26th International Geological Congress
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Precambrian bedrock of southern
and eastern Finland

Guide to excursions 001 A+C

Edited by Kai Hytönen

Geological Survey of Finland
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AND EASTERN FINLAND

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KAI HYTÖNEN

GEOLOGICAL SURVEY OF FINLAND
ESPOO 1980

A program for a nine-day excursion, dealing with the Precambrian bedrock of southern and eastern Finland, is presented. The main objects of the excursion are the following: The Wiborg rapakivi massif in southern Finland, its evolution and different varieties of rapakivi. Karelian metamorphic belt in eastern Finland; stratigraphy and evolution of the belt. Mantled gneiss domes of the Kuopio area (reactivated basement rocks of the Karelian belt). Metamorphic zoning in the Rantasalmi—Sulkava area within the Savo schist belt in the transitional zone between Svecofennidic and Karelian rocks. The classical Tampere area; principal rocks of the Svecofennidic Tampere schist zone and their petrography, stratigraphy and tectonics. Orbicular rock. Svecofennidic migmatitic rocks in southern Finland. Visit to the Geological Survey of Finland in Otaniemi near Helsinki.

Key words: excursion guide, metamorphic rocks, plutonic rocks, Precambrian, Finland.

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CONTENTS

The Wiborg rapakivi massif — Atso Vorma .............................................. 6
Prekarelidic basement, Prejatulian and Jatulian in the Kiihtelysvaara area —
Lauri J. Pekkarinen ................................................................................. 8
Kalevian formations in the Kiihtelysvaara—Tohmajärvi area —
Lauri J. Pekkarinen .................................................................................. 12
Mantled gneiss dome in the Kuopio area — Jorma Paavola ................. 13
Progressive metamorphism in the metapelites in the Rantasalmi—Sulkava area
— Kalevi Korsman ...................................................................................... 15
Northern contact zone of the Wiborg rapakivi massif — Ahti Simonen ...... 18
The Tampere schist zone and the plutonic rocks of the Kuru area — Ahti
Simonen ...................................................................................................... 18
Metasediments, metavolcanics and plutonic rocks between Tampere and
Hämeenlinna — Ahti Simonen ............................................................... 22
Visit to the Geological Survey of Finland ............................................... 23
Migmatitic and metasomatic rocks in Helsinki — Ilpo Laiti .................... 24
Rocks in the surroundings of Helsinki ..................................................... 26.
DAILY ROUTES

Excursion No. 001A: 27th June—5th July, 1980
Excursion No. 001C: 19th July—27th July, 1980

First day 27th June 19th July Helsinki—Hamina—Lappeenranta ....... 6
Second day 28th June 20th July Lappeenranta—Kiihtelysvaara—Joensuu .. 8
Third day 29th June 21st July Joensuu—Tohmajärvi—Kuopio ........ 12
Fourth day 30th June 22nd July Kuopio—Rantasalmi—Sulkava—Mikkeli . 13
Fifth day 1st July 23rd July Mikkeli—Kouvola—Lahti—Tampere .... 18
Sixth day 2nd July 24th July Tampere—Ylöjärvi—Kuru—Tampere .... 18
Seventh day 3rd July 25th July Tampere—Nokia—Hämeenlinna—Helsinki 22
Eighth day 4th July 26th July Helsinki—Otaniemi—Helsinki ........ 23
Ninth day 5th July 27th July Helsinki and its surroundings ........... 24

Excursion leaders:
Kai Hytönen and Kalevi Korsman
Geological Survey of Finland, SF-02150 Espoo 15

In this guide the excursion stops are designated by two numbers, the first for the day, the second for the stop. Example: 2—3 means the 3rd stop on the second day. The name of the locality is given next to the numbers. The index number of the topographic map 1:100 000 and the x- and y-coordinates of the locality are given in brackets.
26th International Geological Congress 1980
Excursion 001A+C
Precambrian bedrock of Southern and Eastern Finland

Fig. 1. Excursion route and daily stops.
THE WIBORG RAPAKIVI MASSIF — by Atso Vorma

Route: Helsinki—Hamina—Lappeenranta

The Wiborg rapakivi massif in southeastern Finland, its evolution and some varieties of rapakivi will be examined (Fig. 2).

The Wiborg (Viipuri) rapakivi massif is the largest (ca. 18,000 sq. km) occurrence of rapakivi in the Baltic Shield. It was emplaced 1,700—1,650 Ma ago into the cratonized parts of the Svecofennidic complexes. It is a postorogenic, epizonal composite massif associated with basic rocks (e.g. anorthosite) on the one side, and porphyry dykes and volcanic equivalents on the other. Contact breccias and chilled banded margins are often encountered against the Svecofennidic country rocks. In a few places the rock shows well-developed alignment of potassium feldspar laths due to magma flow. The rock is largely without any noticeable flow texture. Signs of high temperature contact metamorphism can be detected in the roof pendants and non-rapakivitic country rocks, even though the Svecofennidic country rock underwent regional metamorphism under the conditions of the upper part of low-pressure amphibolite facies before the emplacement of the rapakivi. The thermal aureole around the massif is revealed by the occurrence of orthoclase zone about 5 km wide in the plutonic country rocks; beyond the aureole these rocks are microcline-bearing. Also, hypersthene-cordierite rocks, adjacent to the contact have been described. Migmatization of the country rock by rapakivi is unknown.

Gravity data suggest that the root zone (stem) of the massif is beneath the Mäntyharju (Ahvenisto) massif (18—20 km deep). From the root, the granite would have spread southeastwards as a sheet that gradually declined from a thickness of ca. 8 km to 5 km at the border. It is postulated that the massif has an extension 5 to 10 km long northwest of the Mäntyharju massif. Thus, the massif appears as an elongate mushroom-shaped intrusion. The present erosion level would be near the roof of the massif.

The rapakivi granites are richer in K, F, Rb, Zr, Hf, REE, Th, and U, and poorer in Ti, Al, Fe, Mn, Mg, Na, P, and Sr than granites in general, and are charcterized by exceedingly low Mg/Fe and K/Rb ratios and a high Ca/Sr ratio. In places the youngest intrusive phases have geochemical characteristics of stanniferous granites with the formation of greisen.

