# DEPARTMENT OF NATIONAL RESOURCES

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1977/26



## GALILEE BASIN SEISMIC AND GRAVITY SURVEY, QUEENSLAND, 1976

### OPERATIONAL REPORT - CLERMONT-ALPHA AREA

by

F. Brassil and W. Anfiloff

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## SUMMARY

The Bureau of Mineral Resources conducted a seismic and gravity survey in the eastern Galilee Basin area from August to December 1976. Two traverses of the survey were recorded during September to December in the Clermont-Alpha area. Both traverses were recorded to investigate the relations between the Galilee, Drummond, and Adavale Basins in this area. Traverse 3 was recorded as a continuation of BMR 1971 Traverse A and extended this traverse to the outcrop of the Anakie Metamorphics. Traverse 4 was recorded to provide a tie between Jericho No. 1 well and the outcrop of the Drummond Basin Sediments on the Capricorn Highway.

Both traverses were recorded digitally with Texas Instruments DFS-IV equipment using 6-fold common depth point recording techniques. Detailed gravity readings were also taken along the traverse.

The seismic data are being processed under contract by Geophysical Service International, Sydney, and final interpretation awaits the completion of processing.

The area was difficult for seismic data aquisition because of high dispersion of seismic energy, poor reflectivity, and complex geological structure.

Preliminary results indicate possible locations for the boundaries between the three basins. There is evidence that the area is highly faulted. A previously unknown trough of Adavale Basin sediments is indicated on Traverse 3. The velocity structure of the area is complex, with high average velocities and a possible velocity inversion at the eastern end of Traverse 3.

# INTRODUCTION

During August to December 1976 the Bureau of Mineral Resources (BMR) recorded four seismic reflection reconnaissance traverses near the eastern margin of the Galilee Basin. The first two traverses were recorded in the Pentland-Hughenden area and are discussed in a separate operational report by Schmidt, Nelson, & Anfiloff (1977). Other two traverses, Traverses 3 and 4 (Fig. 1), were recorded in the Clermont-Alpha area during September to December. The object of these traverses was to investigate the relations between, and the relative extents of, the Galilee, Drummond, and Adavale Basins in this area (see Fig. 2).

Traverse 3 extended Traverse A of the 1971 BMR seismic survey to complete a tie from Lake Galilee No. 1 well eastwards to the Anakie Metamorphics. As the oldest sediments in Lake Galilee No. 1 well were identified as belonging to the Adavale Basin (Vine, 1972), and the Lower Palaeozoic Anakie Metamorphics underlie the Drummond Basin to the east, Traverse 3 was intended to provide information on the nature and position of the eastern boundary of the Adavale Basin. Traverse 4 was intended to provide similar information on the eastward extent of the Adavale Basin sediments encountered at the bottom of Jericho No. 1 well (Alliance Oil, 1965), and the relations of this Adavale Basin sequence to the Drummond Basin which crops out in the east.

Gas was discovered in the Adavale Basin at Gilmore No. 1 well; and there were oil and gas shows at Lake Galilee No. 1 and a gas show at Koburra No. 1. These hydrocarbons could have migrated from deeper rocks, possibly of Adavale Basin age. Thus if the Adavale Basin did extend farther north and east than its present known limits, the petroleum prospectivity of the region would be upgraded.

Traverse 3 was recorded as planned from the eastern end of the 1971 BMR Traverse A to the outcrop of the Anakie Metamorphics, but owing to lack of time the location of Traverse 4 was altered from the original plan and its length reduced considerably. Traverse 4 was originally intended to link Jericho No. 1 well to the outcrops of the Silver Hills Volcanics at Mount Beaufort, but this would have involved a large distance across uncleared country, and as only two weeks of survey time remained the traverse was recorded along the main eastwest highway through Alpha.

Gravity measurements were made at 0.5 km intervals along both traverses using a Worden gravity meter.

This report presents details of operations and preliminary results available at the end of the survey. Further data processing and detailed analysis of the seismic and gravity data will be required before a final interpretation report is completed.

## SEISMIC OPERATIONS

The operational details for both traverses are tabulated in Appendix 1, DFS IV settings in Appendix 2, and personnel and equipment in Appendix 3. The traverses were surveyed by the Department of Administrative Services Survey Office Special Projects Sections. The traverses were pegged and levelled, and checked using electronic distance measurement. Each geophone station was numbered consecutively, and stations were 83.33 m apart. Survey staff comprised a surveyor, a technical officer, and two chainmen, using two vehicles supplied by the Survey Office. Detailed location maps of Traverses 3 and 4 are given in Figures 3 and 5.

### Traverse 3

Traverse 3 comprised a traverse between BMR 1971 Traverse A and the Anakie Metamorphics, a short cross-traverse, Traverse 3B, two expanded spreads, two shallow refraction profiles and continuous weathering spreads and uphole shoots. Recording began at the western end on 25 September 1976 and ended on 17 November 1976. The main traverse was 88.67 km long and was recorded to give six-fold common depth point (CDP) coverage. The crew operated from a camp near Beresford homestead, approximately midway along the traverse (Fig. 3). A local bulldozer and operator were hired to clear 33 km of traverse, the remainder being along the Clermont-Laglan road.

The drilling was generally slow, and this was the main cause of delays in recording. The slow drilling was caused partly by shallow unconsolidated gravel beds, which necessitated the use of water injection and mud drilling in many places, and partly by the use of 3 and 5-hole patterns on the second half of the traverse. Twenty four rig-days were lost, 19% of available drilling time, 9 due to repairs needed after the trip to Traverse 3 from Charters Towers, and 15 due to breakdown, maintenance, and bad weather. The drill prime-movers became bogged very easily after only moderate rainfall.

At the beginning of the traverse a comparison of a single hole at 45 m, a single hole at 22.5 m and a 3 x 9 m hole pattern at 10 m spacing showed that results from a single hole at 22.5 m loaded with 9.1 kg of charge were satisfactory. Hole depth was reduced to 18 m to improve the drilling rate, but gradually increased again to 27 m to improve record quality as the weathering layer became deeper. A charge size of 9.1 kg was generally satisfactory until around station 2400 from where it was increased to 18.2 kg and occasionally up to 27.3 kg to improve energy input into the ground.

Midway along the traverse, noise problems became severe, and for the second half of the traverse hole patterns of 5 x 9 m, 5 x 4.5 m, and 3 x 18 m were used. The usual hole spacing was 20 m for 5 hole patterns and 30 m for 3 hole patterns, and charges of 18.2, 20.5, or 27.3 kg were used. Comparison shots were recorded at intervals along the traverse to monitor the suitability of shooting parameters. A geophone array of 16 geophones in line 6 m apart was used for the whole line. The shot was fired at the east end of the spread, on trace 1; giving a 1926.67 m offset to the centre of the most distant geophone group. This large offset was chosen to give good resolution of deep structures and good velocity control.

Record quality varied from good to very poor and was generally fair. In the interval from station 2353 to station 2405 the record quality was particularly poor and the interval was re-shot. The poor record quality was attributed to a deep unconsolidated sand layer. The re-shot section was recorded using 32 geophones per trace, with the shot on trace 24 at the western end of the spread, using 3 x 18 m holes at 30 meter spacing, loaded with 9.1 kg of charge per hole. The shots were on the odd-numbered stations, enabling these records to be stacked with the original records to give 12-fold CDP coverage (see Fig. 4). These re-shot records are much better than the original ones.

