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AN INTERPRETATION OF GEOPHYSICAL OBSERVATIONS ON THE NORTHERN MARGIN OF THE EASTERN OFFICER BASIN

B.E. MILTON
A.J. PARKER

Department of Mines
South Australia

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DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
PETROLEUM EXPLORATION DIVISION

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by

B.E. MILTON
SENIOR GEOPHYSICIST

and

A.J. PARKER
STUDENT
SEISMIC GEOPHYSICS SECTION

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CONTENTS PAGE

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The major axis of the Eastern Officer Basin Bouguer gravity anomaly is displaced about 25 to 30 km north of the major axis of the magnetic basement trough associated with this basin (Fig. 1). During the Department of Mines seismic field season in 1972, some weeks were spent carrying out refraction and reflection profiling along the northern margin of the basin and although reflection results are somewhat indeterminate due to poor velocity information, a re-interpretation of the location of the northern margin of the basin appears necessary as a result of the seismic work. Although overthrusting of 'crystalline basement' along the northern boundary of the basin has been tentatively suggested as the reason for the displacement of the gravity and magnetic effects, the M.S.L. contour of the interpreted depth to magnetic basement has been arbitrarily chosen to represent the northern limit of the basin (Krieg, 1972).

Three north-south seismic refraction lines laid down south of the Everard Ranges in 1972 recorded a high speed refractor of 5.5 km/s on the northern section of the lines at a depth of between 100 and 150 m below surface and this is interpreted as originating from the southern extension of the granites of the Everard Ranges. A change in refractor velocity to 3.6 km/s occurs at about the

M.S.L. magnetic basement contour at the same depth as the high speed refracting horizon and is interpreted as a sedimentary event.

Reflection profiles shot along an east-west line a few kilometres to the south of this velocity change show a reflection section similar to that obtained in the vicinity of Conaus, AusSun, Exoil, Transoil well Munyarai No. 1 and indicate the presence of flat lying sediments to a depth of about 4500 m. Two north-south reflection lines were then shot from the east-west profile to the refraction lines and a consistent reflector at a depth of nearly 1400 m below M.S.L. plotted north to the high speed refractor. This reflection has a small amount of northerly dip over the 9 km for which it has been plotted. Deeper reflections are also present on the records, but are not of good enough quality to use for accurate depth determinations, the deepest being between 4500 and 5000 m below M.S.L. Over the granite, the record quality deteriorates, but partial reflections appear on a number of the seismograms below the granite and suggest a continuation of the horizons recorded to the south. Disagreement is also evident between seismic and magnetic interpretation on the EO line (Moorcroft, 1969) which intersects the Munyarai structure. Seismic reflectors over the northern 8 km of this line show persistent northerly dip with the deepest reflection at about 2.7 secs (two-way time; 270 m datum) which could originate from a horizon at a depth in excess of 6000 m, while the magnetic basement contours in the same region have a southerly dip of more than 600 m at a depth of 4500 m.

An examination of the anomalies on which depths to magnetic basement were calculated reveals that those north of the M.S.L. contour are classified as 'intra-basement', while those to the south are 'supra-basement' (Steenland, 1965). The patterns of total magnetic intensity to the north of this contour show much greater disturbance than those to the south, while ground magnetic profiles show a large, distinctive anomaly at the change of refraction velocities on each north-south line. This is taken as evidence that magnetic effects to the north originate from shallow granite, while those to the south originate from a deeper magnetic basement, and that interpreted depths from both origins have been contoured as one horizon.

Quantitative interpretation has been undertaken on a north-south Bouguer gravity profile using the seismic depths, density information from Munyarai No. 1 and seismic velocities, and part of the magnetic basement depth profile, and a postulated basin section constructed to account for the geophysical data (Fig. 2). A modified interpretation of the magnetic basement contour plan has also been prepared, which places the magnetic and gravity features in coincidence (Fig. 1).

