Examining Cross-Cutting Relationships of Veining/Brecciation Episodes in the Miocene Point Arena Formation using Cathodoluminescence, EDX, and EBSD

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Abstract
The Point Arena area is located approximately 165km north of San Francisco and consists of a Mesozoic Salinian block granitic basement overlain predominantly by marine shales and mudstones, which are bounded on the east by the San Andreas Fault (SAF). Of particular geologic interest is the Miocene Point Arena Formation which records multiple episodes of veining and brecciation. Samples exhibiting high densities of vein material collected from these outcrops were analyzed under cathodoluminescence (CL) in combination with energy-dispersive X-ray spectroscopy (EDX) and electron backscatter diffraction (EBSD). These analyses indicate that at least three different episodes of fracturing and mineral precipitation can be documented in this area manifesting in two cross-cutting sets of calcite veins and one set of quartz veins.

EBSD Explained
EBSD is a non-destructive technique used for the examination of the crystallographic texture of a material. A high energy electron beam (typically 15-30kV) is rastered over the sample surface and the diffraction pattern from the electron beam is measured using an EBSD detector. The EBSD technique is particularly useful for determining cross-cutting relationships because it can be used to map the crystallographic orientation of the sample.

EDX Explained
EDX is an analytical technique used for the elemental analysis of a material. A high energy electron beam is directed at the sample surface, and the characteristic X-rays emitted by the sample as a result of the electron beam are detected by an EDX detector. The energy and intensity of the characteristic X-rays are then used to determine the elemental composition of the sample.

Conclusions
• These analyses indicate that at least three different episodes of fracturing and mineral precipitation can be documented in this area manifesting in two cross-cutting sets of calcite veins and one set of quartz veins.
• EBSD was the most useful technique for determining cross-cutting relationships for these samples.
• Variable hit rate of the EBSD analysis along with the band contrast image significantly aided in the determination of cross-cutting relationships.
• Cathodoluminescence was particularly useful at mapping the thin (5-30 micron) quartz veins. Because the grain size of many of the calcite veins is so small, individual grains were difficult to discern on the EBSD analysis and thus cathodoluminescence was used to aid in the determination of cross-cutting relationships.

References