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CONTENTS

SUMMARY

A complex of upper amphibolite facies, migmatic gneisses, and granites, occupying a large area between Karesuando and Huuki in northeastern Sweden, is interpreted as basement to the surrounding Svecokarelian volcanic and sedimentary (greenstone) belts. This interpretation is based on regional geological and geophysical surveys. The gneiss area shows distinctly different geophysical anomalies compared with the surrounding granitic and supracrustal areas. The most significant feature is a strong positive gravity anomaly which reaches +15 mgal and covers an area of about 20×70 km. Within it lies a series of banded, magnetic anomalies, trending broadly north—south in an S-shaped regional structure extending over 100 km. Petrophysical studies and model computations show that the central part of the structure is a culmination composed of basic—intermediate gneissic rocks.

The main evidence for the basement interpretation is as follows:

1. The magnetic anomaly pattern over the migmatic gneisses is different from that obtained over the supracrustal formations.
2. The lithology of the gneisses differs from that of the supracrustal rocks.
3. The gneisses are homogeneously metamorphosed in upper amphibolite facies, while the supracrustal rocks show rather rapid changes in grade of metamorphism and crystallisation within the amphibolite facies.
4. The gravity anomaly is clearly related to a major culmination.
5. The supracrustal rocks occur in smaller basins around the gneiss-culmination, thus occupying a position above the basement gneisses.
6. Thick units of clastic sediments within the Svekokarelian formations are apparently eroded from sialic rocks, the granite-gneiss basement being the most probable source, and
7. some granodioritic massifs around the gneiss-structure, intruding the gneisses, are dated as about 2.3 Ga. This so-called "mixed age" implies that the gneisses must have been formed earlier than 2.3 Ga. These rocks represent basement material regenerated during the Svecokarelian (about 1.9 Ga) orogeny.

An approximate age of 1.9 Ga was obtained on zircons from a granodioritic gneiss in the southern part of the gneiss complex. This age is considered to represent the most recent metamorphic event.

Hitherto only two analyses of basement gneisses from this region give ages prior to the age of metamorphism, i.e. about 2.8 Ga in the Kiruna area and 2.7 Ga at Ropinsalmi, northwest of Karesuando in northern Finland.

The gneiss structure is surrounded by a broad belt of potash granites. They have previously been considered as younger than this orogeny, because, in places they intersect older rocks. These phenomena, however, may also be interpreted as regeneration phenomena. Structurally, these granites belong to the basement. Assuming the existence of a differentiated continuous early sialic crust, a model is proposed for the development of the greenstone belts and the tectonic development of the area.

INTRODUCTION

GEOLOGICAL SURVEYS

The results of earlier investigations are summarized on the geological map of Norrbotten county (Ödman 1957). On this map, vast areas of migmatitic rocks occur to the west, south and southeast of Karesuando in northeast Sweden. They were thought to represent Svecokarelian metamorphosed supracrustals together with metamorphosed plutonites of an orogenic granite series, the Haparanda Series. A systematic re-mapping of Norrbotten carried out by the Geological Survey of Sweden (SGU), combined with an aeromagnetic investigation, started in 1961. The map sheets so far published on the scale 1:50 000 are: 29J (Offerberg 1967), 28L (Padget 1970), 29L (Witschard 1970), 29K (Eriksson and Hallgren 1975), 28J (Witschard 1975), and 28M (Padget 1977), while the following sheets are in preparation: 30–31L (Ambros), 29–30M (Lindroos). The present paper deals essentially with the migmatic gneisses southeast of Karesuando on the map-sheets 29–30M and 30–31L and the surrounding granitic and supracrustal terrains.

GEOPHYSICAL SURVEYS

Aeromagnetic measurements were made in 1961–1963. The line spacing was 200 m with measurements every 40 m and a flight-altitude of 30 m. Printed maps are published on the scale of 1:50 000. During 1972–1974 a regional gravity survey was carried out. Measurements were made along profiles at 5–10 km intervals, with 1 km between the gravity stations. The anomalies are terrain corrected and compiled to Bouguer anomaly maps, which will be published on the scale of 1:250 000 together with the description of the geological maps.

The structure under consideration lies close to the Swedish-Finnish border, and aeromagnetic and gravity data from Finland are included among the data used for the interpretation.

Rock samples, collected during the mapping in 1967–1973, have been measured with respect to the physical properties density, magnetic susceptibility and remanent magnetization. In this paper, a compilation has only been made for the densities of the major rock-units; the complete data will be published with the map descriptions.

GEOLOGY AND STRATIGRAPHY

GENERAL CONSIDERATIONS

A major part of northern Sweden is occupied by migmatitic gneisses. One large area occurs between Karesuando and Muonionalusta, about 100 km east of Kiruna, in northeastern Sweden. This gneiss area is about 1 000 km^2. It is surrounded by granitic rocks, beyond which occur narrow belts of volcanic and sedimentary supracrustal rocks. All these rocks were previously thought to be of Svecokarelian age (Ödman 1957). Granitic to gabbroic massifs within this area were interpreted as members of an orogenic series of plutonic rocks, the Haparanda Series. The extensive potash-rich granites were considered to be still younger intrusions, belonging to the Lina Granite Series. Ödman divided this series into two petrographical series: the ”syenite” and the ”migmatite-granite” series. Recently the Haparanda intrusions were dated to approximately 1.9 Ga (Welin et al. 1970). Intrusive rocks of the ”syenite” series have ages of 1.53–1.56 Ga (Gulson 1972). The age-relationships of the ”migmatite-granites” are uncertain, as radiometric ages of both 1.56 Ga and 1.82 Ga (Welin et al. 1970, Gulson 1972) have been obtained. On map sheet 28J, they are shown to be associated with the Kiruna Porphyries (Witschard 1975), the latter being about 1.6 Ga (Welin et al. 1971). The process of migmatization of the Svecokarelian supracrustal rocks and the older plutonic rocks was assumed to be connected with the formation of the potassium-rich granite, the Lina granite (Geijer 1931, Ödman 1957); a regional migmatization was thus linked with granitic intrusions and not with tectonic deformation. However, field evidence from the Lainio-area (29L, Witschard 1970) seems to indicate that a large part of the Lina granite is formed by latekinematic granitization of sediments, and this occurred ”in relation to a phase of tectonic deformation” (Witschard 1970, p. 84).

