New tectono-stratigraphic interpretations of the Pilbara Craton, Western Australia

by

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The Geological Survey of Western Australia (GSWA) program of 1:100 000-scale geological mapping in the north Pilbara granite–greenstone terrane has now been in progress for four years, and the new information obtained has led to major reinterpretations of the region's stratigraphy, structure and tectonic evolution. The mapping forms part of a joint project between GSWA and the Australian Geological Survey Organisation (AGSO), and currently employs about ten geoscientists. Most of the geological field mapping is being undertaken by GSWA, whereas AGSO staff are concentrating on mineralization and the interpretation of regional airborne magnetic, gamma-ray spectrometric, and gravity data.

Previous geological interpretations of the Pilbara Craton are generalized into two distinct models:

1. In the regional interpretation presented by Hickman (1983), the north Pilbara granite–greenstone terrane evolved from a single segment of continental crust formed at about 3500 Ma. The greenstone belts are the synformal remnants of a craton-wide 3500–2900 Ma supracrustal succession of volcanic and sedimentary rocks, referred to as the Pilbara Supergroup. Lower parts of this succession exhibit an essentially 'layer-cake' stratigraphy, with the same formations occurring in most greenstone belts of the east and west Pilbara. Upper units of the Pilbara Supergroup were deposited after diapiric deformation, and were restricted to separate basins. A lithostratigraphic subdivision was applied to the greenstone succession.
2. In the late 1980s and 1990s various workers interpreted the north Pilbara granite–greenstone terrane as an assemblage of tectono-stratigraphic domains. These domains are separated by northeast–southwesterly trending faults considered to have a long history of development and reactivation (Krapez, 1993). Using principles of sequence stratigraphy the greenstones are subdivided into four megasequences, each representing a megacycle of fore-arc, arc, and/or back-arc geotectonic evolution associated with convergent margin processes. Seventeen second-order supersequences record separate basins or basin phases. According to Barley (1997) the supersequences are stacked, recording progressive westwards growth (accretion?) of the craton, and can be related to the opening and closure of ocean basins.

The 1:100 000 mapping between 1995 and 1999 has established that the north Pilbara granite–greenstone terrane can be divided into western and eastern terranes separated by the Mallina Basin (Fig. 1). These two terranes exhibit different tectonic styles and major stratigraphic differences.

The western terrane, which comprises the Whim Creek Belt and all units to the west of this, is characterized by northeast-trending granitoid complexes and greenstone belts, numerous closely spaced east- and northeast-striking faults, and by granitoids which are structurally relatively simple and discordant to the greenstone stratigraphy. In contrast, the eastern terrane is dominated by dome-and-syncline structures in which the granitoid complexes are composite ovoid structures, and the greenstone belts exhibit no preferred structural trend. Granite–greenstone contacts are generally sheared, and parallel to adjacent greenstone stratigraphy.

Stratigraphic differences between the two terranes are very considerable, although the precise degree of difference is still being tested. In particular, the oldest rocks of the western terrane are 3270 Ma, and the 3490–3420 Ma Warrawoona Group is absent. In the eastern terrane the oldest rocks are 3660–3590 Ma gneisses (Nelson, in prep.), and the oldest greenstones are 3515 Ma. In addition, the east Pilbara contains no equivalents of the 3125–3115 Ma Whundo Group or the 3010–3000 Ma Whim Creek Group.

The differences between the western and eastern terranes are not explained by progressive westward accretion. Geochronology from the eastern terrane has identified rocks older than 3400 Ma near its eastern and western margins, indicating no trend of east-west younging. Moreover, the western terrane has provided isotopic evidence for 3490–3450 Ma sources for certain of its granitoids and greenstones. Both terranes contain stratigraphic units and granitoids spanning the 3270–

