GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

ROBERTSON

WESTERN AUSTRALIA

SECOND EDITION

SHEET SF51-13 INTERNATIONAL INDEX

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BY

I. R. WILLIAMS AND I. M. TYLER

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Robertson 1:250 000 geological sheet, Western Australia(Second edition)

by I. R. Williams and I. M. Tyler

INTRODUCTION

The ROBERTSON* 1:250 000 map sheet (SF51-13) is bounded by latitudes 23° and 24° and longitudes 120° and 121° 30'E. The name is derived from the Robertson Range which extends over 90 km north-northeast through the centre of the area.

The Jigalong Aboriginal Community Reserve, which has a population of approximately 500 people, occupies the central part of ROBERTSON. A permit, issued through the Aboriginal Affairs Planning Authority, is required to enter the reserve. The Robertson Range, Walagunyah (Walgun), Billinnooka and Wokalba (Bobbymia) pastoral leases are managed by the Jigalong Community.

Sylvania and Weelarrana Homesteads lie near the western boundary, whilst parts of Balfour Downs, Ethel Creek, and Bulloo Downs pastoral leases extend onto northern and western ROBERTSON. A small holding at Mundiwindi, which includes a Telecom booster station, is also occupied. An exploration camp is maintained near the McCamey Iron prospect 10 km northwest of Jimblebar. The country east of the abandoned No. 1 Vermin Fence is generally unoccupied.

Station homesteads and the Jigalong Community are linked by gravel roads to the sealed Great Northern Highway, which lies to the west of ROBERTSON. The old Great Northern Highway, which originally passed through ROBERTSON is now only maintained as far as the Jigalong Community turnoff. The large, regional mining town of Newman lies 40 km northwest of Sylvania Homestead on NEWMAN.

Station and mineral-exploration tracks give good access to the country west of the abandoned No. 1 Vermin Fence. Local tracks are found around Jigalong and Robertson Range Homestead. A rough track follows the north side of Savory Creek and a graded track links Robertson Range Homestead with the headwaters of Boondawari Creek. The rest of the country east of the No. 1 Vermin Fence is trackless.

PREVIOUS INVESTIGATIONS

A brief compendium of early geological work is given in de la Hunty (1969). Subsequent publications refer mainly to the iron-ore potential of the Hamersley Basin sequence in the region (Ward et al., 1975) and to copper (Barley, 1974; Marston, 1979) and chromite mineralization (Bye, 1975) of the Sylvania Inlier. A brief reference has been made by a number of authors in attempts to regionally correlate the Precambrian sedimentary sequences known to occur in the region (Daniels, 1975; Goode, 1981; Goode and Hall, 1981; Chuck, 1984; Muhling and Brakel, 1985; Williams, 1987).

* Names of 1:250 000 scale map sheets are in block capitals e.g. ROBERTSON.

CLIMATE, VEGETATION, AND PHYSIOGRAPHY

The climate is arid, and the main precipitation occurs in the late summer to early winter period (February–June, average rainfall 200–270 mm). The summers are hot and have a mean maximum temperature 30.7° C; the winters, mild and have a mean minimum temperature of 15.4° C. A winter minimum temperature of -5° has been recorded at Mundiwindi.

ROBERTSON covers the triple junction between the Fortescue, Ashburton and Keartland phytogeographic districts (Beard, 1981). The flora of the Fortescue district consists mainly of shrub steppe on spinifex (*Triodia* sp.) hummock-grass sand plains, linear groves of mulga (*Acacia aneura*) separated by "buckshot gravel" plains, and minor woodlands of low mulga. The eastern end of the Hamersley Range is covered with Snappy Gum (*Eucalyptus brevifolia*) and buck spinifex (*Triodia basedowii*). The Ashburton district is dominated by low mulga woodlands that have a distinctive striped photo-pattern; these woodlands are interspersed with mulga groves and spinifex sandplain. The Keartland district, which corresponds to the Little Sandy Desert, consists of spinifex-covered sand dunes and shrub steppe between the dunes. Scattered desert bloodwood (*Eucalyptus dichromaphloia forma*), desert oak (*Casuarina decaisneana*) and patches of grass trees (*Xanthorrhoea* sp.) are a distinctive feature of the sand-dune country.

De la Hunty (1969) described some of the physiographic characteristics of ROBERTSON and commented on the drainage systems. Beard (1975) summarized the historical development of physiographic natural region terminology for the area. His conclusions and proposals are incorporated in Figure 1.

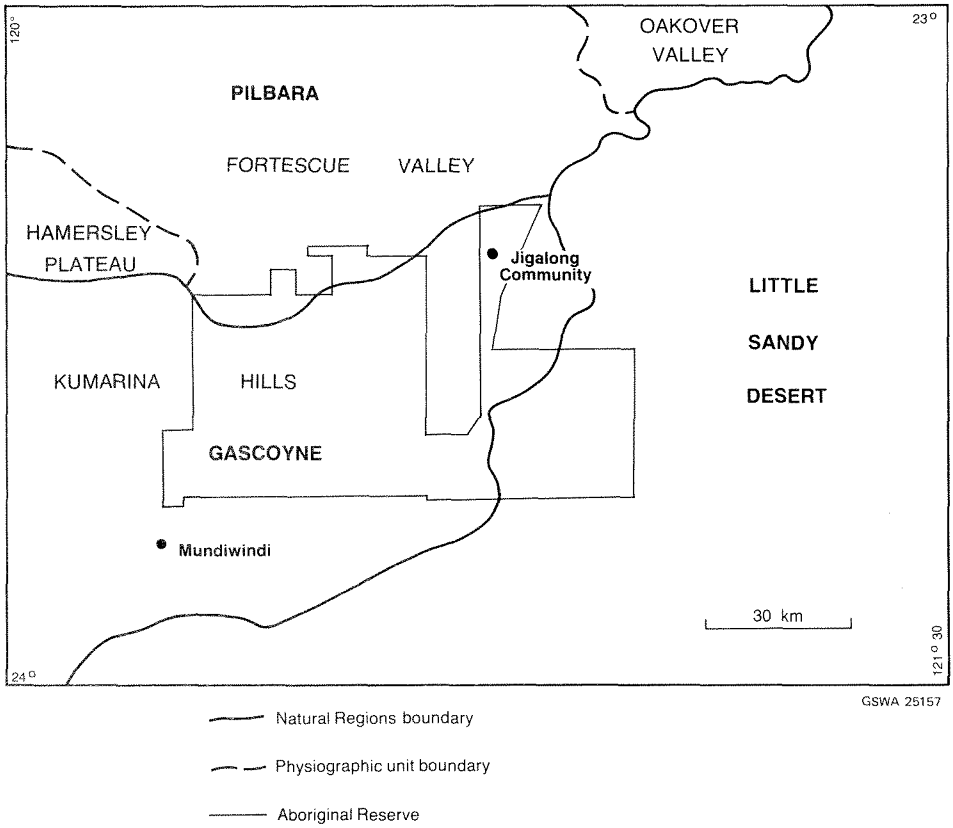

Figure 1. Natural regions and boundaries of physiographic units.

The three phytogeographic districts, previously described, also correspond to Beard's Pilbara, Gascoyne, and Little Sandy Desert natural regions. The Pilbara region on ROBERTSON can be subdivided into Hamersley plateau, Fortescue valley, and Oakover valley physiographic units. The Gascoyne region on ROBERTSON belongs to the Kumarina Hills physiographic unit (Beard, 1975).

The physiographic sketch map also delineates the main morphologic units (Fig. 2). These fall broadly into two main groups. The first group covers areas of deposition, for example the Fortescue River and Savory Creek alluvial flood plains, and adjoining low-slope deposits with little or no erosion. This group also includes the eolian deposits. These typify the Little Sandy Desert region, and consist of longitudinal (seif), chain and net dunes.

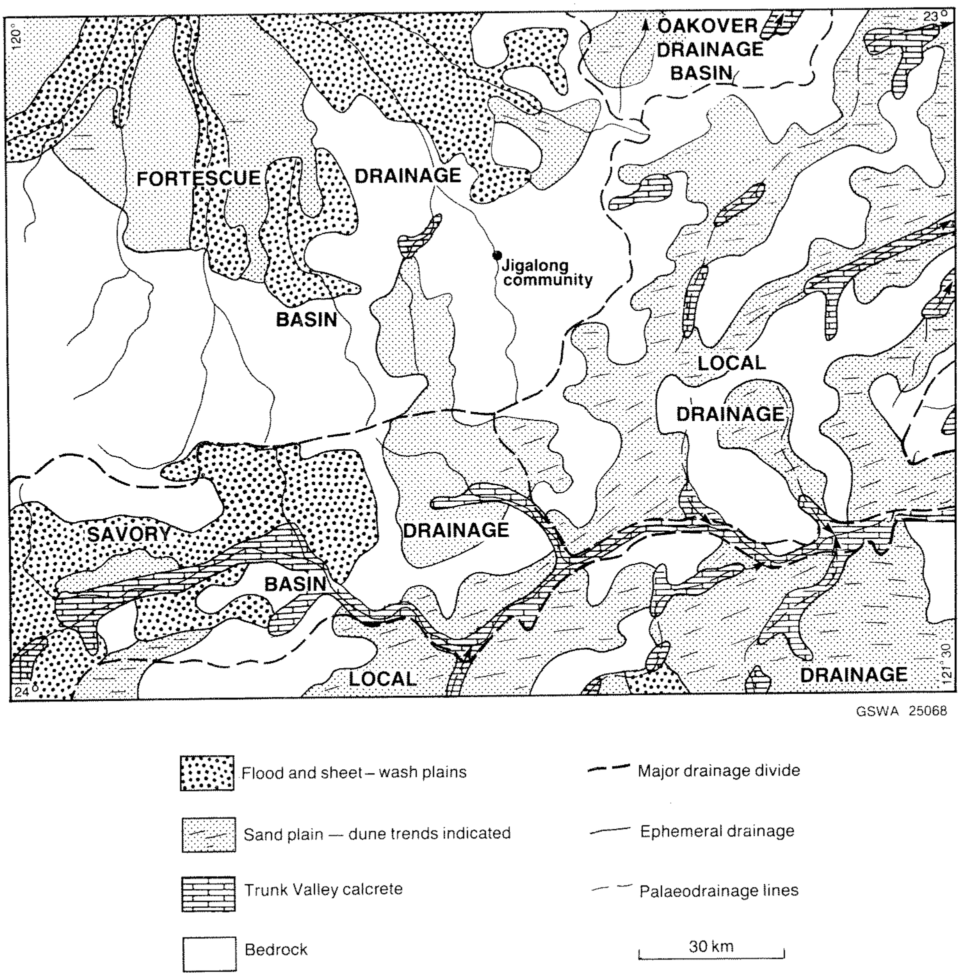

Figure 2. Physiographic features.

The dunes trend 290° in the east, but swing to 230° in the southwest part of the ROBERTSON. Net dunes commonly occupy the broad valleys, which are thought to be part of a buried Tertiary drainage system (van de Graaff et al., 1977). These valleys also contain eroded, calcreted palaeodrainages. The second group includes bedrock exposure and areas of moderate to strong erosion, for example, laterite breakaways and dissected older colluvium (*Czc*).

Relief is greatest on the western margin of ROBERTSON, where Shovelanna Hill (805 m ASL) rises over 300 m above the Fortescue River flood plains. The lowest point, 436 m ASL, is recorded in the Fortescue valley on the northern boundary of ROBERTSON. A belt of low hills stretches from Woggaginna Hill (684 m ASL) east to the Robertson Range (with a maximum height of 650 m ASL). The latter forms a prominent north-northeasterly trending sandstone scarp up to 90 m high. Overall, however, relief in the hilly region is rarely more than 150 m.

The Little Sandy Desert is characterized by low, rocky island hills rising to 100 m above the sand dunes. The headwaters of Boondawari Creek are terminated in places by prominent laterite scarps 30 m high.

ARCHAEAN GRANITE–GREENSTONE

Archaean granite–greenstone, unconformably overlain by the 2750 Ma Fortescue Group, crops out within three inliers on ROBERTSON. The largest of these is the Sylvania Inlier (Fig. 3), which extends onto NEWMAN (Tyler et al., 1990). The Shovelanna Inlier is separated from the Sylvania Inlier by the Painkiller Bore Fault. A small part of the Billinnooka Inlier (Williams, 1989) is exposed north of Billinnooka Homestead on the northern margin of ROBERTSON.

Daniels and MacLeod (1965) initially referred to the Sylvania Inlier as the "Sylvania Dome" in analogy to outcrops of granite–greenstone in the southwest Hamersley Basin. However, Tyler (in press) has shown that the structural controls on the outcrop of the Sylvania Inlier are complex and the term "inlier" is preferred.

Areas of greenstone occur at Jimblebar and Woggaginna Hill, and there are minor outcrops near Sylvania. They comprise low to medium-grade mafic and ultramafic volcanics, clastic metasediment, cherts, and banded iron-formation (BIF), all of which are intruded by a number of mafic to ultramafic sills. By far the most extensive outcrop, and the most complete stratigraphy, is at Jimblebar. At Coobina a large chromite-bearing ultramafic body intrudes the Jimblebar belt. Both the greenstone belt and the ultramafic body show evidence of at least two, and probably three, phases of large-scale folding. Extensively recrystallized granitoid that intrudes the greenstone belts, forms the major part of the inlier. Xenoliths of an early foliated and/or banded granitoid phase (a unit which crops out on NEWMAN; Tyler et al., 1990) and a distinctive hornblende-bearing granitoid are also present. Both granitoids and greenstones are intruded by numerous mafic dykes.

