

The Nature of Mineral Interfaces at the Nanoscale

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Rocks are polycrystalline aggregates of mineral grains separated by a complex network of nanometre-scale interfaces. These interfaces, comprising phase, grain and twin boundaries, play a crucial role in determining the physical properties and mechanical behaviour of the bulk rock. An important aspect of these interfaces is their composition. However, the geochemistry of mineral interfaces remains poorly understood, primarily because analysing these tiny features is technologically challenging. Site-specific atom probe tomography (APT) offers an approach to quantify the major, minor, trace, and isotopic composition of mineral interfaces at sub-nanometre resolution. APT analyses of different mineral interface types demonstrate the ubiquitous presence of nanometre-scale geochemical segregations that record different compositions from the adjacent host grains. These interfacial segregations, typically comprising incompatible trace elements, represent a fundamental yet poorly studied aspect of mineral aggregates that may serve as significant repositories for geologically and economically important trace elements. In addition, grain boundary segregations will impact grain boundary processes, including grain boundary diffusion, fluid advection, interface-coupled dissolution-precipitation and dislocation-mediated interfacial re-equilibration, and affect bulk rock rheological properties and electrical conductivity. This talk presents a multiscale workflow for analysing mineral interfaces. It highlights some of the controls, complexities, and longevity of interfacial segregations and their broader implications for economic mineral systems and geophysical surveys.