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Mapping Cryptic Telescoping Events in Porphyry-Epithermal Systems Through Integrated Microtextural-Chemical Pyrite Analysis at the Bonanza-Type Brucejack Au-Ag Deposit

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Telescoping, the mechanism by which shallow, low-temperature hydrothermal alteration and mineralisation are superimposed onto deep, high-temperature hydrothermal assemblages, is thought to have played a key role in forming some of the world's largest porphyry-epithermal gold deposits. Although the causes of telescoping, namely rapid, erosion-driven syn-hydrothermal degradation of paleosurfaces and sector collapse of volcanic edifices, are now well recognised, relatively little is known about (1) the prevalence of telescoping during the different stages of porphyry-epithermal deposit formation, and (2) the evolution of telescoped architectural characteristics, especially in multi-pulsed hydrothermal systems. These knowledge gaps exist because mineral assemblages related to early alteration events are commonly obliterated during later overprinting. Recent research has, however, shown that the intra-grain microtextural and trace element record from hydrothermal pyrite can provide a window onto the early, pre-telescoped alteration history of a deposit, in addition to capturing information on the nature of the telescoping process. We have investigated hydrothermal pyrite from Brucejack, a strongly telescoped, bonanza-type epithermal Au-Ag deposit in northwest British Columbia, Canada, to gain insight into the early history of alteration. Backscatter SEM imaging and LA-ICP-MS analyses of pyrite from two vertical sample transects reveal an evolution from magmatic- (elevated Co-Ni; cubic growth zonation) to epithermal- (elevated As-Au; colloform, oscillatory growth zonation) type fluids. We show that this evolution, which is otherwise cryptic due to overprinting by subsequent alteration and emplacement of bonanza-style epithermal veins, was caused by telescoping. Three-dimensional modelling of the microtextural and trace element signatures in pyrite demonstrates that this telescoping led to >1-km vertical and lateral compression of the Brucejack hydrothermal system. Furthermore, we document a previously unrecognised telescoping-reversal event in the deposit, as evidenced by localised mantling of Co-Ni on As-Au growth zones.