DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1974/95

MEASUREMENT OF EARTH MOVEMENTS IN THE GUNNING/DALTON AREA, NSW. - REPORT OF FEASIBILITY INVESTIGATION, 1971.

by

G.B. Simpson

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SUMMARY

The Gunning/Dalton area in south-eastern NSW, which has a history of minor earthquake activity, was examined to determine the suitability of the area for a laser-beam geodimeter survey, to measure earthquake-produced earth movements and to locate sites for about eight geodimeter stations.

The geology of the area consists of sediments of Upper Ordovician age, intruded by granite and acid porphyry dykes of Siluro-Devonian age. The rocks have been faulted, and the major faults show three dominant trends: 360°, 320°, and 270°. Many of the granite/sediment boundaries in the area are faulted.

The Gunning/Dalton area is considered unsuitable for a geodimeter survey because of:

(i) the absence of a well-defined plane of movement,

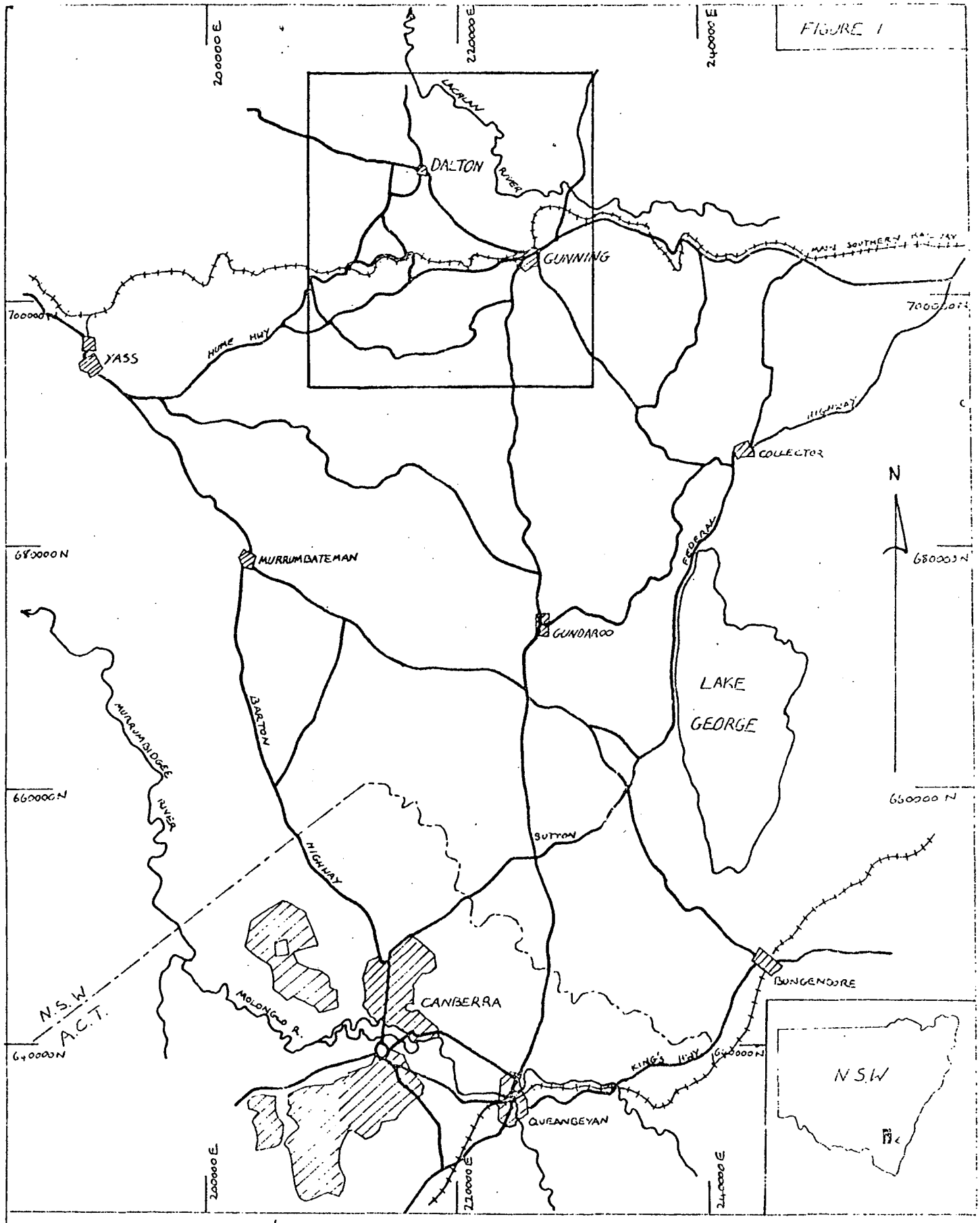
(ii) the difficulty in measuring the small expected movements,

