

# Tectonic evolution and mineralization of the east Kimberley

by

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Regional geological mapping of the Halls Creek Orogen in the east Kimberley region was carried out by the Geological Survey of Western Australia (GSWA) and the Australian Geological Survey Organisation (AGSO) between 1990 and 1995. The mapping has resulted in substantial revision of the stratigraphy and tectonic units that make up the Halls Creek Orogen (Tyler, 2000). To augment the geological mapping, a study of the mineralization of the orogen was also undertaken (Sanders, 1999). More recently, further work has been undertaken so as to provide industry with a data package on CD-ROM, comprising digital spatial indexes for exploration activities and all known mineral occurrences, along with a report and a map (Hassan, in prep.). The data package enables the spatial distribution of mineralization to be analyzed within the framework of the revised stratigraphy and new tectonic model for the Halls Creek Orogen; the package also includes parts of the King Leopold Orogen and the Granites–Tanami Complex.

The Halls Creek Orogen developed between the Kimberley Craton to the northwest and the North Australian Craton to the southeast. The orogen formed in the Palaeoproterozoic, but it also records a long history of intermittent reactivation until the end of the Palaeozoic. The orogen comprises the Palaeoproterozoic Lamboo Complex, the deformed margins of the Palaeoproterozoic Speewah and Kimberley Basins and their correlatives, and the deformed elements of a number of Mesoproterozoic, Neoproterozoic, and Palaeozoic sedimentary basins.

The Lamboo Complex includes all the deformed and metamorphosed plutonic, volcanic, and sedimentary rocks formed between c. 1910 and c. 1790 Ma, and is divided into three north-northeasterly trending zones: the Western, Central, and Eastern zones (Fig. 1). The zones are bounded by major fault systems, and each zone has a unique geological history: the zones probably represent terranes (Tyler et al., 1995). The presence of terranes, and the different geophysical nature of the crust on either side of the Lamboo Complex (Shaw et al., in press), indicates that it contains a Palaeoproterozoic plate margin. The three zones were probably brought into their current positions

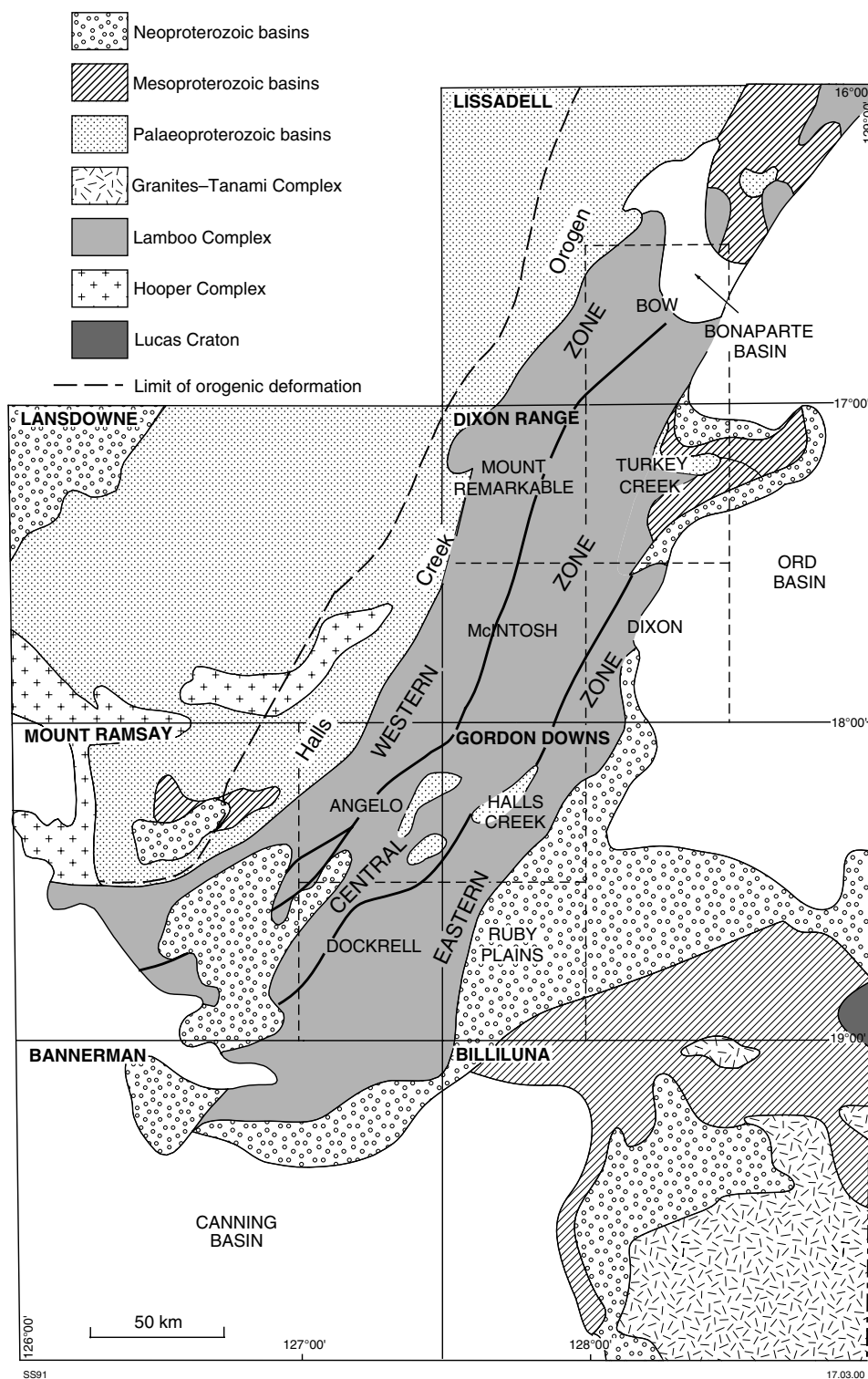
by a combination of subduction and large-scale strike-slip faulting (Tyler et al., 1995; Sheppard et al., 1999).

