GEOLOGINEN TUTKIMUSLAITOS

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STRATIGRAPHY AND SEDIMENTATION OF THE SVECOFENNIDIC, EARLY ARCHEAN SUPRACRUSTAL ROCKS IN SOUTHWESTERN FINLAND

BY
AHTI SIMONEN

WITH 17 FIGURES IN TEXT, 8 TABLES AND 2 MAPS

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PREFACE

The present study is based on the geological re-mapping of Southwestern Finland carried out by the Geological Survey of Finland and deals mainly with the stratigraphy and sedimentation of the early Archean schists. The geological re-mapping of Southern Finland started in the year 1936 under leadership of the late Dr. Erkki Mikkola whose death in the Winter War 1939—40 was a great loss to geological research in Finland. During the years 1940—44 the regular research work was at standstill, because all field geologists of the Geological Survey were in the army. The mapping work was continued immediately after the World War II and the geological re-mapping of the classical Tampere schist area was undertaken in the year 1945 as part of the program of the Geological Survey of Finland. Now an area of about 30 000 km^2 has been re-mapped in Southwestern Finland, but most of the map sheets and explanations are still under preparation.

The author will thank his collegues in the Geological Survey for helpful discussions of many problems. Especially he wishes to thank his friend Dr. Maunu Härme who during the years 1950—52 has taken an active part in the revision of the geological sketch maps of Southern Finland.

To his chief, Professor Aarne Laitakari, Director of the Geological Survey of Finland, the author wishes to express his sincere gratitude for kindness in allowing to devote a large part of time to the present work, and in allowing its publication by the Geological Survey.

Mr. Olavi Helovuori, Mr. Olavi Kouvo and my wife Laura have assisted in calculations of Niggli numbers and average compositions. Miss Thyra Åberg has drawn the figures and maps. Professor Etta MacDonald and Mr. G. Melcher have kindly revised the English of my manuscript. To all the persons mentioned the author is greatly indebted.

Ahti Simonen.

Geological Survey of Finland, Helsinki, June 1952.

INTRODUCTION

The name J. J. Sederholm (1863—1934) will be mentioned always in connection with the geological study of the Finnish Archean rock crust. He was the pioneer in the study of pre-Cambrian geology, marking out the way for the studies of the oldest geological history of the globe. On the basis of his investigations the actualistic method for the first time proved correct in the study of the Archean rock crust (Sederholm, 1891 and 1897), and migmatites and granitic rocks (Sederholm, 1907, 1923, 1926 and 1934) were brought into the theatre of lively scientific discussions. Sederholm was first of all a field geologist. He did not consider rocks to be only museum specimens, but he tried to make them alive. He stressed that geology is a science of time, and the study of the succession of events, and therefore, the stratigraphic classification of the pre-Cambrian formations runs like a red thread through his whole work.

The historical outlines of the stratigraphic studies in Finland, described in a separate paragraph of this paper, show distinctly many difficulties in the interpretation of the stratigraphy in the metamorphic, nonfossiliferous Archean formations. The investigator of this problem often risks serious mistakes, especially in making correlations between separated schist areas. Also Sederholm's stratigraphic classification has been criticized and re-interpreted by later investigators. According to our present views, two orogenic cycles, Svecofennidic and Karelidic, have taken place in the pre-Cambrian rock crust of Finland. The early Archean rocks of Southwestern Finland, including both Svionian and Bothnian formations, belong to the root zone of the Svecofennidic mountain chain.

New methods of studying the evolution of the Svecofennidic rock crust were initiated by the investigations on structural geology, carried out first by Wegmann and Kranck (1931) in the archipelago east of the town of Helsinki. The intraformational stratigraphy of the different kinds of the Svecofennidic supracrustal rocks is, however, poorly known. Only some local interpretations on the sequence have been published. Detailed geological maps of wider areas, in the scale of 1 : 20 000 or 1 : 42 000, and the explanation of structural features show, however, new possibilities to advance in the labyrinth of the Svecofennidic rock crust.

An attempt will be made in the present paper to throw light upon the stratigraphy and sedimentation of the Svecofennidic supracrustal rocks in Southwestern Finland. The structural features and petrographic char-

acteristics of the rocks will be described only so much as is necessary for the interpretation of the principal problems of this paper.

Since the classical study of Sederholm (1897), the well-preserved Tampere schist belt has been the most important key area for the Archean geology in Finland, and its re-mapping has given rise to the new ideas presented in this paper. Some suggestions on the stratigraphy of the schists in Southern Finland are made and the correlations of the highly metamorphic supracrustal rocks to the well-preserved rocks of the Tampere area are put forth. Some general conclusions on the geology of the Svecofennidic rock crust are presented for discussion.

HISTORICAL OUTLINES OF THE STRATIGRAPHIC CLASSIFICATION

The earliest geological studies and the first geological mapping in Southern Finland, carried out about one century ago, have already revealed the fact that the crystalline schists are older than the associated gneissose and massive granites. The age relation of these granite types has been known for a long time. The gneissose, grey-colored oligoclase granites are older than the massive, red-colored granites of more pegmatitic character. Sederholm (1893), accordingly, called these two Archean granite groups older and younger granites, respectively.

Sederholm believed on the basis of his own field observations that in Southwestern Finland also there were some early Archean, so-called Bothnian formations younger than the highly metamorphic, crystalline basement penetrated by the older granites. Sederholm introduced the term» Bothnian» for the first time in the year 1893 when he identified the widely distributed Archean basic volcanics of Southern and Western Finland as a stratigraphic unit of the Bothnian system deposited during the interval between intrusions of older and younger granites. According to this idea, the Bothnian supracrustal rocks are younger than the grey-colored, gneissose granites (called also granites of the first group, urgranites, or pre-Bothnian granites), but older than the red-colored, mainly massive granites of the coast type (called also granites of the second group, microcline granites, or post-Bothnian granites). The first definition of the Bothnian system was based mainly on the observations made in the wide uralite porphyrite area of Tammela—Kalvola, studied by Sederholm (1891).

The stratigraphic position of the Bothnian supracrustal rocks has been discussed in more detail in Sederholm's classical paper (1897), dealing with the Archean schist zone of the Tampere area where the Bothnian basic volcanics are associated with well-preserved sedimentary rocks represented by conglomerates, argillaceous and arenaceous sediments. Sederholm concluded that the Bothnian schists of the Tampere area are separated by a

great unconformity, situated along the southern margin of the Bothnian schist belt, from the highly metamorphic gneisses and gneissose granites which form the crystalline basement for the deposition of the Bothnian supracrustal rock series. According to Sederholm, the gneissose granites similar to the older granites in Southern Finland penetrate only the oldest, so-called Svionian gneisses in the crystalline basement, whereas the Bothnian schists have been penetrated only by the younger, massive granites of the wide granite area of Central Finland occurring north of the Tampere schist zone. Therefore, the gneissose granites south of the Tampere schist belt were called pre-Bothnian granites and the granites of the large central areas in Finland were named post-Bothnian granites.

Table I. Sederholm's (1932) stratigraphic schema of the pre-Cambrian rocks in Finland.

IV cycle (Late pre-Cambrian)	Jotnian	Olivine diabases Sandstones of Pori
		Unconformity
	Hoglandian	Rapakivi granites Ossipites and diabases of Jaala
III cycle (Karelidic)		Great unconformity
	Post-Jatulian epoch of diastrophism	Lapland granites Granites of Oulu river, Kajaani etc. Granites of Onas, Bodom, Åva etc. in Southern Finland
	Kalevian and Jatulian	Conglomerates, quartzites and schists in Eastern and Northern Finland
II cycle (Younger Archean)		Great unconformity
	Post-Bothnian epoch of diastrophism	Granites of central area in Finland
	Bothnian	Bothnian metabasalts and sedimentary schists in Southwestern Finland
	Ladogan	Ladogan schists NW of Lake Ladoga
	Lapponian	Lapponian iron-bearing formations and greenstones in Finnish Lapland
I cycle (Kataarchean)		Unconformity
	Post-Svionian epoch of diastrophism	Gneissose granites of the Sveco-Fennian range and of Eastern Finland
	Svionian	Schists and gneisses of the leptite formation of Southern Finland
		Substratum unknown

Sederholm (1910) enlarged his stratigraphic classification to comprise the whole Fennoscandian rock crust and modified his ideas in many later papers, presenting his last views in 1932 in the explanation to the geological map of Fennoscandia. The main points of Sederholm's stratigraphic schema concerning the Finnish pre-Cambrian rocks are presented in Table I. On the basis of our present views some remarks must be made. The Hoglandian intrusive rocks are now included in the Jotnian formation in which the order of succession: 1) intrusion of rapakivi granites, 2) deposition of the arkosic »oldest red sandstone», 3) intrusion of olivine diabase dikes, has been proved correct in the unmetamorphic, late pre-Cambrian rock series of Satakunta in Southwestern Finland (cf. Sederholm, 1897; Laitakari, 1925; Kahma, 1951). The stratigraphic classification of the schist formations in Eastern Finland has undergone many modifications and nowadays the Jatulian, Kalevian as well as Ladogan formations are connected to the Karelidic cycle (cf. Eskola, 1927 and 1941). The tectonic studies of Wegmann (1928) have given important support to the explanation of the Karelidic mountain chain, and the stratigraphy and tectonics of the Karelian formations has been discussed and summarized in the papers of Väyrynen (1933 and 1939). The geological studies in Finnish Lapland carried out by Erkki Mikkola (1941) give some evidence that the Lapponian schists as well as the extensive, so-called granulite formation belong to the Karelidic cycle. The newest local interpretation on the intraformational stratigraphy of the Karelidic supracrustal rocks has been presented by Härme (1949) based on his studies of the Kemi area in Northern Finland. The stratigraphic position of the Bothnian formation and new lines of stratigraphic studies in pre-Cambrian territory will be discussed below in more detail.

In Sederholm's classification, the Bothnian supracrustal rocks were included in an independent period in the development of the pre-Cambrian rock crust of Fennoscandia. They represent the second cycle of sedimentation, deposited on the deeply denuded crystalline basement composed of the highly metamorphic supracrustal rocks of the first Svionian cycle of sedimentation and of the gneissose granites of the first group. The orogenic movements connected with the intrusion of the granites of the second group have tilted the Bothnian strata into vertical position and caused the origin of a new crystalline basement which has later been the floor for the deposition of the supracrustal rocks of the third, Karelidic cycle of sedimentation.

Based on observations of the age relations of the supracrustal rocks with granites, Sederholm connected the following separated schist areas in Southwestern Finland (see Fig. 1) to the Bothnian formation:

Enklinge area; metabasalts and sedimentogenous schists,
Pellinge area; metabasalts,
Hyvinkää area; metabasalts,
Tammela—Kalvola area; metabasalts,
Tampere area; metabasalts and sedimentogenous schists.

All Bothnian schist areas are characterized by a rich occurrence of basic volcanics, porphyrites and tuffites. The sedimentary rocks are represented by conglomerates, argillaceous and arenaceous sediments. Pure quartzites and limestones are lacking.

The independent stratigraphic position of the Bothnian formation has been, however, criticized by many geologists. Mäkinen (1915) remarked that the granites, considered pre-Bothnian by Sederholm, penetrate the

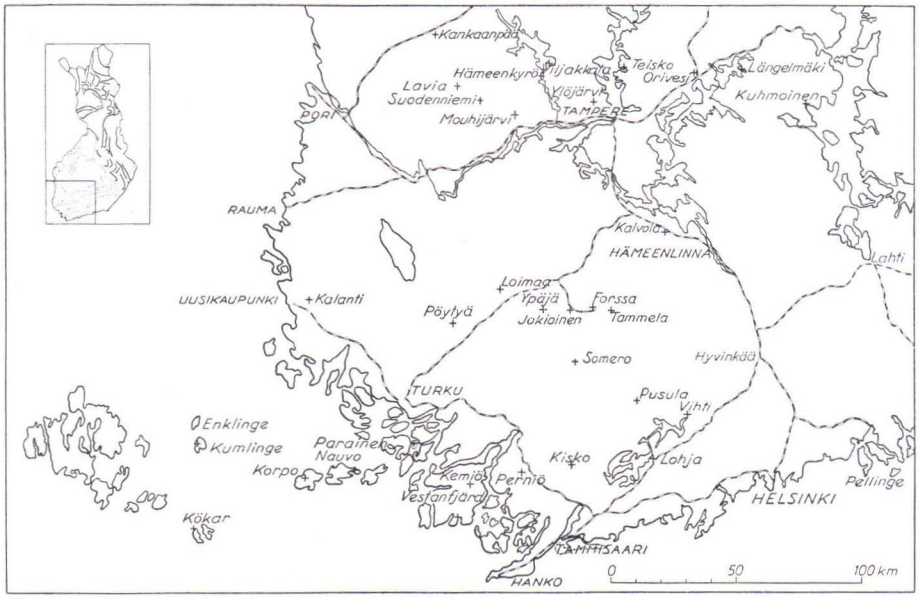


Fig. 1. Map of Southwestern Finland showing the position of the localities mentioned in the text.

Bothnian schists in the Tampere area and some conglomerate occurrences in the Bothnian do not mean a deep denudation, as supposed by Sederholm, but show an intraformational mode of occurrence. The new field observations in the most remarkable Bothnian schist formations in the Tammela —Kalvola (Eskola, 1936; Simonen, 1948b) and Tampere areas (Wahl, 1936) have shown that the oldest gneissose granites penetrate the Bothnian schists. Therefore, in regard to the intrusive contacts, there is no difference between the Bothnian schists and the Svionian gneisses.

The Swedish geologists took a sceptic attitude towards Sederholm's idea concerning the great unconformity between Svionian and Bothnian formations. Many lively discussions on the »sub-Bothnian unconformity» and on the granite classification have appeared in the series »Geologiska Föreningens i Stockholm Förhandlingar». The Saxå, Grythytte, and Skellefte

areas in Sweden, considered as Bothnian formations by Sederholm, have been included by Swedish geologists in the Svionian leptite formation.

However, in spite of many objections, Sederholm was firm in his original concept and looked for the sedimentation floor of the Bothnian formation. Sederholm returned to the study of the Tampere schist area in 1928. When the new, more detailed geological mapping carried out by Erkki Mikkola in the Lavia—Suodenniemi schist zone revealed new conglomerate beds and breccias containing angular fragments of diorite in an arkosic matrix, Sederholm (1931) interpreted these occurrences as Bothnian basal formations, originated by secular weathering. He considered them to be distinct evidence for the sub-Bothnian unconformity which had been questioned by many leading Scandinavian geologists. Eskola (1941) remarked, however, that the conglomerates of the Suodenniemi area do not show the character of real basal conglomerates separating two different orogenic cycles because they do not contain migmatite boulders, indicators of a deep erosion. The conglomerates and weathering breccias show only that during the deposition of the Bothnian strata the denudation has been deep enough to reach the infracrustal rocks, intruded at an early orogenic state, and the »sub-Bothnian unconformity» is result of a local erosion during the orogenic evolution. On the basis of this interpretation, both Svionian and Bothnian supracrustal formations would have received their present characteristics in the same, so-called Svecofennidic orogeny. Concerning Sederholm's (1932) stratigraphic schema (Table I) we can state that, according to our present views, the representatives of his second cycle may be included in those of the first or third cycles, and accordingly only two orogenic cycles, Svecofennidic and Karelidic, have taken place in the pre-Cambrian rock crust of Finland.

Sederholm's stratigraphic classification of the supracrustal rocks was based in it's essential points on the age relations of the schists to the granitic rocks of different age. Sederholm classified the pre-Cambrian granites in Fennoscandia into four groups and supposed that every orogenic cycle was associated with intrusions of a granite group. Accordingly, the granites of the first group were connected with the folding of the Svionian supracrustal rocks, the granites of the second group were associated to the diastrophism of the Bothnian strata, and the granites of the third group were connected to the Karelidic cycle. The granites of the fourth group were represented by the late pre-Cambrian rapakivi granites which have not taken part in the orogenic movements.

Since the time of Sederholm great progress in the knowledge of the Finnish granites has been achieved and now the granite classification is made on the basis of magmatectonical points of view. Every orogenic cycle is associated to intrusions of different kinds of granitic rocks which are classified into three main groups, the so-called synkinematic, late-kinematic,

and postkinematic granites, according to the terms proposed by Eskola (1930, p. 138).

The synkinematic intrusive rocks of the Svecofennidic mountain chain are mainly gneissose granites or granodiorites associated with more basic differentiates, but also the crystallization products of the trondhjemitic and charnockitic suite are met with. The different paths of magmatic differentiation are caused only by the different amounts of the volatile substances in the parent magma. The migmatite-forming microcline granites of the coast type (the granites of the second group in Sederholm's classification) are late-kinematic granites of the Svecofennidic orogeny. The separation of the synkinematic and late-kinematic granite types is usually relatively easy in Southern Finland where the orogenic movements have caused a remarkable gneissose texture in the synkinematic rocks, especially at the margins of the intrusive bodies which occur conformably with the Svecofennidic schists. On the other hand the late-kinematic microcline granites are massive and form migmatites with the schists and synkinematic intrusive rocks. The sharp separation of the different magmatectonical types is not so easy in either the Tampere schist belt or the adjoining wide granite area of Central Finland, where many transitional varieties from the gneissose synkinematic types into massive late-kinematic intrusive rocks occur. As a general rule, however, it must be mentioned that the quartz dioritic and granodioritic bodies and the associated basic differentiates usually show slightly developed gneissose margins, whereas the younger microcline granites are massive. The migmatites, related to the intrusion of microcline granites, are not in the Tampere area so common as in Southern Finland. Petrochemically, in Southern Finland there are clear differences between the synkinematic and the late-kinematic intrusives (cf. Simonen, 1948a), but in the Tampere area many transitional varieties occur, so that no marked break between chemical composition of the synkinematic granodiorites and the late-kinematic potash granites has been observed. In addition to the widely distributed synkinematic and late-kinematic intrusive rock types, some massive potash granites also occur in Southern Finland, penetrating the late-kinematic migmatite-forming granites. These small granite bodies (Onas, Bodom, Åva etc.), included by Sederholm in the third granite group, probably represent the postkinematic granites of the Svecofennidic orogeny.

In terms of the magmatectonical granite classification, we can state that both synkinematic and late-kinematic granites of the Svecofennidic orogeny penetrate the Svionian as well as Bothnian schists in Southwestern Finland, and therefore the »sub-Bothnian unconformity» falls into the Svecofennidic cycle. On the basis of the new magmatectonical granite classification it is evident that both Svionian and Bothnian formations belong to the same orogenic cycle.

Different magmatectonical types of intrusive rocks have been found also in the Karelidic mountain chain. The large bodies of »post-Kalevian» microcline granites are late-kinematic, whereas the synkinematic rock types occur only sporadically. The granodiorites and associated basic differentiates which occur north of the Gulf of Bothnia, and are included in the so-called Haparanda series (Ödman, Härme, A. Mikkola, and Simonen, 1949; Härme, 1949; A. Mikkola, 1949), are now the best-known representatives of the Karelidic synkinematic intrusive rocks. Wide areas of the Karelidic synkinematic intrusives probably occur in the western part of Finnish Lapland where some types of Hetta granites and the members of the syenite series in the Muonio area (E. Mikkola, 1941), show characteristics of the synkinematic intrusions. Since the grade of metamorphism of the Karelidic supracrustal rocks increases in the vicinity of the synkinematic intrusive bodies, the Karelidic greenstones, phyllites, and mica schists are represented in the western part of Finnish Lapland by highly metamorphic amphibolites and sillimanite gneisses. The late pre-Cambrian rapakivi granites are considered postkinematic, since their relationship to the Karelidic orogeny is analogous to the relations shown by the massive granites of Onas, Bodom, Åva, etc. in regard to the Svecofennidic mountain folding. Special mention must be made of the occurrence of mantled gneiss domes in the Karelidic range of Eastern Finland. Eskola (1949 and 1951) has shown that these domes have originally been separate granodioritic or quartz dioritic intrusive bodies, associated to the Svecofennidic cycle, having been remobilized and updomed during the Karelidic orogeny. During the doming, the migmatitization and granitization have taken place especially along the margins of these old intrusions. The large areas of gneissose granites in Eastern Finland and east of the northern end of the Gulf of Bothnia, consisting of great numbers of separate intrusive bodies, also belong in the class of granitized domes whose original material belongs to the orogenic intrusions of a pre-Karelidic, Svecofennidic orogeny. Eskola's interpretation of the mantled gneiss domes, i.e., that the Svecofennidic elements have taken part in the Karelidic movements in Eastern Finland, throws light upon many puzzling problems in the classification of the pre-Cambrian rock crust. This must be especially remembered in the course of future studies when the boundary zone between Svecofennidic and Karelidic orogenic formations will be re-mapped.

