Evaluation of Paleoproterozoic basin development on the northern Yilgarn Craton

Sandra Occhipinti, Roger Hocking, Mark Lindsay, Amanda Jones, Alan Aitken, Stephen Sheppard, Iain Copp, Franco Pirajno and Vaclav Metelka.

Centre for Exploration Targeting, School of Earth Sciences, The University of Western Australia, 35 Stirling Hwy, Crawley, WA 6009, Australia

Centre for EXPLORATION TARGETING

1. Introduction

New and published regional geological, geochronological, geochemical and geophysical data suggest that a revised tectonic model for the evolution of Paleoproterozoic basins on the northern Yilgarn Craton is warrented. The basins formed as a response to both extensional and compressional processes in the early Paleoproterozoic along the craton's margin. Early rifting and basin formation led to the formation of the Yerrida Basin at c. 2180 Ma as a single sub-basin containing the Windplain Group. This led to the eventual development of the Bryah and Mooloogool Sub-basins of the Yerrida Basin at c. 2030 Ma, and voluminous extrusion and intrusion of mafic rocks. The depth, and nature of the Bryah Sub-basin suggests that it corresponds with a rift axis, and is the deepest part of the Yerrida Basin. Continued rifting along the northern Yilgarn margin resulted in subduction of the Yilgarn Craton beneath the sutured Glenburgh–Pilbara craton. Eventual convergence resulted in volcanism and rift-sediment deposition ceasing in the Bryah and Mooloogool Sub-basins, the onset of pro-foreland basin development (Padbury Basin) in the west, and approximately NE–SW rifting further east, forming the Earaheedy Basin, all at c. 2000 Ma. Banded iron-formation and granular iron-formation in the Robinson Range and Frere Formations was deposited much later (c. 1890 Ma) in a large basin that deepened from east to west, covering the Earaheedy and Yerrida Basins. The deepest parts of this basin coincide with the Bryah Sub-basin, which represents the most rifted portion of the Yilgarn Craton in this region. Deposition in all basins probably ceased with the onset of the Capricorn Orogeny at c. 1820 Ma.

Figure 1: Time-space plot of geological units in the Bryah, Padbury, Yerrida and Earaheedy Basins. colors correspond with *Map inset area a*

