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Tittel

Gravimetric indications of basement undulations below cambrosilurian deposits east of Røros, Southern Norway

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Sammendrag

The first part of this study indicates the serpentinite complex at Raudhammeren, Røros, is a rather thin lens-like body. An extensive residual gravity anomaly (about 10 mgal, approximately 15 km wide) covers a greater area than the outcropping serpentinite complex. A possible explanation for this is an undulating basement topography beneath the Cambro-Silurian rock sequence in the area. This postulated undulation is in agreement with geo logic observations on the granitic basement where it is exposed in several windows.

GRAVIMETRIC INDICATIONS OF BASEMENT UNDULATIONS BELOW THE CAMBRO-SILURIAN DEPOSITS EAST OF RØROS, SOUTHERN NORWAY *

GISLE GRØNLIE & INGOLF J. RUI

Grønlie, G. & Rui, I. J.: Gravimetric indications of basement undulations below the Cambro-Silurian deposits east of Røros, southern Norway. *Norsk Geologisk Tidsskrift*, Vol. 56, pp. 195–202. Oslo 1976.

The first part of this study indicates that the serpentinite complex at Raudhammeren, Røros, is a rather thin lens-like body. An extensive residual gravity anomaly (about 10 mgal, approximately 15 km wide) covers a greater area than the outcropping serpentinite complex. A possible explanation for this is an undulating basement topography beneath the Cambro-Silurian rock sequence in the area. This postulated undulation is in agreement with geologic observations on the granitic basement where it is exposed in several windows.

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The present study was made as a contribution to two projects: the Norwegian Geotraverse Project (Heier 1969) which is supported by the Norwegian Council for Science and Humanities (NAVF) and the Røros Project (Bugge & Rui 1970) which is supported by the Norwegian Council for Scientific and Industrial Research (NTNF) and Norwegian mining companies.

This paper discusses results from a small part of a larger regional gravimetric survey of the central Caledonides of south Norway (map sheet Røros, series M 515, 9–12°E, 62–63°N). An abstract of this work has been presented by Grønlie & Rui (1975).

The area discussed is situated east of the town of Røros (Fig. 1). It was decided to make a detailed gravimetric survey in this area to investigate the depth and three dimensional extent of the Raudhammeren serpentinite body. When a rather large anomaly was found which could not be matched to the serpentinite body, it became necessary to look for alternative explanations. This paper gives gravimetric evidence for an undulating basement beneath the Cambro-Silurian overthrust complex in this part of the Trondheim Region of the Norwegian Caledonides.

Geology

The area shown in Fig. 1 has been divided into three main tectonic units which are:

* Publication No. 119 in the Norwegian Geotraverse Project and No. 13 in the Røros Project of the Institute of Geology, University of Oslo.

