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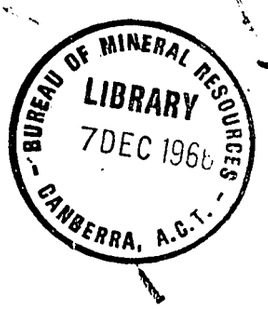

THE MINES AND MINERAL DEPOSITS OF THE KATHERINE-DARWIN AREA.

by

P.W. Crohn

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INTRODUCTION

With a few exceptions, the known mines and mineral deposits of the Katherine-Darwin Region fall naturally into a small number of subdivisions, based in part on geographical location, and in part on mineralogical and structural similarities, which are regarded as indicative of genetic relationships.

Gold, copper, silver-lead-zinc, tin, tungsten, uranium, and iron ores are the main minerals which have been produced to date or are known to exist in mineable quantities in the area, either alone or in various combinations.

HISTORY

Gold is reported to have been discovered in 1865, but the discovery was not confirmed till 1869 (Bauer, 1964); by 1881 mining activity appears to have been widespread throughout the area, and by the end of the century, most of the major mineral deposits (other than uranium and iron ore) had been discovered and were being worked. These included gold at Pine Creek, Union Reefs, Brocks Creek, and Northern Hercules; tin at West Arm, Mount Finniss, Mount Wells, and Mount Shoobridge; silver-lead at the Evelyn mine; copper at Daly River; and copper-gold at Iron Blow. In the early years of this century, these deposits were supplemented by the discoveries of tin at Maranboy, Hayes Creek, and Horseshoe Creek, and wolfram at Wolfram Hill, but mining activity began to decline about 1920 and did not improve until the post-war development of the early 1950's began to take effect.

Since then, mineral production has been dominated by the discovery of the uranium-copper orebodies of the Rum Jungle area in 1949; the uranium

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* Only key references have been specifically quoted in the descriptive accounts of the various mines and mineral deposits, but numerous other relevant reports, both published and unpublished, are listed in the general bibliography. Information on old workings and production statistics, unless otherwise stated, has been largely obtained from Annual Reports of the Director of Mines, Wardens and Inspectors of Mines, Northern Territory, but it has not generally been possible to acknowledge the sources of this information in detail in the text. K.R. Yates (BMR) collated much of the information which was derived from these references and is used in this account.

orebodies of the South Alligator River area, discovered in 1953-54; and the Frances Creek iron orebodies, which came into production in 1966.

Owing to incomplete production records, especially before about 1890, the relative importance of many of the mines and mineral deposits is difficult to assess. When recorded production figures are converted to values at current prices, the Rum Jungle area (uranium, copper, and subordinate lead) and the South Alligator River area (uranium and minor gold) are estimated to have accounted for about three-quarters of the total recorded mineral production of the region (excluding construction materials). This is all the more striking since neither was a major producer before 1950. Of the remaining localities, the most productive have been the Spring Hill/Union Reefs/Pine Creek mineral belt (gold, tin, copper, and silver-lead), the Brocks Creek/Cosmopolitan Howley area (gold, copper), Mount Wells (tin), Wolfram Hill/Horseshoe Creek (tin, wolfram, gold, copper, lead), West Arm/Mount Finniss (tin, gold, tantalite), Maranboy-Yeuralba (tin, wolfram, copper), and Iron Blow/Yam Creek (copper, gold). Other significant producers have been the Northern Hercules area (gold, copper, silver-lead, tin), Daly River (copper), Mount Shoobridge (tin, copper), Umbrawarra (tin), Woolwonga (gold), and Hayes Creek (tin).

In terms of individual metals, uranium (including the estimated uranium content of stockpiled ore) is estimated to make up approximately two-thirds of the total value of the recorded mineral production of the region (excluding construction materials), although this cannot be computed exactly, since the selling price of uranium produced at Rum Jungle has not been made public. Of the remaining metals, copper has been the most important (28,900 tons of metal in concentrates and stockpiled ore at Rum Jungle, plus 29,600 tons of ore from other localities, estimated to average about 15 percent Cu). This is followed by gold (recorded production about 520,000 oz, which is known to be incomplete), and tin (recorded production about 7000 tons of concentrate, which is also known to be incomplete). Other significant contributions have been made by silver-lead (4100 tons of lead in Rum Jungle concentrates and 4000 tons of silver-lead ore from other localities), and wolfram (830 tons of concentrate). Tantalite (15 tons of concentrate) and manganese (450 tons of ore) have been minor contributors.

The total recorded production of gold and tin concentrates is greater than the figures obtained by adding up the known production from individual mines (see Table 14), because the source of some production is not recorded, especially in the case of alluvial workings before about 1890.

Excluding uranium and construction materials, the value of recorded production of the whole region would amount to about $52,000,000 at current (1966) prices.

GENESIS

The most important orebodies of the Katherine-Darwin Region, in terms of value of production, are the uranium-copper-lead deposits of the Rum Jungle area, and the uranium-gold deposits of the South Alligator River area. Both these groups show pronounced stratigraphical or lithological control; most of the orebodies lie in carbonaceous or chloritic and in part pyritic shales and slates, which are assigned to the Golden Dyke Formation in the Rum Jungle area and to the Koolpin Formation in the South Alligator River area. Most of the deposits in the Rum Jungle area also lie within a few hundred feet of the contact of these slates with the underlying Coomalie Dolomite; in the South Alligator River area comparable dolomites occur, but their relation to the ore deposits is not as close. In both areas, the major deposits also occur close to the unconformity between Lower Proterozoic and Carpentarian or Adelaidean rocks, and in the South Alligator River area several of them actually transgress the unconformity. The major deposits in both areas also occur close to major faults or shear zones. However, in the South Alligator River area, at least one of the deposits occurs in a volcanic neck, apparently related to lavas within the Carpentarian succession, while at Rum Jungle the relation of the orebodies to the Rum Jungle Complex is obscure, since at least part of the complex antedates the deposition of the Lower Proterozoic sedimentary rocks.

Condon & Walpole (1955) interpreted most of the dolomite occurrences in the South Alligator River area and some in the Rum Jungle area as reef breccias, and concluded that the uranium mineralization is syngenetic because it is persistently associated with a particular sedimentary facies, although metal values may have been redistributed during subsequent folding and nearby igneous activity. More recently the origin of the deposits in the South Alligator River area has been attributed to the Carpentarian acid volcanics (Stewart, 1965), although Prichard (1965) still accepts the earlier interpretation; Spratt (1965) treats the reef hypothesis with some reservations for the Rum Jungle area.

The gold deposits of the Cosmopolitan Howley/Bridge Creek area and at the Golden Dyke mine also show strong stratigraphical control; economic mineralization is virtually restricted to the pyritic slates and schists which contain nodules and lenses of quartz. The beds are part of the Golden

Dyke Formation, and although most of the disseminated pyrite was probably syngenetic, the gold mineralization was probably younger and controlled by the favourable physical and chemical characteristics of the beds.

Except for occurrences of iron ore and construction materials, most of the remaining mines and mineral deposits are of hydrothermal origin and comprise quartz veins, fissure lodes, greisens, and pegmatites, commonly located within the Lower Proterozoic sedimentary rocks near one or other of the major granitic intrusions. Several groups of deposits are clustered around the composite Cullen Granite batholith and the nearby (and probably related)Mount Shoobridge, Burnside, Margaret, Prices Springs, McKinlay, and Wolfram Hill Granites. They comprise the tin-copper-lead deposits of the Mount Shoobridge area; the Hayes Creek tin field; the gold deposits of Brocks Creek, Woolwonga, and Yam Creek; the complex gold and base-metal sulphide lodes of Iron Blow and Mount Bonnie; the tin and tin-copper deposits of Mount Wells, Mount Masson, and Mount Harris; the lead occurrences of Minglo and Namoona, and the silver-lead-zinc lodes of the Evelyn and McCarthys mines; the Northern Hercules gold mine; the copper and copper-gold-arsenic lodes of Coronet Hill, Mount Davis, and Mount Diamond; the tin and wolfram lodes, in part with minor copper and lead, of Wolfram Hill, Hidden Valley, Emerald Creek, Horseshoe Creek, Mount Todd, and Yenberrie; and the gold deposits of Wandie, Driffield, Mount Todd, and Woolngi.

In addition, a major re-entrant of sediments within the Cullen batholith contains a highly productive group of deposits, most of which are localized on a large shear zone which closely follows the north-westerly axis of the re-entrant. The deposits include the gold, tin, and silver-lead occurrences of the Burrundie/Spring Hill/Flora Belle area, the auriferous lodes of the Union Reef and Pine Creek areas, and the copper deposits of Copperfield.

Many of the deposits associated with the Cullen Granite are characterized by complex mineral associations, such as gold-copper-lead-zinc at Iron Blow and Mount Bonnie, tin-copper at Mount Wells, tin-lead at Emerald Creek, and wolfram-copper-molybdenum at Yenberrie. A range of conditions from mesothermal to hypothermal appears to be represented by these associations.

Nearly all the deposits are associated with faults or shear zones, but some degree of stratigraphical or lithological control is evident; the more massive sulphide deposits, such as Iron Blow and Mount Ellison, and the silver-lead lodes, such as the Evelyn, are generally found in the black slate/chert/dolomite environment of the Golden Dyke Formation, whereas the

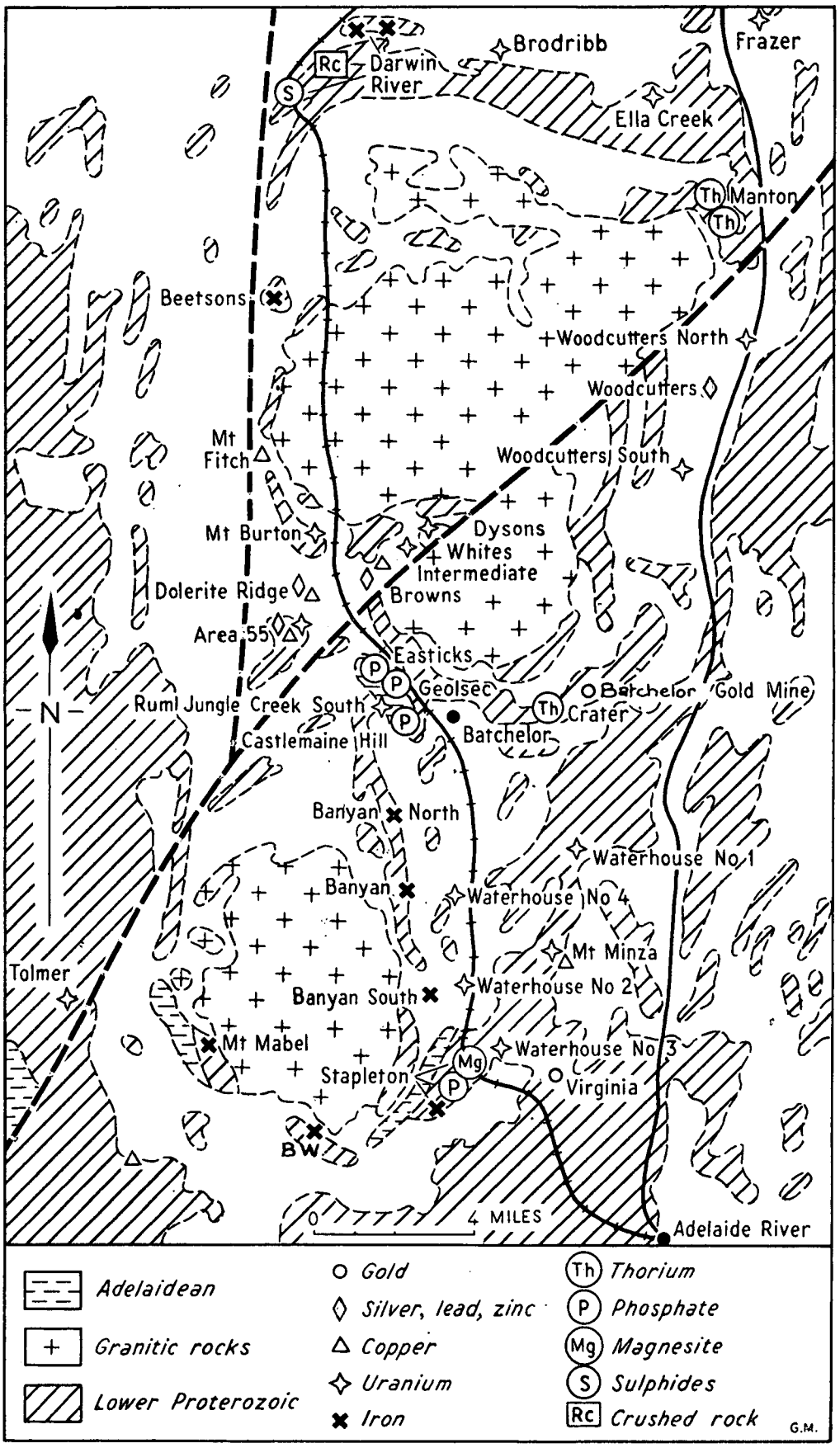

Fig. 25 Mineral deposits, Rum Jungle area

bulk of the quartz-gangue gold and tin deposits occurs in the greywacke and slate of the Burrell Creek and Masson Formations.

In the south-east, the tin and tin-wolfram-copper deposits of Maranboy and Yeuralba are also closely associated with granitic intrusives and show many similarities to some of the deposits near the Cullen Granite.

In the west, the tin-tantalite deposits of the West Arm/Mount Finniss/Mount Tolmer belt and the copper deposits of the Daly River area may be related to the Litchfield Complex; a southern extension of this belt includes the gold deposits of Fletchers Gully and the tin lodes of the Collia and Buldiva areas, which are closely associated with the Allia and Soldiers Creek Granites.

Supergene enrichment of iron-rich sediments in the Masson Formation is thought to have been responsible for the Frances Creek iron-ore deposits (mostly hematite); Pritchards Lode at Mount Bundey (magnetite and minor sulphides, oxidized to martite) is a product of magmatic segregation or contact metasomatic replacement resulting from the intrusion of the Mount Goyder Syenite.

RUM JUNGLE AREA (Fig. 25)*

Rum Jungle Mines

Jensen (1915a); Condon & Walpole (1955); Rhodes (1965); Fitzgerald & Hartley (1965); Spratt (1965).

The Rum Jungle area is the outstanding mineral producer of the Katherine-Darwin Region, largely owing to the production of uranium since 1949. Base metals, notably copper and lead, are associated with several of the uranium orebodies and also form separate bodies in the same general geological setting. A number of phosphate rock occurrences are also known.

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* All available geological data on the Rum Jungle area are currently being reviewed and compiled by the Bureau of Mineral Resources, and it is hoped to undertake a similar review for the South Alligator area. For this reason, only summaries of the geology and economic geology of these two areas are given here, although the deposits are of outstanding importance.

Before 1949, only small-scale production of copper is recorded from this area, including about 60 tons of 11 percent ore in 1907. Two diamond drill holes were put down to inclined depths of 300 and 320 feet in 1913, but significant copper values, between 1 and 5 percent, were only encountered in the secondarily enriched zone, between 35 and 67 feet inclined depth, in one of the holes (Jensen, 1915a). Since 1949, intensive exploration by the Bureau of Mineral Resources and Territory Enterprises Pty Ltd has resulted in the discovery and delineation of four uranium orebodies, two copper orebodies, one large low-grade lead occurrence, and a group of phosphate rock occurrences; several other promising uranium and base-metal prospects are still under investigation at the time of writing (June, 1966).

Most of the uranium and base-metal orebodies located occur within a relatively small area, locally known as the 'Embayment', in which Lower Proterozoic sedimentary rocks occupy a re-entrant in the Rum Jungle Complex. The orebodies are restricted to pyritic black slate or chloritic schist of the Golden Dyke Formation, close to its contact with the underlying Coomalie Dolomite.

The sedimentary rocks dip off the Rum Jungle Complex in a broad dome-shaped structure, and the complex has been shown, at least in part, to antedate them (Rhodes, 1965). The 'Embayment' which is formed by the displacement of the complex for about 3 miles along the Giants Reef Fault, is occupied by a broad west-pitching synclinal structure, complicated by tight minor folding and intense shearing of many of the rocks. Orebodies appear generally to be related to these minor structures.

Most of the orebodies occur at a relatively constant depth, between 100 and 300 feet below the present surface. The present surface in many places also coincides fairly closely with the old erosion surface separating the Lower Proterozoic rocks from unconformably overlying sandstone and breccia of probable Adelaidean age.

The orebodies are thus broadly controlled by stratigraphy - being confined to the lower portion of the Golden Dyke Formation - but the part played in ore localization by the Giants Reef Fault, the Rum Jungle Complex, minor structural features, the unconformity surface, and lithological changes within the Golden Dyke Formation itself, have not been completely assessed.

Within the Embayment, Whites orebody, which was the site of the original uranium discovery in the Rum Jungle area, consisted of disseminated uranium and copper mineralization in a steeply south-dipping zone, 50 to 80

feet wide and about 400 feet long, which has been mined by an open cut to a vertical depth of 350 feet. Uraninite, torbernite, chalcopyrite, bornite, and galena were the main ore minerals, and production amounted to 270,000 tons of ore averaging 0.33 percent U_3O_8 and 3.4 percent Cu, plus 279,000 tons averaging 2.8 percent Cu, 76,000 tons averaging 5.4 percent Pb, and 40,000 tons averaging 0.28 percent U_3O_8 only, (Spratt, 1965; Fitzgerald & Hartley, 1965). Cobalt, and to a lesser extent nickel, occurred in some of the copper and lead ore, but could not be economically extracted. Samples contained 0.75 percent Co. 97,600 oz of silver have been recorded in the copper concentrates.

At Dysons, about a mile east of Whites, another north-easterly-trending lens of mineralized material has been mined by open cut to a depth of 150 feet, yielding 154,000 tons of ore with an average content of 0.34 percent U_3O_8. Uraninite and saleeite were the main ore minerals.

Immediately south-west of Whites, the Intermediate Deposit, which was a copper orebody without associated uranium mineralization, has been mined by open cutting. 350,000 tons of ore, assaying 3 percent Cu, and 40,000 tons of oxidized ore and 200,000 tons of low-grade material have been produced. The geological setting is similar to Whites deposit (Moyses, 1965).

Browns prospect, which is also within the 'Embayment' area, is the only major lead deposit known in the Rum Jungle area. It is 1 mile south-west of Whites, and occurs in graphitic, sericitic, and talcose slate and schist comparable to those at Whites. The primary ore minerals are galena and minor chalcopyrite, sphalerite, and linnaeite; cerussite and malachite predominate in the oxidized zone, within about 50 feet of the surface. This deposit has been traced for about 3000 feet in length and 1200 feet in depth, and varies in width from about 40 to 160 feet; the average grade has not been disclosed. The body trends east-north-east and dips to the south; the dip is shallow near the surface, but steepens to about 85° at a depth of 150 feet (Thomas & Whitcher, 1965).

Outside the Embayment area, only two orebodies have been worked. At Mount Burton, 3 miles west of Whites, a small lenticular body containing disseminated torbernite, pitchblende, malachite, and chalcocite has been mined to produce 6000 tons of ore, averaging 0.21 percent U_3O_8 and 1.04 percent Cu, and 1400 tons averaging 2.66 percent Cu. The host rocks were pyritic black slate and minor quartzite, underlain by dolomite (Spratt, 1965).

At Rum Jungle Creek South, 4 miles south of Whites, uraninite was the main ore mineral, and production, some of which is still stock-piled, amounted to 653,000 tons of ore, averaging 0.4 percent U_3O_8. The host rock is chloritic schist, occupying a north-west-trending syncline between the Rum Jungle Complex and the Waterhouse Granite. The orebody occurred just below the present base of oxidation, at a depth of about 100 feet, and was about 750 feet long, 150 feet wide, and 130 feet thick, elongated parallel to the fold axis in the host rocks (Spratt, 1965)

Another small secondary copper orebody has recently been indicated by auger and waggon drilling at Mount Fitch, 5 miles north-west of Whites. The main ore minerals are malachite and chalcocite, and the deposit overlies low-grade pyrite-chalcopyrite mineralization in both the Golden Dyke Formation and the Coomalie Dolomite.

The known phosphate occurrences of the Rum Jungle area are largely concentrated near Castlemaine Hill, 1½ miles east of Batchelor township, and include the Geolsec and Eastlicks deposits. Similar occurrences have also been recorded from the Waterhouse and Stapleton areas, from 6 to 8 miles south of the township. All the deposits occur at or close to the Lower Proterozoic/Adelaidean unconformity, overlying weakly phosphatic dolomite and siltstone of the Coomalie Dolomite and Golden Dyke Formation, and are regarded as the products of sedimentation and supergene concentration in the period immediately preceding the deposition of the Adelaidean rocks. The phosphate rock occurrences range from a lilac or red apatite siltstone and sandstone to a quartz breccia with a phosphatic matrix. Fluorapatite is the dominant phosphate mineral, generally associated with finely divided hematite. Assays range up to 37 percent P_2O_5, with 4 to 18 percent Fe_2O_3 and from 1 to 33 percent Al_2O_3. Reserves are estimated at about 5,000,000 tons of phosphate rock, averaging 10 percent P_2O_5, of which about 1,000,000 tons are in the Geolsec deposit. The material is suitable for use as ground rock phosphate, but not for the manufacture of superphosphate, and there are at present no plans for its immediate utilization (Pritchard & Cook, 1965).

Of other prospects in the area, Area 55, 5 miles west-north-west of Batchelor township, appears to offer the best possibilities. Low-grade uranium, copper, and lead mineralization has been encountered in drill holes put down to test geophysical and geochemical anomalies in Golden Dyke and Coomalie Dolomite rocks, and appears to be related to minor structural features, including shear zones and steeply plunging fold axes. Further work is in progress.

Other prospects which offer possibilities for the occurrence of both uranium and base-metal deposits are Dolerite Ridge, between Area 55 and Mount Burton; the Celia Creek area, 12 miles north of Batchelor township; the Rum Jungle East area (Woodcutters prospects) between Manton Dam and the Batchelor turn-off on the Stuart Highway; and the Gould Airfield and Waterhouse areas, south of Batchelor township. Further geophysical and geochemical surveys, with provision for follow-up diamond drilling, are now being undertaken by the Bureau of Mineral Resources in the Rum Jungle East and Gould Airfield areas.

Outlying Prospects

Away from Rum Jungle, a number of other radioactive anomalies occur around the margin of the Rum Jungle Complex. They include the Brodribb, Ella Creek, Manton, and Crater prospects, but on the available information these are unlikely to have any potential for economic development.

The Brodribb prospect, 15 miles north of Rum Jungle, has been tested by extensive costeaning and six diamond drill holes totalling 1580 feet, but the radioactivity appears to be concentrated in superficial ferruginous deposits overlying pyritic slate of the Golden Dyke Formation, and no primary mineralization of economic grade has been located (Sullivan, 1953b, unpubl.; Matheson, 1953b, unpubl.). At Ella Creek, 3 miles to the east, and at Frazer, another 4 miles to the north-east, conditions appear to be similar (Smith, K, 1953, unpubl.; Sullivan, 1953b, unpubl.).

At the Crater prospect, 1 mile north-east of Batchelor township, mineralization occurs in beds of the Crater Formation, especially in a conglomerate, 90 feet thick, which strikes west-north-west and dips south at 40°. This prospect was tested by two diamond drill holes totalling 1140 feet, and the radioactivity was found to be due to detrital grains of thorianite in the conglomerate (MacKay, 1953c, unpubl.; Rhodes, 1960, unpubl.). The Manton prospect, 15 miles north-north-east of Batchelor, is also in beds of the Crater Formation, and may be of the same type.

Twelve miles south-west of Rum Jungle, the Tolmer uranium prospect occurs in rocks of the Burrell Creek Formation about half a mile north of the Giants Reef Fault. This prospect has been tested by Rio Tinto Exploration, but no ore bodies of economic grade were discovered.

There are also four separate radioactive prospects, known as Waterhouse No.1, 2, 3, and 4, in the area between 4 and 8 miles south and

south-east of Batchelor township. Some detailed geological and geophysical work has been done on all of them, and No.2 has been tested by a shallow shaft put down by United Uranium N.L. and two diamond drill holes put down by the Bureau of Mineral Resources. However, results to date are regarded as inconclusive, and a further investigation by the Bureau of Mineral Resources is in progress at the time of writing (June 1966).

A number of quartz-tourmaline stringers, ranging from a few inches to several feet wide, occur in arkosic grit and quartz-pebble conglomerate of the Lower Proterozoic Crater Formation 3 miles east of Batchelor township. One of them, at the Batchelor prospect, was worked in 1943 and yielded 12 oz of gold from about 12 cwt of ore. The stringer appears to have been almost completely removed in the course of this operation, and no other occurrences of auriferous material have been located in the area (Sullivan, 1946c, unpubl.; Crohn, 1965a, unpubl.).

At the Virginia Mine, 1 mile east of Stapleton Siding, 24 oz of gold are reported to have been obtained before 1891, and workings are reported to have included a shaft 120 feet deep (Tenison Woods, 1886; Parkes, 1892).

At the Little Finniss River Crossing on the Stapleton/Mount Tolmer road, traces of copper have been reported from poorly exposed slate, probably of the Burrell Creek Formation.

Occurrences of iron ore are known from the Darwin River, Beetsons, Stapleton, and Mount Mabel areas, and magnesite from the Stapleton area. These are discussed on pp. 63 and 71.

SOUTH ALLIGATOR RIVER AREA (Fig. 26)

Condon & Walpole (1955); Prichard (1965).

The South Alligator River area consists of a north-westerly belt of Lower Proterozoic rocks centred on El Sherana, about 170 miles south-east of Darwin. . . . The Koolpin Formation, consisting of shale and siltstone, in part pyritic and carbonaceous, with minor chert, dolomite, and silicified dolomite, contained the bulk of the uranium mined from the area, and lithologically bears a striking resemblance to the Golden Dyke Formation, which is the predominant host rock for the uranium mineralization in the Rum Jungle area.

