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GEOLOGY OF THE DAVYHURST 1:100 000 SHEET WESTERN AUSTRALIA

by

S. Wyche and W.K. Witt

DEPARTMENT OF MINES
WESTERN AUSTRALIA

NEARANGING 2937	DAVYHURST 3037	BARDOC 3137
	KALGOORLIE SH 51-9	
MOUNT WALTER 2936	DUNNSVILLE 3036	KALGOORLIE 3136

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Contents

Appendix

Figures

Tables

Geology of the Davyhurst 1:100 000 Sheet, Western Australia

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Abstract

The Davyhurst 1:100 000 sheet contains granitoid rocks and a greenstone sequence comprising mainly basalt, ultramafic rocks and felsic volcanic and volcaniclastic sedimentary rocks of the Archaean Kalgoorlie Terrane. Banded iron-formation and basalt of the adjacent Barlee Terrane occur west of the Ida Fault, a major regional structure. The complete Kalgoorlie Terrane stratigraphy -- consisting of a lower basalt unit, a komatiite unit, and an upper basalt unit overlain by a unit of felsic volcanic and volcaniclastic sedimentary rocks, all unconformably overlain by a conglomerate unit -- is well-exposed in the Ora Banda Domain in the eastern part of the sheet area. The stratigraphy is less clear in the Coolgardie and Bullabulling Domains in the centre and west. All Archaean rocks have undergone low- to medium-grade metamorphism, and there are areas of intense deformation, mainly associated with D_3 shears. A D_2 upright fold, the Kurrawang Syncline, is exposed in the Ora Banda Domain, and other, less well-defined, D_2 folds are indicated in the Coolgardie Domain.

There is significant historical and recent gold production from Davyhurst and Callion in the northwest, and from the Siberia and Carnage mining centres in the east.

Keywords: Davyhurst, Siberia, granite - greenstone, Archaean, gold, Kalgoorlie Terrane, Eastern Goldfields Province.

Introduction

The DAVYHURST* 1:100 000 geological map sheet (SH51-9-3037) lies within the central northern part of the Kalgoorlie 1:250 000 sheet. DAVYHURST generally consists of deeply weathered granite - greenstone terrain extensively covered by Cainozoic surficial deposits. Gold has been mined from a number of localities on DAVYHURST during the past 100 years, and recent advances in processing technology, coupled with a favourable gold price, have led to reworking of a number of the old mines, and mining of some new discoveries.

Localities referred to in these notes for which Australian Map Grid (AMG) references have not been given, are shown in Figure 1.

Access and habitation

DAVYHURST can be reached by formed roads from Coolgardie, from Broad Arrow via Ora Banda, and from Canegrass Swamp on the Kalgoorlie - Menzies road. There are sheep station homesteads at Credo and Carbine, and mineral exploration and production from gold mines in the region results in the establishment of transient settlements.

Access to greenstone areas is generally good along main roads, station tracks and exploration grids, but many granite outcrops are difficult to reach, with only limited access along fencelines and station tracks.

Climate

The region has a semi-arid climate. The City of Kalgoorlie - Boulder, about 80 km to the southeast, has an average annual rainfall of 257 mm, and an average 63 wet days per year (Australian Bureau of Statistics, 1989). Although rainfall is fairly evenly distributed throughout the year, summer rain tends to be more episodic than winter rain.

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* Capitalized names in these notes refer to standard 1:100 000 map sheeets.

Temperatures are commonly greater than 40°C in the hottest months (December - March) and there are occasional frosts in the coldest months (June - August).

Physiography

The region is part of an extensive plateau on which greenstones form low rocky ridges (usually less than 50 m above the surrounding plains). The highest elevations above sea level are 520 m at Mount Carnage in the southeast, and 534 m at a point (AMG 2640 - 66588) within the greenstone sequence southwest of Callion. Wangine Lake and Rowles Lagoon have the lowest elevations, 380 m and 400 m respectively. There are sand dunes over granite in the northeast.

DAVYHURST is drained by ephemeral streams in poorly defined channels. The Rowles Lagoon lake system acts as an internal focus for drainage in the southeast, and streams drain towards Wangine Lake in the north. There are external drainage systems to the northwest and northeast.

The region lies within the Coolgardie Botanical District which marks a transition between the Roe Botanical District to the south, dominated by Eucalypt species, and the Austin Botanical District to the north, dominated by Acacia species (Beard, 1990). It contains a range of woodland and shrubland assemblages, including a wide variety of Eucalypt, Acacia, Grevillea, Casuarina and Melaleuca species. Trees are generally larger and more abundant in the heavier, less depleted soils over greenstone belts than over granite.

Previous work

Early descriptions of the gold mines around Davyhurst were given by Gibson (1904); Gibson (1908) and Montgomery (1910) described mines around Chadwin Well, Carbine and Carnage; and Montgomery (1909) described those in the Siberia district. Witt (in prep.) reviewed the gold deposits in the eastern part of DAVYHURST.

The first published geological map of the area was that of Kriewaldt (1969). Since its publication, extensive mineral exploration, mainly for gold and nickel, with detailed remapping by the Geological Survey of Western Australia (GSWA) and ongoing academic studies, have brought about a major revision of ideas concerning the stratigraphy, structure and tectonic history of the Eastern Goldfields. Griffin (1990a) and Swager et al. (1990) provide recent reviews of the regional geology. Ollier et al. (1988) described the landscape history and regolith of the Kalgoorlie region.

Unpublished maps and data produced as a result of mineral exploration are available through the WAMEX open-file system at the GSWA library, but there is very little published exploration information.

Current work

Mapping of DAVYHURST is part of an ongoing program of 1:100 000 mapping in the Eastern Goldfields Province by the GSWA and, more recently, the Bureau of Mineral Resources (BMR). The eastern part of DAVYHURST was mapped by W. K. Witt (1985-86) using 1:25 000 colour and 1:50 000 black-and-white air-photographs taken in 1979. The western part was mapped by W. M. Hunter (1988) and S. Wyche (1989) using 1:25 000 colour air-photographs taken in 1988. Aeromagnetic interpretations are based mainly on the 1:100 000 total-field magnetic contour map (Aerodata Holdings Ltd, 1986).

Mapping of greenstone belts generally involved many detailed traverses whereas granites were visited only where outcrops identified from air-photographs were easily accessible along tracks and fencelines.

Nomenclature

All the Archaean rocks described have been subjected to low- to medium-grade metamorphism, but for ease of description the prefix 'meta-' is omitted.

In these notes, 'komatiite' refers to ultramafic rocks with relict platy olivine spinifex textures. Arndt and Nisbet (1982) used the term more broadly to describe ultrabasic extrusive rocks with more than 18 % MgO. The term 'high-Mg basalt', equivalent to 'komatiitic basalt', is used to characterize a basaltic rock which shows relict pyroxene spinifex textures. These rocks typically contain between 10 and 18% MgO (Cas and Wright, 1987).

Precambrian geology

Introduction

Swager et al. (1990) have divided the Kalgoorlie region into a number of tectonostratigraphic terranes bounded by major shear zones. DAVYHURST lies mainly within the Kalgoorlie Terrane but also contains part of the adjacent Barlee Terrane of Myers (1990) in the west. The Barlee Terrane is equivalent to the Callion Terrane of Swager et al. (1990). The two terranes are separated by the Ida Fault (Fig. 1).

The Kalgoorlie Terrane is further subdivided into a series of fault-bounded structural-stratigraphic domains. DAVYHURST contains parts of the Ora Banda, Coolgardie and Bullabulling Domains (Fig. 1). An interpretation of the Precambrian geology is shown in Figure 2. Stratigraphic successions of the domains on DAVYHURST are shown in Table 1.

U - Pb isotopic studies of zircons (summarized in Swager et al., 1990) indicate an age of greenstone deposition around 2.7 Ga for the Kalgoorlie Terrane but there are no published data from DAVYHURST.

Swager (1989) and Swager and Griffin (1990) have described four phases of deformation, D_1 to D_4, in the Kalgoorlie region (Table 2), of which D_2 upright folds and D_3 regional-scale transcurrent faults are the most readily recognizable on DAVYHURST. Witt and Swager (1989) described several phases of granitoid intrusion in the Bardoc - Coolgardie area, and their classification has been used to characterize granitoid rocks on DAVYHURST.

All Archaean rocks have been metamorphosed. Metamorphic grade ranges from predominantly greenschist facies in the southeast to amphibolite facies in the northwest. It is generally higher close to contacts with granitoid rocks.

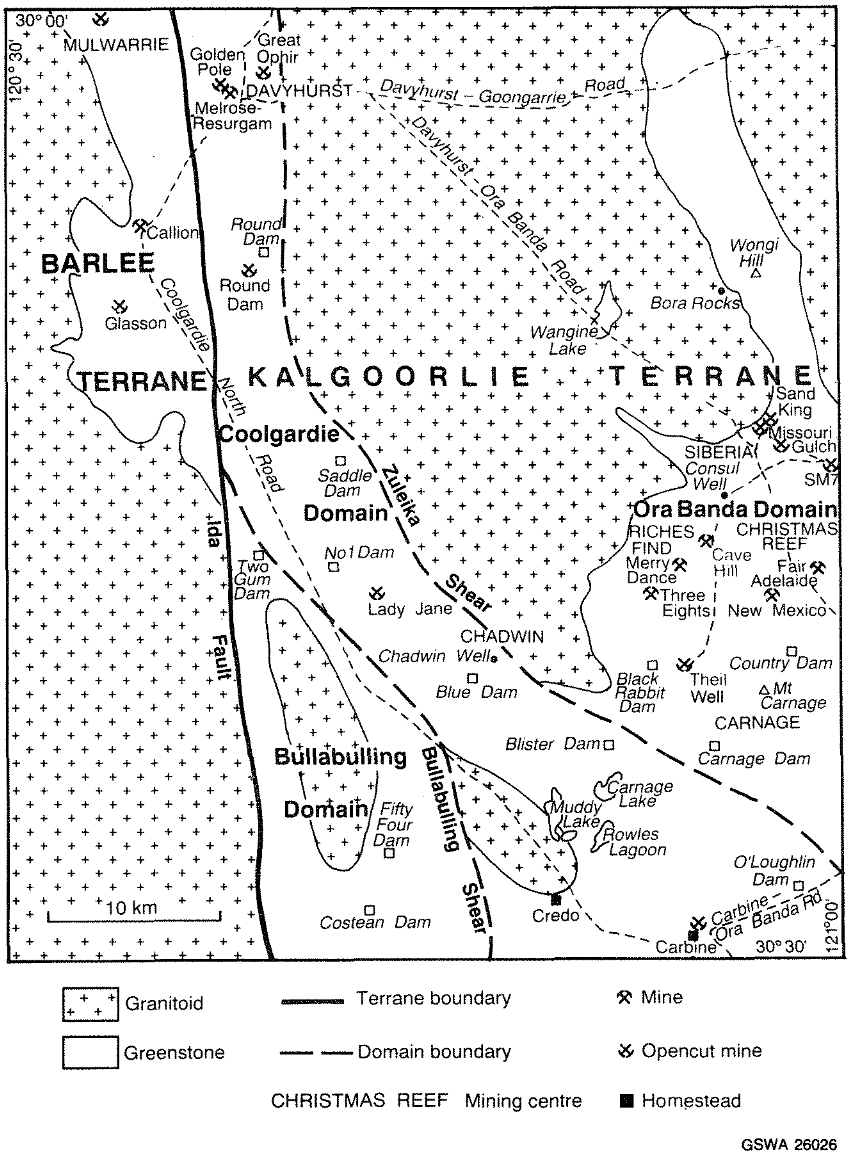

Figure 1. Localities and geological setting

Proterozoic mafic and/or ultramafic dykes do not outcrop on DAVYHURST but are indicated by aeromagnetic lineaments. One dyke intrudes felsic and sedimentary rocks in the Coolgardie Domain in the south and another may intrude the Ora Banda sequence in the northeast.

