DEPARTMENT OF MINES ENERGY
SOUTH AUSTRALIA

REPORT BOOK NO. 90/73

MINTABIE OPALFIELD MINING AND GEOLOGY

GEOLOGICAL SURVEY

by

I.J. TOWNSEND

SENIOR GEOLOGIST

MINERAL RESOURCES BRANCH

NOVEMBER 1990

DME 272/78

FRONTISPIECE

Mintabie Opal Field, aerial view September 1979 looking west at early workings on Mintabie scarp and part of town area on plains below in foreground.

E00080

CONTENTS PAGE NO

CONTENTS PAGE NO

TABLES

FIGURES

PLATES

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

Rept.Bk.No. 90/73
D.M.E. No. 272/78
Disk No. E00080

MINTABIE OPAL FIELD

ABSTRACT

Mintabie Opal Field was discovered in the early 1920's by a stationhand named Larry O'Toole working on Granite Downs Station. Mining began in earnest in 1976 since when it has developed into one of the most important production centres in Australia.

Precious opal appears to be confined to occurrence in Mintabie beds, a kaolinitic sandstone of presumed Ordovician Age, conformably overlying Blue Hills Sandstone within the Palaeozoic Officer Basin.

The sediments were partly silicified in the ?Miocene - Pliocene; silicification is considered to be responsible for deposition of opal in cracks and fissures of brittle rocks.

Opal is found in bedding plane partings, in multiple discontinuous *levels*, and infilling vertical to angled joints. Top grade Mintabie opal matches in quality and value crystal and black opal from anywhere in Australia.

Sandstone and shale of Early Cretaceous age which onlaps Mintabie beds in the southern part of the field (by analogy with occurrence elsewhere) may provide potential host rock for opal.

INTRODUCTION

Australia produces about 95% of the world's precious opal and has dominated world markets since the late 1800's; the remainder from Brazil, Mexico, USA and Indonesia. Most Australian opal has been won from Coober Pedy and Andamooka in South Australia, White Cliffs and Lightning Ridge in New South Wales, with minor production from many other small fields in Queensland, New South Wales and South Australia.

Mintabie was discovered in the early 1920's but harsh climate conditions and remote location meant that it was generally deserted and production was small and sporadic In 1976 a number of finds were made using bulldozers, since whent h e number of miners increased rapidly. As the nearest Registration Office was at Coober Pedy, 340 km to the south, an office of the South Australian Department of Mines and Energy (SADME) was opened and a Precious Stones Field (PSF) was proclaimed. In 1979 the Mineral Resources Section of SADME initiated geological investigations at Mintabie to map the distribution of host rocks, record the nature and occurrence of opal.

This report presents the results of detailed geological mapping undertaken 1979-82 and subsequently to include examination of exposures resulting from expansion of the field. The regional geology, detailed stratigraphy, distribution of host rocks and mining methods are presented, together with summaries of historical and geological data.

LOCATION AND ACCESS

Mintabie is situated on Granite Downs Pastoral lease, now part of Pitjantjatjara Aboriginal land, in the Far North of South Australia, approximately 1000 km northwest of Adelaide. Nearest major towns are Coober Pedy, 290 km southeast by road and Alice Springs in the Northern Territory 450 km to the north.

Mintabie is 40 km by unsealed road to the west of Marla, on the sealed Stuart Highway where fuel and supplies are available.

Access to Mintabie from Coober Pedy is northerly via the Stuart Highway for 250 km to Marla Township (opened November 1982), then 4 km north to the signposted turnoff. A well graded track extends westerly for 36 km to Mintabie town area.

Access from Alice Springs is provided by a dirt track which turns off the Stuart Highway 10 km south of Chandler Railway Siding (Fig. 2). This track crosses the Tarcoola-Alice Springs Railway line 3 km from the road junction and is followed southwards past Davey Bore for a total distance of 37 km. I n general, all tracks are negotiable by conventional vehicles but infrequent heavy rains can make tracks impassable to all vehicles. The unsealed airstrip at Mintabie was constructed by opal miners to Flying Doctor Service standards and is one of the best unsealed strips in the Far North, used frequently by visitors, opal buyers as well as the Flying Doctor.

CLIMATE PHYSIOGRAPHY AND VEGETATION

Climate is typical of inland Australia with maximum summer temperatures in the high forties (°C) and minimum overnight winter temperatures of 0° to -5°C. The irregular rainfall averages 250 mm per annum, often resulting from a single period of heavy rain which floods the country and closes all access tracks.

The opalfieldis located at the margin of a dissected, northeast facing cuesta which forms a prominent northwest-southeast trending scarp averaging 15 to 20 m in height. The cuesta dips gently southwest below a tableland covered by east-west trending sief dunes. Several large claypans on the plains below are the focus of an internal drainage system. Mulga (Acacia Aneura) is the dominant vegetation on the tableland, in the sandy interdune corridors and on sand dunes; there are occasional clumps of red mallee (E. Socialis).

On the plain below the scarp, red gums (E. Camaldulensis) line the larger water courses, such as Ammaroodinna Creek, but away from the creeks mulga predominates.

The density vegetation lends an attractive setting for Mintabie, in contrast to other generally treeless South Australian opal fields, particularly after rain when a profusion of wild flowers add colour to the scene.

HISTORICAL REVIEW

H.Y.L. Brown visited Mount Johns in 1880 and in 1904 (Brown, 1904) travelled from Trainor Hill along Ammaroodinna Creek heading northwest and probably passed within 10 km of Mintabie scarp, visible from Mount Johns.

The earliest 'reported' discovery of opal at Mintabie, was interpreted by O'Leary (1977) as 1919 when Aboriginals were reputed to have brought black opal to Coober Pedy. O'Leary interpreted "black opal" mentioned in an article on the Stuart Range Opal Field (Queensland Government Mining Journal, 1919) as opal which must have come from Mintabie. However, Coober Pedy and a number of other localities along Stuart Range, have produced some black opal and it is possible that it came from one of these deposits and not necessarily Mintabie.

An article titled 'South Australian Opal' in the Queensland Government Mining Journal (1929) states that black opal was found "200 miles north of Coober Pedy" and the most likely locality is Mintabie. A less likely alternative source of this black opal is Ouldburra Hill on Welbourn Hill Station (Townsend and Scott, 1982).

Hiern, (1967) states the date of discovery as 1931, based on the report of 'an opal occurrence 15 miles SW of Mount Johns(Mining Review No. 54, p 63).

Graham (1961) stated that he visited Mintabie in 1922 accompanied by Larry O'Toole, 'a handy old Territorian' who discovered opal while sinking wells on Granite Downs Station. Mintabie is 12 km west of Sailors Well and it is quite possible that opal was discovered around the time of this well sinking in the early 1920's. These dates cannot be substantiated but it is likely that opal was found either by local Aboriginals possibly as early as 1919 or white man in 1921 or 1922.

Although Coober Pedy miners knew of Mintabie and its potential riches, perhaps as early as the 1920's, the place was visited only intermittently to the early 1960's. The remoteness required a 680 km round trip to replenish supplies from Coober Pedy; the surface rocks were difficult to penetrate, and the oppressive summer heat discouraged even the hardiest opal miner from staying permanently.

In the early 1960s explosives were first used to penetrate the surface silcrete and some substantial opal finds were made. Miners report having worked at Mintabie in 1958, 1962 and 1964, and these reports are confirmed by production figures of opal buyers covering the years 1958 to 1965 (Table I).

When Hiern visited and mapped the Mintabie area in 1964, however, the field was deserted.

One person was working at Mintabie when visited by Army Surveyors in 1968 (J. Harrison, SADME pers. comm.). R e n a Briand (1971) describes her trip to Mintabie with Coober Pedy miner Johnny Kovak in late 1969 , and reports that two miners were working at that time.

R.B. Major and G.W. Krieg during the course of mapping EVERARD 1:250 000 geological sheet, report minor activity on one visit (G.W. Krieg SADME pers. comm.).

L.C. Barnes (SADME pers. comm.) visited Mintabie during 1973 while mapping WINTINNA; no activity was evident on that occasion.

In 1976 two Croation miners, made a good find using a bulldozer. This discovery was the focal point for other miners with money and equipment, and the population of Mintabie grew from two in mid 1976 to approximately 250 in mid 1979, with a marked decline in population over hot summer months. In 1980, the population declined to about 100 but increased again in 1981 through to its peak in early 1988.

Fuel deliveries approximately twice a week allowed rapid development of the settlement at Mintabie from 1977-1980, marked by the establishment of a number of permanent residences. A licensed restaurant, the Goanna Grill, was opened in 1981 (Plate 5). Mintabie Town Bore (Plate 3), financed, drilled and equipped by the Mintabie Progress Association provides a supply of good quality water (Appendix D4).

In early 1979 a new township (Marla) was established, on the Stuart Highway, adjacent to the Tarcoola-Alice Springs railway. Train services commenced in October 1980, Marla was proclaimed in 1982 and the Stuart Highway sealed through to the Northern Territory making fuel and supplies to Mintabie more readily available.

In April 1979, the Department of Mines and Energy appointed an Area Officer at Mintabie with temporary office and accommodation established in June 1979 (Plate 4). In 1982 an area office and permanent house were established at Marla but it soon became obvious that registrations also had to be conducted on the field and an office caravan was once again located at Mintabie. In June 1987 (Plate 5) a more permanent transportable style office was established at Mintabie for field registrations.

Since the late 1970s there have been a number of notable changes to Mintabie town area, starting with the grant of a licence to the Goanna Grill restaurant.

- A second restaurant licence was granted to Nagy's; the Goanna Grill granted a full Hotel licence.
- A radio tower and 3 public telephones have been installed by Telecom together with a number of private phones.

The Mintabie Progress Association has raised funds to establish the following;

- A Flying Doctor clinic caravan and transportable room to house medical supplies.
- A Community Hall which served as the school until 1987 when the Government established a school to cater for the 50 plus students living on the field.
- A second and larger tank at the water bore to cope with an increasing population thought to be 1500 - 2000 in 1987, with connection now offered to a reticulated water supply for $300 (1989).

In addition

- Australia Post have installed a Post Office and Post Mistress.
- A fuel depot has been established to provide the large volume of diesel being consumed by an extensive range of large scale mining machinery.
- A supermarket was erected in 1987 to supplement the smaller stores present since the late 1970s and even a fast food outlet has emerged to cater for miners and tourists.
- Two caravan parks are now available for the increasing tourist trade.

All of these changes occurred in just over a decade and seem quite remarkable considering the remoteness, and that Mintabie has **NO POWER SUPPLY.** Each camp provides its own power using a generator or negotiates a share arrangement with a nearby owner.

LEGISLATION

In 1978 the Pitjantjatjara Council sought protection from prospecting and mining on land considered to be sacred. Further, the Granite Downs Pastoral Lease was subject to a lands right claim by the Aboriginal People. The main concern was that opal miners might scar or desecrate areas of Aboriginal significance although the right of opal miners to prospect unknown areas was recognised.

Following geological inspection by J.G. Olliver (Supervising Geologist) and L.C. Barnes (Senior Geologist) in October 1978 an area of 200 km^2 was outlined to encompass opal diggings and rocks considered as extensions having potential for hosting opal. The surrounding land which was subject to land rights claim was reserved from section 7 of the Mining Act (gazetted February 1979) thus prohibiting prospecting and mining for opal. Five declared sacred sites in the region had been previously reserved from Sections 4 to 8 of the Mining Act, to protect them from mining operations .

Restricting opal prospecting and mining to the 200 km^2 Mintabie area was considered a temporary measure to permit the following;

- Time to carry out geological investigations and define the full extent of potential opal bearing ground. This would ensure the the optimum area with opal potential was incorporated in the Precious Stones Field (PSF) and that areas with little or no potential, could be excluded.
- The conditions for mining on Aboriginal Land to be determined and incorporated into the Pitjantjatjara Lands Right Bill.

An area of 400 metres around the airstrip (then pastoral land) was outlined and pegged to comply with Mining Act & Pastoral Act Regulations, and miners were forbidden to mine within this area. In addition an area of 220 ha covering most of the dwellings on the plain below the scarp (Fig. 4) was delineated in preparation for a declared "Town Area". This proposal was made to protect the more permanent constructions and to separate the residential area from the many dangers associated with living and mining on the scarp. Miners were encouraged to build within this "Town Area" for their own protection. The Mintabie Progress Association assisted the Area Officer in encouraging miners to follow this proposal, although a "Town Area" could be proclaimed only after the Pitjantjatjara Lands Right Bill was finalised.

Following geological investigations during 1979 and 1980, an area of 660 km^2 was proposed as a PSF, but no enlargement was forthcoming and the original defined area of 213 km^2 was declared a Precious Stones Field on 27 November 1980.

Many discussions were held involving Government, the Pitjantjatjara Council, the Mintabie Progress Association; a Select Committee was set up to determine arrangements, including Mintabie PSF and the "Town Area". The Pitjantjatjara Land Right Act was proclaimed in March 1981. The Act declares the Granite Downs Pastoral lease, which included Mintabie Precious Stones Field, to be Pitjantjatjara Land. The town area and PSF (Fig. 4) were leased to the crown for 21 years. Once the Land Rights Act had been declared, the following four areas were reserved from the Parts IV to VIII of the Mining Act (see Fig. 4).

- 50 m radius around the Telecommunications Radio Tower.
- 30 m radius around the Mintabie Town Bore.
- 150 m (originally 400 m) either side of the central line of the airstrip and 400 m from either end of the airstrip. The lateral distance was reduced from the initial 400 m once the Pastoral Act no longer applied, making more ground available for mining.
- The town area defined by Lands Department as section 1491, out of hundreds, EVERARD, as land leased to Lands Department from the Pitjantjatjara Council until 2002.

These restrictions were regazetted with the reduced airstrip modifications in August 1986.

OPAL PRODUCTION

Although Mintabie was first listed as a field in 1933 the first recorded production was in 1935, and any prior production was probably sold at, and allotted to, Coober Pedy. Since 1915, records of South Australian opal sales were based on returns submitted to the Department of Mines by Australian buyers. As the number of overseas buyers increased, and returns by Australian buyers were no longer representative, this method of determining production was considered unreliable and returns were dispensed with from 1970 and alternative methods of assessment considered.

From 1970-1977 Departmental officers estimated annual production from discussions with miners and buyers. As the method lacked objectivity a formula was developed by officers in the Department of Mines and Energy to estimate the value of opal production. The formula is based on a field survey to count and categorise equipment and the number of miners operating at each field (Crettenden et al., 1979), and incorporates a cost of living factor, capital outlay on equipment, operating costs and depreciation.

Equipment surveys have been conducted for each field since 1978.

Table I summarises the Mintabie production figures gained via returns from the early 1930's through to 1970, departmental estimates from 1970 to 1977 and formula-generated production figures since 1978. The figures for 1968-1970 are listed in the register as "OTHER FIELDS" setting them aside from Coober Pedy and Andamooka. Crettenden et al (1980) assumed this to be Mintabie but some of the smaller fields including Stuart Creek could have been included in these figures. Some production (1969) has even been attributed to Lightning Ridge Opal Field (NSW); thus production figures between 1968 and 1970 are suspect.

TABLE I

VALUE OF PRODUCTION - MINTABIE OPAL FIELD

	Pounds	Dollars	Information Source
1935	34	68	
1936	85	170	
1937-38	-	-	
1939	48	96	
1940-48	-	-	
1949	5	10	
1950-53	-	-	Buyers
1954	60	120	Production
1955	15	30	Returns
1956	-	-	
1957	-		
1958	1250	2 500	
1959	500	1 000	
1960		-	
1961	2325	4 650	
1962	3854	7 708	
1963	1925	3 850	
1964	1630	3 260	
1965	975	1 950	
1966	-		Fields other 1967
-		than	
1968		6 150	Andamooka &
1969		183 775?	Coober Pedy
1970		400 000?	
1971-1975		NIL	
1976		1.5 million	Estimated
1977		2.5 million	
1978		6.5 million	Calculated
1979		6.1 million	from
1980		5.6 million	equipment
1981		3.0 million	count.
1982		6.1 million	
1983		7.3 million	
1984		9.2 million	
1985		15.6 million	
1986		19.2 million	
1987		28.2 million	
1988		39.0 million	
TOTAL		150.4 million	

MINING METHODS

Prior to 1976, the hand dug shaft was the main method of mining. Miners searched gullies at the base of the scarp for *floaters*, or *nobbies*, to locate a *vertical* or opal filled joint. They began sinking shafts alongside joints and driving when the quality of the opal improved, or a horizontal seam (*level*) was encountered. The very tough, silicified sandstone was extremely difficult to work and only a few hand dug shafts were sunk. Plate 15, shows an old hand dug shaft in the wall of a modern bulldozer cut. Today pneumatic picks and explosives are used to sink shafts if a Calweld drill is not available.

In 1976, a large bulldozer was brought to the area and this changed the scale of mining at Mintabie. With one or two large strikes there was an influx of miners and equipment and by early 1979 there were 26 bulldozers at Mintabie, almost half the number then operating at Coober Pedy, where the population was 6 000. Together with large earth moving equipment came more conventional mining equipment; the latter are popular because of the very high running costs associated with D9 bulldozers and scrapers.

The various types of equipment and mining techniques being used in 1990 are discussed below.

PROSPECTING

Calweld and auger/rotary drill rigs are used to prospect a claim by grid drilling; the intersection of opal *traces* assist siting of shafts and open cuts.

UNDERGROUND MINING

Calweld drilling rig - generally used for shaft sinking. A Calweld (Plate 7) drills a hole of between .75 m and 1.0 m diameter to a depth of approximately 25 m using a 3-stage telescopic kelly, a rotary table and a hydraulic pulldown system. The bucket when full is withdrawn from the drillhole, pulled sideways along a boom for 3-4 m, and emptied by releasing the hinged base (Plate 8).

Normally the miner sinks two or more shafts and drives between them to allow air circulation underground. Blower pipes, PVC pipe or a sail may be used (Plate 10) to catch the breeze and enhance air circulation. Plate 11 shows an electric blower being used to force air down an auger hole, circulate through the workings and exhaust through other shafts.

Driving between shafts is normally achieved by pneumatic pick (Plate 9), or by drilling and blasting; when *potch* with colour or precious opal is found, the miners revert to use of hand pick, screwdriver or pocketknife.

Access to underground workings is usually gained by a set of ladders (each 3 m long) which hook together, or by one of the following methods also used for removing mullock.

Hand winch - was used extensively in the early days but is now almost completely replaced by power devices and kept only as a standby unit.

Air winch - operated by compressed air (Plate 12) and is generally used for access but can be used for removing mullock.

Electric winch - often seen mounted on miners' motor vehicles; is powered by battery and used mainly for access.

Yorke hoist - a petrol driven winch, mounted on a vertical pipe and secured by three wires from the top of the pipe (Plate 10), allows full rotation of the boom and enables the operator to spread mullock away from the shaft. A safety hook is used to prevent dislodgement of the bucket.

The operation requires two miners, one above operating the hoist, and one below filling the bucket and sliding it on greased water pipe or rails from the working face to the shaft. The shaft collar is built up by boxing with wood or galvanised iron to prevent mullock falling back down the shaft.

Self unloader, or automatic bucket tipper - can be operated by a single miner from underground (Plate 13).

A full bucket is strapped to the cradle, a lever tripped to engage the winder motor and the bucket is hauled to the surface and over an arc of two parallel rails emptying the mullock away from the shaft. The motor is then automatically disengaged and a spring loaded device returns the bucket to a position where gravity carries it to the bottom of the shaft.

Blower - essentially a large scale vacuum cleaner (Plate 14); the impeller or *blower* fan reduces the pressure in the bucket and material placed near the mouth of the underground collection pipe is pressured up to the bucket which can be emptied manually, or, in more sophisticated machines, automatically. *Blowers* are not as popular at Mintabie as at Coober Pedy, where they are required only to extract claystone. Quartz sandstone at Mintabie is abrasive to steel pipes and impellers; fragments of silcrete blocks (*angelstone*) cause dents and damage to pipes and connections.

Tunneling machines (Barnes and Townsend, 1982 , Robertson and Scott, 1987) as used at Coober Pedy were found to be unsuitable at Mintabie because of the incidence of *angelstone*.

Bobcat - small rubber tyred front-end loader which has become popular at Mintabie during the late 1980s and has been used successfully in tunnelling from the side of bulldozer cuts (Plate 18). Silicification does not usually extend from the surface deeper than about 5 m; below that rock is soft enough to allow blasting and removal by bobcat more cheaply than bulldozing an open cut.

OPEN CUT MINING

Bulldozers - used extensively to work amalgamated claims, are the largest equipment used including Komatsu 355A, Caterpillar D9 (Plate 15) or D10. The largest bulldozers have difficulty ripping thick silcrete unless jointed. Prior to bulldozing, an airtrack drill may be used to pattern drill the silcrete to permit use of explosives (generally nitropril) to break hard rock.

Spotters normally follow the bulldozer while ripping (Plate 16) to check for *traces* of opal. If colour is observed the miner reverts to using a pick, hammer or screwdriver, to gouge the opal (Plate 17).

GEOLOGICAL SETTING

GENERAL

Mintabie Opalfield is at the eastern end of the Officer Basin, a large sedimentary basin of Adelaidean to Middle Palaeozoic age which extends westwards into Western Australia.

In the Mintabie area, Palaeozoic sediments unconformably overlie Adelaidean sediments of Marinoan age, known locally as Rodda Beds (Krieg, 1973, Brewer et al 1987) and are unconformably capped by Cretaceous sandstone and shale, and/or unnamed Tertiary sandstone, both of which are in part silicified. Younger Tertiary to Quaternary units (Fig. 3) form a thin veneer over most older units.

The Palaeozoic succession comprises sediments of Cambrian age (Marla Group), overlain unconformably by a thick sandstone sequence, considered to be of probable Ordovician age (Munda Group). The Palaeozoic rocks crop out on the basin margin, thus outlining the synclinal eastern lobe of the Officer Basin (Fig.3); they are described below in ascending stratigraphic order.

CAMBRIAN (MARLA GROUP)

Observatory Hill Formation - brown and pink laminated siltstone and shale, with platy chert interbeds and chert nodules.

A basal conglomerate, derived from Adelaidean sediments and Musgrave Block granite, crops out around the margin of the eastern Officer Basin margin. This unit, described from outcrop near Wallatinna Homestead, has been formally named Wallatinna Formation (Benbow 1982). Precious opal occurs in conglomerate at Wallatinna opal diggings 10 km southwest of the homestead (Townsend and Robertson, 1980, Figs 2 & 3).

The Formation crops out around the eastern margin of the Officer Basin; near Gap Bore in the north, patchily along the eastern margin, near Wallatinna Homestead and southwest at the Wallatinna opal diggings in the south and southwest of Mintabie.

Arcoeillinna Sandstone (Trainer Hill Sandstone, Lower Member, Krieg 1973) - well sorted, red-brown weathered, cross-bedded, arkosic sandstone, with interbeds of micaceous siltstone and sandstone unconformably overlying Observatory Hill Beds (Krieg, 1973). This Lower Member, renamed Arcoeillinna Sandstone (Benbow, 1982), is separated from the Upper Member of Trainor Hill Sandstone by a widespread conglomeratic unit.

Mount Johns Conglomerate - Red, arkosic conglomerate and sandstone near Mt. Johns, grading southwards to finer grained dolomitic siltstone (Apamurra Member; Benbow 1982) with occasional larger grains or pebbles near Mount Byilkaoora (Fig.3). Along the southern margin of the basin upper and lower parts of the Trainor Hill Sandstone were mapped as one unit as it is finer grained (Krieg, 1973).

Trainor Hill Sandstone - white, cross-bedded, kaolinitic sandstone containing some thin conglomerate bands which Krieg (1973) included with Mount Johns Conglomerate.

As a result of detailed mapping on the eastern margin of the Officer Basin, Benbow (1982) retained the name Trainor Hill Sandstone for the upper member.

ORDOVICIAN (Munda Sequence)

Mount Chandler Sandstone - disconformably overlies Trainor Hill Sandstone, and is generally a greyish-white, hard, quartzitic sandstone, (Sample RS 238 Appendix D) slightly feldspathic in the upper parts, and in places contains distinctive "pipe rock", U-shaped burrows, and some tabular cross-bedding. Recrystallisation has occurred over most of the eastern portion of the Officer Basin as a result of folding and faulting of the sandstone to produce hard, dense quartzite which crops out prominently.

Indulkana Shale - red-green shale and calcareous siltstone separates Mount Chandler Sandstone from the overlying Blue Hills Sandstone, acting as a marker bed, particularly in the Mount Johns Range area. It has been dated radiometrically as Ordovician (460 +/- 15 Ma) (Webb, 1978).

Blue Hills Sandstone - described by Krieg (1973) from the Blue Hills area, is a red-brown weathered, kaolinised, quartz sandstone with massive white quartzite (Sample RS 237 Appendix D) and thinly bedded sandstone bands. The unit grades upward from massive, quartzitic sandstone to more arkosic sandstone.

The upper part of Blue Hills Sandstone comprises interbeds of quartzite and softer, arkosic, kaolinitic sandstone, indicating a gradual, alternating change to the overlying kaolinitic sandstone.

Krieg (1973) called the transitional sequence of sediments 'Cartu Beds', and separated these from the overlying Mintabie beds because of an apparent unconformity. However this gradational unit is now considered part of the Mintabie beds with no unconformity. These interpretations are discussed under "Age of the Mintabie beds".

Mintabie beds - white, medium to coarse grained, well sorted, kaolinitic sandstone, with some thin graded bedding. The unit also shows large scale cross-bedding (Plate 20) and contains green clay interbeds. Much of the upper parts of the Mintabie beds are silicified, forming massive silcrete outcrop and contain grey clay-infilled tubules and younger red- infilled tubules similar to those at Coober Pedy (Robertson and Scott, 1987).

DEVONIAN

Sediments of Devonian age intersected in Munyarai No.1 well are absent on the shallow eastern shelf of the basin, being restricted to the deeper parts of the Officer Basin.

MESOZOIC

Waitoona Beds - informally named by Krieg (1973) and described as a coarse grained, poorly sorted, feldspathic, kaolinitic, quartz sandstone unconformably overlying Mintabie beds. By correlation with Brewer Conglomerate (Wells et al. 1970) of the Amadeus Basin, Krieg (1973) attributed a ?Lower Carboniferous age to Waitoona Beds. However they correlate equally well with De Souza Sandstone in the Amadeus Basin, and also with sandstone overlying Mintabie beds and underlying fossiliferous Early Cretaceous shale (Townsend 1981) at Mintabie.

Waitoona Beds are herein correlated with the De Souza Sandstone of the Amadeus Basin, the Cadna-owie Formation and/or Algebuckina Sandstone of the Great Artesian Basin, and unnamed Mesozoic sandstone at Mintabie (Fig.3), and are considered to be of Late Jurassic to Early Cretaceous age.

Marree Subgroup - dark grey marine shale of Early Cretaceous age, generally bleached off-white to buff, and silicified in outcrop. In many areas boulder beds are present near the base. Marree Subgroup is widely distributed through the Great Artesian Basin, forming the white, silcrete capped mesas of the Stuart Range, and extending westwards towards Marla. Isolated outliers of silicified Marree Subgroup claystone cap Adelaidean rocks near Wantapella Swamp (Fig. 3), and Paleozoic rocks of the eastern Officer Basin.

TERTIARY

Unnamed Sandstone - medium to coarse grained, subrounded, quartz sandstones, containing reworked Mesozic and Ordovician sandstone clasts, and Musgrave Block quartz pebbles. In many places it is cemented with silica forming a "greybilly" silcrete, and widely distributed capping mesas through much of the Great Artesian Basin, and Palaeozoic rocks of the Officer Basin.