GREENSTONE BELTS

Stratigraphy

The Jimblebar belt can be divided into two parts, which are separated by the Battery Fault (Fig. 3). The rocks in the western part strike east to northeast and dip to the south and southeast. Layering in mafic–ultramafic sills indicates northward younging and overturning.

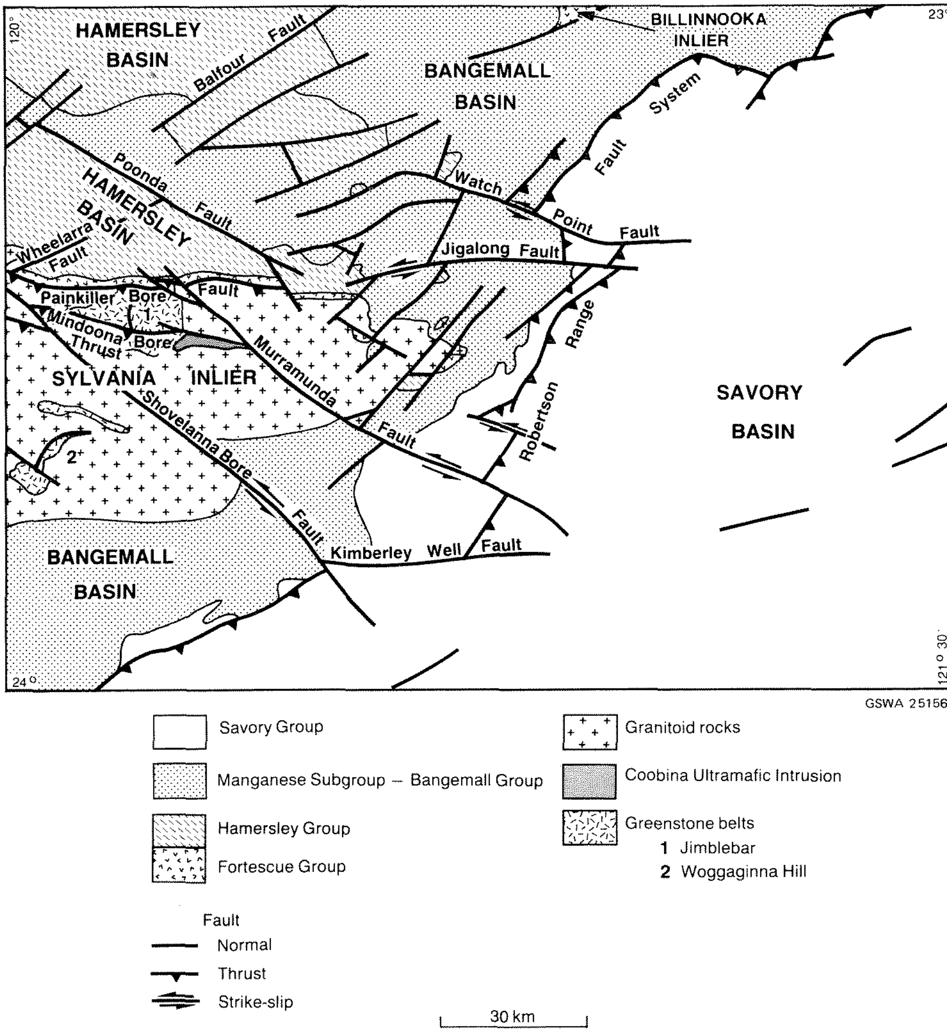

Figure 3. Tectonic sketch map.

The strike of the belt in the eastern half swings from easterly to northerly. Younging directions from layered sills near Coobina are to the north and west.

The successions in the two parts are outlined in Figure 4. The lithologies at the top of the eastern succession are correlated with those at the base of the western succession. The composite thickness of these units, including the sills, is nearly 12 km. The Jimblebar succession and the discontinuous units at Woggaginna Hill and Sylvania cannot be confidently correlated.

De la Hunty (1969) noted a similarity between the rocks of the greenstone belt on ROBERTSON and those of the "Warrawoona Series" on ROY HILL. In this study, a correlation with the upper part of the Pilbara Supergroup (cf. Hickman, 1983) is preferred. The main BIF at Jimblebar may be correlated with the Cleaverville Formation of the Gorge Creek Group. However, because of the considerable geographical separation and lack of continuous outcrop the units have not been formerly included in the Pilbara Supergroup.

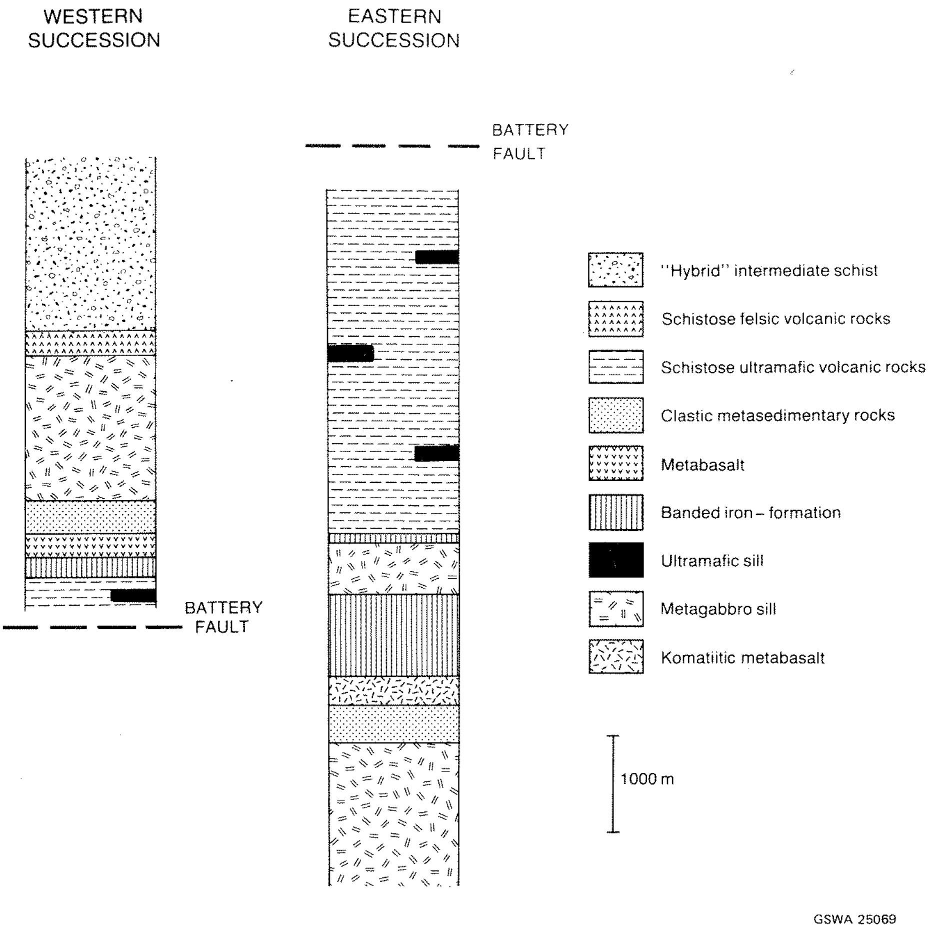

Figure 4. Stratigraphy of the Jimblebar belt.

Mafic and ultramafic volcanic rocks

Ultramafic rocks include a 500 m thick sequence of amphibole–talc–chlorite schist and tremolite–talc schists (*ua*) that occurs 2 km northwest of Coobina. Individual units range from 1 to 50 m thick, and a rapid alternation of the two types suggests that the schists represent deformed and metamorphosed ultramafic lavas. Tremolite–chlorite–talc schist interlayered with banded iron-formation at Woggaginna Hill may also have had an extrusive origin. East of Sylvania a silicified cap rock (*uz*) has developed on ultramafic schist.

Fine-grained, weakly foliated amygdaloidal metabasalt (*bb*) occurs 1 km northwest of Jimblebar. Amygdales occur as flattened quartz, or quartz–epidote aggregates up to 5 mm long. Amphibolitic schist (*ba*) is a more deformed version of the amygdaloidal metabasalt (*bb*). North of Coobina several horizons of amphibolitic schist occur. Structures present in thin section indicate that the schist was originally komatiitic basalt (*bu*).

Mafic and ultramafic intrusive rocks

A zone of mafic–ultramafic sills that have a strike length of some 20 km and a thickness of up to 1.5 km occurs south and east of Copper Knob. The dominant rock type is metagabbro (*bg*). Within the metagabbro, discontinuous layers of coarse leucogabbro (*bo*), with good cumulate textures, are present as well as pods and lenses of serpentinite (*us*), metaperidotite (*up*), and metapyroxenite (*ux*). Extensive areas of silicified ultramafic rocks occur 4 km northeast of Copper Knob.

Other mafic–ultramafic sills crop out in the Jimblebar belt, particularly north and east of Coobina. One such sill shows a succession ranging from serpentinite, through a distinctive feldspathic metapyroxenite containing large (10 mm) tremolite pseudomorphs after pyroxene, to metagabbro which is leucocratic towards the top. A leucocratic metagabbro sill at the eastern margin of the belt locally grades into anorthosite.

Layered, dominantly ultramafic, sills intrude ultramafic schist between Coobina and Jimblebar. They consist mainly of metapyroxenite, but usually show a simple layering that is more gabbroic towards the top. Serpentinite, with relic olivine crystals, may occur at the base.

Medium to coarse-grained, foliated or banded amphibolite crops, out between Sylvania and Woggaginna Hill. It consists of bluish-green to green hornblende, plagioclase (oligoclase–andesine), epidote, clinozoisite, quartz, and, rarely, biotite. The rocks show extensive recrystallization; but primary igneous features, notably relic cumulus textures and rhythmic layering, have occasionally been preserved. Numerous 20–30 mm thick quartz–feldspar veins of metamorphic origin lie subparallel to the foliation.

Pods of meta-anorthosite, and pods and lenses of serpentinite and ultramafic schist, are also associated with the amphibolite. This relationship, together with relic igneous features, indicates a layered intrusion, or series of layered intrusions, which have been disrupted by later granitoid intrusion and deformation.

Felsic volcanic rocks

A prominent ridge of distinctive, reddish-purple, weathered, fine-grained, felsic schist (*zc*) occurs towards the northwest margin of the Jimblebar greenstone belt. At Copper Knob, it is a porphyroclastic rock containing 40–50% quartz–feldspar (K-feldspar and/or plagioclase) porphyroclasts and composite quartz–feldspar fragments in an anastomosing matrix of quartz, feldspar, and dark-green chlorite. Some of the internal textures of the porphyroclasts show beta-quartz forms, while others show microcrystalline intergrowths of quartz and feldspar, a texture normally associated with devitrified felsic volcanics. Quartz–albite–chlorite–hornblende–biotite–garnet schist is also present. The garnet has a spessartite–almandine composition (Barley, 1974).

Clastic metasedimentary rocks and cherts

Two horizons of clastic metasedimentary rocks (*lq*), interlayered with chert, occur within the Jimblebar belt. A mixed metasedimentary sequence up to 400 m thick of interlayered chert, metaquartzite, granitic conglomerate, quartzofeldspathic schist, metapelitic schist, and calcareous metapsammite, crops out in the western succession. Chert is best developed near Jimblebar, and occurs as a locally ferruginous, grey and white banded rock with a well-developed alternation of milky and dark bands up to 10 mm thick. It is associated with quartzofeldspathic schist, which may have a felsic–volcanic origin.

Flaggy, fine-grained, well-foliated, granoblastic to lepidoblastic, fuchsitic metaquartzite forms prominent ridges. Associated with the metaquartzite is a banded, calcareous metapsammite. The banding, which is up to 0.3 m thick, is probably a primary sedimentary feature. The metapsammite is fine-grained, foliated, and leucocratic. The rock comprises 50–60% quartz, 20% feldspar (K-feldspar dominant), 15% hornblende, and 5% clinozoisite. It is probably a metamorphosed feldspathic sandstone or arkose which, by the presence of abundant amphibole and clinozoisite, had a significant calcic plagioclase component.

Metapelites are not abundant. They are typically fine-grained, granoblastic to lepidoblastic, and consist of subequal amounts of quartz and muscovite with either biotite or chlorite.

A conglomerate containing well-rounded, undeformed granitoid boulders up to 0.5 m in diameter and supported within a strongly cleaved quartzofeldspathic matrix, occurs southeast of Mindoona Bore.

Banded iron-formation

Banded iron-formation in the Jimblebar belt is of the magnetite–hematite (*ih*) type. It is well banded and typically flaggy. Locally it grades into ferruginous chert or grey and white banded chert. West of Coobina there is a thinly banded iron-formation (*ia*) which has a distinctive shaly appearance in outcrop. It contains two amphiboles; a deep blue-green hornblende and colourless grunerite. Both form porphyroblastic laths which make up 50% of the rock and are orientated parallel to banding. Granoblastic quartz and magnetite constitute the rest of the rock.

Banded iron-formation (*im*) is also exposed near Sylvania and Woggaginna Hill. These units are fine to medium-grained, extensively recrystallized, and comprise quartz and magnetite up to 3 mm across. Prexisting amphibole is suggested by clay-mineral pseudomorphs.

