BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

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GEOLOGY OF THE HATCHES CREEK REGION 1:100 000

MAP SHEET, NORTHERN TERRITORY

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CONTENTS

SUMMARY

A detailed reconnaissance survey of the Hatches Creek region map sheet area, which covers the northeastern part of the Precambrian Davenport Geosyncline, was undertaken in 1981. The oldest rocks exposed are greywacke and siltstone of the 1850-1820 m.y. Warramunga Group in the far north. These were tightly folded and metamorphosed about 1810 m.y. ago, before being overlain unconformably by the Hatches Creek Group, which crops out extensively to the south. The Hatches Creek Group is intruded by granite plutons probably about 1660 m.y. old. The Proterozoic rocks are overlain by flat-lying Cambrian rocks of the Georgina Basin sedimentary succession and by Cainozoic sediments.

The Hatches Creek Group is at least 10 000 m thick, and is characterised by ridge-forming quartz-rich arenites and recessive sedimentary rocks, including some carbonates, and felsic and mafic volcanics. The sedimentary rocks were deposited in shallow marine to fluvial environments. The sequence is divided into Lower, Middle, and Upper parts, comprising 6, 7, and 5 informally named formations, respectively, and it includes intrusions, mainly sill-like, of granophyre, feldspar porphyry, dolerite, and gabbro. Before being intruded by granite the sequence was folded, faulted, and regionally metamorphosed to greenschist facies.

Tungsten, bismuth, copper, and gold have been produced from the area, but no mines are currently (1982) being worked. Deposits of tungsten, bismuth, and copper, with minor molybdenum, occur in quartz veins, mainly near Hatches Creek, and are probably related to granite intrusions. The gold mineralisation is closely related spatially and probably genetically to dolerite and gabbro.

INTRODUCTION

The Hatches Creek region map sheet is bounded by latitudes 20°25'S and 21°00'S and longitudes 135°00'E and 135°47'E. It occupies the southwestern part of FREW RIVER* and incorporates HATCHES, western half of HANLON and southernmost part of EPENARRA. The map sheet is named after the abandoned mining settlement of Hatches Creek in the southwest (latitude 20°56'S, longitude 135°12'E), and covers the northeastern part of the Davenport Geosyncline - an area of Precambrian rocks situated between the Precambrian Arunta and Tennant Creek Blocks to the south and north, respectively, and between the Palaeozoic Wiso and Georgina Basins to the west and east, respectively. The Hatches Creek region contains outcrops of Warramunga Group (in far north) and Hatches Creek Group rocks and felsic and basic intrusives, all of which are Proterozoic, flat-lying Cambrian sedimentary rocks of the Georgina Basin succession, and Cainozoic generally unconsolidated sediments.

A detailed reconnaissance survey of the Precambrian rocks of the Hatches Creek region was carried out by the authors from June to October 1981. Some additional information was obtained during the 1982 field season by I.P. Sweet (BMR), who studied sedimentological aspects of the Hatches Creek Group (Sweet, in preparation), and also by D.H.B. Laboratory investigations have included petrographic and petrological studies (still in progress). The survey is part of the Davenport Geosyncline project being carried out jointly by the Bureau of Mineral Resources (BMR) and the Northern Territory Geological Survey (NTGS). The broad aims of this project are

1, to determine the detailed stratigraphy, structure, geological history, and mineral potential of the Davenport Geosyncline;
2, to determine the tectonic setting and crustal evolution of this part of central Australia;
3, to provide the geological framework for a, the interpretation of the subsurface geology of the margins of the Georgina Basin and Wiso Basin, b, concurrent airborne and surface geophysical investigations, and c, concurrent stream sediment and weathered rock geochemistry;
4, to relate the geology of the Arunta region to the south with the Tennant Creek region to the north.

Footnote * Names of standard 1:250 000 sheet areas are in capital letters underlined; names of standard 1:100 000 sheet areas are in capital letters not underlined

The Davenport Geosyncline project was started in 1981 and is due to be completed in 1984.

Habitation and access

The only permanent habitation in the map area is at Epenerra homestead in the far north. An unsealed road connects this homestead and the abandoned Hatches Creek settlement with the Stuart Highway to the west via Murray Downs homestead in the south and Kurundi homestead in the north. Tracks joining this unsealed road provide limited access to other parts of the area. Travel by vehicle across country is relatively easy in the north, but is impeded by numerous steep-sided strike ridges to the south. Airstrips suitable for light aircraft are located at Epenarra, at Kurinelli outstation 30 km southwest of Epenarra, and near the Pioneer mine at Hatches Creek.

Climate

The region has a semi-arid tropical climate. Climatic data for Barrow Creek to the southwest and Tennant Creek to the northwest indicate that the average annual rainfall is about 300 mm, most of which is received from November to March. On average there are about 30 rainy days per year. Maximum temperatures of over 40°C are common in the summer months and minimum temperatures of less than 10°C are common in winter. Frosts occur occasionally in July. Climatic features are discussed in greater detail by Slatyer (1962).

Vegetation

Spinifex with sparse low trees and shrubs is the most abundant vegetation (Perry & Lazarides, 1962). Small patches of "turpentine" bush on rocky ridges and of mulga and gidgea in depressions are common locally. Eucalypts line some of the larger watercourses, especially near waterholes. A variety of grasses grow on plains and valley flats.

Topography and drainage

The map sheet lies mainly within the Davenport Range subdivision of the Northern Uplands of Mabbutt (1962). It is characterised by long and commonly sinuous, steep-sided, narrow to broad, ridges and valleys. The main ridges typically have concordant summit levels (bevelled crests). There are also cuestas, hogs back ridges, mesas, and extensive plains (especially in the

north). Flat sandy semi-desert with low sand dunes predominates in the far east. The local relief rarely exceeds 100m.

The largest drainage system in the map sheet is that of the northward-draining Frew River and its main tributaries Lennee, Hatches, and Mia Mia Creeks in the west. To the east are the drainage systems of the northward-draining Teatree and Hanlon Creeks, the eastward-flowing Poison and Yaddanilla Creeks in the far east, and the southeasterly draining Gastrolobium Creek in the south. These watercourses flood-out and disappear on the plains. According to Mabbutt (1962), the Frew River previously flowed into a former lake system on the Barkly Tableland.

Water supplies

Numerous permanent, semi-permanent and seasonal waterholes, some several hundreds of metres long, occur along the main water-courses, and also in many of the smaller creeks within the ranges in the west and south. A few waterbores, in various states of repair, are located on plains in the central and northern parts of the area. For a general account of the water resources see Jones & Quinlan (1962).

Previous investigations

The only previous systematic geological survey of the map sheet was undertaken by Bureau of Mineral Resources geologists in 1956 as part of broad reconnaissance survey of the whole of the Davenport and Murchison Ranges. Results of this work were published in a BMR Report (Smith & others, 1961), in the explanatory notes for FREW RIVER (Smith, 1964) and three adjoining map sheets - BONNEY WELL (Smith, 1970), BARROW CREEK (Smith & Milligan, 1964), and ELKEDRA (Smith & Milligan, 1966). A detailed investigation of the Hatches Creek mineral field was carried out at the same time by Ryan (1961). These publications contain accounts of previous investigations in the map area to 1962. More recently, brief descriptions of the general geology and mineralisation in the region have been given by Crohn (1976) and Roarty (1977).

Map compilation

The accompanying preliminary edition map of the Hatches Creek Region was compiled using vertical colour aerial photographs at about 1:25 000 scale, taken in September 1980, for HATCHES 1:100 000 sheet, and FREW RIVER RC 9 black

and white vertical aerial photographs at about 1:80 000 scale, taken in 1963, for HANLON and EPENARRA. Field data was plotted on transparent overlays on the aerial photographs and then transferred onto photo-scale compilation sheets by the draftsman (C.L. Knight, BMR).

Rock nomenclature

Terms used are as defined in the Glossary of Geology (Bates & Jackson, 1980).

Sandstones are classified according to the scheme of Pettijohn, Potter, & Siever (1972). Grainsize terms are fine, 0.125 to 0.25 mm; medium, 0.25 to 0.5 mm; coarse, 0.5 to 1 mm. Bedding thickness terms are laminated, less than 1 cm; thin-bedded, 1 to 50 cm; medium-bedded, 50 cm to 2 m; thick-bedded, over 2 m.

The classification recommended by Streckeisen & others (1973) is used for plutonic igneous rocks. Grainsizes for igneous rocks are fine, less than 1 mm; medium, 1 to 5 mm; coarse, 5 mm to 3 cm. Terms describing metamorphic facies and grades are as defined by Turner & Verhoogen (1960).

OUTLINE OF GEOLOGY

The Hatches Creek region map sheet covers the northeastern part of the Davenport Geosyncline, a major Proterozoic tectonic unit which is situated between two Proterozoic terrains, the Arunta region to the south and the Tennant Creek region to the north, and is overlain to the west and east by Lower Palaeozoic sediments of the Wiso and Georgina Basins, respectively.

The oldest rocks exposed in the map sheet are interbedded greywacke and siltstone of the Warramunga Group in the far north. This group is between 1850 and 1820 m.y. old, and was tightly folded on a medium scale, wave length of folds generally less than a kilometre, probably about 1810 m.y. ago. Following a period of erosion, the Warramunga Group was overlain by the Hatches Creek Group, a sequence, more than 10 000 m thick in places, of shallow water sediments and interlayered felsic and mafic volcanics at least 1660 m.y. old.

The Hatches Creek Group is divided into Lower, Middle, and Upper parts. In the Lower Hatches Creek Group the six formations recognised are

partly lateral equivalents, whereas the seven formations of the Middle Hatches Creek Group and five of the Upper Hatches Creek Group form a mainly layer-cake-type sequence. The formation names have not yet been formalised. The group as a whole is characterised by ridge-forming arenite units separated by less resistant units of commonly much weathered sedimentary and volcanic rocks. Many of the volcanic rocks were previously mapped as intrusives. The sedimentary rocks consist largely of detrital quartz derived from outside the region and feldspar (commonly altered), mica, lithic clasts, and kaolinitic/sericitic material, some of which represent locally derived volcanic detritus; some carbonates and possible evaporites are also present. Most ridge-forming arenites are quartz-rich, whereas recessive sandstones are generally feldspathic or lithic and commonly have a relatively abundant clayey or micaceous matrix. Widespread cross-bedding and ripple marks, common convolute bedding and related structures, rare mud cracks and moulds and casts of evaporite minerals, and the presence of stromatolites in one formation and of pebbly to conglomeratic beds in several formations indicate that most, if not all, the sediments were deposited in shallow water. The volcanic rocks include both lavas and pyroclastics, and were erupted either subaerially or into shallow water.

The basal formation of the Lower Hatches Creek Group in the north is the Epenarra Volcanics, which consists of felsic and minor mafic lavas and pyroclastics, invariably much altered, together with interlayered partly volaniclastic sediments. It lies unconformably on the Warramunga Group and is overlain by, and also passes laterally into, the Rooneys Formation to the east and the Kurinelli Sandstone to the west. The Rooneys Formation, which is overlain by Kurinelli Sandstone to the south, is formed mainly of thin bedded, fine-grained, locally schistose, quartz-poor arenite and siltstone. The Kurinelli Sandstone consists of thicker bedded, coarser-grained, and more quartzose clastic rocks. In the south, near Hatches Creek, it includes two distinctive members. These are the Endurance Sandstone Member, which is similar in lithology to the Rooney Formation to the north, and the Warnes Sandstone Member, in which original bedding appears to have been destroyed, perhaps during pre-consolidation slumping.

Overlying the Kurinelli Sandstone is a mainly ridge-forming unit of pebbly arenite, the Taragon Sandstone, which is overlain by, and partly

interlayered with, felsic lavas of the Treasure Volcanics. This volcanic unit also includes some basaltic and probably andesitic lavas and interlayered clastic sediments. A probable correlative of the Treasure Volcanics, the Mia Mia Volcanics, is exposed in the core of a large dome in the far south. It consists mainly of highly altered and strongly cleaved felsic pyroclastics, but also includes some felsic lavas and interlayered arenites. These volcanic formations are overlain conformably and possibly also disconformably by the Unimbra Sandstone, the lowest unit of the Middle Hatches Creek Group.

The Unimbra Sandstone is one of three major region-wide ridge-forming units of quartzose arenite, the others being the Coulters Sandstone and the Errolola Sandstone, at the centre and top respectively of the Middle Hatches Group. The Unimbra Sandstone includes some felsic lavas, similar to those of the Treasure Volcanics, in the far southwest. It is overlain by another unit of mainly felsic volcanic rocks, the Arabulja Volcanics, and a laterally equivalent unit of variably volcaniclastic arenites and finer grained sedimentary sedimentary rocks, the Yeeradgi Sandstone, both of which are overlain by the Coulters Sandstone. This formation is separated from the younger Erropola Sandstone by recessive clastic and calcareous rocks of the Frew River Formation, which locally includes some stromatolites, and overlying basaltic lavas of the Kudinga Basalt. The latter formation generally contains thin bands of ridge-forming feldspathic arenite near its base.

The Alinjabon Sandstone, at the base of the Upper Hatches Creek Group, is conformable on the Errolola Sandstone. It consists of interbanded ridge-forming arenites and recessive finer grained sedimentary rocks and one or more flows of highly altered mafic lava. The overlying recessive Leenee Creek Formation, mainly quartz-poor friable arenite and siltstone, is exposed in the west, in the central parts of large synclinal folds; in the east (in HANLON) it is overlain by easterly dipping ridge-forming arenite and minor recessive siltstone of the Canulgerra Sandstone, recessive sedimentary rocks of the succeeding Vaddingilla Formation, and ridge-forming arenite of the Yaddanilla Sandstone, the youngest formation of the Hatches Creek Group exposed in the region.

Formations of the Lower Hatches Creek Group are intruded by sill-like bodies of granophyre, felsic porphry, dolerite and gabbro, which may be comagmatic with some of the felsic and mafic volcanics of the group, and also by granite plutons. There are also some granophyre sills within the Unimbra Sandstone of the Middle Hatches Creek Group in the far southwest.

The Hatches Creek Group and sills intruding it have been folded into several major, upright, open to tight synclines, anticlines and domes. They have also been displaced by numerous faults and probably some bedding-plane thrusts, and are regionally metamorphosed to greenschist facies. Some major faults are marked by ridge-forming quartz veins. A pronounced axial plane cleavage is developed in many of the Hatches Creek Group rocks, especially in the fine-grained sedimentary rocks and in felsic pyroclastics. The main folds have wavelengths of several kilometres, somewhat sinuous trends, and variable plunges. Smaller scale subsidary folds are developed locally, mainly in the axial zones of the major folds. The folding and metamorphism, and much of the faulting, are thought to have taken place before the emplacement, probably about 1660 m.y. ago, of the granite plutons.

Tungsten and associated subordinate copper and minor bismuth and molybdenum mineralisation in the map area, mainly near Hatches Creek, is probably related to granite intrusions. The ore minerals occur in cross-cutting quartz veins which post-date the main folding event. Traces of copper minerals have also been found in basalts of the Hatches Creek Group. Gold mineralisation is closely related spatially and probably genetically to dolerite and gabbro bodies intruding the Hatches Creek Group.

The Warramunga and Hatches Creek Groups are overlain by flat-lying Lower Palaeozoic (mostly Cambrian) unmetamorphosed conglomerate, sandstone, chert, and siltstone of the Georgina Basin succession, and by unconsolidated Cainozoic sediments.

DESCRIPTIVE NOTES ON PRECAMBRIAN UNITS

Warramunga Group

Map symbol: Pw.

Nomenclature. Named by Ivanac (1954). No constituent formations identified in HATCHES CREEK REGION, although some have been recognised near Tennant Creek (Dodson & Gardener, 1978).

Distribution. Far north of map sheet, mainly southeast of Epenarra homestead.

Thickness. Not known for several reasons: tight folding, lack of marker beds, widely separated and generally sparse exposures, neither stratigraphic top nor base identified.

Airphoto expression. Low hilly terrain with mainly medium tones; outcrop area southeast of Epenarra homestead has rounded ridges and a dendritic drainage pattern.

Rock types. Medium to fine-grained greywacke and siltstone which are much weathered (kaolinitic and lateritic), and medium to thin bedded.

Structure. Beds are tightly folded about steeply dipping axial planes; wave lengths of folds are typically less than 1 km. Folding pre-dates deposition of the Hatches Creek Group, and probably took place at about 1810 m.y. (Black, 1977, 1981).

Metamorphism. Probably lower or middle greenschist facies; little apparent recrystallisation; no diagnostic minerals identified.

Relationships. Overlain unconformably by agglomerate and felsic porphyry of the Epenarra Volcanics, Hatches Creek Group, at GR 703363, 4.3 km southeast of Epenarra homestead, and by flat-lying Cambrian beds, mainly conglomerate. Unconformity with overlying Hatches Creek Group well exposed in OORADIDGEE and BONNEY to west and northwest.

Age. Felsic volcanics of the Bernborough Formation within the Warramunga Group north of Tennant Creek have been isotopically dated by the U-Pb zircon method at between 1849 and 1819 m.y. (Black, 1981).

Mineralisation. Cut by quartz-hematite veins containing small amounts of wolframite and pyrite at Woodenjerrie mine (GR 280370), which was worked for tungsten in 1952-1953; production minor; workings consist of shallow shafts (collapsed), pits and costeans.

Hatches Creek Group

Nomenclature. Named by Hossfeld (1954), presumably after Hatches Creek mining field in S HATCHES; name retained, but usage slightly modified, by Smith & others (1961) and Ryan (1961), whose usage is followed in this report (see Remarks below). Not previously subdivided into constituent formations.

