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J. F. Ivanac

COMMONWEALTH OF AUSTRALIA.



DEPARTMENT OF SUPPLY AND SHIPPING.

# MINERAL RESOURCES SURVEY.



## REPORT No. 1946/33.

**PRELIMINARY GEOLOGICAL REPORT ON PROPOSED HYDRO-ELECTRIC WORKS IN THE KOSCIUSKO AREA.**

by

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*CANBERRA.*

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Plans Nos. 1452, 1453.

## I. SUMMARY.


1. A geological reconnaissance has been made of portion of the Kosciusko area and a preliminary geological plan compiled from air photographs and field observations.

2. The geology of the area consists of Ordovician metamorphics intruded by granite and gneissic granite. The present topography is largely the result of uplift and block faulting in late Tertiary time.

3. Only the eastern and western ends of the Murray tunnel could be inspected in the field, but interpretation of air photographs indicates that only about ~~three~~ FOUR miles of the tunnel will lie in metamorphics and the remaining ~~26~~ 25 miles in granitic rocks.

4. The principal problems in engineering geology are discussed, and the conclusion reached that, although there are at least two critical sections along the tunnel line, there appear to be no reasons why the tunnel could not be constructed and maintained.

5. The water problem is discussed. It is not considered likely that inflow of water will seriously hamper construction, but it is not possible to estimate quantities and further investigation is suggested.

6. Proposed works for the hydro-electric scheme on the Upper Snowy River are also considered. The four water races and the dam on Spencer's Creek will be costly undertakings, but construction of the remaining dams and the tunnels should present no unusual problems.

7. A programme for detailed investigation of the projects is suggested.


## II. INTRODUCTION.

In October, 1946, the Department of Works and Housing requested that a preliminary geological investigation be made of proposed hydro-electric works in the Kosciusko area. Since very little geological mapping had been previously carried out in the area, only a reconnaissance could be attempted in the few weeks available for the work.

A preliminary geological plan was first prepared from aerial photographs and attempts made to check its accuracy in the field. Messrs. Dimmick and Smith spent 10 days during November on a reconnaissance of the western area and Messrs. Noakes and Gardner made a preliminary investigation of the proposed sites for dams and tunnels in the Kosciusko area. Unfortunately, both field parties were handicapped by unseasonable weather, floods and snow, and only the eastern and western end of the proposed Murray tunnel line could be inspected. However, the combined field work allowed a more accurate interpretation of the aerial photographs to be made and preliminary geological plan was revised. Geological information was then superimposed onto a topographical plan of the area and onto a section of the proposed tunnel provided by the Department of Works and Housing (Plates 1 and 2.)

In December, a short visit was made to the Kiewa Hydro-electric project in Victoria to compare geological conditions there with those of the Kosciusko area and thanks are extended to Mr. Lang and Mr. Condon of the State Rivers and Water Supply Commission for arranging the inspection. The writer wishes to acknowledge the co-operation and assistance of Messrs. Dimmick, Smith and Gardner in the field and office work and to thank Dr. W.R. Browne of the University of Sydney for helpful discussions on the geology of the area.

## III. GENERAL GEOLOGY.

The geology of the area between the Snowy and the Murray Rivers has been covered partly by reconnaissance and partly by a study of aerial photographs. Plate 1 is, therefore, a reconnaissance plan and may be subject to considerable alteration. However, the suggested geological boundaries along the tunnel line are believed to be fairly accurate and no major alterations are anticipated. The actual position of all significant faults has not been established, although the zones within which significant faulting may be found are referred to in the text.

The geology of the area consists of metamorphic rocks of probable Ordovician age, intruded by granitic rocks of three different ages. The present relief and topography are largely contingent on block faulting associated with the Kosciusko uplift in Late Tertiary time.

### A. METAMORPHIC ROCKS.

The metamorphic rocks occur mainly in the western half of the area and outcrop along the tunnel line in narrow belts between intrusive granite. They have not been examined along the line of the tunnel, but reconnaissance work to the south indicates that the principal rock types are quartzite and phyllite. In most places the metamorphics strike approximately north and south and are vertical or dip very steeply to the west. Intrusive contacts between metamorphics and granitic rocks are not well defined but consist of a zone in which granite grades through partly digested material into metamorphic rock.

