

Unravelling the sources of silica in early-Archaean cherts with silicon isotopes

S.H.J.M. VAN DEN BOORN¹, M.J. VAN BERGEN¹,
P.Z. VROON² AND W. NIJMAN¹

¹Department of Earth Sciences, Utrecht University, Utrecht,
The Netherlands (boorn@geo.uu.nl)

²Faculty of Earth and Life Sciences, Free University
Amsterdam, Amsterdam, The Netherlands
(pieter.vroon@falw.vu.nl)

Significant controversy exists regarding the origin of silica in early-Archaean cherts and the mechanism of their formation. Solving these questions is opportune, since recent studies have used oxygen and silicon isotopic signatures of cherts to infer high temperatures for early-Archaean oceans (Knauth and Lowe, 2003; Robert and Chaussidon, 2006). For example, do these cherts represent primary precipitates from a silica-saturated Archaean ocean or are they the products of hydrothermal emanations (Kato and Nakamura, 2003)?

We present silicon isotope data for a suite of samples from well-studied chert outcrops (3.0-3.5Ga) in the Pilbara greenstone belt (Western Australia). Our samples cover a range of depositional environments, and include both stratiform and dike cherts. Based on mineral assemblages (sericite, Ti-oxide and zircon versus Fe-(oxy)hydroxides), major element chemistry (e.g. Al₂O₃ content) and Eu and Y/Ho anomalies, we distinguish chemically precipitated cherts (C-cherts) from silicified-precursor cherts (S-cherts). The silicon isotopic composition ($\delta^{30}\text{Si}_{\text{NBS28}}$) of C-cherts ranges from -1.6‰ to 0.7‰, whereas S-cherts are all positive and range from +0.1‰ to +1.1‰. The observed trend for C-cherts is attributed to mixing between ³⁰Si-depleted hydrothermal fluids and ³⁰Si-enriched seawater. S-cherts, on the other hand, are inferred to be products of pervasive silicification of volcanic precursor material by seawater. Hence, we envisage the involvement of three main reservoirs of silica in the formation of Archaean cherts: (1) seawater; (2) hydrothermal fluids; and (3) precursor sediments or rocks. We show that Si isotopes are particularly effective in discriminating seawater from hydrothermally derived silica. In addition, the silicon isotopic composition of chert-dike samples facilitates the distinction between silicified precursor fragments (e.g. entrained sediments that slid into cracks from the sea floor) and purely chemical precipitates.

Our findings point to multiple modes of chert formation in the early Archaean, which has important implications for the interpretation of their geochemical signatures in terms of seawater properties.

References

- Knauth L. P. and Lowe D. R. (2003). *GSA Bulletin* **115**(5), 566-580.
Robert F. and Chaussidon M. (2006). *Nature*, **443**, 969-972.
Kato Y. and Nakamura K. (2003). *Precamb. Res.* **125**, 191-243.

Genesis of intermediate to silicic igneous rocks at the end of the Sveconorwegian (grenvillian) orogeny

J. VANDER AUWERA, M. BOGAERTS AND O. BOLLE

Department of Geology, University of Liège, Belgium
(jvdauwera@ulg.ac.be)

The origin of voluminous granitoids at convergent plate margins and in postcollisional settings is a key question in understanding the evolution of the continental crust. In southern Norway, the end of the Sveconorwegian collision orogeny (1.13-0.9 Ga) was marked by the emplacement of abundant ferroan, metaluminous granitoids (0.96-0.95 Ga) mainly in the center of the Telemarkia terrane. These granitoids are dominated by intermediate to silicic compositions but rare mafic facies do also occur. We present here a quantitative assessment of the possible process linking these mafic facies to the dominant intermediate compositions using a combination of available major and trace elements as well as experimental data. Fractional crystallization of an ilmenite bearing noritic cumulate from the parent mafic composition produces a residual liquid with an appropriate intermediate composition after 67 % crystallization. There is also a good match between the calculated and observed trace elements as well as H₂O contents of the residual liquid. However, the calculated La and Ce contents are lower than the observed ones. 20% to 30% non modal batch melting of an amphibolitic source equivalent in bulk composition to the mafic facies also provides a good match between observed and calculated major and trace elements composition. Moreover, considering an H₂O content of the amphibolitic source of 1.25%, the produced intermediate liquid has an H₂O content ranging from 4 to 6 wt % in agreement with experimental constraints on the H₂O contents of the intermediate facies (5-6 wt % H₂O). This degree of partial melting is in agreement with modelled melt escape threshold which allows segregation and transfer of magma towards the upper crust. Thus both fractional crystallization and non modal batch melting satisfactorily predict the geochemical features observed in the granitoids and it is possible that both processes occurred simultaneously. Interestingly, both processes produce abundant mafic rocks, either as cumulates or residues, which must be equivalent to twice as much as the observed granitoids. As geological and geophysical evidence for large volumes of dense mafic rocks in the mid sveconorwegian crust is lacking, we suggest that these dense mafic rocks were produced in the lower crust but at a pressure lower than about 1 GPa as the low La/Yb of this magmatic suite precludes the involvement of garnet in their petrogenesis. Formation of these granitoids thus contributed to the vertical stratification of the proterozoic continental crust from a mafic lower crust to a more evolved upper crust.