Constituent formations. 18 newly named formations and two newly named members recognised in the Hatches Creek Region - Epenarra Volcanics, Rooneys Formation, Kurinelli Sandstone, Taragan Sandstone, Treasure Volcanics and Mia Mia Volcanics, which are assigned to Lower Hatches Creek Group; Unimbra Sandstone, Yeeradgi Sandstone, Arabulja Volcanics, Coulters Sandstone, Frew River Formation, Kudinga Basalt, and Errolola Sandstone, which are assigned to Middle Hatches Creek Group; and Alinjabon Sandstone, Lennee Creek Formation, Canulgerra Sandstone, Vaddingilla Formation and Yaddanilla Sandstone, which are assigned to Upper Hatches Creek Group. Kurinelli Sandstone includes Warnes Sandstone Member and Endurance Sandstone Member. An additional newly named formation, Edmirringee Volcanics, is present in NE DAVENPORT RANGE. The new names have not yet been formalised.

Lower, Middle and Upper Hatches Creek Group (Blake & others, 1982). Base of Unimbra Sandstone (the lowest major ridge-forming formation in the sequence) is taken as boundary between Lower and Middle Hatches Creek Group, as it marks the base of region-wide layer-cake stratigraphy. Units below Unimbra Sandstone, those of Lower Hatches Creek Group, interfinger laterally with one another. Top of uppermost region-wide

ridge-forming formation, Errolola Sandstone, is taken as boundary between Middle and Upper Hatches Creek Group.

Distribution. Crops out extensively in HATCHES, W HANLON, and S EPENNARA of FREW RIVER, and in adjoining parts of ELKEDRA, BONNEY WELL, and BARROW CREEK.

Thickness. Probably at least 13 000 m:- Lower Hatches Creek Group, 5000 m+; Middle Hatches Creek Group, average about 3700m: Upper Hatches Creek Group (in HANLON), 4300 m+.

Rock types. Ridge-forming sandstones (quartz arenite, feldspathic/lithic quartz arenite, and minor conglomeratic arenite) and recessive sedimentary rocks (friable sandstone, siltstone, shale, and some carbonates) and volcanics (basaltic lavas, felsic lavas and pyroclastics).

Structure. Strata moderately to tightly folded and extensively faulted; dips gentle to steep and locally overturned. Fold structures include large dome in SW, several major anticlines and synclines (wave lengths of several kilometres), and local small folds (wave lengths less than 1 km). See separate section (Structure of the Hatches Creek Group) for details.

Metamorphism. Regionally metamorphosed to greenschist facies and possibly locally to lower amphibolite facies; axial plane cleavage well developed in some units; schistose rocks present locally; metamorphic minerals commonly developed are chlorite, epidote, sericite/muscovite, and greenish-brown biotite. Contact metamorphism resulting in recrystallisation (hornfels) is restricted to within a few metres of igneous intrusions.

Relationships. Overlies Warramunga Group unconformably in north; base not seen elsewhere; overlain unconformably by flat-lying Phanerozoic strata; intruded by dolerite/gabbro (unit Ed), granophyre and feldspar porphyry (unit Egy), and granite (unit Eg).

Age. Younger than 1810 m.y. and older than 1660 m.y. Unconformably underlying Warramunga Group includes felsic volcanics north of Tennant Creek which have been isotopically dated by U-Pb zircon method at between 1819 and 1849m.y.

(Black, 1981), and it was folded, prior to the deposition of Hatches Creek Group rocks, at about 1810 m.y. (Black, 1977). Granite intruding the Hatches Creek Group has been dated by the Rb-Sr method (Riley, in Compston & Arriens, 1968), at 1695 m.y., using $1.39 \times 10^{-11} y^{1}$ as the decay constant for Rb 87, or 1660 m.y., using $1.42 \times 10^{-11} y^{-1}$ as the decay constant, and by the K-Ar method (Hurley & others, 1961) at 1320 - 1540 m.y.

Correlations. Possible correlatives include the Tomkinson Creek beds in the north of the Tennant Creek Block (Dodson & Gardener, 1978), the Mount Winnecke Sandstone of The Granites-Tanami region (Blake & others, 1980), Division 3 rocks of the Arunta Inlier (Stewart & Warren, 1977), and Carpentarian units of the McArthur Basin, Pine Creek Inlier, and Mount Isa Inlier (Plumb & others, 1981).

Mineralisation. The Lower Hatches Creek Group is cut by quartz veins containing W, Au, Cu, and minor Bi and Mo minerals, mainly in the vicinity of Hatches Creek, in HATCHES, Mafic laves of the Group locally contain Cu minerals in amygdales.

Remarks. According to Hossfeld (1954), the Hatches Creek Group comprises rocks he had previously assigned to the Hatches Creek Series and the Top Series (in AGGSNA, 1941). Smith & others (1961) extended the Group to include the Bottom Series (AGGSNA, 1941, and Hossfeld, 1954), which was considered by Hossfeld to be overlain unconformably by the Hatches Creek Series but was found by Smith & others to be essentially part of the same concordant and generally conformable sequence. Of the three units recognised by Hossfeld (in AGGSNA, 1941), the Bottom Series corresponds to the Mia Mia Volcanics of the Lower Hatches Creek Group, the Hatches Creek Series is equivalent to parts of the Kurinelli Sandstone, Taragan Sandstone and Treasure Volcanics of the Lower Hatches Creek Group and the Unimbra Sandstone, Arabulja Volcanics, and Coulters Sandstone of the Middle Hatches Creek Group, and the Top Series comprises parts of the Taragan Sandstone and Treasure Volcanics of the Lower Hatches Creek Group.

The sedimentary rocks of Hatches Creek Group appear to be shallow water deposits, partly marine and partly fluvial (Sweet, in prep.). The associated

volcanics may be partly subaerial and partly subaqueous.

Epenarra Volcanics

Map symbol. Ꝑhr, Ꝑhr$_s$.

Derivation of name. Epenarra homestead, GR 272394, EPENNARA, FREW RIVER.

Distribution. In northern HATCHES and adjoining part of EPENNARA; extends west into DAVENPORT RANGE, EPENNARA, OORADIDGEE, and BONNEY

Type section. Yet to be selected.

Thickness. Uncertain because of faulting; maximum probably more than 3000m.

Airphoto expression. Low to very low ridges and mounds with variable airphoto tones; bedding trends visible in parts.

Rock types. Ꝑhr: generally recessive felsic and mafic? volcanics and mainly subordinate sedimentary rocks. Ꝑhr$_s$: ridge-forming arenite and minor volcanics, mainly in upper part of formation. Quartz veining common.
Felsic volcanics: generally phyllitic to schistose and much altered; pale to dark shades of grey, purple, pink and brown; include quartz-feldspar porphyry and feldspar porphyry which are mainly ignimbritic, breccia (angular volcanic fragments in arenite matrix), agglomerate, and fine to medium grained, thin-bedded to laminated tuff, lappilli tuff, and highly tuffaceous arenite. Mafic? volcanics: very altered fine-grained reddish brown rocks; commonly amygdaloidal; non porphyritic.
Arenites: white to pale grey, or iron-stained; quartzose to volcaniclastic; medium grained to coarse-grained, also conglomeratic, with angular to rounded pebbles of vein quartz and fine-grained volcanic rocks; medium to thin bedded; generally silicified, locally glassy, and variably sheared; cross bedding common. Arenites in upper part of formation are commonly identical to either those of Kurinelli Sandstone or those of Rooneys Formation.

Structure. Steeply-dipping and generally south-facing; commonly cleaved. Cleavage is mostly subparallel to bedding, and is crenulated in places.

Relationships. Unconformable on Warramunga Group 4.5 km SE of Epenarra homestead; overlain conformably to S by Kurinelli Sandstone and Rooneys Formation, parts of which appear to be lateral equivalents of the Epenarra

Volcanics; unconformably overlain by flat-lying Cambrian rocks of the Georgina Basin sedimentary succession; intruded by sill-like bodies of granophyre and dolerite.

Mineralisation. None known.

Remarks. May include oldest rocks of Hatches Creek Group in region. Consists of probably partly subaerial volcanics and shallow water sediments laid down on irregular surface of considerable relief formed on Warramunga Group rocks.

Rooneys Formation

Map symbols. Ꝑhn, $Ꝑhn_{sh}$.

Derivation of name. Rooneys Yard (GR 308430), HATCHES, FREW RIVER.

Distribution. Northern HATCHES and HANLON.

Type section. Near Kurinelli gold mine, from axis of small anticline at GR 066180 (base) to GR 032207 (top).

Thickness. Uncertain because of scattered outcrops and variable dips: about 1200 m exposed in type section.

Airphoto expression. Low ridges, hills, cuestas, mesas and mounds; medium to dark tones.

Rock types. Ꝑhn: mainly non-schistose, thin-bedded to laminated, variably micaceous siltstone and fine-grained arenite shades of grey and less commonly green, or iron-stained; friable to silicified; some calcareous beds in places; bedding plane partings well developed; arenites more commonly feldspathic and/or lithic (tuffaceous?) than quartzose; some convolute and recumbent cross-bedding. $Ꝑhn_{sh}$: micaceous siltstone and arenite in E, now mainly pale grey to iron-stained, fine to medium grained muscovite-quartz schist and micaceous quartzite.

Structure. Ꝑhn is mainly flat-lying to gently dipping, $Ꝑhn_{sh}$ is moderately to steeply dipping.

Relationships. Ꝑhn is conformable on Epenarra Volcanics, conformably overlain by Kurinelli Sandstone, and intruded by dolerite and granophyre sills in W

and by granite in E. Parts are probably laterally equivalent to parts of Epenarra Volcanics and Kurinelli Sandstone. Ꝑhn$_{sh}$ is intruded by granite; contacts with other units of Hatches Creek Group are concealed; it maybe a much older unit, perhaps part of the Warramunga Group.

Mineralisation. Ꝑhn is cut by auriferous quartz veins in Kurinelli area, NW HATCHES.

Remarks. Ꝑhn probably representa a shallow water deltaic sequence (Sweet, in preparation) which may consist partly of volcanic material erupted during penecontemporaneous volcanism.

Kurinelli Sandstone

Map symbols. Ꝑhk, Ꝑhk$_v$, Ꝑhk$_w$ (Warnes Sandstone Member), Ꝑhk$_d$ (Endurance Sandstone Member).

Derivation of name. Kurinelli gold mine, GR 041206, northwest HATCHES, FREW RIVER.

Distribution. Central and northern HATCHES; extends west into BONNEY WELL and BARROW CREEK. Warnes Sandstone Member and Endurance Sandstone Member crop out in southern central HATCHES.

Type section. Yet to be selected.

Thickness. Uncertain because of folding and faulting; probably at least 2000 m in places.

Airphoto expression. Ꝑhk: series of strike ridges and cuestas, with mainly medium tones and clearly visible bedding trend lines, separated by depressions. Ꝑhk$_v$ recessive, exposed only on gullied footslopes. Ꝑhk$_w$: Knobbly ridges with medium tones, bedding trends typically absent. Ꝑhk$_d$: recessive with relatively dark tones and faint bedding trends.

Rock types. Ꝑhk: ridge-forming feldspathic, lithic and quartzose arenites; recessive siltstone, friable arenite, thin-bedded tuffaceous? beds, and rare felsic (andesitic?) lava and silicified ashstone. Ꝑhk$_v$: recessive andesitic lava and minor fine-grained tuffaceous beds. Ꝑhk$_w$ and Ꝑhk$_d$: described separately.

Arenites: white to pale grey or pink or iron-stained; friable to silicified; weakly calcareous and possibly evaporitic in a few places, also volcaniclastic/tuffaceous; generally well bedded; thin bedded, especially in lower part, to thick bedded, especially in upper part; fine to medium-grained, generally coarsest in upper part; mainly well sorted, but grit clasts and small pebbles, mainly of quartz, present in some beds; sand grains well rounded to angular, consist of quartz and sparse to abundant feldspar and/or volcanic rock and/or kaolinite; some muscovite flakes commonly present; sparse to abundant kaolinitic matrix; cross-bedding common; ripple marks, convolute and recumbent bedding, and bedding planes with mudstone/siltstone pellets common in places.

Siltstone: iron-stained to bleached, thin bedded to laminated; commonly friable and feldspathic/kaolinitic; variably micaceous; rarely calcareous; possibly tuffaceous.

Andesitic lava: maroon to reddish-brown - iron-stained, much altered; very fine grained, non porphyritic, and generally no amygdales; platy jointing common. Some andesite may be intrusive rather than extrusive.

Relationships. Conformable on Epenarra Volcanics and Rooneys Formation in north; overlain conformably by Taragan Sandstone; intruded by gabbro/dolerite, granophyre, and granite. Probably includes lateral equivalents of Epenarra Volcanics and Rooneys Formation near base and Taragan Sandstone near top.

Mineralisation. Cut by quartz-veins containing tungsten, gold and copper minerals.

Remarks. Sedimentary structures indicate that the formation was probably deposited in shallow marine, deltaic, and associated fluvial environments (Sweet, in preparation). Part of feldspathic/lithic/kaolinitic content may represent contemporaneous tuffaceous and/or volcaniclastic detritus.

Warnes Sandstone Member of the Kurinelli Sandstone

Map symbol. Ehk_w.

Derivation of name. Warnes Gully, between Hatches and Mia Mia Creek, at about GR 180871, HATCHES, FREW RIVER.

Distribution. In Hatches Creek mining area, southern central HATCHES.

Type section. From about GR 192886 to GR 192878. Here the member is well exposed on two strike ridges, but neither its top nor base are exposed. Contacts with underlying and overlying undivided Kurinelli Sandstone are exposed at GR 202910 and GR 178877 respectively.

Thickness. 0 to about 500 m.

Rock types. Variably feldspathic/lithic quartz arenite: bleached to iron-stained; medium to coarse grained; poorly sorted, with scattered grit grains and small pebbles of vein quartz common; friable to patchily silicified; irregularly jointed; bedding absent or poorly displayed; rare cross-bedding.

Relationships. Forms conformable lenses within Kurinelli Sandstone; intruded by dolerite/gabbro and granophyre.

Mineralisation. Cut by some W-bearing quartz veins, as on south side of Wolfram Hill at Hatches Creek.

Remarks. Forms distinctive knobbly ridges of essentially non-bedded and poorly sorted quartzose arenite. Original bedding may have been destroyed by slumping and/or earthquake (volcanic?) shaking prior to consolidation.

Endurance Sandstone Member of the Kurinelli Sandstone

Map symbol. Bhk_d.

Derivation of name. Endurance mine, GR 914190, HATCHES, FREW RIVER.

Distribution. Southern central HATCHES, near Hatches Creek.

Type section. 1.5 km east of Pioneer mine, from GR 202930 (base) to GR 203925 (top). Here typical rock types of member - thinly interbedded greywacke and siltstone - are intruded by dolerite/gabbro and overlain and underlain by feldspathic arenites of undivided Kurinelli Sandstone.

Thickness. 0 to about 500 m.

Rock types. Grey, thinly interbedded fine-grained micaceous greywacke and siltstone which are generally quartz-poor and commonly show graded bedding; minor medium to thin bedded, variably feldspathic, quartz arenite.

Relationships. Conformable lens within Kurinelli Sandstone. Intruded by dolerite/gabbro.

Mineralisation. Cut by quartz veins containing W and Bi mineralisation.

Remarks. Generally finer grained, more micaceous, and less quartzose than other parts of Kurinelli Sandstone. May represent a tongue of Rooneys Formation.

Taragan Sandstone

Map symbols. Ꝑho, $Ꝑho_1$.

Derivation of ame. Taragan Waterhole, GR 057102, on Lennee Creek, HATCHES, FREW RIVER.

Distribution. Main outcrops in central HATCHES, in general vicinity of Old Police Station Waterhole, GR 195048, and to south. Also crops out to east, and extends west into DAVENPORT RANGE.

Type section. In DAVENPORT RANGE.

Thickness. Maximum probably over 1000 m, as near abandoned Demseys homestead (GR 392005) and possibly also in general vicinity of Old Police Station Waterhole (GR 185065).

Airphoto expression. Ꝑho: strike ridges, cuestas, and plateaus with mainly moderate tones and prominent joint and bedding trend lines. $Ꝑho_1$: depressions, low hills and mounds with darker tones than Ꝑho.

Rock types. Ꝑho: quartz-arenite and feldspathic lithic quartz arenite which are generally pebbly; minor beds of conglomerate and siltstone; felsic lava present locally. $Ꝑho_1$: siltstone, mudstone, and friable arenite which may be feldspathic; minor silicified arenite and calcareous beds.

Arenites: pale pinkish to grey or white; friable to silicified; medium to thick bedded; medium to coarse-grained and commonly poorly sorted, with sparse to abundant, well rounded to angular granules, pebbles and less commonly cobbles and small boulders of (in order of decreasing abundance) vein quartz, pink, red, grey and black chert, white to grey quartzite and quartz arenite, and feldspathic arenite; cross bedding common (includes some of recumbent-fold type); ripple marks present in places.

Siltstone and mudstone: pink, red and grey; finely laminated in places as at GR 242915; calcareous at GR 228088; variably micaceous.

Felsic lava: generally similar to that of overlying Treasure Volcanics.

Relationships. Conformable between Kurinelli Sandstone below and Treasure Volcanics above, and probably interfingers with parts of these units; intruded by granophyre and dolerite/gabbro. Contact between Taragan and Kurinelli Sandstones is taken as base of lowest pebbly bed in the sequence.