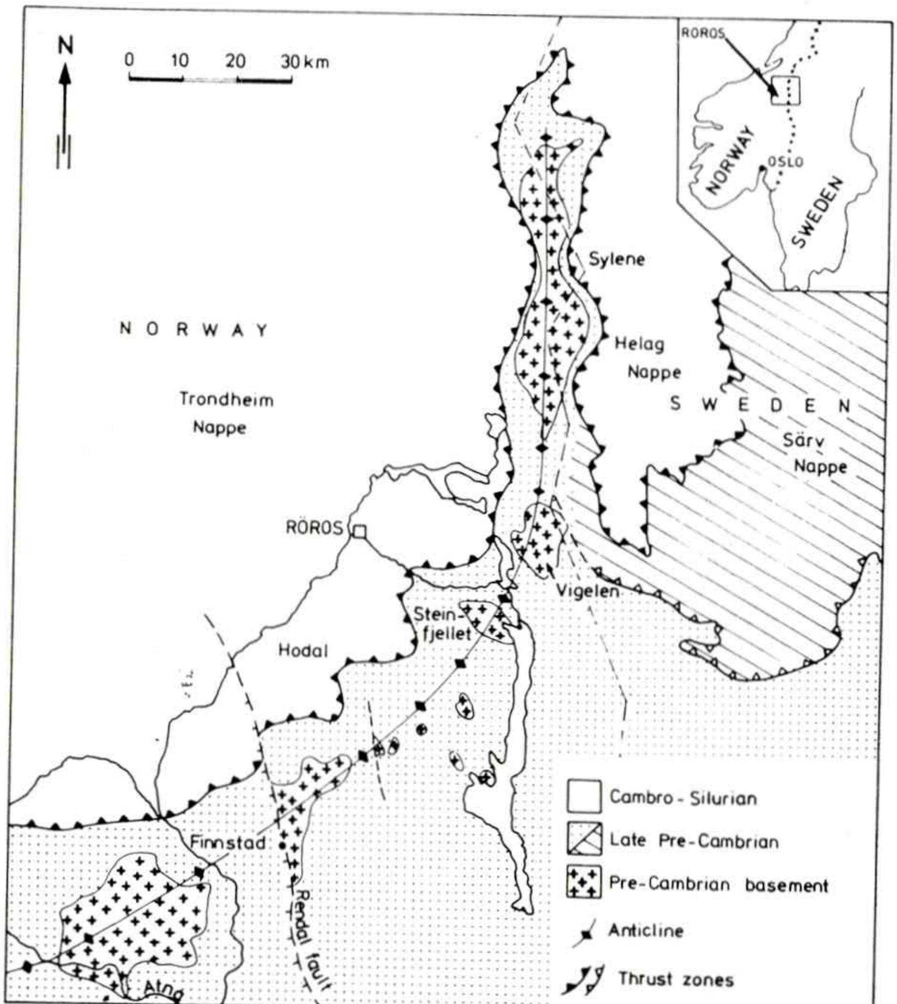

Fig. 1. Simplified tectonic map from the southeastern Trondheim Region and adjoining areas in Sweden.

The Cambro-Silurian schists of the Trondheim – Helag Nappe.
The Late Precambrian Sparagmites in the Caledonian front.
The Precambrian basement.

The overthrusted Cambro-Silurian rocks of the southeastern Trondheim Region consist of a thick series of eugeosynclinal, essentially sedimentary rocks which have been subjected to complex polyphase deformation and regional greenschist facies metamorphism during the Caledonian orogeny (Rui 1972). The supracrustals are in part heavily dissected by meta-gabbro intrusions, mostly of small size. Interlayered in the Cambro-Silurian schists is a narrow, stratabound zone of abundant ultramafic bodies (serpentinites, soapstones) which can be traced for more than 150 km along the strike. The ultramafics are particularly abundant in the area to the southeast and east of Røros (Figs. 2 and 3) where they follow two parallel zones on either side of an elongated meta-gabbro intrusion. The largest of the ultramafic bodies are found at Feragen (14 km²) and Raudhammeren (5 km²) – the latter is studied in more detail here.

The areas to the east of the Trondheim Nappe consist of light coloured, flaggy quartzites and meta-arkoses which belong to the Late Precambrian