The author has summarized in Table II the present conceptions on the orogenic classification of pre-Cambrian rocks in Finland though he is fully aware that this summary is not generally accepted in all points by different investigators and that much new detailed field work will be inevitable. Table II gives only the principal points of the orogenic classification and does not include the scattered data available on the sequence of the supracrustal rocks in different schist formations.

Table II. Orogenic classification of pre-Cambrian rocks in Finland.

Postorogenic Jotnian group		Olivine diabase dikes
		Jotnian sandstone formation of Satakunta Basal formation
		Postkinematic intrusions Rapakivi granites
II orogenic cycle (Karelidic)	Migmatitization and granitization	Late-kinematic intrusions Post-Karelian microcline granites Synkinematic intrusions Granodiorites and associated rocks of the Hapa-randa series. Some members of the Hetta granites and syenite series in western part of Finnish Lapland
	Mountain folding	Some members of the granulite formation in Lap-land Ophiolitic, ultrabasic intrusions
		Supracrustal rocks of Kumpu—Oraniemi, Lapponian and granulite formations in Lapland Supracrustal rocks of Kainuu, Perä-Pohja and Utajärvi—Kiiminki areas in Northern Finland Ladogan, Kalevian and Jatulian formations in Eastern Finland Basal formations
I orogenic cycle (Svecofennidic)		Postkinematic (intraorogenic) intrusions Granites of Onas, Bodom, Åva etc. in Southern Finland
	Migmatitization and granitization	Late-kinematic intrusions Migmatite-forming microcline granites of coast type Synkinematic intrusions
	Mountain folding	Granodiorites and associated rocks in the Sveco-fennidic range of Southwestern Finland and Pohjanmaa Infracrustal rocks of trondhjemitic and charnockitic suite in Southwestern Finland Gneiss domes in the Karelidic range and large areas of gneissose granites in Eastern Finland
		Supracrustal rocks of Bothnian and Svionian formations in Southwestern Finland and Pohjanmaa Supracrustal rocks in Savo (?) Remains of the pre-Karelidic supracrustal rocks in the wide gneissose granite area of Eastern Finland Basal formations unknown

The historical outline on the stratigraphic classification of the pre-Cambrian rocks in Finland shows that many of Sederholm's conclusions, which were guiding principles for the geological mapping at the time of their presentation, have been proved to be incorrect by later investigations. However, Sederholm's rules for working out the pre-Cambrian stratigraphy are still the guide posts for future studies. Now, in retrospect, we can say

that Sederholm laid too great a significance on some local unconformities, and his conclusions on the orogenic granites have been modified by later investigations. Furthermore, in many cases the separation of the age groups was erroneously based only on the different grade of metamorphism. But at the same time we must confess that our present knowledge on the stratigraphy of Finnish pre-Cambrian rock crust is not so high as was believed some decades ago. The construction of the pre-Cambrian stratigraphic system has been, to use Sederholm's own words, like Penelope's weaving, unravelling nightly the work that has been done during the day. We must not, however, become pessimistic. The guiding principles in the study of pre-Cambrian stratigraphy set forth by Sederholm have been shown to be valid, and the new, more detailed geological mapping, taking into account the structural features, shows new lines for working out the intraformational stratigraphy of the metamorphic pre-Cambrian schist formation. An attempt will be made in this paper to describe the sequence of the supracrustal rocks and conditions of their sedimentation in the early Archean, Svecofennidic rock crust of Southwestern Finland.

THE TAMPERE SCHIST BELT

The classical Bothnian schist belt north of the town of Tampere belongs, according to the views of orogenic classification, to the Svecofennides. This conclusion has been decisively proved correct by the results of detailed geological re-mapping of the area. Many new observations show that the synkinematic granodiorites of the Svecofennidic orogeny penetrate the well-preserved Bothnian schists which pass in many localities without unconformity into highly metamorphic gneisses of the Svionian type. According to our present views, the Svecofennidic strata are represented in their present condition by the schists with different grade of metamorphism, and, therefore, the interpretation of stratigraphy and sedimentation of the well-preserved supracrustal rocks of the Tampere schist belt may be also elucidative for the study of highly metamorphic Svecofennidic gneisses in Southern Finland.

STRUCTURE AND STRATIGRAPHY

The first interpretation of structure and stratigraphy of the Tampere schist belt was presented by Sederholm (1897) who considered the Bothnian schist zone as a coherent bundle of supracrustal strata tilted into vertical position by the orogenic movements. Sederholm did not assume the folding tectonics, and, according to his views, the base of the upturned strata was towards the south in the supposed line of the »sub-Bothnian unconformity». By means of this simple structural picture it should be easy to determine the stratigraphic sequence of the supracrustal rocks because a section on

the geological map from south to north, perpendicular to the strike of the schist belt, should represent the original succession of the strata from the oldest to the youngest member. Sederholm concluded that the varved sediments of the southern part of the Tampere schist belt represent the lowest member of the Bothnian strata, underlying the basic volcanics of the northern part of the schist zone. This conclusion was in good harmony with the observations of graded bedding made by Sederholm on the eastern shore of Lake Näsijärvi, which show that the bases of the varves are mainly to the south. The new observations in the Tampere schist belt show, however, that the structure is more complicated than Sederholm supposed and that an intense folding has taken place.

The study of the structural geology has been one of the main tasks during the course of the detailed re-mapping of the Tampere zone and the new observations have already been described by many authors (Neuvonen and Matisto, 1948; Härme and Seitsaari, 1950; Seitsaari, 1951; Simonen and Kouvo, 1951; Huhma, Salli, and Matisto, 1952; Simonen, 1952). Structural features are, therefore, presented in this connection only as much as it is necessary for the interpretation of stratigraphic sequence of the folded supracrustal strata.

All contributors on the tectonics of the Tampere schist zone have suggested nearly horizontal fold axes for the main folding, and vertical or steep axial planes, parallel to the bedding planes, striking in east-west direction. The folds with gently pitching fold axes are common in the wide varved schist areas and, furthermore, the variations in the position of the base of the succession, determined by the graded bedding observed on the shores of Lake Näsijärvi, indicate an intense isoclinal folding due to the horizontal compression acting along north-south lines (see Fig. 2). Gently plunging vertical or slightly overturned isoclinal folds are predominant, and sporadically there are also structures similar to the monoclines and structural terraces. All folds are characterized by true or flexure folding and the deformation of the varved sediment seems to be due only to the sliding through bending (cf. Simonen and Kouvo, 1951).

Small isoclinal folds, typical in the wide varved sediment area, have not been directly observed in the more competent parts of the Tampere schist zone consisting predominantly of basic volcanics, but by means of the graded bedding of thin varved sediment intercalations and by means of some repeated beds one is, however, able to construct the isoclinal folds, from many hundred metres to a few kilometres wide. The geological map of the schist belt (Map I), showing thin beds of remarkable length, supports the presumption of nearly horizontal fold axes.

The best preserved part of the Bothnian formation trending from Viljakkala across Lake Näsijärvi into Teisko has shown to be a key area for the explanation of structure and stratigraphy of the whole Tampere schist

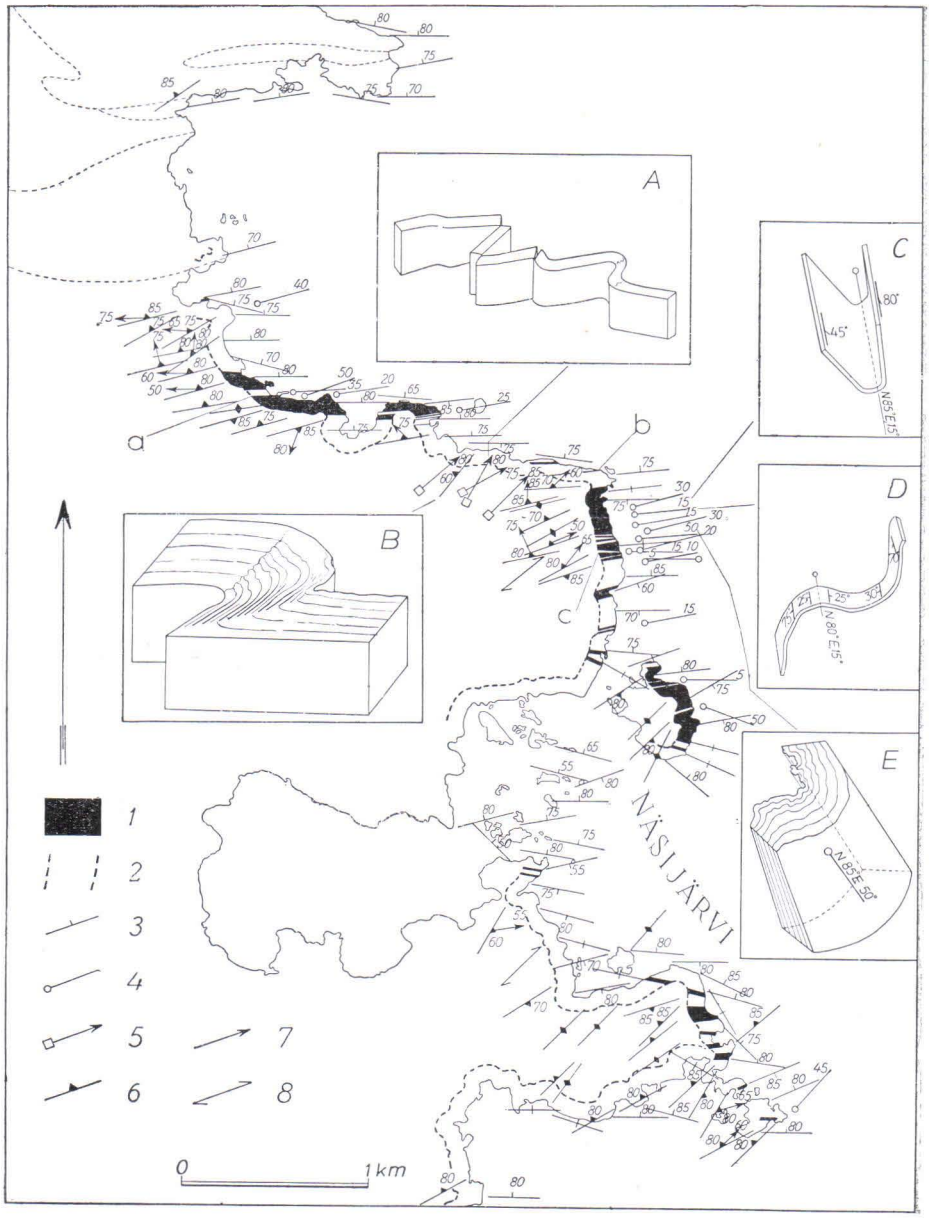


Fig. 2. Tectonic observations in the varved schists on the western shore of Lake Näsijärvi. According to Simonen and Kouvo (1951). 1, bases of the varves to the north; 2, bases of the varves to the south; 3, strike and dip of bedding and bedding cleavage; 4, fold axis; 5, fold axis of minor folds; 6, fracture cleavage; 7, lineation; 8, fault. Drawings of the folds: A, undulation and minor folds with shear fractures on the limb of an isoclinal fold; B, minor fold with fracture cleavage and shear joints; C, overturned isoclinal fold; D, monocline; E, steeply dipping fold.

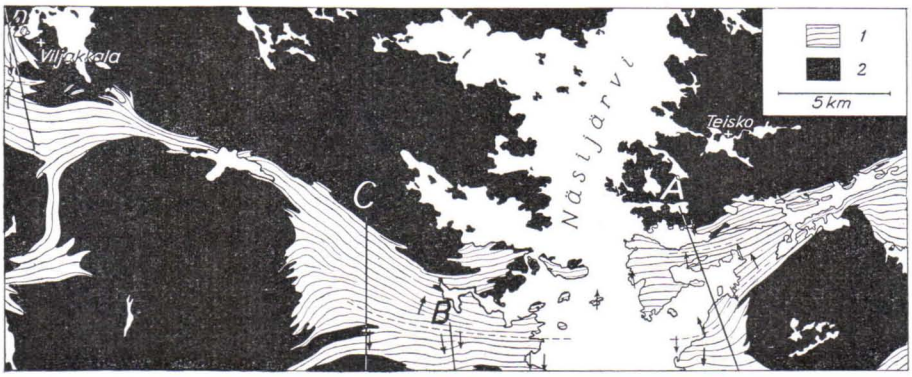


Fig. 3. The Tampere schist belt. Observations on the superposition of the strata and location of vertical sections (A—D). Direction of arrow towards the base. 1, supracrustal rocks; 2 infracrustal rocks.

belt, because there the excellent exposures of varved sediment make it possible to determine the superposition of the beds by means of graded bedding. The interpretation of the structure and stratigraphy of the Viljakkala—Teisko zone is described briefly below with the help of vertical sections (Fig. 4). The locations of cross sections and the points of observations on the superposition of nearly vertical beds by means of graded bedding are presented in Fig. 3.

Explanation of the cross sections

A. Eastern side of Lake Näsijärvi. — This vertical section shows that the alternating beds of conglomerates and basic volcanics are bordered both in the south and north by quartz-feldspar schist. The superposition, determined by graded bedding, indicates that the tuffite conglomerate beds overlie the quartz-feldspar schists and the structure of this part of schist zone is a syncline. This structural picture makes evident that the deposition of the conglomerate beds has taken place after a volcanic phase represented by the basic volcanics, shown on the geological map of the discussed area between quartz-feldspar schist and conglomerate. The varved phyllites in the southern part of the cross section underlie the quartz-feldspar rocks. The structure of the Kämmenniemi area is anticlinal and there basic volcanics overlie the quartz-feldspar schists.

According to the structural picture, the sequence of the supracrustal rocks on the eastern side of Lake Näsijärvi is from the highest to the lowest member:

— conglomerates and basic volcanics,
— basic and intermediate volcanics (tuffites and porphyrites),
— quartz-feldspar rock with thin intercalations of varved sediment,
— varved phyllite.

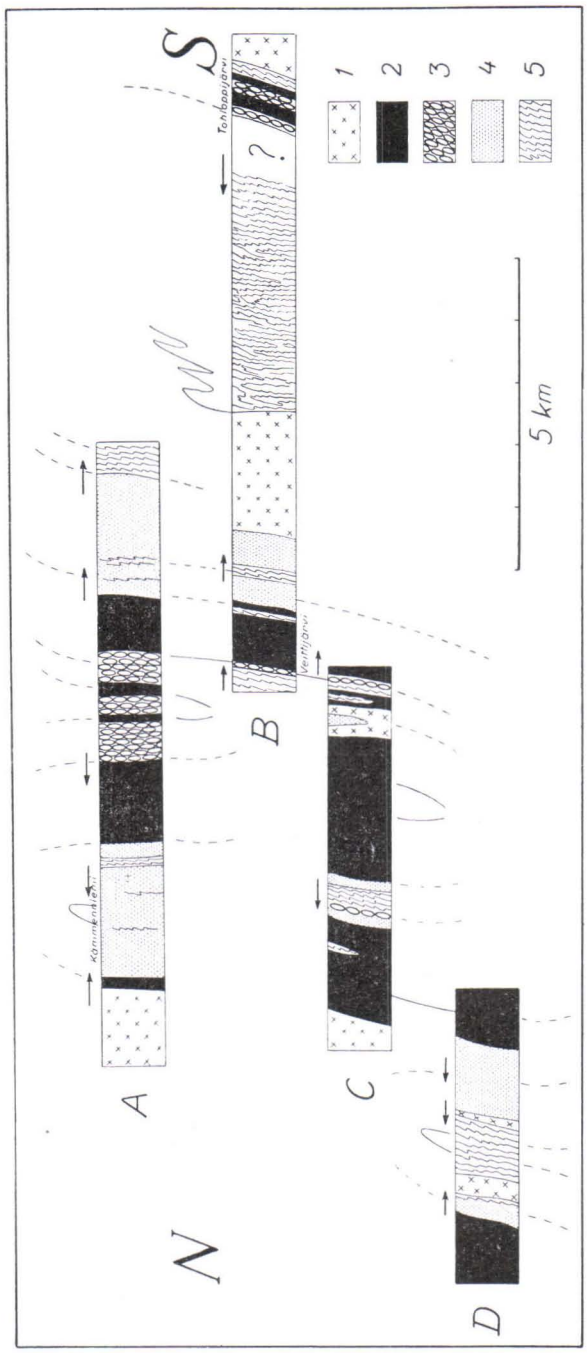


Fig. 4. Vertical sections of the Viljakkala—Teisko schist zone. A, Eastern side of Lake Näsijärvi. B—C, The Ylöjärvi schist area. D, The Viljakkala schist area. 1, infracrustal rocks; 2, basic and intermediate volcanics; 3, conglomerates; 4, quartz-feldspar schists; 5, phyllites. Arrow shows the direction of the base determined by graded bedding.

B—C. The Ylöjärvi schist area. — The structure as well as stratigraphy of the Ylöjärvi schist area is similar to that of the eastern side of Lake Näsijärvi. The base of the Veittijärvi conglomerate is to the south and a thick bed of basic and intermediate volcanics separates the conglomerates from the underlying quartz-feldspar rocks and varved phyllites. The conglomerate of Veittijärvi is associated with more numerous beds of quartz-feldspar rock and phyllite than the thick conglomerate member on the eastern side of Lake Näsijärvi. The geological map, and order of superposition determined by graded bedding, suggest that the structure of the northern part of the Ylöjärvi schist area is a wide syncline and, therefore, the conglomerate bed of Veittijärvi with associated thin beds of other sedimentary rocks appears again some kilometres north of the Veittijärvi zone. The basic volcanics, shown on the geological map between the conglomerate zones, represent the highest stratigraphic member of the supracrustal rock series in this area.

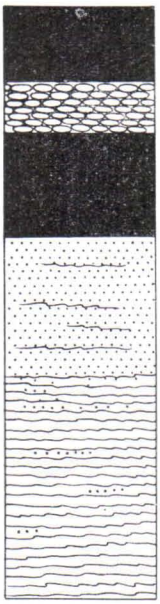
The varved phyllites, showing wide distribution in the southern part of the Ylöjärvi area, are intensely

folded (cf. Fig. 2). The base of the varved strata at the northern margin of the phyllite area is to the south and some few observations at the southern margin are opposite, suggesting that the large phyllite area of Ylöjärvi is probably a wide anticlinorium with many isoclinal folds.

The conglomerates and basic volcanics of Tohloppijärvi in the southern part of the Ylöjärvi schist area may be connected on the basis of their lithologic features to the similar rocks in the Viljakkala—Teisko schist zone.

C. The Viljakkala schist area. — The basic and intermediate volcanics in the southern part of the Viljakkala schist area form the most western extension of the volcanics which occur at the northern margin of the Ylöjärvi schist area and they belong, therefore, to the volcanic member underlying the conglomerates. To judge from base determinations, made by observation of graded bedding, the structure of the Viljakkala schist area is an anticline, the volcanics appearing in the northern part of the schist area as a result of folding. The volcanics overlie the sedimentary rocks, quartz-feldspar rocks, and varved phyllites, which occur in the central part of the schist area, and the stratigraphic sequence of the strata, i.e. basic volcanics, quartz-feldspar schists and varved phyllites, is similar to that obtained

Table III. Stratigraphic sequence of the supracrustal rocks in the Viljakkala—Teisko schist zone.



Rock types	Thickness in metres
Basic volcanics	> 1 000
Conglomerates and associated beds of other sedimentary rocks	700— 800
Basic and intermediate volcanics	800—1 500
Quartz-feldspar rocks (arkoses, graywackes and pyroclastics)	1 500—2 200
Varved sediments (graywacke-slates)	> 3 000
Total thickness	> 7 000—8 500

in the other schist areas of the Tampere belt. South of the Viljakkala area the volcanics pass through quartz-feldspar rock into mica schists and mica gneisses which represent the highly metamorphic varieties of the varved phyllites.