COOBINA ULTRAMAFIC INTRUSION

The Coobina ultramafic intrusion crops out at the eastern end of the Jimblebar greenstone belt. Chromitite pods and lenses occur extensively in a bulbous outcrop of serpentinite at the intrusion's western end. A chromite-bearing sill is exposed at the greenstone–granitoid contact 5.5 km west of Coobina. The serpentinite exhibits an adcumulate texture and pseudomorphed olivine crystals; it may have originally been a dunite. Layering occurs in the chromitite pods and lenses and is marked by chromite-rich bands alternating with more serpentine-rich rock. The eastern part of the intrusion is more pyroxene-rich. The rocks are coarse grained with large tremolite crystals pseudomorphing pyroxene. These are set in a groundmass of serpentine and chlorite after fine grained olivine.

The intrusion is extensively veined by late granitoid and pegmatite. However, the main contacts against granitoid are faulted or sheared and associated with quartz veining and local development of cleavage. The general trend of the layering, defined by chromitite pods, is truncated by the granitoid contacts.

The intrusion shows both sill-like and dyke-like characteristics. Chromitite pods and lenses occur at the junction between the sill-like and the dyke-like parts. Tyler (in press) interpreted the pods and lenses as representing relic primary layering in a magma chamber feeding a sill in the greenstone succession. The dyke-like portion represents a feeder system to this magma chamber. It intruded an earlier granitoid phase, which now remains only as xenoliths within later granitoid.

MINOR INTRUSIONS

Low sinuous ridges of schistose mafic to ultramafic rocks up to 5 m wide (*do*), cut across the stratigraphy in the Jimblebar belt. They are interpreted as a series of dykes that were intruded prior to deformation and metamorphism of the greenstone sequence.

GRANITOID ROCKS

Granitoid rocks are the most extensively exposed units in the Sylvania and Billinnooka inliers. In the Sylvania Inlier, three types of granitoid rocks have been recognized. The early banded and/or foliated granitoid recognized on NEWMAN (Tyler, 1990; Tyler et al., in press) occurs only as xenoliths in later granitoid on ROBERTSON. The second granitoid, here referred to as the "main granitoid", occupies the largest area. It ranges from syenogranite to granodiorite, and varies in grain size and megacryst content. It intrudes both the foliated and/or banded granitoid and the greenstone belts. The third type of granitoid also intrudes the greenstone belts and has alkaline affinities.

The main granitoid

Two distinct phases are seen in the main granitoid. A medium, even-grained syenogranite to monzogranite occurs as dykes, veins, and patches, in a medium to coarse, even-grained (*ge*) to sparsely porphyritic (*gv*) monzogranite to granodiorite. A widespread pegmatite phase is also present as veins and dykes. The granitoid is recrystallized, and textures and mineral assemblages are essentially metamorphic. Both microcline and plagioclase megacrysts are present and can be up to 20 mm in length. A true porphyritic rock is not usually developed and megacrysts rarely exceed 10–15% of the rock. Contacts between even-grained and sparsely porphyritic varieties are gradational.

The monzogranite to granodiorite phase has a biotite–epidote–plagioclase (oligoclase–andesine)–microcline (usually perthitic)–muscovite–quartz assemblage with minor amounts of sphene, apatite, allanite, fluorite, carbonate, and opaques. K-feldspar crystals are sometimes replaced by myrmekitic intergrowths.

Samples collected from the main granitoid around Emerald Bore give a Rb–Sr whole-rock age of 2520 ± 130 Ma (R_i = 0.716; Tyler et al., in prep). This age is typical of the tin granites from the northern Pilbara (cf. Trendall, 1983) and appears to reflect partial resetting during uplift and dewatering of the Hamersley Basin (Tyler et al., in prep). The granitoid has similar field relations and mineralogy (cf. Blockley, 1980; Hickman, 1983) to granitoids exposed in the Pilbara, however Sm–Nd model ages (T_{DM} = 3154 Ma) are younger suggesting a different source (Tyler et al., in prep). The Rb–Sr date is younger than the preferred age for the overlying Fortescue Group (cf. Trendall, 1983).

A small granitic exposure in the Billinnooka Inlier consists of leucocratic muscovite–biotite monzogranite.

Hornblende-bearing granitoid

The hornblende-bearing granitoid (*gh*) is restricted in its occurrence. The unit intrudes the main granitoid and greenstone near Woggaginna Hill. The rock is a medium- to coarse-grained, equigranular syenogranite to monzogranite that contains numerous mafic clots ranging up to 30 mm in diameter. Primary igneous banding is preserved in places.

The typical assemblage is quartz–microcline (perthite)–oligoclase–hornblende–epidote, with accessory sphene, apatite, allanite, zircon, and (rarely) biotite. The amphibole is hastingsite, and grains reach 8 mm in length.

Augite is present near Woggaginna Hill, and in places, it is rimmed by hornblende intergrown with epidote and sphene.

Samples collected 14.5 km southeast of Sylvania give a Rb–Sr date of 2720 ± 350 Ma (R_i = 0.7027; Tyler et al., in prep.) interpreted as the result of burial metamorphism under the Hamersley Basin. A Sm–Nd model age of T_{DM} = 3312 Ma, has also been obtained (Tyler et al., in prep.).

Hybrid rock

Along the northern and western margins of the Jimblebar greenstone belt is an unusual rock (*zh*) of intermediate composition. It is usually a weakly foliated, fine to medium-grained quartz–amphibole–albite assemblage with minor amounts of coarse apatite, opaques, and zircon.

Associated with the units are veins and patches of an altered, garnet-bearing granitoid. Intermediate material can be seen to grade into the granitoid, and the lithology is thought to represent assimilation of a metagabbro sill by the main granitoid.

STRUCTURE

Three periods of deformation (D_{1g}–D_{3g}) affected the greenstone belts prior to the intrusion of the main granitoid.

First deformational phase

The earliest phase of deformation (D_{1g}) is characterized by a widespread, generally pervasive, layer-parallel foliation in most of the greenstone belt units. This probably reflects early isoclinal folding and/or thrusting (e.g. Myers and Watkins, 1986). Pull-apart of chromitite lenses at Coobina may have developed during this event.

Second deformational phase

The second phase of deformation (D_{2g}) is characterized by large-scale close to tight folds. Extensive small-scale folding is present in BIF and banded cherts. An axial-plane cleavage is typically restricted to small-scale fold hinges.

The Jimblebar greenstone belt consists of two major folds. These have been named the western anticline and the eastern syncline and are separated by the Battery Fault. The anticline closes 3 km north of the old battery. The fold structures are overturned to the northwest; axial planes dip southeast; and much of the western part of the belt is inverted.

The closure of the eastern syncline has been obscured by the main granitoid. M-type folds, related to this closure, can be found in a large BIF xenolith in the granitoid west of Garden Well.

The Battery Fault developed prior to the third phase of deformation and is characterized by a zone of high strain subparallel to the axial surfaces of the D_{2g} folds. It probably represents a limb failure or minor thrust formed during folding.

At Coobina, Bye (1975) recognized large-scale folding of chromitite pods and lenses about northeast-trending axes, probably related to D_{2g}.

Third deformational phase

The third deformational (D_{3g}) event is characterized by upright, open to close, steeply plunging folds. These may be conjugate in form and have box profiles. The present outcrop pattern of the Jimblebar belt is due to the interference of two fold phases: southeast-plunging D_{3g} structures have refolded large-scale D_{2g} folds. Small-scale D_{3g} structures in the east plunge to the southwest, and the belt may be the remnant of a regional scale, conjugate box fold.

Small-scale structures take the form of crenulation and kink-banding of the D1g foliation. An associated crenulation cleavage may develop. In more massive lithologies, particularly BIF and chert, a spaced, disjunctive cleavage is present.

D_{3g} folds have also been recognized in the Coobina ultramafic.

METAMORPHISM

Metamorphism of the greenstone belts in the Sylvania Inlier, an event here designated M_g, took place under greenschist-facies conditions. Peak metamorphism was synchronous with the D_{1g} fold event.

In mafic rocks, mineral assemblages are typically actinolite–chlorite–albite–epidote–biotite–quartz. In pelitic metasedimentary rocks, assemblages comprise quartz–chlorite–muscovite, or quartz–muscovite–biotite; and indicate at least biotite-zone conditions. Higher grade (albite–epidote amphibolite facies) assemblages may be seen in some greenstone belt rocks but can be related either to later Hamersley Basin burial metamorphism (M_h) or Capricorn Orogeny metamorphism (M_c).

POST-GRANITOID MINOR INTRUSIONS

Within the Sylvania Inlier, Tyler (in press) has recognized two groups of mafic dykes; those which post-date granitoid intrusion and predate the Capricorn Orogeny, and those which post-date the Capricorn Orogeny.

The first group (d_1) is a suite of north-northeast-trending dykes which are progressively rotated to a east-northeast direction by later deformation (Suite 1 of Tyler, in press). Scarce east-trending dykes (d_2) constitute a second suite of the first group (Suite 2 of Tyler, in press). Suite 1 dykes do not appear to intrude the Fortescue Group and are correlated with the Black Range dyke swarm of the northern Pilbara (Hickman and Lipple, 1975).

Suite 1 dykes are typically medium- to coarse-grained, and igneous textures are often preserved. Their mineralogy, however, is metamorphic and varies according to grade from amphibole (blue-green)–plagioclase (oligoclase–andesine)–quartz–chlorite–epidote assemblages to hornblende–plagioclase (oligoclase–andesine)–quartz assemblages. In the higher grade examples, igneous textures are not preserved. Suite 2 dykes have a similar mineralogy to Suite 1 dykes.

HAMERSLEY BASIN

The Hamersley Basin is a late Archaean to early Proterozoic depositional basin covering most of the southern part of the Pilbara Craton (Trendall, 1983). Three stratigraphic groups have been recognized. These are the mafic-volcanic dominated Fortescue Group, which unconformably overlies granite–greenstone terrane and whose base has been dated elsewhere at around 2750 Ma (Pidgeon, 1984; Richards and Blockley, 1984); the banded iron-formation dominated Hamersley Group dated at around 2500 Ma (Compston et al., 1981); and the more restricted, clastic-dominated Turee Creek Group, which is not exposed on ROBERTSON.

The Fortescue and Hamersley groups crop out along the northern margin of the Sylvania Inlier (Fig. 3). They also crop out as several small inliers at the eastern end of the Sylvania Inlier beneath the Manganese Subgroup. A previously unrecorded, faulted inlier of the Hamersley Group occurs 9 km west-southwest of Jigalong. The Carawine Dolomite crops out between the abandoned Walagunya Homestead and Durack Well. The Fortescue Group is exposed adjacent to granitic basement in the Billinnooka Inlier at the northern edge of the sheet. The stratigraphy of the Hamersley Basin on Robertson is shown in Tables 1 and 2.

FORTESCUE GROUP

The stratigraphy of the Fortescue Group near the Sylvania Inlier on ROBERTSON (Table 2) varies considerably from that exposed on NEWMAN (Horwitz, 1976; Tyler, 1986; Tyler et al., 1990; Tyler, in press). Correlations between these sequences and those exposed in the southwestern Hamersley Basin and the northern Pilbara are not well enough established to formally name units beneath the Jeerinah Formation. Two informal units have been identified and are referred to as the mafic volcanic unit and the basal metasedimentary unit.

In the Billinnooka Inlier, units included in the Fortescue Group can be readily correlated with the Kylena Basalt and the Tumbiana Formation on BALFOUR DOWNS (Table 2).

Basal metasedimentary unit

In general, the contact between basement and the basal metasedimentary unit (*Fs*) of the Fortescue Group is faulted, although an unconformity has been observed in the Shovelanna Inlier and near the Murramunda–Jigalong road at the east end of the Sylvania Inlier. The land surface on to which the Fortescue Group was deposited had a varied topography, which is reflected by local variations in the thickness and lithology of the basal unit. In the Shovelanna Inlier, a very immature, poorly sorted conglomeratic sandstone is present at the unconformity. This sandstone contains sand to pebble-sized clasts of quartz and microcline, together with lesser amounts of matrix clay. The unit is less than 20 m thick and is in contact with the mafic volcanic unit. A kilometre east of the Shovelanna Inlier, a distinctive iron-stained shale, which is at least 100 m thick, underlies the volcanic unit. The base of this shale is not seen.

Mafic volcanic unit

The mafic volcanic unit (*Fb*) consists dominantly of metabasaltic to meta-andesitic lava interlayered with minor tuffaceous units. Feldspar laths, now altered to albite, form both groundmass crystals and phenocrysts. Other minerals include chlorite, amphibole, epidote, and minor amounts of sphene.

