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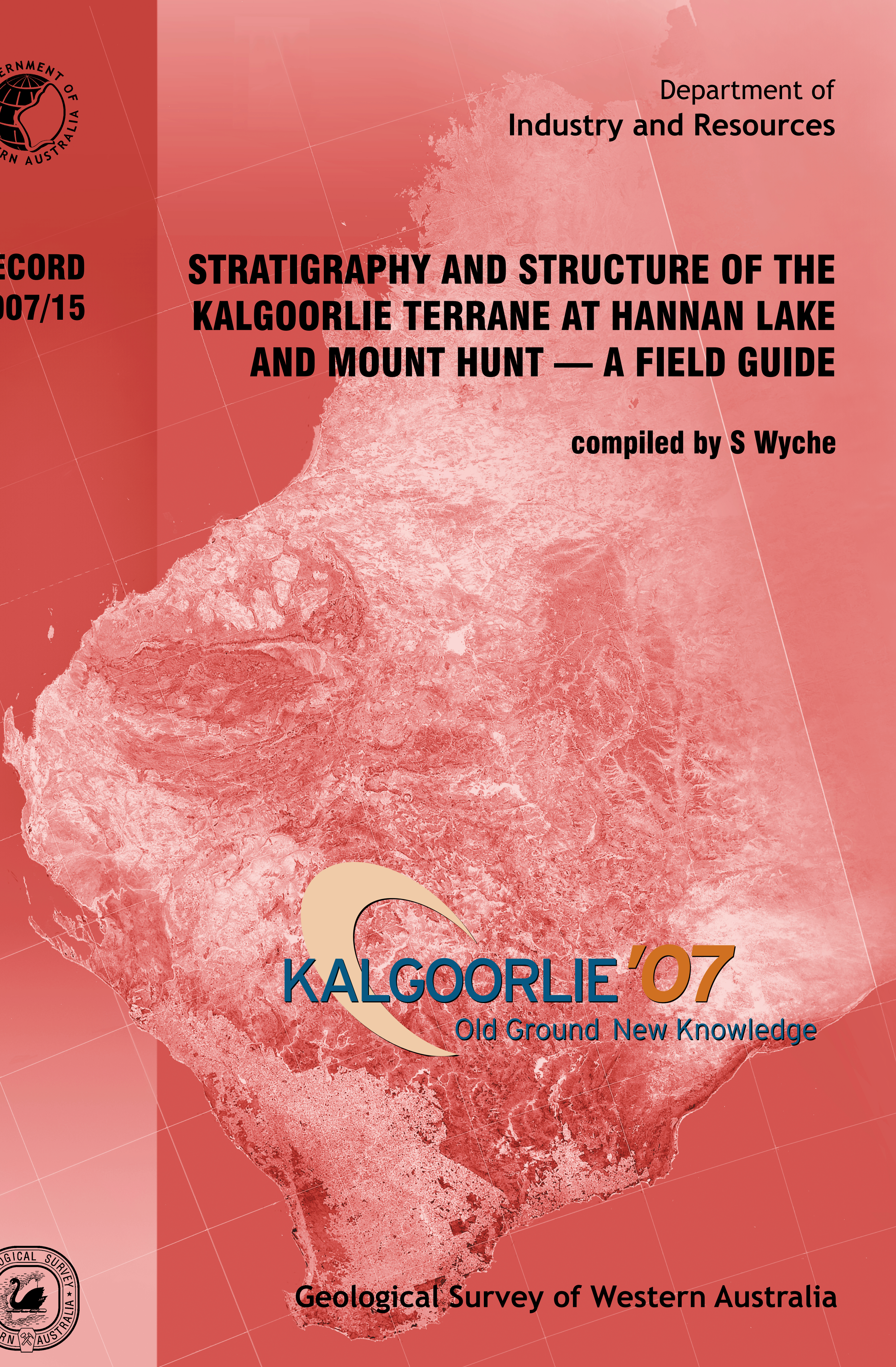
STRATIGRAPHY AND STRUCTURE OF THE KALGOORLIE TERRANE AT HANNAN LAKE AND MOUNT HUNT — A FIELD GUIDE

compiled by S Wyche



KALGOORLIE '07
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Geological Survey of Western Australia

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

Record 2007/15

STRATIGRAPHY AND STRUCTURE OF THE KALGOORLIE TERRANE AT HANNAN LAKE AND MOUNT HUNT — A FIELD GUIDE

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Perth 2007

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Orthophoto of the Mount Hunt area showing highlights of the geological traverse (reproduced by permission of the Western Australian Land Information Authority, CL 44/2007)

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Note that driving in this area is not recommended after rain as tracks are very slippery and potentially boggy.

Introduction

This field guide presents a description of the geology along a traverse from Serpentine Bay on Hannan Lake, across Mount Hunt, to the Goldfields Highway, about 10 km south of Kalgoorlie–Boulder. The traverse crosses the main lithostratigraphic elements of the succession within the Kalgoorlie Terrane of the Eastern Goldfields Superterrane that hosts world-class deposits of gold at Kalgoorlie, and nickel at Kambalda.