Mineralisation. Cut by quartz-veins containing W and Cu minerals near Hatches Creek.

Remarks. Probably represents fluvial sediments, possibly laid down by braided streams (Sweet, in prep.). In the south, near Hatcher Creek, the formation is taken to include a band of ridge-forming pebbly arenite which is separated from the main outcrop of Taragan Sandstone to the north by altered andesitic volcanics and minor interlayered arenites assigned to the Treasure Volcanics.

Treasure Volcanics

Map symbols. Ꝑht, Ꝑht$_s$, Ꝑht$_m$.

Derivation of name. Treasure mine, GR 199869, near Hatches Creek, HATCHES, FREW RIVER.

Distribution. Southern HATCHES and western HANLON; extends west into DAVENPORT RANGE.

Type section. 14 km NW of Hatches Creek, HATCHES, from GR 128988, where the formation conformably overlies Taragan Sandstone, to GR 098941, where it is overlain concordantly by Unimbra Sandstone. In this section of 5 km the main rock types of the Treasure Volcanics are well exposed, dipping 15-40°SW. From NE (base) to SW (top), the section consists of Ꝑht, 45 m; Ꝑht$_s$, 150 m; Ꝑht, 200 m; Ꝑht$_s$, 125 m; Ꝑht$_m$ and minor Ꝑht$_s$ and intrusive Ꝑgy, 550 m; Ꝑht$_s$, 20 m; Ꝑgy sill, 325 m; Ꝑht$_s$, 50 m; Ꝑht and minor Ꝑht$_s$, 200 m; Ꝑht$_s$, 80 m; Ꝑht, 75 m; Ꝑht$_s$, 125 m; and Ꝑht, 80 m.

Thickness. About 1700 m in type section; may be about 3500 m thick near abandoned Demseys homestead (GR 392005), but possibly partly repeated here by strike faulting.

Airphoto expression. Volcanic rocks form mainly low rounded ridges, undulating terrain and depressions, and have medium tones (felsic lavas) to dark tones

(basaltic lavas); interlayered sandstones form strike ridges and cuestas with mainly pale to very pale tones.

Rock types. Ꝑht: felsic lava; minor interlayered bedded tuff, quartz arentite, and feldspathic quartz arenite. $Ꝑht_m$: basaltic lava; minor interlayered quartz arenite, feldspathic/volcaniclastic arenite, and epidotic quartz arenite. $Ꝑht_s$: quartz arenite and feldspathic quartz arenite; minor pebbly beds.

Felsic lava: shades of grey, pink, maroon, purple and reddish-brown (dependent on degree of iron-staining): little altered and felsitic (cherty) to much altered and micaceous; intensely weathered (lateritised) in places, especially in east; probable range in composition from andesite to rhyolite, with rhyodacite predominating; commonly spherulitic and amygdaloidal/vesicular; forms mainly tabular flows, some at least 100 m thick.

Rhyodacite contains small phenocrysts of albitic plagioclase (euhedral tabular) ± quartz (partly resorbed β-type) + ferromagnesium minerals (pseudomorphed by chlorite and, less commonly, biotite, 'sericite', epidote, leucoxene, and/or opaque oxide) set in a fine grained groundmass typically consisting of quartz (commonly as plates, possibly after tridymite, and as poikilitic/'ophitic' patches)+ interstitial alkali feldspar + chlorite and/or mica (sericite and/or greenish-brown biotite) + opaque granules; quartz, chlorite, epidote, carbonate, celadonite and pyrite fill amygdales.

Lava of probably andesitic composition predominates only near Hatches Creek; it is now much altered, and consists mainly of fine-grained greenish-brown biotite and/or chlorite, together with muscovite and quartz; small amygdales infilled with quartz and mica and small pseudomorphed feldspar phenocrysts are common; porphyroblasts of muscovite and/or tourmaline are present near the Treasure mine.

Many lava flows show platy jointing in lower part parallel to base of flow, and contorted flow-banding in upper part; some also have brecciated and agglomeratic margins, scoriaceous and rubbly tops, and fissured tops infilled with arenite to depths of several metres. A felsic dyke-like intrusion

cutting Taragan Sandstone at GR 234885 is a possible feeder dyke for a lava flow.

Bedded tuff: purple to maroon; friable; laminated to thin bedded; fine to coarse-grained; commonly micaceous.

Basaltic lava: dark to pale bluish grey and greenish grey; massive to more commonly amygdaloidal and vesicular; commonly epidotic; scoriaceous and brecciated flow margins common; possible feeder dyke at GR 100963. Least altered samples examined consist mainly of plagioclase laths + partly ophitic clinopyroxene ± olivine (pseudomorphed) ± opaque oxide + secondary epidote, chlorite, actinolite and sericite; amygdales are infilled with epidote, chlorite, quartz, calcite, and, at GR 094976, traces of chysocolla and malachite.

Arenites: friable to silicified; pale grey, pink, iron-stained, or bluish-grey and glassy; mainly medium-bedded; well to poorly sorted; fine to coarse-grained; pebbles of vein quartz and felsic lava present locally; cross-bedding common; mud cracks observed at a few localities; some bedding planes with siltstone/mudstone pellets.

Relationships. Conformably overlies and in places interlayered with Taragan Sandstone; overlain conformably and possibly also disconformably by Unimbra Sandstone; intruded by sills of granophyre and dolerite/gabbro.

Correlations. Probably similar in age to much of Mia Mia Volcanics.

Mineralisation. Cut by quartz veins containing W, Bi and Cu minerals in vicinity of Hatches Creek; some mafic volcanics in W contain traces of copper minerals (malachite, chrysocolla).

Remarks. Volcanics were probably erupted either subaerially or into shallow water; no pillow lavas have been identified. Lavas are least altered where gently dipping. Interlayered sedimentary rocks include both shallow marine and fluvial types (Sweet, in preparation). Many arenites are identical to those in overlying Unimbra Sandstone, and represent a similar depositional environment.

Mia Mia Volcanics

Map symbols. Ꝑhm, Ꝑhm$_s$.

Derivation of name. Mia Mia Creek in southwest HATCHES, FREW RIVER. Headwaters of this northerly flowing creek drain much of outcrop area.

Distribution. Confined to core of large dome in southwest HATCHES.

Type section. From GR 164835, where the formation is overlain by Unimbra Sandstone, to about GR 163810, in central part of dome. The main rock types of the unit are well represented in this section.

Thickness. Probably at least 2000 m; base not exposed.

Airphoto expression. Generally recessive, mainly forming low hills and undulating terrain with medium to pale tones, but includes some ridge-forming sandstone with pale tones.

Rock types. Ꝑhm: felsic volcanics, generally cleaved; minor thin arenite bands. Ꝑhm$_s$: variably feldspathic/lithic quartz arenite; minor volcaniclastic conglomerate (at GR 199805) and thin felsic volcanic bands.

Felsic volcanics: much altered massive tuff, which may be ignimbritic, subordinate lava, and minor thin bedded to laminated tuff; shades of grey, pink, maroon, purple, and green; generally phyllitic to schistose; commonly contain secondary muscovite/sericite + greenish-brown biotite and/or chlorite ± tourmaline ± opaque minerals. Lavas include vesicular and amygdaloidal rhyodacite 'flows' and cherty flow-banded rhyolite; they, and some buffs, contain phenocrysts of feldspar (mainly microcline?) ± quartz + altered ferromagnesian minerals.

Arenites: generally silicified and locally glassy; mainly medium bedded and medium to coarse-grained; quartzose to feldspathic and volcaniclastic; range from widespread bands to local lenses; most common in upper part of formation; cross-bedding common, ripple marks present locally.

Relationships. Overlain conformably or disconformably by Unimbra Sandstone and intruded by leucocratic biotite muscovite granite and pegmatite.

Bedding in arenites near top of formation parallels that of overlying Unimbra Sandstone.

Correlations. Probably a lateral equivalent, at least in part, of Treasure Volcanics. One major difference is that tuffs predominate in Mia Mia Volcanics but are rare in Treasure Volcanics; another is that microcline rather than albitic plagioclase appears to be the main phenocryst phase in Mia Mia Volcanics.

Mineralisation. None known.

Remarks. Outcrop area possibly represents a major volcanic centre, eruptions from which may have been largely subaqueous, rather than subaerial: this could account for fragmental rocks being much more abundant than in Treasure Volcanics.

Unimbra Sandstone

Map symbols. Ꝑhs, Ꝑhs$_v$.

Derivation of name. Unimbra Rockhole on the Frew River at GR 112894, HATCHES, FREW RIVER.

Distribution. Southern and eastern parts of map sheet; extends into MURRAY DOWNS, ELKEDRA, and BONNEY WELL.

Type section. Not yet selected.

Thickness. Ranges from about 100 m, as near Unimbra Rockhole, to probably more than 1000 m.

Airphoto expression. Major planated (flat-topped) broad strike ridges with pale tones and clearly visible bedding trends; some recessive darker toned bands in SW of map sheet (Ꝑhs$_v$).

Rock types. Ꝑhs: variably feldspathic (and lithic?) quartz arenite; also includes small exposure of pale greenish flow-banded rhyolite at GR 515046. Ꝑhs$_v$: felsic lava, similar to that of Treasure Volcanics, interlayered with Ꝑhs in SW.

Arenites: pale grey, pink, or white, or iron-stained; mainly medium bedded; medium to coarse grained; moderately well sorted with commonly subangular sand grains; grit clasts and pebbles of vein quartz and subordinate volcanic rocks present in laces, mainly near base; abundant cross-bedding; ripple marks and bedding planes with mudstone/siltstone pellets moderately common; rare pyrite? casts; 5 m-thick band of pale greenish rhyolitic? breccia exposed near top of formation at GR 240874; open to tight mesofolds, with wave lengths of 100-500 m, developed near some major faults and hinge areas of major folds; e.g., near GR 215835.

Relationships. Conformable or disconformable on Treasure Volcanics and Mia Mia Volcanics, and may locally interfinger with Treasure Volcanics; overlain conformably by Arabulja Volcanics and Yeeradgi Sandstone; intruded by granophyre in SW.

Mineralisation. None known.

Remarks. Basal formation of Middle Hatches Creek Group. Variations in thickness may be partly due to deposition on an irregular surface. Probably deposited in both shallow marine and fluvial environments (Sweet, in preparation).

Yeeradgi Sandstone

Map symbols. Ꝑhd, Ꝑhd$_t$.

Derivation of name. Yeeradgi Rockhole, GR 223468, BONNEY, BONNEY WELL.

Distribution. Southern and eastern HATCHES and western HANLON; extends west into BONNEY WELL and BARROW CREEK.

Type section. Yet to be selected.

Thickness. Maximum probably about 800 m.

Airphoto expression. Less resistant to erosion than underlying and overlying sandstone units; forms mainly low strike ridges with pale to medium tones and well marked trend lines.

Rock types. Ꝑhd: arenites and subordinate siltstone, mudstone, ashstone, shale, and rare calcareous beds. Ꝑhd$_t$: bedded tuff and tuffaceous arenite.

Arenites: pink to purple or reddish-brown (iron-stained); variably feldspathic, lithic (tuffaceous, volcaniclastic), and kaolinitic (tuffaceous?); commonly micaceous; friable to silicified; medium to fine-grained; medium to thin-bedded; cross-bedding common; some bedding planes with mudstone pellets; metamorphic 'sericite' ± biotite commonly present in matrix.

Bedded tuff: grey, purple, or pink; variably micaceous, hematitic, and feldspathic/lithic (volcaniclastic); quartz-poor; friable, medium to fine-grained; thinly bedded; some ripple marks cross-bedding.

Ashstone: greenish or buff; very fine-grained (cherty); thin bedded to laminated.

Siltstone, mudstone, and shale: pale to dark grey or iron-stained; commonly phyllitic; thin bedded to laminated; rare calcareous and carbonaceous beds.

Relationships. Conformable on Unimbra Sandstone; overlain conformably by Coulters Sandstone; passes laterally into, and in places overlain by, Arabulja Volcanics.

Mineralisation. None known.

Remarks. Probably deposited in fluvial environments (Sweet, in preparation). Contains significant amount of detritus (feldspar, mica, lithic clasts, ash) from penecontemporaneous volcanism.

Arabulja Volcanics

Map symbols. Ꝑha, Ꝑha$_p$.

Derivation of name. Arabulja Waterhole on Murray Creek in northeast MURRAY DOWNS, BARROW CREEK.

Distribution. Southern and eastern parts of map sheet extends into ELKEDRA, BARROW CREEK and BONNEY WELL.

Type section. Yet to be selected.

Thickness. Mainly less than 500 m in map sheet.

Airphoto expression. Recessive formation, with medium to dark tones, situated between two major ridge-forming sandstone formations.

Rock types. Bha: felsic lava; minor interlayered bedded tuff and feldspathic arenite. Bha_p: dacitic feldspar porphyry.

Felsic lava in SW: pink, purple, and reddish-brown; non porphyritic or with small phenocrysts of alkali feldspar (mainly microcline?) ± quartz, ± pseudomorphs after olivine?; quartzofeldspathic groundmass, vesicular in part. Flows have platy jointing in lower parts and contorted flow-banding in upper parts.

Felsic lava in E: very weathered, iron-stained, vesicular.

Feldspar porphyry (Bha_p): forms most of formation in southern and eastern HATCHES; massive to more commonly phyllitic or schistose; dark grey (unweathered, little altered) to shades of purple or reddish-brown (weathered and/or micaceous); contains abundant tabular phenocrysts of white feldspar about 3mm long in fine-grained matrix; some epidotic alteration; locally autobrecciated near base (e.g., at GR 272896); grades up into fine-grained friable tuff (poorly exposed); dacitic in composition and probably ignimbritic. Fresh samples examined in thin section contain phenocrysts of sodic plagioclase + opaque oxide + apatite, and irregular mafic clots (green-brown biotite, chlorite, opaque oxide) ± megacrystic green hornblende in fine-grained foliated and possibly eutaxitic groundmass of quartz, alkali feldspar, biotite and/or chlorite and/or sericite/muscovite, and opaque oxide; metamorphic minerals present include biotite, sericite/muscovite, chlorite, epidote, albite, sphene, quartz, and possibly hornblende.

Bedded tuff: grey, purple, pink or greenish; fine to medium-grained; thinly bedded.

Arenite: generally pink; feldspathic/lithic/kaolinitic; friable to silicified; medium to fine-grained; medium to thin bedded; cross-bedding common.

Relationships. Conformable on Unimbra Sandstone; overlain conformably by Coulters Sandstone; intruded by granophyre in far SW; passes laterally into,

and in places overlies, Yeeradgi Sandstone.

Mineralisation. None known.

Coulters Sandstone

Map symbols. Ꝑhc, Ꝑhc$_1$.

Derivation of name. Coulters Waterhole on the Frew River, GR 028781, HATCHES, FREW RIVER.

Distribution. Southern HATCHES and western HANLON; extends into ELKEDRA, BONNEY WELL, and BARROW CREEK.

Type section. Near road from Hatches Creek to Murray Downs in vicinity of Coulters Waterhole, HATCHES: from GR 027800, where the formation overlies felsic lava of Arabulja Volcanics, to GR 034801, where it is overlain by Frew River Formation. Here the formation is well exposed in strike ridges dipping 50° - 60° E.

Thickness. About 700 m in type section; ranges from about 300 m (e.g., 12 km north of type section) to at least 1000 m (e.g., in southern central HATCHES). Apparent thicknesses of up to 5000 m in southeast HATCHES may result from repetition of beds by strike faulting.

Airphoto expression. Broad flat-topped ridges with mainly pale tones; bedding trends readily distinguishable; narrow depressions parallel to bedding mark minor recessive beds.

Rock types. Ꝑhc: quartz arenite, variable feldspathic/lithic and kaolinitic quartz arenite, and minor pebbly arenite. Ꝑhc$_1$: recessive friable (kaolinitic/sericitic) feldspathic arenite; near top of formation in southeast.

Arenites: pale grey to pale pink, or iron-stained to bleached; generally silicified; thick bedded and well jointed (especially near base) to thin bedded; abundant cross bedding, some of which is of recumbent fold type; ripple marks generally rare. Most beds are medium-grained and well sorted, but some gritty beds, bedding planes with quartz grit or mudstone pellers, and, especially near base of formation, beds with scattered pebbles of vein quartz

and, less commonly, volcanic rocks, are also present.

Relationships. Conformable on Arabulja Volcanics and Feeradgi Sandstone; overlain conformably by Frew River Formation.

Mineralisation. None known.

Remarks. A region-wide ridge-forming sandstone marker unit which was probably deposited on a broad shallow marine shelf.

Frew River Formation

Map symbol. Ehf.

Derivation of name. Frew River, the main watercourse in HATCHES, after which FREW RIVER is named. The formation is best esposed in headwaters of creeks draining into the Frew River in southwest HATCHES and southeast DAVENPORT RANGE.

Distribution. Southern HATCHES and western HANLON, extends into ELKEDRA, BONNEY WELL, and BARROW CREEK.

Type section. Along small creek from GR 009834, where formation overlies Coulters Sandstone (gradational conformable contact), north to GR 010838, where formation is overlain by basaltic lava of Kudinga Basalt. Here about 50 m of thin to very thin bedded quartzose, feldspathic and kaolinitic arenites and micaceous siltstone showing ripple marks, mud-cracks, and, in one bed, halite casts, is overlain by about 450 m of mainly carbonates - thinly bedded yellow, brown, and pink stromatolitic dolomite and ripple-marked dolomitic arenite and grey limey beds. The stromatolites present include oncolitic forms 50 cm across, algal mats, and Conophyton.