TABLE 1. LATE ARCHAEAN AND PROTEROZOIC STRATIGRAPHY

Age (Ma)	*Tectonic unit*	*Rock unit*	*Lithology*	*Estimated thickness* (m)
>800	Savory Basin	SAVORY GROUP		
		Boondawari Formation	Diamictite, sandstone, siltstone, mudstone, rhythmite, conglomerate, oolitic dolomite, stromatolitic dolomite.	800
		Mundadjini Formation	Sandstone, siltstone, shale; minor conglomerate, dolomite.	800
		Coondra Formation	Sandstone, pebbly sandstone, boulder conlomerate.	1000
		Watch Point Formation	Shale, siltstone; sandstone.	400
1000–1100	Bangemall Basin	MANGANESE SUBGROUP		
		Balfour Formation	Shale, siltstone, sandstone.	1500
		Jigalong Formation	Mudstone, sandstone, conglomerate.	50
		Enacheddong Dolomite	Dolomite; minor shale, chert.	0–1250
		Stag Arrow Formation	Sandstone, siltstone, shale, conglomerate, dolomite, stromatolitic dolomite, chert.	500–1700
		Pinjian Chert Breccia	Chert breccia	100
	Hamersley Basin	HAMERSLEY GROUP		
		Boolgeeda Iron Formation	Iron-formation, jaspilite, chert, shale.	200
		Woongarra Volcanics	Rhyolite, rhyodacite, tuff, iron-formation.	260
		Weeli Wolli Formation	Iron-formation, shale, jaspilite	420
		Brockman Iron Formation	Iron-formation, chert, shale.	
		Yandicoogina Shale Member	Shale.	50
		Joffre Member	Iron-formation, chert.	200–300
		Whaleback Shale Member	Shale, chert, iron-formation.	22
		Dales Gorge Member	Iron-formation, shale.	56–85
2490		Mount McRae Shale	Shale, chert, iron-formation	23
		Mount Sylvia Formation	Shale, chert, iron-formation	35
		Wittenoom Dolomite	Dolomite, chert, shale.	180
		Carawine Dolomite	Dolomite.	30
		Marra Mamba Iron Formation	Chert, iron-formation, shale.	90–110
		FORTESCUE GROUP		
		Jeerinah Formation	Phyllite, chert; minor tuff, sandstone.	200–600
		Mafic volcanic unit	Andesite, basalt; minor tuff.	150–600
		Basal metasedimentary unit	Conglomerate, sandstone, shale.	20–100
		Tumbiana Pisolite	Pisolitic tuff, mudstone, lithic sandstone.	30
2760		Kylena Basalt	Basalt	Small outcrop

TABLE 2. CORRELATION OF HAMERSLEY GROUP AND FORTESCUE GROUP UNITS

Sylvania Inlier Area	*Walagunya–Billinnooka area*
Hamersley Group	
Boolgeeda Iron Formation	
Woongarra Volcanics	
Weeli Wolli Formation	
Brockman Iron Formation	
Mount McRae Shale	
Mount Sylvia Formation	
Wittenoom Dolomite	Carawine Dolomite
Marra Mamba Iron Formation	
Fortescue Group	
Jeerinah Formation	
Mafic volcanic unit	
Basal metasedimentary unit	
Tumbiana Formation	
Kylena Basalt	
Granite–greenstone terrane	

Amygdales up to 4 mm in diameter are filled with chlorite, epidote, and calcite. Both amygdales and feldspar laths show an alignment which may reflect a primary flow banding.

Tuffaceous units have an intermediate composition, and consist of amphibole, feldspar, and minor amounts of sphene and chlorite in a quartzofeldspathic matrix. Amphibole crystals are typically well aligned, and a foliation tends to wrap the feldspar crystals. Lithic fragments are also present.

The unit varies from 600 m thick south of Shovelanna Hill to 150 m thick at the Murramunda–Jigalong road.

Jeerinah Formation

The Jeerinah Formation (*Fj*) includes phyllite, chert, and subordinate tuff. There are two chert horizons up to 5 m thick, one towards the base of the unit and the other very near the top. The actual top of the Jeerinah Formation is marked by a transition from shale into internally podded chert bands of the Marra Mamba Iron Formation.

Towards the eastern end of the Sylvania Inlier, a cross-laminated medium-grained sandstone is at the base of the formation. This probably correlates with the Woodianna Sandstone Member, typical of the basal Jeerinah Formation in the northern Pilbara (Hickman, 1983; Williams, 1989). Above the sandstone is a relatively thin succession of interbedded phyllite and chert.

HAMERSLEY GROUP

The typical Hamersley Group sequence, as described by MacLeod et al. (1963), MacLeod (1966) and Trendall and Blockley (1970), can be seen north of the Sylvania Inlier (Table 2). To the northeast, the group is represented by the Carawine Dolomite. This formation is typical of the Hamersley Group on NULLAGINE and BALFOUR DOWNS (Hickman, 1978; Williams, 1989).

There has been considerable speculation concerning the environment of deposition of the Hamersley Group BIFs as it has no modern analogue. Models have ranged from a restricted barred basin, closed to the south (Trendall and Blockley, 1970; Trendall, 1975a); through a shelf environment open to the ocean in the northwest (Horwitz and Smith, 1978; Ewers and Morris, 1981); to a platform or bank isolated from adjacent land masses (Morris and Horwitz, 1983; McConchie, 1984). These authors have also discussed the possible mechanisms of BIF deposition.

Marra Mamba Iron Formation

Regionally, the Marra Mamba Iron Formation (*Hm*) has been divided into a lower chert–BIF member, a middle shaly member and an upper BIF member (Trendall and Blockley, 1970). The upper BIF member was formally named the Mount Newman Member by Kneeshaw (1984).

On ROBERTSON, the formation is poorly exposed: only the lower member crops out to any great extent. The Mount Newman Member is generally marked by a ferruginous, lateritic cap (Ward et al., 1975). The top of the unit is not exposed.

De la Hunty (1969) estimated the thickness of the Marra Mamba Iron Formation as no more than 91 m; however, the unit thins from 110 m in the west to 90 m near the Murramunda–Jigalong road.

Wittenoom Dolomite

The Wittenoom Dolomite (*Hd*) is poorly exposed. The upper part of the unit, which comprises interbedded thin chert, shale, dolomite, and minor amounts of BIF, is exposed in an anticline 3.5 km west-southwest of Wheelarra Hill.

De la Hunty (1969) estimated the thickness as 183 m. Poor outcrop and possible structural repetition make a more accurate estimate difficult to obtain.

Carawine Dolomite

Small scattered outcrops of the Carawine Dolomite (*Hc*) (Hickman, 1983) occur between Durack Well and the abandoned Walagunyah Homestead. The formation is recrystallized, brown-weathering, grey dolomite characterized by distinct bedding and microbial lamination. Oncolites, and undescribed forms of domical and small-columnar stromatolites occur 7 km south and 9 km west of Windaroo Well.

The Carawine Dolomite is partially replaced and unconformably overlain by the Pinjian Chert Breccia. The Carawine Dolomite is interpreted as a shallow-water facies equivalent of the Wittenoom Dolomite.

Mount Sylvia Formation and Mount McRae Shale

Bruno's Band, a distinctive marker horizon of BIF within the Mount Sylvia Formation (*Hs*), is well exposed on ROBERTSON. At Wheelarra Hill only two BIF bands of the Mount Sylvia Formation, rather than the usual three (cf. Trendall and Blockley, 1970), are seen. The unit is 35 m thick and the two BIFs are separated by a shale bed. The Mount

McRae Shale conformably overlies the Mount Sylvia Formation. Ward et al., (1975) describe it as a pink and white-weathering shale up to 23 m thick. The top 5–0 m of the formation is locally ferruginous.

Brockman Iron Formation

The Brockman Iron Formation (*Hb*) is well exposed on ROBERTSON and forms prominent strike ridges. Overall thickness of the formation is approximately 450 m. It is subdivided into the Dales Gorge Member, Whaleback Shale Member, Joffre Member, and Yandicoogina Shale Member.

The stratigraphy of the Dales Gorge Member has been described in detail by Trendall and Blockley (1970). It is an alternating sequence of 33 BIF and shale "macrobands". At Wheelarra Hill, the member is 85 m thick (Ward et al., 1975), but it may be as thin as 56 m in mineralized areas.

The Whaleback Shale Member is an interbedded sequence of shale, chert and BIF. It is 22 m thick at Wheelarra Hill (Ward et al., 1975).

The Joffre Member consists dominantly of BIF with minor amounts of shale. At Wheelarra Hill, Ward et al. (1975) have identified a median shale–tuff zone, informally named the "Ferro Gully shale". Where the Joffre Member is mineralized, it is less than 200 m thick; elsewhere it is about 300 m thick.

The Yandicoogina Shale Member is about 50 m thick and overlies the Joffre Member.

Weeli Wolli Formation

The Weeli Wolli Formation (*Hj*) conformably overlies the Brockman Iron Formation and consists of interbedded BIF, chert, and shale. The BIF is often jaspilitic. The sequence is intruded by several metadolerite sills (*Hjd*).

The metadolerite is typically fine to medium-grained, and is usually highly altered. It contains relic pyroxene with chlorite, epidote, and relic albite that is kaolinized. Rocks are typically silicified and carbonated, and opaques are leucoxenized.

North of Shovelanna Hill, the unit is approximately 420 m thick and individual BIF units average 10 m in thickness.

Woongarra Volcanics

The Woongarra Volcanics (*Hw*) is a 260 m thick sequence of rhyodacite and rhyolite. The central BIF member, recognized in the Kalgan area of NEWMAN (Tyler et. al., 1990) extends onto ROBERTSON. It can be recognized north of Wheelarra Hill.

The felsic rocks are locally porphyritic. The rhyolite contains quartz phenocrysts and the rhyodacite contains albitized plagioclase laths. The groundmass contains devitrified material, chlorite, and leucoxenized opaques. It is not certain whether these rocks are extrusive or intrusive in origin.

Boolgeeda Iron Formation

The Boolgeeda Iron Formation (*Ho*) is the uppermost unit of the Hamersley Group. Trendall and Blockley (1970) suggested that the unit can be subdivided into an upper and lower iron-formation separated by a poorly exposed shaly unit. The lower BIF is typically flaggy, dense, black to dark brown and well laminated. The upper unit is finer grained, finely laminated and has a shaly appearance. The Boolgeeda Iron Formation is approximately 200 m thick, but the top of the formation is not exposed.

Pinjian Chert Breccia

Scattered outcrops of the Pinjian Chert Breccia (*cb*) extend east from the Fortescue River to the Walagunyah Homestead. The breccia contains small enclaves of the older Carawine Dolomite east of Durack Well. A small, faulted outcrop of chert breccia, identical to the Pinjian Chert Breccia, lies unconformably beneath the Manganese Subgroup of the Bangemall Group 1 km north of Limestone Well.

The contact between the Pinjian Chert Breccia and the Carawine Dolomite is complex. In some places the breccia gradually replaces the dolomite, but in others it unconformably overlies it. The gradational contact indicates a complex history of dissolution and progressive replacement by chalcedonic and opaline silica, all followed by brecciation and further silicification. The Pinjian Chert Breccia has been interpreted as a Proterozoic siliceous duricrust or silcrete (Williams, 1989).

METAMORPHISM

Burial metamorphism within the Hamersley Basin has been recognized and described by Smith et al. (1982). ROBERTSON lies outside their main area of observation but the Hamersley and Fortescue groups on NEWMAN were in the pumpellyite–actinolite facies and the lower greenschist facies.

As will be discussed later, many rocks of the Sylvania Inlier and the Hamersley Basin rocks on ROBERTSON were deformed during the early Proterozoic Capricorn Orogeny. Rocks are foliated and have been recrystallized during an accompanying metamorphic event designated M_c by Tyler (in press). Metamorphic grades in the Hamersley Basin rocks were similar to those established during Hamersley Basin burial metamorphism (M_h).

In the Sylvanie Inlier, evidence of a static metamorphic event that recrystallized the main granitoid and post-dated the M_g event in the greenstones is present. It is thought to be equivalent to the M_h event (Tyler, in press). On ROBERTSON, evidence of the static metamorphic event is preserved in mafic rocks exposed in zones of low strain between Sylvania Homestead and Woggaginna Hill. Mineral assemblages there indicate that metamorphism took place under albite–epidote–amphibolite facies conditions; and Tyler (in press) has estimated temperatures and pressures of at least 550°C and 300 MPa.

CAPRICORN OROGENY

The Capricorn Orogeny (Gee, 1979) post-dates the Suite 2 dykes and pre-dates the Manganese Subgroup unconformity. The east-trending shear zones in the Sylvania Inlier were formed during the orogeny. In the Fortescue and Hamersley Groups to the north, large east-trending folds represent the eastern extent of the Ophthalmia Fold Belt (Gee, 1979). Tyler (in press) and Tyler and Thorne (1990) have suggested that the deformation events in the Sylvania Inlier and the Hamersley Basin are directly linked. The observed shear zones and north-facing folds were interpreted as a northerly directed foreland fold and thrust system, that developed at the northern margin of the Capricorn Orogen. The deformation occurred between 2200 and 1600 Ma (Libby et al., 1986) and is related to the collision of the Pilbara and Yilgarn cratons (Thorne and Seymour, 1991; Tyler, in press; Tyler and Thorne, 1990).

DEFORMATION IN THE SYLVANIA INLIER

In the Sylvania Inlier, both shear zones and foliation in granitoids trend generally easterly; but, south of Sylvania Homestead, they swing to the southwest; and, towards the eastern end of the inlier, particularly near Red Hill, they swing southeast. Dips tend moderately to steeply south in the northern part of the inlier, and north in the southern part. Rocks within shear zones have a pronounced stretching lineation on foliation surfaces; this lineation maintains a north-northeast orientation whatever the trend of the foliation. Shear zones in the southern part of the inlier are folded into large, open to close, east-trending structures.

Strain is heterogeneous, and it is possible to trace foliated granitoid into chlorite–mica-bearing quartzofeldspathic schists. Where sparsely porphyritic granitoid is foliated, feldspar phenocrysts form augen. South of Sylvania, a chlorite–muscovite–biotite–kyanite–quartz schist occurs marginally to a strip of greenstone, and grades into foliated granitoid to the north.

Textures in the shear zones are blastomylonitic. Recrystallization is not as great north of Sylvania. Shear zones cut the granitoids and greenstones. The Mindoona Bore Thrust in the Jimblebar belt has a reverse sense of movement. The position of this thrust is marked by strongly sheared, foliated, and lineated rocks. Small-scale D_{2g} folds south of Mindoona Bore have been refolded.

