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Frome Report No. 7200-G-43

SURFACE STRUCTURAL GEOLOGY OF SELECTED AREAS IN THE GAMBIER-ROBE-NARACOORTE DISTRICT, SOUTH AUSTRALIA

by

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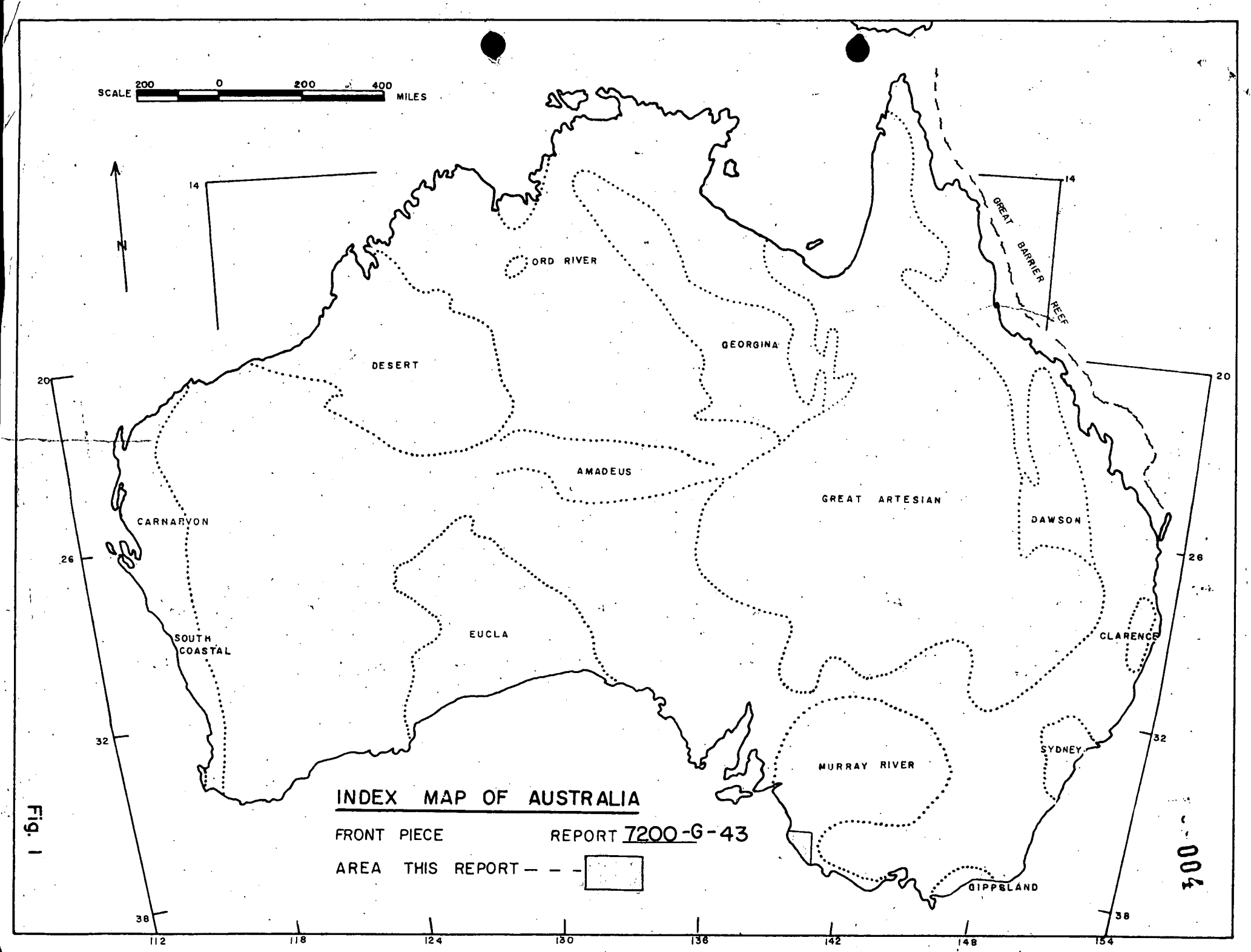
Frome-Broken Hill Co. Pty. Ltd.,
Melbourne,

January 25, 1957.



INDEX MAP OF AUSTRALIA

FRONT PIECE REPORT 7200-G-43

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Fig. 1

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ABSTRACT

The report covers surface geologic mapping in the vicinities of Mount Schank, Tantanoola and Naracoorte, and investigation at several sites of alleged oil seeps.

West of Mount Schank exposed mid-Tertiary Gambier limestone is very gently folded along northwest axes, probably in adjustment to minor motion among fault blocks. Fault traces approach two mean orientations, north-northwest and west-northwest, and are marked by low scarps, karst features and dolomitisation. Between Tantanoola and The Bluff, a north-northwest fault - about coincident with a previously postulated anticlinal axis - divides east-dipping dolomitised Gambier limestone in the high cliff on the east from the dune-covered downthrown block on the west. Meager indications of west dip near the cliff permit interpretation as anticline faulted at crest, anticline faulted on east flank, or faulted east-dipping monocline; in the two latter instances, reversal indications are from drag along fault plane. In the Naracoorte area, lower and upper members of the Gambier formation, poorly exposed and thoroughly weathered, are thought to dip very gently westward from the Victorian border to Naracoorte Dune, in which drag along Kanawinka Fault may be invoked to explain Gambier limestone in anomalously elevated position. Formation base may outcrop near east edge of Hynam-Koppamurra Dune.

At Haines' Landing on Glenelg River near Nelson, Victoria, reported oil seep was investigated, but nothing found. Oily substance floating on the sea at Geltwood Beach north of Lake Bonney was tested in laboratory; negative result may be due to accidental leakage of sample in transport, leaving only seawater. Viscous material collected subsequently from hightide

line at Geltwood Beach proved to be petroleum, but it cannot be said whether material came from a passing ship, was borne naturally by currents from a distant source, or originated locally. Additives were not detected in samples.

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SURFACE STRUCTURAL GEOLOGY OF SELECTED AREAS IN THE GAMBIER-ROBE-NARACOORTE DISTRICT, SOUTH AUSTRALIA

GENERAL DESCRIPTION

The region is an emergent coastal plain floored by almost flat-lying mid-Tertiary Gambier and Naracoorte reef detrital, cherty limestones, upon which terraced Pleistocene dunes parallel successive fault-uplifted shores. Early Quaternary ash and basalt peaks from Mount Graham to The Bluff, some barely protruding from their dune calcarenite mantles, dominate the south central skyline, while the slightly later Quaternary isolated compound volcanic cones of Mt. Gambier and Mount Schank constitute the first historic and most prominent landmarks of the entire region. Except near Mount Schank, no significantly large area exists free of effective concealment by Quaternary dunes, shallow marine to freshwater interdune deposits or, most ubiquitously, by sandy and podsolic soils. Rocks other than those mentioned outcrop only in the vicinity of Knight's Quarry, type locality of the Knight Group gravel and clay.

