DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

OPEN FILE

REPORT BK. NO. 89/2

EXCURSION GUIDE TO DIAPIRS OF THE FLINDERS RANGES, SPECIALIST GROUP IN TECTONICS AND STRUCTURAL GEOLOGY CONFERENCE, KANGAROO ISLAND, 2 - 3 FEBRUARY 1989.

by

W. V. PREISS

REGIONAL GEOLOGY BRANCH

JANUARY, 1989. DME. 239/77.

CONTENTS PAGE

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRTALIA

Rept. Bk. No. 89/2
DME NO. 239/77
Disk No. NEC 3

EXCURSION GUIDE TO DIAPIRS OF THE FLINDERS RANGES, SPECIALIST GROUP IN TECTONICS AND STRUCTURAL GEOLOGY CONFERENCE, KANGAROO ISLAND, FEBRUARY 1989.

Key Words: Diapirs, Adelaide Geosyncline, Flinders Ranges, stratigraphy, sedimentation, structural geology, tectonics, late Proterozoic, Callanna Group, Burra Group, Umberatana Group, Delamerian Orogeny.

INTRODUCTION

The Flinders and Mount Lofty Ranges of South Australia contain well exposed late Proterozoic and early to middle Cambrian dominantly sedimentary rocks, deposited in the Adelaide Geosyncline and deformed during the Cambro-Ordovician Delamerian Orogeny; a regional synthesis of these events has been presented by Preiss (1987), with a comprehensive bibliography, and is further summarised by Preiss (1988). Although the stratigraphy is relatively consistent across the basin, with well defined lateral facies changes, the degree and styles of deformation differ markedly from south to north. These differences can probably be attributed to the following factors:

(i) the degree of crustal attenuation in the older Precambrian basement during the rifting phases of the Adelaide Geosyncline

(ii) reactivation of older lineaments in the basement

(iii) distribution and orientation of the major compressional forces

(iv) regionally variable heat flow, as represented by metamorphic grade

(v) thickness of the Adelaidean-Cambrian sedimentary cover,

and

(vi) the presence or absence of suitable decollement surfaces in the lower parts of the cover sequence.

The southern Mount Lofty Ranges near Adelaide (Fig. 1) are characterised by strongly asymmetrical F_1 folds, overturned to the west and northwest, and associated with gently to moderately east-dipping slaty cleavage and small to medium-scale thrusts. Adelaidean and early Cambrian rocks in the western and central Mount Lofty Ranges were metamorphosed to greenschist facies, as were the retrograded, originally high-grade, metamorphics of the pre-Adelaidean basement occurring in the cores of asymmetrical and faulted anticlines. Adelaidean and Cambrian metasediments occurring east of the basement inliers underwent amphibolite-facies metamorphism (to sillimanite grade), local migmatisation and granite intrusion; high heat flow appears to have been largely controlled by a north-northwest-trending lineament believed to have been active since at least early Adelaidean time (the G_2 Corridor of O'Driscoll, 1983; Coward, 1976). These higher-grade metasediments were significantly refolded by D_2 and D_3 events, which had only limited effect on the low-grade rocks west of the inliers (Offler and Fleming, 1968). Few F_1 folds have been recognised in the high-grade zones, and evidence for them may have been largely obliterated by D_2 and D_3.

In contrast, sediments of the northern Mount Lofty Ranges were folded into much more upright, long, arcuate anticlines and synclines, commonly slightly asymmetrical to the east. These folds form the Nackara Arc that sweeps from a meridional trend in the south to east-northeasterly near Olary and towards Broken Hill. Overprinting relationships between cleavages in the Olary region (Berry et al., 1978), and fold-interference patterns in the Nackara Arc (e.g. Mount Grainger area) and central Flinders Ranges (e.g. Wilpena Pound, Bibliando Dome, Blinman Dome) suggest that earlier, generally meridional folds (possibly coeval with F_1 in the southern Mount Lofty Ranges) were refolded by northeast to east-northeast-trending folds. These two Delamerian fold phases in the Nackara Arc have been referred to as D_4 and D_5 in previous literature on the basement structures of the Olary region, but the timing of D_5 in relation to Delamerian D_2 and D_3 in the south is not known.

The northern Flinders Ranges are characterised by arcuate folds comparable to those of the Nackara Arc, with trends swinging from northwesterly in the northwest to northeasterly in the northeast. Between these two arcuate belts, the central Flinders Ranges is a zone of much more weakly deformed rocks. Although moderately steep dips occur in places (up to 60°) the folds are very broad and lack substantial cleavage development. Gentle domes and basins dominate and there are some significant high-angle faults and strike-slip faults.

It is this region that contains most of the larger diapiric structures of the Adelaide Geosyncline, some coincident with the cores of anticlinal domes, but not all. This excursion is designed to examine a few of these diapirs, their relationships to the host rocks, and deformational structure within and around the diapirs. Because of constraints of time and access, it will not be possible to demonstrate all the critical relationships on this excursion, but the reader is referred to the following literature for further discussion of the available evidence:

Mawson (1942), Howard (1951), Sprigg (1952), Parkin et al. (1953), Webb (1960, 1961), Mumme (1961), Coats (1964, 1965), Dalgarno and Johnson (1968), Coats (1971), Coats (1973), Barnes (1972), Mount (1975, 1980), Kitch (1975), Haslett (1976), Murrell

(1977), Burns et al. (1977), White (1983), Parker (1983), Lemon (1985), Preiss (1985, 1987).

GEOLOGY OF THE CENTRAL FLINDERS RANGES DIAPIRS

Stratigraphy and sedimentation

Callanna Group.

The Callanna Group (of Willouran age) is interpreted as a rift-basin sequence deposited in the earliest stages of the evolution of the Adelaide Geosyncline. Deposition was largely confined to north-northwest-trending troughs, and the G_2 corridor is suggested to have formed the southwestern faulted margin of the main trough (Preiss, 1987), although this feature was completely buried by younger Adelaidean sedimentation.

The basal Arkaroola Subroup, known in sequence only from the Mount Painter area, Barrier Ranges, and Peake and Denison Ranges, comprises fluvial to shallow-marine coarse clastics, followed by partly stromatolitic carbonates and finally by the altered, mafic Wooltana Volcanics and equivalents. A poorly defined Rb-Sr isochron date of about 830 Ma (Compston et al., 1966) may approximate the time of extrusion. Since the discovery of the Beda Volcanics of the Stuart Shelf by Mason et al. (1978), these have often been equated with the Wooltana Volcanics, but available geochronology suggests a much older age (Webb and Coats, 1980; Page et al., 1984). Lavas probably equivalent to the Wooltana Volcanics occur as dismembered xenoclasts within many of the diapirs, but their correlation leaves some uncertainty since minor volcanism is known to have persisted later.

The Curdimurka Subgroup is a very thick, mixed clastic-carbonate sequence with indications of evaporitic conditions. The abundance of evaporite mineral pseudomorphs in the Willouran Ranges type area (as described by Rowlands et al., 1980) may suggest increasingly restricted conditions towards the north, where the fault-bounded trough extended deep into the craton. The most southerly known occurrence of the Curdimurka Subgroup near Spalding (Preiss, 1974) contains only rare halite casts and may reflect closer proximity to the open sea.

The stratigraphy of the Curdimurka Subgroup has been determined with greatest confidence in the Willouran Ranges, (Forbes et al., 1981), where disruption of the sequence is least severe. A comparable but more faulted sequence has been assembled in the Peake and Denison Ranges by Ambrose et al. (1981). In the central Flinders Ranges, assembly of the partially disrupted sequence has been sucessful in the Worumba Anticline (Preiss, 1985), but even here, many of the units are bounded by generally bedding-parallel disrupted tectonic contacts. It may be speculated that such disruption was localised along sedimentary horizons originally rich in evaporite minerals which have, however, left no trace. The commonly disrupted contacts between the Arkaroola and Curdimurka Subgroups and between Callanna Group and Burra Group may have been such evaporitic beds.