Two expanded spreads were recorded, at stations 2390 and 2764, with maximum offsets of 4 km and 6 km respectively, to determine the velocity structure.

Two shots were recorded split spread single-fold on a cross traverse, Traverse 3B, to determine if the reflections recorded on Traverse 3 were true vertical reflections and not side reflections especially as an expanded spread indicated a velocity inversion and unusually high near-surface velocities.

Two shallow refraction profiles were recorded at the eastern end of the traverse, to determine the refraction velocities and depth of the Silver Hills Volcanics and the Anakie Metamorphics.

Weathering spreads were shot routinely at every cab position along the traverse, i.e. at every 24th station. This spread was a 24-channel split spread using a single geophone per channel, with geophones 8 m apart. At certain locations a deep hole was used and shots fired into the spread at intervals up the hole. The two-dimensional Meissner plot of first-break times versus hole depth provides details of the near-surface velocity structure. The amount of information extracted from the weathering spreads was a function of the depth and complexity of the weathered layers. The depth of weathering could be determined where it was shallow (less than about 40 m), but not if it was deep. However, in any case the weathering shots provided control of the velocity of the weathered layer and this information could not normally be obtained from normal production shots. Uphole times from production shots could not be used for weathering corrections because of an unknown and variable delay of approximately 8 ms caused by a malfunction in the I/O Radio Firing Unit.

Traverse 4

Traverse 4 was shot in two sections, one short section on the western side of Alpha, and the bulk of the traverse on the eastern side (Fig. 5). The gap occurred because time limitations precluded shooting through the town. Recording was commenced at the eastern end on 22 November 1976 and completed on 2 December 1976.

Recording was mainly single-fold with four patches of six-fold. The traverse was shot with varying fold as a compromise between the quality of six-fold data and the higher traversing rate of single-fold data. Total length of traverse is 40 km, of which 6 km is at full six-fold coverage (Fig. 6). The traverse was shot entirely along the Capricorn Highway and there was no access problem or need for bulldozing.

Drilling was slowed by hard siltstone and shale bands and areas of deep weathering. The loss of one rig for six days owing to a major breakdown also limited drilling capacity. Normally, holes of 27 m were used except for areas of deep weathering near the Belyando River where 36 m or 45 m holes were used. Charges of 18.2 kg were used on the western part of the traverse;

this was increased to 27.3 kg for the eastern part of the traverse.

The traverse was recorded using split spreads shot on trace 12 with 83.33 m station interval. The split spread was used because the strata under investigation were shallow and hence would not be resolved by long offsets.

Record quality was fair to bad, and usually poor. The noise level was high and reflection quality poor. Lack of time precluded any large amount of experimentation to determine a better shooting arrangement. Digital processing may improve the data, but a clear resolution of the geological structure is not certain.

## GRAVITY OPERATIONS

Over the period 27/10/76 to 26/11/76, gravity observations were made at every sixth station along the seismic traverses. This represents a station spacing of 500 m. W. Anfiloff made 165 observations along Traverse 3 and P. Petkovic made 140 observations along Traverse 4, using gravity meter W169 (C.F. = 0.10114 mGal/div). Nine readings were also taken along each of the cross-traverses 3A and 3B.

Traverse 3 was tied to base 6306.1254, which is situated at benchmark AG54 near Laglan, and Traverse 4 was tied to base 6305.0420, which is situated at benchmark AA20, on the Capricorn Highway. The traverses were also connected to other gravity bases in the area. The results of these connections, and the discrepancies in the measured intervals are shown in Tables 1 and 2.

Table 1: Traverse 3 - Corrections to Gravity Base Stations

| BASE | OBSERVED GRAVITY (1963) | OBSERVED GRAVITY (1976 | DIFFERENCE (mGal) |
|---|---|---|---|
| 6306.1254 | 978964.90 | 978964.90 | 0.00 |
| 6306.1311 | 978761.64 | 978761.67 | 0.03 |

Table 2: Traverse 4 - Corrections to Gravity Base Stations

| BASE | OBSERVED GRAVITY (1963 | OBSERVED GRAVITY (1967 | DIFFERENCE (mGal) |
|---|---|---|---|
| 6305.0420 | 978781.58 | 978781.58 | 0.00 |
| 6305.0421 | 978789.84 | 978789.84 | 0.00 |
| 6305.0422 | 978795.69 | 978795.65 | 0.04 |
| 6305.0423 | 978789.11 | 978789.01 | 0.10 |
| 6305.0424 | 978783.77 | 978783.61 | 0.16 |
| 6305.0425 | 978792.48 | 978792.34 | 0.14 |
| 6405.0426 | 978790.31 | 978790.16 | 0.15 |
| 6305.0427 | 978788.38 | 978788.21 | 0.17 |
| 6305.0428 | 978780.10 | 978779.89 | 0.21 |

The connections to bases along Traverse 4 show a progressive increase in discrepancy in the interval measured between the primary base (6305.0420) and the other bases occupied (6304.0421 to 6305.0428). The discrepancy does not correlate with the size of the interval measured, and was not removed by using the calibration factor of 0.10107 obtained at the calibration range in Canberra after the survey. A systematic error therefore appears to have been introduced in the course of the gravity survey along Traverse 4. This error was reduced by applying a linear correction factor, resulting in a maximum discrepancy of 0.04 mGal.

The gravity profiles for Traverses 3 and 4 are shown in Figures 7 and 8.

## SEISMIC DATA PROCESSING

Weathering corrections were determined using refraction interpretation of production shots, and weathering and uphole shoot records. See Table 3 for reduction details.

GSI Sydney have been contracted to digitally process the seismic data. The processing will involve CDP gather, brute stack, filter analysis, velocity analysis, autostatics, time variant filtering, time variant scaling, time variant deconvolution, stack, and possibly migration and coherency filtering.

Table 3: Static Reduction Parameters

| | Traverse 3 | Traverse 4 |
|---|---|---|
| Datum | 200 m | 300 m |
| Replacement velocity | 2000 $ms^{-1}$ | 3500 $ms^{-1}$ |
| Weathering depth | 0 m - 100 m | 20 m - 70 m |
| Weathering velocities | 500 $ms^{-1}$ - 1200 $ms^{-1}$ | 1000 $ms^{-1}$ - 1500 ms |

## PRELIMINARY RESULTS

The interpretation shown in Figures 9 and 10 were made in the field from unprocessed field records. It is emphasised that these interpretations could differ significantly from the interpretation of final processed sections.

### Traverse 3

#### Seismic results

The major feature of Figure 9 is a trough of sediments at the centre of the traverse near Beresford homestead with a possible total thickness of about 10 km. The bulk of the thickening is in the Adavale Basin sequence; the Drummond Basin is of fairly constant thickness up to its eastern margin. This eastern margin is formed mainly by gradual thinning of the basin disrupted in several places by large normal faults upthrown to the east. The whole section appears to be extensively faulted, and further data processing could reveal more faulting than is at present indicated. Evidence for the faulted nature of the eastern margin of the Drummond Basin is also provided by the shallow refraction results at the eastern end of the traverse, which were so disrupted that interpretation of refractor velocities was extremely difficult.

