A Process-Based Explanation for IOCG Diversity

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The diversity of iron oxide Cu-Au (IOCG) deposit characteristics partly relates to our desire for all-encompassing classification. It takes only a modest amount of cynicism to say that "too many deposits have been labeled as IOCG," particularly during the last exploration boom when rocks previously described as skarns, mantos, carbonatites, etc., were thrown into the IOCG basket in the hope of gaining some traction with the exploration or research sectors. Despite this background, there is genuine scientific uncertainty about whether there is a meaningful genetic connection across the IOCG definition that relates to a particular set of geological processes. The deposits and associated regional iron-rich systems containing economic Cu + Au do have some common characteristics globally, even if there is a spectrum broader than that defined for many other hydrothermal deposits. Fluid inclusion studies reveal seawater or basinal brine sources for many IOCG ingredients, consistent with 100- to 1,000-km^2 alteration systems, indicating widespread passage of fluids, dissimilar to fluid evolutionary and spatial paths in porphyries. Long-distance, long-timescale hydrothermal circulation is typically invoked, and an important endmember model for IOCG deposits relies solely on this mechanism for sourcing metals.

However, varying between and within districts, there may be admixtures of more obvious magmatic-hydrothermal components, to different degrees, recorded in the fluid and mineral chemistry, and ultimately in the geometallurgy. Furthermore, many of the world's largest IOCG deposits are hosted in hydrothermal breccias which are spatially restricted, contain most of the ore, and show definitive structural controls. Some of the breccias show evidence for geologically rapid breccia formation (fluidization) and equally rapid ore precipitation, a process distinct from the "gentle" regional circulation of brines. This paradox (fast, dynamic breccia-hosted ores sitting in slow, regional circulation cells) is central to the set of processes that explain IOCG diversity, ultimately relating to the geodynamics. Regional circulation of the brines was mostly caused by thermal effects of widespread intrusion at depth. At Cloncurry, late-stage magma mingling then triggered focused volatile release and rapid expulsion of CO_2-rich fluid from the tops of the intrusions, producing explosive brecciation and effectively upwardly entraining rocks, fluids, and dissolved metals at >km scales, a mechanism that may have operated to some degree in many IOCG breccias. Physical mixing of ingredients in these pipes contributed to the diversity of genetic signals in breccias hosting the ores. The mechanism is not exclusive, but represents a signal of the evolution of IOCG systems from slow, regional brine circulation (which may have assembled most ingredients and formed early ores), driven by broad magma emplacement at depth, to a final, rapid contribution to the system triggered by late magmatic mingling and brecciation with volatile release.

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