The conclusions drawn from the explanations of vertical sections are summarized in Table III which shows the sequence of the supracrustal strata in the Viljakkala—Teisko schist formation from the highest to the lowest stratigraphic member. The thickness of the different strata have been approximated from the vertical sections and from the geological map of the area (Map I). The thickness of the supracrustal strata, visible in the Viljakkala—Teisko schist zone, is up to 7 000—8 500 metres, which must be considered as a minimum for the original thickness of the whole supracrustal series deposited in the Tampere area, because the basement is unknown and the highest volcanic member of the strata is only partly exposed. We are not greatly wrong, if we conclude that the original thickness of the strata has been at least 8 kilometres.

The stratigraphic sequence observed in the supracrustal rocks of the Viljakkala—Teisko zone, appears also in the easternmost part of the remapped Tampere schist belt, northeast of the town Tampere. According to Seitsaari (1951), the schists of the easternmost part form one nearly vertical limb of a big fold and the base of the strata is towards the south, as indicated by graded bedding. Therefore, a section from north to south, perpendicular to the trend of the schist zone, will show the stratigraphic sequence from the highest to the lowest member. The basic volcanics overlie the sedimentary strata represented by quartz-feldspar rocks and phyllites; the conglomerates occur as interbeds in the basic volcanics.

The structure of the western part of the Tampere schist belt is not known in detail, because the graded bedding, important for determination of stratigraphic sequence, was destroyed by the metamorphic recrystallization. Some stratigraphic correlations to the schists of the Viljakkala—Teisko zone can be made only by means of the geological map and lithologic features.

The geological map of the Tampere schist belt (Map I) shows that the varved sediments of the Viljakkala—Teisko zone continue as a coherent belt to the west, forming the predominant rock type of the Mouhijärvi—Suodenniemi—Lavia schist zone. The grade of metamorphism increases westwards, so that the varved phyllites pass gradually into mica schists and mica gneisses. Arkosic sandstones, representing the quartz-feldspar rocks of the Viljakkala—Teisko zone, occur only sporadically in the western part of the Tampere schist belt. The basic volcanics of the Kankaanpää area may be connected to those of the eastern part of the Tampere belt. The manner of occurrence of the conglomerates in the western part of the Tampere belt is, however, different from that in the Viljakkala—Teisko zone.

The conglomerates do not occur between the lower and upper volcanic members, as is the case in the Viljakkala—Teisko zone, but they form thin beds deposited before the main volcanic phase of evolution. The conglomerates of Suodenniemi, containing diorite boulders in an arkosic matrix, represent local denudation during the deposition of the supracrustal strata (cf. p. 12).

It has not been possible to determine the stratigraphic sequence of the supracrustal rocks in the separated, so-called Heittola schist area at the northern end of Lake Kyrösjärvi, but the rock types are lithologically very similar to those of the Viljakkala—Teisko zone. A rich occurrence of acid porphyries is a special characteristic feature of the Heittola area. Many small, separated schist areas occur sporadically in the wide granite area of Central Finland. The correlation of these schist areas in the parishes of Parkano, Jalasjärvi, Virrat, Vilppula, Saarijärvi, etc. to the coherent Tampere schist belt seems credible on the basis of many similar lithologic features of these rocks.

Our present knowledge on the stratigraphy of the schists in the Tampere belt is still incomplete in many details, but the new methods of study show that the determination of stratigraphic sequence in ancient supracrustal beds, folded into vertical position, is possible in some suitable cases. The summarized type section, presented in Table III, has shown to be valid in wide areas of the Tampere belt and it corroborates Sederholm's (1897) conclusion that the basic volcanics overlie the sedimentary rocks in this classical schist area.

PETROGRAPHY

The detailed petrographic descriptions of supracrustal rocks in the Tampere schist zone have been presented in Sederholm's (1897 and 1931) papers. Many new investigations (Rankama, 1948; Simonen and Neuvonen, 1947; Seitsaari, 1951; Simonen and Kouvo, 1951) and explanations to the new geological maps (Huhma, Salli, and Matisto, 1952; Simonen, 1952) have completed the knowledge on the petrology of this important area. The present author summarizes in this connection only some main features, important for the interpretation of the origin and deposition of the supracrustal rocks.

PHYLLITES AND MICA SCHISTS

Varved sediments, usually called phyllites, form the lowest member of the stratigraphic sequence in the Tampere schist belt. They are characterized by well-preserved graded bedding (Fig. 5) which has been interpreted as seasonal, originated under cool or temperate climatic conditions

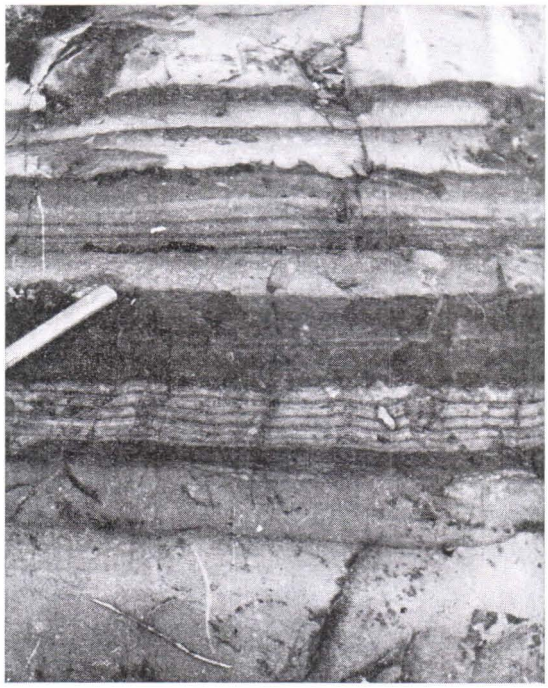


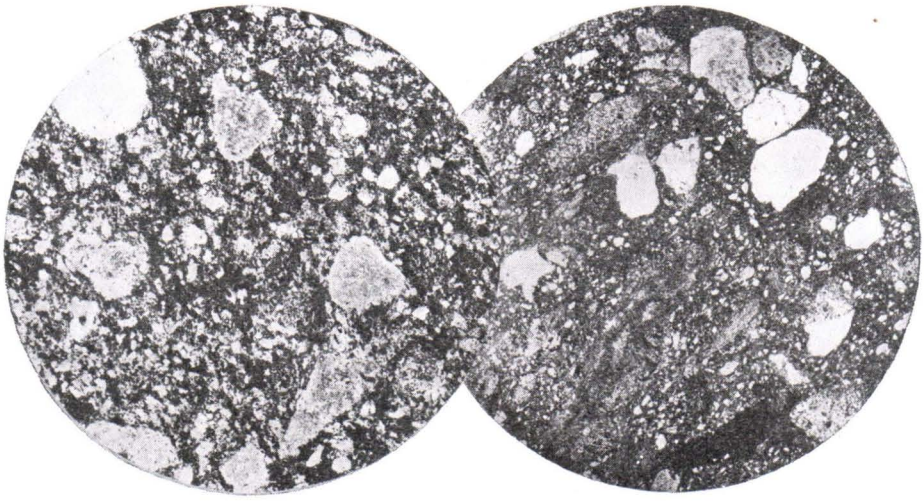
Fig. 5. Varved sediment. Eastern shore of Lake Näsijärvi. Ajonokka. Photo V. Pääkkönen.

(Eskola, 1932). The thickness of the varves varies greatly from some millimetres to some metres. The sequences of the thin beds show conspicuous similarities to the Pleistocene varved clays, but commonly the varves are rather thick, about 13 cm in average, and there are also some megavarves, up to 1—3 metres in thickness, which indicate extremely rapid deposition.

The coarse-grained psammitic base of the varves often shows petrographic features similar to that of a graywacke sandstone (Fig. 6). It contains angular or subrounded particles of quartz and feldspar and sometimes also small rock fragments of quartzite and slate in the microcrystalline matrix which is similar to the fine-grained slaty upper portion of the varve. The varved schists of the Tampere area, therefore, must be considered as an intimate association of graywacke and slate. The sorting of different material has not been complete, and the presence of a remarkable amount of fresh feldspar shows that the chemical weathering of material has been incomplete. Concerning the petrographic details of the varved sediments, the author refers to the recently published paper of Simonen and Kouvo (1951), dealing with the excellent exposures of varved schists on the shores of Lake Näsijärvi.

The graded bedding has been destroyed in many cases by the metamorphic recrystallization due to the intrusions of the infracrustal rocks. Then the graywacke-slates pass gradually into highly metamorphic mica schists and mica gneisses, which are usually stratified rocks with granoblastic texture. The mica schists and mica gneisses are rich in quartz and feldspar and sometimes they contain small porphyroblasts of aluminous silicate minerals which indicate the Al_2O_3-excess of the primary rock.

The chemical composition of the varved sediments (Table IV, Anal. 1—12) varies within wide limits, from that of a shale to that of an arkosic sandstone. The greatest part of the analyses are intermediate between the above-mentioned end members, showing that the separation of argilla-



A. B.

Fig. 6. Graywacke sandstone portions of the varves. A. Particles of feldspar and quartz in a mica-rich phyllitic matrix. Lielahti. 1 km NW of the Niemi farm. 18 x. B. Particles of feldspar and quartz and sedimentogenous rock fragments in the fine-grained matrix containing chlorite, sericite, and disseminated carbon. Lielahti. 400 m NW of the Niemi farm. 9 x. Photo A. Matisto.

ceous from arenaceous materials has not been complete during the process of sedimentation. The varved rocks must be, therefore, considered as a mixture of clay and sand, and in addition some CaO-rich varieties (Table IV, Anal. 5 and 9) contain volcanic ash material. The average chemical composition of the varved sediments (Table V) shows conspicuous similarities to that of graywackes in many geosynclinal deposits. Normative relations of [Or] : [Ab] : [An] are presented in Fig. 9 and comparisons with the chemistry of other Svecofennidic sediments are discussed below (p. 44).

QUARTZ-FELDSPAR ROCKS

In many localities the quartz-feldspar rocks of the Tampere schist belt overlie the varved sediments or occur as thin associated beds with conglomerates of the area. They are usually massive, grey-colored rocks, especially in the vicinity of the phyllites, showing petrographic similarities to the graywacke portions of the varved schists. They contain small angular particles of quartz, feldspar, and rock fragments of slate, in a fine-grained mica-bearing matrix. In some varieties, occurring predominantly in close association with the conglomerates of the area, the mica-bearing matrix is lacking, the rock then resembling arkosic sandstone. A wide occurrence of an arkosic sandstone, showing cross bedding, has been described by Sederholm (1897) from Mauri in Suoniemi.

On the basis of mineralogical composition, the chemistry of sedimentary quartz-feldspar rocks is similar to that of the graywacke portions of the varved schists. The chemical analysis of an arkose sandstone from Mauri is presented in Table IV, Anal. 13.

Some very fine-grained varieties of quartz-feldspar rocks, lacking distinct evidences of sedimentary origin, are interpreted as acid pyroclastics. They are characterized by extremely high content of Na_2O, not known in ordinary weathering sediments (see Table IV, Anal. 14—15). In many cases, however, it has been impossible to decide in the field whether a quartz-feldspar rock originally has been a volcanic ash deposit or a normal sedimentary rock. Different kinds of quartz-feldspar rocks have been altered by metamorphic recrystallization into granoblastic leptites and leptite gneisses, having lost the structural and textural features of the primary rock.

CONGLOMERATES

Thick conglomerate deposits are characteristic of the Tampere schist belt and they have remarkable persistance along the strike. Conglomerates (Fig. 7) are poorly sorted, containing well-worn, rounded or subrounded boulders and pebbles of different rock types in a heterogeneous matrix of sand, clay, or pyroclastics.

The diversity of the pebbles in the conglomerates on the both sides of Lake Näsijärvi has been described thoroughly by Sederholm (1897). The pebbles are predominantly volcanics and sedimentary rocks of the same type as in the surrounding schist formation, and only some very few pebbles of granitic rocks have been observed. The predominance of basic and intermediate volcanic pebbles in the conglomerates of the Viljakkala—Teisko zone is easy to understand, because the conglomerates of this zone overlie a thick sequence of volcanics. However, only in one case has it been possible to determine with some probability the source of the pebbles: on the eastern side of the Veittijärvi conglomerate the pebbles are predominantly of a well-known type of reddish-brown porphyrite occurring as a thick lava bed just south of the conglomerate occurrence. This evidence shows that the pebbles have not been transported very far.

The matrix between rounded pebbles is often a mixture of sand and clay, containing small angular fragments of rocks and minerals. Sometimes basic pyroclastics, mixed usually with detrital material, form the predominant part of the matrix.

The conglomerates are associated with thin beds of graywacke-slates and arkosic sandstones which indicate the rapid fluvial deposition of conglomerates. On the other hand the rich occurrence of basaltic lavas, tuffites, and agglomerates as interbeds in the conglomerates of the Viljakkala—

Fig. 7. Conglomerate of Veittijärvi. Photo J. J. Sederholm.

Teisko zone are signs of a lively volcanic action at the time of conglomerate deposition. Some varieties intermediate between real conglomerates and agglomerates must be considered as volcanic conglomerates.

The above-described conglomerates occur between lower and upper volcanic members of the stratigraphic sequence, and, therefore, they contain abundant volcanic material. Only two small conglomerate beds, underlying the basic volcanics, have been observed in the Viljakkala—Teisko zone and they are entirely lacking in volcanic material. One of these beds occurs in Kämmenniemi just below the basic volcanics and it contains pebbles of quartz-feldspar rock in a sericite-rich, argillaceous matrix. Furthermore, a thin interbed of gravel, containing pebbles of quartzite in a clayey matrix, has been described by Seitsaari (1951) from the southern part of the wide phyllite area east of Lake Näsijärvi.

The petrographic characteristics of the conglomerates in the Suodenniemi—Lavia schist zone are different from those in the Viljakkala—Teisko area. The pebbles are predominantly of infracrustal rocks and in some localities the conglomerate material is derived from the underlying intrusive rock body (cf. Sederholm, 1931). The matrix of conglomerates has been primarily a poorly sorted sandstone of arkose or graywacke character but it has been usually altered by metamorphic recrystallization into biotite-plagioclase gneiss. The conglomerates of the Suodenniemi—Lavia zone occur interbedded with mica schists and mica gneisses rich in quartz and feldspar and they do not show an intimate association with basic volcanics as the thick conglomerate beds in the Viljakkala—Teisko schist zone.

VOLCANICS

Rich occurrence of basic and intermediate volcanics is characteristic for the upper part of the supracrustal rocks in the Tampere schist belt, while in the lower part only some few thin interbeds of basic volcanics are found. Basic and intermediate volcanics are mainly pyroclastics, lava flows occurring only sporadically. The acid pyroclastics, described in connection with quartz-feldspar rocks, and some small occurrences of acid lava flows are, however, interbedded with the sedimentary rocks of the area.

Pyroclastics or tuffites are characterized by banding of different layers, causing a striped appearance, and many different varieties occur within a small area. The original clastic texture, showing fragments of plagioclase or hornblende in the finer-grained matrix, can be observed only in the best-preserved parts of the tuffites. Thin agglomeratic and blastoporphyritic beds afford the best evidence for volcanic origin. Tuffite interbeds in deposits of fluviatile origin show that flowing water has reworked and transported the pyroclastic material and many intermediate varieties from basic pyroclastics into graywacke sandstones have been found. Petrochemically the analyzed basic tuffites (Table IV, Anal. 16—23) are very similar to the basic lavas of the area.

The volcanic rocks which crystallized from the lava flows usually show blastoporphyritic texture, but also other relict textures indicating a volcanic origin have been observed. In his classical paper Sederholm (1897)

Fig. 8. Perlite texture. Western shore of Lake Näsijärvi. Lielahti. 20 x. Photo A. Matisto.

described porphyritic, ophitic, fluidal, and amygdaloidal types of volcanics. Pillow lavas have been found in the Viljakkala area (Stigzelius, 1944) and a vitrophyric perlite texture (Fig. 8) of volcanic glass has been observed in an acid, potash-rich lava flow in Lielahti. Intrusions of small sheet-like bodies of metadiabases, metagabbros and metadiorites (e.g. lavialites) are associated with extrusions.

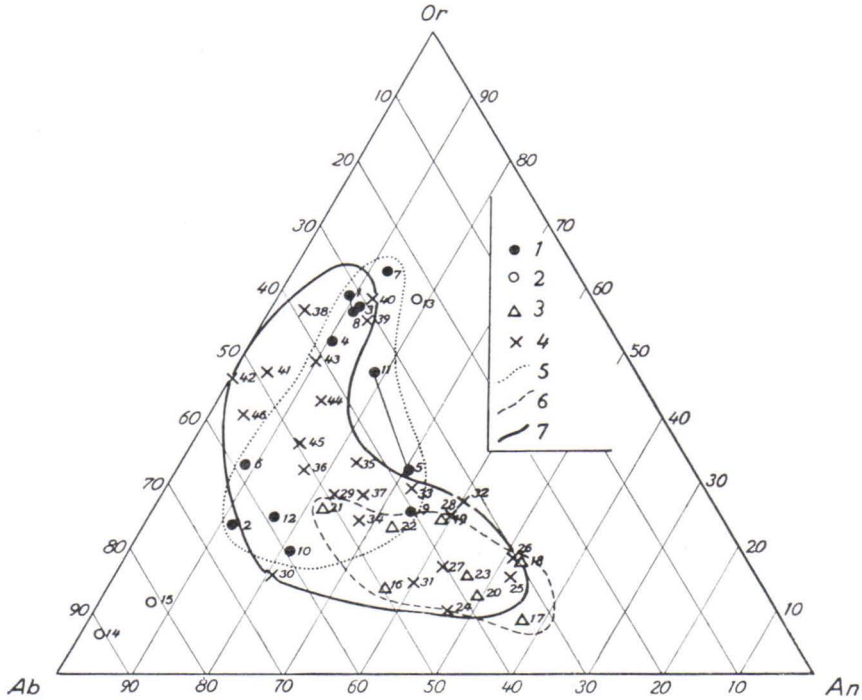


Fig. 9. Normative [Or] : [Ab] : [An] diagram of the supracrustal rocks in the Tampere schist belt. 1, graywacke-slates; 2, quartz-feldspar rocks; 3, basic tuffites; 4, porphyrites and porphyries; 5, field of graywacke slates; 6, field of basic tuffites; 7, field of blastoporphyritic volcanics. Numbers refer to Table IV.

The chemical composition of volcanic rocks varies from basaltic to rhyolitic (Table IV, Anal. 24—46). Basaltic uralite and plagioclase porphyrites are predominant, acid volcanics occurring only sporadically. Many intermediate types are found (cf. Fig. 9). The presence of trachyandesitic and some extremely potash-rich varieties is a peculiar characteristic of the volcanic rock family of the Tampere area. Seitsaari (1951) pointed out that the chemical composition of potash-rich types is not original, but that the potash of these rocks has increased by metasomatism. According to this interpretation, the well-preserved volcanic microtextures of potash-rich rocks (cf. Fig. 8) are, however, difficult to understand since metasomatism commonly destroys primary textures. The importance of potash metasoma-

tism has been also doubted by Seitsaari when he assumes (1951, p. 18) that »the existence of trachyandesitic porphyrite and alkali-rich feldspar porphyry may imply a gentle alkaline tendency of the lava differentiation in the area». Soda-rich varieties of lava rocks have not been found, though the analyzed acid pyroclastics (Table IV, Anal. 14—15) are soda-extrema.

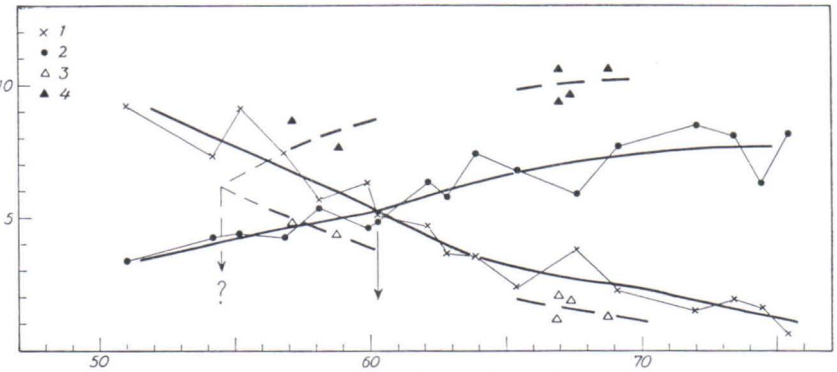


Fig. 10. Lime-alkali diagram of the volcanics in the Tampere area (cf. Table IV, Anal. 24—46) Abscissa, percentage SiO_2; ordinate, percentage CaO or alternatively $Na_2O + K_2O$. 1, CaO and 2, $Na_2O + K_2O$ for the normal calcic types of volcanics. 3, CaO and 4, $Na_2O + K_2O$ for trachyandesitic and potash-rich volcanics.