(iii) the problems of building station foundations on fresh rock in a deeply weathered zone, and

(iv) the possibility that movements on the faults may be vertical, and more easily measured using levelling techniques.

If it is decided to establish a geodimeter survey in the Gunning/Dalton area, it is recommended that further geological mapping be done prior to the construction of the stations, and that the stations should be founded on fresh rock.

The possibility of measuring earth movements using permanent survey markers, and of monitoring water-table fluctuations caused by earth tremors, should be considered.



LOCALITY MAP– Gunning/Dalton area NSW

Scale 1 : 375000

0 5 10 15 miles

0 5 10 15 20 km

Road
Railway
River
State boundary
Built-up area

I55/A16/915

As accompanying [illegible] 4/95

INTRODUCTION

In 1971 the Division of National Mapping, Department of National Development, was evaluating the proposal that is should measure earth movements in the Gunning seismic zone, using a laser-beam geodimeter technique. The Division of National Mapping requested that the Bureau of Mineral Resources (BMR) determine the suitability of the area for such a survey, and that they select possible sites for the geodimeter stations. Eight stations would be required; the maximum distance between any two stations must be less than 10 kilometres, line-of-sight visibility is required between stations, and good foundation material is required at each station.

The Gunning/Dalton area is located approximately 60 km due north of Canberra City (Fig. 1).

Previous Work

Reconnaissance mapping was carried out in the Gunning area for the Goulburn 1:250 000 Geological sheet (NSWDM, 1968). The only detailed mapping consists of three Australian National University (ANU) B.Sc. theses in the area to the south of Gunning. Officers of the BMR have made two surveys in the area: the first, by G.F. Joklik and G.M. Burton (Joklik, 1950), followed earth tremors in March 1949 and the second, by Joklik & Casey (1952) followed tremors in November 1952. Dr J.R. Cleary of the ANU Geophysics Department has been monitoring seismic activity in southeast Australia since 1958; he has paid particular attention to the Gunning area, which is the most active zone in terms of the frequency of shocks (Cleary, 1967).

Present investigation

Airphoto interpretation of the area was carried out by C.J. Simpson from RC9 (1:80 000) black and whie aerial photographs. The area examined extends from Lake George, to the southeast of Gunning, to Blakney Creek, northwest of Gunning.

The seismicity of the Gunning area was discussed with Dr Cleary, who provided a plot of the epicentres located in this area during the period 1958 to 1970 (Fig. 3).

A more detailed airphoto interpretation of the Gunning/Dalton area was then made by C.J. Simpson and G.B. Simpson.

Geological mapping of the Gunning/Dalton area was carried out by G.B. Simpson; the main tasks were to check the airphoto interpretation, to locate structural features along which movements might be expected to occur, and to determine foundation conditions at possible geodimeter station sites.

GEOLOGY OF THE GUNNING/DALTON AREA

Regional geology

The Gunning seismic zone is underlain by metasediments of Upper Ordovician age, and occupies part of the Cullarin Horst to the west of the Lake George Fault. The metasediments are intruded by granites of Siluro-Devonian age, the Wyangala and Gunning Batholiths. To the north and north-east of Gunning the remnants of a Tertiary basalt lava sheet cap the hills.

Gunning/Dalton area

The geology of the Gunning/Dalton area is presented in Plate 1. The metasediments comprise slate, shale, and sandstone of Upper Ordovician age, that have been intruded by gneissic and massive biotite granite of Siluro-Devonian age.

The metasediments are strongly cleaved in a general north-south direction, which is dominant; however, near the granite margins, the cleavage tends to be parallel to the contact.