Streams are few and poorly integrated, forcing large scale government construction of artificial ditches to drain swamps that abound inland. Most natural drainage proceeds underground by percolation, through solution-enlarged joints and caves, and - in the Mount Gambier-Mount Schank vicinity - into numerous large sheer-walled sinkholes to exposed watertable. Underground drainage across the region derives from catchment scurces beyond the Victorian border besides local rainfall, as evinced by the large, steady replenishment at any season of water withdrawn for industrial and domestic use from Mount Gambier's crater lakes (Ward, 12).

Aside from fishing, which is minor and not so directly dependent on geologic influence, the economy of the Lower Southeast depends mainly on

sheep grazing, abetted by viticulture at Coonawarra. Since World War I, forests of several pine species from California's Coast Range have been planted by the South Australian government on major dunes, thus reclaiming otherwise useless land and providing basis for local timber and pulp industries. Crushed basalt from many quarries suitably close to construction projects acquires increased importance with dwindling reserves of Knight's Quarry gravel for concrete aggregate and Up-and-Down Rocks dolomite for railway ballast. Gambier limestone, because of its accessible abundance, cutting ease, massiveness, exposure hardening and attractive whiteness, is so widely employed as building block and veneer that it stamps the architectural identity of the region, contrasting notably with the sombre basalt edifices common eastward in Victoria. The Naracoorte limestone, though but lately dignified by its own distinctive geologic name (Ludbrook, 6), has apparently been long recognised as less desirable than the Gambier, at least for public buildings; however it lends itself to rubble and ashlar masonry.

STRATIGRAPHY:

Sedimentary Rocks

Various paleontologists differ significantly on age of lithologic units in this region. Ludbrook's latest available usages (6, 7, 8) are followed here.

MIDDLE EOCENE: Knight Group - Excavation at the type locality, Knight's Quarry, 6 miles northwest of Mount Gambier, exposes 13½ feet of quartz gravel and plastic mottled clay unconformably overlain by thin basal conglomerate and normal limestone of the Gambier formation. Clays around Lakes Leake and Edwards and on the west flank of The Bluff are more probably ascribable to the Knight than to weathered basalt. At the last-mentioned,

site, stratigraphic relationship to nearby Gambier limestone is ambiguous, therefore it is worth mentioning that clay is known above Miocene limestone correlatable with Gambier, for Tindale (11, p.137) shows ascending sequence of Miocene limestone, lower Pliocene oyster beds, red clay and dune calcarenite.

MIOCENE: Gambier Formation - Ludbrook notes three components in the Gambier formation, a basal conglomerate, and polyzoal limestone Gambier and Naracoorte members.

Basal conglomerate - Knight's Quarry reveals a mere 1½ feet of the quartz pebble conglomerate, but the inclusion of blackish brown limonite nodules poses an interesting interpretive problem on the northeast of some inland dunes. Laterite soil belts with such nodules, mapped beside the dunes by the State Lands Department, are obviously like the Dundas laterite of western Victoria's basalt plain. Question is, may the South Australian soil type not derive from basal Gambier concealed and heretofore unsuspected in neighboring dunes? Gambier formation is known to be thin, for example, east of Naracoorte Dune (168 feet in Comaum Bore) and upfaulting associated with dune sites would raise the formation base closer to the surface.

Gambier limestone member - The Gambier member is a white, porous, cemented limestone composed entirely from polyzoal bioherm detritus, with restricted dolomite zones and numerous widespread chert horizons.

Bryozoal fragments and foraminifera bulk greatest in the limestone, although occasional pelecypod valves, echinoid tests and spines might compel greater notice. Fragility of echinoid remains and nearly exclusive fossil constitution suggest deposition in situ or with little transport.

Chert occurs as nodule and slab horizons rather than coalesced beds, definitely replacing limestone, most likely silica provenance being the basaltic eruptives. The typical chert nodule progresses from chalky

coat inward through milky to brown to gray-black core, utlimate core color ostensibly determined by nodular thickness. Pale flecks attest erstwhile fossils.

Naturally exposed dolomite is tan to brown, crystal-faceted, seldom disaggregated but then mistakable for quartz sand, usually in cemented brick-shaped blocks. Unweathered dolomite in quarries is massive, pink or tan, and of course, crystalline. Linear outcrop randomly oriented toward limestone strikes, and common but not invariable association with slight, vague to prominent topographic scarps prompts interpretation of dolomite as a prime fault diagnostic. Dolomite bedding at Up-and-Down Rocks well back from the inferred fault plane is readily explicable as vertical zonation, lateral extent varying with receptiveness of individual limestone beds to replacement, again possibly from basic magmatic source.

Crespin (2, pp.24-26), describing the Nelson bore, assigns both flint and dolomite to an unnamed Gambier formation member, but O'Mara prefers to impute no stratigraphic significance to the dolomite at all. Where Gambier limestone member is well exposed at the surface, the great number of closely spaced chert horizons defies distinction of one from another for purpose of structural reference. Where poorly exposed, paucity of chert affords a dubious yardstick for regional facies variation.

Naracoorte limestone member - The Naracoorte limestone outcrops in and east of Naracoorte Dune, and has till recently been mapped simply as Gambier formation. Elevation to status as the upper member by Ludbrook (original reference not known) is presumably accorded on paleontologic grounds, yet can be justified by divergent lithologic tendencies, too. Both Gambier and Naracoorte members comprise similar fossil debris, but the Naracoorte preserves more original material, like porcellaneous or nacreous coatings. The massive, pure carbonate Gambier member is white when quarried, weathers to

drab grey. The rubbly Naracoorte member is not quite as white to begin with, and weathers pale buff to tan as well as grey. Besides carbonate, the Naracoorte contains detectable amounts of quartz grains and initially disseminated clay, whose residual concentration from leaching forms impervious seals and consequent perched watertables. Dolomitisation has not been observed affecting Naracoorte member, nor Gambier where the two occur together along Kanawinka Fault, yet elsewhere dolomitisation of Gambier along faults is prominent. Explanation may be sought in relative distance from a magnesium source, and it is suggested that basalt magma is the source. Such reasoning further reduces stratigraphic significance of dolomite.

PLIOCENE TO RECENT:

Besides volcanics, the formations of this period embrace marine shell beds and marls, beaches, mixed marine-subaerial dunes, swamp and lake beds, podsol and laterite soils.

Marine Beds - Definite marine beds include marl intercalated with oyster and other pelecypod beds that transect present dunes and veneer interdunal flats, and beach sands underlying dunes, mantling shoreward dune flanks and inland flats. Reefal horizons depicted by Sprigg (8, p.56) within Woakwine Dune may be of the same type found by O'Mara on Burleigh Dune: concentric algal growths filling depressions in calcarenite pinnacles. The beach sands plus wavecut terraces and notches mark stillstands in receding Pleistocene seas, correlatable with eustatic levels on other continents.

