Records of A-type and I-type plutonism from the northern Aravalli craton, NW India: Age, petrogenesis and regional tectonic implications

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The northernmost segment of the Aravalli craton in NW India records two significant, discrete granitoid emplacement events at ca. 1711-1660 Ma and ca. 1822 Ma. The most unusual feature of 1711-1660 Ma plutonism is the occurrence of almost pure albite, classifying these rocks as alkali-feldspar granites. The individual plutons are predominantly composed of hastingsite or annite-bearing microcline-albite granites. The albite granites, which represent the subordinate facies, contain actinolite and magnesio-ferrohornblende or clinopyroxene. They are further characterised by low K_2O (~0.5 wt%) and high Na_2O (~7.0 wt%) abundances, whereas the microcline-albite granites show normal concentrations of alkali elements. The occurrence of virtually pure albite in these rocks has been attributed to varying extents of albitisation from moderately albitised microcline-albite granite to completely albitised albite granite. These granitoids are ferroan, metaluminous, typical within-plate A-type granites, and are derived from high-temperature melts (850-900^{o}C). Initial ε(Nd) values range from -1.3 to -6.2 and correspond to mean crustal residence ages of 2.5 to 2.1 Ga. The geochemical and geochronological data for the A-type granitoids, and their comparisons with other correlative events documented in rocks farther south and southeast, signify a widespread and prominent rift-related regime during the late Palaeoproterozoic in the Aravalli craton. The 1822 Ma older plutonism, different from that of the A-type granitoids, is recorded by foliated biotite-bearing peraluminous, calc-alkaline, I-type monzogranites, which carry signatures of continental-arc setting. These rocks exhibit a restricted range of initial Nd values between -4.8 and -5.1 which correspond to a mean crustal residence age of 2.5 Ga. The lack of petrological and geochronological information for the 1822 Ma magmatism in the adjoining areas limits the scope of regional correlation of such an event.

Upscaling reaction rate laws in geochemical reactive transport using pore-scale network models

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Reliable predictions of reactive transport in geological porous media are important in carbon geosequestration studies and other engineering applications, including aquifer remediation and nuclear waste disposal. Given the size of geological systems to be used for CO_2 geosequestration (in excess of 100's of km^2) and the long time horizon for predictions (10^2-10^3 years), explicit resolution of system heterogeneities at the micro-scale (i.e., the pore scale) is infeasible. Consequently, practical geochemical reactive transport models invariably operate at the continuum scale, in turn requiring various assumptions of homogeneity over averaging volumes far exceeding pore and grain sizes. However, sub-grid heterogeneities can undermine the macro-scale model accuracy, e.g., mineral weathering rates predicted from lab-scale data can overpredict observed field-scale rates by several orders of magnitude.

This study focuses on reaction rate laws describing acid-driven mineral dissolution and examine whether reaction rates applicable at the pore-scale are applicable at the larger continuum scale. We use a pore-scale advection/diffusion/reaction model that includes kinetic precipitation/dissolution of anorthite/kaolinite clays and simulates the inflow of acidic CO_2-rich brine under high-pressure conditions relevant to carbon geosequestration. The 4 mm^3 pore network structure was estimated using X-ray computed tomography of sandstone cores, while the statistical distribution of reactive minerals was estimated using back-scatter electron imaging and energy-dispersive X-ray spectroscopy. The cores are from the Viking formation in the Alberta sedimentary basin (Canada), which is a potential site for CO_2 storage.

We investigate whether the averaged concentrations of species and the mineral dissolution rates in the distributed pore network can be adequately approximated using a lumped model with volume-averaged parameters. For the anorthite/kaolinite system, the discrepancy between the pore-scale simulation and its lumped approximation increases with the acidity of the inflow brine and the heterogeneity of the reactive mineral distribution. The scaling effect can be reduced by replacing the volume-averaged mineral surface areas in the lumped model with "effective" reactive area parameters (calibrated a posteriori) that implicitly compensate for variations in active reactive areas due to sub-grid heterogeneities in the mineral distribution and reaction rates.