Northern
Territory
Government

Geology and mineral resources of the Northern Territory

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Northern Territory Geological Survey
Special Publication 5

Chapter 7: Halls Creek Orogen

BIBLIOGRAPHIC REFERENCE: Ahmad M and Scrimgeour IR, 2013. Chapter 7: Halls Creek Orogen: in Ahmad M and Munson TJ (compilers). *'Geology and mineral resources of the Northern Territory'. Northern Territory Geological Survey, Special Publicatio*n 5.

Chapter 7: HALLS CREEK OROGEN

M Ahmad and IR Scrimgeour

INTRODUCTION

The Halls Creek Orogen (HCO) is a north-northeast-trending orogenic belt that occurs mainly in Western Australia, where it flanks the eastern side of the Kimberley Craton (**Figure 7.1**). The extreme northeastern outcropping extension of this belt (about 136 km^2) is exposed in the Northern Territory. The HCO is unconformably overlain by the Kimberley, Speewah and Carr-Boyd basins to the west and northwest, by the Victoria, Birrindudu, Ord and Osmond basins to the east and southeast, and by the Canning and Louisa basins to the south. The orogen comprises variably deformed and metamorphosed sedimentary, volcanic, and intrusive Palaeoproterozoic rocks with protolith ages that are dominantly in the range 1910–1800 Ma. Dunster *et al* (2000) also included the Fitzmaurice Group as part of the HCO, but this is now considered to be included in the Fitzmaurice Basin.

The most detailed studies of the HCO were undertaken by the Geological Survey of Western Australia (GSWA) during the 1990s (Griffin and Grey 1990, Tyler *et al* 1995, Tyler *et al* 1999, Blake *et al* 2000). In the main outcrops in Western Australia, the HCO has been divided into three zones (terranes) – the Western, Central and Eastern zones (Tyler *et al* 1995). The boundaries between these zones are interpreted to be major strike-slip faults. The *Western Zone* is composed of low- to high-grade turbiditic metasedimentary rocks of the Marboo Formation (ca 1870 Ma), unconformably overlain by felsic volcanic rocks of the Whitewater Volcanics (1855 Ma). These were deformed, metamorphosed and intruded by granitoid, gabbro and subvolcanic porphyries during the 1865–1850 Ma *Hooper Orogeny* (Tyler and Page 1996). The *Central Zone* is dominated by metasedimentary and meta-igneous rocks of the Tickalara Metamorphics, which were deformed and metamorphosed between 1865 and 1856 Ma, and at 1850–1854 Ma (Page and Sun 1994, Tyler and Page 1996, Bodorkos *et al* 1998). Deformation and metamorphism was followed by the deposition of sedimentary and felsic volcanic rocks between 1845 and 1840 Ma, and intrusion of granites and gabbros during the *Halls Creek Orogeny* between 1835–1805 Ma. The *Eastern Zone* comprises low-grade metamorphic and metavolcanic rocks of the Halls Creek Group that unconformably overlie 1920–1900 Ma granitoids and volcanic rocks.

Early tectonic models for the Halls Creek Orogen involved an intraplate extensional model, involving mantle underplating, extension and orogenesis (eg Etheridge *et al* 1987). However, Sheppard *et al* (1999a) proposed a subduction model in which the Western Zone formed as a rift marginal to the Kimberley Craton, the Central Zone represents a rifted oceanic island arc, and the Eastern Zone formed as a passive margin on the North Australian Craton. In this model, the 1865–1850 Ma Hooper Orogeny reflects the accreting of an island arc (Central Zone) onto the eastern margin of the Kimberley Craton (Western Zone), and the ca 1835 Ma Halls Creek Orogeny reflects the collision of the North Australian Craton (Eastern Zone) with the Kimberley Craton (Tyler *et al* 1995, Sheppard *et al* 1999a).

The exposed units of the Halls Creek Orogen in the Northern Territory (**Figure 7.2**) belong to the Western Zone of the orogen (Carson *et al* 2006, Worden *et al* 2008) and include the Marboo Formation, Whitewater Volcanics, Bow River Granite and unnamed dolerite dykes. Brief descriptions of these rock units are included in Whitehead and Fahey (1985) and Dunster *et al* (2000). The Halls Creek Orogen has previously been correlated with the Litchfield Domain of the Pine Creek Orogen, although recent studies have highlighted problems with any direct correlation (Carson *et al* 2009).

