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Gosses Bluff Seismic Survey, Northern Territory, 1969

by

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SUMMARY

Two radial traverses each about 16 miles long were surveyed through Gosses Bluff using variously single coverage and 3-, 6- and 12- fold multiple coverage.

No reflections are recorded in the immediate vicinity of the Bluff shallower than about 18,000 feet, although good continuous reflections occur deeper than this. The shape of the zone of disruption is deduced to be a shallow saucer of diameter about 14 miles super-imposed on a roughly hemispherical bowl of diameter 8 miles and depth 3½ miles.

This report presents provisional conclusions only, dependent upon further processing for confirmation. The work is part of the USGS/BMR joint project on Gosses Bluff.

1. INTRODUCTION

A programme of seismic work was carried out by the Bureau of Mineral Resources (BMR) Seismic Party No. 1 in the Gosses Bluff area of the Amadeus Basin, N.T., during the period April to August 1969.

Gosses Bluff, which lies in the Amadeus Basin about 110 miles west of Alice Springs, is a circular feature about 2 miles in diameter and rising about 800 feet above the Missionary Plain. The Bluff, originally thought to be a diapiric structure, is currently considered to have been formed by the impact of an extra-terrestial body.

Gosses Bluff seismic survey was part of a combined geological and geophysical investigation of the feature being undertaken jointly by the United States Geological Survey (USGS) and BMR. The USGS, which undertakes astrogeological studies for the National Aeronautics and Space Administration, is studying the Gosses Bluff structure, and other similar structures throughout the world, mainly in order to contribute to a greater understanding of similar features on the surface of the Moon.

The joint project commenced with geological mapping of the structure in 1967, followed by further mapping and detailed aeromagnetic and gravity coverage in 1968. Concurrent with the seismic survey in 1969, the gravity work was completed and a brief follow-up ground magnetic survey was conducted.

The seismic survey was intended to define the various structural features of the Bluff more precisely than had been possible from previous investigations.

Preliminary results and conclusions, immediately at the end of the field survey, are presented in this report. Further processing and detailed analysis of the seismic data will be required before a final interpretative report is completed.

2. GEOLOGY AND PREVIOUS GEOPHYSICS

Geology

The geology of the Amadeus Basin has been described in detail by Wells, Ranford, Cook, & Forman (1967).* The Amadeus Basin is an east-west-trending structural depression covering about 80,000 square miles of the southern

* Now in press as Bur. Miner. Resour. Aust. Bull. 100.

part of the Northern Territory. An unmetamorphosed sedimentary section more than 30,000 feet thick is preserved above the Precambrian basement. The basin is bounded by the basement rocks of the Arunta Complex on the north and the crystalline rocks of the Musgrave-Mann Complex on the south. The east and west margins are not well defined, being obscured by younger sediments of the Great Artesian and Canning Basins respectively. A generalized stratigraphic column of the northern Amadeus Basin is shown in Table 1.

The structural pattern is mainly broad, flat-bottomed, assymetric synclines with narrow anticlines and uplifts complicated by thrust faults and diapirism. The most striking structural features of the area are reflected in the MacDonnell Ranges and the system of folds. Two major orogenic events deformed the sedimentary section, the Petermann Ranges Orogeny and the Alice Springs Orogeny, discussed by Forman (1966) and Forman & Milligan (1967).

Two formations in the Amadeus Basin have been found (Wells et al., 1967) to contain salt, namely the Proterozoic Bitter Springs Formation and the Cambrian Chandler Limestone. The Bitter Springs Formation has been shown to contribute towards diapirism.

Gosses Bluff, which was discovered by Edmund Gosse in 1873, is located near the northern margin of the Amadeus Basin about 110 miles west of Alice Springs. It is a prominent circular range about 2 miles in diameter rising about 800 feet above the general level of the Missionary Plain. The range encircles a pound about 1 1/4 miles in diameter that is only slightly elevated above the level of the plain.

The first geological investigation of Gosses Bluff was carried out in 1956 by Prichard & Quinlan (1962). Their opinion that the structure was of diapiric origin, with the Bitter Springs Formation the mobile unit, was supported by McNaughton, Quinlan, Hopkins, & Wells (1968) and gained widespread acceptance. Brunnschweiler (1957) suggested that the Bluff was formed by the injection of an acid igneous plug which subsequently resisted orogenic movements; however, this postulate was not generally accepted. In 1964 K.A.W. Crook, of the Australian National University, recognized a shatter cone in Gosses Bluff. This threw serious doubt on the diapiric hypothesis. Crook & Cook (1966) subsequently showed that Gosses Bluff had many of the features of a crypto-explosive structure. They were unable to agree on whether the explosive force was of intra-terrestial (crypto-volcanic) or extra-terrestial (astrobleme) origin. Later, however, they agreed on the astrobleme origin (Cook, 1966) and estimated the minimum diameter of the structure to be 10 miles.

The United States Geological Survey (USGS), which makes astrogeological studies for the National Aeronautics and Space Administration, is interested in geological features which may have been caused by impact of extra-terrestial bodies on the Earth's surface. Probable impact structures, throughout the world, have been investigated by Dietz (1961, 1967, 1968) and other researchers in order to obtain a better understanding of the formation of such structures. Features such as the Sudbury structure in Canada, the Vredefort Ring of South Africa, and the Ries Crater in Germany have now been recognized as astroblemes. The USGS is particularly interested in the distinct similarity between such structures and the circular structures on the Moon which have undoubtedly been caused by the impact of meteorites or comets.

Gosses Bluff is composed of beds of Mereenie Sandstone and the basal sandstone of the Pertnjara group in a vertical or steeply dipping attitude. The beds of the Larapinta group inside the Bluff also are generally almost vertical and at the centre are folded into a tight anticline. An exploratory well, Gosses Bluff No. 1 (Pemberton & Planalp, 1965), sited in the centre of the structure, was drilled to a total depth of 4535 ft. The well site was chosen on the assumption that Gosses Bluff was a salt dome. The well was in very steeply dipping Larapinta Group sediments throughout and did not encounter salt before its abandonment. Outside the Bluff, highly disturbed strata have been mapped out as far as 7 miles from the Bluff centre.