The present study shows that the gneisses differ in several aspects from the surrounding rock complexes. We have not found any unit or rock sequence comparable with the surrounding supracrustal groups. The gneisses are, in contrast to the supracrustal groups, homogeneously metamorphosed in upper amphibolite facies; locally granulite facies assemblages may be present. The gneiss structure is a culmination – a very large dome. The supracrustal rocks occur in synforms around the culmination thus occupying a higher structural level.

The granitic belt around the gneiss culmination is regionally conformable

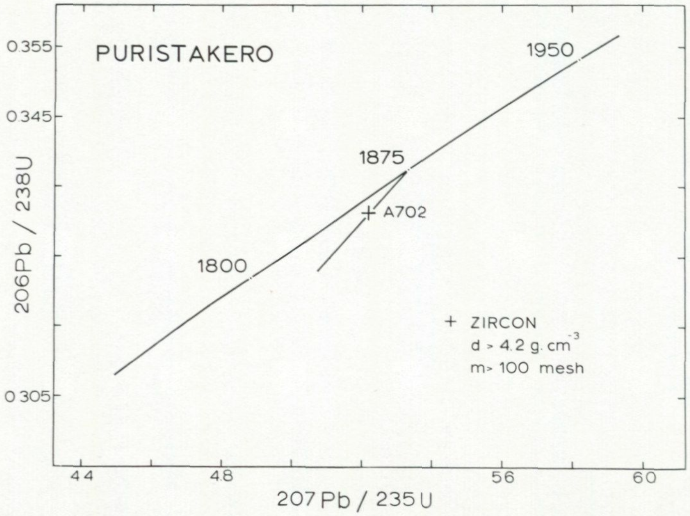

Fig. 1. U/Pb isochron diagram for the Puristakero granodioritic gneiss. Sample no. 1 in Fig. 3.

with the gneisses. A major part of these granitic or granodioritic massifs belongs to the basement and are interpreted as differentiates regenerated during the regional orogenic deformation. The granodiorites in the northern part of the gneiss structure are strongly foliated and show locally intrusive contacts to the gneisses supporting an earlier age for the gneiss-deformation than the intrusion of granodiorite. One massif, around and north of Muonionalusta, has recently been dated to about 2.3 Ga (M. Lehtonen, Geol. Surv. of Finland, personal comm.). This age is a ”mixed age”; part of the zircons are about 1.9 Ga old and part much older. A radiometric age was also determined on zircons from a rather common gneiss-type. The rock is granodioritic, strongly foliated, in part banded and gneissic. This gneiss is cut by dykes of a red, potash granite. The age obtained on these gneisses is about 1.9 Ga (Fig. 1). According to Dr O. Kouvo (who made

No. in Fig. 3	Locality	Rock	Appr. radiometric age (Ga)
1	Puristakero	Granodioritic gneiss	1.88
2	Muonio	Granodiorite	1.96 2.27
3	Kangosjärvi	Monzonite	1.88
4	Kihlanki	Granite	1.82

Fig. 2. Preliminary dates on some rocks from the Karesuando-Muonionalusta area. Age determinations were carried out by the U/Pb method on zircons by Dr O. Kouvo, Geol. Surv. of Finland. The decay constants used for the calculations; U 235 = $(7.0381 \pm 0.0048) \times 10^8$ yr and U 238 = $(4.4683 \pm 0.0024) \times 10^9$ yr.

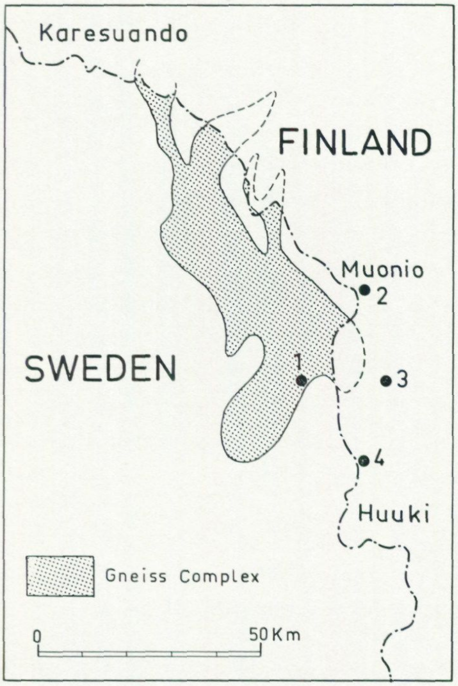

Fig. 3. Map showing sample localities for the age determinations listed in Fig. 2.

the determination) the zircons are typical for deepseated rocks; however, the age could also represent the latest metamorphic event.

Potassium-rich granites and syenites also occur within the supracrustal rocks, in the form of domes which strongly deform the penetrated rocks. In this area, more than ten domes can be identified on the aeromagnetic maps. They are all found within, or very close to the supracrustal belts. They are therefore interpreted as being formed by a re-adjustment of the inversed density structure created when heavy supracrustal rocks were piled upon a light basement.

Although no systematic petrographic studies have been done, at least four main categories of granitic rocks appear to be present. One category is generally granodioritic associated with the basement gneisses. A second, generally granitic or monzonitic in composition, occurs in a broad belt around (and possibly in smaller massifs or as dykes within) the basement. Granitic to syenitic rocks of a third suite, form circular or elliptic diapiric bodies or domes within or close to the supracrustal formations. And fourthly, a series of potassium-rich granites (perthite granites) are found outside the area studied; they appear to be associated with younger volcanic rocks.