The Koolpin Formation is overlain with a strong angular unconformity by Carpentarian rhyolite flows and pyroclastics (Edith River Volcanics),

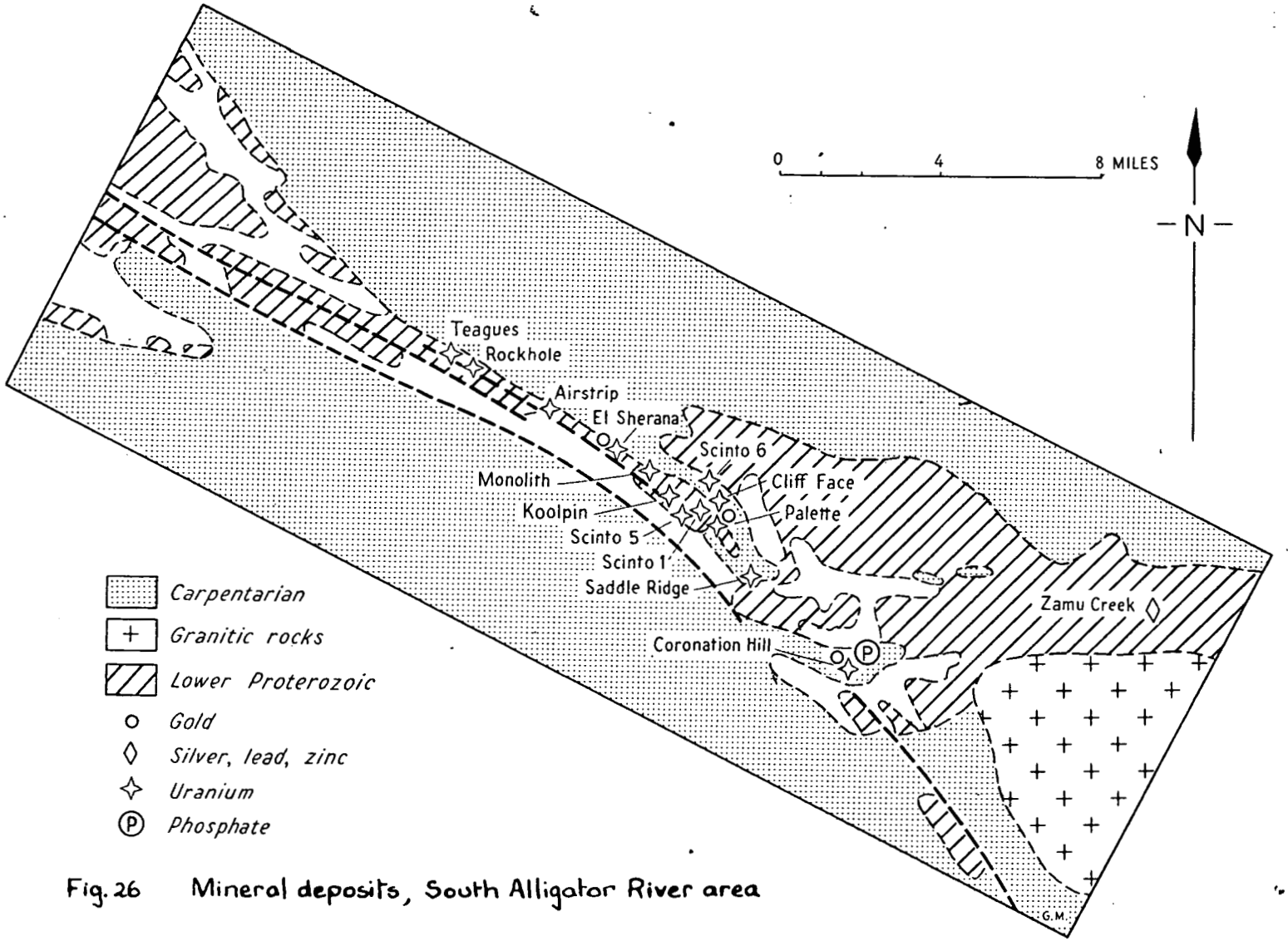

Fig. 26 Mineral deposits, South Alligator River area

and by sandstone and conglomerate with minor interbedded volcanics (Kombolgie Formation). It is also intruded by volcanic necks related to the Edith River Volcanics, by sills and dykes of dolerite, gabbro, and diorite (Zamu Complex), and by the Malone Creek Granite.

Economic mineralization in the area is restricted to relatively small, high-grade uranium deposits, some with subordinate gold, although minor occurrences of copper, lead, and phosphate rock have also been recorded.

The most important mineral deposits lie within the central part of the belt, covering an area of about 15 by 2 miles from Rockhole mine in the north-west to Coronation Hill in the south-east. However, related occurrences are also known at Coirwong Gorge on the north-western extension of the belt, and at Sleisbeck to the south-east, a total distance of about 60 miles.

All the deposits in this group have been worked by United Uranium N.L., except for the Rockhole and Teagues deposits, which were worked by South Alligator Uranium N.L., and Sleisbeck, worked by North Australian Uranium Corporation N.L.

Of the individual deposits, El Sherana and El Sherana West have had the largest output; El Sherana produced 38,400 tons of ore averaging 0.5 percent U_3O_8, and El Sherana West 21,300 tons of ore averaging 0.8 percent U_3O_8. The ore consisted of massive pods and disseminated veinlets of pitchblende, associated with minor amounts of secondary metatorbernite, autunite, and gummite, and some gold. Small amounts of pyrite, galena, and chalcopyrite were present in places. Most of the ore was obtained from the carbonaceous shale of the Koolpin Formation, generally within 150 feet of the contact with the unconformably overlying Carpentarian sandstone; a little ore was also found in the Carpentarian beds close to the unconformity.

The Rockhole and Teagues deposits, with a total output of 13,200 tons of ore averaging 1.1 percent U_3O_8, have a similar setting, although the proportions of ore in the Lower Proterozoic and Carpentarian formations varied in different parts of the deposits. Minor gold was again present.

Palette (4700 tons of ore averaging 2.5 percent U_3O_8), Scinto 5 (5700 tons, 0.4 percent U_3O_8), Koolpin Creek (2300 tons, 0.12 percent U_3O_8, and Skull (530 tons, 0.5 percent U_3O_8), also conformed to this pattern, although only Palette carried significant gold.

Sleisbeck (600 tons, 0.4 percent U_3O_8) also occurs in rocks of the Koolpin Formation, but the bulk of the ore was found in a quartz-hematite breccia which is regarded as a silicified dolomitic rock, and the deposit is associated with minor phosphate rock occurrences similar to those of the Rum Jungle area.

At Saddle Ridge (29,800 tons, 0.2 percent U_3O_8), only secondary uranium minerals were encountered, but they occurred both in shale of the Koolpin Formation and in Carpentarian tuff; they were also associated with minor occurrences of phosphate rock.

At Coronation Hill (25,700 tons, 0.3 percent U_3O_8), pitchblende with minor gold and some phosphatic material occurred in tuff, breccia, and altered rhyolite forming a volcanic neck associated with the Edith River Volcanics, and at Scinto 6 (1700 tons, 0.15 percent U_3O_8), pitchblende occurred in altered dolerite of the Zamu Complex.

Minor occurrences from which no production has been recorded include the Airstrip, Monolith, Scinto 1, Cliff Face, and Coirwong uranium prospects.

In the Zamu Creek area, about 15 miles east-south-east of El Sherana mine, an isolated lead prospect occurs in basic intrusives of the Zamu Complex. Total recorded production is about 20 tons of silver-lead ore, mined between 1948 and 1950.

A small copper prospect occurs in chert and siltstone of the Gerowie Formation, associated with dykes and sills of dolerite and amphibolite, about 4 miles north-east of Coirwong Gorge. This was tested by Broken Hill Pty Co. Ltd by diamond drilling about 1958, but the results were disappointing.

OTHER RADIOACTIVE PROSPECTS

Outside the Rum Jungle and South Alligator River areas, radioactive prospects are known from several parts of the region, but none is of major economic importance.

At the Adelaide River mine, 2½ miles south of Adelaide River township, 3800 tons of ore averaging 0.5 percent U_3O_8 have been mined from a shear zone in greywacke and siltstone of the Noltenius Formation. The shear zone trends north and dips steeply east; the main ore-shoot pitches south at about 45°. The ore consisted of pitchblende with some pyrite and

chalcopyrite and occurred partly in small iregular quartz veins and partly as disseminations in the sedimentary rocks. Original exploration and development work involved 9 shafts, the deepest to 200 feet, and 14 diamond drill holes totalling 3989 feet; the ore was worked from two levels. In 1959-60 after the mine was abandoned the Bureau of Mineral Resources put down a further four drill holes totalling 2490 feet. After this later drilling, ore reserves in 1960 were calculated to be 1500 tons of broken ore, averaging 0.5 percent U_3O_8 and 5500 tons of possible ore, averaging 0.22 percent U_3O_8 (Plumb, 1960, unpubl.).

At George Creek, 9 miles south of Adelaide River township, surface indications of torbernite occurred in similar host rocks; the primary ore again consisted of small concentrations of pitchblende, pyrite, and chalcopyrite in joints and minor shear zones. Exploratory work consisted of seven diamond drill holes totalling 1540 feet and a shaft 126 feet deep, with 200 feet of drives and cross-cuts. One hundred and twenty tons of ore, averaging 0.26 percent U_3O_8, were extracted, and reserves in 1960 were estimated to be about 250 tons of comparable grade (Arkin & Walpole, 1960, unpubl.).

At the ABC prospect, 11 miles north-east of Katherine township, autunite and phosphuranylite occur in interbedded tuff and amygdaloidal basalt of the Carpentarian McAddens Creek Volcanics. This prospect has been tested by about 2000 feet of costeaning and 57 diamond drill holes totalling 2550 feet; ore reserves in 1955 were estimated at 1050 tons averaging 0.4 percent U_3O_8 (Matheson, 1953c, unpubl.; Gardner, Rade & Britten, 1955, unpubl.).

A group of prospects occurs in the southern part of the Cullen Granite; they include the Fergusson River prospect; the YMCA or Edith River prospects, from 1 mile east to 3 miles south-south-east of Edith River Siding; Tennysons prospects, from 2 to 4 miles west-south-west of Edith River Siding; Hore and O'Connors prospect, 5 miles west-north-west of Edith River Siding; and the Yenberrie prospect, 5 miles north of Edith River Siding. They all have a number of features in common: they consist of small quartz veins and disseminations containing predominantly secondary minerals such as torbernite and meta-autunite, in places in association with apatite and finely divided hematite or with limonitic gossanous material; and they are generally located on northerly or north-north-westerly steeply dipping shear zones associated with silicification and greisenization of the surrounding granite. Individual shoots are

invariably small, and range from 12 to 18 inches wide and up to 25 feet long; the grade at the surface has been estimated as 0.1 to 0.2 percent U_3O_8 (Fisher, 1952, unpubl.; Gardner, 1953b, e, unpubl.).

The conglomerate and arkose of the Mount Partridge Formation are radioactive at Spring Peak and Mount Basedow near Jim Jim Creek. The radioactivity is attributed to thorium-bearing minerals, probably monazite, in the sediments. These rocks in the eastern part of the Pine Creek Geosyncline are in a similar stratigraphical position to the thorium-bearing Crater Formation near Rum Jungle.

Other radioactive prospects, which are located in areas of major base-metal occurrences or are themselves associated with base-metal deposits, are mentioned later. They include the Fleur de Lys mine (Brocks Creek area), the Mount Shoobridge uranium prospect (Mount Shoobridge area), Madigans prospect (Mount Finniss/West Arm area), and the Burrundie prospect (Iron Blow/Mount Bonnie area).

BROCKS CREEK AREA (Fig. 27)

The Brocks Creek area was one of the earliest to be developed in the Katherine-Darwin Region; the main products were gold with minor copper and some bismuth. The economic deposits include both sulphide lodes and zones of disseminated quartz-sulphide mineralization associated with favourable beds in the Lower Proterozoic Golden Dyke Formation, and especially with a number of distinctive beds containing nodules and lenses of quartz in a matrix of slate or schist. These beds have been referred to in the past as 'pressure conglomerates', 'nodular siltstones', 'silicified dolomites', and 'quartz-lens schists', and their origin is still incompletely understood.

Cosmopolitan Howley Group of Mines

Parkes (1892); Brown (1895); Brown & Basedow (1906); Jensen, Grey & Winters (1916); Hossfeld (1942, unpubl.); Sullivan & Iten (1952); McQueen (1959, unpubl.); Vanderplank (1965, unpubl.).

The Cosmopolitan Howley mine has been the largest single producer in the area. Gold is reported to have been discovered here in 1879, and mining continued with minor interruptions until 1904; from1908 to 1915 some gold was obtained by cyaniding the tailings dumps. In 1938 a major programme of underground exploration was undertaken by Anglo-Queensland Mining Pty Ltd, and their shaft was re-opened by Brocks Creek Uranium N.L. in 1955. Diamond drilling was undertaken by the Mines Branch, N.T.

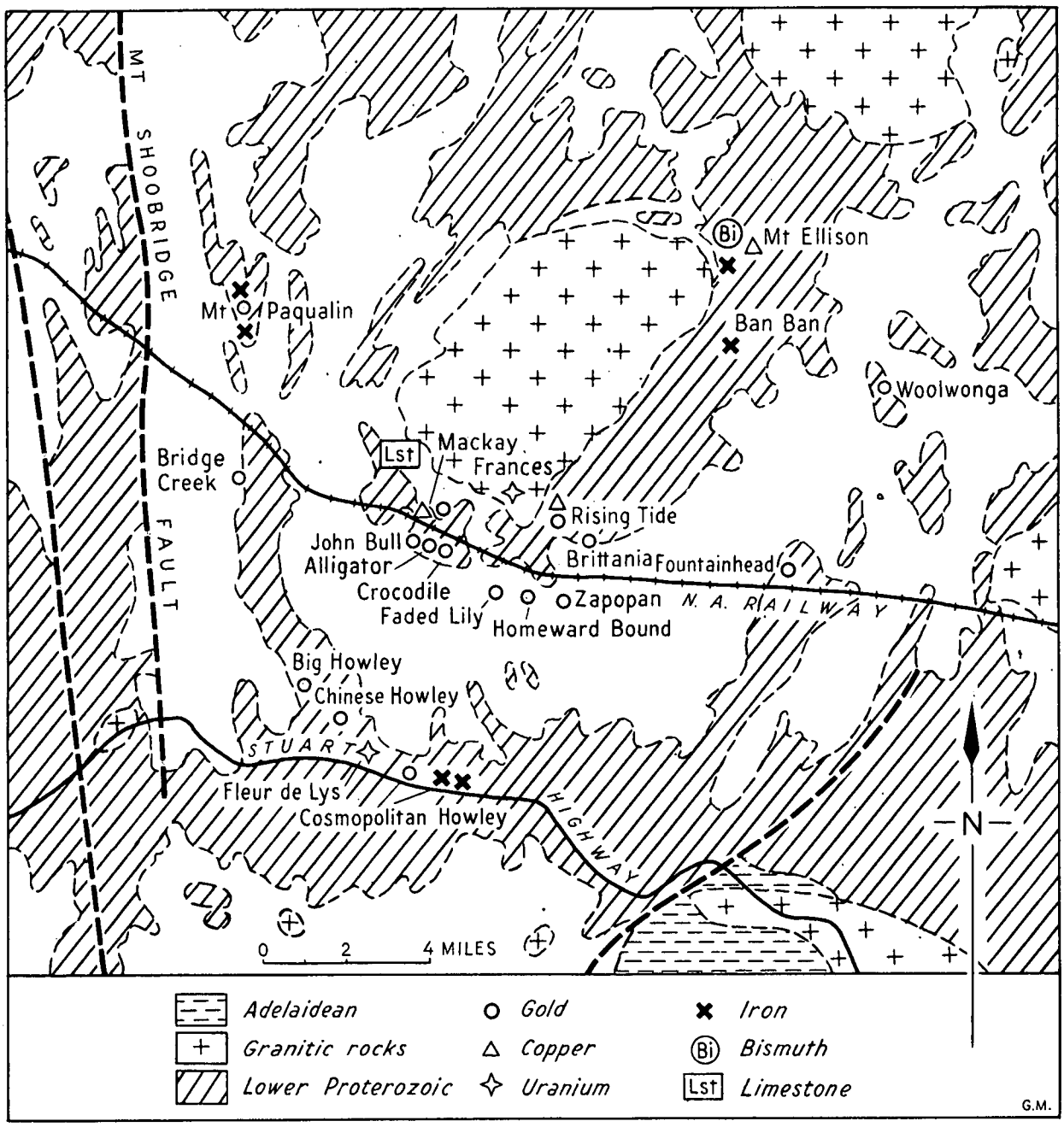

Fig. 27 Mineral deposits, Brocks Creek area

Administration, in 1948 and 1963, and by the Bureau of Mineral Resources in 1957-59.

Recorded production is 33,780 oz of gold from about 50,000 tons of ore, but this is almost certainly incomplete.

Workings consist of nine open cuts, up to 250 feet long, 40 feet wide, and 80 feet deep, together with a number of old shafts and stopes, mostly now inaccessible, and the Anglo-Queensland 1938 shaft, which is 175 feet deep and has some 600 feet of drives and cross-cuts at the 170-foot level.

The workings broadly follow the contact between a graphitic shale sequence, some 500 feet thick, and the underlying chloritic schist with minor mica schist and quartzite. The quartz-lens schists are best developed in the basal part of the graphitic shale sequence. The workings follow the contact around the nose of the north-west-pitching Howley Anticline, with a marked concentration near the axes of minor drag-folds, most of which appear to pitch at about 55°, parallel to the major fold. The lodes have probably been extensively leached to a depth of 20 feet below the present surface.

All major ore shoots above the water-table, i.e. within about 100 feet of the surface, have probably been worked out. The best prospects for re-opening the mine lie in the discovery of extensions or repetitions of the known shoots in depth, which must be expected to be refractory ores, rich in pyrite and arsenopyrite.

The best intersections on the 170-foot level were 10.8 dwt Au per ton over 25 feet, 150 feet south-west of the shaft, and 8.1 dwt over 27 feet, 40 feet north of the shaft, but it appears that most of the workings on this level are in the footwall of the main mineralized zone (Sullivan & Iten, 1952).

The logs of the diamond drill holes show that core recovery was generally poor in the ore zones, and the core assays do not give a reliable indication of the grade of the ore. The sludge assays which represent the softer more mineralized parts of the lodes, were appreciably higher than the assays of the cores. However, sludge assays are available for only one hole, which had 15-foot and 85-foot intersections averaging about 10 dwt per ton. The best core assays from 9 holes were 16 feet at 8.6 dwt per ton and 10 feet at 6.8 dwt per ton (McQueen, 1959, unpubl.; Vanderplanck, 1965a, unpubl.).

North-west of the Cosmopolitan Howley mine, further gold occurrences have been worked at the Chinese Howley, Big Howley, Bridge Creek, and Mount Paqualin, all of which lie on or close to the crest of the Howley Anticline, and in or close to the graphitic shale horizon which is the main host rock at the Cosmopolitan Howley mine. Recorded production from this group of mines (excluding the Cosmopolitan Howley) is 32,450 oz, of which at least 13,000 oz came from the Big Howley mine. (Sullivan & Iten, 1952).

At the Chinese Howley mine, steeply dipping quartz reefs from 6 to 12 inches wide have been intermittently worked over a zone 3000 feet long, but the bulk of the production is believed to have come from associated alluvial deposits.

At the Big Howley mine, the main reef was a saddle-shaped body, 20 feet thick at the crest, which pitched to the north-west at 33°, parallel to the bedding of the surrounding sedimentary rocks. This was worked between 1882 and 1903 by means of an extensive system of open cuts, a 300-foot adit, and two shafts 171 and 190 feet deep. Tailings were cyanided intermittently until 1915, but no work has been done on the mine since then.

At Bridge Creek, a group of small but locally very rich leaders, ranging in width from 1 or 2 inches to about 18 inches, has been intermittently worked since 1873. Parkes (1892) records five shafts from 50 to 70 feet deep in this area, and workings were reported to have reached a depth of 110 feet in 1914. The area was re-examined in 1964 by a local syndicate, which costeaned the surface, but no follow-up work has been done as yet. Total recorded production is 1190 oz, but this is known to be incomplete.

At Mount Paqualin, a group of small workings is known, but the production has not been recorded.

Fleur de Lys Mine

Firman (1955b, unpubl., 1956, unpubl.); McAndrew (1954b).

The only prospect in this vicinity which has been worked for minerals other than gold is the Fleur de Lys mine, 1 mile north-west of the Cosmopolitan Howley; it contains torbernite, malachite, azurite, and cuprite in the oxidized zone, and uraninite, pyrite, chalcopyrite, and chalcocite in the primary zone. According to Firman (1956) the ore occurs in shear zones in thin-bedded siltstone and slate. Five shafts, up to 100 feet deep, were in existence in 1955, when the mine was being worked by Brocks Creek Uranium N.L., but the only recorded production is about 440 lb of U_3O_8 in 1954-55.

Zapopan/John Bull Group of Mines

AGGSNA (1940); Parkes (1892); Brown (1895); Brown & Basedow (1906); Jensen (1915); Jensen, Gray,& Winters (1916); Cottle (1937a); Rayner & Nye (1937); Sullivan & Iten (1952).

At Brocks Creek, a line of workings extends in a west-north-westerly direction for about 6 miles; the main mines, from east to west, are Zapopan, Faded Lily, Alligator, Crocodile, and John Bull. The line appears to be associated with a structure, possibly a major fault, which slightly transgresses the bedding of the host rocks (Cottle, 1937d).

The Zapopan has been the largest producer in this group, and was worked from 1885 to 1911. Tailings were treated intermittently until 1933. According to Brown & Basedow (1906), the main reef worked had an average width of 3 to 5 feet, and trended east with a dip of about 60° to the south. It was worked to a depth of 225 feet. Two other reefs and an irregular quartz body were also worked. Throughout the mine, the best values were found at the intersections of the major reefs with cross-reefs. Recorded production is 26,650 oz of gold from about 40,000 tons of ore. Two diamond drill holes are reported to have been put down in 1908 and three in 1915, but no payable shoots were intersected, although No.4 bore intersected a heavily mineralized section assaying up to 10 percent Pb between 149 and 184 feet, and core from No.5 bore between 479 and 484 feet assayed 5.9 dwt Au per ton (Jensen, 1915). The host rock, from the evidence of dump material, was mainly slate and hornfels, but Jensen, Gray & Winters (1916) also record quartzite, chert, sericite schist, and garnetiferous amphibolite from the immediate vicinity of the lodes.

Little is known about the Victoria and Morning Star mines which are situated on the line of lode between Zapopan and the Faded Lily.

The Faded Lily has a shaft 212 feet deep, with 400 feet of drives on the bottom level. At this level, the lode was reported to be 8 to 13 feet wide, assaying 1 to 2 dwt Au per ton. The country rock was graphitic andalusite-sillimanite hornfels, cut by quartz-tourmaline veins. A diamond drill hole put down in 1914 to a depth of 504 feet failed to encounter any downward extension of the lode (Jensen, 1915).

The Alligator mine worked a system of small quartz leaders in amphibolite. At least three shafts are reported to have been sunk, the deepest to 90 feet. Some of the leaders were apparently extremely rich.

At the Crocodile mine, conditions apparently were very similar to those at the Alligator.

The John Bull mine included several shafts; the deepest was 135 feet, on a lode 1 foot 8 inches wide, which was worked for a length of about 100 feet.

The Homeward Bound mine is in this group but its location in relation to the other mines is unknown. Workings up to 100 feet deep are reported over a length of 300 feet.

The total recorded production of the mines in this group, exclusive of the Zapopan, is 6370 oz, but this is certainly incomplete.

Another mine in this vicinity is the Mackay and Francis, which was described by Jensen, Gray, & Winters (1916) as working a 9-inch lode rich in chalcocite. Assays of up to 36 percent Cu and 13 dwt Au per ton were reported, but no production is recorded.

Brittania/Fountain Head Group of Mines

Parkes (1892); Brown (1895, 1908b); Jensen, Gray, & Winters (1916); AGGSNA (1937, 1940); Cottle (1937b, 1937d); Rayner & Nye (1937b, 1937f); Sullivan & Iten (1952).

To the east and north-east of Brocks Creek, another group of mines comprises the Brittania, Rising Tide, and Fountain Head mines.

The Brittania mine, 2 miles north-east of Brocks Creek Siding, was worked intermittently from 1875 to at least 1893. The main lode was at least 350 feet long and up to 1 foot 6 inches wide, and was thought by Cottle (1937d) to follow a major north-westerly fault zone. Several small rich leaders were also worked, and the workings included two open cuts 120 and 150 feet long, and several shafts, the deepest to 60 feet. Total recorded production (incomplete) is 840 oz of gold from 220 tons of ore.

The Rising Tide mine, 1½ miles north-north-east of Brocks Creek, consists of two shafts, 80 and 100 feet deep, on the flanks of a north-westerly quartz-filled fault, close to its intersection with an east-north-easterly zone of graphitic slate with abundant small discontinuous gossanous cappings. Some copper staining occurs in the gossanous zone, and a strong geochemical anomaly was obtained around the intersection of the fault and the gossanous zone by the Bureau of Mineral Resources in 1950 (Sullivan & Iten, 1952). However, only pyrite has been reported from the shaft, and

there is no recorded production.

In 1959, a geophysical survey by the Bureau of Mineral Resources delineated four electro-magnetic anomalies, of which one coincided with a small gossanous outcrop and two others appeared to be related to an amphibolite sill (Hays, 1959, unpubl.). In 1963, a diamond drill hole was put down to a depth of 295 feet by the Bureau to test one of the anomalies, but only pyritic mineralization was found (Shields, 1965, unpubl.). It appears that base metals, especially copper, have undergone surface enrichment in this area, and the surface concentrations have apparently been derived from very low-grade material in the primary sulphide zone.