Milton (1968) deduces from this and other evidence that the Gosses Bluff structure is between 8 and 14 miles in diameter. Glikson (1969) concludes it is between 12 and 14 miles in diameter. Previous seismic investigations indicate a depth of disruption of about 4 miles. The zone of disruption was thus, prior to this survey, assumed to be a bowl up to 14 miles in diameter and 4 miles deep.

The present topographic feature is the result of erosion, the area surrounding the Bluff itself having been reduced to a peneplain.

The currently most favoured theory of origin is that Gosses Bluff is an astrobleme, formed by the impact of a low-density object such as a comet. Glikson (1969) puts forward the arguments in favour of Gosses Bluff being an astrobleme and also presents a schematic drawing of the formation of the structure.

As a result of the joint USGS/BMR project, a new geological map of Gosses Bluff has been produced (Glikson, 1969). The formations exposed at the surface have been faulted into blocks several hundreds of feet long and several tens of feet thick. Some of these blocks (plates) have been displaced out of position and even overturned. It is likely that this small-scale block-faulting has occurred throughout the disrupted zone. Much of the area inside and around the Bluff is covered by breccia which has been formed from the original debris strewn over the crater floor. This breccia has been found to be up to 500 ft thick, overlying various dipping blocks of the Pertnjara Formation or Mereenie Sandstone. It may even lie underneath these blocks in places.

Previous Geophysics

Magnetic. A regional airborne magnetic and radiometric survey of the Amadeus Basin was carried out by the BMR in 1965 (Young & Shelley, 1966). They found the depth to magnetic basement in the north-central region to be approximately 35,000 feet.

Richards (1958) and Brunnschweiler, Leslie, & Richards (1959) found a small magnetic anomaly associated with Gosses Bluff superimposed on a strong westerly gradient. The small size of the anomaly suggested that the structure did not have an igneous core. Detailed aeromagnetic coverage of Gosses Bluff was obtained in 1968 as part of the BMR/USGS joint project (Young, 1970). Small negative anomalies of up to 70 gammas were found from the northwest to the south and on the east side of the Bluff and were interpreted as near-surface bodies which might have been overturned. The follow-up ground magnetic survey in 1969 found that the anomaly to the south of the Bluff was extremely intense and associated with thermally metamorphosed breccia (Sedmik, pers. comm.).

Gravity. The BMR made gravity surveys using helicopters in the Amadeus Basin in 1961 (Langron, 1962) and in 1962 (Lonsdale & Flavelle, 1963). GAI (1965) took gravity readings along all their seismic lines in the northern part of the basin. The data indicate an asymmetrical elliptical basin with the north-central portion represented as a regional gravity low, suggesting that sediments are more than 30,000 feet thick.

Semi-detailed gravity work on Gosses Bluff prior to 1967 indicated a circular gravity low. Richards (1958) suggested that this might be indicative of a salt intrusion and that a small positive feature in the centre of the Bluff could possibly indicate the presence of a cap rock formation. The 1968/1969 detailed Gosses Bluff Gravity Survey confirms the circular gravity low but indicates there is no central high. Analysis of this work is continuing.

Seismic. Seismic traverses were surveyed by BMR in 1961 (Moss, 1962) to determine the structure of the southern margin in the eastern part of the Amadeus Basin and also (Turpie & Moss, 1963) to investigate the structure of the basin in the Palm Valley - Hermannsburg area. In 1962 BMR surveyed a regional traverse across the Missionary Plains from the MacDonnell Ranges in the north through Gosses Bluff to the Gardiner Range in the south (Moss, 1964).

The results of the Missionary Plains survey indicated a maximum thickness of at least 33,000 feet of sediments under the Missionary Plain to the north of Gosses Bluff. The quality of seismic data in the vicinity of the Gosses Bluff structure was very poor, with little continuity of reflections. However, all the seismic evidence available supported the theory that Gosses Bluff was a diapiric structure of the salt-dome type, although none of the evidence would discount the astrobleme theory. The Bitter Springs Formation was considered as a possible source of the necessary mobile material.

The Missionary Plains geophysical survey carried out during 1965-1966 by GAI (1965, 1967) for Magellan Petroleum (N.T.) Pty Ltd consisted of seismic (and gravity) coverage over the northern part of the Amadeus Basin. The quality of the seismic data generally is good in the relatively undisturbed parts of the basin and the reflection character was found to be very consistent. The results indicate that Gosses Bluff lies on an arcuate ancestral uplift which extends northeasterly from the Gardiner fault, through the Tyler Anticline (a subsurface feature) to and possibly under the MacDonnell Ranges. The network of traverses, shown in Plate 1, provides an excellent base for the present survey, permitting the extremities of the present traverses to be tied together and also tied into known geology at Palm Valley No. 1 and Tyler No. 1 wells.

The GAI seismic lines also exhibited very poor reflection quality near Gosses Bluff. The deeper reflections in general continued closer to the Bluff. A marked improvement in reflection quality was obtained on traverse 2-G using 4-fold multiple coverage.

The reason for the deterioration in record quality of both the GAI and BMR work near the Bluff was the presence of shot-generated noise, particularly random noise, probably caused by the increased disturbance of the formations. Random noise can be attenuated by an increase in the number of holes, the number of geophones, or the multiplicity of the coverage. Coherent noise can be attenuated by careful design of the hole pattern, geophone pattern, and multiple coverage spread geometry.

3. OBJECTIVES AND PROGRAMME

Objectives

The request for seismic work at Gosses Bluff was made more with the objective of defining its various structural features more clearly, so that the type of structure to be expected from the impact of a body from space may be known more precisely, rather than determining the origin of the structure. However, there are a few features of the structure which can be investigated by the seismic method, which may yield more evidence on the origin of the structure.

The main objectives of the survey were to use seismic reflection and/or refraction methods:

1. To demonstrate the continuity and undisturbed character of the deeper horizons below the structure. If the source of the disruptive force is at the surface of the earth, there will be a limit to the depth penetration of this disruptive force.

2. To outline the shape of the region of disrupted strata. The zone of disruption would be expected to be bowl-shaped, if the source is near the surface of the earth, whereas the disruption caused by an intrusion from below would be much narrower, perhaps confined to a cylinder round the intrusive plug.