Regional setting

The Kalgoorlie Terrane is the westernmost of at least three fault-bounded tectono-stratigraphic terranes that make up the Eastern Goldfields Superterrane of the Yilgarn Craton (Fig. 1; Barley et al., 2002; Cassidy et al., 2006). These terranes are defined on the basis of distinct associations of volcanic facies, ages of volcanism, and geochemistry. The Kalgoorlie Terrane has been subdivided into a number of fault-bounded domains with broadly similar stratigraphy and inferred geological history. Because of its great economic significance, the Kambalda Domain, which embraces the gold deposits at Kalgoorlie and the nickel deposits at Kambalda, is probably the best documented in terms of its stratigraphy and structure (Swager et al., 1995; Krapež et al., 2000; Barley et al., 2002). All greenstones in the Kalgoorlie Terrane have been metamorphosed, ranging from very low (prehnite–pumpellyite facies) to moderate (amphibolite facies) grades (Mikucki and Roberts, 2004).

Greenstones in the Kalgoorlie Terrane were deposited mainly between 2.71 Ga and 2.66 Ga, although occurrences of older greenstones have been reported locally (Cassidy et al., 2006). The generalized stratigraphy consists of a lower mafic–ultramafic succession overlain by, and locally interbedded with, an association of dominantly felsic volcanic and volcaniclastic rocks, the Black Flag Group. Greenstones in the Kalgoorlie Terrane are unconformably overlain by a late-basin succession of turbiditic metasedimentary rocks, represented in the Kalooorlie area by conglomerate and sandstone of the Kurrawang Formation. The mafic–ultramafic succession typically contains a lower basalt unit, a komatiite unit, and an upper basalt unit, although the basalt units are not necessarily present in all domains. The age of the mafic–ultramafic succession is constrained by SHRIMP U–Pb zircon ages of c. 2708 Ma from volcanic rock associated with komatiite near the Ballarat–Last Chance mine at Kanowna; c. 2705 Ma from felsic volcaniclastic rock interbedded with ultramafic rock in the Bulong Complex southeast of Kalgoorlie (Nelson, 1997); and an age of c. 2692 Ma on detrital zircons from the Kapai Slate at Kambalda (Claoué–Long et al., 1988).

Greenstones of the Kalgoorlie Terrane have been interpreted in terms of both volcanic arc (e.g. Krapež et al., 2000; Barley et al., 2002), and mantle plume (e.g. Bateman et al., 2001a) tectonics. In the volcanic arc model, the mafic–ultramafic succession represents a backarc basin and the felsic volcanic and volcaniclastic association represents arc-related volcanism.

There has not been complete consensus about the detailed deformation history of the Eastern Goldfields Superterrane. However, most authors agree that early low-angle deformation (thrusting with or without extension) was followed by a protracted period of broadly east–west compression, with various authors interpreting local and more regional extensional events, possibly associated with granite emplacement, during this time (e.g. Archibald et al., 1981; Hammond and Nesbit, 1992; Swager, 1997; Swager et al., 1997; Weinberg et al., 2003; Blewett et al., 2004). The deformation nomenclature used in this guide follows that of Swager (1997), in which D_1 represents a low-angle thrusting event; F_2 is upright folding due to regional shortening; and D_3 represents strike- and reverse-slip faults, also due to regional shortening.

