# Gravity Indications of Deep Sedimentary Basins below the Norwegian Continental Shelf and the Vøring Plateau* A Discussion

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A recent publication by Grønlie & Ramberg (1970) invites some critical comments. From an analysis of gravity data, the authors indicate the existence of three sedimentary basins on the Norwegian continental shelf and Vøringplatået. The largest basin has a maximum depth of 7000/10000 m, depending on the density contrast used (p. 386). These figures are in striking agreement with other geophysical results (Åm 1970, pp. 51 and 57). The authors also conclude that 'the outline of the basins seems related to the occurrence of ridges parallel to the NNE Caledonian direction' (p. 375). In the following discussion it will be shown that these conclusions are based on somewhat doubtful assumptions and arguments.

In order to study the gravity field which is presumed to be due to the sedimentary basin known to exist below the shelf, the regional field has to be removed. To determine a correct regional field, however, is extremely difficult in areas situated at the transition between continental and oceanic regions. Since the final result (form and thickness of the sediments) strongly depends upon the regional field chosen, a sophisticated quantitative interpretation cannot be made. However, if such an interpretation is attempted, a thorough discussion leading to a suggestion of the most probable regional field would be expected. What then do we find? 'As a first assumption we have assumed the whole negative low (see Fig. 4, profile AA′) to be caused by the surface sedimentary deposits. We have *therefore* assumed that *the smoothed gravity profile along the geotraverse* (profile AA′) gives the most correct regional field' (p. 382, present author's italics). This is actually no argument at all. The authors will surely agree that there is a difference between the regional field in profile AA′ and e. g. CC′ (Fig. 3). One might also wonder what regional the authors would have chosen if the geotraverse happened to be somewhere else. A more reasonable choice of regional for each of the profiles would give much smaller depths.

The lack of sediments on the shelf revealed by the isostatic anomalies (Figs. 5 and 7) is remarkable. However, the use of isostatic anomalies based on the Airy concept p. 382 is rather doubtful in this case since it assumes a crust of constant average density. A more likely isostatic correction, taking into account the existence of a large sedimentary basin on the shelf, would give much larger residual anomalies, and hence greater sedimentary thicknesses.

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In their interpretation the authors assume a uniform basement without density contrasts. From gravity work on land (e. g. Fig. 3, p. 380) it is seen that this is evidently not the case. The implication of this assumption is that where a dense body exists in the basement, the authors will tell us there is a basement ridge.

This leads us to 'the occurrence of ridges parallel to the NNE Caledonian direction' (p. 375). Since the Bouguer anomalies are 'preferred on the shelf' (p. 388), the ridge neatly drawn in the continuation of Lofoten (Fig. 8b, based on isostatic anomalies) will not be considered. The 'dam' at the outer part of Vøringplatået (Fig. 8b) is probably all right, but it should be noticed that the main reason for choosing the 'correct' solution (Fig. 8b instead of Fig. 8a) was the seismic and magnetic evidence for a volcanic 'ridge' in this area (pp. 386 and 389).

The reason why a ridge has been drawn on the shelf in Fig. 8a is the positive Bouguer anomaly at 67°N, 8°E in Fig. 3. This anomaly is interpreted by the authors as being due to a basement ridge 'which seems to be a continuation of the Lofoten *trend*' (p. 389). As pointed out earlier, the basement is considered uniform and without density contrasts. However, it is stated that 'the positive isostatic anomalies in the Lofoten and Smøla regions (profiles AA′, BB′, DD′ and EE′) are probably due to the heavy intrusive rocks of these regions' (pp. 385–386). Why then do the authors not present a discussion ruling out the possibility that the 67°N, 8°E anomaly is most likely due to a heavy intrusive body?

Magnetic measurements show that the anomaly in question is associated with a highly magnetic body (Åm 1970, p. 55) which points to a basic intrusive. Neither the manetic nor the gravity data, however, are able to exclude the possibility that the top of this basic body forms a topographic high in the basement surface. As a matter of fact, Lofoten is known to form such a ridge, and there is also good evidence for a ridge associated with the northward extension of the 67°N, 8°E magnetic anomaly. (The reason why a ridge can be seen here and not further south is that the magnetic body is situated at a much shallower depth). Therefore, by analogy and extrapolation, the top of the heavy magnetic body in question is supposed to form a basement ridge.

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# Reply to Mr. Knut Åm

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We wish to thank Mr. K. Åm for giving us the opportunity to clarify points in our study that might not be apparent to everybody.