Dunes. The great crossbedded calcarenite ranges parallel successive shorelines fixed in some measure by inferred or known faults upthrown landward. They were amassed from reworked Gambier and contemporaneous clastics, cemented by reprecipitation, and weather pale to darker buff (like Naracoorte limestone). Gambier chert plus quartz grains (from granite terrane to the

to the north?) amount roughly to 20% of the dune rock, and some silica grains show crystal faces suggesting authigenic growth.

Sprigg (8, P.61) denies submarine bay-bar origin, insists that accumulation is preeminently eolian, admitting beach foundation for some ranges. Isolated large marine shells provide no contradiction, for modern shells - pecten, oyster, abalone and other gastropods, plus cuttle-bone - have been seen driven before the wind or lodged where only wind could have driven them. Yet criteria for distinguishing marine from eolian bedding are disputable, likewise grain surface or shape traits. Definite marine beds present to at least some degree and fixed rather than migratory character of the ranges during growth, favor mixed interpretation. Retention here of the term "dune" connotes merely acquiescence to entrenched place names.

Naracoorte Dune gives certain instance of an entirely different essential character to part of the topographic mass. The young crossbedded rock at James' Quarry and at the Naracoorte Caves complex on the range crest accounts for a superficial few feet; the underlying rock is up-faulted Gambier formation, although the west side of the dune is cross-bedded rock down to the level of surrounding country.

Other Deposits - The swamp and lake deposits are thin, not readily confused with units of significance to the geologic problems undertaken, and besides are still widely inundated by contemporary puddles, ponds and swamps. Likewise soils in the region, mostly podsols, are geologically unremarkable, except for the laterite mentioned under Gambier formation stratigraphy, to be discussed again later under structure of the Naracoorte area. The unfortunate aspect of these "other deposits" - swamp, lake and soil - is their concealment of what one would like to see.

Secondary Processes and Features - Dolomitisation and chertification have been treated already under affected stratigraphic units; dolomitisation will figure again in discussion of structure and structural criteria.

Among solution features, large sinks occur only in Gambier limestone in the vicinity of Mount Gambier and Schank, and caverns accompany faults often enough to use them in extrapolation if not identification of faults. "Runaway holes" is the name applied to funnel sinks big enough to locate on State land maps; most of them are quite small, are widely dispersed over various formations, very seldom exposing the rock beneath. Their significance is ambiguous; in the Naracoorte area, they vaguely suggest a large, crude joint system. Small, shallow depressions in the area may have been initiated by solution and enlarged by wind. East of Kongorong, a small area pimpled by such depressions shows up distinctly on air photographs, but ground search revealed no exposed rock or reason for their concentration. Because rocks of the region are chemically homogeneous, weathering reacts uniformly upon them, minimising instead of emphasising the slight differences.

So-called travertinisation acts upon all the carbonate rocks; it obliterates lithologic traits and dangles false structural bait. The process involves surface solution and reprecipitation practically in place, the resultant rock being usually dirty grey, marly in texture, porous to crumbly or hard, and banded, spalling along bands. Independently of true bedding bands parallel existing exposed surfaces - reefal knobs, open joints, bedding if that fortuitously coincides with an exposed surface, but mostly just the topographic surface. Reprecipitation bands within the dunes mark percolation channels and old exposed surfaces (like fossil soil horizons). In the Naracoorte area, similar material was seen to fill solution cavities, coating or replacing rock fragments in the cavities.

VOLCANICS: Igneous rocks exposed are all basaltic eruptive, flow and ejectamenta. Ejectamenta include the full size range from ash through lapilli, scoria and bombs, each size falling into rather well-sorted beds, as in the cones of Mount Gambier and Mount Schank. Plio-Pleistocene age determination rests on fortunate intercalation of ash and calcarenite dune beds. Flow basalt includes varieties nonvesicular and vesicular, with or without amygdaloidal filling, with or without modal olivine. Olivine seen has all been fresh.

Although all the basalt types are known from single localities, there is ostensible sequence in place and time. The type containing olivine, generally with minor or absent vesicularity, is more typical of the Mount Graham to Bluff range, and is probably oldest. Next comes non-olivine basalt, and last the ejectamenta, which characterise Gambier and Schank.

Eruption seems to have occurred through fissures coincident with prior faults. Very minor concomitant radial faulting is suspected from two short photo lineaments on the west flank of Mount Schank, but not established there or elsewhere (the tongue jutting northwest from Mount Schank, caused by late fissure intrusion under superficial ash, appears radial but parallels the general fault trend). Other inferred faults at Mount Schank appear to transect rather than radiate. Lake Leake surely and Lake Edward possibly occupy collapsed calderas, and here particularly traces were sought of ring and cone dikes, besides radial faults - unsuccessfully.

STRUCTURE -

Structural Criteria:

Faults: Dislocations visible on the ground are without demonstrable exception joints and slump surfaces. Faults have been inferred at the surface from lineaments on photographs, topographic scarps, caves and alinements of caves or other solution features, dolomitisation, "steep" dips (over 5 degrees), occurrence of Gambier formation in dunes at elevations above adjacent flats, and from sub-surface correlation of lithologic logs from widely separated wells. On the ground, there is no fault trace or plane that can be pointed out, let alone measurable displacement, however sure one may be from other valid evidence that a fault is closeby or underfoot. Upthrown sides have been taken to coincide with topographically positive sides of scarps, or with broadening of synclinal form lines (conversely for anticlinal).

Dips: Formations with structurally significant attitudes are the Pre-Pliocene Naracoorte and Gambier limestones. Post-Pliocene rocks have flat to high initial dips not related to older underlying topography or structure, but these rocks do hide and are easily confused with the older rocks. Dips, apart from slump and fault drag, do not surpass 5 degrees, most are less than 3, so one understates in calling their estimation "subjective". In sinkholes or quarries exposing rock to sideward scrutiny, a chert horizon, a faint bedding plane detected from solution response, give rare reliable basis for measurement, but vigilance must be exercised to discriminate sedimentation criteria from old soil lines and water lines.

Bald surfaces of massive rock in the midst of flat or gently rolling field leave one with no alternative but to guess what is bedding, then use compass to bestow quantitative appearance on direction pointed

by physiological senses. In the Mount Schank area, rock knobs occur with solution depressions, vertical fluting, and spalls. Without marker beds, the alidade does not allow definition of regional slopes or upwarps. The formidable array of discouraging factors notwithstanding, structural mapping at large scale was attempted in several areas.

The reader must decide for himself, where no single dip is guaranteed valid, whether zero multiplied infinitely still yields zero, or whether dips statistically numerous enough will override random chance and unconscious prejudice to yield the semblance of truth. West of Mount Schank, plotted field data correlate surprisingly well with bedding traces or form lines and lineaments. These were not visible on the ground, but were subsequently transposed from air photographs in the office.