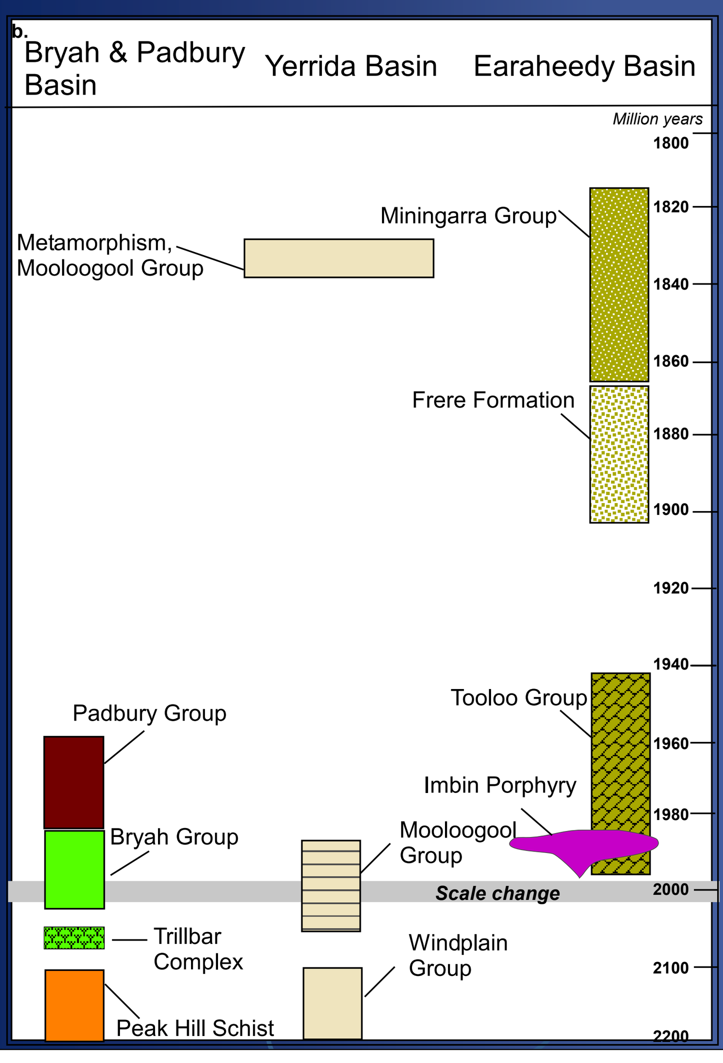
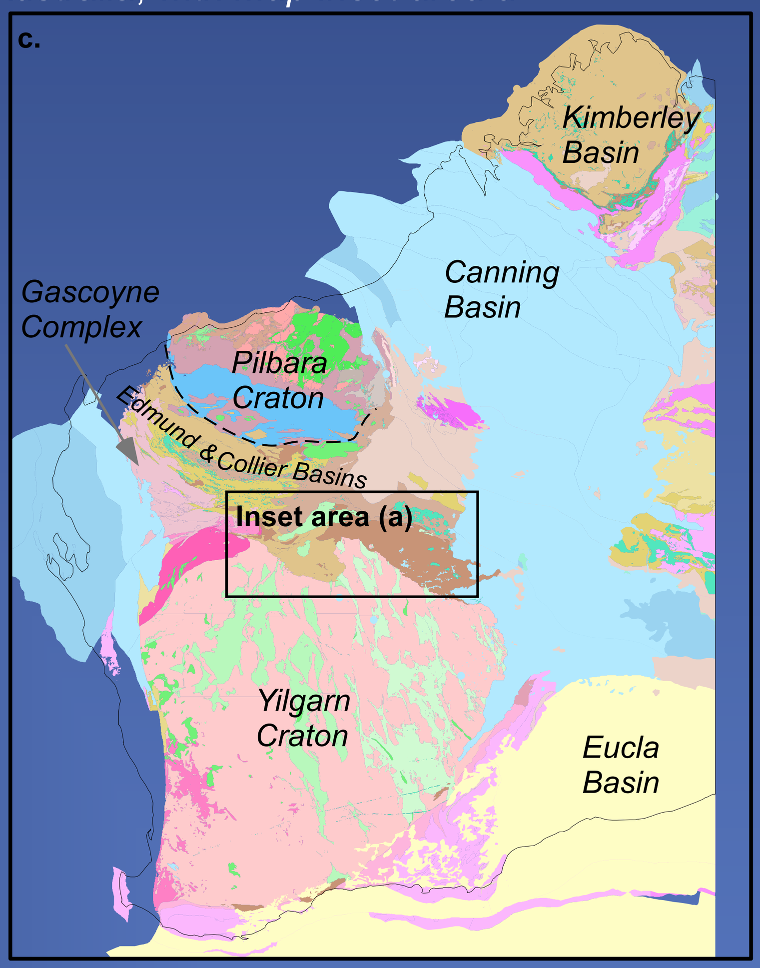