The expanded spreads have not yet been fully analysed but they indicate that the shallow velocities are generally high and that there may be a velocity inversion in the area of station 2764. Detailed velocity analysis will be carried out to resolve the velocity structure.

Gravity results

The Bouguer anomaly profiles for reduction densities between 2.0 and 3.0 $tm^{-3}$ show little variation because of the flatness of the terrain. The anomaly at the western end of the traverse is part of the high associated with the Donnybrook Anticline. A local bump in the anomaly around station 2630 correlates with a bump in the elevation profile, and may be caused by a dense formation intersecting the ground surface at a steep angle. At the eastern end of the traverse, a marked increase in gravity level marks the boundary between the Drummond Basin and the Anakie Metamorphics.

Traverse 4

Seismic results

The interpretation shown in Figure 10 is sketchy because of poor data quality. A possible boundary between the Galilee Basin and Drummond Basin is indicated.

Gravity results

The wavelength of the pronounced anomaly between stations 4060 and 4300 suggests structure in the basement.

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ALLIANCE OIL (N.L.), 1965 - Well Completion Report, Alliance-Jericho, No. 1 ATP 81P, Qld. Bur. Miner. Resour. Aust. Petrol Search Subs. Acts Rep. 65/4141 (unpubl.).

SCHMIDT, D.L., NELSON, A., & ANFILOFF, W., 1977 - Galilee Basin seismic survey, Queensland, 1976. Operational Report - Pentland-Hughenden area. Bur. Miner. Resour. Aust. Rec. 1977/27 (unpubl.).

VINE, R.R., 1972 - Relationships between the Adavale and Drummond Basins, APEA J., 1972, 58-61.

## APPENDIX 1

## OPERATIONAL STATISTICS

| | TRAVERSE 3 | TRAVERSE 4 |
|---|---|---|
| Recording commenced | 23 September | 22 November |
| Recording completed | 17 November | 2 December |
| Length of traverse | 88.67 km | 40 km |
| No. of recording days worked | 34 | 9 |
| Recording days lost | 6 | 1 |
| Fold | 6 | 6, 1 |
| Station range | 2000-3064 | 4012-4024, 4180-4648 |
| Total number of shots | 751 | 134 |
| Number of production shots | 561 | 95 |
| Average number of shots/recording day | 22.1 | 14.9 |
| Average number of production shots /recording day | 16.5 | 10.6 |
| Average surface coverage/recording day | 2.75 km/day | 4.4 km/day |
| Maximum number of shots/day | 52 | 30 |
| Maximum number of production shots/day | 37 | 19 |
| Explosives used | 7247.6 kg | 1707.3 kg |
| Detonators used | 1501 | 139 |
| Total number of rig days worked | 102.5 | 21 |
| Rig days lost | 24 | 9 |
| Meters drilled | 18423.5 m | 2705.5 m |
| Bulldozing | 33 km | Nil |

## APPENDIX 2

## DFS IV INSTRUMENT SETTINGS

| | |
|---|---|
| Recording mode | Digital |
| Format | SEG - B |
| No. of input channels | 24 DATA, 4 auxilliary |
| Tape | 9 Track, 800 BPI NRZI, ½ inch |
| Record length | 6 seconds (some 16-seond records) |
| Sample rate | 2 milliseconds |
| Gain constant | 42dB |
| Input filters | L.C.: 12 Hz at 36dB/octave |
| | H.C.: 124 Hz at 72dB/octave |
| Notch filter (50 Hz) | In on Traverse 3 |
| | Out on Traverse 4 |

# APPENDIX 3

## PERSONNEL AND EQUIPMENT

### Personnel

#### Geophysical Branch

| | |
|---|---|
| Party Leader | J. Pinchin |
| Geophysicists | J. Bauer (P/T) |
| | A. Nelson (GSQ) |
| | P. Petkovic |
| | H. Stagg (P/T) |
| | W. Anfiloff (P/T) |
| | D. Schmidt |
| | F. Brassil |
| Party Clerk | W. Gunner |
| Technical Officers | G. Jennings (P/T) |
| | W. Trenchuk (P/T) |
| Field Assistants | L. Rickarrdson |
| | R. Cherry (P/T) |
| Mechanics | T. Johnson |
| | D. McIntyre (P/T) |
| Wages Hands | 15 |

#### Petroleum Technology Section

| | |
|---|---|
| Toolpusher | E. Cherry |
| Drillers | T. Shanahan |
| | K. Huth |
| | J. Henry |
| Drill Offsiders | W. McDermott (P/T) |
| Drill Mechanic | J. Mesics |
| | J. Keyte |

#### Dept. Admin. Scrivces - Australian Surveying Office

#### Special Projects

| | |
|---|---|
| Surveyors | P. Boersma (P/T) |
| | L. Walter (P/T) |

| | |
|---|---|
| Technical Officers | I. Kaczorepa (P/T) |
| | J. Alp (P/T) |
| Chainmen | 2 |

Equipment

| | |
|---|---|
| Recording system | TI DFS-IV |
| Camera | SIE TRO-6 |
| Geophones | GSC 20D 8 Hz, 1280 units |
| Cables | SCG-5, 265 m, 18 units |
| Switch gear | I/O ROTALONG |
| Shooting equipment | I/O RFU |
| Transcievers | CODAN G424 SSB, 4 units |
| | PYE CAMBRIDGE FM 100, 6 units |

Vehicles

| | |
|---|---|
| Recording truck | Bedford 3 tonne 4 x 4 |
| Shooting truck | Bedford 3 tonne 4 x 4 |
| Workshop | International D1610 3 tonne 4 x 4 |
| Flat tops | 2 x International D1610 3 tonne 4 x 4 |
| Water tankers | 2 x International D1610 3 tonne 4 x 4 |
| Personnel carriers | Landrover SWB |
| | Toyota SWB |
| | Toyota Landcruiser Panel Van LWB |
| | Landrover Panel Van LWB |
| Geophone Carriers | 3 x Landrover LWB |
| Stores truck | International D1310 30 cwt 4 x 4 |
| Developing truck | International D1310 30 cwt 4 x 4 |
| Surveyors vehicles | 2 x Landrover LWB |
| Drills | 3 x MACK 8 x 6; Mayhew 1000 |
| Tankers | 3 x AEC Militant 6 x 6 |

Trailers

| | |
|---|---|
| Office caravan | 4-wheel |
| Kitchen caravan | " |
| Ablutions caravan | " |
| Explosives magazine | " |
| Workshop trailer | " |
| General purpose (2) | " |
| Drill trailer | " |
| Welding | 2-wheel |
| Generator | " |