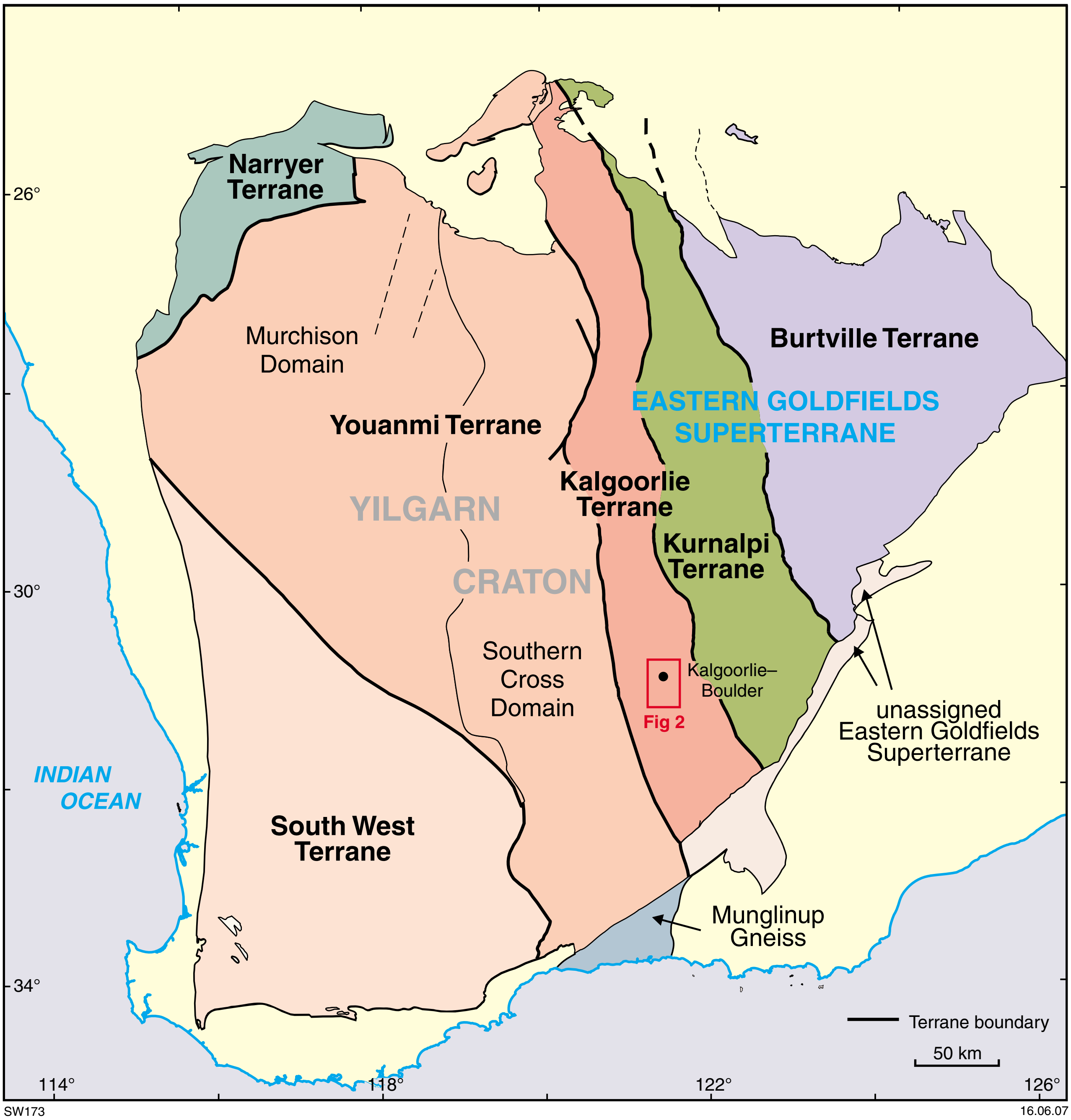

Figure 1. Subdivisions of the Yilgarn Craton

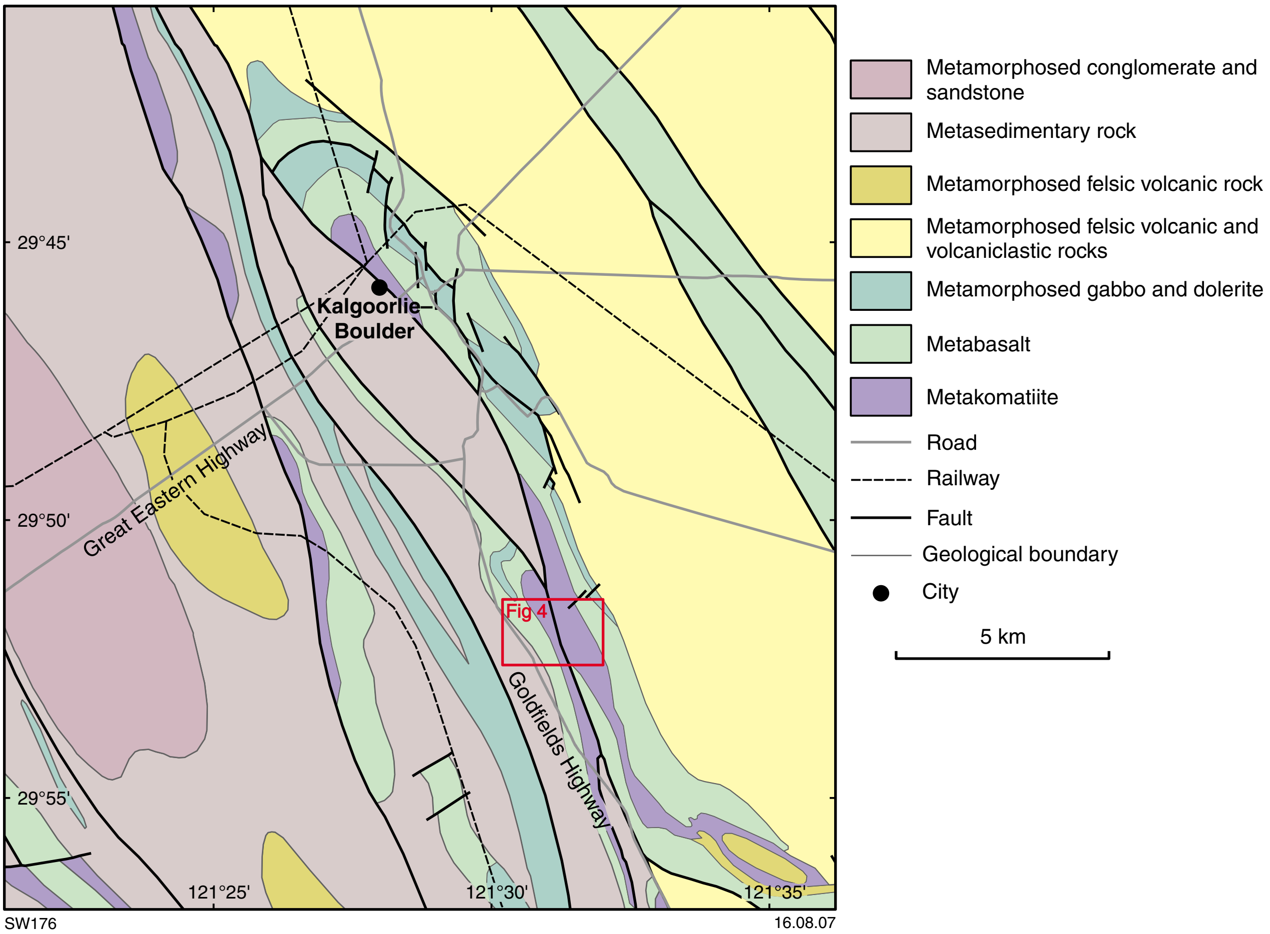

Figure 2. Interpreted bedrock geology of the Kalgoorlie area

Mineralization

The Kalgoorlie Terrane hosts numerous gold deposits including the world-class deposits on The Golden Mile and at Mount Charlotte (e.g. Bateman et al., 2001b). The main host rock for the Kalgoorlie gold deposits is the Golden Mile Dolerite. This formation has been mapped in the northern part of the Mount Hunt area (Fig. 2) but is not exposed along the traverse.