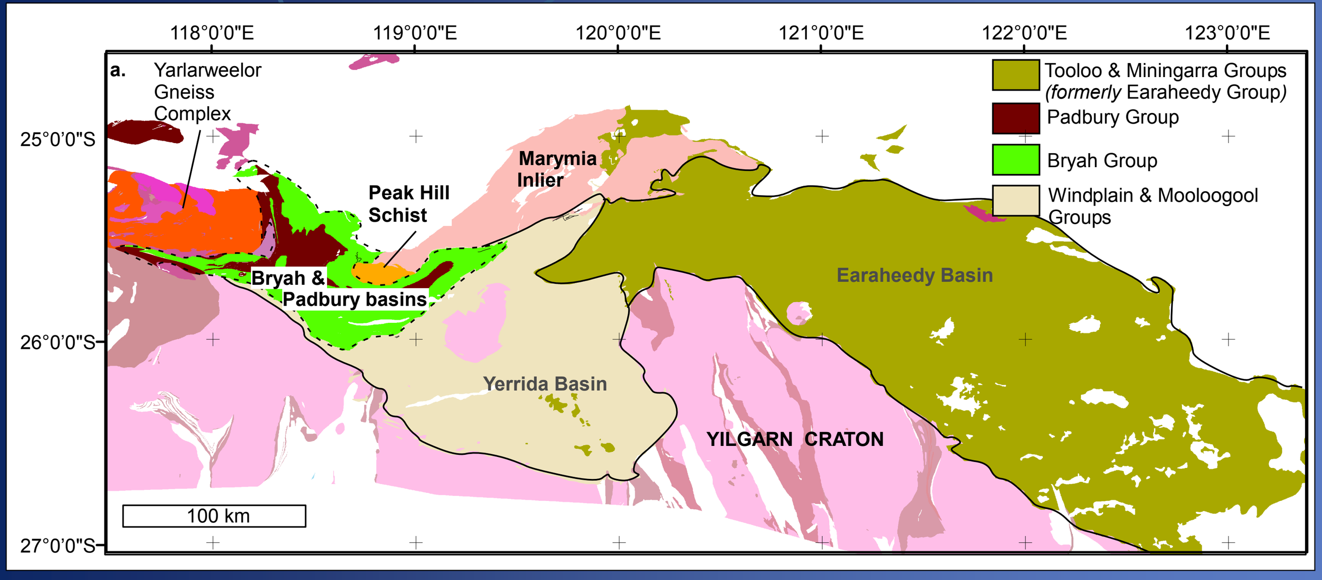
Figure 2: Simplified geological map of Western Australia, with *Map inset area a*



