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Deep Sedimentary Basin below Northern Skye and the Little Minch

THE existence of a negative gravity anomaly of amplitude about 20 mgal below northern Skye was first pointed out by Tuson[1], who interpreted it as being due to a sedimentary basin bounded at its NE margin by a large NW–SE fault. Our recent geophysical work confirms the existence of this basin, defines its margins more accurately, and provides evidence for the age of the infilling.

Fig. 1 shows the Bouguer anomaly map of the region, compiled from marine and land surveys by the Institute of Geological Sciences and detailed traverses on the Trotternish peninsula by the University of Glasgow. The gravity reaches a minimum of about 6 mgal on Trotternish, in the area of the Glasgow seismic profiles 1 and 2, whereas the extremely steep gradient off the coast of Harris continues south parallel to the landward coastline of the Outer Isles about as far as South Uist. Thus the basin seems to be deepest below northern Skye, and to be bounded on its NW side by a large normal fault, which we shall call the Minch Fault, without implying agreement with Dearnley's hypothesis[2] of transcurrent movement. North-west of the Minch Fault there is a contribution to the gravity peak from Lewisian rocks of abnormally high density. On Harris, gravity falls off slowly to the NW owing to increasing granitization of the basement.

Marine refraction surveys in the Minch have been carried out by IGS and Glasgow. The two IGS lines xx′ and yy′ shot over the west of the basin give the following mean structure: 200 m of material of P-wave velocity 3.0 km s^{-1}, overlying 1 km of rock of velocity 3.9 km s^{-1}, overlying rock of velocity 4.8 km s^{-1}. The first two layers are presumed to be of Mesozoic age, overlying the third of Torridonian. Two NW–SE refraction lines between Trotternish and Harris shot by Glasgow in 1971 were mostly unsuccessful, because of energy transfer problems caused by the intrusive igneous rocks which 850 km of sparker and magnetic traversing show to outcrop over more than half the area of the sea bed north

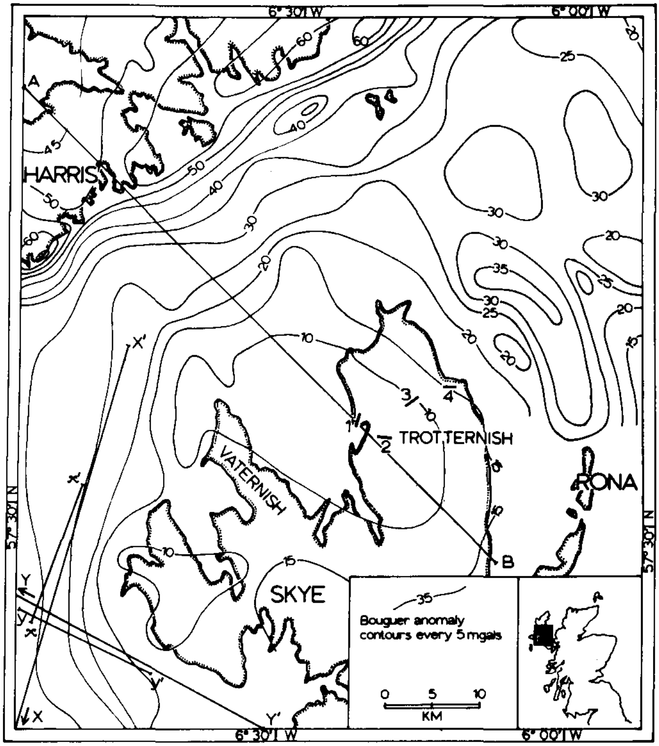

Fig. 1 Bouguer anomaly map of the Little Minch—northern Skye area. AB, Line of section (see text); XX′, YY′, IGS marine reflexion profiles; xx′, yy′, IGS marine refraction profiles; 1–4, Glasgow land reflexion profiles.

of Skye. Preliminary deep reflexion experiments were, however, more promising, and a programme of deep marine reflexion seismic work is planned for summer 1972.