Stratigraphy

Kalgoorlie Terrane

Table 1 shows the generalized stratigraphy for the Kalgoorlie Terrane, and summaries of the stratigraphic successions of the Ora Banda, Coolgardie and Bullabulling Domains on DAVYHURST. The generalized succession consists of a lower basalt unit, overlain by komatiite, which is in turn overlain by an upper basalt unit, followed by felsic volcanic and sedimentary rocks. This sequence is unconformably overlain by a formation of polymictic conglomerate and coarse sandstone. There are intrusions of broadly conformable mafic - ultramafic sills at various levels. Not all elements of the stratigraphy are present in all domains.

Newly named stratigraphic units, the Black Rabbit Member of the Missouri Basalt, the Rowles Lagoon Monzogranite and the Two Gum Monzogranite, are described in the Appendix.

Ora Banda Domain

The Ora Banda stratigraphy has been described by Witt (1990) from BARDOC but, because the lowest part of the sequence, the Pole Group, is best exposed on the eastern part of DAVYHURST, it is described in detail for the first time here. Figure 3 presents summary sections through the Wongi and Missouri Basalts, the formations which make up this part of the sequence.

The base of the exposed greenstone sequence is consistently represented by deformed or intrusive contacts with granitoids. The thickest sections (about 2.5 km) of the lowermost formation, the Wongi Basalt, are in the Wongi Hill area. Wongi Basalt includes a diverse range of volcanic rocks and layered mafic sills. However, the lack of correlation between the three localities in Figure 3 suggests that individual components may not be regionally extensive.

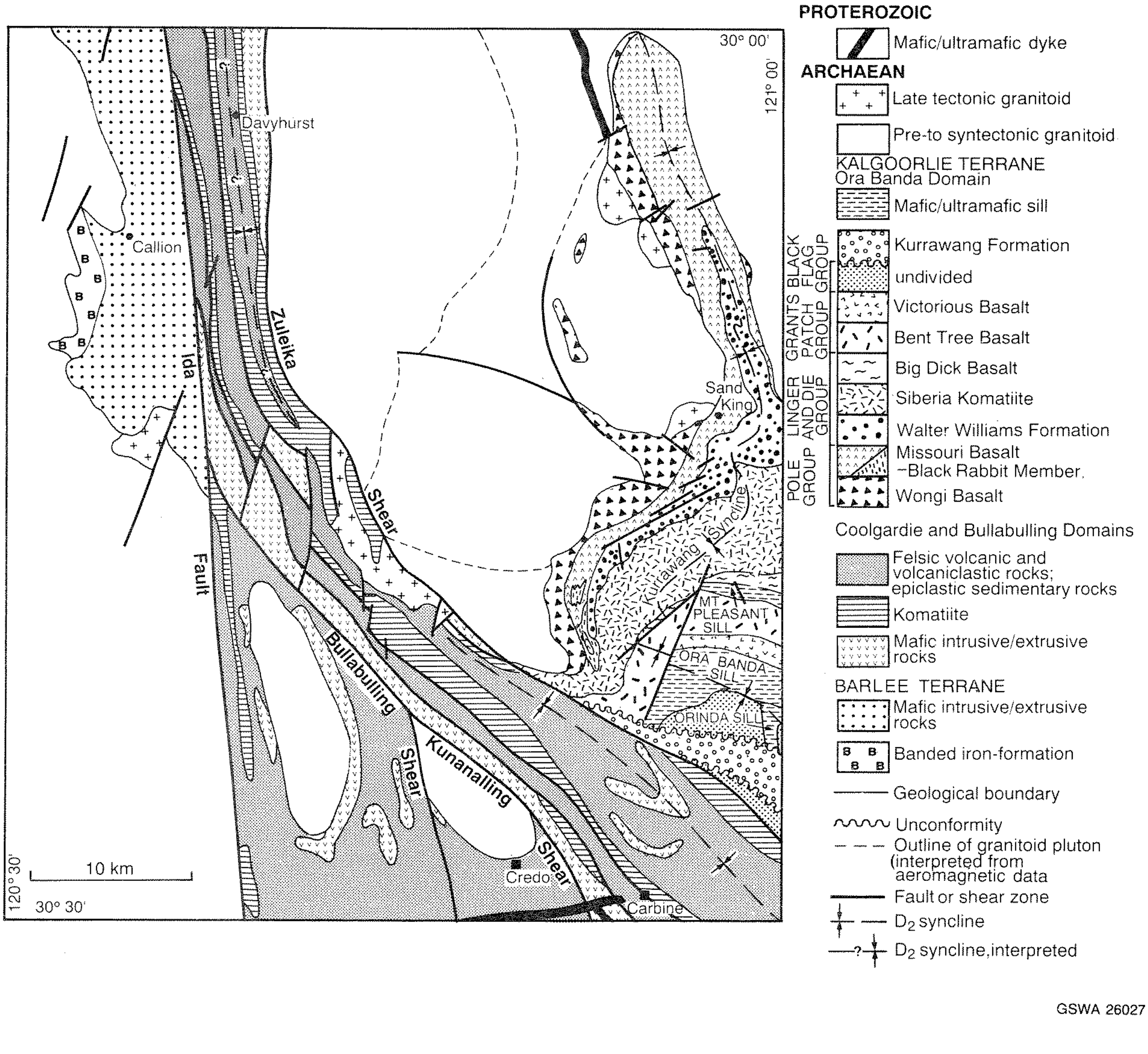

Figure 2. Interpreted Precambrian geology

TABLE 1. Stratigraphic successions of the Kalgoorlie Terrane on DAVYHURST (adapted from Swager et al., 1990)

GENERALIZED SUCCESSION	CHARACTERISTIC ROCK TYPES	ORA BANDA DOMAIN	COOLGARDIE DOMAIN	BULLABULLING DOMAIN
Polymictic conglomerate unit	Polymictic conglomerate, immature sandstone; coarse trough cross-beds, graded beds	Kurrawang Formation	Absent	Absent
Felsic volcanic and sedimentary unit	Felsic volcaniclastic sedimentary rocks ranging from coarse clastic sandstone to interbedded sand/siltstone. Rhyolite to dacite, locally andesite; lava, tuff, agglomerate	BLACK FLAG GROUP: Orinda Sill; Ora Banda Sill	Felsic volcanic and sedimentary rocks	Felsic volcanic and sedimentary rocks
Upper basalt unit	High-Mg and tholeiitic basalt; massive, pillowed and vesicular lavas	GRANTS PATCH GROUP: Victorious Basalt; Bent Tree Basalt; Mt Pleasant Sill	Absent or thin and discontinuous	Not recognized
Komatiite unit	Thin, variolitic-textured, high-Mg basalt at top. Thin komatiitic flows with minor interflow sedimentary beds, overlying thicker komatiitic flows and/or massive olivine adcumulate	LINGER AND DIE GROUP: Big Dick Basalt; Siberia Komatiite; Walter Williams Formation	Thin high-Mg basalt at top. Spinifex-textured flows with subordinate peridotitic orthocumulate	Poorly exposed ultramafic schist
Lower basalt unit	Tholeiitic and high-Mg basalt flows, subaqueous. Rare felsic volcaniclastic interbeds	POLE GROUP: Black Rabbit Member; Missouri Basalt; Wongi Basalt	Poorly exposed basalt and amphibolite	Poorly exposed basalt and amphibolite

GSWA 26031

Basalt flows with variolitic and/or coarse pyroxene spinifex textures are abundant. Other basalt flows contain small (< 1 mm) acicular amphibole grains which may pseudomorph skeletal pyroxene, but could also be of metamorphic origin. In the Wongi Hill area, there are quartz-filled amygdales in non-variolitic flows in the lower part of the Wongi Basalt. Two thin horizons north of Bora Rocks contain porphyroclasts of rounded quartz and subhedral plagioclase up to 1 cm in diameter in a matrix of quartz - chlorite - plagioclase schist. They probably represent immature sedimentary rocks with a granitoid provenance.

Chemical analyses of Wongi Basalt span compositions up into the high-Mg basalt range (5 - 13% MgO). One sample of komatiite containing 18.9% MgO has been collected from this formation, but komatiite is only a minor component. A basaltic andesite unit containing 4.1% MgO from south of Old Well does not appear to be genetically related to the more mafic members of the Wongi Basalt (based on geochemical evidence, P. A. Morris, personal communication, 1990).

Wongi Basalt includes several layered mafic sills, generally 100 - 150 m thick. A typical sill has three zones. The lowermost zone (zone 1) is a dolerite with up to 5% subequant to tabular plagioclase phenocrysts in a medium- to coarse-grained (1 - 2 mm) doleritic groundmass. Phenocrysts increase in size upwards through the zone to a maximum of 1 cm, and a weakly developed centimetre-scale modal layering is present locally. The change from zone 1 to zone 2 is gradual and marked by a decrease in the abundance of plagioclase phenocrysts. Zone 2 is a 'spotty-textured' leucogabbro with prominent pyroxene phenocrysts up to 1 cm in diameter. Millimetre- to centimetre-scale modal layering is abundant. Pyroxene increases in abundance (and size?) upwards towards zone 3, a mafic dolerite, in which blue-grey quartz or granophyre is generally present. Grain size ranges from 1 mm to 1 cm, and there are plumose aggregates of pyroxene pseudomorphs up to several centimetres long in places. Apparent cyclic repetition of the layering near Bora Rocks could represent several intrusions separated by narrow screens of basalt.