The model chosen for calculation of theoretical Bouguer gravity values results in a close coincidence with the observed profile over the section of interest. It was constructed by placing horizontal sheets on top of each other, calculating the gravity effect of each at the surface and summing the results, as shown in Figure 2. The southern section of the model is in agreement to a depth of 5000 m with depths to magnetic basement calculated by

Steenland, but to the north magnetic values decrease while model depths continue to deepen. This is in agreement with the limited seismic data available.

To account for the reversal of slope of the Bouguer profile at latitude 27°20'S, a granite overthrust is inferred, with the slope of the thrust plane about 10° towards the north. This continues for 15 km, where there is a sudden decrease of the thrust slope, which accounts for the flattening of the Bouguer anomaly curve. The steepening of the gravity profile 55 km to the north is accounted for by the assumed northerly limit of the sediments.

A density contrast of 0.45 g/cm^3 was assumed between the sediments of the basin and the granite and basement rocks for purposes of calculation. This was based on the density measurements of core from Munyarai No. 1, which gave an overall value of 2.3 to 2.4, and the values estimated from seismic velocities for granite and basement of 2.7 to 2.8 g/cm^3 (Nettleton, 1970).

Further evidence for an overthrust was supplied by the results of ground magnetic values read along the seismic lines. An abrupt change in the character of the magnetic profile takes place at the change in seismic refraction velocities. Calculations made on a distinctive anomaly at this locality are in agreement with the gravity interpretation. Using an infinite dyke model, the estimated depth to the top is 300 m below surface (M.S.L.), the thickness 1000 m and the model has a shallow dip to the north, all these features corresponding with the top horizontal sheet of the overthrust as conceived for the gravity model.

This model analysis has resulted in a basin section similar to that conceived for both the Amadeus and Ngalia basins. Overthrust faulting along the northern margins of these basins and the consequent extension of sediments under basement rocks is recognised as contributing to the northern displacement of the gravity depression relative to the basin axis in each case, but this has not been generally considered sufficient to explain completely the phenomenon (Brown, 1970). The model here proposed to account for a similar displacement in the Eastern Officer basin does so by a consideration of the density contrast between the sediments of the basin and the igneous/metamorphic rocks of the basement and overthrust, with no additional effect from postulated intra-basement density changes required.

The age of the overthrust appears to be at least post-Ordovician and the situation along the northern margin similar to that created along the northern margin of the Amadeus basin in the Alice Springs orogeny. Further evidence to test the validity of this concept will be sought during the Department of Mines 1973 seismic field season.

B.E. Milton

8.2.73

B.E. MILTON
SENIOR GEOPHYSICIST

and

John Parker

A.J. PARKER
STUDENT
SEISMIC GEOPHYSICS SECTION

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Krieg, G.W., 1972. Explanatory Notes for the Everard 1:250 000 Geological Map. Dept. Mines unpublished report. R.B.72/121.

Moorcroft, E., 1969. Seismic Reflection, Refraction and Gravity Survey, Eastern Officer Basin, 1966. Min. Rev. Adelaide, 126: 58-70.

Nettleton, L.L., 1970. Eastern Officer Basin Gravity Survey P.E.L. 10 and 11, South Australia. Rept. by Geophysical Associates Pty. Ltd. for Murumba Oil N.L. (S. Aust. Dept. of Mines open file Env. 1196 - unpublished).

Steenland, N.C., 1965. Eastern Officer Basin Aeromagnetic Survey O.E.L. 28, S.A. Rept. by Adastra Hunting Geophysics Pty. Ltd. and Geophysical Associates Pty. Ltd. for Exoil Pty. Ltd. (S. Aust. Dept. of Mines open file Env. 527 - unpublished).

Appendix 'A'

Results of interpretation of ground magnetic profile on seismic line EK.

A regional gradient was removed from the magnetic profile, and the resultant anomaly examined by three methods based on thin dyke like bodies to obtain (i) depth to top of the dyke, (ii) thickness and (iii) dip.

1. Reference: Grant, F.S. & West, G.F., 1965. Interpretation Theory in Applied Geophysics. McGraw-Hill Book Co. p319.

   (i) Step model: depth to top of dyke 300 m

2. Reference: Bruckshaw, J.M. & Kunaratnam, K., 1963. The Interpretation of Magnetic Anomalies due to Dykes. Geophysical Prospecting Vol. XI No. 4 p509.