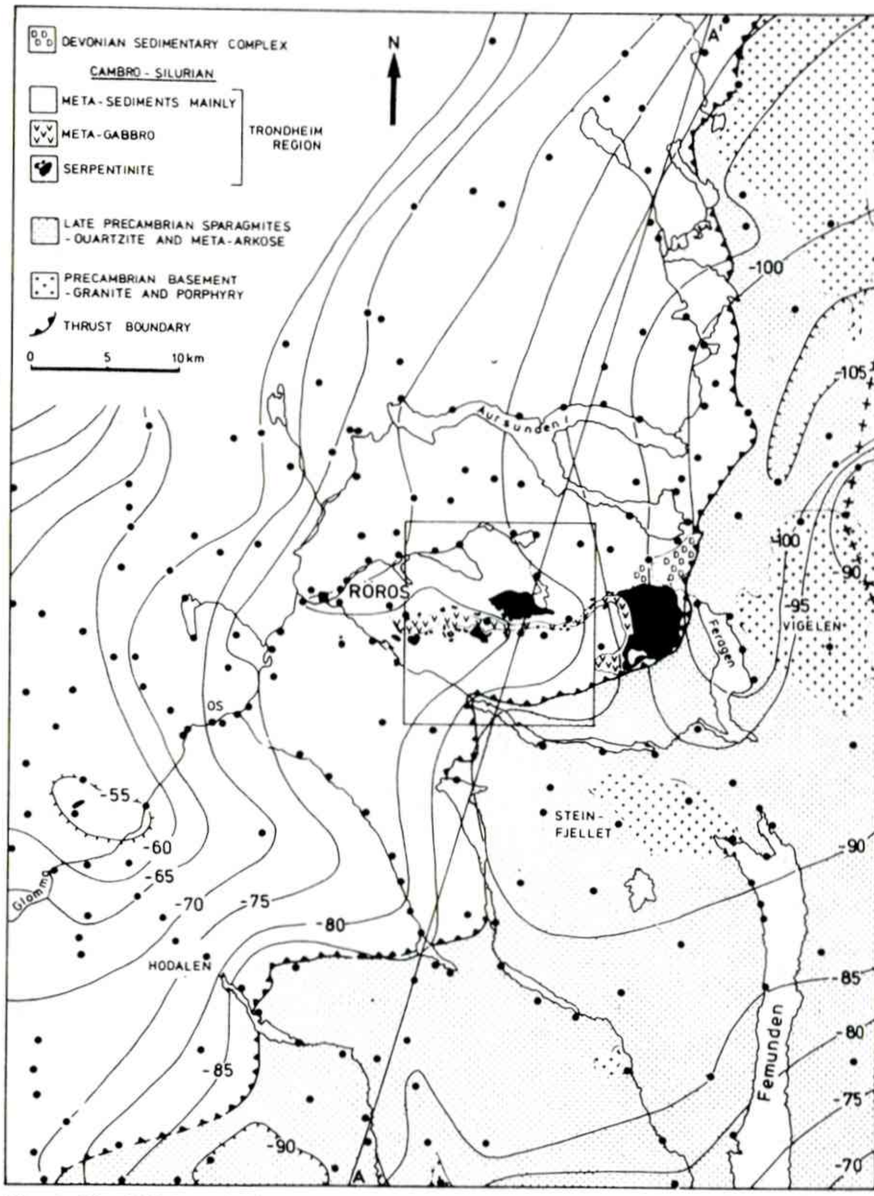

Fig. 2. Simplified geological map from the Røros district with superimposed Bouguer gravity anomaly contours. Framed area is shown in Fig. 3.