Engineering problems encountered in the metamorphics will arise mainly from their lack of strength and cohesion, particularly near the surface. The less competent phyllitic beds will probably be buckled and isoclinally folded in many places and the quartzite will probably be closely jointed in most places and overthrust faulted or extensively shattered in others. The steep dip of the beds is a distinct advantage, and both types, particularly the quartzite, should hold fairly well under deep cover. The percentage of quartzite in the metamorphics along the tunnel line is not known but exposures to the south suggest it may be approximately 50 per cent. It will not be possible to avoid incompetent strata in construction, since the tunnel line lies approximately normal to the strike of the metamorphics.

### B. IGNEOUS ROCKS.

Granitic rocks occupy the greater part of the area particularly on the eastern side. The principal intrusion is the Berridale batholith of Devonian age, which occupies most of the area east of the Geehi and outcrops again on the west near Khancoban. The rock is typically a massive biotite hornblende granite. Along the Upper Snowy, the rock shows incipient gneissic foliation which becomes more apparent with increased altitude and to the west, and in the vicinity of the main divide, the rock becomes a gneiss.

Dr. W.R. Browne, of Sydney University, believes that this gneiss represents an older Silurian intrusive which has been intruded and partly digested by the Berridale granite and that much of the gneissic foliation in the Berridale granite, between Jindabyne and the main divide, is due to the incorporation of Silurian gneiss. This is a logical explanation of the transition into gneiss but at least some of the incipient gneissic foliation in the Berridale granite may be referred to a zone in the granite near its contact with metamorphic rocks. The number and size of metamorphic fragments included in the granite and the occurrence of gold on the Kosciusko block suggest that the roof of the batholith has not long been removed from this area.

A narrow meridional belt of metamorphics occurs along the main divide in the region of Kosciusko, and appears to have been an inclusion or "screen" within the Silurian gneiss. This belt appears to pinch out to the north before the tunnel line is reached.

Considerable complexity is expected in the granites west of the Geehi. Dr. Browne has identified a micaceous Ordovician granite south of the tunnel line and detailed work along the tunnel may therefore reveal the presence of the three granitic types. The Khancoban granite and the porphyritic granite near Bogong Creek appear to be the Berridale type, but granite between the Bogong and the Geehi appears strongly gneissic and similar to the Silurian gneiss.

The gneiss will probably have closer jointing than the massive granite and may, therefore, yield more water and not stand as well, particularly near the surface. The contacts between the igneous rocks themselves will probably be assimilation contacts, and have no effect on engineering works, apart from providing very hard rock. Driving costs in granite and in gneissic granite should be much the same, although the gneissic granite will shatter more readily. Driving costs in the metamorphics should be lower, but this must be offset against additional lining required.

The work of the Victorian Electricity Commission on the Kiewa hydro-electric scheme in Victoria is of considerable interest as geological conditions there and along the Murray tunnel have many similarities. The No. 3 tunnel at Kiewa was constructed, partly in gneiss but mainly in Devonian granodiorite which is massive and jointed like the Berridale granite. The remaining five tunnels, yet to be constructed, will lie mainly in a gneiss which, although of different origin, is probably comparable with the Geehi gneiss as regards the closer and more complex joint pattern.

C. STRUCTURAL GEOLOGY.

The major structural features of the area consist of block faulting and are referable to the Kosciusko uplift. The general picture, suggested by the reconnaissance, is well illustrated in the section on Plate 2. The high country on and to the east of the main divide, is a horst bounded on the west by step faults, in the vicinity of the Geehi and Bogong valleys, and on the east by warping and faulting west of the Snowy-Eucumbene Junction. Traces of the uplifted Tertiary peneplain can be seen on the Kosciusko block and remnants of this same surface will probably be found on the faulted block between the Geehi and the Bongong.

Evidence of smaller step faults can be seen in aerial photographs of the main Kosciusko block and of the country west of the Geehi. Furthermore the zones of major faulting probably contain a number of fault zones along which movement has taken place.

Dr. W.R. Browne has pointed out probable step faults on the eastern side of the block, along the Kosciusko Road above the Thredbo River. These have not been traced north of the Snowy River and it seems likely that the main structure bounding the block to the east is a warp along which irregular step faulting has occurred.

Older structural features will also be found, particularly in the metamorphics, and some of the faults identified on aerial photographs may be older shears and not normal faults. On the Kosciusko block, a north easterly structural control is apparent in the parallel valleys of the Thredbo, the Upper Snowy and in the series of valleys along the Kosciusko road. There is some evidence of block faulting along the Thredbo and a suggestion of the same along the Upper Snowy. This may represent an early trend of Tertiary faulting, on which the later, meridional faulting was superimposed. However, other structural influences may be involved and detailed work is needed along the Upper Snowy to establish whether or not faulting has taken place.