   (i) Depth to top: range from z = 240 to 690 m
   $\bar{z}$ = 438 m
   RMS z = 461 m

   (ii) Thickness: for $\bar{z}$, t = 875 m
   RMS z, t = 923 m
   Range of t; 488 to 1372 m

   (iii) Dip: 6° towards N

3. Reference: Moo, J.K.C., 1965. Analytical Aeromagnetic Interpretation. The Inclined Prism. Geophysical Prospecting Vol. XIII No. 2 p203.

   (i) z = 259 to 335 m

   (iii) Dep 15° to N

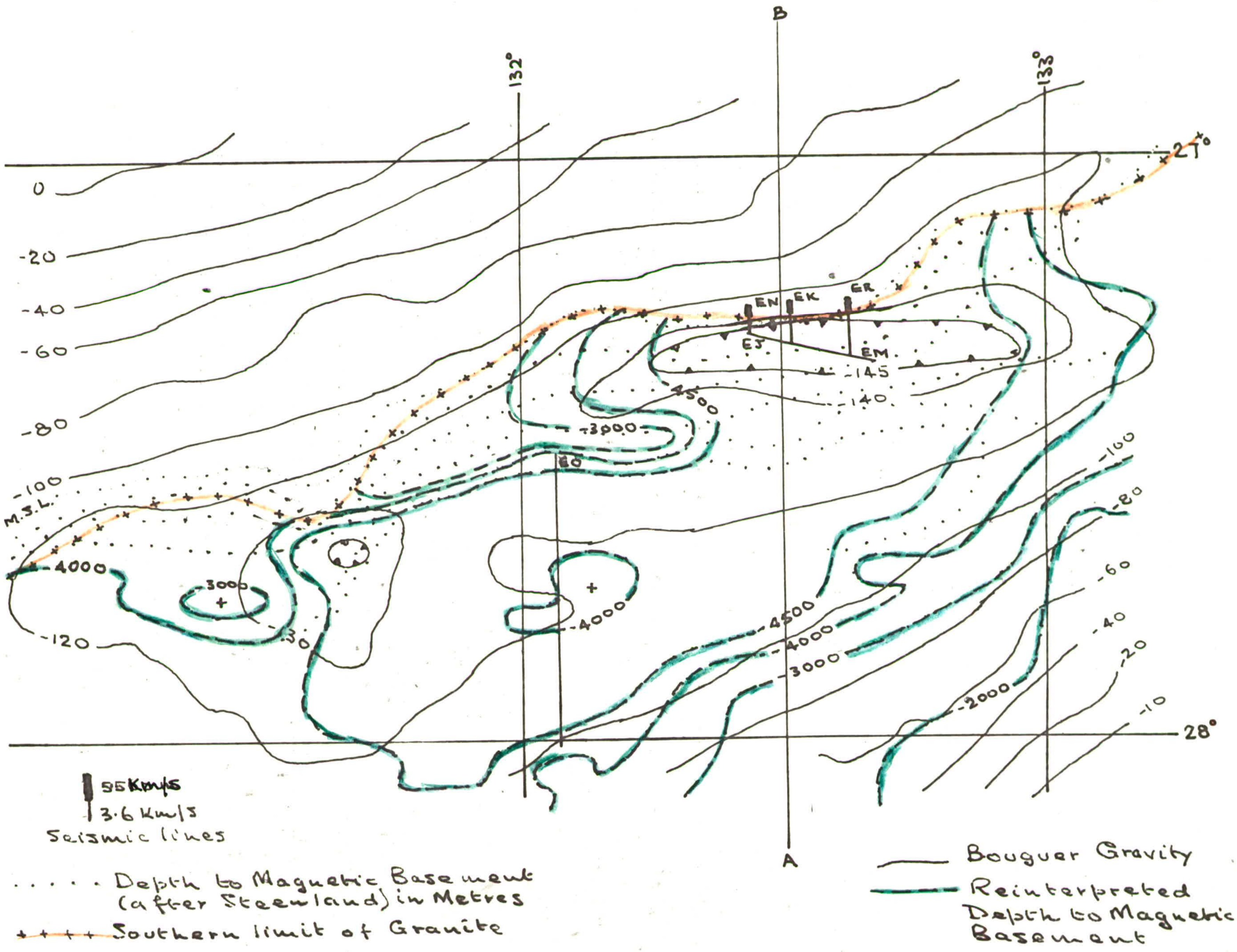

Fig. 1 EASTERN OFFICER BASIN - Contours of Bouguer Gravity and Depth to Magnetic Basement