In mineral composition most of the rapakivis are truly granitic, the most basic varieties (locally called tirilite) being either quartz syenites or quartz monzonites. The major minerals are potassium feldspar, either orthoclase or microcline, oligoclase and quartz (idiomorphic »high quartz»). Mafic minerals are represented by very iron-rich varieties, viz. siderophyllitic biotite, hastingsitic hornblende, fayalitic olivine and grunerite.

Textual varieties of rapakivi are represented by wiborgite, i.e. rapakivi granite in sensu stricto, which is characterized by densely packed ovoidal
Fig. 2. Finnish part of Wiborg rapakivi granite massif with adjoining satellite massifs. 1. Svecofennidic rocks; 2—11. subjotnian rocks; 2. diabase; 3. gabbro-anorthosite; 4—11. rapakivi suite; 4. wiborgite; 5. pyterlite; 6. porphyritic rapakivi; 7. granite porphyry; 8. equigranular rapakivi granites; 9. porphyry aplite; 10. dark-coloured varieties of rapakivi; 11. porphyry dykes, and 12. outer margin of thermometamorphic orthoclase aureole around Wiborg massif. Figures refer to excursion stops, arrows along highways to excursion route. According to A. Vorma.

Potassium feldspar phenocrysts, ca. 3 to 4 cm in diameter, mantled by oligoclase shells; by pyterlite, a rapakivi with potassium feldspar ovoids mostly without a plagioclase shell; by porphyritic rapakivi — actually several varieties — with angular instead of ovoidal phenocrysts; by different kinds of equigranular rapakivi from coarse to fine in grain size, and from granitic to quartz syenitic and quartz monzonitic in composition; by porphyry aplites, i.e. equigranular rapakivis with scattered ovoidal and/or angular potassium feldspar phenocrysts and by granite-porphyritic rapakivis with ovoidal and/or angular phenocrysts. Granite-, aplite-, pegmatite- and quartz dykes and sets of subparallel quartz porphyry dykes are also encountered.

Miarolitic cavities indicating the presence of fluid phase under low confining pressure are fairly common. Rapakivi pegmatites occur more rarely than in granitic rocks crystallized deeper in the earth’s crust.

Rapakivi magma is postulated to have generated in the lower crust either during Svecofennidic orogeny (the emplacement being post-
orogenic) or after it (the emplacement being postorogenic, the granite anorogenic).

**Excursion stops**
1—1. Tesjoki, Ruotsinpyhtää. (3023: x = 6706.7, y = 460.8). Porphyry aplite. A fine- to medium-grained rapakivi granite with scattered potassium feldspar ovoids and angular phenocrysts.
1—2. Pyhtää, (3023: x = 6708.9, y = 479.4). Equigranular biotite rapakivi.
1—3. Langinkoski, Kotka. (3023: x = 6708.9, y = 494.0). Large-ovoidic wiborgite with abundant fragments of country rocks of rapakivi.
1—4. Summa, Vehkalahti. (3042: x = 6717.2, y = 506.7). Typical wiborgite of the Wiborg massif with disintegration of rapakivi into »moro».
1—5. Hamina. (3042: x = 6719.1, y = 509.8). Quartz porphyry dyke with chilled margins against the country rock.
1—6. Tullisenlampi, Lemi. (3134: x = 6775.3, y = 551.7). Tirilite, a quartz syenitic — quartz monzonitic variety of rapakivi.

**PREKARELIDIC BASEMENT, PREJATULIAN AND JATULIAN IN THE KIIHTELYSVAARA AREA — by Lauri J. Pekkarinen**

Route: Lappeenranta—Imatra—Kitee—Tohmajärvi — Kiihtelysvaara — Joensuu

A section through the Karelidic schist belt in the Kiihtelysvaara—Tohmajärvi area southeast of the town of Joensuu will be examined (Fig. 3 and Table 1).

The bedrock of the area is characterized by distinct bipartition, the western part belonging to the Karelidic schist belt and the eastern part to the Presvekokarelian basement complex. The Karelides are an ancient mountain range that arose during the Precambrian era and extends from Lake Ladoga to Lapland. In the area the Karelian sediments accumulated unconformably upon the Prekarelian basement. The rocks of the Prekarelian basement are 2 600—2 800 Ma old.

The lowest Karelian sediments are Prejatulian cratonic graben or half-graben accumulates; these are overlain by cratonic shallow-water (sea) and (partly) marine Jatulian accumulates. Also encountered are Jatulian metabasaltic lavas, pyroclastic and hypabyssal rocks (metavolcanics and metadiabases), which intruded into the Jatulian sediments and partly extruded upon them about 2 000—2 100 Ma ago, presumably in three injection periods. During an abrupt change in sedimentation conditions, miogeosynclinal »Kalevian» flysch sediments were deposited upon the Jatulian group. In the Kiihtelysvaara—Tohmajärvi area this deposition started about 2 000 Ma ago. The age of the beginning of the Kalevian sedimentation is still a subject of discussion. A conglomerate bed, representing an unconformity, occurs fairly regularly between the Jatulian and Kalevian groups.

In this area sedimentation and volcanic activity were followed by deformation and metamorphism during the Svecokarelian orogenic phase about 1 800 Ma ago. The Karelides trend regularly north-northwest. Although folding
was not very intense in the Karelian schists, different phases of deformation are detectable. The most conspicuous feature is the folding of the sediments of the synclinal basin against the rigid platform of the Prekarelian basement; hence the axial planes of the folds dip fairly regularly to the west.

The effect of Svecokarelian folding within the Prekarelian basement complex appears primarily as numerous fracture and fault zones.

The Prejatulian and Jatulian sediments, which were originally gravel, arkosic sand and clays containing carbonate and carbon, were metamorphosed under conditions of the greenschist facies into metaconglomerate, arkosite, quartzite, dolomite and carbonaceous slate. The grade of metamorphism increases to the west; thus the Kalevian sandy clay sediments were metamorphosed largely under conditions of the amphibolite facies and were transformed into mica schists,
which often contain porphyroblasts of staurolite and andalusite. The boundary between the metamorphic facies does not, however, exactly follow the boundary between the sediment facies.

No granitoids have been encountered in association with the Karelianides in the contact zone of the Karelian formations and the Prekarelidic basement complex. Farther south, however, they have been encountered in the Tohmajärvi (Fig. 3) and Kitee areas; the best known are the late-orogenic (age group 1 800—1 850 Ma) Petrovaara trondhjemite and Kitee granite.