## IV. ENGINEERING GEOLOGY.

### A. MURRAY TUNNEL PROJECT.

(1) General. - The proposed pressure tunnels from the Jindabyne storage west to Swampy Plains Creek will be approximately 29 miles long. Approximately 25 miles will traverse granitic rocks and the remaining 4 miles will lie in metamorphics.

The principal problems in the engineering geology are considered to be -

(a) Driving and maintaining the tunnel in weak or shattered rock.

(b) Controlling the inflow of water during construction.

(c) Preventing leakage of water from certain sections of the tunnel when in operation.

(d) Precautions from damage to works and tunnel by seismic activity.

These problems are to a large extent inter-dependent and will only be encountered over certain sections of the tunnel line, depending on the type of rock, the type and extent of fracturing in the rock, rainfall and the position of the tunnel relative to the surface and to the water table. The first three problems may involve grouting and/or lining in some sections of the tunnel. The fourth problem does not appear important as so far there is no evidence to suggest that significant earthquakes are likely to occur.

Driving and maintaining the tunnel in granitic rocks appears to be a straightforward mining operation and little lining should be required, unless it is needed to reduce friction to a minimum when the tunnel is in operation. Sections of the tunnel in which difficulties may be encountered are -

i. Where the tunnel lies in the zone of surface weathering above the water table where much of the rock is friable and will need support.

ii. In the immediate vicinity of major fault zones where support may be necessary and where inflow of water will increase.

iii. Where the tunnel traverses rock which lies below, but close to the water table where inflow of water from joint and fracture planes is likely to reach a maximum.

iv. Sections which have backs of 2,000 feet or more where the increase in temperature will be considerable and ventilation problems will become greater.

These remarks apply equally to tunnel construction within metamorphics or granite but a higher percentage of lining can be anticipated in the metamorphics since up to 50 per cent of the rocks may consist of relatively incompetent strata and much of this may require permanent support. Pending more detail on the rocks and their structures it is suggested that allowance be made in the preliminary estimates for lining all of the metamorphic rocks traversed by the tunnel.

(2) <u>Geology of the Murray Tunnel.</u>

(a) <u>Snowy River to Geehi River</u> - From the intake at the eastern end the tunnel will lie in granitic rock for about 17 miles to the Geehi Valley. From the intake it will traverse a meridional zone of warping and faulting possibly some miles in length before penetrating the rock underlying the main Kosciusko block. The tunnel may not require support in the warped zone, apart from sections lying in the weathered zone or across major fractures, but inflow of water may be relatively high. The tunnel passes some 900 feet below the Snowy River and should, therefore, receive no water from that source, but the suggested fault along the Snowy Valley needs investigation. West of the Snowy River the tunnel attains backs of up to 3,000 feet and much of this section should prove relatively dry. However, ground temperatures will be high and ventilation may be difficult. The granitic rocks will become more gneissic towards the west and will eventually grade into gneiss with strong foliation and a closer system of jointing. Water may therefore increase noticeably as the Geehi valley is approached. Dykes will be found particularly in the more massive granite towards the east but these are only likely to cause difficulty in or near the zone of weathering.

(b) <u>Geehi River to Bogong Creek</u> - It has not been decided whether the tunnel is to pass under the Geehi River or emerge in the Geehi valley, but in either case this area is a critical one and detailed geological mapping will be necessary before the best position for the tunnel can be decided. Major normal faulting is expected in both the Geehi and Bogong valleys and in both places there will probably be more than one fault zone.

The Geehi River does not appear to occupy a fault zone where the tunnel intersects it, but major faults may lie along the granite contact to the west or in the gneissic granite to the east. West of the Geehi the tunnel will pass from gneissic granite into metamorphic rocks across a faulted contact which will probably yield water and require support. The metamorphic belt is about half a mile in width, but the tunnel has over 5,000 feet of backs in this section and the rocks should stand fairly well. Farther west, the tunnel traverses approximately 1½ miles of granitic rock then returns into metamorphics about 1½ miles from the Bogong surge tank. The granitic rock will probably be similar to that encountered at the Geehi - gneissic and closely jointed - and some sections may require support towards the western margin. The remainder of the tunnel east of the Bongong, including the surge tank, lies in phyllite and quartzite. The geology of the

Bogong valley will need to be mapped in detail before the best position of these works is decided and at this stage it is wide to assume that all will require lining for support and to prevent leakage from the tunnel.