The Western zone of the Lamboo Complex is a continuation of the Hooper Complex in the King Leopold Orogen in the west Kimberley. The Western zone is dominated by the felsic volcanic rocks of the 1865–1850 Ma Whitewater Volcanics and cogenetic granites of the Paperbark supersuite. These felsic rocks were accompanied by unlayered mafic intrusions, and layered mafic–ultramafic intrusions. The mafic and felsic igneous rocks were probably emplaced following accretion of a continental fragment(s) to the eastern edge of the Kimberley Craton sometime before c. 1900 Ma (Griffin et al., in press).

In the Central zone, mafic volcanics, volcanoclastics, and turbidites of the c. 1865 Ma Tickalara Metamorphics may represent either an oceanic arc fringing the Kimberley Craton above a new southeasterly dipping subduction zone, or a basin along the margin of the craton above a northwesterly dipping subduction zone/strike-slip plate margin (Sheppard et al., 1999). The rocks were deformed and metamorphosed at medium to high grade and intruded by sheets of tonalite at 1850–1845 Ma. Mafic and felsic volcanic rocks, and sedimentary rocks, of the c. 1841 Ma Koongie Park Formation were deposited in a basin associated with extension behind the convergent/strike-slip plate margin. The Koongie Park Formation is coeval with the Sally Malay layered mafic–ultramafic intrusions (Hoatson and Blake, in press).

The Eastern zone consists of siliciclastic sedimentary rocks, and mafic and alkaline volcanic rocks of the Halls Creek Group. These were deposited between c. 1880 and c. 1845 Ma on a substrate of continental crust. The Halls Creek Group preserves a record of deposition on a passive continental margin (Sheppard et al., 1999). These rocks were first deformed between c. 1820 and c. 1810 Ma during the Halls Creek Orogeny.

Siliciclastic rocks of the Speewah Group were deposited unconformably on the Western zone at c. 1835 Ma. Voluminous granite plutons of the



**Figure 1.** Location of published 1:100 000 and 1:250 000 map sheets in the east Kimberley and their relationship to major tectonic units. Also shown are the three zones that form the Lamboo Complex

1835–1805 Ma Sally Downs supersuite mainly intruded the Central zone during deformation and medium- to low-grade regional metamorphism of the Halls Creek Orogeny, which marked the amalgamation of the Eastern zone with the combined Western and Central zones. Between 1805 and 1790 Ma, the southern end of the Lamboo Complex

was intruded by granites of the San Sou suite, which may represent an extension of granite plutonism in the Granites–Tanami Complex (Page and Sun, 1994).