Fig. 2 is a compilation of some radiometric age determinations from the area studied; the sample localities are shown in Fig. 3. All determinations are by the U/Pb-method on zircons.

PETROGRAPHIC DESCRIPTION

The main rock-units of this region can be divided into four complexes: *The Gneiss Complex, The Supracrustal Complex, The Plutonic Rocks,* and *Dykes*. They are shown on Plate I compiled from the 1:50 000 geological map sheets together with the magnetic structures and the gravity anomalies. The configuration of the supracrustal rocks is simplified, and the younger volcanic and sedimentary groups (mainly porphyries around Lainio in the central part of the map area) are not distinguished from the older groups (which dominate among the supracrustals in this area). Among the mafic intrusions, only the largest are marked (G); ring-shaped types (RG) are very characteristic for this area. Three of the latter are exposed on the map sheets 29–30M, occurring as gabbroic cone sheets.

The dimensions and tectonic positions of the main rock units are illustrated in a schematic profile (Plate II). The profile runs NE–SW across the basement and the extensive granite terrains of Lainio, and further to the southwest over small supracrustal belts of the Vittangi-Saittajärvi area. The geophysical model is based on the observed gravity and aeromagnetic anomalies, and is in accordance with geological surface-observations.

The Gneiss Complex is composed of different migmatitic gneisses mainly of acid to intermediate composition. Petrographically, most of them are biotite-gneiss and pyroxene-amphibole-gneiss. Most widespread is a grey, banded biotite-gneiss. The somewhat darker, amphibole-rich types have a dioritic to granodioritic composition. In some areas a strongly foliated diorite occurs. It has, however, not been possible to separate this rock-type and the amphibole-dominated gneisses in the field; on the map sheet 29M, homogeneous, gneissose diorite has been observed to pass transitionally into amphibole-gneiss with increasing development of the general schistosity. The dated diorite from Puristakero is cut by dykes of a red granite as well as bands or veinlets of a coarse pegmatite. This potassium-rich granite is very similar to that surrounding the Gneiss Complex, and it is obvious that the gneisses and associated dioritic massifs are earlier than the granite. On the other hand, among the biotite-gneisses, gradual transformations from gneiss to granite are observed, indicating that granitization of sediments has also played a role in the development of granitic rocks within the structure.

On map-sheet 30L, a body of foliated diorite, very similar to the Puristakero diorite, has been observed intruding the northwest corner of the large, S-shaped gneiss-structure. The diorite around and north of Muonionalusta is also strongly foliated, and cut by dykes of a younger red granite.

Within the Gneiss Complex, small areas occur with clearly stratified rocks: quartzitic gneiss, quartz-sillimanite-gneiss and garnet-bearing gneiss. A cordierite-bearing gneiss occurs at Muonio in Finland. On map-sheet 30M, north of the village of Muonionalusta, the quartzitic gneiss forms a thin, but long, partly folded horizon comformable with the surrounding gneisses. Although, this quartzitic gneiss is strongly recrystallized, smaller sections show a stratification formed by rhythmic layering of darker heavy minerals and lighter quartz.

It should be noted that the amphibole- and pyroxene-gneisses are found side by side, and even in a single outcrop some parts may contain up to 30 % pyroxene, others almost nothing. Much of the amphibole is formed from the pyroxene; and biotite is often chloritized. In both processes magnetite may be formed. Strongly uralitized rock-types contain a lot of magnetite in the form of large idiomorphic grains. These late-crystallized magnetite-grains occur within those bands or layers containing the pyroxene-amphibole association. During these processes, therefore, an existing compositional banding will give rise to a magnetic banding. The width of single bands varies, according to the observed aeromagnetic anomalies, from a few tens of metres to hundreds of metres.

There is some evidence indicating high-grade metamorphic or anatectic conditions: the foliated diorites or granodiorites contain irregular antiperthites in the form of sutured rims between plagioclase- and microcline-crystals. The Puristakero diorite contains mainly prismatic, needle-like zircons of a type characteristic for deep-seated granitic rocks i.e. magmatic conditions. Finally, some mineral textures resemble those found among granulites.

Among the biotite-gneisses, so-called augen-gneisses are found with microcline porphyroblasts measuring 1–4 cm. The granitoid components of the biotite-gneisses are, however, commonly plagioclase-dominated. They occur as layers parallel with the schistose, paleosome components. Migmatitic types of the basic gneisses are, on the contrary, not well-banded; the coarser granitic parts occur as irregular injections or as dykes (Fig. 4) occasionally forming breccias. Away from the distinctly banded central region, i.e. at higher stratigraphic levels, granitic intrusions increasingly disturb the structures.

The Supracrustal Complex surrounds the gneiss-region. The supracrustal rocks are usually separated from the gneisses by large areas of granites (cf. Plate I). They lie in basins around the gneiss culmination, and occur as rather long and narrow, generally isoclinally folded belts.