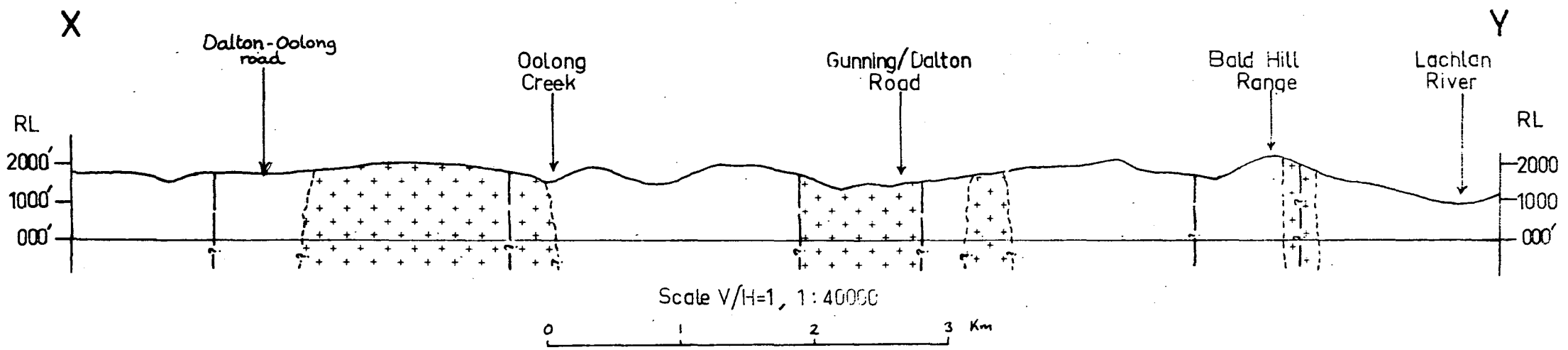
Intrusive acid prophyry and aplite dykes crop out 2 km west of Dalton. As these parallel the northwest trend of the sediment cleavage and general bedding strike in this area, the intrusion of the granite, and formation of the cleavage may have taken place at the same time.

A series of 'granitized' beds trending north-south crop out on the eastern slopes of the Bald Hill Range (Plate 1). The 'granitized' beds were first described by Joklik (1950), and consist of a thin band of massive granite grading eastwards and westwards into banded gneiss, then into mica schist, and finally into slate. The 'granitized' beds are either faulted out to the north by an east-trending fault near Bald Hill or lens out to the north, as indicated by the narrowing of the surface outcrop.

Structural geology

Airphoto examination of the Gunning seismic zone revealed a number of major continuous northwest-trending lineaments.

Geological mapping in the Gunning/Dalton area identifies the lineaments as the surface traces of faults. The faults show three dominant trends which are approximately 320°, 360°, and 270°, and these define the northern margin of the Gunning Batholith. The direction of movement at these faults has not been determined.



Geological Cross-section of the Gunning/ Dalton Area, NSW (as indicated on Plate 1)