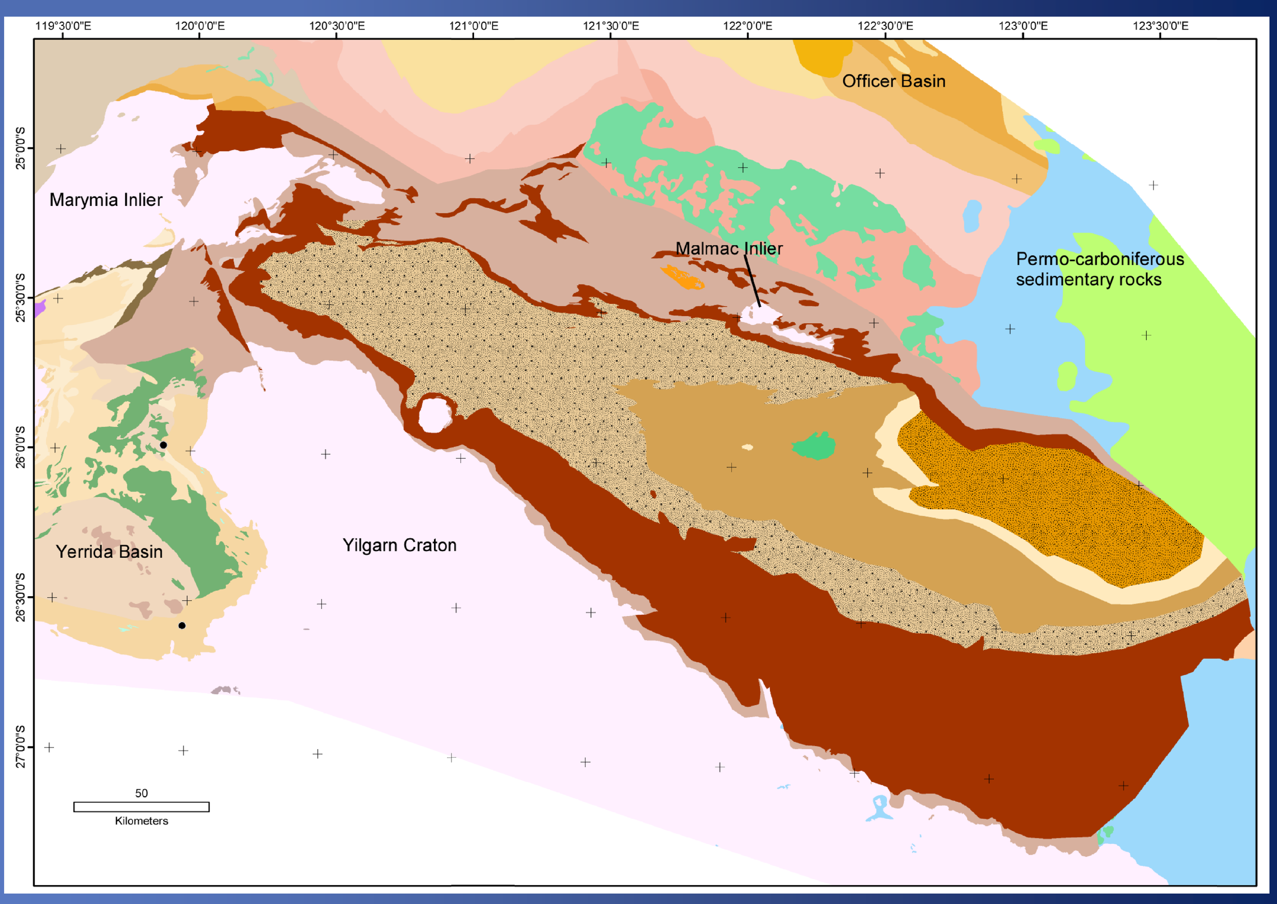
Geological Setting

The Capricorn Orogen developed between the Archean Pilbara and Yilgarn Cratons during periods of rifting and convergence in the Paleoproterozoic and Neoproterozoic. Cratonic blocks beneath the Capricorn Orogen include the Pilbara and Yilgarn Cratons and Glenburgh Terrane. The Glenburgh and Pilbara Cratons were amalgamated during the Opthalmian Orogeny at c. 2215–2145 Ma. The combined Pilbara Craton and Glenburgh Terranes accreted to the Yilgarn Craton during the 2005–1950 Ma Glenburgh Orogen to form the West Australian Craton. Subsequent reworking events that variably resulted in deformation, magmatism, metamorphism and magmatism include the 1830–1770 Ma Capricorn Orogeny, 1680 –1620 Ma Mangaroon Orogeny, c. 1385–1200 Ma Mutherbuken event and 1030–955 Ma Edmundian Orogeny. Within the southern part of the Capricorn Orogen, sedimentary and volcanosedimentary basins formed between 2200 Ma and 1820 Ma as a response to the tectonothermal evolution of the region. This paper reviews the development of these basins and places them in the context of the overall development of the West Australian Craton.

Below: *Map inset area a,* illustrating the location of the Bryah, Padbury, Yerrida and Earaheedy Basins