In the Worumba Anticline, the oldest unit (Wirrawilka Beds) is an upward-shallowing sequence of 100 m of laminated carbonaceous siltstone overlain by 50 m of cryptalgal laminated carbonates, with low-relief stromatolites, laminar fenestrae, quartz pseudomorphs after diagenetic ?gypsum and thin lenses of flat-pebble packstone.

The Niggly Gap Beds, consisting of at least 400 m of interbedded micaceous siltstone and fine to coarse-grained, feldspathic, micaceous and lithic sandstone, conformably overlie the Wirrawilka Beds. Halite casts are commonly preserved on the soles of sandstone beds, and occasional silty or sandy dolomite units are interbedded. Heavy mineral lamination, mudcracks and other very shallow water indicators are abundant. Carbonates are cupriferous in several areas.

The Arkaba Hill Beds, originally defined by Mount (1980) in the Arkaba Diapir, are interpreted to overlie the Niggly Gap Beds, but all known contacts are tectonic. The sequence consists of 200 m of carbonaceous siltstone overlain by 336 m of micaceous siltstone and fine sandstone, alternating with stromatolitic and laminated carbonate. A distinctive fenestral dolomite is a useful marker. This unit represents a transgressive-regressive cycle, reflecting a similar environmental range to the Wirrawilka Beds - Niggly Gap Beds sequence, from shallow-basinal to intermittently emergent (including sabkha) environments.

The Arkaba Hill Beds pass gradationally into deeper-water carbonaceous silts of the Kirwan Siltstone, 160 m thick, which is associated with syngenetic pyrite and minor copper mineralisation. The next regressive phase is represented by the 280 m thick, stromatolitic Waraco Limestone; slumped stromatolite columns and soft-sediment deformation suggest syndepositional gravity sliding in the lower, cherty member. The middle member includes supratidal dolomite, in part recrystallised to coarse marble, and passes up into further carbonaceous siltstone of the upper member.

The boundary between the Waraco Limestone and the overlying 416 m thick Worumba Dolomite Beds is mostly disrupted, being preserved as a sedimentary contact in only one section. Laminated cream dolomite with tepee structures forms lower and upper members separated by a carbonaceous siltstone middle member. The Worumba Dolomite Beds are the youngest unit of the Callanna Group occurring in sequence in the Worumba Anticline. Dismembered blocks of siltstone, dolomite and limestone incorporated in associated intrusive breccias show clear lithological affinities with the

Curdimurka Subgroup, but cannot be confidently assigned to any particular units.

The igneous rocks of the Worumba area include both dolerite and basalt. All are extensively altered, possibly by deuteric processes, but not penetratively deformed. All occur as xenoclasts in intrusive breccia. The basalts are tentatively correlated with the Wooltana Volcanics, and in two xenoclasts, can be seen to be disconformably overlain by Niggly Gap Beds.

The dolerites occasionally show intrusive contacts with Curdimurka Subgroup sediments, but mostly within xenoclasts. The geochemistry of igneous rocks in the Flinders Ranges diapirs has been studied by Gum (1987), who considered the basalts and dolerites to be closely related and typical of continental flood basalts.

Burra Group

The Burra Group (of Torrensian age) typically commences with an influx of coarse clastics in other areas. However, these are not known in the Worumba Anticline, where the oldest Burra Group sediments are blue-grey, laminated dolomites with abundant tepee structures and minor black chert and magnesite conglomerate of the 1 300 m thick Wirreanda Dolomite Beds. The base and top of the sequence are everywhere tectonic, except where this unit is unconformably overlain by the Umberatana Group. Separate from the Worumba Dolomite Beds and occurring only on the west limb of the Worumba Anticline, is the remainder of the Burra Group, forming a continuous stratigraphic sequence. The base of the sequence is marked by a discordant contact with intrusive carbonate breccia. A silty unit of undifferentiated River Wakefield Subgroup is overlain by 270 m of Yednalue Quartzite, followed by the Skillogalee Dolomite, a blue-grey dolomite sequence about 1 000 m thick with abundant stromatolites, black chert and magnesite conglomerate. A thick, lenticular and interdigitating sedimentary megabreccia on the west limb of the Worumba Anticline is interpreted as a series of subaerial debris flows shed from actively rising fault scarps to the north or northeast. A silty, fine-sandy and dolomitic sequence 250 m thick above the Skillogalee is the youngest unit of the Burra Group in this area (Auburn Dolomite equivalent).

Umberatana Group

A disconformity or angular unconformity everywhere separates the overlying Umberatana Group (of Sturtian to early Marinoan age) from older rocks. The oldest formation of the Umberatana Group in this area (Holowilena Ironstone) consists of dolomitic, sandy and locally ferruginous basal breccia, ferruginous diamictite and thinly laminated hematitic siltstone, totalling about 100 m. These represent the oldest sediments of the Sturtian glaciation, but are preserved only in restricted erosional remnants. Tectonic activity in the form of faulting and tilting preceded deposition of the overlying Wilyerpa Formation, a basinal clastic lateral equivalent of the widespread marine-shelf Sturtian tillites. The Wilyerpa commences with the thin, sandy and conglomeratic Warcowie Dolomite Member, followed by a variably thick sequence of basinal green siltstone with sandstone interbeds, many showing evidence of deposition by turbidity currents. There are occasional diamictite and conglomerate lenses, and dropstones in quiet-water sediments attest to the persistence of floating ice. The thickness of the Wilyerpa Formation increases northwards across a series of west-northwest-trending syn-sedimentary faults, from 120 m near "Worumba" to around 1 800 m near "Warcowie". These faults mark the southwestern boundary of the Sturtian Baratta Trough, probably the youngest of the Adelaidean regional graben structures.

Post-glacial marine transgression across the whole Adelaide Geosyncline and much of the Stuart Shelf caused widespread deposition of fine sediments in quiet water. The Tapley Hill Formation is typically an extremely thinly laminated carbonaceous siltstone, with thin dolomite interbeds at the base. A number of lime-cemented conglomerate interbeds are interpreted as subaqueous debris flows shed from submarine escarpments. The Tapley Hill Formation is up to 2 km thick in the Worumba area and is the youngest unit to be visited on the excursion. For a discussion of subsequent events in the Adelaide Geosyncline the reader is referred to Preiss (1987).

Structure and Tectonics

Late Proterozoic sedimentation in the Adelaide Geosyncline is believed to record evolution from rift-dominated tectonics in the early Adelaidean to broad crustal subsidence in the late Adelaidean. Preiss (1983) suggested that the regional unconformity between Burra Group and Umberatana Group may be a "break-up" unconformity, but it is clear that localised rifting persisted after this hiatus during the Sturtian glaciation. Besides, there are no unequivocal data to indicate that a continental separation (drift phase) ever took place, either during the early Sturtian, or the early Cambrian as suggested by von der Borch (1980). No remnants of oceanic crust have been located anywhere in the exposed Delamerian fold belt and their possible presence under the Cainozoic cover of the Murray Basin remains speculative.

The central Flinders Ranges region to be visited on this excursion is part of an intracratonic basin, bounded to the west by the Gawler Craton and to the east by the

Curnamona Cratonic Nucleus, which was a relatively positive block during sedimentation and remained largely undeformed during the Delamerian folding.

During the early Adelaidean, sedimentation was probably confined to fault-bounded troughs, but these faults were buried by younger sediments and can be observed only where reactivated as compressional structures during the Delamerian Orogeny. The Callanna Group is confined to northwest-trending troughs; the Worumba Trough of the central Flinders region was probably bounded to the west by faults along the G_2 corridor, which separates regions with relatively shallow basement and no diapirs (hence inferred to contain little or no Callanna Group) to the west from regions with diapirs and deep basement to the east. The eastern margin of the trough is interpreted to be buried beneath Burra and Umberatana Group sediments somewhere in the vicinity of Yunta; in the Olary region to the east of Yunta, basement again becomes shallow to outcropping, forming the cores of anticlines, and Burra and Umberatana Group sediments rest directly on basement.