An extensive layered mafic sill, up to 700 m thick, is present at the base of Missouri Basalt in the north, but does not occur in the Black Rabbit Dam area (Fig. 3). It consists of a lower, mafic-rich gabbro with coarse pyroxene oikocrysts (up to 1.5 cm) which passes up into a 'spotty-textured' leucogabbro. This in turn is overlain by iron-rich quartz dolerite. The rock types and layering are like

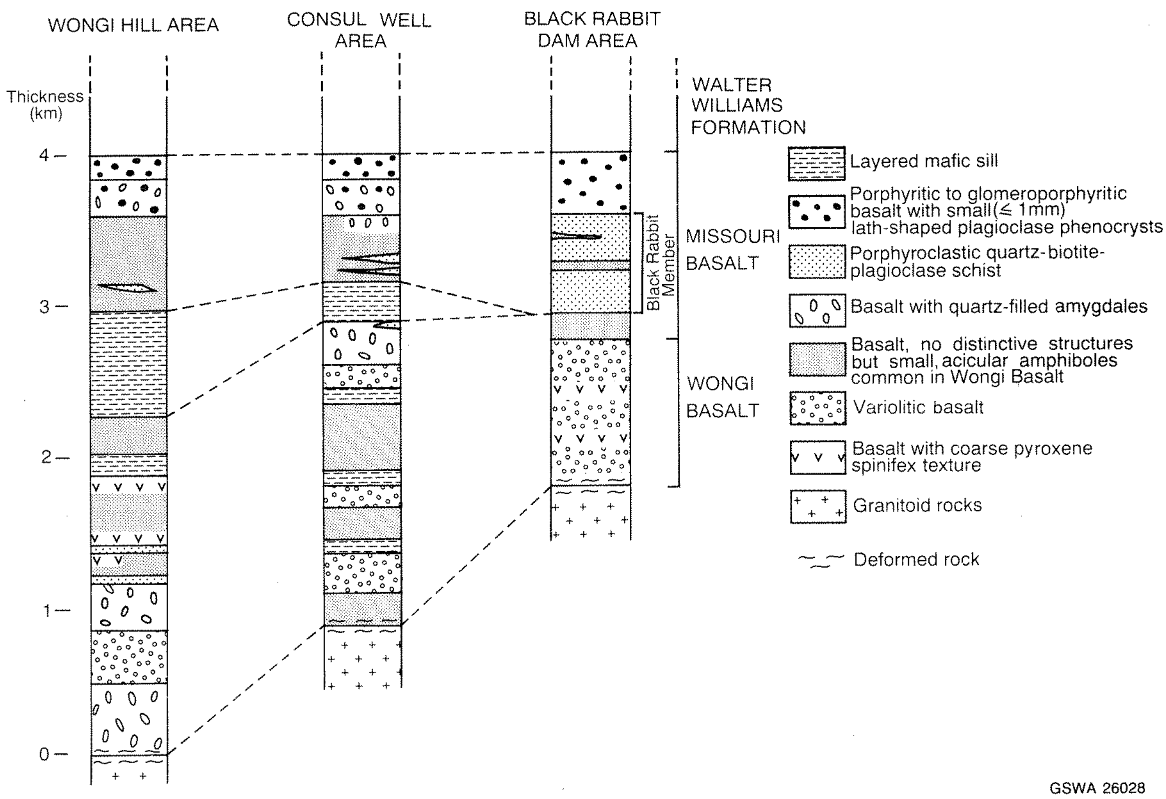

Figure 3. Stratigraphy of the Wongi and Missouri Basalts

those of the Mount Ellis Sill (Witt, 1990), and the bulk composition is probably also similar (tholeiitic).

The Missouri Basalt is a uniformly tholeiitic formation (Witt and Harrison, 1989; Morris, 1990) up to 1 km thick. It lacks distinctive textures, although acicular amphibole occurs locally. Quartz-filled amygdales increase towards the top and the uppermost flow (or flows) is a distinctive porphyritic to glomeroporphyritic unit with plagioclase phenocrysts up to 1 mm. Pillow structures are exposed in openpit mines at Sand King and Missouri. A unit of felsic porphyroclastic schist, the Black Rabbit Member, is interbedded with the basalt near Siberia, and becomes dominant near Black Rabbit Dam where it may be more than 800 m thick (Fig. 3). Poorly preserved grain-size layering, possibly representing bedding, indicates that it is probably a metamorphosed sedimentary rock derived from an acid to intermediate, granitoid or volcanic source.

The Pole Group is overlain by the Linger and Die Group which is made up of the Walter Williams Formation, the Siberia Komatiite, and the Big Dick Basalt (Table 1). The Walter Williams Formation lenses out to the west so that the Siberia Komatiite directly overlies the Missouri Basalt south of Black Rabbit Dam. A complex association of olivine orthocumulate, pyroxenite, gabbro and leucogabbro at the contact between the Walter Williams Formation and the Siberia Komatiite was described by Witt and Harrison (1989). Sections across this contact from DAVYHURST and BARDOC are shown in Figure 4. The consistent occurrence of high-Mg gabbro at this stratigraphic level suggests that the mafic rocks may be derived by fractionation from a komatiitic liquid (Arndt et al., 1977). The leucogabbro with cumulus diopside and oikocrysts of sphene and magnesiohornblende is probably the ultimate product of this process.

The top of the Linger and Die Group is marked by the Big Dick Basalt, a unit of high-Mg basalt with abundant variolitic textures.

The Linger and Die Group is conformably overlain by basalts of the Grants Patch Group. The lower basalt, the Bent Tree Basalt, is tholeiitic basalt with conformable intervals of dolerite and gabbro. The upper basalt, the Victorious Basalt, is a coarsely plagioclase-phyric rock which does not outcrop on DAVYHURST but is interpreted in the subsurface in the southeast, near Country Dam.

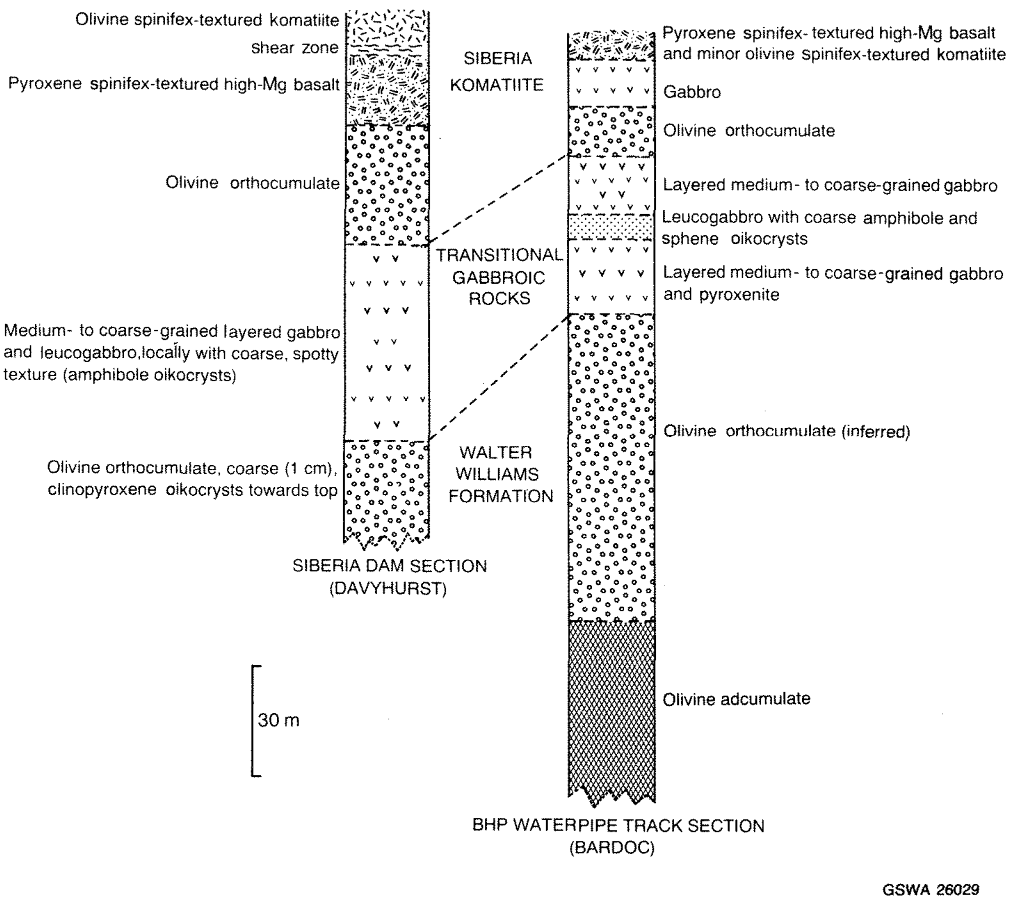

Figure 4. Transition between the Walter Williams Formation and the Siberia Komatiite -- approximate thicknesses only (adapted from Witt and Harrison, 1989)

The Black Flag Group, which represents the felsic volcanic and sedimentary rock unit of the generalized Kalgoorlie stratigraphy, does not outcrop on DAVYHURST.

Polymictic conglomerate and sandstone of the Kurrawang Formation, the uppermost formation of the Kalgoorlie sequence, occur in isolated outcrops and scree around AMG 2960 - 66370, east of Blister Dam.

The Ora Banda sequence contains several broadly conformable, layered mafic - ultramafic sills. The Mount Pleasant, Ora Banda and Orinda Sills outcrop on DAVYHURST (Table 1, Fig. 2) but are best exposed to the east, on BARDOC (Witt, 1990).

Coolgardie Domain

The Coolgardie Domain stratigraphy, described on DUNNSVILLE to the south (Swager, 1990) and KALGOORLIE to the southeast (Hunter, in prep.) is similar to that in the Ora Banda Domain except that the uppermost conglomerate unit, the Kurrawang Formation, is absent, and the upper basalt unit is either absent or thin and discontinuous (Table 1).

Rocks of the Coolgardie Domain are not well exposed on DAVYHURST and the distribution of rock types suggests that it is mainly represented by the upper part of the sequence. The best exposures occur along the southern side of a D_2 syncline near Chadwin Well, where the felsic volcanic and sedimentary rock unit directly overlies the komatiite unit, as on DUNNSVILLE and KALGOORLIE.

The abundant ultramafic - mafic sills of the Ora Banda Domain do not occur in this sequence. However, a broadly conformable leucogabbro unit which outcrops near Chadwin Well may be at the same stratigraphic level as the Powder Sill, a leucocratic mafic intrusion in the Coolgardie Domain to the southeast on KALGOORLIE (Hunter, 1988, in prep.).

Bullabulling Domain

The Bullabulling Domain is poorly known and very poorly exposed, but appears to be dominated by felsic volcanic and sedimentary rocks with subordinate basalt. Lenses of ultramafic rock along the Ida Fault in the west, interpreted mainly from aeromagnetic data, are strongly deformed (Fig. 2). Their relationship to the rest of the Bullabulling Domain is unclear.

Barlee Terrane

The Barlee Terrane has no established stratigraphy, but contains rock types similar to those further west in the Southern Cross Province described by Griffin (1990b). It is separated from the Kalgoorlie Terrane by the Ida Fault. On DAVYHURST, it is represented by an east-dipping sequence which includes units of banded iron-formation (BIF), a rock type which does not outcrop in the Kalgoorlie Terrane. The BIF is intercalated with shale, chert, basalt, dolerite, and gabbro, and overlain by a sequence of basalt and dolerite with thin interbeds of shale and felsic porphyry. No olivine or pyroxene spinifex-textured rocks were recorded in the Barlee Terrane on DAVYHURST and the mafic sequence appears to be dominated by tholeiitic basalt (see **Geochemistry**).

Granitoid rocks

In the past, granitoid rocks of the Eastern Goldfields have been divided into 'internal' granites (i.e. within greenstone belts) and 'external' granites (i.e. between greenstone belts) (Sofoulis, 1963). Some attempts have been made to characterize this division on the basis of composition and relationships, but data are sparse (Hallberg, 1988; Bettenay, 1988).