The world-class nickel deposits at Kambalda (Marston, 1984; Barnes, 2006), about 50 km south of Kalgoorlie–Boulder, are hosted by the Kambalda Komatiite, which is interpreted as the same komatiite formation that outcrops at Mount Hunt.

Hannan Lake and Mount Hunt

Most of the described stratigraphy of the Kambalda Domain, except for the lower basalt unit that is not exposed in the Kalgoorlie district, can be seen in the Mount Hunt area. The komatiite unit is represented by the Kambalda Komatiite (formerly called the Hannan Lake Serpentinite: e.g. Travis et al., 1971), and the Devon Consols Basalt. The Kapai Slate marks the top of the Devon Consols Basalt. The Paringa Basalt, which represents the upper basalt unit, occupies the highest part of Mount Hunt. The Black Flag Group, which outcrops on the western side of the Goldfields Highway, represents the upper felsic volcanic and volcaniclastic association. The late-basin succession is not exposed at Mount Hunt, but lies about 10 km to the west, where it is represented by the Kurrawang Formation.

The Hannan Lake – Mount Hunt traverse examines the stratigraphy of the Kambalda Domain, which is interpreted as a D_1 thrust sheet, repeating and overlying the sequence at Kambalda. The traverse crosses the axial plane of the regional F_2 anticline, the northern continuation of the Kambalda Anticline. The F_2 hinge is sheared out by the D_3 Boulder–Lefroy Fault. At Hannan Lake, the succession youngs eastwards and is the continuation of the mineralized sequence south from Kalgoorlie. At Mount Hunt, the overall younging is to the west, but the succession is complexly folded and sheared.

The Hannan Lake – Mount Hunt traverse*

Drive south along the Goldfields Highway for about 4 km from the large roundabout on the southern outskirts of Kalgoorlie–Boulder to a solitary tree on the left-hand side of the highway (MGA 356388E 6587588N) near a blue road sign (P 1 km). Turn left onto a track and travel 1.7 km to a bend in the track (MGA 357590E 6588850N). Turn sharp right off the main track, cross a swale, and travel south-southeast for 1.6 km to a junction with a southeasterly trending track (MGA 357920E 6587080N). Turn onto the track and follow it for about 1 km to a small headland that juts out into Serpentine Bay on Hannan Lake (MGA 358690E 6587100N).

Serpentine Bay

Extensive outcrops of serpentinite of the lowest exposed unit of the Kambalda Komatiite are found on the western shore of Hannan Lake (Fig. 3; Locality 1 on Fig. 4). The rocks at Serpentine Bay are atypical in that they have been strongly affected by talc–carbonate alteration. However, this alteration has preserved spinifex textures (Fig. 5) indicating the extrusive nature of the ultramafic flows, which vary in thickness from 1 to 10 m. Some flows show classic asymmetries in the spinifex textures (Fig. 6), indicating that the sequence youngs to the east. A typical cumulate base (B-zone) now consists of talc–carbonate–serpentine(–magnetite), which has replaced an original dunite or peridotite with 2 to 3 mm olivine grains. The spinifex zones, with coarse sheaf-spinifex blades up to 30 cm long followed by fine-grained, random spinifex and a thin aphanitic flow top, are now talc–carbonate–albite–chlorite(–magnetite). Albite content may be up to 15%.

To the west, the bulk of the Kambalda Komatiite is a strongly serpentinized orthocumulate peridotite comprising medium-grained, granular olivine pseudomorphs with interstitial amphibole and chlorite. East of the headland (Fig. 4), islands in Hannan Lake contain east-facing pillow basalt (Devon Consols Basalt), cherty sedimentary rock (Kapai Slate), and komatiitic basalt (Paringa Basalt). Deep drilling below the lake has helped establish the regional stratigraphy (Travis et al., 1971).

Mount Hunt

There are several tracks that lead back to the main south-southeasterly trending track. Return to this main track and head south to a track intersection marked by a tree on its southeastern side (MGA 358031E 6586696N). Turn right and drive up the track for 300 m, past an outcrop of silicified pelite on the right-hand side of the track, to an open area on the north side of a creek (MGA 357775E 6586595N).

* Locality descriptions are mainly modified from Griffin et al. (1983), and Keats (1987), with contributions from Hallberg (1972), Williams and Hallberg (1973), and Groves and Gee (1980)

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Figure 3. View to the east from the summit of Mount Hunt, with Serpentine Bay and Hannan Lake in the middle distance