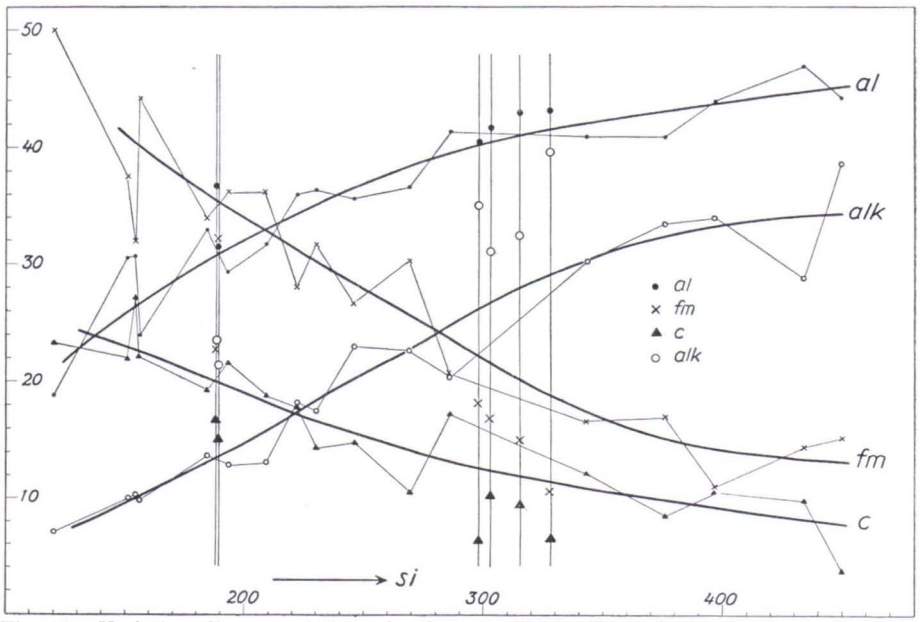


Fig. 11. Variation diagram of the volcanic rocks (Table IV, Anal. 24—46) in the Tampere area. Differentiation curves are drawn for normal calc-alkalic types of volcanics. Trachyandesitic and potash-rich volcanics are marked by means of vertical lines.

The lime-alkali diagram of the volcanics (Fig. 10) shows that the greatest part of them belongs to a normal calc-alkalic magma type. The lime-alkali index of the normal types is about 60, but the trachyandesitic and potash-rich lavas represent a more alkalic magma type whose lime-alkali index may be about 55. The variation diagram, based on the Niggli values given in Table IV, is presented in Fig. 11. The trachyandesitic and potash-rich rocks differ distinctly from the normal calc-alkalic types. They have higher al- and alk-numbers, whereas the fm- and c-numbers are lower than those of the normal types of volcanics in the Tampere area.

CONDITIONS OF SEDIMENTATION

The interpretation of depositional history of ancient sediments has been made easier by the great progress achieved during the last years in the study of sedimentary petrology. The vertical changes, observed in the lithology of a stratigraphic column, make it possible to draw conclusions about changes of ancient environments with time, and furthermore, lithologic features and lithologic associations give an idea of the tectonic behavior of the underlying crust during the sedimentation. The newest studies have shown that the tectonics of the depositional area have strongly influenced the character and thickness of accumulating sediments. The many recent investigations on sedimentation referred to and discussed in the excellent books of Pettijohn (1949), Twenhofel (1950), and Krumbein and Sloss (1951) are important for students of Archean metamorphic rocks because the new tectono-environmental aspects of sedimentation show new lines for study of the earth's history as registered in the sedimentary rocks of fossiliferous as well as nonfossiliferous formations. An attempt will be made in this section to reconstruct the changing conditions prevailing during sedimentation of Archean supracrustal rocks in the Tampere schist belt.

Many contributions on the conditions of sedimentation of varved rocks in the Tampere schist belt have been presented. Sederholm (1897) pointed out the seasonal control of deposition and Eskola (1932) considered the varved sediments as seasonal accumulations under cold or temperate climatic conditions. Recently Simonen and Kouvo (1951) stated that the varved sediments of the Tampere area show many conspicuous similarities to the graywacke slates of other orogenic belts. According to the new investigations on sedimentary tectonics (cf. Pettijohn, 1943), the graded bedded graywackes are typical representatives of thick detrital accumulations in geosynclinal basins with high degree of tectonic activity.

The graywacke character of the sandstone portions of the varves indicates that the erosion, transportation, and sedimentation have been rapid. The chemical weathering and sorting of material have been incomplete.

Table IV. Chemical analyses of supra-

A. Graywacke-slates

	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2	56.63	60.64	59.84	58.89	64.80	64.14	62.93	63.93	65.49	67.87	69.68	77.00
TiO_2	1.04	0.67	0.75	0.86	0.50	0.67	—	0.82	0.60	0.58	0.50	0.42
Al_2O_3	22.41	16.86	14.19	20.39	17.51	16.41	15.72	16.92	15.89	14.99	14.71	11.32
Fe_2O_3	0.58	1.42	6.56	1.16	0.81	1.20	0.97	0.79	1.04	0.56	0.64	0.88
FeO	5.05	4.92	4.97	6.01	3.34	3.95	5.43	5.04	5.40	3.53	2.62	2.02
MnO	0.06	0.08	0.08	0.06	0.07	0.04	—	0.04	0.06	0.04	0.04	0.04
MgO	2.35	3.37	3.00	2.04	1.36	2.53	2.23	2.15	2.15	1.25	0.92	0.68
CaO	1.28	1.96	1.53	1.20	4.16	1.56	1.42	1.36	3.62	2.88	2.30	1.52
Na_2O	2.31	5.41	1.74	2.00	3.02	4.24	1.62	1.98	2.20	4.36	2.51	2.84
K_2O	6.15	2.83	4.64	3.92	3.70	3.44	5.96	4.94	2.04	2.12	4.92	1.68
P_2O_5	0.12	0.26	0.31	0.19	—	0.36	—	0.16	0.32	0.17	—	0.14
H_2O+	2.19	1.31	2.45	3.31	0.72	1.63	} 2.83	1.43	1.21	1.25	0.96	1.05
H_2O-	0.18	0.07	0.07	0.05	0.10	0.10		0.23	0.06	0.06	0.08	0.13
BaO	0.05	—	—	—	—	—	—	—	—	—	—	—
S	0.08	—	—	—	—	—	—	0.02	—	—	—	—
C	0.31	—	—	—	—	—	—	—	—	—	—	—
	100.79	99.80	100.13	100.08	100.09	100.27	99.11	99.81	100.08	99.66	99.88	99.72
si	195	207	212	220	232	250	258	260	260	298	335	497
al	45.6	33.8	29.6	44.9	36.9	37.7	37.4	40.6	37.1	38.8	41.7	43.1
fm	28.4	35.0	48.2	33.7	28.3	31.2	34.8	32.8	33.9	23.2	19.6	22.0
c	4.7	7.2	5.8	4.8	15.9	6.5	6.1	5.9	15.4	13.6	11.9	10.5
alk	21.3	24.0	16.4	16.6	18.9	24.6	21.7	20.7	13.6	24.5	26.8	24.6
k	0.64	0.26	0.64	0.56	0.45	0.35	0.71	0.62	0.38	0.24	0.56	0.28
mg	0.43	0.49	0.33	0.34	0.26	0.47	0.39	0.40	0.37	0.35	0.54	0.30

D. Blastoporphyritic

	24	25	26	27	28	29	30	31	32	33	34	35
SiO_2	50.98	54.16	55.18	56.84	58.07	57.18	58.79	59.93	60.24	62.14	62.79	63.80
TiO_2	0.59	1.11	0.80	0.62	0.49	0.72	0.90	0.87	0.96	0.74	0.80	0.64
Al_2O_3	13.56	18.49	18.61	14.74	17.68	18.96	16.77	15.44	15.47	17.09	16.86	15.70
Fe_2O_3	1.85	0.83	2.74	1.04	1.61	2.16	2.28	3.20	2.45	1.83	2.56	4.73
FeO	10.58	7.34	5.23	6.59	5.46	3.10	5.50	4.32	5.54	4.04	3.89	1.22
MnO	0.24	0.09	0.42	0.16	0.15	0.08	0.10	0.07	0.15	0.07	0.11	0.12
MgO	7.42	4.32	3.09	6.40	3.25	1.80	2.32	3.45	2.57	2.05	2.27	1.47
CaO	9.20	7.30	9.09	7.47	5.71	4.76	4.43	6.28	5.06	4.66	3.66	3.55
Na_2O	2.56	2.50	2.40	2.64	2.73	4.74	5.54	3.16	2.15	3.03	3.36	3.52
K_2O	0.84	1.73	2.05	1.62	2.66	3.94	2.04	1.48	2.68	3.35	2.44	3.92
P_2O_5	0.33	0.31	—	0.23	0.41	0.40	0.33	0.37	0.32	0.19	0.24	0.34
H_2O+	2.17	1.41	} 0.60	1.24	1.49	1.57	1.18	1.07	1.98	0.79	1.15	1.08
H_2O-	0.05	0.21		0.21	0.13	0.13	0.07	0.08	0.09	0.12	0.05	0.06
CO_2	—	—	—	—	—	—	—	—	—	—	—	—
	100.37	99.80	100.21	99.80	99.84	99.54	100.25	99.72	99.66	100.10	100.18	100.15
si	120	151	154	156	184	188	189	193	209	222	230	246
al	18.8	30.5	30.7	23.9	32.9	36.8	31.7	29.3	31.7	36	36.4	35.7
fm	50.8	37.5	31.9	44.3	33.9	22.9	31.7	36.1	36.3	28	31.6	26.7
c	23.3	22.0	27.2	22.1	19.3	16.8	15.2	21.7	18.8	18	14.4	14.8
alk	7.1	10.0	10.2	9.9	13.7	23.5	21.4	12.9	13.2	18	17.6	23.0
k	0.18	0.31	0.36	0.29	0.39	0.38	0.20	0.24	0.45	0.42	0.32	0.42
mg	0.51	0.48	0.40	0.60	0.45	0.39	0.35	0.46	0.39	0.39	0.39	0.32

crustal rocks in the Tampere schist belt.

B. Quartz-feldspar rocks

13	14	15
75.52	72.29	75.02
—	0.18	0.15
14.64	14.31	12.84
1.42	1.32	0.45
0.95	0.97	1.48
—	0.03	0.04
0.30	trace	0.42
1.33	0.92	1.20
0.97	7.72	6.00
3.53	0.82	1.20
—	0.30	0.23
} 1.06	0.75	0.73
	0.03	0.23
99.72	99.64	100.02
486	374	424
55.5	43.7	42.8
14.9	9.5	12.6
9.2	5.2	7.3
20.4	41.6	37.3
0.71	0.07	0.12
0.19	—	0.28

C. Basic and intermediate tuffites

	16	17	18	19	20	21	22	23
SiO_2	51.71	48.81	50.10	52.09	56.10	52.82	56.26	65.16
TiO_2	0.44	1.28	2.18	1.35	0.91	1.04	0.81	—
Al_2O_3	15.26	17.39	18.50	19.28	14.18	14.78	15.05	15.56
Fe_2O_3	0.77	4.30	4.69	4.24	2.33	0.89	2.22	2.11
FeO	4.64	6.93	7.30	6.26	6.62	7.70	4.86	3.39
MnO	0.22	0.21	0.26	0.14	0.15	0.19	0.14	0.36
MgO	5.67	4.36	2.30	3.97	6.71	3.85	6.86	2.40
CaO	12.13	8.43	8.08	5.37	7.32	7.67	5.90	6.70
Na_2O	3.55	1.43	2.32	2.78	2.30	2.66	3.16	2.54
K_2O	1.36	0.52	1.90	2.62	1.08	1.88	2.36	1.47
P_2O_5	0.43	0.28	0.28	0.28	0.30	0.28	0.29	—
H_2O+	0.57	2.65	2.38	1.48	1.91	2.33	2.00	} 1.11
H_2O-	0.07	0.10	0.09	0.08	0.12	0.03	0.12	
CO_2	3.32	3.02	—	—	—	4.23	—	—
	100.14	99.71	100.38	99.94	100.03	100.35	100.03	100.80
si	131	132	138	145	154	157	157	232
al	22.8	27.8	30.0	31.6	22.8	25.8	24.7	32.6
fm	33.4	42.8	36.6	40.2	47.7	38.6	44.9	29.6
c	32.9	24.6	23.8	16.0	21.5	24.4	17.6	25.5
alk	10.9	4.7	9.5	12.1	7.9	11.1	12.8	12.1
k	0.20	0.19	0.35	0.38	0.24	0.32	0.33	0.28
mg	0.64	0.42	0.26	0.41	0.57	0.44	0.64	0.43

volcanics.

36	37	38	39	40	41	42	43	44	45	46	
65.40	67.58	66.95	66.96	67.40	68.76	69.08	72.01	73.38	74.54	75.36	SiO_2
0.57	0.26	0.67	0.66	—	0.35	0.38	0.41	0.19	0.21	0.11	TiO_2
15.06	16.71	15.40	15.66	15.62	15.37	13.99	13.33	13.79	13.70	12.05	Al_2O_3
1.01	1.04	0.00	0.92	} 3.15	1.65	1.88	0.93	0.65	0.88	1.12	Fe_2O_3
4.64	2.52	3.42	2.27		0.57	1.48	2.13	1.32	1.15	1.87	FeO
0.07	0.06	0.06	0.01	—	0.05	0.13	0.03	0.02	0.04	0.03	MnO
1.71	1.32	0.76	0.70	0.56	0.32	0.39	0.54	0.32	0.55	0.09	MgO
2.40	3.80	1.13	2.10	1.87	1.28	2.27	1.48	1.93	1.58	0.60	CaO
3.56	3.14	3.40	2.66	2.51	4.47	3.48	3.14	3.34	3.04	3.96	Na_2O
3.24	2.82	7.20	6.74	7.10	6.25	4.28	5.36	4.73	3.16	4.20	K_2O
0.33	0.47	0.33	0.10	—	0.04	0.56	0.14	0.13	0.10	—	P_2O_5
2.25	0.90	0.67	0.95	} 0.50	0.84	0.65	0.57	0.45	0.86	0.15	H_2O+
0.09	0.07	0.07	0.03		0.12	0.02	0.08	0.09	0.09	0.05	H_2O-
—	—	—	—	—	—	1.23	—	—	—	—	CO_2
100.33	100.69	100.06	99.76	98.71	100.07	99.82	100.15	100.34	99.90	99.59	
269	286	298	303	315	328	343	376	397	434	450	si
36.6	41.6	40.5	41.8	43	43.2	41.0	41	44	46.9	42.2	al
30.2	20.7	18.2	16.9	15	10.6	16.6	17	11	14.4	15.2	fm
10.6	17.2	6.4	10.3	9.5	6.5	12.1	8.5	11	9.9	3.8	c
22.7	20.5	35.2	31.0	32.5	39.7	30.3	33.5	34	28.8	38.8	alk
0.38	0.37	0.58	0.62	0.66	0.48	0.45	0.53	0.48	0.41	0.41	k
0.35	0.40	0.28	0.28	0.26	0.21	0.17	0.24	0.23	0.33	0.05	mg

A. Graywacke-slates.

1. Slaty, darker portion of a varve. Ajonokka. Aitolahti. Sederholm (1913, p. 23).
2. »Leptitic phyllite». Vaavujärvi. Orivesi. Seitsaari (1951, p. 14).
3. Phyllite. N of Lake Vaavujärvi. Teisko. Seitsaari (1951, p. 14).
4. Varved phyllite. Valkeekivi. Ylöjärvi. Simonen and Neuvonen (1947, p. 253).
5. Varved sediment, dark layer. Mansonsalmi, Ikaalinen. Huhma, Salli and Matisto (1952, p. 70).
6. Phyllite. Vaavujärvi. Orivesi. Seitsaari (1951, p. 14).
7. Phyllite. E of Lake Näsijärvi. Aitolahti. Sederholm (1913, p. 23).
8. Coarse-grained, lighter portion of the same varve as in Anal. 1. Ajonokka. Aitolahti. Sederholm (1913, p. 23).
9. Phyllite. Koskue. Jalasjärvi. Lokka (1950, p. 50—51).
10. Varved schist. Valkeekivi. Ylöjärvi. Simonen and Neuvonen (1947, p. 253).
11. Varved sediment, light layer of the same varve as in Anal. 5. Mansonsalmi. Ikaalinen. Huhma, Salli and Matisto (1952, p. 70).
12. Coarse-grained base of a megavarve rich in quartzite pebbles. Reuhari. Ylöjärvi. Simonen and Neuvonen (1947, p. 253).

B. Quartz-feldspar rocks.

13. Arkose sandstone. Mauri. Suoniemi. Sederholm (1913, p. 34).
14. Quartz-feldspar rock, hälleflinta. Lepomäki. Ylöjärvi. Simonen and Neuvonen (1947, p. 252).
15. Quartz-feldspar rock, leptite. Kiviniemenlahti. Ylöjärvi. Simonen and Neuvonen (1947, p. 252).

C. Basic and intermediate tuffites.

16. Calcite-bearing amphibolite. N of Valkeekivi. Ylöjärvi. Simonen (1952, p. 65).
17. Albite-epidote-chlorite schist. S of Lake Hirvijärvi. Ylöjärvi. Simonen (1952, p. 65).
18. Basic tuffite. N of Paroinen. Ylöjärvi. Simonen (1952, p. 65).
19. Basic tuffite. Koskue. Jalasjärvi. Lokka (1950, p. 50).
20. Basic tuffite. Vähä-Antinsaari. Teisko. Simonen (1952, p. 65).
21. Calcite-bearing amphibolite. Aitoniemi. Aitolahti. Simonen (1952, p. 65).
22. Hornblende schist. NW shore of Lake Pappilanselkä. Orivesi. Seitsaari (1951, p. 14).
23. Basic tuffite. Löytökorpi. Kankaanpää. Sederholm (1897).

D. Blastoporphyritic volcanics.

24. Uralite porphyrite. N of Keijärvi. Ylöjärvi. Simonen (1952, p. 66).
25. Porphyrite. Mahlu. Saarijärvi. Wilkman (1936, p. 129).
26. Lavialite. Lavijärvi. Lavia. Mäkinen (1915).
27. Diabase. W of Niemi farm. Ylöjärvi. Simonen (1952, p. 66).
28. Uralite porphyrite. Mustajärvi. Parkano. Lokka (1950, p. 32).
29. Tranchyandesite. E of Mastosjärvi. Ylöjärvi. Simonen (1952, p. 66).
30. Trachyandesite. E end of Lake Vaavujärvi. Orivesi. Seitsaari (1951, p. 14).
31. Plagioclase porphyrite. Kiialanniemi. Ikaalinen. Huhma, Salli and Matisto (1952, p. 70).
32. Diorite porphyrite. Paroinen. Ylöjärvi. Simonen (1952, p. 66).
33. Porphyrite. Mahlu. Saarijärvi. Wilkman (1936, p. 127).
34. Porphyrite. Koskue. Jalasjärvi. Lokka (1950, p. 50).
35. Feldspar porphyry. E of Mastosjärvi. Ylöjärvi. Simonen (1952, p. 66).
36. Quartz-plagioclase porphyry. Paroinen. Ylöjärvi. Simonen (1952, p. 66).
37. Quartz porphyry. Kiialanniemi. Ikaalinen. Huhma, Salli and Matisto (1952, p. 71).
38. Potash-rich porphyry. Lielahti. Tampere. Simonen (1952, p. 66).
39. Potash-rich porphyry. Tervakivi. Teisko. Simonen (1952, p. 66).
40. Potash-rich feldspar porphyry. Varvuejärvi. Teisko. Sederholm (1897, p. 68).
41. Potash-rich feldspar porphyry. N of Lake Valkeajärvi. Orivesi. Seitsaari (1951, p. 14).
42. Quartz porphyry. Härkilepo. Ylöjärvi. Simonen (1952, p. 66).
43. Quartz porphyry. Lehtolankylä. Saarijärvi. Wilkman (1936, p. 122).
44. Granite porphyry. Mahlu. Saarijärvi. Wilkman (1936, p. 124).
45. Quartz porphyry. Koskue. Jalasjärvi. Lokka (1950, p. 50).
46. Feldspar porphyry. Kovelahti. Ikaalinen. Huhma, Salli and Matisto (1952, p. 71).

