

# Relating quantitative microstructure to fluid chemistry in pyrite

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A gold-bearing, pyrite-rich quartz conglomerate from the Welkom goldfield, South Africa, has been studied using optical and reflected light microscopy, scanning electron microscopy (SEM), electron back-scattered diffraction (EBSD) and electron microprobe to investigate the relationship between intragrain microstructure and geochemistry in weakly-deformed, single pyrite crystals.

SEM-based atomic number contrast (ANC) imaging of pyrite shows no microstructural complexity associated with major element compositional zoning. However, orientation contrast imaging (OCI) reveal complex internal structures including bands, box-work textures, sub-domains and fine undulatory textures that all relate to changes in orientation of the pyrite crystal lattice. Quantification of these intracrystalline microstructures via automatic EBSD mapping reveal the presence of low angle boundaries ( $2-10^\circ$ ), with occasional  $10^\circ$  misorientation boundaries, that reflect progressive rotation of the crystal lattice by up to  $45^\circ$ . The dispersion of crystallographic axes around single crystal directions and the coincident geometry of misorientation axes indicate that crystallographic variations are associated with the formation and migration of [100] dislocations during plastic deformation of pyrite.

Electron microprobe compositional analyses indicate non-systematic variations in trace element geochemistry in the pyrite (As typically occurs at the 100-200 ppm level, Ni 50-200 ppm and Co around 50 ppm). In areas corresponding to the presence of intragrain low-angle boundaries, As concentrations in excess of 1000 ppm are present. These data indicate that deformation-related plastic microstructures are controlling the modification of pyrite trace element chemistry and that high concentrations do not necessarily represent mineral inclusions. This control on chemistry is interpreted to reflect increased permeability in microstructural boundaries and the chemical modification of pyrite by subsequent fluid-pyrite interactions within these relatively high permeability microstructural zones. These results have wide implications for the relationship of trace element chemistry in sulphides to ore fluid histories, sulphide provenance analysis, siting of Au in arsenian pyrite and even the mechanical and flotation properties of sulphides in general.