The exposed contact between the Sylvania Inlier and the Hamersley Basin rocks is here interpreted as a south-dipping thrust fault for most of its length, rather than an unconformity as previously mapped (de la Hunty, 1969). The fault is parallel to shear zones and foliation within the inlier, and to a well-developed, south-dipping foliation in the Fortescue Group. It has been named the Painkiller Bore Fault.

DEFORMATION IN THE HAMERSLEY BASIN

The Hamersley Basin rocks have been deformed by an early event (D_{1c}), that locally produced layer-parallel folds, and a later regional-scale fold event (D_{2c}).

The folds related to the early deformation phase have only been seen at one locality — 4.5 km north-northeast of Wheelarra Hill. The folds occur in the Boolgeeda Iron Formation, are small, tight to isoclinal, and occur within 2–3 m of the base of the formation. The axial surfaces parallel the bedding.

The second deformation was a major regional folding event and resulted in folds of all scales. The closure of the regional-scale Shovelanna Syncline (Halligan and Daniels, 1964) occurs towards the western edge of the sheet. Folds are generally north-facing, tight to isoclinal, and have steeply to gently inclined, south-dipping axial surfaces and moderately to gently west-plunging axes; easterly plunges occur locally. Asymmetrical folds have short, steeply dipping limbs and long, gently dipping limbs. As the Painkiller Bore Fault is approached, folding is more intense and steep limbs are in places overturned.

A well-developed axial-plane cleavage has developed in the Fortescue Group and shale units of the Hamersley Group. In shale units, a continuous slaty cleavage is present; but more massive units, particularly chert bands in the Jeerinah Formation, display a spaced, disjunctive cleavage. A foliation is also seen in mafic units.

METAMORPHISM

Smith et al., (1982) interpreted very low- and low-grade metamorphic mineral assemblages throughout the Hamersley Basin as the product of burial metamorphism (M_h), which reached a peak at the end of Turee Creek Group times. The formation of an axial-plane cleavage associated with D_{2c} folds implies a later, Capricorn age metamorphic event (M_c) superimposed onto the earlier burial metamorphic event. Grades reached during the M_c event were similar to those reached during M_h.

Mineral assemblages in the Fortescue Group are consistent with the pumpellyite–actinolite facies (Smith et al., 1982). Mineral assemblages in the metadolerites intruding the Weeli Wolli Formation indicate prehnite–pumpellyite facies conditions.

The Sylvania Inlier on ROBERTSON was extensively deformed during the Capricorn Orogeny. Suite 1 mafic dykes are deformed and foliated, and were recrystallized during the M_c event. Mineral assemblages generally indicate albite–epidote amphibolite facies. In some samples collected near Woggaginna Hill, mineral assemblages are indicative of the amphibolite facies. Amphibolite facies assemblages also occur in the Suite 1 mafic dykes that were sampled between Emerald Bore and Sylvania Homestead.

Rocks in shear zones between Sylvania Homestead and Woggaginna Hill show a high degree of recrystallization. A schistose rock exposed 6 km south-southeast of Sylvania Homestead, which in the field can be traced into a deformed granitoid, has the assemblage kyanite–chlorite–biotite–muscovite–quartz. Chlorite is well crystallized and is intergrown with biotite and muscovite. At 550°C (the minimum temperature of peak M_h burial metamorphism interpreted in this area) kyanite–chlorite stability may be achieved by an isothermal increase in pressure to in excess of 500 MPa, which is equivalent to 18 km of overburden (Tyler, in press).

THE WHEELARRA FAULT AND RELATED STRUCTURES

The Wheelarra Fault is a complex series of east-northeast-trending normal, reverse, and wrench faults. There is a horizontal offset of 11 km; and drag associated with dextral movement has affected both the Painkiller Bore Fault and the axes of adjacent D_{2c} folds. Ward et al. (1975) reported dips of 30° to the east on one of the faults.

The Wheelarra Fault and the conjugate northwest-and northeast-trending faults seen in the Jimblebar belt are probably contemporaneous with the Mount Whaleback Fault. These faults have influenced the development of the Bresnahan Basin (Tyler et al., 1990).

BANGEMALL BASIN

INTRODUCTION

A detailed review of the Manganese Subgroup, previously the Manganese Group defined by de la Hunty (1963) on ROBERTSON, has shown that it can be correlated with the Collier Subgroup of the Bangemall Group. This has confirmed the tentative proposal of Muhling and Brakel (1985) that the Manganese sequence was a subgroup of the Bangemall Group and, hence, part of the Bangemall Basin. The changes in the stratigraphy of the Bangemall Basin are described in Table 3.

TABLE 3. COMPARATIVE CHART OF PRECAMBRIAN STRATIGRAPHY, POST HAMERSLEY BASIN

de la Hunty (1969)	*This publication*
	Savory Group
	Boondawari Formation
	Mundadjini Formation
Waltha Woora beds	Coondra Formation
	Watch Point Formation
-- UNCONFORMITY --	-- UNCONFORMITY --
	Manganese Subgroup
Unnamed shale	Balfour Formation
	Jigalong Formation
Unnamed dolomite	Enacheddong Dolomite
Bee Hill Sandstone	Stag Arrow Formation
	-- UNCONFORMITY --
Pinjian Chert Breccia	Pinjian Chert Breccia
-- UNCONFORMITY --	-- UNCONFORMITY --
Overlying, variously, rocks of Hamersley Basin, Sylvania Inlier, and Billinnooka Inlier	

BANGEMALL GROUP–MANGANESE SUBGROUP

The Manganese Subgroup extends from the Billinnooka area on the northern margin of ROBERTSON, diagonally through the Jigalong area, and around the eastern end of the Sylvania Inlier to Weelarrana in the southwestern corner of ROBERTSON (Fig. 3). Exploratory hydrocarbon drilling in the Fortescue River flood plain 23 km north-northwest of Shovelanna Hill on NEWMAN, intersected a sequence of dolomite, siltstone, sandstone, and glauconitic sandstone. Such lithologies are characteristic of the Manganese Subgroup. The discovery of this sequence at depth suggests that the Manganese Subgroup also extends northwest from the Limestone Well area. The Poonda Fault forms the southwestern border of the subgroup.

The Manganese Subgroup rests with angular unconformity on the granite–greenstone terrane of the Sylvania and Billinnooka inliers, and the Fortescue and Hamersley Groups of the Hamersley Basin. The unconformity is well-exposed between Limestone Well and the Jigalong Community road.

The Stag Arrow, Enacheddong, and Balfour Formations (Williams, 1989), and the newly defined Jigalong Formation, have been included in the Manganese Subgroup on ROBERTSON. The correlation with the Collier Subgroup of the Bangemall Group is given in Table 4.

The Manganese Subgroup is unconformably overlain by the newly recognized Savory Group (defined below).

TABLE 4. CORRELATION CHART BETWEEN MANGANESE SUBGROUP ON ROBERTSON AND COLLIER SUBGROUP IN THE BANGEMALL BASIN

Collier Subgroup (a)	*Manganese Subgroup*
Ilgarari Formation	Balfour Formation
	Jigalong Formation
	Enacheddong Dolomite
Calyie Sandstone	Stag Arrow Formation
Backdoor Formation	Woblegun Formation
Wonyulgunna Sandstone	

NOTE: (a) Muhling and Brakel (1985)

Stag Arrow Formation

The Stag Arrow Formation (*MNs*) is the basal unit of the Manganese Subgroup on ROBERTSON (Williams, 1989). It is 500–1500 m thick and can be partly correlated with the Calyie Sandstone on COLLIER (Williams, 1987). The formation contains several mappable lithologic units which could, at some future date, allow further subdivision.

The formation is largely fine to coarse-grained sandstone, but also contains some siltstone, shale, and conglomerate, and lesser amounts of dolomite and chert. East of Limestone Well, a thin and discontinuous basal conglomerate unconformably overlies the Hamersley Group. The conglomerate grades rapidly upwards to a coarse-grained sandstone. Clasts of red and blue-banded chert and jasper in the conglomerate resemble rocks of the Hamersley Group. Interbedded grey dolomite and shale also occur locally at the unconformity and are interpreted as lagoonal deposits; they are succeeded by the transgressive shallow-marine clastics more typical of the Stag Arrow Formation.

The lower half of the Stag Arrow Formation, west of Jigalong, is an upward-fining sequence. Towards the top of this sequence, several lenses of brown-weathering dolomite and stromatolitic dolomite containing a new morphospecies of *Conophyton* recorded by Grey (1986) occur 10 km south, 2.5 km southwest, and 10 km west of Windaroo Well. Elsewhere on ROBERTSON carbonates are scarce in this formation.

East of Billinnooka Homestead and south of the Sylvania Inlier, the Stag Arrow Formation is largely an arenaceous sequence. Many sandstones contain glauconite, and it is abundant in the upper part of the sequence. Glauconitic sandstone typically weathers to a brown colour and is thinly to thickly bedded and coarse grained. Laminated glauconitic sandstone is interbedded with shale and siltstone. Sedimentary structures are well developed and include load casts and tool marks, such as grooves, and prod, skip, and bounce marks. However, some beds, which are largely free of tool marks, contain enigmatic bedding-plane markings resembling strings or chains of beads. Grey and Williams (1989) have interpreted such structures as possible impressions of megascopic algae. Three widely separated outcrops of the algae-bearing sandstone, the main exposure lying 8 km south-southwest of Millarie Bore, occur on ROBERTSON.

The Stag Arrow Formation was deposited in a stable shallow-marine shelf environment.

Enacheddong Dolomite

The Enacheddong Dolomite (*Mne*) (Williams 1989) conformably overlies the Stag Arrow Formation. It is discontinuously exposed across ROBERTSON. Its main outcrops are in fault-bounded basins north of the Sylvania Inlier. The well-bedded nature of the formation is emphasized by its striped air-photo pattern.

It is multicoloured and ranges from thick-bedded to laminated, fine-grained and thin-bedded dolomite. Interbeds of dolarenite, dololutite, and dolomitic breccia, are abundant. Northwest of Manganese Bore, thin-bedded, fine-grained dolomite is extensively interbedded with ferruginous and manganiferous shale, calcareous ironstone, and blue-banded chert. Some ferruginous, manganiferous shales contain millimetre-scale banding similar to BIF. Although the laminated dolomite may be of algal origin, stromatolitic forms have not been found in the Enacheddong Dolomite.

In areas, such as the Billinnooka area and 2 km northeast of Jigalong Well, where the formation is predominantly dolomitic, it has been largely silicified and brecciated.

The combination of dolomitic breccia, an enriched clastic component in the dolomite, and well-bedded dolomite suggests deposition possibly marginal to a marine shelf.

Jigalong Formation

The newly defined Jigalong Formation (*Mnj*) (Table 5) is a thin, but persistent, marker horizon that can be traced from east of Walagunyah (Walgun) Homestead to just northeast of Weelarrana. It disconformably overlies the Enacheddong Dolomite. Where the Enacheddong Dolomite is absent the formation rests disconformably on the Stag Arrow Formation. The Jigalong Formation post-dates the silicification and formation of chert breccia in the Enacheddong Dolomite.

The Jigalong Formation is an upward-fining sequence of polymictic conglomerate, sandstone, siltstone, and silicified green mudstone. Glauconite is an accessory mineral in all lithologies. The matrix and clast-supported basal conglomerate is discontinuous and patchy, and contains granule to cobble-sized clasts. Banded chalcedony and chert, derived from the underlying Enacheddong Dolomite, are common clasts.

The formation resembles a large turbidite unit, possibly related to a submarine fan, deposited during a transgressive marine phase.

Balfour Formation

The Balfour Formation (*Mnb*), (Williams, 1989), is a transgressive sequence on ROBERTSON. Wherever its contact with underlying formations is exposed, it appears to be conformable. However, a regional disconformity is evident in that on BALFOUR DOWNS and in the Millarie Well area the formation lies on the Stag Arrow Formation; around Billinnooka and Windaroo Well areas it lies on the Enacheddong Dolomite; and in the region between Jigalong and Weelarrana it rests on the Jigalong Formation (Fig. 5).

The basal unit of the formation is a grey-green manganiferous shale, which weathers to manganese oxide cappings.

On ROBERTSON, the Balfour Formation is the youngest formation included in the Manganese Subgroup. The formation consists of grey-green to dull maroon-weathering shale with lesser amounts of siltstone and fine-grained sandstone, and minor interbeds of

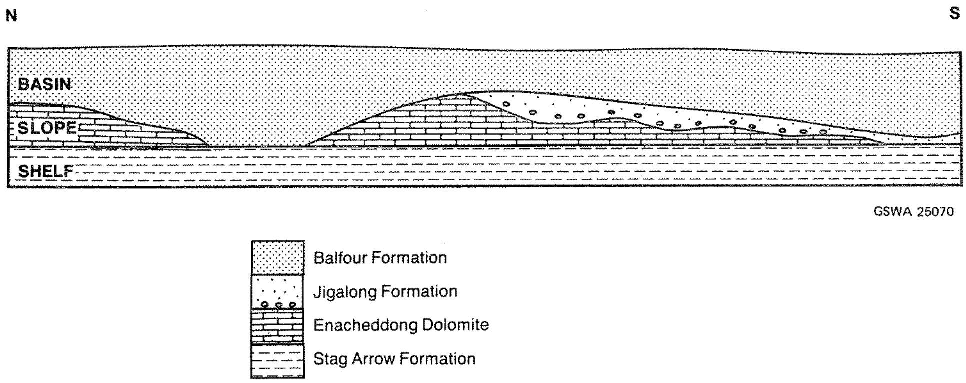

Figure 5. Manganese Subgroup stratigraphic relationships.

fine-grained glauconitic sandstone and calcareous siltstone. The coarser material contains abundant clay (after feldspar), iron-rich minerals (magnetite, hematite, and pyrite), and detrital muscovite and a little biotite. Graded and ripple bedding are present.