The second day will be devoted to rocks of the Prekarelidic basement, Prejatulian and Jatulian.

Excursion stops

2—1a. Särkilampi, Kiihtelysvaara (4241: x = 6923.7, y = 517.4). Rocks of the Prekarelidic basement. Hornblende- and biotite-chlorite schists and amphibolite show intense Prevecokarelidic small-scale folding. Banded quartz-magnetite rocks of »iron formation» occur as small lenses in the transition zone between the amphibolite and the biotite-chlorite schist. The Prekarelidic schists are cut by folded veins of tourmaline granite.

2—1b. Särkilampi, Kiihtelysvaara (4241: x = 6923.9, y = 517.2). Contact between the Prekarelidic basement and the Karelian metasediments. Karelian basal strata.

The depositional basement below the unconformity contains Prekarelidic grey granodiorite and quartz diorite with tourmaline granite veins and narrow schist schlieren. The lowest member in Karelian Sequence is a breccia conglomerate with subangular fragments deriving from the underlying bedrock. In some places the breccia conglomerate is in sharp contact with its basement; in others the contact is gradational on account of a breccia. The breccia conglomerate is succeeded sharply by a big-cobbled con-
glomerate with rounded fragments composed predominantly of Prekarelidic pale trondhjemite, tourmaline granite and vein quartz with some rare schist fragments. The conglomerate grades into a small-pebbled horizontally bedded conglomerate whose pebbles have the same composition as the former big-cobbled variety. The small-pebbled variety further into a horizontally bedded arkosite, which, on account of the carbonate content, has been eroded deeper and is not exposed.

2—1c. Särkilampi, Kiihtelysvaara (4241: x = 6923.9, y = 517.1). Upper arkosite. Diamond core drilling data show that the lower horizontally bedded arkosite grades rapidly into a somewhat more coarse-grained cross-bedded upper arkosite. Its granular grains are quartz and potassium feldspar embedded in a sericite-rich matrix. Rounded quartz and granite pebbles occur here and there. In the upper part of this formation the feldspar of the arkosite is intensely sericitized (presumably an ancient weathering crust); the most severely altered portions, however, are covered by a thick soil blanket and are not exposed.

2—1d. Särkilampi, Kiihtelysvaara (4241: x = 6923.4, y = 516.8). Lower Jatulian quartzite. The Jatulian lower quartzite horizon begins with a sericite quartzite that rests unconformably on the upper arkosite. The basal contact of the sericite quartzite is, however, not exposed at this site. The granular grains in the sericite quartzite are almost invariably quartz embedded in a matrix that contains abundant sericite in addition to quartz. Typically the sericite quartzite exhibits cross-bedding, although this is seldom easily recognisable, and thin quartz conglomerate interbeds. Upwards in the sequence the abundance of sericite gradually diminishes and the rocks grade into purer orthoquartzites in which the granular grains and matrix are almost totally quartz. The abundance of sericite increases again in the upper part of the lower quartzite horizon, which also contains some very narrow quartz conglomerate interbeds.

2—2a. Kalkunmäki, Kiihtelysvaara (4241: x = 6922.7, y = 516.6). Jatulian volcanite. Basaltic lava flows were discharged on the lower quartzite formation. They are mainly encountered as slightly porphyric metalavas with albitic plagioclase as the predominant phenocrysts, although in the upper portion pale amphibole also occurs as phenocrysts. The uppermost portion contains layered chlorite-rich schists that were tuffs and tuftites in origin. The upper contact of the volcanites is not exposed; magnetic survey, however, suggests that the total thickness of the volcanite layers is about 80 m.

2—2b. Kalkunmäki, Kiihtelysvaara (4241: x = 6922.8, y = 516.4). Upper Jatulian quartzite and the quartz-bearing dolomite. The volcanites are succeeded by quartzites that are pinkish or greyish in colour due to the presence of chlorite, magnetite and fine-grained hematite in addition to quartz and sericite in the matrix between the granular quartz grains. Some layers show andalusite. Quartz conglomerate interbeds a few decimetres wide are typical of the rock. The rounded quartz pebbles are embedded in a matrix of quartz sand that is often rich in sericite and pinkish in colour due to the fine-grained hematite. Slate interlayers a few decimetres wide are present here and there in the upper part of the quartzite formation. The topmost layers are carbonate-bearing and grade upwards into a quartz-bearing dolomite.
2—3. Hyypia, Kiihtelysvaara (4241: x = 6926.7, y = 515.5). Metadiabase. The lower Jatulian quartzite formation is crosscut by a metadiabase dyke almost 100 m wide that represents the ancient feeding channel of the lava flows that discharged into the above quartzite formation. The rock is darker at the margin of the dyke than in the middle and is mainly composed of plagioclase (oligoclase), chlorite, biotite, epidote and carbonate. Small amounts of hornblende occur sporadically. The paler rock in the middle is richer in plagioclase and, apart from the aforementioned minerals, contains some quartz. Lower Jatulian quartzite is exposed around the dyke but the contact proper is not visible. The U-Pb age of the zircon from the metadiabase is about 2 100 Ma.

KALEVIAN FORMATIONS IN THE KIIHTELYSVAAARA—TOHMAJÄRVI AREA — by Lauri J. Pekkarinen

Route: Joensuu — Kiihtelysvaara — Valkeavaara — Tohmajärvi — Mulo — Joensuu — Kuopio

The excursion in the Kiihtelysvaara—Tohmajärvi area continues. The targets to be visited today are the Kalevian formations, particularly their basement formation (Fig. 3 and Table 1). Kalevian basal conglomerates, the overlying graded-bedded quartzite and the grading of the quartzite into mica schist with staurolite porphyroblasts will be examined. On the way back to Joensuu we shall stop at the Mulo schist. This is a tremolite-bearing black schist that is an intraformational component of the Kalevian mica schist formation.

Excursion stops

3—1. Kortevaara, Kiihtelysvaara (4241: x = 6929.5, y = 514.3). Kalevian basal conglomerate. The lower contact of the conglomerate bed is not exposed, but the adjacent outcrops suggest that the bed is about 15 m thick. Its pebbles, cobbles and boulders are a collection of Jatulian rocks such as quartzite, metavolcanites, metadiabases and carbonaceous slate. Prekarelidic plutonites and schists are, however, lacking. Most of the fragments are subrounded; some angular ones are also encountered. The matrix is composed mainly of quartz, micas and carbonate and contains lenses rich in micas. The conglomerate is overlain by a layer of grey quartzite 15 m thick with narrow phyllitic intercalations. The quartzite grades into a mica schist with small staurolite porphyroblasts.