That part of the Flinders Ranges underlain by troughs of Willouran age is characterised by diapiric anticlinal cores.

Basement rocks are occasionally found within these cores, but only as dismembered small blocks intermixed with a variety of other xenoclasts of sedimentary and igneous origin, of various ages. It is suggested that major decollement zones, possibly controlled by evaporite-rich horizons within the Callanna Group, permitted folding of the Adelaidean and Cambrian cover independently of the basement in this region, while to the east and west of the troughs the basement was folded together with the overlying Burra and Umberatana Groups.

There has been considerable debate about how much of the diapiric activity occurred during the Delamerian Orogeny, and how much took place during Adelaidean and Cambrian deposition. Mount (1975) showed that at least the last phases of movement occurred after the main folding in the central Flinders Ranges, but this is generally in the form of relatively narrow, dyke-like bodies of carbonate breccia passively intruded into high structural levels. The larger anticlinal cores, however, show evidence of an earlier history of movement. Dalgarno and Johnson (1968) showed that the Enorama Diapir was exposed during deposition of the Etina Formation (middle Umberatana Group), with dolomite of the Etina Formation lapping unconformably onto a volcanic xenoclast. This region has been mapped in detail by Lemon (1985, 1986), who has outlined the movement history from sedimentary facies studies. Other evidence of movements during the Adelaidean in the northern Flinders Ranges was summarised by Coats (1973).

In the Worumba Anticline, Preiss (1985) outlined evidence for deformation of the Callanna Group and lower Burra Group prior to the Sturtian glaciation. Isoclinal folds of variable but generally steep plunge were mapped. Many of the Callanna Group units in the Worumba Anticline are preserved as long, steeply dipping strips separated by narrow faults and breccia zones that are broadly concordant with bedding. Some of the faults juxtapose units believed to have been in sedimentary contact originally, but others have produced repetition of the sequence. One such fault slice of Niggly Gap Beds is overturned and unconformably overlain by Sturtian rocks, indicating that overturning took place before the Sturtian. One possible interpretation is that these are imbricate thrust slices and recumbent isoclinal folds formed during an early phase of movement, but it is not clear whether this was a major compressive event or due to gravity sliding. The latter possibility may be favoured by the general absence of an axial plane cleavage associated with the isoclinal folds. The evidence of sedimentary megabreccia in the Skillogalee Dolomite indicates significant uplift of the region to the north and northeast during mid-Torrensian time, and the structures in the Callanna Group could be related to this tectonic activity, but at a deeper level in the sedimentary pile.

If the low-angle thrust and recumbent fold model for structures in the Callanna Group core is accepted, the present steep orientation of these structures could be accounted for by Delamerian folding. The regional Worumba Anticline is asymmetrical, with an eastern limb of Umberatana Group dipping at 30-40 degrees east. The western limb of Burra Group and Umberatana Group is much steeper to overturned, and has no sedimentary contacts with the more highly deformed core; it is instead separated from the core by a kilometre-wide zone of intrusive carbonate breccia. The eastern boundary of the core is also in places marked by faulting and intrusive breccia, but elsewhere an unconformable relationship is locally preserved with the Umberatana Group. The axis of the regional anticline is broadly coincident with the more sinuous faulted axis of the much tighter ancestral anticline within the core.

The right-angle bend in the Worumba Anticline axis from meridional in the south to east-west in the north, where it passes eastwards into the Bibliando Dome, has been interpreted by Preiss (1985) as the result of fold interference by two Delamerian fold phases. Evidence to support this concept is the presence of northeast-trending transecting slaty cleavage (related to the second phase) in both east and west limbs of the Worumba Anticline, as well as in the core, in the southern portion of the anticline where the major axis trends north-south. Cross-folding in the core is also attributed to the second Delamerian phase.

Basement-derived xenoclasts are relatively rare in the Flinders Ranges diapirs; none has been found in intrusive breccias at Worumba. However, the Blinman Diapir contains mylonitic gneiss, granite, and deformed metaconglomerate xenoclasts, while Mount (1975) recorded calc-silicate gneiss from Arkaba. The Beltana Diapir contains large granite blocks and smaller xenoclasts of foliated amphibolite, intermingled with more abundant and larger rafts of Adelaidean and Cambrian sediments.

EXCURSION GUIDE

DAY 1: Thursday, 2 February, 1989 (Fig. 2).

STOP 1. Niggly Gap area, Worumba Anticline.

(a) The bus will drive along the Willow Waters road east of Hawker to the "Worumba" entrance gate. From here we shall walk southwards through Arkaba Hill Beds, Kirwan Siltstone and Waraco Limestone.

Note the following features:

- Interbedded carbonates and clastics of Arkaba Hill Beds, in places cut by apophyses of intrusive breccia.
- Thinly laminated carbonaceous Kirwan Siltstone showing no evidence of axial plane cleavage despite folding into a steeply north-plunging, antiformal, tight to isoclinal syncline.

. Possible soft-sediment folding in laminated limestone of Waraco Limestone; broken and slumped stromatolite columns.

. Recrystallised dolomite marble near top of Waraco Limestone in keel of syncline.

(b) On the east limb of the syncline, walk back down through the sequence (Waraco Limestone, Kirwan Siltstone, Arkaba Hill Beds) to a narrow, dyke-like body of carbonate breccia that marks the faulted axis of the ancestral Worumba Anticline. Note the change of sedimentary younging directions across this boundary: the Arkaba Hill Beds young to the west, while the Wirrawilka Beds young to the east.

Breccias within this dyke-like body may be polygenetic. Some appear to be derived directly from fracturing of the dolomitic wall rocks (both Arkaba Hill Beds and Wirrawilka Beds); some are clearly discordant to the bedding in the anticlinal limbs, and some show alignment of clasts parallel to the dyke-margins. Near-surface modification of breccias by solution-collapse mechanisms is also possible.

(c) Note stromatolites in Wirrawilka Beds and cross-bedding in overlying Niggly Gap Beds which indicate younging directions.

Walk up section through Niggly Gap Beds, noting halite casts, immature sandstones, micaceous siltstones and minor carbonates, and the irregular style of deformation of these rocks. Beds are in places overturned, and locally brecciated in situ.

(d) At the eastern edge of the Niggly Gap Beds, another dyke-like carbonate breccia body separates these beds from the Wirreanda Dolomite Beds (interpreted as lower Burra Group). The breccia contains lenticular xenoclasts of dolomite possibly derived from the Wirrawilka Beds.

STOP 2. 1 km east of Niggly Gap, Worumba Anticline.

Return to bus here after briefly examining blue-grey dolomites of Wirreanda Dolomite Beds and their contact with breccia.

STOP 3. Worumba Homestead area.

At this point, examine transecting cleavage in Tapley Hill Formation on east limb of Worumba Anticline.

STOP 4. Willow Creek gorge, Worumba Anticline.

Here we shall examine the contacts between carbonate breccia and a 1 km-long xenoclast of Worumba Dolomite Beds cut by Willow Creek gorge. Tepee structures in the dolomite provide evidence of westerly younging directions in this block.

STOP 5. Willow Creek Workings area.

(a) Examine copper mineralisation in brecciated Niggly Gap Beds and carbonate breccia around the old workings just south of the track. Note small xenoclasts of dolerite. Note that 3 km to the south of this point is a dolomite xenoclast intruded by dolerite, probably prior to incorporation in the breccia.

(b) Walk north from the track over a ridge in carbonate breccia containing another lenticular dolomite xenoclast. Note more dolerite bodies. At the northwestern margin of the carbonate breccia, note cross-cutting contact with north-south-striking Skillogalee Dolomite on the west limb of the Worumba Anticline.

DAY 2: Friday, 3 February.

STOP 6. Arkaba Diapir (Fig. 3).

A short walk into Arkaba Creek from the main road allows inspection of a relatively gently-dipping contact between flow-banded carbonate breccia and laminated siltstone of Tapley Hill Formation. The breccia truncates the bedding in the host rock, and contains a variety of small xenoclasts aligned to define a flow-layering parallel to the contact.