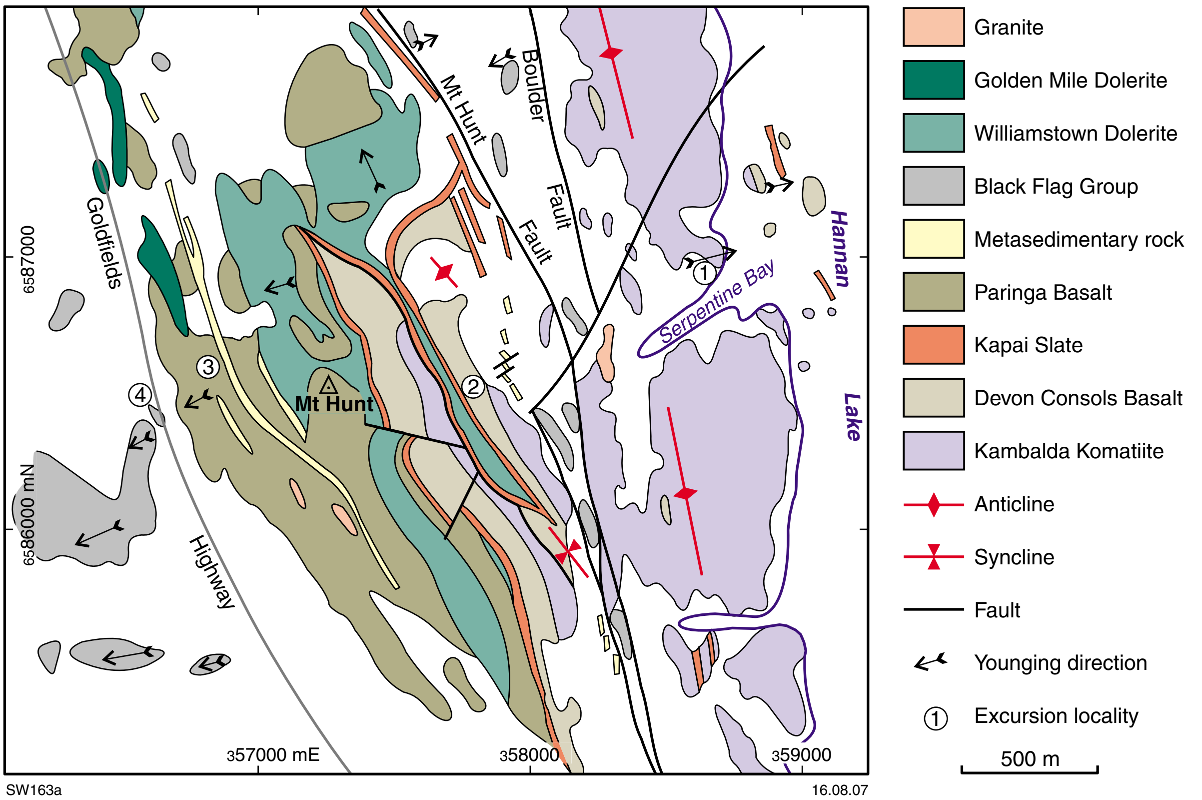

Figure 4. Outcrop sketch of the Mount Hunt – Hannan Lake area (adapted from Grif n et al., 1983; Keats, 1987)

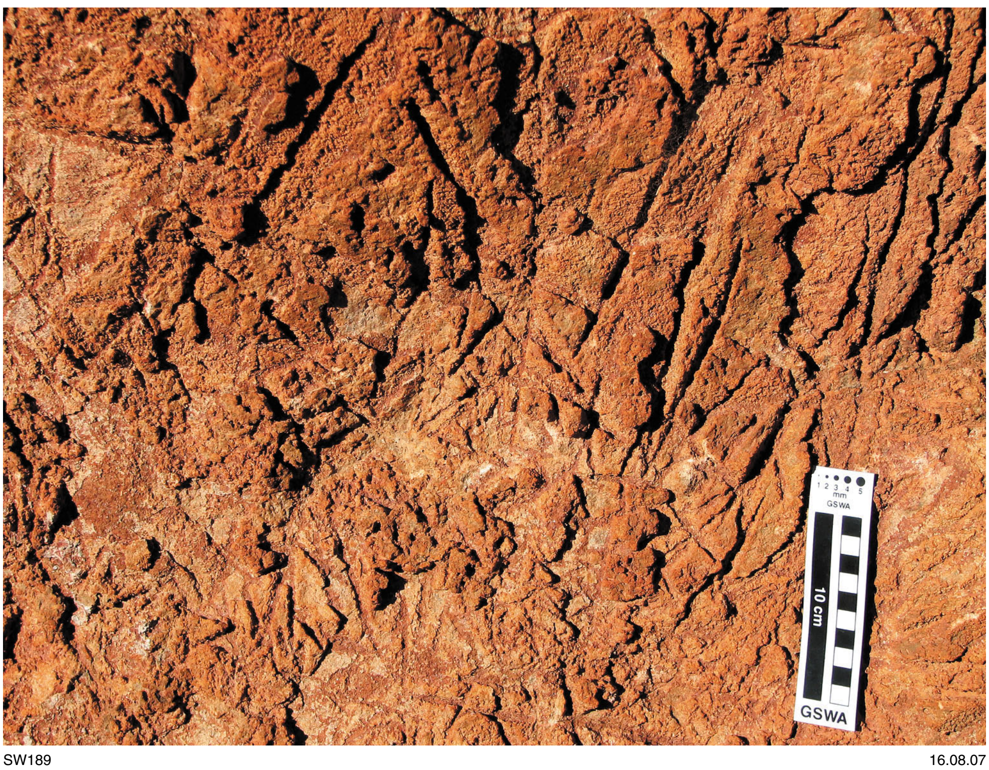

Figure 5. Randomly oriented pseudomorphs after platy olivine-spinifex texture in carbonate-altered, serpentinized komatiite at Serpentine Bay (MGA 358730E 6587070N)