The Fountain Head mines, 6 miles east of Brocks Creek, were intermittently worked from 1883 to 1951. The auriferous quartz veins range from a few inches to about 5 feet wide and up to 300 feet long. They generally trend north-west, parallel to the axis of a major anticline in the host greywacke and slate of the Lower Proterozoic Burrell Creek Formation. The workings consisted of numerous open cuts and at least three shafts, the deepest to about 100 feet. Two diamond drill holes were put down in 1908 to vertical depths of 520 and 490 feet, but no payable lodes were encountered.

Total recorded production is 9870 oz, of which a substantial proportion, especially in the early years of the mine, appears to have come from alluvial deposits.

Mount Ellison Mine

Brown & Basedow (1906); Jensen, Gray, & Winters (1916); Sullivan & Iten (1952).

The Mount Ellison mine, 10 miles north-north-east of Brocks Creek, lies in graphitic shale at the same stratigraphic horizon as the Cosmopolitan Howley mine. The mine was worked from 1891 to 1911 by means of a number of shafts, of which the deepest was 228 feet with workings at five levels (Brown & Basedow, 1906). The main lode strikes north-north-west, parallel to the enclosing sedimentary rocks, and dips steeply to the east. The thickness was reported to range from a few inches to about 3 feet, and numerous cross-fractures and subsidiary shears were encountered in the workings. The ore was oxidized to the 70-foot level, with a zone of secondary cuprite and chalcocite below, which passed into the primary quartz-chalcopyrite-pyrite ore. Bismuth minerals were present in both the primary

and oxidized ore. Recorded production is about 3250 tons of copper ore, averaging about 20 percent Cu, most of which came from the oxidized and secondarily enriched zones. About 3 tons of bismuth was also produced. A diamond drill hole put down by the Australian Mining and Smelting Co. to a depth of 348 feet in 1955 encountered only disseminated pyrite mineralization; Murray (1955, unpubl.) has suggested that the lode was not intersected because it pitches north, parallel to the pitch of a tight anticlinal fold in the surrounding sedimentary rocks.

IRON BLOW/MOUNT BONNIE/GOLDEN DYKE AREA (Fig. 28)

The Iron Blow/Mount Bonnie/Golden Dyke area contains a number of gold and base-metal mines within a belt of Golden Dyke sedimentary rocks extending from the Stuart Highway to the railway near Grove Hill.

Yam Creek Mines

Parkes (1892); Jensen, Gray, & Winters (1916); McDonald (1901); Rayner & Nye (1937c); Sullivan & Iten (1952).

The most northerly workings in this belt are the Yam Creek gold mines, on the Priscilla Line of Reefs; they include Radfords Blow and the Princess Louise and Temperance mines as well as numerous alluvial workings in adjacent valleys (Neates Gully, Port Darwin Camp, Sandy Creek, Stuart Gully). Gold has been won from this area intermittently between 1872 and 1910 for a total recorded production of 15,400 oz; no records are available for the appreciable production from alluvial and eluvial deposits worked in the early years. Some copper mineralization is also recorded in the area, but no copper ore appears to have been produced.

The workings were mostly on quartz leaders in interbedded slate and sandstone. Both the reefs and the surrounding sedimentary rocks generally have a northerly strike, but the reefs generally dip east at 50° to 75°, whereas the sedimentary rocks usually dip west. Workings include one shaft 186 feet deep and numerous other shafts between 50 and 150 feet deep, a 200-foot adit, and several hundred shallow pits, costeans, and small open cuts. A 600-foot cross-cut has been driven west from the 186-foot level of the main shaft. Reefs ranged in width from a few inches to about 6 feet and exceptionally to 12 feet, and carried up to 10 percent pyrite in the primary zone. The average grade of all the ore mined was apparently about 7 dwt per ton.

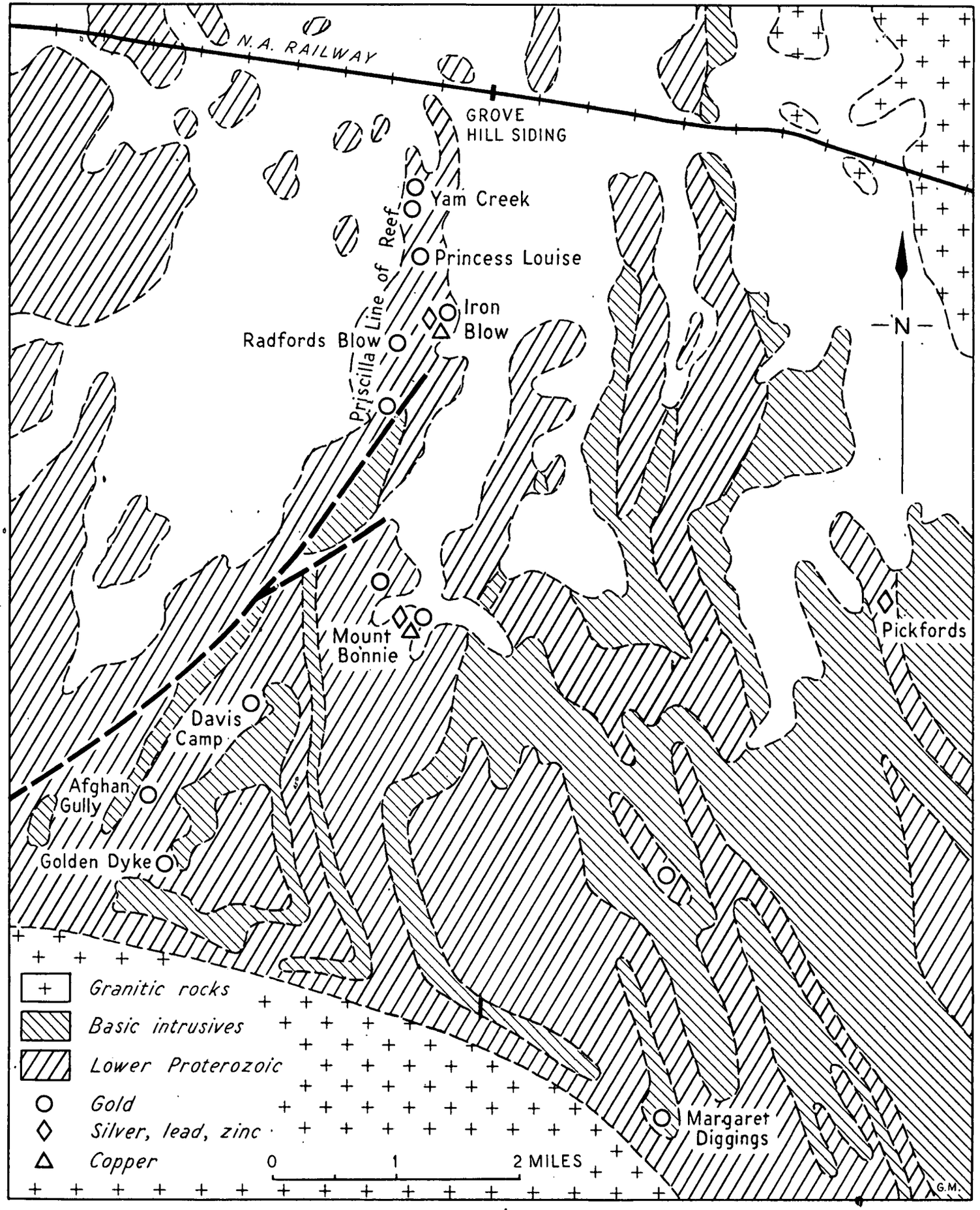

Fig. 28 Mineral deposits, Iron Blow/Mount Bonnie/Golden Dyke area

Iron Blow and Mount Bonnie Mines

Parkes (1892); Brown (1907); Brown & Basedow (1906); Jensen (1915); Jensen, Gray, & Winters (1916); Hossfeld (1937a); Rayner & Nye (1937e); Noakes (1949); Sullivan & Iten (1952); Dunn (1961, unpubl.); Rix (1964a, unpubl.).

At the Iron Blow mine, 2 miles south of Grove Hill Siding, a complex gold and base-metal lode was worked intermittently between 1873 and 1914. Workings consisted of a main shaft 215 feet deep with about 400 feet of drives on the 100-foot level and 200 feet on the 200-foot level, and five other shafts and an open cut 150 feet long. The recorded production is 13,700 tons of ore from a quartz-sulphide lode in a north-trending shear zone with a steep easterly dip. The country rock consists largely of carbonaceous and sericitic slate of the Golden Dyke Formation with minor quartzite bands. The lode has been tested by two diamond drill holes put down in 1906 and 1912 to depths of 444 feet and 467 feet, and by six diamond drill holes totalling 2333 feet, which were put down in 1963 by the Mines Branch, N.T. Administration, under an agreement with United Uranium N.L. This work has shown that the main lode, from which all past production has been obtained, thins considerably below the 200-foot level, and that the probable remaining ore reserves are only about 40,000 tons above the 200-foot level and 10,000 tons below this level. The grade ranges from 4 to 6 dwt Au per ton and 0.2 to 1.0 percent Cu, with 4 to 5 percent Pb, 6 to 14 percent Zn, and 10 to 20 oz of Ag in places. The drilling has also disclosed that a second lode is present below the 200-foot level on a parallel shear zone which crops out 150 feet west of the main shear, and carries little or no mineralization at the surface. This lode is a pyrrhotite-rich body with 0.8 percent Cu and 4.0 percent Zn over a true width of 33 feet at a vertical depth of about 350 feet (Rix, 1964a, unpubl.). South of this intersection, a magnetic anomaly was located by a geophysical survey by the Bureau of Mineral Resources in 1960 (Skattebol, 1962, unpubl.), but the hole drilled to test the anomaly did not intersect any magnetic material. The magnetic anomaly may be caused by a southerly extension of the pyrrhotite lode at a greater depth than that calculated by the geophysicists; some further testing may be warranted.

South of Iron Blow, some minor workings lie on the line connecting Iron Blow and Mount Bonnie mines, but no details are available.

The Mount Bonnie mine, 2½ miles south of Iron Blow, consists of an adit 240 feet long, which is connected to the surface workings by a series of inclined shafts and intermediate levels. The lode exposed in the workings trends north-east and dips north-west at about 45°. A north-trending outcrop of gossanous material immediately east of the workings does not appear to have been tested at depth. The mine is reported to have been worked intermittently between 1903 and 1916, but no records of production are available (Jensen, Gray, & Winters, 1916). Two diamond drill holes were put down in 1916 to depths of 370 and 411 feet to test the downward extension of the lode, but the results are not available. The ore appears to be comparable to that mined at Iron Blow, with low gold and copper values, moderate lead and zinc, and locally high silver, but the available information is insufficient to assess the tonnage and grade of ore which may still remain in the mine.

Golden Dyke Group of Mines

Brown (1895); Jensen, Gray, & Winters (1916); Hossfeld (1936c); AGGSNA (1936, 1940); Noakes (1949); Sullivan & Iten (1952).

To the south-west of the Mount Bonnie mine, a group of small gold mines and prospects includes Davis Camp, Afghan Gully, and Golden Dyke (which is also known as the Shackle). The area has been worked intermittently since 1872; most of the work was done at the Golden Dyke mine, which has a main shaft 100 feet deep, with nearly 500 feet of drives at the 100-foot level. The lode consists of a zone of quartz and sulphide impregnation in slate and sandstone of the Golden Dyke Formation with minor beds containing quartz nodules, possibly at the same stratigraphic horizon as the lodes of the Cosmopolitan Howley mine. The lode trends north-west and dips at about 70° to the south-west, parallel to the bedding of the surrounding sedimentary rocks; it is close to a group of large amphibolite sills.

Recorded production from the Golden Dyke mine is only 1400 oz of gold, but the main shoot at the 100-foot level is reported to have averaged 7 dwt per ton over a length of 360 feet and a width of up to 10 feet (Hossfeld, 1936c), so that some further testing may be warranted.

Four miles south-east of the Golden Dyke mine, a group of shallow workings, situated at least in part in amphibolite, is known as the Margaret Diggings. Both reef and alluvial gold are reported to have been won but the production is not recorded.

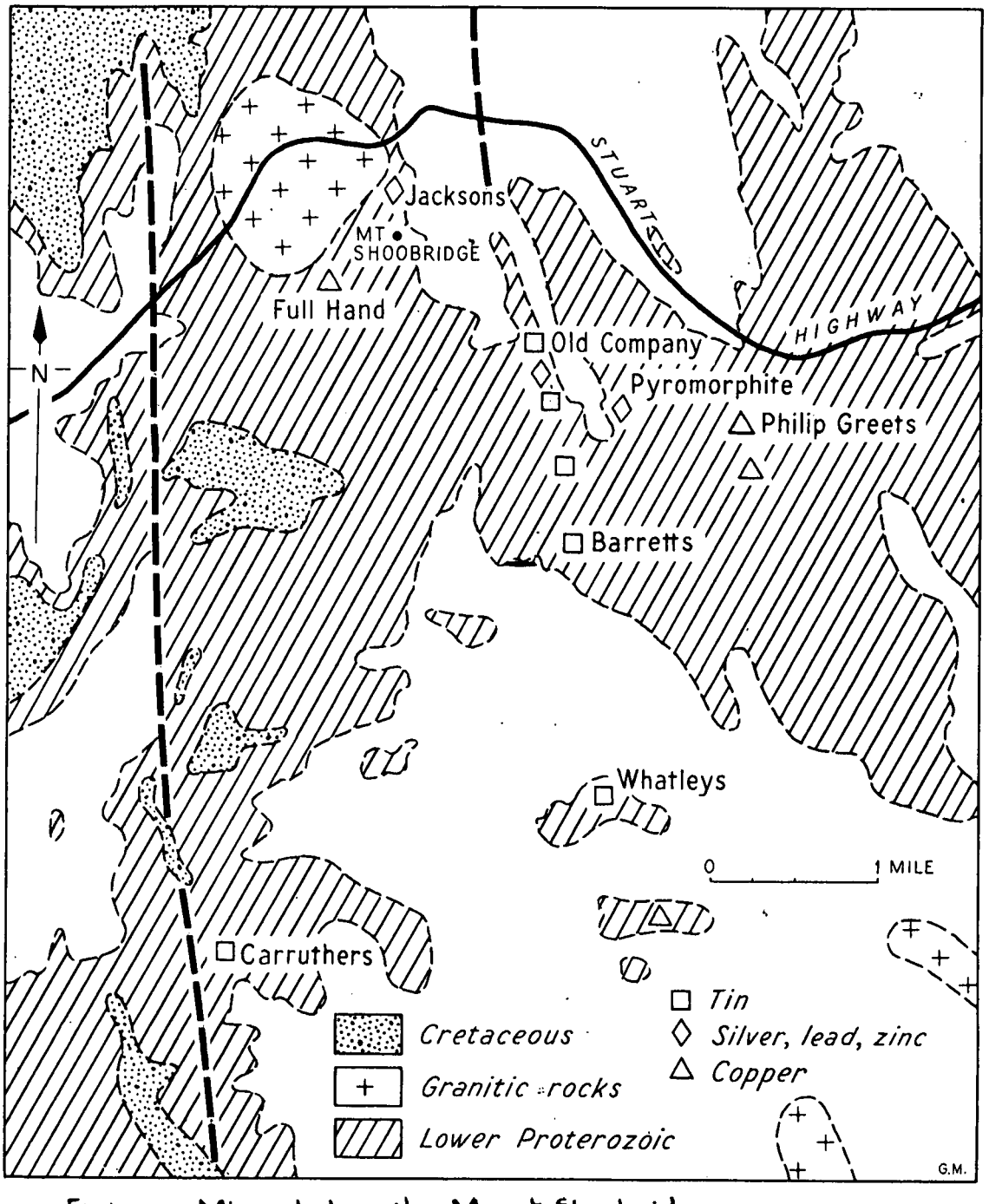

Fig. 29 Mineral deposits, Mount Shoobridge area

At Pickfords mine, also known as the Bonnie Jean, 4 miles east of Mount Bonnie, some lead and copper mineralization is known in a group of quartz reefs and a graphitic shear zone, all of which trend a few degrees west of north. The host rock is slate of the Golden Dyke Formation, and the lodes are close to amphibolite sills. No production is recorded.

Burrundie Uranium Prospect

A uranium prospect has been recorded 4 miles west-south-west of Burrundie Siding, mainly in gossanous cappings overlying carbonaceous and probably pyritic slate of the Golden Dyke Formation; but it appears to offer no possibility of economic development (Stewart, 1954, unpubl.; Firman, 1955a, unpubl.).

MOUNT SHOOBRIDGE AREA (Fig. 29)

Parkes (1892); Brown (1895); Brown & Basedow (1906); Jensen, Gray, & Winters (1916); AGGSNA (1940); Sullivan & Iten (1952); Corbett (1960, unpubl.).

In the Mount Shoobridge area a series of small tin mines and lead and copper prospects occurs in pegmatites, quartz veins, and mineralized shear zones in Golden Dyke sedimentary rocks. Many of them are associated with major meridional structures, such as the Mount Shoobridge Fault, and they may be genetically related to the nearby Shoobridge Granite.

The most productive mine of the group has been the Mount Shoobridge or Old Company mine, 1½ miles south of the Stuart Highway, which has been worked intermittently since 1882. The main workings consist of four shafts, of which the deepest was 180 feet deep and had about 400 feet of drives on three levels. The major workings were on a steeply dipping quartz-muscovite reef from 2 to 8 ft wide, trending north-north-west, which contained patchy cassiterite shoots over a length of 300 feet. Other workings were on groups of pegmatite and greisen stringers, which occur sporadically throughout a zone 1200 feet long and about 100 feet wide. Individual stringers are commonly only a few inches thick, but a few attain a thickness of several feet. The total recorded production from this group of workings is 145 tons of tin concentrate.

At Barretts mine, 1½ miles south of the Old Company workings, an irregular body of greisen and pegmatite, elongated in a north-westerly direction, has been exposed for a length of about 300 feet with a maximum

width of about 90 feet. The body dips to the north-east at an average of only about 30°, and most of the workings, consisting of shallow shafts, costeans, and open cuts, are less than 20 feet deep. Recorded production is 115 tons of tin concentrate.

Other mines close to the old road from Mount Shoobridge to Barretts mine include the Chinamans Hill and Halls Creek prospects, both of which consist of shallow shafts and open cuts on greisen and pegmatite dykes, but no details of production are available.

Copper and lead occurrences are known from numerous prospects in this general area, but few of them are of economic importance.

At Jacksons mine, 1 mile north-west of the Old Company workings, narrow seams of galena and cerussite occur in feldspar porphyry and adjoining quartz-mica schist, and an average grade of 3 percent Pb has been estimated for a zone 300 feet long and about 50 feet wide (Patterson, 1958b, unpubl.). Recorded production is 2 tons of silver-lead ore.

At the Full Hand prospect, also known as the Dead Finish, half a mile south-west of Jacksons mine, two lodes are recorded. One, trending north-north-east, ranged from 1 to 3 feet thick, and is reported to have contained patches of very rich copper ore in the oxidized zone. The other, trending east-north-east, consists of a graphitic shear zone up to 9 feet wide; it contains disseminated copper and lead minerals and can be traced on the surface for over 1000 feet. This mine was worked intermittently from 1903 to 1909, and several shafts were sunk, the deepest being 120 feet. Recorded production is only 14 tons of copper ore. These lodes also carry minor amounts of radioactive minerals, but not in economic concentrations (Rosenhain & Mumme, 1953b, unpubl.).

At Philip Greets copper mine, 1½ miles south-east of the Old Company workings, an almost vertical lode, striking a few degrees east of north, is exposed for a length of about 900 feet with an average width of about 3 feet. It was worked between 1901 and 1912 from a large number of shafts, the deepest being 140 feet; recorded production is about 360 tons of ore, averaging 25 to 30 percent Cu.

Other prospects in this area, for which no details are available, include Whatleys and the Pyromorphite show (lead), and Carruthers prospect (tin).

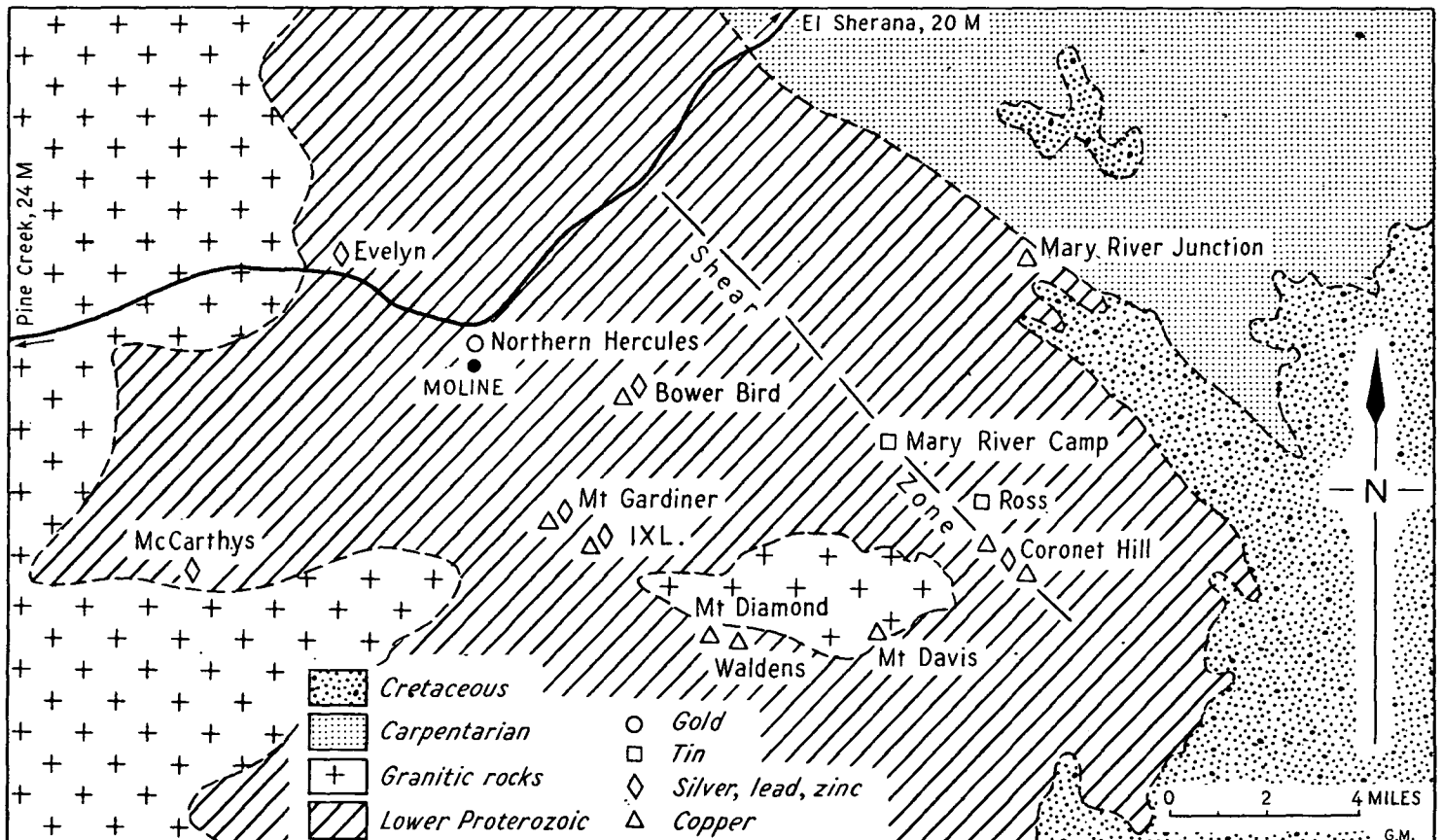

Fig. 30 Mineral deposits, Northern Hercules/Coronet Hill area

During 1963, the area around the Old Company/Barretts mine mineralized zone was re-examined by United Uranium N.L., and a large number of waggon drill holes were put down. One diamond drill hole was also put down by the Mines Branch, N.T. Administration, under an agreement with the Company, but only low-grade tin and lead mineralization was found.

NORTHERN HERCULES/CORONET HILL AREA (Fig. 30)

The Northern Hercules/Coronet Hill area is centred on Moline township, at the site of the old Northern Hercules mine, and contains a number of formerly highly productive mines which have been worked for gold, copper, and silver-lead-zinc.

Northern Hercules Mine

Parkes (1892); Brown (1895); Brown & Basedow (1906); Jensen (1919); Larsen (1957, unpubl.); Rayner & Nye (1937g); Sullivan (1940, unpubl.); Summers (1957a, unpubl.).

The Northern Hercules has been the main gold producer in this area, and has been worked intermittently between 1880 and 1908 and between 1954 and 1957. The mine was also referred to as the Eureka or Houschildts Rush in its early years and as Hercules in the 1930's. The old Maybell mine was later included in the Northern Hercules. Recorded production is 32,800 oz of gold and a small tonnage of copper concentrate, but this is known to be incomplete.

The most recent and comprehensive accounts of the mine are by Summers (1957a, unpubl.) and Larsen (1957, unpubl.). The workings have opened up three parallel quartz-sulphide lodes in a north-north-westerly shear zone, of which the most easterly has been the most productive. Pyrite and arsenopyrite, with minor copper, lead, and zinc sulphides, are present in the unoxidized ore, but much of the early production was from the oxidized zone. The country rock consists of greywacke and slate of the Burrell Creek Formation.

The lodes dip to the west at 65° to 70° and were originally worked from a number of shallow shafts and open cuts, but the main shaft was sunk to a depth of 440 feet in 1956, and a total of at least 4000 feet of driving and cross-cutting has been done on the 200, 300, and 400-foot levels.

At the 300-foot level, three separate shoots with a total length of about 400 feet were present in the eastern lode. They ranged from 3 feet

6 inches to 5 feet wide with from 12 to 22 dwt Au per ton, but both the width and the average grade are reported to have fallen off sharply at the 400-foot level. The central and western lodes have not been worked below the zone of oxidation. All the lodes have also been extensively tested by diamond drilling and major extensions or repetitions of the known shoots are unlikely to be discovered within an economic depth from the surface.