HOLOCENE

Dune Sand/Alluvium - red aeolian quartz sand forming east-west trending seif dunes of red aeolian sand covering much of the eastern Officer Basin particularly west of the Mintabie scarp. Elsewhere talus, claypans, creek alluvium occur forming a thin veneer over all older rocks.

GEOLOGY OF PRECIOUS STONES FIELD AND ENVIRONS

PREVIOUS INVESTIGATIONS

Geological

The first geological map of the eastern Officer Basin was compiled by Sprigg in 1952 (Plan No. 52-276 in Departmental records), and modified in Sprigg and Wilson (1958). Sprigg used very broad units, combining Cambrian and Ordovician with Mintabie beds and assigned them all a tentative ?Upper Devonian age, that is, he considered Mintabie beds were part of the sequence, or conformable on, Blue Hills Sandstone. Sprigg considered the coarse clastics, (unnamed Mesozoic sandstone), overlying Palaeozoic rocks in the Mintabie - Blue Hills area to be of Cretaceous to Tertiary age.

McKenzie (1959) in a report for Exoil, named the Officer Basin sediments the "Mt. Johns Group" and gave them a broad Lower Palaeozoic age, again incorporating Mintabie beds, as currently defined, in the conformable sequence. The younger coarse clastics were mapped as Cretaceous (Aptian) sandstones.

Packham and Webby (1969), considered the younger coarse clastics to be Carboniferous, relating them to the Brewer Conglomerate, part of the Pertnjara Group of the Amadeus Basin (Wells et al 1970).

Major and Krieg (1972) mapped EVERARD 1:250 000 geological sheet, and in the explanatory notes, compiled by Krieg (1973)., considered the coarse clastics (Waitoona Beds) to be Carboniferous in age.

Geophysical

Numerous geophysical investigations including gravity, aeromagnetics, and seismic, have been carried out over much of the eastern Officer Basin. Seismic work was initiated by SADME in 1969, on the Emu to Officer (EO) line and gravity measurements taken during traverses. Subsequent Departmental and private company seismic lines were traversed giving reasonable control. A summary is presented in Milton (1979) for the Officer Basin in South Australia and by Milton and Parker (1973) for the northern margin of the eastern Officer Basin. A summary of geophysical information together with all geological maps and reports have been collated by Youngs and Pitt (1980).

INVESTIGATIONS 1979-1981

From 1979 the Mineral Resources Section of SADME undertook mapping of the eastern portion of the Officer Basin, its margin and overlying rocks in the Mintabie area.

Opal occurrences were mapped as follows;

- Wallatinna opal diggings (Townsend and Robertson 1980), 15 kilometres south of Mintabie (Fig. 2).
- Vesuvius opal diggings (McCallum 1980), 15 km northeast of Marla.
- England Hill, Ouldburra Hill and Sarda Bluff, 100 km, 185 km and 200 km respectively north west of Coober Pedy (Townsend and Scott 1982).
- Lambina opal diggings, located 50 km east of Granite Downs homestead (Flint 1980).
- Granite Downs (Nichol 1975).

All of these occurrences are reported with locality maps in Handbook No. 5 Opal, South Australia's Gemstone. (Barnes & Townsend, 1982).

A base plan, at a scale of 1:10 000, covering the workings was compiled, the Australian Map Grid (AMG) superimposed and several AMG grid points located on the ground for later grid surveying by A. Hack and N. Edwards of the SADME surveying section.

The Department of Lands produced a contoured photomosaic of the area, at the same scale, from aerial photography flown in Nov. 1978.

Most of the detailed mapping was carried out near the current workings (Old Field) and along the Mintabie scarp over a distance of approximately 4 km.

Open cuts were logged (Figures 4 and 5, Appendix B). Sections were measured along the scarp and on an outlying silcrete capped butte (Figure 4, Appendix C ,Figure 6). Shafts and underground workings were logged (Appendix D, Figures 4 and 5).

Mintabie has been visited annually since the detailed mapping of 1979-81 to monitor expansion and activity on the field and follow the Cretaceous sandstone on Mintabie beds contact, hidden by sand dunes and alluvium away from the scarp. Bulldozer cuts have progressively exposed this contact which can now be presented with greater certainty.

STRATIGRAPHY

Precambrian

Sturtian and Marinoan rocks crop out north of Mintabie between Gap Bore Range and Chambers Range in the core of a broad anticlinal structure.

Adelaidean rocks exposed comprise, in ascending order;

- Belair Subgroup equivalent - multicoloured siltstone with quartzite interbeds.
- Chambers Bluff Tillite - conglomerate and quartzite.
- Wantapella Volcanics - altered vescicular basalt.
- Tapley Hill Formation equivalent - blue-grey laminated siltstone.
- Rodda Beds; equated with Amberoona and Balcanoona Formations of the Adelaide Geosyncline, or Wilpena Group (Preiss 1988) - grey-green and khaki calcareous

and dolomitic siltstone, grey sandy limestone and dolomite and calcareous,feldspathic sandstone and pebble to cobble conglomerate.**Palaeozoic**

Cambrian

Observatory Hill Formation - brown and pink laminated siltstone and shale characterised by platey chert interbeds and chert nodules.

Within the PSF, exposure is limited to small scattered outcrops of brown siltstone with platey cherts cropping out north of Mintabie near Gap Bore. Better outcrops are exposed along the eastern margin of the Officer Basin just south of Wallatinna Homestead (Fig. 3).

SADME Byilkaoora 1 intersected 223 m of Observatory Hill Beds between 156 m & 379 m (Benbow and Pitt 1979).

A basal conglomerate derived from Adelaidean sediments and Musgrave Block granites is exposed along the eastern Officer Basin margin, and southwest of Wallatinna Homestead (Fig.3), where the name, *Wallatinna Formation* (Benbow, 1982) was derived. This conglomeratic basal unit hosts the opal at Wallatinna Opal Diggings (Townsend and Robertson1980).

Arcoeillinna Sandstone (formerly Trainor Hill Sandstone, Lower Member) - well sorted red brown weathering cross bedded arkosic sandstone with interbeds of micaceous siltstone (Benbow 1982). It unconformably overlies Observatory Hill Beds, and crops out poorly in the western end of Gap Bore Range. Best exposures are in Mount Johns Range northeast of Mintabie (Fig. 3) where the unit reaches a maximum thickness of nearly 100 metres. 57 m of Arcoeillinna Sandstone was intersected in Byilkaoora 1 between 98.8 and 155.8 m (Fig.3a).

Mount Johns Conglomerate - red arkosic conglomerate and sandstone near Mount Johns, grades southwards to finer grained dolomitic siltstone, the *Apamurra Member* (Benbow 1982) near Mount Byilkaoora, which separates Arcoeilinna Sandstone from Trainor Hill Sandstone and attains a maximum thickness of 80m in the Mount Johns area down to less than two metres in

Byilkaoora No. 1. (Benbow 1982). Conglomerate is absent south of Byilkaoora No.1.

Trainor Hill Sandstone - white, cross bedded, kaolinitic sandstone containing thin conglomerate bands similar to Mount Johns Conglomerate. A maximum thickness of 370 m was interpreted by Benbow (1982) from the measured type section at Mount Byilkaoora.

Trainor Hill Sandstone crops out boldly on the eastern margin of the Officer Basin north to Mount Johns where it lenses out against overlying Mount Chandler Sandstone.

Ordovician

Mount Chandler Sandstone - greyish white, hard quartz sandstone and quartzite, disconformably overlying Trainor Hill Sandstone. It is slightly feldspathic in the upper part and contains destinctive "U" shaped burrows or pipe rock of organic origin and displays tabular crossbedding.

Mount Chandler Sandstone crops out boldly around the eastern margin of the basin from Cartu Hill in the south to Mount Johns in the northeast and westward to Blue Hills Range (Fig.3). It is thickest in the Mount Johns region where it attains 100 m (Krieg 1973). In the northern part of the PSF near Gap Bore a tough recrystallised quartzite crops out strongly and dips nearly 70^0 southwards (Sample RS 238 Appendix D).

Indulkana Shale - red and green shale and calcareous siltstone separates Mount Chandler Sandstone from the overlying Blue Hills Sandstone. It is best exposed as a narrow bed in the Mount Johns area where it attains a maximum thickness of 60 m. Generally, outcrop is poor and often the unit is hidden by soil cover in a valley between the two resistant sandtones it separates.

Blue Hills Sandstone - red-brown weathered, fine to medium grained, well sorted, kaolinitic sandstone with massive white quartzite and thin sandstone interbeds. The upper part of Blue

Hills Sandstone comprises massive beds of quartzite interbedded with thin cross-bedded kaolinitic sandstone. It becomes more kaolinitic upwards and is capped conformably by the kaolinitic sequence of Mintabie beds.

Blue Hills Sandstone reaches a maximum thickness of approximately 1 300 m and crops out prominently in the Blue Hills and Mount Johns Ranges and at Cartu Hill. Outcrop can be mapped discontinuously between these prominent ranges. Red brown weathered slightly kaolinitic sandstone with large scale cross-bedding, crops out in the Trainor Hill area (Fig. 3) on the eastern boundary of the PSF. Within the PSF, sandstone and massive white quartzite (RS 237 Appendix D) crops out in the Gap Bore range along the northern margin.

White massive quartzite which correlates with Blue Hills Sandstone crops out 1 km southwest of Old Field and 1 km further west (Fig.4).

Mintabie beds - white, medium to coarse grained, well sorted, kaolinitic sandstone with thin graded bedding. Large scale cross bedding is prominent (Plate 20) and in less weathered exposures green clay interbeds are present.In the lower unit red-brown and chocolate, clayey sandstone and siltstone crop out poorly. The top is eroded but drillhole data suggest Mintabie beds are over 100 m thick and probably much thicker towards the centre of the Officer Basin.

Within the PSF, Mintabie beds crop out boldly along a prominent northwest-southeast trending scarp on cuesta (frontispiece) and in a number of low hills and mesas north of the scarp and east to Apamurra Bore (Fig. 4).

Scattered low outcrops are present in interdune corridors 1-2 km south and west of the escarpment but eslewhere Mintabie beds are covered by Cretaceous, Tertiary and Holocene sediments. Mintabie beds are exposed in low cliffs at Pundalarinna Lagoon and southwest towards Printie Bore scattered outcrops of kaolinitic sandstone are correlated with Mintabie beds (Fig. 3).

This indicates their continuation southwestwards into the central Officer Basin.

Mesozoic

Late Jurassic to Early Cretaceous

Unnamed sandstone - a medium to very coarse grained, poorly sorted, kaolinitic, quartz sandstone unconformably overlies Mintabie beds and older rocks.

Within the PSF in bulldozer cut No. 16 (Fig. 5) 2 m of medium to coarse grained, poorly sorted, kaolinitic sandstone infills a channel cut into the Mintabie beds (Plate 22). Sandstone is overlain by fossiliferous Marree Subgroup of Early Cretaceous age.

In the southwestern portion of the PSF and in the Pundalarinna-Printie Bore-Munda Hill area, numerous outcrops of poorly sorted kaolinitic sandstone with occasional quartzite clasts, overlie Mintabie beds. Outcrop is poor and limited to low hills and interdune corridors. Stratigraphic relationships are uncertain but this sandstone is lithologically similar to channel fill sandstone at Mintabie. In many places Mesozoic sandstone was reworked and silicified during Tertiary times.

Northeast of the PSF in the Wantapella Swamp-Granite Downs area, medium to coarse grained,poorly sorted, kaolinitic sandstone infills channels cut into weathered Precambrian rocks, and is correlated with Cadna-owie Formation (Wopfner et al 1970) of Late Jurassic to Early Cretaceous age.

South, in the Wallatinna Waterhole area and eastwards onto WINTINNA, up to 10 m of medium to very coarse, quartz sandstone crops out in low hills and escarpments. These sediments are correlated with the Algebuckina/Cadna-owie Formation and the unnamed sandstone at Mintabie, and represent the basal Great Artesian sediments onlapping the eastern Officer Basin. West of the PSF, in Blue Hills to Bilka Bilka Tank area, conglomeratic sandstone overlies unconformably Blue Hills Sandstone. Krieg (1973) named these coarse clastics Waitoona Beds but they are here considered to be a coarser facies equivalent of the unnamed sandstone at Mintabie. They are considered to correlate directly with De Souza Sandstone in Northern Territory and Algebuckina Sandstone in the South Australian portion of the Great Artesian Basin. Both sandstone and conglomerate facies are shown as unnamed sandstone (Fig. 3.)

Early Cretaceous

Marree Subgroup - a grey, marine clay containing silt and sand lenses, now deeply weathered, chemically altered and variably silicified.

Only one good exposure was observed within the early workings, in bulldozer cut 16 (Fig. 5, Plate 22). Two to three metres of sandy claystone with thin coarse grained, sand lenses overlies unnamed channel-fill sandstone. An irregular boulder bed near the base contains quartzite and siltstone boulders up to 0.75 m in length (Plate 23) in a silty claystone matrix. The claystone in part strongly silicified and contains fossil molluscs, *Gari forbesi* (Ludbrook, Plate 24), which confirm an Early Cretaceous (Aptian) age, (Townsend 1981). Bleached, partly silicified, Marree Subgroup claystone crops out extensively southeast and east of Mintabie near Ammaroodinna Hill and on WINTINNA. It is likely that there are many other small outliers of Marree Subgroup overlying older rocks in the eastern Officer Basin but obscured by Tertiary to Holocene sediments.

West of the PSF in BilkaBilka - Watjal Tank area, quartzite cobbles and boulders litter the surface on many low rises, indicating erosion of basal Marree Subgroup.

Widespread scattered remnants of Marree Subgroup suggest an early Cretaceous sea covered large areas of the eastern Officer Basin.

Tertiary

Miocene

Mount Sarah Sandstone - medium to coarse grained mature quartz sandstone, in many places strongly silicified ("grey billy" silcrete) crops out in the PSF and surrounding areas. This sandstone often appears to be derived locally from underlying Mesozoic Sandstone or Palaeozoic rocks rather than fluviatile Tertiary sands or grits transported any great distance.

Ages of deposition and silicification are difficult to determine and likely to span much of the Miocene.

On the escarpment at the southern edge of the opal workings, up to 3 m of medium to very coarse sandstone (Sample RS 199 Appendix D) overlies Mintabie beds with sharp contact. Small quartz pebbles and occasional silcrete pebbles are incorporated in the sandstone. Thin claystone interbeds are present and both sandstone and claystone have been strongly silicified by opaline silica forming tough massive silcrete and porcellanite. This silicified sandstone is considered to be of Tertiary age and may correlate with ? Miocene silicified sandstone overlying Marree Subgroup in the Stuart Range (Pitt and Barnes, 1977).

West from the scarp, silcrete outcrop is poor and occurs either as float in interdune corridors, or rubbly outcrop on low, rounded hills. Silicified sandstone caps Mintabie beds and unnamed Mesozoic sandstone in the Pundalarinna Lagoon- Munda Hill area.

Although it is almost impossible to determine stratigraphic relationships between silicified sandstone and the underlying rock, much of the sandstone appears to have been derived locally rather than being transported large distances, but most silcrete shows some evidence of reworking and incorporation of younger detritus. Deposition and silicification is likely to have spanned a long period of time. The main silicification occurring at the top is considered to be the same age everywhere and all silcrete is shown as equivalent to Mount Sarah Sandstone (Miocene) (Figure 3).

Holocene

Dune Sand/Alluvium - red brown aeolian sand and east-west trending seif dunes, overlie older rocks.

Below the escarpment, alluvial silt flats and claypans have been developed away from the coarse sand and gravels of the major drainage channels.

STRUCTURE

Palaeozic rocks of the eastern Officer Basin have been folded into a broad syncline, gently plunging southwesterly. In the eastern lobe, dips are low, less than 10^{0}, but the rim has been sharply upturned to 60^{0}. Upturning is most apparent at Gap Bore Range north of Mintabie where Blue Hills Sandstone dips at 60^{0}S but flattens southwards to less than 10^{0} within half a km.

The over-steepened marginal dip plus the presence of macro cross- bedding (primary dips) have resulted in some confusion in structural interpretation.

The broad eastern lobe has been repeatedly but gently folded about slightly arcuate northwest - southeast trending axes parallel to the scarp. In the Mintabie area where more detailed structural information is available, five separate fold axes have been interpreted and are shown by the wavy outcrop pattern on the basin margin (Fig. 3). These folds have formed gentle southwest and northeast dips (generally less than 10^{0}) and bring Blue Hills Sandstone to the surface 1 km southwest of Old Field (Section Fig. 4).

Mintabie scarp is the southwestern limb of an eroded anticline.

At the margin of the structural syncline, large-scale faulting displaces Palaeozoic rocks. However only one significant fault has been recognised within the Mintabie workings although several prominent opal bearing joints occur parallel to these axes.

GEOLOGY OF OPAL DIGGINGS

The oldest rock unit exposed at Mintabie is a small outcrop of Blue Hills Sandstone near drillhole 1, (Fig. 4) 1 km southwest of the Old Field. Mintabie beds, which conformably overlie Blue Hills Sandstone, crop out extensively along the escarpment and have been intersected in most diggings.

Along the southern margin of the diggings Mintabie beds are unconformably overlain by thin Mesozoic sandstone and Early Cretaceous Marree Subgroup and are capped by thin silicified Tertiary Sandstone and Holocene sand.

The rocks are described below in ascending stratigraphic order.

PALAEOZOIC

Blue Hills Sandstone - a fine to medium grained, massive meta-quartzite which crops out at several localities on the field and has been intersected in many prospecting drillholes. Bedding is difficult to discearn in small outcrops but at two localities, near drillhole 1 and 1 km further west, bedding can be seen at two local highs with Mintabie beds dipping conformably away from Blue Hills Sandstone. It is unlikely that opal of any quality will be found in Blue Hills Sandstone which has proved too hard for auger-rig penetration. Shallow undulating Blue Hills Sandstone has become a natural boundary on the northern side of Grasshopper Ridge in prospecting for host rock, Mintabie beds.

Mintabie beds

(a) Lithology

Detailed lithology of Mintabie beds is given in Appendix D (Samples P 715 & P716/68, RS 200-204 RS 217 RS 245 and RS 271). Locations for these samples are shown on figures 3, 4 and 5.

Using measured sections and drillholes 1, 2 and 3, which penetrated siltstone and claystone below the massive sandstone prominant in the scarp the Mintabie beds were separated into two Members.

Mintabie beds, lower member (units 1-4). Basal beds of sandstone lie conformably on Blue Hills Sandstone at Cartu Hill and Blue Hills Range and the two localities southwest of Old Field where the contact can be observed.

Drillhole 1 (Fig. 7) is interpreted as intersecting Blue Hills Sandstone and hence contains the lower member of Mintabie beds.

Drillhole 3 (Fig. 6) was logged by R. Shepherd (Hydrogeology Section) from cuttings laid out on the ground. It intersected almost 80 m of interbedded siltstone, sandstone and shale below 13 m of white kaolinitic sandstone. Drillhole 2 was logged by Sheard (1981) and is depicted in Fig. 6. Unit numbers have been allocated to prominent lithologies observed in drillholes and outcrop.

<u>Unit 1</u> (15 m^+) In the Mintabie opal diggings the lowest unit intersected is predomiantly a claystone. (Drillholes 1 & 2). At the margin of the basin a sandstone unit overlies the Blue Hills Sandstone and grades upwards to a claystone which Krieg (1973) named Cartu Beds. The claystone is sandy and green-grey to brown in colour.

<u>Unit 2</u> Sandstone, clayey chocolate-brown to red-brown (25 m^+) with siltstone interbeds. In the drillhole it appears to be coarser grained and the clay is bleached white (kaolinitic).

Unit 3 Siltstone and sandstone, in red-brown and white 10 m) bands are interbedded with red and red-brown claystone and clay.

Unit 4 Claystone, brown and grey-green in colour, sandy (4 m) in part. A green, silty claystone crops out south of Apamurra Bore and is interpreted as correlating with claystones intersected in Drillhole 2.

Mintabie beds, upper member (units 5-11)

Unit 5 Sandstone, massive off-white to yellow brown in (6 m) colour, is feldspathic and is fine to coarse grained. It is cross-bedded and forms a prominent band in the scarp south of Drillhole 2.

Unit 6 Sandstone, yellow , fine to medium grained (5 m) and clayey. It is much less resistant than units 5 and 7. It is generally scree-covered and forms a steep slope between the bounding resistant sandstones.

Unit 7 Sandstone, white to off-white in colour, medium- (2-4 m) grained. It is kaolinitic, silicified and cross-bedded (Plate 20). Weathering has removed the more clayey bands enhancing the macro cross-bedding.

Unit 8 Sandstone, friable, off-white and clayey and fine (5 m) to medium grained.

Unit 9 Sandstone, partly silicified off-white to pale (2 m) yellow, medium-grained and cross-bedded in part. Flat-bedding is the more dominant while cross-bedding is of a smaller scale than unit 5 in section 3 (Appendix B) (Fig. 6).

Unit 10 (15 m) Sandstone, red, white, yellow and pink, kaolinitic and clayey. It is less resistant to weathering than units 5, 7 and 9 and much is scree covered. It is similar to unit 11 but contains more clay. The unit is also opal-bearing.

Unit 11 (?15 m+) Sandstone, fine to medium grained with some coarse bands. It is kaolinitic and variably silicified in the upper 3-5 m and contains macro cross-bedding and flat-bedding, both of which are emphasised by weathering and silicification (Plates 15 and 16). Bedding below the zone of silicification can still be observed but is much less obvious. (Plates 21 & 26).

Most of the workings at Mintabie occur in this more massive cross-bedded kaolinitic sandstone and continue into unit 10 - both of which have been variably silicified and are difficult to distinguish in the subsurface.

The upper member of the Mintabie beds dominates the Mintabie scarp, the dominant lithology being a white, fine to medium grained, well sorted, feldpsthic sandstone .

Most exposures display a fine-grained, kaolinitic sandstone, alternating with a coarser-grained, more quartzose, massive sandstone, as shown in Plate 21.

Clay interbeds which highlight bedding, are common throughout the upper member and clay lenses occur up to 0.5 m thick. In some of the open-cuts the clay bands are often pale green to pale-yellow in colour but in outcrop, are generally bleached white. In outcrop near cut 11, however, (Fig. 4), west of Appamurra Bore, the green colour is preserved by silicification. The cause of the green colouration is unknown as the silicified sample was composed almost entirely of quartz (A 2571/79 Appendix D).

Adjacent to cut 11 a claystone interbed exhibited a bioturbation-like structure. However this may have resulted from desiccation cracks being infilled with sandstone. Within the sandstone, the clay is generally kaolin, although halloysite and alunite have been identified (RS 209 Appendix D). Red-brown, silty sandstone has been observed in gullies at the base of the escarpment near measured section 3. This is considered to be an iron-stained, less weathered variation of unit 6, the upper member of Mintabie beds.

Yellow and red-brown iron-staining is also present to the north of the airstrip at measured section 2 (Fig.4).

In the prominent more massive units, Mintabie beds display macro and micro cross-bedding (Plates 20 & 21) and graded-bedding is common. They are variably silicified and in the uppermost 5 m (Plates 15 & 16) silicification has created a very tough massive silcrete.

In many places Mintabie beds contain infilled cylindrical structures or tubules. These tubules are of two generations; the older ones are infilled with grey, silicified claystone, and younger ones with red, silty to sandy material. Both are thought to be insect burrows similar to those at Coober Pedy (Barker 1980, Robertson and Scott, 1987).

Composite thicknesses from drillholes, outcrops and bulldozer cuts suggest that Mintabie beds are over 100 m thick. They comprise an upper, resistant sandstone member and a lower, generally finer grained, less resistant sandstone and shale member.

Drillhole 3 (Appendix C) penetrated 90 m of interbedded sandstone, siltstone and shale, of which 77 m are the lower member of Mintabie beds. Blue Hills Sandstone was not intersected.

The top of the Mintabie beds is undefined because the upper member sandstone dips basinward and could increase in thickness greatly.

(b) Structure

Throughout the field, Mintabie beds occupy the southwestern limb of a broad anticline trending northwest - southeast, and dip 5° to 10° southwesterly. The crest and northeast limb are eroded and Mintabie beds are obscured by younger sediments except for the lone mesa north of the escarpment, (measured section 4, Fig. 6) and smaller remnants west of this mesa.

Mintabie beds are well jointed particularly in the upper silicified portion. Joints observed are steeply dipping and tend to be of limited lateral extent although some extend a few tens of metres, (Plate 25, open cut 3 Appendix B).

The predominant orientation of the joints is parallel to the scarp in cuts (3, 9, and 14) (Appendix B) whose major joint directions are between 310° and 320°. These joints are caused by folding of competent rocks (eg. sandstone) and they parallel the fold-axis.

Opal has been found on prominent joints at right angles to the fold-axis. Cross-joint directions measured in opal producing *verticals* in Shafts 4, 8, 14 (Plate 25 and Appendix C) and in cuts 7 and 14 (Appendix B) varied between 215° and 220°.

While variations in joint directions occur the known good opal finds have mainly been confined to joints in these directions. More opal is found on bedding planes or *levels* than is found in joints or *verticals* but the quality from some *verticals* has been excellent.

Slickensiding was observed underground in shafts S4 and S5 dipping generally south-west at 20° and similar to primary bedding on foreset beds. This was the only direction of movement observed although minor displacements on joints (*slides*) must have occurred to produce the saccharoidal opal found in some joints.

(c) Age

Early workers, notably Sprigg (Sprigg & Wilson 1958) included Mintabie beds within a conformable lower Palaeozoic sequence. Krieg (1973 separated Mintabie beds from the underlying Cambro-Ordovician sequence and assigned a ?Devonian age to them.

The break between 'Cartu beds', the uppermost unit of Krieg's Cambro-Ordovician sequence, and Mintabie beds was based on;

- marked lithological difference between Cartu beds and Mintabie beds
- a supposed angular unconformity between the Cambro-Ordovician sequence and Mintabie beds.

As described by Krieg, 'Cartu beds' comprise kaolinitic sandstone with interbeds of green claystone and red-brown sandstone, and are conformable on Blue Hills Sandstone. This lithology is identical to that of lower parts of the Mintabie beds as exposed in bulldozer cuts and shafts and around the base of the escarpment.

Thus 'Cartu beds' are considered to be a more shaley less weathered variation of the Mintabie beds, and are not a separate unit. The contact between Krieg's Cartu beds and Blue Hills Sandstone, where observed north of Cartu Hill and south of Blue Hills, is conformable, with interbeds of quartzite and softer kaolinitic sandstone. This is conformably overlain by kaolinitic sandstone, identical to Mintabie beds. Interbeds of siltstone and shale increase above this basal kaolinitic sandstone.

The structural break between Blue Hills Sandstone and Mintabie beds is not supported by recent mapping. The concept of this break was based on;

- moderate southerly dips in Blue Hills Sandstone in the Gap Bore area, contrasting with shallow southwesterly dipping Mintabie beds

- moderate westerly dips in Blue Hills Sandstone in the Sailors Well area, as shown on EVERARD, in contrast to the shallow dip at Mintabie.

It is considered that the moderate dips in the Gap Bore range are the result of local upturning of the syncline rim as immediately south of the range, Blue Hills Sandstone is nearly flat lying and of the same attitude as nearby Mintabie beds.

The moderate dips recorded on Blue Hills Sandstone in the Sailors Well area are believed to result from measurements on macro cross-bedding as the overall dip in this area is only about 5^0 to the southwest. On the eastern edge of the PSF Blue Hills Sandstone dips about 5° southwesterly and although the contact between Blue Hills Sandstone and Mintabie beds is not exposed, Mintabie beds a few hundred metres further west dip at the same angle.

