Hidden in plain sight: using Atom Probe Tomography to understand the formation of invisible gold deposits in North American, China, and Europe

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Carlin-type gold (CTG) mineralization is one the best studied, yet poorly understood gold mineralization styles in the world. These deposits occur predominantly along NW-SE trends in central Nevada and are characterized by invisible gold thought to be hosted in sulfide minerals (Cline et al., 2005; Gopon et al., 2019). CTG accounts for 9 % of worldwide gold production, with all of it currently coming from five mining districts in northern and central Nevada. The discoveries of new CTG deposits in the Yukon Territory, Canada, southwest China, and Kyrgyzstan as well as the presence of significant CTG-like-gold in already known deposits in Europe will drastically increase the importance of these deposits in the upcoming years. Furthermore, the presence of gold associated high-tech metals in some of these deposits makes this deposit type potentially important for the Green Energy Transition and mineral resource security. Despite the vast resource that CTG deposits entail, surprisingly little is known about their formation mechanisms, fluid source, or even the manner in which the gold is hosted. We know that the gold tends to occur as trace elements within pyrite, which are difficult to study with the “normal” range of geology tools. With the recent application of atom probe tomography to geologic materials we now have the nano-analytical techniques to truly understand these cryptic and globally important deposits. We combine high-resolution electron probe microanalysis (EPMA) and laser ablation inductively coupled mass spectrometry (LA-ICP-MS) with atom probe tomography (APT). Using a select number of examples from North America, Europe, and China we present data that help to constrain how gold is hosted in these deposits, why sulfide minerals make such great hosts for gold and other critical metals, and share insights from atomic scale trace element and isotopic analysis into the formation mechanisms of these deposits.