

Late Jurassic Farallon-Izanagi triple-ridge subduction and transform fault subduction producing Middle Jurassic Cu mineralization. The Cretaceous porphyry Cu mineralization resulted from subduction of the Izanagi plate beneath the South China continent.

P1.18

Formation and Exhumation of the Mid-Jurassic Porphyry Copper Systems in Dexing, SE China: Insights From Geo-/Thermo-chronological Studies

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The Dexing porphyry Cu-Au and Yinshan polymetallic (Pb-Zn-Ag-Cu-Au) deposits are giant porphyry ore systems in Dexing City, which is one of the most important ore districts in China. The two deposits are adjacent to each other, and nearly identical in magma genesis and formation ages, but they exhibit remarkable contrasts in metallic assemblages. The Dexing deposit produces porphyry type Cu-Au ores, with a significant proportion being eroded, while the Yinshan deposit produces vein type Cu-Au ores and epithermal Pb-Zn-Ag veins in coexistence with abundant volcanic rocks and a remnant volcanic conduit. This interesting observation indicates that they experienced different exhumation and erosion histories, leading to the different exposure levels.

Here, we present new geo/thermochronological results. The Dexing deposit has a molybdenite Re-Os age of ~170.3 Ma, zircon U/He (ZHe) age of ~114.4 Ma and apatite U/He (AHe) age of ~8.0 Ma. By contrast, the Yinshan deposit has a much older ZHe (~132.6 Ma) and AHe age (~29.6 Ma). Combining these results with published age data, we established complete time-temperature frameworks for the two deposits from the beginning of porphyry formation to cooling through hydrothermal mineralization and initial exhumation, to final uplift to near surface. Through reverse modeling, it is suggested that both the Dexing and Yinshan deposits experienced rapid magmatic-hydrothermal cooling to around 250 °C during the first several million years (172 to 168 Ma), followed by a protracted (~40 m.y.) and extremely slow cooling to around 180 °C. The initial rapid cooling is characteristic of most porphyry systems. However, the protracted and slow cooling seems much like a unique feature of old porphyry systems, and may be caused by great emplacement depth or prolonged hydrothermal supplies. During the Early Cretaceous (125 to 105 Ma), the Dexing deposit underwent rapid cooling, while the Yinshan deposit experienced slow cooling to around 75 °C. During

the following 70 to 100 m.y., temperatures remained stable at around 75 °C, indicating that they stayed unchanged at that depth. It is because of this stable and prolonged preservation that the two old porphyry systems survived from disappearance by erosion. In the Oligocene (35 to 25 Ma) the Yinshan deposit was exposed to surface. Later in the Pliocene (~3 Ma), the Dexing deposit reached the surface.

We tentatively propose that the rapid Cretaceous cooling of the Dexing deposit corresponded to a regional uplift event which was recorded by contemporary rapid accommodation of 1800 m of sediments in the Leping-Dexing basin. In contrast, because the Yinshan deposit is on the edge of the basin, it experienced slow cooling in response to relative subsidence. Similarly, differential uplifts in the Oligocene and Pliocene were likely to be controlled by the basin evolution.

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New Insights on West African Tectonics and Iron Mineralisation Based on Zircon U-Pb SHRIMP Geochronology and Structural Mapping

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Three main types of iron mineralisation occur in West Africa: Palaeoproterozoic BIF-style on the Leo-Man Shield (e.g. Simandou), Neoproterozoic specularite of hydrothermal origin (e.g. in the Marampa Group), and metamorphic magnetite (e.g. in the Kasila Group). Understanding the distribution of major tectonic units and reconstruction of the geological evolution of the region are keys to assessing the prospectivity for iron mineralisation in underexplored areas.

Mapping, combined with zircon U-Pb geochronology of key units in Guinea and Sierra Leone, confirmed the presence of Archaean units with low metamorphic grade, ascribed to the Leo-Man Shield, structurally overlain by allochthonous units of the Marampa Group, which includes metavolcanics. To the west, an upper-amphibolite to granulite-facies grade metasedimentary/metavolcanic succession occurs (Kasila Group). To the east of the Marampa Group, a succession of largely undeformed coarse clastics and volcanics occurs (Rokel River Group).

New zircon U-Pb geochronology of gneisses from the basement to the Marampa Group (Kenema Assemblage) in Sierra Leone indicated ages between ~3.17 and 2.85 Ga, within the range of published U-Pb data on rocks from the Leo-Man Shield farther east (3.54 – 2.71 Ga). One sample from a magnetite-rich unit in the Kasila Group, interpreted to be of volcanic origin, gave a crystallisation age of 1.94 Ga. Detrital zircons from two samples of the Marampa Group,

one chloritic schist and one quartzite, yielded a broad range of between 3.2 and 1.1 Ga, including main populations at 3.05, 2.85, 2.2 – 1.8, 1.5 and 1.1 Ga. The youngest concordant detrital zircon, dated at 1030 ± 40 Ma, provides a maximum age of deposition. Source regions for some of these populations in the Marampa samples are not present within the West African Craton, but are present in the Amazonia Craton. Most samples analysed show evidence of Pb-loss, with regressions towards 0.5 Ga. Four concordant analyses in one sample provide an age of 588 ± 7 Ma, interpreted to reflect peak metamorphism in the Rokel-Kasila Belt. This metamorphic age falls within cooling age ranges on biotite, muscovite and hornblende across the region, ranging from 585 to 510 Ma.