Where exposed southwest of the opal field, Blue Hills Sandstone dips about 3° south-westerly, similar to the overlying Mintabie beds.

Both Mintabie beds and Blue Hills Sandstone have been gently folded about northeasterly - southwesterly fold axes, and where in contact, or in close proximity, have the same attitude.

Mintabie beds conformably overlie Blue Hills Sandstone, and are therefore of similar age i.e. Middle to Late Ordovician, based on a Middle Ordovician age for the Indulkana Shale (Webb 1978).

MESOZOIC

Unnamed Sandstone and Marree Subgroup

Unconformably overlying Mintabie beds is a 2-8 m thick sequence of sandstone and sandy claystone of Mesozoic age. These rocks crop out south of Old Field in the scarp and are exposed in bulldozer cuts and several shafts. The best exposure is in bulldozer cut 16 (Plate 22 ,and Appendix B). The unnamed sandstone infills a channel cut into Mintabie beds. It is correlated with Algebuckina Sandstone/Cadna-owie Formation of the Great Artesian Basin, De Souza Sandstone of the Northern Territory and 'Waitoona Beds' further west in the Officer Basin. The overlying claystone contains shelly fossils (Plate 24) which establish an Early Cretaceous age, thus correlating the unit with Marree Subgroup in the Great Artesian Basin (Townsend 1981). Weathered greyish-green clay and sandy clay, in places containing quartzite cobbles and boulders, was intersected in several shafts around the southern margin of the opal field (Fig. 5) and in several Calweld drill holes southwest of the field (Fig. 4).

In many places, Marree Subgroup claystone rests directly on Mintabie beds, the unnamed Mesozoic sandstone being restricted to infilling of channels. (Section A-A', Fig. 4).

CAINOZOIC

Tertiary

Mount Sarah Sandstone equivalent

Up to 3 m of strongly silicified sandstone and silcrete crops out near the top of the escarpment immediately southeast of the diggings. The sandstone, which is medium to very coarse-grained and contains some reworked silcrete clasts, is of presumed Miocene age (samples RS 199 and 218 Appendix D). The silicified sandstone thins westwards and is absent over most of the area of opal workings, silcrete in this area resulting from silicification of Mintabie beds.

Silicification of Tertiary sandstone, Cretaceous sandstone and shale, and Mintabie beds, is thought to be contemporaneous, and to be of late Tertiary, Miocene to Pliocene age.

Quaternary (?Pleistocene)

In several places on the upper slopes of the escarpment, notably about 1 km north of the airstrip (Fig. 4) there are small exposures of bright red-brown, moderately well cemented, sandy silt and conglomerate containing pebbles and cobbles of Mintabie beds.

The characteristic colour and lithology of these sediments suggest that they are of the same age and origin to similar sediments widespread throughout the north of South Australia. The calcrete and gypcrete, often developed in these sediments elsewhere, however, are not evident at Mintabie. The sediments, of presumed Pleistocene age, are thought to equate to widespread, 'lateritic' soils capping much of the Stuart Range southeast of Mintabie. At Coober Pedy these sediments, known as Russo Beds (Robertson and Scott,1987), are up to 10 m thick but at Mintabie are less than 1 m. The red-brown silt and sand also infills tubules and both horizontal and vertical joints in the upper part of Mintabie beds, (Plates 15 and 16).

Holocene

Bright red-brown, aeolian sand overlies Mintabie beds over most of the field. In interdune corridors the sand is 0.5 m to 3 m thick, while the southeasterly - northwesterly trending longitudinal dunes are up to 10 m high.

Below the escarpment, alluvial silt and clay obscures all older rocks.

DISTRIBUTION OF OPAL

COMPOSITION AND STRUCTURE

Opal is comprised of silica and water($SiO_2.nH_2O$) and precious opal generally has a water content of 6-10%.Examination of opal using the Scanning Electron Microscope has shown precious opal to be composed of regularly arranged minute spheres of silica (Plate 28). (Sanders 1964). This regular array of predominantly cubic close-packed spheres diffracts white light from the voids into a complete spectral array, which can be seen by rotating the specimen while observing a particular colour area.

Water in precious opal is contained in the voids, probably in the form of water vapour. Silica spheres are cemented by silica, partly filling the voids, and if completely filled, results in clear glassy *potch*. If only small voids remain, well-cemented crystal opal results.

The colour of opal is determined by sphere size, as well as the regular sphere arrangement; red colour is produced by largest spheres (up to 400 nm, 1 nanometre = 10^{-9}m.) and rotation will produce all the spectral colours.

Green and blue opal colours are produced by spheres of 250 nm size while the purple & blue coloured opal is produced by spheres of 150 nm diameter.

Below 150 nm, *potch* results even if the silica spheres are well ordered.

More detailed descriptions are outlined in 'Opal, South Australia's Gemstone' by Barnes and Townsend (1982).

Work carried out on Mintabie *potch* has shown that in white *potch*, the sphere size is very small to undetectable and is unordered (Plate 30). Black *potch*, however, contains some spheres of the size to show a red colour (greater than 360 m) but they are variable and are unordered or only partly ordered (Plate 29).

Several authors have suggested various reasons for black opal. Darragh (1976) suggests fine carbon inclusions and O'Leary (1977) finely divided iron oxide. It is not known what causes the black colour in Mintabie *potch* but the author considers it to be a function of void size. Black *potch*, for example, can turn white when it is exposed to the sun, the resulting cracks and crazes forming larger voids for reflection and dispersion of white light. Some dark inclusions have been noted in precious opal, however, suggesting black potch could arise through appropriate void size and inclusions.

FORMATION

By successfully synthesising opal in the laboratory, Darragh and Perdix (1973) were able to demonstrate that opal forms from the slow and ordered deposition of silica spheres of the required size from a colloidal suspension. The laboratory process was improved by Pierre Gilson who manufactured and marketed synthetic opal from the early 1970's and later sold the process to the Japanese.

Natural opal is thought to have been deposited from silica-rich ground water, permeating through rock. Silica in ground water is derived from weathering and alteration of silicate minerals, such as feldspar and montmorillonite, forming predominantly kaolin and silica which can be dissolved in small amounts in ground water. A rising and falling water table, caused by varying weather conditions, would concentrate silica during prolonged arid periods and the resulting colloidal suspension could deposit silica spheres in perched water tables or cracks and fissures in favourable beds.

Accumulation must be very slow to produce an ordered array of similar sized spheres. A fast rate of deposition would cause haphazard arrangement or variable sphere size, or both, generally producing *potch*. Several accumulations of opal and possibly some *potch* layers, produce the final seam which may be horizontally banded. Precious opal is occasionally deposited in the pore-space between sand grains. More often it was deposited very quickly, thus forming common opal-cemented sandstone known as silcrete or porcellanite. Opal may well have been formed at the same time as much of the silcrete throughout Australia, during Late Tertiary. Dr A.R.Milne (pers. comm.), who has been working on the age of silcrete and opal at CSIRO, suggests an age of 18 million years ago for the formation of most Australian opal.

OCCURRENCE

At Mintabie, opal occurs within Early Palaeozoic Mintabie beds. At Wallatinna, precious opal occurs in Cambrian conglomerate (Townsend & Robertson 1980). *Potch* and some precious opal has been found on Granite Downs about 40 km northeast of Mintabie, in weathered, Precambrian, granite gneiss (Barnes & Townsend 1982).

Cretaceous sediments host precious opal at Vesuvius 20 km northeast of Marla.

VERTICALS

Verticals at Mintabie consist of near vertical joints or joint planes which persists for only a few centimetres up to 10's of metres as in plate 25, shaft 14 and Cut 3. (Appendix B & C).

They appear to be related to the cross folding axis which produced the escarpment and occur both parallel to the axis (315^0 - 320^0) and nearly at right angles (220^0). *Verticals* in these directions have produced good opal including some top quality black opal, particularly in Old Field.

Verticals have probably not produced the same quantity of opal as seams but the quality from some *verticals* compares favourably with the best black opal from Lightning Ridge. Joints observed appeared to exhibit little movement but saccharoidal opal must have undergone some slight, secondary movement to crush the opal. Slickensiding may also be post opalisation as no opal was observed in these structures.

Verticals observed in cut 3 (Appendix B) extend 30 metres diagonally across the cut, and beyond, but few were traceable from one cut to an adjacent one. However several *verticals* were reported to extend for 150 m at Grasshopper Ridge.

Verticals vary from pencil line thickness to an average of 3-5 mm but occasional *verticals* of up to 20 mm occur. No vertical greater than the 20 mm thick opal piece shown in Plate

31, was observed at Mintabie. Most *verticals* were filled with white, *bony potch*, yellowish in places, or pale blue *potch* often enveloped by black *potch* at the contact with adjacent sandstone. *Verticals* occurred from the surface down to 20 m and there were no indications to suggest that they do not extend to greater depth.

Floaters derived from surface *verticals* and eroded into gullies led to discovery in 1922? and have been observed near the native well (Plate 2) during mapping in 1980.

LEVELS

Most of the opal at Mintabie has come from *levels* which occur either along sandstone bedding planes or from near horizontal planes which cross-cut bedding. Many *levels* are ironstained (Plates 9, 26 & 27) which the miners believe is a good sign, although the iron is introduced at a later stage than the opal. Iron staining indicates some remnant porosity, however, which suggests opalisation may have occurred through groundwater movement. Silicification occurs along bedding planes forming sandstone bands of light-grey colour, cemented by opaline silica (RS 207 Appendix D). Opal seams may occur within the band or at the sandstone boundary which sometimes show speckled colours, as the porespace is filled with precious opal.

Some *levels* have been followed for 10's of metres without making a *pocket;* a lens shaped thickening of precious opal. A *pocket* may also occur as a small area within a seam of say 5 mm thickness, that for no apparent reason, displays good colour while surrounded by *potch*.

Seams have been observed from near surface (1-2 m) down to 23 m although the upper 15 m appears to be the optimum for the occurrence within units 10 & 11 of Mintabie beds. *Slides* or *slips,* so named by the miners, are generally cross-beds or oblique joints sometimes filled with opal but there appears to be no displacement. Seams, *levels* or oblique joints vary from 1-2 mm up to approximately 20 mm, although thicker seams are found at other fields. Depths at which opal occurs varies greatly even in adjoining claims. Indications from opal occurrences in bulldozer cuts and shafts suggest that *levels* are discontinuous and are not laterally extensive.

TYPE AND QUALITY

The colour and quality of opal from Mintabie can match that from any Australian field. Black opal can equal the best from Lightning Ridge, crystal opal, the best from Andamooka and White Cliffs and the crystal and milky-white opal is similar to that from Coober Pedy. *Verticals* at Mintabie appear to have produced the best quality black with good crystal opal, while seams or *levels* have produced good quality semi-black , crystal and white pinfire opal.

The value of rough opal produced from Mintabie varies from $20-$30 an ounce for low quality white opal through $200 -$300 per ounce for good quality crystal-fire opal up to $6 000 -$ 8 000 per ounce for good quality black opal.

When cut and polished, Mintabie opal sells for;

- $ 10 - $100 per carat for white opal,
- $ 100 - $500 per carat for good crystal opal
- $ 500 - $10 000 per carat for the darker opal (blue green to black opal) and up to $10 000- $12 000 for thick, top grade crystal with black *potch* backing.

These figures are highly subjective but cover most variations quoted by dealers and miners in 1989.

Some of the opal shows tendency to crack and, initially, this characteristic gave Mintabie a bad name. However, the mining and marketing of top quality opal has since lived down that reputation.

The suspect opal appears to have been recovered from below the water table from *seams* and *verticals*. Shallower dry occurrences usually produce solid opal free from cracking. Some *verticals* in shallower sandstone, contain sugary crumbly opal resulting from slight movements along joints, subsequent to opalisation. This opal generally breaks up on mining and does not get into the market, other than as chips, so does not pose a problem.

Excessive explosive charges or firing of shots close to pockets of opal cause cracking but such opal tends to fall to pieces on recovery and finds its way into chip-jars or onto mullock heaps.

POTENTIAL

Opal has been found over a distance of 6 km along the escarpment from Old Field in the southeast to Grasshopper Ridge in the northwest. In the corridors between sand dunes, opal has been found a distance of 2-3 km from the scarp. Southwest of the scarp, thickening sand may hamper exploration necessitating drilling for prospecting purposes.

There is a possibility of finding opal in Cretaceous sediments which appear to thicken south of the diggings. Vesuvius and Lambina opal diggings to the west- northwest of Mintabie and Sarda Bluff (35 km west of Marla Township) produce opal from Cretaceous sediments (Barnes and Townsend,1982). Opal might be present in an Andamooka type *level* associated with basal boulder-beds, or similar to Coober Pedy in *levels* and *verticals* in claystone above the basal boulder-bed. Further there is a possibility of opal at or near the contact with the overlying Tertiary similar to Ouldburra Hill 40 km southwest of Marla, (Townsend and Scott 1982) as much of the silcrete is silicified with opaline-silica.

Although precious opal at the Wallatinna opal diggings occurs in rocks of Cambrian Age, indications are that Cretaceous sediments once thinly covered these diggings as remnants are preserved 15 km north at Mintabie and in outcrops south of Moyles Dam (Fig. 3).

Thus most outcrops in the Wallatinna Homestead area through to Ammaroodina Hill which were probably covered with Cretaceous and Tertiary sediments have the potential to produce precious opal.

HYDROGEOLOGY

Water supplies from Mintabie and surrounding areas were investigated and reported by Shepherd and Read (1979).

Samples taken from Apamurra Bore, Sailors well and from the town water supply bore, (Fig. 3), proved to be potable except for children under the age of 5, when nitrates can cause problems (Appendix E).

Pump testing was carried out in May 1979 on the town bore; results are a report by Sheard (1981).

Mintabie town water supply, (Drillhole 4 Appendix C) was drilled prior to 1979; pump tests indicated that at 30 m^3/day, and subject to population increase, the bore would probably fail within 2 years and hence alternative sources were sought.

Drillhole 1 (drilled by SADME) discovered water at 42.5 m with a standing water level at 9.2 m below ground level (R.L. 359.3) (log in Appendix C and depicted in Figure 7) . It was drilled as an alternative water supply to the town bore but with a salinity of 2737 mg/l was well above the recommended maximum level of 1500 mg/l for human consumption.

A well drilled below the escarpment east of the airstrip produced high salinity water (1958 mg/l) and a small supply of 4 m^3/day the water level being 11.25m (R.L. 341.7) (log in Appendix C, drillhole 2 and see Figure 6).

In shaft 12 (Appendix C) standing water was measured at 9.1 m from surface (R.L. 367.9) and in shaft 11 at 9.5 m (R.L. 366.5).

Perched water tables occur as in Shaft No. 8, where water was intersected and a small seep existed in the access shaft between 16-20 m, but was dry below. Similar seeps have been reported elsewhere.

Within the area of opal workings a permanent water table is not apparent but beyond (Fig. 4), it appears to be more consistent.

SUMMARY AND CONCLUSIONS

1. Mintabie beds which host opal occurrence are of probable Middle Late Ordovician age.
2. Marree Subgroup sediments (Early Cretaceous) comprise a marine shale with a basal boulder-bed overlying a kaolinitic poorly sorted sandstone
3. Opal occurs in:-
   - *verticals*, joints from 1mm up to 20 mm, the two prominent directions being nearly parallel to the Mintabie Scarp (315 - 320 °) and at right angles (approximately 215 °)
   - *Levels*: near-horizontal fractures which follow and cut across bedding within sandstone of Mintabie beds.
4. Opalisation is associated with the younger of two major periods of silicification probably of Miocene age.
5. Top quality black Mintabie opal rivals black opal from Lightning Ridge or crystal opal from Andamooka and Coober Pedy. As at other fields opal recovered from water tables may crack during recovery or polishing but opal recovered from dry rocks has no such tendency.

ACKNOWLEDGEMENTS

The author wishes to thank the Mintabie Area Officers Mr. Ian Kimber (and his wife Karla) and Steve Sigler (and his wife Sonia) without whose help, cooperation and knowledge this report could not have been written. The cooperation received from the miners at Mintabie was greatly appreciated in allowing access to workings.

REFERENCES

Barker, I.C., Barnes, L.C. and Benbow, M.C., 1979. The Russo Beds, Q. geol. Notes, geol. Surv. S.Aust., 71: 2-7.

Barker, I.C., 1980. The Stratigraphy and Opal Occurrences of the 14 and 17 Mile Opalfields, Coober Pedy, South Australia. M.Sc. thesis, University of Adelaide.

Barnes, L.C., 1974. WINTINNA 1:250 000 geological sheet SG153-14 (unpublished - preliminary) Geol. Surv. S. Aust.

Barnes, L.C. and Pitt, G.M., 1976. Silcrete, sediments and stratigraphy. S. Aust. Dept. Mines report 76/119 (unpublished).

Barnes, L.C. and Pitt, G.M., 1977. The Mount Sarah Sandstone. Q. geol. Notes geol. Surv. S. Aust., 62:2-8.

Barnes, L.C., Townsend, I.J. and Nicol, G.J., 1980. Opal in South Australia. S. Aust. Dept. Mines and Energy report 80/26 (unpublished).

Barnes, L.C., and Townsend, I J., 1982. Opal, South Australia's Gemstone. S. Aust. geol. Surv. Handbook No. 5.

Benbow, M.C. and Pitt, G.M., 1979. Byilkaoora No. 1 well completion report. S. Aust. Dept. Mines and Energy report 79/115 (unpublished).

Benbow, M.C., 1982. A revision of the Early Cambrian - ?Devonian Stratigraphy of the eastern Officer Basin based on detailed mapping of the Mount Johns Range. S. Aust. Dept. Mines report, R.B.

Briand, R., 1970. White man in Hole. Abbert Litho Arts, Melbourne.

Brown, H.Y.L., 1904. Opal. Rev. Min. Operations., S. Aust. 2:12.

Carr, S.G., Olliver, J.G., Conor, C.H.H. and Scott, D.C., 1979. Andamooka Opal Fields. The Geology of the Precious Stones Field and the results of the subsidised Mining Programme. Rep. Invest. geol. Surv. S. Aust. 51.

Continental Oil Comapny of Aust. Ltd., 1969. Munyarai No. 1 well, South Australia, stratigraphic drilling project. Well completion report. S. Aust. Dept. Mines and Energy open file Env. 979 (unpublished).

Crettenden, P.P., Flintoft, M.N., Ewen, S.J. and Watkins, D.C., 1980. The Opal Industry in South Australia. S. Aust. Dept. Mines & Energy report 79/11.

Darragh, P.J., and Dendix, J.L., 1973. Precious Opal - Developments towards synthesis C.S.I.R.O. The Australian Gemmologist 11(11) 17-21.

Flint, D.J., 1980. Lambina Opal workings. S. Aust. Dept. Mines and Energy report 80/103.

Hiern, M.N., 1967(a). Mintabie Opalfield. Min. Rev. Adelaide 122:33-36.

__________________(b). Opal Deposits in Northern South Australia Min. Rev. Adelaide, 122:37-39.

Keeling, J.L., 1975. Opal in South Austrlia. Mineral Information Series. Geol. Surv. S. Aust. 16 pp. (Brochure).

Krieg, G.W., 1967. Continental stratigraphic well, Officer No. 1 well completion summary. S. Aust. Dept. Mines report No. 744 (unpublished).

____________1969. Geological developments in the eastern Officer Basin of South Austrlia. Aust. Pet. Explor. Assoc. J., 9:8-13.

Krieg, G.W. and Major, R.B., 1972. Everard map sheet, Geological Atlas of South Australia, 1:250 000 series. Geol. Surv. S. Aust.

Krieg, G.W., (Compiler) 1973. EVERARD, South Australia. Explanatory Notes, 1:250 000 geological series Sheet SG/53-13. Geol. Surv. S. Aust.

McCallum, W.S., 1980. Vesuvius Opal Diggings. S. Aust. Dept. Mines and Energy, report 80/38 (unpublished).

McKenzie, K.G., 1959. A geological reconnaissance of the Woomera-Maralinga area, for Exoil N.L. S. Aust. Dept. Mines and Energy open file Env. 59 (unpublished).

Milton, B.E., 1979. A summary of geophysical exploration of the western and eastern Officer Basin in South Austrlia. S. Aust. Dept. Mines and Energy report 79/38 (unpublished).

____________ and Parker, A.J., 1973. An interpretation of geophysical observations on the northern margin of the eastern Officer Basin. Quart. geol. Notes, geol. Surv. S. Aust., 46:10-14.

Packham, G.H. and Webby, B.D., 1969. The geology of the Officer Basin in the Everard 1:250 000 map area, for Murumba Oil N.L. S. Aust. Dept. Mines and Energy open file Env. 1147 (unpublished).

Pitt, G.M., Benbow, M.C. and Youngs, B.C., 1980. A review of recent geological work in the Officer Basin, South Australia. Aust. Pet. Explor. Assoc. Jl. 20.

____________ and Youngs, B.C., 1980. A source book for the Officer Basin Area in South Australia. S. Aust. Dept. Mines and Energy report 80/5 (unpublished).

Queensland Government Mining Journals 1919. Opal Fields of South Australia. Qd. Gov. Min. J., 15th Oct. 1919.

Queensland Government Mining Journal 1929. South Australian Opal. Qd. Gov. Min. J., 14th Dec. 1929, P 530.

Robertson, R.S. and Scott,D.C.,1987. Coober Pedy Opal Fields. Geology of the Precious Stones Field and results of the subsidised exploration program 1981. S. Aust. Dept. Mines and Energy report 83/7 (unpublished).

Scott, D.C.and Robertson,R.S.,1983. Coober Pedy Opal Fields- Results of the Subsidised Exploration Program 1981. S. Aust. Dept. Mines and Energy report (unpublished).

Sheard, M.J., 1981. Mintabie Opal-Field, town water supply investigations. S. Aust. Dept. Mines and Energy report 81/43 (unpublished).

Sprigg, R.C., 1952. Everard Military sheet, regional Geological plan. S. Aust. Dept. Mines and Energy Plan Index 52-276.

Sprigg, R.C. and Wilson, B., 1958. The Musgrave Mountain Belt in South Australia. Geol. Rdsh 47, (2) 531-542.

Thomson, B.P. (Compiler), 1980. Geological Map of South Australia 1:1 000 000 scale. Geol. Surv. S. Aust.

Townsend, I.J. and Robertson, R.S., 1980. Wallatinna opal diggings. S. Aust. Dept. Mines and energy report 80/34 (unpublished).

Townsend, I.J., 1981. Discovery of Early Cretaceous sediments at Mintabie opal field. Quart. geol. Notes geol. Surv. S. Aust. 77.

Townsend, I.J., and Scott, D.C., 1982. Sarda Bluff, Ouldburra Hill Opal Diggings. S. Aust. Dept. Mines and Energy report 81/17.

Townsend,I.J., Wildy,R.L.,Barnes,L.C. and Crettenden,P.P., 1988. The Opal Industry in South Australia 1984-86. Mineral Resour. Rev., S. Aust., 156 : 106-107.

Webb, A.W., 1978. Geochronology of the Officer Basin. Amdel Project Progress Report Nos. 1 & 2, 1/1/220. S. Aust. Dept. Mines and Energy open file Env. 3325 (unpublished).

Wildy, R.L. and Barnes, L.C., 1985. The Opal Industry in South Australia - 1983. Mineral Resour. rev., S.Aust., 155: 80-81.

Wopfner, H., Freytag, I.B. and Heath, G.R., 1970. Basal Jurassic-Cretaceous rocks of western Great Artesian Basin South Aust: Stratigraphy and Environment. Bull. Am. Ass. Petrol. Geol. 3:54.

APPENDIX A
GLOSSARY OF TERMS

GLOSSARY OF TERMS

In a few cases the miners term differs markedly from geological meanings and in these cases both definitions are included. Unless otherwise stated the definitions refer to terms as applied at Mintabie.

Angel Stone - miner's term

Bands of grey silicified sandstone in white sandstone, may be associated with precious opal or *potch*.

Cabochon - term used throughout the gemstone industry

A stone, in the case of opal a piece of solid precious opal, cut into an elliptical, round or polygonal shape with a flat base and domed top. A stone cut in this manner is described as being cut en *cabochon*.

Common Opal - geological definition

Opal which, unlike precious opal does not show a play of colours and generally has a dull lustre. Includes - *bony potch*, hyalite and *chalky potch*.

Craze - term used throughout the opal industry

The tendency for opal to crack; opal exposed to the atmosphere at the surface slowly dries out and may eventually craze. An opal first crazes, showing numerous hair like fractures throughout, and may break into pieces.

Doublet, see *Opal doublet*

Floaters - miner's term

Pieces of opal or *nobbies* weathered out of *verticals* and *levels* and found as lag material in gullies or on scree slopes close to mesas or scarps.
Floaters may display a play of colour, but generally are bleached white owing to drying out and crazing.

Imitation opal

Any artificial material that resembles precious opal but does not have its physical or chemical structure; includes, slocum stone, 'tinsel', nacrous shells.

Level - miner's term

A near-horizontal structure defined by silicification, yellow limonite staining, or a near-horizontal bedding plane parting.

Nobbies - miner's term (see also *Floaters*) Pieces of opal derived from erosion of a *vertical* or *level*. Term used only rarely in South Australia, but commonly at Lightning Ridge, NSW, where it refers to opal found in the form of small nodules.

Noodling

The practice of sifting through mullock heaps for small pieces of precious opal inadvertently discarded by the miners. A number of people on the opal fields rely entirely on noodling for a living. Professional noodlers either sift through the waste material by hand or use a noodling machine (see Crettenden et al 1979). Tourists and others casually searching the dumps for pieces of opal are also noodling.

Opal - geological definition

All hydrates of silica, SiO_2, $H2_0$, including synthetic, natural precious and common opal but not imitation material; alternative term is opaline silica.

Opal miners generally restrict use of the term opal to precious opal, calling material that does not show a good play of colours *potch*.

Opal diggings

Opal workings that lie outside a declared Precious Stones Field, e.g. Wallatinna opal diggings.

Opal doublet or Doublet - term used throughout the opal industry

A layer of precious opal, onto one face of which has been fixed an opaque base of natural or artificial material. The base is generally dark to enhance the opal's fire; it may be black *potch*, or more commonly a grey or black synthetic called *vitrolite*. Minitabie 'semi-black' opal is a natural doublet.

Opal field

An area of opal workings that lies within a declared Precious Stones Field.

Opal solid or Solid - term used throughout the opal industry

No other natural or artificial material is fixed to the opal to enhance its fire.

Opal triplet of Triplet - term used throughout the opal industry

A thin layer of precious opal, onto one face of which is fixed an opaque base of natural or artificial material, and onto the other face a clear domed top of natural or artificial material (to magnify and to protect the opal). Best quality triplets have a clear quartz top; others a clear plastic top. Triplets can make use of very thin slices of precious opal which would otherwise be rejected, and is a cheap method of effectively finishing opal.

Opalised shell - geological definition

Fossil shell replaced and/or body chamber infilled partially or wholly by opal (see Skin shell and Solid shell).

Porcellanite - geological definition

Completely silicified shale or siltstone, composed almost entirely of silica, often opaline silica; typically has a conchoidal fracture and, superficially, resembles porcelain.

Potch - miner's term

Applied to any opal considered valueless by miners even though it may exhibit some colour flashes. Opal showing a few colour flashes may be referred to as *potch* with colour. There are many varieties of *potch* - *jelly potch* is clear and glass-like; white, milky, grey and black *potch;* honey and *chalky potch* (soft crumbly white opaline silica).

Geological definition - opaline silica with no play of colours.

Precious opal - geological definition

Any naturally occurring homogenous opal exhibiting a play of colours. There are many varieties of precious opal, the names being based on background colour and colour pattern.