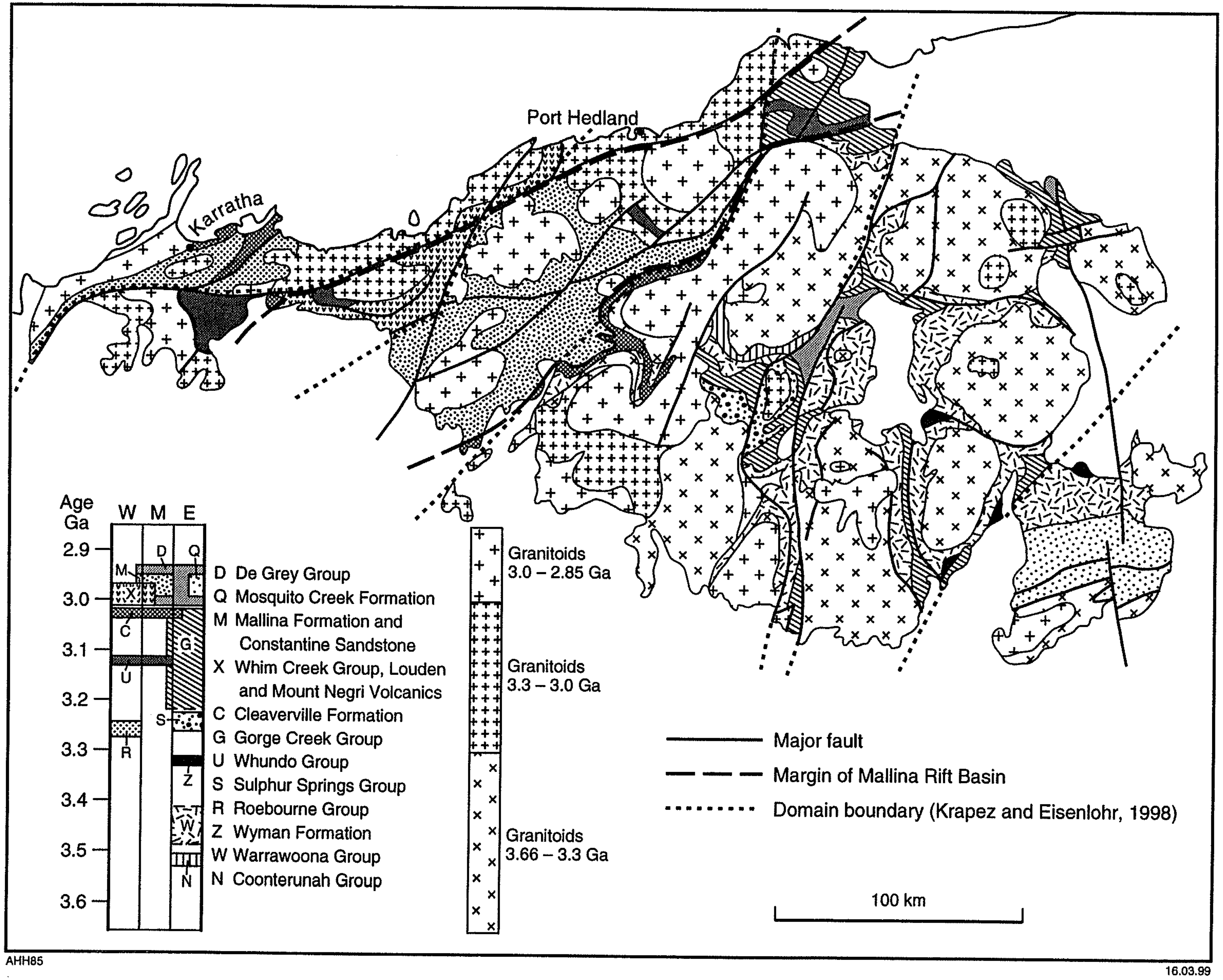

Figure 1. Tectono-stratigraphy of the north Pilbara granite–greenstone terranes

2920 Ma age range, and stratigraphic correlation may eventually be confirmed between 3270–3250 Ma formations of the Roebourne Group and the c. 3260–3240 Ma Sulphur Springs Group. The two terranes were in contact before 3020 Ma because the 3020–3015 Ma Cleaverville Formation occurs in both. Certainly, convergent-margin environments can explain some of the west Pilbara units, probably from 3130 Ma onwards, and this is consistent with their location on the northwestern margin of the Pilbara Craton.

The five northeast-trending domain boundaries, claimed by Krapez and Eisenlohr (1998) to be long-lived crustal structures, appear to be merely late-stage (c. 3050–2900 Ma) strike-slip faults. No major structural or stratigraphic differences have been established across the two lineaments in the eastern terrane; mapping of the eastern margin of the Mallina Basin has shown that the lineament proposed here is not a continuous structure; and the lineament near the western margin of the Mallina Basin, crosses the Mallina Basin–Whim Creek Group association. The Sholl Shear Zone (the most westerly lineament) records post-3010 Ma (probably also post-2925 Ma) dextral movement of 30–40 km, displacing the Whim Creek Group, the Cleaverville Formation, and the Andover Intrusion (Hickman, in prep.). Greater, sinistral movement occurred at some time between 3115 Ma (Whundo Group) and 3015 Ma. Shear zones within the Mallina Basin may represent post-3000 Ma reactivation of a concealed tectonic zone separating the eastern and western terranes.

Mapping of the western terrane, and the greater part of the Mallina Basin, is now complete, and has resulted in a major revision of the stratigraphic succession. Restricted to the area south of the Sholl Shear Zone, the volcanic rocks of the 3125–3115 Ma Whundo Group were derived from juvenile crust, possibly in a subduction-zone environment (Smith et al., 1998; Sun and Hickman, 1998). In contrast, the 3270–3250 Ma Roebourne Group occurs only north of the Sholl Shear Zone, and Nd-isotopic data indicate derivation from much older rocks (Sun and Hickman, 1998). The Cleaverville Formation has been dated at 3020–3015 Ma, overlies both the Whundo Group and the Roebourne Group and, in addition, provides a stratigraphic link between the western and eastern terranes. The 3010 Ma Whim Creek Group unconformably overlies the Whundo Group and the Cleaverville Formation, and at least partly underlies the Mallina Formation. The Mallina Basin post-dates 3000 Ma, and is an extensional basin underlain by continental crust (Smithies et al., 1999).

New information from the east Pilbara includes identification of 3660–3590 Ma gneiss, separation of the 3260–3240 Ma Sulphur Springs Group from the much older Warrawoona Group, and detailed subdivisions of the Gorge Creek Group in two areas. Additionally, mapping and geochronology around Marble Bar have clearly demonstrated that the Warrawoona Group is not tectonically duplicated or inverted by major horizontal movements, as was proposed by Van Haaften and White (1998), but is a normal, 13 km-thick succession, as originally interpreted by Hickman (1983). Another important development has been confirmation of the diapiric model for dome and sycline development (Van Kranendonk and Collins, in press).

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