3. To investigate if a foreign intrusive material exists in the structure. If an intrusive body is in the core of the structure there will be a zone of no reflections, otherwise if the deeper reflecting horizons can be followed into and through the core it may be taken that there is no intrusive material.

Further objectives related to the details of the structure were:

4. To determine if there is a peripheral syncline surrounding the disrupted region.

5. To map the attitude of the strata within the disrupted region and the dip and throw of the larger faults present.

6. To determine if the strata are folded into an anticline at depth in the centre of the structure (this could be important for the oil and gas potential of the structure).

7. To determine if any folds have been induced in the strata outside the region of disruption.

8. To map the areas and thicknesses of breccia present in the disrupted region outside the present Bluff.

9. To determine the relationship of the Gosses Bluff structure to the other structural conditions in the area, in particular the anticline on which Gosses Bluff stands.

Programme as planned

Seismic reflection results obtained on previous surveys in the vicinity of Gosses Bluff have varied in quality from fair to very poor. The present survey planned a considerable increase in effort compared to previous surveys. Optimum hole and geophone patterns would be used to attenuate coherent and random noise according to the principles set out by Fail (1962) and Smith (1956). Multiple coverage also would be used where necessary employing the methods of Mayne (1962, 1967).

A summary of the programme as planned at the start of the survey is as follows:

(1) Uphole shoot, noise test, and programmed gain tests on southwest arm of traverse GB/A (see plate 1) to establish shooting and recording parameters.

(2) Continuous reflection profiling on traverse GB/A to be shot through the Bluff from southwest to northeast using single coverage away from the Bluff where reflection quality was good and 6-fold CDP near the Bluff where quality was poor. Profiling would be extended to about 8 miles from the Bluff centre on either side. Continuous coverage would be obtained under the Bluff walls by using offset shots. Existing GAI seismic lines would permit a tie between traverse GB/A and Tyler No. 1 well.

(3) Continuous reflection profiling to be shot through the Bluff on traverse GB/B (see Plate 1) from northwest to southeast in a similar manner to (2).

(4) An expanded spread for detailed vertical velocity determination to be shot on the southwest arm of traverse GB/A and possibly another on the northeast arm. Velocity information is necessary for processing the seismic data, especially the CDP work, for conversion from time to depth scales, and also for approximate density determination by the BMR Gravity Group.

(5) Reflection profiling to be carried out over parts of traverses crossing the Bluff in north-south and east-west directions.

(6) One or more of the major traverses to be extended to about 10 miles from the Bluff centre to determine if any folds have been induced in the strata outside the region of disruption.

(7) Tests using the Controlled Directional Reception method (Riabinkin et al., 1962) to be made in an attempt to determine the attitude of the shallow strata near the centre of the structure.

(8) The extent of brecciation to be investigated from refraction breaks on reflection records, from shot hole drilling and from shallow refraction work.

Programme as carried out

The planned programme was modified slightly as the survey progressed. Details of the programme carried out are given below with some mention of the reasons for modification and the techniques used:

(1) Uphole shot, noise test and programmed gain tests (as planned).

(2) Continuous reflection profiling was shot through the Bluff on traverse GB/A from southwest to northeast (see Plate 1). Single coverage was sufficient to record reasonable reflections beyond 4½ miles from the Bluff centre. Closer to the Bluff and through the Bluff wall 3-fold CDP was used. Rate of progress indicated that the general use of 6-fold CDP over this region would have been excessively time-consuming; however, 6-fold CDP was shot over one small portion of the traverse where reflection quality was particularly poor. On the northeast arm a tie was made to GAI line 2-F at 6 miles from the Bluff centre (see Plate 1). Further extension was impracticable because of the foothills of the MacDonnell Ranges. The geophone station interval was 110 feet, the geophone group normally 32 per trace, of length 140 feet and width 90 feet, and the hole group normally three in line with the traverse.

(3) Continuous reflection profiling was shot through the Bluff on traverse GB/B from northwest to southeast (see Plate 1). Again single coverage was used beyond 4½ miles from the Bluff centre and 3-fold CDP close to and through the Bluff. In order to improve spatial filtering to attenuate low velocity noise events, the length of the geophone group was increased to 300 feet with consequent width reduction to 30 feet. The geophone station interval was then increased to 220 feet in order to prevent ground mixing and to increase productivity. The northwest arm of traverse GB/B could not conveniently be extended beyond 7½ miles from the Bluff centre because of the foothills of the MacDonnell Ranges. The southeast arm was extended to 10 miles from the Bluff centre (see Plate 1) in an attempt to determine if any folds have been induced in the strata outside the region of disruption and because the gravity work had indicated greatest extension of the structure in this direction.

(4) 24-fold CDP was shot inside the Bluff on both traverses GB/A and GB/B. This was a maximum effort attempt to determine the presence or absence of reflections from shallower than about 18,000 feet or the shallowest depth from which reflections had been recorded under items (2) and (3). The intention was to obtain 12-fold coverage within the Bluff, but, because of the limited area over which the geophone spread could be moved, the technique was that of 24-fold in order to obtain 12-fold coverage or greater over a reasonable length of traverse. In fact 12-fold coverage was obtained over 3/4 mile on both traverses GB/A and GB/B.

The 24-fold multiple coverage data may yield useful vertical velocity information by application of statistical methods such as dynamic correlation analysis (Schneider et al., 1968) during digital processing.

(5) Three expanded spreads were shot for detailed vertical velocity information, to the southwest, southeast, and northeast of the Bluff in regions where the reflection quality was good. Variability in velocities obtained indicated the need for as much velocity information as possible. Expanded

spread velocity information was supplemented by velocities deduced by t $-\Delta t$ analyses from normal reflection records.

(6) When a velocity survey was being conducted in Tyler No. 1 well 8½ miles northeast of the centre of Gosses Bluff, the shots were recorded by a geophone spread at the well. This will facilitate better correlation between seismic reflections recorded and formations penetrated by the well. With a view to integration of this survey with GAI seismic work around Gosses Bluff, the loop of seismic lines around the Bluff was completed by joining GAI line 2-C to 2-D by traverse GB/2-C (see Plate 1).