Black opal - precious opal with black or dark background colour of blue, green or brown.

Milky, grey and white opal - precious opal with milky, grey or white background colours, respectively.

Semi-black opal - precious opal with a dark grey background. Mintabie 'semi-black' is white or clear opal with a natural backing of black *potch*.

Harlequin opal - precious opal showing regular mosaic-like pattern in rounded, angular or roughly square patches of about equal size; the most highly prized of all colour patterns.

Flag opal (or flagstone opal) - precious opal with colour pattern resembling flagstone paving.

Pinfire opal - precious opal with very small or pinpoint-sized specks of colour.

For a complete description of the various types of precious opal see O'Leary (1977).

Miner's term - opal miners generally restrict the term precious opal, or opal, to saleable precious opal. Opal that shows some colour but is not saleable is called *potch*.

Precious Stones Field (PSF)

A gazetted area within which only Precious Stones Claims of 50 m square or 100 by 50 m can be pegged; all PSF's are proclamined to a depth of 50 m . Mintabie PSF was gazetted on 27.11.80.

Sand-shot opal - term used throughout the opal industry

Precious opal containing grains of sand or silt. The sand is often concentrated in one area dulling the opal. Sand-shot opal does not polish well and the surface is generally finely pitted.

Sandstone - Geological definition

A sedimentary rock composed principally of grains of clastic material (generally quartz) with a grain size betwen 0.0625 mm (silt) and 2 mm (grit). The opal host rock at Mintabie is a true sandstone.

- Miners term: - Coober Pedy miners use this term to describe the deeply weathered silty claystone which hosts opal at that field. This rock (similar to Andamooka *kopi*) is not a true sandstone.

Sandstone opal, see *Sedimentary opal*

Seam opal or *Seam* - miner's term and geological term

A layer of opal formed in a horizontal or near- horizontal structure, either in a *level* or along a bedding plane. The layer of opal may vary in thickness from a fraction of a millimetre to over 100 mm.

Sedimentary opal - geological definition

Opal deposited predominantly in sediments, from silica-rich meteoric groundwater. Much Australian opal occurs in bleached, mottled and speckled shale which resembles sandstone; hence the term sandstone opal.

Silcrete - geological definition

Any rock cemented (silicified) or replaced by any form of secondary silica, notably quartz, chalcedony or opaline silica. Mintabie miners generally use the term in referring to the 'greybilly' silcrete overlying the sandstone.

Slide or slip - miner's term

Any angled joint or bedding, or less often, a minor fault. It is a term used more at Andamooka and Coober Pedy for minor faults showing dislocation.

Solid, see *Opal solid*

Spotter - miner's term

Person engaged to follow closely behind a bulldozer searching for signs of opal (Plate 16).

Synthetic opal - opal dealers' and jewellers' term

Synthesised opal with similar physical and chemical structure to precious opal.

Gilson opal - one type of synthetic opal manufactured by Pierre Gilson of Switzerland.

Trace - miner's term

1. Small pieces of opal brought up by a drill rig. With good *trace* the pieces of opal show enough colour to encourage the miner to sink a shaft or bulldoze a cut.
2. A thin seam or layer of opal in a *level* or *vertical* which, if it shows enough colour, encourages the miner to continue to drive.

Triplet, see *Opal triplet*

Vertical - miner's term

Joints, of near vertical orientation with little or no apparent movement;may be filled with opal, *potch* and/or limonite.

APPENDIX B
MEASURED SECTIONS

MEASURED SECTIONS - OUTCROPS (B1-B4)

(For locations see Figure 4 & 5)

MEASURED SECTION - BULLDOZER CUTS (B5-B16)

B-SECTION NO. 1

Location 100 m west of M16, southeast end of scarp (Fig. 4).

Coord: 332300: 6976500

RL Top: 394.6 (Top of silcrete)

Depth (m)	Description
1-5	(Variable) Dune Sand (Holocene) Red, medium grained quartz sand, rounded and iron stained, part of an east-west trending sief dune.
5-7	Silcrete (Tertiary). Off white to pale grey, coarse grained (sand up to gravel size) sub angular to rounded, occasional rounded silcrete pebble hard tough, resistant, cemented by opaline silica (R.S. 199 Appendix D26).
7-9	Conglomerate (Tertiary). Red, brown ferruginised silicified, contains large angular fragments of Mintabie beds up to cobble size and quartz sand grains in a fine to very coarse mixture variably silicified.
9-14	Sandstone - (Mintabie beds - ?Ordovician) white fine to medium grained kaolinitic, more clayey and silicified than below. Vertical joints common, bedding more obvious because of alternating grain size. Well sorted within layers, iron stained.
14-21	Sandstone (Mintabie beds - ?Ordovician) white fine to medium grained, kaolinitic, bedding not obvious, well sorted, some red iron staining, thin clay lenses and clasts. Two types of tubules present, older filled with grey clay, silicified, younger filled with red clayey sandstone.

R.L. Base 378.6

SECTION 2

Location: Northernmost part of scarp, 150 m southeast of peg No.

1044

Coords: 3219400: 6979000

R.L. Top: 376.0

Mintabie beds

Depth (m)	Description
0-2	Sandstone, off white, fine to medium grained, platy to flaggy partly silicified forming a more resistant band, clayey in part. Silicification has occurred in less clayey bands.
2-4.5	Sandstone white fine grained, silicified and forms a resistant outcrop. Yellow-brown iron staining along jointing and bedding.
4.5-6.7	Sandstone: off-white similar to uppermost unit, contains some preferentially silicified bands.
6.7-8.7	Sandstone: similar to above unit, flaggy and partly silicified.
8.7-12.5	Sandstone white to yellow iron stained near base in creek, fine to medium grained, cross bedded.

R.L. Base 363.5 m

SECTION 3

Location: Prominent Hill at edge of scarp.

300 m north of Mines and Energy Allotment (Fig. 4).

Coords: 330700: 6978300

R.L. Top:

Depth (m)	Description
0-7	Sandstone medium grained, some coarse, cross bedded with beds between 5 mm and 50 mm, fine grained and clayey (union kaolin) between slaggy beds which are silicified. Silicification varies along strike and may represent drape silcrete.
7-15	Sandstone, medium grained, multicoloured red, white, yellow, pink, kaolinitic clayey, less resistant to weathering, much scree covered.
15-16.1	Sandstone, off white to pale yellow medium grained quartz only minor clay, falt bedded mainly some cross bedding, partly silicified.
16.1-20.1	Sandstone; off white clayey, friable, fine to medium grained quartz with clay coating. (weathered).
20.1-21.6	Sandstone, white to off white medium grained, kaolinitic, silicified. Kaolin appears to be 5-10%. Sandstone is cross bedded in part and grainsize is larger.
21.6-26	Sandstone, yellow, fine to medium grained, clayey, less resistant to weathering, contains thin resistant sandstone bands and rest covered by steep scree slope (i.e. terraced).
26.0-29.3	Sandstone, yellow brown (weathered fine to coarse grained quartz sandstone, subrounded to rounded with minor white feldspar or kaolin grains, large scale cross bedding with foresets dipping generally 5-20° northeasterly. Bedding is emphasised by alternating coarse and fine grained quartz (graded bedding). Larger scale cross bedded sandstone is coarser grained. The unit is very resistant to weathering as it is composed almost entirely of quartz with only minor feldspar. The unit is not silicified.

R.L. Base 384.4 m

SECTION 4

Location: Lone Mesa 4 km north of town

Coords: 331800: 6981500

R.L. Top: 373.8 m

Tertiary

Depth (m)	Description
0-1.5	Silcrete, silicified hard conglomerate containing white quartz pebbles, rounded, up to 2 cm in a "grey-billy" silcrete matrix.
1.5-2.0	Sandstone/conglomerate very weathered and reworked Mintabie beds infiltrated by sand, granules of quartz and red soil.

Mintabie beds (?Ordovician)

2.0-4.0	Sandstone, coarse to very coarse, feldspathic, white, partially silicified.
4.0-8.0	Sandstone, white, fine to medium grained, feldspathic, interbedded with coarse sandstone bands up to 20 mm thick. Small scale scour structures and tubules in sandstone, some thin clay bands (1 cm) near top.
8.0-13.0	Sandstone, white, friable, medium grained, very poor outcrop.
13.0-19.0	Sandstone, white medium to coarse grained feldspathic, kaolinitic. Ferrgunous band yellow to brown, 50 mm thick at 13 m.
19.0-22.0	Sandstone off white to yellow brown fine to medium grained, feldspathic.
22.0-25.0	Sandstone, white mainly scree covered.

R.L. Base 348.8

APPENDIX B

MEASURED SECTIONS - BULLDOZER CUTS

CUT. NO. 1

Location: 150 m west of peg M4 (Fig. 5).

Coords: 330900: 6976800

R.L. Top: 378.0 m

Depth (m)	Description
0-2.5	Sand, red-brown sandy soil, medium to coarse grained, rounded, erosional surface and depth varies.
2.5-6.0	Sandstone, white to off-white, kaolinitic, fine to coarse grained, variably silicified.
6.0-20	Sandstone, white, medium to coarse grained, kaolinitic, massive large scale cross-bedding and alternating or graded bedding.
20-22	Sandstone, pale green, medium to coarse grained clayey and damp.

Opal found down to 22 m in both *verticals* and seams. good opal found as deep as 20.7 m. Black *potch* some with colour observed in the walls in *verticals* and seams.

T.D. 22

R.L. Base 356.0 m

CUT NO. 2.

Location: adjacent to peg 1050 Roger and Wendy

Coords: 331200: 6977300

R.L. top = 375 m (interpreted from orthophoto)

Surface removed through most of this area of intensely bulldozed edge of the scarp.

Depth (m)	Description
Surf.-3.0	(approx). Sandstone, white to pale yellow iron stained fine to medium (grained cross bedded as observed in neighbouring cuts particularly the cuts near pegs M4 and 1049 adjacent to access track.
3.0-10.0	Sandstone, white cross bedded kaolinitic fine to medium grained.
10.0-12.0	Thin interbedded sandstone bands (10-30 cm) grey to off white hard, silicified probably with opaline silica. Opal was found as thin layers either side of uppermost bank (10 cm) of silicified sandstone. (Sample RS 201 and 207 Appendices D4 & D10. Interbedded with sandstone white, friable kaolinitic. Rarely contain thin opal seams. (Samples RS202 and 203 Appendix D5 and D6).

There are several hard sandstone bands within this unit the basal ore being up to 1 m in places most are thinner.

12.0-13.0	Sandstone clayey, yellow to pale orange (slightly iron stained) (RS200 Appendix D3) grades down to yellow-green-grey sandstone which the miners consider non prospective.

R.L. Base 362.0 m

CUT NO. 3.

Location: 100 m northeast of peg M22 (Fig. 5)

Coords: 330800: 6977300

R.L. Top: 378.8 m

Depth (m)	Description
0-.30	Sand, red sandy soil, fine to medium grained, rounded.
.30-1.0	Sandstone, silicified (silcrete). White to pink and yellow, clayey in part. Jointed and infilled by recent sandy soils.
1.0-2.3	Sandstone silicified kaolinitic, well banded. Sand red to yellow infilling joints and replacing interbeds which were possibly more clayey.
2.3-3.4	Sandstone, white silicified in part. Fine to medium-grained ccasionally coarse much more massive, less infilling contains thin clay seams (kaolinitic) up to 2-3 cms thick.
3.4-8.0	Sandstone, white, medium to coarse, kaolinitic, salt and pepper appearance, cross-bedded. alternating bedding of medium size grains with coarse size. Sequence dipping due south approx. 10°.

Predominant jointing at 320o. Opal found as a seam at 6.7 m, 1 cm thick, generally *potch*, some colour.

T.D. 8.0

R.L. Base 370.8 m

CUT NO. 4.

Location: 200 m northeast of peg M6 (Fig. 5)

Coords: 330700: 69773

R.L. 377.0 m

Depth (m)	Description
0-1	Red sandy soil fine to medium-grained rounded.
1-5	Sandstone silicified (silcrete) off-white weathered and jointed, well-bedded and infilled with red-orange soil down to 2.5 m. Red tubules present in upper silcrete.

5-12	Sandstone white kaolinitic, massive fine to medium-grained with occasional clay seam 3 cm at 8.2 m 5 cm clay seam at 10.0 m. Small scale cross-bedding.

T.D. of cut 12.0 m - Dry.

CUT NO. 5.

Location: 50 m north of peg M6 (Fig. 5)

Coords: 330600: 69771

R.L. Top: 376.5 m

Depth (m)	Description)
0-1.8	Reworked silcrete, jasper breccia and red-brown sandy and pebbly soil. Red tubules visible in silicified sandstone boulders.
1.8-4.3	Silcrete, silicified sandstone medium-grained sandstone well-sorted, well-bedded and jointed, bedding and joints infilled with red-orange surface soil bands up to 20 cm thick.
4.3-7.8	Sandstone, white to off-white, medium grained, partially silicified occasional tubule filled with silicified grey mud.
7.8-12.0	Sandstone, white, medium-grained some coarse grains, salt and pepper appearance, kaolinitic, some clay beds up to 1 cm, wavy.

T.D. 12 m - Dry.

R.L. Base 362.5 m

CUT NO. 6.

Location: 50 m east of peg M7 (Fig. 5)

Coords: 330400: 6977300

R.L. 377.6 m

Depth (m)	Description
0-.50	Soil, red-brown, silty to sandy, fine to coarse grained and cobbles of silcrete, some golden brown, iron-stained and polished.
.5-1.12	Sandstone (variable thickness), off-white fine-grained some medium and red clay staining along joints and bedding.
1.2-3.0	Sandstone to claystone, clayey at top, more sandy at base, clay is pale green. Sands are iron-stained purple (?primary) and later yellow iron-staining introduced.
3.0-5.0	Sandstone, pink at top with pale green clay seams up to 2 cm thick grading down to white sandstone medium-grained and clay seams partly silicified.
5.0-12.0	Sandstone white fine to medium grained (unsilicified) traces of darker bedding on the small scale. Horizontal seams of *potch* and opal at 10.5 m. *Verticals* filled with white sugary siliceous material. All beds appear to be dipping gently southwards up to 5°.

T.D. 12.0

R.L. Base 365.6 m

CUT NO. 7

Location: North of Water Bore and Peg M7 (Fig. 5)

Coordinates: 330400: 6977200

R.L. Top: 377.3 m

Depth (m)	Description)
0-.50	Soil, red-brown, sandy plus buckshot limonitic gravel and silcrete cobbles.
.50-1.2	(varies in thickness) Sandstone, off white mainly fine grained some medium with red clay staining along joints and bedding, silicified.

1.2-3.0 Claystone and sandstone. Silicified clayey at top, more sandy at base. Green clay and purple ironstaining (primary) restricted to sand. Yellow iron staining is late infilling through joints after silicification.

3.0-5.0 Sandstone, pinkish at top with pale greenish clay seams up to 2 cm thick grading down to white sandstone, medium grained with clay seams all partly silicified and cross bedded.

5.0-12.0 Sandstone, white, fine to medium grained, friable, traces of darker bedding on the small scale, very fine grained. Horizontal seams of *potch* and opal at 10.5 m. *Verticals* filled with white powdery ?siliceous mineral ?halloysite. Cross bedded on upper silicified sandstone on southwest wall of "Tee cut". All beds dip generally southwards 5°. Jointing at 050° (Vert) and 047° (Vert).

R.L. Base 365.3 m

CUT NO. 8.

Location: 50 m north of peg M5 (Fig. 5)

Coords: 330900: 6977100

R.L. 378.0 m

Depth (m) Description

0-2.0 Red-brown sandy soil, buckshot gravel and thin local calcrete, reworked silcrete of cobble size.

2.0-4.2 Sandstone, off-white pinkish in lenses. Some thin clay bands, green (2 cm), red-brown clay staining via joints, bedding and abundant tubules, well-bedded. Seam of *potch*, up to 1 cm thick at depth of 3.5 m. Gypsum associated with this bedding (rare). All silicified to some extent.

4.2-8.2	Sandstone, white fine to medium-grained, occasional tubule. Bedding dipping 7½° S.W. strike 115°. Near vertical *potch* 305°.

T.D. 8.2

R.L. Base 369.8 m

<u>CUT NO. 9</u>.

Location: 200 m north of peg M15 (Fig. 5)

Coords: 330400: 6977700

R.L. Top 382.4

<u>Depth (m)</u>	<u>Description</u>
0-.40	Red-brown sandy soil, quartz grains, rounded and ironstone gravel. Minor platy calcrete.
0.40-1.5	Sandstone, white silicified, medium grained jointed and interbedded with infilling from surface material. Almost flat-lying. Red clay stained through joints and bedding minor cross-bedding.
1.5-6.5	Sandstone, white, medium to coarse grained, cross-bedded, white clay banding, occasional tubules. 4 m *vertical* of *potch*, *trace* of colour only (strike 315°). More massive than above.
6.5-9.9	Sandstone, white as above but more clayey, and sand generally finer grained, abundant jointing.

T.D. 9.9

<u>CUT NO. 10</u>

Location: East end of Airstrip (Fig. 4)

Coords: 330100: 6978400

Depth (m) Description

0-2 Silcrete, sandstone, white to off-white grading to pink (in bands) silicified, fine to medium grained.

2-6 Claystone/sandstone, clay seams up to 2-3 cm thick, wavy in part. Sandstone white as above. Beds dipping southerly at 5o cross-bedded and jointed. Gypsum present in joints and parted bedding. Abundant joints where opal was supposedly found.
Sample RS 204 Analysis A2572/79.

T.D. 6.0 m.

CUT NO. 11

Location: 2½ km est of Appamurra Bore (Fig. 4)

Coords: 326900: 6979400

R.L.

Small westernmost cut (3 m deep)

Depth (m) Description

0-3.0 Silty claystone, pale green silicified, iron-stained on joints and bedding plane partings infilled thin sandstone beds are white. Green colour apparently associated with claystone only. Beds dip 10°S strike 105° below main bulldozer cut. Sample A2571/79.

Larger cut (3 m deep x 50 m long)

Depth (m) Description

0-3.0 Sandstone, white to off-white, fine grained, massive, silicified, kaolinitic, jointed, only minor thin green clay seams. Series of 5-6 slick 'n' sided clay bands, probably bedding, dipping 9°S. Bedding dips on wall 6-9° strike 240° sandstone is silicified. Some tubules filled with red and yellow surface material.

T.D. 3.0 m.

CUT NO. 12.

Location: 100 m southeast of M22 (Fig. 5)

Coords: 330900: 6977200

R.L.: 378.0

Depth (m)	Description
0-0.50	Red-brown sandy soil with limonite pebbles and cobbles.
0.50-0.90	Calcrete, platy interbedded in silicified sandstone, jointed and broken up.
0.90-4.0	Sandstone, silicified, white, medium-grained, contains abundant tubules, red-brown staining in joints and bedding partings.
4.0-5.8	Sandstone similar to above but is yellow to buff iron-stained.
5.8-9.8	Sandstone, white, massive fine to medium grained, thin clay stringers, wavy bedding, jointed (strike 136o). Bedding dips 4°S.W. More massive, less tubules. Clay seam 5-6 cm at 9.5 m.
9.8-10.6	Sandstone, more clayey than above. Opal seams found at depth of 8 m but up dip from section and below clay seam. 3-4 opal seams up to 7 mm thick, with colour parallel to bedding.

T.D. 10.6 m.

R.L. Base 367.4 m

CUT NO. 13.

Location: 20 m north of peg 1062 (Fig. 5)

Coords: 330700: 6977400

R.L. Top: 380.0 m

Depth (m)	Description
0-0.50	Sand, red-brown sandy soil. Fine to coarse-grained, poorly sorted.
0.5-3.0	Sandstone, white to off-white, fine grained, some medium, silicified, minor tubules infilled with grey clay. Bedding joints and *verticals* infilled with red-orange iron-stained silty sand. Some thin clay stringers.
3.0-11.3	Sandstone, white, fine-to-medium grained, occasional coarse, kaolinitic more massive, jointed.

T.D. 11.3 m

R.L. Base 368.7 m

CUT NO. 14

Location: 100 m east of peg M20 (Fig. 5)

Coords: 330750: 6977400

R.L. Top: 382.0 m

Depth (m)	Description
0-3.0	Sand, erosional surface, variable to 5 m, red.
3.0-5.0	Silcrete, sandstone, off-white banded jointed, infilled with surface sandy soil via joints to bedding partings. Graded bedding, cross-bedding both small and large scale. Some coarse grained sandstone. Vertical joints at 305, 308, 319 & 295°, cross joints at 45, 44 & 46°.
5.0-10.0	Sandstone, white medium to coarse grained kaolinitic cross-bedded and dipping 9°N. One of the few observed to be dipping north. Opal found at 5.5 m 6.5 m in seams only.

T.D. 10.0 m.

R.L. Base: 372.0

CUT NO. 15.

Location: 100 m southeast of peg M17 (Fig. 5)

Coords: 330800: 6976900

R.L. Top = 378.0

Depth (m)	Description
0-2.0	Variable erosion surface. Red-brown sand, medium to coarse-grained, rounded.
2-5.5	Sandstone, fine to coarse-grained, off-white to buff, kaolinitic cross-bedded and dipping in part up to 45° (foresets). All generally dipping S.E. Horizontal joints cross-cut bedding, vertical and bedding joints all infilled with pale yellow to yellow sandy clays and occasional grey clay also filling minor tubules.
5.5-15.0	Sandstone, white massive, kaolinitic medium to coarse-grained, graded bedding, large scale festoon cross-bedding.

T.D. 15.0 m.

R.L. Base 363.0 m

CUT NO. 16.

Location: Southern most cut in Figure 5, adjacent to peg M3.

Coords: 331300: 6976700

R.L. Top: 393.2 m

Depth (m)	Description
0-0.5	Red-brown sandy soil, gibbers.

Tertiary to Quaternary

0.50-3.5	Sandy pebbly clay conglomerate, containing silicified claystone on jasper breccia all draped over an old land surface (palaeosol).

Mesozoic (Marree Subgroup)

3.5-6.0 Claystone grey to pale grey and buff partly silicified only generally soft and homogeneous - weathered. Contains boulders near based including quartzite (most resistant) some up to 70 cm (Plate 23) as well as some siltstone and silty claystone boulders where shale can be observed. All are weathered except the quartzite boulders.

Unnamed Sandstone

6.0-7.4 Sandstone, white, medium to coarse and very coarse, well-rounded, some pebbles of milky quartz, poorly sorted as opposed to the Mintabie beds, kaolinitic. Is a coarser sandstone and poorly sorted.

Ordovician (Mintabie beds)

7.4-12.0 Sandstone, white, fine to medium-grained well-sorted large scale cross-bedding some coarser gravels but good sorting along bedding. Massive, silicified unlike the Mesozoic sandstone.

T.D. 12.0

CUT NO. 17

Location: Southern area 250 m northeast of M1 peg (Fig. 5)

Coords: 331600: 6976800

R.L. Top: 386.0 m

Depth (m) Description

0-.50 Red-brown gibber soil, conglomerate of rounded silcrete boulders and red dune sand mixed to form an alluvial cover.

.50-2.5 Sandstone, white, massive, medium grained quatz grains with a kaolinitic matrix, silicified and weathered, platy, orange iron staining in the bedding (infilling via joints from above). Bedding dips 5-10° towards 170° (Sample RS271 Appendix D16).

2.5-8.0 Sandstone, white, massive, bedding much less obvious, silicified in parts, minor jointing and some gypsum. A slickensided joint containing gypsum parallel with bedding separates the platy sandstone from the more massive lower sandstone. Some clay clasts observed and thin clay interbeds.

T.D. 8.0 m

APPENDIX C

LOGS OF DRILLHOLES AND SHAFTS

(For locations see Figure 4 and 5)

C-DRILLHOLE 1 (5543/61)

Location: 1 km southwest of peg 1059 (Fig. 4)

Coords: 328400: 6975900

R.L. Top: 368.5 m

Depth (m)	Description
0-1.5	Red-brown quartz dune sands on a silty sand.
1.5-2.0	Gravels, lateritic, brown, with some silt and sand as matrix.
2.0-3.2	Sandstone, rubbly angular fragments 2-8 cm across, yellow to white in colour.
3.2-16.2	Sandstone, white to off-white and cream and pink, kaolinitic, more clayey in the lower half and contains thin red clay bands.
16.2-23.6	Pale red to pink clay with some mottling near top.
23.6-37.0	Sandstone, off-white, quartz, clayey, subrounded quartz grains.
37.0-42.5	Yellow-brown clay and dark brown shale 10-15 cm thick, sandy and darker between 40 and 41 m.
42.5-45.0	Sandstone, white to pale grey quartz sandstone, coarse grained fractured and cemented, high porosity (contains large amounts of water).

E.O.H. 45.0 m.

DRILLHOLE 2 (5543/60)

Location: (50 m South of Dept. of Mines and Energy - Area Office) (Fig. 4)

Coords: 331000: 6978200

R.L.: 353.0 m

Depth (m)	Description
0-1	Red-brown sandy soil and silt with white sandstone rubble.
1-4.5	Sandstone, off-white to pale yellow siltstone interbed, coarse grained in sandstone.
4.5-5.5	Shale, red, fissile.
5.5-7.0	Clay, grey sandy, stiff plastic to hard, grades to grey/green to grey-blue colour.
7.0-11.5	Sandstone, red-brown, hard, pales with depth to yellow and pale grey-brown.
11.5-13.2	Sandstone grey and brown, clayey above basal 20 cm.
13.2-15.6	Siltstone and shale, brown grades down into grey-green.
15.6-28.2	Sandstone siltstone and shale interbeds. Sandstone, hard white, red. Siltstone, red-brown. Shale, grey and red-brown.
28.2-51.0	Sandstone, clayey, red-brown becoming more shaly at base.
51.0-60.0	Shale, sandy laminated, hard, grades into dark grey shale with brown clay seams at intervals of 5-8 cm.

E.O.H. 60 m.

DRILLHOLE 3 (5543-49)

Location: 50 m east of Goanna Grill (Fig. 5)

Coords: 331500: 6977300

R.L. Top: 362 m.

Depth (m)	Description
0-0.5	Topsoil, sandy clay, orange.
0.5-13.5	Sandstone, white kaolinitic (Mintabie beds).
13.5-19.5	Shale, grey and dark grey (?pyritic) and minor sandstone.
19.5-91	Sandstone, v. fine silty brown-chocolate with some brown siltstone.

E.O.H. 91 m.

<u>DRILLHOLE NO. 4 (5543/50)</u> (Town Water Supply)
Location: 40 m southwest of peg M7 (Fig. 5)
Coords: 330400: 6977050
R.L. Top of casing: 375.6 m
Level to which water rose: 15.65 m
Total dissolved solids 1213.0 mg/litre
ph: 7.3
Depth of hole: 33 m
No log is available for this drillhole as it was drilled and completed prior to any Departmental personell stationed on the field.

<u>SHAFTS</u>
Shaft S1 (Len and Tim)
Location: 100 m west of peg M4.
Coords: 330900: 096850
R.L.: 378.7 m

0-?2.5 m	Red, sandy soil, minor clay (hidden by shaft collar).
2.5-19 m	Sandstone, white, medium grained, kaolinitic cross bedded, dipping generally southeast at approximately 10o. Also hard grey sandstone bands up to 20 cms thick. Blue *potch* at 14 m follows bedding, vertical joints and *levels*, cut across bedding. Opal was present in 5 thin seams (2-3 mm thick) at 18 m generally following bedding. Nop iron staining associated with opal which occurs both above and below the hard grey sandstone.

Shaft S2 (Marcello-Charlie)

Location: 150 m west of peg M4.