Scale 1:1 000 000

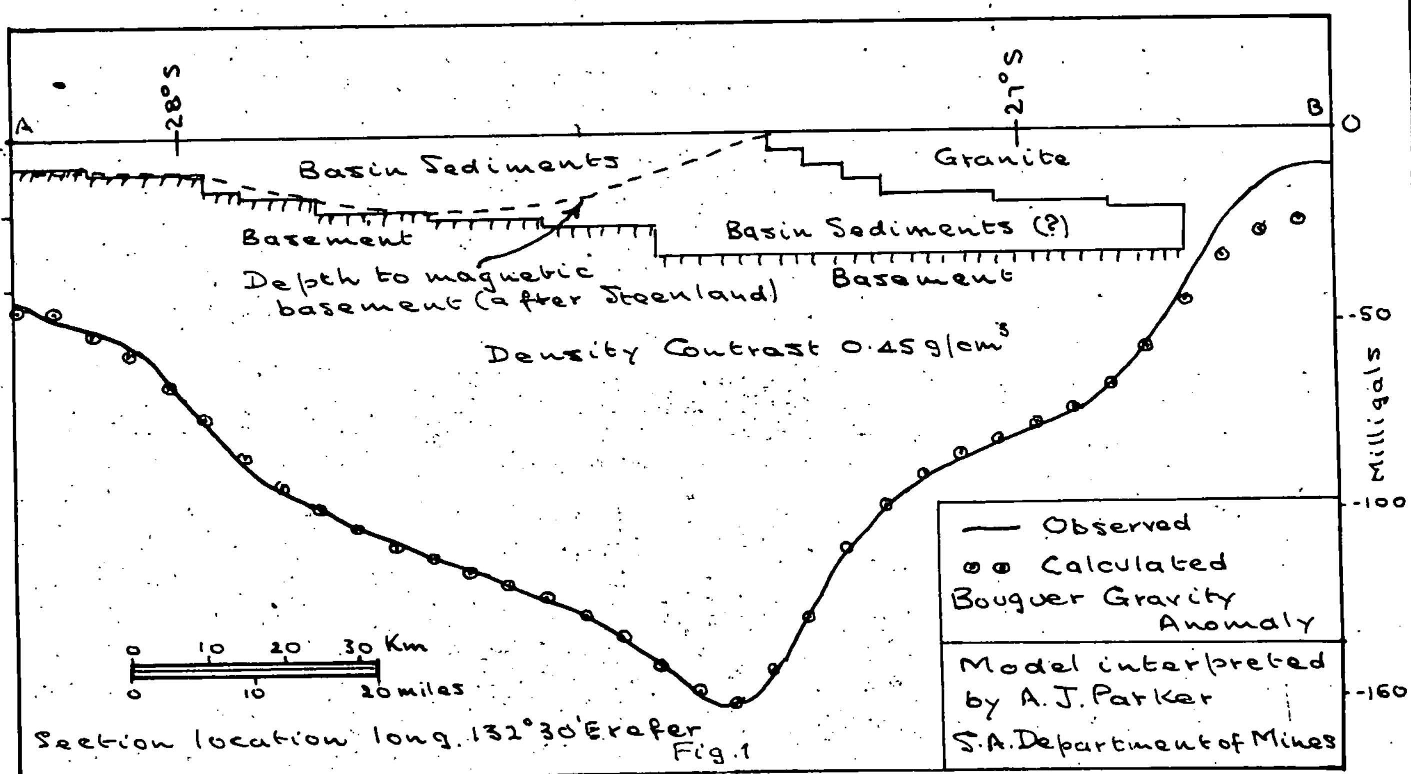

Fig. 2 EASTERN OFFICER BASIN – Gravity Profile Observed and Calculated from Basin Section Model