Coronet Hill/Mount Davis/Mount Diamond Group of Mines

Parkes (1892); Brown & Basedow (1906); Brown (1908b); Jensen (1919); Ruxton & Shields (1962, unpubl.).

Among the copper mines of the area, the Coronet Hill, Mount Davis, Mount Diamond, Walden, IXL, and Mount Gardiner mines form a group which stretches from 6 to 12 miles south-east of Moline, close to an outlying lobe of the Cullen Granite batholith.

At Coronet Hill, a group of quartz-sulphide lodes occupy a major north-westerly shear zone, which in part forms the boundary between chert of the Golden Dyke Formation to the north-east and greywacke and siltstone of the Burrell Creek Formation to the south-west. All the lodes dip steeply to the south-west.

The workings extend intermittently over a total length of about 9½ miles and consist of two adits from which about 1000 feet of drives and cross-cuts have been driven, and at least eight shafts, of which the deepest is about 120 feet. Most of the work appears to have been done between 1916 and 1918.

The lodes average 2 to 3 feet thick, with occasional bulges up to 10 feet, but assay values are very erratic. Of a group of 35 samples taken in 1961, 12 gave assays of over 5 percent Cu, 20 contained 8 to 30 oz Ag per ton, and 2 contained over 15 percent Pb (Ruxton & Shields, 1962, unpubl.). Pyrite and arsenopyrite are always present in the primary ore, and scorodite (iron arsenate) commonly occurs in the oxidized zone. Gold is generally low (less than 1 dwt per ton), but up to 0.7 percent Bi and traces of antimony may be present.

Recorded production is about 250 tons of ore, averaging 22 percent Cu. In 1961, six diamond drill sites were selected as a result of a survey by the Bureau of Mineral Resources (Ruxton & Shields, 1962, unpubl.), but no further work has been done as yet.

Evelyn Mine

Parkes (1892); Brown (1895); Brown & Basedow (1906); Jensen (1919); Hossfeld (1937e); Rayner & Nye (1937i); Rowston (1957, unpubl.).

At the Evelyn mine, 3 miles north-west of Moline, a group of small silver-lead-zinc lodes occurs in limestone and calcareous slate of the Golden Dyke Formation. The lodes were worked between 1886 and 1890; the original workings consisted of seven shafts, the deepest to 116 feet, and a number of open cuts and adits of which few details are available. The lodes have since been re-examined on several occasions, and United Uranium (N.L.) have now (June 1966) reopened the mine.

Nine separate lodes have been recognized in the area, mostly trending a few degrees west of north and dipping steeply to the east. The largest had an average width on the surface of 4 to 5 feet and has been traced for a length of about 250 feet. The lodes transgress the bedding of the host rocks, which trends west-north-west, and are associated with a zone of brecciation, silicification, and iron-impregnation defined by a prominent outcrop of quartz-hematite breccia at Pinnacle Hill, immediately south-east of the main workings. Galena and sphalerite are the main ore minerals in the primary zone, but hydrozincite, smithsonite, cerussite, anglesite, and secondary copper minerals occur in the oxidized zone.

Total recorded production is about 2200 tons of ore containing 600 tons of lead and 89,000 oz of silver, most of which was probably obtained from the oxidized zone.

Rowston (1957, unpubl.) reported that a diamond drill hole put down by Zinc Corporation in 1955 intersected 4 feet of ore assaying 20 percent Pb, 8 percent Zn, and 25 oz Ag per ton at a depth of about 250 feet below the outcrop of the main lode, but a shaft designed to test the occurrence was abandoned before reaching its target.

Three holes totalling about 500 feet were drilled to the north of the main workings by United Uranium N.L. in 1964, and met with disappointing results. In 1965 further exploration included the rehabilitation of the original main shaft to a depth of 100 feet, and underground driving and drilling which confirmed the continuity of the main lode to a depth of at least 265 feet and six subsidiary lodes to a depth of 100 feet or more.

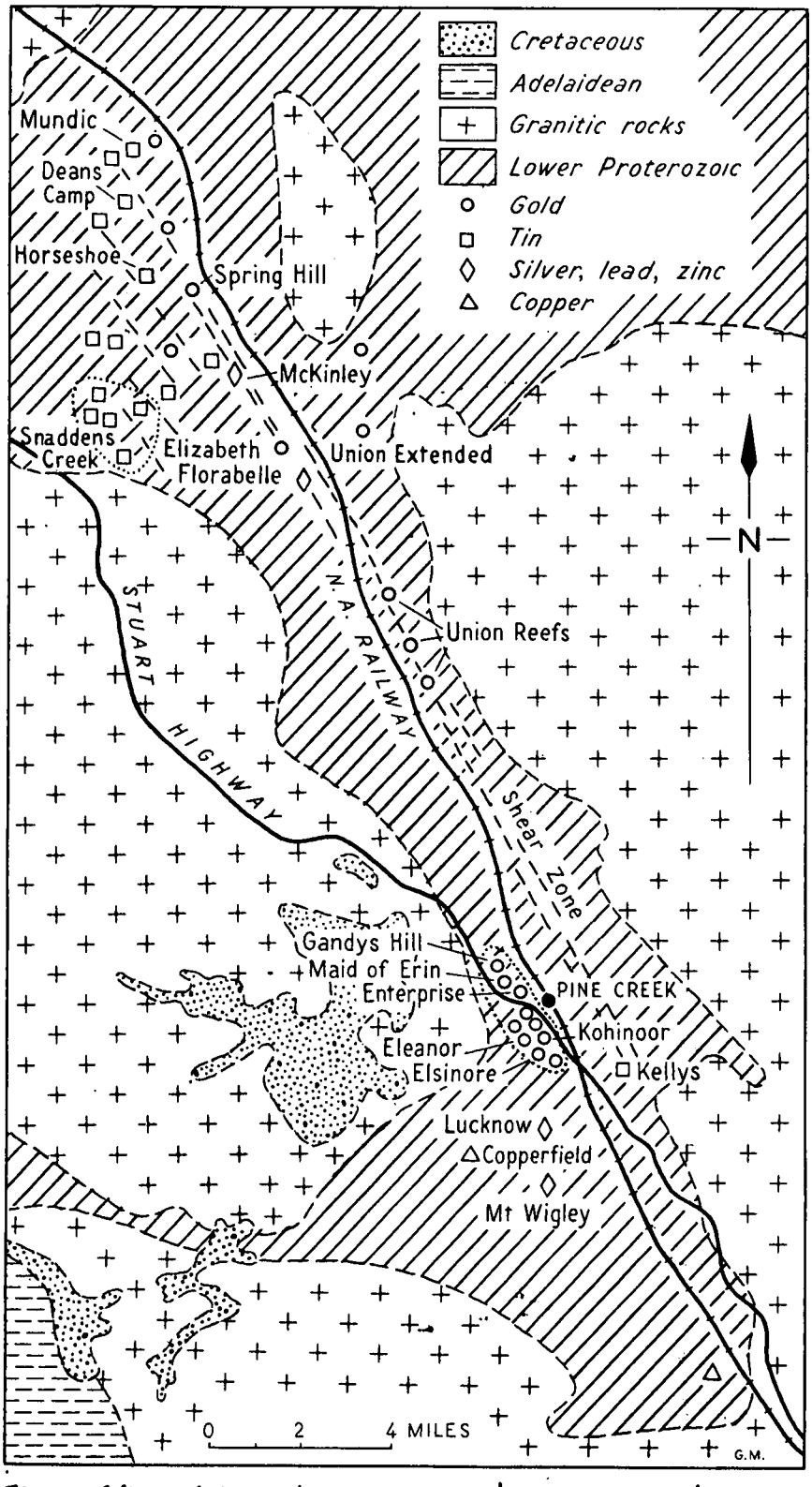

Fig. 31 Mineral deposits, Spring Hill / Union Reefs / Pine Creek area

Other Mines and Prospects

Among the smaller mines of this area, some information is available on the Mary River Junction, McCarthys, Bower Bird, and Ross mines.

At the Mary River Junction mine, 12 miles east of Moline, 69 tons of rich copper ore are reported to have been won from shallow workings in 1913 and 1917-18. The mine was re-examined in 1963 by United Uranium N.L., but no further mining was done (Rix, 1964c, unpubl.).

At McCarthys silver-lead mine, 7 miles south-west of Moline, a 3-foot lode was worked between 1912 and 1918 from several shafts, the deepest being 80 feet. The lode strikes northerly, transgressing the bedding in the surrounding hornfels and andalusite-chiastolite schist derived from greywacke and slate of the Masson Formation by metamorphism by the nearby Cullen Granite (Jensen, 1919). Total recorded production is 570 tons of ore containing 70 percent Pb and 10 oz Ag per ton.

At the Bower Bird mine, 5 miles east-south-east of Moline, both silver-lead and copper ore have been mined on a small scale, but the only record of production is 8 tons of argentiferous galena in 1913.

The only known occurrences of tin in the area are at the Mary River Camp locality, 4 miles north-west of Coronet Hill, and at Ross prospect, about 1 mile north of Coronet Hill. Recorded production is 45 tons of tin concentrate from Mary River Camp, but none from the Ross prospect.

SPRING HILL/UNION REEFS/PINE CREEK AREA (Fig. 11)

In the Spring Hill/Union Reefs/Pine Creek area, a group of mines occupies a north-north-west belt about 25 miles long, which coincides partly with a major shear zone, and in the south with a major re-entrant in the Cullen Granite batholith. Gold is the main mineral mined, with subordinate tin, silver-lead-zinc, and copper.

Spring Hill Group of Mines

Parkes (1892); Brown & Basedow (1906); Jensen, Gray, & Winters (1915); Jensen (1919).

The most northerly group of mines consists of the tin and gold mines of the Spring Hill and Burrundie areas, which have been worked intermittently since 1882.

At Deans Camp, also known as Jimmys Knob, 2 miles south of Burrundie, narrow seams of rich tin ore occur in a feldspar porphyry intrusion and in adjoining black slate. Workings include several adits and a number of shafts, the deepest to 107 feet.

At the Mundic mine, half a mile east of Deans Camp, a number of shafts have been sunk on an east-west 2-foot quartz-pyrite-cassiterite reef. Workings extend over a length of about 500 feet, and the deepest shaft is reported to be 100 feet deep.

At the Horseshoe mine, west of Spring Hill Siding, both lode and alluvial tin are reported to have been won. At least one shaft was sunk on a kaolinized porphyry dyke, and others on a gossanous shear zone at the contact of an amphibolite intrusion; the deepest shaft is reported to have been 60 feet deep.

Other known tin occurrences include the Snaddens Creek alluvial tin field and a number of other workings for which no detailed information is available.

Production was about 300 tons of tin concentrate, mostly obtained before 1930; but the records do not generally indicate the production from individual mines, and the total is almost certainly incomplete. Production of about 15 tons of concentrate has also been recorded from the area since 1950.

Among the gold mines, Spring Hill was the most important. The main lode worked a ferruginous quartz reef, from 18 inches to 5 feet and in places up to 12 feet wide, which strikes north and dips to the east at about 55°. The country rock consists of well-jointed black slate of the Burrell Creek Formation. Several shafts were sunk between 1882 and 1896, the deepest to 345 feet. In 1913, an adit was driven right through the hill without encountering any payable shoots, and in 1934-38 another adit was driven for 980 feet, but was abandoned 200 feet short of its target. The most recent attempt to re-open the mine was in 1951-55, but this was also abandoned as the results were not up to expectations. Total recorded production is 21,170 oz of gold.

About 2 miles south-east of Spring Hill, the McKinlay silver mine was worked from 1888 to 1893 by means of at least ten shafts, the deepest to 130 feet, and by an adit 230 feet long. The lode was reported to strike north and dip to the east at about 55°; it had an average width of 3 feet

and contained galena, cerussite, and pyrite. Total recorded production is 15 tons of lead, about 40,000 oz of silver, and 735 tons of silver-lead ore of unspecified grade. Assays of up to 30 percent Pb and 3700 oz Ag per ton were reported.

About 2 miles south-south-east of the McKinley mine, the Elizabeth gold mine was worked between 1891 and 1897. It consisted of five shafts, from 50 to 80 feet deep, sunk on a 3-foot quartz reef which strikes north-north-west and dips 60° east, parallel to the bedding of the surrounding sedimentary rocks, which are locally altered to schist. Total recorded production is 3440 oz of gold.

In the Flora Belle mine, about half a mile south of the Elizabeth, a vertical 3-foot lode trending north-north-west, contained galena, sphalerite, marcasite, and arsenopyrite in the primary zone. Seven shafts were sunk on the lode, the deepest to 250 feet. Recorded production is 133 tons of silver-lead ore, but this is probably incomplete.

Union Reefs Group of Mines

Parkes (1892); Brown (1895, 1907); Brown & Basedow (1906); Jensen (1915, 1919); Hossfeld (1936b); White, et al (in press).

In the Union Reefs area, two parallel north-north-west lines of lodes have been worked over a total length of about 2½ miles. Most of the work was done between 1873 and 1906, with sporadic activity since.

Total recorded production from this group of mines is about 54,700 oz of gold, but returns from extensive tributing operations were only partly recorded.

The lodes include a large number of quartz reefs, commonly en echelon, in two sub-parallel north-north-west shear zones (Union line and Lady Alice line) which are part of a larger structure extending for at least 20 miles from near Pine Creek in the south to Spring Hill in the north. Within the Union Reefs area, individual reefs range up to about 15 feet wide and several hundred feet long. Pyrite and arsenopyrite with minor galena and copper sulphides are present in most of the lodes below the water-table, and some of the lodes also contain relatively abundant calcite, dolomite, and ankerite. The country rock consists of steeply dipping slate and greywacke of the Burrell Creek Formation, partly metamorphosed to low-grade hornfels.

Workings consist of a large number of shafts, open cuts, adits, and costeans, but few penetrate below the water-table, which is generally encountered at about 100 feet. The two deepest shafts, now inaccessible, were the Millars No. 10 (200 feet), and the South Union No.1 (170 feet).

Two diamond drill holes were put down in 1903-04 to inclined depths of 861 and 1052 feet (531 and 746 feet vertical depths), and assay results of up to 19 dwt Au per ton were obtained, but the widths of the lode intersections were not recorded and no follow-up work appears to have been done (Brown, 1906).

Four additional holes to inclined depths between 400 and 480 feet (350 to 400 feet bertical depths) were drilled in 1913-14, but no assay results of more than 3 dwt per ton were obtained, although the No. 3 hole recorded a 6-foot lode intersection which assayed 10.2 percent Pb at a vertical depth of about 380 feet (Jensen, 1915).

In 1963-64, the Bureau of Mineral Resources undertook a comprehensive re-examination of the entire field and drilled 13 holes totalling 6200 feet. Results confirm that the lode system extends below the level of the deepest existing workings, but the better values occur in relatively small shoots. One shoot is estimated to contain reserves of 23,000 tons of ore, averaging 21 dwt of gold per ton (White et al, in press).

To the north of the Union Reefs field, the Union Extended mine was worked between 1875 and 1908 by means of a number of shafts up to 120 feet deep, and at least one large open cut. The lodes were generally irregular and discontinuous quartz stringers, commonly only a few inches wide, although there were a few larger reefs up to 15 feet wide. Some very rich concentrations of secondary gold were associated with irregular bands of dolomite, probably representing zones of replacement in the sheared sedimentary rocks. Total recorded production is 3500 oz of gold, including production from the nearby Isabel and Penders Hill leases, of which no other details are known.

Pine Creek Group of Mines

Parkes (1892); Brown (1895, 1908b); Brown & Basedow (1906); Jensen (1915, 1919); Jensen & Oliver (1914); Hossfeld (1936a); Kleeman (1937); Rayner & Nye (1937h); Noakes (1949); Vanderplank (1965b, unpubl.).

Pine Creek has been the largest producer of gold in the Katherine-Darwin Region, containing about 15 separate mines, of which the Enterprise,

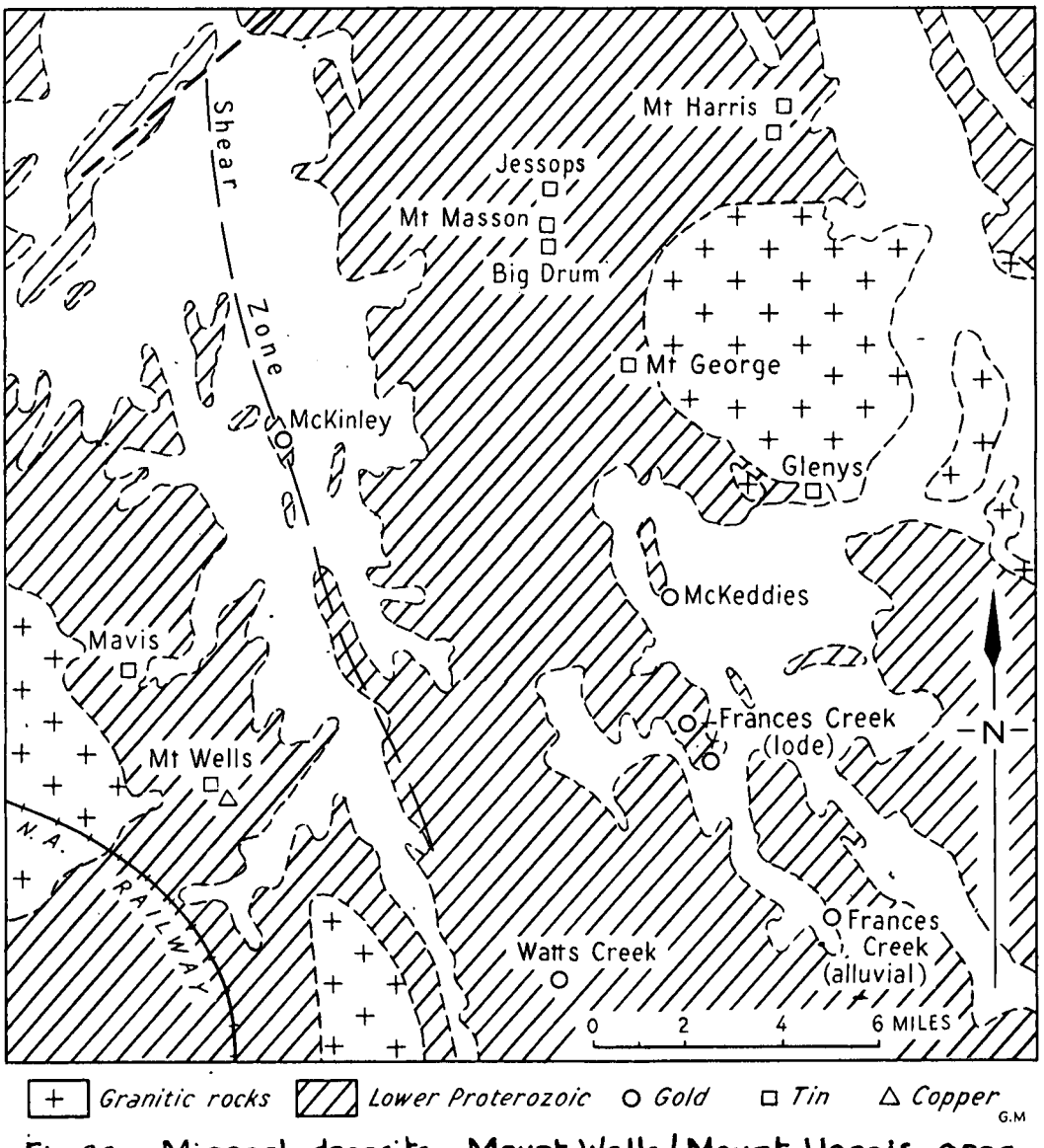

Fig.32 Mineral deposits, Mount Wells/Mount Harris area

Eleanor, and Elsinore have been the most important. The field has been worked intermittently from the early 1870's, with the bulk of the work between about 1880 and 1914. The recorded production totals about 76,100 oz from 54,000 tons of ore (Hossfeld, 1936a). However, a total of at least 95,000 oz is thought to be a better approximation, although it cannot be apportioned accurately between the various mines.

The field extends over a north-north-westerly belt about 4 miles long and about half a mile wide. All the workings are on quartz reefs in slate and greywacke of the Burrell Creek Formation, in part altered to low-grade spotted hornfels by the nearby Cullen Granite. Pyrite and arsenopyrite are present in all the lodes below the zone of oxidation, and galena and chalcopyrite occur sporadically.

The reefs are of two main types. One group consists of steeply dipping bodies, many of them several hundred feet long, which strike parallel to the enclosing sedimentary rocks. In vertical section, they are commonly parallel to the bedding for part of their depth, although they may cut across the bedding where they cross a fold axis. Where two reefs are present on opposite limbs of a fold, a considerable thickness of quartz may be developed at the intersection near the fold axis, and the resultant formations have been described as saddle reefs. The vertical depth of the reefs is generally small compared to their strike length, and they generally pitch parallel to the nearby fold axes, at 10° to 30° to the south. The best examples of lodes of this type are in the Enterprise and Kohinoor workings.

The other type of lode consists of smaller leaders, from a few inches to about 2 feet wide, dipping to the south-east at an average of about 30°. The leaders are generally grouped one above the other. Such lodes were best developed at the Eleanor mine, where values of over 4 oz Au per ton have been recorded in places.

The most northerly workings are the Gandys Hill, Maid of Erin, and International mines, which consist of numerous shallow shafts and open cuts on small irregular quartz leaders in hornfels. The sedimentary rocks in this area are more intensely metamorphosed than those in the central and southern parts of the field, and this may account for the absence of the larger and better defined type of reef.

At the Enterprise and North Enterprise mines, half a mile west of Pine Creek township, a large south-pitching saddle reef and minor parallel

reefs have been worked on both limbs of the anticline for a strike length of about half a mile. The North Enterprise includes part of the old Monarch, Newcastle and Emperor leases. Most of the workings are shallow shafts and open cuts, but a 260-foot shaft, the deepest on the field, has been sunk near the southern end of the line of workings, and a 400-foot adit has been driven on the North Enterprise lease. A 280-foot north drive from the shaft and extensive stopes from the adit are on the east limb of the saddle reef, but the reef is substantially intact over a length of 800 feet between the shaft and the adit. In this area, it has an estimated vertical extent of 100 to 150 feet and an average width of 3 to 4 feet.

The shaft was sunk before 1915 to follow up a diamond drill hole intersection of 4 feet of laminated quartz, assaying 4½ oz Au per ton, but in the drive the lode in the immediate vicinity of this intersection assayed only about 12 dwt, and little work was done until 1962, when the shaft was re-opened by Messrs R. and M. Blake. A limited amount of driving has since been done, and a trial parcel of about 720 tons of ore has been extracted to investigate the treatment characteristics of the ore. This yielded 120 oz of gold plus about 32 tons of concentrate containing another 190 oz of gold, i.e., an average overall recovery of about 10 dwt per ton.

In 1964, two diamond drill holes were put down by the Mines Branch, N.T. Administration, under an agreement with the leaseholder. One of these, about 600 feet north of the shaft, obtained an intersection of 6 feet of lode material (inclined width), assaying 21 dwt per ton, which confirmed the continuity of the lode between the North Enterprise and Enterprise workings. The other hole, which was designed to intersect the lode about 100 feet down dip from the intersection on the 260-foot level of the main shaft, obtained only scattered low-grade intersections (Vanderplank, 1965, unpubl.).

South of the Enterprise, the gap in the main ridge through which the Stuart Highway passes, may represent a transverse fault, since the main line of workings south of the gap appears to be displaced several hundred feet to the east.

South of the gap, on the Sultana, Ophir, Bashi Bazook, Czarina, and Sagabiel leases, only small irregular groups of leaders appear to have been worked, but records for this group of mines are incomplete. A diamond drill hole put down on the Sagabiel lease in 1913 obtained an intersection assaying 4 oz 11 dwt per ton from 559½ to 560½ feet inclined depth, but this has not been followed up.

At the Southern Cross, Henry George, Christmas, New Year, New Thunderer, Kohinoor, North Australian, and Michaelmas leases 1 mile south of Pine Creek township, another large saddle reef and associated spurs were worked from a number of open cuts and three adits, the longest being 700 feet. The reef system has a southerly pitch, and extensions of the known shoots might be expected underneath the southern part of the existing Kohinoor workings, but only low values were encountered in two diamond drill holes put down by the Mines Branch, N.T. Administration, in 1965.

Immediately west of the Kohinoor lease, the Eleanor mine has been one of the most productive on the field, most of the gold being obtained from a group of relatively narrow, gently dipping leaders. The main shaft has a depth of 180 feet, and other workings include an adit 300 feet long, a large open cut, and several shallower shafts. A diamond drill hole was put down on this lease by the Mines Branch, N.T. Administration, in 1965, but no payable intersections were obtained.

In the most southerly part of the field, comprising the Democrat, Republic, Chin Phillips, Rack-a-Rock, Rising Sun, Elsinore, Golden Gate, Sydney, and North Star leases, workings are still more widely spaced and records of past activity are poor. The deepest shaft was the Dashwood Shaft on the Elsinore lease, with a depth of 210 feet; no payable lodes were encountered and no stoping was done. A geophysical survey (Rayner & Nye, 1937h) indicated a number of possible occurrences of non-outcropping quartz reefs which might warrant testing, but no systematic follow-up work has been done.

Other Mines and Prospects

A number of other mines and prospects have been worked at various times in the Pine Creek district.

At the Caledonia mine, about 4 miles north-east of Pine Creek, a production of 460 oz of gold is recorded, and at Lucknow, 2 miles south of Pine Creek township, 150 tons of silver-lead ore was produced in 1907.

At Mount Wigley, 4 miles south of Pine Creek, a north-north-west galena-bearing quartz reef was worked in 1907 from a shaft at least 25 feet deep (Jensen, 1919). The lode is reported to have been 2½ feet wide, and the recorded production is 60 tons of silver-lead ore.