Mount Schank Area - (cf. Plate 1)

As mapped here, the Mount Schank area embraces about fifty square miles disposed in a crude parallelogram, most of it in Blanche Hundred, but extending north and east into Blanche and Kongorong Hundreds. Physically it is bounded on the east by Burleigh Dune and Mount Schank, on the south by MacDonnell Dune, on the west by a fault (or fault zone) a little over a mile east of Kongorong at the nearest, and on the north by a road, an arbitrary limit in the absence of a natural one. The area is easily accessible from Mount Gambier, nine miles northeast, by paved road that passes Mount Schank on the way to Port MacDonnell on the coast.

The terrain is almost flat, about 75 feet above sea level, with trivial relief afforded by a few slight mounds and numerous gentle scarps reaching fifteen feet maximum height. Burleigh Dune climbs a hundred feet above the plain, and Mount Schank from its four hundred foot eminence commands all. Of surface streams there is not a trace, but many large

sinkholes drop sheer to watertable about thirty feet below the plain.

The area is sometimes referred to by the name "Mount Salt" (Reeves and Evans, Sprigg, inter alia), after an old homestead shown in the west central portion of the accompanying map. Origin of the name remains obscure. Sufficient to say, there is neither salt nor mount here. However, just northeast of the homestead is a six square mile patch in which - except for a large grove of native trees - Mount Gambier limestone lies almost entirely bare, very conspicuous on air photos. This patch has long since attracted geologic notice to the area, but has not heretofore been mapped in detail.

The obvious fold pattern involves dips so slight that structure has been attributed to minor jostling among basement fault blocks (Sprigg). O'Mara after about two months of large scale planetable mapping there, emerges with far more detail, but substantial concurrence with previous published opinion.

The author thinks his structural interpretation is fully set forth on the accompanying map, requiring only the addition of a few explanatory remarks. To avoid appending question marks to everything, only the most questionable of the questionable are so marked. Of the fold axes indicated, it should be said there are so many they mask larger inferable features, which, to avoid further graphic clutter, are therefore simply marked "High" and "Low".

As for maximum exposed section, the geometric nicety of cross-sections would here be futile or invalid. In its place is substituted a generous estimate of 450 feet thickness, based on maximum distance from the "high" northwest to the low northeast, respectively, of Mount Salt Homestead, allowing average dip of 2 degrees.

Up and Down Rocks (Tantanoola Anticline). (cf. Plate 2)

Between The Bluff and Tantanoola is a high seacliff, known variously as Up-and-Down or Hanging Rocks, of dolomitised Gambier limestone. The cliff extends about $1\frac{1}{2}$ miles north-northwest from the old Mount Gambier-Tantanoola road toward the Mount Gambier-Adelaide Highway. The high point of the cliff, about 100 feet above base, is near the south end. Down to the south tip it descends to a slight vague scarp turning eastward along the upthrown extrapolation of the Bluff or Tartwaup Fault. Northward the cliff maintains fairly uniform elevation for about a mile, then descends very perceptibly to a cross road, beyond which its prolongation, if any, is buried under dune. The cliff is the sheerest and highest in the region, and its constituent dolomite more abundant than at other localities. A marine beach, wavecut notch and sea cave mark former sealevel; a second cave, opening vertically from the cliff's back slope, behind the first cave, is somewhat hazardous to enter. The back slope is thinly mantled by Plio-Pleistocene shell beds. South and west of the cliff lie forested calcarenite dune, while west of the cliff's north end, interdune flat exposes some undolomitised Gambier limestone. West of the forested dune, soil reveals a patch of volcanic ash; elsewhere on this side Gambier is presumed at shallow depth but not visible.

About 1915, South Australian Oil Wells located an oil exploration bore near the south end of the cliff east of the presently operative quarry, hoping for entrapment against the upthrown side of the Tartwaup fault; whether the company postulated an anticline to boot isn't clear. They penetrated from Gambier limestone (or dolomite?) into Knight sand at 392 feet, bottomed in Knight at 1532, with a gas show (no analysis extant) as sole reward. Dixon investigated the area early in 1956 and contended existence of an anticline, sharply flexed but not faulted.

Assigned to follow up Dixon's lead, O'Mara engaged briefly in detailed planetable mapping, easily verified east flank of the postulated structure with dips to 8°, found sparse and controvertible evidence for a south nose, but bogged down and quit the search for surface evidence of north nose and west flank. O'Mara infers his fault along the cliff base from obvious evidence, the facts that the cliff and dolomite are there. If trivial scarps and minor dolomitisation, taken alone generally warrant faults elsewhere, certainly a good example of each in conjunction ought to clinch the argument rather than prove the exception. O'Mara's 11° south-westerly dip in the south end of the main quarry would better support a south nose were it not in an extensively blasted, jumbled spot. Dixon agrees that the 2° westerly dip on the brink of the northern quarry is rather small andin an excellent position for slump. A 2° easterly dip in undolomitised Gambier limestone west of the cliff's north end could be too small to mean anything by itself, could indicate prevalent east dip, or could lend credence to anticline interpretation with northwestward axial swing to put the dip on its appropriate east flank - as one likes it. No other structural data at all were found westward of the cliff.

Unfortunately, air photos were not to hand during the course of field study; subsequently they were scrutinised and faint form lines, presumably of Gambier bedding, can be construed as localising a synclinal axis between The Bluff and Up-and-Down Rocks, giving a rough measure of crest-to-trough fold separation and closure expectable. Incidentally, of Dixon's two southerly dips - 15° and 5° - noted in company with O'Mara (Dixon 3, Plate I) - closer to The Bluff, bulldozers have bodily removed the larger one in the process of road improvements. Presence of Knight clay on the west flank of The Bluff, mentioned here under stratigraphy of that unit and mapped by Dixon, has no bearing on Tantanoola Anticline.

Sprigg's diagram through the northern quarry (10, p.58) shows dolomite above limestone at the wavecut notch, uninterrupted east dip and no fault. Tindale - concerned with Pleistocene marine phenomena, speleology and vertebrate paleontology, but interested in geology, too - depicts a section through Tantanoola and North Caves (11, p.133) shows beach deposits at the wavecut notch level, shell and intercalated volcanic ash beds on the back slope of the cliff; flat beds; inferred fault upthrown on the east, with flinty limestone beneath dune sand west of the fault, and dolomite top to bottom in the cliff on the east.

Reconciling his own information with selected data he is willing to admit from Dixon, Sprigg and Tindale, O'Mara concludes that structurally there is an anticline downfaulted westward close to or barely east of and subparallel to its axis by the now-named Tantanoola Fault, minimum throw 100 feet, and also downfaulted southward by the Bluff Fault, throw not estimated. Placing the Tantanoola Fault locus, as does Tindale, at the base of the cliff, and extending it precisely through the evident limestone-dolomite contact at the northern quarry - as contact was shown by Sprigg and corroborated by O'Mara - puts all limestone west of the fault and all dolomite east (Main quarry section is entirely dolomite, mostly pink, tan at base).