(7) Controlled Directional Reception was used over a small portion of traverse GB/B near the Bluff wall on the northwest arm (see Plate 1) in an attempt to determine the attitude of the shallow strata near the centre of the structure.

(8) Some shallow refraction shots were recorded on traverse 8182 north of the Bluff (see Plate 1). This traverse was very close to a line along which Glikson (1969) mapped outcrops of bedrock and breccia in some detail. The shallow refraction programme was designed to determine the difference in velocity between the bedrock and breccia. An attempt was also made to determine extent of brecciation from refraction breaks on reflection records from traverse GB/A and GB/B.

Time did not permit work on either of the proposed north-south or east-west lines through Gosses Bluff. Also no refraction programme other than the shallow refraction mentioned above was undertaken. A feasibility study indicated that a small amount of refraction work would yield little information. Time would not have permitted a major refraction study.

Throughout the survey quality control of the seismic records was maintained at the highest level possible with the staff available. Tests of the recording equipment were conducted regularly.

Compatibility of data with the requirements of digital processing was considered throughout the survey. Programmed gain was used in the recording of all main traverses.

4. RESULTS AND CONCLUSIONS

Results and conclusions from major traverses

On both traverses GB/A and GB/B many good reflections were recorded at distances from the Bluff centre greater than 4 miles. Closer to the Bluff reflection quality deteriorated and the shallower reflections were absent. Plate 2 shows the main reflection events recorded on traverse GB/B and illustrates that near the Bluff there are reasonable quality deep reflections but a complete absence of shallower events. The results of the 12-fold CDP inside the Bluff are seen to indicate reflections no shallower than those recorded previously. The results from traverse GB/A are very similar, the only difference being that this traverse runs along rather than across the regional anticline.

These results are as yet only provisional as further processing of the data is required. In particular, the static corrections (Vale, 1959) used to date have been very inaccurate owing presumably to a particularly non-uniform weathered layer caused by the variable geological conditions. Dynamic corrections to correct reflection curvature have also been poor and require revised velocity data from improvement (see last section). These poor corrections have had seriously adverse effects on the CDP stacking. Reprocessing with revised corrections and possibly some stages of digital processing are planned in order to verify the above results. However, provisional conclusions can be drawn as follows:

There is a limit to the depth penetration of the disruptive force (objective 1). This is not greater than 18,000 feet below the present ground surface.

There is no intrusive core in the structure as the deeper reflections can be followed continuously under the Bluff (objective 3).

The shape of the region of disrupted strata is roughly a bowl of diameter about 8 miles and depth about 3½ miles (objective 2). Recent geological mapping by Milton (1968) and Glikson (1969) indicates disruption as far as 7 miles from the Bluff centre. Thus the total zone of disruption may be of the form of a shallow saucer on top of a roughly hemispherical bowl, as shown schematically in Plate 4. This is the shape of the disruption associated with the Ries Crater astrobleme in Bavaria (Milton, pers. comm.).

These conclusions tend to support the theory that Gosses Bluff is an astrobleme. Further conclusions related to the minor objectives of the survey are:

There is no direct evidence from the seismic sections of a peripheral syncline (objective 4). This may be only because reflection quality is too poor in this region.

Also there is no indication that the strata are folded into an anticline at depth in the centre of the structure (objective 6). This could also be a consequence of poor reflection quality.

There is no evidence of folds induced in the strata outside the region of disruption (objective 7). Confirmation of this conclusion requires final processing.

From the main reflections recorded (Plate 2) and from provisional geological correlations from Tyler No. 1 and Palm Valley No. 1 wells (indicated in Plate 2), it is possible to postulate undisturbed formation boundaries (bold lines, Plate 3). The surface geology along traverse GB/B was supplied by D.J. Milton (USGS). With this information and considering the approximate requirements of volume filling, a possible cross-section through Gosses Bluff along traverse GB/B was drawn (Plate 3). This will form the main working hypothesis for further analysis of the survey data.

It can be seen from Plate 3 that the shallowest formation which is shown to be undisturbed is the Hugh River Shale. This lies above the Chandler Limestone and Bitter Springs Formation (Table 1), which are the only probable sources of diapirism.

Results and conclusions from other investigations

The experimental use of the method of Controlled Directional Reception during the Gosses Bluff Survey will be the subject of a separate report (Brown, 1970a). Use of the method on traverse GB/B near the Bluff wall produced record with an apparently improved signal-to-noise ratio and some interesting steeply dipping events. Further analysis is required to determine if these events are genuine reflections (objective 5).

The velocity investigations mentioned in programme as carried out in item (5) above and in addition a further expanded spread on traverse GB/L (Brown, 1970b) and the velocity data from Gosses Bluff Seismic Survey, 1962 (Moss, 1964) together yielded the array of velocity-time graphs shown in Plate 5. For the t-Δt analysis northwest, large possible errors of measurement make the lower part of the curve doubtful. We thus have a fairly clear difference between velocities on the north and south sides of the Bluff. Further velocity analysis is required.

The shallow refraction work on traverse 8182 resulted in a very confused picture. Analysis of refraction breaks on reflection records produced some interesting velocity trends along traverse GB/B. Both of these will require extensive further analysis if objective 8 is to be satisfied.

Further work

Further work on Gosses Bluff data will be directed initially towards the refinement of static and dynamic corrections and further processing by analogue means. Digital processing will be undertaken when the limit of improvement has been reached by analogue processing and it is felt that further improvement is still possible.

A reinterpretation of the record sections will then be undertaken including integration with the BMR 1962 work and all the GAI lines in the area. Use will be made of traverse GB/2-C and the results of the Tyler No. 1 well velocity survey (United Geophysical Corporation, 1969). The above conclusions will then be reappraised. Also it may be possible to comment on the relationship between Gosses Bluff and other structural conditions in the area (objective 9).

Other further work will be as described in the previous section.

