A comment on a gravity interpretation of the Horg area in the Trondheim Region, Norwegian Caledonides *

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The principal structure of the Horg area is a regional NNE-SSW trending fold which is usually regarded as a syncline (the Horg Syncline). A modified synclinal model based on interpretation of Bouguer gravity data has recently been proposed. In the new synclinal model a hypothetical fault with ca. 10 km downthrow of the western flank had to be introduced to fit the gravity data. Geological field evidence of this huge fault is feeble. When the regional gravity field is taken into account the gravity data from the Horg area fit an anticlinal model better than the proposed new synclinal version.

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This note discusses the conclusions reached by Åm et al. (1973) on the 'Interpretation of gravity data from the Horg Syncline of the Trondheim Region Caledonides', which appeared in a paper from Norges Geologiske Undersøkelse.

During the last century the Cambro-Silurian succession in the surroundings of Horg (Fig. 1) has been regarded as a classical area for an understanding of the geology and stratigraphy of the Trondheim Region. This is mainly due to the low metamorphic grade of the rocks paired with the presence of several fossiliferous horizons. Biostratigraphic evidence is otherwise rather scarce in the Trondheim Region.

Horg is situated in the centre of a regional structure, which has been interpreted as a fold with an axial trend about NNE-SSW. The core of the structure is occupied by the Middle to Upper Ordovician Hovin Groups, which are successively flanked by the Arenigian/pre-Arenigian Støren Group and the supposed Cambrian Gula Group (Fig. 1). The principal structural question has been whether the fold should be regarded as a syncline or an anticline. This discussion has been summarized by Vogt (1945:454). After Carstens (1920) a synclinal model (The Horg Syncline) seems to have been generally accepted. More recently, Chaloupsky (1970) has shown that the area consists of a complex system of syn- and anticlinorial folds rather than being deformed by simple open folding (Fig. 2).

Even though more recent authors generally prefer a synclinal model, there is nevertheless no unambiguous evidence – at least in the available literature –

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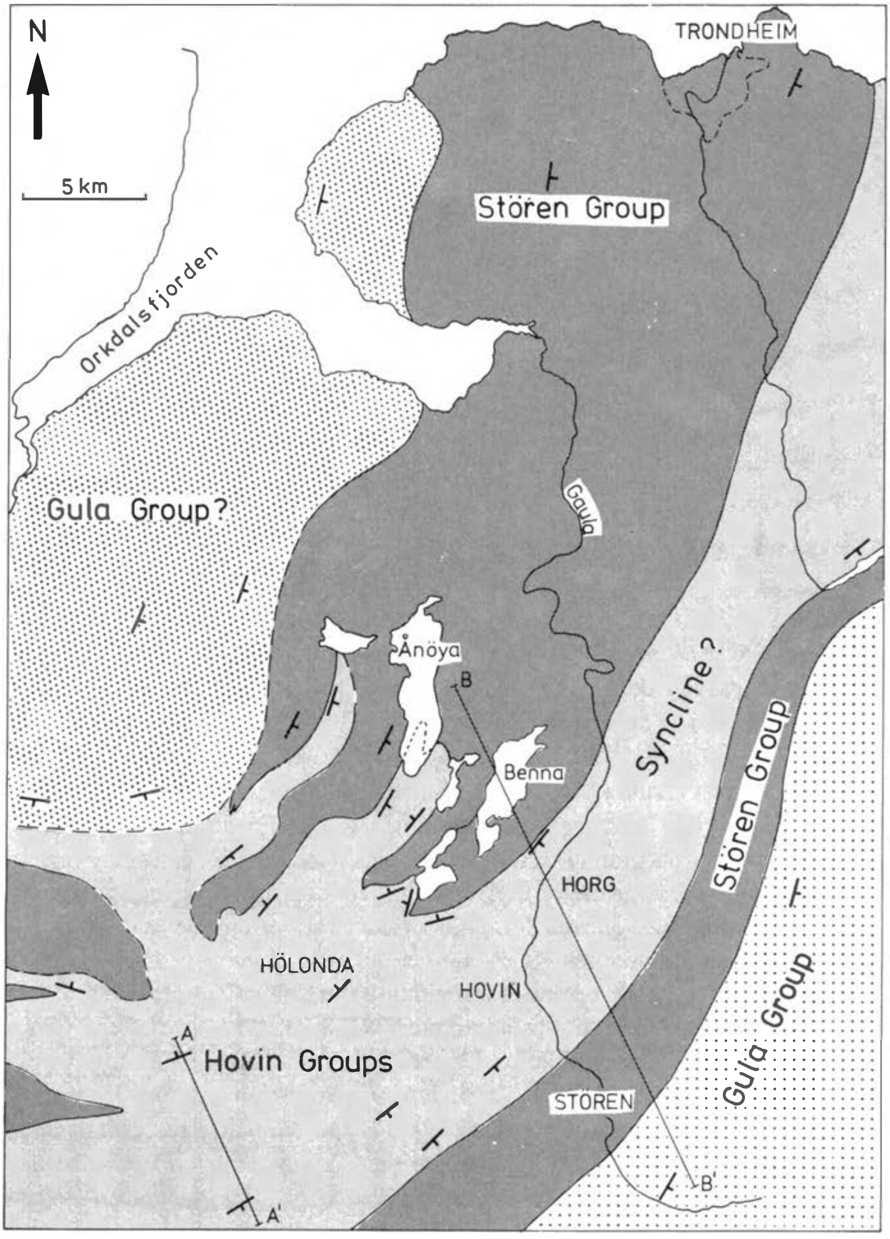

