Modeling silicate-rich fluids at high pressures

T. FOCKENBERG[1], M. BURCHARD[2] AND W.V. MARESCH[1]

[1]Ruhr-Universitaet Bochum, Institut fuer Geologie, Mineralogie und Geophysik, D-44780 Bochum; Germany (thomas.fockenberg@rub.de, walter.maresch@rub.de)
[2]Mineralogical Institute, Heidelberg University, Im Neuenheimer Feld 236, 69120 Heidelberg, Germany (burchard@min.uni-heidelberg.de)

Comprehension of rock-forming processes at depths corresponding to the lower crust and active subduction zones requires an understanding of silicate-rich fluids coexisting with rock-forming minerals. However, existing models for aqueous silicate solutions are difficult to extrapolate to pressures higher than 0.5 – 1.0 GPa. An alternative approach is to treat H_2O in terms of a statistical thermodynamic model involving a dynamic equilibrium between "gas-like" disordered and "liquid-like" clustered molecules (Gerya and Perchuk, 1997; Gerya *et al.*, 2004), where X(liq) is the mole fraction of the latter. Gerya *et al.* (2005) successfully tested this approach for SiO_2-H_2O solutions to 1300°C and 2 GPa. We extend this model to include the the ionization of water, combining available and also new experimental solubility data for quartz (SiO_2), corundum (Al_2O_3), wollastonite ($CaSiO_3$), grossular ($Ca_3Al_2Si_3O_{12}$), zoisite ($Ca_2Al_3Si_3O_{12}(OH)$), sanidine ($K_{0.9}Na_{0.1}AlSi_3O_8$) and albite ($NaAlSi_3O_8$) in pure H_2O, as well as quartz and corundum solubilities in KOH solutions, to develop a simple thermodynamic description for aqueous fluids in the model system KNCASH. ΔG_r of dissolution reactions is thus expressed in terms of the standard-state molar thermodynamic parameters ΔH°_r, ΔS°_r, $\Delta Cp(T)_r$, $\Delta V(T,P)_r$ the molality of the dissolved species, pH and X(liq). The model successfully returns the available experimental data. The formalism requires data on speciation to define the influence of X(liq) and pH on the reaction and to determine the number of species and reactions involved. However, a simplified "component" approach for oxides can be developed to approximately model KNCASH fluids from 0.2 to 3 GPa. The incorporation of pH into the model reduces the need for "mixing terms" to describe the interaction of dissolved oxides. Calculations suggest the formation of alumina-silica, alkali-silica, alkali-alumina as well as silica-alumina-alkali species. This information can also be directly derived from a comparison of the different experimentally investigated fluid-solid systems. There is no indication at present for the formation of multi-oxide complexes with Ca.

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Cosmogenic ^{3}He exposure dating of the Quaternary lavas at Fogo, Cape Verdes: Dating flank collapse and magmatic reorganisation

J.P.T. FOEKEN[1], S. DAY[2,3] AND F.M. STUART[1]

[1]Scottish Universities Environmental Research Centre, East Kilbride, UK
[2]Benfield UCL Hazard Research Center, University College London, UK
[3]Institute of Geophysics and Planetary Physics, University of California Santa Cruz, USA

Construction and destruction of young ocean island volcanoes is often episodic and governed by periods of intense volcanism and flank collapse. Conventional dating methods are often insufficient to constrain late Quaternary events; rocks may be too young to be dated precisely by $^{40}Ar/^{39}Ar$, or lack datable material (e.g. charcoal) for ^{14}C. Cosmogenic ^3He exposure dating of basaltic lavas is a powerful alternative, with potential to date flows beyond a few kyr. We present results from a study to date Quaternary lavas of Fogo, Cape Verdes. The growth of Fogo occurred in two main stages, separated by a large flank collapse removing the summit and eastern flank of the pre–collapse Monte Amarelo volcano. The collapse produced a 9 km wide escarpment with a headwall cliff that is still 1 km high despite the infilling with over 1.5 km of post–collapse lava flows from the Cha das Caldeiras volcano. Dyke swarms in the Monte Amarelo volcano indicate that the collapse was preceded by a structural reconfiguration of an initially radial dyke swarm to a single, dominantly north–south swarm across the summit region. This coincided with an eastward shift in magmatic activity. The recent history of the Cha das Caldeiras volcano has seen similar structural reconfiguration of dyke swarms and eastward shift of volcanism resulting in the extinction of post–collapse volcanic rift zones in the west of the island. Dating these events is vital for understanding the timing of (future) volcano flank collapses of Fogo.

Lava flows erupted immediately prior to, and after the collapse bracket its age and exposure ages from two pre-collapse ankaramite flows yield 24 and 110 ka, while post-collapse flows yield 14 to 9 ka. We infer two possible scenarios; (i) the collapse occurred between 14 and 24 ka or, (ii) the young exposure age of the pre-collapse flow is an artefact of ash cover/erosion and collapse occurred closer to 110 ka. This has profound implications for the interpretation of future flank collapses on Fogo. The post-collapse flows are among the youngest flows on the western side and the early Holocene ages imply that the magmatic reconfiguration and possible onset of renewed instability of the eastern flank has been developing for several thousand years. If the collapse occurred between 14 and 24 ka, flank instability may be in its early stages. If the collapse occurred around 110 ka, the duration of the pre-Monte Amarelo collapse reorganization may be comparable to the duration of the present one, with the prospect of a near-future collapse likely.