Witt and Swager (1989) described the structural setting and geochemistry of granitoid rocks in the northern part of the Kalgoorlie Terrane and identified three groups, based mainly on relationships with regional structures in the greenstones: pre-D_2 to syn-D_2 'domal'granitoids, post-D_2 to syn-D_3 granitoids, and late tectonic granitoids. They suggested the pre- to syn-D_2 granitoids may have intruded as sheets near the base of the greenstone sequence or as diapirs, and that the post-D_2 to syn-D_3 granitoid plutons are diapiric intrusions. Evidence for diapirism includes:

(a) ductile deformation along granitoid contacts;
(b) contact-parallel shear zones which locally transgress lithological boundaries in greenstones;
(c) preserved shear microstructures which indicate granite-up - greenstone-down movement; and
(d) contact-parallel foliations with down-dip lineations. In the granitoid plutons west of Siberia, foliation dips away from the centres of the diapirs at a shallow angle, suggesting proximity to the roofs;
(e) pushing aside of a D_2 fold axis west of Siberia.

Archaean rock types

Ultramafic rocks (*Au, Auk, Aud, Aup, Auox*)

Ultramafic schist (*Au*) has been mapped mainly in the Coolgardie Domain, where it is typically pale- to dark-green tremolite schist which may contain chlorite, plagioclase, and magnetite. Chlorite is more abundant in the south. This schist may be derived from either ultramafic rock or high-Mg basalt but protoliths are difficult to distinguish in the field.

Komatiite (*Auk*) includes all ultramafic rocks which display olivine spinifex textures. It generally contains tremolite + magnetite ± chlorite ± serpentinite ± plagioclase in areas of greenschist-facies metamorphism. In areas of higher metamorphic grade, it is typically composed of tremolite with minor magnetite. Tremolite pseudomorphs olivine plates and is enclosed by interstitial felted tremolite + magnetite ± chlorite ± plagioclase.

Adcumulate dunite (*Aud*) in the east of DAVYHURST has been assigned to the Walter Williams Formation (Table 1; Hill et al., 1987; Witt, 1990). Coarse-grained (up to 2 cm) adcumulate texture is preserved in ferruginous silica caprock developed over the Walter Williams Formation. Olivine obtained from drillholes which have intersected the adcumulate is mostly fresh with a brown pleochroism typical of metamorphosed relict olivine (Hill et al., 1987).

Outcrops of olivine orthocumulate and mesocumulate (*Aup*) are associated with the dunite of the Walter Williams Formation. These rocks occur above and below the olivine adcumulate, are typically altered, and contain serpentine ± carbonate pseudomorphs after olivine (up to 3 mm diameter) in a matrix of fine-grained tremolite, chlorite, serpentine, magnetite, ± talc. Olivine adcumulates are separated from overlying peridotitic cumulate (olivine orthocumulate) by a layer of coarse-grained olivine harrisite (Hill et al., 1987; Hill and Barnes, 1990).

Samples collected from the upper olivine orthocumulate horizon of the Walter Williams Formation contain anomalous concentrations of chromite. Centimetre-scale banding is defined by variation in size (0.5 - 3 mm) and abundance (65 - 100%) of serpentinized cumulus olivine. There may also be a regular variation in cumulus pyroxene. Cumulus chromite occurs as small (0.2 - 0.4 mm), subhedral to euhedral grains interstitial to cumulus olivine. Overall concentrations range from 3 to 10%, but there are local concentrations of up to about 30% chromite in bands up to 6 mm thick and in spherical aggregates up to 2.5 cm across. At these higher levels of concentration, cumulus chromite almost completely occupies the intercumulus space between olivine grains, and chromite grains are commonly sintered (Hulbert and von Gruenewaldt, 1985). All chromite grains display broad, zoned margins of titanomagnetite, probably the result of postcumulus modification by reaction with the intercumulus melt (Haggerty, 1981). In some samples, there is a narrow outer rim of hematite which is attributed to weathering.

Peridotitic orthocumulate occurs at the base of both the Mount Pleasant and Ora Banda Sills. In the Mount Pleasant Sill, it consists of fine-grained olivine orthocumulate with amphibole oikocrysts, which in places grades up into coarser grained olivine - clinopyroxene mesocumulate. The orthocumulate section at the base of the Ora Banda Sill is seen only in drillholes on DAVYHURST because of the thick laterite cover. Outcrops to the east on BARDOC have been described by Witt (1990).

Thin units of serpentinized olivine orthocumulate and mesocumulate with relict interstitial olivine spinifex textures (mapped as *Aup*), outcrop south of Round Dam and near Muddy Lake.

Orthopyroxene adcumulate and orthopyroxene - plagioclase adcumulate (*Auox*) overlie peridotitic orthocumulate in the Ora Banda Sill on the northern flank of Mount Carnage. The adcumulates are poorly exposed, medium grained (2 - 3 mm), patchily altered, and contain cumulus orthopyroxene ± plagioclase and may contain intercumulus clinopyroxene, plagioclase and biotite (Witt, 1990).

Mafic extrusive rocks (*Ab, Abm, Abo, Abpf, Abp, Ama*)

Mafic extrusive rocks, including amphibolite, make up a large part of the greenstone sequences. Although both tholeiitic and high-Mg varieties are present, they are difficult to distinguish in the field where pyroxene spinifex textures have not been preserved.

Massive, fine- to medium-grained mafic rocks (*Ab*) have not been subdivided. They are thought to be derived from mainly extrusive tholeiitic basalt intercalated with subordinate high-Mg basalt. These rocks occur at two levels within the Ora Banda sequence -- in the lower part of the Missouri Basalt, and in the Bent Tree Basalt -- and are widespread through the Coolgardie Domain and Barlee Terrane. They contain roughly equal amounts of calcic amphibole and plagioclase, and small amounts of epidote, titanite, and opaque minerals. Clinopyroxene is present in areas of higher metamorphic grade in the northwest. Quartz-filled amygdales are characteristic of the upper part of the Missouri Basalt, and have been noted in the Barlee Terrane (e.g. about 4 km north of Callion, at approximately AMG 2671 - 66685). Pillow structures have not been widely recognized but may be masked by the generally strong deformation. Skeletal plagioclase grains in a fine-grained basalt horizon, 5 km north of Callion at AMG 2677 - 66708, may indicate rapid cooling. Flow-top breccias and pillow structures occur in similar rocks in the Bent Tree Basalt to the east on BARDOC (Witt, 1990).

High-Mg basalt (*Abm*) is characterized by the presence of relict pyroxene spinifex textures in which clinopyroxene, now replaced by amphibole, has assumed skeletal, dendritic, arborescent, and fan-like forms. It is generally composed of tremolite - actinolite ± subordinate plagioclase (up to 30%) with minor opaque minerals, usually magnetite. Chlorite may be present in areas of lower metamorphic grade. There are high-Mg basalts at two levels within the Ora Banda sequence -- the Wongi Basalt at the base, and the Big Dick Basalt immediately above the Siberia Komatiite (Table 1). High-Mg basalts in the

Coolgardie Domain are mainly associated with ultramafic units between Carbine and Davyhurst.

Basalts which display variolitic textures (*Abo*) typically consist of a fine, felted groundmass of acicular amphibole ± chlorite ± subordinate (up to 30%), very finely recrystallized plagioclase with abundant pale, cryptocrystalline varioles which can range in diameter from 1 mm to >1 cm. Varioles are generally paler and possibly more felsic than their host lava and a variety of mechanisms have been proposed for their origin. These include liquid immiscibility, metamorphism, alteration, and chilling processes during extrusion of the lava (Arndt and Nisbet, 1982). Varioles are most commonly seen in, but are not exclusive to, high-Mg basalt. There are well-preserved pillow structures in variolitic basalt near Theil Well but they have not been recognized in high-Mg and variolitic basalts in the Coolgardie Domain on DAVYHURST where they may have been destroyed by the generally strong deformation.

A unit of porphyritic basalt and dolerite (*Abpf*) at the top of the Missouri Basalt near Wongi Hill consists of plagioclase phenocrysts (up to 1 mm) in a fine-grained matrix of plagioclase and calcic amphibole. Pillow structures are preserved in openpit mines in the Siberia district. The unit is distinguished from coarsely plagioclase-phyric basalt and dolerite (*Abp*) of the Victorious Basalt, known locally as 'cat rock', at the top of the upper basalt unit in the Ora Banda sequence. The latter unit has been mapped on adjacent BARDOC and interpreted as extending west onto DAVYHURST in the subsurface near Country Dam.

Amphibolite (*Ama*) is used here to describe completely recrystallized basalt and dolerite in which no original textures are apparent. Prismatic hornblende and fine, polygonal, granoblastic plagioclase which shows little or no twinning, are the main constituents. Clinopyroxene is present locally. Compositional variations are indicated by different proportions of plagioclase to amphibole. Amphibolite generally shows a well-developed metamorphic foliation and is most abundant near granitoid intrusions.

Mafic intrusive rocks (*Ao, Aod, Aog, Aogl, Aor, Aogq, Aon, Aonl, Aov, Aox*)

In many places the fine-grained or basaltic mafic rocks described above contain coarse-grained layers with relict igneous textures mapped separately as dolerite (*Aod*), gabbro (*Aog*) or unsubdivided mafic intrusive rocks (*Ao*). These units are compositionally similar to the basalt in which they occur and typically consist of hornblende and plagioclase with accessory opaque oxides ± titanite. Biotite is present in places in the north (e.g. AMG 2670 - 66696). Most of the units are considered to be intrusive but some may be parts of thick flows. One outcrop (AMG 2645 - 66616) between BIF horizons in the Barlee Terrane contains a fine- to medium-grained rock in which tremolite has largely replaced pyroxene with some pseudomorphs cored by relict igneous clinopyroxene. Plagioclase is a minor (< 10%) constituent. The outcrop has been assigned to *Aog* as the precursor rock may have been a pyroxenite or mafic gabbro.

A body of coarse (3 - 4 mm) leucogabbro (*Aogl*) intrudes the unit of felsic volcanic and volcaniclastic sedimentary rocks near Chadwin Well and may be at the same stratigraphic level as the Powder Sill on KALGOORLIE (Hunter, in prep.). Although broadly conformable, it appears to cut across the sequence at a shallow angle in some places. The leucogabbro is completely recrystallized and contains more than 60% plagioclase with green hornblende ± minor biotite and titanite. A thin unit of leucogabbro between high-Mg basalt and komatiite around AMG 2850 - 66398 (west of Blue Dam) is finer grained (1 - 2 mm) and more mafic and may be a separate intrusion.

Thin horizons of felted tremolite-rich rock (*Aor*), possibly derived from pyroxenite or high-Mg basalt, are scattered through the Wongi Basalt west of Black Rabbit Dam and near Riches Find.