3—2. Valkeavaara, Kiihtelysvaara (4232: x = 6919.0, y = 517.4). Kalevian quartzite. The contact between the Kalevian and Jatulian formations is not exposed. Data from diamond drilling, however, show that the Kalevian formations begin with a layer of basal conglomerate about half a metre thick that rests unconformably on Jatulian carbonaceous slate. The conglomerate is succeeded by a roughly 15 m thick layer of dark graded-bedded quartzite that grades rather rapidly into a mica schist with local staurolite and andalusite porphyroblasts.
3—3. Kirkkoniemi, Tohmajärvi (4232: \( x = 6899.7, y = 519.8 \)). Kalevian conglomerate. A lense-like occurrence of polymictic conglomerate some 2 km long is encountered in the anticlinal ridge at Kirkkoniemi, Tohmajärvi. This conglomerate, whose western end rests on Jatulian volcanites is considered as a Kalevian basal conglomerate.

The conglomerate is rather poorly sorted. As a rule, fragments abound and the share of the matrix is low, although in some parts of the deposit the matrix predominates. The conglomerate also contains phyllite or mica schist interlayers. Pebbles as large as an egg or a clenched fist predominate; in some places, however, small coarser portions occur in which the diameter of the largest boulders is about 1 m. The fragments are generally sub-rounded; nevertheless, the conglomerate is not completely devoid of angular fragments. Most of the fragments are of various rocks of the Prekarelidic basement complex, most commonly trondhjemite, granodiorites, quartz diorites, aplite, migmatites and vein quartz. The rest of the fragments are Jatulian rocks, such as quartzites, carbonaceous slates, volcanites and diabasic rocks. The matrix in the conglomerate is greywackey, but it varies in composition, the main minerals being quartz and feldspar; carbonates and mica-rich lenses occur in places. At the western end of the conglomerate the matrix contains hornblende. The portions rich in micas show garnet and staurolite porphyroblasts. The upper part of the conglomerate formation contains grey quartzite intercalations similar to those at Valkeavaara, which suggests that the conglomerate may grade into mica schist through a quartzitic transitional variant.

3—4. Kemie, Tohmajärvi (4232: \( x = 6901.1, y = 518.5 \)). Staurolite-bearing mica schist. The lower part of the Kalevian mica schist formation contains fairly abundant staurolite porphyroblasts, often with cruciform twins. Garnet and andalusite porphyroblasts have been encountered in addition to staurolite.

3—5. Mulo, Pyhäselkä (4223: \( x = 6935.6, y = 492.7 \)), slightly beyond the area shown in Fig. 1). Black slate. Exposed in the road cut is a black slate darkened by a fine-grained graphite and showing actinolite bundles. Locally the rock contains appreciable iron sulphides. Some carbonate and accessory gypsum occur in the joint and weathering surfaces.

**Fourth day**

**MANTLED GNEISS DOME IN THE KUOPIO AREA — by Jorma Paavola**

Route: in Kuopio

In the morning the excursion will head for the Jynkkä area, 5 km south of Kuopio, where our target is an Archaean mobilized basement gneiss dome and its superincumbent mantle of younger Karelidic sedimentary strata. We shall visit outcrops of basement gneiss, basal conglomerate, the volcanic unit and mica schist (Fig. 4). The basement gneiss often forms hills, whereas the younger metasediments occur on slopes and in valleys. The dip of the beds along the slopes is generally very steep.
Excursion stops

4—1. Petosenmäki, Kuopio (3242: $x = 6971.2$, $y = 531.7$). Polymetamorphic basement gneiss. The core of the basement gneiss dome will be examined in a road cut almost 500 metres long. Rocks of both para- and orthogneiss types are present. The dominating rock is a strongly migmatized granodioritic to quartz dioritic gneiss; various types of banded mica and hornblende gneisses, augen gneisses and amphibolites also occur. The main minerals of the basement gneiss are quartz, potassium feldspar, plagioclase, biotite and hornblende. Epidote, muscovite, chlorite and carbonate occur in varying amounts. The gneiss is cut by several granitic, granite pegmatitic and amphibolitic dykes of different ages.

4—2. Lippumäki, Kuopio (3242: $x = 6971.2$, $y = 533.4$). Polymictic conglomerate with arkosic and carbonate-rich intercalations. It is part of the basal formation of the sedimentary rocks in the area. Most of the pebbles are various types of leucocratic Archaean basement rocks and the main minerals are microcline, quartz, oligoclase and biotite, with some epidote, carbonate, sericite and chlorite. Darker fragments are rare. The pebbles are 2—20 cm in size; they are usually well rounded and often somewhat flattened and lineated. The matrix consists of arkosic material. In some places skarn intercalations about 1 metre thick show boudinage structure.

4—3. Vaivanen, Kuopio (3242: $x = 6972.5$, $y = 534.4$). Amphibolite with pillow lava structure. It is part of the 100- to 400 metres thick horizon of basic metavolcanic rocks, that overlies the dolomiteskarn unit. The pillows, which vary from some tens of centimetres to one metre or so, consist of
hornblende, partly altered to biotite, plagioclase (An$_{40-50}$) and sphene. The matrix is carbonate-rich, and hence deeply eroded.

4—4. Rahkamäki, Kuopio (3242: x = 6972.6, y = 532.8). Mica schist. It represents the uppermost known stratigraphic unit of the Kuopio area. Although the rock is strongly metamorphic, the bedding is generally distinct. Graded bedding shows a pelitic upper and a psammitic lower part. In some places the beds form large open folds. The main minerals are quartz, plagioclase (An$_{40-50}$), biotite, pinitized poikiloblastic cordierite, fibrous sillimanite and small staurolite porphyroblasts. The accessory minerals are zircon, apatite, tourmaline and opaque. Garnet is present in some lower horizons. The rock contains graphite- and pyrite-bearing intercalations.