The fine-grained, clayey matrix between coarse mineral particles and rock fragments shows that the deposition of arenaceous and argillaceous material have taken place at the same time. This is probably due to flocculation of argillaceous material by salt water in a marine environment. High boron content of the varved schists points also towards marine environment (cf. Simonen and Kouvo, 1951).

The coarse-grained sandstones, with particles measuring up to 5—7 mm in diameter, support the idea of shallow-water, neritic environment of deposition. The accumulation of a 3 kilometres thick, continuous graywacke-slate sequence has been, however, possible in the sedimentary basin which has subsided at the same rate as sediments were deposited. Rapidly accumulated varved rocks indicate accordingly a high degree of tectonism during sedimentation. These conditions are characteristic of geosynclinal deposition during which »poured in» type of sediment accumulated in a mobile subsiding trough. New ideas on the geosynclinal deposition have been recently set forth by Kuenen and Migliorini (1950) who suggest that density currents, taking place along continental slopes, may carry the coarse clastic sediments to bathyal and abyssal depths and cause graded bedding, characteristic of many thick geosynclinal graywacke accumulations.

The quartz-feldspar rocks of graywacke or arkose type, overlying the graywacke-slates, have accumulated under conditions of moderate subsidence in an unstable depositional area. The erosion, transportation, and deposition have continuously been so rapid that no complete chemical weathering has taken place. The graded bedding, characteristic of sediments deposited in still bottom water, has been observed only in thin interbeds of graywacke slates, but on the other hand the cross bedding and ripple marks, indicating deposition in stable platforms, are lacking, and the sandstones are usually massive. The sedimentation of poorly sorted sandstones has probably taken place in a neritic environment but the associated acid pyroclastics and some thin conglomerate beds suggest a transitional, littoral environment of deposition.

The basic volcanics, overlying the sedimentary succession of graywacke-slates and sandstones, represent more terrestrial conditions of deposition. They have accumulated probably on the volcanic island arch systems rising from the geosyncline. This assumption explains the source of detrital material for the deposition of thick conglomerate interbeds rich in volcanic pebbles. The rapid sedimentation of thick heterogeneous conglomerates with associated sediments has taken place in the subsiding depositional areas along the margins of uplifted volcanic island arch systems. In accordance with this assumption is the mode of occurrence of the conglomerates of the Viljakkala—Teisko zone which is similar to some Archean conglomerates of the Canadian Shield described by Pettijohn (1943) as basin-

margin accumulations so that «the present outcrops coincide with the margins of original basins of deposition». Pettijohn concluded that »the conglomerates thus mark the limits of sedimentation in Archean time and give more promise of reconstruction of the paleogeography of this ancient time than might be expected».

The characteristics and manner of occurrence of the conglomerates in the Suodenniemi—Lavia schist zone, however, deviate from those in the Viljakkala—Teisko area. Their sedimentation has taken place before widespread volcanic activity and the presence of diorite pebbles indicates a deep local erosion. The conglomerates and associated sediments of the Suodenniemi—Lavia zone are derived from a tectonically active area which has uplifted during the earliest orogenic disturbances. These kinds of positive intrageosynclinal geanticlines, giving material to subsiding sedimentation troughs, are typical in many geosynclines.

The origin of the thick beds of basic volcanics corresponds to the acute time of orogenic evolution, taking place after the deposition of axial portions of geosynclinal sediments, graywacke-slates and sandstones. The lower horizon of basic volcanis, underlying the conglomerates in the Viljakkala—Teisko zone, consists of basic and intermediate tuffs and associated lava flows. Pillow lavas, characteristic of many orogenic belts, have been found only in the Viljakkala schist area. Submarine environment of deposition is indicated, however, by the tuffite interbeds in the water-deposited sediments, and the volcanic ash material has been reworked and intimately mixed with the weathering sediments. Thin interbeds of volcanic conglomerates and agglomerates are common. The upper division of volcanics, overlying the conglomerates in the Viljakkala—Teisko zone, contains predominantly basic tuffs and lavas, intermediate types not being so common as in the lower volcanic horizon.

Taken as a whole, the supracrustal rock group of the Tampere schist belt shows conspicuous similarities to many geosynclinal deposits of later age. The thick accumulation of sediments and initial volcanic activity are characteristics of linear, mobile, so-called eugeosynclinal belts (cf. Kay, 1947). Lithologic characteristics of sediments accumulated in subsiding geosynclinal troughs differ from those of sediments deposited in more stable areas and especially the lithologic associations (cf. Dapples, Krumbein and Sloss, 1948) give an idea of the tectonic conditions during sedimentation. Graywacke-greenstone association in many orogenic belts has been pointed out already by Bailey (1930 and 1936) and Tyrrell (1933) who consider these rocks as representing orogenic sedimentary and igneous facies. The characteristics of eogeosynclinal association have been discussed thoroughly by Pettijohn (1943) who writes: »..... excessive thickness, especially of the conglomerates, abundance of graded bedding, rarity of cross bedding, and absence of ripple mark, the graywacke nature of the arenaceous beds,

the absence of true quartzites and limestones and scarcity of normal argillaceous sediments, and the association with greenstones and tuffs are all the earmarks of a geosynclinal facies of sedimentation». The thick supracrustal rock group of the Tampere schist belt, measuring at least 8 km in thickness, shows all of the above-mentioned characteristics of the eogeosynclinal deposits.

SVECOFENNIDIC SUPRACRUSTAL ROCKS IN SOUTHERN FINLAND AND THEIR CORRELATION TO THE SCHISTS OF THE TAMPERE BELT

Supracrustal rocks showing lithologic similarities to the well-preserved schists of the Tampere area have a wide distribution in the broad Svecofennidic zone of Southern Finland. Sederholm (1897) reported that the best-preserved parts of the Southern Finnish rock crust, consisting chiefly of basic volcanics, show many conspicuous analogies to the supracrustal strata of the Tampere area, and he connected many separated schist areas of Southern Finland, including the Tampere schists, in the same so-called Bothnian formation (see p. 10). Sederholm's correlation has been proved valid by many later investigations, but at the same time it has become evident that many gneisses of Southern Finland represent only highly metamorphic, coarse-grained alteration products of the well-preserved schists of »Bothnian type». According to our present views, the grade of metamorphism of the Svecofennidic strata can vary within wide limits; so for example phyllites pass gradually through mica schists into mica gneisses, basic volcanics into migmatitic hornblende gneisses. In the following paragraphs the structural, stratigraphic, and petrographic features of the supracrustal rocks in Southern Finland will be briefly described and the correlations to the schists of the Tampere area will be discussed.

STRUCTURE AND STRATIGRAPHY

Structural geology of the Svecofennidic rock crust in Southern Finland is generally very complicated, and therefore stratigraphic conclusions based on the structural geology can be made only sporadically in some suitable cases. The present author will describe in this connection only such main features of the structural geology of Southern Finland as are necessary for stratigraphic interpretations.

The preliminary results of the new geological mapping carried out by the Geological Survey of Finland in the broad belt of basic volcanics in the Kalvola—Tammela area support the assumption of structural features

similar to those met with in the basic volcanics of the Tampere schist area. The geological map (Map II) indicates a nearly horizontal position of fold axes of principal folding although the linear structures observed on the nearly vertical bedding planes are generally very steep. Some repeated beds and a few well-preserved sedimentary structures which allow the

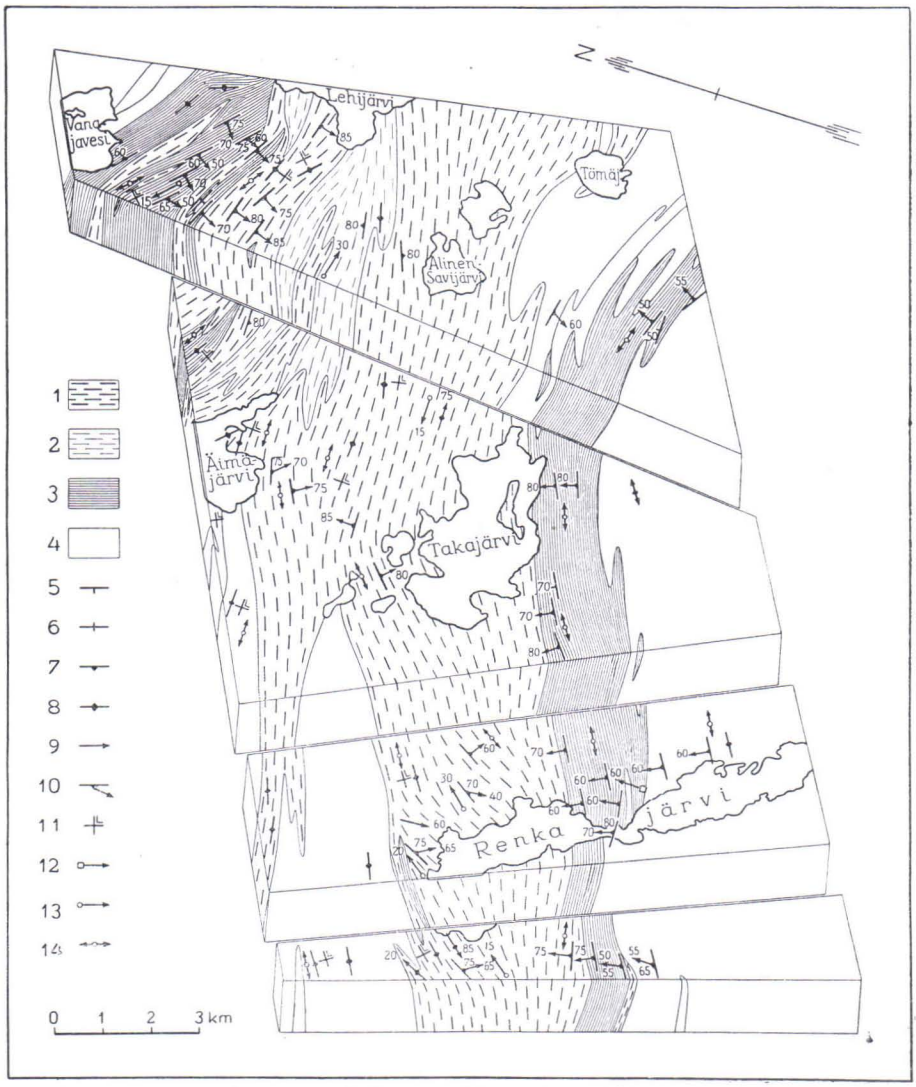


Fig. 12. A wide syncline west of the town Hämeenlinna (Simonen, 1949). 1, basic and intermediate volcanics; 2, acid tuffite, 3, mica schist; 4, infracrustal rocks; 5, strike and dip of stratification; 6, strike of vertical stratification; 7, strike and dip of foliation; 8, strike of vertical foliation; 9, lineation; 10, foliation with linear element; 11, vertical lineation; 12, folding axis of minor fold (crenulation on the limbs of the big folds); 13, folding axis; 14, horizontal folding axis; 13 and 14 have been determined by means of the a-lineation and foliation. According to the field observations of I. Salli, M. A.

determination of the sequence of beds suggest isoclinal folding. It has been possible to reconstruct by means of field observations some nearly vertical synclines and anticlines and they show that the basic volcanics overlie, in a similar manner as in the Tampere area, the sediments represented mainly by the mica schists and quartz-feldspar rocks. Unfortunately, the greatest part of the new observations on the structure and stratigraphy of the Tammela—Kalvola area are still unpublished. Simonen (1949) has, however, described a wide syncline west of the town of Hämeenlinna (Fig. 12) in which the mica schists underlie the basic volcanics. The synclinal structure and stratigraphic succession has been checked in this case by means of some few observations on the graded bedding visible in the best-preserved parts of the mica schists.

The basic volcanics of the Kalvola—Tammela area border in the west on a wide area of mica gneisses or kinzigites (Map II). The kinzigites are intensely folded, fold axes as well as linear structures usually dipping gently towards the east. This structural feature and the geological map (Map II) suggest the idea that the kinzigites disappear under the basic volcanics, coming to the surface at the eastern side of the volcanic rock area. This suggestion is in harmony with observations made in the Tammela—Kalvola area, where basic volcanics overlie the sediments. According to our present views, it seems probable that the areas of basic volcanics correspond to deep synclines and depressions of the Svecofennidic mountain chain. The tectonic observations and the geological map of the volcanic rock area of Somero (Fig. 13) indicate that the diapiric updoming of wide migmatitic granite

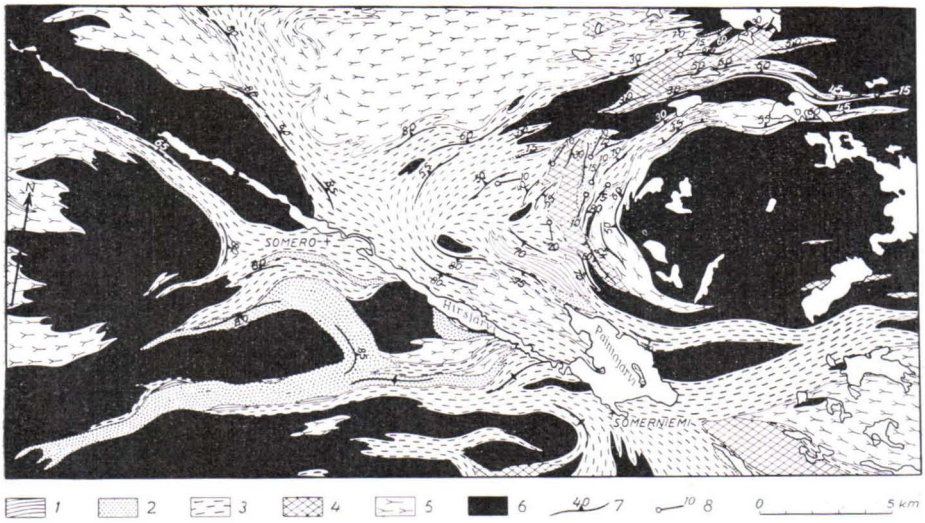


Fig. 13. Geological sketch map of the Somero district. 1, mica schists and mica gneisses; 2, quartz-feldspar rocks; 3, basic volcanics; 4, gabbros and diorites; 5, quartz-diorites and granodiorites; 6, migmatitic microcline granites; 7, dip of bedding planes; 8, fold axis.

bodies on both sides of the volcanics has tilted the strata into a wide depression.

Metzger has described (1928, 1945 and 1947) the structural features of many limestone occurrences in Southern Finland and he can give many local interpretations on the stratigraphy of the Svecofennidic sedimentary strata. The cross section of the Parainen (Pargas) area (Fig. 14) by Metzger

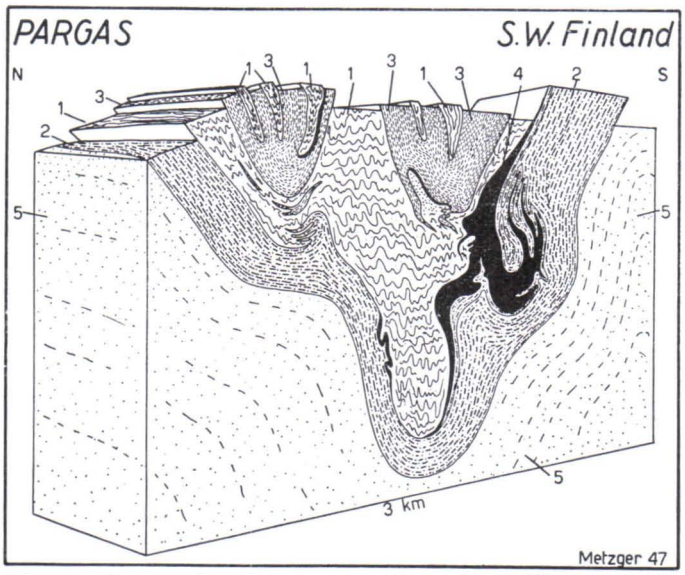


Fig. 14. Cross section of the Parainen (Pargas) area (Metzger, 1947). 1, kinzigite; 2, amphibolite; 3, upper amphibolite; 4, limestone; 5, granitized kinzigite.

(1947) shows that limestones and calcareous schists occur as thick intercalations in the kinzigites. Many limestone deposits of Southern Finland occur also as intercalated beds in the sedimentary leptites. From the stratigraphic point of view it is interesting to note in this connection that the limestones and calcareous schists occur predominantly in the coastal area, but they are almost absent in the wide areas of the Svecofennidic rock crust. This peculiar feature of distribution is important for the interpretation of sedimentation of the Svecofennidic rocks in Southern Finland (see p. 59).

The new geological mapping in the leptite belt of Southern Finland, trending from Kemiö to Lohja, indicates strong isoclinal folding and fold axes are generally nearly horizontal, pitching to the east or west. According to the preliminary results [1]) of the detailed geological field work carried out by the Finnish Ore Company (Suomen Malmi Osakeyhtiö), the sequence of the supracrustal strata in the Orijärvi area is as follows:

[1]) lecture hold by Mr. Toivo Mikkola, M. A., September 28th, 1950, at the Geological Society of Finland. Orijärven alueen rakennetta ja stratigrafiaa. Geologi. No 7. 1950.

— amphibolite (metabasalt),
— polymictic conglomerate,
— calcareous horizon containing leptitic schists,
— mica schist.

This sequence of intensely folded and repeated strata is approximately only one kilometer thick, but it shows some conspicuous similarities to that of the Tampere schist area. It is essential to note that the basic volcanics in this part of the Svecofennidic chain also overlie the sediments.

Gently dipping fold axes and linear structures have been observed also in the wide area of pyroxene gneisses in Western Uusimaa, but the stratigraphy is still poorly known. The geological map of the area (Parras, 1941) indicates an intense folding of the strata which consist mainly of kinzigites and calcareous sediments metamorphozed into pyroxene gneisses.

The structural geology of the wide migmatite areas in the coastal part of Southern Finland is very complicated. Many important details on the structural evolution of the migmatite areas have been, however, presented in the studies of Wegmann and Kranck (1931), Kranck (1933 and 1937), and Edelman (1949). Sometimes the old designs of the primary Svecofennidic tectonics can be observed as a structure relict in almost entirely granitized parts of the migmatitic rock crust, but in many cases the diapiric upward movement of migmatite granite bodies has caused steep axial pitches. The structural features of many migmatite areas must be regarded at the present state of our knowledge as a »versteinerter Unsinn», in the words of Hans Cloos (1947).

Summarizing, we can state that wide areas of the Svecofennidic rock crust in Southern Finland are characterized by intense isoclinal folding around nearly horizontal fold axes in east-west direction. The interpretation of structural geology has given in some suitable cases possibilities for drawing stratigraphic conclusions. The preliminary results suggest that in all parts of Southern Finland the basic volcanics overlie the sediments. Local interpretations on the stratigraphy of the Svecofennidic sedimentary rocks in Southern Finland have been made, but much more data must be available before a reliable stratigraphic correlation of the sequences observed in the different schist areas should be attempted. The preliminary results of stratigraphic correlation suggest, however, that the new ideas on the stratigraphy as well as on the conditions of sedimentation, suggested by observations in the Tampere schist area, can be used as working hypotheses for the explanation of the highly metamorphic schist formations in Southern Finland.

PETROGRAPHY

The main types of the Svecofennidic supracrustal rocks in Southern Finland will be briefly described and the correlations to the schists of the

Tampere area will be presented. Special attention is called to those petrographic features which may be useful for explaining the conditions of sedimentation.

PHYLLITES, MICA SCHISTS, AND MICA GNEISSES

The widely distributed Svecofennidic sediments are represented by three different types of micaceous schists: phyllites, mica schists, and mica gneisses (kinzigites).