At Copperfield, 4 miles south-west of Pine Creek, mining was carried out intermittently between 1872 and 1917, and total recorded production is

2140 tons of ore averaging about 12 percent Cu. The main lode trends north-north-west and dips west at about 60°. It had an average width of 3 to 5 feet, and was worked from at least six shafts, the deepest being 130 feet. Most of the ore was obtained from the oxidized zone (Parkes, 1892; Brown & Basedow, 1906; Jensen, 1919).

Another small copper prospect occurs half a mile west of the railway, 10 miles south of Pine Creek township. Here, a 3-foot north-north-westerly quartz reef with cuprite and malachite occurs at the contact of a quartz-feldspar dyke with the surrounding slate and metagreywacke; it has been exposed in a 10-foot prospecting pit, but no production is recorded (Crohn, 1965d, unpubl.).

The only tin production in this area has come from Kellys mine, 3 miles south-east of Pine Creek township, where a series of small cassiterite-bearing ferruginous quartz veins occur in a north-south zone of sheared slate and sandstone about three-quarters of a mile long (Brown, 1908b). Recorded production is 2 tons of tin concentrate from about 32 tons of ore, mined in 1908 and 1909.

MOUNT WELLS/MOUNT HARRIS AREA (Fig. 32)

The Mount Wells/Mount Harris area has been dominantly a tin producer. All the tin appears to have been derived from fissure lodes of quartz and cassiterite with varying amounts of sulphides. Near the surface the sulphides are commonly oxidized to limonite and hematite, and the outcrops range from ironstained quartz to highly gossanous material in which it is difficult to identify the cassiterite.

Mount Wells Mine

Parkes (1892); Brown (1895); Brown & Basedow (1906); Jensen, Gray, & Winters (1916); Rayner & Nye (1937); Noakes (1949); Smith (1958, unpubl.).

Mount Wells, 2½ miles north of Burrundie Siding, was the earliest of these mines to be worked, and was also by far the largest producer. The mine was worked intermittently from 1879 to 1929. Three main lodes and numerous minor lodes and groups of stringers crop out on the crest and upper slopes of the hill, which rises to 860 feet above sea level, or about 400 feet above the level of the surrounding valleys. The lodes are generally 1 to 4 feet wide, although stockworks and groups of stringers associated with the main lodes have locally been worked for widths of 20 feet or more. The lodes strike a few degrees east of north and dip east at about 80°. The

country rock is micaceous slate and greywacke of the Burrell Creek Formation. Workings consist of numerous open cuts and shafts, the deepest being 160 feet, and of three major and several minor adit levels. At least 3600 feet of cross-cutting and driving was done on the three major adit levels, but most of the workings are no longer accessible. In 1957, the Broken Hill Pty Co. Ltd drilled three holes, totalling 1540 feet, to test the persistence of the lodes below the existing workings, but no intersections of payable ore were obtained (Smith, 1958, unpubl.).

Recorded production is about 1530 tons of tin concentrate from about 100,000 tons of ore, with an average grade of just under 1 percent Sn. The most recent production was 5 tons of concentrate (from old battery sands) in 1963. The primary ore contained varying amounts of pyrite and chalcopyrite and traces of wolfram and scheelite, but the only recorded production other than tin was 7 tons of 37 percent copper ore in 1917.

A Government Battery for the treatment of ore from various small producers in the area was opened in 1962 at the site of the old Mount Wells plant.

Jessops Lode/Mount Masson Group of Mines

Hays (1958, unpubl.; 1960, unpubl.).

About 15 miles north-north-east of Mount Wells, a group of workings on a north-south fault zone comprises Jessops Lode and the Mount Masson and Big Drum mines. All these mines occur in greywacke and slate of the Masson Formation (Hays, 1960, unpubl.).

Jessops Lode, discovered in 1957, consists of an almost incoherent mass of angular quartz, slate, and iron oxide fragments in a matrix of fine quartz, iron oxide, and cassiterite. The upper part of the lode was probably formed by the collapse of the original sulphide-rich lode after a decrease in volume resulting from oxidation and leaching. The lode trends roughly north and has been worked by an open cut about 160 feet long and 8 feet wide, and by an adit 60 feet long, which opens off the north end of the open cut. The dip is westerly at about 60° in the open cut, flattening to about 35° in the adit. The Billy Can lease covers a southern en echelon extension of Jessops Lode. To June 1965, recorded production of tin (in concentrates) from both leases is about 100 tons from about 10,000 tons of ore.

At Mount Masson, mining has been carried out intermittently since 1942, and the total recorded production to June 1965 is 31 tons of tin (in concentrates) from 2870 tons of ore. The main workings consist of an adit 240 feet long, and a water shaft 120 feet deep, on the same line of lode. In the adit, from which all the production has been obtained, the lode ranges from a few inches to about 3 feet thick and dips almost vertically.

In 1963, a waggon-drilling programme was undertaken by United Uranium N.L. to search for repetitions or extensions of the known lodes at Jessops and Mount Masson mines, but the results were disappointing (Grenning, 1963, unpubl.).

At the Big Drum, just south of Mount Masson an adit 105 feet long has been driven on an ironstained quartz reef from a few inches to about 3 feet wide, but only sparsely disseminated tin has been encountered and total production is only 0.5 tons of tin concentrate (Crohn, 1963b, unpubl.).

Other Mines and Prospects

The Mavis mine, about 5 miles north-west of Mount Wells, was discovered in 1958 and had produced 3.5 tons of tin concentrate to the end of 1962. The lode consists of a cassiterite-bearing quartz reef with minor hematite and limonite, which has been partly exposed in a small adit and several open cuts over a total distance of about 600 feet. It is 6 inches to about 3 feet wide, and includes some extremely rich patches of coarse cassiterite. The reef appears to follow the bedding of the surrounding sedimentary rocks, which consist of Lower Proterozoic slate and greywacke folded into a series of large relatively open folds, plunging to the north at 30° to 40° (Dunn, 1960, unpubl.). This lode appears to offer good prospects of further small to medium-scale production.

At Mount Harris, 6 miles east-north-east of Jessops Lode, a group of leases of which the Nelson, Buffalo and Margaret are the most important have been worked intermittently since 1956. The country rock consists of slate and greywacke of the Masson Formation. The area contains numerous lodes, ranging from networks of small leaders to reefs several feet thick, most of which appear to fill tension gashes associated with north-trending faults. Some but not all of the lodes are highly ferruginous, and several contain traces of gold as well as tin. To June 1965, recorded production of tin (in concentrates) is about 10 tons from 900 tons of ore, and further investigation of the area appears to be warranted (McQueen, 1956, unpubl.; Hays, 1958, unpubl., 1960, unpubl.).

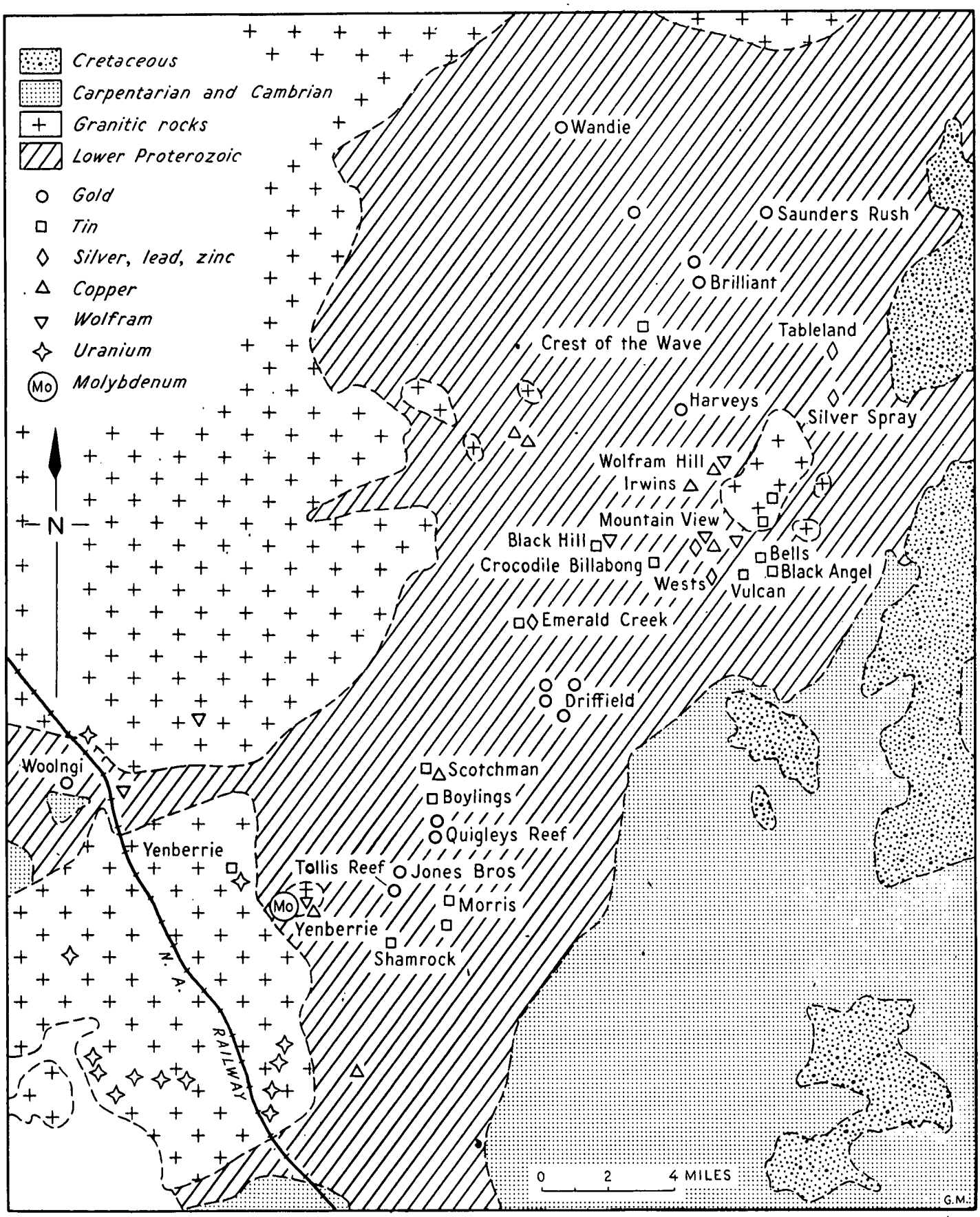

Fig. 33 Mineral deposits, Wolfram Hill / Mount Todd area

At Mount George, 12 miles north-east of Mount Wells, a group of quartz veins and stockworks has been mined intermittently since 1926 by means of one large and several small open cuts for a total recorded production of 12 tons of tin concentrate. The workings are in contact-metamorphosed slate and greywacke of the Masson Formation within half a mile of the contact of the Cullen Granite.

Five miles south-east of Mount George, the Glenys leases, formerly known as Lucys Diggings, lie in a comparable position relative to the Cullen Granite. Small quartz-cassiterite stringers have been worked from a series of shallow shafts and small open cuts, but there is no record of production. A recent investigation has shown that this area may also contain some 10,000 cubic yards of eluvial material averaging between 5 and 15 lb of cassiterite per cubic yard (Hays, 1963a, unpubl.), but lack of water in the dry season and difficulty of access in the wet season have prevented systematic exploitation of the deposits, and the recorded production is only 0.2 tons of tin concentrate.

WOLFRAM HILL/MOUNT TODD AREA (Fig. 33)

The Wolfram Hill/Mount Todd area covers a north-westerly belt, some 30 miles long and 8 to 10 miles wide, which stretches from near Ranford Hill to the Stuart Highway at Edith River. The belt contains a variety of mines, mostly small, from which gold, tin, wolfram, and lead have been obtained. The belt trends generally parallel to the south-eastern margin of the Cullen Granite, and many of the mines in the northern part of the belt are closely associated with the Wolfram Hill Granite. The mineralization is probably related to the intrusions.

Wandie, Crest of the Wave, and Wolfram Hill Mines

Brown & Basedow (1906); Brown (1908b); Jensen (1919); AGGSNA (1938); Kleeman (1938); Thyer, Rayner, & Nye (1938).

The most northerly workings in the Wolfram Hill/Mount Todd area are the mines of the Wandie Goldfield, which extend over several square miles. Auriferous quartz reefs strike north-north-west and dip vertically or steeply to the west, approximately parallel to the enclosing sedimentary rock, which is mainly fissile slate of the Burrell Creek Formation. The field was worked between 1895 and 1905, and the recorded production is 6380 oz of gold. Numerous shafts are reported to have been sunk to water level, which was generally encountered at about 60 feet, but the bulk of the production

appears to have been from alluvial workings.

Two other small mines, known as Saunders Rush and the Brilliant mine, are situated about 5 miles south-east of Wandie, but no details of their production are available.

The most northerly tin mine of the Wolfram Hill/Mount Todd area is the Crest of the Wave, 5 miles south of Wandie; it has been worked intermittently since 1907. The main lode was a quartz-cassiterite reef with minor arsenopyrite, which was worked from several shafts to a maximum depth of 150 feet over a strike length of about 450 feet. The lode strikes north-west and dips south-west at 60°; the strike is parallel to the trend of the enclosing rocks, which are mainly chlorite schist derived from argillites of the Burrell Creek Formation. The average width of the lode was only 8 inches, but the average grade was exceptionally high and the total recorded production is 143 tons of tin concentrate. Minor parallel lodes are also known. The mine was re-examined in 1963 by United Uranium N.L., but no further work has been carried out.

In the immediate vicinity of the Wolfram Hill Granite, a group of mines has been worked for tin, wolfram, and lead.

At Wolfram Hill itself, two parallel lines of lode have been intermittently worked since 1900. The lines trend north-west to north-north-west and dip steeply to the east, sub-parallel to the bedding of the indurated siltstone of the Burrell Creek Formation, and a prominent joint direction. The best ore occurred in steeply pitching pipes up to 50 feet in length and 10 feet in maximum width, the deepest of which was worked to 130 feet. The ore consists of wolfram and chalcopyrite with minor pyrite and arsenopyrite in a gangue of quartz and black mica. Recorded production is about 630 tons of wolfram concentrate, averaging 70 percent WO_3, and 230 tons of copper ore averaging 30 percent Cu.

At Irwins mine, a quarter of a mile west of Wolfram Hill, rich copper ore is reported to have been obtained from a north-westerly lode, from 4 to 10 feet wide, which was worked to a depth of 40 feet. No production figures are available.

At the Silver Spray mine, 4 miles east-north-east of Wolfram Hill, a series of quartz lenses with galena and sphalerite occur in a north-north-west zone over a total length of about 2000 feet. Individual shoots range up to 100 feet long and 2 feet wide. The only recorded production is 85 tons of galena, mined between 1905 and 1907. A prospect known as the

Tableland is recorded about 1 mile north of the Silver Spray, but no details of its production are available.

At the Last Hope (or Harveys) mine, 2 miles north-west of Wolfram Hill, a number of shallow shafts have been sunk on a group of auriferous quartz reefs, most of which strike east, but the recorded production is only about 30 oz.

On the southern margin of the Wolfram Hill Granite, a series of small mines are collectively referred to as the Hidden Valley field; they include the Vulcan, Black Angel, and Bells tin mines, the Mountain View and Black Hill wolfram mines, Wests lead mine, and a group of unnamed lead prospects centred on Crocodile Billabong, 3 miles south-west of Wolfram Hill.

At the Vulcan, Black Angel, and Bells mines, disseminated cassiterite occurs in breccia zones in slate. Many of the zones dip at relatively low angles and shoots of payable ore are small. Workings consist of open cuts, adits, and shafts, the deepest being about 60 feet; the total recorded production since 1905 is about 50 tons of tin concentrate.

At the Mountain View mine, wolfram has been won from a group of pegmatite veins which strike north-west to north-north-west and dip at about 30° to the north-east. Most of the veins ranged from an inch to about 6 inches in thickness, and were worked from short adits and underhand stopes. No separate production figures are available, and the production has been included with the figures for Wolfram Hill.

Small wolfram-bearing quartz veins are also known from Black Hill, $4\frac{1}{2}$ miles south-west of Wolfram Hill, but production appears to have been negligible.

The only recorded production of silver-lead ore from this area is from Wests mine, $1\frac{1}{2}$ miles west of Hidden Valley, where 25 tons of ore averaging 70 percent Pb and 34 oz Ag per ton was mined. In 1958, the Australian Mining and Smelting Company investigated this mine and a number of nearby prospects, but with generally disappointing results. The most encouraging indications were obtained at a prospect three-quarters of a mile south-west of Crocodile Billabong, where costeaning revealed a 33-foot zone of cerussite veinlets in siltstone; but four diamond drill holes failed to intersect payable ore at depth (Patterson, 1958a, unpubl.).

A number of small tin mines are also known within the Wolfram Hill Granite. At two of these, Connells and Martins claims, disseminated cassiterite occurred within the granite itself; at Kellys claim cassiterite and minor wolfram occurred in a lode containing quartz, iron oxides, and argillaceous material. No records of production are available, but the amount cannot have been large.

Emerald Creek and Driffield Mines

Brown (1895, 1908b); Brown & Basedow (1906); AGGSNA (1938); Hossfeld (1941); Rattigan & Clark (1955, unpubl.).

The Emerald Creek tin field, about 8 miles south-west of Wolfram Hill, consists of a group of small lodes, most of which are quartz reefs with cassiterite, iron oxides, and secondary lead minerals at the surface. The deepest workings are reported to be about 70 feet deep. Little work has been done below the water-table and appreciable amounts of sulphides could be expected in the primary ore.

Recorded production between 1908 and 1913, is about 42 tons of tin concentrate, the greater part of which was probably from alluvial deposits. Only sporadic gouging has been undertaken since then.

The Driffield gold field, about 2 miles south-east of Emerald Creek, was one of the earliest fields in this belt to be worked. Between 1882 and 1912, Creers, Lady Jane, Lady Mary, Gordon and Parrys mines were operated on from numerous shafts and open cuts, the deepest to about 100 feet. The lodes consisted of quartz with minor iron oxides, and showed considerable variation in strike and dip. Many of the payable shoots were small and very irregular, which made systematic development almost impossible. The country rock consists of extensively faulted slate of the Burrell Creek Formation (Hossfeld, 1941). The total recorded production is about 5300 oz of gold from 10,700 tons of ore, but this is known to be incomplete.

Horseshoe Creek and Mount Todd Mines

Brown & Basedow (1906); Brown (1908b); Jensen (1919); AGGSNA (1937, 1938, 1939); Cottle (1937a); Hossfeld & Nye (1941); Rayner & Nye (1937a); Rattigan & Clark (1955, unpubl.).

Between Driffield Creek and the Edith River, some 8 miles to the south, another group of small tin and gold mines make up the Horseshoe Creek and Mount Todd fields. Most of the mines were discovered and worked between 1902 and 1914, with only sporadic small-scale activity in more recent years (Cottle, 1937a; Hossfeld & Nye, 1941).

The Horseshoe Creek field includes the Scotchman, Boylings, Doris, Ethel, Marie, and Keenans mines, in all of which cassiterite-bearing quartz-kaolin lodes with minor copper minerals were worked. The lodes generally occupy shear zones which trend north to north-west, sub-parallel to the strike of the surrounding slate and greywacke of the Burrell Creek Formation. Most of the lodes are irregular lenticular bodies, partly en echelon, with variable dips. The length of payable shoots ranged from 20 to 200 feet, and the width from a few inches to about 4 feet. All the payable shoots above the water-table appear to have been worked out, the deepest workings being about 150 feet. Recorded production is about 650 tons of tin concentrate, including some production from alluvial deposits.

In the Mount Todd field, both tin and gold have been produced. The main tin producers were the Morris and Shamrock mines, which resemble the Horseshoe Creek mines in the attitude and size of ore shoots and the type of lodes. Total recorded production is 180 tons of tin concentrate, including some from alluvial deposits. About 5 tons of the total amount have been won since 1958.

Among the gold mines of this area, the Jones Brothers Reef appears to have been the most extensively worked, and has a recorded production of 915 oz. It is a ferruginous quartz reef, which has been traced on the surface for about 2000 feet, striking a few degrees east of north and dipping steeply to the east. The country rock consists of tightly folded greywacke and slate of the Burrell Creek Formation. The width of the reef ranges from about 1 to 3 feet, with average values of about 16 dwt per ton in two shoots, totalling about 1200 feet in length. It has been worked from five shafts, the deepest to 150 feet, and from a number of open cuts. In 1938-39, five diamond drill holes were put down by Mount Todd Gold Mines N.L. to test the downward extension of the reef, but the results were disappointing. Below water level, the lode contains pyrite, arsenopyrite, and minor chalcopyrite and galena.

Tollis Reef, 1 mile south of Jones Brothers, has been worked on a small scale from a shaft 35 feet deep, but no details of production are recorded. The reef strikes north-west and has been traced on the surface for 4000 feet with a width of from 1 to 4 feet. Samples taken from the shaft in 1937 gave an average of 14 dwt Au per ton over a width of about 2 feet, and surface samples gave an average of 4.5 dwt (Cottle, 1937a).

Quigleys Reef, (or New Mount Todd), 1½ miles north-east of Jones Brothers, has also been traced over a length of 3000 feet and has a maximum width of 7 feet. It has been opened up by means of a 110-foot adit, numerous small

open cuts, and several shafts, the deepest to 80 feet. Four samples taken in 1941 gave an average grade of 13 dwt Au per ton over a width of 20 inches in the adit, and surface samples averaged 8.7 dwt, but no production is recorded (Hossfeld & Nye, 1941).

Yenberrie Mines

Gray & Winters (1916); Jensen (1919); AGGSNA (1938); Rattigan & Clark (1955, unpubl.).

The Yenberrie wolfram field is situated about 2 miles west of Mount Todd. The lodes consist of greisenized quartz-aplite dykes and are confined to a stock of the Cullen Granite, about half a square mile in area, which is intruded into greywacke and slate of the Burrell Creek Formation. Within the granite, nine quartz-aplite dykes are known, of which the largest is over 1000 feet long and about 60 feet wide. The dykes strike consistently north-north-west and dip steeply to the west. Within the dykes, wolfram and minor molybdenite occur in quartz reefs, which commonly strike parallel to the trend of the dykes, and also as small disseminations, especially on joint planes and in small seams rich in mica.

Recorded production is about 160 tons of wolfram, 2½ cwt of molybdenite and a small quantity of bismuth. Most of the ore has been obtained from the quartz reefs, which average about 1 foot thick and occasionally attain 2 or 3 feet. The reefs were worked from numerous shallow shafts and small open cuts, but none of the workings extends below water level, which mostly lies at a depth of 30 to 40 feet. Below this level, minor pyrite, arsenopyrite, copper sulphides, and bismuth minerals accompanied the wolfram and molybdenite. The grade of the disseminated occurrences does not appear to have been systematically investigated, and some further testing may be warranted (Gray & Winters, 1916).

Woolngi Mines

Jensen (1919); Rattigan & Clark (1955, unpubl.).

The Woolngi gold field, at the southern extremity of the area, occupies an isolated position in a deep re-entrant within the Cullen Granite, about 20 miles south-east of Pine Creek. The field was worked mainly between 1896 and 1908, with only sporadic small-scale activity in more recent years. The main lode worked was a quartz reef which trends east for part of its course,

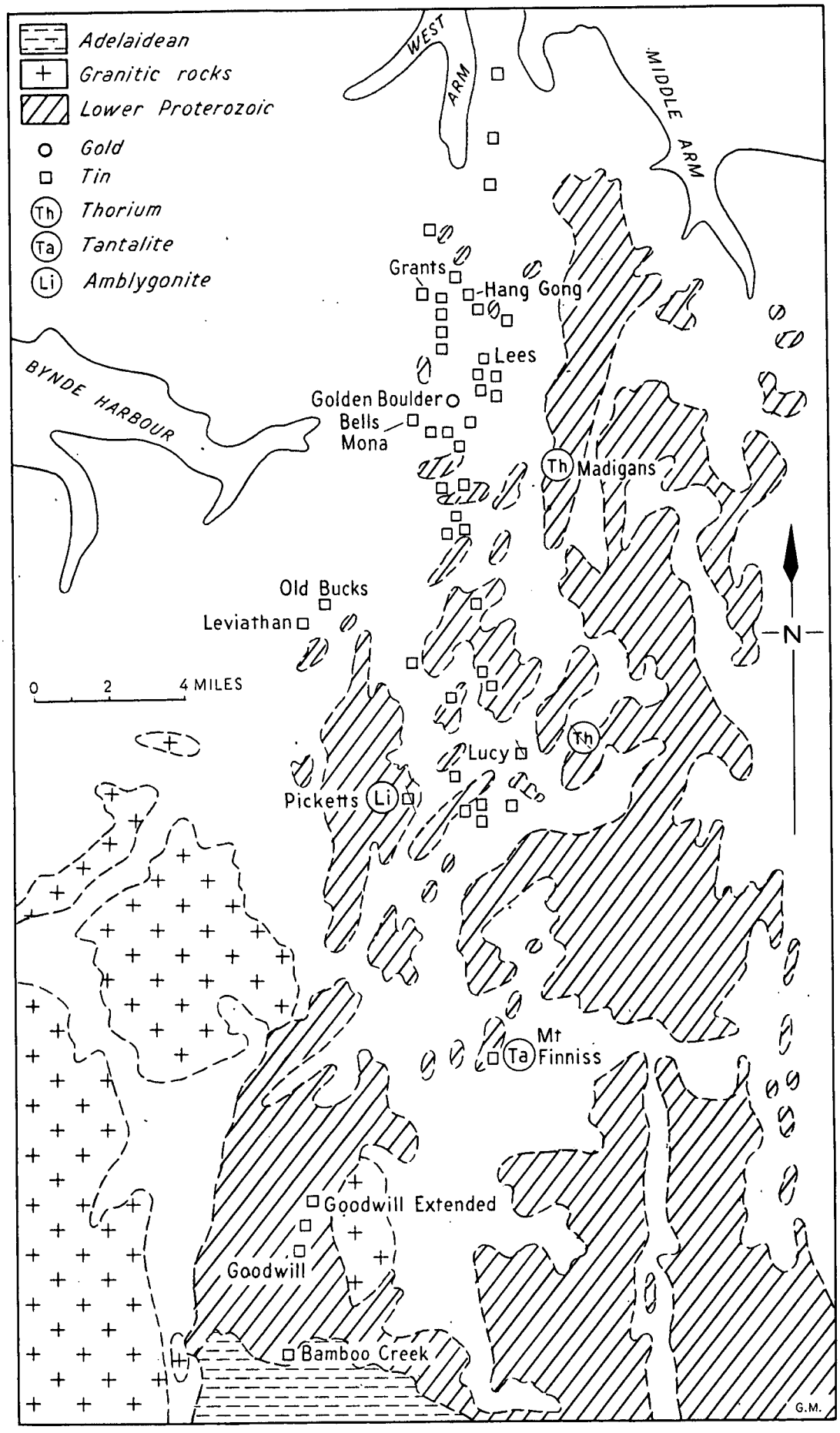

Fig. 34 Mineral deposits, West Arm area

but swings to the north-north-west in the west. It has been worked from several shafts, at least one of which reached a depth of 90 feet, and from two adits, 160 feet and 90 feet long. The average width of the reef is reported to have been 3 feet, and recorded production, which is known to be incomplete, is about 4600 oz of gold.