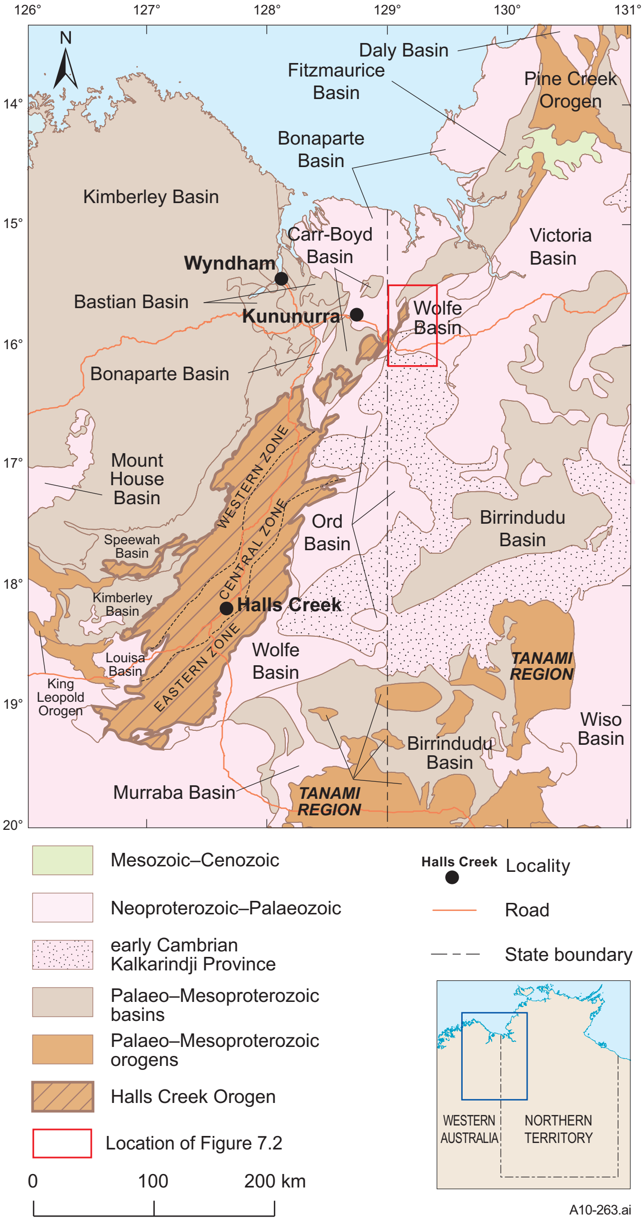

Figure 7.1. Regional geology of Halls Creek Orogen. NT geological regions from NTGS 1:2.5M GIS database. WA geological regions simplified and slightly modified from Tyler and Hocking (2001); some small outliers/inliers omitted. Extent of Kalkarindji Province in WA slightly modified from Glass and Phillips (2006).

PALAEOPROTEROZOIC

Marboo Formation

A succession of ferruginous fine-grained, greenschist facies phyllite and schist that outcrops within the Northern Territory and extends into Western Australia was originally mapped as the Halls Creek Group by Whitehead and Fahey (1985) and Dunster *et al* (2000). However, extrapolation of the mapped geology from Western Australia, and the association of the unit with the Whitewater Volcanics and Bow River Granite, indicates that the unit is almost certainly the (LP3 of Ahmad 2000) Marboo Formation (Griffin *et al* 1993). The phyllite and schist shows rare evidence of compositional layering (**Figure 7.3a**) and contains muscovite, quartz, sericite, chlorite and haematite, with minor chloritised biotite and epidote and local andalusite (**Figure 7.3b**, Sweet *et al* 1974, Whitehead and Fahey 1985). Whitehead and Fahey (1985) interpreted felsic volcanic rocks near Nigli Gap as being part of this unit. In Western Australia, the Marboo Formation has been interpreted as part of submarine fan system sourced from the north to northeast (Hancock 1991). The formation was deformed during the Hooper Orogeny in the interval 1865–1850 Ma (Tyler *et al* 1995). In the Northern Territory, the first deformation is associated with a greenschist-facies foliation that dips moderately southwest (Whitehead and Fahey 1985). A sample of foliated fine-grained chloritic siltstone from the Marboo Formation in Keep River National Park in the Northern Territory has a maximum deposition age of 1871 ± 4 Ma (Worden *et al* 2008), which is effectively identical to a maximum deposition age of ca 1872 Ma derived from the Marboo Formation in Western Australia (Tyler *et al* 1999).

Whitewater Volcanics

The Whitewater Volcanics (P4 of Ahmad 2000) comprise red-brown porphyritic rhyolite and rhyodacite, containing angular phenocrysts of quartz and feldspar up to 2–4 mm in length, set in grey-pink groundmass of finely crystalline microcline, intergrown with quartz, sericite and plagioclase (**Figure 7.4**). A sample of Whitewater Volcanics from within the Northern Territory has yielded a SHRIMP U-Pb zircon age of 1849 ± 6 Ma (Worden *et al* 2008), which is within error of conventional and SHRIMP U-Pb zircon ages of 1850 ± 5 Ma and 1854 ± 5 Ma, respectively, for the unit within Western Australia (Page and Hancock 1988, Sheppard *et al* 1999a). The Whitewater Volcanics unconformably overlie the Marboo Formation, and are intruded by the Bow River Granite

[1] Names of 1:250 000 and 1:100 000 mapsheets are in large and small capital letters, respectively, eg AUVERNGE, Keep.