All trace of the exact site of the old bore has vanished, but from its approximate location about level with the main quarry floor on strike and within the same fault block, a reasonable Gambier thickness results from adding Gambier-Knight contact depth to cliff height above quarry floor, about 450 feet total. This accidentally equals thickness estimated in the Mount Schank area, but since there is not a clue of Knight's proximity to the surface near Mount Schank, by implication the Gambier formation must thicken southeastward.

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Naracoorte Area (cf. Plate 3)

The Victorian border on the east, 36°51 south latitude on the north and Naracoorte Dune on the west delimit the acute triangular area, about 300 square miles, treated here as the Naracoorte area - the extreme northeast corner of the exploration licence territory granted to the Frome-Broken Hill Company. It includes all of the Hundred of Jessie, and parts of Joanna, Comaum, Robertson and Naracoorte Hundreds. Investigation was carried a few miles north of the licence area boundary to an approximate east line through the small town of Kybybolite.

The small scale published geologic map (Sprigg, 9) shows the land east of Naracoorte Dune as surfaced by Gambier limestone with a few small dunes and swamps; and west of Naracoorte Dune, unbroken cover by superficial soil and dunes, besides large swamps. The sole structural feature recorded is Kanawinka Fault on the east edge of Naracoorte Dune. Ludbrook has since divided limestone in the Naracoorte area into two members, Gambier and overlying Naracoorte, based on fossil content.

O'Mara devoted nearly two months to field structural reconnaissance of the area, discovered practically nothing of value to add to published material, at least in the way of data definitely verifiable in the field. Three dozen dips mapped amount to three per square mile. Worse, many of the dips are suspected to be on topography, not bedding; or on dune, not Gambier formation. Swamp, soil and dune cover is more extensive by far than the purposely generalised published map shows, and the pitifully few and poor exposures allow only guesses as to identity or structural attitude. Naracoorte Creek and Mosquito Creek with its one tributary, Yelloch Creek, traverse rather than drain the area, finding their tenuous way in and out of swamps to lose themselves in bigger lagoons west of Naracoorte Dune.

For the Kanawinka Fault, a slight scarp on the Struan-Wrattonbullie road is perhaps the only new jot of ground evidence not already known and taken into account in previous mapping. For the rest, the Kanawinka Fault and other linear features shown on the accompanying map (Plate 3) were drawn to pass through caves and runaway holes, or to coincide with photo lineaments, and no basis, ground or photo, was found for projecting the Kanawinka Fault north of the town of Naracoorte. Attention is invited to the fact that few lineaments are traced outside the main dune mass.

Then let speculation enter where fact fails. As stated earlier, lateritic soil with limonite nodules occurs east of some dunes - here, specifically noted at three sites all adjacent to the low, discontinuous Koppamurra-Hynam Dune range east of Naracoorte Dune. Source for the nodules is not evident in the vicinity; they resemble nodules in Dundas laterite of western Victoria and in basal Gambier conglomerate of Knight's Quarry. Grant the premise that the nodules derive from basal Gambier conglomerate. Local streams are incompetent to transport any but fine suspension load, and are too few to accomplish lateral distribution, so nodules must be about in place - i.e. weathering from immediately adjacent or subjacent beds. In Comaum bore, 4 feet of limestone with quartz grit and sand plus 10 feet of coal measures with pyrite nodules reportedly underlies 360 feet of Gambier limestone (undivided in 1952, but upper part noted silty, like description in this paper of clay in Naracoorte), and overlies Knight clay (first 100 feet of section not cored), which in turn is over Mesozoic beds. Correlating the pyritiferous zone with nearest limonite nodules on the surface north of Wrattonbullie gives a 2/3 degree dip component between the two sites. Outcrop east of the Koppamurra

limonite limit is absent or unidentifiable; to the west, despite their questionable character, one could construe a belt of Gambier, followed westward by an overlying belt of Naracoorte.

The foregoing amounts to inference of uncomplicated gentle dip westward from nearly exposed base of the Gambier around the Koppamurra-Hynam Dune line as far as Naracoorte Dune, involving maximum thickness probably not more than 375 feet (1 degree average dip in 4 miles). But since Naracoorte-Gambier member contact occurs high up in Naracoorte Dune east of Kanawinka Fault, there must be upward drag and possibility of closure against the fault. Corbett's independent conclusions (1, pp.4-5) generally support this hypothesis.

ALLEGED OIL SEEPS:

In July 1956 the author investigated a reported oil seep at Haines' Landing on the Glenelg River north of Nelson, Victoria, where globules of "oil" had been sampled in river mud and an unsuccessful shallow exploratory bore drilled. Both banks were searched from the banks and from a rowboat from Curran's Creek to a third of a mile below Haines' Landing, and the bottom probed systematically without result. Thanks are due to Mr. J. L. Bond and family, present occupants of the property, for their co-operation.

On three occasions in May and June 1956, the author visited Geltwood Beach on the seacoast west of Millicent and Rendelsham, north of Lake Bonney. Oil has been reported in the sea here intermittently, tales of it going back sixty years. On the first visit, nothing unusual was sighted. On the second, what seemed to be oil was observed fifty yards offshore, and the author swam out to obtain a sample. The material was brown, oily in appearance and floated as a film on the waves over a patch a few hundred feet wide.

Chemical analysis by Vacuum Oil Company was completely negative. It is possible that some of the sample was lost in transport, since the bottle seal was faulty and the skimmed sample mostly seawater to begin with. On the third visit, no oil was seen in the water, but tarry material was collected all along high tide line. This sample, according to analysis, was petroleum residue, but whether naturally evaporated crude or refined could not be told, nor was there evidence to prove local origin or jettison from a coastal ship. On no occasion was evidence seen of oil on shore above tidal reach, on seaward or landward side of the dune. The author is indebted to many local residents for enthusiastic offers of information, but especially to Mr. Melvin Schinckel of Millicent for acting as guide, arranging transportation, etc.

Mr. John Bain of Frome-Broken Hill Company's staff accompanied Schinckel and O'Mara on the third visit.