PROGRESSIVE METAMORPHISM IN THE METAPELITES IN THE RANTASALMI—SULKAVA AREA — by Kalevi Korsman

Route: Kuopio—Rantasalmi—Sulkava—Mikkeli

In the afternoon we shall study progressive metamorphism in the metapelites in the Rantasalmi—Sulkava area, part of the Svecokarelidic schist belt of Savo. The grade of metamorphism increases southwards. Progressive metamorphism has produced the following zonality in the metapelites: mica schist zone, K-feldspar—sillimanite zone, K-feldspar—cordierite zone migmatized by potassium granite, and garnet—cordierite—sillimanite zone intensely migmatized by potassium granite (Fig. 5). The mica schist zone was metamorphosed under conditions of the amphibolite facies, and the garnet—cordierite—sillimanite zone under conditions of the granulite facies. Grading from the amphibolite to granulite facies takes places between the K-feldspar—cordierite and garnet—cordierite—sillimanite zones. Common mineral assemblages of the metapelites are given in Table 2. Table 3 shows the chemical composition of some samples.

Excursion stops

4—5. Marja-aho, Joroinen (3233, x = 6888.4, y = 544.3). Mica schist. Graded bedding and lamination typical of turbidites are preserved in the northern part of the mica schist zone. Quartz and plagioclase occur as fragments, 0.3 to 1.5 mm in size, in the psammitic bottom part of the metapelite layer. The pelitic top part is largely equigranular, the grain size ranging from 0.01 to 0.02 mm.

4—6. Haapataipale, Rantasalmi (3233, x = 6881.5, y = 552.7). K-feldspar—sillimanite gneiss. The boundary between the mica schist and K-feldspar—sillimanite zones is easily delineated by the absence or presence of sillimanite, a mineral readily recognisable in the outcrops. K-feldspar occurs as poikiloblastic grains, 2.5 to 5 mm in size. The K-feldspar—sillimanite gneisses have retained their bedding well; graded bedding, however, is not visible.
Fig. 5. Geological map of the Rantasalmi and Sulkava areas. The study area is outlined. Isograds: I the K-feldspar—sillimanite isograd and the southern boundary of the mica schist zone; II the K-feldspar—cordierite isograd and the southern boundary of the K-feldspar—sillimanite zone; III the hypersthene isograd; IV the garnet—cordierite—sillimanite isograd and the southern boundary of the K-feldspar—cordierite zone. Circled numbers refer to excursion outcrops. According to K. Korsman.

Table 2.
Common mineral assemblages of metapelites in the Rantasalmi—Sulkava metamorphic zones

<table>
<thead>
<tr>
<th>Metamorphic zone</th>
<th>Mineral assemblage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mica schist zone</td>
<td>quartz—oligoclase—muscovite—biotite</td>
</tr>
<tr>
<td>K-feldspar—sillimanite zone</td>
<td>quartz—K-feldspar—oligoclase—sillimanite—biotite ± muscovite</td>
</tr>
<tr>
<td>K-feldspar—cordierite zone</td>
<td>quartz—K-feldspar—oligoclase—sillimanite—biotite—cordierite—or garnet</td>
</tr>
<tr>
<td>Garnet—cordierite—sillimanite zone</td>
<td>quartz—K-feldspar—sillimanite—cordierite—garnet ± plagioclase</td>
</tr>
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Table 3.
Chemical composition (wt %) of samples in the Rantasalmi—Sulkava metamorphic zones

<table>
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<tr>
<th></th>
<th>4—5a *)</th>
<th>4—5b</th>
<th>4—6a</th>
<th>4—6b</th>
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<th>4—8a</th>
<th>4—8b</th>
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<td>71.1</td>
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<td>FeO (total)</td>
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<tr>
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<td>3.0</td>
</tr>
<tr>
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<td>0.8</td>
<td>3.0</td>
<td>3.0</td>
<td>7.6</td>
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<td>98.7</td>
<td>98.3</td>
<td>97.9</td>
<td>99.6</td>
<td>102.6</td>
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4—5a. Mica schist, bottom part of layer
4—5b. Mica schist, top part of layer
4—6a. K-feldspar—sillimanite gneiss
4—6b. Tourmaline-bearing pegmatite
4—7. K-feldspar—cordierite gneiss
4—8a. Garnet—cordierite—sillimanite gneiss
4—8b. Microcline granite

*) The numbers refer to excursion outcrops (Fig. 5)

Tourmaline-bearing pegmatite veins have been encountered in the southern part of the mica schist zone and in the K-feldspar—sillimanite zone.

4—7. Ronkala, Juva (3233, x = 6872.9, y = 562.2). Migmatitic veined K-feldspar—cordierite gneiss. Bedding is distinct in the northern part of the K-feldspar—cordierite zone, as in the present outcrop, but in the southern part it is not easily recognisable. Cordierite is usually fairly abundant. Practically all the outcrops in the zone also contain garnet, although the content is low: in the northern part it is less than one percent and in the southern from 1 to 1.5 percent. Cordierite and garnet occur as porphyroblasts, whereas the K-feldspar grains are often poikiloblastic. The composition of garnet is: almandine 81 %, pyrope 14 %, spessartine 3 % and grossular 2 %.

4—8. Soittomäki, Sulkava (3144, x = 6854.7, y = 572.2). Garnet—cordierite—sillimanite gneiss. The garnet—cordierite—sillimanite zone contains a higher proportion of migmatizing granite than does the K-feldspar—cordierite zone. Bedding is only visible in exceptionally calcium-rich parts of the garnet—cordierite—sillimanite gneiss outcrops. In thin sections fairly large portions of the gneisses are composed of garnet, cordierite and sillimanite, which are often separated from each other by granitic segregations. K-feldspar does not occur as poikiloblastic grains, and hence the texture differs from that of the K-feldspar—cordierite gneisses. The quantity of garnet reaches several percent. Cordierite is frequently intensely pinitized, and the K-feldspar sericitized, whereas in the metapelites of the other zones the amount of water-bearing alteration products is low. The retrogressive metamorphism was due to the high water content in the migmatizing granite magma. The composition of garnet is almandine 76 %, pyrope 20 %, spessartine 1 % and grossular 3 %.
NORTHERN CONTACT ZONE OF THE WIBORG RAPAKIVI MASSIF — by Ahti Simonen

Route: Mikkeli—Kouvola—Lahti—Tampere

Trip into the town Tampere takes a great deal of time and only few outcrops in the northern contact zone of the Wiborg rapakivi massif will be studied in the road cuts (Fig. 2). The main problems associated with rapakivi were studied during the first day of this excursion and so we shall do no more than just take a brief look at equigranular rapakivi granite of the Suomenniemi satellite massif, a Postsvecokarelian diabase and the northern contact of the Wiborg massif against Svecofennidic migmatites.