Fig. 1. Simplified geological map of parts of the western Trondheim Region showing the three main rock units involved in the discussion of the tectonic structure of the Horg area. Geological section A—A' is shown in Fig. 2, gravimetric profile B—B' is shown in Fig. 3.

that this is the only possible interpretation. The attitude of the bedding and the symmetry of folds across the Horg structure (Fig. 2) favour an anticlinorium, i.e. consistent with models proposed by Kierulf, Brøgger and Bugge in different papers (see Vogt 1945:454).

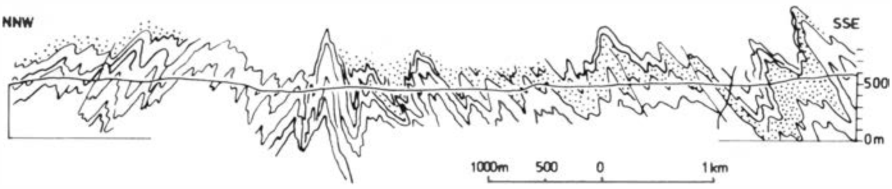

Fig. 2. Geological section (A—A' in Fig. 1) showing the fold style in the Hovin Group across the Horg structure. Stippled: dark banded slate. White: various sediments and thin interlayered volcanics. Simplified from Chaloupsky (1970).

A correct interpretation of the structural framework of the Horg area is of utmost importance, since different models imply different solutions to the stratigraphy and the gross regional structures of the Trondheim Region in general.

Åm et al. (1973) discussed the structure of the Horg area based on Bouguer gravity anomaly data. Their discussion is solely based on the assumed synclinal model, even though the gravity data allows other solutions. In their treatment of the anomaly data, Åm et al. made no attempt to subtract the regional field from the local gravity measurements. This is important in local studies, because, by subtracting a plausible regional field, one can correct for variations in the depth to the Moho-discontinuity and for the larger deep-seated crustal effects. There is in Norway a Moho dipping from the coast mostly towards the east (Kanestrøm & Haugland 1971), thereby producing a gradient in the regional gravity field from the west to the east.

No regional gravity measurements have been published from the vicinity of the Horg area. To estimate a regional gradient we have used a linear regional gradient of —4 mgal/10 km, and with absolute gravity values decreasing from –7 to –17 mgals going along Åm et al.'s profile in fig. 6 (1973:36). The decreasing gradient and the values are taken from an unpublished Bouguer gravity map of southern Norway by Ramberg (pers. comm). The gradient is in accordance with published gradients from the Jotunheimen area (–6 mgals/10 km) based on measured values and computed from seismic and isostatic models (Smithson et al. 1974). The gradient of —4 mgal/10 km is therefore a conservative estimate.

The residual anomalies obtained assuming this regional gravity field, are much smaller than the anomalies shown by Åm et al. If the density contrast of 0.13 g/cm^3 is used between the volcanic Støren Group and the Hovin and Gula groups, two things become evident. The large thickness of the western limb (3.5 km), as calculated by Åm et al., can be considerably reduced as Åm et al. suggest. Further, the eastern limb continues down to about 10 km depth, but the horizontal deep-seated plate below the central part of Åm et al.'s synclinal model disappears.