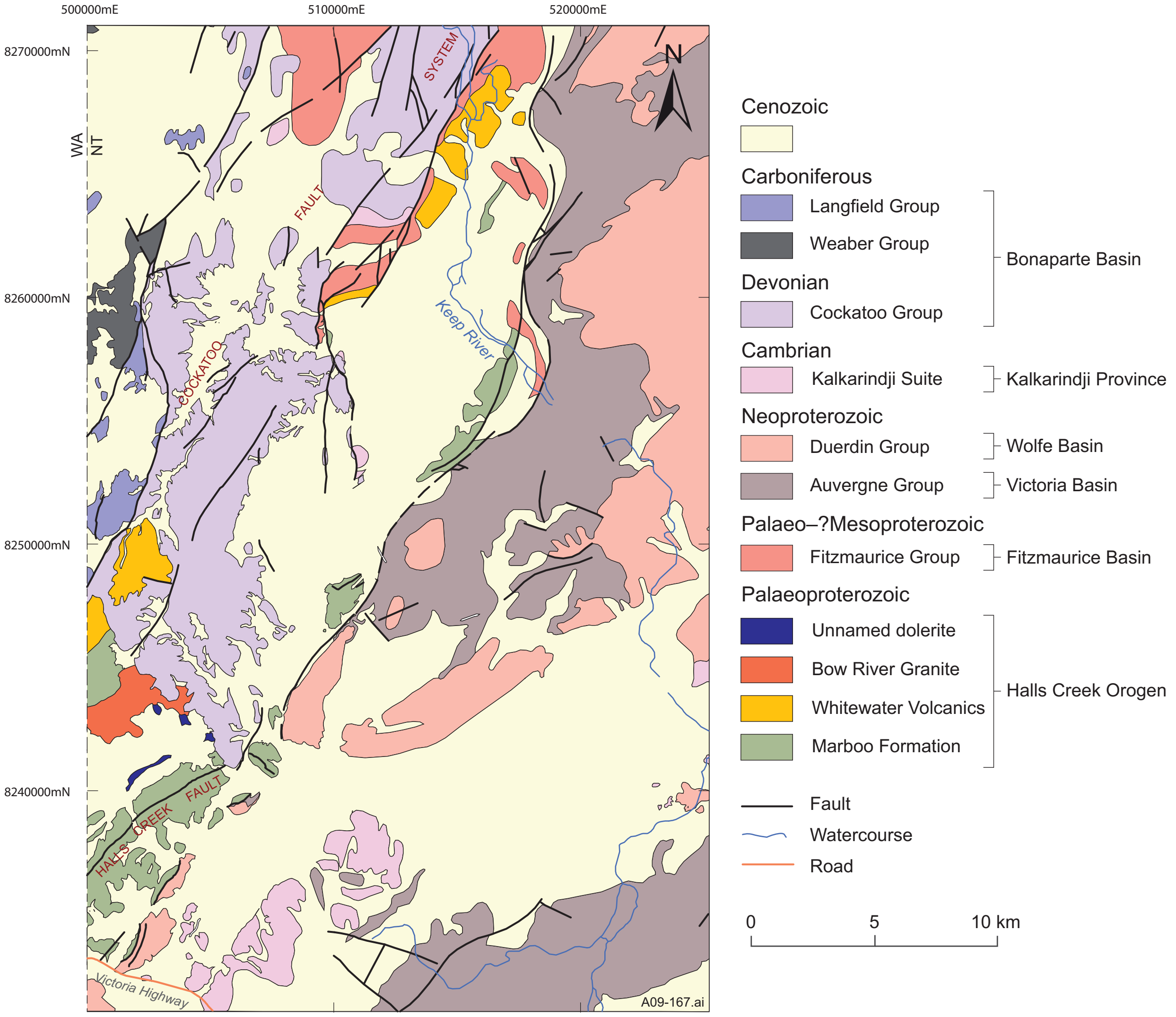

Figure 7.2. Geology of Halls Creek Orogen in Northern Territory from NTGS AUVERNGE[1] GIS database. Location shown in **Figure 7.1**.

(Plumb and Veevers 1991). Blake *et al* (2000) considered the Whitewater Volcanics to have been subaerial, on the basis of the predominance of ignimbrites over lava flows.