WEST ARM/MOUNT FINNISS/FLETCHERS GULLY AREA

The West Arm/Mount Finniss/Fletchers Gully area comprises a belt of country nearly 120 miles long and up to 10 miles wide, and contains a large number of tin and tantalite-bearing greisens and pegmatites, generally intruded into greywacke and slate of the Lower Proterozoic Noltenius and Burrell Creek Formations.

At least 90 separate mines and prospects are known in this belt, most of them in the northern section between West Arm and Bamboo Creek. The recorded production from individual mines is generally small.

West Arm/Mount Finniss Group of Mines (Fig. 34)

Parkes (1892); Brown & Basedow (1906); Brown (1908b); Playford (1904); Noakes (1949); Summers (1957b, unpubl.).

The West Arm/Bamboo Creek portion of the belt trends north and extends over an area about 40 miles long and 6 miles wide. It consists mostly of gently undulating to moderately steep hills, rising about 200 feet above the surrounding alluvial flats. Tin was discovered in 1886, and total recorded production to 1957 (probably incomplete) is 585 tons of tin concentrate and 15 tons of tantalum concentrate (Summers, 1957b, unpubl.).

The pegmatites are generally small and range up to some hundreds of feet long and tens of feet wide, and are elongated north or north-north-east, parallel to the dominant direction of shearing and the regional trend of the fold axes in the surrounding sedimentary rocks. Many of the pegmatites are zoned and in most of them the feldspars are kaolinized and chlorite is developed. Some of the alluvial deposits on the flanks of the hills have been worked on a small scale, but no true alluvial deposits of economic grade have been proved in the area, in spite of several extensive investigations by Australian and overseas companies.

The Hang Gong Wheel of Fortune is situated 1 mile north of Observation Hill, 71 miles by road from Darwin, and has a total recorded production of

189 tons of tin concentrate, mostly produced in 1904 and 1905. It was re-opened in 1956, and the eluvial deposits have since been worked by Mr W. Farlow for a recorded production of 1.1 tons of concentrates.

Workings consist of one large open cut, 100 by 20 feet, and two smaller open cuts, all partly caved. There are also three shafts, to 15 feet deep, and numerous shallow pits and costeans. It appears that all the near-surface mineralized shoots within the pegmatite have been worked out, but substantial amounts of eluvial material, containing both tin and tantalite, still remain (Crohn 1963a, unpubl.).

Bells Mona mine is 3 miles south-west of Observation Hill and has a total recorded production (probably incomplete) of 13.5 tons of tin concentrate. The main workings consist of two open cuts 280 by 70 feet, 10 feet deep, and 90 by 50 feet, 8 feet deep. There are also five shafts, of which two were reported in 1908 to be 42 and 62 feet deep. Some stoping was carried out from the 62-foot level, but two diamond drill holes, 405 and 126 feet long, put down in 1910, encountered only traces of tin (Summers, 1957b, unpubl.).

The Leviathan mine is on the east bank of Leviathan Creek, 9 miles south-south-west of Observation Hill, and has a total recorded production of 170 tons of tin concentrate, all of which was obtained before 1909. Workings consist of two open cuts, 150 by 20 feet, 20 feet deep, and 120 by 30 feet, 10 feet deep. Parkes (1892) reported that three shafts were being worked, but these can no longer be identified. The pegmatites were reported to be up to 15 feet wide and zoned, with most of the mineralization concentrated in the marginal quartz-mica zones. This mine now appears to be worked out (Summers, 1957b, unpubl.).

The Mount Finniss mine, 17 miles south-south-west of Darwin River Siding, and 1½ miles from the Finniss River, has a total recorded production of 19 tons of tin concentrate and 12 tons of tantalum concentrate. The workings consist of two 40-foot shafts, five small open cuts, and numerous shallow pits and costeans. The pegmatite has overall dimensions of 600 by 250 feet and is strongly zoned, with a core of massive milky quartz, surrounded by zones of kaolinized feldspar, quartz-feldspar-mica, and quartz-mica. Cassiterite and tantalite are scattered throughout the pegmatite, with a slight concentration in the kaolinized feldspar zone. A survey of the associated eluvial deposits in 1944 indicated reserves of about 50,000 cubic yards containing 0.84 lb of tantalite per yard with subordinate tin.

Two diamond drill holes put down in 1956 showed that the pegmatite bottoms at shallow depth (Hughes, 1944, unpubl.; Summers, 1957b, unpubl.).

The Goodwill mine, 15 miles due west of Rum Jungle Siding, has a recorded production (probably incomplete) of 7.6 tons of tin concentrate, mostly obtained between 1936 and 1950. The workings consist of an open cut, 190 feet long, 50 feet wide, and up to 35 feet deep; only minor remnants of pegmatite are now left in the walls of the open cut (Summers, 1957b, unpubl.).

The Goodwill Extended mine lies 2 miles north of the Goodwill mine, on the east bank of Walkers Creek. No production records are available, but the mine is known to have been worked in 1956. Workings consist of four shafts, the deepest being 48 feet, and several open cuts. At least five small irregular pegmatites are present, most of them showing pronounced zoning. The mineralization is generally scattered throughout the pegmatites, with some local concentrations in the quartz-mica wall zones. Some further exploration may be warranted (Summers, 1957b, unpubl.).

The Bamboo Creek mine, 19 miles due west of Rum Jungle Siding, and 1½ miles south of the junction of Bamboo and Walkers Creeks, has a total recorded production of 46 tons of tin concentrate and 5 cwt of tantalite concentrate. Workings consist of three open cuts and an adit 250 feet long. All shoots above the adit level have been worked out and some underhand stoping has also been done. The pegmatite is a lenticular body, about 250 by 60 feet in horizontal extent, which pitches steeply. The ore minerals appear to have been restricted to the footwall side of the pegmatite body and a limited amount of further exploration may be warranted in search of downward extensions or repetitions of the known shoots (Reid 1953, unpubl.; Owen, 1954b, unpubl.; Summers, 1957b, unpubl.).

Considerable shallow testing has been undertaken at Grants mine, 1½ miles north-west of Observation Hill; at Lees mine, three-quarters of a mile south of Observation Hill; at the Old Bucks mine, 8 miles south-west of Observation Hill; and at the Lucy mine, on the east bank of the Annie River, 10 miles west of Darwin River Siding. However, little or no production is recorded from these prospects, and no further work is thought to be warranted (Summers, 1957b, unpubl.).

Only one mine in this area has recorded a significant gold production. This is the Golden Boulder, 2 miles south-south-west of Observation Hill, which is reported to have produced 620 oz of gold.

Picketts mine, 3½ miles west-south-west of the Lucy mine, has attracted recent attention because of the occurrence of amblygonite, but attempts to re-open the mine have not been successful.

Two radioactive prospects occur in the Charlotte River area, one 12 miles north-west and the other 9 miles west of Darwin River Siding. The more northerly, known as Madigans, consists of thorium minerals in fracture zones of ferruginous sandstone and has been tested by two diamond drill holes, totalling 290 feet, but economic development is not feasible. (Hyde, 1956, unpubl.).

Mount Tolmer/Fletchers Gully/Buldiva Group of Mines

Parkes (1892); Brown (1895); Hossfeld (1937b, c); Noakes (1949).

South of the Tabletop Range (Tolmer Plateau), tin has been worked at Mount Tolmer (also known as Blyth), 25 miles due west of Adelaide River township. Most of the production came from a group of greisens or altered pegmatite dykes up to 30 feet wide. The dykes strike roughly north and are intruded into greywacke and slate of the Noltenius Formation. Minor eluvial and alluvial deposits were also worked. Workings in 1889 were reported to include two shafts, 60 feet and 32 feet deep, and some shallow pits and open cuts, but the area was abandoned in 1894. Since then, the area has been worked on a small scale on several occasions, and total recorded production is 75 tons of tin concentrate, of which at least 45 tons were won before 1891.

A mica occurrence is recorded near Prospect Hill, about 8 miles south of Mount Tolmer. It is apparently associated with a pegmatite similar to those in other parts of this tin belt, but no production is recorded.

Another small group of workings occurs at Fletchers Gully, 25 miles south of Daly River Police Station; gold has been the main mineral won. Alluvial gold was discovered in 1905, and both lode and alluvial deposits were worked intermittently until 1940. According to Hossfeld (1937b), the auriferous lodes consisted of quartz veins in shale of the Noltenius Formation, close to the axis of an anticline trending north-west. Some of the veins were associated with subvertical shears; others occupied tension gashes dipping at low angles to the north-east or south-west. Veins were

mostly only a few inches wide; the largest were 2 to 3 feet. The most consistent vein was Bigmouths Reef, with an average width of 3 inches, which was worked over a length of 200 feet and to a depth of 100 feet.

Tin was worked in a number of small pegmatite dykes in the same vicinity.

Total recorded production is 2450 oz of gold and 4.2 tons of tin concentrate.

The Muldiva and Buldiva tin fields, 10 miles south-east of Fletchers Gully, and the Collia tin field, another 12 miles to the south-south-east, are closely associated with the Soldiers Creek Granite, but still lie within the general meridional belt under discussion.

At Buldiva, tin has been won from numerous small pegmatite lenses intruded into the Soldiers Creek Granite and the nearby Noltenius Formation, from a basal conglomerate in the overlying Cretaceous Mullaman Formation, and from recent eluvial and alluvial deposits.

The pegmatites are concentrated in a zone embracing the margin of the Soldiers Creek Granite and the adjoining country rock, and are mostly low grade. Thirteen samples taken in 1937 over average widths of 30 inches averaged 0.63 percent Sn, with only 4 samples in excess of 1 percent (Hossfeld, 1937c). The payable pockets in the basal conglomerate of the Mullaman Formation are small (average thickness 12 inches) and irregularly distributed. The bulk of the production has come from the eluvial and alluvial deposits, and some further prospecting for additional deposits of this type appears to be warranted.

At Muldiva, some production has come from quartz-mica-tourmaline-cassiterite lodes intruded into schist and granulite. The largest lode ranged from 1 to 2 feet wide and has been traced for about 150 feet, but the bulk of the production was from alluvial deposits.

At Collia, alluvial tin was discovered in 1922, and the field has been worked intermittently since then. Most of the production has come from shallow pockets in small watercourses, and additional deposits of this type, and of eluvial material, may still remain to be discovered. Quartz-tourmaline veins are abundant in the Soldiers Creek Granite in this vicinity, but no tin-bearing lodes, which could have provided the source of the alluvial deposits, have been found.

Total recorded production from Buldiva, Muldiva, and Collia is 45 tons of tin concentrate.

DALY RIVER AREA (Fig. 35)

Parkes (1892); Brown (1895, 1908b); Brown & Basedow (1906); Hossfeld (1937d, 1938); Noakes (1949).

The Daly River area includes a group of copper and silver-lead deposits, most of which are situated on two subparallel shear zones; the shear zones trend a few degrees east of north, and each can be traced for about 5 miles.

The largest producer has been the Daly River copper mine near the southern end of the western shear zone, about 8 miles north of the Daly River Police Station. The mine was worked intermittently from 1884 to 1918; the workings consist of a large open cut, some 250 feet long, about 30 feet wide, and up to 100 feet deep, and five shafts up to 120 feet deep. In the open cut, nearly all the lode material has been removed; it is reported to have consisted largely of malachite, azurite, and chalcocite, with quartz and limonite gangue, and to have occurred as bunches and stringers in a shear zone in slate of the Burrell Creek Formation. Sulphides, including minor amounts of chalcopyrite, are visible in the waste rock from several of the shafts, but it appears that little ore was extracted from any of the shafts, and a diamond drill hole put down by Zinc Corporation Ltd failed to intersect any significant ore occurrences under the open cut.

Recorded production is about 6000 tons of ore, averaging 20 percent Cu, practically all of which was obtained from the oxidized zone. No zone of secondary enrichment has been recorded, and the primary ore, consisting largely of disseminated chalcopyrite, was apparently too low-grade for economic extraction (Hossfeld, 1937d). However, some further testing of the lodes near the existing shafts may be warranted, especially in view of the possibility that the ore shoot in the open cut may have a shallow pitch and may therefore have been missed by the Zinc Corporation drill hole.

To the north of the Daly River mine, the main workings on the western shear are the Wheal Danks group of mines, which were worked intermittently from 1887 to 1904.

At Wheal Danks South, three shafts up to 35 feet deep were sunk on a cellular ironstone gossan with quartz and malachite. At Wheal Danks itself, workings consist of two shafts 95 feet deep, a 200-foot tunnel, and

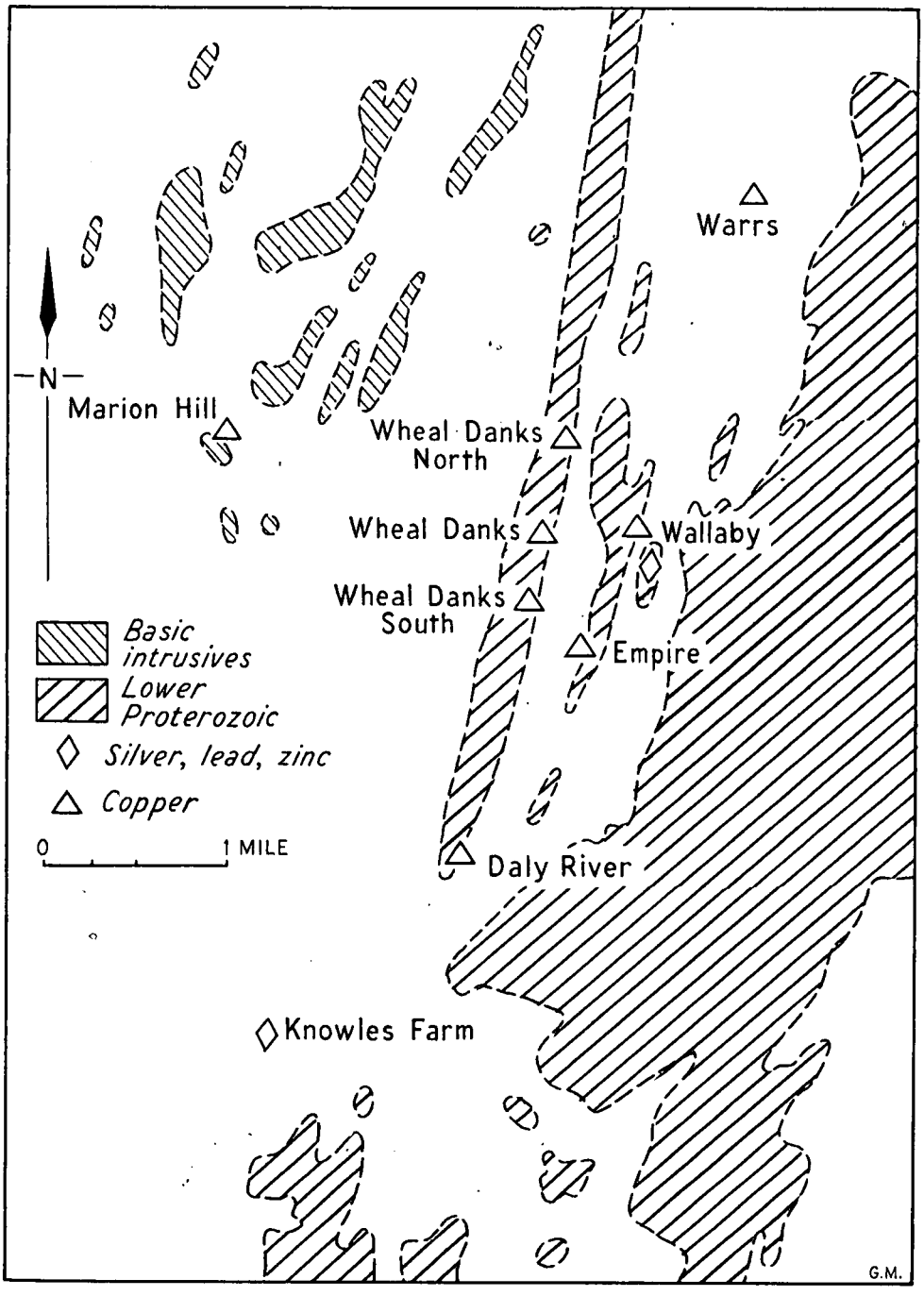

Fig. 35 Mineral deposits, Daly River area

a winze 125 feet deep from the tunnel. At Wheal Danks North, the main workings are two open cuts. At both localities, assays of lode and dump material average about 2 to 4 percent Cu and 1 to 3 dwt Au per ton (Hossfeld, 1937d), but recorded production is about 500 tons of ore averaging 28 percent Cu, which probably represented hand-picked material.

On the eastern shear zone, the most southerly workings are at the Empire mine, where two shafts were sunk to depths of 20 feet and 40 feet. A north-trending shear zone with copper staining over a width of up to 4 feet can be traced for 150 feet on the surface. In the shafts, chalcopyrite and arsenopyrite are recorded. Recorded production is 5 tons of high-grade ore (probably over 25 percent Cu)and 138 tons of low-grade ore (probably less than 10 percent Cu).

About 1 mile north of the Empire mine, the Wallaby mine has workings on both copper and silver-lead lodes. The copper lode has a shaft 40 feet deep, from which 30 tons of ore, averaging 35 percent Cu, have been produced, but the remaining portions of the lode are reported to be of very low grade (less than 1 percent Cu).

The silver-lead lodes have been opened up by two shafts, the deeper to 35 feet, and by several costeans. The lodes consist of a number of small quartz reefs in a zone 300 feet long and about 20 feet wide, and contain cerussite, anglesite, mimetite and pyromorphite. Assays range up to 5 percent Pb, 2 dwt Au, and 4 oz Ag per ton, but no production has been recorded (Hossfeld, 1937d, 1938).

At Warrs mine, another 2 miles to the north, a group of copper-stained quartz reefs and shear zones in slate has been exposed in shallow shafts and prospecting pits over a total strike length of about 500 feet, but no production is recorded.

Two isolated occurrences of silver-lead minerals are also known from the Knowles Farm prospect, 2 miles south-west of the Daly River copper mine. No production is recorded, but several costeans have been dug and selected samples of gossan are reported to have given high silver and lead assays, with minor copper and gold (Hossfeld, 1937d).

A copper prospect is also known in an extensive area of dolerite in the Marion Hill area, 3 miles north-west of the Daly River copper mine, but no production is recorded.

Altogether, although the recorded production from the belt is small, some further prospecting of the two main shear zones by geophysical survey and diamond drilling may be warranted.

MARANBOY-YEURALBA AREA

Maranboy Mines (Fig. 36)

Gray & Jensen (1915); Thyer, Rayner, & Nye (1937, unpubl.); Lewis (1937, unpubl.); Noakes (1949); Iten (1950, unpubl.); Walpole (1952, unpubl., 1958a); Mackay (1960, unpubl.).

The Maranboy field, situated 40 miles south-east of Katherine township, has been worked intermittently since 1913, and the total recorded production to 1952 is about 1280 tons of tin concentrate containing 800 tons of metallic tin. This was obtained from about 50,000 tons of ore, with an average recovery grade of 1.6 percent Sn. The records do not generally indicate the lease from which individual crushings were obtained. Only about 3 tons of tin concentrate have been produced since 1952.

The main source of production has been from stanniferous quartz-tourmaline lodes trending east-south-east or south-south-east, the east-south-easterly set being the more important of the two. The cassiterite occurs in places as finely disseminated crystals, but more commonly as groups of small stringers in joints and brecciated zones. Minor production has also been obtained from greisens especially in the northern part of the field. The country rock consists of greywacke, siltstone, and shale of the Burrell Creek Formation, which has been folded into a major south-east pitching anticline with minor tight crenulations in the axial zone.

The Main lode with a total length of 13,000 feet has been the most important producer, especially in its central 4000-foot zone which has an average width of about 8 to 25 feet. The lode is covered by the Star of the West, Osman, Anaconda, Ray, Eureka, Bull and Southern Claim leases. The Stannum King lode, 3500 feet south of the Main lode, has been next in importance and was worked from the Ibis, Stannum King, Klondyke, Red Cross and Progress leases. Both lodes strike east-south-east and dip steeply to the north. The only other important producer has been the Cosmopolitan lode, in the northern part of the field, which also trends east-south-east but dips steeply to the south. In all the lodes, the payable shoots range up to 400 feet long and are separated by barren or low-grade sections of comparable or greater length.

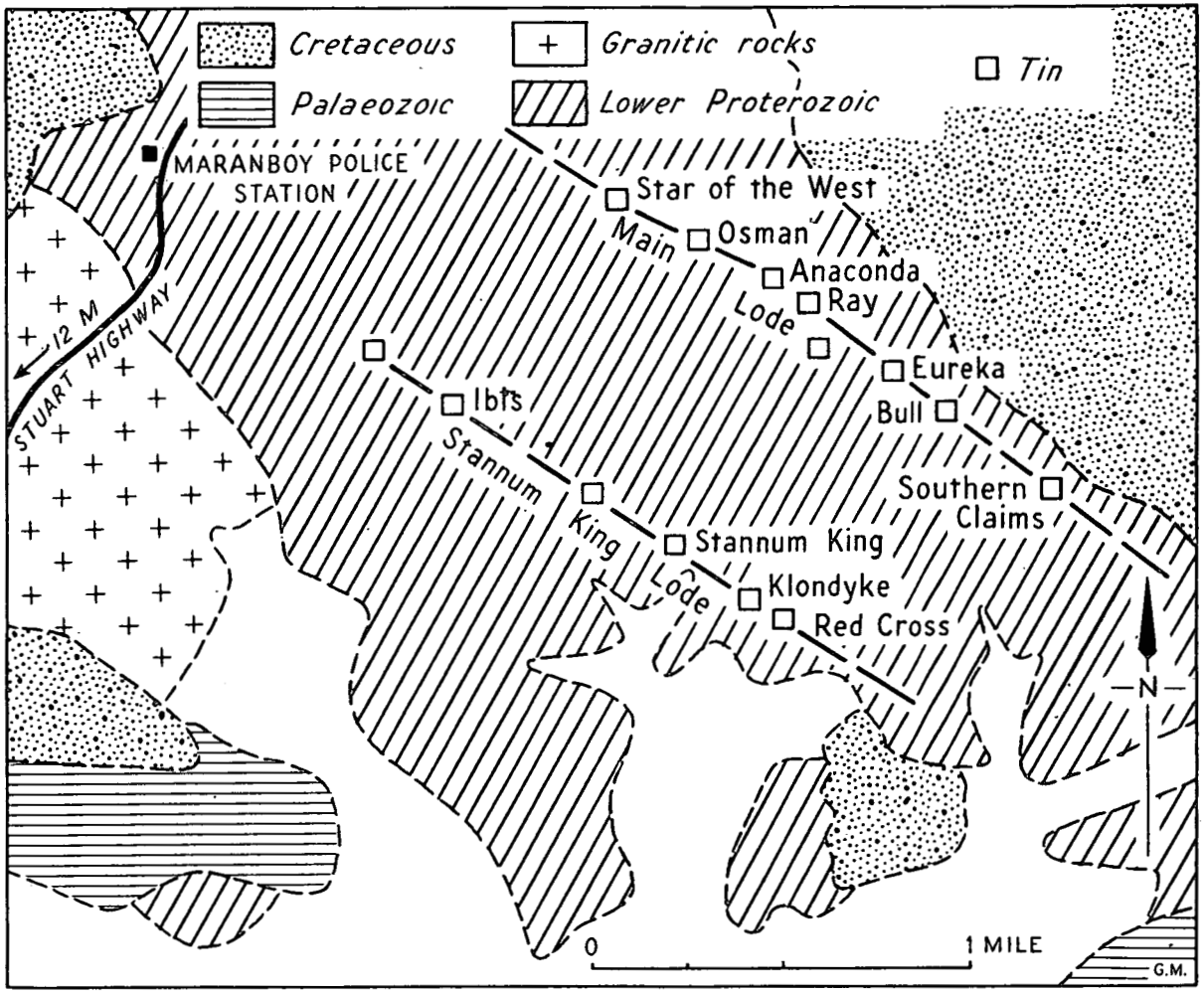

Fig. 36 Mineral deposits, Maranboy area

Workings consist of a very large number of shafts and open cuts, and are generally less than 120 feet deep, the main exceptions being the Tiger Shaft on the Ray lease, which is 140 feet deep. In 1958, a shaft was sunk by United Uranium N.L. on the Osman lease to a depth of 250 feet; a cross-cut at the 125-foot level encountered 17 feet of lode material averaging 1.7 percent Sn, but results on the 250-foot level were disappointing.