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APPENDIX A

Staff and Equipment

STAFF

Party Leader	A.R. Brown
Geophysicists	J.B. Willcox (9.4.69 to 29.6.69)
	D.G. Townsend (7.6.69 to 20.8.69)
	P. Harrison (27.7.69 to 20.8.69)
Observers	G.S. Jennings (3.4.69 to 13.6.69)
	W. Trenchuk (9.6.69 to 27.6.69)
	G.L. Abbs (22.6.69 to 20.8.69)
Assistant Observers	W. Greenwood (16.5.69 to 17.7.69)
	L. Hemphill (18.7.69 to 20.8.69)
Shooter	H. Pelz
Surveyor	M. Downing, Department of the Interior
Toolpusher	E.H. Cherry
Drillers	E.D. Lodwick
	A. Zoska
Mechanic	E.C. McIntosh
Clerk	E. Fryk
Field Hands	16
Geologist	D.J. Milton, USGS (19.6.69 to 2.8.69)

EQUIPMENT

Seismic amplifiers	SIE PT-700
Oscillograph	SIE TRO-6
Magnetic recorder (FM)	SIE PMR-20

Geophones	Hall-Sears HS-J, 14 Hz
Drilling rigs	Mayhew 1000 (2)
Other vehicles	Bedford recording truck
	Bedford workshop
	Bedford water tankers (5)
	Bedford tray trucks (2)
	International utility
	Landrovers, 109" (5)
	Landrover, 88"
	Trailers (8)

Camping and miscellaneous equipment

APPENDIX B

OPERATIONAL STATISTICS

Sedimentary basin		Amadeus
Camp site		Gosses Bluff
Survey commenced		April 3rd, 1969
Survey completed		August 20th, 1969
Miles of traverse surveyed		50
Topographic survey control		Department of the Interior gravity grid
Total number of holes drilled		1324
Total footage drilled		120, 103
Explosives used		76,500 lb. Geophex
Number of detonators used		2140
Shot-point interval (basic)		1320 feet
Geophone station intervals		110 feet 220 feet
Common geophone groups	(a)	32, in 4 lines of 8 parallel to traverse, spacing in line 20 feet, spacing between lines 30 feet.
	(b)	32, in 2 lines of 16 parallel to traverse spacing in line 20 feet, spacing between lines 30 feet.
Other geophone groups		8 in line with traverse, 16 in two lines parallel to traverse, 24 in three lines parallel to traverse, 48 in three lines parallel to traverse, spacing in line predominantly 20 feet.
Common hole pattern		3 in line parallel to traverse, spacing 50 feet
Other hole patterns		single 2 in line with traverse 5 " " " 6 in two lines parallel to traverse 5 in line perpendicular to traverse 9 " " " " " (last two for CDR only)
Common hole depths		85 feet 100 feet

Common charge sizes	80 to 300 lb per shot
Normal tamping	solid
Normal recording mode	Programmed gain
Normal recording filters	L/16 - KK/135
Datum for corrections	2300 feet A.S.L.
Weathering velocity used	2500 feet per second
Sub-weathering velocity used	11000 feet per second

The survey Operations Chart is shown in Plate 6.

