

Archean tectonics as a guide to mineralization potential in the Pilbara

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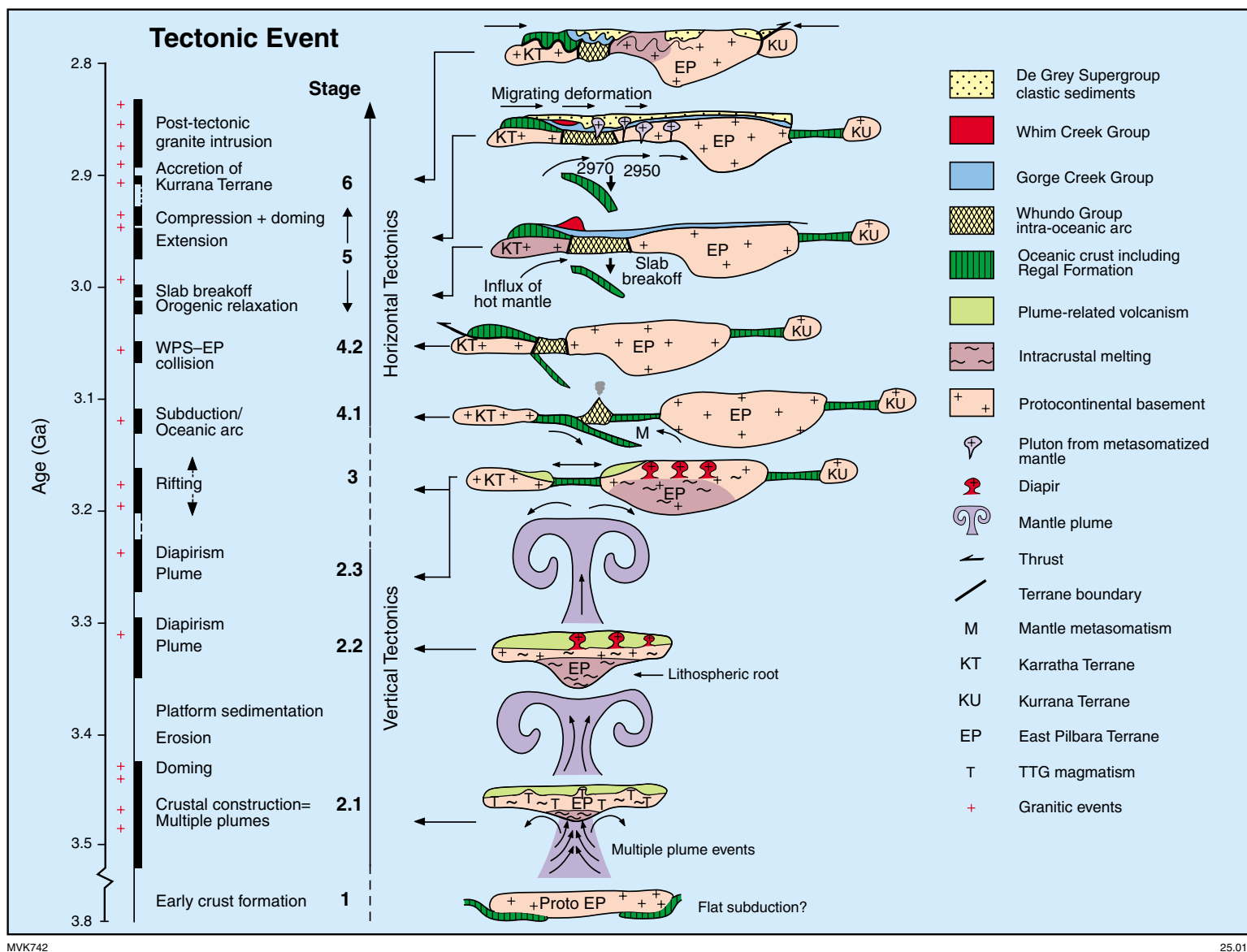
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Different mineralization styles in the Archean Pilbara Craton can be ascribed to changes in tectonic style throughout its approximately 800 m.y. evolution, from an early stage of plume-dominated tectonics (3.53–3.2 Ga) to later stages dominated by horizontal tectonics (3.2–2.83 Ga, Fig. 1; Van Kranendonk et al., in press). The Pilbara Craton contains five geologically distinct terranes. The 3.53–3.17 Ga East Pilbara Terrane represents the ancient nucleus of the craton, and comprises predominantly igneous rocks that were produced as a result of three distinct mantle plume events erupted onto yet older, but now largely cryptic, sialic crust (Van Kranendonk and Pirajno, 2004). These events include the 3.53–3.42 Ga Warrawoona Group and coeval Callina (3.50–3.46 Ga) and Tambina (3.45–3.42 Ga) Supersuites; the 3.35–3.31 Ga Kelly Group and coeval Emu Pool Supersuite (3.32–3.29 Ga); and the 3.27–3.24 Ga Sulphur Springs Group and coeval Cleland Supersuite (3.27–3.22 Ga). Heat from plumes caused voluminous ultramafic–mafic–felsic magmatism, uplift, and extension of the crust. Each plume event was accompanied by intracrustal melting that generated early tonalite–trondjemite–granodiorite (TTG), and then progressively more evolved granitic magmas that were emplaced into the upper crust during periods of partial convective overturn. Mantle melting events caused severe depletion of the subcontinental lithospheric mantle, making the East Pilbara Terrane a stable, buoyant, unsubductable protocontinent by 3.2 Ga (Smithies et al., 2005b). Mineralization styles associated with these events include synvolcanic copper–zinc–lead–barite volcanic-hosted massive sulfide (VHMS) deposits and hydrothermal barite–zinc–lead–copper sedimentary replacement deposits; polymetallic and base metal deposits in c. 3.45 Ga felsic porphyries; mesothermal gold deposits in shear zones around granitic domes (3.31 and 3.24 Ga); and local copper–molybdenum porphyry mineralization (3.31 Ga). Underexplored mineralization styles include komatiite-hosted nickel deposits in plume volcanic rocks, and nickel–copper – platinum group element deposits in East Pilbara Terrane rift-margin volcanic rocks.