In 1958-59, eleven diamond drill holes were put down by the Bureau of Mineral Resources on the Anaconda and Osman leases, but only three encountered payable tin ore. These were all on the Anaconda lease, and the results, from vertical depths between 350 feet and 600 feet below the surface, were 12 feet 6 inches (true width) of 1.51 percent Sn, 6 feet of 1.47 percent Sn, and 7 feet 3 inches of 1.56 percent Sn (Mackay, 1960, unpubl.).

Walpole (1958a) estimated that 170,000 tons of ore, averaging 1.06 percent Sn, remained in the lodes to the level of the deepest workings in each block; a smaller tonnage of somewhat higher average grade could presumably be obtained by selective mining. At the time of writing (June 1966), a further programme of deep test-drilling is being undertaken by Metals Exploration N.L. and a group of associated companies.

The King River mine is about 10 miles north-west of Maranboy. Gray & Jensen (1915) report some activity in this area in 1913, but Walpole (1958a) reports most production taking place after 1929. The lode is in a quartz-tourmaline vein striking north-west and dipping steeply to the south-east. The ore consists of stringers of coarse cassiterite ranging from 1/16 inch to 3 inches in width. An open cut and two shallow shafts have produced about 111 tons of ore containing about 4.7 tons of tin concentrate.

Yeuralba Mines

AGGSNA (1937, 1938, 1939); Hossfeld (1939, unpubl.); 1939; Noakes (1949); Ward (1950, unpubl.); Walpole & Drew (1953, unpubl.); Walpole (1958a).

At Yeuralba, 20 miles north of Maranboy, a number of hydrothermal tourmaline and topaz-bearing lodes have been worked intermittently for tin, tungsten, and copper since about 1924. They include The Gates, O'Sullivan's Camp and Yeuralba King mines. Recorded production is about 40 tons of wolfram concentrate, 12 tons of tin concentrate, and 50 tons of copper ore averaging 24 percent Cu.

Except for the Yeuralba King mine, which lies some distance to the east of the remaining mines of the group, the lodes are located in and

immediately around the Yeuralba Granite, which crops out over an area of about 20 square miles; it is intruded into greywacke and shale of the Burrell Creek Formation which are extensively altered by contact metamorphism. The granite is hydrothermally altered along major fracture zones trending north-east and north-north-west; the greisen, quartz-tourmaline, and quartz-topaz-tourmaline lodes are closely associated with the fracture zones, especially the north-north-west set. In addition to wolfram and cassiterite, the lodes contain some scheelite, fluorite, apatite, and bismuth and copper minerals.

All the existing workings are shallow, and little systematic testing has been done. Walpole & Drew (1953, unpubl.) list 17 separate greisen and lode formations, ranging from 200 to over 2000 feet long and from 50 to 400 feet wide, which they consider warrant further testing. Grab samples of eight of these occurrences gave assays ranging from a trace to 0.95 percent WO_3 and up to 0.59 percent Sn.

Extensive alluvial and eluvial deposits are present around some of the lodes, but sampling by a local syndicate in 1963 showed that only relatively small areas are payable (Hays, 1963b, unpubl.).

Copper occurs in small en echelon shears in an amphibolite dyke about 8 miles east of Yeuralba but little is known about the workings.

Hossfeld (1939, unpubl.) reports some gold values from the Ludan prospect which is within a shear zone on the western margin of the amphibolite which contains copper.

MISCELLANEOUS MINES AND PROSPECTS

A number of isolated and generally small mines and prospects do not fit readily into any of the groups discussed previously. Most of them have been worked for gold, a few for tin, copper, or lead, and one for manganese.

Adelaide River/McKinlay River area

Parkes (1892); Brown (1895); Jensen, Gray, & Winters (1916); AGGSNA (1936, 1937).

A number of gold mines occur in the Burrell Creek Formation between the Adelaide and McKinlay Rivers, north of the railway.

The Mount Ringwood mines, are 25 miles north-east of Brocks Creek, and were worked between 1894 and 1902 for a total recorded production of about 2800 oz of gold. Workings consisted of numerous shafts to depths of 50 or 60 feet, and the auriferous lodes ranged in width from 4 to 15 feet. The country rock consists of greywacke and siltstone of the Burrell Creek Formation.

The Great Western, Great Northern, and Star of the North mines, 20 miles north of Brocks Creek, have a broadly similar setting. Recorded production between 1896 and 1920 is about 3600 oz of gold. The deepest shaft in 1904 was reported to be 120 feet deep. One large quartz reef, 14 feet wide, was worked, but some rich crushings also appear to have been obtained from other smaller lodes.

At Mount Tymm, 18 miles north-west of Brocks Creek, work appears to have been carried out intermittently between 1891 and 1897 on a group of auriferous quartz reefs from 1 to 3 feet wide, but recorded production is only 6 oz of gold.

The McKinlay gold mine, also known as Hardys, is situated 20 miles east-north-east of Brocks Creek, near the McKinlay River crossing on the present Mount Wells/Mount Harris road. A series of auriferous quartz reefs, with limonite, clay, and minor pyrite and arsenopyrite, appear to be associated with a major north-north-west shear zone in sandstone, slate, and chlorite schist of the Burrell Creek Formation. Assays of up to 13 dwt Au per ton over a width of 4 feet 8 inches are recorded, and a zone over 40 feet wide is reported to average 2.7 dwt per ton,(Hossfeld, 1940), but the recorded production is only 7 oz of gold. This shear zone may warrant some further prospecting.

The Woolwonga gold mines, 10 miles north-east of Brocks Creek, were worked intermittently between 1871 and 1908 for a total recorded production of over 9200 oz of gold. Production was from a series of reefs up to 2 feet wide and 300 feet long, most of which occurred in a major north-westerly shear zone, with minor reefs in tension openings at right angles to this. The country rock consists of sandstone and slate of the Burrell Creek Formation. Most of the workings are in the oxidized zone; the deepest shaft, to 170 feet, encountered primary ore consisting of quartz, pyrite, and arsenopyrite, but this was low grade - of the order of 2 dwt per ton - and could not be treated economically (Voisey, 1937; Rayner & Nye, 1937d).

Maude Creek/Watts Creek/Frances Creek Area (Fig. 32)

Brown & Basedow (1906); Jensen (1919).

The Maude Creek/Watts Creek/Frances Creek area from 10 to 15 miles north-east, east, and south-east of Burrundie Siding, contains several groups of small gold mines and alluvial workings. The main centres of alluvial production were Frances Creek, near the junction of its two main tributaries, McKeddies diggings on Maude Creek, and the Watts Creek diggings, which are actually situated in the headwater region of Frances Creek. The only recorded production is 130 oz from Frances Creek and 21 oz from the Watts Creek diggings.

A group of quartz reefs 4 miles north-west of the Frances Creek gorge was opened up before 1936 by several shallow shafts and small open cuts, but no records of production are available. Another attempt to work the reefs was made by a local syndicate in 1962, but only a trial parcel which yielded 8 oz of gold, has been produced (Crohn, 1963c, unpubl.).

Before 1940, some prospecting for gold had also been done on the ironstone outcrops in the Frances Creek area, which are now being developed as a source of iron ore. Assays of around 2 dwt Au per ton were reported from parts of the Ochre Hill occurrences, but no production is recorded.

Spring Peak/Mundogie Hill Area

At Yemelba, 40 miles north-north-east of Moline township, a group of auriferous quartz reefs was worked intermittently between 1933 and 1939. The reefs contain iron oxides, minor pyrite, and locally some copper minerals, and occur in siltstone, sandstone and conglomerate of the Lower Proterozoic Mount Partridge Formation, associated with north-north-westerly shear zones. Recorded production is about 250 oz of gold.

About 12 miles north-west of Yemelba, some gold has been won from the Mundogie Hill locality, mostly from small eluvial and alluvial deposits, but no records of production are available.

About 10 miles north-east of Mundogie Hill, near Spring Peak, a number of small tin-bearing quartz reefs in sandstone of the Mount Partridge Formation were discovered in 1955. Costeaning and diamond drilling of the prospect did not locate occurrences of economic importance.

Namoona/Minglo Area

Debnam (1955b, unpubl., 1955d, unpubl.).

Two lead occurrences are recorded from the area north-west of Goodparla Homestead.

At Namoona, 15 miles north-west of Goodparla Homestead, small bunches and disseminated grains of galena and cerussite, in part associated with veinlets and irregular blows of quartz, are widespread in a north-westerly zone in greywacke, siltstone and shale of the Lower Proterozoic Masson Formation. Geochemical testing by the Bureau of Mineral Resources has shown a lead anomaly over a strike length of about a mile and a width of several hundred feet, but costeaning and diamond drilling by Australian Mining and Smelting Co. Ltd in 1955 showed that the average grade near the surface was low. However, the costeans did reveal several seams of massive galena up to 2 feet wide, some bedded and some in small shear zones; some of them might be suitable for selective mining by prospectors or small syndicates.

The Minglo occurrence, 6 miles west of Namoona, has not been tested to the same extent, but appears to be associated with a more sharply defined shear zone, and the host rocks in this area show evidence of contact metamorphism by the nearby Cullen Granite. The ore consists of galena and anglesite; the anglesite occurs in bands surrounding cores of galena. At present the prospect is being selectively mined and small parcels of hand-picked ore are being produced. In the period 1964-65 18.4 tons of ore containing about 58 percent Pb and 4.5 oz Ag per ton were produced.

Hayes Creek Area

Jensen, Gray, & Winters (1916); AGGSNA (1940); Sullivan & Iten (1952); Dunn (1963, unpubl.).

The Hayes Creek area contains a group of small tin mines and prospects, situated a few hundred yards north of the Stuart Highway, about 8 miles south-east of Brocks Creek Siding.

The lodes consist of quartz-cassiterite veins with minor iron oxides, and are concentrated in the intensely fractured axial portion of a north-north-easterly anticline. Most of the lodes, which range from a few inches to about 6 feet in width, trend parallel to the axis of this fold, but the dips range from about 30° to vertical. The country rock consists of greywacke and slate of the Burrell Creek Formation (Dunn, 1963, unpubl.). Workings include several adits, the longest about 300 feet, and numerous

small open cuts and stopes from the surface. The lodes have been worked intermittently since 1915, and the total recorded production is 156 tons of tin concentrate, including a small amount from alluvial deposits in Hayes Creek itself. The most recent attempt to re-open the workings was in 1962, but only about 0.75 tons of tin concentrate, mostly from old dumps, were obtained before the attempt was abandoned.

Umbrawarra/Stray Creek Area

Jensen (1919).

The Umbrawarra/Stray Creek area, from 10 to 15 miles south-west of Pine Creek, contains the only known substantial tin occurrences within the Cullen Granite. Both the Umbrawarra and Stray Creek fields have been worked intermittently from about 1909, and the total recorded production is 269 tons of tin concentrate from Umbrawarra and 18 tons from Stray Creek, with the bulk of the production in each case coming from alluvial deposits. The alluvial deposits consisted mainly of small relatively rich pockets in flat-bottomed creek valleys, commonly controlled by small rock bars; other occurrences of this type may still be present. The primary deposits appear to have been mainly small zones of disseminated cassiterite in chloritized granite; these also may warrant further investigation to determine whether any extensive low-grade deposits, suitable for large-scale development, are present.

Minor deposits of alluvial tin have been recorded from Nellie Creek, about 15 miles north-east of Pine Creek, and from the headwater region of the Douglas River, 10 to 15 miles north-west of Pine Creek. Recorded production from the two areas is only 3 tons and 2 tons of concentrate respectively, but they may warrant further prospecting by individuals or small syndicates.

Myra Falls Area

A small tin occurrence has been recorded from the Myra Falls area, which is situated in an embayment of the Arnhem Land Plateau, about 20 miles south-east of Oenpelli Mission (Gray, 1915). Minor cassiterite-bearing quartz veins and traces of apatite, beryl, and copper minerals have been noted in schist and gneiss of the Archaean Myra Falls Metamorphics, but the only recorded production is a few hundred weights of tin concentrate from alluvial deposits.

Katherine River Area

Parkes (1892); Brown (1895); Rattigan & Clark (1955, unpubl.).

The Katherine River area contains several small gold and copper occurrences, of which the Maude Creek field, 15 miles east of Katherine, has been the most important. Leases include Cemetery, Dalhonzie, Golden Creek, Golden Tree, Hibernia, Lady Maud, Maud Hill and Mystery. In this field, a group of ferruginous quartz reefs occurs in basic lava and tuff of the Lower Proterozoic Dorothy Volcanics and in altered basic intrusives. The reefs range up to 7 feet in width and show variable dips and strikes. Workings consist mainly of shallow shafts and open cuts, and total recorded production is about 540 oz of gold, won mostly in 1890-92 and 1932-40. Minor copper mineralization is associated with many of the reefs, but no production of copper is recorded (Cottle, 1937e).

About 250 oz of gold are also reported to have been obtained from the Mount Gates area, about 6 miles north-west of Maude Creek. The area was worked mainly between 1890 and 1895; the workings consisted of several shafts up to 30 feet deep, and most of the gold came from three narrow quartz reefs in metamorphosed sandstone and slate intruded by altered dolerite and granite dykes.

At the Carpentaria mine, 3 miles north of the Maude Creek workings, copper mineralization occurs sporadically for about a mile in a north-north-westerly zone in basic lava, tuff, and altered intrusives similar to those in the Maude Creek area. Most of the mineralization consists of azurite and malachite in minor shear zones, and none of the workings has exposed the primary ore. The workings consist mainly of shallow shafts and short adits, most of which were probably developed between 1902 and 1919. Total recorded production is only 20 tons of copper ore of unspecified grade.

Green Ant Creek Area

Owen (1954b, unpubl.); Dunn (1955, unpubl.).

In the Green Ant Creek area, a number of small manganese prospects occur a few hundred yards south of the Stuart Highway, almost exactly 100 miles from Darwin. The occurrences consist of irregular bodies of low-grade manganese ore at the unconformity between steeply dipping greywacke and siltstone of the Burrell Creek Formation and overlying subhorizontal beds of the Cretaceous Mullaman Formation. Some of the ore may have been deposited on the eroded surface of the Burrell Creek beds, but most of it appears to have been formed by replacement of siltstone below the unconformity,

presumably by solutions circulating before the Cretaceous beds were laid down. Recorded production is about 450 tons of ore in 1954-56 and 90 tons in 1964. The ore was used in the treatment plant at Rum Jungle, but the prospects of further production are not encouraging because of the low grade and the patchy distribution of the ore.

Other Mines and Prospects

The Pig Hole mine, 10 miles south-east of Marrakai Homestead, is thought to have been a small gold producer in the early years of this century, but no details are available. It is reported to have produced 15 oz of gold in 1940.

At Mount Tolmer South, 10 miles north-north-east of Litchfield Homestead, a copper occurrence is recorded in phyllite and schist of the Noltenius Formation, but there was probably no production.

At the Daly River Gorge, upstream from Daly River Police Station, some shallow workings in Adelaidean sandstone, are thought to have been put down for gold, possibly localized in a major fault zone, but no records of production are available.

IRON ORE DEPOSITS

Occurrences of iron ore are known from several widely separated localities in the Katherine-Darwin Region. They do not fit into the groupings adopted for the hydrothermal types of deposit discussed separately.

The three main potential sources of iron ore in the area, in order of importance, are Frances Creek near Burrundie, Pritchards Lode at Mount Bundey, and the Darwin River/Batchelor/Waterhouse area.

Frances Creek Area (Fig. 37)

Crohn (1961a, unpubl.; 1965b, c, unpubl.).

In the Frances Creek area, about 10 miles east of Burrundie Siding and 120 miles south-east of Darwin, a group of iron ore deposits has been under investigation since 1961 by Northern Iron Mining Corporation Ltd, assisted by the Mines Branch, N.T. Administration. Considerable work has also been done on the deposits by New Consolidated Goldfields (A'sia) Pty Ltd under a former option agreement, and by MacDonald Construction Co. under a current working agreement with the leaseholders. Altogether, some 220 wagon drill holes and 6 diamond drill holes have been put down on the deposits to the end of 1964, supplemented by numerous costeans and surface samples.

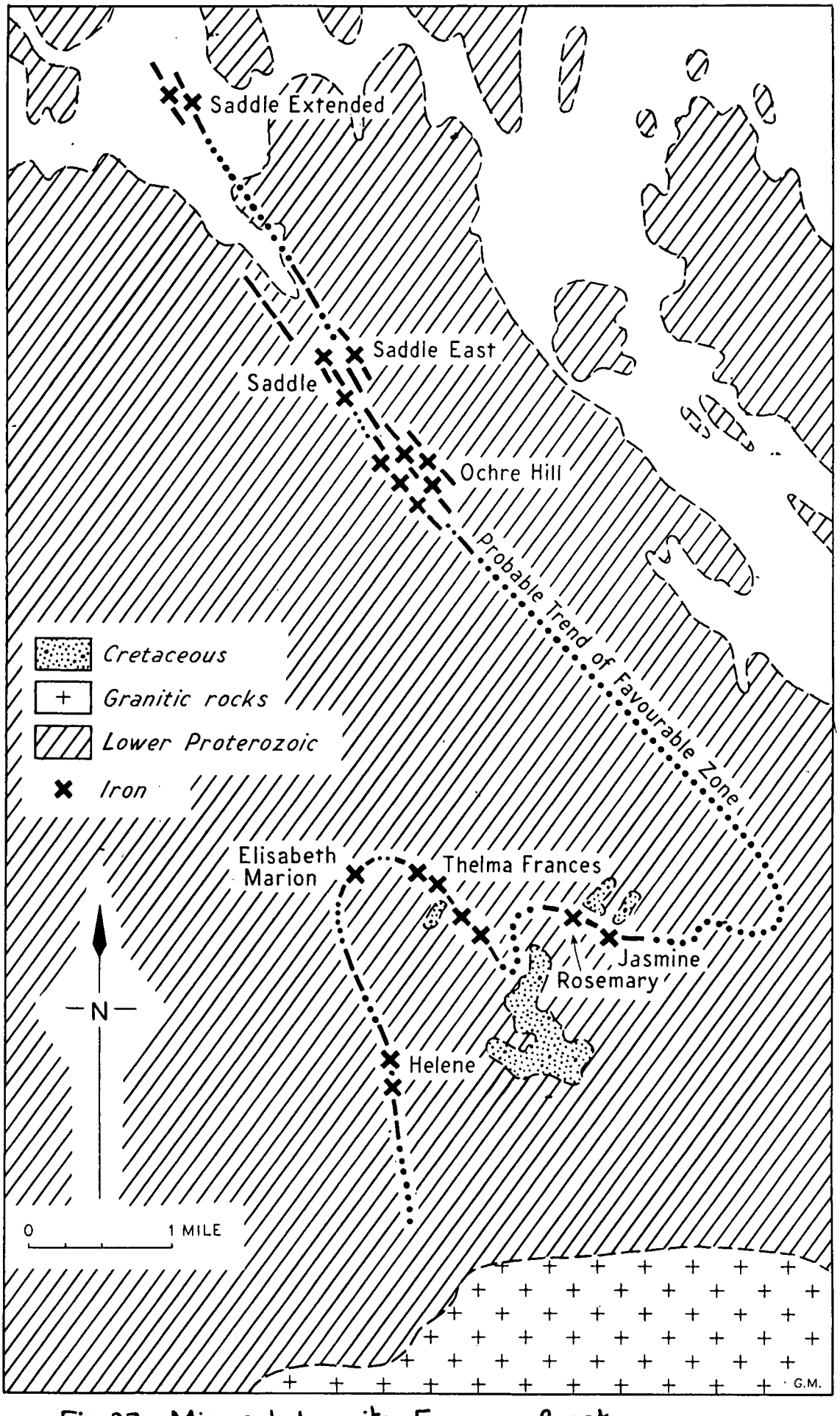

Fig. 37 Mineral deposits, Frances Creek area

An agreement to export 3 million tons of ore to Japanese buyers was announced early in 1965. Average grade of the material to be mined is estimated at 63 to 64 percent Fe.

The deposits crop out intermittently over a strike length of about 15 miles, closely following the bedding of the Lower Proterozoic Masson Formation, which consists of greywacke, siltstone, and slate, folded into open folds of varying amplitude, generally with moderate to steep northerly pitches. The deposits have been individually named, the most important, from north to south, being Saddle Extended, Saddle, Ochre Hill, Thelma Frances, and Helene; others are Elizabeth Marion, Jasmine, and Rosemary. The most prominent outcrops are those associated with the Thelma Frances deposit, which consists of a tabular body about 1500 feet long and in almost vertical cliffs up to 50 feet high. The largest tonnages, however, are contained in the Helene No. 7 and 8 leases, where a group of lenticular bodies appears to result from the thickening of one or more ore horizons on minor fold axes, which pitch north at moderate angles.

The orebodies appear to have resulted from supergene enrichment of a group of ferruginous beds in the Masson Formation. No pyrite or other sulphides have been encountered in any of the deposits, and the results of diamond drilling at Ochre Hill suggest that the primary material consisted of sheared and brecciated greywacke and slate with disseminated iron oxides, and some concentrations in joints, bedding planes, and other openings. The proportion of hematite to limonite increases from north to south towards the contact of the Cullen Granite, but it is not possible to show conclusively that this is the direct result of the granitic intrusion. It is clear, however, that the supergene enrichment is pre-Cretaceous as the Thelma Frances deposit is in part overlain by flat-lying deposits of the Cretaceous Mullaman Formation.

Pritchards Lode, Mount Bundey Area

Dow & Pritchard (1958, unpubl.); Dunn (1964, unpubl.).

In the Mount Bundey area, 60 miles south-east of Darwin, a bold ironstone outcrop, known as Pritchards Lode, can be traced on the surface for about 2000 feet with an average width of about 40 feet, and several smaller, less well exposed bodies occur within a few hundred yards. These lodes were noted by the Bureau of Mineral Resources in 1956, but a diamond drill hole put down by the Bureau in 1958 passed under the main outcrop at a vertical depth of about 300 feet without intersecting any lode material.

Subsequently leases were taken up over the area by Newsam Mining Company Pty Ltd, and in 1962 16 diamond drill holes, totalling about 2000 feet, were put down by the Mines Branch, N.T. Administration, under an agreement with the leaseholders to evaluate the deposit as a source of iron ore. A contract has been made for the export of about 1.4 million tons of ore from this deposit to Japan.

The main lode trends north-east and dips almost vertically; most of the associated minor bodies lie in a north-south zone which diverges from the main lode near its southern extremity. The only rocks exposed near the lodes are a coarse-grained slightly foliated syenite, of the Mount Goyder/Mount Bundey igneous complex, and a few aplite dykes cutting the syenite. However, in several of the drill holes, remnants of metamorphosed and metasomatically altered sedimentary rocks were encountered, and the lodes may have been formed by magmatic segregation or by partial replacement of a large sedimentary inclusion in the syenite, or of a combination of both (Dunn, 1964, unpubl.).

To an average depth of about 80 feet below the outcrop, the lodes average about 64 percent Fe and consist essentially of martite (hematite after magnetite) which is strongly magnetic and locally shows minor boxworks. Below about 80 feet, the lode material is mainly magnetite, with occasional remnants of partly replaced country rock and blebs and veinlets of pyrite and minor chalcopyrite. Sulphur in this section ranges from 1 to about 5 percent and copper from 0.1 to 0.5 percent.

On the flanks of the lodes, there are also extensive deposits of boulder and scree ore, which are locally more than 6 feet thick, and which could probably be upgraded by a relatively simple sink-float process.

Both ground and airborne magnetometer surveys have been carried out over the area surrounding the known lodes, but although the lodes give rise to pronounced and easily recognised magnetic anomalies, there are no indications of comparable non-outcropping bodies in the immediate vicinity.

Darwin River/Batchelor/Waterhouse Area

Dunn (1962a, b, unpubl.).

In the Darwin River/Batchelor/Waterhouse area, small ironstone bodies are developed by enrichment of Lower Proterozoic ferruginous beds which, in part, resemble a banded iron formation; and by enrichment of ferruginous sandstone in the unconformably overlying Adelaidean succession, and quartz-hematite breccias, some of which are probably tectonic in origin, and some

are basal deposits of the Adelaidean succession. Some of the ironstone bodies in this area may have been derived from primary sulphide lodes by oxidation.

Several of the deposits have recently been investigated by Nevsam Mining Co. Pty Ltd; individual deposits generally appear to be small, but in many cases the deposits of rubble or scree ore on the flanks of the ironstones are likely to be of greater economic importance than the bodies themselves.

The most northerly group of deposits occurs from 2 to 3 miles north-east of Darwin River Siding, where gossanous ironstones several hundred feet long crop out intermittently on east-trending strike ridges of the Golden Dyke Formation. Apparent outcrop widths of the ironstone range up to 75 feet; no estimate of their vertical extent has been made, but they are probably oxidation products of pyritic bodies.

At Beetsons deposit, about 1 mile west of the railway, 5 miles south of Darwin River Siding, comparable outcrops occur on a strike ridge about half a mile long, trending a few degrees east of north. Several costeans and a shallow shaft show that the lode consists of irregularly alternating bands of dense hematite, cavernous hematite and goethite, and some low-grade ferruginous material. A considerable quantity of boulder and scree ore occurs on the eastern flank of the ridge.

Another group of prospects, including the BW prospect, occurs about 7 miles west of Stapleton Siding, where bands and lenses of massive hematite occur in a steeply dipping ferruginous slate, about 200 yards south of the southern margin of the Waterhouse Granite. The area has been tested by means of a number of costeans and shallow prospecting shafts, which show that the individual hematite bodies are very small; but they are surrounded by a considerable area of hematite rubble which may be suitable for upgrading.

At Mount Mabel, near the western margin of the Waterhouse Granite, ironstone has been formed by superficial enrichment of ferruginous sandstone in the Adelaidean Depot Creek Sandstone Member; bands and lenses also occur in brecciated Lower Proterozoic banded iron formation, but the individual bodies appear to be small. The area also contains a few outcrops of a magnetite schist, estimated to contain between 10 and 30 percent magnetite, but this has not yet been systematically investigated.