Granite —Siluro-Devonian

Shale, slate and sandstone — Ordovician

Geological boundary

---------- position approximate

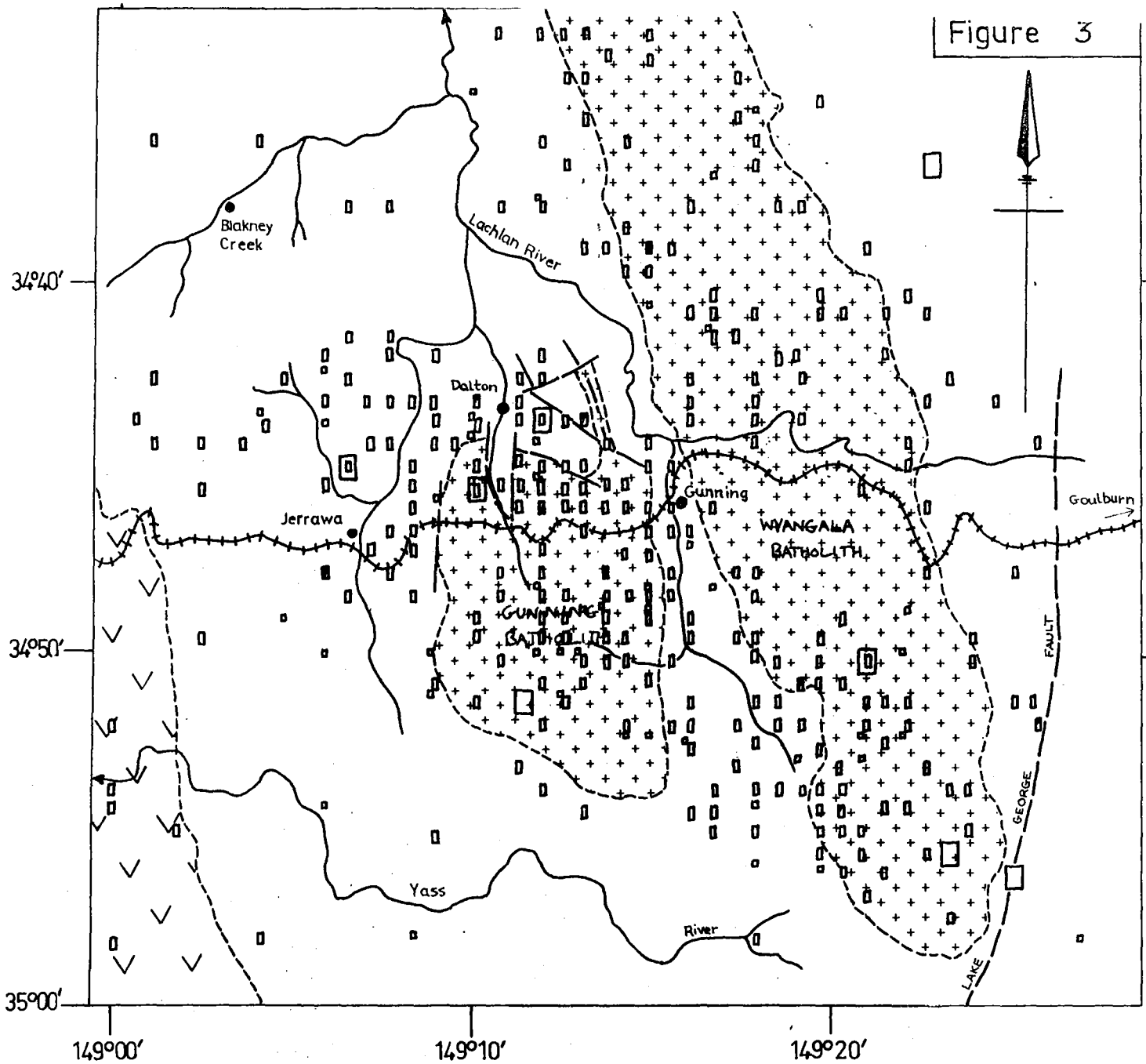
-----?----- inferred and concealed

—— —— Fault, position approximate

——?—— Fault, inferred and concealed

Figure 2

Figure 3



Regional Geology of the Gunning Area, NSW

with locations and magnitudes of earth tremors occurring between 1958 and 1970

(after Cleary 1967)

Scale 1 : 250000

0 5 10 15 20 Kilometres

- Granite — Siluro-Devonian
- Volcanics — Middle Silurian
- Metasediments — Upper Ordovician
- Geological boundary, position approximate
- Fault, position approximate

Earth tremor epicentre magnitudes

- <1.5
- 1.5 — 3.0
- 3.0 — 4.5
- No magnitude given
- Town
- Railway
- River

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Where the fault zones crop out, they consist of a number of parallel shear zones separating wedges of sediments and granite. Wedges of sediments are also present in fault zones in the granite; they are exposed in a railway cutting 7 km due west of Gunning, at a point 0.5 km north of the Gunning/Dalton road 5 km from Gunning, and in a road cut on the Hume Highway on the western margin of the Gunning Batholith.

The strong cleavage in the sediments largely obliterates any trace of he bedding except on the western margin of the intrusion, where shale and sandstone are seen dipping at 40° to 70° to the north. Near the granite contact the sediment cleavage is usually parallel to the contact.

During the investigation, no conclusive evidence was seen of earth displacements attributable to the recent seismic activity monitored by Cleary (1967). In view of the small displacements recorded in the area, a study of drainage patterns and physiography may identify features attributable to displacement. Some shattered outcrops of shale were observed near a faulted north-trending granite contact, 2 km east-northeast of Oolong. (see Plate 1).