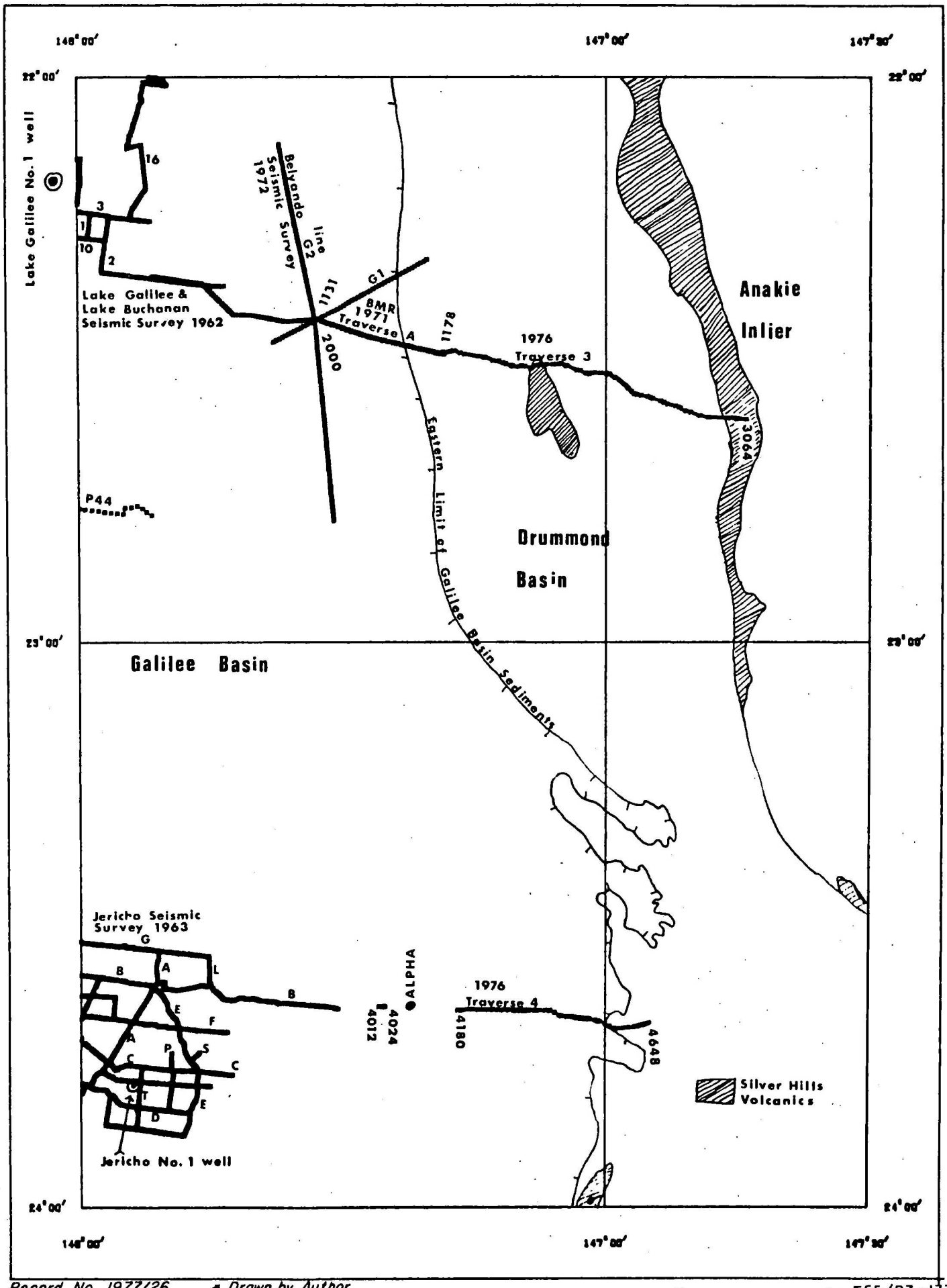
## APPENDIX 4

### SPREAD PARAMETERS

| | TRAVERSE 3 | TRAVERSE 4 |
|---|---|---|
| Geophone station interval | 83.33 | 83.33 m |
| Spread type | off end | split |
| Shot on trace | 1, 24* | 12 |
| Spread length | 0-1916.67 m | 916.67 m - 0 - 1000 m |
| No. of geophones/input channel | 16, 32* | 16 |
| Geophone pattern | SINGLE LINE<br>TWO LINES* | SINGLE LINE |
| Geophone spacing in line | 5 m | 5 m |

* ON RE-SHOT SECTION

SCALE 1 1000000.

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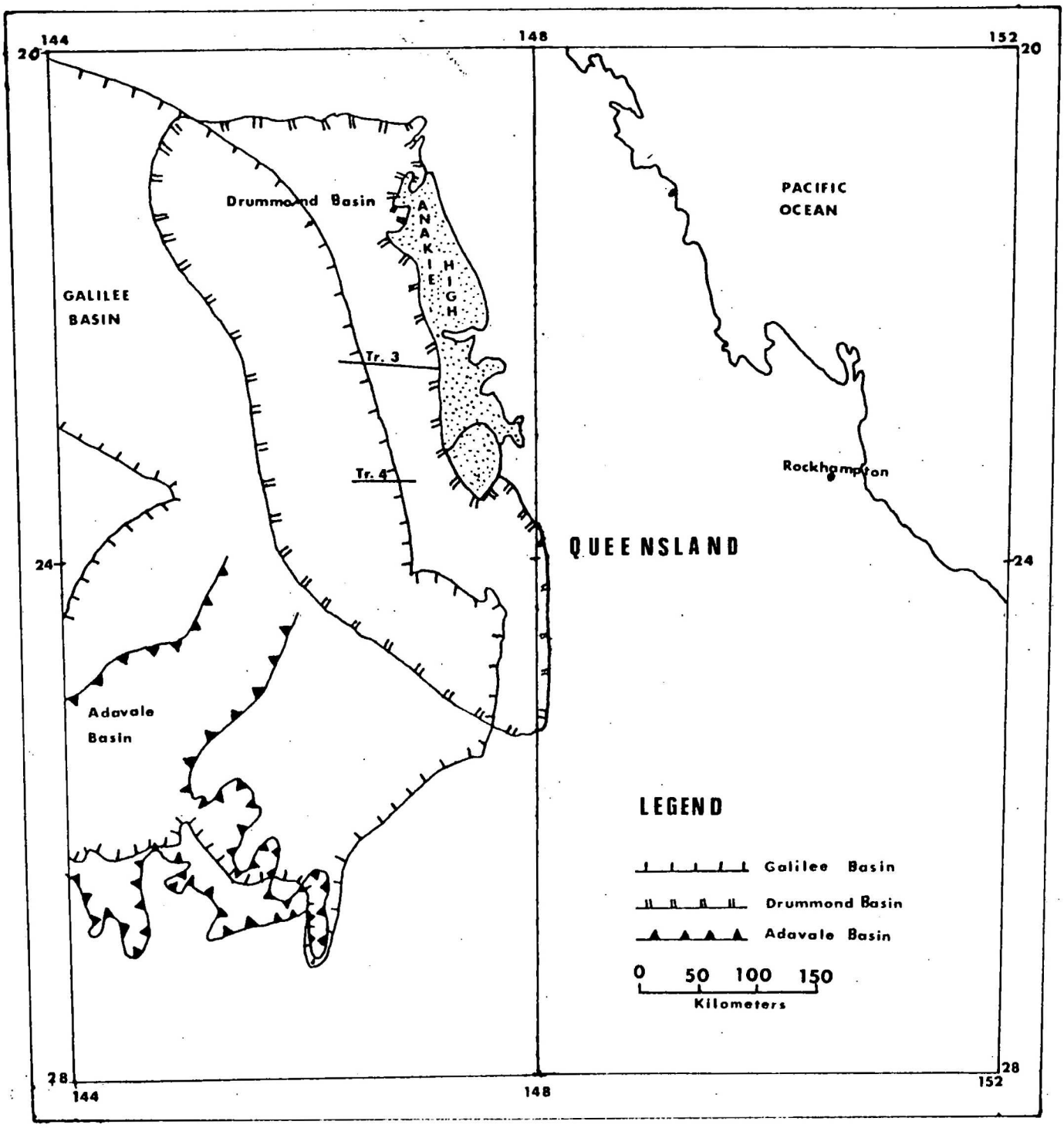
0 10 20 30 Km