Deep marine reflexion profiles have been obtained for IGS along tracks XX′ and YY′ beside their refraction lines. Profile YY′ is reproduced in Fig. 2. Application of the IGS refraction velocities to these reflexion profiles shows that the maximum thickness of layer with a velocity of 3.0 km s^{-1} is about 300 m, and the maximum thickness of the layer with a velocity of 3.9 km s^{-1} is about 2.5 km.

Seismic reflexion work was carried out on Trotternish by Glasgow during summer 1971, using a twelve-channel analogue recorder. Three of the four surveys, shot on Jurassic outcrop, were designed to produce velocity-depth sections, whereas the

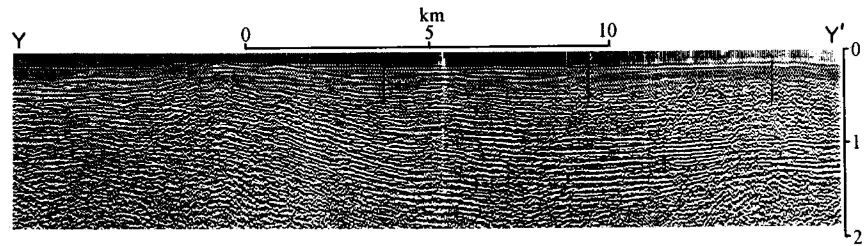

Fig. 2 Deep reflexion profile YY′. Vertical scale: two-way travel time.

last (No. 3 on Fig. 1) was a short length of continuous profile shot on the Tertiary lavas in an attempt to locate the NW–SE fault postulated by Tuson. About 120 useful shots, each using 1 to 1.5 kg of gelignite, were fired, and reflexions were obtained down to nearly 3 km.

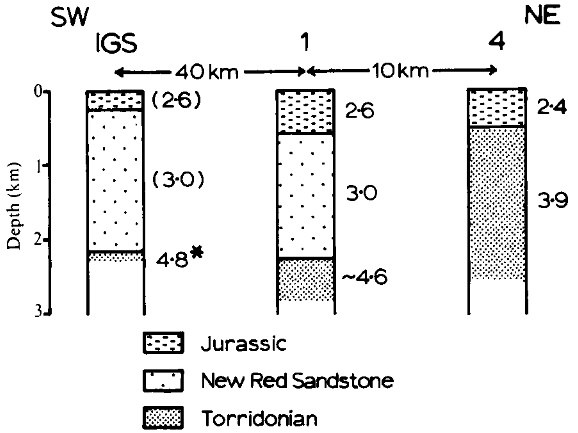

Fig. 3 Interval velocity against depth for Glasgow profiles 1 and 4, and maximum thicknesses from IGS work west of Skye. Geological interpretation shown by ornament. Brackets, assumed velocity from profile 1; *, IGS refraction velocity.

Fig. 3 shows interval velocity plotted against depth for profiles 1 and 4, together with the geological interpretation. The third column shows the maximum thicknesses obtained from the IGS marine reflexion profiles when the interval velocities from Glasgow profile 1 are used instead of refraction velocities. Profiles 2 and 3 give similar results to profile 1. The top layer is interpreted in each case as Jurassic, and the bottom layer as Torridonian, the base of which was probably not reached. It is acknowledged that this layer may include Upper Palaeozoic rocks of similar physical properties. On profile 1 the intermediate layer, whose base is an excellent seismic reflector, is interpreted as New Red Sandstone. This accords with Tuson's view and agrees with recent sedimentological evidence proposed by Steel[3] for the existence of a complex Mesozoic–Upper Palaeozoic trough in the Minch. 350 new gravity readings observed by Glasgow in traverses across Trotternish also support this inference. The SE–NW trending gradient is steeper (up to 3 mgal km^{-1}) than Tuson's forty or so observations permitted him to determine, and the base of the anomaly is flatter.