Neither primary contacts between basement and greenstone cover, nor basal formation of the type occurring upon the Finnish gneiss basement, have been identified. The lowest unit of this area is found in the Vittangi (29K) and the Karesuando (30–31L) areas. It has been named the Tjärro Quartzite Formation (Eriksson and Hallgren 1975). It contains sericitic quartzites with transitions to pure ortho-quartzites including thinner zones of siltstone and dolomite. This basal unit is not exposed in the Pajala-Kaunisvaara area. In the Kolari area, the lowest unit is a quartzite occurring below the formation bearing the Rautuvaara iron ores (Hiltunen and Tontti 1976). The correlation of this quartzite with the

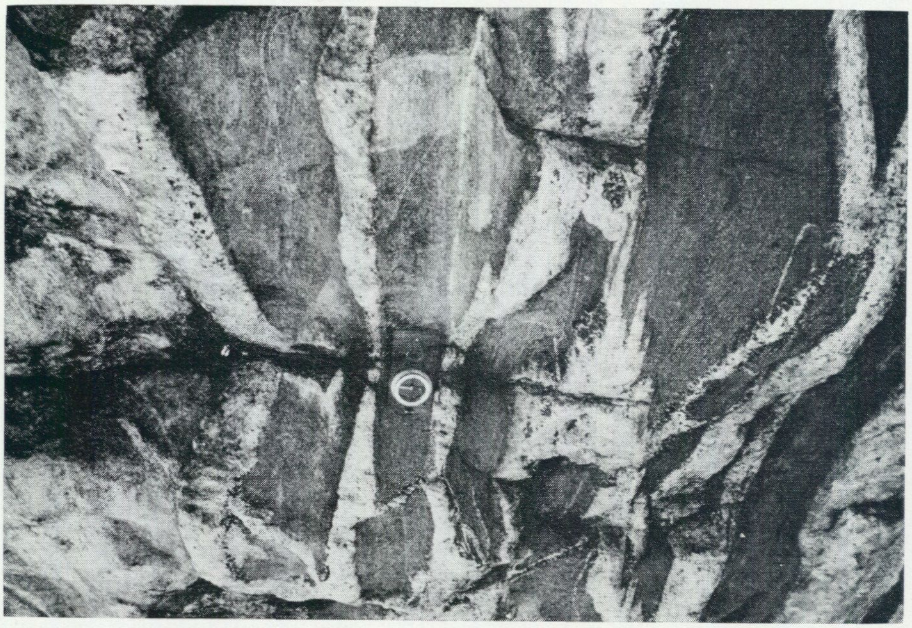

Fig. 4. Migmatic gneisses. Map-sheet 30M SE.

Tjärro Quartzite Formation is uncertain: its stratigraphic position is below the amphibolitic rocks between Kolari (Finland) and Ristimella (Sweden), which can be correlated with the volcanic greenstones of the Kaunisvaara-Pajala region.

The above mentioned quartzitic sediments may represent an epicontinental deposition, indicating erosion of the basement before the greenstone volcanism described below.

The major supracrustal sequence (c. 4 km thick) is composed of several formations of volcanic and volcaniclastic rocks, generally referred to as greenstones. The basaltic lavas are partly layered and tuffitic, locally with amygdaloidal, pillow and breccia structures. Mica-schists, graphitic schists and limestones occur within the volcanic rocks. Stratabound iron ores are found at several stratigraphic levels. In most cases they are associated with carbonate-rocks and graphitic sediments. Their sedimentary origin is obvious, though the ultimate source for the iron is still unclear.

The greenstones are in places overlain by a predominantly clastic sedimentary unit represented by quartzites and schists. Within well-preserved parts of the psammitic lithologies, black-sand lamination, graded-bedding, ripple-marks and cross-bedding occur, indicative of shallow-water deposition (Fig. 5). These sediments represent a distinct lithological change from the greenstones. They are not volcaniclastic being eroded from the acidic basement. On the local scale (Sahavaara-Tapuli, 29M) they are comformable; on a regional scale (28M) they seem

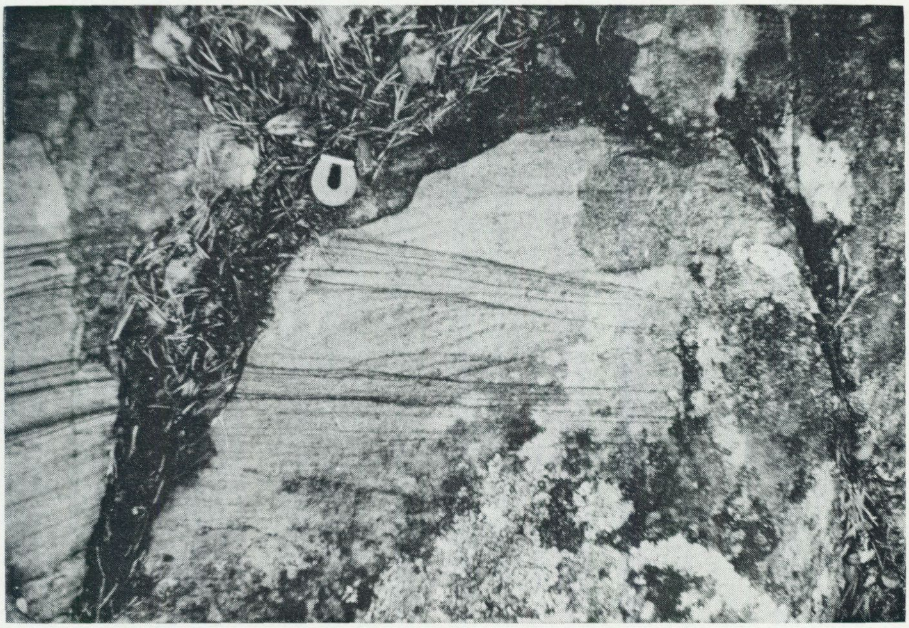

Fig. 5. Cross-bedding in sandstone (Pakakurkio Group), map-sheet 29M SW.

to be transgressive (Padget 1977). In the Käymäjärvi area, a thin basal conglomerate is found in the bottom of the succession.

The greenstones and the clastic sediments are the most frequent and characteristic supracrustal rock-units in north and northeast Sweden. A detailed study of the volcanic sequence (the Vittangi Greenstone Group) has recently been made in the Vittangi area (Eriksson and Hallgren 1975). The sediments were first studied in the Tärendö area (the Pahkurkio Group) by Padget 1970.