F55/B3-133A

**LOCATION MAP** **Fig 1**




REGIONAL GEOLOGICAL SETTING Fig. 2

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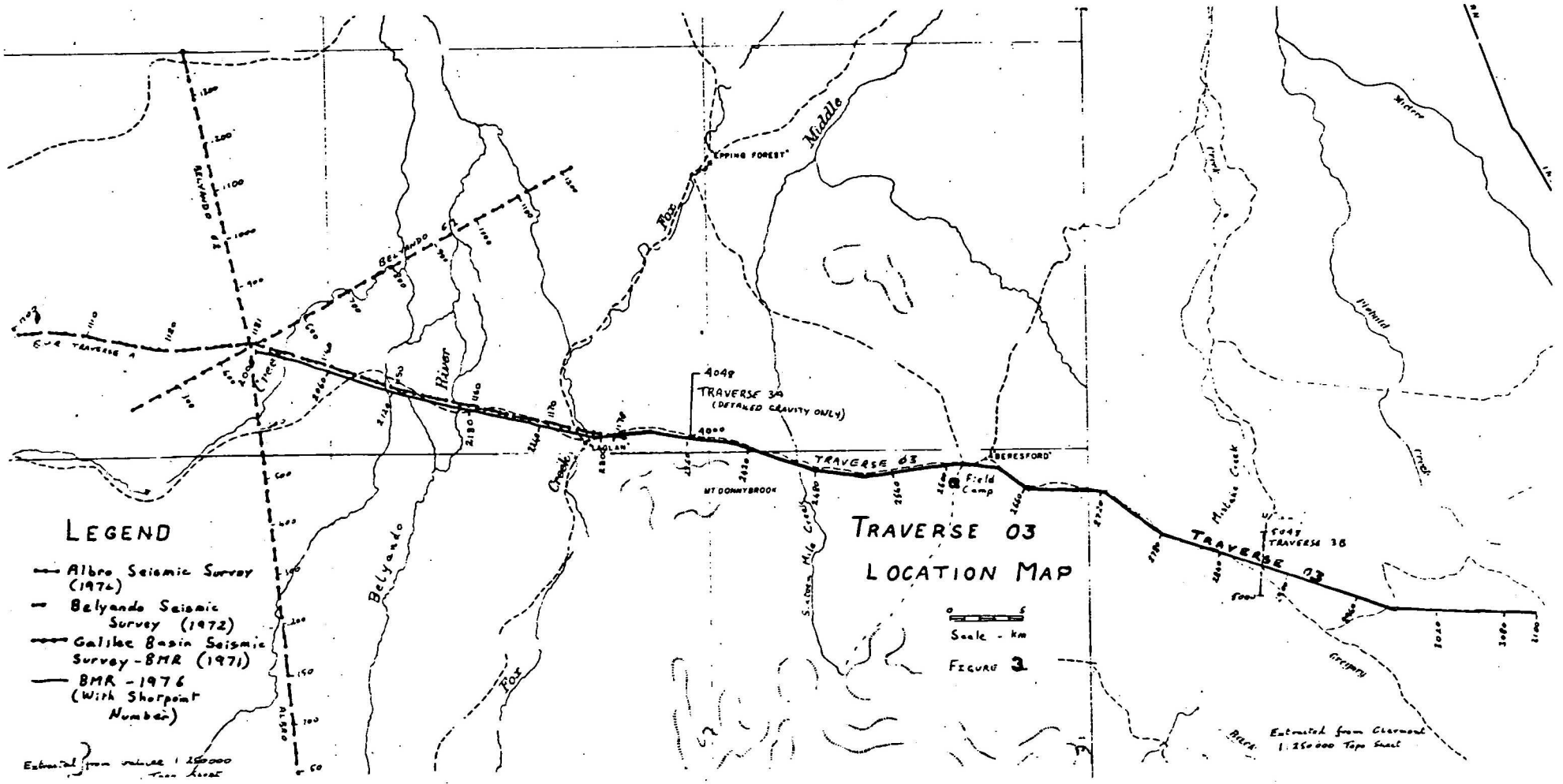


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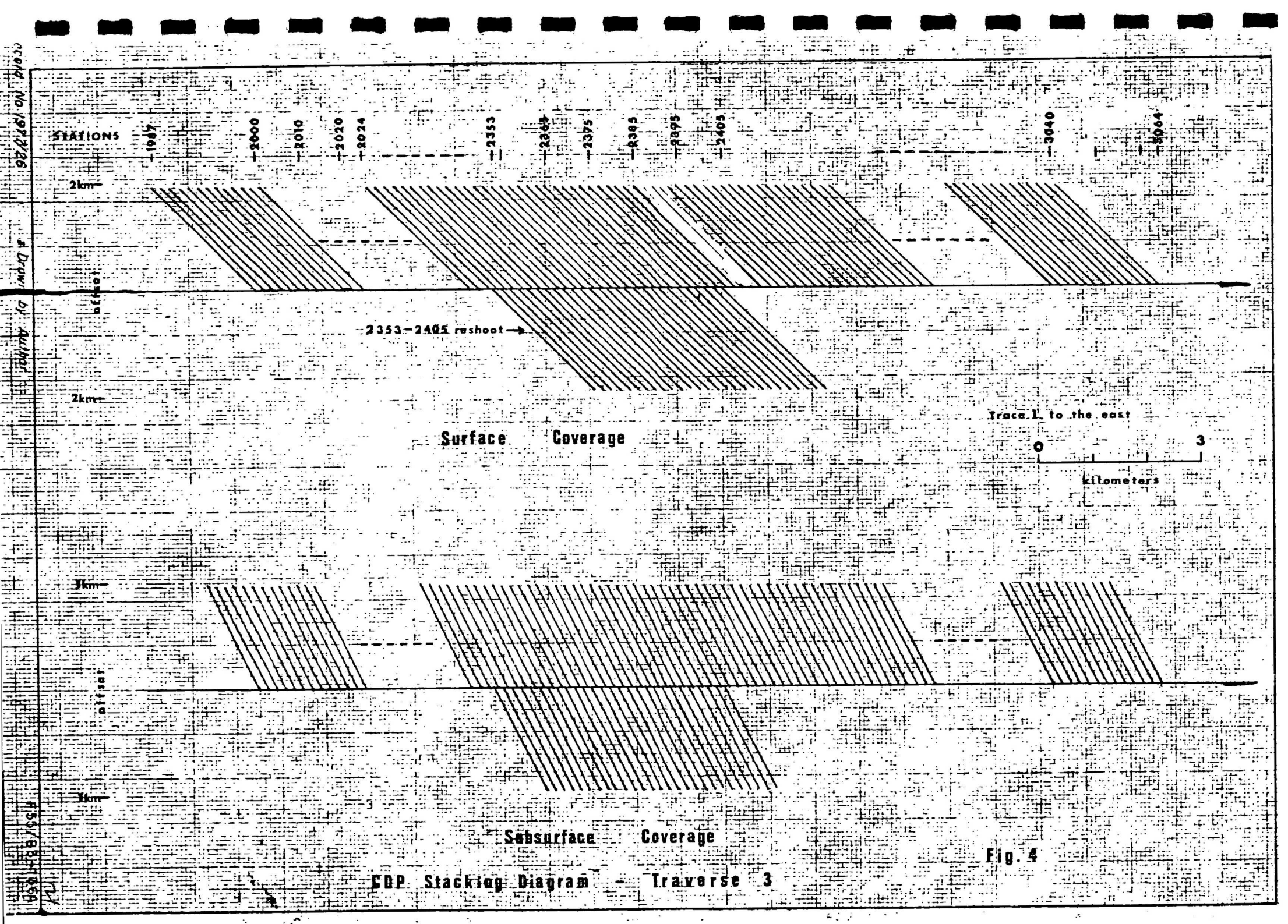


