Invisible gold in arsenopyrite revealed by correlated Atom Probe Microscopy, NanoSIMS and Maia Mapping

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Auriferous sulphides, most notably pyrite (FeS_2) and arsenopyrite (FeAsS), are some of the most important strategic minerals on Earth because they host gold in many of the world's major gold deposits. To increase our understanding of mineralisation processes, we combined atom probe microscopy (APM), high-resolution secondary ion mass spectrometry (NanoSIMS) and synchrotron X-ray fluorescence microscopy (XFM) mapping with the Maia detector on arsenopyrite from the giant Obuasi gold deposit, Ghana.

The gold-rich arsenopyrites are shown to have undergone partial replacement by gold-poor, nickel-enrich arsenopyrite and indicate that large quantities of gold were remobilised via infiltration of only small volumes of fluid. The data shows arsenopyrite replacement produced strong chemical gradients at crystal-fluid interfaces due to an increase in fS_2 during the reaction, which enabled efficient removal of gold to the fluid phase and development of anomalously gold-rich fluid.

Atom probe tomography data at the sub-nanometre resolution revealed two types of gold distribution in distinct sub-domains of the same arsenopyrite grain with, metallic gold nanoparticles (C_{Au} = 724 ppm) and gold homogeneously distributed in the crystal lattice (C_{Au} = 2,224 ppm). These results are not consistent with previous models that point to gold concentration as the key control on gold distribution. Instead, the data indicate the critical importance of crystal growth-rate in controlling gold primary distribution, with slow growth-rate promoting the formation of metallic gold clusters, whilst rapid growth-rate promotes homogeneous gold distribution within the arsenopyrite lattice.

These results provide fundamental information on gold distribution during ore deposit formation and deliver a framework for more efficient metallurgical extraction of gold from sulfides.