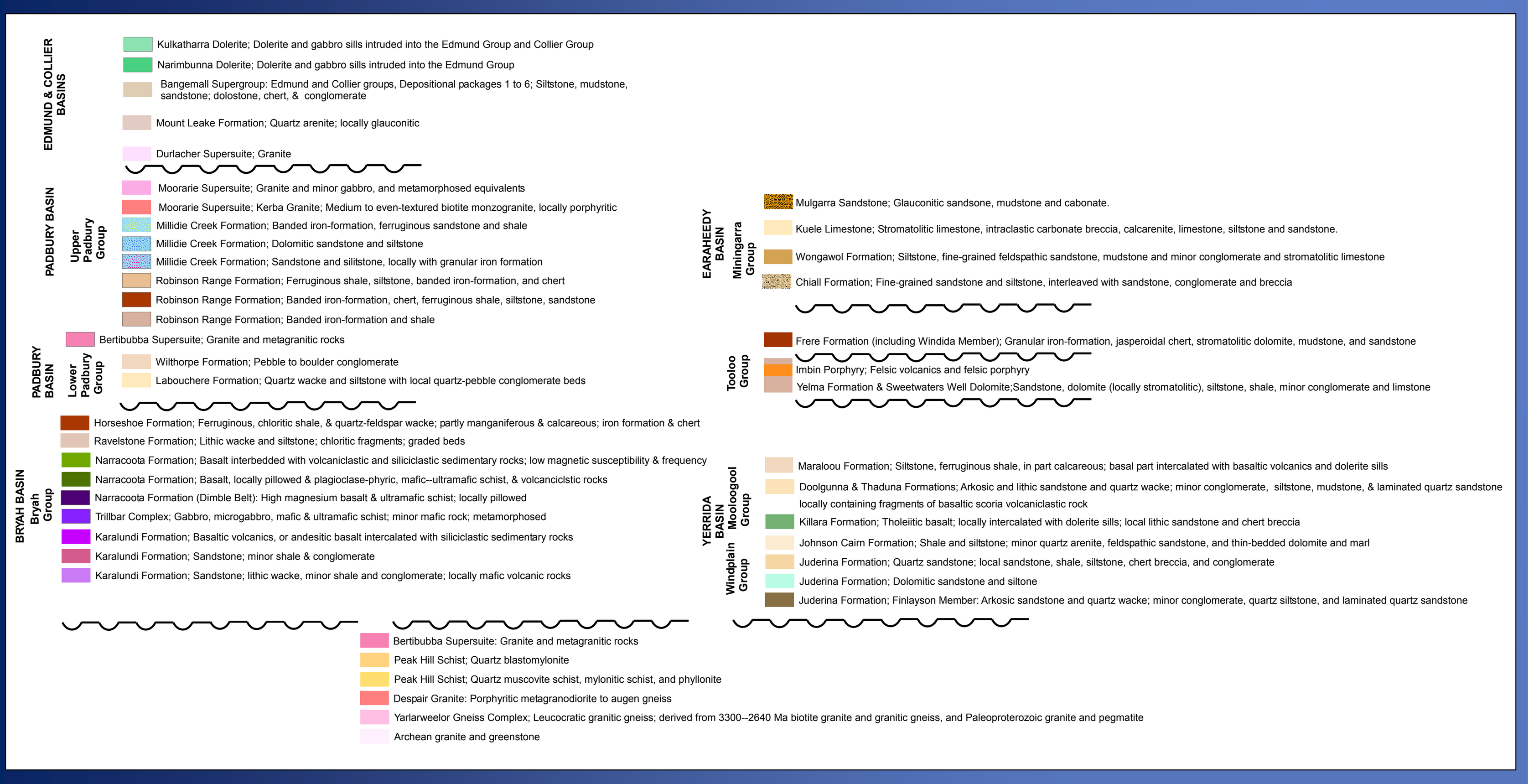


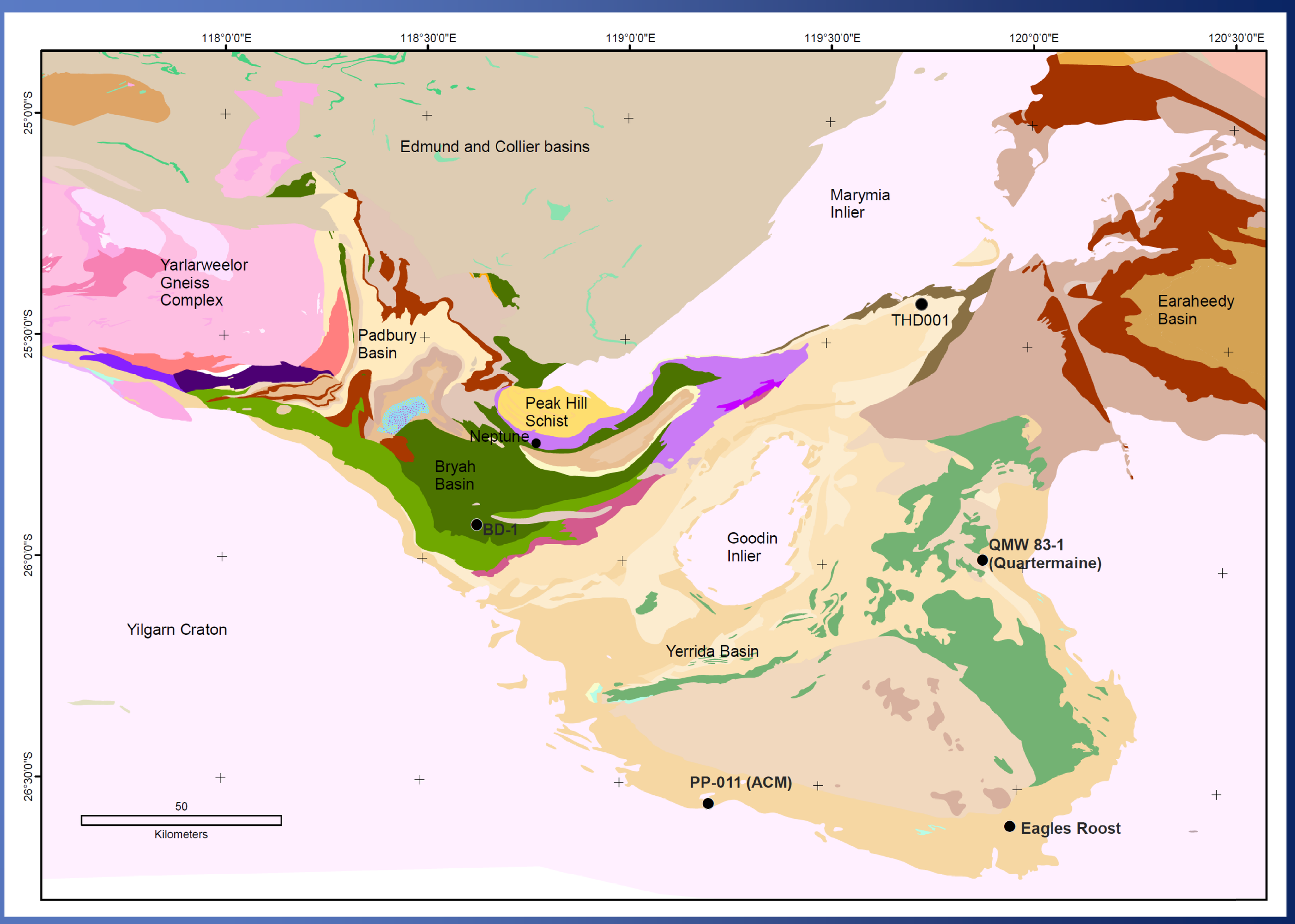
Right:: Geological map of the Earaheedy Basin, legend below



Below and Right: Geological map of the Yerrida, Bryah and Padbury Basins, legend above