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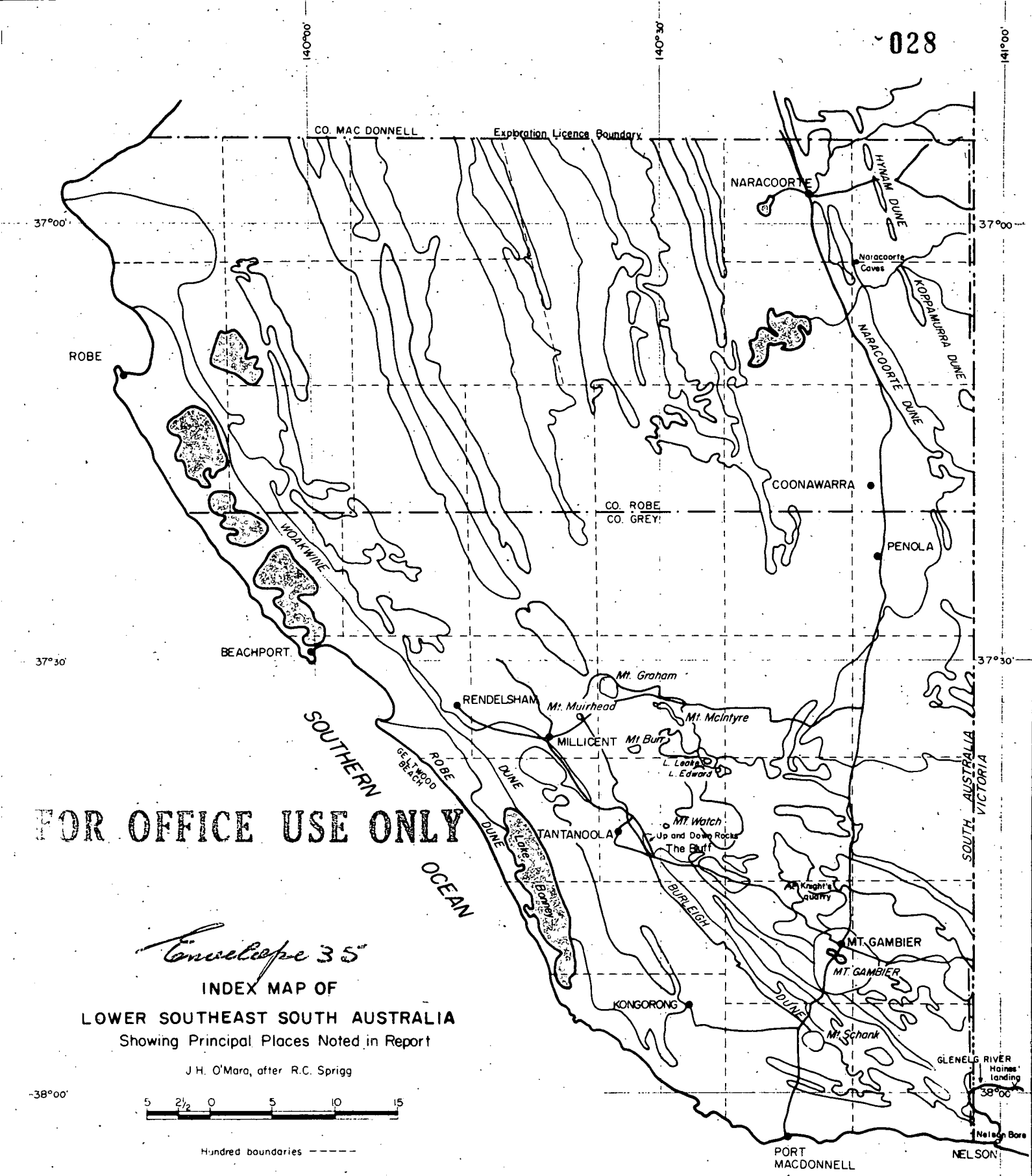

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INDEX MAP OF

LOWER SOUTHEAST SOUTH AUSTRALIA

Showing Principal Places Noted in Report

J H. O'Mara, after R.C. Sprigg

FIGURE 2

7. LUDBROOK, N. H. "Notes on Five Early Oil Bores in the Lower Southeast of South Australia", South Australian Department of Mines, Palaeontological Report No. 13/56, Adelaide, 1956.

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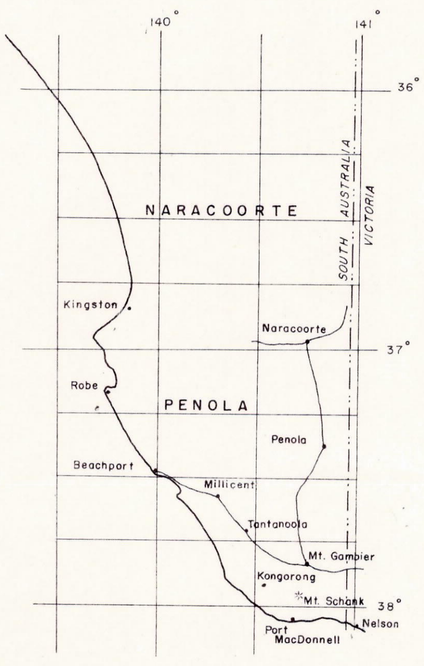
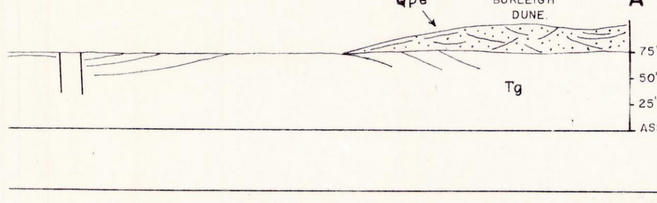
INDEX MAP



LEGEND

PLIO-PLEISTOCENE	
Qpm — MARINE ALGAL FILLINGS IN PINNACLED Qpe CAVITIES.	BEDDING FORM LINES IN GAMBIER LIMESTONE FROM PHOTO.
Qpe — "AEOLIANITE", CALCARENITE PLUS QUARTZ & CHERT SAND, SUSPECTED IN PART MARINE. SOME INTERBEDDED Qpv ASH.	HIGH — STRUCTURALLY HIGH AREAS, LESSER ANTICLINAL AXES WITH PLUNGES
Qpv — BASALTIC ASH, LAPILLI, BOMB BEDS.	LOW — STRUCTURALLY LOW AREAS, LESSER SYNCLINAL AXES WITH PLUNGES.
Qpf — BASALT FLOWS, VESICULAR, NONVESICULAR & SCORIACEOUS.	TOPOGRAPHIC SCARP, HACHURED TOWARD LOW SIDE.
MIOCENE	
Tg (CHERTY) — GAMBIER LIMESTONE MEMBER OF GAMBIER FORMATION, SHOWING DOLOMITISED BAND.	LARGE SINKHOLE, STEEPWALLED, EXPOSING WATERTABLE.
DIPS, INCLINED & HORIZONTAL.	LARGE DEPRESSION OR SINKHOLE.
JOINTS, INCLINED, VERTICAL & ASSUMED VERTICAL.	SMALL DEPRESSION OR SINKHOLE.
U/D — FAULTS, INFERRED FROM FIELD & AIRPHOTO OBSERVATIONS.	QUARRY.



Eastern Sheet

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SURFACE STRUCTURAL GEOLOGIC MAP OF THE MOUNT SCHANK AREA, SOUTH AUSTRALIA.

FROM PLANETABLE AND AIR PHOTOGRAPHIC STUDY.

PLATE I

FROME REPORT :- Surface Structural Geology of Selected Areas in the Gambier – Robe – Naracoorte District, South Australia.

By :- J.H. O'MARA.

1 INCH = 1000 FEET.

1000 0 1000 2000 3000 4000

0 ¼ ½ ¾ MILE

JAN. 25, 1957.