In the western part of the map area, the sediments are overlain by a sequence of porphyries, previously named the Porphyry Group. These extrusive rocks are generally of acidic to intermediate composition. Field observations on the map sheet 30L indicate a considerable discordance between these volcanic rocks and the lower groups (Ambros 1970). Similar pophyries from Kiruna have an age of about 1.6 Ga; much younger than the greenstones (Welin et al. 1971). These porphyries have been interpreted to be of subaerial origin; in the area studied their extension is very limited and the mode of their emplacement has not been studied.

In the Vittangi area, the porphyries are overlain by quartzites and conglomerates belonging to the Mattavaara Quartzite Group (Eriksson and Hallgren 1975). They represent the youngest supracrustal rocks of this region, and are also found in the Tärendö (28 L) and Pajala (28M) areas, and in Finland.

The Plutonic Rocks comprise those deep-seated rocks which occur outside the Gneiss Complex and within the supracrustal formations. They were formerly regarded as comprising an older suite, the Haparande Series, mainly composed of dioritic, granodioritic and gabbroic rocks, and a younger suite, formerly called the Lina Granite Series, dominated by potash-rich granites.

The Haparanda Series is thought to represent differentiated synorogenic intrusions (Ödman 1957), at least 1.9 Ga old. The Lina Granite Series comprises a variety of intrusives with different ages and modes of emplacement. One type occurs as discordant, late-kinematic intrusions, and is younger than the Haparanda Series. It seems to be accompanied by some basic intrusions. The other type is a migmatitic granite with associated pegmatites. The latter is frequently met with south of the Gneiss Complex and characteristically contains remnants of the gneiss basement. The above mentioned granite-types are dominated by a red, mainly coarse-grained microcline-granite. As red granites of ”the Lina type” have been shown to be as old as 1.82 Ga (Welin et al. 1971; cf. Figs. 2–3), we have preferred to divide the Plutonic Rocks on Plate I into two suites: *acid plutonic rocks* including granites, syenites and monzonites, and *intermediate plutonic rocks* dominated by diorites and granodiorites. The age determinations from the Finnish side indicate no significant age-differences between these rocks. The ”mixed age” of 2.3 Ga for the Muonio granodiorite was interpreted to be due to the presence of a fraction of both secondary, ”metamorphic” zircons, and primary, much older zircons. One interpretations is, that this granodiorite represents mobilized basement material emplaced during the 1.9 Ga old regional deformation.

Dykes. Within the map-area about 10 sub-circular high magnetic structures, up to c. 10 km in diameter, are distinguished; they are marked with G and RG on Plate I. On the map-area 29–30M, three of the ring-structures (RG) are exposed. They contain gabbroic rocks, which petrographically are clearly different from the other, larger gabbro-massifs. Some are of alkaline affinities. They occur as sub-circular dykes or cone sheets. Two of them (29M) are completely circular and occur undisturbed in red granite of the Lina-type. Locally they show chilled margins to the granite.

COMPARISON OF THE SUPRACRUSTAL COMPLEX AND THE GNEISS COMPLEX

a. Many of the rock types which are most characteristically associated with the Supracrustal Complex do not occur in the Gneiss Complex. Graphitic schists, carbonate rocks and iron ores are completely missing.

b. The grade of metamorphism and recrystallization is high and rather homogeneous across the entire gneiss area. The supracrustal rocks are generally less metamorphosed and, characteristically, preserve original volcanic and sedimentary features. The grade of recrystallization varies considerably over short distances.

c. Detailed studies of the aeromagnetic maps indicate that the fold-pattern of the two complexes is different. The gneiss-culmination is a mega-structure which in detail includes complicated minor structures. The supracrustal complexes above the basement occur as linear, fold belts. The major folds are generally isoclinal with horizontal axes and vertical axial surfaces. The amplitude of these folds is about 2–5 km.

d. The youngest supracrustal rocks have not been found in the basement area. However, the regional distribution of the porphyries seems to be independent of the occurrence of either the basement or the lower supracrustal rocks.

GRAVITY AND MAGNETIC ANOMALIES

The central gravity high, Plate I, reaching +15 mgal, is about 20 km wide and 70 km long. It has a relatively low horizontal gradient, with average 1.5 mgal km^{-1}. Some positive anomalies of 5–10 mgal amplitude at a wavelength around 3 km are superimposed. This central high is surrounded by a belt of negative anomalies down to −35 mgal with a width of 20 km on the western and southern sides, and about 10 km on the northern and eastern sides. Outside this belt, a series of positive anomalies with wavelengths less than 25 km occur. Their horizontal gradients are steep, about 3–5 mgal km^{-1}, and regionally these anomalies seem to lie superimposed on a gravity low – in principle a continuation of the negative belt. The extension of the total structure is 75–100 km.

The aeromagnetic anomalies reveal a close correlation with gravity in a regional sense (Plate I and Fig. 6). The central gravity high coincides with a series of banded magnetic anomalies, broadly north-south trending in an S-shaped regional structure. In its central part, a series of deep magnetic minima shows a symmetric arrangement characteristic for an anticline where magnetic rocks (mainly biotite-gneisses) overlie low magnetic rocks (mainly pyroxene-amphibole-gneisses). Another indication for outwards-dipping structures is found in the low magnetic gradient observed on the profile (Plate II) with letters A and B respectively. The smaller gravity highs correspond to sub-circular magnetic anomalies caused by conical dyke systems of basic rocks. The negative gravity belt corresponds to a magnetically low area, almost devoid of structures. The gravity highs of intermediate wavelengths are occupied by high-magnetic anomalies. These show a banded and folded pattern which differs from that observed within the central anomaly complex. On detailed aeromagnetic maps, dislocation-lines, fold-patterns and stratified rocks can be identified. In places, dips of magnetic bands can be estimated. This information provides a good basis

Unit	Gravity	Magnetic
Central area	Central high with positive anomalies of short wavelengths	Banded moderately high anomalies; high-magnetic sub-circular anomalies
Surrounding belt	Negative anomalies	Magnetic smooth area
Banded complexes	High-gradient, positive anomalies with intermediate wavelengths	Banded and folded patterns dominated by high anomalies
Dome-structures	Lows with short wavelengths, mainly within banded complexes	Low sub-circular anomalies

Fig. 6. Geophysical characteristics for different parts of the mega-structure.

for structural analysis. A near-surface structural element, only faintly apparent on the gravity map, is usually enhanced on the magnetic map. Thus, among the gravity highs of intermediate wavelengths (surrounding the negative anomaly belt) a number of rounded magnetic lows, having diameters around 5 km, can be observed. They resemble dome-structures, deforming the surrounding structures and trends. These domes have not been observed outside areas with supracrustal rocks (where neither magnetic nor gravity anomalies of this type are found.) Combining gravity and magnetic anomalies, various characteristics can be assigned to different parts of the mega-structure as indicated in Fig. 6.