Quartz gabbro and granophyre (*Aogq*) at the top of the Ora Banda Sill (Fig. 2) around AMG 3078 - 66372 extends east onto BARDOC (Witt, 1990). The gabbro, which contains large grains of muscovite and quartz, is overlain by a thin layer of granophyre, consisting mainly (80 - 90%) of quartz and feldspar. The gabbronorite (*Aon*) which makes up the bulk of the sill contains cumulus orthopyroxene, clinopyroxene and plagioclase. Good exposures can be seen on the flanks of Mount Carnage where it shows a clear millimetre-scale igneous lamination. The igneous crystallization sequence determined by Williams and Hallberg (1973) is as follows: olivine → olivine + orthopyroxene →

orthopyroxene → orthopyroxene + plagioclase → orthopyroxene + plagioclase + clinopyroxene → plagioclase + clinopyroxene. The Ora Banda Sill is typical of many Archaean mafic/ultramafic sills in the Eastern Goldfields.

A unit of leucogabbro and plagioclase-rich gabbronorite (*Aonl*) on eastern DAVYHURST near the New Mexico mine represents a zone in the middle of the Mount Pleasant Sill (Fig. 2; Witt, 1990; Witt et al., 1991). A marker horizon at the base of this unit (*Aov*) consists of coarse, equigranular gabbronorite with a weak banding on a scale of tens of centimetres defined by variations in plagioclase content.

Quartz gabbro (*Aox*) with up to 15% quartz in granophyre occurs towards the top of the Mount Pleasant Sill, immediately below the uppermost gabbro. It is enriched in iron and titanium, indicated by actinolitic amphibole after clinopyroxene and abundant ilmenite.

Intermediate volcanic and volcaniclastic rocks (*Aiv*)

Intermediate volcanic and volcaniclastic rocks occur in isolated outcrops within felsic volcanic and volcaniclastic sedimentary sequences. Outcrops are usually too small or too poorly exposed to be mappable but those at AMG 2723 - 66603 in the Coolgardie Domain and AMG 2845 - 66272 in the Bullabulling Domain have been mapped. The latter outcrop contains relict feldspar phenocrysts up to 3 mm long. The rocks may have ranged in composition from andesite to basaltic andesite. Intermediate rocks within felsic volcanic and volcaniclastic sequences immediately to the east on BARDOC were assigned to the Pipeline Andesite in the Black Flag Group by Witt (1990).

Felsic volcanic and volcaniclastic rocks (*Afv, Afp*)

Felsic rocks (*Afv*), which are mainly extrusive, are abundant in the upper part of the greenstone sequence. They are extensively recrystallized, intensively deformed, deeply weathered, and usually poorly exposed in small outcrops. They are typically associated with clastic sedimentary rocks and may include epiclastic components. Relict textures and minerals indicate that precursor rock types included rhyolitic and dacitic quartz and feldspar porphyries. However, original textures have been recorded in only a few places, e.g. AMG 2797 - 66465, immediately east of No. 1 Dam.

Coarsely porphyroclastic felsic rock (*Afp*) is generally strongly deformed and consists of large (up to 1.5 cm) porphyroclasts, mainly plagioclase, in a fine, recrystallized quartzo-feldspathic matrix which, in places, contains abundant strongly pleochroic, dark red-brown metamorphic biotite. It occurs in the Zuleika Shear near Chadwin Well, and in a thick unit near Black Rabbit Dam where it interfingers with the Missouri Basalt. It may represent an intrusive felsic porphyry which is comagmatic with felsic volcanic rocks of the Black Flag Group or a later granitoid intrusion. However, as upper and lower contacts are stratigraphically controlled, banding -- defined by variations in biotite content and size and number of plagioclase porphyroclasts -- suggests it is more likely to have been a sedimentary rock derived from a volcanic or granitoid source.

Two thin horizons of quartz - chlorite - plagioclase schist (also shown as *Afp*) occur within the Wongi Basalt northwest of Wongi Hill. They contain porphyroclasts of rounded quartz and subhedral plagioclase and probably represent sedimentary rocks with a granitoid provenance.

Sedimentary rocks (*As, Asf, Aci, Ac, Ash, Ass, Akc*)

Sedimentary rocks are most abundant in the western part of DAVYHURST where siltstone, sandstone and volcaniclastic sedimentary rocks are commonly associated with subordinate acid and intermediate igneous rocks. Because all the rocks have been metamorphosed, original textures are difficult to recognize. Minerals are metamorphic biotite, muscovite, hornblende, and, in some instances, garnet and andalusite. Thin sandstone, shale and chert units are intercalated with mafic volcanic rocks locally, and there are prominent horizons of BIF within a sequence of fine- to coarse-grained mafic rocks in the Barlee Terrane.

The metamorphism and deep weathering make it difficult to distinguish rock types and so most sedimentary rocks have not been subdivided. The rocks designated (*As*) include shale, siltstone, sandstone and volcaniclastic sedimentary rock. Sedimentary structures such as bedding are generally obscured by foliation, although graded bedding and small-scale cross-beds are preserved in places (e.g. 5 km northwest of Davyhurst at AMG 2693 - 66793).

Rocks considered to be mainly volcaniclastic (*Asf*) are typically fine to medium grained and poorly sorted with a mixture of patchily recrystallized quartz and feldspar.

Prominent BIF (*Aci*) west of Callion consists of several units of thinly bedded to laminated, very fine-grained magnetite and recrystallized quartz, separated by dolerite and gabbro. Individual units contain outcrop-scale intrafolial folds, microscopic layer-parallel zones of mylonite and late, small-scale faults oblique to bedding.

Chert (*Ac*) northwest of Davyhurst at AMG 2693 - 66761 has light and dark banding on a scale of 2 to 10 mm and is locally brecciated. It separates a western, mainly tholeiitic basalt sequence from a sedimentary sequence in the east. Adjacent rocks are strongly deformed. The chert is associated with black shale and may be a zone of silicification along the Ida Fault.

Thin units of shale and chert (*Ash*) occur as interflow sedimentary rocks within the mafic and ultramafic sequences in the Ora Banda Domain, and within the mafic sequences in the Coolgardie and Bullabulling Domains, and the Barlee Terrane. Although metamorphosed, original bedding features, including light and dark banding in chert, can be seen locally. Thin interflow sedimentary units of siltstone, sandstone, and pebbly sandstone (*Ass*) have been mapped in the Siberia district.

Polymictic conglomerate (*Akc*) of the Kurrawang Formation, which unconformably overlies the Black Flag Group (Table 1), occurs in sparse outcrops around AMG 2960 - 66370, east of Blister Dam. Clasts are up to 25 cm long, poorly sorted, generally well rounded and ellipsoidal, and include granitoid, sedimentary rock, and felsic and mafic igneous rock. The formation differs from the probably contemporaneous Merougil Conglomerate which occurs south of Kalgoorlie (Swager et al., 1990) in that it contains internally folded BIF clasts, possibly derived from the Barlee Terrane in the west. In better exposures of the Kurrawang Formation on KALGOORLIE, the matrix is typically a poorly sorted sandstone with a foliation defined by metamorphic biotite (Hunter, in prep.).

Porphyry (*Apq, Apa, Aph, Apg*)

Fine-grained, mesocratic to leucocratic porphyritic rocks, interpreted as intrusive, occur throughout most of the Ora Banda sequence but have not been found in the Kurrawang Formation. They may have been emplaced over a considerable period (Witt, 1990).

Quartz - feldspar porphyry (*Apq*) occurs in thin units (generally <2 m) and consists of phenocrysts (mainly up to 2 mm but locally up to 5 mm) of quartz and plagioclase in a fine-grained, recrystallized quartzo-feldspathic matrix which contains minor sericite ± biotite. Although generally conformable, some units appear to cut across regional trends. In the eastern part of DAVYHURST, they occur mainly within mafic and ultramafic rocks in the lower part of the Ora Banda Domain sequence. In the northwest, foliated quartz - feldspar porphyry units are very abundant in the tholeiitic basalts of the Barlee Terrane around Mulwarrie.

Quartz-poor, albite-rich porphyry (*Apa*) has been mapped only in the Siberia Komatiite.

Hornblende - plagioclase porphyry (*Aph*) occurs mainly within the ultramafic formations of the Ora Banda sequence. An isolated outcrop of recrystallized hornblende porphyry within tholeiitic basalts in the Barlee Terrane at AMG 2664 - 66572 contains metamorphic clinopyroxene and epidote.

A unit of fine-grained granite porphyry and granophyre (*Apg*) intrudes basalts around AMG 3075 - 66447 and extends east onto BARDOC (Witt, 1990).

Granitoid rocks (*Ag, Agl, Agla, Agm, Agmb, Agmr, Agmt, Agmw, Agmg*)

Granitoid rocks on DAVYHURST are generally deeply weathered and poorly exposed in low, exfoliated outcrops. They range in composition from syenogranite to tonalite.

Undivided granitoid rocks (*Ag*) occur mainly in the west and central north. In the west, they range in composition from syenogranite (e.g. around AMG 2602

- 66458) to monzogranite and granodiorite, with monzogranite being the most abundant in outcrop. They are commonly slightly porphyritic, typically contain biotite (up to 20%) and generally show evidence of deformation (strained quartz, recrystallization, alignment of biotite grains). Feldspars are commonly altered. Microcline is perthitic in places, and plagioclase shows zoning and the development of both antiperthitic and myrmekitic textures. Locally there are large xenoliths of coarse-grained quartz - feldspar - biotite gneiss in sharp contact with the granitoids (e.g. AMG 2688 - 66430). Granitoid rocks in the central north have not been subdivided because they can only be seen in scattered, deeply weathered outcrops. Aeromagnetic data (Aerodata, 1986) suggest the presence of numerous granitoid intrusions in this area (Fig. 2).

Late tectonic granitoid rocks (*Agl*) range in composition from syenogranite to tonalite (Witt and Swager, 1989). They are comparatively small bodies at the margins of, or transgressive to, greenstone belts. Near Siberia, they consist of coarse, weakly recrystallized biotite monzogranite. However, one outcrop near the Zuleika Shear (AMG 2827 - 66444) east of the Lady Jane mine contains quartz-poor, albite-rich, clinozoisite-bearing monzodiorite. The Fair Adelaide Granite (*Agla*) is a late tectonic syenogranite which intrudes komatiite near the Fair Adelaide mine. It is medium grained, equigranular, and contains a small amount of biotite.

Undivided monzogranite (*Agm*) has been mapped in the central part of DAVYHURST where it has been interpreted by Witt and Swager (1989) as a cluster of diapiric intrusions of post-D_2 to syn-D_3 granitoid which have pushed aside a D_2 synclinal fold axis during emplacement. The monzogranite is medium to coarse grained, commonly porphyritic, and generally contains a small amount of biotite. Hornblende is a minor constituent in places. Quartz is strained, and there is commonly a strong contact-parallel foliation near the margins of plutons, mainly defined by the alignment of biotite and zones of more or less intense recrystallization, e.g. west of Black Rabbit Dam. At AMG 2839 - 66557, porphyritic monzogranite is clearly intruded by a fine-grained, equigranular, leucocratic monzogranite.

The Bora Monzogranite (*Agmb*) is a medium-grained (0.5 - 3 mm), equigranular, biotite monzogranite which outcrops in the northeast at Bora Rocks. It is distinguished from adjacent late tectonic granitoid rocks by the presence of a marked regional foliation and scattered mafic enclaves.