The Arkaba Diapir was mapped in detail by Mount (1975) and his conclusions summarised by Mount (1980). The breccia is considered to have been intruded passively into extensional fractures in the cover. This phase of intrusion has been observed by Mount (1975) to cut across mesoscale folds in the host rock, and hence probably occurred late in the Delamerian Orogeny. It probably represents a higher structural level than the almost-in-situ brecciation observed in places at Worumba. Mount (1975, 1980) described a suite of minerals (calcite, dolomite, chlorite, clay, adularia feldspar, hematite, magnesio-riebeckite, quartz, stilpnomelane, talc, analcite, barite, brucite, epidote, ilmenite, phlogopite, rutile and tourmaline) as characteristic of the intrusive breccias. A very low-grade metamorphic environment with abundant saline solutions, rich in CO_2, was envisaged. White (1983) suggested that the intrusive features and alteration products associated with diapirs are best explained by an origin as carbonatite intrusions, although Mount (1975) excluded this possibility. A carbonatite origin has also been proposed by Lottermoser (1988) for carbonate breccias in the Umberatana area of the northern Flinders Ranges, but these show significant differences from the diapirs examined on this excursion, and may lie outside the area of Curdimurka Subgroup deposition.

<u>STOP 7. Oraparinna Diapir - Linke's Barite Mine</u> (Fig. 4).

At this site, barite veins cut the Tapley Hill Formation and are themselves disrupted by diapiric breccia.

The Tapley Hill Formation here forms a large xenoclast completely surrounded by carbonate breccia. Barite occurs as veins of coarse-gained platy radiating crystals with patches of early-formed quartz and later, cross-cutting calcite in fractures. There are also coarse siderite-barite-quartz intergrowths, and dispersed pyrite and chalcopyrite. Linke's Lode is the largest producer of oil-drilling grade barite in Australia (37 000 t since 1980).

STOP 8. Enorama Diapir (Fig. 5).

At this point, the uppermost carbonate band of the Etina Formation (Umberatana Group) rests unconformably on a mafic volcanic xenoclast in carbonate breccia. This block was emplaced, probably by diapiric processes, before deposition of the Etina Formation, and possibly formed an island in the shallow sea of that time. Fine-grained dolomite from this carbonate band penetrates down deep fissures in the volcanic rock, and rounded cobbles and boulders of mafic rock are incorporated near the base of the carbonate.

The dolomite is overlain by green shales recording a marine transgression. Lemon (1986) showed that the tectonic history of this region conforms with the expected effects of salt withdrawal from around a diapir, forming a peripheral sink (rim syncline).

STOP 9. Blinman Diapir (Fig. 6).

(a) At the southern margin of the Blinman Diapir, the gentle dips of the Blinman Dome are sharply upturned. This feature has been suggested to be due to drag on the intruding breccia mass, but is in striking contrast to the passive style of intrusion seen at Arkaba and some other high-level apophyses.

(b) Basement xenoclasts of the Blinman Diapir. A small outcrop of mylonitic gneiss surrounded by carbonate breccia near the Blinman Hotel is interpreted as a basement block rafted up in the intruding breccia. Other xenoclasts nearby include granite and a deformed metaconglomerate, possibly also derived from the basement.

STOP 10. Port Augusta: end of Flinders Ranges part of excursion.

W.V. Preiss

W. V. Preiss,

January, 1989.

REFERENCES

Ambrose, G. J., Flint, R. B. and Webb, A. R., 1981. Precambrian and Palaeozoic geology of the Peake and Denison Ranges. Bulletin, Geological Survey of South Australia, 50.

Barnes, L. C., 1972. Geological Investigation of the Burr Crush Zone. Mineral Resources Review, South Australia, 132:7-35.

Berry, R. F., Flint, R. B. and Grady, A. E., 1978. Deformation history of the Outalpa area and its application to the Olary Province, South Australia. Transactions of the Royal Society of South Australia, 102:43-53.

Burns, K. L., Stephansson, O. and White, A. J. R., 1977. The Flinders Ranges breccias of South Australia - diapirs or decollement? Quarterly Journal of the Geological Society of London, 134:363-384.

Coats, R. P., 1964. The geology and mineralisation of the Blinman Dome Diapir. Report of Investigations. Geological Survey of South Australia, 26.

Coats, R. P., 1965. Diapirism in the Adelaide Geosyncline. Australian Petroleum Exploration Association Journal, 5:98-102.

Coats, R. P., 1971. Regional geology of the Mount Painter Province. In: Coats, R. P. and Blissett, A. H., Regional and economic geology of the Mount Painter Province. Bulletin, Geological Survey of South Australia, 43:17-140.

Coats, R. P., 1973 (compiler). COPLEY, South Australia. Explanatory Notes, 1:250 000 geological series. SheetSH/54-9. Geological Survey of South Australia.

Compston, W., Crawford, A. R. and Bofinger, V. M., 1966. A radiometric estimate of the duration of sedimentation in the Adelaide Geosyncline, South Australia. Journal of the Geological Society of Australia, 13: 229-276.

Coward, M. P., 1976. Large scale Palaeozoic shear zone in Australia and present extension to the Antarctic Ridge. Nature, London, 259:648-649.

Dalgarno, C. R. and Johnson, J. E., 1968. Diapiric structures and late Precambrian - early Cambrian sedimentation in Flinders Ranges, South Australia. Memoir, American Association of Petroleum Geologists, 8:301-314.

Forbes, B. G., Murrell, B. and Preiss, W. V., 1981. Subdivision of lower Adelaidean, Willouran Ranges. Quarterly Geological Notes, Geological Survey of South Australia, 79:7-16.

Gum, J., 1987. Geochemistry of the mafic igneous rocks found in Enorama Diapir, central Flinders Ranges, and their relationships to similar rocks found in nearby diapirs and volcanic bodies throughout the Flinders Ranges. University of Adelaide, B.Sc. (Hons) thesis (unpublished).

Haslett, P. G., 1976. Lower Cambrian carbonate stratigraphy and sedimentology, Old Wirrealpa Spring, Flinders Ranges, South Australia. University of Adelaide, Ph. D. thesis (unpublished).

Howard, P. F., 1951. The basic igneous rocks of the Blinman Dome. Transactions of the Royal Society of South Australia, 74:165-188.

Kitch, R. B., 1975. A redefinition of the base of the Burra Group in the late Proterozoic Adelaidean Supergroup, South Australia. In: Abstracts, First Australian Geological Convention, Geological Society of Australia, Adelaide 1975, pp. 6-7.

Lemon, N. M., 1985. Physical modelling of sedimentation adjacent to diapirs and comparison with late Precambrian Oratunga breccia body in central Flinders Ranges, South Australia. American Association of Petroleum Geologits Bulletin, 69:1327-1338.

Lemon, N. M., 1986. Blinman to Enorama - a one day excursion. In: V. A. Gostin (compiler). Proterozoic clastic sedimentation in relation to glaciations ,and tectonism, Flinders Ranges, South Australia. Field Guide, Excursion 27B, Adelaide, 31 August - 7 September, 1986. 12th International Sedimentolgical Congress. 11 pp.

Lottermoser, B. G., 1988. A carbonatitic diatreme from Umberatana, South Australia. Journal of the Geological Society of London, 145:505-513.

Mason, M. G., Thomson, B. P. and Tonkin, D. G., 1978. Regional stratigraphy of the Beda Volcanics, Backy Point Beds and Pandurra Formation on the southern Stuart Shelf, South Australia. Quarterly Geological Notes. Geological Survey of South Australia, 66:2-9.

Mawson, D., 1942. The structural character of the Flinders Ranges. Transactions of the Royal Society of South Australia, 66:262-272.

Mount, T. J., 1975. Diapirs and diapirism in the Adelaide "Geosyncline", South Australia. University of Adelaide, Ph. D. thesis (unpublished).

Mount, T. J., 1980. The Arkaba breccia intrusion and the Arkaba Hill Beds, Flinders Ranges. Quarterly Geological Notes. Geological Survey of South Australia, 74:4-11.