PETROPHYSICAL STUDIES AND MODEL COMPUTATIONS

PETROPHYSICAL STUDIES

Fig. 7 shows the composite density distributions for the main rock units of the mega-structure. All distributions cover wide ranges. The basement rocks have a dominating low density component, but significant intermediate and high density distributions also occur. The lower parts of the supracrustal rocks have dominantly intermediate to high density, while the upper parts (Porphyry Group) have low and intermediate densities. Granites and granodiorites have mean densities in the range 2.65–2.70 g cm^{-3}. With regard to the magnetic properties, it appears that remanent magnetization is negligable in all rocks, except for some mafic intrusions. Susceptibility varies within four orders of magnitude, and again,

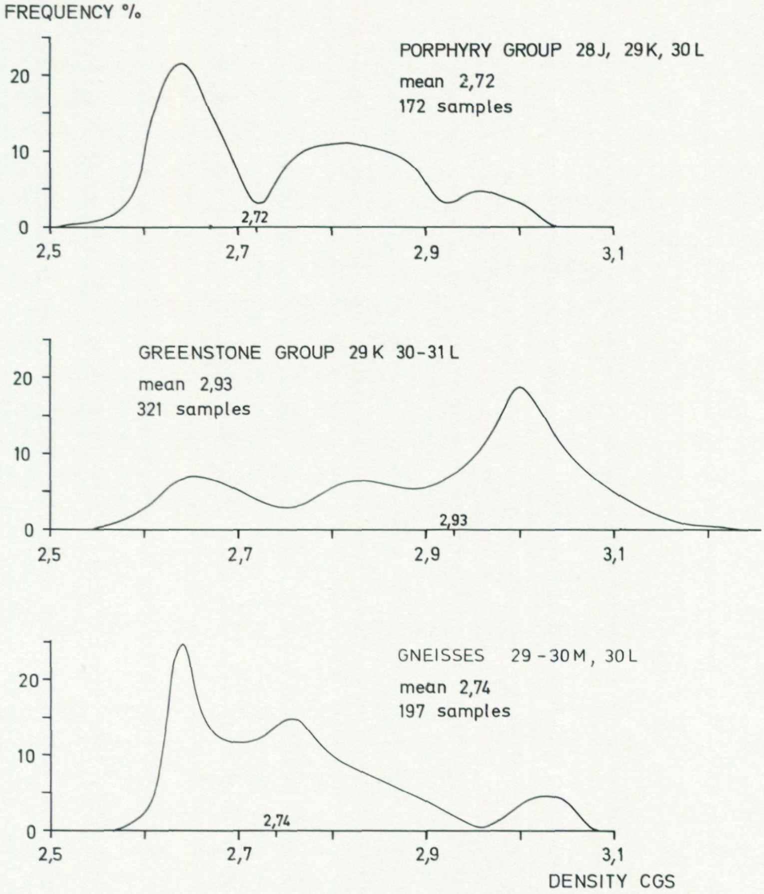

Fig. 7. Density spectra of major rock complexes. Class width 0.04 cgs (g/cm³).

the main rock-units show significant differences in their susceptibility distribution. The upper limits for sub-distributions in susceptibility are:

Gneisses	3×10^{-3} cgs
Greenstones and sediments	5×10^{-3} cgs
Porphyries	1×10^{-2} cgs
Granitic rocks	2×10^{-3} cgs

Rather similar data on density and susceptibility have been published from other Precambrian shield areas (Gibb 1968, Krutikhovskaya et al. 1973). Granitic parts of the basement tend to suffer much less from weathering than the other rock-types. They are probably over-represented among the density samples. The mean values used in the interpretation are however computed from all samples regardless of the areal distribution of each rock type. This will lead to an underestimation of the density contrasts (and an over-estimation of computed depths).

MODEL COMPUTATIONS

Model computations show that all gravity anomalies can be explained with near-surface rock masses. The central area is interpreted as a large culmination with an amplitude of at least 6 km. Its central part is assumed to be occupied by intermediate to basic gneisses, while the outer parts contain acid to intermediate gneisses. The surrounding negative anomaly belt is a conformable belt of less dense rocks, mainly granites. The outermost belt, with high anomalies of intermediate wave-lengths, corresponds to highly folded and faulted supracrustal rocks. They are interpreted as relatively shallow synclinoria with depths up to 3 km. Some distortions can be correlated to the occurence of granitic domes. These typically occur where the supracrustal rocks occupy large areas.

The computations are made using two-dimensional model bodies with polygonal cross-sections. For some sub-models, end corrections have been applied. The boundaries in the geophysical model should not be interpreted as rock boundaries but rather as the mean position of the interface between regimes where either rock type is likely to dominate.