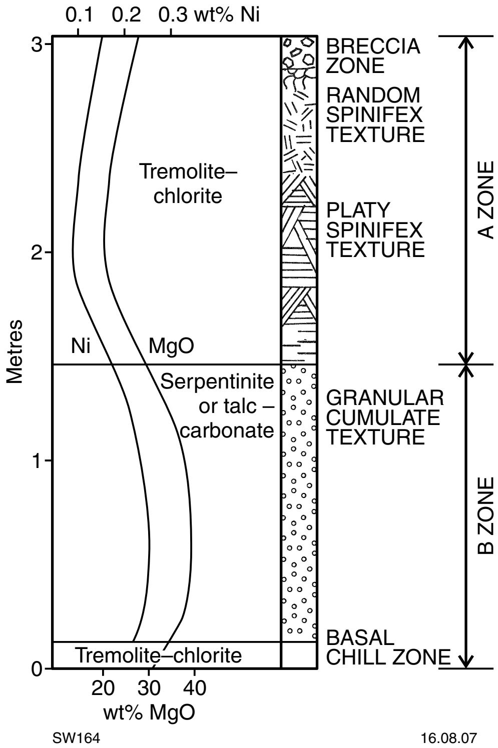

Figure 6. Diagrammatic section and geochemical pro le through a thin, unmineralized, metamorphosed komatiite ow-unit differentiated from peridotite to picrite (after Marston, 1984)

The outcrop of Devon Consols Basalt at the start of the Mount Hunt traverse is best exposed in the creek immediately south of the track (Location 2 on Fig. 4 — MGA 357824E 6586567N). Here it consists of variolitic basalt with well-preserved pillow structures. The pillows have a pale, feldspar-rich core and a greenish marginal phase with a groundmass of chlorite, clinozoisite, and tremolite (Hallberg, 1972). A transitional zone between core and margin consists of varioles made up of locally coalescing, spherical masses of radiating albite and amphibole plus chlorite (i.e. uralitized acicular pyroxene), whereas the marginal phase consists of plagioclase ($An_{5–25}$) in a felted groundmass of chlorite, clinozoisite, and tremolite (Hallberg, 1972). The origin of the varioles remains unresolved, but they are common in basalts at the lower end of the MgO range within high-Mg series (10–18 wt% MgO). Because they locally overprint primary volcanic structures, but have themselves been deformed during regional deformation events, the varioles may represent early alteration or devitrification textures.

A few metres west of the creek, the Kapai Slate, which overlies the Devon Consols Basalt, outcrops as a well-exposed chert marker (MGA 357785E 6586530N). At depth, the chert becomes carbonaceous and pyritic slate. Several episodes of deformation are indicated by the presence of small-scale, low-angle faults and two phases of steep-dipping, tight folds.

Immediately west of the Kapai Slate and south of the track, the base of the Williamstown Dolerite can be seen in small rubbly outcrops of peridotite, now a talc–tremolite–serpentine(–magnetite–apatite) rock. Euhedral olivine has been pseudomorphed by serpentine; euhedral prismatic orthopyroxene has been replaced by talc–tremolite; and intergranular clinopyroxene has been replaced by chlorite, serpentine, or both. Farther south, a more differentiated portion of the Williamstown Dolerite consists of gabbro in which pyroxene has been altered to fine, fibrous tremolite and chlorite, and to plagioclase that is partially altered to chlorite.

Williams and Hallberg (1973) studied the Williamstown Dolerite sill in some detail in the hinge of the major fold, about 1 km to the north. They showed that the sill outcrops continuously over at least 2 km, is bifurcated, has a thickness of about 400 m, and displays marked differentiation. All primary minerals are altered, but texture preservation allows recognition of the original mineralogy. A lower ultramafic zone consisted of a peridotite unit (olivine and orthopyroxene) overlain by a thin orthopyroxenite unit, followed by a mafic zone with a lower norite–gabbro unit (orthopyroxene, plagioclase, and clinopyroxene) and an upper gabbro (plagioclase and clinopyroxene).

Continuing the traverse westwards, the Kapai Slate is crossed again (MGA 357725E 6586490N) in what is interpreted as the west limb of a very tight D_1 syncline. Next are some small rubbly outcrops of Devon Consols Basalt. A major fault is crossed next and the whole sequence is repeated. A possible interpretation of the geometry is shown in Figure 7. According to this interpretation, an early, isoclinal fold pair (F_1), in which the short limb is thinned and sheared out (Figs 7a,b), was tilted into a steeply west-dipping orientation on the west limb of the regional anticline (F_2), and refolded by a discontinuous, asymmetric F_3 fold (Swager, 1989). In the side of the hill, extensive outcrop of variolitic Devon Consols Basalt contains large, weathered-out varioles (Fig. 8; MGA 357525E 6586500N). The overlying Kapai Slate is marked by a line of shallow gold workings that have now been infilled (MGA 357495E 6586475N). The Williamstown Dolerite is poorly exposed, being largely covered by talus from Mount Hunt. The final ascent to the summit of Mount Hunt crosses Paringa Basalt, which consists of metamorphosed pyroxene-spinifex-textured basalt characterized by skeletal and acicular amphibole that pseudomorphs primary clinopyroxene, and minor biotite in a matrix of fine-grained amphibole, chlorite, clinozoisite, albite and quartz. The acicular textures range in scale from a few millimetres up to 30 mm.