Fig. 4

CDP Stacking Diagram - Traverse 3

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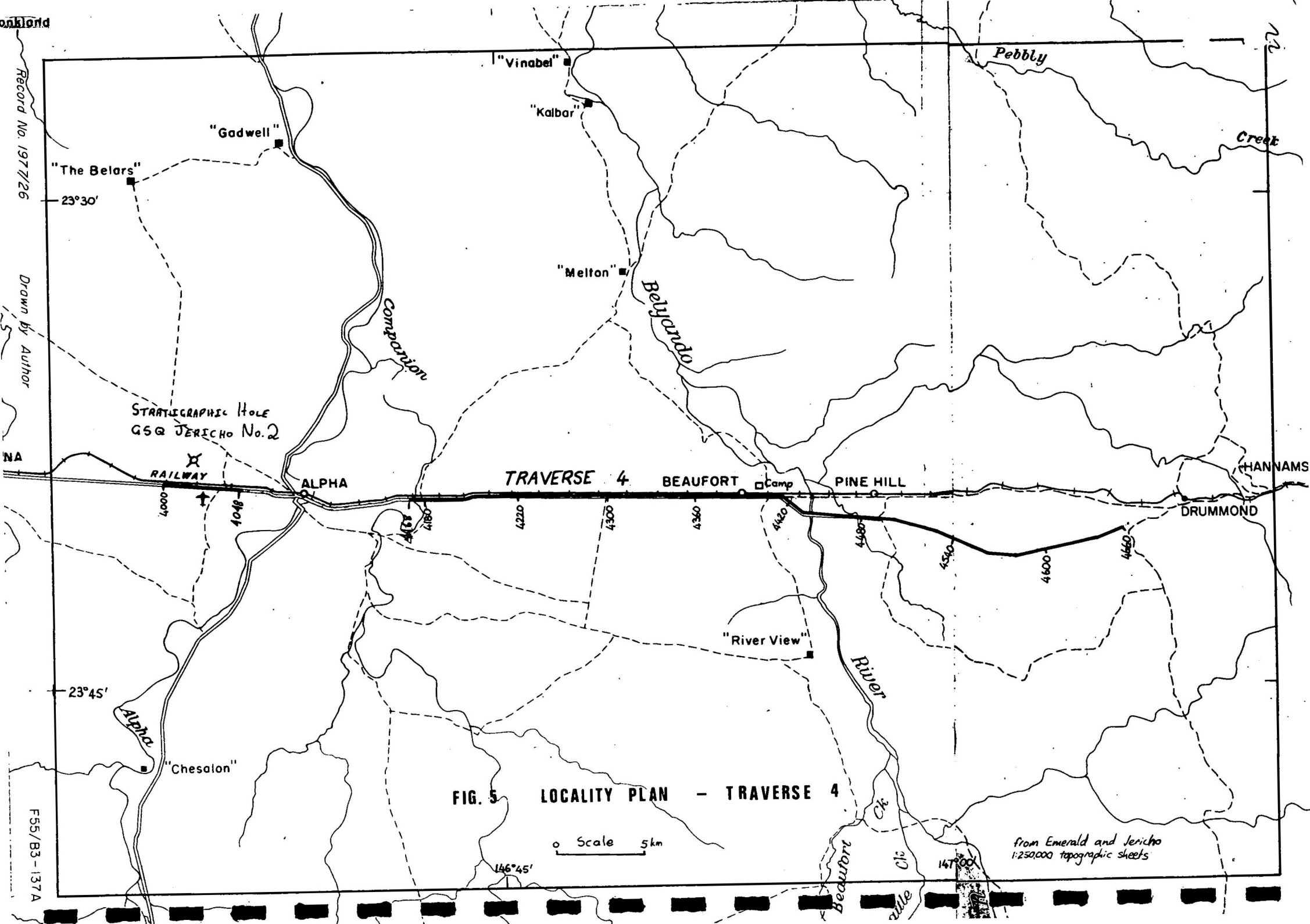
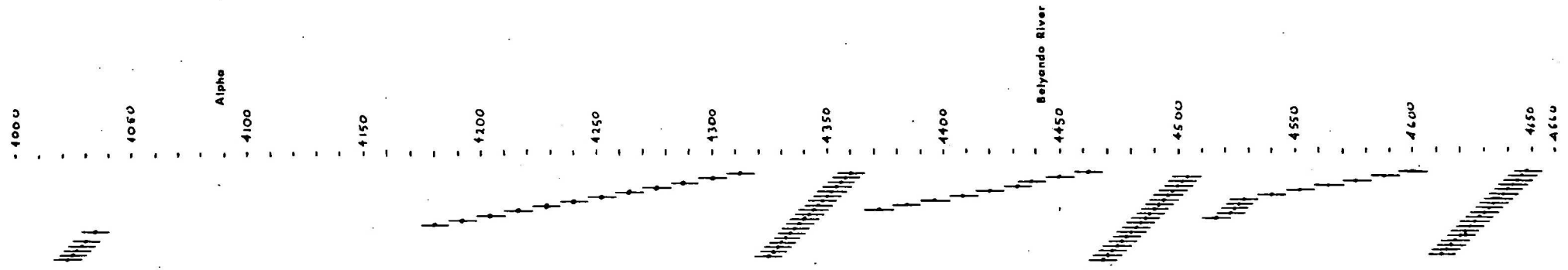