The phyllites occur only in the best-preserved Svecofennidic schist zone of the Tampere area and their petrographic features have been described in this paper (see p. 23).

The mica schists, containing usually porphyroblasts of cordierite and andalusite, occur sporadically in the schist areas characterized by the rich occurrence of basic volcanics and the stratigraphic position of the mica schists seems to correspond to that of the varved phyllites in the Tampere area. The relict structure of graded bedding, observed sporadically in the well-preserved parts of the mica schists in the Kalvola—Tammela (Eskola, 1936), Renko—Aulanko (Simonen, 1948b and 1949), and Orijärvi (Tuominen and Mikkola, 1950) areas, justifies the correlation of varved phyllites and mica schists. The graded bedding shows that the conditions of deposition of the mica schists have been similar to those prevailing during the sedimentation of the varved schists in the Tampere area.

Rich occurrence of strongly recrystallized mica gneisses is a characteristic feature of the highly metamorphic and migmatitic Svecofennidic rock crust in Southwestern Finland. The coarse-grained garnet- and cordierite-bearing gneisses, so called kinzigites, are especially widely distributed. In Sweden and Finland the origin of the garnet-cordierite gneisses has been the object of many discussions. Some authors (Wegmann and Kranck, 1931; Magnusson, 1936) have presented the garnet-cordierite gneisses as magnesia metasomatic rocks, originated in close connection with the regional granitization. This assumption has been important to the petrological interpretations of the modern transformists (cf. Read, 1948). In the terms of the frontist geologists, the Finnish kinzigites represent the basic front, or widespread basification, advancing before the main theatre of granitization. The newest investigations (Hietanen, 1943 and 1947; Metzger, 1945; Parras, 1941 and 1946), carried out in the wide mica gneiss areas of Southwestern Finland show, however, that the kinzigites are paragneisses with the primary chemical bulk composition and, therefore, there are no evidences of the »basic front» in the Finnish kinzigites. Niggli (1946), on the basis of the above-mentioned new Finnish studies and on the new petrochemical data of Finnish rocks, has also pointed out that kinzigites have not undergone

secondary enrichment in Fe, Mg and Ca. The sedimentary origin and argillaceous character of the Swedish cordierite- and garnet-bearing gneisses in Sörmland has been pointed out especially by Backlund (1937).

The distinct sedimentogenous structures and textures of the Finnish kinzigites have been destroyed in many cases by the strong metamorphic

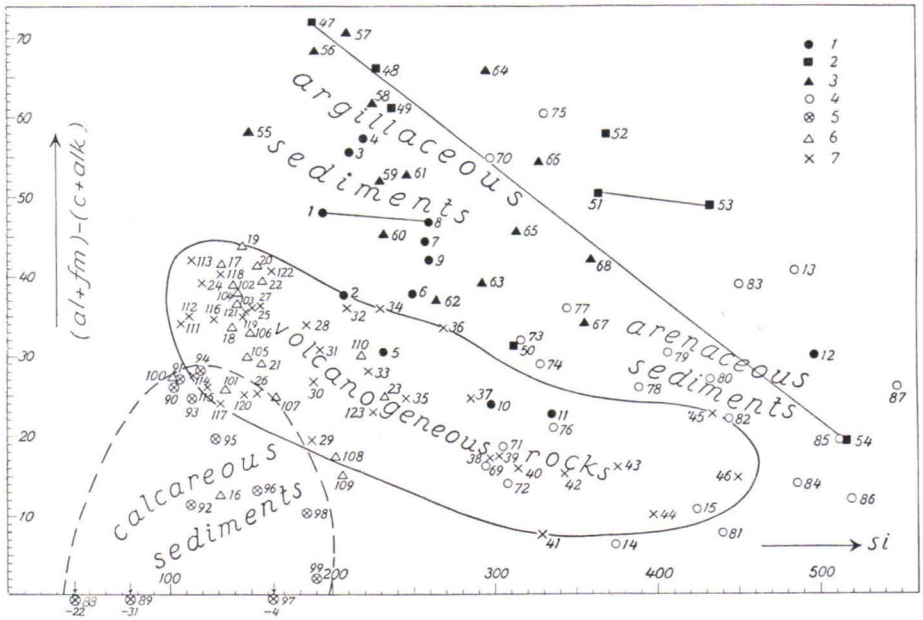


Fig. 15. The (al + fm)—(c + alk) diagram of the Svecofennidic supracrustal rocks in Southwestern Finland. 1, varved schists; 2, mica schists; 3, kinzigites; 4, quartz-feldspar rocks (leptites); 5, calcareous schists; 6, tuffites; 7, blastoporphyritic volcanics. The numbers refer to the chemical analyses in Tables IV, VII and VIII.

recrystallization, but in the best-preserved parts of the kinzigites in the Kalanti area there are alternating layers of arenaceous and argillaceous composition and in some cases the stratification resembles that of the varved sediments (cf. Hietanen, 1943). The indistinct banding of different layers, due to the primary variations in the sedimentary strata is, however, a common structural feature of the highly metamorphic kinzigites. Furthermore, the calcareous concretions and graphite-bearing bands suggest the sedimentary origin. The gradual transition from the mica schists into kinzigites observed in the some parts of the Svecofennidic rock crust shows that the kinzigites represent only a highly metamorphic variety of the Svecofennidic micaceous schists.

The chemical composition of the Svecofennidic phyllites (Table IV), mica schists, and mica gneisses (Table VII) varies within the same limits and shows the chemical characteristics of normal sediments rich in argillaceous material. The (al + fm)—(c + alk) diagram (Fig. 15) of the Svecofennidic

supracrustal rocks shows that the phyllites, mica schists, and kinzigites occupy the same field and differ distinctly from the other supracrustal rocks. Sandy portions of the megavarves (Table IV, Anal. 12) and the light layers in mica schists (Table VII, Anal. 54) reperesent the most siliceous members of the strata and they are similar to the Svecofennidic sandstones. Chemical analyses made from the psammitic and pelitic portions of the same sample (Table IV, Anal. 1 and 8; Table VII, Anal. 47 and 54; Table VII, Anal. 51 and 53) show that the sandstone portions are richer in SiO_2 but lower in Al_2O_3 and K_2O than the corresponding pelitic parts. The difference between clay and sand portions is especially high in the cordierite-biotite schist of Kisko (Table VII, Anal. 47 and 54). This is, according to Tuominen and Mikkola (1950), due to the metamorphic differentiation related to folding. This same rock is unique because the content of K_2O in the sandy part is higher than in the dark portion.

Table V. Average chemical composition of sedimentary rocks.

	1		2		3		4		5	6	7	8	9
SiO_2	[1]) 12	64.32	8	68.59	14	64.51	19	73.08	64.2	68.1	77.8	75.5	58.10
TiO_2	11	0.67	8	0.56	14	0.61	19	0.38	0.5	0.7	0.6	—	0.65
Al_2O_3	12	16.44	8	13.44	14	15.83	19	12.89	14.1	15.4	9.5	11.4	15.40
Fe_2O_3	12	1.38	8	1.55	14	2.36	19	0.66	1.0	3.4	0.9	2.4	4.02
FeO	12	4.36	8	5.26	14	4.67	19	2.69	4.2	3.4	2.6	—	2.45
MnO	11	0.06	8	0.07	10	0.09	17	0.05	0.1	0.2	0.2	0.2	—
MgO	12	2.00	8	2.33	14	2.91	19	1.19	2.9	1.8	1.6	0.1	2.44
CaO	12	2.07	8	1.30	14	1.46	19	2.00	3.5	2.3	1.2	1.6	3.11
Na_2O	12	2.85	8	1.86	14	2.50	19	2.73	3.4	2.6	2.0	2.0	1.30
K_2O	12	3.86	8	3.04	14	3.10	19	3.20	2.0	2.2	1.5	5.6	3.24
P_2O_5	9	0.23	6	0.17	10	0.05	15	0.18	0.1	0.2	0.2	trace	0.17
H_2O	12	1.79	8	1.77	14	2.11	19	0.90	2.2	2.1	1.7	0.6	5.00
BaO	1	0.05	3	0.12	—	—	2	0.11	—	—	—	—	—
C	1	0.31	1	0.07	—	—	—	—	—	—	0.2	—	0.80
CO_2	—	—	—	—	—	—	—	—	1.6	—	0.5	0.4	2.63
S	2	0.05	4	0.24	—	—	2	0.16	—	—	0.1	—	—
SO_3	—	—	—	—	—	—	—	—	—	—	—	—	0.64
		100.44		100.37		100.20		100.22	100.00		100.4	99.8	99.95

1. Graywacke-slate, Tampere schist belt (Table IV, Anal. 1—12).
2. Mica schist, Southern Finland (Table VII, Anal. 47—54).
3. Kinzigites, Southern Finland (Table VII, Anal. 55—68).
4. Leptites, Southern Finland (Table VII, Anal. 69—87).
5. Average graywacke. Pettijohn (1949).
6. Average graywacke. Tyrrell (1933).
7. Average subgraywacke. Pettijohn (1949).
8. Average arkose. Pettijohn (1949).
9. Average shale. Clarke (1924).

The average chemical compositions of the phyllites, mica schists, and kinzigites (Table V) are very similar, suggesting that the same primary material has been metamorphozed in the evolution of the mountain chain,

[1]) The numbers of this column show how many determinations have been available for calculation.

different ptx-conditions producing different grades of metamorphism. Chemical composition of the Svecofennidic micaceous schists varies from that of a shale to that of a sand, but the greatest part of the chemical analyses as well as the average compositions are intermediate between these extreme limits and show conspicuous similarities to the chemical compositions of the graywackes of orogenic belts (cf. Table V), which according to Pettijohn (1943) average two parts shale to one part arkose. The graywacke-slate character of the phyllites in the Tampere area has been recently stressed by Simonen and Kouvo (1951). Parras (1946) has pointed out that the kinzigites of Southwestern Finland must be considered as a mixture of sand and clay. The chemical characteristics of the Svecofennidic phyllites, mica schists, and kinzigites show that the chemical weathering has been incomplete, and therefore these schists usually contain a remarkably high content of feldspar.

The above described correlations show that the graded bedded graywacke-slates of the Tampere area have as counter parts the mica schists and mica gneisses in the highly metamorphic, Svecofennidic rock crust of Southern Finland. The stratigraphic position beneath the basic volcanics, the primary structural and chemical features of the phyllites, mica schists, and kinzigites are similar, suggesting that all these rocks have been deposited under similar conditions in the axial portion of the sediments in the Svecofennidic geosyncline. According to this conclusion, the phyllites, mica schists, and kinzigites seem to represent three different metamorphic zones of the Svecofennidic graywacke succession. The mineralogical, structural, and textural characteristics as well as the mineral facies of the different isometamorphic zones of the Svecofennidic graywacke-slates have been summarized in Table VI.

Table VI. Zones of isometamorphism of the Svecofennidic graywacke-slates.

Zones of metamorphism	Mineralogy		Structure	Texture	Mineral facies
	Main minerals	Porphyroblasts			
phyllites (graywacke-slates)	quartz feldspar biotite and/or chlorite muscovite	no porphyroblasts	graded bedding	Blastoclastic	epidote-amphibolite facies
					amphibolite facies
mica schists	quartz feldspar biotite muscovite	andalusite cordierite	stratified (graded bedding as rarity)	granoblastic or porphyroblastic	
mica gneisses (kinzigites)	quartz feldspar biotite	almandine cordierite sillimanite	banded	porphyroblastic or granoblastic	pyroxene-hornfels facies

The grain size increases in the rock series phyllite→mica schist→kinzigite and this is one of the best field evidences indicating the grade of metamorphism. But the mineral assemblages of the different schist types also show the different conditions of metamorphism. The stable mineral association cordierite—garnet—microcline, observed in the kinzigites of Western-Uusimaa, indicates PT conditions very similar to those in the pyroxene hornfels facies, and these kinzigites occur regionally in close association with pyroxene gneisses in which the assemblage hypersthene-diopside is characteristic (cf. Parras, 1941). The microcline, however, is not always stable together with cordierite and almandine in the Finnish kinzigites. The mineral associations of the wide kinzigite area of Kalanti, for example, correspond according to Hietanen (1943) to those of the amphibolite facies. Among the kinzigites metamorphozed under the conditions of the amphibolite facies have been observed microcline-bearing varieties in which the altered cordierite is probably a relic from a high-temperature subfacies (cf. Hietanen, 1943; Simonen, 1949). Summarizing, we can state that the Finnish kinzigites have been metamorphozed under temperature conditions ranging from those of the pyroxene hornfels facies to those of the amphibolite facies.

The Svecofennidic mica schists are classical representatives of the amphibolite facies described for the first time by Eskola (1914 and 1915) in the Orijärvi region. Cordierite and andalusite are the most common porphyroblastic aluminous silicate minerals, almandine occurring in the iron-rich varieties. Sillimanite occurs together with andalusite only sporadically.

The phyllites in the Tampere area with excellent primary structures and textures represent the lowest grade metamorphism in the Svecofennidic rock crust. The mineral association biotite—muscovite—plagioclase is the most common one and indicates temperature conditions similar to those of the amphibolite facies. Some chlorite-bearing varieties, lacking the biotite, have, however, not reached the PT-conditions of the amphibolite facies. As a result of contact metamorphism at the margins of intrusive bodies, varved sediments have been recrystallized, being now mica schists containing pseudomorphs after porphyroblasts of aluminous silicate minerals. The normal phyllites with the same chemical bulk composition do not contain aluminous silicate minerals typical of the amphibolite facies, and therefore may be considered as the products of low-temperature metamorphism.

The different mineral assemblages of the metamorphic zones have originated at different temperatures prevailing during metamorphism. According to the mineral facies classification (Eskola, 1939), the progressive increase of temperature took place in the isochemical rock series phyllite→mica schist→kinzigite. This increase is, however, very slight and the greatest

part of the Svecofennidic sediments have been metamorphozed under the conditions of the amphibolite facies.

The main structural features of the Svecofennidic rock crust support the idea that the different metamorphic varieties of the graywacke-slates form strata many kilometres thick, underlying the basic volcanics. The phyllites as well as mica schists always occur just beneath the volcanics, representing, therefore, the upper part of the thick graywacke succession. It is a striking feature on the new geological map of Southwestern Finland (cf. Map II) that the micaceous schists of low and intermediate grade of metamorphism occur regularly in closest connection to the basic volcanics. Outwards from the volcanic rock areas the phyllites and mica schists pass gradually into highly metamorphic mica gneisses. These geological evidences suggest that in the graywacke- slate succession of the Svecofennides a zone of a lower grade metamorphism overlies one of higher grade and, therefore, the metamorphic zones have in some degree also a stratigraphic importance, as is the case in many other geological formations (reference must be made especially to the classical upward succession of gneiss, schist, and phyllite of the Central European area). In many cases, however, the zone of high grade metamorphism cuts across the beds, metamorphosing also the upper part of the graywacke slates into highly metamorphic mica gneisses. The mica schists of many schist areas of Southern Finland usually are in the same stratigraphic position as the phyllites in the best-preserved Svecofennidic schist area of Tampere.

The relationship between stratigraphic position and grade of metamorphism seems to suggest that the increase of the grade of metamorphism is partly due to the depth, but depth alone is not the main factor of metamorphism. The field evidence from other formations shows that the grade of metamorphism does not always increase with depth and on the other hand the lowest portions of many thick geosynclinal deposits are non-metamorphic. Many studies on the evolution of the Svecofennidic rock crust in Southwestern Finland (cf. Wegmann and Kranck, 1931; Simonen, 1948b; Edelman, 1949) show that the deformation and metamorphism of the supracrustal strata has taken place in close connection with the mountain folding and with the intrusions of the synkinematic intrusive rocks. The temperature conditions favourable for the regional metamorphism of the supracrustal rocks have been caused by the synkinematic intrusions in the root zone of the mountain chain, and the lowest portion of these rocks were in a position deep enough to be changed into coarse-grained gneisses by high-grade metamorphism.

According to the ideas of Read (1948), the transfer of material has taken place in metamorphism of all grades and »the regionally metamorphosed rocks most likely result from the passage of waves or fronts of metasomatizing solutions out from the central granitization core about which arise the zones

of metamorphism». This interpretation requires that the migmatite front is not independent either in place or time of the metamorphic stratigraphy. The chemical data on the rock series phyllite→mica schist→mica gneiss in the Svecofennidic rock crust do not, however, support the idea of gradual change in the chemical bulk composition with the increase of grade of metamorphism, and mention must be made that there is a distinct break in the chemical composition of mica gneisses and of migmatite granites. Furthermore, the field evidence in the different parts of the Svecofennidic rock crust shows that granitization occurred later than the metamorphism. Therefore, the migmatite front seems to be independent in time from the main phase of metamorphism.

The description of the Svecofennidic sediments has lead us to the depth of the earth where many important rock-making processes have taken place. In the scope of the present study, dealing with stratigraphy and sedimentation of the ancient supracrustal rocks, it is not possible to discuss the problems of plutonic rocks in more detail. Therefore, the author hopes to be able in the near future to contribute also to the knowledge of the plutonism in the Svecofennides.

QUARTZ-FELDSPAR ROCKS—LEPTITES

Quartz-feldspar rocks or leptites occur richly in Southern Finland, especially in the Kemiö—Lohja zone, and their petrographic characteristics are very similar to those of the quartz-feldspar rocks in the Tampere schist area. This marked similarity has been already pointed out by Eskola (1932, p. 38) who writes: »Much of the fine-grained Bothnian quartz-feldspar rocks could well be called leptites, and certainly would be called so, if they occurred in the leptite regions».

In earlier investigations the leptites of Southern Finland have been interpreted mainly as acid lavas and pyroclastics, but a purely sedimentary sandstone character of some few leptites has been pointed out also. Through the new geological mapping in Southern Finland it has been shown, however, that the relative abundance of sedimentary leptites is greater than was supposed earlier. The leptites occur usually in close association with micaceous sediments and the greatest part of the leptites contains minute amounts of aluminous silicate minerals (almandine, cordierite, or sillimanite), indicating the Al_2O_3-excess typical for metamorphozed weathering sediments with a minute portion of argillaceous material. The distinct evidences of volcanic origin of leptites are rare.

The origin of the leptites in the Kemiö—Lohja zone has been discussed recently in the papers of Tuominen and Mikkola (1950) and Eskola (1950). Tuominen and Mikkola suggest the sedimentary origin of the leptites be-

cause these rocks are characterized by an excess of alumina and are often clearly layered and »the amount of acid volcanics, probably existing among the leptites of the region, must be relatively small». Eskola (1950) admits that the occurrence of sedimentogenous leptites is much more common than he had supposed in 1914, but at the same time he points out evidences for the volcanic origin of some leptites in the Orijärvi area.

The data recently presented from the Kemiö—Lohja zone make it evident that there the origin of the leptites is very similar to that of the quartz-feldspar rocks in the Tampere area among which sandstones are predominant, but also some beds of pyroclastics and acid lavas occur. The new unpublished studies in the Tammela—Kalvola area also indicate that there the sedimentogenous quartz-feldspar rocks are more abundant than quartz-feldspar rocks of volcanic origin. The greatest part of the leptites in the Tammela—Kalvola area (Map II) are shown on the geological map between basic volcanics and mica schists, having, therefore, similar stratigraphic position as the quartz-feldspar rocks in the Tampere area. The leptites in the Orijärvi area also underlie the basic volcanics.

The variations in the grade of metamorphism of the quartz-feldspar schists are not so distinct as those observed in the Svecofennidic, micaceous rocks. The lack of aluminous silicate minerals in the quartz-feldspar rocks of the Tampere schist area indicates probably a metamorphism of a lower grade than that of the leptites in Kemiö—Lohja zone. Occasionally leptites pass gradually into the coarse-grained leptite gneisses whose original structures were entirely destroyed by metamorphic recrystallization.

