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Quartz fabric-based deformation thermometry: examples of its application, relationships to petrology-based PT paths, and potential problems

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The quartz c-axis fabric opening-angle thermometer proposed by Kruhl (1998) offers a potential analytical technique for estimating deformation temperatures in rocks deformed by crystal plastic flow. However, in addition to deformation temperature, opening-angle is also sensitive to other variables such as strain rate, degree of hydrolytic weakening, and 3D strain type. Unless the influence of these individual variables can be quantified, use of fabric opening-angle as a deformation thermometer remains problematic and controversial. Over the last decade close correlations between: a) deformation temperatures indicated by fabric opening-angles and, b) temperatures of metamorphism indicated by trace element and mineral phase equilibria analyses, have been reported from a range of different tectonic settings, thereby arguably giving support to the use of opening-angles as a deformation thermometer. However, it needs to be demonstrated that the similar temperatures estimated by the different methods are related to the same geologic event, and therefore occupy at least a similar position on the PTt path - something that is in practice difficult to achieve for an individual rock sample. In cases where temperatures indicated by opening angles and mineral assemblages are markedly different, these differences could, for example, be explained by penetrative deformation and mineral growth/diffusion occurring at different times. Alternatively, when apparent deformation temperatures based on quartz fabrics are significantly greater than temperatures indicated by synchronous metamorphic mineral assemblages, this might be due to extreme hydrolytic weakening of quartz.

We illustrate this talk on the pros and cons of using fabric opening-angles as a deformation thermometer with examples from: a) Aureoles of forcibly emplaced plutons in the White-Inyo Range of eastern California where crystal-plastic deformation and recrystallization was short-lived and synchronous with contact metamorphism. b) Footwall to the South Tibetan Detachment in the Mount Everest area where deformation is demonstrably related to the exhumation stage of a petrologically well-constrained PT path. c) Hanging wall to the Main Central Thrust in the Sutlej Valley of NW India where deformation temperatures inferred from fabric opening angles are closely similar to temperatures of metamorphism indicated by garnet-biotite and oxygen isotope-based thermometry. d) Moine, Ben Hope and Naver thrust sheets of NW Scotland where structurally upwards-increasing deformation temperatures are compared with temperatures indicated by garnet-biotite thermometry. e) Mylonitic quartzites in footwall to Moine thrust at the Stack of Glencoul where hydrolytic weakening may have played an important role in deformation/recrystallization and associated fabric development. f) Thrust sheets in the Appalachians of Vermont that display a complex PTt history due to thrust sheet loading.

Kruhl, J.H. 1998. Reply: Prism- and basal-plane parallel subgrain boundaries in quartz: a microstructural geothermobarometer. Journal of Metamorphic Geology, 16, 142-146.