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Lithospheric and tectonic settings of IOCG systems in Australia

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Large iron oxide copper-gold (IOCG) deposits are comparatively rare and potentially highly valuable exploration targets, typically also containing elevated U, REE, Mo, Ag and other metals. These diverse Cu-Au deposits are hosted by magnetite- to hematite-rich breccias, are embedded within regional- to deposit-scale Na-, K-, Ca- and Fe-rich hydrothermal alteration, and range in age from Archean (e.g., Carajás district, Brazil) through Proterozoic (e.g. Gawler Craton and Cloncurry district, Australia), to Mesozoic (e.g., Chilean Iron Belt) or younger. Proposed geological and tectonic settings of IOCG deposits are also diverse, broadened by the inclusion by some workers of other deposit types which may or may not be affiliated with IOCG deposits (e.g. magnetite-apatite or Kiruna-type). As more data become available on the geology of IOCG provinces, the tectonic and lithospheric settings of the major IOCG deposits are resolving into two principal categories: (a) syn- to post-orogenic reactivated margins of cratonic blocks, distant from active plate margins, and (b) continental margin magmatic arcs. IOCG setting (a) represents a combination of previously proposed settings characterised by 'orogenic basin collapse' and 'anorogenic magmatism' [1, 2]. Here we emphasise the critical role of orogenesis in setting (a) and, based on studies of some of the world's major IOCG provinces in Australia, propose that higher grade mineralisation formed during extension following a switch from compressional tectonism. This tectonic evolution permitted hydrothermal fluids from both deep and shallow sources to mix within the upper crust, imparting the characteristic metal and alteration signatures of the IOCG mineral systems. Unlike the calc-alkaline-dominated magmatism in the continental margin magmatic arc setting (b), magmatism in setting (a) is characterised by bimodal mafic (± rare ultramafic) and A- to high-temperature I-type felsic magmatism. These and other characteristics of setting (a) such as rapid exhumation are not easily reconciled in anorogenic models involving mantle plumes [2]. A model of 'plume-modified orogenesis' at a convergent margin has been proposed [3] to account for the combination of tectonism and magmatism during the Mesoproterozoic in the regions of Australia's major IOCG provinces (Gawler Craton, Mt Isa Inlier). Alternatively, removal (e.g. by delamination) of gravitationally unstable lithospheric mantle and/or lower crust, over-thickened during orogenesis, may account for the switch from compression to extension, bimodal magmatism, exhumation, and elevated geothermal gradients that drove IOCG fluid flow [4]. Recently available geophysical and isotopic data for the Australian IOCG provinces provide new insights on the nature and evolution of the underlying lithosphere. Both the Olympic IOCG Province in the Gawler Craton and the Cloncurry IOCG district in the Mt Isa Inlier are located along the eastern margins of cratons with thick lithosphere as defined by crustal and mantle seismic, electrical conductivity, and neodymium isotope data. However, the uppermost mantle to the west of the IOCG provinces has anomalously slow seismic velocities [5] which, in the case of the Gawler Craton where more detailed magneto-telluric data are available, is also unusually electrically conductive [6]. These observations are consistent with re-fertilised and/or metasomatised mantle, although the timing and origin of such modifications are unclear. The location of the anomalous upper mantle zones directly beneath the same Mesoproterozoic igneous rocks spatially and temporally related to IOCG deposit formation points to a genetic link with the speculated metasomatised mantle. Improved understanding of this possible link will permit further testing of tectonic models, thereby enhancing exploration targeting for IOCG deposits in Australia and globally.

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