The chemical analyses of the leptites (Table VII, Anal. 69—87) vary within wide limits, but usually they show similarities to those of the arkosic sandstones. The average chemical composition of the leptites (Table V) is similar to that of many arkosic sandstones. The (al + fm)—(c + alk) diagram of the Svecofennidic supracrustal rocks (Fig. 15) shows that the greatest part of the leptites deviate from the »magmatic field» and occupy a field corresponding to siliceous members of the Svecofennidic sediments. The chemical composition of many leptites is very similar to that of the sandstone portions of the graywacke-slates and many transitional types from pure arenaceous into argillaceous members occur. Most of the leptites must be considered as impure arkoses mixed with argillaceous material and, therefore, the sedimentary leptites are products of incomplete sorting and weathering. Some leptites show chemical as well as textural characteristics (blastoporphyritic texture) of acid rhyolitic lavas, but soda and potash extreme types, common in the leptite region of Central Sweden, do not occur in Southern Finland (cf. Fig. 16).

Table VII. Chemical analyses of supra-

A. Mica schists

	47	48	49	50	51	52	53	54
SiO_2	57.95	61.37	61.94	69.10	72.64	72.99	75.88	76.86
TiO_2	0.75	0.68	1.31	0.50	0.34	0.47	0.29	0.16
Al_2O_3	20.11	13.50	15.63	14.50	11.57	10.32	10.78	11.12
Fe_2O_3	0.53	4.72	3.29	1.04	0.85	0.73	0.52	0.69
FeO	7.38	7.14	5.99	3.71	5.36	7.03	4.07	1.40
MnO	0.07	0.09	0.10	0.06	0.09	0.06	0.04	0.02
MgO	5.36	3.16	2.75	1.35	1.97	1.99	1.66	0.42
CaO	0.81	0.91	1.16	1.54	1.99	2.15	1.63	0.24
Na_2O	1.78	1.43	1.58	3.66	1.47	0.57	1.74	2.68
K_2O	2.72	3.45	3.59	3.73	2.18	2.02	1.64	4.96
P_2O_5	0.35	0.19	0.10	—	0.18	—	0.12	0.08
H_2O+	1.99	2.71	2.46	1.02	1.36	1.09	1.39	1.02
H_2O-	0.06	0.29	0.21	0.10	0.05	0.32	0.04	0.05
BaO	0.21	—	—	—	0.05	—	—	0.10
C	—	—	—	—	—	0.07	—	—
S	0.44	—	—	—	0.21	—	0.07	0.23
	100.48	99.64	100.11	100.31	100.31	99.81	99.87	100.13
si	188	228	238	313	365	370	433	516
al	38.4	29.6	35.5	38.7	34.3	30.9	36.2	44.0
fm	47.6	53.4	45.0	26.9	40.9	48.0	38.2	15.6
c	2.8	3.6	4.8	7.5	10.7	11.7	10.0	1.7
alk	11.2	13.4	14.7	26.9	14.1	9.4	15.6	38.7
k	0.50	0.61	0.60	0.40	0.49	0.70	0.38	0.55
mg	0.55	0.33	0.35	0.34	0.36	0.31	0.37	0.27

C. Lep-

	69	70	71	72	73	74	75	76
SiO_2	68.11	67.69	69.52	68.72	69.42	71.14	70.69	71.11
TiO_2	0.47	0.51	0.64	0.38	0.90	0.58	0.56	0.40
Al_2O_3	14.40	12.49	13.58	15.48	14.21	13.82	14.26	11.95
Fe_2O_3	1.03	1.36	0.51	0.06	0.34	1.57	0.97	1.04
FeO	2.67	7.31	3.75	1.98	3.44	3.05	4.68	2.95
MnO	0.08	0.02	0.19	—	0.07	—	0.03	0.12
MgO	1.22	2.06	1.22	1.25	1.91	1.39	2.69	1.61
CaO	4.83	1.56	4.53	3.18	2.95	2.58	1.41	3.97
Na_2O	2.61	1.59	3.55	3.68	2.94	3.51	1.23	2.37
K_2O	3.09	3.00	1.47	3.98	2.24	2.36	2.36	2.85
P_2O_5	0.12	0.26	0.20	—	0.06	—	0.14	0.19
H_2O+	0.57	1.68	} 0.71	} 0.84	1.04	} 0.66	0.87	0.20
H_2O-	0.17	0.13			0.00		0.06	0.10
CO_2	—	—	—	—	0.45	—	—	0.89
BaO	0.12	—	—	—	—	—	—	—
S	0.08	—	—	—	—	—	—	—
	99.57	99.66	99.87	99.55	99.97	100.66	99.95	99.75
si	295	298	305	308	317	329	332	336
al	36.8	32.4	35.1	41.0	38.3	37.7	39.5	33.3
fm	21.3	45.0	24.2	16.0	27.7	26.8	40.8	27.2
c	22.4	7.4	21.4	15.5	14.5	12.8	7.1	20.1
alk	19.5	15.2	19.3	27.5	19.6	22.7	12.7	19.5
k	0.44	0.55	0.21	0.42	0.33	0.31	0.56	0.44
mg	0.37	0.30	0.33	0.56	0.47	0.36	0.46	0.42

crustal rocks in Southern Finland.

B. Kinzigites

	55	56	57	58	59	60	61	62	63	64	65	66	67	68
SiO_2	51.88	56.08	61.98	62.13	61.34	61.76	64.33	64.46	68.79	68.41	69.00	69.67	70.90	72.46
TiO_2	0.95	0.89	0.96	0.58	0.59	0.84	0.95	0.54	0.33	0.54	0.63	0.06	0.28	0.35
Al_2O_3	18.28	19.23	15.87	16.49	17.18	16.91	17.12	17.52	13.28	15.70	13.42	13.30	14.19	13.11
Fe_2O_3	2.32	3.12	1.09	2.68	2.00	2.00	0.84	3.33	5.99	0.52	1.48	1.86	1.20	4.55
FeO	8.06	6.38	6.64	7.20	5.40	4.42	6.08	1.40	1.65	5.83	4.09	4.30	2.45	1.54
MnO	0.19	0.07	0.23	0.07	0.09	0.01	0.07	—	—	0.04	0.08	—	0.01	—
MgO	5.56	3.81	6.29	2.90	2.66	2.74	2.73	1.74	1.73	3.09	2.32	2.40	1.40	1.41
CaO	4.04	0.64	1.51	1.28	1.62	1.40	1.74	1.86	1.56	0.50	1.64	0.23	0.96	1.48
Na_2O	1.23	2.17	1.60	1.89	2.93	3.56	2.89	2.08	4.24	1.30	2.95	1.41	3.25	3.54
K_2O	3.29	2.95	1.86	3.20	2.77	3.63	2.36	5.86	2.08	3.38	2.09	5.05	3.62	1.28
P_2O_5	0.04	0.01	0.11	0.00		0.04	0.24	—	—	0.04	0.01	—	0.00	—
H_2O+	3.14	3.32	1.92	1.48	2.63	1.84	0.89	1.12	0.16	0.77	1.72	1.71	1.25	0.39
H_2O-	1.46	1.40	0.28	0.52	0.77	0.84	0.12			0.12	1.00		0.67	
	100.44	100.07	100.34	100.42	99.98	99.99	100.36	99.91	99.81	100.24	100.43	99.99	100.18	100.11
si	149	190	209	226	230	232	247	264	293	296	314	328	356	360
al	31	38.5	31.5	35.4	38	37.5	38.6	42.5	33.5	40.0	36.0	36.9	42	37.0
fm	48	45.6	53.8	45.4	38	35.1	37.7	26.0	36.0	42.9	36.8	40.3	25	34.0
c	12	2.3	5.5	5.0	7	5.7	7.1	8.0	7.0	2.3	8.0	1.2	5	8.0
alk	9	13.6	9.2	14.2	17	21.7	16.5	23.5	23.5	14.7	19.2	21.6	28	21.0
k	0.64	0.47	0.43	0.53	0.38	0.40	0.35	0.65	0.25	0.63	0.32	0.70	0.42	0.19
mg	0.49	0.42	0.59	0.35	0.39	0.44	0.41	0.41	0.30	0.46	0.43	0.42	0.41	0.31

tites

77	78	79	80	81	82	83	84	85	86	87	
71.00	74.50	75.06	75.44	75.28	75.18	74.98	77.33	76.86	78.02	78.40	SiO_2
0.61	0.27	0.56	0.27	0.12	0.15	0.24	0.06	0.16	0.11	0.17	TiO_2
12.45	12.11	11.28	11.98	13.19	12.92	12.38	12.83	11.22	12.22	12.13	Al_2O_3
0.83	0.59	0.48	0.49	0.26	0.16	0.48	0.46	0.69	0.61	0.66	Fe_2O_3
4.10	2.81	3.32	2.05	1.30	2.02	2.23	0.45	1.40	0.86	0.76	FeO
0.05	0.05	0.06	0.01	0.04	0.03	0.04	0.05	0.02	0.01	0.03	MnO
1.68	1.35	1.45	1.30	0.08	0.59	1.35	0.64	0.42		0.43	MgO
2.26	0.76	2.48	2.70	1.23	0.57	0.33	1.43	0.24	0.41	0.64	CaO
3.38	2.55	2.71	1.28	4.32	2.53	1.89	3.01	2.68	4.28	1.68	Na_2O
1.34	3.39	1.75	3.50	3.70	5.34	4.52	3.30	4.96	3.16	4.52	K_2O
0.43	0.05	0.28	0.11	0.06	0.08	0.48	0.11	0.08	—	—	P_2O_5
1.90	0.95	0.69	0.86	0.39	0.49	0.92	0.48	1.02	0.35	0.61	H_2O+
0.06	0.38	0.14	0.09	0.08	0.11	0.13	0.08	0.05	0.13	0.13	H_2O-
—	—	—	—	—	—	—	—	—	—	—	CO_2
—	—	—	—	—	—	—	—	0.10	—	—	BaO
—	—	—	—	—	—	—	—	0.23	—	—	S
100.09	99.76	100.26	100.08	100.05	100.17	99.97	100.23	100.13	100.16	100.16	
345	389	407	433	440	444	451	486	513	519	548	si
35.7	37.5	36.1	40.5	45.5	45	43.8	47	44.1	48.0	50.0	al
32.3	25.5	29.1	23.1	8.4	16	25.7	10	15.5	8.0	13.0	fm
11.8	13	14.4	16.6	7.7	4	2.1	9	1.9	3.0	5.0	c
20.2	24	20.4	19.9	38.4	35	28.4	34	38.4	41.0	32.0	alk
0.21	0.47	0.30	0.64	0.36	0.58	0.61	0.42	0.55	0.33	0.64	k
0.38	0.41	0.40	0.48	0.08	0.32	0.47	0.55	0.27	—	0.36	mg

A. Mica schists.

47. Dark layer of mica schist. Haapaniemi. Kisko. Tuominen and Mikkola (1950, p. 77).
48. Cordierite-andalusite mica schist. SW of the town Hämeenlinna. Simonen (1948, p. 22).
49. Cordierite-bearing mica schist. N of the town Hämeenlinna. Simonen (1948, p. 22).
50. Biotite gneiss. Männäinen. Kalanti. Hietanen (1943, p. 16).
51. Dark layer of mica schist. Kisko. Lokka (1950, p. 22—23).
52. Phyllite. Hyyppiämäki. Kisko. Eskola (1914, p. 150).
53. Light layer of mica schist. Kisko. Lokka (1950, p. 20—21).
54. Light layer of mica schist. Haapaniemi. Kisko. Tuominen and Mikkola (1950, p. 77).

B. Kinzigites.

55. Garnet kinzigite. Vellua. Kalanti. Hietanen (1943, p. 16).
56. Cordierite-sillimanite kinzigite. Hietanen (1943, p. 16).
57. Cordierite gneiss. Vellua. Kalanti. Hietanen (1943, p. 16).
58. Cordierite-garnet kinzigite. Kullanperä. Lappi. Hietanen (1943, p. 16).
59. Cordierite kinzigite. Kuuantaka. Kalanti. Hietanen (1943, p. 16).
60. Garnet-cordierite kinzigite. Häähäjärvi. Kalanti. Hietanen (1943, p. 16).
61. Kinzigite. Haarjärvi. Sammatti. Parras (1941, p. 502).
62. Kinzigite gneiss. Parsby. Parainen. Metzger (1945, p. 23).
63. Kinzigite gneiss. Limberg. Parainen. Metzger (1945, p. 23).
64. Kinzigite. Huhti. Nummi. Lokka (1950, p. 18—19).
65. Cordierite-garnet kinzigite. Pehto. Kalanti. Hietanen (1943, p. 16).
66. Cordierite gneiss. Attu. Parainen. Pehrman (1931, p. 24).
67. Plagioclase-cordierite gneiss. Vellua. Kalanti. Hietanen (1943, p. 16).
68. Kinzigite gneiss. Limberg. Parainen. Metzger (1945, p. 23).

C. Leptites.

69. Leptite, blastoporphyritic. Skogböle. Tenala. Eskola (1914, p. 137).
70. Leptite. Stusnäs. Dragsfjärd. Lokka (1950, p. 22—23).
71. Leptite, even-grained. Vetjo. Kisko. Eskola (1914, p. 141).
72. Leptite. Samfällighet. Parainen. Metzger (1945, p. 36).
73. Leptite gneiss. Niksor. Finby. Pehrman (1952, p. 21).
74. Plagioclase-biotite gneiss. Attu. Parainen. Pehrman (1931, p. 19).
75. Leptite. Iilijärvi. Kisko. Lokka (1950, p. 22—23).
76. Plagioclase gneiss, diopside-bearing. Hermala. Lohja. Lokka (1950, p. 20—21).
77. Leptite, N of Hämeenlinna. Simonen (1948, p. 22).
78. Leptite, blastoporphyritic. Lapinkylä. Kisko. Eskola (1914, p. 132).
79. Leptitic schist. Enklinge. Kumlinge. Åland. Sederholm (1934).
80. Leptite. Kulla. Dragsfjärd. Lokka (1950, p. 22—23).
81. Leptite gneiss. Lammala. Westanfjärd. Lokka (1934, p. 22—23).
82. Leptite gneiss. Ollinsaari. Lohja. Lokka (1934, p. 18—19).
83. Cordierite leptite. Paavola. Lohja. Parras (1941, p. 502).
84. Leptite. Kuovila. Pohja. Lokka (1950, p. 20—21).
85. Leptite. potash-rich. Iilijärvi. Kisko. Lokka (1950, p. 22—23).
86. Leptite, even-grained. Liipola. Kisko. Eskola (1914, p. 145).
87. Leptite, even-grained. Aijala. Kisko. Eskola (1914, p. 143).

OTHER SEDIMENTARY ROCKS

The widely distributed, predominantly argillaceous or arenaceous sediments in Southern Finland are sometimes associated with conglomerates, true quartzites, limestones, and calcareous schists whose areal distribution is, however, very small.

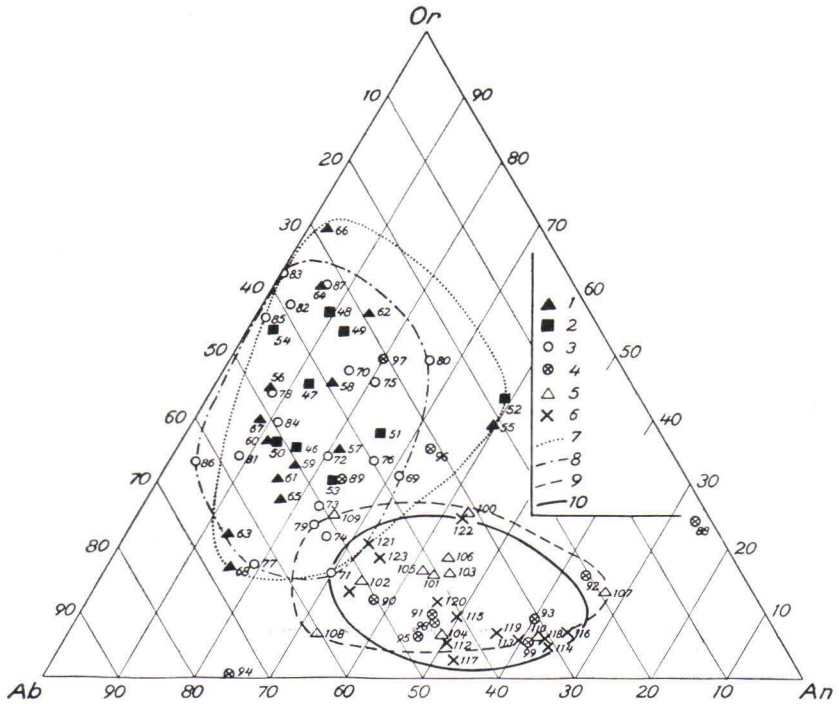


Fig. 16. Normative [Or] : [Ab] : [An] diagram of the supracrustal rocks in Southern Finland. 1, mica schists; 2, kinzigites; 3, leptites; 4, calcareous schists; 5, tuffites; 6, blastoporphyritic volcanics; 7, field of mica schists and kinzigites; 8, field of leptites; 9, field of tuffites; 10, field of blastoporphyritic volcanics. Numbers refer to Tables VII and VIII.

Conglomerates occur as thin beds and they do not correspond to great unconformities, but only local intraformational interludes of sedimentation. Volcanic conglomerates and agglomerates are widely distributed especially in the porphyrite area of Tammela—Kalvola and they are lithologically quite similar to many occurrences in the Tampere schist area.

True quartzites form only some very few occurrences in Southern Finland and they are entirely lacking in the Tampere schist area. The Svecofennidic quartzites are usually highly recrystallized glassy types, but sometimes relicts of blastoclastic texture and primary banding can be observed.

The rare occurrence of the quartzites in the Svecofennidic rock crust has given rise to many theoretical discussions because it was supposed that since argillaceous types show such a wide distribution, pure quartzites should also have been deposited on a large scale. According to Backlund (1937), the quartzites disappeared as a result of regional granitization, but this interpretation was criticized by Finnish geologists (Eskola and Nieminen, 1938; Hietanen, 1938) because evidently quartzites are generally very resistant to granitization, remaining well-preserved. Eskola (1938) concluded that »quartzites, if they ever existed, have not been obliterated by granitization» and he suggested the removal by deep erosion would have been the main factor for their disappearance, although he admits at the same time that »there is no direct evidence of such an event registered in the rocks».

The observations on the conditions of the Svecofennidic sedimentation presented in this paper indicate that chemical weathering has not been complete, also that transportation and deposition have been so rapid that the separation of argillaceous from arenaceous material has not taken place completely. Therefore, the suitable stable conditions for deposition of true quartzites have not been reached during the Svecofennidic geosynclinal sedimentation. The rarity of true quartzites in the geosynclinal association has been stressed especially by Pettijohn (1943) who points out that »true quartzites, with their cross-bedding and ripple marking, devoid of an argillaceous matrix, with an introduced mineral cement, belong to a different sedimentary facies from the graywackes». In the light of these conclusions it is easy to understand the rarity of pure quartzites in the Svecofennidic geosynclinal strata exposed on the present surface. The widely distributed Svecofennidic sediments are mixtures of clay and sand in different proportions, and the extreme end members, i.e. pure shales and true quartzites, are rare. Similar ideas on the rarity of the quartzites in Southwestern Finland have been pointed out by Eskola (1927) when he writes: »Die Sache muss wohl so verstanden werden, dass im Grundgebirge die Sandderivate meistens nicht als reine Quartzite, sondern als quarzreiche Glimmerschiefer, Gneise und Leptite vorhanden sind». Parras (1946) also has emphasized the impure character of the Svecofennidic kinzigites in which the separation of the hydrolysatic and residual sediments has been incomplete.

Pure limestones form many small occurrences in the southern coastal area of Southwestern Finland, but they are almost lacking in the wide area situated approximately north of the line Turku—Hyvinkää (see Fig. 1). The Tampere schist belt is also devoid of limestones. The Svecofennidic limestones are usually calcitic, dolomitic varieties being subordinate. Concerning the petrographic and mineralogical details of the limestones the

author refers to the memoir »Suomen kalkkikivi — Limestones in Finland» written by Eskola, Hackman, Laitakari and Wilkman (1919).

The calcareous schists — diopside amphibolites and diopside gneisses — occur mainly in the same southern coastal area as the limestones. These stratified rocks have been originally marls in which the detrital material has been deposited simultaneously with calcium carbonate. In the present metamorphic condition some varieties resemble mineralogically and chemically the metamorphic basic volcanics, but usually their high content of CaO appears mineralogically in the form of diopside, scapolite, or calcite. The chemical analyses of the Svecofennidic calcareous sediments are presented in Table VIII (Anal. 88—99). In the (al + fm) — (c + alk) diagram of the Svecofennidic supracrustal rocks (Fig. 15) the field of calcareous sediments differs distinctly from the other supracrustal rocks.