FIG. 5 LOCALITY PLAN – TRAVERSE 4




SUBSURFACE COVERAGE

TRAVERSE 4

Fig. 6

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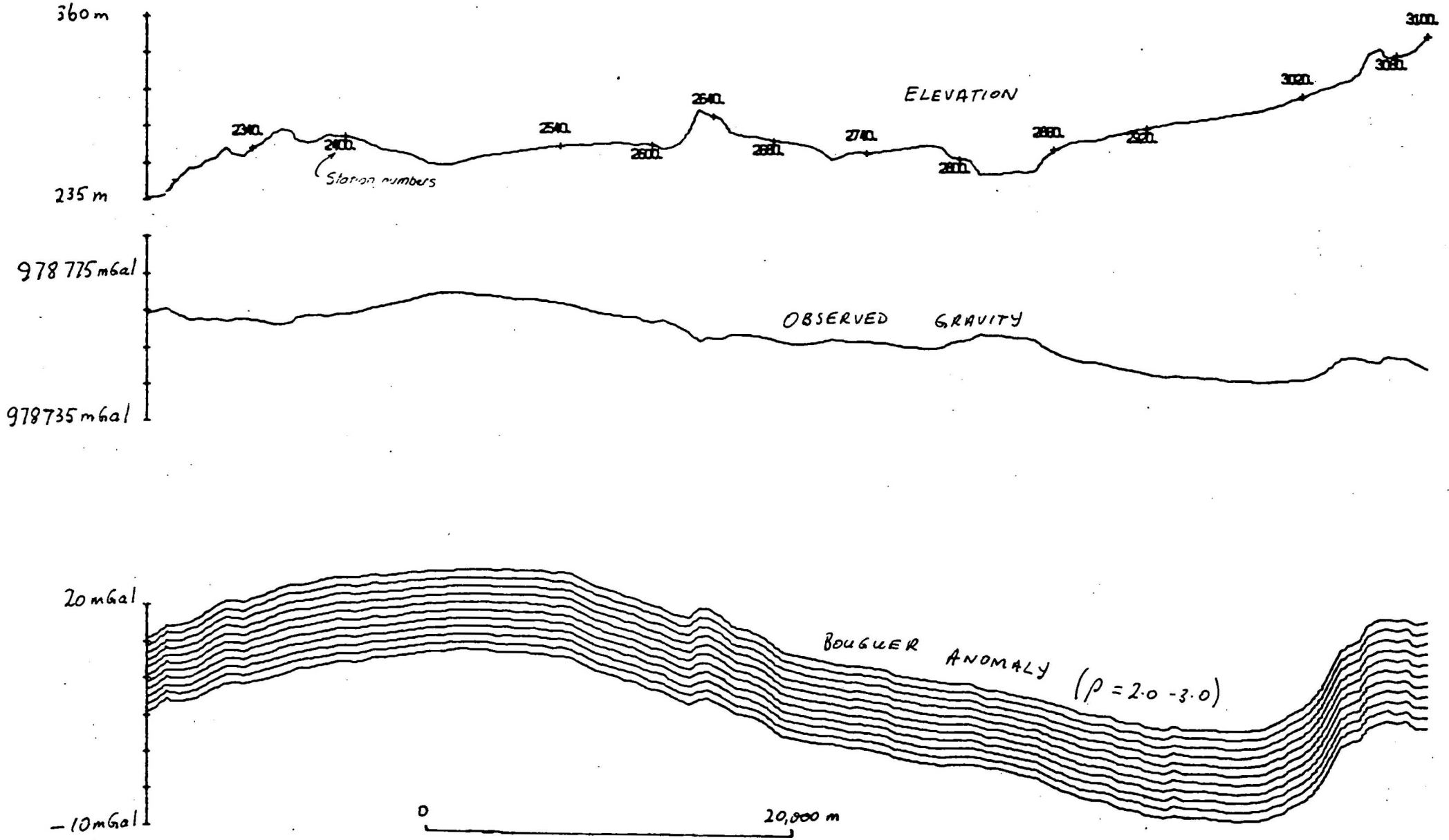
23




GRAVITY AND ELEVATIØN PRØFILES. TRAVERSE 3. Fig. 7

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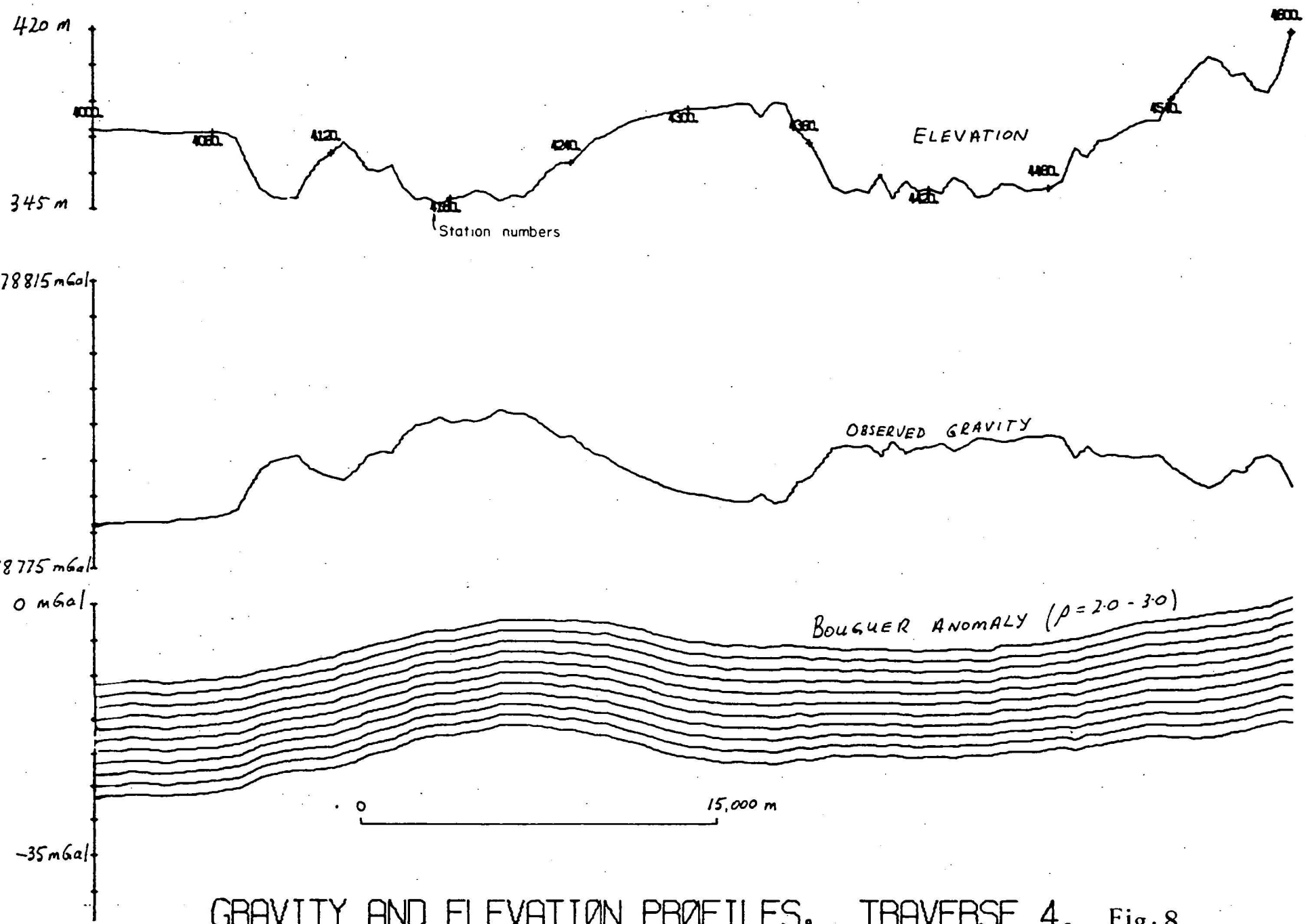