The Rowles Lagoon Monzogranite (*Agmr*), which intrudes the greenstone sequence around Credo Homestead, is medium to coarse grained with scattered plagioclase phenocrysts (up to 1 cm). There is a moderate amount of biotite (up to 8%), some of which is secondary. Plagioclase is commonly zoned. The rock has a weak to moderate foliation, and quartz is commonly strained. Outcrops are generally deeply weathered and, even where relatively fresh, plagioclase is partly saussuritized.

The Two Gum Monzogranite (*Agmt*) is a very poorly exposed elongate body immediately east of the Ida Fault in the southwestern part of DAVYHURST. Aeromagnetic data suggest that it extends more than 15 km from north to south, but is possibly less than 5 km east to west at its widest point. The few outcrops are deeply weathered but generally show a weak foliation. A thin section of drill cuttings from a bore at AMG 2805 - 66312, 2 km northwest of Fifty Four Dam, consists of medium-grained monzogranite containing hornblende, biotite and epidote, with large phenocrysts of partly saussuritized, zoned plagioclase. Quartz shows strain effects and is commonly recrystallized.

The Cawse Monzogranite (*Agmw*) outcrops in the northeast of DAVYHURST, north of Wongi Hill, and extends southeast onto BARDOC. It is fine to coarse grained (0.4 - 10 mm), seriate to porphyritic, and generally contains biotite. On DAVYHURST, it is extensively recrystallized and strongly foliated. Witt and Swager (1989) have classed it as a pre- to syn-D_2 granitoid intrusion because of the intense, pervasive foliation which parallels the D_2 axial plane foliations of adjacent greenstones.

There is a small area of the fine- to coarse-grained, seriate to porphyritic, biotite-bearing Goongarrie Monzogranite (*Agmg*) in the northeast around AMG 3071 - 66713. It outcrops mainly on BARDOC to the east (Witt, 1990), and on MENZIES to the northeast (Swager and Witt, 1990; Swager, 1991).

Minor intrusions (*p*, *q*, *a*)

Veins and dykes of pegmatite (*p*), quartz (*q*), and aplite (*a*) occur throughout the greenstone sequences but are most abundant along granitoid - greenstone contacts. The presence of foliated aplite at the granitoid - greenstone contact in the northeast (AMG 3998 - 66781) indicates that at least some of these bodies were emplaced before tectonism ceased. Extensive areas of white-quartz scree associated with quartz veins (e.g. west of Credo Homestead around AMG 2880 - 66262 and southwest of No. 1 Dam around AMG 2773 - 66452) appear as white patches on airphotos and mask underlying greenstone sequences.

Geochemistry

Major-element and selected trace-element analyses were carried out on 16 basalt samples from the western part of DAVYHURST. Nine samples came from the Barlee Terrane and 7 from the Kalgoorlie Terrane (6 from the Coolgardie Domain and 1 from the Bullabulling Domain). A Jensen cation diagram (Fig. 5) shows all the samples from the Barlee Terrane plotting in the tholeiitic field, whereas those from the Kalgoorlie Terrane include both tholeiitic and high-Mg basalts. The analyses reflect the apparent lack of high-Mg (pyroxene spinifex-textured) basalts in the Barlee Terrane on DAVYHURST. However, these samples were collected from only a small part of the Barlee Terrane, an entity whose complete dimensions have yet to be defined.

Structure

Four major deformational regimes, D_1 to D_4, have been recognized in the Kalgoorlie Terrane (Table 2; Swager, 1989; Swager and Griffin, 1990; Swager et al., 1990) of which all but D_1 are seen on DAVYHURST. Although a D_1 thrust fault has been recognized to the south on DUNNSVILLE (Swager, 1990), no unequivocal D_1 structures have been recorded on DAVYHURST.

The D_2 northwest-trending regional upright folding and perhaps at least partially concurrent, north- to northwest-trending transpressional (D_3) events are clearly represented on DAVYHURST. The most prominent structures are two, probably long-lived, faults, the Ida Fault in the west, and the Zuleika Shear which traverses the sheet area from northwest to southeast. North- to northeast-trending lineaments and faults, in places marked by quartz veins, which cut across granitoid - greenstone contacts may be related to D_4 regional shortening. Some of these late faults show a small amount of dextral offset (e.g. at AMG 2833 - 66409).

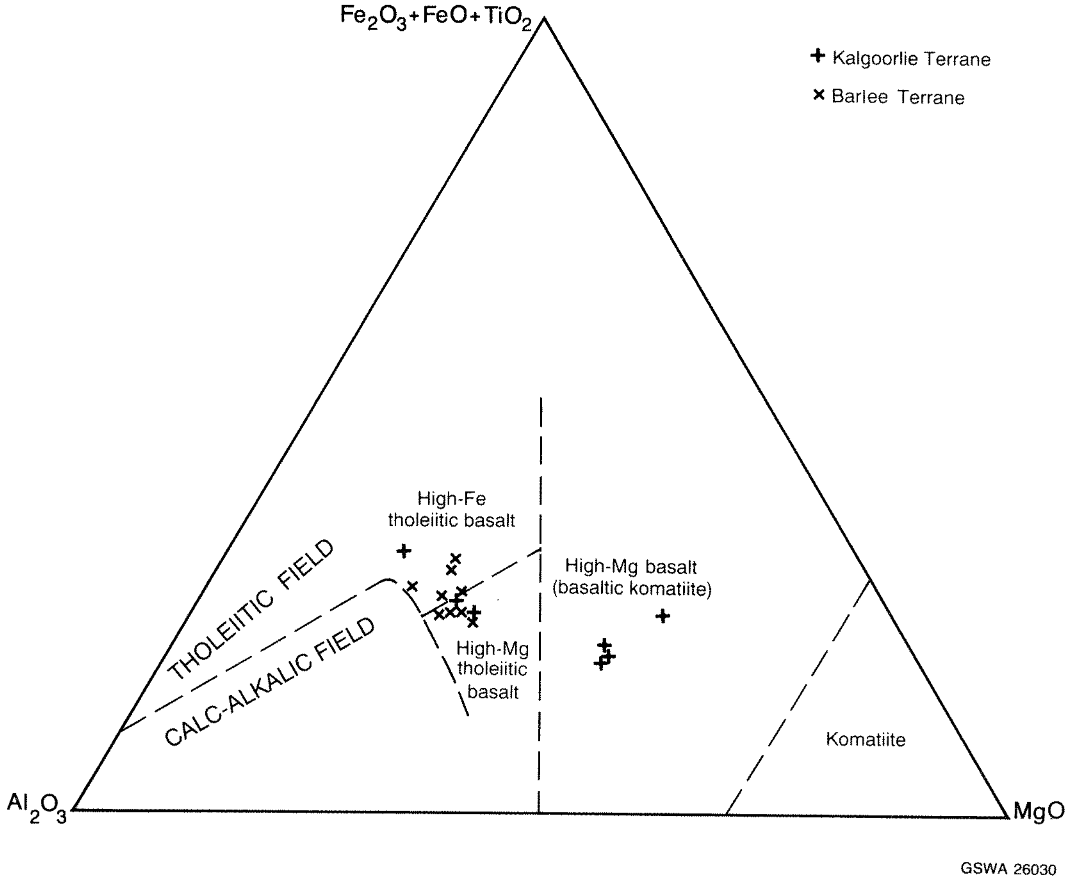

Figure 5. Jensen cation diagram (Jensen, 1976) for 16 basalt analyses from DAVYHURST

Table 2. DAVYHURST deformation history
(Refer to Figures 1 and 2)

	Regional deformation history	*Evidence on DAVYHURST*
D_4	Regional shortening; oblique north- and northeast-striking faults	North and northeast of the Two Gum Monzogranite
D_3	East-northeast - west-southwest shortening; north- to northwest-striking transcurrent faults	Zuleika Shear, Kunanalling Shear, Bullabulling Shear, Ida Fault
D_2	Northwest- to north-northwest-striking regional upright folds	Kurrawang Syncline; syncline extending southeast from Chadwin Well
D_1	Thrust stacking, recumbent folding	Not recognized

Terrane and domain boundary faults

The Ida Fault and the Zuleika and Bullabulling Shears are the only boundary faults which occur on DAVYHURST (Fig. 1). The most obvious movement on these structures clearly postdates D_2 folding but they are probably long-lived features which may have been active throughout the period of greenstone deposition and deformation. The faults generally pass through areas of poor outcrop, but zones of intense shearing are seen in places (e.g. Chadwin Well). The Ida Fault and Zuleika Shear are most clearly delineated on aeromagnetic maps (Whitaker, 1990).

The Ida Fault forms the boundary between the Kalgoorlie and Barlee Terranes (Fig. 1; Swager et al., 1990). The fault has very poor surface expression, but coincides with a magnetic lineament west of the Two Gum Monzogranite which is associated with sparse outcrops of strongly sheared sedimentary, mafic, and ultramafic rocks. The position of the fault in the northwest of DAVYHURST is difficult to locate precisely due to the lack of continuous outcrop and the diffuse patterns in the aeromagnetic contours in this area. It is taken to be the boundary between the sequence containing abundant ultramafic, felsic volcanic and sedimentary rocks (Coolgardie Domain) and that dominated by mafic rocks with subordinate BIF and fine-grained sedimentary rocks (Barlee Terrane), and may be marked by the chert horizon (*Ac*) at AMG 2693 - 66761. Neither the amount nor the direction of displacement on the Ida Fault are apparent, but the lack of corresponding successions across the fault suggests that movement has been large and probably includes a significant component of crustal shortening.

The Zuleika Shear (Fig. 1; Swager et al., 1990) can be traced southeast from Davyhurst for over 250 km. It forms the boundary between the Coolgardie and Ora Banda Domains on DAVYHURST, and the Coolgardie and Kambalda Domains further to the southeast. The shear is marked by a zone, in places more than 1 km wide, of attenuation and strong deformation and has been intruded by late tectonic granitoids north of Chadwin Well. Rafts of greenstone within granitoid rocks along the shear zone are poorly exposed and, in some instances, known only from drillholes and aeromagnetic data. They may be products of granitoid intrusion and/or tectonic interleaving.

The Kurrawang Formation, in the core of the D_2 Kurrawang Syncline to the southeast on KALGOORLIE (Hunter, 1988), appears to have been deposited mainly adjacent to the Zuleika Shear on southeastern DAVYHURST (Fig. 2). This suggests that movement on the Zuleika Shear controlled deposition, i.e. the Zuleika Shear was probably active prior to the D_2 folding episode. Incipient en echelon folding of the Kurrawang Syncline, and small-scale structures at Zuleika and Blue Funnel to the southeast on KALGOORLIE (Hunter, 1988), indicate sinistral movement on the shear. However, different fold geometries and stratigraphic mismatch -- the absence of the upper basalt unit of the generalized stratigraphy in the Coolgardie Domain (Table 1) -- across the Zuleika Shear, make it hard to estimate the amount of movement.