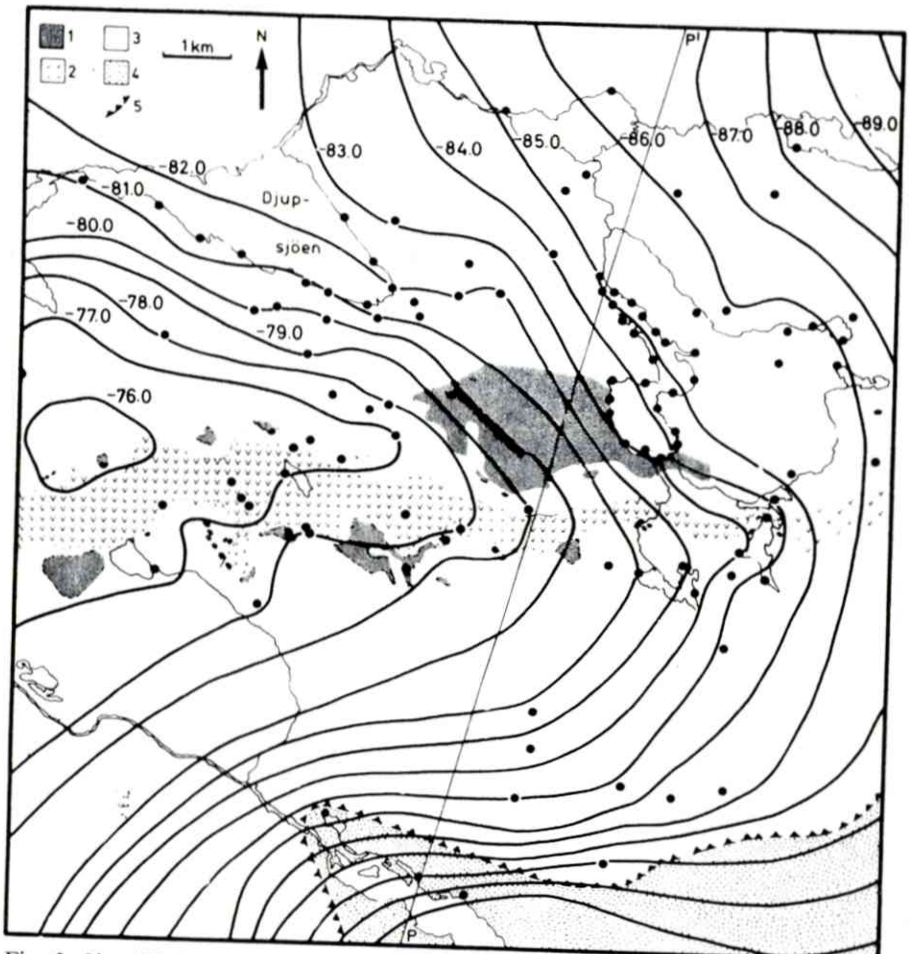

Fig. 3. Simplified geological map from the Raudhammeren serpentinite area to the southeast of Røros. For detailed location se Fig. 2. 1 – Serpentinite, 2 – Meta-gabbro, 3 – Undifferentiated Trondheim schists, mainly meta-sediments, 4 – Sparagmite, 5 – Thrust zone. Bouguer gravity anomaly contours are superimposed. Black dots – gravity stations. UTM-coordinates.

Sparagmite Suite of southern Norway. The sparagmites rest with autochthonous-parautochthonous contact (often with basal arkoses or conglomerates) on Precambrian granites and porphyries which are exposed in several windows in the sparagmite cover. An extensive sheet of similar, but overthrusted sparagmites occurs in the Särv Nappe on the Swedish side of the border (c.f. Strömberg 1962).

The Sylane-Vigelen windows lie in the core of an extensive anticlinorial structure. The Steinfjellet, Finnstad, and the Atnasjø windows probably occupy similar structural positions in a southwestern extension of this anticline. The fact that the basement rocks are exposed only in windows at intervals along the axis of the anticline and show dome-like structures suggests that they represent pronounced axial culminations in the anticline.

Major irregularities in the surface of the granitic basement can be readily demonstrated. In the depression between the lakes Femunden and Feragen (Fig. 2), for instance, the basement is covered by sparagmites at an altitude of about 660 metres a.s.l., while in the peaks of Vigelen to the north, the basement contact must have been at least 700 metres higher.

These marked undulations of the axis of the anticline are probably due to a late superimposed NW–SE cross-folding which is pronounced throughout the southeastern Trondheim Region, particularly in the areas between Hodalen and Feragen/Aursunden (Fig. 2), where it is responsible for the sinuous outcrop of the thrust zone. According to J. P. Nystuen (pers. comm.) this NW–SE cross-folding is also conspicuous in the northern part of the sparagmite region. A corresponding phase of folding has been reported from the nappe complexes in southwestern Jämtland on the Swedish side of the border (Strömberg 1962).

Structural relationships between the Cambro-Silurian schists and the Devonian sedimentary complex (Fig. 2) clearly show that the thrusting of the Trondheim Nappe and the superimposed NW–SE cross-folding are pre-Lower Devonian in age (Rui 1972, Roberts 1974).