GRAVITY AND ELEVATIØN PRØFILES. TRAVERSE 4. Fig. 8

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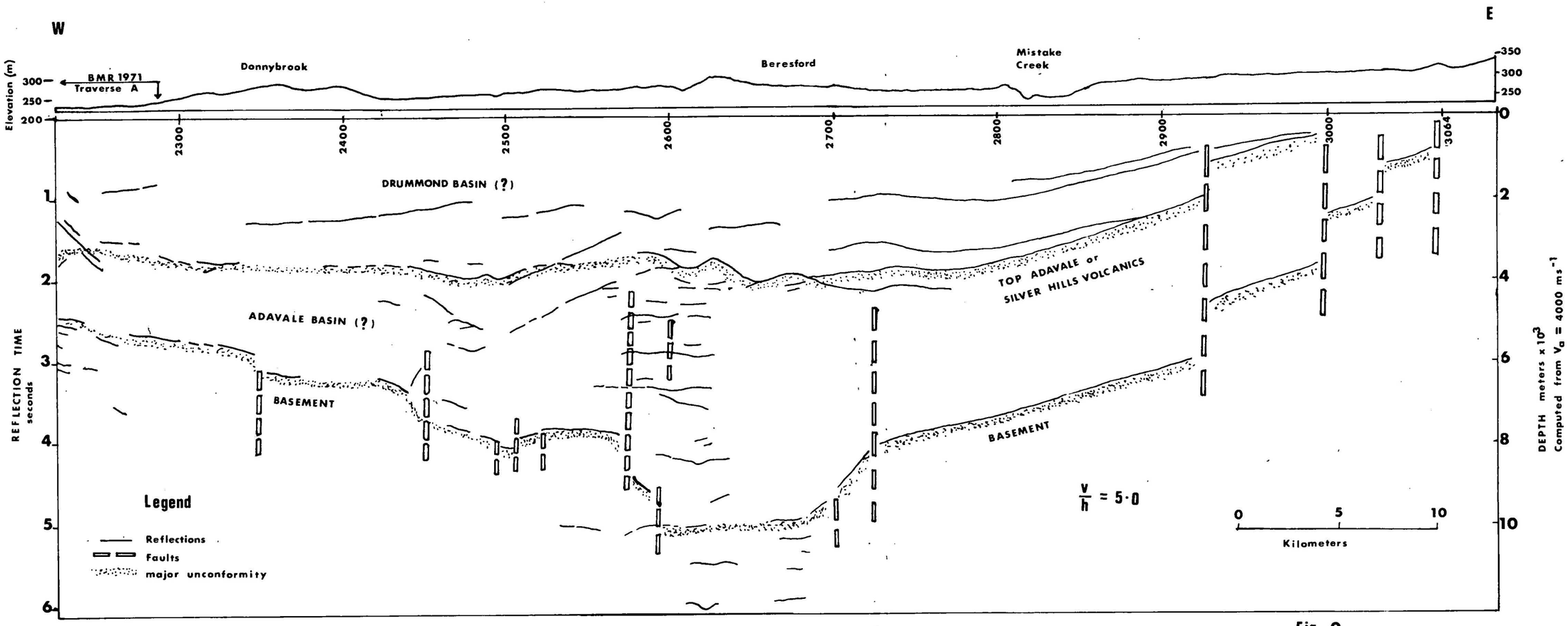


Fig. 9

TRAVERSE 3 FIELD INTERPRETATION

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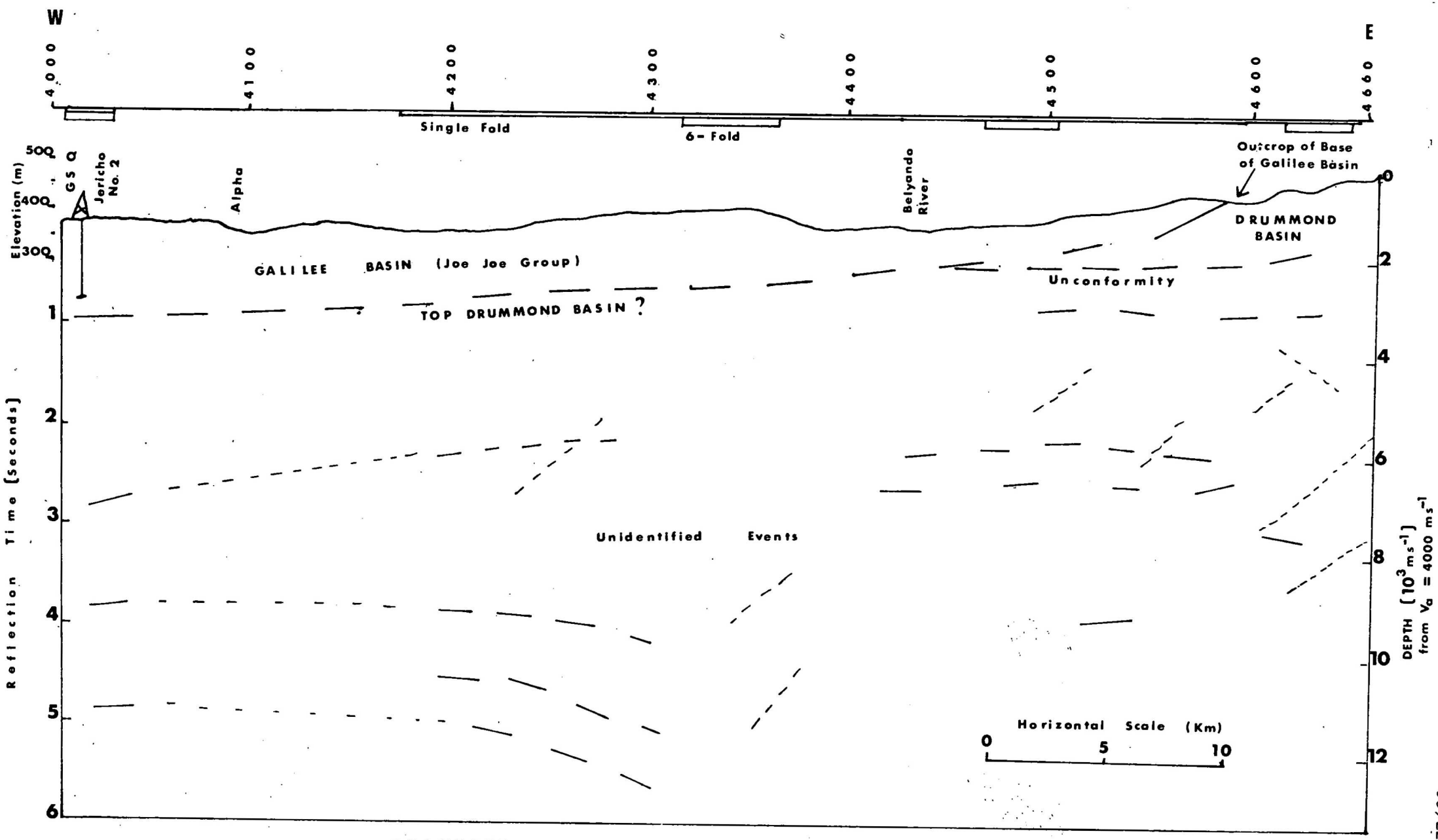


TRAVERSE 4 FIELD INTERPRETATION

Fig. 10

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