ENV 35-1

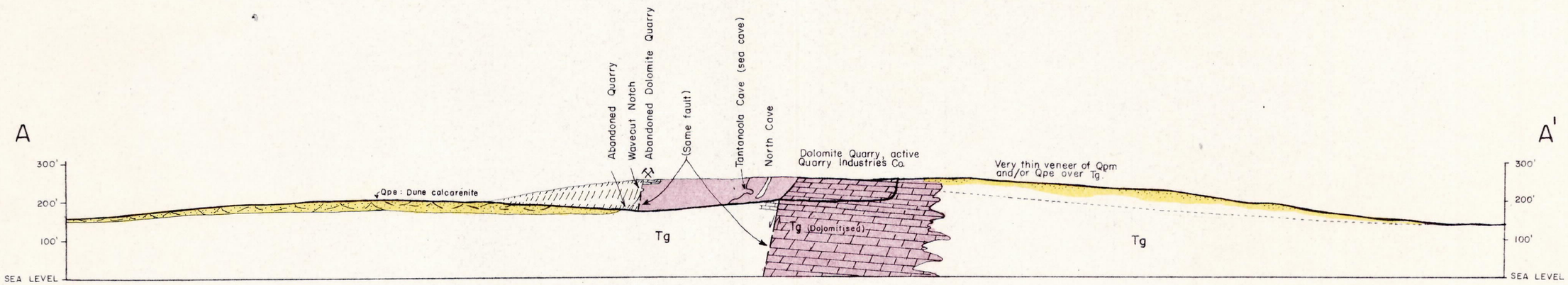
7200-G-43

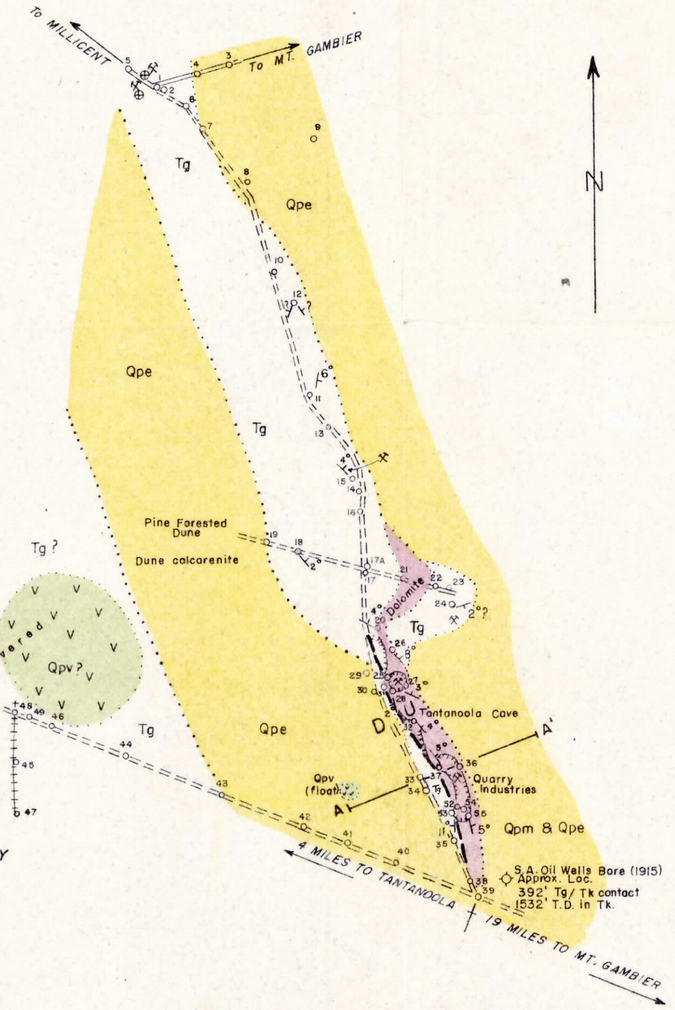
DIAGRAMMATIC CROSS SECTION

UP-AND-DOWN, ROCKS NEAR TANTANOOLA, SOUTH AUSTRALIA.

(With background features projected upon section plane)

HORIZONTAL & VERTICAL SCALES: 1 INCH = 200 FT.





LEGEND

PLIO-PLEISTOCENE	Qpm	MARINE SHELL BEDS
	Qpe	DUNE CALCARENITE
	Qpv	BASALT
MIOCENE	Tg	GAMBIER LIMESTONE, DOLOMITISED ALONG FAULT.
EOCENE	Tk	KNIGHT SANDS AND GRAVELS, NOT EXPOSED

FAULT

STEEP SCARP (NATURAL CLIFF & MAN-MADE QUARRY FACES)

HORIZONTAL DIP

2° DIP

SURVEY STATION

QUARRY

FROME BROKEN HILL CO. PTY. LTD.
Exploration Department.