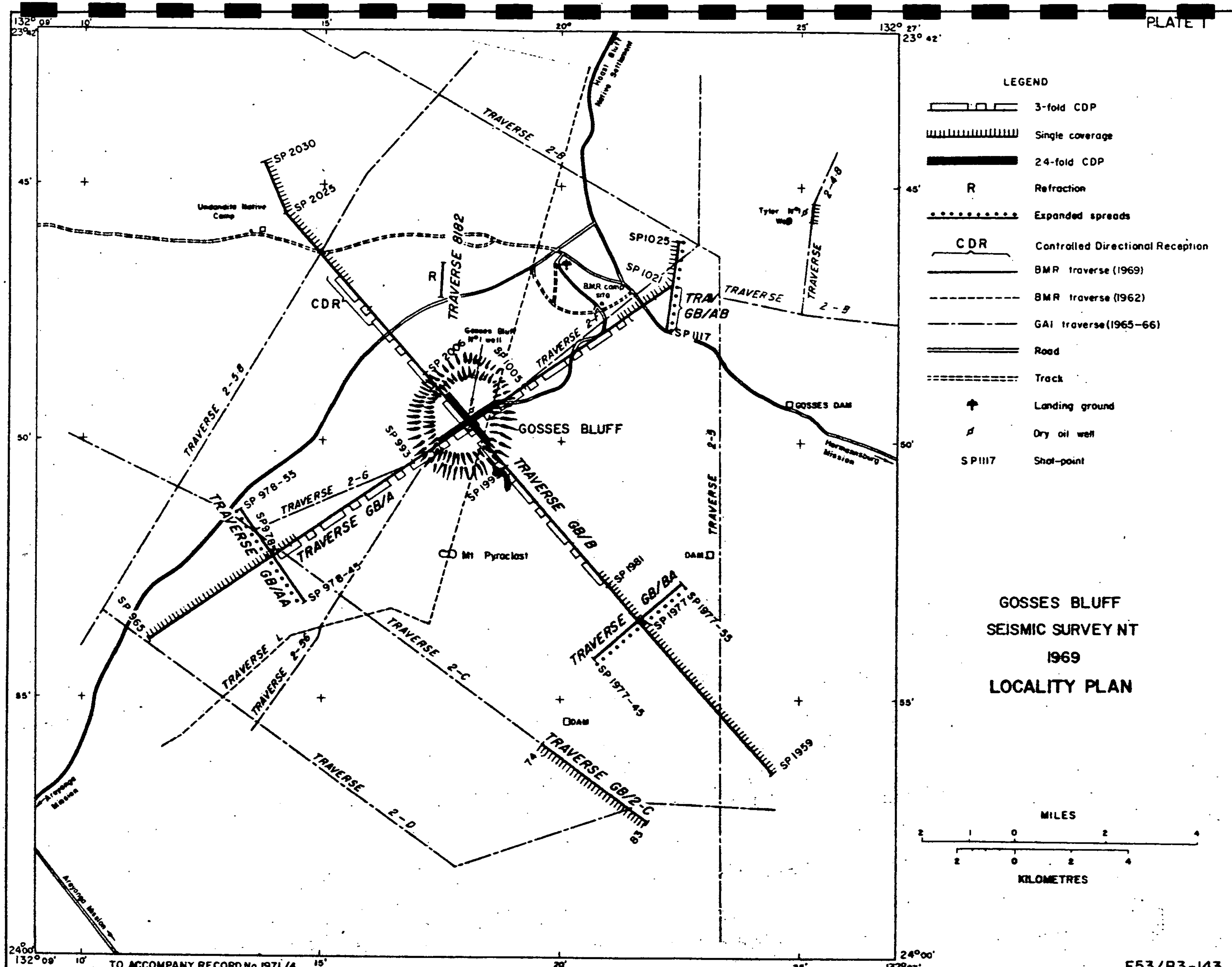
TABLE 1

AGE		GROUP	FORMATION (WEST)	PREDOMINANT LITHOLOGY	FORMATION (EAST)	PREDOMINANT LITHOLOGY	THICKNESS
PERMIAN?-RECENT			MINOR SUPERFICIAL DEPOSITS				0' – 1,000'
DEVONIAN – CARBONIFEROUS ?		PERTNJARA	BREWER	CGL, SS			0' – 12,000'
DEVONIAN – CARBONIFEROUS ?		PERTNJARA	HERMANNSBURG	SS			0' – 3,000'
DEVONIAN – CARBONIFEROUS ?		PERTNJARA	PARKE	SLTST, SS			0' – 3,000'
SILURIAN ? DEVONIAN			MEREENIE	SS			600' – 2,500'
ORDOVICIAN	UPPER	LARAPINTA	CARMICHAEL	SS, SLTST			0' – 500' ?
ORDOVICIAN	UPPER	LARAPINTA	STOKES	SLTS, SH, LS			0' – 1,800'
ORDOVICIAN	MIDDLE	LARAPINTA	STAIRWAY	SS, SLTST			0' – 1,800'
ORDOVICIAN	LOWER	LARAPINTA	HORN VALLEY	SLTST, SH, DOL			0' – 800'
ORDOVICIAN / CAMBRIAN	LOWER / UPPER	LARAPINTA	PACOOTA	SS, SLTST			900' – 3,500'
CAMBRIAN	UPPER	PERTAOORTA (CLELAND SS)	GOYDER	SS, DOL, SH			0' – 1,600'
CAMBRIAN	MIDDLE	PERTAOORTA (CLELAND SS)	PETERMANN	SS	JAY CREEK (SHANNON)	LS	2,500' – 6,000'
CAMBRIAN	MIDDLE	PERTAOORTA (CLELAND SS)	DECEPTION	SLTST	HUGH RIVER	SLTST	2,500' – 6,000'
CAMBRIAN	MIDDLE	PERTAOORTA (CLELAND SS)	ILLARA	SS	GILES CREEK	DOL	2,500' – 6,000'
CAMBRIAN	MIDDLE	PERTAOORTA (CLELAND SS)	TEMPE	SH, SLTST, LS	GILES CREEK	DOL	2,500' – 6,000'
CAMBRIAN	LOWER	PERTAOORTA (CLELAND SS)	CHANDLER	SALT, SH, LS	TODD RIVER	DOL	0' – 1,000'
CAMBRIAN	LOWER	PERTAOORTA (CLELAND SS)	ARUMBERA	SS, SLTST, CGL			0' – 3,000'
UPPER PROTEROZOIC		(CARNEGIE SS)	PERTATATAKA	SH, SLTST, DOL, LS			0' – 4,000'
UPPER PROTEROZOIC		(CARNEGIE SS)	AREYONGA	SH, SS, DOL, CGL			0' – 4,000'
UPPER PROTEROZOIC			BITTER SPRINGS	LS, DOL, SALT, SH			3,000' ±
UPPER PROTEROZOIC			HEAVITREE	QTZITE, SS, SLTST			2,000' ±
PRECAMBRIAN			ARUNTA	IGNEOUS & METAMORPHIC ROCKS			

