Metasomatic controls on volatile storage in the sub-cratonic lithospheric mantle

CHARLOTTE G. JACKSON[1] & SALLY A. GIBSON[1]

[1]Department of Earth Sciences, University of Cambridge, CB2 3EQ, cj340@cam.ac.uk

The sub-cratonic lithospheric mantle (SCLM) represents Earth's oldest mantle reservoir. Over the past 3 billion years this has undergone metasomatic enrichment by volatile-rich asthenospheric melts and subduction-related fluids, making it an important but poorly constrained repository for elements such as H, S, C, F, Cl. Recent experiments have shown that the abundant nominally volatile-free mantle minerals (NVFMMs), such as olivine, orthopyroxene, clinopyroxene and garnet, have the capacity to hold the entire H, F and Cl budget of the upper mantle within their crystal structure. Despite this, studies of mantle xenoliths indicate that olivine and pyroxenes host much lower quantities of volatiles. Research on the controls of water storage in NVFMMs has highlighted that pressure, temperature and metasomatism all play a role, but the relative importance of each of these parameters is controversial. Greater constraints on the storage of water and the halogens in NVFMMs are therefore critical in refining the significance and storage capacity of the SCLM as a volatile reservoir. We have undertaken systematic high-precision Secondary Ion Mass Spectrometry (SIMS) analyses of water, fluorine and chlorine in mineral separates (olivine, orthopyroxene and clinopyroxene) from two suites of peridotite xenoliths (n=18) entrained from the Kaapvaal craton (Bultfontein, South Africa, and Mothae, Lesotho). We have combined the SIMS analyses with EPMA and LA-ICP-MS analyses of major and trace elements, respectively, and provide the first detailed investigation of halogen storage in NVFMMs from a cratonic setting. Our samples extend from 70 to 170 km in the Kaapvaal craton. The deepest (>130 km) and least metasomatised samples show elevated contents of H and F in nominally volatile-free phases. Metasomatism appears to strip the NVFMMs of F rather than introduce more. The carbonatite component of the metasomatic agent correlates negatively with F concentration, decreasing to a minimum F concentration at the carbonatite ledge (21 kbar). Preliminary results confirm widespread enrichment in water and show for the first time elevated F at the base of thick, metasomatised, ancient cratonic mantle. This has important implications for its viscosity and hence long term stability.