Coords: 330850: 698900

R.L.: 378.1 m

0-2.0 m Red, sandy soil.

2.0-13.7 m Sandstone, white medium grained kaolinitic, bedding dipping 12 approximatel East. Approximate *level* at 12. 8 m and 4-5 seams follow bedding and are associated with harder grey opal cemented sandstone. Seams up to 3 mm thick with minor colour which apparently improved later.

Shaft S3 (Mario-Tarzan)

Location: 750 m south of Town Bore

Coords: 330400: 69769

R.L.: 374.7 m

0-1 m Red, sandy soil, partly clayey.

1-13 m Sandstone, white kaolinitic silicified near surface. Seams of *potch* parallel to bedding and some cross cutting bedding. Predominantly *potch*, minor colour. Some cross bedding dipping generally S.E. at 5-10°. Vertical striking 320°.

Shaft S4 (Dick Hall)

Location: 150 m south of Town Water Bore.

Coords: 330350: 0976900

R.L.: 374.1 m

0-1.0 m (approx.) Red-brown sandy soil.

1.0-16.8 m Sandstone, white kaolinitic medium grained, silicified in part. Bedding dipping 6° E.S.E. Hard grey silicified sandstone showing pinfire colour (opaline cement) and shows yellow-brown iron staining and *potch* seam within the sandstone showing some colour. Seam at 16.3 horizontal. Away from seam cross bedding dips are up to 40°S. Overall dip much less 5-10° S.W. *Vertical* trending 215°. Minor slickensiding at 15 m.

Shaft S5 (Lenny Butts)

Location: 150 m southwest of Town Water Bore.

Coords: 330300: 6976900

R.L.: 373.5 m

0-~1 m	Depth of soil unknown, hidden by shaft collar.
1-18.3 m	Sandstone, white kaolinitic cross bedded. Seam of thin opal at 17.0 m associated with a band of hard grey sandstone. Iron staining associated with *level* (Plate 4) which is near horizontal. Slickensiding at 10-12 m.

Shaft S6 (A.C.T. mining)

Location: 200 m southwest of Town Water Bore.

Coords: 330250: 6976900

R.L.: 373.0 m

0-~1 m	Red-brown surface soil.
1-21.3 m	Sandstone white kaolinitic. *Traces* of *potch* seams and one *vertical* - no colour. Iron staining is present on thin seams. Sandstone is damp but not seeping. Shaft filled to 5 m with water during heavy rains by direct inflow to shaft but was easily removed by blower.

Shaft S7 (John Fowell)

Location; 70 m east of peg M10A

Coords: 330400: 6976750

R.L.: 371.8

0-1 m	Red-brown sandy soil.
1-12 m	Sandstone white to off-white. Silicified in upper part. Several thin seams on *levels* at 9-11 m, containing *potch* and colour. Vertical structures contain purple and orange iron staining some cross bedding and tubules are common. This was a hand dug shaft which shows the features uch better than shafts drilled with a Calweld rig. A white fluorescent powder was discerned in some of the *verticals*. Dips generally south at ~10°.

<u>Shaft S8</u>

Location: 20 m south of peg M. 19.

Coords: 330500: 6976800

R.L. 378.8

0-2 m	Red dune sand.
2-18.3 m	Sandstone, white kaolinitic medium to coarse grained silicified in uppermost 2-3 m. Mainly horizontally bedded in shaft. Grey silicified (opaline) sandstone at 17 m and blue *potch* and opal associated with it. Bedding is wavy and the opal/*potch* follows the bedding, and yellow iron staining is present through some of the workings (Plates 26 & 27).

Less than 10 from this shaft a *vertical* was later found containing both black opal and crystal opal on black *potch*, up to nearly 2 cm thick (Plate 26), in its thickest part. Approximate orientation of *vertical* was ?215° as related by miner.

Shaft S9

Location: 30 m southwest of M6.

Coords: 6977150

R.L.: 376.0

0-.50 m Red-brown sandy soil.

.5-9 m Sandstone, white kaolinitic. Medium to coarse grained. *Vertical* from 8-9 m only 2-3 mm thick but carrying good colour. A vertical seam and a curved oblique seam joined and thickened slightly.

Shaft S10 (Ashley and Mike)

Location: 70 m west of M6

Coords: 330450: 6977200

R.L. 377.1

0-.5 m Red sandy soil.

.5-8.5 m Sandstone, white to off white kaolinitic, silicified in part and contains thin clay stringers (1-2 cms) through much of the sandstone which is medium to coarse grained and shows some graded bedding. One clay seam is 5 cm in thickness. A near vertical joint striking 80° dipping 75° N showed a thin *trace* of opal which cut out below at a horizontal clay seam. Second vertical joint strikes at 295°.

Shaft S11 (Abandoned)

Location: 200 m south of peg M19

Coords: 330500: 697660

R.L.: 376.0 m

Holocene

0-1.6 m Soil, red-brown with polished rounded quartz up to 3 mm silcrete pebbles and buckshot gravel, pebble of silcrete within silcrete. Variably eroded surface.

Cretaceous

1.6-6.1 m Sandstone generally fine to medium-grained white to off-white mottled iron staining, multiple wavy joints infilled with coarser grained material i.e. polished quartz as above and larger quartz pebbles bedding not obvious.

6.1-6.3 m Grit to pebble conglomerate, very coarse grit containing pebbles and cobbles up to 500 mm and claystone clasts up to 300 mm. Iron staining introduced via vertical joints giving pink, yellow and purple. Sharp top boundary, wavy bottom boundary.

6.3-9.5 m Sandstone fine to medium-grained white to off-white as for 1.6-6.1.

Water level 9.5 m.

Pink sandstone on dump must be below water level.

T.D. of shaft 13.25 m.

Shaft S12 (Abandoned)

Location: 500 m west of peg 1056. (Fig. 5)

Coords: 329600: 6976800

R.L.: 370.5 m

Holocene

0-1.3 m Red-brown sandy soil, clayey below 0.8 m.

Tertiary

1.3-2.0 m Sandstone, very clayey fine to very fine grained, buff to light orange-brown some dark reddish-brown mottling, hard, well-cemented.

2.0-2.7 m Sandstone similar to above but coarser (fine to medium grained) and contains coarse quartz pebbles up to 3 mm and some angular fragments of ?Mintabie beds.

2.7-3.4 m Sand fine to medium-grained, slightly clayey, small pebbles as above.

3.4-4.1 m Silcrete, white to off-white silicified sandstone, fine-grained.

<u>L. Jurassic to E. Cretaceous</u>

4.1-5.0 m Sand/Gravel (50:50).
Sand v. fine to fine grained off-white to brown. Gravel, well-rounded poorly sorted. 1 mm to 2½ cm, some pebbles to 4 cm. Soft and loose.

5.0-6.8 m Sandstone, off-white and orange, mottled very fine to fine-grained occasional grain of 2 mm size.

6.8-7.2 m Fine sandstone with no larger grains.

7.2-9.1 m Sandstone, off-white with some orange mottling, fine grained partly silicified.

Water level 9.1 m.

Depth of shaft 9.8 m.

<u>Shaft S13 (Abandoned)</u>

Location: 140 m northeast of peg M6.

Coords: 330600: 6977300

R.L.: 377 m

0-1 m Soil and silcrete rubble.

1-10.5 m Sandstone silicified in part, med. to coarse grained, kaolinitic.

(8.3 m) Clay seam, white, kaolinitic, varies in thickness 5-10 cm.

(9.7 m) Clay seam, white kaolinitic, 5 cm thick.

Trace of precious opal in adjacent hole (prospecting hole at 7.4 m - 1-2 mm wide sub-horizontal seam.

<u>Shaft S14 (Mat Jukic)</u>

Location: Adjacent peg M8

Coords: 330700: 6976850

R.L.: 375.8 m

Surface soil hidden by shaft collar. Depth of workings = 15 m.

Observations. Major joint dipping 80°N striking at 220° shown in Plate 25.

This was the most prominent joint observed in the subsurface and it was reputed to have produced some good opal. Alternative medium and coarse grained sandstone displays the cross bedding shown in Plate 21 by contrasting white and pale grey beds.

APPENDIX D

Rock Sample Descriptions
Extracted from Amdel reports.

Samle No. AMDEL REPORT

Mintabie beds at Mintabie P.S.F.

P715/68, P716/68MP 1757-69

RS 200-209, 217GS 2814/79, GS 261/80

RS 245 GS 1845/80

RS 271 GS 5078/80

A 2571/79, A2572/79GS 264/80

Blue Hills Sandstone

RS 237 GS 1845/80

Mt Chandler Sandstone

RS 238 GS 1845/80

Sandstones from Blue Hills Area

P 713/68 P 714/68MP 1757-69

RS 81 RS 82GS 5078/80

Younger units, Mintabie P.S.F.

RS 272 RS 273 (E. Cretaceous)

RS 199 RS 218 (Tertiary) GS 2814/79, GS 261/80

Sample: P715/68

Location:

Everard four-mile sheet. (Mintabie Beds. ?Prominent outcrop near Section 2. Fig. 4).

Rock Name:

Arkosic sandstone.

Hand Specimen:

Pale buff to pinkish sandstone. Slightly friable.

Thin Section: 22020

A visual estimate of the constituents gives the following:

	%
Quartz	45-50
Feldspar	45-50
Lithic grains	Trace
Epidote	1-2
Opaque grains	1-2
Zircon	Trace
Apatite	Trace
Garnet	Trace
Tourmaline	Trace
Clay	Trace

The rock contains layers of well sorted quartz and feldspar grains with minor heavy mineral grains. Grain size varies in the different layers - some are predominantly grains between 0.1 and 0.3 mm, others are of grains from 0.05 - 0.1 mm.

Quartz and feldspar grains are subangular to rounded, apatite and zircon grains are generally well rounded, other grains vary. The detrital mineral grains are closely packed but there has been very little interpenetration of adjacent grains.

Minor amounts of clay and traces of sericite occur in some interstices and along some grain boundaries.

Feldspar grains include microcline, orthoclase and plagioclase. Many are fresh but some are partly weathered. Plagioclase is slightly more abundant than in other specimens.

Heavy mineral grains are more abundant than in previous specimens - particularly epidote. There are also rare composite grains of quartz/epidote and feldspar/epidote.

History:

Sedimentary rock containing detrital material derived from a granitic or gneissic terrane. It probably accumulated in shallow water in a fairly high energy environment.

It differs from other specimens in the presence of apatite.

Sample: P716/68

Location:

Everard four-mile sheet. Mintabie Beds. (Prominent outcrop near Section 2. Fig. 4).

Rock Name:

Sandstone/siltstone.

Hand Specimen:

Pinkish brown, friable sandstone with thin layers of silt and/or shale.

Thin Section: 22021

A visual estimate of the constituents gives the following:

	%
Quartz	60-70
Feldspar	20-30
Lithic grains	5-10
Mica flakes (mainly biotite)	3-5
Heavy mineral grains include:	1-3
Epidote	)
Garnet	)
Opaque grains	)
Sphene	)
Zircon	)
Tourmaline	)

The rock contains layers of well sorted medium sand sized (0.1-0.3 mm) grains alternatively with layers of fine sand (0.03 - 0.08 mm) and a few thin layers of silt.

Quartz and feldspar grains are subangular to rounded in the coarser grained layers, and angular to subangular in the finer grained layers.

Partly altered and crumpled mica flakes are common along some silt layers.

Elongated grains are roughly parallel to the layering.

In general, the detrital grains are closely packed and there are few interstices. Traces of iron oxide stained clay occur as films coating some grains, in interstices and along some silt or shale layers.

Garnet, epidote and opaque grains are the most abundant heavy minerals.

Some feldspar grains are fresh, some are partly weathered.

History:

Sedimentary rock.

It contains less feldspar, more finer grained material and more mica than previous specimens.

Sample: 5543; RS200; TS41276

Location: Mintabie, Open cut. Mintabie Beds. (Cut 2 adjacent to peg 1050, Fig 5).

Hand Specimen:

A pale yellow to pale orange, friable sandstone containing abundant clay. Bedding is poorly defined except where the rock tends to split along some bedding planes.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Quartz	25-30
Detrital feldspar	20-25
Iron oxide-stained clay	40-50
Lithic grains	2-3?
Heavy mineral grains	Trace

This sandstone contains poorly sorted detrital quartz and feldspar grains, a few altered lithic grains and a few heavy mineral grains, loosely cemented by a matrix of clay stained by iron oxide.

Detrital quartz and feldspar grains vary in size from about 0.5 mm up to about 0.6 mm and the feldspar includes both potash feldspar and plagioclase. Microcline is probably the most abundant feldspar. There are a few lithic grains composed predominantly of fine-grained mica or sericite, a few of microcrystalline quartz, and a few completely altered grains.

Heavy mineral grains include opaque oxide and zircon. The sediment originally contained a few detrital mica flakes, but most of these have been deformed and altered and now merge with the matrix leaving only one or two altered muscovite flakes. The detrital quartz and feldspar grains are mainly subangular with a few angular feldspar fragments and some subrounded quartz grains.

Elongate grains tend to be subparallel, probably to the direction of bedding, but there are no clearly defined bedding planes in the area sectioned and no variation in composition or grain size.

Most of the detrital mineral grains are not touching, although some are only separated by a thin film of clay and some appear corroded. They are now cemented by fine-grained, iron oxide-stained clay which has at least partly recrystallized to micaceous flakes with moderate birefringence. No evidence of silicification of the matrix was found.

<u>Conclusion</u>:

Argillaceous and feldspathic sandstone.

Sample: 5543 RS 201; TS41277

Location:

Mintabie, Roger's claim. Off-white, hard sandstone, Mintabie Beds. (Cut 2, Fig 5).

Hand Specimen:

An almost white, medium-grained sandstone which is slightly friable and contains white clay.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Detrital quartz	50-60
Detrital feldspar	10-15
Detrital grains replaced by clay and opal	10-15
Heavy mineral grains	Trace
Interstitial clay and opal	10-15

This sandstone is composed of moderately well sorted quartz and feldspar grains, many of which have a grain size of between 0.1 and 0.3 mm, with a few, scattered, larger grains up to about 0.8 mm. Many of the grains are subrounded to subangular and there is only a slight tendency for elongate grains to be subparallel to the direction of bedding. The rock contains some completely altered grains, some of which have been replaced by turbid, impure opal and some by clay partly silicified by opal, and the external shape of some of these suggests that they may have been feldspar grains. Heavy mineral grains are mainly opaque oxide, zircon and tourmaline, and these are slightly more abundant than in the previous two specimens. There are a few opaque oxide or leucoxene grains up to 0.3 mm in size.

In general, the detrital grains in this sediment are closely packed, some are welded and a few interpenetrate. Some are surrounded by thin films of clay and the remaining interstices contain either clay or opal or clay partly replaced by opal.

Conclusion:

Feldspathic sandstone in which clay in interstices and replacing some mineral grains has been partly silicified by opal.

Sample: 5543 RS202; TS41278

Location:

Mintabie, open cut near scarp. White, soft sandstone, Mintabie Beds. (Cut 2 Fig 5).

Hand Specimen:

A slightly friable, white sandstone containing clay. Towards one end of the specimen submitted there are some thin veins up to 1mm thick of opal showing a play of colours which could therefore be described as precious opal.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Quartz	40-50
Detrital feldspar	25-30
Altered grains (mainly clay)	10-15
Heavy mineral grains	Trace
Interstitial clay	5-10
Opal	3-5 (difficult to estimate)

The sandstone is composed of moderately well sorted detrital quartz and feldspar grains with a common grain size of about 0.15 to 0.3 mm, but there are larger grains up to 0.8 mm in size scattered throughout the sediment. There are also many grains which have been replaced by turbid masses of clay, possibly with some associated opaline silica, and the general shape of some of these suggests that they may have been feldspar. Many of the detrital grains are subangular to subrounded. Heavy minerals grains are mainly opaque oxide, probably leucoxene.

Throughout most of the rock the detrital grains are closely packed and a few are welded and/or interpenetrate, but many are separated by thin films of slightly micaceous clay which has crystallized or recrystallized in situ. Some interstices are lined with a very thin film of this clay, a few have been filled or almost completely filled by clay, and some interstices contain opal associated with this clay.

The veins noted in the hand specimen are 0.5 to 1 mm thick and these are composed almost entirely of clear opal. Those included in the area sectioned are subparallel and there are also a number of other, much smaller, veins about 0.1 to 0.2 mm thick which cut the rock essentially in the same direction. These also contain opal of varying turbidity. The boundaries of these veins are rather irregular and, in general, they do not cut across detrital quartz or feldspar grains. Where opal has penetrated the rock adjacent to the vein it has been deposited after crystallization of the films of clay along grain boundaries and lining interstices.

Conclusion:

Feldspathic sandstone cemented mainly by films of clay along grain boundaries. Veins of opal have formed after crystallization of the interstitial clay.

Sample: 5543 RS203; TS41279

Location:

Mintabie open cut scarp area, Mintabie Beds. (Cut 2 Fig 5).

Hand Specimen:

A white sandstone very similar to RS202 in that it contains white clay and is also cut by a thin vein of opal showing a play of colours.

Thin Section:

This is essentially similar to sample RS202 and a full description would involve needless repetition. It consists essentially of detrital quartz and feldspar grains and some completely altered grains which have been replaced mainly by clay. These are closely packed and are loosely cemented by clay, much of which occurs as thin films along grain boundaries and lining interstices. The texture suggests that this clay has crystallized in situ and in some interstices it appears to be associated with, or followed by, turbid opal. Some of the turbid, altered grains may also contain opal associated with the secondary clay.

The section contains portion of the vein of precious opal which, along parts of its length, is about 2 mm thick with clearly defined boundaries which, however, do not cut across detrital mineral grains. The vein then passes into a zone where its boundaries are not well defined and it occurs in poorly defined and coalescing veinlets and irregular patches in a zone about 4-5 mm thick. Some detrital quartz and feldspar grains in this zone are completely surrounded by opal and adjacent to the vein opal fills some interstices which are lined with a thin film of the authigenic clay. Some turbid opal occurs in less regular veinlets and patches in other parts of the rock and some is almost certainly associated with the clay which has replaced some detrital grains.

Conclusion:

Feldspathic sandstone loosely cemented by clay which has crystallized in situ. It contains some opal associated with the clay and is cut by a vein of precious opal.

Sample: 5543 RS204; TS41280

Location:

Mintabie. Bulldozed mesa (Cut 10, Fig 4). Mintabie Beds.

Hand Specimen:

A pink sandstone with one slightly irregular joint surface which is partly encrusted with pale grey opal. When the hardness of the rock is tested with a needle point there is, in some places, a zone varying in thickness up to about 8-9 mm adjacent to the vein which is harder than the remainder of the rock, but this zone appears to be poorly defined and of very variable thickness.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Quartz	45-50
Detrital feldspar mainly microcline	20-25
Altered grains	3-5
Heavy mineral grains	1-2
Interstitial clay	10-15?
Opal	10-15? (difficult to estimate)

The sandstone is very similar to samples RS202 and 203 in that it contains detrital quartz and feldspar grains (mainly microcline) which are moderately well sorted and have a common grain size of 0.1 to 0.3 mm, but there are some larger grains up to 1 mm long scattered throughout the rock. There are some altered grains which have been replaced by clay and some heavy mineral grains, mainly opaque oxide or leucoxene. The detrital grains are generally closely packed but very few are welded or interpenetrate. Throughout parts of the rock they are cemented by extremely fine-grained clay, but there are also some patches and poorly defined veins or vein-like areas in which interstices contain turbid opal.

The joint noted in the hand specimen contains opal, some of which is clear and some shows curved lines of staining. Adjacent to this joint many interstices in the rock contain turbid opal and there are also numerous very small veins of turbid opal generally less than 0.05 mm thick along grain boundaries and also cutting a few detrital quartz grains. In some areas these veins and patches of turbid opal occur in the sandstone for distances of up to about 8 mm from the joint, but in another area in for distances of up to about 8 mm from the joint, but in another area in the thin section they only extend for about 2 mm from the joint. The pattern formed by this partial silicification of the sandstone is very irregular and most of the interstitial opal is probably associated with clay.

Conclusion:

Feldspathic sandstone with opal along a vertical joint. Opal has also penetrated the rock for distances of up to about 8 mm from the joint but this partial silicification is very irregular and patchy.

Sample: 5534 RS205; TS41333

Mintabie Beds

Hand Specimen:

A pale grey to almost white sandstone with some seams of grey opal with patches of bluish opal and some veins of pale grey opal.

Thin Section:

As the composition varies a quantitative estimate of the various minerals would serve little purpose.

The sandstone contains well sorted detrital quartz and feldspar grains, commonly 0.3 to 0.6 mm in size, and also numerous weathered or altered grains which have been replaced by clay and by clay and opal. There are a few heavy mineral grains, mainly opaque oxide or leucoxene. The grains are moderately closely packed and a few are welded, but there has been very little interpenetration of grains. Many of the grains are surrounded by an extremely thin film of clay? and most interstices contain opal. This interstitial opal is present both above and below the opal. This interstitial opal is present both above and below the veins and from the thin section it is not possible to distinguish any difference in the degree of silicification in the different zones.

The large opal seam near the top of the sample has zones of varying turbidity with some sharply defined boundaries suggesting interruptions and possibly more than one episode of deposition of opal. In a thin, discontinuous zone generally less than 1 mm thick along the lower boundary the rather turbid opal contains some very small splinters of quartz and some microspherular grains up to about 20 microns in diameter now composed of almost opaque to dark brown iron oxide. Some of these occur in groups and the general appearance suggests the possibility that they could originally have been microspherular pyrite. In some of the opal slight staining defines some straight and parallel bands which may have been horizontal, and in the upper portion of the larger seam there are some lines of staining suggesting swirl patterns.

Conclusion:

Opal seams in partly weathered, feldspathic sandstone. Opal indistinguishable from, and in many places continuous with, that in the veins fills interstices in the sandstone.

Sample: 5543 RS206; TS41282

Location:

Loose sample of sandstone with opal seam, Mintabie Beds near Cut 2 (Fig 5).

Hand Specimen:

Slightly friable, white sandstone with a thin seam of opal about 1-2 mm thick which is approximately horizontal and shows some play of colour. A rather inexact test of hardness made by running a steel point over a freshly cut surface suggests that the rock is slightly harder, and therefore probably partly silicified, in a zone up to about 5 mm thick below the opal seam and in some areas in a zone up to 2 mm thick above the opal seam, but this is probably not a very accurate test.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Quartz	60-65
Detrital feldspar	25-30
Grains replaced by clay	3-5
Heavy mineral grains	Trace
Interstitial clay	3-5?
Opal	5-10

The sandstone is very similar to that in previous specimens except that it is not very well sorted and grains vary in size from about 0.1 to about 0.6 mm. Microcline is the dominant feldspar and many of the detrital grains are subangular to subrounded. There is a slight tendency for elongate grains, particularly cleavage fragments of feldspar, to be subparallel to the bedding. There are a few heavy mineral grains, mainly opaque oxide or leucoxene, and there are numerous grains which have been replaced by clay. The marked turbidity of some of these altered grains strongly suggests that they have also been partly silicified by opal. In general, the grains are closely packed, but most of them are separated by a very thin film of clay which has crystallized in situ. Some interstices are filled by clay and some contain opal. Opal occurs in interstices both above and below the opal seam and in the thin section there is no conclusive evidence to show whether or not silicification does seem to be more extensive in zones adjacent to the seam and immediately above the main seam there are a few smaller, branching veinlets connected to the seam. The seam of opal is about 1-2 mm thick and it has a very sharply defined, stained zone about 0.5 to 0.8 mm thick along its base and a discontinuous and more irregular stained zone along portion of the upper part of the seam. This suggests at least one interruption during deposition of the opal.

Conclusion:

Feldspathic sandstone with a thin, almost horizontal seam of precious opal. Inconclusively evidence suggests that silicification by opal may be slightly more extensive below the seam than above, but the suggestion is very tentative.

Sample: 5543 RS207; TS41283

Location:

Mintabie. Roger's pit (hard, off-white to grey sandstone). (Cut 2).

Hand Specimen:

A very pale yellowish-grey to almost white sandstone with indistinct bedding defined by some variation in grain size, but this is not regular and there are a few small pockets of coarser-grained sandstone a few millimetres in size. The rock tends to split along a few bedding planes, giving slightly rough surfaces.

When the rock is examined by binocular microscope it is apparent that many detrital grains (probably feldspar) have been replaced by white clay. A few tiny patches showing play of colour typical of precious opal were also observed, mainly in a small pocket of the coarser-grained sediment and traces of this opal were also seen in one of the altered detrital grains replaced mainly by white clay. This observation shows that the rock contains opal, some of which probably occurs along grain boundaries and in interstices, but it is also associated with clay replacing some detrital grains.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Quartz	40-45
Detrital feldspar, mainly microcline	30-35
Altered grains replaced by clay and opal	10-15
Lithic grains	Trace
Heavy mineral grains	1-2
Interstitial clay and opal	5-10

The sandstone is composed of well sorted detrital quartz and feldspar grains, many of which are between 0.1 and 0.2 mm in size, but there is some variation in the grain size in different layers in that coarser-grained layers have grains commonly 0.2 to 0.4 mm in size and there are finer-grained layers with grains about 0.05 to 0.1 mm in size. There are also a few scattered larger grains about 0.8 mm in size. Heavy mineral grains, mainly opaque oxide or leucoxene with trace amounts of zircon are concentrated mainly along two of the finer-grained layers but a few grains are also scattered throughout the rock.

Many of the detrital quartz and feldspar grains are subangular to subrounded and elongate grains tend to be subparallel to the bedding. Altered grains, probably mainly feldspar, have been replaced by extremely fine-grained, almost isotropic clay and, as noted in the hand specimen, some have been replaced by both clay and opal and these appear very turbid in thin section due to differences of refractive index between the clay and opal.

The detrital grains are closely packed, many are welded along surfaces of contact and a few interpenetrate. There are very thin films of an authigenic clay mineral along many grain boundaries and this clay has a moderate birefringence. Some interstices contain opal.

Conclusion:

Feldspathic sandstone very similar to RS201. It is finer-grained than some of the other samples and also detrital grains show more evidence of welding. Most of the clay apparent in hand specimen is in the form of altered detrital grains, possibly feldspar. The rock is partly silicified by opal, some of which occurs in interstices and some is associated with clay replacing some detrital mineral grains.

Sample: 5543 RS208; TS41284

Location:

Sample near Cut 2 (Fig 5). Soft white sandstone, with opal. (Mintabie Beds).

Hand Specimen:

A friable, almost white sandstone with a thin seam of opal about 1-2 mm thick. The sample contains abundant white clay found in thin section to be largely altered detrital grains, probably feldspar.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Quartz	35-40
Feldspar, mainly microcline	25-30
Altered and partly altered feldspar (clay)	15-20
Interstitial clay	5-10
Opal	5-10? (difficult to estimate)
Heavy mineral grains	Trace

The sandstone is composed mainly of detrital quartz and feldspar grains 0.2 to 0.4 mm in size with a few heavy mineral grains and a few lithic grains now composed largely of sericite and clay. Many of the detrital grains are now very turbid and have been partly or completely replaced by very fine-grained clay, possibly with a little opal associated with the clay, but where these two minerals are closely associated it is not always possible to determine the exact composition. The detrital grains are closely packed, some are welded and some interpenetrate,but many are separated by very thing films of extremely fine-grained, authigenic clay. Similar clay lines most of the remaining interstices and many interstices have been filled or almost completely filled by this clay, some of which occurs as minute flakes or fibres projecting in from the surface of the interstices. In some areas near the seam of the opal some interstices contain opal but, because of the very fine grain size and intimate intergrowth of clay and opal, it is not possible to accurately determine the extent of the silicification.