An examination of the quartzites will also be necessary to determine what variations in porosity may be expected in the rock. The degree of silicification is probably high, but if some sandy beds are only partially silicified they may function as acquifers and yield water when exposed in the tunnel.

(c) Bogong Creek to Swampy Plains River. - West of Bogong Creek the tunnel traverses about 1¾ miles of metamorphic rocks and then returns into granite in which the remainder of the works are situated. This section lies west of the major zones of normal faulting and has a lower rainfall than the sections to the east. The metamorphics are likely to contain up to 50 per cent quartzite so that the tunnel will probably not have to be lined throughout. The Khancoban granite is massive and appears similar to the Berridale granite found east of the main divide. No lining should be necessary in this rock, although it would be advisable to allow for lining the surge tank and tunnel to the west of it pending a detailed examination of the area.

(3) SUMMARY OF WATER PROBLEMS.

Evidence provided by the No. 3 Tunnel at Kiewa and by underground workings in granite and metamorphic rocks suggests that with the exception of 3 or 4 short sections, the inflow of water into the Murray Tunnel will not be sufficient to hamper construction. The Kiewa tunnel is about 1 miles in length and is constructed in granodirite lying within a high rainfall belt. Water seepage during construction was adequately handled by 2 small Worthington Pumps with a three inch delivery. Furthermore, the greater part of the tunnel is unlined and has stood satisfactorily for 2 years.

On the other hand where many miles of tunnel are to be constructed without an outlet, small seepages from rock fractures will aggregate into a ~~flow~~. considerable flow

It is not possible to estimate the quantity of water likely to be involved, but it is suggested that useful data may be found in technical literature and an examination of any existing underground workings in the Kosciusko or adjourning ~~works~~ areas might be of value.

The critical sections along the proposed Murray tunnel are believed to be

(1) Under the Geehi Valley.

(2) Through the warped zone west of the intake.

Relatively high water flow may also be expected in the metamorphics immediately east of the Bogong.

It is not possible to estimate the rate at which water may enter the tunnel in any of these sections, but none of them is far from the surface and it is very difficult to envisage an inflow (~~of water~~) which could not be handled by pumps.

Significant loss of water from the tunnel during operation could only take place in shattered or weathered zones comparatively close to the surface, where the hydrostatic head of the meteoric water would be less than that of the water in the pressure tunnel itself. Such zones must obviously be lined to support the rock as well as to conserve the water, but they should constitute a very small proportion of the total work.

B. SNOWY RIVER AUXILIARY POWER SCHEME.

This scheme involves three dams, approximately 9 miles of tunnel, and between 50 and 60 miles of water race to be constructed mainly within the water shed of the Snowy River above its confluence with the Eucumbene. With the exception of some miles of water race, all of these works will lie in granite within the Kosciusko fault block. The proposed location of dams and tunnel lines is shown on Plate 1.

WATER RACES -

Four water races have been proposed to deliver additional water to storage areas. Three races discharge into the Spencer's Creek storage and one race delivers water from the Gungahlin River into the Diggers Creek storage. All of these races will lie in granite or gneissic granite with the exception of short sections of the Kosciusko race, which may traverse metamorphics near Mount Kosciusko itself.

With the exception of the Gungahlin race, all will lie entirely above the lower limit of Pleistocene glaciation and only portions of the race lines will traverse massive outcrops in which an unlined race could be maintained. Considerable sections of each race will have to be constructed in the deep mantle of surface weathering, which occurs on most of the slopes in this region. This surface mantle consists of soil, boulders and deeply weathered rock material and is likely to be over 20 feet in thickness, particularly on the lower slopes of glaciated valleys. The depth of the zone is dependent on terrain and conditions of weathering rather than on rock type, but it is likely to be less over metamorphics than over granite.

Fluming would be necessary in these areas to avoid loss of water into the surface material and loss of the race by ground slips. Furthermore the overflow from flumes during flood periods may have to be controlled to prevent scouring of the unconsolidated material supporting the flume.

A field investigation of the race lines has not been made but a study of the air photographs suggests that between half and three-quarters of each race may need to be flumed.

