

Geology and Tectonic Evolution of the Archean North Pilbara Terrain, Pilbara Craton, Western Australia

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Abstract

Results from a multidisciplinary geoscience program since 1994 are summarized for the North Pilbara terrain of the Pilbara Craton. Major findings include the recognition of three separate terranes with unique stratigraphy, geochronological, and structural histories; the ca. 3.72 to 2.85 Ga East Pilbara granite-greenstone terrane, the ca. 3.27 to 2.92 Ga West Pilbara granite-greenstone terrane, and the ≤ 3.29 Ga Kuranna terrane in the southeast. These are separated by two late, dominantly clastic sedimentary basins deposited within tectonically active zones; the ca. 3.01 to 2.93 Ga Mallina basin in the west and the undated Mosquito Creek basin in the east.

The oldest supracrustal rocks are the ca. 3.51 to 3.50 Ga Coonterunah and ca. 3.49 to 3.31 Ga Warrawoona Groups in the East Pilbara granite-greenstone terrane, deposited on fragments of older sialic crust to 3.72 Ga. The Warrawoona Group is subdivided into three main (ultra)mafic-felsic volcanic cycles including from base to top, the Talga Talga (3.49–3.46 Ga), Salgash (3.46–3.43 Ga), and newly defined Kelly (3.43–3.31 Ga) Subgroups. These dominantly basaltic rocks include chert beds containing Earth's oldest stromatolites and are interbedded with significant felsic volcanics erupted intermittently from 3.49 to 3.43 Ga during emplacement of sheeted sodic granitoid sills. Estimates of autochthonous stratigraphic thickness range from 9 to 18 km. Deformation involved extensional growth faulting, local folding, and tilting of greenstones away from synvolcanic granitoid domes. Rapid partial convective overturn of upper and middle crust occurred at 3.32 Ga during voluminous potassic felsic magmatism, followed by deposition of the Budjan Creek Formation at 3.31 Ga.

Granitoid plutonism at ca. 3.29 Ga in the Kuranna terrane preceded deposition of ultramafic through felsic volcanics and chert in the West Pilbara granite-greenstone terrane (3.27–3.25 Ga Roebourne Group) and western margin of the East Pilbara granite-greenstone terrane (3.26–3.24 Ga Sulphur Springs Group). Geochemical and isotopic data suggest that volcanism resulted from plume-related rifting of the East Pilbara granite-greenstone terrane, which was accompanied by granitoid plutonism and deformation. Following this was ca. 100 m.y. of relative quiescence during which locally economic concentrations of banded iron-formation and siliciclastics of the Gorge Creek Group were deposited in the East Pilbara granite-greenstone terrane.

Thereafter, geologic events are more consistent with microplate tectonics, commencing with deformation at 3.15 Ga followed by deposition of 3.13 to 3.11 Ga bimodal volcanics in the West Pilbara granite-greenstone terrane (Whundo Group), which have juvenile Nd isotope signatures and thus may represent either a rift or island-arc succession. Basaltic rocks and minor felsic tuff were deposited in the East Pilbara granite-greenstone terrane at 3.06 Ga and possibly in the West Pilbara granite-greenstone terrane (Regal Formation). At 3.02 Ga, the Whundo and Roebourne Groups share a common history of deposition of banded iron-formation and granitoid plutonism across the Sholl shear zone, suggesting accretion at, or immediately preceding, this time. This was followed by deposition in the Mallina basin of the volcanic Whim Creek Group at 3.01 Ga, possibly as an arc, and then the 2.97 to 2.93 Ga volcanic Bookingarra (west) and clastic De Grey (east) Groups during periods of intracontinental rifting interspersed with compression and granitoid intrusion. The geochemistry of 2.95 Ga high Mg diorites (sanukitoids) indicates a previous episode of subduction during either the Whundo or Whim Creek Groups or both. Final events include emplacement of ultramafic-mafic layered intrusions (2.925 Ga in the West Pilbara granite-greenstone terrane), local shearing and lode Au mineralization (2.92 Ga in the West Pilbara granite-greenstone terrane, 2.90 Ga in the Mosquito Creek basin, 2.89 Ga in the East Pilbara granite-greenstone terrane), and intrusion of fractionated, Sn-Ta-Li-bearing granites to 2.85 Ga (East Pilbara granite-greenstone terrane).