Thickness. About 500 m in type section - may be close to maximum thickness.

Airphoto expression. Recessive, largely concealed by Cainozoic alluvial and colluvial sediments. Most exposures are in gullies, where bleached bedrock shows up as white patches.

Rock types. Thin-bedded, fine-grained, friable, kaolinitic arenite, micaceous siltstone, and cherty mudstone - these are commonly dolomitic and/or

calcareous in upper part of unit; subordinate silicified and locally glassy, medium to fine-grained, quartz arenite and feldspathic quartz arenite, mainly near base of unit; sedimentary structures include ripple marks, cross-beds, gritty laminae, bedding planes with mudstone pellets, and rare mud cracks and halite casts; stromatolitic in places, as in type section.

Relationships. Conformable on Coulters Sandstone; overlain conformably by Kudinga Basalt.

Mineralisation. None known.

Remarks. Sedimentary structures, stromatolites, and indications of former evaporites indicate deposition in very shallow water to intertidal and possibly also sabkha environments. Can be considered a potential host for stratiform/stratabound Pb-Zn-Cu deposits.

Kudinga Basalt

Map symbols. Ꝑhb, Ꝑhb$_s$.

Derivation of name. Kudinga Creek in northeast DAVENPORT RANGE, BONNEY WELL.

Distribution. Southern HATCHES and western HANLON; extends into ELKEDRA, BONNEY WELL, and BARROW CREEK.

Type section. Not yet selected.

Thickness. Generally between 400 m and 600 m.

Airphoto expression. Recessive, generally poorly exposed; mainly forms gently undulating terrain and plains with dark tones; two thin bands of low-ridge-forming sandstone with paler tones commonly present at or near base.

Rock types. Ꝑhb: flows of amygdaloidal and scoriaceous to massive basalt; minor interlayered arenite. Ꝑhb$_s$: feldspathic quartz arenite.

Basalt: greenish to dark grey; feldspar phenocrysts present locally; commonly highly weathered and friable; invariably somewhat altered, with

albite, amphibole (pale green, actinolitic), biotite, calcite, chlorite, epidote, pyrite, and quartz as common secondary, minerals; mainly epidote, chlorite and quartz in amygdales; flow-margin breccia, consisting of basalt fragments in epidotic quartzite, exposed near GR 342864; no pillow lava recorded in map area but some found in DAVENPORT RANGE (A.J. Stewart, personal communication, 1981).

Arenites: mostly pink to maroon; fine to coarse grained; silicified; variably feldspathic; cross-bedding common, ripple marks less common; thin bedded to laminated dark grey micaceous arenite (=basaltic tuff) at GR 012840; minor calcareous arenite and glassy, mainly epidotic, quartz arenite.

Relationships. Conformable on Frew River Formation; overlain unconformably by Errolola Sandstone.

Mineralisation. Copper minerals - malachite and minor azurite - occur in quartz veins in basalt at GR 377875.

Remarks. Important stratigraphic marker. Basalt flows and associated sediments probably laid down on a broad shelf mainly covered by shallow water.

Errolola Sandstone

Map symbol. Ꝑhe.

Derivation of name. Errolola Rockhole on the Frew River at GR 043807, southwest HATCHES, FREW RIVER.

Distribution. Southern HATCHES and western HANLON; extends into ELKEDRA, BONNEY WELL, and BARROW CREEK.

Type section. In DAVENPORT RANGE.

Thickness. About 600 m thick near Errolola Rockhole; ranges from about 500m in southwest to more than 1200 m in east.

Airphoto expression. Broad flat-topped strike ridges with mainly pale tones and well displayed bedding trends.

Rock types. Quartz arenite and subordinate feldspathic/lithic/kaolinitic quartz arenite: white to pale grey or pink, or iron-stained; silicified to friable;

mainly medium bedded, medium grained and well sorted; some bedding planes with siltstone pellets or quartz grit clasts; sparse pebbles in a few beds; cross-bedding very common, ripple marks less common.

Relationships. Conformable on Kudinga Basalt; overlain conformably by Alinjabon Sandstone.

Mineralisation. None recorded.

Remarks. Youngest formation of Middle Hatches Creek Group, and youngest widespread ridge-forming unit of the Group. Deposited in shallow water, mainly on intertidal flats and adjoining subtidal environments (Sweet, in preparation).

Alinjabon Sandstone

Map symbols. Ꝑhi, Ꝑhi$_v$.

Derivation of name. Alinjabon Rockhole on Bonney Creek, GR 590183, DAVENPORT RANGE, BONNEY WELL.

Distribution. Southwest and southeast HATCHES and western HANLON; extends into ELKEDRA, BONNEY WELL, and BARROW CREEK.

Type section. Yet to be selected.

Thickness. Ranges between about 450 m and 750 m.

Airphoto expression. Two or three narrow strike ridges with pale tones, lower than that of adjacent Errolola Sandstone, separated by narrow depressions.

Rock types. Ꝑhi: ridge-forming quartz arenite and feldspathic quartz arenite; minor recessive arenite, siltstone, shale, and, at base in southwest HATCHES, mafic lava overlain by tuffaceous arenite (at GR 045839) and greywache (at GR 023846). Ꝑhi$_v$ (only in HANLON): recessive mafic lava and interlayered sediments - micaceous siltstone, shale, tuffaceous? arenite and quartz arenite.

Ridge-forming arenite: white to pale grey; silicified and locally glassy; thin-bedded, with platy partings common; fine to medium-grained; cross-bedding generally uncommon; rare convolute bedding, quartz pebbles, and mudstone pellets.

Recessive arenite: iron-stained; friable, with abundant sericitic or kaolinitic matrix; feldspathic/lithic; medium to thin bedded; medium-grained; commonly cross-bedded.

Siltstone: micaceous and locally calcareous.

Mafic lava: generally much altered/weathered and iron-stained; medium to fine-grained doleritic to basaltic texture; non porphyritic; amygdaloidal; some secondary chlorite, biotite, epidote and actionolite.

Relationships. Conformable on Errolola Sandstone; overlain conformably by Lennee Creek Formation.

Mineralisation. None known.

Remarks. Probably represents shallow marine shelf deposits with possible deltaic influence (Sweet, in preparation). Volcanics at base are youngest reported from the Hatches Creek Group.

Lennee Creek Formation

Map symbol. Ehl.

Derivation of name. Lennee Creek, which joins the Frew River at GR 180180, HATCHES, FREW RIVER.

Distribution. Southwest and southeast HATCHES in (central parts of major synclines) and western HANLON; extends into ELKEDRA, BONNEY WELL, and BARROW CREEK.

Thickness. Maximum about 1500 m, in HANLON.

Type section. Yet to be selected

Airphoto expression. Gently undulating terrain and low strike ridges in broad depressions; variable, mainly pale, tones.

Rock types. Recessive friable arenite, siltstone and shale; minor thin bands of ridge forming quartz arenite.

Friable arenite: much weathered, iron-stained to bleached; medium to fine-grained; feldspathic/lithic/kaolinitic/sericitic; commonly micaceous and locally calcareous; mainly thin bedded; cross-bedded in places.

Relationships. Conformable on Alinjabon Sandstone; overlain conformably by Canulgerra Sandstone; contacts generally concealed.

Mineralisation. None known.

Remarks. Sweet (in preparation) believes the formation was deposited in a subtidal environment, in deeper water, lower energy environments than the units above and below it.

Canulgerra Sandstone

Map symbol. Ꝑhu.

Derivation of name. Canulgerra Rockhole on Yaddanilla Creek, GR 650968, HANLON, FREW RIVER.

Distribution. Western HANLON, also present in ELKEDRA, DAVENPORT RANGE, and BONNEY.

Type section. Yet to be selected.

Thickness. About 500 m.

Airphoto expression. Parallel strike ridges, with mainly moderate tones, separated by narrow depressions.

Rock types. Ridge-forming arenite and recessive interbedded feldspathic or lithic friable arenite and micaceous siltstone. Ridge-forming arenite is quartzose to feldspathic, generally silicified, thin to medium bedded, mainly medium-grained, and commonly cross-bedded and ripple-marked.

Relationships. Conformable on Lennee Creek Formation, overlain conformably by Vaddingilla Formation.

Mineralisation. None known.

Remarks. Probably deposited in shallow marine shelf environment, mainly intertidal (Sweet, in preparation).

Vaddingilla Formation

Map symbol. Ꝑhv.

Derivation of name. Vaddingilla Rockhole on Yaddanilla Creek at GR 677983, HANLON, FREW RIVER.

Distribution. Confined to western HANLON.

Type section. Yet to be selected.

Thickness. About 800 m.

Airphoto expression. Recessive, poorly exposed.

Rock types. Thinly interbedded siltstone, shale and arenite which are friable and highly weathered. Arenite is generally reddish-brown; variably feldspathic, micaceous, and kaolinitic; fine to medium-grained; rather poorly sorted; cross-bedded in places.

Relationships. Conformable on Canulgerra Sandstone to west; conformably overlain by Yaddanilla Sandstone to east.

Mineralisation. None known.

Remarks. Probably marine.

Yaddanilla Sandstone

Map symbol. Ꝑhy.

Derivation of name. Yaddanilla Creek in western HANLON, FREW RIVER.

Distribution. Confined to western HANLON.

Type section. Yet to be selected.

Thickness. May be 1000 m or more thick, if it includes outcrops mapped as Ꝑhy? in far E; top not exposed.

Airphoto expression. Strike ridges with moderate to pale tones separated by narrow depressions.

Rock types. Ridges are formed of quartz arenite and feldspathic quartz arenite; no exposures found in depressions between ridges. Arenites are white to pale grey, medium-bedded, medium-grained, and cross-bedded; some bedding planes have casts of mudstone pellets;

Relationships. Conformable on Vaddingilla Formation.

Mineralisation. None known.

Remarks. Youngest formation of the Hatches Creek Group exposed in the region. Was probably deposited in a shallow marine shelf environment.

Igneous Intrusions

Granophyre, microgranite, intrusive feldspar porphyry

Map symbol. Ꝑgy.

Distribution. Mainly in western HATCHES

Form. Sills ranging from a few metres to several hundreds of metres thick; minor small dykes and irregular bodies.

Airphoto expression. Undulating terrain and footslopes with mainly smooth medium tones; also small mesas capped by dark toned laterite.

Rock types. Granophyre, feldspar porphyry: fine-grained and pink or maroon to very fine-grained and dark grey or greenish (altered glass?); commonly exposed as small, smoothly rounded boulders with paler weathered crusts; difficult to distinguish from other fine-grained igneous rocks where lateritised; xenoliths rare; vesicles/miarolitic cavities present in places; spherulitic textures common, especially near margins of intrusions; prominent jointing parallel to sill margins common.

Granophyre generally contains sparse to abundant pdenocrysts of albite ± microcline (rare) ± quartz (rare) ± biotite (commonly altered) ± pseudomorphed amphibole or pyroxene ± opaque minerals, together with irregular fine-grained mafic clots (biotite and/or chlorite + opaques) and disseminated sulphide minerals set in a fine to very fine-grained groundmass consisting mainly of micrographic quartz and alkali feldspar; zircon and apatite occur as accessory minerals; secondary minerals present may include chlorite, biotite, epidote, sericite/muscovite, hematite, calcite, and greenish-brown amphibole (rare). Feldspar porphyry differs from granophyre in having a very fine-grained microgranitic rather than a micrographic groundmass.

Structure. Folded with country rocks.

Metamorphism. Regionally metamorphosed to greenschist facies; primary textures preserved but original ferromagnesian minerals commonly pseudomorphed by greenish-brown biotite or chlorite. Some intrusions are bounded by aureoles of hornfels (recrystallised country rock) a few metres thick.

Relationships. Intrude formations of Lower Hatches Creek Group and also, in southwest, Unimbra Sandstone and Arabulja Volcanics of Middle Hatches Group; relationship to dolerite and gabbro intrusions not clear.

Mineralisation. Some disseminated sulphides, mainly pyrite, commonly present; sulphur-stained quartz veins containing hematite, magnetite, and possibly gold probably cut much weathered, richly porphyritic granophyre at GR 020020.

Remarks. May be comagmatic with, and similar in age to, felsic volcanics of the Hatches Creek Group. Some sills in far southwest have chilled, bulbous, lower contacts indicating possible emplacement into unconsolidated sediments.

Dolerite and gabbro

Map symbol. Ed.

Nomenclature. Previously mapped near Hatches Creek in southwest as Pedlar Gabbro (Ryan, 1961).

Distribution. Mainly in western half of HATCHES.

Form. Sills, some possibly several hundreds of metres thick, cross-cutting sheets, and irregular bodies. Internal variations in grain-size and common presence of thin screens of country rocks indicate that many of the mafic bodies are multiple intrusions.

Airphoto expression. Generally recessive, commonly being exposed in gullied footslopes, but also form low mounds and undulating terrain strewn with rounded boulders; dark tones.

Rock types. Fine-grained dolerite to coarse grained gabbro: typically dark grey to dark greenish grey where little weathered; difficult to distinguish from lateritic granophyre where laterised; rarely porphyritic; primary clinopyroxene, orthopyroxene (rare), and calcic plagioclase (An_{40-80}) preserved in places; ophitic textures; common uralitic alteration, interstitial micrographic quartz and alkali feldspar, and secondary epidote, chlorite, albite, biotite, sericite, and actinolitic amphibole

Structure. Folded with country rocks.

Metamorphism. Low to probably upper greenschist facies; commonly cut by veins of quartz, chlorite, epidote, calcite, and white mica. Some intrusions have narrow contact aureoles.

Relationships. Intrude formations of Lower Hatches Creek Group; relationship to granophyre not known.

Mineralisation. Cut by W, Au and Cu-bearing quartz veins near Hatches Creek and by Au-bearing quartz veins near Kurinelli; commonly contain disseminated sulphide minerals.

Remarks. May be comagmatic with basalts of the Hatches Creek Group.

Granite

Map symbol. Pg.

Distribution. Central north, northwest and southwest of map sheet

Airphoto expression. Low hummocky to undulating terrain and plains with scattered spheroidal boulders; smooth pale to dark tones (bleached to iron stained).

Rock types. In central north pinkish, fine to coarse-grained muscovite and biotite-bearing granite containing about equal amounts of sodic plagioclase and microcline (locally as phenocrysts), some myrmekite, and minor amounts of allanite, apatite, calcite, chlorite, epidote, opaque oxide, sphene, and zircon; generally much weathered; xenoliths common; locally sheared.

In northwest: medium to coarse grained porphyritic granite and minor fine-grained granite; very weathered.

In southwest: pinkish, medium to coarse-grained, even-grained, muscovite granite, somewhat weathered and apparently non xenolithic, which contains about equal amounts of sodic plagioclase and perthitic microcline and small amounts of biotite. Veins and pods of quartz-feldspar pegmatite, medium to fine-grained muscovite granite, and medium-grained greisen cut adjacent Mia Mia Volcanics.

Relationships, correlations and age. Intrudes Mia Mia Volcanics in SW and Rooneys Formation, Kurinelli Sandstone and possibly Taragon Sandstone in NE; intrudes Epenarra Volcanics in OORADIDGEE. Similar granites, dated at 1695 m.y. (Rb-Sr, in Compston & Arriews, 1968) (or 1660 m.y. if value 1.42 x

$10^{-11}y^{-1}$ is used as decay constant for Rb^{87}) and 1320 - 1540 m.y. (K-Ar, Hurley & others, 1961), exposed in other parts of Davenport Geosyncline.

Mineralisation. None known in granite; tungsten mineralisation at Hatches Creek may be related to the granite in the southwest (Ryan, 1961).

Remarks. Probably much younger than, and unrelated to, felsic volcanics of Hatches Creek Group, as appear to post-date main folding events of region.

DESCRIPTIVE NOTES ON PHANEROZOIC UNITS

Cambrian

Map symbol. Є.

Nomenclature. Preciously mapped as Gum Ridge Formation (Smith, 1964).

Distribution. Small scattered outcrops in central and eastern HATCHES and western HANLON; more extensive outcrops, but generally poorly exposed, in southern EPENARRA.

Airphoto expression. Flat-topped low hills (some mesas), mounds, and small capping on ridges, with smooth pale to dark tones (dark where lateritised); many outcrop areas drained by short dark-toned sinuous gullies.

Rock types. Conglomerate, sandstone, chert, siltstone. Conglomerate contains rounded to angular pebbles, cobbles and boulders of locally derived Hatches Creek Group rocks, mainly quartzose arenites, in sparse to abundant sandstone matrix; also includes some lenses of sandstone.

Sandstone is friable to silicified, ferruginous to bleached, and generally poorly sorted.

Chert is thinly banded or brecciated; hyolithid fossils found near GR 270100. Siltstone is locally interbedded with chert, as at GR 340030 (overlying conglomerate and sandstone).

Relationships. Unconformable on Precambrian rocks.

Age. At least partly Cambrian, but, as generally unfossiliferous, could be of various ages.

Remarks. A mainly flat-lying sequence resting on an irregular eroded surface. The sediments probably represent alluvial fan, scree, and shallow marine deposits, and are part of the Georgina Basin succession. Commonly capped by laterite up to about 1 m thick, especially in north.

Cainozoic

Laterite ferricrete

Map symbol. Tl.

Description. Highly ferruginous, friable to cemented material in which no original parent rock structures or textures are present; most widespread in E and N; form cappings 1-3 m thick on ridges, hills, mesas, and mounds; smooth dark tones on airphotos; cappings represent remnants of upper part of probably Tertiary weathering profiles.