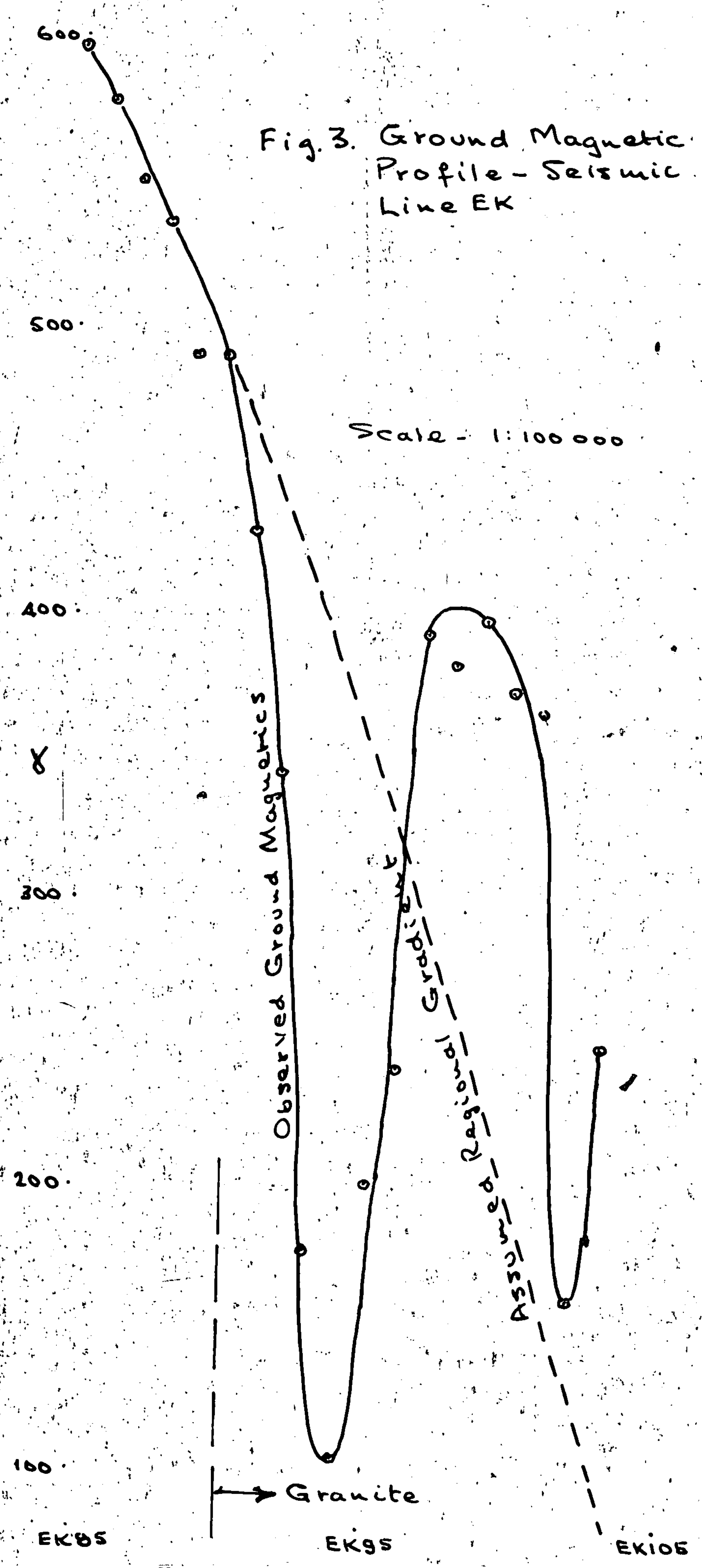

Fig. 3. Ground Magnetic Profile - Seismic Line EK
Scale - 1:100 000
600
500
400
300
200
100
γ
Observed Ground Magnetics
Assumed Regional Gradient
Granite
EK85
EK95
EK105