The difference between layer velocity values obtained by Glasgow and the otherwise similar IGS results in the west is probably related to the difference in methods of measurement (reflexion and refraction respectively). Similar thicknesses of the intermediate (?N.R.S.) layer are deduced for both sites (see Fig. 3). Fig. 4 is an attempt to synthesize the data into a section along line *AB* of Fig. 1. The regional gradient has been estimated from values over the Lewisian basement near the ends of the profile, on Lewis and on South Rona. A two-dimensional approximation has been used for the gravity calculation, for there is insufficient seismic control to justify greater sophistication. Densities are based on work by Tuson[1]. The effect of a denser basement (a contrast of 0.14 g cm^{-3}) in the east of Harris is small. The granite shown in the model (a contrast of -0.16 g cm^{-3}) is a very schematic representation of the granitization to the west of Harris, but

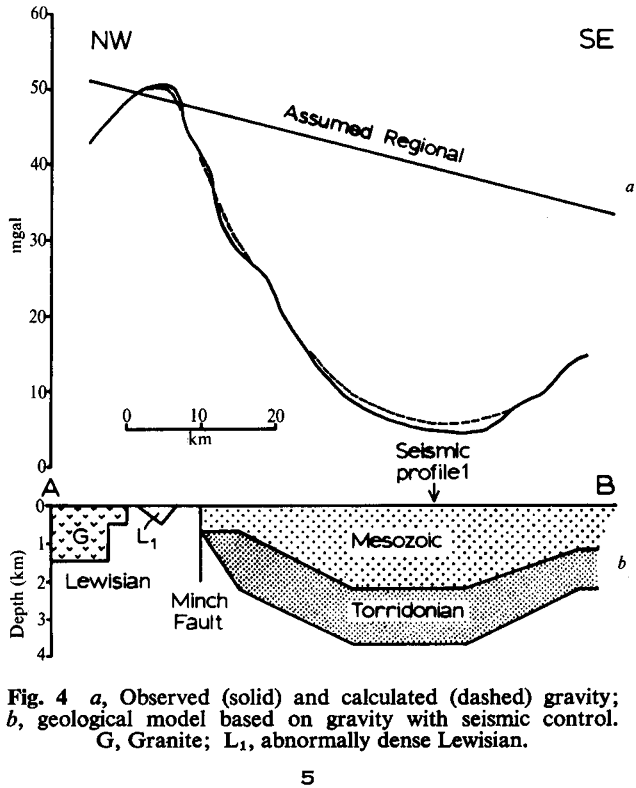

Fig. 4 *a*, Observed (solid) and calculated (dashed) gravity; *b*, geological model based on gravity with seismic control. G, Granite; L_1, abnormally dense Lewisian.

it shows that there is no difficulty in accounting for the observed fall of gravity towards the west. A wide range of density contrasts for the Mesozoics is possible; the value of -0.31 g cm^{-3} was chosen during work on other profiles in the Minches where more seismic reflexion control was available. Apart from the single point where Glasgow reflexion profile 2 fixes the depth to the Torridonian, it is not in general possible to separate the effects of variation in thickness of the Mesozoic layers and the Torridonian; the latter is assumed to have an appreciable density contrast with Lewisian basement (-0.12 g cm^{-3}). Fig. 4 therefore shows only one of many possible models. The Mesozoic layer thins to both north and south, and it is this which causes most of the gravity basin effect. The model of Fig. 4 presents a grossly simplified picture of what in reality must be a very complicated geological section. In particular, the Minch Fault is represented here as a simple normal fault, but evidence being collected by IGS indicates it to be a complex fault zone in which Palaeozoic and Torridonian rocks may be incorporated.

The northern Skye–Little Minch basin is one of a chain of deep sedimentary troughs extending up the west coast of Britain and across the continental shelf[4] west of the Orkneys and Shetlands. Geological control on the interpretation of its probable infilling is comparatively good, and Skye itself is a convenient platform for detailed geophysical work. The Minch Fault, bounding the NW side of the trough, is probably typical of the NNE trending faults controlling deposition on the shelf west and north of Scotland, and its position, as deduced from gravity evidence, suggests a close relationship to the Outer Isles Thrust. There is no evidence from our geophysical data for the existence of a transcurrent Minch Fault in the Little Minch. The NE margin of the basin is bounded at depth by a NW or NNW trending fault; faults of this trend seem to have been important in the early Mesozoic[3], but to have had no discernible effect on the development of Jurassic or later sediments. The basin's margins to the south and SE are ill-defined. Such asymmetry appears to be characteristic also of the North Minch basin[5] and of basins *C* and *G* (refs. 4, 6) west of the Orkneys.

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