Silcrete

Map symbol. Ts

Description. Angular clasts of quartz in very fine-grained to amorphous siliceous matrix; widespread as small patches, mostly too small to show at 1:100 000 scale, on ridges, hills, mesas, and mounds; pale tones on airphotos; formed during Tertiary weathering.

Calcrete

Map symbol. Czk.

Description. Cellular inorganic limestone forming two small outcrops in northeastern HATCHES (near GR 430230); forms low mounds, with speckled white to medium airphoto tones, on plain. Chemical deposit formed by evaporation of groundwater probably during Tertiary.

Vein quartz rubble

Map symbol. Czq.

Description. Colluvial and residual deposits flanking ridge-forming quartz veins in northern central HATCHES; speckled and streaky white and medium tones on

airphotos; probably partly Quarternary and partly Tertiary.

Gravel, sand

Map symbol. Czc.

Description. Alluvial and colluvial probably pre-Quarternary sediments forming dissected fans (incised by active water courses) flanking sandstone ridges throughout region; poorly consolidated to unconsolidated.

Colluvial and fluvial

Sand, gravel, silt, clay

Map symbol. Qc.

Description. Unconsolidated Quarternary colluvial and fluvial, also some aeolian, sediments deposited on plains, valley floors, and fans throughout region.

Lacustrine

Clay, silt, sand

Map symbol. Ql.

Description. Unconsolidated Quarternary sediments deposited in small claypans in northern HATCHES.

Fluvial

Sand, silt, clay, gravel

Map symbol. Qa.

Description. Unconsolidated Quarternary sediments deposited on floodplains along main watercourses throughout region.

STRUCTURE

The structure of the map sheet is dominated by large upright folds, outlined by ridge-forming resistant arenites and valley-forming recessive volcanic and sedimentary units of the Hatches Creek Group, and by major faults marked in many places by upstanding quartz veins. Cambrian and younger sediments are flat-lying and have been affected by neither folding or faulting. The main structures are shown in the Structural Sketch on the Preliminary Edition map.

Major structural features are tight folds in the southwest; a large dome, also in the southwest, with the Mia Mia Volcanics exposed in its core; broad open folds in the northwestern, central, and eastern parts of the map sheet an east-trending zone of intense quartz veining and local shearing in the far north; and two subparallel west-southwest-trending faults up to 24 km apart in the central west. These last two faults appear to mark opposite sides of a major fault block which extends westwards into DAVENPORT RANGE. Smaller scale structures include folds and major crenulations, with amplitudes of 100 m to 1 km, on the flanks of the Mia Mia dome (e.g., near GR 125865 and GR 220840), and tight folds of similar size in the Warramunga Group near Epenarra homestead in the far north. Cleavage in volcanic and sedimentary rocks in the southwest generally appears to be parallel or nearly so to the axial planes of local folds. Cleavage in rocks elsewhere, such as in schist of the Rooneys Formation (unit Ehn_{sh}), is related to either folding or faulting.

The axial planes of all major folds appear to be close to vertical, and are commonly arcuate in plan. The tight folds in the southwest, which in places are almost isoclinal, have trends ranging from easterly to northerly. The Mia Mia dome is elongated east-west. The open folds in the northwest have southwesterly trends and those in the south have southeasterly trends. In the east the exposed Hatches Creek Group rocks lie on the western flank of a very large syncline or structural basin, the eastern part of which is not seen. The variations in fold trends may be due to the folds being wrapped around relatively more competent nucleii, such as the Mia Mia Volcanics in the core of the Mia

Mia dome.

Most of the faulting is probably related to the same stresses that caused the folding of the Hatches Creek Group, the faults developing when deformation reached the stage where the rocks fractured rather than continuing to fold. Several faults have throws of many kilometres. One such fault forms the southeastern side of the postulated major fault block in the central west; it separates Kurinelli Sandstone to the south from Treasure Volcanics and Taragan Sandstone to the north, and, as rocks and structures on either side cannot be readily matched, must have had considerable vertical and horizontal movements. One splay of this major fault is the Mia Mia Fault, which has a horizontal displacement of about 1.5 km (Ryan, 1961). There may also be some major strike faults: these could account for the Coulters Sandstone in the southern central part of the area being abnormally thick. Other strike faults, possibly representing décollement zones, may be located within carbonate bands of the Frew River Formation, as appears to be the case in DAVENPORT RANGE to the west.

The folding and faulting possibly result from large-scale gravity sliding. The décollement surface for this postulated sliding presumably underlies the Warramunga Group, as no shearing is evident at well-exposed contacts between the Warramunga and Hatches Creek Groups in OORADIDGEE and BONNEY to the west. The deformation was accompanied by low grade regional metamorphism, and was followed, or possibly accompanied, by emplacement of granite into the cores of anticlinal structures such as the Mia Mia dome.

METAMORPHISM

Regional

All Precambrian rocks in the map area, except probably the granites, have been affected by low-grade regional metamorphism. The effects of this metamorphism are most obvious in volcanics, and are commonly not readily apparent in the quartz-rich arenites of the Hatches Creek Group.

Warramunga Group

Greywacke and siltstone of the Warramunga Group have well preserved clastic textures and do not appear to have been significantly recrystallised.

However, they have been tightly folded, and although no diagnostic minerals of a specific metamorphic facies have been found in them, they have probably been regionally metamorphosed to lower greenschist facies.

Hatches Creek Group

The following features indicate that most, if not all, rocks of the Hatches Creek Group have been regionally metamorphosed to greenschist facies.

1. Sedimentary rocks: megascopic and microscopic sedimentary features are generally well preserved, but metamorphic white mica and biotite (greenish-brown) are common matrix constituents in arenites and siltstones.

2. Felsic volcanic rocks: tuffs are commonly cleaved and typically contain metamorphic muscovite/sericite and biotite; lavas generally have at least some megascopic igneous textures preserved and characteristically contain euhedral phenocrysts of plagioclase which is now albite but was originally of more calcic composition, together with partly resorbed β-type quartz showing variably undulose extinction, and ferromagnesian minerals replaced by chlorite and/or greenish-brown biotite and oqaque minerals. The phenocrysts lie in a fine to very fine-graine, variably recrystallised, quartzofeldspathic groundmass containing metamorphic muscovite, biotite, and/or chlorite.

3. Basaltic lavas: megascopic and some microscopic igneous features are generally preserved, and remnants of igneous pyroxene are present locally. Common secondary and amygdale minerals are albite, actinolitic amphibole, epidote, chlorite, biotite, quartz, and calcite.

4. Interlayered granophyre sills: microscopic igneous textures are preserved, but phenocrysts of originally more calcic plagioclase are now albite, and primary ferromagnesian minerals are pseudomorphed by chlorite or green-brown biotite.

5. Dolerite and gabbro intrusions: ophitic textures are typically clearly evident, and plagioclase laths commonly show igneous zoning. Primary pyroxene is generally partly or completely replaced by secondary green amphibole. Other secondary minerals commonly present are epidote, chlorite, biotite, sericite, and albite.

The presence of dark greenish brown hornblende of possibly metamorphic origin in dacitic feldspar prophyry of the Arabulja Volcanics (unit Ꝑha$_p$) east of Hatches Creek indicates that the regional metamorphism may have locally reached upper greenschist or lower amphibolite facies.

Because of the prevailing greenschist facies regional metamorphism, the felsic volcanics of the Hatches Creek Group and the associated granophyre intrusions cannot be satisfactorily dated by either the Rb-Sr or K-Ar methods. Any Rb-Sr ages obtained may date the regional metamorphism, but are likely to be uninterpretable, judging from the experience of Black (1981) in the Tennant Creek area and Page (1978) in the Mount Isa region. K-Ar dates are likely to give minimum ages for the metamorphism.

Contact

Granophyre, dolerite, gabbro, and granite intrusions commonly have contact metamorphic aureoles. These range in thickness from less than a metre to probably over 100 metres. In the aureoles quartz arenites and feldspathic arenites are metamorphosed to quartzitic hornfels in some of which quartz and feldspar show micrographic textures. The relatively coarse grain-size of mica schist mapped as unit Ꝑhn$_{sh}$ of the Rooneys Formation may be the result of contact metamorphism by nearby granitic bodies.

Felsic lavas of the Treasure Formation appear to be more metamorphosed in the Hatches Creek mining area than elsewhere, possibly due to contact metamorphism related to underlying granite: the lavas now consist mainly of fine-grained recrystallised aggregates of quartz, muscovite, biotite, and commonly tourmaline which in places is porphyroblastic.

Greisen present locally within the Mia Mia Volcanics in the east of the Mia Mia dome is probably the result of contact metamorphism and metasomatism related to the granite exposed at GR 185805.

MINERAL RESOURCES

Tungsten, gold, copper, and bismuth have been produced from mines in the Hatches Creek region. The most intensely mineralised part of the area, near the abandoned mining settlement of Hatches Creek in the southwest,

is the Hatches Creek Wolfram Field, which was mapped in detail by Ryan (1961). Almost all the recorded production of tungsten, and all that of copper and bismuth, has come from this field. Most of the gold has come from small mines near Kurinelli in the northwest (Roarty, 1977).

Mining began near Hatches Creek in 1913, and was carried out sporadically until late 1957 (Ryan, 1961). Some mining was also carried out during the late 1960's, mainly at the Pioneer mine, and some developmental work, including testing of mine dumps, was undertaken by a private company in 1981. Few of the mines have been worked to depths greater than 30 m, and none is deeper than 100 m. Underground workings are now inaccessible, and most shafts have caved-in. Details of individual mines are given in Ryan (1961), and are summarised below. Up to 1958 about 3000 tonnes of tungsten concentrates (about 65% WO_3), 5.7 tonnes bismuth concentrates, and 70 tonnes copper concentrates had been produced from the field. The tungsten production includes a small amount of eluvial concentrates.

The lodes near Hatches Creek are quartz veins of various orientations. They are generally steeply dipping and mainly between 15 and 45 cm wide. Ore minerals present (Ryan, 1961) include the tungsten minerals wolframite, scheelite, tungstite, and probably cupro-tungstite; the bismuth minerals bismutite, bismuthinite, and native bismuth; the copper minerals chalcopyrite, chalcocite, covellite, bornite, malachite, azurite, and chrysocolla; molybdenite; very sparse cassiterite; and traces of gold. Quartz and subordinate mica are the main gangue. The mineralised veins cut Kurinelli Sandstone, Taragan Sandstone, and Treasure Volcanics of the Lower Hatches Creek Group, and also dolerite and gabbro. They appear to postdate the folding of the Hatches Creek Group, and are thought to be related to a postulated underlying granite, perhaps part of the granite exposed intruding the Mia Mia Volcanics to the south (at GR 185805).

A few small tungsten mines and prospects are present to the north, where wolframite-bearing quartz veins, well away from any exposed granite, cut the Treasure Volcanics, Kurinelli Sandstone, and Warramunga Group.

Gold in the Kurinelli area, and also at the Crystal gold mine near Hatches Creek (at GR 219953), occurs in quartz veins cutting gabbro and dolerite intrusions and associated screens and xenolithic blocks of thinly bedded siltstone and fine-grained arenite of the Rooneys Formation (near Kurinelli) and the Endurance Sandstone Member of the Kurinelli Sandstone (at the Crystal mine). The total recorded production from the Kurinelli area is about 13.6 kg gold (Roarty, 1977), made up of about 12.4 kg reef gold and 1.2 kg alluvial/eluvial gold. The auriferous quartz veins may be related to the main folding event affecting the Hatches Creek Group. The close association with dolerite and gabbro indicates that the gold may be derived from a mafic igneous source.

A few small copper deposits have been worked near Hatches Creek, where copper minerals are commonly present in tungsten-bearing quartz veins. There is also a small abandoned copper mine to the east (at GR 376875), situated in amygdaloidal lava of the Kudinga Basalt. Traces of secondary copper minerals have been noted in basaltic lava of the Treasure Volcanics (at GR 095976), and minor disseminated chalcopyrite is present in some dolerite and gabbro bodies.

Economic potential

The Hatches Creek Wolfram Field may become economic as a result of rises in metal prices combined with more efficient mining methods and metallurgical processes. Ryan (1961) inferred ore reserves for the field of around 1000 tonnes of tungsten concentrates in 1958. Because the region has been extensively proposected over many years, and quartz veins generally form prominent topographic features, it is unlikely that any significant new deposits of Hatches Creek type will be found in other parts of the map sheet.

The irregular distribution, small size, and overall low grade of the known auriferous quartz veins indicate that there is little likelihood of finding a major reef gold deposit in the map sheet.

Small amounts of copper, bismuth, and possibly molybdenum may be obtained from the tungsten-bearing quartz veins near Hatches Creek; however

there appears to be no possibility of finding large deposits of these elements in this type of lode.

The most prospective target for base metal deposits may be the Frew River Formation of the Middle Hatches Creek Group. This formation contains carbonates, is locally stromatolitic, and appears to have been deposited in very shallow marine, lacustrine, or sabkha environments; the carbonates are similar to those associated with the McArthur River lead-zinc deposit, and are possibly of comparable age. Hence the Frew River Formation can be considered a potential host for syngenetic stratiform mineralisation. No base metal occurrences are known within the formation, but this may be partly a function of the formation being a recessive unit largely concealed by surficial Cainozoic sediments.

Notes on mines and prospects

Pioneer Mine, W (GR 185921)

References: Jensen (1955), Ryan (1961).

Surface Workings: shafts, costeans, pits; main shaft with poppet head; worked to depth of 63 m.

Country rocks: gabbro and dolerite (Pedlar Gabbro of Ryan, 1961); screens of arenite and siltstone, Kurinelli Sandstone.

Lodes: quartz reefs up to about 1 m wide striking about 060° and dipping 40-70°S.

Ore and gangue: wolframite and scheelite, with bismutite, chalcocite, azurite, malachite and limonite in oxidised zone, and native bismuth, bismuthinite, tetrahedrite, pyrite and chalcopyrite below water table; minor molybdenite present throughout. Some gold is associated with bismuthinite and chalcopyrite. Quartz, the main gangue, is accompanied by mica, feldspar, and less commonly epidote and tourmaline.

Production: 442 tonnes concentrates 1935-1958, assaying 66-67% WO_3; average grade mined about 2.2% WO_3. Also worked in late 1960s.

Endurance mine, W, Bi (GR 190914)

Reference: Ryan (1961).

Surface workings: shafts to depth of 12 m, pits, costeans.

Country rocks: altered gabbro; arenite and siltstone, Kurinelli Sandstone, exposed nearby to north.

Lodes: quartz reefs up to 35 cm wide striking about 060° and dipping 55-70°.

Ore and gangue: scheelite, wolframite, bismuthinite, bismuth and copper carbonates; quartz and subordinate epidote, mica, and sericite.

Production: 7.5 tonnes mixed wolframite-scheelite-bismuth concentrates 1952-1958.

Ricketty Kate mine, W (GR 200910)

Reference: Ryan (1961).

Surface workings: shallow shaft, pits, costeans; maximum depth worked about 3 m.

Country rocks: arenites of Kurinelli Sandstone.

Lodes: northeast striking quartz reefs up to 30 cm wide dipping 45-85°S.

Ore and gangue: wolframite and small amounts of copper and bismuth minerals, with quartz and minor mica.

Production: 9 tonnes wolframite concentrates recorded to 1952.

Black Diamond mine, W (GR 195905)

Reference: Ryan (1961).

Surface workings: shafts, pits, costeans; maximum depth worked about 60 m.

Country rocks: arenites, Warnes Sandstone Member of Kurinelli Sandstone.

Lodes: quartz veins striking about 060° and dipping 60-80°S.

Ore and gangue: wolframite and quartz; very minor scheelite, bismutite, malachite, iron oxides; some mica.

Production: 87.2 tonnes concentrates 1939-1958.

Bonanza mine, W (GR 192903)

Reference: Ryan (1961).

Surface working: shaft, pits; worked to depth of at least 30m.

Country rocks: arenites, Kurinelli Sandstone.

Lodes: quartz veins up to 45 cm wide striking about 060° and dipping 60-75°S.

Ore and gangue: wolframite, quartz; minor scheelite; some copper and bismuth minerals.

Production: 56.92 tonnes concentrates recorded 1938-1954.

Green Diamond group of mines, W, Cu (GR 181902)

Reference: Ryan (1961).

Surface workings: shaft (maximum depth 41 m), pits, conteans,

Country rocks: arenites, Warnes sandstone Member of the Kurinelli Sandstone.

Lodes: quartz veins up to 45 cm thick dipping 35-60°S; strike approximately parallel to bedding in country rocks.

Ore and gangue: wolframite, scheelite, tungstite, azurite, malachite, bismutite, bismuthinite, cuprite, nature copper, iron oxides, pyrite, chalcopyrite, quartz; subordinate muscovite, kaolin.

Production: 58.3 tonnes tungsten concentrate 1937-1958. Some tungsten and copper concentrates produced in 1968 (Cu ore sent to Mount Isa).

Treasure group of mines, W - Treasure (GR 197868), Hidden Treasure (GR 198862), Next Treasure (GR 195866).

Reference: Ryan (1961).

Surface workings: shafts, pits, costeans; maximum depth about 55m.

Country rocks: altered andesitic? lavas and some interlayered arenites, Treasure Volcanics, underlain to N and overlain to S by ridge-forming quartzose and pebbly arenite, Taragan Sandstone. Most lodes are in volcanics.

Lodes: quartz veins, generally less than 30 cm wide, striking north with vertical to steep westerly dips.

Ore and gangue: wolframite and quartz; traces of copper, bismuth and lead minerals; minor biotite (no scheelite).

Production: 329.75 tonnes concentrates 1936-1958.

