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The hidden life of pyrite: how low can it go?

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Pyrite is the most abundant sulphide mineral in the Earth's crust, being present in most rock units but only volumetrically important in sulphide ore deposits. Thus, rheological behaviour of pyrite does not have significant implications for crustal deformation as a whole, but it does for deformation of ore deposits. Therefore, understanding pyrite behaviour in ore deposits may help understanding of deformation in rocks where it is of low abundance. Pyrite is a difficult mineral to study because it is both opaque and cubic, two properties that hide most of its microstructure when studied using optical microscopy as well as standard SEM back-scattered electron imaging. Etching can reveal some of the internal secrets of pyrite, but the technique is not universally applicable. The generally accepted view from such studies, coupled with experimental deformation and some TEM studies, is that pyrite is a robust mineral, which, under typical geological strain-rates, deforms by plastic deformation mechanisms above ~425 °C and by brittle or pressure-solution diffusive mechanisms below.

Over the last decade or so, the advent of reliable and fast SEM-based electron backscattered diffraction (EBSD) systems, coupled with orientation contrast (OC) imaging techniques, has revolutionised study of microstructure in cubic minerals. Plastic deformation can now be readily identified in pyrite; it is no longer hidden.

Freitag et al (2004) documented relatively low temperature (~350 °C) plastic deformation of pyrite from Green's Creek, Alaska, raising the possibility that pyrite deforms plastically at lower temperatures than is generally accepted. In this presentation we describe pyrite microstructures from a series of pyrite-rich polymetallic ore deposits (Parys Mountain, Anglesey; Løkken, Norway; Baia Borsa, Romania), deformed at low temperature metamorphic conditions (~200-420 °C). Our results (Barrie et al. 2009) indicate that pyrite grains in all of the ore deposits studied preserve internal lattice 'distortion' or 'bending' indicating plastic deformation mechanisms operated. Many pyrite grains in the ore deposits also contain low-angle (~2°) sub-grain boundaries or 'dislocation walls', indicating that both dislocation glide and creep deformation mechanisms have operated within the pyrite grains. These results indicate that plastic deformation of pyrite, under geological strain-rates, can go down to as low as ~200 °C suggesting the brittle-ductile transition in pyrite occurs at temperatures potentially as low as ~200 °C; much lower than the generally accepted temperature of ~425 °C. Many pyrite grains in sulphide ore deposits preserve internal chemical zonation of trace elements (e.g. Large et al. 2009). The potential relationship between plastic deformation and trace element distribution in pyrite will be discussed.

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