Gravity interpretation

Most of the regional gravity measurements were carried out with the help of car transportation. These data are supplemented with data from the Norges Geografiske Oppmåling (NGO), some of which were collected from mountainous areas with the aid of helicopters. The detailed net from the Raudhammeren area was measured mostly on foot.

Gravity observations were reduced by standard methods (Dobrin 1960). Terrain corrections were carried out to a distance of 22 km. This was done with the aid of a digital computer (Grønlie & Ramberg 1973) with the inner zones determined by Hammers' (1939) method. The terrain corrections varied from 0.3 mgal to 2.0 mgal, and the error of the gravity anomaly values is mostly dependent on the accuracy of the terrain correction. Since the topography is not marked, the corrections are relatively small; the error is estimated to be less than ± 0.5 mgal.

The Bouguer gravity-anomaly map is shown in Fig. 2 and a more detailed Bouguer anomaly map of the Raudhammeren area is shown in Fig. 3. The Bouguer anomalies in the area (Fig. 2) have large negative values; this is in accordance with the theory of an isostatically compensated mountain chain. This has been demonstrated by Ramberg & Grønlie (1969), Smithson et al. (1974), and Grønlie & Rui (1975). In this study, interest is focused on the variations in the gravity field which are superimposed on the isostatically compensated gravity field. The high above the Raudhammeren area, which is shown on a larger scale in Fig. 3, is interesting, likewise the gravity low over the exposed belt of granitic basement to the east in Fig. 2.

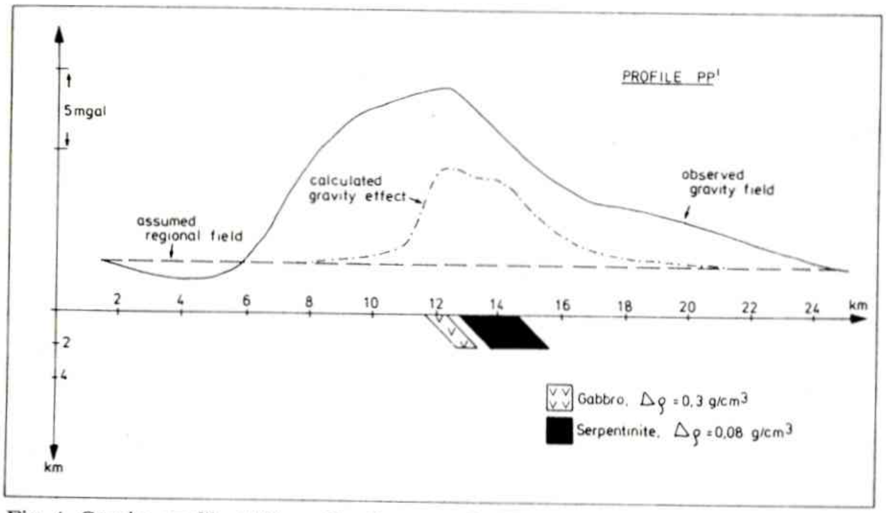

Fig. 4. Gravity profile (PP′ on Fig. 3) across the Raudhammeren serpentinite complex.

A profile (marked PP′ on Fig. 3) crossing the Raudhammeren serpentinite and the associated meta-gabbro is shown in Fig. 4. The maximum anomaly is approximately 10 mgal and the anomaly width about 15 km. The serpentinite and the meta-gabbro are only exposed over 2 to 3 km of the total anomaly distance. The profile (PP′) is approximately normal to the strike of the bodies and a dip of 45° represents a rough average of observed dip angles.

Five density measurements were carried out on different specimens from the serpentinite body, giving an average of 2.72 (± 0.09) g/cm³ with the highest value at 2.81. Six specimens from the meta-gabbro gave an average of 3.00 (± 0.02) g/cm³. The density of the surrounding rocks as a whole was taken to be 2.72 g/cm³, which is in accordance with other estimates (Smithson et al. 1974). This gives an unexpectedly low density contrast for the serpentinites, even if the highest value of 2.81 g/cm³ is used and there is an expected contrast for the denser gabbro.

