

Pressure induced phase transition in hydrous Sr-anorthite

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A recent survey of hydrous species and concentrations in igneous feldspars (Johnson and Rossman, 2004) shows that feldspars may contain structural OH (0-512 ppm H₂O) and structural H₂O (0 – 1350 ppm). However, little is known about the defect locations of the trace hydrous species, their concentrations as a function of pressure and temperature and their effect on the physical properties. In this contribution we report on OH in Sr-anorthite including in-situ FTIR experiments as a function of pressure in a diamond anvil cell (DAC) in regions of OH stretching and lattice vibrations to evaluate the effect of OH on pressure induced phase transitions.

Two syntheses were performed at 20 kbar and 700 °C in a piston cylinder apparatus. The monoclinic products (space group *I2/c*) consist of 100 - 300 µm large clear single crystals which were investigated by FTIR, X-ray diffraction and electron microprobe. Polarised single crystal infrared spectra in the OH stretching region showed a broad but weak band centered around 3400 cm⁻¹ plus three sharp and intense bands: band (1) at 3628 cm⁻¹, band (2) at 3598 cm⁻¹ and band (3) at 3500 cm⁻¹. We interpret the broad band to result from OH stretching vibrations of structural water and/or molecular water in inclusions. From the pleochroic behaviour we assigned band (1) to vibrations of a O3-H dipole and bands (2) and (3) to O6-H dipoles most probably bonded both to O8 oxygens but occurring in different chemical environments (Al, Si). The water content of the synthetic Sr-anorthite is with 1100 ppm twice the maximum value observed for natural anorthite.

The DAC experiments in the OH stretching region show a clear change in the behaviour of band (1) between 8 and 9 GPa which was fully reversible upon pressure release. We interpret this as an indication for a phase transition in that region. For pure monoclinic Sr-anorthite McGuinn and Redfern (1994) described only one phase transition at 3.2 GPa, i.e. from monoclinic to triclinic (I1-). For a feldspar with composition Ca_{0.2}Sr_{0.8}Al₂Si₂O₈ Nestola *et al.* (2004) observed an additional transition at 7.3 GPa from monoclinic *I 2/c* to a not further specified monoclinic symmetry. Most probably the observed transition in this study corresponds to the transition described by Nestola *et al.* (2004). As observed for hydrous ringwoodite (Chamorro Perez *et al.*, 2006) the presence of structural bonded OH and/or H₂O may trigger the transition and/or displace phase boundaries as compared to the dry system.

References

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The δ¹⁸O of the Ocean at 3.8 Ga

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The recently discovered hydrothermally altered sheeted dike complex at Isua, Greenland provides insights into the 3.8 Ga ocean and may resolve the long standing controversy regarding the δ¹⁸O of ancient oceans and sediments. It has been argued that the very low δ¹⁸O Archean cherts (12 to 24‰ SMOW) may have precipitated from a hot Archean ocean, a conclusion incompatible with some models of atmosphere and seawater compositions. Critics of a hot ocean have invoked moderate surface temperatures but a very low δ¹⁸O ocean (-13‰). The δ¹⁸O of the ocean is held at its present value by a balance of low and high temperature water rock interactions primarily linked to plate tectonic processes. Thus as long as there is extensive hydrothermal alteration of the seafloor by seawater the δ¹⁸O of the oceans will be near 0‰. A -13‰ ocean would impose a very large ¹⁸O-depletion on any hydrothermally altered rock. The Isua dikes range in δ¹⁸O from 5.7 to 6.9‰ giving no evidence of low, but rather a slightly enriched ¹⁸O seawater at 3.8 Ga. The data from Isua as well as previous studies on pillow lavas from Pilbara and Barberton show that a very low δ¹⁸O ocean is untenable and that modern style seafloor spreading, including hydrothermal systems, may have been operating in the Archean.

The δ¹⁸O of the pillows and dikes indicate that the earliest ocean crust had already reacted chemically with seawater. This has great implications to the composition of the oceans themselves because seawater/seafloor rock reactions are known to massively affect if not control the chemical make up of seawater. The composition of seawater (as well as the inferred hydrothermal systems) may also play a role in the evolution of life.