Mumme, I. A., 1961. Geophysical investigation of the Blinman Dome. Transactions of the Royal Society of South Australia, 85:7-11.

Murrell, B., 1977. Stratigraphy and tectonics across the Torrens Hinge Zone between Andamooka and Marree, South Australia. University of Adelaide Ph. D. thesis (unpublished).

Offler, R. and Fleming, P.D., 1968. A synthesis of folding and metamorphism in the Mount Lofty Ranges, South Australia. Journal of the Geological Society of Australia, 15:245-266.

Page, R. W., McCulloch, M. T. and Black,L.P., 1984. Isotopic record of major Precambrian events in Australia. In: Proceedings of the 27th International Geological Congress, Moscow, 1984, vol. 5:25-72.

Parker, A.J., 1983. Tectonic development of the Adelaide fold belt. In: Adelaide Geosyncline sedimentary environments and tectonic settings symposium, Adelaide, 1983. Abstracts, Geological Society of Australia, 10:23-28.

Parkin, L. W, Reyner, M. L., Pitman, R. K. and Johns, R. K. 1953. Serle map sheet, Geological Atlas of South Australia, 1:63 360 series. Geological Survey of South Australia.

Preiss, W. V., 1974. The River Broughton Beds - a Willouran sequence in the Spalding Inlier. Quarterly Geological Notes. Geological Survey of South Australia, 49:2-8.

Preiss, W. V., 1983. Depositional and tectonic contrasts between Burra Group and Umberatana Group sedimentation. In: Adelaide Geosyncline sedimentary environments and tectonic settings symposium, Adelaide, 1983. Abstracts, Geological Society of Australia, 10:13-16.

Preiss, W. V., 1985. Stratigraphy and tectonics of the Worumba Anticline and associated intrusive breccias. Bulletin. Geological Survey of South Australia, 52.

Preiss, W. V., (Compiler) 1987. The Adelaide Geosyncline - late Proterozoic stratigraphy, sedimentation, palaeontology and tectonics. Bulletin. Geological Survey of South Australia, 53.

Preiss, W. V., 1988. A stratigraphic and tectonic overview of the Adelaide Geosyncline, South Australia. South Australian Department of Mines and Energy, report 88/19 (unpublished).

Rowlands, N. J., Blight, P. G., Jarvis, D. M. and von der Borch C. C., 1980. Sabkha and playa environments in late Proterozoic grabens, Willouran Ranges, South Australia. Journal of the Geological Society of Australia, 27:55-68.

Sprigg, R. C., 1952. Sedimentation in the Adelaide Geosyncline and the formation of the continental terrace. In: Glaessner, M. F. and Rudd, E. A. (Eds), Sir Douglas Mawson Anniversary Volume. University of Adelaide, pp.153-159.

von der Borch, C. C., 1980. Evolution of late Proterozoic to early Palaeozoic Adelaide foldbelt, Australia: comparisons with post-Permian rifts and passive margins. Tectonophysics, 70:115-134.

Webb, A. W. and Coats, R. P., 1980. A reassessment of the age of the Beda Volcanics on the Stuart Shelf. South Australian Department of Mines and Energy report 80/6 (unpublished).

Webb, B. P., 1960. Diapiric structures in the Flinders Ranges, South Australia. Australian Journal of Science, 22:9.

Webb, B. P., 1961. The geological structure of the Blinman Dome. Transactions of the Royal Society of South Australia, 85:1-6.

White, A. H., 1983. Speculations on the Adelaide Rift and the origins of diapirs. In: Adelaide Geosyncline sedimentary environments and tectonic settings symposium, Adelaide, 1983. Abstracts, Geological Society of Australia, 10:3-6.