Legend for maps to right



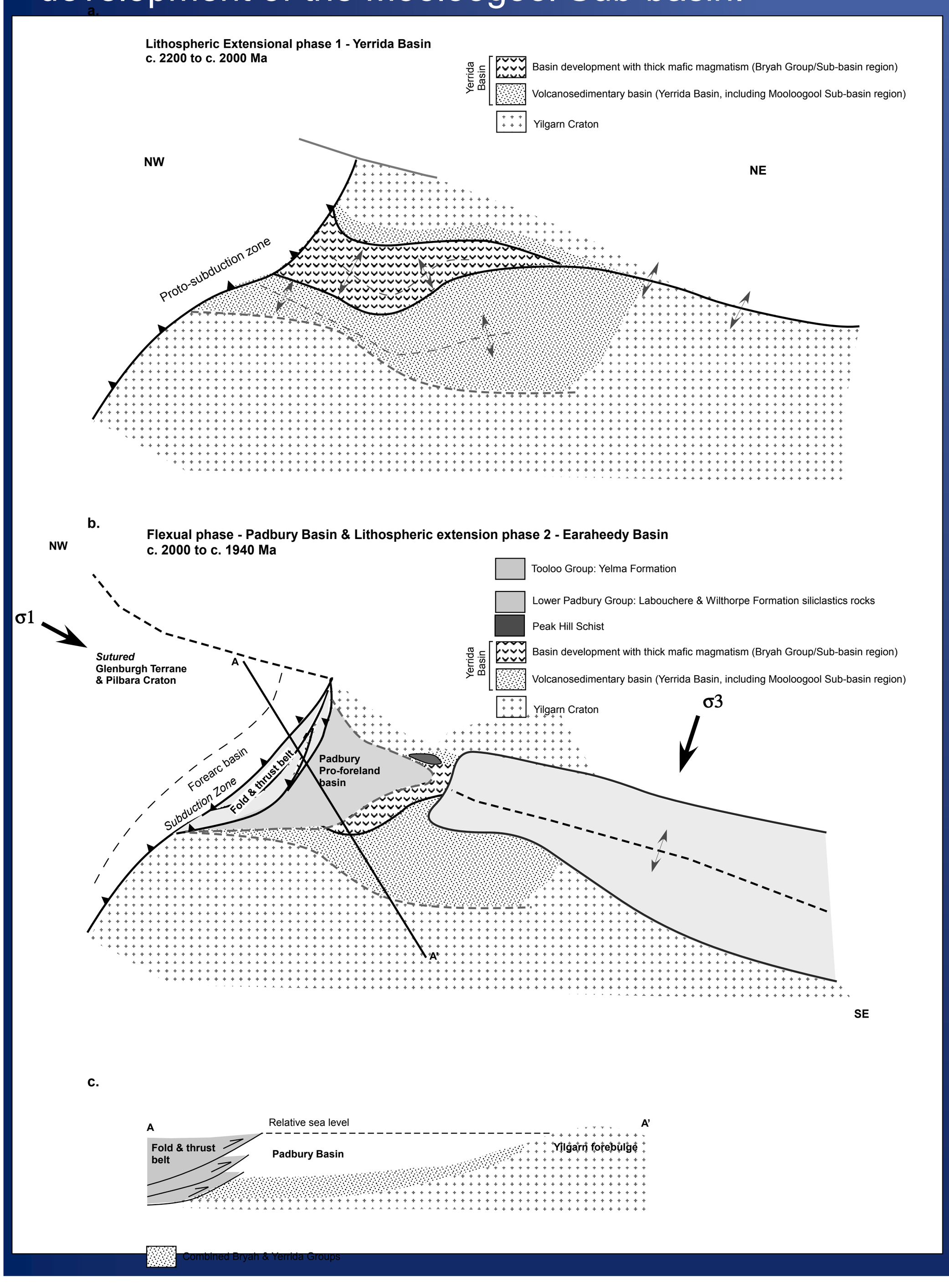


Basin Development

Basins that developed along the northern Yilgarn Craton margin between 2200 and 1820 Ma formed in response to prolonged periods of extension and compression that affected the craton margins during the Paleoproterozoic during assembly of the supercontinent Columbia. Initially, these basins formed as a response to extensional processes, resulting in the deposition of locally derived siliciclastic detritus. Continued subsidence and limited siliciclastic influx from a low-relief Yilgarn Craton provenance led to shallow-marine environments and deposition of carbonates, including stromatolitic dolostone and evaporite.