The opal seam is about 1-2 mm thick, part of it is clear, some is turbid and in one area the boundaries have become diffuse and there is a zone of opal about 4-5 mm in size containing scattered detrital quartz and feldspar grains.

Conclusion:

Feldspathic sandstone in which a moderately large proportion of the detrital grains have been replaced or partly replaced by clay. It is cut by a thin seam of opal and, adjacent to this seam, some interstices contain opal.

Sample: 5543 RS209

Location:

Tony's and Peter's claim. (Cut 3).

Hand Specimen:

The material is very pale green to almost white, translucent and brittle and it breaks with a conchoidal fracture. Some of it disintegrated into small fragments when immersed in water.

It was identified by X-ray diffraction as hydrated halloysite with traces of alunite, quartz and chlorite.

Sample: 5543 RS217; TS41862

Location: Cut No 17, Mintabie Beds (Fig 5).

Rock Name:

Arkose

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	70
Feldspar	15-20
Opaques and semi-opaques	5
Lithic fragments	5
Clay	3
Heavy minerals	1

This is a well-sorted fine-grained sandstone characterised by the abundance of feldspar and the excellent sorting and roundness of the grains. Some zones are cemented with ferruginous material but there are large areas of the rock in which opaque material is present in trace amounts only.

The average grain size of the rock is approximately 0.12 mm but there are a few grains as much as 0.4 mm in size; despite this, the sample appears to be well-sorted and many of the grains are subround in shape. The grains have been modified during diagenesis and there are many long and concavo-convex grain boundaries and the sample has a very well cemented aspect. The detrital feldspar is generally fairly fresh and consists of both plagioclase and potassium feldspar. Both types show twinning and this is only partially obscured by sericitic alteration. Some quartz grains show small overgrowths but these were not observed on the feldspar grains.

As a result of pressure solution there is only a small amount of intergranul space and this is filled partly by secondary quartz and partly by thin films of clay and hematitic material. These components together comprise probably less than 5% of most of the rock although, as mentioned above, there are a few irregular bands where opaque material comprises as much as about 10% of the rock.

Detrital heavy minerals are a minor component of the sample and opaques and garnet were identified as well as more common varieties such as zircon and ?rutile.

Conclusion:

This is a well cemented fine-grained arkose which, despite the abundance of feldspar, shows considerable evidence of maturity particularly in the lack of clay and the excellent sorting and roundness of the grains.

Sample: 5543 RS245:

Location:

Silty claystone S. of Apamurra Bore. (Mintabie Beds - Fig. 4).

Clay Mineralogy:

X-ray diffraction of the greenish to brownish clay gives the following mineral constituents:

Quartz	Co-dominant
Feldspar (K-feld.>plag)	Co-dominant
Muscovite	Accessory
Mixed-layer clay*	Accessory
Calcite	Accessory

* Further detailed work would be required to specifically identify the individual components.

Sample: 5543 RS271; TS43151

Descriptive Information:

Bulldozer cut, Mintabie Beds sandstone. (Cut 16, Fig 5).

Hand Specimen:

A white sandstone containing apparently well sorted sand grains in a matrix of white clay. Staining of the specimen with cobaltinitrite shows that it contains moderately abundant potash feldspar grains and close examination shows that there are also some grains now composed of white clay which have not stained with cobaltinitrite.

Thin Section:

Mineral Assemblage	%
Quartz	30-35
Potash feldspar mainly microcline	25-30
Grains now composed of sericite and clay	10-15
Opaque oxide and leucoxene	Trace-1
Zircon	Minute Trace
Interstitial clay	25-30

This sediment contains well sorted grains of quartz and microcline, some feldspar and/or lithic grains which have been completely replaced by clay and a few heavy mineral grains cemented by interstitial clay which is probably mainly kaolinite.

Most of the detrital grains are between 0.2 mm and 0.4 mm in size with a few up to 0.5 mm and most of them are subrounded with a few well-rounded grains. Some feldspar grains and also grains which have been replaced by clay are elongate and these tend to be subparallel to the direction of bedding as shown by slight variations in grain size. Along one edge of the section there is a finer-grained layer in which many of the detrital grains are between 0.1 and 0.2 mm in size. Grains which have been replaced by clay are very turbid and at least a few still retain evidence of former cleavage planes indicating that at least some of these were probably feldspar. A few contain sericite and a few may have been lithic grains but their origin cannot be determined. Heavy mineral grains are mainly rounded opaque oxide and leucoxene with a few zircon grains, the largest of which is 0.2 mm in size. One small muscovite flake was found.

The detrital grains are moderately closely packed and many are just touching but only a few have become welded and there is no evidence of interpenetration of grains. Interstices are filled with very fine-grained clay which has crystallized or recrystallized in the interstices and in places forms very thin colloform-like layers surrounding grains and lining interstices.

Conclusion:

Argillaceous and feldspathic sandstone containing well-sorted but immature detrital grains.

MINERALOGY OF TWO SAMPLES

1. INTRODUCTION

Two samples of clay submitted by Mr J Townsend of the South Australia Department of Mines and Energy were as follows:

A2571/79 Mintabie - green? clay. Cut 11, Fig (silicified).

A2572/79 Mintabie - Cut 10 - Station A.

Their mineralogy (in particular, clay mineralogy) was to be determined on the bulk material and on the -2 m fraction.

2. PROCEDURE

Powdered subsamples of the bulk material were examined by X-ray diffractometry and the results interpreted by standard procedures.

A weighed amount of A 2571/79 was dispersed in water using an electric blender and allowed to sediment to produce -2 m material by the pipette method. This was used to produce oriented clay preparations on ceramic plates which were examined in the diffractometer, and diagnostic tests were applied as appropriate.

The other sample, A 2572/79, was not so treated because of its high content of gypsum, revealed in the bulk examination. This made it certain that this sample would flocculate when dispersed in water. The low solubility of gypsum renders its washing-out impracticable, and therefore further work with this sample could not be carried out.

3. RESULTS

The results are tabulated below. Minerals are listed in approximate order of decreasing abundance, using the semi-quantitative terms given below.

	A 2571/79		A 2572/79	
Bulk Material	Opaline silica	D	Gypsum	D
Quartz	A-SD		Montmorillonite	A
Kaolinite	A		Kaolinite	A
Calcite	A		Quartz Tr	
Mica	Tr-A		Feldspar?	Tr
Feldspar?	Tr			
-2 m fract. %	17			
Mineralogy	Opaline silica	D		
	Mica/illite	SD		
	Kaolinite	A	(not available)	
	Calcite	A		
	Quartz	Tr		

D	=	Dominant.	Used for the component apparently most abundant, regardless of its probable percentage level.
SD	=	Sub-dominant.	The next most abundant component(s) providing its percentage level is judged above about 20.
A	=	Accessory.	Component judged to be present between the levels of roughly 5 and 20%.
Tr	=	Trace.	Components judged to be below about 5%.

Sample: 5543 RS237; TS 42449

Location:

Blue Hills Sandstone near Gap Bore (See Fig. 3).

Hand Specimen:

A pale creamy pink, medium/fine-grained rock.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	90-93
Pore Spaces	7-10
Clay? etc.	Trace

This is apparently a very pure sandstone, with grains and crystals of quartz etc. plus remaining pore spaces making up over 99% of the sample.

The grain size ranges from 0.03 mm to 0.5 mm, most components being around 0.15 mm. They consist now of interlocking quartz crystals but with a significant amount of pore space apparently crystals but with a significant among of pore space apparently still unoccupied. At rare crystal junctions there may be traces of material now visible largely as a local cloudiness, probably aggregated very fine dark specks or possibly clay material. A slight cloudiness also marks many crystal boundaries, but this seems to result from tiny inclusions along and within the crystal edges. The quartz itself though relatively unstrained, shows distinctive overgrowth structures, and the original grains were clearly sub-angular to rounded in the main. There are also very rare grains derived from fine recrystallised quartz and/or quartzite.

Conclusion:

A welded but porous sandstone, displaying overgrowth structures.

Sample: 5543 RS238 TS42450

Location:

Mt Chandler Sandstone near Gap Bore (Fig 5).

Hand Specimen:

A tough, pale slightly brownish grey medium-fine granular rock.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	97
Pore Spaces	3
Muscovite	Trace
Plagioclase)	
Biotite)	Extremely Rare
Tourmaline)	
Opaque phases?)	
Heavy minerals?)	

This sample is slightly coarser than the previous (generally about 0.2 mm grain size) and with the welding of original grains more advanced as seen by suturing of junctions. Over-growth structures can be appreciated less readily and less frequently. Much of the quartz has a local cloudiness due to minute inclusions in planes and patches: consequently it looks deceptively like feldspar, which is in fact extremely rare (1 grain found). Some small flakes of muscovite may be interstitial but most occur as inclusions in quartz, as does the extremely rare biotite. Tourmaline (1 grain found) is zoned pale olive to bluish. Traces of opaque phases and heavy minerals which could not be identified with certainty may in fact be contaminant in the section, though some resemble possibly recrystallised leucoxene.

Conclusion:

A sandstone/quartzite.

Sample: P713/68

Location:

Everard four-mile sheet. Blue Hills area.

Rock Name:

Arkose.

Hand Specimen:

Pink to yellowish sandstone with layers of varying grain-size. Cross bedding is clearly indicated on part of the specimen.

Thin Section: 22018

A visual estimate of the constituents gives the following:

	%
Quartz	50-60
Feldspar	20-30
Clay	10-20
Lithic grains	Trace
Opaque grains	Trace
Muscovite	Trace
Zircon	Trace
Tourmaline	Trace
Rutile	Trace

The section includes layers of sediment of varying grain size, but in general, individual layers are well sorted.

Some layers contain rounded and subrounded grains of quartz and fresh to cloudy weathered feldspar commonly between 0.5 and 0.6 mm. Interstices contain cloudy, extremely fine grained clay with a few very small quartz grains. There has been only very minor welding of detrital grains by interpenetration caused by pressure solution.

Another layer is composed mainly of angular to subangular quartz, feldspar, opaque grains, rare micaceous grains, and very rare zircon grains commonly between 0.04 and 0.08 mm. Interstices contain mainly clay.

The coarser grained layer adjacent to the fine grained layer contains some fine grained quartz and feldspar in interstices between the large grains - that is, there is a gradual transition with no sharply defined bedding plane.

Other layers of sediment are generally similar to those described above but some are not as well sorted, and the clay matrix in places is stained with iron oxide.

Heavy mineral grains are more abundant along the zone or cross bedding.

History:

Sedimentary rock composed of material derived from granitic or gneissic terrain. It could have accumulated near the mouth of the river.

Sample: P714/68

Location:

Everard four-mile sheet. Blue Hills area.

Rock Name:

Arkosic siltstone.

Hand Specimen:

Reddish sandstone with fine layering.

Thin Section: 22019

A visual estimate of the constituents gives the following:

	%
Quartz	60-70
Feldspar	20-30
Heavy mineral grains and Opaques	1-2
Mica	1-2
Interstitial clay	5-10

A well sorted sediment containing angular to subangular quartz and feldspar grains, rare lithic grains and a few flakes of mica and heavy mineral grains. Grain size is generally between 0.02 and 0.05 mm.

Elongated grains, including cleavage fragments of feldspar and mica flakes, are roughly parallel to the layering. The grains are closely packed and many have a surface film of iron oxide.

Extensively weathered feldspar grains are more abundant than in the previous specimens but there are also a few fresh grains. Potash feldspar predominates. Opaque grains are the most abundant heavy minerals. There are very rare zircons and aggregates of sphene (leucoxene). Mica flakes have been partly replaced by clay minerals.

Very fine grained, iron oxide stained clay occurs in interstices and along grain boundaries.

History:

Sedimentary rock.

The sediment was probably deposited in deeper water with less wave and current action than specimens P712/68 and P713/68. More extensive weathering of feldspar grains suggests longer transport and slower sedimentation.

Sample: 5543 RS81; TS43154

Descriptive Information:

Blue Hills Area ?Mintabie Beds.

Hand Specimen:

An almost white sandstone containing quartz grains and an abundance of soft, interstitial clay.

Staining with cobaltinitrite does not show any potash feldspar.

Thin Section:

Because of the slightly friable nature of the rock some of this plucked out during preparation and the proportions given below may therefore not be strictly accurate. It contains the following minerals:

Mineral Assemblage	%
Quartz	70-75
Grains now composed of sericite and clay?	2-3
Interstitial clay	20-25

This is composed mainly of detrital quartz grains cemented by interstitial clay which has probably crystallized or recrystallized in the rock.

The detrital grains are not very well sorted and vary in size from 0.2 mm to 0.8 mm with a few up to 1 mm long and most of them are subrounded to angular.

There are a few altered lithic and/or feldspar grains which are now composed mainly of sericite and a few of clay and they do not show any recognizable relict textures. One small flake of muscovite was found and one or two small, elongate patches of turbid sericite which could represent completely altered biotite. Some of the sericitic and clay grains tend to merge with the matrix.

The detrital grains are moderately closely packed and many are just touching. A few have become welded and very few show some evidence of interpenetration. Interstices contain fine-grained clay occurring as very small flaky or micaceous aggregates and some of this clay contains clouds of minute voids. Only in a few places were small spherulitic aggregates found similar to those in sample 5543 RS272.

Conclusion:

Argillaceous sandstone.

It differs from sample 5543 RS271 in that detrital feldspar was not found and the detrital grains are not as well sorted. It therefore shows a greater similarity to sample 5543 RS272 than to RS271. There are, however, no very distinctive features which could aid correlation of these samples.

Sample: 5543 RS82; TS43155

Descriptive Information:

Blue Hill Area, sandstone above ?Mintabie Beds.

Hand Specimen:

A moderately coarse-grained sediment containing poorly sorted quartz grains and some grains composed of white clay which vary in size up to 2 to 3 mm long. These are cemented by a clay matrix.

Staining with cobaltinitrite shows no evidence of potash feldspar.

Thin Section:

Mineral Assemblage	%
Quartz	70-75
Interstitial clay	20-25
Grains composed of sericite and clay?	3-5 (possibly more)
Leucoxene grains	Trace
Zircon	Minute Trace

The detrital grains in this sample are poorly sorted and vary in size from 0.1 mm to 2 mm with a few much larger quartz and clay grains 2 to 5 mm long. Some of the larger grains are quartz aggregates or fragments of vein quartz and there is one grain of ?quartzite. There is also a grain now composed of quartz and clay showing textures which are either micrographic or myrmekitic but no feldspar has survived. Some grains are now composed of sericite and some of clay but these do not show any recognizable relict textures from which to determine the original nature of the grains. There are a few small heavy mineral grains mainly leucoxene and zircon. Some of the quartz grains are subrounded, a few are well-rounded and some, particularly the larger fragments of vein quartz, are angular or subangular.

The detrital grains are moderately closely packed, a few are welded and very few interpenetrate. Most of them are separated by films of clay and similar clay fills or partly fills most interstices. Some of this clay is stained by iron oxide and some of its shows curved structures and occasional small spherulitic structures.

There is one thin zone or band less than 1 mm thick along which there are angular quartz fragments cemented by some very fine-grained quartz and the general appearance suggests that this could be a shearing plane along which there has been some granulation of the rock and a large quartz fragment in this zone certainly shows evidence of fracturing and incipient granulation in places.

<u>Conclusion</u>:

Argillaceous sandstone composed of poorly sorted quartz grains and a few sericitic and clay grains cemented by clay.

Allowing for local variations it could possibly be related to sample 5543 RS272 but in general it is slightly coarser-grained and possibly shows a greater variation in grain size. There are no distinctive features to aid correlation.

Sample: 5543 RS272; TS43152

Descriptive Information:

Bulldozer cut sandstone above Mintabie Beds (Cut 16 - Mesozoic Sandstone, Figs 4 & 5).

Hand Specimen:

A very pale orange-grey to almost white sandstone which is not as well sorted as sample RS271 and contains a few larger grains 1 to 2 mm in size but these do not appear to be concentrated in layers.

Staining with obaltinitrite does not show any potash feldspar.

Thin Section:

Mineral Assemblage	%
Quartz	55-60
Interstitial clay	35-40
Recognizable grains of clay	3-5
Opaque oxide and leucoxene	Minute Trace
Tourmaline	Minute Trace
Zircon	Minute Trace

This sample consists mainly of poorly sorted quartz grains and a few composed mainly of clay cemented by a matrix composed of fine-grained clay which has crystallized or recrystallized in the rock.

Most of the detrital grains are between 0.1 mm and 1 mm in size but there are a few larger quartz grains up to 2 mm and a few lithic grains now composed mainly of clay 1 to 3 mm in size. Some of the quartz grains are angular, many are subrounded and a few are well-rounded but it is possible that the grain boundaries have been modified by corrosion as some of them show small embayments in which there are now curved and small spherules of clay. Most of the grains now composed of clay are subrounded to well-rounded but a few elongate clay-bearing grains are angular. In the hand specimen one of these lithic grains has the general appearance of silcrete but the presence of this could not be confirmed in the thin section. There are, however, a few lithic grains composed mainly of very turbid clay containing a few scattered, subangular quartz grains up to 1 mm long. Heavy mineral grains are mainly opaque oxide and leucoxene with a few zircon grains and very few tourmaline grains and they vary in size up to 0.2 mm. Some of the larger angular quartz grains in this rock show numerous intersecting planes containing extremely fine-grained dark impurity or clouds of minute voids or vacuoles.

The detrital grains are loosely paced and in general they are not touching and are separated by interstitial clay. In a few places there is evidence to suggest that at least a few of the grains may have a coating of clay generally less than 0.1 mm thick showing some concentric structure but in general, evidence of this coating is not preserved. The interstitial clay has clearly crystallized or recrystallized in the rock and in many areas it shows small curved structures and mutually interfering spherulites less than 0.1 mm in size.

Conclusion:

Argillaceous sandstone composed of poorly sorted quartz grains and a few grains of clay now cemented by interstitial clay.

Sample: 5543 RS273; TS43153

Descriptive Information:

Bulldozer Cut 16 above Mintabie Beds. (Fossiliferous sandy claystone) Marree Subgroup (Figs 4 & 5).

Hand Specimen:

A very pale pinkish-orange to buff-coloured, fine-grained clay-like rock with one irregular layer a few millimetres thick containing coarse sand grains and in another zone of the rock there are sand grains scattered through the clay-like material. One zone in the rock shows numerous thin, elongate voids which could once have contained shelly fossils but a careful search did not reveal any conclusive evidence to prove that these were in fact fossils.

The clay-like material is relatively hard and some crushed portions were therefore separately examined in refractive index liquids. Many particles were found to have a refractive index of less than 1.48 and it is therefore concluded that the clay-like material contains a moderate amount of opal. In one void a few very thin rods or filaments of opal were also found.

Staining with cobaltinitrite does not show any potash feldspar.

Thin Section:

The matrix of this rock is a slightly turbid mass of very fine-grained clay and opal, much of which is isotropic or almost isotropic but it does contain minute flakes and particles of a birefringent clay mineral. Turbidity due to differing refractive indices between clay and opal obscures finer details in this matrix and it is not possible to give an accurate estimate of clay and opal. There are a few minute dark particles and in some zones there may be some dispersed leucoxene. In some zones in this matrix there are curved fractures. No definite evidence to suggest the former presence of fossils was found but there are a few small elongate voids now containing secondary clay which could be interpreted as having been an evaporite mineral such as gypsum but the evidence is not conclusive and this suggestion should be regarded with caution.

The sandy layer noted in the hand specimen contains subangular and subrounded quartz grains 0.5 to 2 mm in size, a few opaque oxide and leucoxene grains up to 0.5 mm in size and a few voids from which an undetermined mineral has been leached or weathered out. Some of these voids are now lined with orange to brown, iron oxide-stained clay and there is one grain or filled void 2 mm long now completely composed of iron oxide-stained clay with a few grains of leucoxene and one small fragment of opaline material. As this extends into an adjacent fracture it almost certainly represents superficial filling of a leached void. In one area there is an elongate mass about 5 mm long of finer-grained sandstone which could have been a small pocket of sand in the original sediment.

Conclusion:

Sandy claystone which has been partly silicified by opal. No definite evidence of fossils was found.

Sample: 5543 RS199; TS41275

Location:

Mintabie, east end of scarp; silcrete (Section 1, Fig 4).

Hand Specimen:

A very pale orange, siliceous rock with a conchoidal fracture. The weathered surface shows an abundance of well-sorted, sand-sized quartz grains, and on one joint surface there is a film of pale yellowish silica. Portion of the sample is stained dull red by iron oxides.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Detrital quartz	70-80
Impure opal	20-30
Detrital heavy mineral grains	Trace
Iron oxide staining	

The rock consists largely of detrital quartz grains which differ from those in many silcretes in that they are moderately well sorted and have a common grain size of about 0.5 to 0.8 mm, with a few up to 1 mm and also a few smaller grains. Many of the grain boundaries have been at least slightly modified by corrosion. There are also remnants of very thin overgrowths of secondary quartz on a few of the grains and these overgrowths appear corroded. Heavy mineral grains are mainly opaque oxides or leucoxene and tourmaline. There are a few traces of very fine-grained mica or sericite and clay which could be remnants of almost completely altered detrital grains now largely replaced by the matrix.

In general, the slightly corroded detrital grains are not touching or are barely touching, and they are cemented by turbid, pale orange to brownish opal which almost certainly contains impurities and is locally stained dark brown by iron oxide and possibly titanium oxide. In general, this opaline cement is uniform without any structure, but there are a few interstices where small voids are lined with a very thin layer of clear opal. In one area fine, colloform-banded opal defines relict textures of cleavage planes in a former detrital mineral grain which has now been completely replaced by clay and opal. This could have originally been a detrital feldspar grain.

Conclusion:

Silcrete with an opaline cement. It was originally a well sorted sandstone.

Sample: 5543 RS218; TS41863

Location:

Section 1, Figure 4.

Rock Name:

Silcrete.

Thin Section:

This rock is typical silcrete and it consists of a heterogeneous collection of quartz grains cemented by turbid material which is probably largely titaniferous secondary oxides of some kind.

The sample is distinctly heterogeneous and the detrital quartz grains range in size from about 1 mm down to virtually submicroscopic grains. The latter tend to occur in specific irregular bands in the rock and in most of the sample the quartz grains range in size from about 0.05 mm to about 0.5 mm. Many of the grains have been slightly corroded by the titaniferous cement but some still show well-rounded outlined although most grains would probably be described as subangular. The quartz itself is generally of the common or plutonic variety and shows slightly undulose extinction. There are a few crystals with a large number of inclusions and this may be vein quartz of some kind. The cementing material is dark in plane polarized light but under high illumination has a very characteristic turbid cream or brown colour which suggest that it is titaniferous. In general this material forms patches no larger than about 0.2 mm but there are one or two places where there are patches up to about 1 mm in size. The latter have a concentric swirling structure probably indicating the mode of deposition of the titanium in cavities in the original sand.

AUSTRALIAN OPAL DEPOSITS

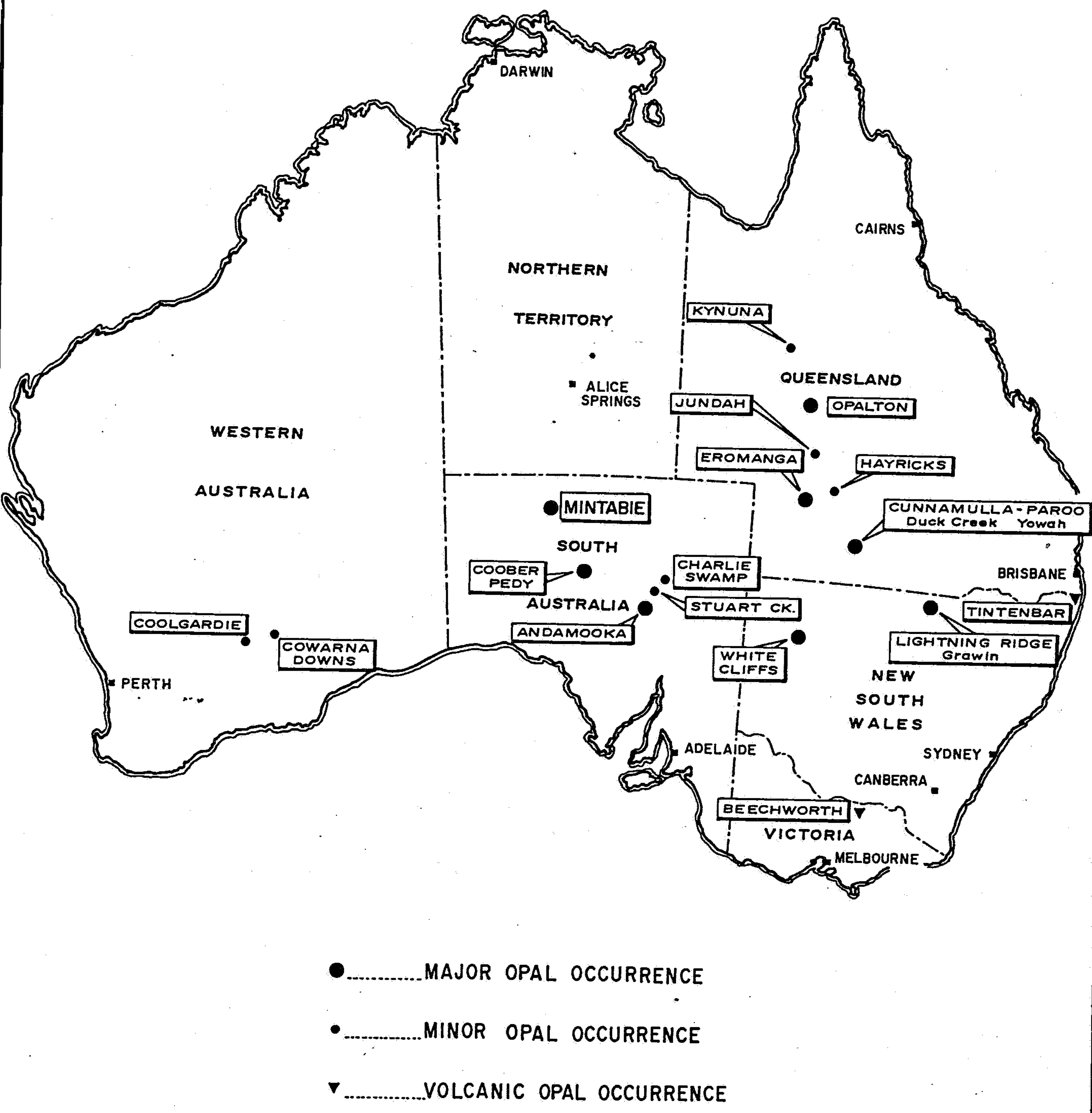


FIG. I

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED I.J.T.	C.D.O. 23·11·84 DATE
MINTABIE OPAL FIELD	DRAWN S.R.	SCALE 23 000 000 approx
LOCALITY MAP	DATE 13/10/81	PLAN NUMBER
	CHECKED	S16079