The Bullabulling Shear (Fig. 1) has been postulated by Swager et al. (1990) to separate the Coolgardie Domain from the poorly exposed, moderately metamorphosed (amphibolite facies), felsic, mafic and ultramafic rocks of the Bullabulling Domain (Swager, 1990). However, the shear is not evident on aeromagnetic maps and is interpreted as coinciding with the strongly sheared contact between greenstones and the Rowles Lagoon Monzogranite at AMG 2868 - 66301.

D_2 structures in greenstones

In the Ora Banda Domain, the D_2 northwest-trending regional upright folding is represented by the Kurrawang Syncline (Fig. 2) whose axis extends from east of Carnage in the southeast to north of Wongi Hill. The fold axis has been displaced to the northeast by the subsequent intrusion of monzogranite west of Siberia (see 'Other structures' below).

The upper part of the Coolgardie Domain succession is exposed on the southern limb of a D_2 syncline which extends from O'Loughlin Dam in the southeast to Chadwin Well. Repetitions of the upper part of the succession in the north between Davyhurst and Saddle Dam may be due to the combined effects of D_2 folding and shearing-out of the lower part of the sequence by east-northeast - west-southwest shortening (transpression) along D_3 transcurrent faults (Fig. 2).

Other structures

A poorly exposed area of complex faulting and interleaving of moderately metamorphosed (amphibolite facies) sedimentary and mafic rocks at the northern end of the Two Gum Monzogranite is marked by abundant outcrop and scree of vein quartz. The structural complexity is probably due to the coincidence of the monzogranite intrusion, the Ida Fault, and the Bullabulling Shear.

The contact of the pre- to syn-D_2 Cawes Monzogranite is well-exposed around AMG 3044 - 66656. A contact-parallel foliation is defined by quartz ribbons and oriented biotite aggregates. Quartz veins, within or at a low angle to the foliation, are abundant. A linear fabric has not been recognized, but asymmetric tails on rotated K-feldspar phenocrysts are consistent with sinistral displacement on the contact.

A D_3 sinistral shear zone, the Cashmans Shear (Witt, 1990) at the base of the Mount Pleasant Sill, extends from BARDOC onto the southeastern part of DAVYHURST. Quartz veining is extensive where the shear changes orientation in the Christmas Reef area.

There is a diverse range of foliations in the Wongi and Missouri Basalts to the west and south of Siberia. Some parallel the margins of granitoid intrusions while others conform to the regional north-northwest structural orientation. Together, they reflect contemporaneous granitoid emplacement and regional deformation. Several bands of tremolite ± chlorite schist (*Aor*) within the basalt sequence cut the primary layering at a small angle but are subparallel to pluton contacts. They are probably zones of intense deformation and recrystallization of mafic/ultramafic country rocks. A pervasive subvertical foliation in the Wongi Hill area which is not parallel to the D_2 axial plane may be related to forceful emplacement of granitoid plutons.

North of Carnage Dam, the axis of the D_2 Kurrawang Syncline is displaced along a series of northeast- to east-northeast-trending dextral faults, interpreted as accommodation faults resulting from forceful diapiric emplacement of post-D_2 to syn-D_3 granitoid to the west (Witt and Swager, 1989). This emplacement has compressed the lower part of the Ora Banda sequence against the D_2 Goongarrie - Mount Pleasant Anticline in the Wongi Hill area, and is probably also responsible for north-trending, second-order folds near Siberia. Contact-parallel foliation with a linear fabric at the margins of the monzogranite intrusions is defined by oriented biotite and grain-size banding which probably reflects patchy recrystallization during deformation.

Metamorphism

A regional overview of metamorphism in the eastern part of the Yilgarn Craton was given by Binns et al. (1976). Metamorphic conditions in the vicinity of DAVYHURST ranged from low-grade (middle greenschist facies) in the southeast to high-grade (middle to upper amphibolite facies) in the west and northwest. Temperature has played a greater role in metamorphism than pressure, with low to moderate pressures in higher grade sedimentary rocks indicated by the presence of andalusite and garnet.

Although most rocks are completely recrystallized, original igneous textures are widely preserved, particularly away from granitoid intrusions and major shear zones. The highest metamorphic grades, indicated by the presence of clinopyroxene (in places retrogressed to fine-grained phyllosilicates), are recorded near late-tectonic granitoid intrusions (diopside at AMG 2791 - 66505, south of Saddle Dam) and near major regional shear zones (retrogressed clinopyroxene in mafic rocks in the Ida Fault at AMG 2759 - 66349). Metamorphic olivine occurs in recrystallized ultramafic rock at AMG 2797 - 66498, near the above-mentioned diopside locality. Relatively high metamorphic grades in pelitic schists in the Bullabulling Domain and adjacent parts of the Coolgardie Domain, are indicated by the presence of garnet at AMG 2766 - 66474 (east of Two Gum Dam), and garnet and andalusite at AMG 2827 - 66241 (southeast of Costean Dam).

Key metamorphic indicator-mineral assemblages are rarely seen in the Ora Banda sequence. Metamorphic grade increases towards the contacts with post-D_2 to syn-D_3 granitoid rocks, and the following features of the Wongi and Missouri Basalts in the Siberia area suggest generally higher grades than on BARDOC (Witt, 1990):

(a) saussuritization of plagioclase is widespread on BARDOC, but less so in the Siberia area;
(b) although igneous textures may be preserved, plagioclase is partly or entirely recrystallized to a mosaic of finer grained anhedra;
(c) amphiboles are typically pleochroic from pale green to blue-green, whereas on BARDOC they are pleochroic from pale green to dark green;
(d) many amphiboles are poikilitic with numerous small, rounded inclusions of plagioclase; and
(e) weak-to-pronounced mineral banding, defined by different proportions of plagioclase and amphibole.

Witt (in prep.) established a regional metamorphic temperature gradient -- increasing from 350°C near Kalgoorlie to around 500°C at Siberia -- based on metasomatic assemblages in broadly synmetamorphic mafic-hosted gold deposits. Late, randomly oriented amphiboles in auriferous alteration assemblages, and in deformed mafic/ultramafic rocks (such as *Aor*), indicate that regional metamorphism outlasted regional deformation and local deformation related to the emplacement of syn-D_3 granitoid plutons. Observations in the Siberia area are generally consistent with earlier studies which concluded that peak metamorphism in the Kalgoorlie Terrane occurred during D_3 regional deformation (Archibald et al., 1981).

Proterozoic mafic and ultramafic dykes (Ꝑdy)

Two magnetic features on DAVYHURST, one trending approximately easterly across the southern margin, and another trending north-northwest in the northeast, are interpreted as manifestations of concealed Proterozoic mafic and/or ultramafic dykes.

Cainozoic geology

No Palaeozoic or Mesozoic rocks have been mapped on DAVYHURST. However, Tertiary rocks occur in palaeodrainage channels and beneath weathered regolith (e.g. sandstones in breakaways around Wangine Lake may date from the Tertiary). Ollier et al. (1988) have described weathering profiles and discussed the evolution of the landscape in the region.

An east-flowing palaeodrainage system, which has been identified in boreholes in the area between Wangine Lake and Camperdown, contrasts with the surface drainage in the same area, which is an internal system focussed on Wangine Lake. Palaeodrainage channels are up to 100 m deep and typically contain a basal quartz-sand unit overlain by clay, although there may be intervals of sandy clay and lenses of siltstone, calcrete, and ferricrete (Kern, in prep.).

Cainozoic units have been distinguished mainly by photointerpretation.

Laterite (*Czl*) obscures much of the greenstone geology in the northwestern part of DAVYHURST. It forms a hard ferricrete crust which is locally reworked to gravel. Where laterite profiles are exposed in breakaways, e.g southwest of Saddle Dam around AMG 2770 - 66517, the ferricrete capping is usually less than 1 m thick. The complete weathering profile extends to a depth of about 60 m near Callion (Glasson et al., 1988). Ollier et al. (1988) suggested that laterite profiles form on lower slopes and valleys as iron solutions pass through relatively porous and permeable sediments on footslopes along drainage lines.

Small areas of silcrete have not been distinguished on the geological map. A silicification profile over basalt can be seen at the Sand King mine (Ollier et al., 1988).

Calcrete (*Czk*) has been mapped over greenstones and appears as dull, white patches on air-photographs. It appears to have formed mainly in situ although the mechanism is not well understood (Ollier et al., 1988).

Sandplain deposits (*Czs*) consist of sheets and dunes of yellow sand. Sand sheets are not uniform in thickness, contain small limonitic pisoliths, and in places overlie indurated sandstone. The presence of west-northwest-trending dunes on northeastern DAVYHURST indicates that they are at least partly aeolian deposits.

Quartzo-feldspathic sand (*Czg*) which appears to have formed in situ over granitoid rock is distinguished in the western and central parts of DAVYHURST.

Gravel, sand, silt and clay (*Czc*), including abundant white vein-quartz scree resulting from erosion of greenstones, has been deposited mainly as sheetwash or as talus at the base of slopes.

Sand, silt and clay (*Czps*) occurs in swampy, commonly thickly vegetated areas around the Rowles Lagoon lake system and at Wangine Lake. These areas are foci for much of the drainage on DAVYHURST and northern DUNNSVILLE and may contain considerable thicknesses of fine sediments.

Permanent and ephemeral lakes (*Czp*) on DAVYHURST contain mainly silt and clay, although Wangine Lake is lined by a salt crust.

Alluvium (*Qa*) consisting of clay, silt, sand and gravel occupies active stream channels.

Economic geology

Introduction

DAVYHURST includes parts of the Coolgardie, North Coolgardie and Broad Arrow Mineral Fields and has a recorded production of more than 16 t of gold (Table 3). Minor mineral production includes silver, tungsten, nickel, cobalt and agate.

Gold

The main gold-producing areas are in the northwest around the old mining localities at Davyhurst, Mulwarrie and Callion, and in the east between Siberia and Theil Well (Fig. 1). However, considerable production has been reported from other parts of the sheet area (Table 3).

Gold deposits on the western part of DAVYHURST generally occur near D_3 shear zones such as the Zuleika Shear, the Kunanalling Shear and the Ida Fault (Fig. 2). Veins and shear zones hosting mineralization appear to be mainly conformable with the regional structure and stratigraphy, and on, or near, geological contacts.

Mines around Davyhurst were described by Hellsten et al. (1990) who divided them into those which occur within a 'western sequence' of dolerite and high-Mg basalt (Golden Pole, Waihi, Homeward Bound, Melrose, Eileen, Lady Ellen and Wheel of Fortune), and those within an 'eastern sequence' of tholeiitic basalts with subordinate ultramafic rock and minor interflow sedimentary rocks and dolerite (Golden Eagle, Great Ophir and Lights of Israel). All deposits are associated with shear zones (Table 3). 'Siliceous lodes' which host the mineralization at the Great Ophir mine may represent an early shear zone in an interflow sedimentary unit within a basalt sequence which has been folded and mineralized during subsequent deformation (Barley and Groves, 1989).

At Callion and Glasson, gold occurs in quartz veins in a sequence of basalts with subordinate metasedimentary and felsic rocks. The gold-bearing vein at the Glasson mine is situated within fine-grained basalt near the contact between fine- and medium-grained basalt (Glasson et al., 1988). At Mulwarrie, gold mineralization appears to be hosted mainly by late quartz veins which, at least locally, can be seen to cut across regional trends. The role of the abundant quartz - feldspar porphyry dykes in controlling gold distribution is not clear.