Bow River Granite

Granitic rocks, mapped as Bow River Granite in the Northern Territory, form part of the Paperbark Supersuite, which intruded in the interval 1865–1850 Ma. These are considered to have been co-magmatic with the Whitewater Volcanics (Sheppard *et al* 1999b). The main exposures of the Paperbark Supersuite are in Western Australia, where the granites are widespread through the Western Zone and include monzogranite, syenogranite and granodiorite, with less-common tonalite. In the Northern Territory, the Bow River Granite comprises typically a pink to green-grey, coarsely crystalline and porphyritic biotite granite (**Figure 7.5a**) with phenocrysts of K-feldspar, which locally display rapakivi textures (**Figure 7.5b**). A sample of undeformed K-feldspar-megacrystic biotite granite from within the Northern Territory has yielded a SHRIMP U-Pb zircon age of 1853 ± 5 Ma (Worden *et al* 2008).

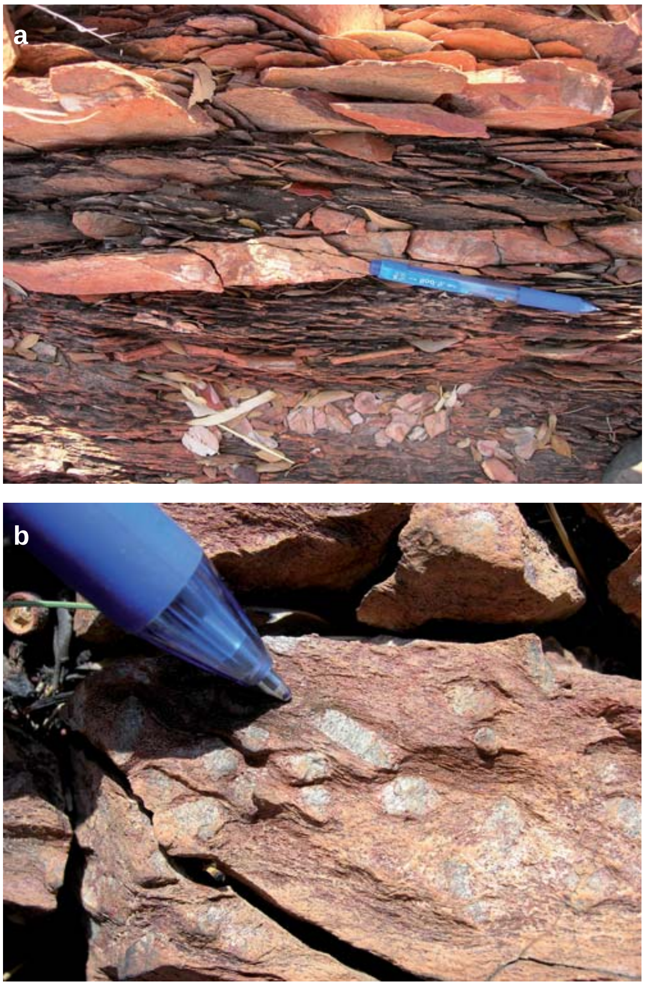

Figure 7.3. Marboo Formation. (**a**) Phyllite showing compositional layering (KEEP: 52K 507550mE 8240914mN). (**b**) Schist showing coarse andalusite porphyroblasts (KEEP: 52K 507523mE 8243134mN).

Figure 7.4. Porphyritic rhyolite of Whitewater Volcanics (KEEP: 52K 500323mE 8245472mN).

Dolerite dykes

Several dolerite dykes intrude the Bow River Granite and Whitewater Volcanics, and are commonly associated with quartz veins. The dolerite is fine to medium grained and porphyritic, with varying degrees of alteration. Plagioclase has been altered to sericite and pyroxene has been replaced by amphibole, chlorite and epidote (Whitehead and Fahey 1985).

Figure 7.5. Bow River Granite (KEEP: 52K 500919mE 8242435mN). (**a**) Typical exposure of Bow River Granite. (**b**) Rapakivi textures in feldspar.

MINERAL RESOURCES

The Halls Creek Orogen in Western Australia contains a number of occurrences of gold, copper-nickel, copper, rare earth elements (REE), diamonds, platinum group elements (PGE), tin, tungsten, kyanite and corundum (Plumb 1990, Blake *et al* 2000). The Central and Western zones of the orogen have a number of layered mafic-ultramafic intrusions that host copper-nickel sulfide and PGE mineralization, including the Sally Malay Ni-Cu deposit (Hoatson and Blake 2000). Most gold deposits are in the Eastern Zone, whereas base metals, including VHMS deposits such as Koongie Park, are largely confined to the Central Zone. No significant mineral occurrences have yet been identified in the Halls Creek Orogen within the Northern Territory.

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