Gold elds Highway

Vehicles should return to the main Goldfields Highway and go to the locality marked with a sign indicating 'PILLOW LAVA' on the eastern side of the road.

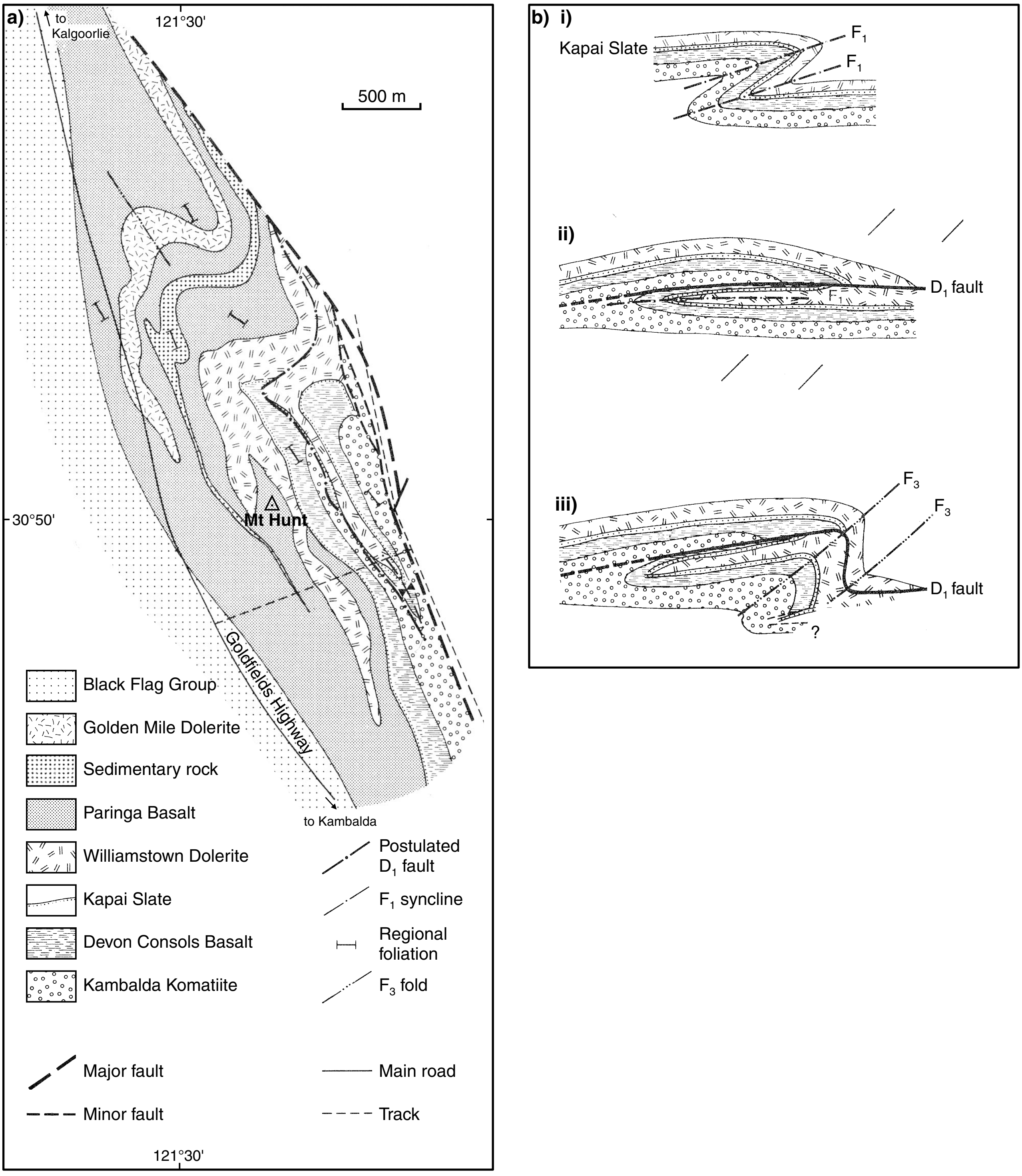

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Figure 7. a) Interpretive geological map of Mount Hunt (modi ed from Swager, 1989, 1990); b) schematic development of fold structures at Mount Hunt; i) initial, asymmetric F_1 fold; ii) development of small-scale F_1 nappe structure, with largely sheared-out short limb; iii) F_3 refolding of the F_1 structure, after it was tilted into a steep orientation during the F_2 upright folding (after Swager, 1989, 1990)