The formation was deposited in a stable, shallow marine basin remote from a source of terrigenous material.

MAFIC INTRUSIONS

The Balfour Formation hosts a suite of fine to coarse-grained dolerite sills and small intrusions. The coarse-grained bodies have been labelled *dc* and occur in the Wadra Hills, around Jigalong and south of Burranbar Pool. The fine-grained variety, labelled *dd*, is identical to the Davis Dolerite (de la Hunty, 1969) and occurs mainly in the area southwest of Billinnooka. A dolerite body 13 km southeast of Jigalong also belongs to this suite.

Both the fine– and coarse-grained dolerites contain relatively fresh clinopyroxene and altered labradorite, accessory magnetite, and lesser amounts of pyrite. Scattered orthopyroxene is found in the coarse-grained dolerite. Patchy development of pumpellyite and prehnite suggests very low-grade static metamorphism.

Mafic dykes are scarce in the Manganese Subgroup. The genetic and temporal relationships between the fine-grained Davis Dolerite and coarse-grained dolerite are unknown.

STRUCTURE

The Manganese Subgroup is moderately folded and extensively faulted. South and east of the Sylvania Inlier, open folds plunge to the northeast and southwest. Minor folds show a consistent s-shaped profile.

The subgroup is exposed in a series of fault-bounded domes and basins north of the Sylvania Inlier. These structures are generally elongated in a north-northeast direction but some structures swing more easterly when adjacent to east-trending strike-slip faults. The dome-and-basin structures are believed to be related to basement block faulting at the margin of the Pilbara Craton. Such faults were active during and after deposition of the Manganese Subgroup.

Tight, similar folds, which trend, and plunge, north–northeasterly and have easterly dipping axial planes, occur in the Millarie Well area. The Manganese Subgroup in this area is folded about axes roughly parallel to the complex Robertson Fault system. Where these fold axes swing to the east, the compressive regime associated with the Robertson Fault system has superimposed large chevron folds onto the pre-existing folds. These chevron folds have north-trending axes. An incipient cleavage has developed in the pelitic rocks, and a spaced cleavage in the sandstone units, particularly in the axial-planar zones.

SAVORY BASIN

SAVORY GROUP

The Savory Group is a newly recognized group that unconformably overlies the Manganese Subgroup of the Bangemall Basin to the west and the younger Yeneena Group to the north (Williams, 1989). It crops out in the southeastern half of ROBERTSON (Fig. 3).

On ROBERTSON, the Savory Group was previously included in Waltha Woora Beds (de la Hunty, 1963). Later, it was included in the Calyie Sandstone of the Bangemall Group (Muhling and Brakel, 1985). However, a regional reassessment of the Calyie Sandstone brought to light correlation problems which were resolved in 1983 on BALFOUR DOWNS (Williams, 1989).

Subsequent detailed mapping on ROBERTSON by Williams (1987) and follow-up reconnaissance work on BULLEN, COLLIER, NABBERU, GUNANYA, and TRAINOR has confirmed that many sedimentary units in this region form a previously unrecognized late Proterozoic Basin. This basin has been called the Savory Basin and is the youngest of a series of overlapping sedimentary basins which occupy the region between the Yilgarn and Pilbara Cratons.

The Savory Group comprises four formations on ROBERTSON. They are the basal Watch Point Formation, the Coondra Formation, the Mundadjini Formation, and the Boondawari Formation. Detailed descriptions and type areas are given in Table 5.

Watch Point Formation

The gently dipping Watch Point Formation (*SVw*) rests unconformably on, or is in faulted contact with, folded rocks of the Manganese Subgroup. The Watch Point Formation unconformably overlies the Balfour Formation, between Jigalong and Cundlebar. Lithological similarities between the two formations probably account for earlier, non-recognition of this contact. However, the Watch Point Formation is, overall, coarser grained. It comprises predominantly maroon-brown to grey, fine-grained sandstone and siltstone with minor amounts of shale, wacke, and fine-grained glauconitic sandstone. The sandstone is less well sorted than those generally found in the Manganese Subgroup. It contains a higher proportion of weathered feldspar, detrital muscovite, and lithic fragments; clay matrix is common; and tourmaline and zircon are abundant accessory minerals. Graded, convolute, ripple-marked bedding, including climbing ripples and small cross-beds, some of which are troughs, are abundant (Muhling and Brakel, 1975). The minor glauconite component indicates periods of stable marine conditions.

TABLE 5. NEWLY DEFINED UNITS OF THE SAVORY GROUP AND MANGANESE SUBGROUP

Formation	*Derivation*	*Type areas*	*Estimated thickness (m)*	*Lithology*	*Stratigraphic relationship*	*Remarks*
Boondawari Formation	Boondawari Soak, 23° 35' 10"S, 121° 27' 40"E	a) Boondawari Creek area, 23° 34' 56"S, 121° 28' 25"E b) Diamictite occurrence, 7.5 km bearing of 030° from Boondawari Soak, 23° 31' 32"S, 121° 29' 57"E	800	Upper sequence of interbedded shale siltstone, dolomite, oolitic dolomite, and stromatolitic dolomite; middle sequence of sandstone, siltstone, and conglomerate; lower sequence of diamictite and rhythmite.	Youngest formation of Savory Group; apparently conformable on underlying Mundadjini Formation; top of sequence removed by erosion.	A shallow-marine glacigenic sequence contains a variety of striated faceted and polished boulders up to 3.5 m in size.
Mundadjini Formation	Mundadjini Spring, 23° 23' 01"S, 121° 10' 40"E	a) 20 km bearing 193° from Savory–Bobbymia Creek junction, 23° 59' 15"S, 20° 50' 15"E b) 16 km bearing 065° Savory–Bobbymia Creek junction, 23° 45' 08"S, 121° 01' 54"E	800	Interbedded sandstone and siltstone, minor conglomerate pebbly sandstone, shale, dolomite.	Conformable between the overlying overlying Boondawari and underlying Coondra Formation; could be (in part) facies equivalent of the upper Coondra Formation.	Includes and evaporitic component; pseudomorphs of salt and gypsum observed.
Coondra Formation	Coondra Coondra Spring, 23° 06' 37"S, 121° 01' 30"E,	a) Area between Coondra Coondra Spring and Boolginya Rock Hole, 23° 06' 37"S, 121° 01' 30"E b) Yooldoowindi Spring area, 23° 30' 14"S, 120° 51' 13"E	1000	Coarse-grained sandstone, pebbly to to boulder-bearing sandstone, debris, flow matrix-supported conglomerate, boulder to pebble conglomerate.	Conformable between overlying Mundadjini Formation and underlying Watch Point Formation; lower contacts may be faulted.	Riverine, high-energy deltaic deposits.
Watch Point Formation	Watch Point, 23° 17' 09"S, 120° 50' 35"E	Section at Watch Point, a) 23° 17' 07"S, 120° 50' 35"E b) 6.5 bearing 105° from Robertson Range Homestead. 23° 28' 29"S, 120° 52' 12"E	400	Shale, micaceous shale, siltstone, silty sandstone, fine-grained sandstone.	Basal unit of Savory Group rests rests unconformably on Manganese Sub-group; difficult to distinguish in places from Balfour Formation, but is recognized structurally by lack of folding.	Marine shelf, distal turbidites.

TABLE 5. NEWLY DEFINED UNITS OF THE SAVORY GROUP AND MANGANESE SUBGROUP — *CONTINUED*

Formation	*Derivation*	*Type areas*	*Estimated thickness (m)*	*Lithology*	*Stratigraphic relationship*	*Remarks*
Jigalong Formation	Jigalong 23° 21' 40"S 120° 45' 32"E	a) 4 km bearing 325° from Jigalong 23° 19' 59"S, 120° 45' 32"E b) 4 km bearing 333° from Robertson Range Homestead, 23° 26' 08"S, 120° 47' 32"E	50	Clast-supported conglomerate, sandstone, siltstone, green silicified mudstone.	Lens–shaped unit lying disconformably between overlying Balfour Formation and underlying Enachedong Dolomite of the Manganese Subgroup.	A good marker horizon; upward-fining sequence of conglomerate to mudstone.

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Coondra Formation

At Watch Point, the upward-coarsening shallow-marine Watch Point Formation (*SVc*) grades into the high-energy fluviatile Coondra Formation. The Coondra sequence is interpreted as a prograding delta. However, north of Watch Point, the Coondra Formation is in faulted contact with the Manganese Subgroup. Southeast and south of Jigalong, the Coondra Formation overlies the Watch Point Formation.

The Coondra Formation is a coarse-grained siliciclastic sequence. In the northern half of ROBERTSON, it is characterized by thick boulder and cobble conglomerates interbedded with coarse-grained cross-bedded sandstones. These lithologies pass southwestwards to a red-brown, medium to coarse-grained sandstone with interbedded granule sandstone and cobble conglomerate lenses.

The conglomerates range from well-sorted, clast-supported, matrix-filled types to poorly sorted matrix-supported debris flows. The latter pass to coarse-grained sandstones which contain randomly distributed cobbles and boulders. Conglomerate beds are up to 25 m thick and can be traced over distances of up to 10 km. Clasts are up to 2.5 m in size and are typically subangular to subrounded. Rock types are sandstone, quartzite, vein quartz, chert, jasper, and distinctive reworked conglomerate clasts. Large trough cross-beds — with sets up to 5 m in size — and current striae are common in the interbedded sandstone units.

Many of the boulder and cobble clasts in the Coondra Formation can be matched with rock types in the Manganese Subgroup. This observation together with consistent current directions from the northwest and north points to a Manganese Subgroup provenance for the Coondra Formation. The current direction changes to southwest and south in the area south of Bobbymia and Savory Creeks.

Mundadjini Formation

The Mundadjini Formation (*SVm*) conformably overlies the Coondra Formation but may also partly be a very shallow-marine facies equivalent of the Coondra Formation. The formation consists of red-brown, thick-bedded, coarse to medium-grained sandstone marked by large, trough cross-beds with sets up to 7 m thick. Small lenses of cobble conglomerate are present. Higher in the sequence the sandstone is interbedded with fine-grained flaggy, sandstone, and siltstone. Minor amounts of maroon to purple shale, white dolomitic shale, and thinly bedded pink dolomite are also present.

The fine-grained clastics of the Mundadjini Formation, contain a variety of sedimentary structures. Good pseudomorphs of halite crystals, up to 20 mm across, have been preserved on bedding planes in a red-brown silty sandstone, 13 km southeast of Twelve Mile Pool on the Savory Creek. Some beds containing halite pseudomorphs also contain ripple marks; and seed-gypsum casts have been found in nearby fine-grained sandstones. Ripple-marked beds, both current and wave generated, are abundant. Ladder ripples and wave-flattened ripples point to shallow-water conditions. Wind-scoured wet-sand structures point to tidal exposure of sand bars.

Overall the abundance of shallow-water structures and the presence of evaporitic minerals indicate nearshore, tidal conditions with periodic subaerial exposure. Localized coastal evaporites (sabkhas) were present.

Boondawari Formation

The Boondawari Formation (*SVb*) appears to conformably overlie the Mundadjini Formation, although the contact is not exposed. The formation consists of up to 30 m thick diamictite beds overlain by interbedded sandstone, conglomerate, rhythmite, mudstone, shale, siltstone and dolomite. The formation was first described in detail by Williams (1987).

The diamictite, of undoubted glacigenic origin, is best exposed at the headwaters of the Boondawari Creek. It is possible that two horizons are present. The westerly occurrence, 2 km southwest of Boondawari Soak, is overlain by a grey-blue rhythmite whose millimetre-scale bedding shows numerous scour marks, graded-bedding, cross-bedding and flame structures. The second horizon is exposed 8 km north of Boondawari Soak and is widely exposed on GUNANYA. It is overlain by an interbedded sequence of coarse-grained sandstone and conglomerate followed by interbedded purple siltstone and grey fine-grained sandstone. This sequence is capped by shale and dolomite. The latter lithology includes oolitic and stromatolitic dolomites.

The diamictite consists of red to purple-weathering, dark-grey mudstone containing striated, faceted and polished pebbles, cobbles and boulders. Some boulders are up to 3.5 m in diameter. The clast lithologies include sandstone, shale, siltstone, banded chert, dolomite, stromatolitic dolomite, quartzite, various schists, gneiss, granite, amygdaloidol basalt, dolerite, and gabbro. The concentration of boulders and cobbles in some areas suggests they were deposited from melting icebergs in a shallow-water, possibly marine, environment.

Williams (1987) correlated these glacigenic rocks with the late Proterozoic sequence described in central Australia (cf. Preiss and Forbes, 1981).

MAFIC INTRUSIONS

A variety of mafic bodies intrude the Savory Group. The most distinctive are shallow-level sills and dykes in the Coondra Formation, generally close to the Robertson Fault system. They weather to a red-purple colour and consist of ferruginized and silicified amydaloidal basalt (*ds*); the groundmass contains small feldspar phenocrysts. Amygdales contain chalcedonic silica, bright-green chlorite, and carnelian-bearing agate. The sandstone overlying the amygdaloidal basalt is recrystallized and has well-developed columnar jointing. Some mafic intrusions appear to post-date the Robertson Fault system.

The medium to coarse-grained quartz dolerite sills and irregular bodies labelled *dg*, intrude all formations of the Savory Group. The largest, named the Boondawari dolerite, is 11 km long and up to 1.5 km wide and intrudes the glacigenic Boondawari Formation, the youngest exposed member of the Savoury Group. Geochronological studies are in progress.