Witt (in prep.) described in detail the regional controls on mineralization, and the geology of gold mines between Kambalda and Menzies. His work forms the basis of the following remarks about gold mineralization on the eastern part of DAVYHURST.

Table 3. Production statistics for major gold mines and mining centres on DAVYHURST

Mining centre / *Mine*	*Dates mined*	*Ore treated (t)* (a)	*Gold (kg)* (a)	*Geological setting*
MULWARRIE (e)	to 1985	29 717	1 216.79	mafic sequence with porphyry dykes and quartz stockworks
Four Mile	to 1984	145	26.01	mafic sequence
Oakley	to 1982	6 612	285.87	mafic sequence with quartz veins under laterite cover
DAVYHURST (e)	to 1989	846 658	8 155.18	
Golden Pole	1900 - 1939	79 704	2 395.2	quartz veins in deformed dolerite
Homeward Bound	1902 - 1911	2 292	125.0	quartz veins in deformed high-Mg basalt
Waihi	1900 - 1917	29 669	592.5	quartz veins in deformed high-Mg basalt
Melrose (Resurgam)	1900 - 1914	2 015	138.8	quartz veins in deformed high-Mg basalt
Eileen - Lady Ellen	1901 - 1916	9 589	188.9	quartz veins in deformed high-Mg basalt
Wheel of Fortune	1900 - 1909	594	18.2	quartz veins in deformed high-Mg basalt
Golden Eagle	1902 - 1936	1 327	13.8	deformed tholeiitic sequence
	1987 - 1988 (c)	295 125	704.71	
Great Ophir	1901 - 1942	9 245	70.2	deformed and altered mafic sequence
Lights of Israel	1906 - 1913	3 846	34.0	deformed and altered mafic sequence
Callion	1899 - 1911	6 145	132.1	quartz veins in a mafic sequence containing felsic rock and interflow sedimentary rocks; extensive laterite cover
Callion/Glasson	1983 - 1989	226 986	1 178.41	
Lady Jane	in 1989	105 408	255.98	deformed mafic and ultramafic sequence
Federal Flag	1901 - 1905	205	11.17	quartz veins in deformed ultramafic rock
CHADWIN (e)	to 1983	12 234	263.49	
Magdala	1909 - 1941	1 973	23.5	felsic and mafic schist in Zuleika Shear
Resolute	1910 - 1936	439	39.3	felsic and mafic schist in Zuleika Shear
Wheel of Fortune	1910 - 1912	237	23.6	felsic and mafic schist in Zuleika Shear
Golden Fence	in 1989	70 000	37.85	laterite and alluvium over deformed felsic and mafic sequence
CARBINE (e)	to 1988	195 424	1 953.51	deformed sedimentary - mafic - ultramafic sequence
Nordenfeldt	1901 - 1915	1 901	77.3	

Table 3. (Continued)

Mining centre *Mine*	*Dates mined*	*Ore treated (t)* [a]	*Gold (kg)* [a]	*Geological setting*
CARNAGE [e]	to 1985	4 868	96.21	quartz veins in closure of Kurrawang Syncline
Black Rabbit				deformed ultramafic rock with subordinate quartz - biotite - plagioclase schist [b]
Theil Well				shear zone with quartz veins and brecciation in highMg basalt [b]
CHRISTMAS REEF [e]				
Fair Adelaide	1897 - 1934	3 856 [b]	17.3 [b]	quartz veins in aplitic phase of late tectonic syenogranite [b]
New Mexico	1897 - 1934	8 976 [b]	430.3 [b]	shear zone with minor quartz veins in high-Mg basalt and gabbro [b]
RICHES FIND [e]	to 1975	10 174	274.94	
Three Eights	1936 - 1941	7 087 [b]	157.93 [b]	shear zone in ultramafic rock and albite-rich porphyry [b]
Merry Dance	1951	5	3.1	shear zone in ultramafic rock and albite-rich porphyry [b]
Pole	1897 - 1914	1 407 [b]	70.4 [b]	shear zone with quartz veins in tholeiitic basalt with associated granophyre [b]
Cave Hill	1908 - 1936	802 [b]	65.36 [b]	shear zone in peridotite [b]
SIBERIA [e]	to 1989	682 634	4 103.25	
Siberia Consols	1901 - 1934	2 320 [b]	172.53 [b]	shear zone in ultramafic rock [b]
Pride of Erin	1975 - 1985	548	27.1	shear zone in ultramafic rock [b]
Golden	1897 - 1917	340 [b]	29.1 [b]	shear zones associated with shaly interflow sediment in high-Mg basalt
Bonnie Doon - Waverley	1897 - 1947	2 938 [b]	87.98 [b]	shear zones in tholeiitic basalt [b]
Missouri	1899 - 1912	1 675 [b]	20.76 [b]	quartz veins in tholeiitic basalt
Sand King	1970 - 1989 [d]	630 392	2 670.6	quartz veins and brecciation in tholeiitic basalt [b]
Majestic	1899 - 1934	105 [b]	4.95 [b]	quartz vein and shear in tholeiitic basalt [b]
Camperdown	1897 - 1947	6 502 [b]	73.22 [b]	shear zones with quartz veining in tholeiitic basalt [b]

(a) Data from Department of Mines records, unless otherwise stated
(b) Witt, in prep.
(c) Includes production from the Waihi open pit
(d) Includes production figures from Camperdown, Missouri and Theil Well
(e) The total figure for each Mining Centre includes production from some small mines not listed

Gold mines between Riches Find and Siberia occur in a broad northeast-trending zone, mainly within the tholeiitic Missouri Basalt and the lower part of the overlying ultramafic units, the Walter Williams Formation and the Siberia Komatiite. Gold is hosted by mainly east-northeast-trending shear zones and related brittle structures which are accommodation structures formed during the forceful emplacement of syn-D_3 diapiric granitoids to the west (Witt and Swager, 1989). As in the western part of DAVYHURST, gold-bearing structures formed on or near geological contacts. Examples include the contact between the Walter Williams Formation and the Siberia Komatiite at Cave Hill, and contacts between komatiite and albite-rich porphyry at Three Eights and Merry Dance. Hill and Bird (1990) described the Sand King mine in which gold occurs mainly in east-northeast-trending quartz - pyrite - biotite veins within tholeiitic Missouri Basalt, near its contact with the overlying Walter Williams Formation.

The largest gold deposit in the Mount Carnage area, Theil Well, is hosted by the high-Mg Big Dick Basalt. Some production has also been reported from gabbroic rocks in the upper part of the Ora Banda Sill at Carnage. Gold-bearing structures are probably related to the syn-D_3 emplacement of granitoid plutons as at Siberia. However, contemporaneous movements on the nearby Zuleika Shear may also have played a role.

Silver

Silver is a valuable by-product of some gold-mining operations. In 1989, a total of 47.293 kg was produced from the Davyhurst district, 2.801 kg was produced from the Lady Jane mine, and 56.805 kg was obtained from the Sand King operation (data from Department of Mines records).

Tungsten

Scheelite occurs in quartz veins and metamorphosed high-Mg basalt at the Golden Pole mine and on the Melrose (Resurgam) leases near Davyhurst. Treatment of 3 353 t of tailings at Golden Pole produced 17 752 kg of concentrates containing 12 337.5 kg of WO_3 between 1954 and 1964 (Baxter, 1978).

Nickel and cobalt

Three lateritic nickel deposits in the Siberia district, the SM7, Gulch, and the Linger and Die deposits, have been described by Elias et al. (1981) and Marston (1984). The SM7 and Gulch deposits lie within DAVYHURST while the Linger and Die deposit is located a few kilometres to the east on BARDOC (Witt, 1990). Western Mining Corporation Ltd has mined the SM7 deposit for use as a siliceous flux in the Kalgoorlie nickel smelter, and also the Linger and Die deposit as high-grade cobalt ore containing less valuable but extractable nickel (Marston, 1984). Material from these deposits has been stockpiled but there has been no recent mining activity.

In these deposits, Mn - Co - Ni concentrations have developed in lateritized dunite - peridotite of the Walter Williams Formation, adjacent to a crosscutting Proterozoic dolerite dyke. Cobalt grades range between 0.1 and 1.0%, locally exceeding 2%, and nickel grades are between 1 and 3% (Elias et al., 1981).

Lithium

Fine purplish-grey lepidolite is abundant in the large easterly trending pegmatite vein which traverses the pit at the Waihi mine. It was described by Simpson (1952) who also noted the presence of similar material on the mine dump at the nearby Golden Pole mine.

Moss agate

Pits are located at AMG 3043-66521 in outcrops of moss agate which has formed over Siberia Komatiite. Similar deposits have been worked to the east on BARDOC (Witt, 1990).

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Appendix

Definitions of new stratigraphic and plutonic names

Name:	**Black Rabbit Member**
Derivation of name:	Black Rabbit Dam (DAVYHURST -- AMG 2968 - 66409).
Type area:	West of Black Rabbit Dam.
Thickness:	May be more than 800 m thick in type area.
Rock type:	Felsic schist with coarse (up to 1.5 cm) porphyroclasts of plagioclase in a fine, recrystallized quartz - feldspar - biotite groundmass. Upper and lower contacts are stratigraphically controlled. The protolith may have been a felsic volcanic rock, but layering, defined by variation in biotite content and size and number of porphyroclasts, suggests that it is a sedimentary rock with a felsic volcanic or possibly granitoid provenance.
Relationships:	Occurs in thick and thin, conformable lenses within the Missouri Basalt (Witt, 1990).
Comments:	Known only on DAVYHURST.

Name:	**Rowles Lagoon Monzogranite**
Map symbol:	Agmr.
Derivation of name:	Rowles Lagoon (DAVYHURST -- AMG 2945 - 66310).
Type area:	West of Rowles Lagoon.
Rock type:	Sparsely porphyritic biotite monzogranite with plagioclase phenocrysts up to 1 cm. Plagioclase is commonly zoned. Outcrops are generally deeply weathered, and, even where relatively fresh, plagioclase is at least partly saussuritized. The rock has a weak to moderate foliation.
Relationships:	Intrudes a greenstone sequence containing amphibolite and volcaniclastic and epiclastic sedimentary rocks.
Comments:	Generally deeply weathered and poorly exposed.

Name:	**Two Gum Monzogranite**
Map symbol:	Agmt.
Derivation of name:	Two Gum Dam (DAVYHURST -- AMG 2741 - 66471)
Type area:	AMG 2805-66312, northwest of Fifty Four Dam.
Rock type:	A thin section of drill cuttings from the type locality shows it to be a biotite- and hornblende-bearing monzogranite containing large (up to 1 cm) phenocrysts of zoned, partly saussuritized plagioclase. Sparse outcrops to the north (AMG 2755-66395) are deeply weathered and even grained and show a weak foliation.
Relationships:	Intrudes a greenstone sequence containing amphibolite and volcaniclastic and epiclastic sedimentary rocks.
Comments:	Very poorly exposed.