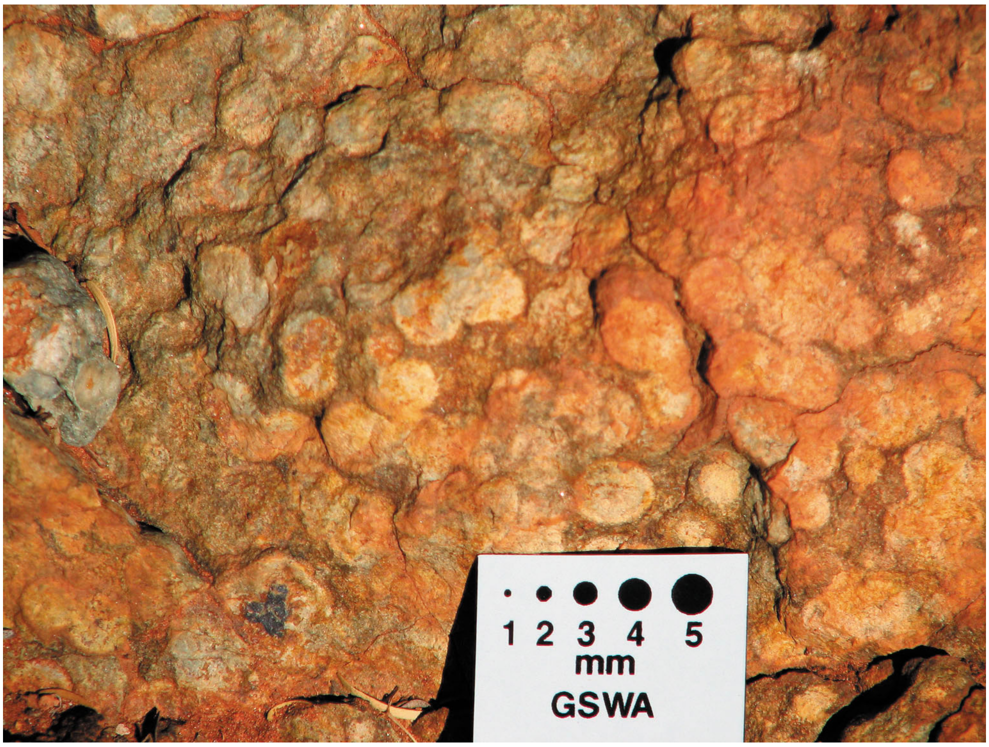

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Figure 8. Variolitic Paringa Basalt on Mount Hunt (MGA 357525E 6586500N)

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Figure 9. Relict pillow structures in saprolite after Paringa Basalt, west of Mount Hunt (MGA 356815E 6586475N)

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Figure 10. Relict hyaloclastite breccia in saprolite after Paringa Basalt, west of Mount Hunt (MGA 356785E 6586300N)

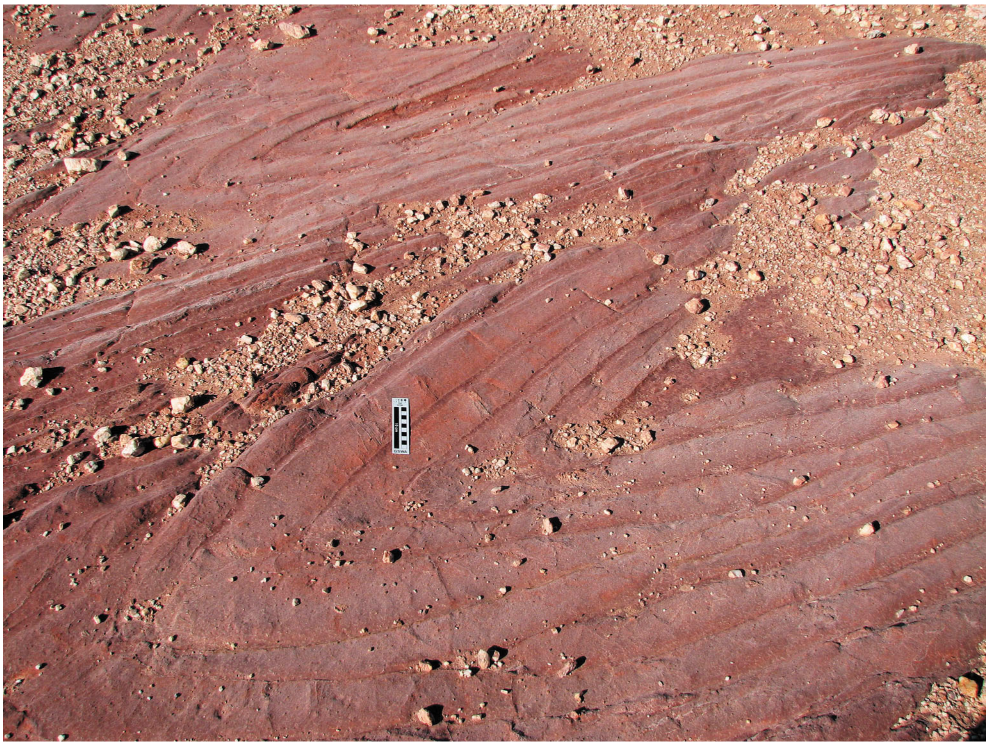

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Figure 11. Folds in graded volcaniclastic beds of weathered Black Flag Group (MGA 356268E 6586122N)

Paringa Basalt

Deeply weathered, pillowed Paringa Basalt outcrops on the eastern side of the highway (Location 3 on Fig. 4; MGA 356815E 6586475N). Younging to the southwest is indicated by the pillows (Fig. 9), whose weathered margins are marked by variolitic textures. Breccias, probably representing hyaloclastite, are also preserved (Fig. 10; MGA 356785E 6586300N). Fresher material from the breakaway edge consists of metamorphosed komatiitic basalt like that in the rest of the Mount Hunt area.

Black Flag Group

Metasedimentary rocks of the Black Flag Group outcrop on the western side of the Goldfields Highway (Location 4 on Fig. 4 — MGA 356695E 6586300N). Graded bedding, current bedding, and scours indicate a consistent westward younging, except where there are local reverses due to minor folding (Fig. 11). The basal beds contain zones of oligomictic conglomerate. Farther west, conglomerates are rarer and the sequence contains an appreciable felsic volcaniclastic component.

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