FIGURES

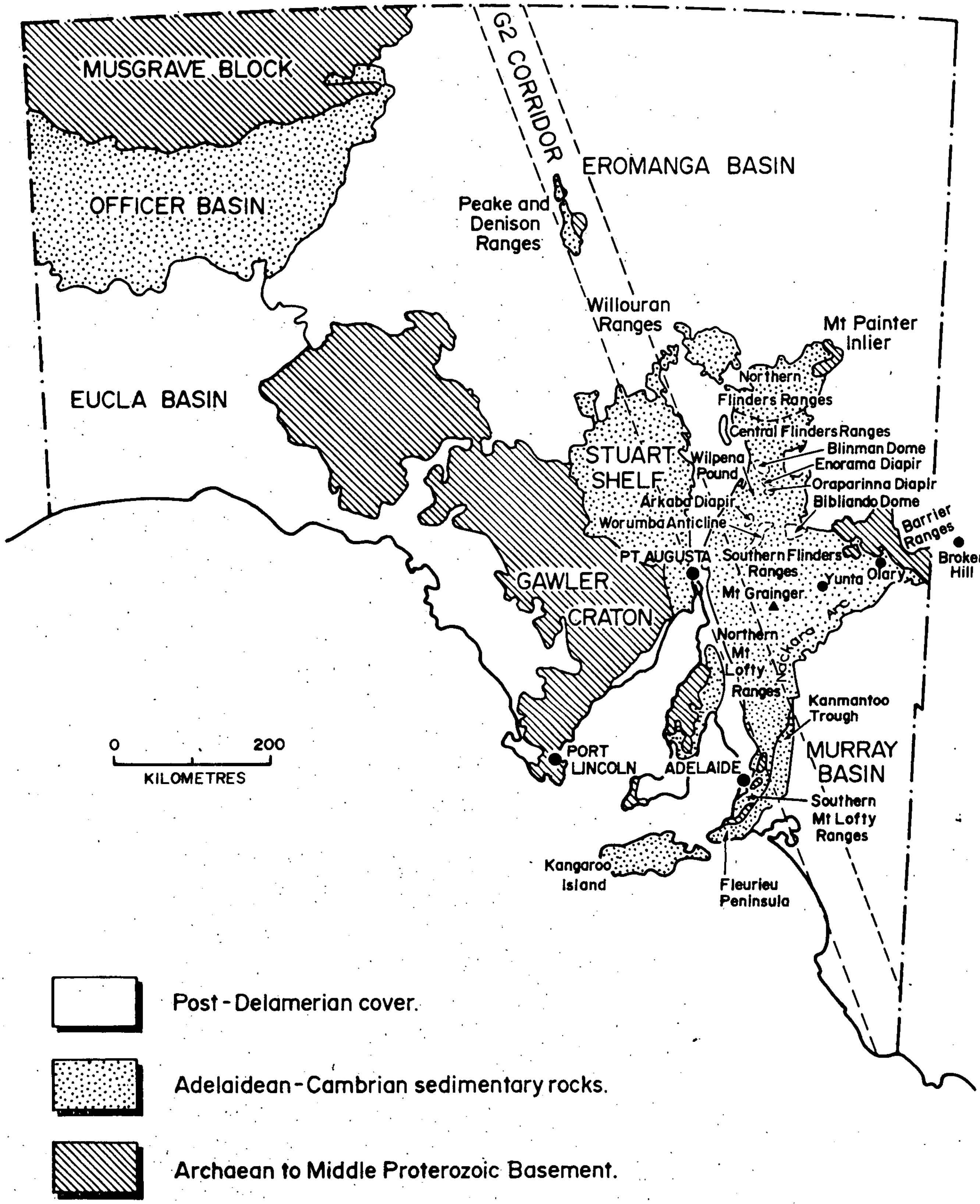


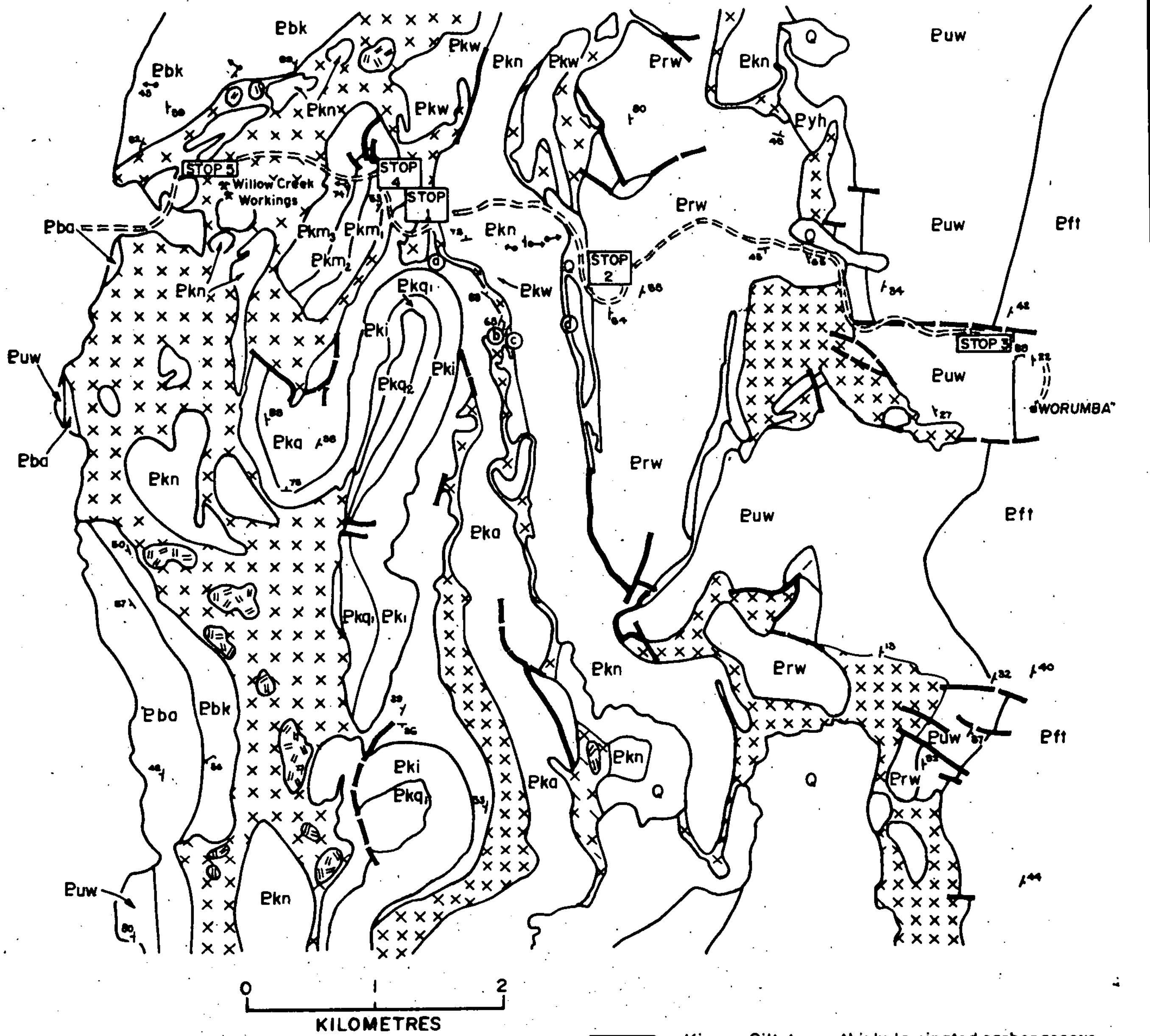
FIG.1

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

EXCURSION GUIDE TO FLINDERS RANGES DIAPIRS

SIMPLIFIED LOCALITY MAP OF ADELAIDE GEOSYNCLINE AND ENVIRONS

COMPILED W. Preiss	C.D.O.	DATE
DRAWN J.W	SCALE	
DATE	PLAN NUMBER	
CHECKED	S 20587	



Q	Quaternary
Eft	Tapley Hill Formation – thinly laminated carbonaceous siltstone, minor dolomite.
Euw	Wilyerpa Formation – green siltstone, sandstone, minor conglomerate; basal dolomite.
Eyh	Holowilena Ironstone – hematitic siltstone and diamictite.
Eba	Auburn Dolomite – siltstone, dolomite, fine sandstone.
Ebk	Skillogalee Dolomite – dolomite, chert, magnesite conglomerate.
Eby	Yednalue Quartzite – feldspathic quartzite.
Erw	Wirreanda Dolomite Beds – dolomite, minor magnesite conglomerate.
Ekm	Worumba Dolomite Beds – dolomite, siltstone.
Ekq	Waraco Limestone – stromatolitic and cherty limestone, dolomite, siltstone.
Eki	Kirwan Siltstone – thinly laminated carbonaceous siltstone.
Eka	Arkaba Hill Beds – dolomite, siltstone, sandstone.
Ekn	Niggly Gap Beds – siltstone, sandstone, halite casts, minor dolomite.
Ekw	Wirrawilka Beds – dolomite, siltstone.
	Dolerite.
	Carbonate breccia.
38	Strike and dip of bedding.
86	Strike and dip of cleavage.
	Fault.
	Younging direction.

UMBERATANA GROUP (Eft, Euw, Eyh)

BURRA GROUP (Eba, Ebk, Eby, Erw)

FIG. 2

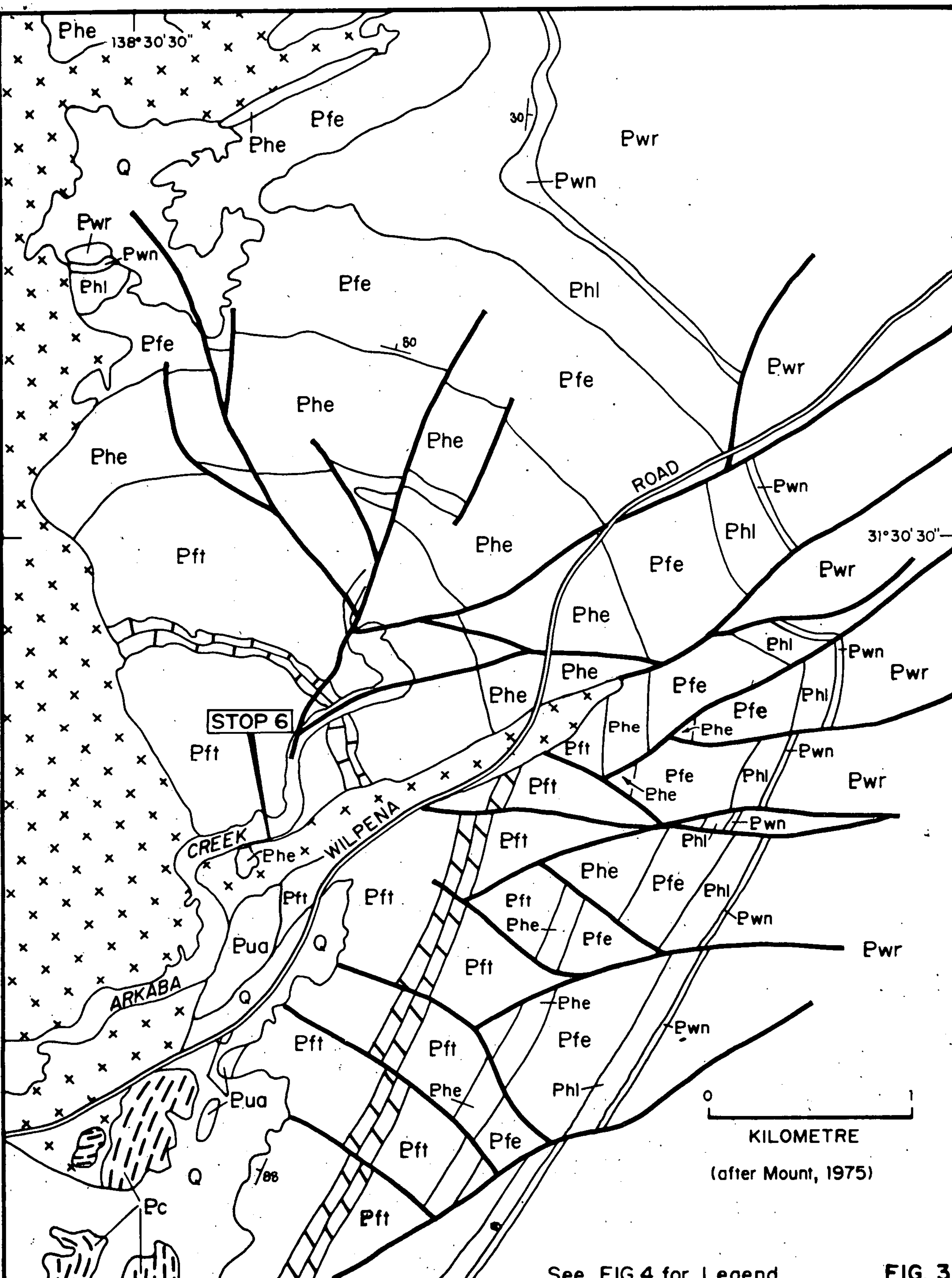
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