Fig. 3 shows Åm et al.'s synclinal model of the Horg area together with our alternative model. The latter is based on the same gravity data, except that

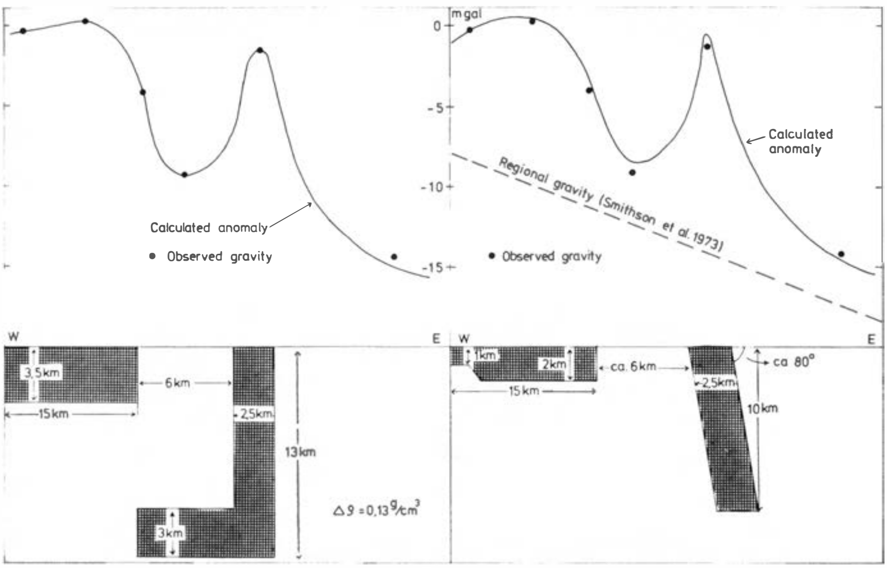

Fig. 3. Åm et al's model based on gravity data from the Horg area is shown on the left. To the right is shown our alternative model based on the same gravity data and assuming a dipping regional gravity field (B—B' in Fig. 1).

a reasonable regional gravity field has been subtracted. Our calculations are hardly consistent with a synformal model.

An important conclusion reached by Åm et al. (1973:36) is that there is no indication of a steeply dipping greenstone plate in the western limb of the Horg Syncline. This means that the gravity data show no clear connection between the greenstones in the western limb and the deep-seated greenstone plate at the bottom of their suggested synclinal model (Fig. 3). This problem is solved by introducing a huge fault (10 km throw), which we find rather dubious, even though Chaloupsky (1970:300) suggests that there may be 'an important tectonic line' between the Sandå and the Krokstad beds of the Hovin Group. A ten kilometre throw, however, might be expected to provide some unmistakable evidence of displacement. Investigations in the surroundings of Hølonda (Chadwick et al. 1962, Chaloupsky 1961, 1970) leave no evidences of such large-scale faulting; neither do the field studies in the Støren–Rennebu area by Rohr-Torp (pers. comm.).

There is also another problem related to the western limb of Åm et al.'s synclinal model. In this model the 'Western greenstone plate' is supposed to be underlain by the Gula Group and superimposed by the Hovin Group, i.e. a normal right way up of the succession if local inversions due to folding are disregarded. This interpretation implies that the Støren greenstone must dip beneath the Hovin sediments in a south-westerly direction. Near Ånøya and Benna the gravity anomalies are comparatively high and well defined above the greenstone. Southwards the gravity contrast between the Støren and the Hovin Groups gradually becomes less distinct, and near the southern border between the two groups the trend of the gravity contours appears more or less random. This indicates that the greenstone is relatively thick in the north, and gradually thins out towards the south.

This variation in thickness may be explained as due to: Primary variations during deposition of the volcanics or secondary thickening and thinning caused by tight folding. If these pronounced lateral variations in the thickness of the greenstones are caused by one of the above alternatives, the discussion of the structure of the Horg area on the basis of the present gravity data is irrelevant. How could one possibly be able to judge about the more deep-seated structures in the other parts of the synform, when it must be realized that the greenstones may vary in thickness from say, a couple of km at Ånøya in the western limb to, practically speaking, zero further south where the Støren Group cannot even be traced below a thin cover of the Hovin sediments?

An alternative explanation for the gravity anomaly pattern above the western limb may be given if we suppose that the whole lithological succession were inverted, i.e. the Støren greenstone rests on the younger Hovin sediments. The thinning of the greenstone towards the south may, thus, be explained as due to erosion. Consequently, if the western limb is inverted, the main Horg structure most likely represents an antiform, e.g. a downward facing syncline. An anticlinal solution will certainly create new problems about the general aspects of stratigraphy and tectonics in this part of the Trondheim Region – particularly the correlation between the Gula Group proper to the east of Støren and the westernmost, stratigraphically more uncertain units to the south of Orkdalsfjorden (Wolff 1967). Other interpretations may for instance involve a thrust between the Støren Group and the enclosing sedimentary units as recently proposed by Gale & Roberts (1974), and Oftedahl (1975). This is, however, beyond the scope of this discussion.

Our conclusions are therefore: The gravity data presented by Åm et al. (1973) cannot be taken in themselves as evidence in favour of the suggested synclinal model. Further, the huge fault which was introduced to fit the gravity data in the western flank is hardly supported by geological field evidence. Finally, the gravity data together with the available geological information from the Horg area fit an antiformal structure better than the proposed new synclinal model.

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