Other localities in which ironstone occurrences have been recorded include Banyan Homestead, Castlemaine Hill, and the East Finniss River Railway Bridge, but none of them have been investigated.

Other Occurrences

Numerous other localities in the Katherine-Darwin Region contain occurrences of ironstone, gossan, or other ferruginous material, and many of these have recently been examined as possible sources of iron ore, but the results have generally not been encouraging.

In the Brocks Creek area, several of the ferruginous outcrops described by Sullivan & Iten (1952) contain sections of massive hematite-goethite ore, especially to the east of the Cosmopolitan Howley mine, at Mount Paqualin, and to the west of Ban Ban Homestead, but the individual shoots of high-grade material are too small for economic exploitation (Crohn, 1961b, unpubl.).

In the Black Jungle Range area, 100 miles east-south-east of Darwin and 50 miles due north of Moline, similar ferruginous outcrops are developed on rocks of the Lower Proterozoic Koolpin Formation, comprising carbonaceous siltstone with minor dolomite and limestone. None of the ferruginous material in this area is of ore grade, except possibly in rare small pods of no economic significance, and the underlying rocks are thought to contain disseminated pyrite rather than hematite or magnetite.

Other areas from which superficially enriched occurrences have been recorded are near Berry Springs, Marrakai Crossing on the Adelaide River, and the junction of the Mary and McKinlay Rivers, all in rocks of the Golden Dyke Formation (Barclay, 1964a, unpubl.)/in the Koolpin Formation near Coirwong Gorge.

At Mount Tolmer, 30 miles south-west of Rum Jungle, a steeply dipping tabular or lenticular ironstone occurs in siltstone and slate of the Lower Proterozoic Noltenius Formation, close to the contact with the unconformably overlying subhorizontal ferruginous Adelaidean Depot Creek Sandstone Member. Towards the top, this steeply dipping lode merges into a flatlying body which follows the unconformity. Several smaller isolated bodies occur in the Adelaidean rocks, probably in minor shear zones. All the occurrences consist partly of dense fine-grained hematite, and partly of a mixture of cellular hematite and limonite which bears some resemblance to a gossan.

The full dimensions of the deposit cannot be determined without further exploration, as both the steeply dipping body in the Noltenius Formation and the flatlying body at the unconformity pass under the Depot Creek Sandstone Member (Crohn, 1964a, unpubl.).

Minor ironstone occurrences are found in the Depot Creek Sandstone in the Tabletop Range, the Florence Creek headwater area, 15 to 20 miles south-west of Rum Jungle, and in the George Creek area, about 10 miles south of Adelaide River township. None show any indications of the presence of economic deposits.

Ironstone occurrences are also known from the Flora River area, about 50 miles south-west of Katherine, where they appear to have been formed by surface enrichment of ferruginous sandstone beds in the Palaeozoic Jinduckin Formation and the Adelaidean Waterbag Creek Formation. It seems that occurrences of ore grade are restricted to small widely scattered pods, probably developed in favourable structural locations, such as minor shear zones (Crohn, 1964b, unpubl.).

A distinctive occurrence of ferruginous material has also been recorded from the Kapalga area, between the estuaries of the South Alligator and West Alligator Rivers (Dunn, 1957, unpubl.). It consists of a steeply dipping lens of ferruginous siltstone in the Lower Proterozoic Mount Partridge Formation. The lens is estimated to have a maximum width of about 100 feet and a possible strike length of 5000 feet; two samples of the richest exposed material assayed 47.9 and 51.8 percent Fe_2O_3 and 7.3 and 22.6 percent TiO_2. The iron and titanium minerals are thought to be detrital in origin and to comprise hematite and ilmenite and/or rutile. The occurrence does not appear to be of economic importance as a source of iron ore, but the titanium content may warrant further investigation.

Oolitic ironstones also occur in the McMinn Formation of the Roper Group in the extreme south-eastern corner of the Katherine-Darwin Region. The occurrences are a westerly extension of the thicker and more extensive deposits in the Roper Bar area which have been tested by the Broken Hill Pty Co. Ltd (Cochrane & Edwards, 1960). On present indications they are not of immediate economic interest.

In the headwaters of Nourlangie Creek a quartz-hematite body crops out in Lower Proterozoic sediments near the contact with the Jim Jim Granite. Broken Hill Pty Co. Ltd drilled the body in 1958 without apparent success.

DISSEMINATED SULPHIDE OCCURRENCES

In this section, some of the major known occurrences of disseminated sulphides and their oxidation products are reviewed as a group, although many of them have already been referred to previously especially in the discussions on the Rum Jungle and Brocks Creek areas and the various iron ore occurrences.

Most of the occurrences are associated with carbonaceous slate and siltstone of the Golden Dyke and Koolpin Formations, or with sills and dykes of dolerite and amphibolite. The occurrences in sedimentary rocks are apparently of syngenetic origin. They do not show any obvious association with quartz-sulphide lodes of the fissure-filling types.

The most northerly occurrence is a pyritic carbonaceous slate, probably of the Golden Dyke Formation, encountered in a water bore 13 miles south of Darwin; similar rock types have probably been responsible for the development of ferruginous outcrops in the Berry Springs area. In the Darwin River area, test-drilling for a proposed dam site has encountered highly pyritic bands in both Golden Dyke and Acacia Gap Tongue rocks; traces of copper sulphides are associated with some of these occurrences, but not, as far as is known, in economic concentrations. Some of the nearby iron ore occurrences, such as Beetsons deposit, may also have been derived from similar material.

In the Rum Jungle area, disseminated pyrite mineralization is widespread, both in carbonaceous and in places in chloritic sedimentary rocks, and in dolerite and amphibolite dykes and sills. The pyrite mineralization occurs in barren areas as well as in association with the uranium and base-metal mineralization. The association of the known orebodies with widespread pyrite mineralization has been known for many years, but its genetic significance is not yet fully understood.

In the Brocks Creek area, disseminated pyrite mineralization and associated ferruginous outcrops have been traced for many miles in carbonaceous beds of the Golden Dyke Formation. The gold mineralization at Cosmopolitan Howley and the copper at Mount Ellison, as well as numerous smaller mines and prospects, are intimately associated with these rocks, but the genetic relationship, if any, between the pyrite and the economic mineral occurrences is not clear. In several instances, base metals, especially copper and zinc, are concentrated in the ferruginous gossan-like outcrops, but are not associated with better or even comparable grades at depth.

Cretaceous
+ Granitic rocks
Lower Proterozoic
Sd Sand
Gv Gravel
Lsd Lime sand
Coral Coral
Clay Clay
Shale Shale
Rc Crushed rock
St Building stone

0 4 8 MILES

N

Coral
Vernon Islands
Coral
Gunn Point
Lsd
Gunn Point
Clay
Lsd
Lsd
Lee Point
Rapid Creek
Shale
Clay
Leanger Swamp
Nightcliff
Clay
Shale
Rapid Creek
Sd
Leanger Swamp
Mandorah
Coral
Noogoo Swamp
Clay
Sd
Hope Inlet
Gv
Howard Springs
Larrekeyah
St
Shale
Wharf Hill
Lsd
Shell Island
17 mile
Rc
Sd
Howard River
Elisabeth River
Sd
Gv
Noonamah
32 mile
Shale
Blackmore River
Sd
Darwin River
Clay
Berry Creek
Sd
Acacia Creek
Rc
Rc
Darwin River
G.M.

Fig. 38 Mineral deposits, Darwin area

In the Black Jungle Range and Coirwong Gorge areas, comparable ferruginous outcrops are developed on rocks of the Koolpin Formation, and the results of a limited diamond drilling programme by the Broken Hill Pty Co. Ltd indicate that pyritic beds provided the source for the iron. No economic mineral deposits have so far been found, but by analogy with the adjoining South Alligator area and the Brocks Creek and Rum Jungle areas, some further investigation of the ferruginous outcrops of the Black Jungle Range and Coirwong areas is warranted.

The ferruginous outcrops near Marrakai Crossing and the junction of the Mary and McKinlay Rivers referred to on p. 64 have also not been systematically investigated for base metals; some testing is warranted.

NON-METALLIC MINERALS (Fig. 38)

Sand, Gravel, and Crushed Rock

In terms of past production, sand, gravel, and crushed rock are the most important non-metallic minerals of the Katherine-Darwin Region, but details of production from individual deposits are generally incomplete.

At present, the main sources of crushed rock for construction purposes in the Darwin area are the quartzite and silicified sandstone of the Acacia Gap Tongue. In 1963-64 recorded production was about 45,000 tons, mainly from the 17-mile and Acacia Gap quarries. In previous years, considerable production has also come from the Darwin River quarry, a few hundred yards east of Darwin River Siding, in rocks of the same formation. This was mostly used in the construction of Darwin aerodrome.

In 1965, quarrying of flatlying basaltic lavas of the Antrim Plateau Volcanics 8 miles east of Katherine township was started for use in the construction of Tindal Air Base.

Small tonnages have also been won from numerous other localities for use in local construction projects and for road construction. The rock types used include granite, acid and basaltic lavas, amphibolite, sandstone, and limestone.

Sand and gravel are widely available throughout the area, although individual deposits are generally small. Near Darwin, sand and gravel have been obtained from Leanyer Swamp and Hope Inlet, from the Adelaide, Howard, Elizabeth, Darwin, and Blackmore Rivers, and from some local beach deposits. Lateritic gravels have also been worked in the Howard Springs and Noonamah areas. Elsewhere, small tonnages have been won from many separate deposits for local use.

In 1963-64, recorded production of the area, mostly for use at Darwin, was about 26,000 tons of gravel and 13,000 tons of sand.

Building Stone

McQueen (1957a, unpubl.).

The only systematic quarrying of stone for building purposes has been undertaken at the Larrakeyah quarry, Darwin, in flatlying leached Cretaceous shale from the pallid zone of the laterite profile. The leached shale is about 35 feet thick and is overlain by about 15 feet of ironstained silicified shale; the leached material has an attractive appearance and can be readily sawn when fresh, but hardens on exposure.

Limestone

Large quantities of limestone occur in several parts of the Katherine-Darwin Region, but both the physical and chemical characteristics are very variable and they have not been used on a large scale.

The largest occurrences are in the gently dipping Lower Palaeozoic 'Daly River Group', especially the 'Tindal Limestone', which crops out over many square miles in the Fenton Airstrip, Katherine, and Tindal areas. The limestone commonly contains zones of silicification, and in places the magnesia content is too high for use in the manufacture of lime or cement. Analyses of grab samples from various localities commonly range from 75 to over 95 percent $CaCO_3$, and from less than 1 to over 20 percent $MgCO_3$, and a detailed test programme would be required to delineate areas suitable for economic development. Lime was manufactured on a small scale for some years at Katherine, the most recent recorded production being 350 tons in 1960-61, but there is no production at the present.

Carbonate rocks are also widespread in the Lower Proterozoic succession, especially in the Celia, Coomalie, Golden Dyke and Koolpin Formations, e.g. at Rum Jungle, the Evelyn mine, and in the South Alligator area, but these rocks are generally too siliceous or too dolomitic for economic exploitation.

Some better-quality lenses of crystalline limestone are reported to be associated with amphibolites in the Brocks Creek area; they are probably of hydrothermal origin. Two occurrences of this type, 4 miles north-west of Brocks Creek and 4 miles west of Burrundie, have been quarried in the past for use in cyanidation and probably as flux for the smelting of metallic ores, but no records of production are available (Jensen, Gray, & Winters, 1916).

Lime Sand

Gardner & Rix,(in prep.).

Large tonnages of lime sand are known from beaches in the Lee Point and Gunn Point areas and from parts of Darwin Harbour, and in spite of a rather high magnesia content, they may be suitable for the manufacture of cement.

In the Lee Point area, deposits aggregate about three-quarters of a mile in length, with widths of at least 600 feet and thicknesses of 3 to 8 feet, and in the Gunn Point area deposits of comparable width and somewhat smaller average thickness occur over a length of about 2½ miles. The deposits average between 60 and 68 percent $CaCO_3$ and 4 to 6 percent $MgCO_3$, but preliminary testing at Australian Mineral Development Laboratories has shown that they may be upgraded to 75 to 80 percent $CaCO_3$ by screening or selective flotation. Of the deposits in Darwin Harbour, only the occurrence on Shell Island has been tested. This is of better quality than the other deposits tested (78 percent $CaCO_3$, 2.5 percent $MgCO_3$), but contains only a relatively small tonnage (probably about 100,000 tons).

Material of comparable composition may also be available from some of the coral reefs, e.g. at Gunn Point and the Vernon Islands, but the physical difficulties of working these deposits are likely to prevent their exploitation in the foreseeable future.

Clay

McQueen (1957b, unpubl.); Gardner & Rix (1963, unpubl.); Rix (1964b, unpubl.).

Deposits of clay suitable both for the manufacture of bricks and ceramics are known in the Darwin area.

Brick clays are of two types - sedimentary clays associated with swamps, as at Leanyer Swamp, Noogoo Swamp, and Berry Creek, and weathering products of Lower Proterozoic shales, as at Wharf Hill, Rapid Creek, and the 32-mile locality. In general, the swamp deposits are more plastic, but some of them, such as the Leanyer Swamp occurrence, carry deleterious amounts of salt and gypsum, and the shrinkage on drying is generally high.

On present indications, the deposits at the 32-mile locality, derived from shale of the Noltenius Formation, are most likely to be of immediate economic interest. At this locality, auger drilling has encountered clay

and weathered shale which appear to be suitable for brick manufacture to an average depth of more than 30 feet over an area of about 400 by 1200 feet, immediately adjoining the railway (Vanderplank, 1964, unpubl.). Further work would probably increase these reserves.

Clay suitable for the manufacture of ceramic is only known from a coastal exposure about 4 miles south of Gunn Point, where Cetaceous kaolinitic and montmorillonitic clays are exposed in the beach and cliff sections. The clays are overlain by 20 to 30 feet of laterite, which forms an extensive plateau from 50 to 100 feet above sea level, bounded by an abrupt scarp on the seaward side. Neither the horizontal nor vertical extent of the deposits can be determined since they pass under the laterite cover to landward and under beach deposits of calcareous sand to seaward. However, from the mode of occurrence, as bedded members of the flatlying Cretaceous Mullaman Formation, it appears likely that the deposits will be of large horizontal extent, and the presence of clay in land-slip material below the laterite scarp suggests a total vertical extent of not less than 30 or 40 feet (Rix, 1964b, unpubl.). A programme of testing by diamond drilling through the laterite cover on the landward side is being carried out by the Mines Branch, N.T. Administration.

Minor occurrences of sedimentary clays are also known from the Nightcliff area, but are not likely to be available for exploitation because of their position within an area zoned for residential purposes.

Graphite

Many of the black shales and slates in the Lower Proterozoic rocks of the Katherine-Darwin Region contain minor amounts of graphite, but there seem to be few occurrences of potentially economic size and grade. The only recorded production is from the vicinity of the Golden Dyke mine in the Burrundie district, from which 2 tons of graphite were won in 1924 for use as a pigment in paint manufacture.

Good-quality graphite has also been reported from the Finniss River area, but no production has been recorded.

Bauxite

No deposits of bauxite have so far been discovered in the Katherine-Darwin Region. Laterite is widespread, mostly developed on flatlying rocks of the Cretaceous Mullaman Formation, and to a lesser extent on Carpentarian, Adelaidean, and Cambrian rocks. It generally appears to be ferruginous or siliceous, but no systematic testing has been undertaken. The nearest

known occurrences of possible economic interest are on Croker Island and Cobourg Peninsula, about 150 miles north-east of Darwin. These were partly delineated by Reynolds Metal in 1960 and are currently being re-examined by United Uranium N.L.

Barite

A group of lodes composed largely of barite with traces of galena has been recorded from a locality 10 miles west of Dorisvale Homestead, 150 miles south of Darwin. There are at least four separate lodes, ranging up to 20 feet wide and 200 feet long, which occur within ferruginous sandstone, siltstone, and sandy limestone of the Adelaidean Waterbag Creek Formation, and are overlain by lateritized Cretaceous sandstone. Most of the surface material appears to be stained and low-grade, and the isolation of the occurrence would be a major obstacle to any economic development, but further testing may be warranted to determine the full extent and average grade of the lodes and to investigate the possible improvement of grade below the zone of weathering (Hays, 1965, unpubl.).

Another occurrence of barite has been recorded within the Soldiers Creek Granite, 5 miles north-west of Collia Waterhole. A sample was reported by Hossfeld (1937c) to assay 58 percent BaO and 4.2 percent SrO, but no details of the extent of the occurrence are available.

Barite also occurs in limestone of the Golden Dyke Formation about 5 miles south-west of the Evelyn mine.

Magnesite

Magnesite nodules have been noted from several localities in the Katherine-Darwin Region, including Rum Jungle, Stapleton, Brocks Creek, and Katherine.

The occurrences appear to be variously derived from intrusive amphibolite and dolerite, from basic lava of the Antrim Plateau Volcanics, from dolomite in the Lower Proterozoic Celia, Coomalie, and Golden Dyke Formations, and from magnesian limestone in the Cambrian 'Daly River Group'. None have been investigated in sufficient detail to establish the available reserves and average grades, but the Stapleton occurrence, probably derived from dolomitic limestone in the Golden Dyke Formation, may be of sufficient size to warrant further investigation, especially in view of its proximity to the existing railway.

Amblygonite

Brown & Basedow (1906); Noakes (1949); Summers (1957b, unpubl.).

The occurrence of amblygonite at Picketts mine in the Finniss River area, 30 miles south-south-west of Darwin, has already been mentioned in connexion with the tin deposits of that area. An analysis of the mineral, quoted by Brown & Basedow (1906), showed 47 percent P_2O_5, 35 percent Al_2O_3, and 7.9 percent Li. Total recorded production from this locality amounts to about 64 tons of hand-picked ore, mostly obtained in 1906 and 1924-25. Recent attempts to resume mining of the deposit have not been successful.

Salt

Tidal salt pans in Shoal Bay just to the north-east of Darwin are harvested to produce most of the local requirements of coarse salt. The average annual production is 750 tons.

Beach Sand

Beach sand near Point Blaze contains about 60 percent heavy minerals (by weight) and reserves are calculated at about 4000 tons of heavy minerals (Ward, 1957, unpubl.). The heavy minerals average 4.0 percent rutile, 16.2 percent zircon, 41.3 percent magnetite, and 31.0 percent hematite. They are not economically attractive because of the low total rutile content and isolation of the deposit.

Coarse rutile crystals occur in a creek bed north-east of Oenpelli Mission (Dunn, 1962), and fine tabular crystals of rutile have also been found in Myra Creek to the south of Oenpelli. These occurrences may be the source of possible rutile-rich beach sands in Van Dieman Gulf.

Coal

Because of the presence of what he believed were Carboniferous fossils on the west coast, especially at Fossil Head, H.Y.L. Brown (1895) recommended boring for coal. Between 1905 and 1911 nine bores were drilled at Port Keats (just to the west of the Katherine-Darwin Region), Cliff Head, Cape Ford, and near Anson Bay between Cliff Head and Cape Ford. Only three of the bores reached their target depth (about 1500 feet), one (at Cliff Head) reached granite basement at 720 feet, and the others were abandoned for various reasons.

The only coal intersected was a number of seams of lignite, from 1 to 3 inches thick, and some carbonaceous sandstone. Two of the bores near Cape Ford produced artesian water at 600 and 1600 gallons per hour.

Phosphate

The phosphate deposits at Rum Jungle and the occurrences in the South Alligator River area have been described on pages 8 and 12.

During 1965 phosphatic beach rock was found at Lee Point near Darwin. The phosphate in the beach rock is thought to be derived from a Cretaceous bed which contains phosphate nodules. The nodular bed is about 30 feet above the base of the Cretaceous at Nightcliff near Darwin and has been found at a similar stratigraphic position in a drill hole at Gunn Point about 20 miles north-east of Darwin.

Although the nodules contain up to 27.0 percent P_2O_5 they only occur in 2 or 3-inch layers and do not appear to be of commercial value. Further investigation is being undertaken.

Underground Water

Noakes (1949) has summarized the information available from water bores in existence to 1946. Most of the bores were drilled by the Army during World War II. Water was generally obtained at depths of less than 300 feet and flowed at rates between 500 to 2000 gallons per hour. Very few of the bores put down into Lower Proterozoic and Cambrian sediments failed to produce water, which in general had a standing water level of 20 to 50 feet below the surface. One bore in Cambrian sediments at Manbulloo south-west of Katherine produced artesian water at a rate of 800 gallons per hour. Bores sited in granitic rocks were not as successful as those in sediments unless they intersected joints, fractures, or weathered zones in the granite. Bores in the Darwin area are generally sited on Cretaceous Mullaman Beds, but water was drawn from the underlying Lower Proterozoic sediments.

Between World War II and about 1960 very few bores were sunk in the Katherine-Darwin Region. The pastoral industry, was mainly dependant on surface water for homesteads and stock.. The municipal supply for Darwin township from the Manton reservoir was adequate. However, since about 1960 an improvement in the state of the cattle industry in the region and a need to augment the Darwin water supply has focussed more attention on the underground water potential.

Stock bores have been drilled in the Daly and Roper River basins, and homestead and service bores throughout much of the rest of the Katherine-Darwin Region. These in general have supported Noakes' (1949) previous observations about the water potential of the various major regions and rock types.

The most outstanding discovery in recent years has been the finding of a major aquifer in the McMinns Lagoon area about 20 miles south-east of Darwin. Officers of the Water Resources Branch recognized sinkholes under the cover of Cretaceous sediments in the McMinns Lagoon area. Subsequent drilling showed that the Cretaceous sediments rest on cavernous Lower Proterozoic dolomite, probably belonging to the Golden Dyke Formation. Tests have produced from 20,000 to 40,000 gallons per hour from some of the bores. It is intended to connect one of the bores to the Darwin water supply and test the drawdown effect of a long-term withdrawal of about 40,000 gallons per hour. The underground water in the McMinns Lagoon area would appear to offer a less expensive alternative to the construction of a dam on the Darwin River to supplement the Darwin water supply.

The Water Resources Branch of the Northern Territory Administration collates all available information on both surface and underground water in the Northern Territory and is at present engaged in detailed studies of a number of areas within the Katherine-Darwin Region.

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TABLE 11: PRODUCTION FIGURES FROM MINES IN THE KATHERINE-DARWIN REGION (to end of 1965)

	Gold (oz)	Tin Concentrate (tons)	Copper (tons)	Copper Ore (tons)	Lead (tons)	Lead Ore (tons)	Silver (oz)	Wolfram Concentrate (tons)	Tantalite Concentrate (tons)	U_3O_8 (tons)	Manganese Ore (tons)
Whites			16,800		4,100		97,600			1,010	
Dysons										520	
Mount Burton			100							10	
Rum Jungle Creek South										2,600	
Intermediate			12,000								
Rum Jungle	10										
Virginia	25										
	35		28,900		4,100		97,600			4,140	
El Sherana	)	(								210	
El Sherana West	)	(								170	
Rockhole + Teagues	)	(								150	
Palette	) 11,570	(								120	
Saddle Ridge	)	(								70	
Coronation Hill	)	(								70	
Other Prospects										30	
Zamu Creek						20					
						20				820	
Cosmo Howley	33,780										
Rest of Howley Line	32,450										
Zapopan	26,650										
Rest of Brocks Creek area	6,370										
Brittania	840										
Fountain Head	9,870										
Mount Ellison				3,250							
	109,960			3,250							
Yam Creek	15,400										
Iron Blow				13,700							
Golden Dyke	1,400										
	16,800			13,700							
Mount Shoobridge		145									
Barretts		115									
Other Prospects				360		2					
		260		360		2					
Northern Hercules	32,800										
Coronet Hill				250							
Mount Davis				990							
Mount Diamond				700							
Waldens				1,220							
Evelyn						2,206	89,000				
Other Prospects		45		15		580					
	32,800	45		3,175		2,780	89,000				
Spring Hill Area	21,170	300									
Elizabeth	3,440										
Flora Belle						130					
McKinley						750	40,000				
Union Reefs	54,700										
Union Extended	3,500										
Pine Creek	94,000										
Caledonia	460										
Lucknow						150					
Mount Wigley						60					
Copperfield				2,140							
Kellys		2									
	175,270	302		2,140		1,090	40,000				
Mount Wells		1,530									
Mount Masson + Others		330									
		1,860									
Wandie	6,380										
Crest of the Wave		143									
Wolfram Hill				230		85		650			
Hidden Valley	30	50				25					
Emerald Creek		42									
Driffield	5,300										
Horseshoe Creek		650									
Mount Todd	915	180									
Yenberrie								160			
Woolngi	4,600										
	17,225	1,065		230		110		810			
West Arm	620	585									
Blyth		75									15
Fletchers Gully	2,450	4									
Buldiva-Collia		45									
	3,070	709									15

TABLE 11 - Sheet 2

	Gold (oz)	Tin Concentrate (tons)	Copper (tons)	Copper Ore (tons)	Lead (tons)	Lead Ore (tons)	Silver (oz)	Wolfram Concentrate (tons)	Tantalite Concentrate (tons)	U_3O_8 (tons)	Manganese Ore (tons)
Daly River				6,000							
Wheal Danks				500							
Empire-Wallaby				175							
				6,675							
Maranboy		1,280									
Yeuralba		12		50				40			
		1,292		50				40			
Mount Ringwood	2,800										
Great Western Group	3,600										
Woolwonga	9,200										
Watts Creek Area	150										
Yemelba	250										
Hayes Creek		156									
Stray Creek		18									
Umbrawarra		269									
Douglas River, etc.		5									
Maude Creek	540										
Carpentaria				20							
Mount Gates	250										
Minglo					11						
Green Ant Creek											450
	16,790	448		20							450
Grand Total	373,520	5,981	28,900	29,600	4,100	4,000	226,600	850	15	4,960	450