2331

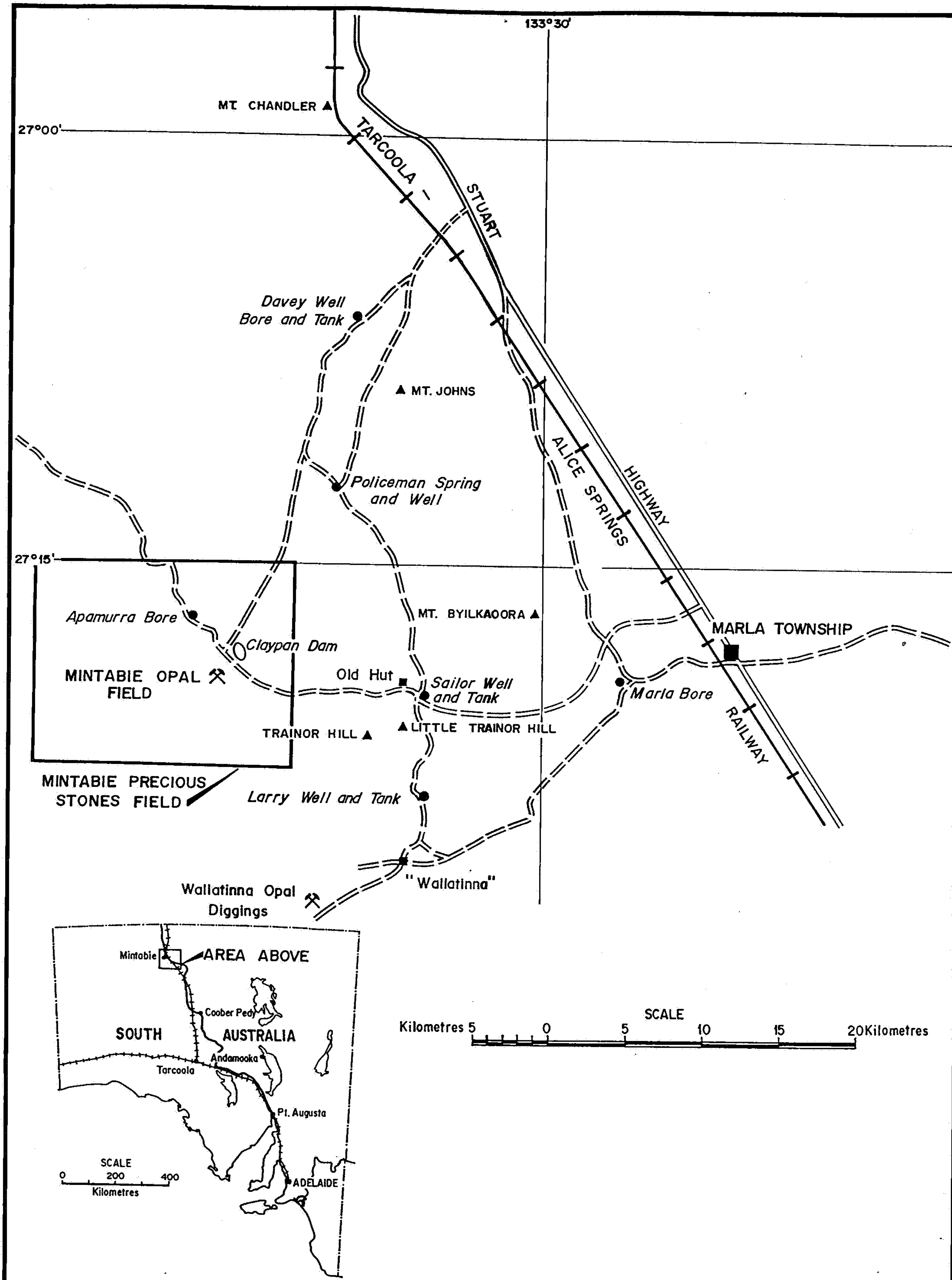


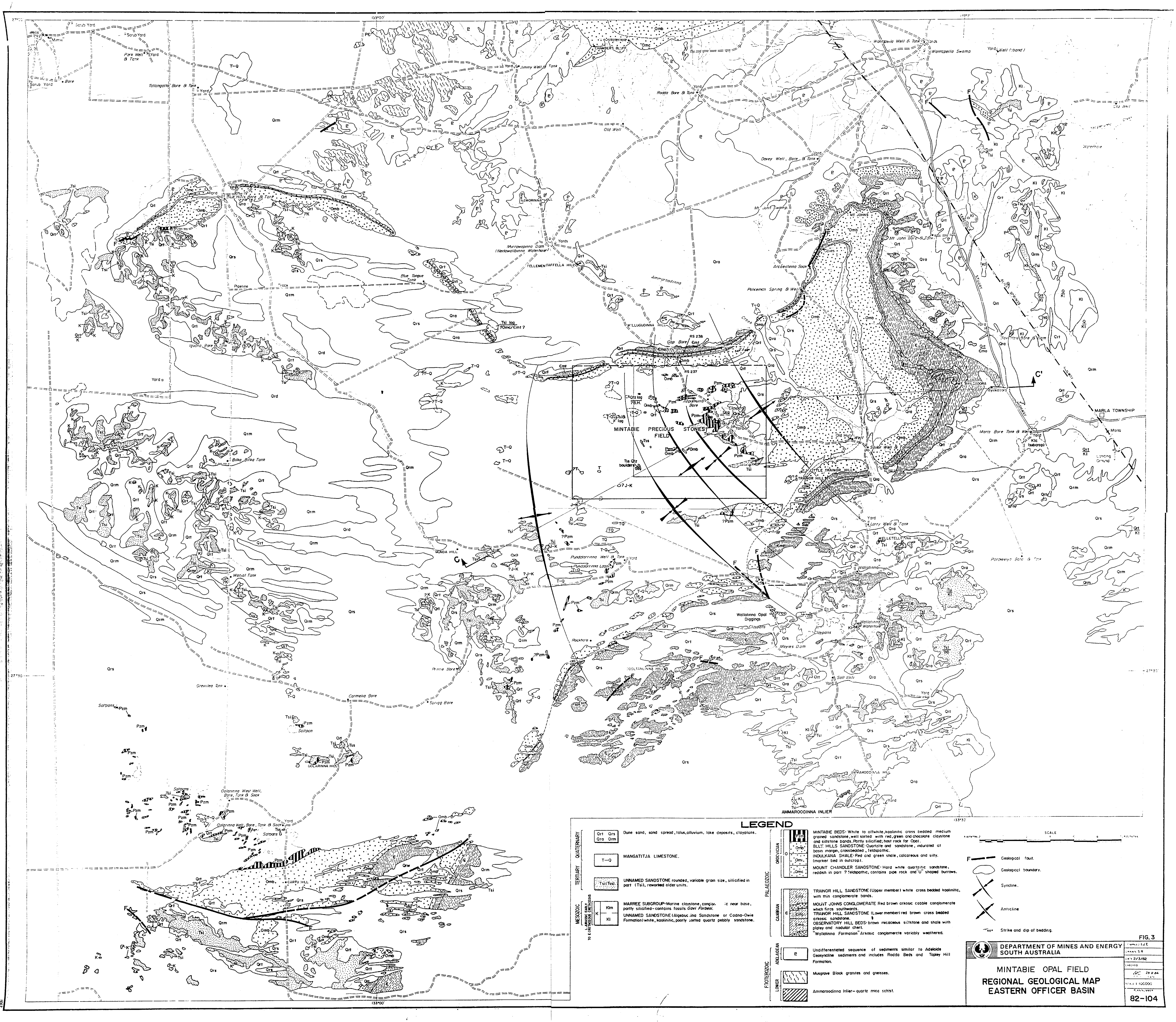
FIG. 2

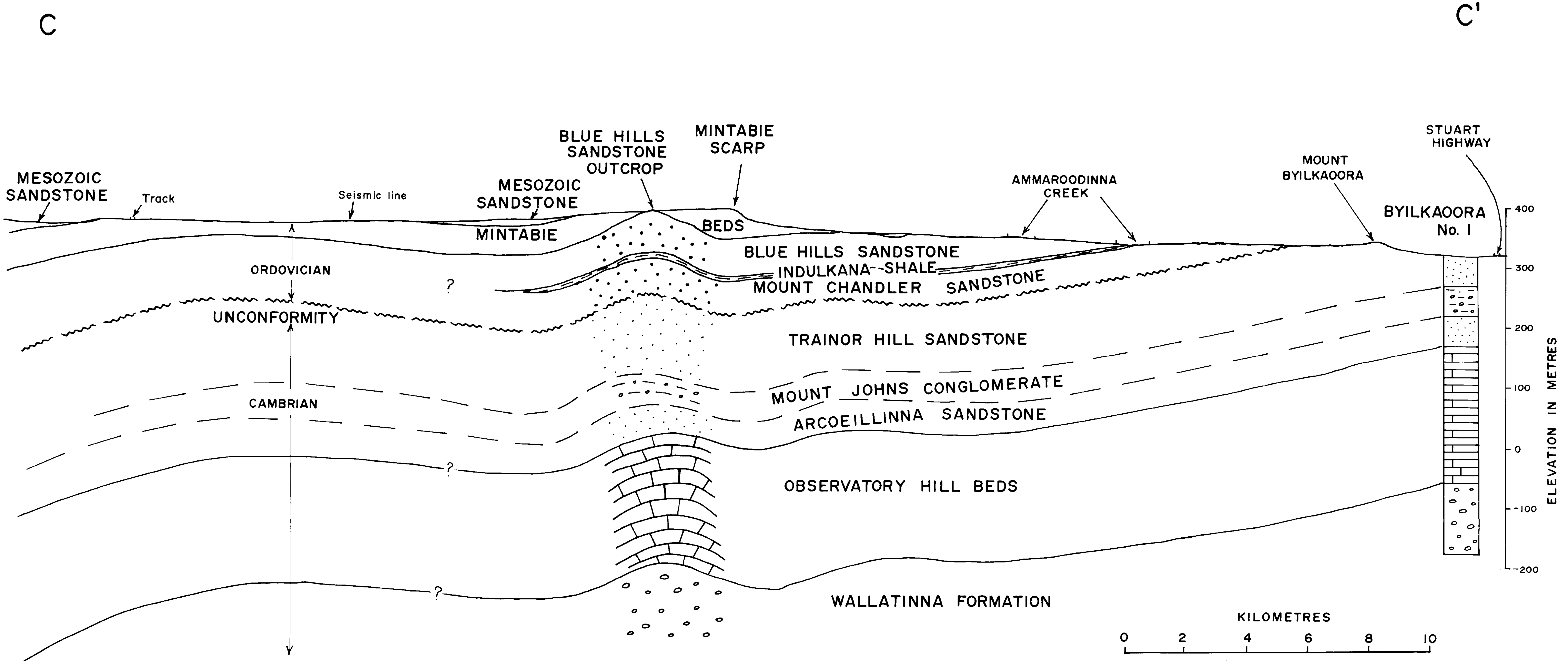
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MINTABIE OPAL FIELD
LOCALITY PLAN

COMPILED	I.J.T.	C.D.O. (signature)	DATE 29·11·84
DRAWN	S.R.	SCALE 1:333000	
DATE	14/10/81	PLAN NUMBER	
CHECKED		S 16080	

2331

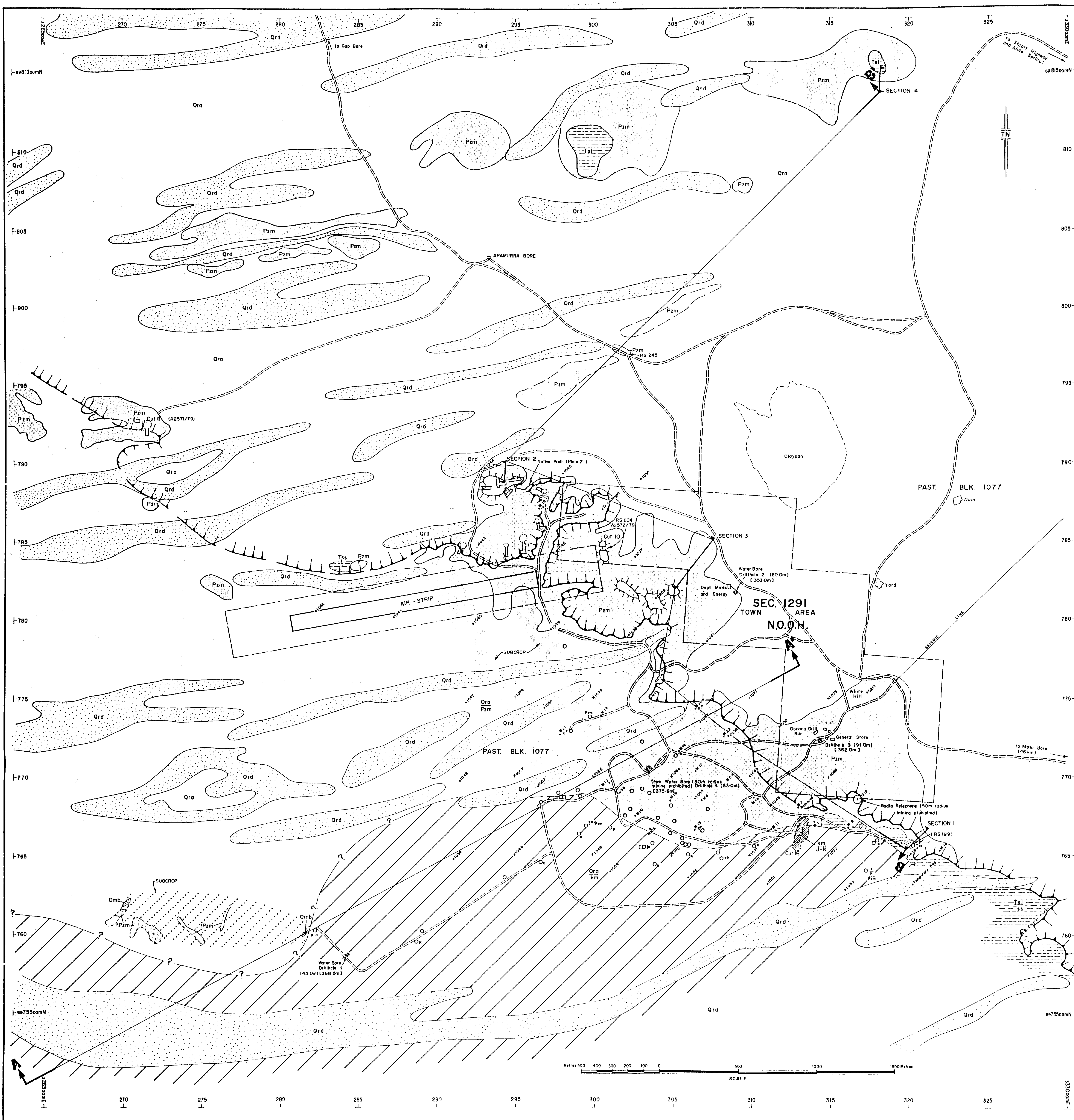

MINTABIE PRECIOUS STONES FIELD
MARLA TOWNSHIP
AMMAROODINNA INLIER
Wallatinna Opal Diggings
LEGEND
QUATERNARY
Qrt Qrs Qra Qrm
Dune sand, sand spread, talus, alluvium, lake deposits, clayplans.
TERTIARY
T—Q
MANGATITJA LIMESTONE.
Tsi(Tss)
UNNAMED SANDSTONE rounded, variable gran size, silicified in part (Tsi), reworked older units.
MESOZOIC
L.JURASSIC EARLY TO E.CRETACEOUS CRETACEOUS
K Klm Kl
MARREE SUBGROUP: Marine claystone, conglor. ic near base, partly silicified - contains fossils Gavi Forbesi.
UNNAMED SANDSTONE (Algebuc.ina Sandstone or Cadna-Owie Formation) white, kaolinitic, poorly sorted quartz pebbly sandstone.
PALAEOZOIC
ORDOVICIAN
O Pzm Omb Omi Omc
MINTABIE BEDS: White to offwhite, kaolinitic cross bedded medium grained sandstone, well sorted with red, green and chocolate claystone and siltstone bands. Partly silicified; host rock for Opal.
BLUE HILLS SANDSTONE: Quartzite and sandstone, indurated at basin margin, crossbedded, feldspathic.
INDULKANA SHALE: Red and green shale, calcareous and silty. (marker bed in outcrop).
MOUNT CHANDLER SANDSTONE: Hard white quartzitic sandstone, reddish in part ? feldspathic, contains pipe rock and "U" shaped burrows.
CAMBRIAN
Є Єmt Єmt Єmo
TRAINOR HILL SANDSTONE (Upper member) white cross bedded kaolinitic, with thin conglomerate bands.
MOUNT JOHNS CONGLOMERATE Red brown arkosic cobble conglomerate which fines southwards.
TRAINOR HILL SANDSTONE (Lower member) red brown cross bedded arkosic sandstone.
OBSERVATORY HILL BEDS: brown micaceous siltstone and shale with platey and nodular chert.
"Wallatinna Formation" Arkosic conglomerate variably weathered.
PROTEROZOIC
ADELAIDEAN
Є
Undifferentiated sequence of sediments similar to Adelaide Geosyncline sediments and includes Rodda Beds and Tapley Hill Formation.
LOWER
Musgrave Block granites and gneisses.
Ammaroodinna Inlier — quartz mica schist.
SCALE
4
8
F Geological fault.
Geological boundary.
Syncline.
Anticline.
40° Strike and dip of bedding.
FIG. 3
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA
MINTABIE OPAL FIELD
REGIONAL GEOLOGICAL MAP
EASTERN OFFICER BASIN
DATE 2/3/82
82-104

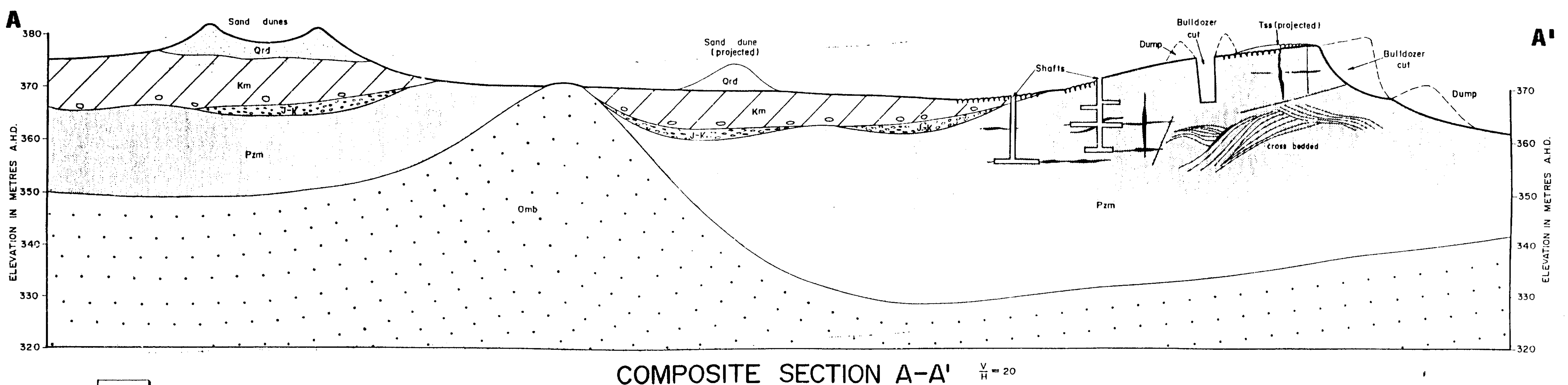


For section line see plan 82-104 (Fig. 3)

FIG. 3A

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED I. J. T.	C D O 29-11-84 DATE
MINTABIE OPAL FIELD SECTION C-C' THROUGH EASTERN OFFICER BASIN	DRAWN D.W.W.	SCALE As shown
	DATE 7.3.83	PLAN NUMBER 83-78
	CHECKED	





COMPOSITE SECTION A-A' $\frac{V}{H}=20$

QUATERNARY
- Qra — Alluvium
- Qrd — Dune sand

TERTIARY
- Tsi / Tss — Silcrete, silicified Tertiary or older unit. Sandstone silicified in part.

MESOZOIC
- Km — Marree Subgroup claystone, thin sand lenses, boulder bed at base. May host opal.
- J-K — Mesozoic sandstone, kaolinitic poorly sorted. May host opal. (Section only)

PALAEOZOIC
- P ORD — Pzm — Mintabie Beds, sandstone kaolinitic cross bedded, well sorted. Minor clay bands, hosts opal.
- M ORD — Omb — Blue Hills Sandstone, Quartzite hard in outcrop. Cross bedded

- Track
- Geological boundary
- Scarp re-interpreted from photographs
- Sand dunes
- Drillhole with depth in metres and elevation in metres AHD
- Shaft, Calweld drillhole
- Bulldozer cut
- Grid intersection with number
- M pegs and numbered stations (PA - position approximate)
- Opal
- Silicified
- Boulders
- Joints
- A A' Location of section
- Measured section see plan 82-106
- Area reserved from the operation of the Mining Act (mining prohibited)

Australian Map Grid derived by Department of Mines and Energy survey from Geodetic stations K673 (Amn-aroodinna) and K674 (Little Trainor), SFBs 553A, 591, 614, LB 504.

FIG. 4

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

MINTABIE OPAL FIELD

GEOLOGICAL PLAN AND SECTION

HOR 1:10 000
VER 1:500

81-240

SCALE

Metres 50 0 50 100 150 200 250 Metres

A.M.G.

LEGEND

QUATERNARY	Qra	Alluvium.	
	Qrd	Dune sand.	
TERTIARY	Tsi / Tss	Silcrete, silicified Tertiary or older unit. Sandstone silicified in part.	
MESOZOIC	Km	Marree Subgroup claystone, thin sand lenses, boulder bed at base. May host opal.	
PALAEOZOIC—? ORD.	Pzm	Mintabie Beds, sandstone kaolinitic cross bedded, well sorted. Minor clay bands. Hosts opal.	

Track.

Geological boundary.

Scarp re-interpreted from photographs.

Sand dunes.

Bulldozer cut.

(392·5m) Height elevation in metres.

S2 Shaft, Calweld drillhole with number.

M13 P.A. M pegs and numbered stations. (P.A. position approximate.)

1069 Grid intersection with number.

Data as at August 1980.

FIG. 5

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

MINTABIE OPAL FIELD

DETAILED PLAN OF MAIN WORKINGS

COMPILED I.J.T.

DRAWN S.R.

DATE 5/2/82

CHECKED

C.D.O. 29-11-84 DATE

SCALE 1:2500

PLAN NUMBER 82-105

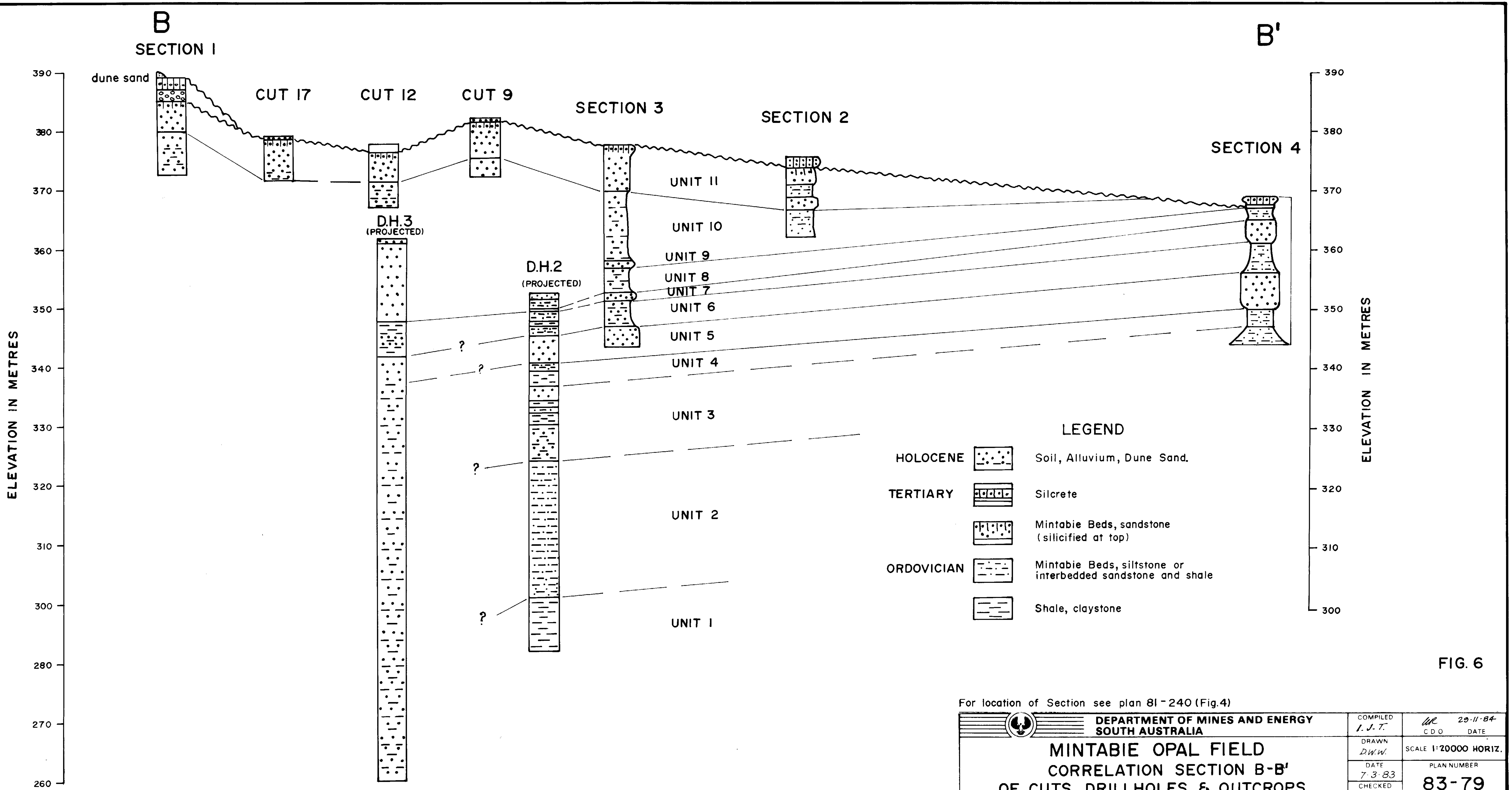


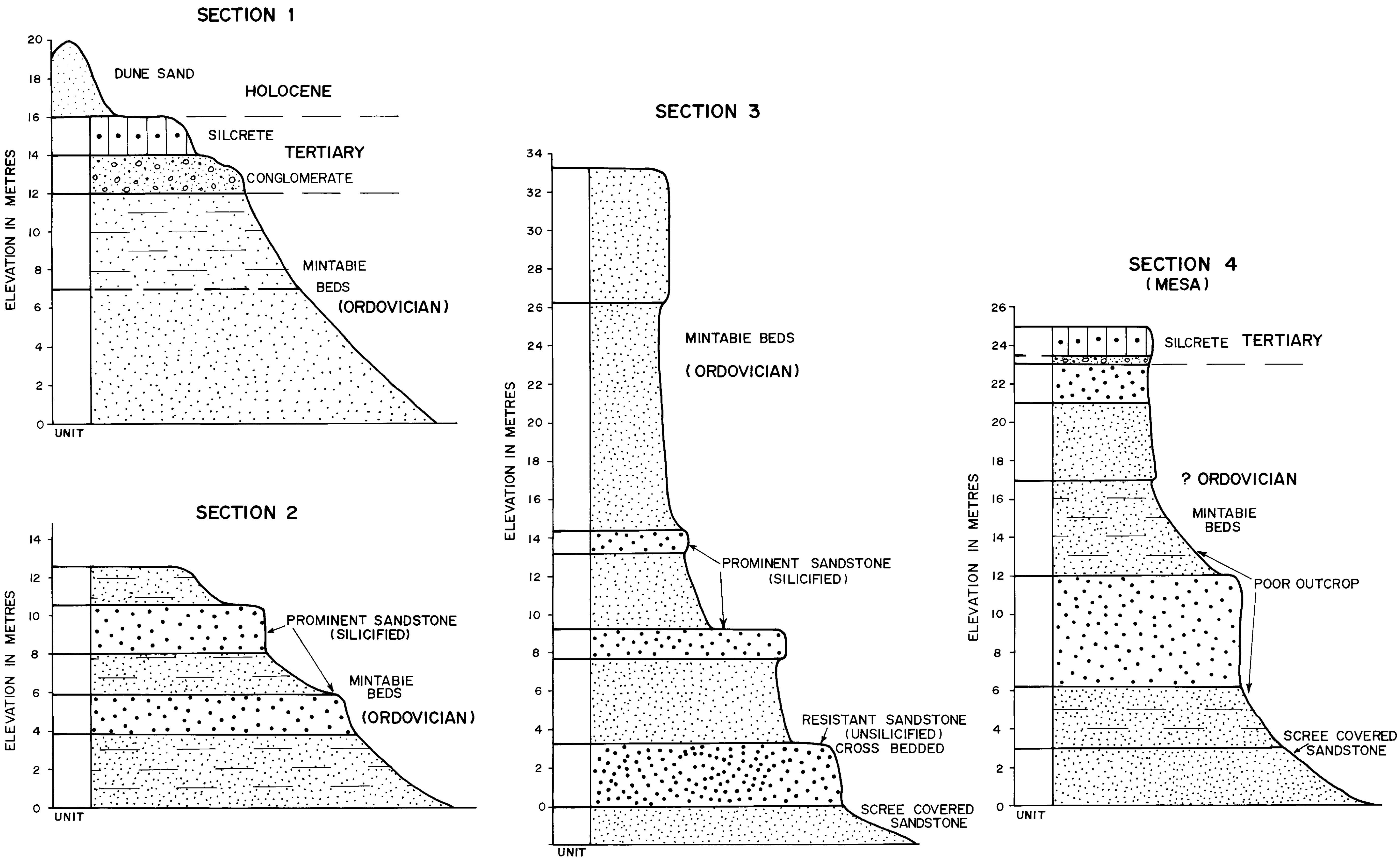
FIG. 6

For location of Section see plan 81 - 240 (Fig. 4)

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MINTABIE OPAL FIELD
CORRELATION SECTION B-B' OF CUTS, DRILLHOLES & OUTCROPS

COMPILED I.J.T.	CDO DATE 29-11-84	
DRAWN D.W.W.	SCALE 1:20000 HORIZ.	
DATE 7-3-83	PLAN NUMBER	
CHECKED	83-79	



For location of sections see fig. 4, plan 81-240.