CONCLUSIONS AND DISCUSSION

The gravity high is interpreted as a basement culmination occupied by gneisses and surrounded by a belt of granitic rocks. The occurence of an upper granitic and a lower gneissic layer is interpreted as the result of an earlier crustal process. The supracrustal rocks occur in belts conformable with this structure, supporting the interpretation that they have been folded contemporaneously with the granite-gneiss basement. The flanks of the gneiss-culmination consist essentially of granites and granodiorites. Domes of granitic rocks occur mainly within or close to the supracrustal belts. The oval granodioritic massifs north of the gneiss-structure are most probably mobilized basement material emplaced during the 1.9 Ga old regional deformation. A minimum for the age of the gneisses is provided by the date of 2.3 Ga obtained on the Muonionalusta-Muonio granodiorite. The earliest sequence of supracrustal rocks is a basal quartzitic formation (Tjärro Quartzite Formation). Thereafter follow thick accumulations of effusive greenstones including units of basalts, pyroclastic rocks and metasediments (Kiruna Greenstones). These are overlain by sequences of sandstones, quartzites and schists generally with well developed sedimentary structures (The Pahakurkio Group). The sediments are exclusively acidic and represent a radical change in the type of sedimentation from the clastic rocks in the greenstone group. The Pahakurkio Group rests generally conformably on the greenstones. However, in the Pajala area their relations on a regional scale are unconformable. Further, in the Käymäjärvi area, a thin basal conglomerate is found in the bottom of the succession, and it is probable that sedimentation started with a marine transgression. The composition of these sediments shows that they were derived from a sialic source, which may possibly have been the granite basement now exposed in the culmination. The gabbroic ring-intrusions (RG on Plate I) have not been affected by the regional deformation. Two of them, on map-sheet 29M Huuki, show chilled margins to the surrounding potash granite and are of post-granitic age. Petrological and geophysical evidence indicates that they are cone-sheets or sill-like intrusions of gabbroic composition (further information is found in description to the map-sheets 29M and 30M; Lindroos, in manuscript).

The basement culmination could be caused by the following mechanism. The greenstones are apparently much heavier (2.9–3.1 g/cm^3) than the underlying basement (2.65–3.03 g/cm^3), exposed in the culmination (cf. Fig. 7). According to Ramberg (1967, 1972), in such a case, doming may appear as a result of gravitational adjustments in the crust. The following highly simplified model is proposed for the tectonic development of the area studied:

A. On an early, widespread granite-gneiss basement a basal quartzitic formation was deposited. A period with mainly basaltic volcanism followed.

B. The accumulation of thick heavy greenstones on sialic light crust created an instability. The greenstone-belts sank and the surrounding crust was uplifted simultaneously. The basement was exposed to erosion and the greenstones were intercalated and overlain by clastic sediments.

C. After the deposition followed a probably long period of regional deformation and plutonic intrusion. The supracrustal rocks were folded – by the action of gravity – with flat-lying axes parallel to the basement border. Within the folded and uplifted basement, rocks at high temperature were moved to regions with lower pressure, creating various types of mobilization, especially of the sialic components. The majority of granitic to gabbroic rocks were emplaced during this period of folding.

D. Under the last phase of deformation the unstable gravity layering was readjusted by the formation of granitic diapirs now seen as rounded structures within the supracrustal belts. This doming caused a re-folding of the intruded rocks giving rise to mainly steep fold axes.

E. Later, porphyritic and andesitic volcanism occurred (the Porphyry Group). These rocks are of continental volcanic origin and associated with mobilization and emplacement of the youngest plutons (perthite granites).

It should be noted, that the diapiric granites have the same composition as the granitic layer of the basement, and a separation on petrological grounds seems impossible. The model described above concerning the development of the greenstone belts on older sialic granite-gneiss-basement, is very similar to interpretations proposed by several Canadian authors (e. g. Barager and McGlynn 1976).

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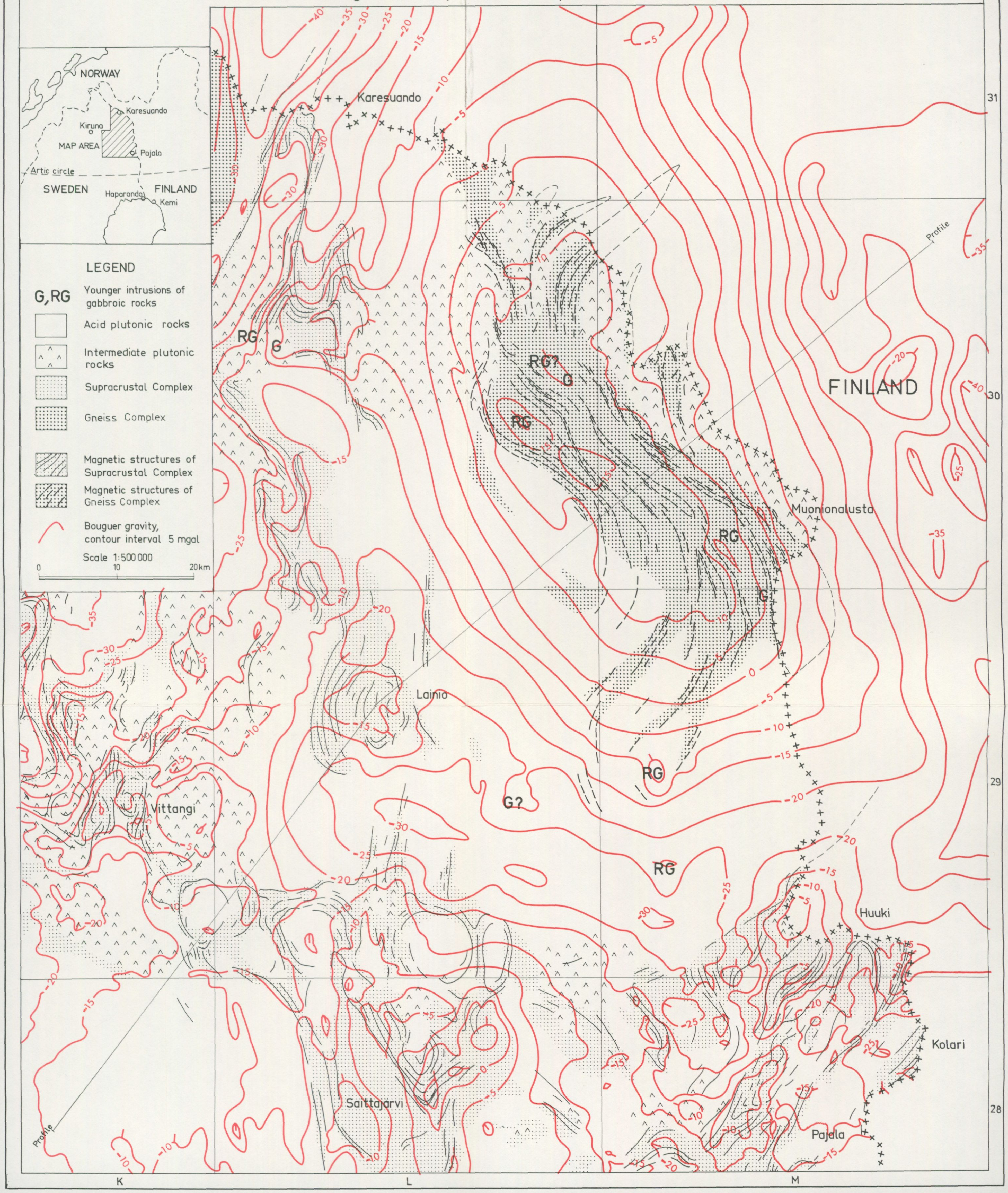
REGIONAL GEOLOGICAL AND GEOPHYSICAL STRUCTURES OF THE PRECAMBRIAN IN NORTHEASTERN SWEDEN