The New South Wales Department of Railways has reported that an embankment 1 km west of Gunning (mileage 173 m 61 c to 173 m 64c) showed evidence of subsidence in October 1952. Remedial measures were taken and proved effective until 1957, when a high water content was again evident in the embankment. The situation was observed until 1963 and it was then considered that the embankment was stable. It was noticed during these observations that the water content of the embankment material appeared to be greater for four weeks after earth tremors in the area.

The embankment is situated near the eastern margin of the Gunning Batholith. At the time of the embankment subsidence, the shocks in the area were not being monitored by Cleary and an accurate plot of earthquake epicentres is not available.

Fault movements

Joklik cited the absence of a Tertiary basalt capping on Bald Hill as evidence of uplift of the Bald Hill Range and subsequent erosion of a lava sheet, the remnants of which are seen capping the hills to the north and northeast of Dalton. This theory, however, assumes the extrusion of lava over a peneplain and not as valley-confined flows.

Cleary (1967) proposed a tentative model for the Gunning/Lake George area, based on the interpretation of seismic data monitored between

1958 and 1961, and on the fault-plane solution of a tremor that occurred to the west of Lake George in February 1961 (Fig. 3). He suggested that the Lake George Fault was an old fault that became resurgent in modern times under the influence of northwest-southeast compressive stress to form the Lake George Scarp. More recently, this fault was intersected by another fault trending northwest, forming a wedge and causing diminution of activity to the south.

The presence of northwest-trending faults in the Gunning seismic zone is indicated by airphoto interpretation and geological mapping. If the recent seismicity is a result of movements in a structural system, as suggested by Cleary, the displacements across the northwest-trending faults in the Gunning area would have a dominant strike-slip component. The presence of sedimentary wedges caught up in the fault zones within the main body of the granite may also indicate strike-slip faulting.

SUITABILITY OF THE GUNNING/DALTON AREA FOR SURVEY TO MEASURE EARTH MOVEMENT

Ideal array of geodimeter stations

The ideal array of stations for a laser-beam geodimeter survey consists of eight stations arranged at the corners of two concentric squares, positioned symmetrically across a well-defined plane of movement (Fig. 4). The stations should be visible from one to another, and with no two stations more than 10 km apart. In such an array the four outside stations should be situated outside the zone of expected seismicity, thus allowing the measurement of absolute displacements of the four inner stations.

Seismicity of the Gunning/Dalton area

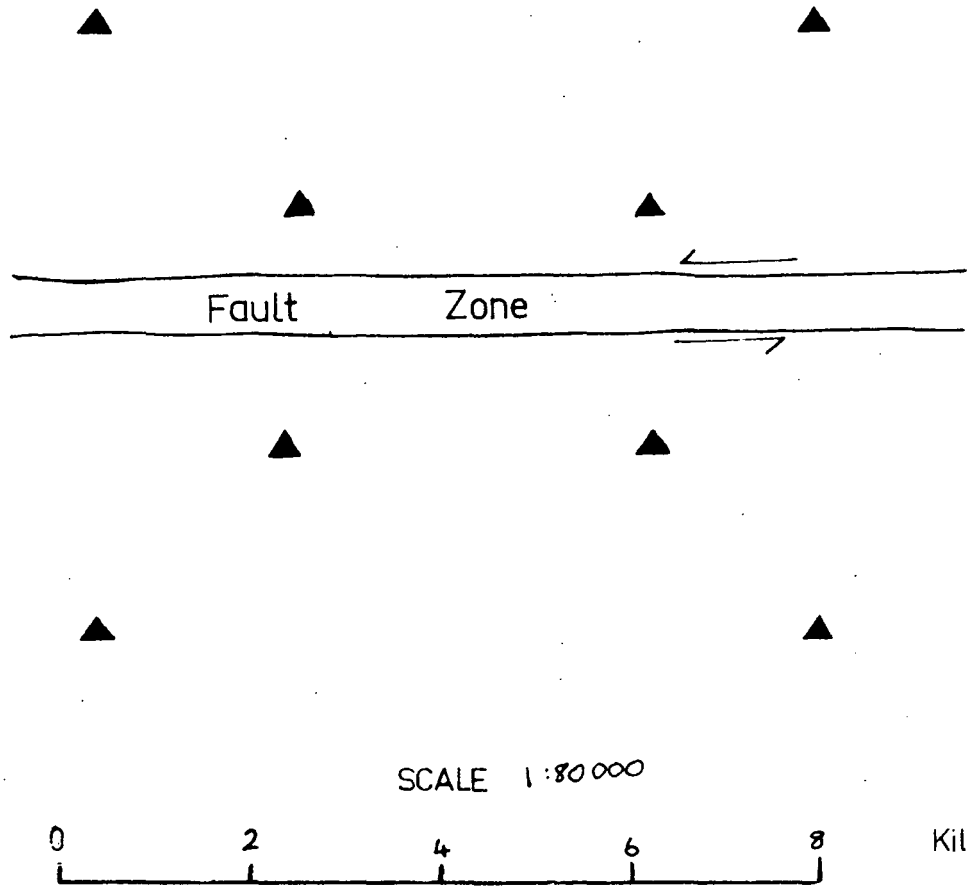
The Gunning/Dalton area had the highest concentrations of shocks within the Gunning seismic zone in the period from 1958 to 1970 (Fig. 3). The area is located across the northern part of the Gunning Batholith and the concentration of shocks may result from movements in the fault system that controls the northern contact of the Batholith.