Fig. 4 is a two-dimensional model (Talwani et al. 1959) based on known geology and measured rock densities. The computed gravity effect from this model cannot explain the large gravity high which is found to the west of the exposed bodies. A westward underground extension of the gabbro and serpentinite complex is not possible for geological reasons.

The small density contrast between the serpentinite and the surrounding rocks means that one has to assume a huge thickness (about 3 to 4 km) of serpentinite to explain the anomaly. This too is unacceptable for geological reasons. One must, therefore, look for an alternative explanation which is geologically more acceptable.

If one looks at the regional map (Fig. 2), oscillatory variations can be observed in the gravity field with wave lengths of the order of 10 to 20 km

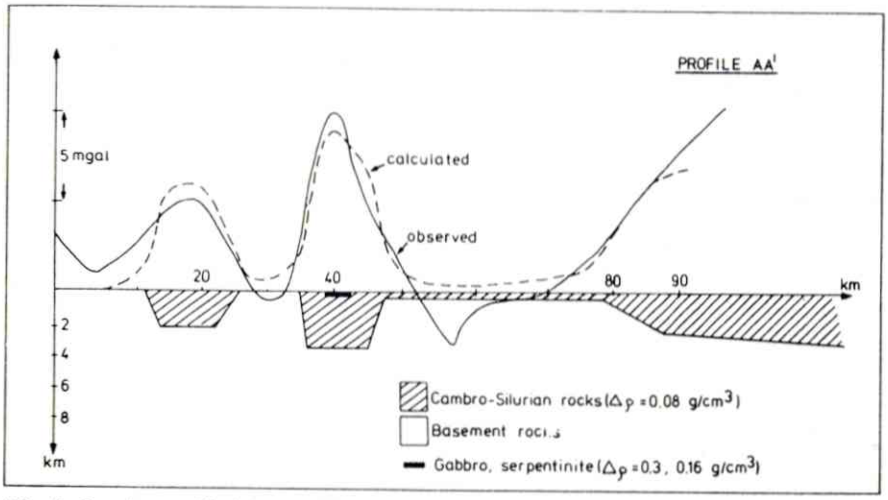

Fig. 5. Gravity profile (AA′ on Fig. 2) showing basement underlations beneath Cambro-Silurian cover east of Røros.

if one follows the edge of the thrust zone. East of the thrust is a series of rather light Precambrian sparagmites ($\varrho = 2.65$ g/cm³) and beneath this series are several dome-shaped granitic rock massifs ($\varrho = 2.65$ g/cm³) which are exposed as windows in the sparagmite. This suggests that the long wave-length gravity anomalies may be caused by undulations in the sparagmitic/granitic basement which presumably underlies the overthrusted Cambro-Silurian deposits.

To investigate this theory a profile (AA′, Fig. 2) has been drawn parallel to the thrust zone (Fig. 5). The regional field along this profile is nearly constant and the variations in the gravity field may, therefore, be ascribed solely to relatively near surface geologic effects.

The density contrast between the Cambro-Silurian deposits and the sparagmitic/granitic rocks is 0.08 g/cm³ (2.73–2.65). The two dimensional model of Fig. 5 matches a calculated gravity effect with the observed variations in the gravity field and a rather good fit is obtained if one places 2–3 km thick Cambro-Silurian blocks under the gravity highs. The gravity lows then correspond rather well with the expected eastward continuation of the dome-shaped granitic rocks.

Concluding remarks

We have demonstrated that the serpentinite/gabbro complex of Raudhammeren is a rather thin lens-shaped body lying at the surface, and that this rock complex cannot explain the rather extensive gravity anomaly in the area. A possible explanation for the gravity anomaly is basement updoming underneath the Cambro-Silurian deposits on both sides of the anomaly.

This explanation is in good agreement with geologic interpretations of field evidence.

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April 1975

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