Between the towns of Mikkeli and Tampere the road passes through typical Finnish countryside where topography is fashioned by peneplained Precambrian crust with accumulations of Pleistocene glacial deposits. Moraine drift, ice marginal and radial eskers flash past the windows of the bus. Between Kouvola and Lahti the road goes along Salpausselkä, the most important ice marginal deposit in Finland. In this region the continental ice sheet started to melt about 10 000 years ago, an event that is celebrated annually by the club of the geology students at Helsinki University.

Excursion stops

5—1. Halmeniemi, Mäntyharju (3132: x = 6798.6, y = 509.8). Equigranular rapakivi granite. This variety is a typical representative of the Suomenniemi rapakivi massif whose U-Pb age for zircon is about 1 670 Ma.

5—2. Lovasjärvi, Valkeala (3132: x = 6783.0, y = 507.9). Diabase. This coarse-grained diabase penetrates the Svecofennidic migmatites. Only slightly older than the oldest rapakivi granites, it belongs to the same phase of mafic, Postsvecokarelian magmatism (~1 680 Ma) as the gabbro anorthosite around Ahvenisto massif and the diabase dikes in Häme.

5—3. Parola, Valkeala (3132: x = 6781.2, y = 505.8). Contact of the Wiborg rapakivi massif. The contact surface of rapakivi dips below the Svecofennidic migmatites. A dark fine-grained variety of rapakivi occurs along the contact followed by pyterlite, which grades into wiborgite with mantled ovoids. Segregations of mafic minerals form flow layers parallel to the contact.

THE TAMPERE SCHIST ZONE AND THE PLUTONIC ROCKS OF THE KURU AREA — by Ahti Simonen

Route: Tampere—Ylöjärvi—Kuru—Tampere

A section through the Tampere schist zone and the plutonic rock complex of Central Finland will be examined. This is a key area for interpreting the Precambrian geology of Finland. A sketch map of the Tampere schist zone, vertical sections and a stratigraphic column are given in Fig. 6 and Table 4.
Fig. 6. The Tampere schist belt with vertical sections. 1. plutonic rocks; 2. mafic metavolcanics; 3. conglomerates; 4. quartz-feldspar rocks; 5. greywacke-slates. Arrow shows the direction of the base determined by graded bedding. According to A. Simonen.

The total thickness of the strata is at least 8 kilometres, and the sequence is markedly similar to the greywacke-basalt association of geosynclinal deposits of younger ages. The accumulation of greywacke-slates and immature sandstones indicates a high degree of tectonism during sedimentation. The predominantly mafic volcanics overlying the sedimentary succession
Table 4.  
Stratigraphic sequence of the strata from top to bottom in the Tampere field. According to A. Simonen

<table>
<thead>
<tr>
<th>Stratigraphic Unit</th>
<th>Thickness in metres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic volcanics</td>
<td>&gt; 1 000</td>
</tr>
<tr>
<td>Conglomerates and associated beds of greywacke-slates and arkoses</td>
<td>700—800</td>
</tr>
<tr>
<td>Basic and intermediate volcanics</td>
<td>800—1 500</td>
</tr>
<tr>
<td>Quartz-feldspar rocks (arkoses, greywackes and pyroclastics)</td>
<td>1 500—2 200</td>
</tr>
<tr>
<td>Greywacke-slates</td>
<td>&gt; 3 000</td>
</tr>
</tbody>
</table>

are products of geosynclinal volcanism in a mobile belt. Thick conglomerate interbeds with associated sediments have accumulated along the margins of the uplifted volcanic island arch systems.

The Tampere schist belt has undergone intense folding that has turned the beds into a vertical or steep position. The strike of the bedding is approximately E-W and the dip is steep. The intense folding in the strata is revealed particularly by the successions of graded beds, whose bases lie alternately to the south and the north. Gently plunging, vertical or overturned isoclinal folds are predominant. The cleavage and schistosity are generally parallel to the bedding. The lineation is vertical or steep and is in the direction of the tectonic a-axis. Mafic metavolcanics are denoted by competent beds that form isoclinal folds varying in width from several hundreds a metres to a few kilometres.

The schists of the Tampere field were metamorphosed and folded about 1 900 Ma ago and were penetrated by Svecokarelidic plutonic rocks. The plutonic rocks of the Tampere area and Central Finland are part of the »granite province» in which quartz diorites, granodiorites and granites predominate.

The rocks of the granite province form a continuous series grading from gabbros into granites. The ultramafics contain olivine and pyroxene as mafic minerals. Some remnants of diopside surrounded by hornblende have been found in gabbros and quartz diorites. Hornblende is the most common mafic mineral in gabbros and quartz gabbros. The association hornblende—biotite is characteristic of quartz gabbros and quartz diorites. Biotite is typical of the granodiorites and granites. Hornblende is lacking from the silicic members of the province. The content of plagioclase is highest in the quartz diorites and decreases towards the silicic members of the province. The anorthite content in plagioclase decreases regularly with increasing silica content of the rock. The abundance of microcline is low in quartz diorites but it increases rapidly towards the silicic members, where it is more abundant than plagioclase. The variations in mineralogical composition in the granite province are presented in Fig. 7. A unique type of plutonic rock, the orbicular rock of Kuru, will be visited at the end of the programme for today.

![Fig. 7. Mineralogical composition of the plutonic rocks in the granite province. 1. quartz; 2. microcline; 3. plagioclase; 4. biotite; 5. hornblende; 6. accessories. According to A. Simonen.](image)
Excursion stops

6-1. Lentäväniemi, Tampere (2123: x = 6824.8, y = 484.8). Greywacke-slate with graded bedding. The beds have been folded into steep isoclines. Texture is blastoclastic. The sand particles, consisting mainly of quartz and feldspar, are in a fine-grained, argillaceous matrix rich in mica and chlorite. Chemical analyses of a lower and upper part of a graded bed are given in Table 5, anal. 1–2.