Application of the ideal array to the Gunning/Dalton area

An ideal array of stations could not be achieved in the Gunning seismic zone owing to the absence of a single well-defined plane of movement.

Figure 4

Ideal array of geodimeter stations



▲ Geodimeter stations

NB. The four outer stations are sited in stable areas to allow the measurement of absolute displacements of the inner four stations

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Because the seismic zone is broad, the four stable stations would be too far apart for accurate measurements. If the distances were reduced to those of the array shown in Figure 4, the outer stations could not be regarded as stable, and the measurements would probably indicate only relative displacements.

Direction of fault movements in the Gunning/Dalton area

Geological and geophysical studies to determine the direction of recent movements across faults in the Gunning/Dalton area have been inconclusive. In general, horizontal movements would be more accurately measured using the geodimeter whereas vertical movements would be more accurately measured by levelling.

Accuracy of measurements in the Gunning/Dalton area

The measurements made by Division of National Mapping would be to an accuracy of $\pm$ 1 centimetre over 10 kilometres using the geodimeter, and $\pm$ 4 millimetres using levelling techniques. It would therefore be difficult to measure small displacements in the order of 1 to 2 millimetres per year.

Station foundation requirements for accurate measurements

Over a long period, movements of such a small order could only be measured if the best possible foundations were provided for the stations. The Gunning seismic zone is situated in an area of deep weathering, in which weathered rock may extend down to 30 metres or more below ground surface; seasonal fluctuations of groundwater in this weathered zone would probably induce foundation movements. To eliminate these the stations would have to be founded on fresh rock.

Selection of possible geodimeter stations

Although the Gunning/Dalton area is not ideal for a geodimeter survey, an array of nine station sites was selected for possible future reference, and they could be useful for measuring relative displacements.

The stations were selected by defining the fault-blocks in the area, and selecting the most suitable hill on each block, taking into consideration the visibility between sites (Plate 1).

Stations A, B, C, D, E, and F were selected to cover movements across the faults that define the northern contact of the Gunning Batholith. Station G

was selected to cover movements in the Bald Hill Range fault system. Station H was selected to cover movements between the Wyangala and Gunning Batholiths, and station J to give one station outside the immediate Gunning/Dalton area. This selection gives a fairly symmetrical array of stations, with four closely spaced stations surrounded by five outer stations. The maximum separation of stations is approximately 10 kilometres, and any reasonably large movement should be measureable across this array.

Inaccuracies in measurement between stations introduced by variations in topography, vegetation, air temperature, and humidity were not considered in the selection of this array of stations.

Application of levelling techniques

An array of permanent survey markers could be of use in detecting vertical displacements over an extended period of time. Such a survey would require foundations of a high standard. The most suitable area for such a survey would be in the area 1 to 2 kilometres east of Oolong to the north of the Hume Highway.