The quartz dolerite has a patchy granophyric to micrographic texture and includes clinopyroxene, zoned and sericitized albite to labradorite, primary brown hornblende, and quartz with abundant magnetite. Secondary green amphibole and biotite are also present. The Boondawari dolerite is intruded by leucocratic dolerite and fine-grained dacitic dykes.

STRUCTURE

The extensive sand cover, scattered outcrops, and lack of good marker horizons in the Savory Group, makes structural interpretation difficult on ROBERTSON. In general, the

Savory Group dips gently east to southeast. However, the western margin of the group is complicated by the Robertson Fault system (Muhling and Brakel, 1985). Folds in the Savory Group adjacent to the fault system have axes parallel to the fault. Such folds are large and open in the Coondra Formation, but are small and tight with easterly dipping axial planes in the underlying Watch Point Formation.

Away from the Robertson Fault system, the folds are open. Fold axes are short and generally trend northwest except in the southeastern corner of ROBERTSON, where they trend towards the north. In the Boondawari Creek area northwest-trending fold axes are truncated by northeast- trending faults. Many of these have horizontal slickensides indicating a strike-slip component.

The northeast-trending Robertson Fault System is interpreted as an imbricate thrust system with observed faults dipping moderately to steeply east. Small-scale fold structures indicate compression. Most exposed fault zones are steep reverse faults interpreted as part of an imbricate fan. Some faults also have a dextral strike-slip component as observed for the Kimberley Well fault.

North of Watch Point, the Coondra Formation (younger) has overidden the Watch Point Formation and is in direct faulted contact with the Manganese Subgroup (older). There is little doubt that the fluviatile boulder conglomerate of the Coondra Formation is derived from the adjacent Manganese Subgroup. This would suggest that the Savory Group (younger) has been thrust up and out of its depositional basin (the Savory Basin) onto its foreland.

However, the actual amount of tectonic transport does not appear to be great. The system is envisaged as a basin inversion with compressional reactivation of pre-existing low-angle fault zones, which were initiated during the earlier extensional phase of the Savory Basin development.

LATE FAULTING

Within the Sylvania Inlier, two major northwest-trending sinistral wrench faults have been observed. These have been named the Shovelanna Bore Fault and the Murramunda Fault. A cleavage is associated with the Shovelanna Bore Fault near Emerald Well.

Faults associated with the Murramunda Fault cut and displace the eastern part of the Jimblebar belt and the Coobina ultramafic. The fault system dies out to the northwest producing large-scale conjugate folding of the Hamersley Group around Innawally Pool.

North-northeast trending faults truncate the eastern end of the Sylvania Inlier. These parallel the trend of the Tangadee Lineament (Muhling and Brakel, 1985).

The region north of the Sylvania Inlier is extensively faulted. The oldest faults trend roughly north. These are intersected by large northeast-trending normal faults such as the Billinnooka and Balfour Faults.

The Robertson Fault System is truncated at high angles by a later series of northwest- to west-trending sinistral strike-slip faults, such as the Watch Point and Jigalong Faults. These are the same age as the Shovelanna Bore and Murramunda Faults and are seen to displace the Manganese Subgroup.

MAFIC DYKES

Two suites of mafic dykes, which post-date Capricorn Orogeny structures, are seen on ROBERTSON. These correspond to Suites 6 and 7 of Tyler (in press).

Suite 6 comprises east-trending dykes (d_6) of which only one is recognized on ROBERTSON (5.5 km north of Sylvania). This is a 1–2 m thick, fine-grained dolerite dyke which comprises plagioclase, olivine, pyroxene, and fine magnetite, together with minor amounts of hornblende.

Suites 7 dykes (d_7) trend generally north-northeast, although some conjugate examples trend northwest. They are up to 3 m thick and vary from fine to coarse-grained. Orthopyroxene, olivine and clinopyroxene are present in some dykes. The dykes trending north-northeast fill faults in the Hamersley Group rocks at Wheelarra Hill (Ward et al., 1975).

The Murramunda Dolerite is a north-trending dyke that crops out near the eastern end of the Sylvania Inlier. The dyke is about 15 km long and has considerable variation in width reaching up to 500 m across. It intrudes, and has metamorphosed, the main granitoid and intrudes the Coobina ultramafic. The Murramunda Dolerite is itself cut by a Suite 7 dyke. Although contacts with the main granitoid appear vertical where exposed, the dolerite has a pronounced scarp along its western margin and this may reflect a moderate to steep easterly dip. It has a similar mineralogy to Suite 6 dykes, and is fine-grained and weakly porphyritic with a subophitic, locally trachyitic texture. Fine-grained magnetite is characteristic and suggests a relationship between the Suite 6 dykes, the Murramunda Dolerite and, possibly, the Davis Dolerite, which intrudes the Manganese Subgroup.

North-northeasterly trending and occasional northwesterly trending dolerite dykes (d_7), now largely kaolinized, occur through out the Savory Group. They appear to post-date the granophyric quartz dolerite sills.

CAINOZOIC

The descriptive, morphologic scheme used for the Cainozoic superficial deposits in this report is a continuation of the scheme formulated for the BALFOUR DOWNS explanatory notes (Williams, 1989).

Four main groupings have been recognized. The youngest comprises unconcolidated stream (*Qa*), lacustrine (*Ql, Qd*), and eolian deposits (*Qs, Qp*) associated with modern drainage and desert sand regions. The second group consists of transported, unconsolidated low-slope deposits lying between the main drainage lines and bedrock outcrop (*Qr, Qw, Qc, Qe*), and (*in situ*) breakdown weathering products of underlying bedrock (*Qb*). The third group consists of semi-consolidated and consolidated duricrust (*Czb, Czl*) and old valley fills (*Czc, Czk, Czo*). These units are subject to quite strong erosion resulting in "badland" topography. Gullies up to 20 m deep occur in *Czc*. The oldest unit is the Oakover Formation (*To*) cf. Noldart and Wyatt (1962), which occurs as remnants of white, opaline silica in the headwaters of the Oakover River.

The Hamersley Surface (MacLeod et al., 1963; Campana et al., 1964), an uplifted and dissected peneplanation surface of probable late Mesozoic to early Tertiary age (Twidale et al., 1985) developed on rocks of the Hamersley Basin. The surface is formed of lateritic duricrust (*Czl*).

ECONOMIC GEOLOGY

GOLD

The main gold production has come from the Shearers and Sunny South leases in the Jimblebar greenstone belt (Table 6).

The main lode at Shearers parallels banding within leached and altered BIF. The mineralization at Sunny South also parallels banding, but is along the margin of the BIF. In both cases, the gold is associated with pyrite and to a lesser extent pyrrhotite and chalcopyrite. The host rock comprises quartz, feldspar, blue-green amphibole, biotite, carbonate, and minor amounts of epidote and apatite. This is probably a metasomatically altered mafic rock adjacent to the BIF.

The relative age of mineralization is not known, but the reported occurrence of gold in quartz veins within granitoid 3 km southwest of Jimblebar (de la Hunty, 1969), indicates a possible relationship to fluid systems active during the intrusion of the main granitoid.

TABLE 6. GOLD PRODUCTION, PEAK HILL GOLDFIELD 1930 - 1987

	Alluvial (kg)	*Dollied* (kg)	*Ore treated* (t)	*Gold therefrom* (kg)	*Total gold* (kg)
Jimblebar mining centre	1.74	7.424	8712	97.544	106.708

CHROMITE

Chromite occurs at two localities. The main occurrence is the well-known Coobina deposit. The second consists of chromitite pods and lenses in a serpentinite sill 3.5 km east of Garden Well.

The deposit at Coobina is the largest known in Australia. It has been described by several authors (de la Hunty, 1969). The most recent descriptions, however, are by Bye (1975) and Baxter (1978). The deposit has been the subject of extensive exploration by BHP Pty Ltd.

Chromite occurs in about 200 pods and lenses, each up to 250 m long and 6 m wide. They are concentrated at the western end of the Coobina ultramafic intrusion. Baxter (1978) reports that the lenses have sharp southern and diffuse northern contacts. The lenses are discontinuous and extensively deformed. Their continuation at depth is uncertain, and this makes the calculation of ore reserves difficult (Bye, 1975).

The chromite ore consists of euhedral to subhedral chromite aggregates (up to 2 mm across) with intergranular chlorite and serpentine. Grades are low and individual lenses range from 46.4% to 50.8% Cr_2O_3. The Cr_2O_3:FeO ratios range from 2.3:1 to 1.35:1 (Baxter, 1978).

COPPER

The copper mineralization in the Jimblebar belt is associated with the felsic volcanic unit. Several copper shows, principally of malachite veinlets and disseminations in anastomosing networks of limonitic veins (Marston, 1979), occur along the length of the unit. The main occurrence is at Copper Knob. Ore production took place between 1959 and 1962 and totalled 84.09 t averaging 8.37% Cu (Marston, 1979). Low nickel:cobalt ratios of iron-sulphides (<0.5) indicate a magmatic-hydrothermal origin for the mineralization (Barley, 1974).

Exploration by Vam Ltd and Endeavour Resources has identified a volume of very low-grade disseminated mineralization, but in the absence of higher-grade concentrations, the prospect appears to have no economic potential (Marston, 1979). The calculated resource is 1 Mt at 0.77% Cu.

IRON

The Hamersley Group lies within the Hamersley Iron Province, as defined by MacLeod et al. (1963). Hematite deposits on ROBERTSON were first recognized during the 1st edition mapping of ROBERTSON (de la Hunty, 1969). Extensive iron-ore exploration has concentrated principally on the Brockman Iron Formation, although some work has been carried out on both the Marra Mamba Iron Formation and the Boolgeeda Iron Formation. A number of "martite(–hematite)–goethite" orebodies (Kneeshaw, 1984) have been identified. The principal deposits are at Wheelarra Hill, also known as Jimblebar or McCamey's Monster (Ward et al., 1975), and at Orebody 18 of Mount Newman Mining Co. at Shovelanna Hill. Iron-ore deposits within the Hamersley Iron Province and their genesis have been discussed by MacLeod (1966), Trendall (1975b), and Morris (1980, 1985). Ore formation took place in the early Proterozoic — after 2000 Ma (Morris, 1985). Tyler (in press) has related ore formation in the southeast Hamersley Basin to the development of the Bresnahan Basin exposed on TUREE CREEK and NEWMAN.

The deposits at Wheelarra Hill have been described by Ward et al. (1975). Typical phosphorous-rich (0.10 - 0.16% P), martite–goethite ore, reaching 55–65% Fe occurs almost continuously along the Brockman Iron Formation for a distance of 22 km. Within this are seven zones where the ore contains less goethite, and grades reach 69% Fe with phosporous contents of between 0.02 and 0.10%. Identified reserves are 797 Mt at 61.5% Fe.

Associated with these deposits are areas of scree ore developed during the Tertiary (Ward et al., 1975). These are related to stripping of the Hamersley Surface and contain fragments of high-grade ore. These deposits are currently being mined.

A limited amount of ore has also formed on the Marra Mamba Iron Formation. This ore is mainly yellow, moderately soft and porous, and contains martite with interstitial goethite. Some local high-grade hematitic ore is present in places (Ward et al., 1975).

MANGANESE

Several widely spaced, low-grade and low-tonnage manganese prospects occur on ROBERTSON (de la Hunty, 1969). A recent summary of activity in the southern half of the Pilbara manganese province as defined by de la Hunty, 1963 for the ROBERTSON prospects, is given by Williams (1989). All occurrences are small, thin cappings of manganese oxide. They are related to weathering and supergene enrichment of manganiferous shales. These occur at the base of the Balfour Formation. Small deposits west and northwest of Windaroo Well have been compared with the much larger deposits at Booginia Hill near Balfour Downs Homestead (de la Hunty, 1963, 1969).

BARITE

Several barite veins, occurring *en echelon* and striking 050°, cross the Billinnooka-Balfour Downs track 7 km north-northwest of the Billinnooka Homestead. Individual veins are up to 5 m wide and 100 m long and the zone containing the veins can be traced for over 500 m.

The veins consist of white, grey, and pink crystalline barite, and contain traces of copper mineralization. The trend of the veins is roughly parallel to regional faulting in the area. The host rocks are dolomite and interbedded shale belonging to the Enacheddong Dolomite.

Barite has also been reported from south of Billinnooka Homestead, but these localities were not located during the present survey.

Galena and associated barite occur in veins within a fault zone forming the northern margin of the Coobina ultramafic intrusion (2 km west of Murramunda).

GEMSTONES

Liesagang-banded opaline and chalcedonic silica has been intermittently worked 4 km southwest of Jigalong. A number of small open cuts and costeans have been developed along silicified fault zones in shale and siltstone of the Stag Arrow Formation. Finely banded violet, purple, blue, and cream-coloured material has been found in the deposits. The material has been used for polishing, tumbling, and slabbing.