After 3.2 Ga, horizontal tectonics dominated over vertical tectonics, leading to 3.12 Ga subduction, and 3.07 Ga accretion of the West Pilbara Superterrane with the East Pilbara Terrane. The West Pilbara Superterrane comprises three terranes separated by major structures. The 3.27 Ga Karratha Terrane includes komatiites that host nickel–copper mineralization. It is separated from c. 3.2 Ga N-MORB-type basaltic rocks of the Regal Terrane by a major folded thrust. These terranes are separated from the 3.12 Ga Sholl Terrane by the crustal-scale, predominantly strike-slip Sholl Shear Zone. The 10 km-thick Whundo Group of the Sholl Terrane has stratigraphic and geochemical characteristics of modern oceanic arcs (e.g. boninites and evidence for flux melting), including VHMS copper–zinc mineralization (e.g. Whundo deposit; Smithies et al., 2005a). The c. 3.2 Ga Kurrana Terrane comprises a variety of granitic rocks emplaced within undated greenstones in the southeastern part of the craton.

Terrane accretion and West Pilbara Superterrane – East Pilbara Terrane collision at 3.07 Ga (Prinsep Orogeny) was followed by development of an intracontinental sag basin (3.02–2.93 Ga De Grey Supergroup) and by west-to-east prograding granitic plutonism (3.00–2.93 Ga) and compressional deformation (2.95–2.91 Ga), most likely as a result of a combination of orogenic relaxation and slab breakoff (Fig. 1). Associated mineralization includes banded iron-formation of the 3.02 Ga Gorge Creek Group (e.g. Yarrrie, Sunrise Hill, and Goldsworthy deposits), 3.01–2.95 Ga copper–zinc VHMS deposits (e.g. Whim Creek deposit), 2.95 Ga vanadium–titanium–magnetite in mafic–ultramafic intrusions, and 2.95 Ga nickel–copper – platinum group element – orthomagmatic gold in mafic–ultramafic sills associated with intrusion of sanukitoids. Orogenic gold deposits formed in 2.95–2.91 Ga thrusts and shear zones across the West Pilbara Superterrane and basins of the De Grey Supergroup (Mallina and Mosquito Creek Basins), analogous with gold-mineralized Neoproterozoic orogens. Late-tectonic ultramafic intrusions (2.92 Ga) were emplaced during transtension and host nickel–copper – platinum group element mineralization (e.g. Munni Munni and Radio Hill Intrusions). Post-tectonic granites (2.89–2.83 Ga) host tin–tantalum–lithium mineralization in a linear zone from the Kurrana Terrane to the eastern Mallina Basin.

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