The Gungahlin race will lie entirely in granite and, although the depth of surface weathering should be less than that encountered along the other races, some sections, particularly toward the intake end, will probably have to be flumed.

DAM SITES.

(a) SPENCER'S CREEK DAM SITE.

A retaining wall of 150 to 200 feet in height is required in Spencer's Creek to provide storage in the mature valleys at the head of the Creek. The only suitable sites for this dam lie half to one mile downstream from Spencer's Creek bridge, toward the lower end of the glaciated valley before the creek falls away into a gorge tract leading to the Snowy River. The basement rock at the site consists entirely of granite, with a varying degree of gneissic foliation, and this will provide suitable foundations when the fresh rock is reached. The system of joints in the granite should present no unusual problems and includes two major steeply inclined planes, one approximately normal to and the other parallel with the retaining wall, and a less pronounced plane dipping flatly at about 10$^{o}$ to the horizontal.

However, the broad cross section of the valley and the considerable depth of scree and weathered material are costly disadvantages but these conditions pertain over the whole of the broad glaciated valley betweenthe road and the upper end of the gorge and cannot, therefore, be avoided if storage over the upper portion of the valley is required.

A more precise location for the retaining wall can be decided when the topographical survey is complete and the required height of the wall established. A programme of drilling can then be planned at one or more sites to establish the thickness of fluvoglacial material and weathered rock on the slopes and across the broad valley floor.

Supplies of sand and aggregate for a concrete construction could best be obtained by crushing and sizing selected fresh granite. Supplies of material for the construction of an earth dam would prove more difficult and would require special investigation.

Access to the Spencer's Creek site is provided by the present Kosciusko Road.

(b) PIPER'S CREEK DAM SITE.

A retaining wall approximately 60 feet in height is required across the Snowy River in the vicinity of Piper's Creek. A suitable site was found on the Snowy about ¼ mile downstream from the mouth of Piper's Creek. Alternative sites could be found in the gorge about 1 mile further downstream, but these would provide smaller storage for the same height of wall.

The site lies entirely in granite, some of which shows incipient gneissic foliation. The joint system is comparable with that noted at Spencer's Creek and should not give rise to unusual problems in leakage. The depth of weathering could not be obtained but it is estimated at less than 20 feet on the lower slopes on either side of the river, but weathering may be deeper upward of 40 feet above river level. The distance between the 60 ft. contours on either side of the river is estimated to be approximately 500 feet.

However, there is some regional evidence to suggest faulting along the Snowy Valley and a detailed investigation will be necessary to decide whether there are faults at the dam site and if so their effect on the construction.

Limited supplies of sand and aggregate could be obtained from flats and terraces upstream from the site and aggregate from this source could be augmented by crushing fresh, massive granite. Supplies of river sand would be inadequate and of doubtful quality since it is almost entirely derived from granite and crushed granite would probably provide a more reliable and less weathered product. Access to the dam site would involve construction of 4 to 5 miles of road, of which about one mile would lie in rugged country adjoining the Snowy River.

(c) DIGGER'S CREEK SITE.

A third dam, approximately 60 feet high, is required across the Snowy near the mouth of Digger's Creek. A suitable site was examined approximately 1 mile below the mouth of Digger's Creek. This lies at the head of a gorge tract and would provide maximum storage over the flats lying immediately upstream. Alternative, and possibly better engineering sites lie further downstream but storage would be lost unless the height of wall were increased.

The site and storage area lie in medium grained granite which bears only traces of gneissic foliation. Drilling will be required to establish the depth of weathering. This should be about 10 feet for the lower 20 to 30 feet on both north and south banks but the zone of weathering will probably be much deeper above this level, particularly on the southern bank. A retaining wall 60 feet high constructed on this site would be approximately 500 feet in length and would impound water for approximately $\frac{3}{4}$ mile upstream, to within $\frac{1}{4}$ mile of the mouth of Digger's Creek. Faulting may have taken place along the Snowy Valley but the possible fault zone lies north of the river, against the northern escarpment of the valley, and should therefore have little or no effect upon the stability of the site.

The position regarding supplies of aggregate and sand is approximately the same as that at the Piper's Creek site described above. Access to the Digger's Creek site would entail a road from the Hotel Kosciusko to the dam site - a distance of approximately 6 miles with a fall of approximately 1,200 feet.

3. TUNNELS.

(a) SPENCER'S CREEK TUNNEL.