Masters Gully mine, W (GR 198862)

Reference: Ryan (1961).

Surface workings: shafts, pits, costeans; worked to depth of 46 m.

Country rocks; altered andesitic? lavas and interlayered arenites, Treasure Volcanics, and, in north, quartz arenite, Taragan Sandstone.

Lodes: 3 main quartz veins with easterly and northerly trends and steep dips.

Ore and gangue: wolframite, quartz; traces of copper, bismuth and molybdenum minerals; some mica.

Production: 95.1 tonnes concentrates 1937-1958.

White Diamond mine, W (GR 200860)

Reference: Ryan (1961).

Surface workings: shaft, pits, costeans; worked to depth of 15 m.

Country rocks: altered andesitic lavas and interlayered arenites, Treasure Volcanics.

Lodes: 2 main quartz veins, up to 40 cm wide, with easterly and northerly trends and steep dips.

Ore and gangue: wolframite, quartz; minor malachite, azurite, chalcocite, molybdenite, muscovite, biotite; traces of bismuth.

Production: 34.53 concentrates 1942-1958, possibly similar productions 1936-1941.

Hen and Chickens mine, W (GR 205861)

Reference: Ryan (1961).

Surface workings: shafts, pits, costeans; worked to depth of about 25 m.

Country rocks: altered felsic lavas and interlayered arenite, Treasure Volcanics.

Lodes: 3 quartz veins striking between 100° and 120 and dipping south; one quartz vein striking 180° and dipping 60-80°W.

Ore and gangue: wolframite, quartz; rare scheelite, minor malachite, chalcocite, covellite, chalcopyrite and possibly native bismuth; some iron oxides and mica.

Production: 24 tonnes concentrate before 1940; 444 tonnes concentrates 1940 - 1958.

BXB mine, W (GR 206858)

Reference: Ryan (1961).

Surface workings: shafts, pits, costeans; worked todepth of about 18 m.

Country rocks: altered felsic volcanics - mainly lavas - and minor interlayered quartz arenite, Treasure Volcanics.

Lodes: 2 sets of north to northeast-trending steeply-dipping quartz veins up to about 40 cm wide.

Ore and gangue: wolframite and quartz; minor scheelite, copper and bismuth carbonates, biotite, kaolinite, and iron oxides.

Production: 19.27 tonnes concentrates recorded to 1957.

Kangaroo group of mines, W (GR 188857)

Reference: Ryan (1961).

Surface workings: shafts, pits, costeans; worked to depth of 41 m.

Country rocks: interlayered arenite and altered felsic lava, Treasure Volcanics, and, in north, quartz arenite, Taragan Sandstone.

Lodes: northeast-trending quartz veins of the Kangaroo Line, and several other quartz veins of various trends; veins mainly steeply dipping and up to 1 m wide.

Ore and gangue: wolframite,quartz, mica; minor molybdenite and copper minerals.

Production: probably at least 100 tonnes concentrates.

Euro mine, W (190859)

Reference: Ryan (1961).

Surface workings: shaft, pits, costeans.

Country rocks: arenites, Taragan Sandstone.

Lodes: northeast-trending quartz veins on the Kangaroo Line.

Ore and gangue: wolframite, quartz, mica.

Production: 1.35 tonnes concentrates 1948-1957.

Hit or Miss group of mines, W (GR 195855)

Reference: Ryan (1961).

Surface workings: several shafts, pits, costeans; worked to depth of 62 m.

Country rocks: altered felsic lava and minor interlayered arenite, Treasure Volcanics.

Lodes: numerous steeply dipping quartz veins, mostly striking between north and northweast.

Ore and gangue: wolframite and quartz, with minor molybdenite and mica, and in east-northeast-trending lodes, abundant copper minerals - azurite, malachite, chrysocolla, atacamite, brochantite, chalcocite, and bornite.

Production: probably more than 400 tonnes concentrates to 1958.

Silver Granites mine, W (GR 193853)

Reference: Ryan (1961).

Surface workings: shafts, pits, costeans; worked to depth of about 28 m.

Country rocks: altered felsic lava, Treasure Volcanics.

Lodes: several steeply dipping quartz veins striking northeast to east-northeast, one vein striking north-northeast.

Ore and gangue: wolframite, malachite, bornite, chalcocite, molybdenite, and native bismuth?, with quartz and some mica.

Production: 19 tonnes concentrates recorded 1938-1957.

Copper Show mine, W, Cu (GR 168853)

Reference: Ryan (1961).

Surface workings: shafts, pits, costeans; worked to depth of about 27 m.

Country rocks: altered felsic volcanics and some thin arenite lenses, Treasure Volcanics.

Lodes: two main quartz veins striking 100° to 140° and dipping 40-80 N; average width about 60 cm.

Ore and gangue: wolframite, scheelite, tungstite, cuprotungstite, malachite, azurite, chalcocite, bornite, bismutite?, limonite, fuchsite?, muscovite, quartz.

Production: about 22 tonnes tungsten concentrates 1938-1956 and 44 tonnes copper concentrates 1950-1955.

Frenchmens Point mine, W (GR 205877) (not named on map)

Reference: Ryan (1961).

Surface workings: pits, costeans.

Country rocks: quartzose arenite, Taragan Sandstone.

Lodes: steeply dipping quartz veins up to 15 cm wide striking east of north.

Ore and gangue: wolframite, quartz.

Production: 5.7 tonnes concentrates, mainly in 1942-1944.

Mine W, Cu (GR 170944)

Surface workings: pits.

Country rocks: fine-grained feldspathic quartz arenite, Kurinelli Sandstone.

Lode: quartz vein.

Ore and gangue: wolframite?, quartz.

Production: not known, minor.

Prospect, Cu (GR 180873)

Surface workings: pits, costeans.

Country rocks: quartz arenite, Kurinelli Sandstone, and chloritic dolerite dyke up to 3 m thick.

Lode: irregular quartz veins.

Ore and gangue: malachite, quartz.

Mine, Cu (GR 376875)

Surface workings: shaft, pits.

Country rocks: altered basaltic lava, Kudinga Basalt.

Lode: quartz veins

Ore and gangue: malachite, quartz, ironoxide, calcite

Production: minor, unknown.

Woodenjerrie mine, W (GR 279369)

Surface workings: shallow shafts, pits, costeans.

Country rocks: medium to thin-bedded greywacke and siltstone, Warramunga Group.

Lodes: quartz veins.

Ore and gangue: wolframite, quartz, hematite, pyrite.

Production: minor; worked 1952-1953.

Crystal mine, Au (GR 219953)

Reference: Ryan (1961).

Surface workings: 2 main shafts, pits.

Country rocks: altered gabbro and dolerite; blocks/screens of fine-grained arenite, Kurinelli Sandstone.

Lodes: quartz veins; main vein trends 025° and dips 45-50° east.

Ore and gangue: gold, quartz, limonite.

Production: none recorded.

Cairns prospect, Au (GR 021018)

Reference: Roarty (1977).

Surface workings: costeans.

Country rocks: altered porphyritic granophyre; arenite and siltstone, Kurinelli Sandstone.

Lodes: quartz and quartz-hematite-magnetite veins.

Ore and gangue: gold, quartz, iron oxides.

Mine (Dempseys Choice), Au (GR 041207)

Reference: Roarty (1977).

Surface workings: shaft, pits, costeans.

Country rocks: gabbro, dolerite.

Lodes: quartz veins.

Ore and gangue: gold, quartz.

Production: about 1200 g Au 1933.

Mine (Kurranelli), Au (GR 036180)

Reference: Roarty (1977).

Surface workings, shaft, pits, costeans.

Country rock: dolerite; thin bedded to laminated micaceous siltstone and fine-grained arenite, Rooneys Formation.

Lodes: quartz veins.

Ore and gangue: gold,quartz.

Production: about 8.215 g Au 1935-1977; 0.5 kg alluvial gold 1926.

Prospect, Au (GR 054202)

Surface workings: pit.

Country rocks: dolerite, gabbro.

Lode: quartz vein.

Ore and gangue: gold?, quartz.

Prospect, Au (GR 030146)

Surface workings: pits, costeans.

Country rocks: altered dolerite; pale pink fine-grained feldspathic arenite, Rooneys Formation.

Lodes: quartz veins.

Ore and gangue: gold, quartz, calcite.

Prospect, Au (GR 027138)

Surface workings: costeans.

Country rocks: altered dolerite; fine-grained feldspathic arenite, Rooneys Formation.

Lode: ?

Ore and gangue: ?

Prospect, Au (GR 061185)

Surface workings: costean.

Country rocks: dolerite, gabbro.

Lode: quartz vein.

Ore and gangue: gold?, quartz, calcite, muscovite.

Prospect, Au (GR 064199)

Surface workings: costean.

Country rocks: gabbro, dolerite; arenite and siltstone, Rooneys Formation.

Lode: ?

Ore and gangue: secondary copper minerals, gold?, quartz.

GEOLOGICAL HISTORY

The earliest event recorded in the map sheetwas the deposition of muddy sands and silts represented by the Warramunga Group, probably by turbidity currents in deep water between about 1850 and 1820 m.y. ago (Black, 1981). Some time after lithification, the Warramunga Group rocks were folded, and subjected to low grade regional metamorphism. Uplift accompanied this tectonism, which has been dated at about 1810 m.y. by Black (1977, 1981), and was followed by a period of erosion, during which the Warramunga rocks were worn down to form low-lying terrain with a moderate to low relief.

Subsequent regional downwarping, possibly due to crustal thinning, resulted in the area becoming part of an extensive, ensialic, depositional basin, the so-called Davenport Geosyncline. The renewed sedimentation was accompanied by felsic and basaltic volcanism and penecontemporaneous high level, subvolcanic intrusions, as represented by the Hatches Creek Group and associated granophyre, felsic porphyry, dolerite and gabbro. During the deposition of this sequence, sedimentation and the accumulation of volcanic products kept pace with subsidence in the basin, so that shallow marine to fluvial and locally subaerial depositional environments prevailed throughout Hatches Creek Group time (see Sweet, in preparation). The earliest volcanism (Epenarra Volcanics) which was largely felsic in character, took place in the north from probably several volcanic centres. Predominantly clastic shallow marine and fluvial sedimentation occurred during and after the volcanism, with the deposition of the Kurinelli Sandstone, Rooneys Formation, and Taragan Sandstone to the south of the Epenarra Volcanics. In places the sediments interfingered with and overlapped the volcanics. These sediments and the younger sediments of the Hatches Creek Group were derived largely from source areas of Warramunga Group and Arunta rocks to the west (Sweet, in preparation), but at some stratigraphic levels they included considerable amounts of locally derived volcanic detritus. A later phase of volcanism from possibly several separate centres in the south is represented by the felsic and subordinate mafic lavas and associated pyroclastics of the Treasure Volcanics and the mainly felsic pyroclastics of the Mia Mia Volcanics. The

eruptions took place on a low plain or shallow shelf, and were accompanied, as earlier, by shallow water clastic sedimentation, with sands being interlayered with and overlapping lava flows and pyroclastic deposits on the flanks of the volcanic piles. Most of the granophyre and feldspar porphyry intrusions in the area may have been emplaced during this period of volcanism.

At the end of Treasure Volcanics time there was a general lull in volcanic activity, and, as subsidence in the basin continued, a thick quartz-rich sand blanket was laid down over the entire area. This sand, which now forms the Unimbra Sandstone at the base of the Middle Hatches Creek Group, was probably deposited in shallow marine shelf to fluvial environments. Subsequent eruptions from a new group of volcanic centres led to the Unimbra sands being overlain by felsic porphyries of the Arabulja Volcanics and laterally equivalent, variably volcaniclastic sediments of the Yeeradji Sandstone. When the Arabulja volcanism ceased, the area became covered once again by a thick, region-wide blanket of shallow marine quartz-rich sand, represented by the Coulters Sandstone. This sand was succeeded by mainly finer-grained clastic sediments and carbonates of the Frew River Formation. The carbonates included some stromatolitic bioherms, and were evidently laid down in very shallow marine, supratidal, or sabkha environments. A period of basaltic volcanism followed, during which flows of Kudinga Basalt were erupted onto a broad plain or shallow shelf underlain by the Frew River Formation. Feldspathic sands were deposited during intervals between eruptions, especially early in Kudinga Basalt time. Some of the dolerite and gabbro intrusions in the area may be genetically and temporally related to this volcanism. After the basaltic eruptions had ceased, a third extensive thick blanket of quartz-rich sand was deposited. The sand, which forms the Errolola Sandstone, was laid down mainly on intertidal flats and in adjoining subtidal environments. Shallow marine and possibly deltaic sedimentation followed, with the deposition of sands and subordinate silts and clays of the Alinjabon Sandstone, the basal unit of the Upper Hatches Creek Group. Sedimentation was accompanied locally by minor mafic volcanism, the last recorded volcanism in the area. Water depth may have increased during deposition of mainly fine-grained sediments of the overlying Lennee Creek Formation. Shallow marine and partly intertidal conditions probably prevailed during the

deposition of the succedding Canulgerra Sandstone, Vaddingilla Formation, and Yaddanilla Sandstone in the east, the youngest exposed units of the Hatches Creek Group.

Some time after the deposition of the Yaddanilla Sandstone the Hatches Creek Group was deformed, probably as a result of large-scale gravity-type sliding, regionally metamorphosed to greenschist facies, and intruded by granite. Granite emplacement appears to have taken place at about 1660 m.y., after the main folding event, but conceivably could have been at least partly responsible for the gravity-sliding tectonism. The tungsten-bismuth-copper-molybdenum mineralisation in the area, mainly near Hatches Creek, may be attributed to late-stage hydrothermal solutions emanating from crystallising granite. The gold mineralisation, on the other hand, may be related to the folding and regional metamorphism, when gold, scavenged by solutions permeating gabbro and dolerite, and also adjacent rocks of the Lower Hatches Creek Group, was deposited in tension cracks, now represented by quartz veins.

As a result of the tectonism and granite intrusion, the region was elevated well above sea level, and became subjected to subaerial erosion. It may have remained land for the remainder of the Precambrian, gradually being worn down to form a mature landscape of low relief, probably not very different from that at the present time. The region was inundated during the Cambrian, when shallow marine sediments of the Georgina Basin sequence were deposited unconformably on the Precambrian rocks, but has probably been part of a large landmass for most of the Phanerozoic, and it has been subjected to continued weathering and erosion, with some fluvial and aeolian deposition, throughout the Cainozoic. The region appears to have been a tectonically stable part of the north Australian craton since about 1650 m.y. ago.

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APPENDIX Thin-sectioned rock samples, Hatches Creek region map sheet

Unit	Registered number	Map symbol	Location (Grid ref.)	Rock type
Warramunga Group	82118426A		284367	Greywacke
	82118426B		284367	Greywacke
Epenarra Volcanics	81110968A	Ꝑhr	029343	Altered quartz - feldspar porphyry
	81110981	Ꝑhr	142362	Cleaved felsic tuff
	81110995	Ꝑhr	325338	Cleaved porphyrite tuff
Rooneys Formation	81111063	Ꝑhn	038209	Feldspathic quartzite:hornfels
	81111068B	Ꝑd	063184	Quartzofeldspathic hornfels: inclusion in dolerite
	81111591	Ꝑhn	097295	Laminated arenite/siltstone
	81111593	Ꝑhn	103304	Fine-grained micaceous arenite
	81114727A	$Ꝑhn_{sh}$	401319	Muscovite schist
	81114727B	$Ꝑhn_{sh}$	401319	Quartz-muscovite schist
	81114733C	$Ꝑhn_{sh}$	396319	Muscovite-quartz schist
	81114744B	$Ꝑhn_{sh}$	364322	Quartz-muscovite schist
	81114852	Ꝑhk?	408303	Schistose micaceous arenite
	81114858	Ꝑhn	342266	Quartz-muscovite schist
	81114924	Ꝑhn	283213	Laminated siltstone/arenite
	81114927	Ꝑhn	294224	Laminated schistose siltstone
	81115047	Ꝑhn	101227	Thin-bedded siltstone/arenite
	82114041	Ꝑhn	032205	Limonitic sub-lithic arenite
	82114162	Ꝑhn	055181	Very fine-grained micaceous clayey arenite

Unit	Registered number	Map Symbol	Location (Grid ref.)	Rock type
	82114164	Ꝑhn	051183	Fine-grained micaceous lithic arenite
	82114167	Ꝑhn	050185	Fine-grained lithic arenite
	82114168	Ꝑhn	049188	Micaceous shale
Kurinelli Sandstone	81110195A	Ꝑhk	178874	Granophyric hornfels
	81110266	Ꝑhk	220926	Hornfelsic feldspathic quartzite
	81111052	Ꝑhk	012207	Volcaniclastic quartzose arenite
	81111059	Ꝑhk	029207	Fine-grained micaceous arenite
	81111199	Ꝑhk	032031	Ashstone: quartz-sercite rock
	81111247	Ꝑhk	006060	Altered very fine-grained igneous rock
	82114042	Ꝑhk	030207	Very fine-grained sublithic arenite
	82114046	Ꝑhk	028207	Very fine-grained clayey arenite
	82114047	Ꝑhk	027207	Very fine-grained lithic arenite
	82114049	Ꝑhk	024206	Fine-grained sublithic arenite
	82114053	Ꝑhk	016211	Fine to medium sublithic arenite
Warnes Sandstone Member	81110209A	$Ꝑhk_w$	218903	Granophyric hornfels/feldspathic quartzite
	81110209B	$Ꝑhk_w$	218903	Granophyric hornfels/feldspathic quartzite
	81118166B	$Ꝑhk_w$	195904	Altered rock
	81118166C	$Ꝑhk_w$	195904	Arenite
	81118251	$Ꝑhk_w$	188919	Quartzite
Taragan Sandstone	81110276	Ꝑho	242915	Laminated ashstone