The use of either geodimeter or levelling techniques for the measurement of absolute displacement along the faults in the Gunning/Dalton area is not expected to provide the accuracy required for reliable results. While a modified array of geodimeter stations may provide relative displacements, and levelling techniques may provide useful data, the installation of stations for the geodimeter or for levelling could only be recommended for the testing and assessment of the technique, and not as a positive move towards measurement of present-day displacement across fault lines.

CONCLUSIONS

1. Geological mapping indicates that a complex system of faults is present in the Gunning/Dalton area, rather than a single well-defined fault.

2. The ideal geodimeter array is not suited to absolute measurement of displacement within a complex system of faults; however, a modified array could be used for the measurement of relative displacement.

3. Horizontal displacement along faults is expected to be too small for accurate measurement by geodimeter.

4. Vertical displacement measurement by levelling techniques would be more accurate than with the geodimeter; however, the vertical displacements are expected to be too small for accurate measurement by levelling.

5. The provision of adequate station foundations on weathered rock would be difficult, but would be necessary for both geodimeter and levelling stations.

6. Groundwater fluctuations due to earth tremors are considered likely in the area, and the monitoring of groundwater levels in observation bores or in existing farm bores or wells could provide a record of seismic activity.

RECOMMENDATIONS

1. The Gunning/Dalton area should not be considered for a geodimeter survey with the ideal array of stations.

2. The installation of either geodimeter or levelling stations should not be regarded as a reliable means of measuring the contemporary displacement across faults in the Gunning/Dalton area.

3. Should the installation of such equipment be required for other purposes, such as training, the opportunity should be taken to test the accuracy of displacement measurements with a modified array of stations.

4. Further geological mapping is recommended before any measurement survey is undertaken in the area.

5. The monitoring of groundwater levels near faults in the Gunning/Dalton area should be considered as a means of investigating the effect of earth tremors on groundwater movement.

REFERENCES

CLEARY, J.R., 1967 - The seismicity of the Gunning and surrounding areas, 1958-1961. J. Geol. Soc. Aust., 14, 22-30.

JOKLIK, G.F., 1950 - Dalton-Gunning area, NSW, earth tremors of March 1949. J. Proc. R. Soc. NSW, 84, 17-27.

JOKLIK, G.F., & CASEY, J.N., 1952 - Gunning district, NSW, earth tremors, November 1952. Bur. Miner. Resour. Aust. Rec. 1952/91 (unpubl.).

NSWDM, 1970 - Goulburn 1:125 000 Geological Series Sheet, SI 55 - 12.

GEOLOGY OF THE GUNNING — DALTON AREA, NSW

Scale (approximate)

1 : 40000

0 1 2 3 4 5 6 Kilometres

- Granite — Siluro-Devonian
- Shale, slate, and sandstone — Ordovician
- 70 — Strike of bedding, dip indicated
- Strike of vertical bedding
- Strike of vertical cleavage
- Strike of vertical foliation
- Shear zone
- Acid dyke
- Geological boundary, position approximate
- Fault, position approximate
- Fault, inferred and concealed
- Air photo lineament,
- Stream
- Road
- Railway
- A — Proposed site for geodimeter station
- X Y — Geological section (see figure 1)
- Sh — Shattered outcrops of shale

Base map prepared and enlarged from an overlay of photograph 1664 of Run 1 (1 : 80000, RC 9, NSW 1918) of the Gunning fault zone. No correction has been made for radial distortion.

DALTON
JERRAWA
OOLONG
GUNNING
GOULBURN
YASS
COLLECTOR
GUNDAROO
GUNNING BATHOLITH
WYANGALA BATHOLITH
Bald Hill
Range
Lachlan River
Jerrawa Creek
Oolong Creek
Gunning Creek
Hume Highway
Railway Embankment

PLATE 1

AMENDMENTS					
No.	DESCRIPTION	AUTHOR	DATE	CHECKED	DATE
A1					
A2					
A3					
A4					
A5					
A6					

SCALE: 1 : 40000

BASE MAP/SURVEY: Prepared from RC9 air photo (Run1, N°1664 NSW 1918)

GEOLOGY BY: G.B. Simpson

COMPILED AND CHECKED: PROJECT GEOLOGIST 20/5/74 — CHECKED AND APPROVED: SENIOR GEOLOGIST

SUPERVISING GEOLOGIST

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BUREAU OF MINERAL RESOURCES
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