The basins that developed during lithospheric extension are large shallow basins, except for the Bryah Sub-Basin. This is probably a function of the buoyant and thick Archean lithosphere (Poudjom Djomani et al., 2001) that underlies the Earaheedy Basin and the southern part of the Yerrida Basin. The deepest basin succession is recorded in the Bryah Sub-basin, corresponding with the largest volume of mafic rock accumulation, and probably the greatest amount of mechanical rifting of Archean lithosphere in the region. It appears, rifting in the Mooloogool Sub-basin and Earaheedy Basin may simply have been limited due to the buoyancy of the Archean Craton on which they formed.

The Model: Rifting along the northern Yilgarn margin resulted in mafic to ultramafic magmatism along its northern margin, now seen in the Trillbar Complex and in the northern part of the Juderina Formation, and eventual differentiation of the Yerrida Basin into the outboard Bryah and inboard Mooloogool Sub-basins on either side of the active Goodin Fault. Basin-wide sulfidic black-shale sedimentation followed, and ultimately, mafic and intermediate magmatism in the Karalundi Formation. This was interspersed with volcaniclastic and siliciclastic sedimentation that became the host rocks for volcanic mafic- and mafic siliciclastic-hosted massive sulphides (Cu, Zn, Au, Ag, Pb), such as the 2.03–2.02 Ga DeGrussa deposit (Hawke et al., 2014; Pirajno et al., 2015). With time, mafic volcanism also migrated to the south with the development of the Mooloogool Sub-basin.



Northwest to southeast subduction of the extended Yilgarn Craton margin beneath the combined Glenburgh–Pilbara craton began by c. 2005 Ma, perhaps coincident with the cessation of mafic volcanism (Narracoota and Karalundi Formations) in the Bryah and Mooloogool Sub-basins. Contrary to some reports, there are no boninites known in the Narracoota Formation that might indicate that the formation formed in a backarc. Recent work has shown that those rocks identified as boninites in geochemistry are silicified mafic volcanics of the Narracoota Formation, or metasedimentary rocks in the overlying Beattie Park Member of the Wilthorpe Formation.

Deposition of chemical and siliciclastic sedimentary rocks in the Bryah and Mooloogool Sub-basins took place after mafic volcanism had ceased in the region, perhaps during a transition period between local extension and collisional processes. Concurrently at c. 2 Ga, there was felsic volcanism in the northeastern Bryah Sub-basin, contrasting the voluminous mafic volcanism earlier in the basin's history. Eventual collision and accretion of the combined Pilbara–Glenburgh craton with the Yilgarn Craton marks both the end of deposition in the Yerrida Basin, and the initiation of the Padbury and Earaheedy Basins. The lowermost units of these basins were deposited as a result of the 2005–1950 Ma Glenburgh Orogeny. However, the overlying iron formations were deposited sometime after the Glenburgh Orogeny, as suggested by the c. 1890 Ma age of the Frere Formation (Rasmussen et al., 2012), during a global phase of iron-formation deposition spurred by global ocean chemistry.

Basin development along the northern Yilgarn margin probably only ceased with the onset of the intracratonic Capricorn Orogeny at c. 1820 Ma. Units such as the Millidie Creek Formation (upper Padbury Group), Kulele Limestone and Mulgarra Sandstone (Miningarra Group) were deposited just prior to this. At this time, basin development was initiated in the northern and northwestern parts of the Capricorn Orogen.

Left: Schematic geological model illustrating the development of 2200–1940 basins along the northern margin of the Yilgarn Craton. a. Development of the Yerrida Basin in response to NE–SW rifting of the Yilgarn Craton margin; b. Formation of the Padbury and Earaheedy Basins over the Yerrida Basin, initially as a response to convergence of the Glenburgh Terrane and Yilgarn Cratons; c. Schematic cross-section illustrating the possible architecture of the Padbury Basin, with a forebulge in the south and a fold and thrust belt in the north (modified after Martin, 1994).