Unit	Registered number	Map Symbol	Location (Grid ref.)	Rock type
	81110282	Eho	251906	Altered fine-grained igneous rock
	81115119	Eho	155082	Lithic arenite
	82114224	Eho	569298	Medium-grained sublithic arenite
	82114229	Eho	572295	Medium-grained sublithic arenite
	82114233	Eho	573293	Medium to coarse-grained sublithic arenite
	82114234	Eho	573292	Medium to coarse-grained sublithic arenite
	82114236	Eho	574291	Clast of recrystallized sandy siltstone
	82114237	Eho	575289	Medium-grained sublithic arenite
	82114303	Eho	186965	Medium-grained sublithic arenite
	82114384B	Eho	187964	Coarse-grained sublithic arenite
	82114386	Eho	196991	Quartz arenite
	82114392	Eho	179016	Fine-grained quartz arenite
Treasure Volcanics	81110087	Eht	219862	Porphyritic felsic lava
	81110088A	Eht	224861	Spherulitic, vesicular, porphyritic felsic lava
	81110169A	Eht	178852	Amygdaloidal altered basaltic lava
	81110173	Eht	204853	Altered andesitic? lava
	81110175	Eht	197867	Altered andesitic? lava
	81110216	Eht	222881	Spherulitic, porphyritic felsic lava
	81110283	Eht	257908	Spherulitic felsic lava
	81110321	Eht	179952	Spherulitic, vesicular, porphyritic felsic lava
	81110321A	Eht	179952	Spherulitic, vesicular, porphyritic felsic lava

Unit	Registered number	Map Symbol	Location (Grid ref.)	Rock type
	81110326	Eht	166953	Spherulitic porphyritic felsic lava
	81110430	Eht	053903	Altered spherulitic, vesicular, felsic lava
	81110430A	Eht	052904	Medium-grained tuff
	81110432	Eht	055904	Altered porphyritic felsic lava
	81110433	Eht	058905	Altered spherulitic porphyritic felsic lava
	81110434A	Eht	062905	Dolerite (lava?) with augite
	81110595	Eht_m	128954	Quartz-feldspar porphyry (sill?)
	81110605B	Eht	104937	Altered amygdaloidal 'andesite'
	81110609	Eht	108948	Porphyritic felsic lava
	81110610	Eht	111951	Spherulitic sparsely porphyritic felsic lava
	81110610A	Eht	112951	Spherulitic sparsely porphyritic felsic lava
	81110614	Eht_m	125954	Amygdaloidal basalt
	81110632A	Eht	107988	Altered felsic lava
	81110641	Eht	098985	Spherulitic porphyritic felsic lava
	81110644A	Eht_m	094976	Ophitic basalt with augite
	81110644B	Eht_m	094976	Amygdaloidal basalt
	81110759	Eht	210848	Altered felsic lava
	81110784	Eht	150943	Spherulitic porphyritic felsic lava
	81110827	Eht	145881	Spherulitic porphyritic felsic lava
	81111089	Eht	062911	Spherulitic porphyritic felsic lava
	81111090	Eht	060913	Spherulitic felsic lava
	81111132	Eht_m	091919	Epidotic amygdaloidal basalt

Unit	Registered number	Map Symbol	Location (Grid ref.)	Rock type
	8111170	Ꝑht	046979	Spherulitic porphyritic felsic lava
	81111176B	Ꝑht$_m$	067996	Amygdaloidal basalt
	81111177	Ꝑht	073994	Quartz-feldspar porphyry lava
	81111179	Ꝑht	074997	Spherulitic porphyritic felsic lava
	81114006	Ꝑht	363990	Spherulitic porphyritic felsic lava
	81114008A	Ꝑht	361980	Quartz arenite
	81114011	Ꝑht	364973	Spherulitic porphyritic felsic lava
	81114037	Ꝑht	391967	Altered rhyolite?
	81114054B	Ꝑht	424017	Altered spherulitic felsic lava
	81114398	Ꝑht	463999	Altered porphyritic felsic lava
	81114432	Ꝑht	344987	Spherulitic porphyritic felsic lava
	81114433	Ꝑht	344986	Spherulitic porphyritic felsic lava
	81114434A	Ꝑht	344984	Spherulitic porphyritic felsic lava
	81114440	Ꝑht	342972	Vesicular porphyritic felsic lava
	81114444B	Ꝑht	340963	Altered felsic lava
	81114803B	Ꝑht	320979	Porphyritic felsic lava
	81114811A	Ꝑht	309948	Spherulitic porphyritic felsic lava
	81118167	Ꝑht	198868	Dacite
	81118170	Ꝑht	113895	Felsic volvanic
	81118171	Ꝑht	109894	Amygdaloidal andesitic basalt
	81118172B	Ꝑht	110889	Felsic volcanic
	81118254	Ꝑht	178955	Felsic volcanic
	81118257B	Ꝑht$_m$	132962	Amygdaloidal basalt
	81118259	Ꝑht$_m$	132962	?
	81118262	Ꝑht$_m$	123957	Basalt
	81118273	Ꝑht	151945	Rhyodacite

Unit	Registered number	Map Symbol	Location (Grid ref.)	Rock type
	81118274	Ꝑht	151945	Porphyritic felsic lava
	82111807	Ꝑht	194855	Altered andesite? lava
	82111808	Ꝑht	194859	Altered amygdaloidal andesite? lava
	82111809	Ꝑht	194864	Altered porphyroblastic andesite? lava
	82111809A	Ꝑht	194865	Altered spherulitic andesite ? lava
	82111810A	Ꝑht	195865	Medium-grained quartz arenite
	82111810B	Ꝑht	195867	Altered porphyroblastic andesite? lava
	82111810C	Ꝑht	196867	Altered amygdaloidal andesite? lava
	82114174	$Ꝑht_s$	160952	Medium to coarse-grained sublithic arenite
	82114176	$Ꝑht_s$	110950	Fine to medium-grained sublithic arenite
	82114178	$Ꝑht_s$	103948	Medium-grained orthoquartzite
Mia Mia Volcanics	81110060A	Ꝑhm	203805	Cleaved porphyritic felsic tuff
	81110061	Ꝑhm	202806	Fine-grained schistose tuff
	81110061A	Ꝑhm	202806	Cleaved porphyritic felsic tuff
	81110062	$Ꝑhm_s$	198804	Cleaved, partly volcaniclastic conglomerate
	81110062A	Ꝑhm	198804	Fine-grained schistose tuff
	81110065	Ꝑhm	192807	Cleaved porphyritic felsic tuff
	81110153	Ꝑhm	164834	Volcaniclastic meta-arenite
	81110156A	Ꝑhm	162825	Porphyritic felsic lava
	81110160	Ꝑhm	171829	Cleaved fine-grained tuff
	81110345	Ꝑhm	111842	Micaceous volcaniclastic arenite
	81110347	Ꝑhm	117837	Thin-bedded lapilli tuff
	81110348	Ꝑhm	120835	Cleaved felsic tuff
	81110348A	Ꝑhm	122835	Altered vesicular rhyolite

Unit	Registered number	Map symbol	Location (Grid ref.)	Rock type
	81110349	Ehm	114832	Laminated fine-grained felsic tuff
	81110353	Ehm	105819	Vesicular porphyritic felsic lava
	81110354	Ehm	103816	Laminated fine-grained felsic tuff
	81110355	Ehm	101813	Altered felsic tuff?
	81110477A	Ehm	152837	Cleaved felsic lava
	81110728	Ehm	178830	Altered felsic ignimbrite
	82118324	Ehm	206822	Schistose felsic volcanic
	82118324B	Ehm	206822	Schistose felsic volcanic
Unimbra Sandstone	81114161B	Ehs	477972	Quartz arenite
	81114386B	Ehs	515046	Flow-banded rhyolite
	82114087A	Ehs	109889	Very poorly sorted lithic arenite
	82114088	Ehs	109889	Quartz arenite
	82114089A	Ehs	109890	Slightly feldspathic arenite
	82114089B	Ehs	109890	Slightly feldspathic matrix-rich arenite
Yeeradgi Sandstone	81110025	Ehd	073812	Ashstone?
	81110028	Ehd	073816	Fine-grained micaceous lithic arenite
	81110053	Ehd	226809	Fine-grained, micaceous, feldspathic quartz arenite
	81110342	Ehd	104852	Thin-bedded fine-grained micaceous arenite
	81110882	Ehd	302917	Ashstone
	81110896	Ehd	296899	Laminated fine-grained micaceous arenite
	81111024	Ehd	088933	Feldspathic arenite/tuffaceous siltstone

Unit	Registered number	Map symbol	Location (Grid ref.)	Rock type
	81114697	Ꝑhd	549102	Laminated tuff
	82114091	Ꝑhd	106886	Fine-grained sub-arkose
	82114093	Ꝑhd	104853	Silty shale
Arabulja Volcanics	81110043	Ꝑha$_p$	230794	Foliated dacitic porphyry with biotite
	81110051A	Ꝑha$_p$	230812	Foliated dacitic porphyry with hornblende
	81110081	Ꝑha$_p$	234815	Altered tuff
	81110095	Ꝑha$_p$	231852	Foliated dacitic porphyry with hornblende
	81110371	Ꝑha	024783	Porphyritic dacitic lava
	81110379	Ꝑha	009798	Porphyritic felsic lava
	81110578	Ꝑha$_p$	275896	Foliated dacitic porphyry
	81110684A	Ꝑha	005825	Altered felsic tuff
	81110684B	Ꝑha	005825	Flow-banded felsic lava
	81110893	Ꝑha$_p$	290905	Dacitic feldspar porphyry (ignimbrite?)
	81114135B	Ꝑha$_p$	474961	Altered porphyry
	81114135C	Ꝑha$_p$	474961	Dacitic porphyry
	81114147	Ꝑha$_p$	490952	Dacitic porphyry with biotite
	81114153	Ꝑha	474939	Weathered dacitic porphyry
	81114488	Ꝑha	424943	Laminated siltstone/arenite
	81118201	Ꝑha$_p$	232810	Dacitic feldspar porphyry with hornblende
	81118237	Ꝑha$_p$	232810	Dacitic feldspar porphyry
Coulters Sandstone	81114227	Ꝑhc	407913	Quartz arenite

Unit	Registered number	Map symbol	Location (Grid ref.)	Rock type
	82114010	Ehc	031800	Fine-grained sublithic arenite
	82114011	Ehc	031800	Orthoquartzite bordering on sublithic arenite
	82114012	Ehc	032801	Medium to coarse-grained quartz arenite
	82114013	Ehc	033801	Partly recrystallised quartz arenite
	82114270	Ehc	241806	Very fine-grained silty arenite
Kudinga Basalt	81110141A	Ehb	268839	Vesicular altered basalt
	81110391A	Ehb	034905	Volcaniclastic arenite
	81110697	Ehb	013842	Basalt with amphibole
	81114088C	Ehb	372868	Weathered amygdaloidal basalt
	81114311	Ehb	412779	Vesicular altered basalt
	81114372	Ehb	377875	Altered basalt
	81114584	Ehb	370878	Altered vesicular basalt
	81114696	Ehb	572103	Amygdaloidal basalt
	81114798	Ehb	378870	Epidotic basalt
	81114798D	Ehb	378870	Epidotic basalt
	81118157A	Ehb	413861	Basalt
	81118158	Ehb	413859	Basalt
	81118159	Ehb	412854	Amygdaloidal basalt
	81118161	Ehb	414851	Andesitic? basalt
	81118162	Ehb	416848	Basalt
	81118163	Ehb	416845	Basalt
	81118164	Ehb	417843	Basalt
	81118168	Ehb	568128	Basalt
	81118210	Ehb	008839	Basalt
	81118214	Ehb	013840	Epidotic basalt

Unit	Registered number	Map symbol	Location (Grid ref.)	Rock type
	81118216	Ehb	013840	Amygdaloidal basalt
	81118218	Ehb	013840	Epidotic basalt
	81118221	Ehb	013840	Epidotic basalt
	81118223	Ehb	013843	Epidotic basalt
	81118224	Ehb	054819	Epidotic basalt
	81118226	Ehb	054820	Epidotic basalt
Errolola Sandstone	81114103	Ehe	387833	Mudstone breccia
Alinjabon Sandstone	81110709	Ehi	044840	Altered basalt? lava
	81114319	Ehi	425814	Quartzose arenite
	81114630C	Ehi	648931	Micaceous siltstone with andalusite
	81114636C	Ehi_v	642924	Vesicular basalt with augite
	81114946	Ehi	582955	Thin-bedded arenite/siltstone
	81118143	Ehi	649931	Micaceous rock
	81118144	Ehi	642927	Basalt
	81118146A	Ehi	643925	Altered basalt
	81118148	Ehi	649948	Altered basalt
	82114203	Ehi	583972	Quartz arenite/sublithic arenite
	82114205	Ehi	583979	Slightly silty slale
Lennee Creek Formation	81114292	Ehl	500803	Fine-grained porous quartzose arenite
	81114299	Ehl	484800	Porous quartzose arenite
	81114346	Ehl	516785	Fine-grained micaceous arenite
	81114640C	QC/Ehl	652940	Lithic quartz arenite

Unit	Registered number	Map symbol	Location (Grid ref.)	Rock type
	81114950	Ꝑhl	056595	Fine-grained quartz arenite
Canulgerra Sandstone	81114628	Ꝑhu	635016	Porous quartz arenite
	82114188	Ꝑhu	625009	Fine to medium-grained sublithic arenite
	82114193B	Ꝑhu	634015	Medium to coarse-grained quartz arenite
Vaddingilla Formation	81114616	Ꝑhv	643028	Lithic arenite
Yaddanilla Sandstone	82114194	Ꝑhy	672005	Fine to medium-grained sublithic arenite.
Dolerite/ gabbro	81110196A	Ꝑd	180871	Subophitic quartz gabbro with amphibole
	81110208	Ꝑd	214906	Quartz gabbro with amphibole
	81110224A	Ꝑd	189894	Ophitic dolerite with amphibole
	81110224B	Ꝑd	189894	Ophitic quartz gabbro with amphibole
	81110224C	Ꝑd	189894	Ophitic quartz gabbro with amphibole
	81110236	Ꝑd	186910	Quartz gabbro with amphibole
	81110237	QC/Ꝑd	188920	Quartz-hornblende gabbro
	81110267	Ꝑd	224927	Altered dolerite
	81110510	Ꝑd	155866	Altered dolerite with amphibole
	81110519B	Ꝑd	166883	Dioritic hybrid rock
	81111022	Ꝑd	273258	Quartz gabbro with augite remnants
	81111034	Ꝑd	109266	Quartz gabbro with augite

Unit	Registered number	Map symbol	Location (Grid ref.)	Rock type
	81111068A	Ed	063184	Quartz gabbro with augite remnants
	81111212A	Ed	027008	Ophitic dolerite with pyroxene
	81111460	Ed	256061	Quartz dolerite with augite
	81111508	Ed	215072	Quartz dolerite with augite remnants
	81111509	Ed	213076	Ophitic gabbro with augite
	81111607	Ed	107299	Ophitic quartz gabbro with augite
	81111727	Ed	054155	Quartz gabbro/diorite
	81111791	Ed	021147	Ophitic dolerite with augite
	81115050	Ed	008236	Fresh dolerite
	81115085	Ed	110186	Weathered quartz dolerite
	81115100	Ed	175045	Dolerite with pyroxene
	81118152	Ed	209957	Gabbro
	81118166A	Ehk_w	195904	Dolerite
	81118230A	Ed	188894	Gabbro
	81118231	Ed	188894	Altered dolerite
	81118232	Ed	188894	Gabbro
	81118233	Ed	188894	Gabbro
	81118234	Ed	188894	Gabbro
	81118241B	Ed	185891	Gabbro
	81118250	Ed	188919	Gabbro
	81118252	Ed	188919	Gabbro
	81118275	Ed	056200	Gabbro
Granophyre and intrusive feldspar porphyry	81110185	Egy	192882	Porphyritic granophyre
	81110189	Egy	188885	Spherulitic porphyritic granophyre
	81110190	Egy	187885	Non-porphyritic granophyre
	81110191	Egy	185885	Non-porphyritic granophyre