GENERALIZED STRATIGRAPHIC COLUMN

NORTHERN AMADEUS BASIN

TO ACCOMPANY RECORD No. 1971/4



TO ACCOMPANY RECORD No. 1971/4

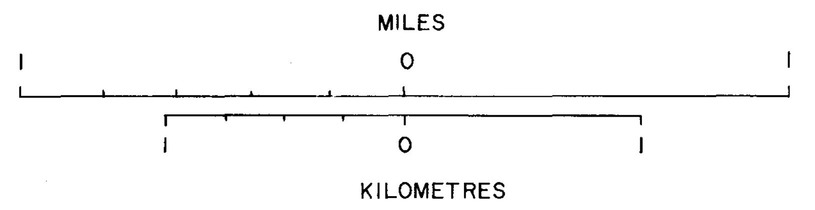
F53/B3-143

PLATE 2

GOSSES BLUFF SEISMIC SURVEY N T 1969

MAIN REFLECTION EVENTS

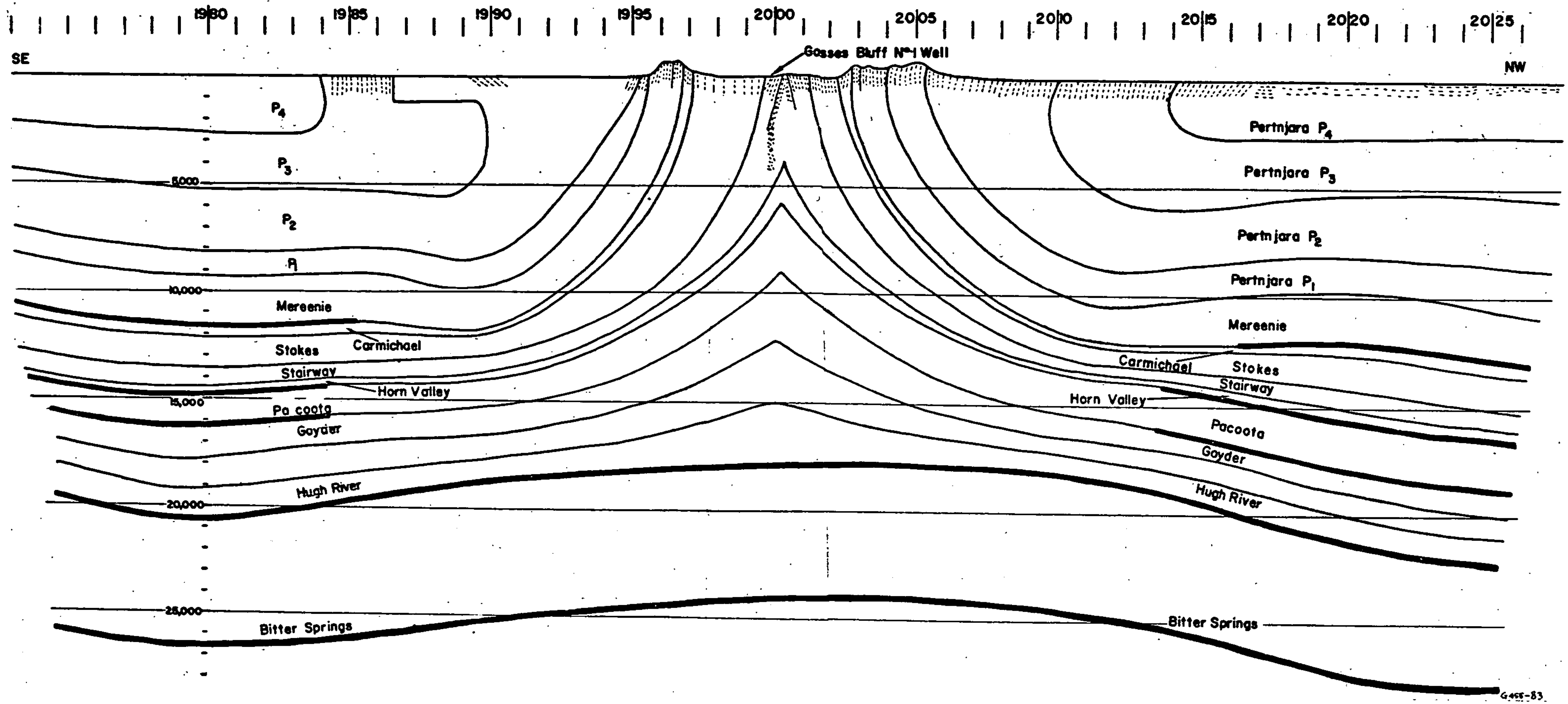
RECORDED TRAVERSE GB/B



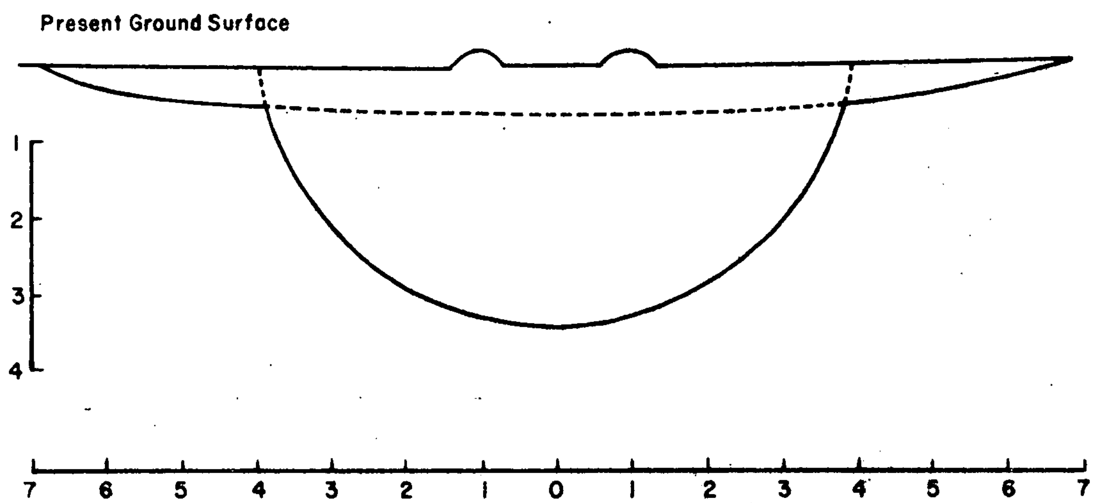
TO ACCOMPANY RECORD No. 1971/4

F53/B3-145

PLATE 3



GOSSES BLUFF - POSSIBLE CROSS-SECTION ALONG TRAVERSE GB/B



