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Variability in fault architecture, mineralogy and fluid flow through faults in granite gneiss exhumed from seismogenic depths in the Italian Alps.

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Faults within crystalline rock are potentially the primary conduits for fluid flow and play an important role within many hydrothermal systems. How fluids move through faults, interact with fault rocks and affect fault rock properties and the evolution of faults is poorly understood. The Monte Rosa Nappe (N.Italy) is composed of late Hercynian granitoids which underwent a complex evolution during the Alpine orogeny, including late greenschist facies regional metamorphism at seismogenic depths. The metagranites are cut by a variety of fracture systems that post-date Alpine metamorphism with several of them containing signatures of flow of different low temperature fluids.

Two small dextral strike slip fault zones (10's -100's metres in length) were studied and are located at Monte Moropass. On average, they have a strike and dip of ĩ20/76NE, and have accumulated tens of centimetres of offset. Detailed field mapping was carried out which included monitoring the host and fault rock properties such as mineralogy, grain size and foliation, fault width, number of fault elements, strike and dip of the fault plane and joint density. Field data, thin section petrography and electron microscopy reveals variations in architecture of fault zones and mineralogy and grain size along and across strike of an individual fault zone. Along strike, fault width and number of fault elements increase from the tips to a maximum at approximately the middle of the fault. Across strike, hydrothermal minerals such as chlorite and epidote are generally more abundant towards the centre of the fault zone. Analysis of the low temperature metamorphic assemblages in the fault rocks is used to provide information on temperature and minimum number of phases of fault activity. Biotite within the fault zone indicates that the maximum temperature reached during faulting is in the order of 400°C. Various crystal-plastic deformation processes can be recognised by analysis of quartz and feldspar textures, which constrain temperature of deformation to be approximately 400°C. Zoned epidotes and multiple generations of chlorite are evidence for a minimum of three periods of fault activity.

Examining faults that have been exhumed from depths where earthquakes nucleate (below 2-4 km and above 11-15 km) can help us to understand the processes of earthquake nucleation and rupture propagation. This study reveals that even small faults can have complex architecture and that within these faults mineralogy, and therefore fluid flow, is variable along and across strike. Fault architecture, mineralogy and fluid content affect the mechanical and petrophysical properties of the fault rock during an earthquake. Field studies of faults should aim to quantify the length scales and magnitudes of these effects so that they can be accounted for in models of earthquake rupture.