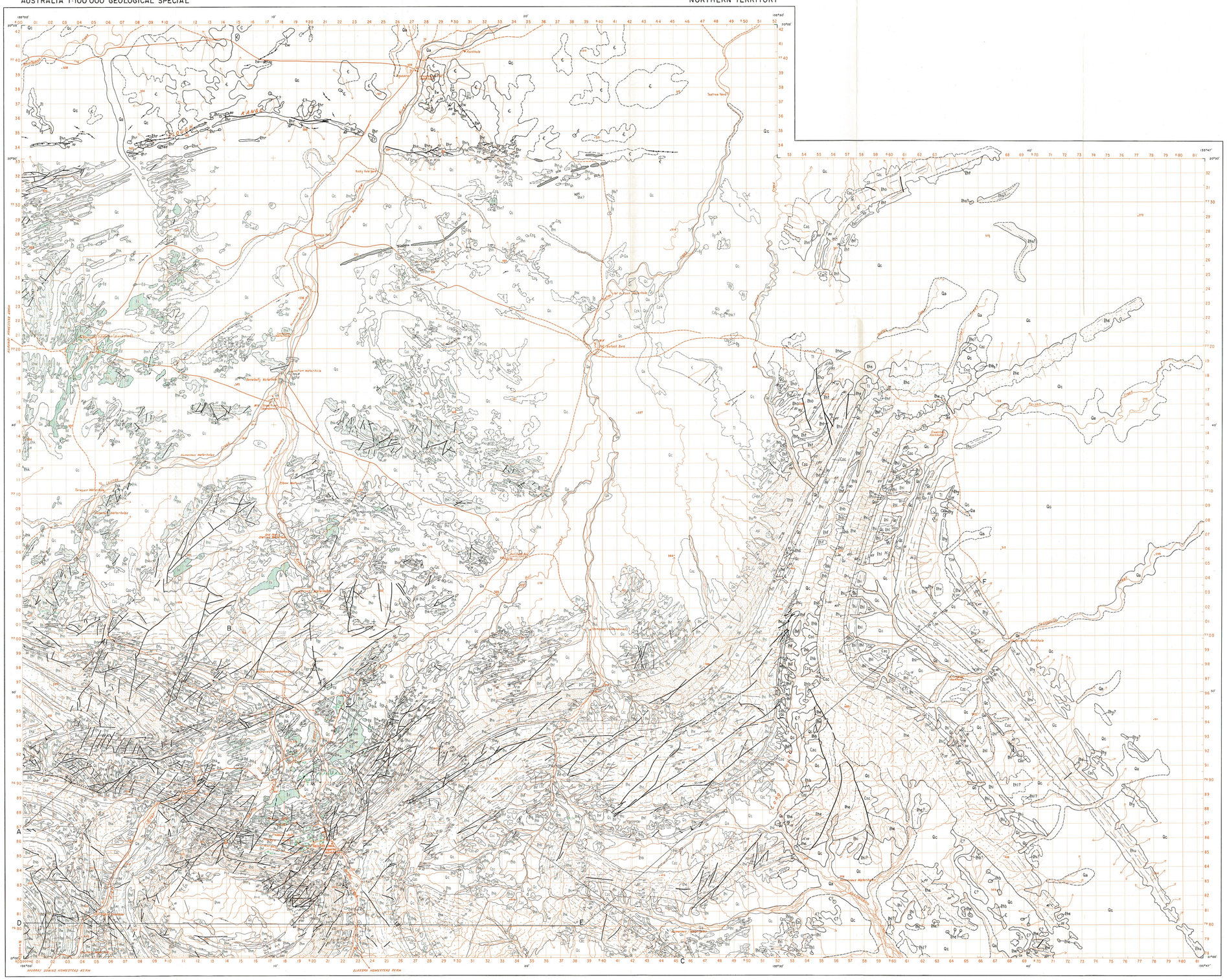
Unit	Registered number	Map symbol	Location (Grid ref.)	Rock type
	81110192	Egy	179884	Microporphyritic granophyre
	81110192A	Egy	179884	Microporphyritic granophyre
	81110195B	Egy	178874	Feldspar porphyry
	81110207	Egy	214900	Porphyritic granophyre
	81110226	Egy	173883	Microporphyritic granophyre
	81110273	Egy	238918	Spherulitic microporphyritic granophyre
	81110374	Egy	021790	Porphyritic granophyre
	81110376	Egy	014794	Porphyritic granophyre
	81110379A	Egy	011798	Feldspar porphyry
	81110380	Egy	013800	Spherulitic porphyritic granophyre
	81110380A	Egy	014800	Feldspar porphyry
	81110382	Egy	019805	Porphyritic granophyre
	81110512	Egy	150865	Spherulitic feldspar porphyry
	81110519A	Egy	166882	Porphyritic granophyre
	81110561	Egy	233889	Sparsely porphyritic granophyre
	81110565	Egy	244890	Spherulitic feldspar porphyry
	81110592	Egy	181968	Sparsely porphyritic granophyre
	81110596	Egy	126951	Porphyritic granophyre
	81110613	Egy	119953	Feldspar porphyry
	81110630A	Egy	107985	Spherulitic felsic porphyry
	81110631	Egy	108986	Spherulitic sparsely porphyritic granophyre
	81110637	Egy	112988	Spherulitic feldspar porphyry
	81110773	Egy	197974	Spherulitic feldspar porphyry
	81110779	Egy	139945	Altered feldspar porphyry
	81110908	Egy	232009	Quartz-feldspar porphyry
	81110926	Egy	267031	Sparsely porphyritic granophyre
	81111199A	Egy	031032	Altered richly porphyritic granophyre
	81111217A	Egy	019018	Altered richly porphyritic granophyre

Unit	Registered number	Map symbol	Location (Grid ref.)	Rock type
	81111448	Ꝑgy	273043	Non-porphyritic granophyre
	81111449	Ꝑgy	270043	Porphyritic granophyre
	81111451	Ꝑgy	270051	Spherulitic porphyritic granophyre
	81111451A	Ꝑgy	270051	Porphyritic granophyre
	81111506	Ꝑgy	211067	Spherulitic granophyre
	81111771	Ꝑgy	214047	Spherulitic porphyritic granophyre
	81114002C	Ꝑgy	389019	Altered granophyre
	81115102	Ꝑgy	170058	Spherulitic felsic porphyry
	81118243	Ꝑgy	187884	Granophyre
	81118244	Ꝑgy	187884	Microporphyritic granophyre
	81118245	Ꝑgy	187884	Granophyre
	81118247	Ꝑgy	187885	Granophyre
Granite	81110065A	Ꝑg	180807	Medium-grained muscovite granite
	81110748	Ꝑg	185804	Coarse biotite-muscovite leucogranite
	81114725	Ꝑg	405293	Muscovite-biotite granite
	81114735B	Ꝑhk?	388306	Foliated microgranite
	81114840	Ꝑg	473270	Medium-grained muscovite-biotite granite

AUSTRALIA 1:100 000 GEOLOGICAL SPECIAL

GEOLOGY OF THE HATCHES CREEK REGION

NORTHERN TERRITORY



Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development and Energy, in collaboration with the Northern Territory Geological Survey, Department of Mines and Energy. Issued under the authority of the Minister for National Development and Energy. Base map compiled by the Bureaus of Mineral Resources from 1:100 000 scale orthophotomap line conversion supplied by the Division of National Mapping.

UNIVERSAL GRID REFERENCE

GRID ZONE DESIGNATION: 53
100 000 METRE SQUARE IDENTIFICATION: NT
SQ
SENDING the SMALLER figures of the grid reference only, the LARGER figures MUST be left in position. Omit ONLY the LARGER figures of the grid number. Example:-
Grid Reference: 3 7 2 3
Grid Number: 3 7 2 3

TO GIVE A STANDARD REFERENCE ON THIS SHEET TO NEAREST 100 METRES
SAMPLE POINT: 3723
1 Read values on the 100 000 metre square indicator to the point.
2 Locate first VERTICAL grid line to LEFT of point and read LARGER figures from scale at the top or bottom of the map. Example: 37 in the bottom margin, or on the line itself.
3 Estimate tenths from grid line to point.
4 Locate first HORIZONTAL grid line BELOW point and read LARGER figures labelling the line in either the left or right margin. Example: 23 in the margin.
5 Estimate tenths from grid line to point.
SAMPLE REFERENCE: 372239
If reporting beyond 10° in one direction, prefix Grid Zone Designation, ex. 53NNT372394
Brown numbered lines are 1000 metre intervals of the Australian Map Grid, Zone 53.
Grid values are shown in full only at the southwest corner of the map. Transverse Mercator Projection

SCALE 1:100000

1 0 1 2 3 4 5 6 7 8 9 10 Kilometres

MAP LOCALITY

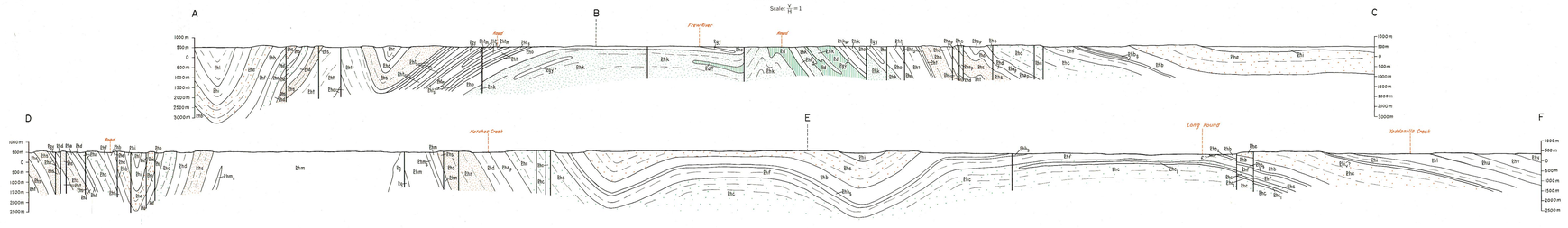
INDEX TO 1:100 000 MAPS
1:100 000 Maps shown in brown

Geology 1956 by K.G.Smith, J.R.Stewart, J.W.Smith, G.R.Ryan, BMR
1961 by D.H.Blake, BMR, S.Wyche, NTGS
1982 by D.H.Blake, I.P.Sweet, BMR
Compiled 1981-82 by D.H.Blake, C.P.Knight, BMR, S.Wyche, NTGS
Design and drafting by Cartography Section, BMR
Drawn by C.P.Knight

SCHEMATIC SECTIONS

Cainozoic sediments omitted

Scale: $\frac{V}{H} = 1$



PALAEOZOIC CAINOZOIC

TERTIARY QUATERNARY

- Qa Sand, silt, clay, gravel: fluvial
- Ql Silt, clay, sand: lacustrine
- Qc Sand, gravel, silt, clay: colluvial and fluvial
- Czc Gravel, sand: dissected alluvial/colluvial fan deposits
- Czq Vein quartz rubble
- Czk Calcrete
- Ts Silcrete
- Tl Laterite, ferricrete

CAMBRIAN

- € Conglomerate, sandstone, chert, siltstone

PROTEROZOIC

- Ꝑg Porphyritic and even-grained granite containing muscovite and/or biotite; minor pegmatite, aplite, greisen: recessive
- Ꝑgy Granophyre, intrusive feldspar porphyry: generally recessive
- Ꝑd Dolerite, gabbro, commonly quartz-bearing; epidotic, uralitic and chloritic alteration: recessive

HATCHES CREEK GROUP

UPPER

- Ꝑhs Jedadinilla Sandstone* — Ꝑhs Ridge-forming quartz arenite and feldspathic quartz arenite
- Ꝑhv Jedadinilla Formation* — Ꝑhv Recessive siltstone, shale, and feldspathic and micaceous arenite
- Ꝑhu Samuleroo Sandstone* — Ꝑhu Ridge-forming feldspathic quartz arenite, and recessive feldspathic arenite and micaceous siltstone
- Ꝑhl Lennee Creek Formation* — Ꝑhl Recessive arenite, siltstone, and shale, minor quartz arenite and calcareous beds
- Ꝑhi Alinjabon Sandstone* — Ꝑhi Ridge-forming quartz arenite and feldspathic quartz arenite; minor recessive arenite, siltstone, shale, calcareous beds and mafic lava; Ꝑhiv Recessive mafic lava, micaceous siltstone, and shale
- Ꝑhe Errolola Sandstone* — Ꝑhe Ridge-forming quartz arenite and subordinate feldspathic quartz arenite, rare pebbly arkosite

MIDDLE

- Ꝑhb Kudinga Basalt* — Ꝑhb Recessive amygdaloidal and coniraceous to massive basalt lava, epidotic and chloritic; minor interlayered arenite; Ꝑhbs Ridge-forming feldspathic quartz arenite; minor basalt lava
- Ꝑhf Frew River Formation* — Ꝑhf Recessive friable arenite and siltstone, commonly calcareous and dolomitic and locally stromatolitic in upper part; minor silicified quartz arenite
- Ꝑhc Coulters Sandstone* — Ꝑhc Ridge-forming quartz arenite and subordinate feldspathic quartz arenite; minor pebbly arenite; Ꝑhcf Recessive friable feldspathic arenite
- Ꝑha Arabulja Volcanics* — Ꝑha Recessive felsic lava, generally porphyritic, minor tuff, feldspathic arenite; Ꝑhap Recessive dacitic feldspar porphyry
- Ꝑhd Yeeradgi Sandstone* — Ꝑhd Ridge-forming feldspathic arenite, recessive arenite, siltstone, mudstone, ashstone, shale, and rare calcareous beds; Ꝑhdt Recessive micaceous tuff and tuffaceous arenite
- Ꝑhs Unimbra Sandstone* — Ꝑhs Ridge-forming feldspathic quartz arenite and subordinate quartz arenite; minor pebbly arenite; Ꝑhsv Generally recessive rhyolitic lava
- Ꝑhm Mia Mia Volcanics* — Ꝑhm Recessive cleaved massive felsic tuff and lava, commonly porphyritic; minor bedded tuff and feldspathic arenite; Ꝑhmq Ridge-forming feldspathic quartz arenite; minor conglomerate and felsic volcanics
- Ꝑht Treasure Volcanics* — Ꝑht Generally recessive andesitic to rhyolitic lava, commonly porphyritic, minor arenite and bedded tuff; Ꝑhtb Recessive basaltic lava; minor interlayered arenite; Ꝑhts Ridge-forming quartz arenite and feldspathic quartz arenite, minor pebbly arenite
- Ꝑho Taragan Sandstone* — Ꝑho Ridge-forming quartz arenite and feldspathic quartz arenite, commonly pebbly; minor conglomerate, siltstone, and felsic lava; Ꝑhoq Recessive siltstone, mudstone and friable arenite; minor silicified arenite and calcareous beds

LOWER

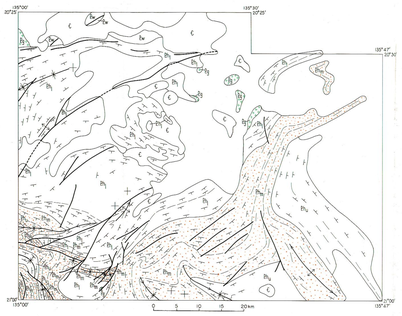
- Ꝑhk Warnes Sandstone Member — Ꝑhkw Ridge-forming feldspathic, lithic and quartzose arenite, minor recessive siltstone and friable arenite, rare felsic volcanic lenses
- Ꝑhk Kurnelli Sandstone* — Ꝑhk Ridge-forming, poorly sorted quartz arenite and feldspathic quartz arenite, massive to poorly bedded
- Ꝑhk Endurance Sandstone Member — Ꝑhke Recessive, thinly bedded, fine grained micaceous greywacke and siltstone, minor feldspathic quartz arenite; Ꝑhkb Recessive andesitic lava, minor tuffaceous siltstone
- Ꝑhr Roonaya Formation* — Ꝑhr Generally recessive, thin bedded to laminated arenite and siltstone, minor ridge-forming feldspathic quartz arenite; Ꝑhrs Generally recessive ochreous micaceous metasiltstone and meta-arenite
- Ꝑhr Epenarra Volcanics* — Ꝑhr Recessive cleaved felsic tuff, porphyritic lava, and agglomerate, volcaniclastic arenite and conglomerate; minor mafic lava and tuff; Ꝑhrq Ridge-forming quartzose to volcaniclastic arenite, pebbly arenite and conglomerate; minor felsic and mafic ? volcanics

WARRAMUNGA GROUP

- Ew Low ridge-forming interbedded phyllitic siltstone and fine grained greywacke

Unconformity * Informal name Facies change

STRUCTURAL SKETCH



CAINOZOIC — Superficial sediments

CAMBRIAN — € — GEORGINA BASIN SEQUENCE

Granite

PROTEROZOIC — UPPER, MIDDLE, LOWER — HATCHES CREEK GROUP

WARRAMUNGA GROUP

Prevailing strike and dip of strata

- Geological boundary
- Fault
- Anticline, showing trend of plunge of axis
- Syncline, showing trend of plunge of axis

Where location of boundaries and faults is approximate, line is broken, where inferred, queried, where concealed, faults are shown by short dashes

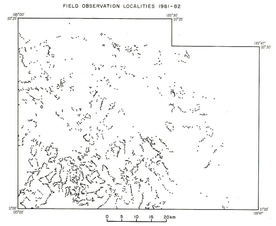
- Strike and dip of strata
- Strike and dip of strata, facing not known
- Vertical strata
- Horizontal strata
- Strike and dip of strata, dip 5°-10° — airphoto interpretation
- Trend-line
- Lineament — airphoto interpretation
- Joint pattern
- Strike and dip of foliation
- Strike and dip of platy flow structure
- Strike and dip of cleavage
- Vertical cleavage
- Dyke, Bi-diorite, unlabelled dykes are quartz
- Quartz vein
- Mine, minor — Au-Gold, Bi-Bismuth, Cu-Copper, W-Tungsten
- Prospect with title production
- Costean

- Bore
- Tank
- Waterhole
- Road
- Track
- Fence
- Landing ground
- Building
- Yard
- Elevation in metres, approximate

INDEX TO NAMED MINES

1.	Pioneer	W
2.	Endurance	W, Bi
3.	Ricketty Nate	W
4.	Black Diamond	W
5.	Bonanza	W
6.	Green Diamond Group	W
7.	Treasure	W
8.	Masters Gully	W
9.	White Diamond	W
10.	Hen and Chickens	W
11.	BXB	W
12.	Mangaroo Group	W
13.	Euro	W
14.	Hit or Miss Group	W
15.	Silver Granites	W
16.	Copper Show	W, Cu
17.	Woodenjerrie (Epenarra)	W

FIELD OBSERVATION LOCALITIES 1981-82



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