Based on the new data, a new tectonic model is proposed for the Rokel-Kasila Belt, in which the Kasila Group is interpreted to form a remnant part of the Amazonia Craton, left attached to the Leo-Man Shield after Neoproterozoic collision. The Marampa Group represents the thrust nappes of intervening oceanic sedimentary successions, which show derivation from both the Amazonian and West African margins, while the Kenema Assemblage forms part of the Leo-Man Shield.

This interpretation facilitates reclassification of the known iron mineralisation, and enables regional-scale prospectivity analysis. Palaeoproterozoic BIFs are widespread over the Archaean shield in greenstone belts and are the most extensive and highest in grade. Specularite deposits are regionally restricted to the Marampa Group, and are controlled by the basal thrust contact with the underlying Kenema-Man Shield. These deposits are generally smaller and have lower grades. Metamorphic magnetite-rich units occur only in the Kasila Group, but are sub-economic because of their low grade and small size.

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Resolving the Timing of Fluid Flow Within Metamorphosed Terranes: U-Pb Age Depth-Profiles of Zircon From the North Caribou Greenstone Belt, Canada

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The 3.0 Ga North Caribou greenstone belt (NCGB) is home to Goldcorp's 2M oz Musselwhite mine. Gold mineralization is hosted in an amphibolite facies banded iron formation, and considering this metamorphic grade, the differentiation of hydrothermal alteration from the metamorphic pattern has proven itself a tedious task. Early regional metamorphism was synchronous with voluminous magmatic activity at

c. 2.86 Ga. The timing of Au mineralization has been broadly resolved to occur between 2.72-2.66 Ga based on garnet-w.r. Sm-Nd ages calculated from garnets of the meta-chemical sediments (Biczok et al. 2011, Precambrian Research 192-195, 209-230).

Seven spatially distributed metasedimentary rocks adjacent to, or overlying, intrusions that are apparent on the regional aeromagnetic map were sampled across the NCGB. Further these rocks possess amphibolite facies assemblages with mm-scale porphyroblasts of cordierite or andalusite and staurolite. The porphyroblasts commonly overprint any dominant foliation, suggesting the thermal peak outlasted, or post-dates, deformation. Constraining the timing of a large scale, high temperature event has historically been limited to this relative assessment. We are exploiting zircon's phenomenon of undergoing coupled dissolution-reprecipitation during hydrothermal episodes to resolve the timing of metamorphism and alteration (Breeding et al. 2004, American Mineralogist, 89(7), 1067-1077; Geisler et al. 2007, Elements, 3(1), 43-50; Schneider et al. 2012, Economic Geology, 107(5), 1043-1072). Fluid-mediated alteration can manifest itself as μm -scale rims on the outer surfaces and within fractures of zircon crystals. Secondary Ion Mass Spectrometry (SIMS) U-Pb depth-profile geochronology, conducted at UCLA, was capable of providing sub-micron age resolution of thin (3-5 μm) rims on unpolished zircons. Analyses of over 100 zircon crystals from the seven samples yield a consistent rim age of c. 2.70 Ga. The depth-profiles appear as gradational or sharp increases of age with depth into the zircon interior. Interior zircon ages for the samples range from c. 2.90 to 3.15 Ga. The age-depth profile corresponds to an increase in Th/U values with penetration into the zircon interior, and young ages coincide with a Th/U of <0.1 (metamorphic derivation), whereas zircon interior values range between 0.4 and 0.7 (igneous derivation).

Not all zircon from a sample exhibit homogeneous rim material. The lack of a younger age rim on some, or part of, the zircon crystals is thought to be a result of incomplete recrystallization due to an armoring effect of neighbouring mineral phases and limited exposure to fluids. Considering that zircon must be separated from the rock to conduct this depth profiling methodology, in situ analysis is not an option to understand the relationships between crystal distribution and fluid movement. Nonetheless, our results can be interpreted as orogen-wide hydrothermal activity dated at c. 2.70 Ga, which coincides with the earlier time period suggested by Biczok et al. (2011) for the Au mineralization at Musselwhite. Considering this temporal link, if indeed we have dated the same hydrothermal event but at a regional scale, there is potential for additional endowment extending far beyond the existing deposit.