6-2. Kiviniemenlahti, Ylöjärvi (2124: x = 6830.6, y = 483.0). Quartz-feldspar schist. Fine-grained, granoblastic rock similar to leptites. The rock has been interpreted as a silicic tuff rich in sodium. Chemical analysis is given in Table 5, anal. 3.

6-3. Kiviniemenlahti, Ylöjärvi (2124: x = 6830.8, y = 483.2). Agglomeratic amphibolite. Fragments and bombs of metavolcanics are in a granoblastic, amphibolitic matrix.

6-4. Pihkapera, Ylöjärvi (2124: x = 6831.2, y = 483.2). Metatrachyandesite. Blasto-porphyrritic plagioclase, altered into epidote and albite in a fine-grained matrix. Chemically, the rock is more alkalic than other metavolcanics of the area (Table 5, anal. 4).

6-5. Veittijärvi, Ylöjärvi (2124: x = 6831.1, y = 478.6). Metaconglomerate. It occurs as a thick intraformational accumulation in the volcanic strata of the Tampere field. The rounded pebbles are mainly metavolcanic rocks underlying conglomerate. The matrix of the conglomerate is heterogeneous, consisting of micaceous schist and meta-arkose.

Table 5.

Chemical analyses of rocks from the Tampere, Kuru, and Hämeenlinna areas

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1. Lower part of graded bed. Ajonokka, Aitolahdi.
2. Upper part of graded bed. Same bed as in Analysis 1.
6. Quartz gabbro, Syväläänkylä, Kuru.
6—6. Ylinen, Ylöjärvi (2124: x = 6836.0, y = 479.7). Quartz diorite. Main minerals are plagioclase, hornblende, biotite and quartz. Texture is hypidiomorphic.

6—7. Kaiharinalahti, Ylöjärvi (2124: x = 6838.6, y = 477.6). Porphyritic granite. Main minerals are microcline, plagioclase, quartz and biotite. The porphyritic grains of microcline contain inclusions of plagioclase.

6—8. Niemikylä, Kuru (2124: x = 6859.4, y = 488.7). Grey granite (Kuru granite). Equigranular, homogeneous granite with microcline, plagioclase and biotite as main minerals. The rock is quarried in many places. Chemical analysis is given in Table 5, anal. 5.

6—9. Syväläntylä, Kuru (2213: x = 6861.0, y = 485.8). Quartz gabbro. Main minerals are plagioclase (≈An₃₂), hornblende and biotite. Small amounts of quartz are present. The rock is equigranular and rather homogeneous; it is quarried. Chemical composition is given in Table 5, anal. 6.

6—10. Parkusjärvi, Kuru (2124: x = 6852.9, y = 480.1). Orbicular rock. This peculiar rock type occurs as two mappable varieties along the contact zone between granodiorite and granite. In one variety, the orbicules consist mainly of plagioclase with a coarse-grained nucleus surrounded by a fine-grained plagioclase shell. In the other variety, the plagioclase orbicules are surrounded by a pink-coloured outer shell of potassium feldspar. The contact between the two principal types of orbicular rock is gradational. The matrix of the orbicular rock is heterogeneous, consisting of quartz diorite, granodioritic and granitic parts. Some granite dykes cut the orbicular rock. Chemical analyses of the different parts of an orbicule are given in Table 5, anal. 7—9.

METASEDIMENTS, METAVOLCANICS AND PLUTONIC ROCKS BETWEEN TAMPERE AND HÄMEENLINNA — by Ahti Simonen

Route: Tampere—Nokia—Tampere—Hämeenlinna—Helsinki

The study of the Tampere area continues. Today we shall take a look at coarse-grained metagreywacke with megabeds and cross-bedded meta-arkose. The well-preserved greywacke-slates that grade into mica gneisses, when they occur as inclusions in plutonic rocks or as paleosome of veined gneiss are examined.

South of Tampere we shall drive through a broad area of migmatitic mica gneisses. North of the town of Hämeenlinna we come to the most eastern end of the Tammela—Kalvola schist zone with mica schists, mafic metavolcanics and granodiorites, which will be studied. The metamorphic rocks in the Tammela—Kalvola area are related to those in the Tampere field. Their importance to our understanding of the Finnish Precambrian is widely recognized, because it was here that Sederholm in 1891 first proved the applicability of the actualistic method to studies of metamorphic Precambrian formations.
Excursion stops


7—2. Koivisto, Nokia (2123: x = 6821.7, y = 460.6). Meta-arkose with cross bedding. Texture is blastoclastic. Subangular particles of quartz and feldspar in a recrystallized matrix rich in quartz, feldspar and muscovite. The age of detrital zircon of the rock is 1 900 Ma, indicating that the rocks of this age acted as a source for deposited material.


7—4. Rosendahl, Tampere (2123: x = 6820.8, 485.7). Migmatitic veined gneiss. In the migmatite front, the micaceous schists with graded-bedding grade into granoblastic mica gneisses in which veins of granitoid rocks are common. Extensive areas in southern Finland consist of migmatitic veined gneisses with plutonic massifs.

7—5. Kuurila, Kalvola (2132: x = 6777.7, y = 503.2). Mica schist. The texture is granoblastic but relics of graded-bedding are visible. Large, spear-shaped porphyroblasts of andalusite intensely altered into sericite are met with.

7—6. Ylinen Savijärvi, Hattula (2131: x = 6767.7, y = 514.5). Uralite porphyrite. Main minerals are hornblende and plagioclase and texture is blastoporphyritic. Primary augite phenocrysts of basaltic rock have been altered by metamorphism into hornblende that shows relics of the crystal forms of pyroxene. The matrix, consisting of hornblende and plagioclase, is fine-grained and granoblastic in texture.

7—7. Myllymäki, Hämeenlinna (2131: x = 6764.5, y = 524.5). Granodiorite. The main mafic minerals are hornblende and biotite; idiomorphic hornblende is typical. Plagioclase occurs as zoned crystals. The abundance of microcline is very low. The granodiorite contains rounded dark inclusions, that represent more mafic differentiation products of granodioritic magma. Chemical composition of the granodiorite is given in Table 5, anal. 10.

VISIT TO THE GEOLOGICAL SURVEY OF FINLAND

Route: Helsinki—Otaniemi—Helsinki

Today will be devoted to a visit to the Geological Survey of Finland in Otaniemi (Fig. 8), about 8 kilometres to the west of Helsinki. The Survey consists of five research departments: petrology, quaternary geology, exploration, geophysics and geochemistry. There is also a small museum.

