A general kinetic model of plagioclase dissolution

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Feldspar dissolution is of great geochemical interest and has been intensively studied in the laboratory. The plagioclase solid-solution series provides a unique candidate for fundamental investigations of feldspar dissolution. Factors that affect dissolution kinetics of a particular plagioclase composition include saturation state, pH, ionic strength, organic ligands and temperature. Feldspars consist of a tectosilicate framework where variation in the distribution of Al and Si generate order/disorder phenomena. In the entire plagioclase feldspar solid solution series, the Al content increases from endmembers albite ($Na[AlSi_3O_8]$) to anorthite ($Ca[Al_2Si_2O_8]$). These factors have significant influence on the dissolution kinetics and are potential indicators of dissolution mechanism.

We use a stochastic model to study plagioclase dissolution. The model incorporates bond-breaking, bond-forming, surface diffusion, detachment and attachment of various Si- and Al- ions and complexes to and from solution. The resulting dissolution is the outcome of the stochastic treatment designed to explore the kinetic behavior of a many-body process. The model involves the full crystal structure, highlighting the essential correlation of dynamics of neighboring sites on the surface.

We examined eight different plagioclase compositions, reprensenting the entire solid solution series. Our results indicate that "unlimited deepening" into the bulk structure by leaching of Al yields a consistent log-linear dependence of dissolution rate on anorthite content. Only when the dissolution process is confined to the top several surface layers, the transitional point (about An_{70}) can be successfully generated. At this point rates accelerate rapidly, and log(rate) departs positively from its linear relationship with An. In the case of (Al, Si) disorder, unlimited leaching of Al results in a 5-fold increase in dissolution rate from low albite to totally disordered high albite. In contrast, (Al, Si) disorder had no discernible effect on reaction mechanism involving the top layers. Subsequent modeling results on ΔG dependence, aluminum inhibition and surface chemistry are all comparable with previous experimental data in the framework of top-layer reaction mechanism. This confirms (1) feldspar dissolution under acidic condtions is a surface-controlled process, (2) surface processes modify the uppermost unit cells by leaching of Al, and (3) a thick layer of precipitates is generated on top of the leached interface.

Partial melting during the exhumation of the UHP rocks in Dabieshan Massif

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The partial melting associated with or induced by decomprssion during the exhumation of the UHP rocks is one of the most important physicochemical processes postdating the collsion event in an orogen. The strongly deformed foliated granite (orthogneiss) and associated felsic or pegmatitic granite pods and veinlets are widespread in the UHP and HP units in Dabieshan massif, which can be interpreted as the result of decompressional partial melting of the UHP rocks in the mid-lower crust under amphibolite face conditions. The granitic and felsic pods or veinlets are clearly intrusive, as they contain deformed enclaves of eclogite, retrograded eclogite and country rock gneiss, and the contact in some cases is cross-cutting. In some localities where larger UHP eclogite bodies occur, there is a gradual transition, from eclogite → amphibolized eclogite → eclogitic amphibolite → amphibolite (frequently with symplectites of plagioclase + amphibole) → (garnet bearing-) biotite hornblende plagioclase gneiss (so called UHP rocks) → (garnet bearing-) foliated granite. The REE distribution patterns of the UHP rocks suggest a common type of protolith. The foliated granite has the geochemical characteristics of A-type granite and formed in the post-COLG environment. The geochemial features and Pb-Sr-Nd isotope tracing indicate that its magma source is related to the UHP rocks.

Most of the partial melting phenomena are concentrated in the fractures within the eclogite, retrograded eclogite and their conuntry rocks, which supports that the partial melting must be happened during the decompressive retrogression of the eclogite to amphibolite facies and the uplift of eclogite to lower-middle crustal level. The large-scale migmatites (metatexites) and the foliated granite (anatexite) of the UHP/HP terrane in the Dabie massif are important geologic records of partial melting and the transfer of the thermal state in the crust. It is also an important physicochemical process in decreasing the competence, enhancing the deformability of the rocks and stimulating the transformation from the compressional regime to the extensional regime.

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