In our work (Grønlie & Ramberg 1970) we conclude that the gravity data indicate the occurrence of: (1) *three major sedimentary troughs* on the Norwegian continental shelf and the Vøring Plateau, and (2) *basement ridges* roughly parallel to the NNE Caledonian direction. The assumptions leading to these conclusions have been criticized by Mr. Åm. Of course few geophysical interpretations are unique without additional geologic and geophysical information. For this reason we have calculated two alternate interpretations based on different trends for regional gravity. Isostatic anomalies were calculated because of the extreme difficulty in distinguishing residual anomalies through the rapid variation in Bouguer anomalies near continental margins.

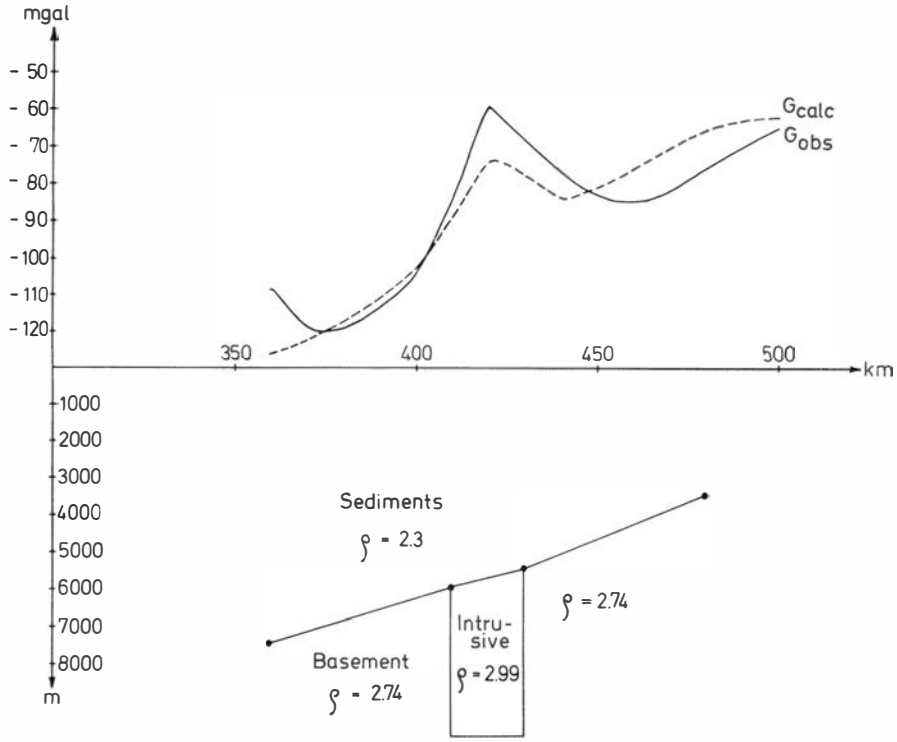


Fig. 1. Supposed intrusive in basement (density contrast 0.25 g/cm$^3$). Calculated gravity effect and gradient differs from residual gravity curve taken from profile DD′, Fig. 4 in the original paper.

Our use of isostatic corrections are in accordance with general practice. What Mr. Åm is suggesting is that we apply geologic corrections which implies that we know the sediment thickness and crustal composition. However, to find this was the aim of our study.

The Bouguer regional was chosen because it is the smooth continuation of the regional gradient found on land, because the profile is perpendicular to the isogal lines, and because the greater distance from coast to continental margin further north was assumed to be caused mainly by sediments. This assumption provided a solution of maximum thickness. The two models should represent the extreme plausible values for an interpretation, as stated in our conclusion (p. 388).

Mean density values were used in our regional study and this is common practice in almost all gravity interpretations. This does *not* imply that we believe the basement to have no density variations (pp. 385–386). We have calculated a model (Fig. 1) to shed more light on our postulated ridge at 67°N, 8°E. Even with a large density contrast (0.25 g/cm$^3$) and a body 10 km deep we failed to come close to the observed anomaly. In order to match the anomaly and gradient we have to assume a topographic ridge. Comparisons with the Lofoten ridge supports this assumption and if the average density of the Lofoten rocks (2.75–2.85) is used, the topographic relief will be even higher.

We are pleased to see that Mr. Åm acknowledges the possibility of a ridge where he previously showed 7 km of sediments (Åm 1970, p. 57). However, he is correct when stating that neither the magnetic nor the gravity data can uniquely solve the ridge problem. But we seem to be nearing better agreement through this discussion.

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