PLANETABLE GEOLOGIC MAP OF UP-AND-DOWN ROCKS, NEAR TANTANOOLA, SOUTH AUSTRALIA.
PLATE 2

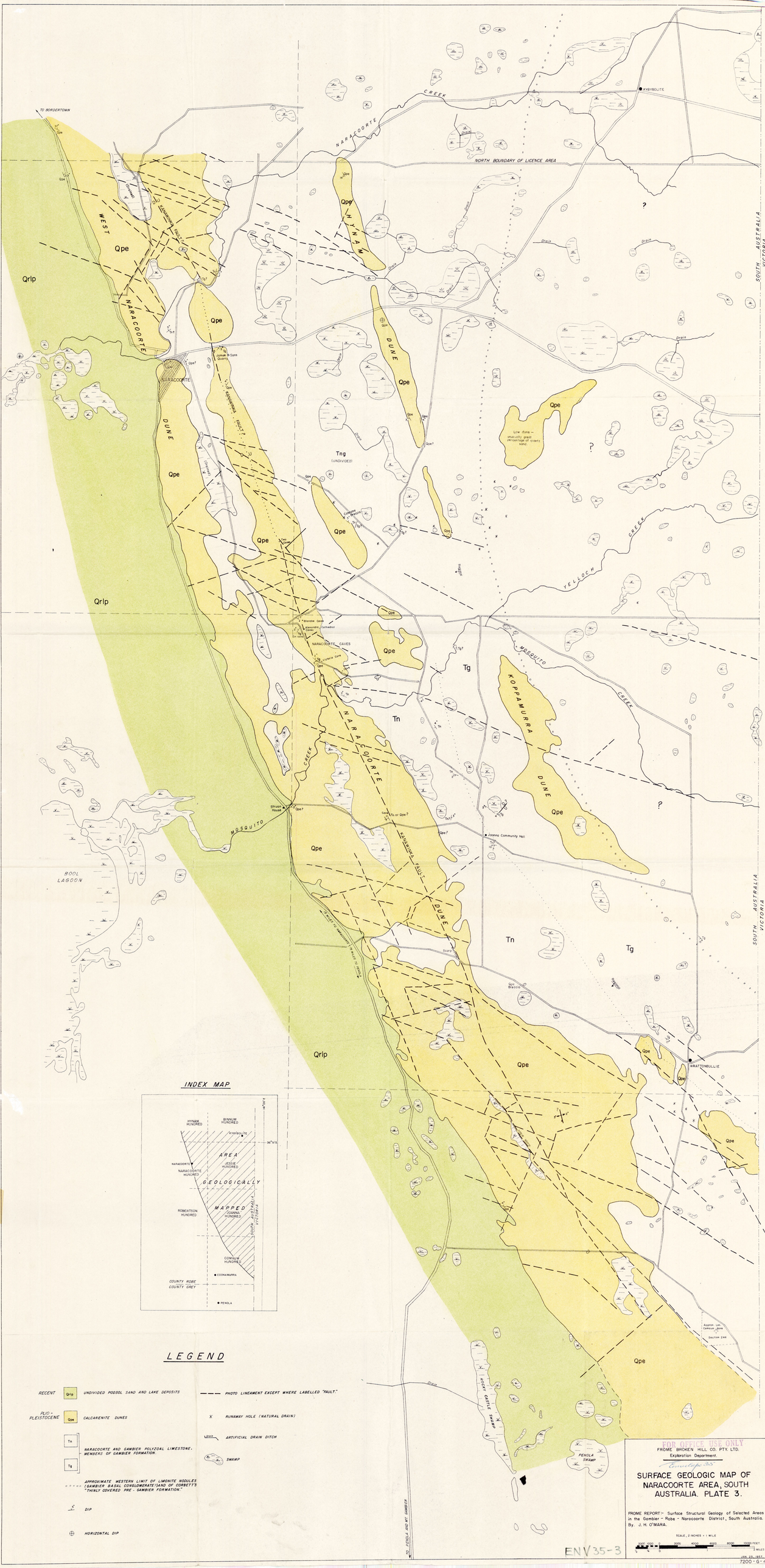
FROME REPORT:- Surface Structural Geology of Selected Areas in the Gambier - Robe - Naracoorte District, South Australia.
By:- J. H. O'MARA.

1 INCH = 2000 FEET

2000' 1000' 0 2000' 4000' 6000'

JAN. 25, 1957.

7200-G-43



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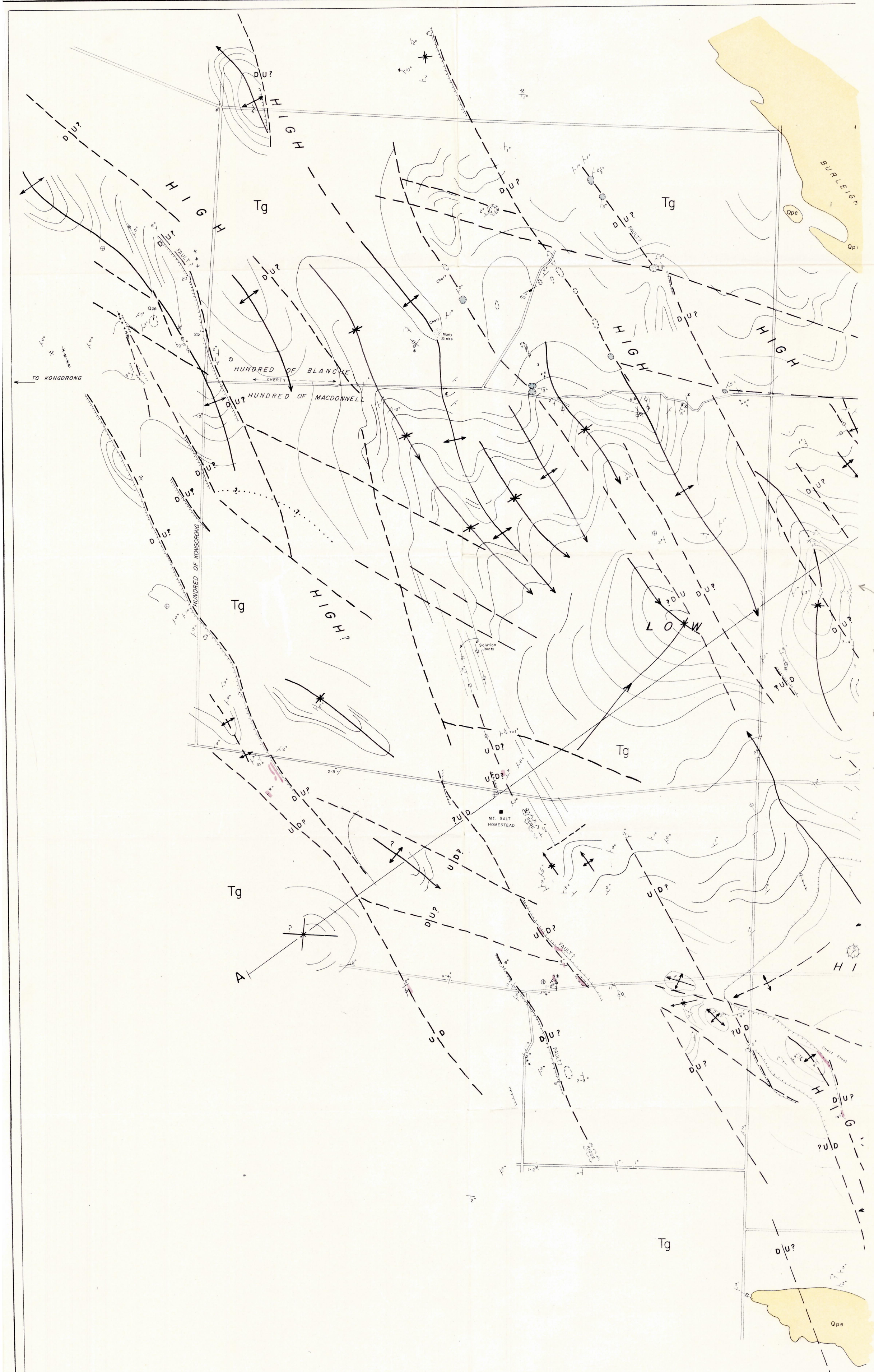
SURFACE GEOLOGIC MAP OF NARACOORTE AREA, SOUTH AUSTRALIA. PLATE 3.

FROME REPORT:- Surface Structural Geology of Selected Areas in the Gambier - Robe - Naracoorte District, South Australia.
By. J. H. O'MARA.

SCALE, 2 INCHES = 1 MILE
0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 FEET
0 1 2 3 MILES

JAN. 29, 1957
7200-G-43

ENV35-3



ENV 35-4

A

DIAGRAMMATIC CROSS SECTION

HORIZONTAL SCALE EQUAL TO MAP.

VERTICAL EXAGGERATED, NOT TO SCALE.

Western Sheet

Envelope 35

JOINS EASTERN SHEET