The Helsinki University of Technology and the Technical Research Centre of Finland are quite close to the Geological Survey. Tapiola Garden City is about one kilometre away.
Route: in Helsinki

In the Helsinki area (Fig. 8) acid plutonic rocks of the synorogenic and late orogenic phases of the Svecokarelidic orogeny predominate. The rocks of the synorogenic phase are rich in sodium whereas those of the late orogenic phase are mainly potassium-dominated granites. Quartz diorites, oligoclase granites, trondhjemites, etc. are more or less granitized by potassium granite, and hence often contain almandine or other Al-rich minerals.

Mica schists, mica gneisses and acid gneisses of arkosic or volcanic origin (often known as leucite gneisses) and amphibolites of volcanic origin occur as remnants of supracrustal rocks. Some of the mica schists and mica gneisses overlie basic volcanics; mostly, however, the volcanics overlie the mica gneisses. The majority of the mica schists and gneisses were originally greywackes. The acid gneisses rich in feldspar are often accompanied by limestones. Many of these gneisses were originally carbonate-bearing and were metamorphosed into diopside gneisses. The mica gneisses are usually garnet- and/or cordierite-bearing, especially if they have been affected by potassium metasomatism caused by potassium granite.

Excursion stops

9—1. The Hietaranta beach and offshore islands (2034: x = 6673.8, y = 550.3). Garnet-cordierite gneiss, the predominant rock in the western part of the cape of Helsinki. The rock, which is rather coarse-grained, plastically deformed and strongly migmatized, has the appearance of veined gneiss. Quartz-feldspar gneiss and amphibolitic intercalations occur in places.

The paleosome of the garnet-cordierite gneiss consists of quartz — often with conspicuous undulating extinction —, oligoclase, biotite and almost completely pinitized cordierite. Fibrous sillimanite is often encountered. Microcline and garnet are common constituents of the neosome.

Although the veined gneiss is plastically folded, the amphibolitic intercalations — or possibly sills — show boudinage structure. The boudins are rounded or lenticular, often several metres in diameter and several metres apart. The amphibolite boudins are almost devoid of granitic veins.

On the nearby islet of Ouri garnet-cordierite gneiss forms a syncline, the axis of which plunges 20°—30° ESE. Thus it seems that, stratigraphically, the garnet-cordierite gneiss underlies the volcanics of the eastern part of the cape of Helsinki.

9—2. Kaivopuisto Park, Helsinki (2034: x = 6671.7, y = 553.3). Folded migmatitic amphibolite. Medium-grained amphibolite is penetrated by numerous pegmatitic dykes. Both the amphibolite and pegmatite dykes are folded around an axis plunging steeply eastwards. The fold opens westwards and its core consists of pegmatite. The pegmatite-amphibolite contacts are quite sharp; no reaction seems to have taken place, the structure of the pegmatite being apparently completely undisturbed. Obviously, the pegmatite dykes are not truly folded, but occupy spaces provided by earlier folded amphibolite. Well-developed glacial striations are visible on the surface of the outcrop.

On top of the outcrop there is a well-rounded erratic block of rapakivi granite of wiborgitic type that was found on the nearby shore and transferred to its present location by the Helsinki municipal authorities. Rapakivi erratics like this are rather common in the Helsinki area. They were obviously transported by floating icebergs,
because no wiborgitic rapakivi occurrences are known in the direction of normal glacial transport.

The effect of land uplift is clearly visible along the shore by Kaivopuisto in the geomorphology. As the land rises, the higher points are the first to enter the zone of wave-action. The waves wash the fine material of the original cover away until practically all that remains is bare bedrock. Thus, an archipelago of rocky islands forms in front of the shoreline which, in turn, is protected from further abrasion. A further stage of development in land uplift can be seen inland in southern Finland where the landscape is dominated by rocky hills interspersed with clay plains.

9-3. Kaivopuisto Park, Helsinki (2034: x = 6671.9, y = 553.5). Cracked diorite. The core of the amphibolitic arch of southeastern Helsinki consists of a fissured, coarse-grained dioritic rock, in which potassium feldspar has crystallized around the cracks. The potassium-rich fluids seem to have filtered into the cracks and from there into the surrounding rock, giving rise to potassium metasomatism. The metasomatic alteration comes to an end, however, only a few centimetres from the fissures.
ROCKS IN THE SURROUNDINGS OF HELSINKI

Route: Helsinki surroundings

9—6. Malmi airport, Helsinki (2043: x = 6682.3, y = 557.9). Cordierite gneiss cut by microcline granite. Cordierites of two ages are present. The dark spots in gneiss are pinitized cordierite formed during regional metamorphism; the dark flecks in late orogenic microcline granite are accumulations of cordierite (partly pinitized) that is an alteration product of the mafic minerals in the gneiss assimilated by microcline granite.

As a rule, the texture of the rock is more or less cataclastic: the albite twin lamellae are bent and in places kinked, the albite crystals are often broken and the epidote mass penetrates the cracks. These rocks are medium to coarse or even pegmatic in grain size.

The albite crystals are usually rather clear or only faintly clouded by a very fine opaque pigment. In contrast, the epidote crystals tend to be heavily pigmented. The reddish colour of the epidote, which is visible megascopically, is obviously due to a hematite pigment; hematite is in fact a fairly common accessory.

The bedrock in the vicinity of helsinkite is rather intensely crushed; slickensides occur in many different directions, and hence the bedrock of the area constitutes a mosaic of blocks of many sizes. This seems to be a general feature of helsinkite occurrences. Helsinki builders know that there is trouble in store when they come up against helsinkite in their work.

The mode of occurrence of helsinkite seems to suggest that it is a product of low-temperature metamorphism and metasomatism in association with block movements.
9—7. Noppo, Hyvinkää (2044: \( x = 6716.7, y = 544.2 \)). Diopside gneiss cut by granite. The main minerals in the gneiss are clinopyroxene (composition intermediate between diopside and hedenbergite, near \( \text{Di}_{50}\text{Hed}_{50} \)), plagioclase, quartz, sometimes carbonate, potassium feldspar and biotite. The accessories are titanite, apatite and zircon. The granite contains accumulations of clinopyroxene and titanite, which originally were constituents of the gneiss.