EXCURSION GUIDE TO FLINDERS RANGES DIAPIRS

SIMPLIFIED GEOLOGICAL MAP OF CENTRAL PART OF WORUMBA ANTICLINE

COMPILED	C.D.O.	DATE
W. Preiss		
DRAWN	SCALE	
J.W.		
DATE	PLAN NUMBER	
CHECKED	S20588	

4758



See FIG. 4 for Legend

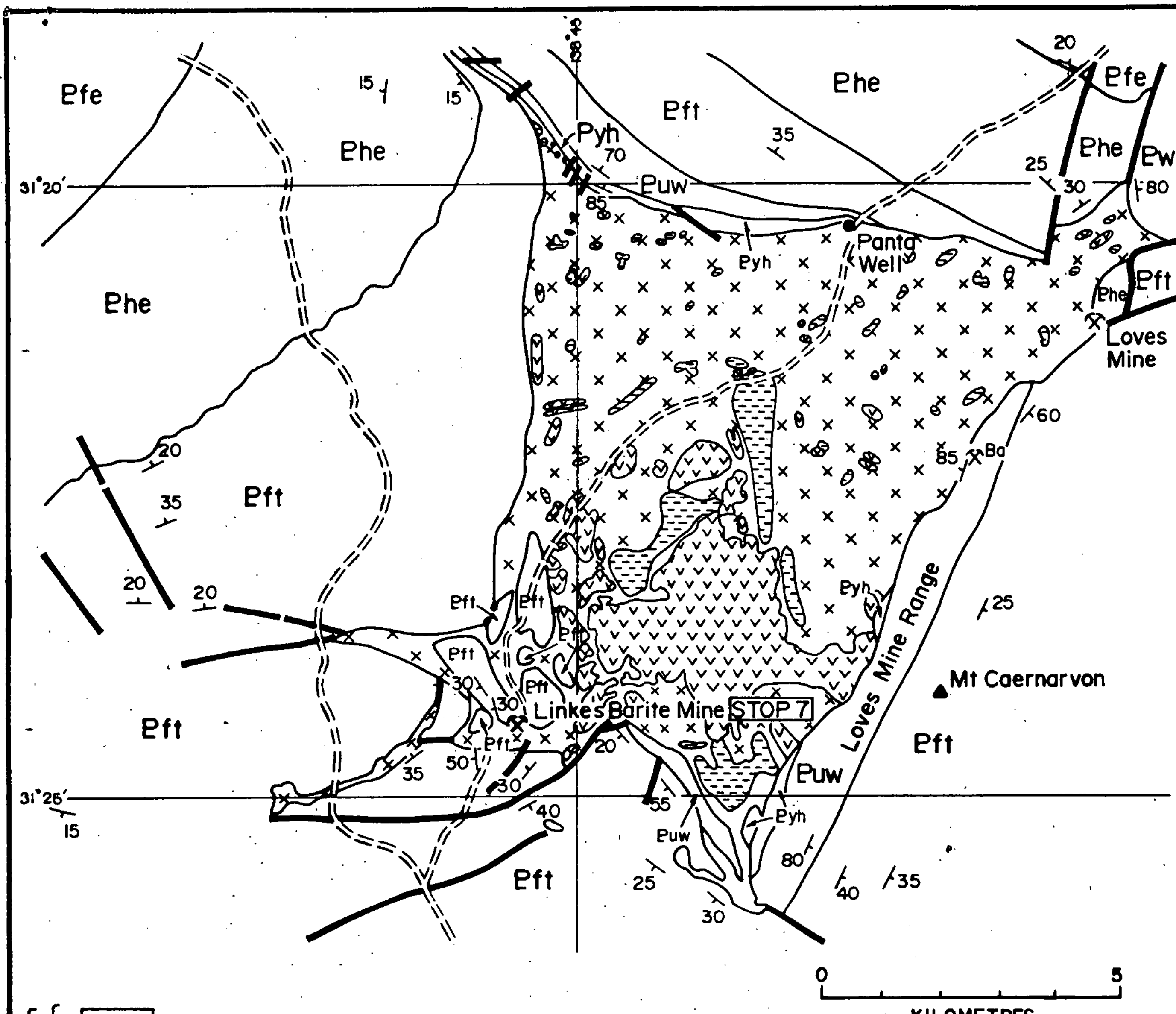
FIG. 3

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

EXCURSION GUIDE TO FLINDERS RANGES DIAPIRS

SIMPLIFIED GEOLOGICAL MAP OF PART OF ARKABA DIAPIR

COMPILED W. Preiss	C.D.O.	DATE
DRAWN L.A.W.	SCALE	
DATE	PLAN NUMBER	
CHECKED	S20589	



ADELAIDEAN

WILPENA GROUP

Ᵽwr	Brachina Formation :- red-brown siltstone.
Ᵽwn	Nuccaleena Formation :- cream dolomite.

UMBERATANA GROUP

Ᵽhl	Elatina Formation :- sandstone, minor diamictite.
Ᵽhz	Trezona Formation :- red limestone, grey-green shale.
Ᵽfe	Enorama Shale :- green shale.
Ᵽhe	Etina Formation :- sandy limestone, grey siltstone, minor conglomerate.
Ᵽft	Tapley Hill Formation :- laminated carbonaceous siltstone, minor dolomite, greywacke.
Ᵽuw	Wilyerpa Formation :- green siltstone, quartzite ; dropstones.
Ᵽua	Appila Tillite :- grey-green diamictite.
Ᵽyh	Holowilena Ironstone :- hematitic siltstone and diamictite.

CALLANNA GROUP

× × ×	Diapiric breccia.
∨ ∨ ∨	Mafic igneous xenoclasts.
- - -	Sedimentary xenoclasts.

