles contain up 3 wt% H_2O and are enriched in Nb-LREE and Zr and depleted in Sr and HREE relative to primitive mantle. δD values for all the analysed grains range from –140‰ to 50‰, including values in the accepted magmatic and mantle range of –90‰ to –60‰. The melt inclusions have high bulk H_2O/alkali ratio values and low bulk K_2O contents.

The petrographic and geochemical features of the hydromagmatic amphiboles suggest the possibility of a significant role for water in the origin of the Archaean ultramafic magmas. The large heterogeneity in δD values indicates preservation of magmatic compositions through low temperature alteration. The petrographic relationships indicate amphibole formation by subsolidus reaction of residual hydrous silicate melt with olivine±pyroxene and melt entrapment within olivine. The magmatic δD values together with experimental amphibole-basalt phase equilibria suggest the olivine residual melts contained ≥3 wt% H_2O. Adjustment for olivine crystallization suggests the initial magmas contained 1-2 wt% H_2O. Such high H_2O contents and the magmatic δD compositions coupled to the bulk composition the melt inclusions implicate melting within amphibole-bearing mantle peridotite. Furthermore, positive correlation of Nb-LREE enrichment and high δD reflects hydrous metasomatism of the peridotite. The favoured model is that some Archaean ultramafic melts were wet and some were dry. If entirely magmatic, the large scatter of the δD values defines the early water cycle, which may have involved recycling of surface water into the mantle.

10^3 - 10^6 year history of the West Antarctic ice sheet

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Numerous observations point to recent retreat of the West Antarctic ice sheet (WAIS) (e.g. Bindschadler and Vornberger, 1998; Shepherd et al., 2001), suggested to be the continuation of drawn-out post-LGM deglaciation (Conway et al., 1999). Further constraints on the history of deglaciation are needed to assess the significance of these recent changes in the ice sheet, and predict its future evolution. We have used cosmogenic nuclide exposure ages of glacial erratics from mountainsides to constrain the timing and rate of the last deglaciation, and paired ^{10}Be-^{26}Al data on bedrock samples to investigate the longer-term history of the ice sheet.

Exposure ages (^{10}Be) on erratics from summits in the Ford Ranges, western Marie Byrd Land, confirm that the peaks were overrun during the LGM, and emerged from beneath the receding ice sheet between 10.4 ± 0.7 ka and 3.6 ± 0.3 ka. Subsequent downwasting has removed 300-700 m of ice, at steady rates of 5-10 cm/yr. The youngest age obtained so far is 590 v 70 yr. We conclude: (i) Most thinning of the WAIS took place in the late Holocene, post-dating climatic warming and eustatic sea level rise by thousands of years. (ii) Deglaciation and grounding-line retreat are still in progress in this sector of the WAIS. (iii) These results support other evidence of prolonged WAIS deglaciation, recent thinning and grounding-line retreat.

One bedrock sample measured so far has an $^{26}Al/^{10}Be$ ratio of 1.4 ± 0.1, far below the production ratio of 6, requiring ancient exposure and prolonged cover by non-erosive, cold-based ice. Minimum cumulative exposure and ice cover times (prior to the Holocene) are 130 kyr and 3.5 Myr, and cumulative exposure is limited to less than 10 kyr in the last 1 Myr. If representative, this result severely restricts suggestions of past ice-sheet collapse.

References

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