APPENDIX FIG. 1

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MINTABIE OPAL FIELD
MEASURED SECTIONS

COMPILED I.J.T.	C.D.O. 29.11.84 DATE
DRAWN S.R.	SCALE As shown
DATE 29/10/81	PLAN NUMBER
CHECKED	82-106

2331

DESCRIPTION OF PLATES

PLATE 1. *Mintabie Township;* View north from radio tower hill, showing part of town in foreground and white Mintabie beds bulldozed over edge of scarp, September 1989. Transparency No.

PLATE 2. *Native well;* Well dug down along *potch* bearing joint in creek draining from scarp north of airstrip (Fig.4). Blue and white *potch* was visible on ironstained rear wall. Transparency No.

PLATE 3. *Town water supply;* October 1989, provided by Mintabie Progress Association. Diesel pump raises water to elevated tanks allowing miners to fill mobile water tanks from overhead pipe. Transparency No.

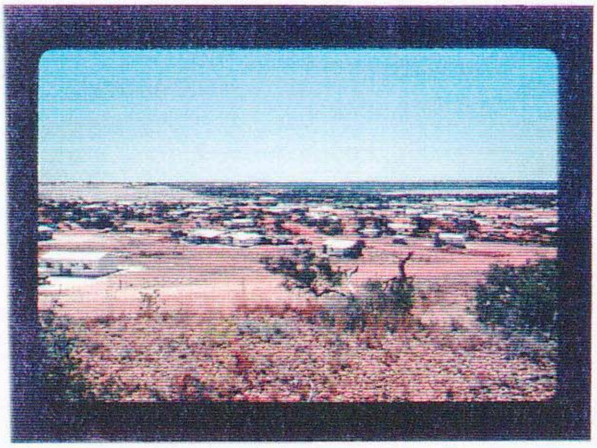
PLATE 4. Early Department of Mines and Energy Area Office and accommodation, June 1979 - April 1982. Accommodation was relocated to Marla in May 1982. Transparency No.

PLATE 5. Department of Mines and Energy, Area Office, October 1990. Transparency No.

PLATE 6. *Mintabie Hotel/Motel;* Formerly Goanna Grill Restaurant and Bar, October 1989. Transparency No.

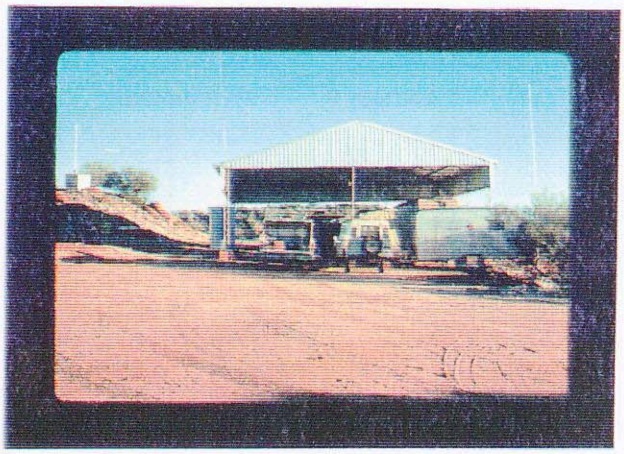
PLATE 7. *Calweld drilling rig;* prospecting a claim at Mintabie, August 1979. Transparency No. 15010.

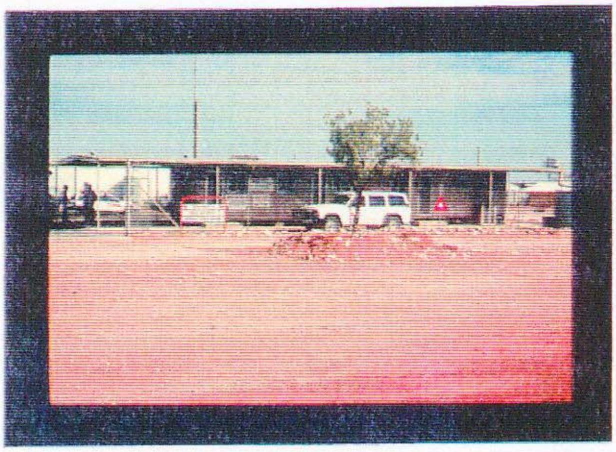
PLATE 8. *Calweld drilling rig;* emptying bucket from prospecting hole or shaft, August 1979. Transparency No. 15675.

1


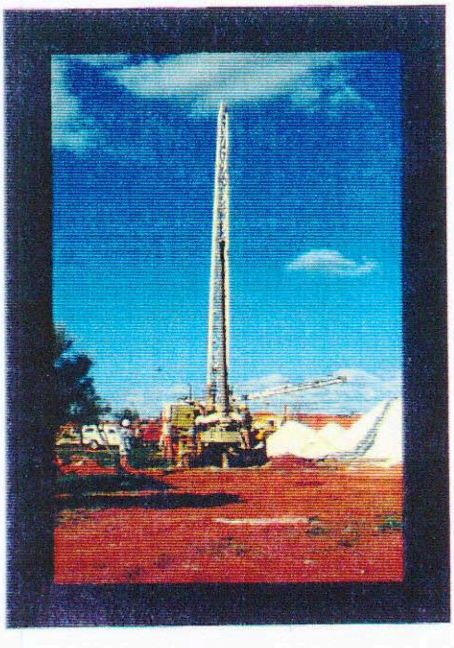
2


3


4


5


6


7


8


Plates 1 to 8

DESCRIPTION OF PLATES

PLATE 9. *Driving underground;* using the pneumatic pick following an ironstained bedding level in shaft S5 at approximately 16m, May 1979. Transparency No.

PLATE 10. *Yorke Hoist;* used for removing mullock, showing a sail to enhance natural circulation, August 1980. Transparency No.

PLATE 11. *Electric blower;* powered by a small generator, used for air circulation. The centrifugal pump forces air down a small auger hole through the workings and out through an access shaft, August 1980. Transparency No.

PLATE 12. *Air winch;* powered by an air compressor, on right hand side of photo, generally used for access to workings, August 1980. Transparency No.

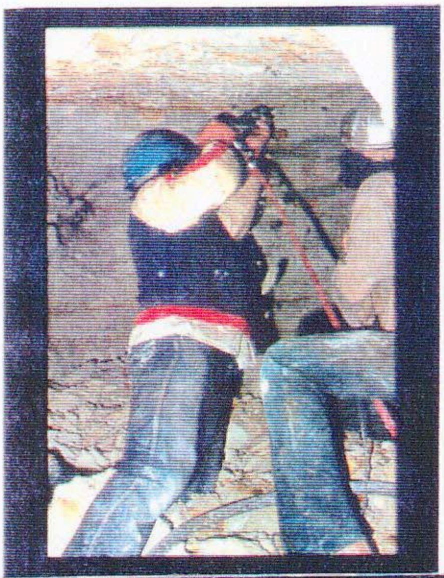
PLATE 13. *Self unloader;* or self tipper, is powered by a generator. A drum of mullock is strapped to a cradle which is hauled to the surface and emptied well away from the shaft, October 1989. Transparency No.

PLATE 14. *Blower;* A large vacuum cleaner which extracts mullock from underground, August 1979. Mullock accumulates in the large bucket which is emptied periodically. Transparency No.

PLATE 15. *Bulldozer cut and old shaft;* September 1979, upper 3m of Mintabie beds are silicified which tends to highlight the bedding, dipping southerly at 5-10°. Bedding is not so obvious in the unsilicified sandstone below. Transparency No. 15068.

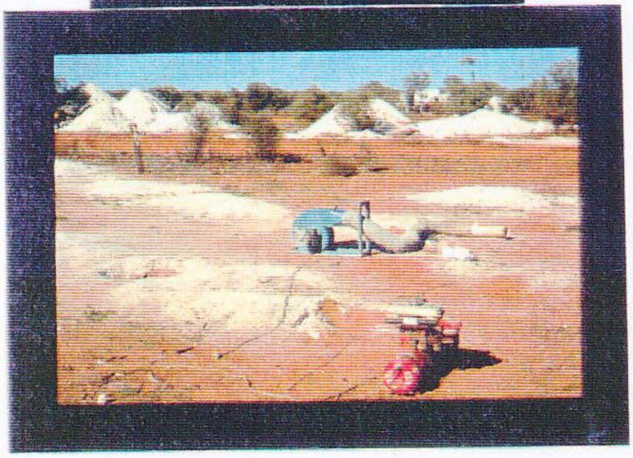
PLATE 16. *Bulldozer with spotters;* Spotters follow the ripping operation, looking for opal, October 1987. Transparency No.

9



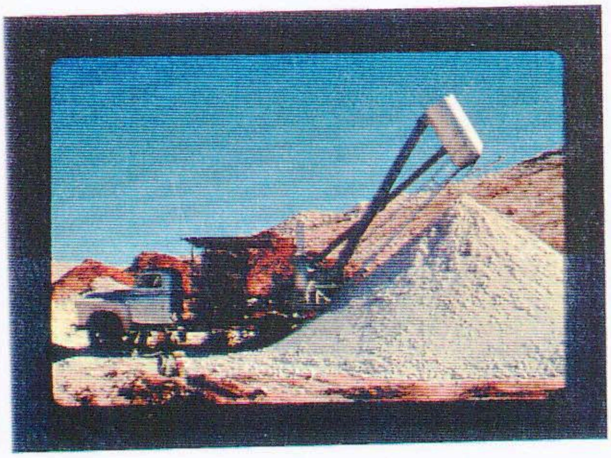
10

11



12

13



14

15

16

Plates 9 to 16

DESCRIPTION OF PLATES

PLATE 17. *Gouging opal in a bulldozer cut;* When opal is detected, the miner reverts to hand mining, using miners pick (lower left) or hammer and screwdriver to remove thin opal seams. Transparency No. 15021.

PLATE 18. *Bobcat;* A small front-end loader, used to remove mullock from a tunnel excavated in the side of a bulldozer cut, September 1989. Transparency No.

PLATE 19. *Bulldozer cut No.1;* A 22m cut dug with bulldozer and excavator, June 1979. Transparency No. 15084.

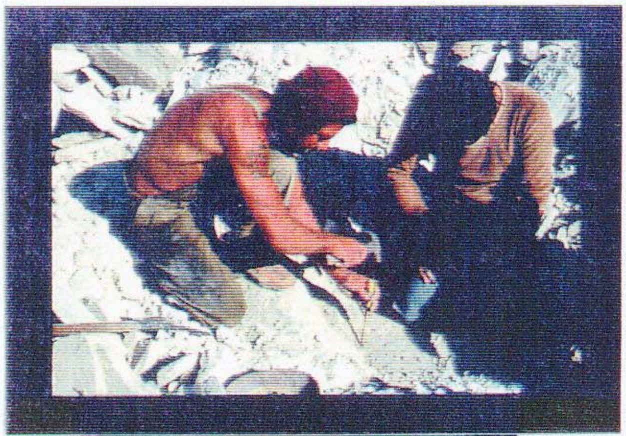
PLATE 20. *Cross-bedded Mintabie beds;* Prominent outcrop of unit 7 near base of measured section 3. Bedding is enhanced by weathering of more feldspathic and clayey interbeds between resistant quartz sandstone beds. Transparency No. 15069.

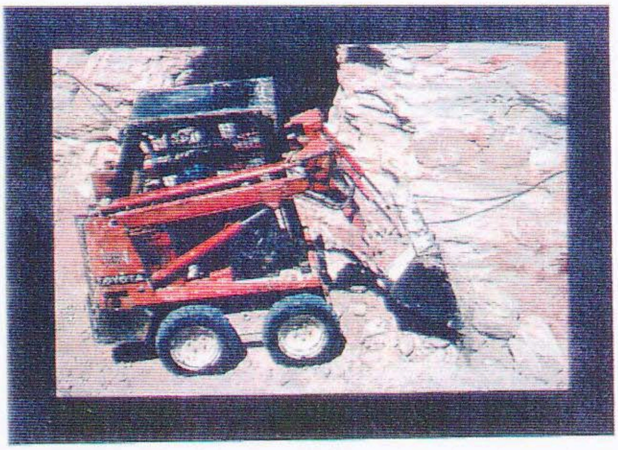
PLATE 21. *Cross-bedded Mintabie beds;* Underground workings (shaft S14) showing bedding, highlighted by darker sandstone and lighter more clayey bands. Transparency No.

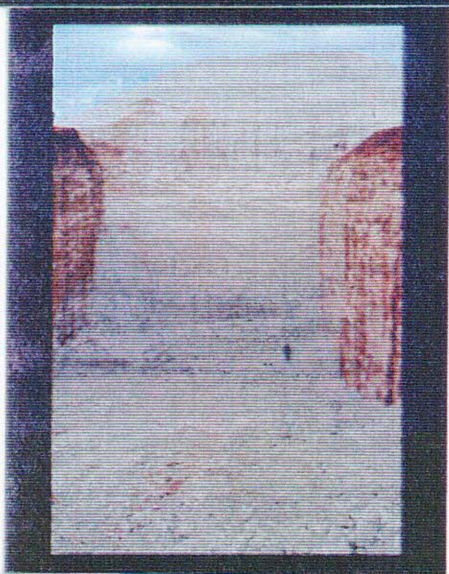
PLATE 22. *Cretaceous sediments on Mintabie beds;* Silicified Tertiary and younger sediments cover exposure of Cretaceous sediments other than in this Cut No. 16 on the southern margin of Old Field September 1979. Transparency No.

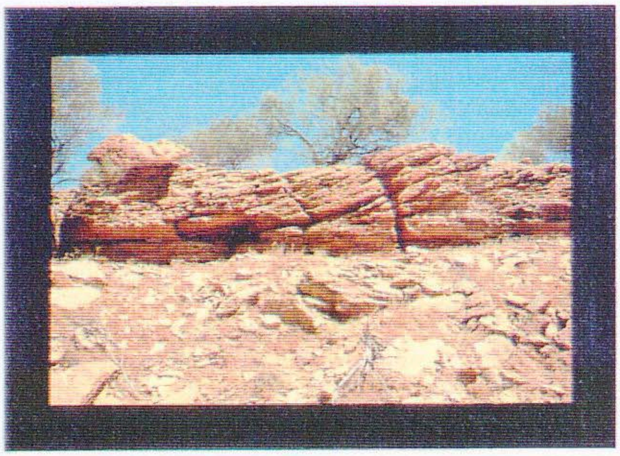
PLATE 23. *Basal quartzite boulder of Cretaceous sandstone;* This boulder was pushed out of Cut No.16, the largest of many observed in the mullock or *in situ* at the cut. Transparency No.

PLATE 24. *Silicified shells from Marree Subgroup;* Fossil shells of *Gari forbesi* (LUDBROOK), found near Cut 16 and retained by Tim Webb. Transparency No.

17



18

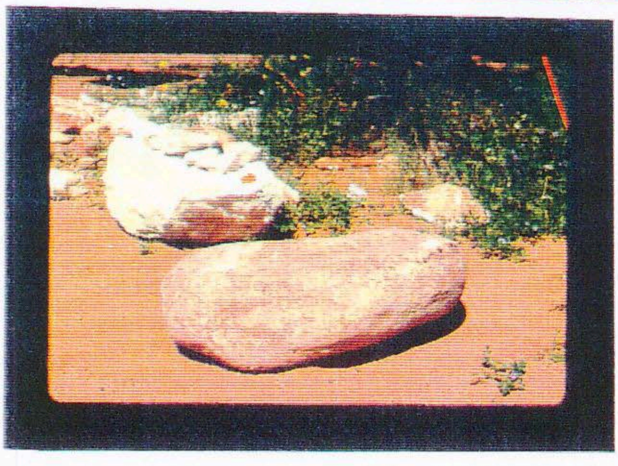
19


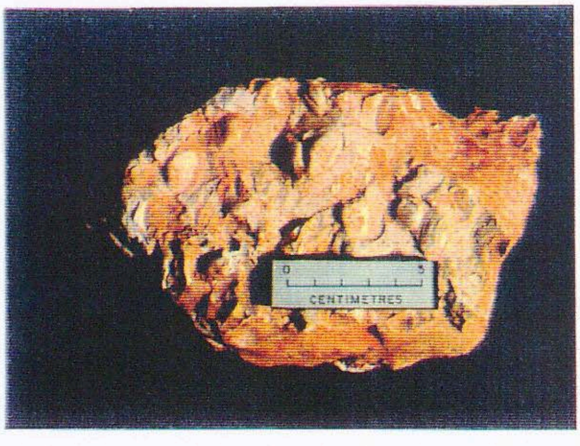

20

21



22

23




24

Plates 17 to 24

DESCRIPTION OF PLATES

PLATE 25. *Near vertical joint;* Joint in underground workings, shaft S14, striking at 220° and dipping 80° northwest. Transparency No. 15071.

PLATE 26. *Opal seam on curved cross-bedding;* Opal seam on bedding is also associated with iron stained *level* at 17m in underground workings in shaft S8, August 1979. Transparency No. 15070.

PLATE 27. *Precious opal in situ;* Close up showing opal with black *potch* at base and iron staining often associated with *levels*. Transparency No. 15072.

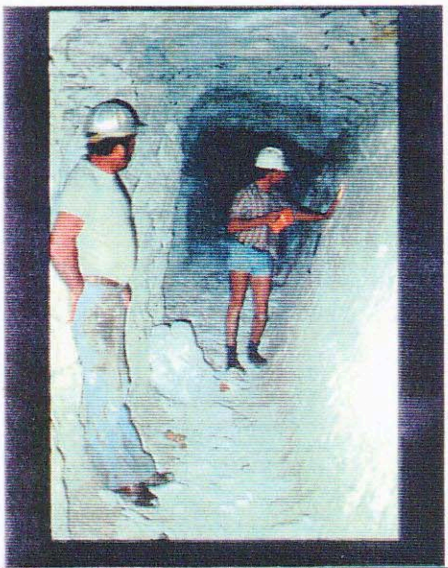
PLATE 28. *Micrograph of precious opal;* Note regular arrangement of silica spheres and boundary between two colour grains. Taken on departmental Scanning Electron Microscope at 10 000 times magnification. Transparency No. 15003.

PLATE 29. *Micrograph of black Mintabie potch;* Note variable sphere size and lack of ordering, required to produce play of colour in precious opal. Magnification is 20 000 times.
Transparency No. 15001.

PLATE 30. *Micrograph of white Mintabie potch;* Almost no silica spheres are visible, framework shows large voids and no ordering. Magnification is 20 000 times. Transparency No. 15002.

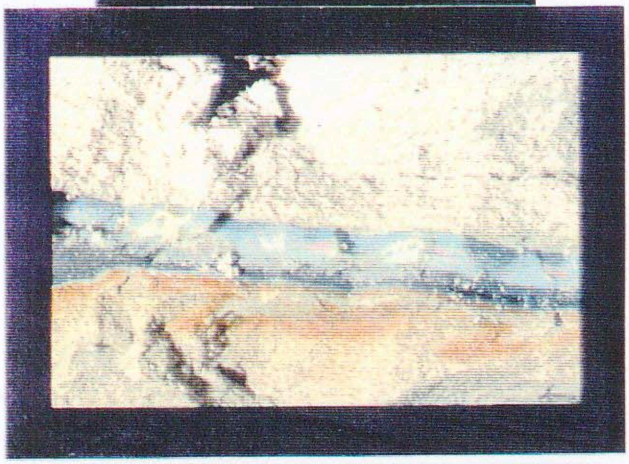
PLATE 31. *Rough black Mintabie opal;* Opal derived from a single *vertical*. Transparency Nos. 15073-4.

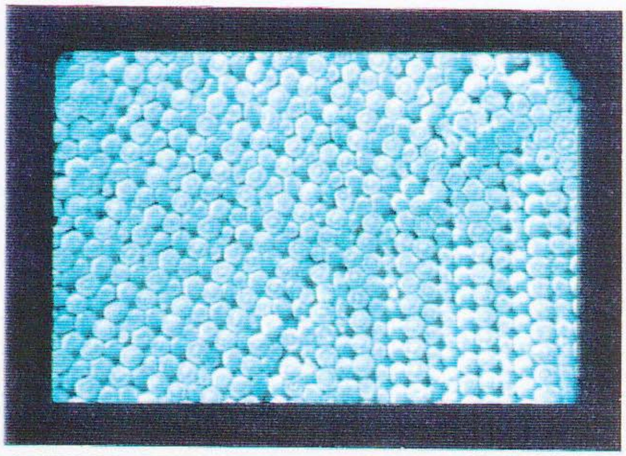
25



26

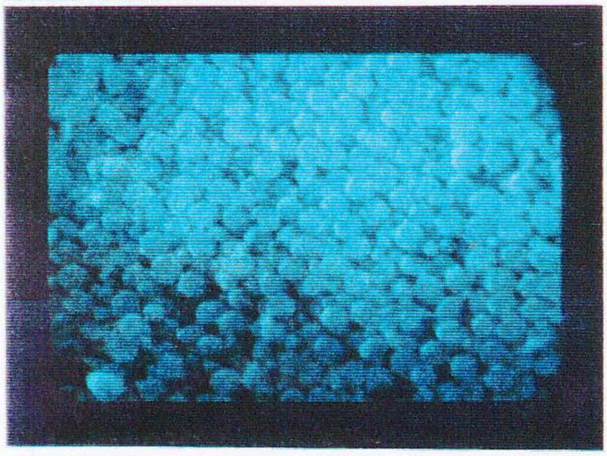
27

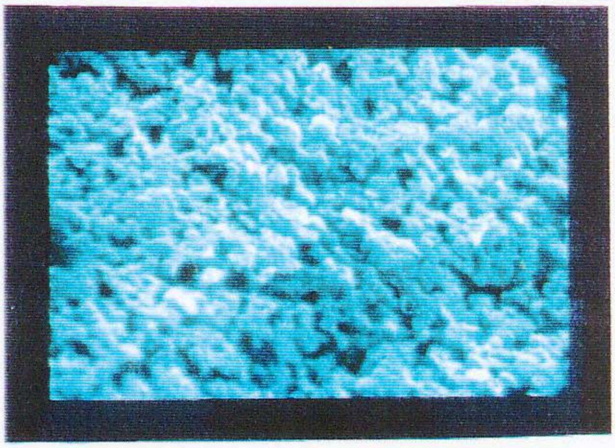




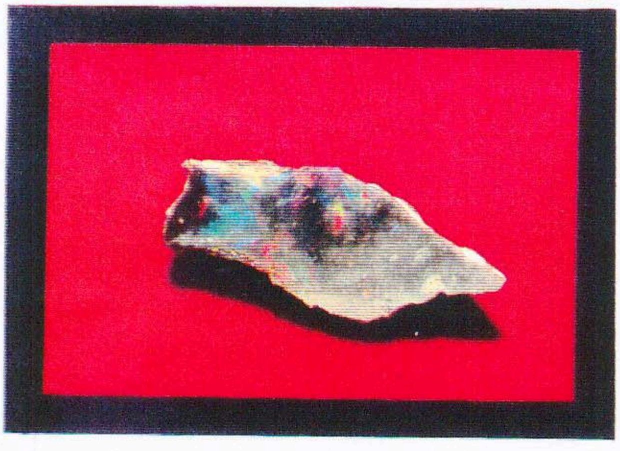
28

29





30



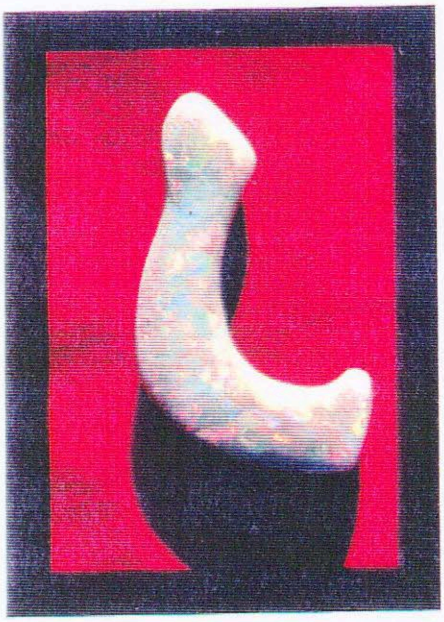
31

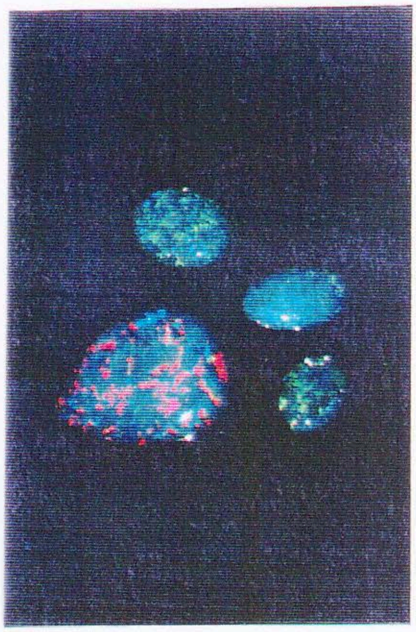
Plates 25 to 31

PLATE 32. *Red-fire crystal and black Mintabie opal;* Selection of good black and crystal opal derived from both *verticals* and *levels*.
Transparency Nos.

PLATE 33. Cross of gold plated metal with central black opal and arms of crystal opal chips. The cross was presented to a hometown church in Croatia, now part of Yugoslavia. Transparency No.

E00080





32

33

Plates 32 and 33