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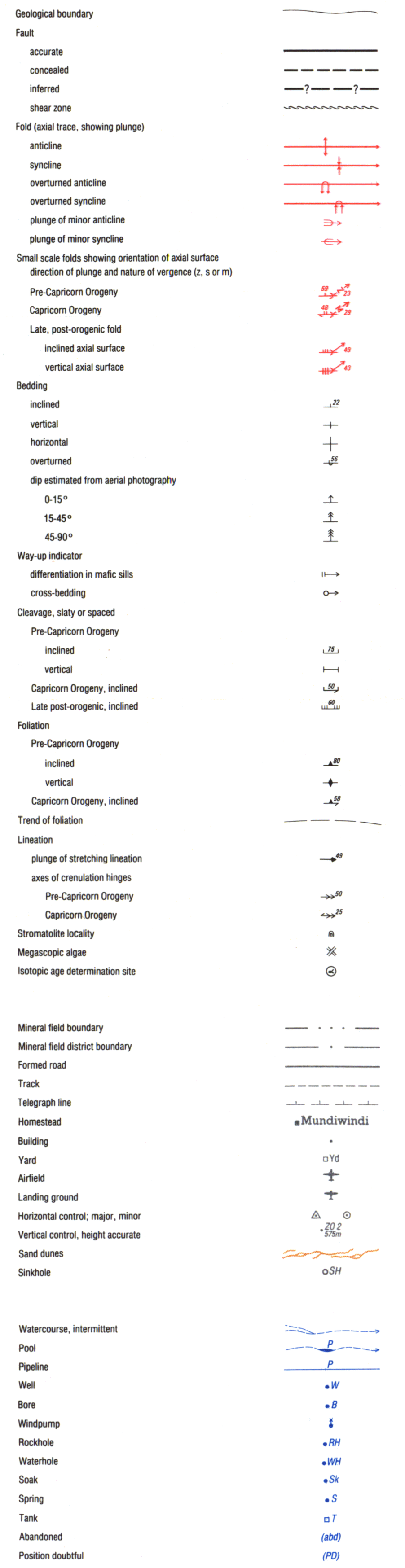

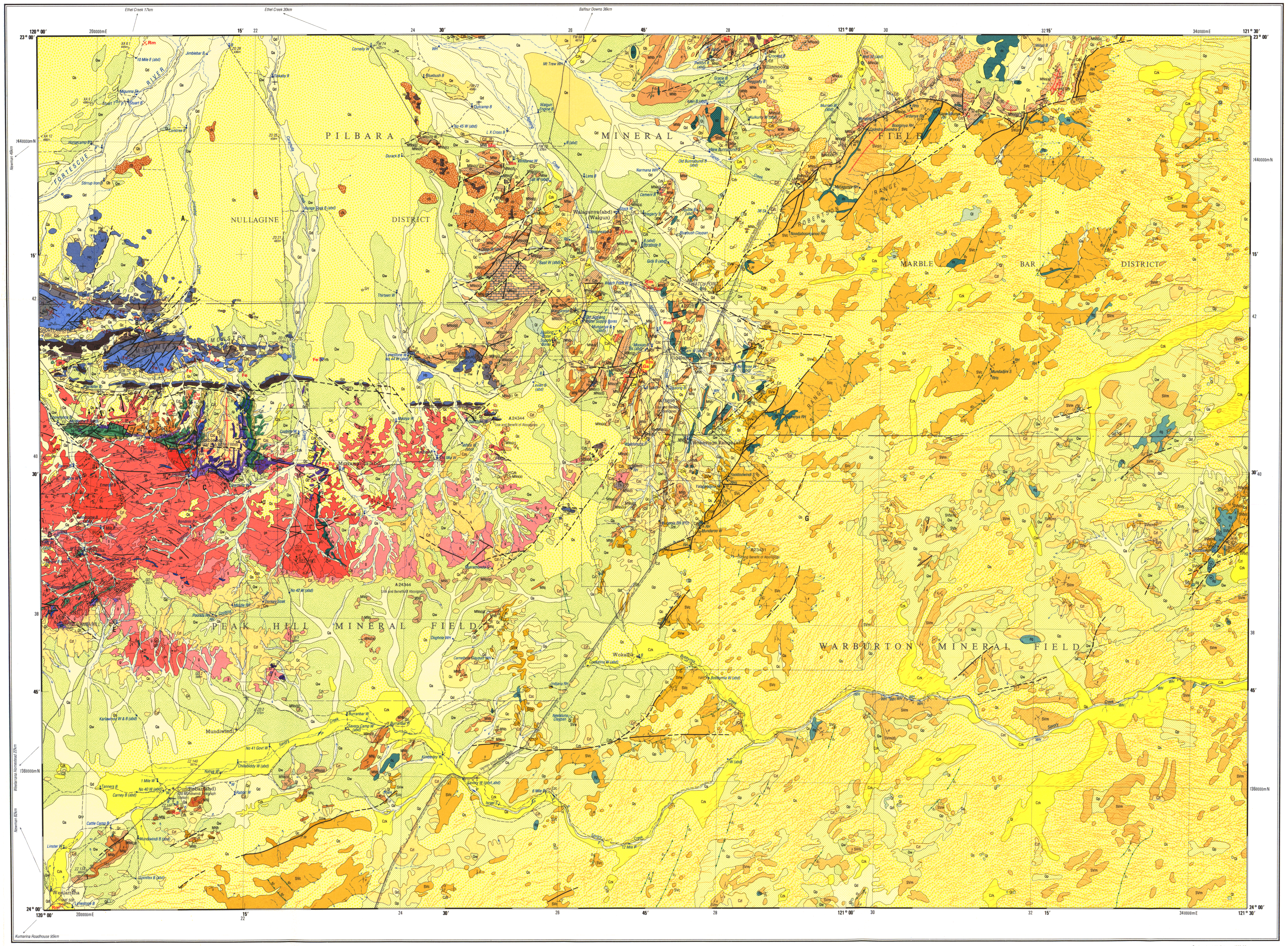

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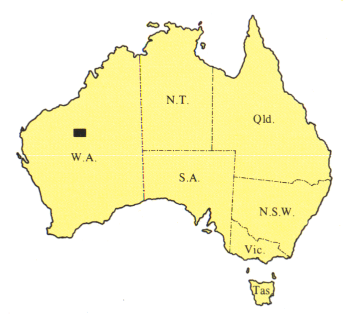

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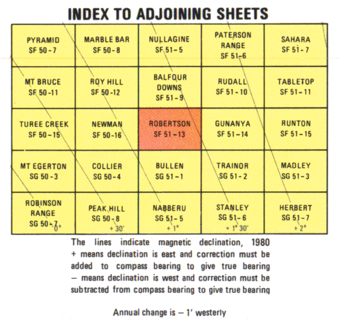

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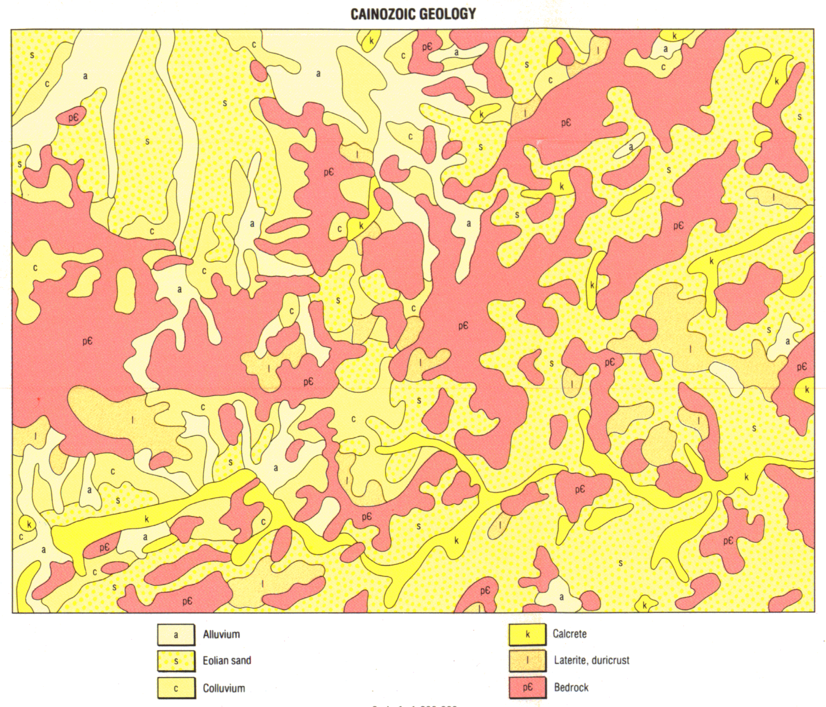

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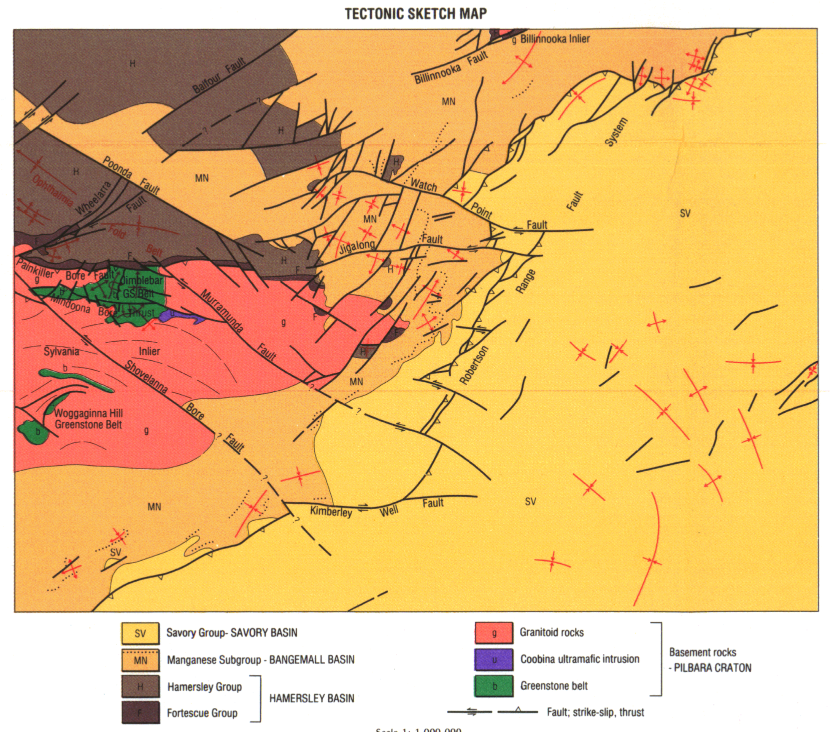
ZONE 51 AUSTRALIAN MAP GRID

TECTONIC SKETCH MAP



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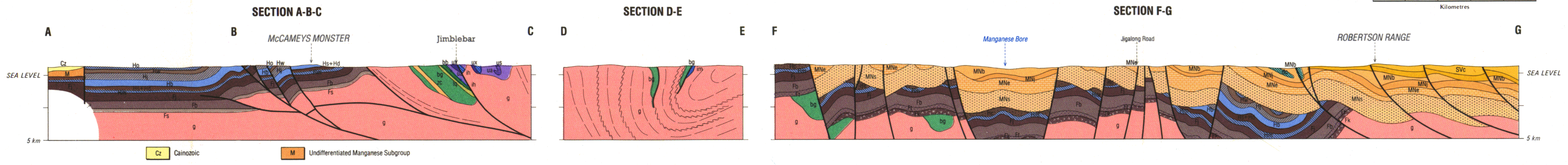

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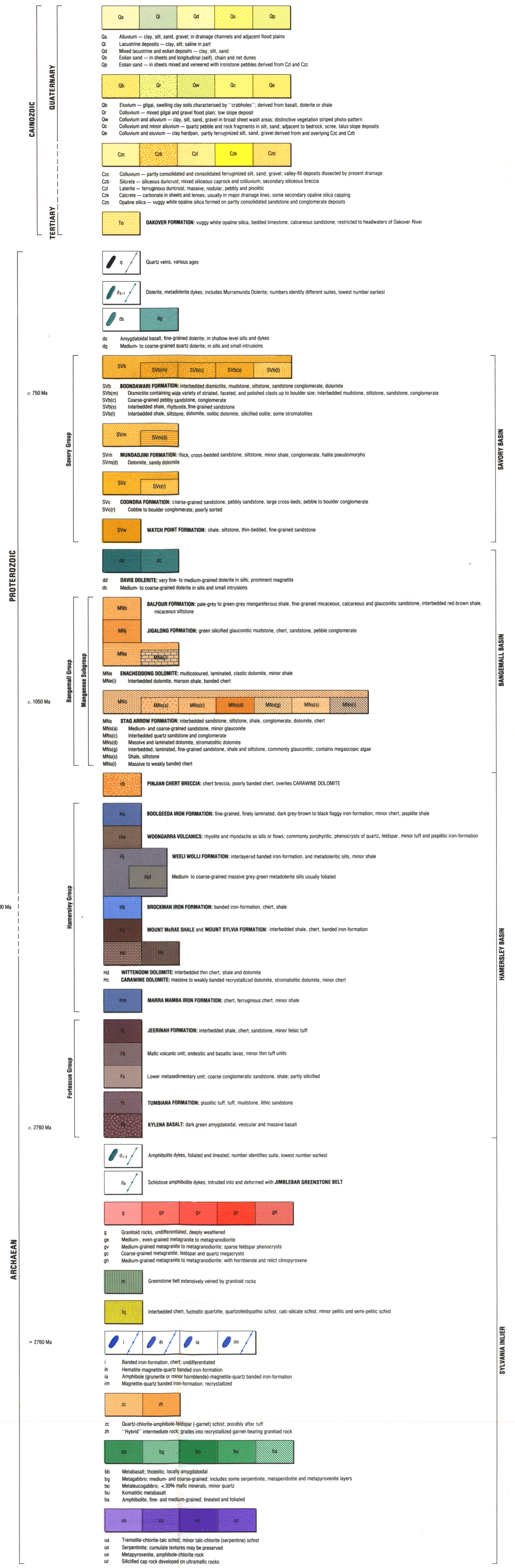

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