Both scales in miles

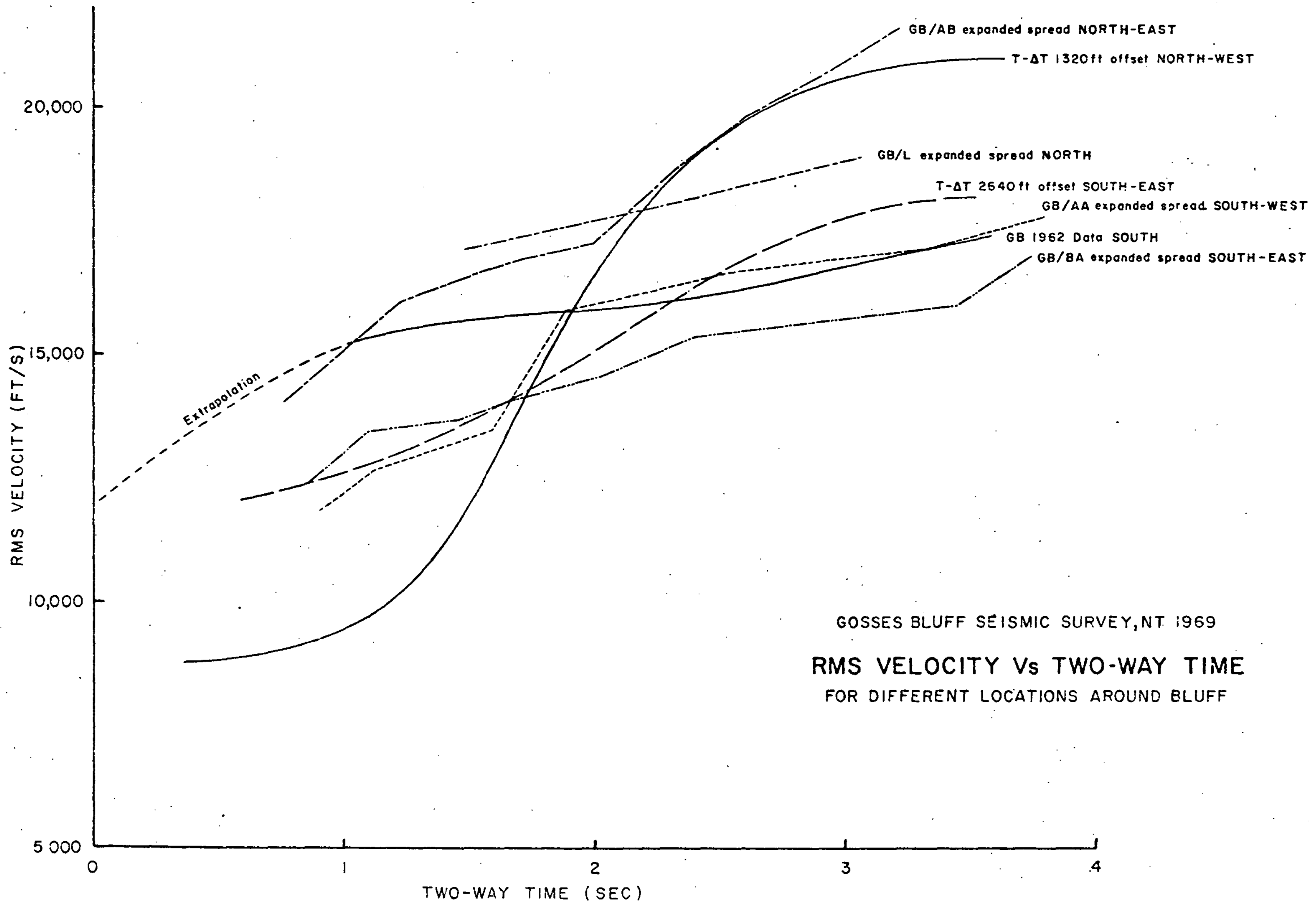
$\frac{V}{H} = 1$

GOSSES BLUFF
PROBABLE EXTENT OF ZONE OF DISRUPTION

F53/B3-159A

TO ACCOMPANY RECORD No. 1971/4

TO ACCOMPANY RECORD No. 1971/4



GOSSES BLUFF SEISMIC SURVEY, NT 1969

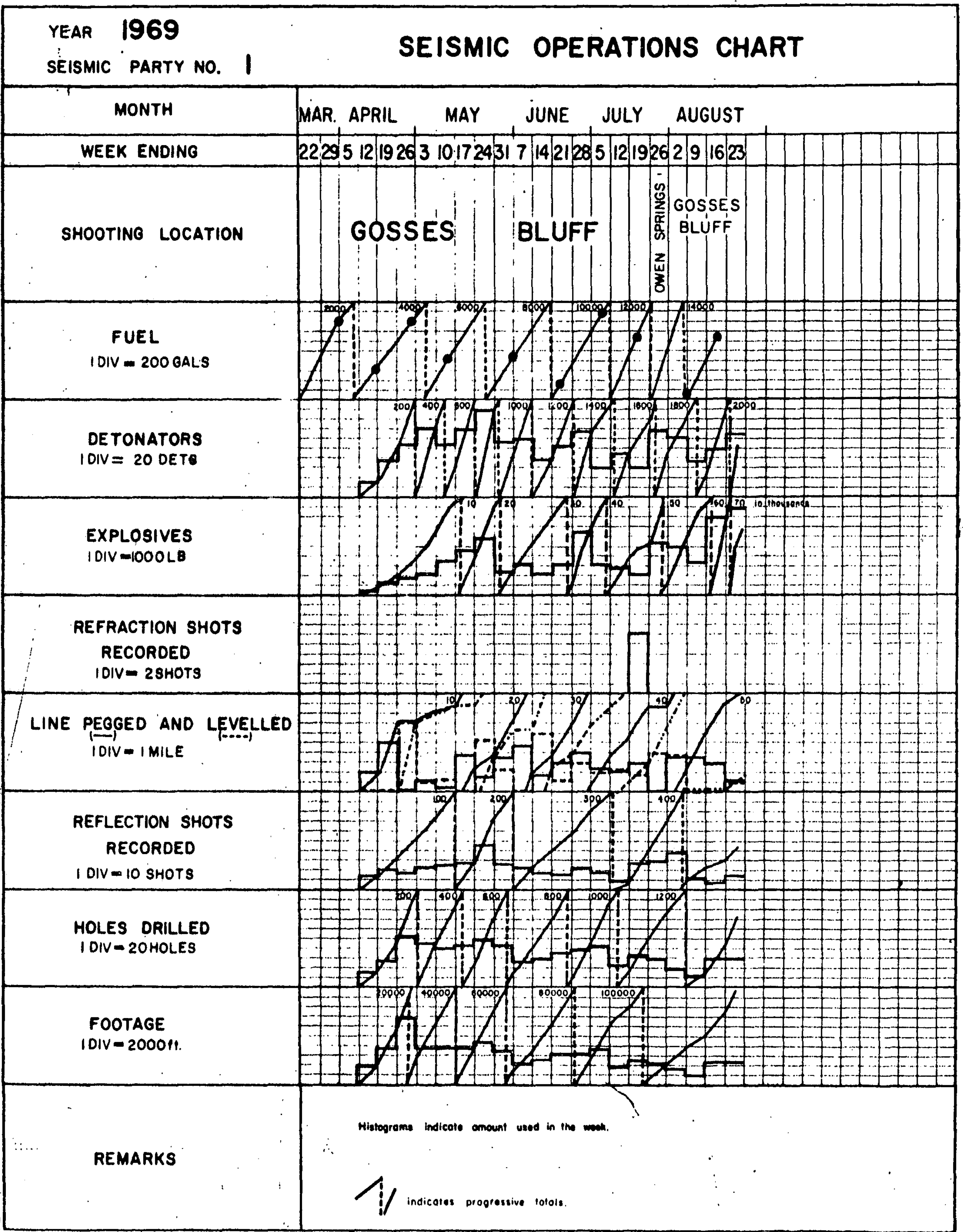
RMS VELOCITY Vs TWO-WAY TIME

FOR DIFFERENT LOCATIONS AROUND BLUFF

PLATE 5

F53/B3-144

PLATE 6



(BASED ON G85/3-128) TO ACCOMPANY RECORD No. 1971/4 F53/B3-146