The Speewah Group and Lamboo Complex are overlain by siliciclastic sedimentary rocks and mafic

volcanic rocks of the Kimberley Group. Siliciclastic rocks of the Texas Downs, Revolver Creek, and Red Rock Formations were probably deposited at the same time as the Kimberley Group. The Kimberley Group was intruded at c. 1790 Ma by voluminous dolerite sills of the Hart Dolerite. Thus, deposition of the Kimberley Group and intrusion of the Hart Dolerite is coeval with the end stages of granite intrusion in the southern Lamboo Complex.

The majority of the over 1330 mineral occurrences documented in the east Kimberley are hosted in rocks of the Lamboo Complex (Hassan, in prep.). A range of mineralization styles, including orthomagmatic PGE–Cr–Ni–Cu–Ti–V, volcanic-hosted massive sulfide (VMS) Cu–Pb–Zn and REE–Ta, vein and hydrothermal Au, base metals, and U, and pegmatite and stratabound W–Sn–Ta have been recognized.

Vein and hydrothermal gold occurrences are concentrated in the Eastern zone of the Lamboo Complex. Many of these occurrences form a northeasterly trend, roughly parallel to the boundary with the Central zone. Most occurrences are hosted in the Biscay Formation. However, a substantial number also occur near the contact between the Biscay Formation and the overlying Olympio Formation, or in alkaline volcanic rocks in the lower part of the Olympio Formation. The gold mineralization has no apparent association with granite intrusions, and instead, gold may have been derived from the mafic and alkaline volcanic rocks during the 400–300 Ma Alice Springs Orogeny (Warren, 1994). There are a few vein and hydrothermal gold occurrences in the Central and Western zones. Of those in the Western zone, some Au(–U) occurrences in the Whitewater Volcanics have quartz-vein textures typical of epithermal deposits.

Significant vein and hydrothermal gold deposits are present in the Palaeoproterozoic Granites–Tanami Complex; the most important of these are the Coyote and Kookaburra prospects. Vein and hydrothermal unconformity-type U–Au mineralization is also hosted in shears and graphitic sedimentary rocks of the Killi Killi beds close to the unconformity with the overlying Mesoproterozoic Birrindudu Group.

In the Central zone of the Lamboo Complex, felsic volcanic rocks of the Koongie Park Formation contain volcanogenic massive sulfide (VMS) Zn–Pb–Cu–Ag(–Au) mineralization. The Mount Angelo Granite, which is probably petrogenetically related to these felsic volcanic rocks, hosts porphyry Cu–Mo(–Ag) mineralization. Felsic volcanic and chemical sedimentary rocks of the Biscay Formation are associated with exhalative volcanogenic Zn–Cu–Pb mineralization in the Eastern zone. Alkaline volcanic rocks of the Butchers Gully Member in the Eastern zone are host to REE–Ta mineralization at the Brockman prospect.

Orthomagmatic Cr–Ni–V–PGE mineralization is hosted by layered mafic–ultramafic intrusions in the Central zone and, to a lesser extent, the Western zone. Layered intrusions and hence this mineralization style, are absent from the Eastern zone.

Although most of the mineral occurrences in the east Kimberley are hosted in the Lamboo Complex, important

mineral occurrences are associated with younger tectonic units. In the Speewah Basin, the Speewah Group and Hart Dolerite contain epithermal base metals, barite, and fluorite mineralization. The exact age of this mineralization is unclear, but it may be as young as Tertiary (Rogers, 1998). Devonian carbonates host base metal mineralization in the Canning Basin. Alkaline igneous intrusions of various ages are also host to significant mineralization. The Mesoproterozoic Argyle (AK1) lamproite pipe contains the world's largest diamond mine. The Neoproterozoic Cummins Range carbonatite has a large inferred resource of REE, and associated Nb and P mineralization.

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