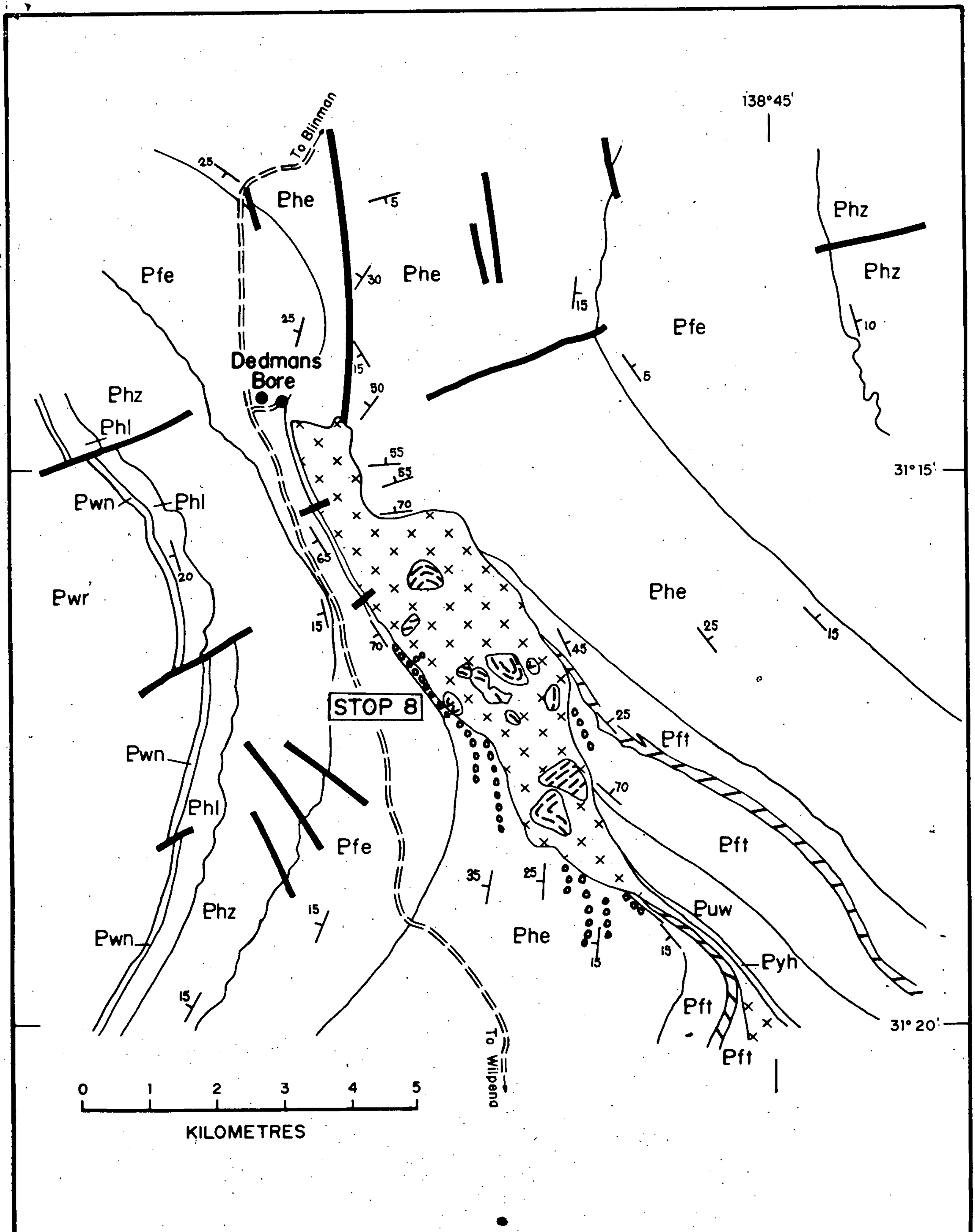
FIG. 4

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

EXCURSION GUIDE TO FLINDERS RANGES DIAPIRS

GEOLOGY OF PART OF THE ORAPARINNA DIAPIR AND LINKES BARITE MINE

COMPILED W. Preiss	C.D.O.	DATE
DRAWN J.W.	SCALE	
DATE	PLAN NUMBER	
CHECKED	S20590	



(after Oraparinna 1:63 360 geological map, Geological Survey of South Australia)

See FIG. 4 for Legend

FIG. 5

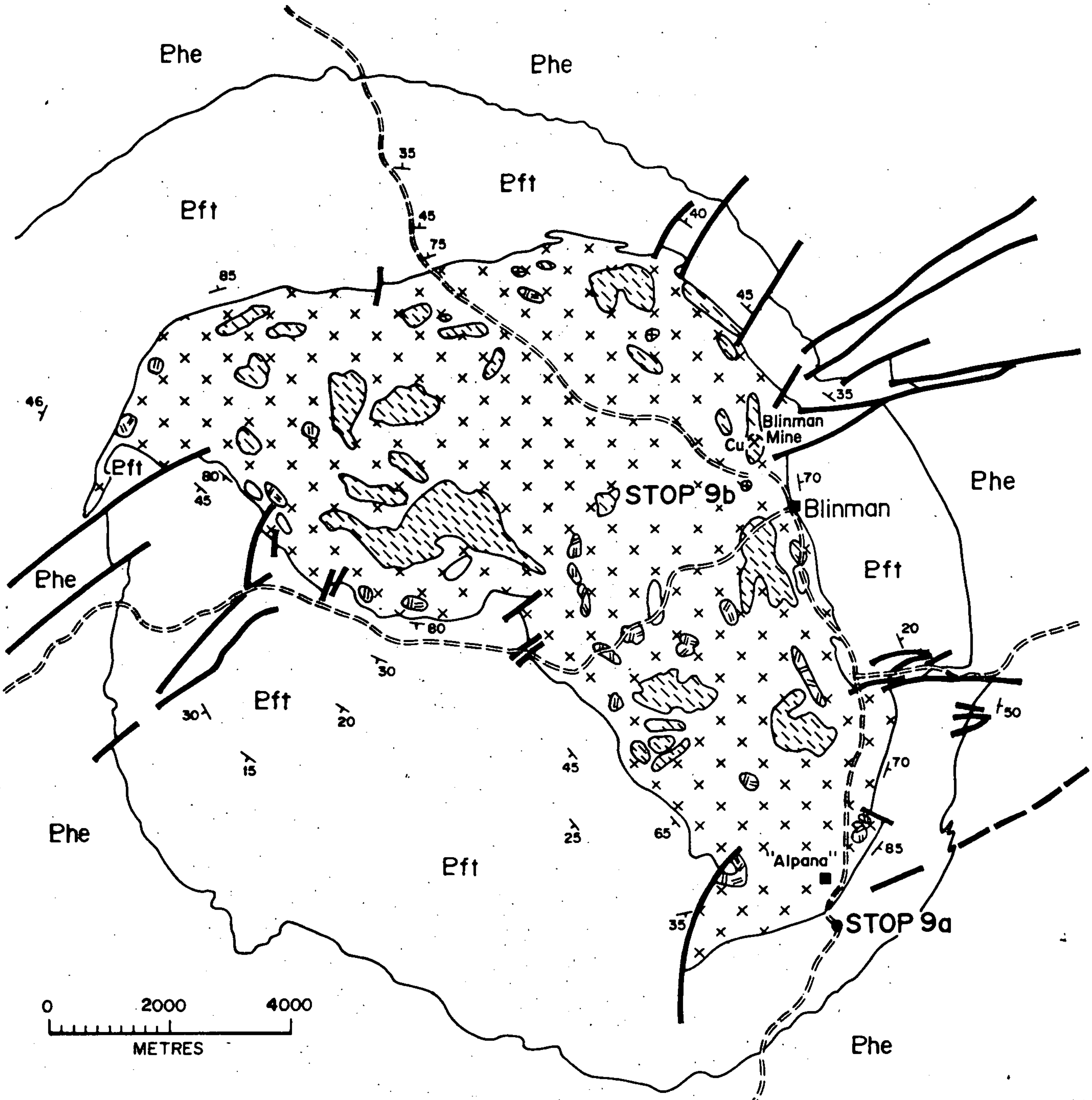
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

EXCURSION GUIDE TO FLINDERS RANGES DIAPIRS

GEOLOGY OF PART OF THE ENORAMA DIAPIR

COMPILED W. Preiss	C.D.O.	DATE	
DRAWN L.A.W.	SCALE		
DATE	PLAN NUMBER		
CHECKED	S20591		

4788



Phe	Etina Formation:- sandy limestone, siltstone
Pft	Tapley Hill Formation:- thinly laminated carbonaceous siltstone, minor dolomite.
× × ×	Carbonate breccia of Blinman Diapir.
	Sedimentary xenoclasts (mainly Callanna Group).
	Mafic igneous xenoclasts (mainly altered dolerite).
⊕	Pre-Adelaidean basement xenoclasts (granite, mylonitic gneiss).

FIG. 6

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

EXCURSION GUIDE TO FLINDERS RANGES DIAPIRS

SIMPLIFIED GEOLOGICAL MAP OF THE BLINMAN DIAPIR

COMPILED W. Preiss	C.D.O.	DATE
DRAWN J.W	SCALE	
DATE	PLAN NUMBER	
CHECKED	S20592	