A tunnel is to be constructed from the main storage at Spencer's Creek for approximately 5 miles to the valley of Piper's Creek where a power station will be installed. The tunnel will lie in jointed granite in which dykes of diorite and aplite and inclusions of metamorphic rocks will probably be encountered. A study of the aerial photographs suggests that at least one minor fault crosses the line of the tunnel, but there is no evidence to suggest that major faults will be encountered.

Topographical plans and sections of the proposed tunnel line are not yet available but the tunnel will have backs ranging from about 200 to 800 feet. Lining will be necessary at the intake and outlet ends of the tunnel and short sections of lining may be required for support through fault zones but in general the rock should drive and stand very satisfactorily. Water will be encountered in driving the tunnel but the quantity should be small and comparable with that encountered in driving the No. 3 tunnel at the Kiewa project in Victoria.

(b) PIPER'S CREEK TUNNEL.

A second tunnel about $3\frac{1}{2}$ miles long is proposed from Piper's to Digger's Creek to deliver water to a second power station near the mouth of Digger's Creek. The tunnel will lie entirely in granite and, from an engineering point of view, should be very similar to the Spencer's Creek tunnel. No faults have so far been located along the line of tunnel but some minor fractures are to be expected. In general, the tunnel will have less backs than the Spencer's Creek one and may therefore make more water during construction. Lining should be required only at intake and outlet and where the tunnel line lies close to the surface.

## V. FUTURE GEOLOGICAL INVESTIGATIONS.

If a detailed investigation of the combined projects is required, a geological survey of the country between the Snowy and Murray Rivers will be essential. This could be carried out in conjunction with a detailed topographical survey of the area. A geological plan of the whole area should be compiled on a scale of $\frac{1}{2}$ inch = 1 mile, to provide a regional picture, and more detailed plans on perhaps 500' = 1" will be required along the lines of the various tunnels and water races. Sites for dams or other surface works, selected with reference to the regional and detailed geological plans, should be mapped in greater detail on a scale of 50' = 1".

The projection of geological contacts, dykes and structural features from the surface to the tunnel lines below will be very difficult where the backs are high, and exploratory drill holes may be required ahead of tunnel construction where the features involved are of sufficient importance. Exploratory shafts and adits may also be advisable in critical sections, particularly in the gneiss at the Geehi and in the metamorphics at the Bogong. These could provide definite evidence on the flow of ground water and on the need for support in the final tunnel.

(L.C. NOAKES)
Geologist.

Canberra.
23.12.46.

## VI. REFERENCES.

The following is a list of publications in which reference to the geology of the Kosciusko area has been found. Some of this information has been of assistance, although no specific references have been made in the text.


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Plate I.
PRELIMINARY GEOLOGICAL PLAN
- OF -
THE KOSCIUSKO AREA
WITH REFERENCE TO THE PROPOSED MURRAY TUNNEL, N.S.W.
0 1 2 3 MILES
Reference
Granite & granitic rocks
Metamorphic rocks
Tentative geological boundaries
Probable faults
Possible faults
83° Dip of metamorphics
Proposed dam sites
Proposed Tunnel line 15/12/46
" " " 20/12/46
Roads
T.N.
M.N.
9°75'E
Geology by:-
L.C. Noakes, T.D. Dimmick, W.C. Smith & D.E. Gardner
Murray
River
Swampy
Plains
River
Geehi
River
Section A
Section B
MAIN
Divide
Snowy
River
Hotel Kosciusko
JINDABYNE
Thredbo
River
Mt. Townsend
Mt. Kosciusko
1453

# GEOLOGICAL SECTION ALONG PROPOSED MURRAY TUNNEL

Scale. { Hor. 1 Inch = 1 Mile
Vert. 1 Inch = 1000 Ft.

SECTION A.


Geology by:-

L. C. Noakes, T. D. Dimmick, W. C. Smith & D. E. Gardner

# GEOLOGICAL SECTION ALONG PROPOSED MURRAY TUNNEL.

## SECTION B

SCALE. HORIZ. 1 INCH = 1 MILE
VERT. 1 INCH = 1000 FT.


## REFERENCE

- GRANITE AND GRANITIC ROCKS
- METAMORPHIC ROCKS
- PROBABLE FAULTING
- APPROXIMATE POSITION OF GEOLOGICAL BOUNDARIES

GEOLOGY BY:-

L. C. NOAKES, T. D. DIMMICK,
W. C. SMITH & D. E. GARDNER.