Plate I

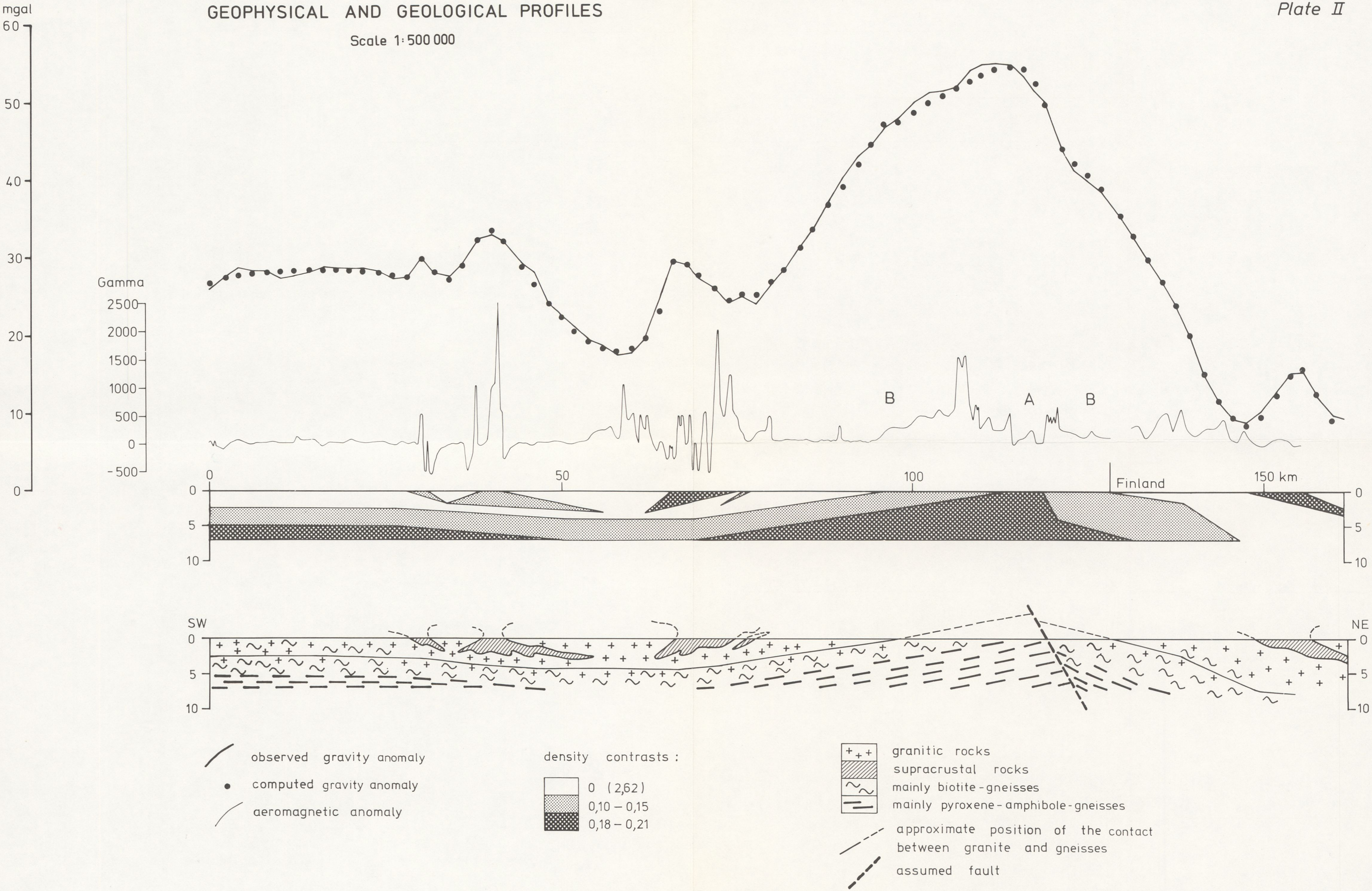
Compiled by H. Lindroos and H. Henkel

Geological Survey of Sweden, 1975



GEOPHYSICAL AND GEOLOGICAL PROFILES

Scale 1:500 000



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