The appearance of limestones and calcareous sediments in the lithologic association of the Svecofennides in the southern coastal area presupposes conditions of sedimentation in some degree different to those prevailing in the main part of the Svecofennidic rock crust, including the Tampere schist belt. This interesting problem will be discussed in the chapter »Summary and concluding remarks».

VOLCANICS

The metamorphic basic volcanics are widely distributed in some parts of the Svecofennidic rock crust. Uralite and plagioclase porphyrites with basaltic bulk composition (Table VIII) are the most common types of the blastoporphyritic volcanics. The uralite porphyrites have been primarily augite porphyrites and their chemical composition is normal basaltic, showing similarities to that of plateau basalts. The chemical composition of the Svecofennidic lavas containing plagioclase phenocrysts ranges from normal basaltic to andesitic. The acid blastoporphyritic varieties are subordinate and their chemical characteristics are poorly known. The blastoporphyritic leptites from the Orijärvi area (Table VII, Anal. 69 and 78) represent, according to Eskola (1914), the rhyolitic Svecofennidic lavas. The basic tuffites of Southern Finland are amphibolitic and their chemical composition (Table VIII) is similar to that of basaltic lavas.

According to Barth (1936), the equation $ab' + 2\ di' + 2.3\ hy' = 123$ gives the position of the boundary surface which separates basaltic liquids precipitating pyroxene from those lavas that precipitate plagioclase. If the left side is greater than 123 the basalt lies in the pyroxene field, but if the sum is smaller than 123, then the basalt lies in the feldspar field. The calculations made by the present author show that the highly meta-

Table VIII. Chemical analyses of supra-

A. Calcareous schists

	88	89	90	91	92	93	94	95	96	97	98	99
SiO_2	23.78	37.46	48.40	49.30	49.61	48.02	51.37	50.51	55.28	57.44	60.24	60.92
TiO_2	1.12	0.86	0.63	0.75	0.56	0.85	1.35	1.85	1.11	0.35	0.98	0.90
Al_2O_3	6.59	7.23	14.02	13.27	15.21	22.11	7.97	17.53	15.77	15.04	13.04	14.50
Fe_2O_3 ...	1.26	0.92	2.04	—	0.89	0.20	6.26	1.36	0.40	0.07	1.30	0.72
FeO	6.36	6.62	9.93	9.72	8.77	8.28	11.50	9.22	7.56	4.32	5.88	5.40
MnO	0.19	0.09	—	0.11	0.05	0.07	—	0.13	0.02	—	0.10	0.11
MgO	7.79	4.42	7.62	8.94	5.02	4.14	5.82	3.02	2.98	2.88	2.95	1.79
CaO	30.90	27.93	12.75	13.03	16.32	11.76	12.03	11.18	10.16	11.36	11.01	12.65
Na_2O	0.83	1.70	3.21	2.51	1.20	2.70	2.98	3.61	2.34	2.44	2.48	1.90
K_2O	0.69	1.60	1.12	0.77	1.36	1.15	0.02	0.69	3.85	5.61	0.71	0.47
P_2O_5	0.12	0.22	—	0.01	0.19	0.47	—	0.69	0.17	—	0.13	0.36
H_2O+ ..	0.99	1.23	0.40	0.67	0.55	0.35	0.24	0.42	0.51	0.36	0.51	0.23
H_2O- ...	0.01	0.18		0.02		0.06		0.09	0.13		0.12	0.20
CO_2	19.20	9.23	—	1.30	0.86	—	—	—	—	0.67	0.90	—
	99.83	99.69	100.12	100.40	100.59	100.16	99.54	100.30	100.28	100.54	100.35	100.15

si	42	75.6	103	106	113	114	119	128	154	164	184	190
al	6.9	8.6	17.5	16.9	20.4	30.8	11.0	26.1	25.8	25	23.5	26.6
fm	32.1	25.8	45.5	46.6	35.3	31.5	53.0	33.7	30.8	23	31.7	24.4
c	58.8	60.2	29.0	30.2	39.7	29.8	29.5	30.3	30.3	35	36.1	42.3
alk	2.2	5.4	8.0	6.3	4.6	7.9	6.5	9.9	13.1	17	8.7	6.7
k	0.35	0.38	0.19	0.17	0.43	0.22	—	0.11	0.52	0.60	0.16	0.14
mg	0.64	0.51	0.54	0.62	0.48	0.46	0.38	0.33	0.40	0.54	0.42	0.34

C. Blastoporphyritic volcanics

	111	112	113	114	115	116	117	118	119	120	121	122	123
SiO_2	48.64	49.73	50.18	48.99	50.78	50.26	52.98	52.39	56.06	52.28	54.13	55.37	63.68
TiO_2	—	0.56	0.70	1.47	0.75	0.79	0.78	0.72	0.92	0.87	1.41	1.30	0.92
Al_2O_3	11.68	16.05	14.58	14.26	18.08	19.49	17.49	17.56	13.97	20.75	16.57	14.76	15.84
Fe_2O_3	10.57	2.44	1.27	1.56	2.80	2.30	0.54	1.33	1.41	2.35	2.25	1.86	1.80
FeO	6.31	7.96	9.14	10.48	5.33	8.57	6.39	11.27	7.59	5.20	7.06	9.55	4.55
MnO	0.39	0.20	0.12	0.31	0.11	0.15	0.13	—	0.09	0.10	0.09	0.14	0.08
MgO	6.78	7.84	9.90	5.77	5.72	4.12	6.00	4.87	6.95	2.70	4.94	3.81	1.99
CaO	10.88	10.22	9.60	12.64	10.80	9.74	11.33	8.84	9.48	8.18	6.38	6.13	5.93
Na_2O	2.90	2.99	1.98	1.69	3.12	2.06	3.16	2.18	2.06	3.82	3.64	2.07	3.42
K_2O	1.01	0.61	0.49	0.41	1.00	0.74	0.31	0.60	0.63	1.55	2.34	2.36	2.02
P_2O_5	—	0.12	—	0.66	—	0.15	—	—	—	—	0.15	0.73	—
H_2O+	1.02	0.87	1.70	1.52	1.06	1.38	0.42	0.65	0.56	1.66	1.41	1.73	0.50
H_2O-		0.16		0.14		0.04	0.15	0.22			0.06	0.10	
	100.18	99.75	99.66	99.90	99.55	99.79	99.68	100.63	99.72	99.46	100.43	99.91	100.73

si	107	112	113	115	123	127	131	132	145	146	147	163	226
al	15.1	21.5	19.5	19.7	25.5	29.0	25.5	25.9	21.3	34.0	26.6	25.6	33.0
fm	51.9	46.0	52.6	44.1	37.5	38.3	36.5	44.2	46.2	28.5	41.1	44.7	28.5
c	25.4	25.0	23.0	31.8	28	26.4	30.0	23.7	26.3	24.4	18.7	19.4	22.5
alk	7.6	7.5	5.0	4.4	9	6.3	8.0	6.2	6.2	13.1	13.7	10.3	16.0
k	0.19	0.11	0.14	0.14	0.18	0.19	0.05	0.15	0.17	0.21	0.30	0.43	0.28
mg	0.43	0.58	0.63	0.46	0.57	0.40	0.61	0.41	0.58	0.39	0.49	0.37	0.45

crustal rocks in Southern Finland.

B. Tuffites

	100	101	102	103	104	105	106	107	108	109	110
SiO_2	45.98	52.69	53.75	52.35	54.17	54.67	55.52	56.44	60.07	61.70	65.96
TiO_2	0.57	1.00	—	1.32	—	1.12	1.16	—	0.84	0.72	0.28
Al_2O_3	16.35	17.02	16.10	15.82	16.15	16.69	15.53	16.17	16.72	13.83	11.13
Fe_2O_3 ...	1.78	2.01	6.36	0.48	2.70	1.41	0.27	7.72	1.26	1.26	0.80
FeO	6.93	7.93	6.38	10.44	8.83	7.57	7.56	3.00	4.57	5.59	5.55
MnO	0.14	0.20	0.27	0.16	0.22	0.17	0.07	0.30	0.28	0.15	0.14
MgO	7.61	4.27	4.53	4.42	4.81	4.41	5.93	2.02	1.75	2.18	5.25
CaO	11.07	9.85	6.53	7.58	7.91	8.23	8.21	10.13	6.71	7.36	8.33
Na_2O	2.81	3.11	3.81	2.64	3.02	3.08	2.56	1.17	4.75	3.37	1.41
K_2O	2.46	1.68	1.62	1.57	0.65	1.78	1.77	1.18	0.77	2.42	0.35
P_2O_5	0.19	0.18	—	0.68	—	0.29	0.14	—	0.29	trace	0.18
H_2O+ ..	1.07	0.61	1.18	2.26	1.04	0.95	1.38	2.37	1.42	0.52	0.92
H_2O- ...				0.10			0.11		0.41	0.16	0.12
CO_2	2.60	—	—	—	—	—	—	—	—	0.23	—
BaO	—	—	—	—	—	0.10	—	—	—	0.04	—
SO_3.....	—	—	0.09	—	0.61	0.07	—	—	—	—	—
	99.56	100.55	100.62	99.82	100.11	100.54	100.21	100.50	99.84	99.53	100.42

si	103	134	139	142	142	148	150	166	202	207	218
al	21.7	25.4	24.6	25.3	24.9	26.6	24.7	28.1	33.1	27.3	21.6
fm	41.9	37.4	44.9	42.9	44.0	38.3	41.7	34.2	25.6	30.2	43.5
c	26.7	26.8	18.2	22.1	22.3	23.9	23.8	52.1	24.2	26.4	29.6
alk	9.7	10.4	12.3	9.7	8.8	11.2	9.8	5.6	17.1	16.1	5.4
k	0.37	0.26	0.22	0.28	0.12	0.28	0.31	0.40	0.10	0.32	0.15
mg	0.61	0.43	0.39	0.42	0.43	0.47	0.57	0.26	0.34	0.36	0.60

A. Calcareous schists.

88. Calcite-hornblende rock. Niksor. Finby. Pehrman (1952, p. 21).
89. Diopside amphibolite. Näkkilä. Nummi. Lokka (1950, p. 18—19).
90. Diopside amphibolite. Storgård. Parainen. Metzger (1945, p. 41).
91. Amphibolite (sedimentogenous). Niksor. Finby. Pehrman (1952, p. 21).
92. Diopside amphibolite. Vetjo. Kisko. Eskola (1915, p. 49).
93. Pyroxene amphibolite. Leikkilä. Sammatti. Lokka (1950, p. 20—21).
94. Diopside amphibolite. Parainen. Metzger (1945, p. 41).
95. Pyroxene amphibolite. Sitarla. Nummi. Lokka (1950, p. 18—19).
96. Diopside-microcline-plagioclase gneiss. Vihti. Lokka (1950, p. 18—19).
97. Lime-rich gneiss. Ersby. Parainen. Laitakari (1921, p. 26).
98. Augite-plagioclase-gneiss. Oinola. Nummi. Lokka (1950, p. 18—19).
99. Diopside-plagioclase gneiss. Kettula. Suomusjärvi. Lokka (1950, p. 20—21).

B. Tuffites.

100. Amydaloidal amphibolite. Valvinokka. Kisko. Eskola (1915, p. 73).
101. Agglomerate, matrix. Kuovila. Pohja. Lokka (1950, p. 70—71).
102. Amphibolite. Lammala. Westanfjärd. Lokka. (1934).
103. Amphibolite. Kulla. Dragsfjärd. Lokka (1950, p. 22—23).
104. Amphibolite. Tytyri. Lohja. Lokka (1934).
105. Amphibolite. Spikarna E of Hangö. Eskola (1914, p. 123).
106. Metabasalt. Kumlinge. Åland. Lokka (1934, p. 27—28).
107. Basic tuffite. Koijärvi. Urjala. Sederholm (1891, p. 119).
108. Intermediate tuffite. Aulanko. Simonen (1948, p. 22).
109. Agglomerate. Skogböle. Tenala. Eskola (1914, p. 153).
110. Hornblende schist. Kuovila. Pohja. Lokka (1950, p. 21).

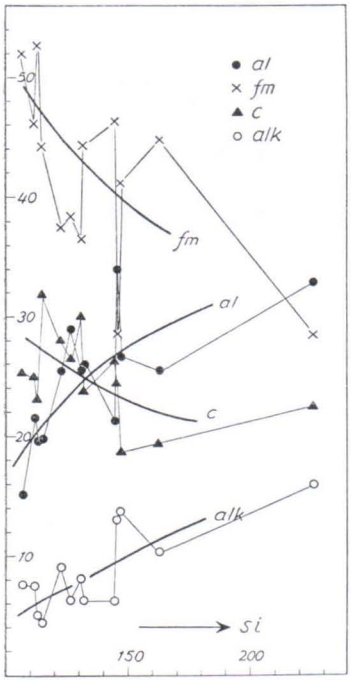


Fig. 17. Variation diagram of the volcanic rocks (Table VIII, Anal. 111—123) in Southern Finland.

morphic Svecofennidic basalts also agree very well with this equation. The sum ab′ + 2 di′ + 2.3 hy′ ranges in the Svecofennidic uralite porphyrites between 130—121 and in the plagioclase porphyrites it is smaller than 120. This observation supports the idea that the primary chemical composition of the Svecofennidic basalts has not undergone great change during the regional metamorphism.

The petrographic and chemical characteristics (Table VIII; Fig. 16 and 17) of the Svecofennidic volcanics in Southern Finland are quite similar to those of the normal calc-alkalic types in the Tampere schist belt. Rocks similar to the trachyandesitic and potash-rich acid lavas of the Tampere area have not been found in Southern Finland. The initial volcanism of the ancient Svecofennidic geosyncline is represented by the lavas of the normal basaltic suite and the spilite keratophyre association typical in many geosynclinal formations of younger age has not been found in the Svecofennides. This is a special feature of the early Archean geosyncline.

SUMMARY AND CONCLUDING REMARKS

The supracrustal rocks and their lithologic association in the crystalline root zone of the Svecofennidic, early Archean mountain chain in Southwestern Finland bear a striking resemblance to the geosynclinal deposits

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C. Blastoporphyritic volcanics.

111. Uralite porphyrite. Pikonkorpi. Kalvola. Sederholm (1891).
112. Blastoporphyritic amphibolite. Riilahden Sorro. Kisko. Eskola (1915, p. 51).
113. Uralite porphyrite. Båtviken. Stor Pellinge. Borgå. Sederholm (1923, p. 34).
114. Uralite porphyrite. Hämeenlinna. Simonen (1948, p. 22).
115. Plagioclase porphyrite. Öster Rysskär. Pernå. Sederholm (1923, p. 36).
116. Andesite. Liipola. Kisko. Lokka (1950, p. 22—23).
117. Blastoporphyritic amphibolite. Orijärvi. Kisko. Eskola (1914, p. 100).
118. Blastoporphyritic amphibolite. Liipola. Kisko. Eskola (1914, p. 104).
119. Uralite porphyrite. Sådholm. Pellinge. Borgå. Mäkinen (1915, p. 634).
120. Meta-andesite. Ägghällan. Pernå. Sederholm (1923, p. 74).
121. Plagioclase porphyrite. Koskenkylä. Pernaja. Lokka (1950, p. 44—45).
122. Plagioclase porphyrite. Parola. Hattula. Simonen (1948, p. 22).
123. Meta-andesite. Pellinge. Pernå. Sederholm (1923, p. 51).

of various times. The graywacke basalt association, characteristic of the actively subsiding, so-called eogeosynclinal belts, forms an at least 8 km thick accumulation in the well-preserved Tampere schist belt. The eogeosynclinal sediments in the Tampere district are represented by graded bedded graywacke-slates, arkose sandstones, and conglomerates. The initial geosynclinal volcanism has produced mainly tuffs and lavas of normal basaltic composition.

The graywacke basalt association has also a wide distribution in the Svecofennidic rock crust of Southern Finland where the eogeosynclinal sediments are, however, highly metamorphic and strongly recrystallized. The graded bedded graywacke-slates of the low-metamorphic Tampere schist belt have as counter parts the mica schists and kinzigites in the highly metamorphic rock crust of Southern Finland, and the blastoclastic arkose sandstones are represented by granoblastic leptites. The basic volcanics of normal basaltic composition, showing conspicuous similarities to the volcanics in the Tampere area, are also widely distributed in Southern Finland.

A characteristic feature of the Svecofennidic as well as of many other eogeosynclinal deposits is the rarity of true quartzites whose deposition requires tectonically stable platforms. Some few Svecofennidic quartzite occurrences mark probably local intervals in the strong tectonic intensity of the ancient geosynclinal belt.

The limestones and calcareous sediments are lacking in the typical eogeosynclinal graywacke-basalt association of the Svecofennides, but they occur in the coastal area of Southern Finland where the deposition of calcium carbonate has taken place simultaneously with argillaceous and arenaceous material. The calcareous facies of geosynclinal deposits is characteristic of the so-called miogeosynclinal belts which represent a transitional phase between eogeosyncline and craton (cf. Krumbein and Sloss, 1951). The sedimentation of limestones and calcareous sediments has taken place in shallow water in those marginal parts of the geosyncline where the tectonic activity during accumulation has not been so great as in the actively subsiding eogeosynclinal belt.

The rocks of the normal basaltic suite represent the initial geosynclinal volcanism of the Svecofennides and some few occurrences of trachyandesitic and potash-rich lavas in the Tampere schist belt show that only locally the magmatic evolution has produced alkali-rich lavas. The soda-rich spilite keratophyre association, characteristic of many geosynclinal belts of later times, has not been found in the Svecofennides.

The stratigraphic observations made in the different parts of the Svecofennidic rock crust support the idea that the basic volcanics overlie the sediments. The term »Bothnian group» can be applied to the Svecofennidic strata characterized by rich occurrence of basic volcanics and the term

»Svionian group» to the axial portion of geosynclinal sediments underlying the basic volcanics. However, at the present state of our knowledge, the drawing of a sharp, well-defined line between the above-mentioned groups is impossible.

REFERENCES

BACKLUND, H. G. (1937) Die Umgrenzung der Svekofenniden. Bull. Geol. Instit. of Upsala 27, p. 219.

BAILEY, E. B. (1930) New light on sedimentation and tectonics. Geol. Mag. 67, p. 77.

—»— (1936) Sedimentation in relation to tectonics. Bull. Geol. Soc. Am. 47, p. 1713.

BARTH, TOM F. W. (1936) The crystallization process of basalt. Am. J. Sci. 31, p. 231.

CLARKE, F. W. (1924) Data of geochemistry. U. S. Geol. Surv. Bull. 770, p. 34.

CLOOS, HANS (1947) Gespräch mit der Erde. München.

DAPPLES, E. C., KRUMBEIN, W. C., and SLOSS, L. L. (1948) Tectonic control of lithologic associations. Am. Assoc. Petrol. Geol. Bull. 32, p. 1924.

EDELMAN, NILS (1949) Structural history of the eastern part of the Gullkrona basin, SW-Finland. Bull. Comm. géol. Finlande 148.

ESKOLA, PENTTI (1914) On the petrology of the Orijärvi region in Southwestern Finland. Bull. Comm. géol. Finlande 40.

—»— (1915) Om sambandet mellan kemisk och mineralogisk sammansättning hos Orijärvitraktens metamorfa bergarter. Bull. Comm. géol. Finlande 44.

ESKOLA, PENTTI; HACKMAN, VICTOR; LAITAKARI, AARNE ja WILKMAN, W. W. (1919) Suomen kalkkikivi. Limestones in Finland. Geotekn. tiedonantoja 21.

ESKOLA, PENTTI (1927) Petrographische Charakteristik der kristallinen Gesteine von Finnland. Fortschritte der Mineralogie, Kristallographie und Petrographie 11, S. 57.

—»— (1930) On the rocks of the Upper Bargousin and Namama regions in Transbaikalia. C. R. Soc. géol. Finlande 3; Bull. Comm. géol. Finlande 92, p. 106.

—»— (1932) Conditions during the earliest geological times as indicated by the Archean rocks. Ann. Acad. Sci. Fennicae, Ser. A, 36, N:o 4.

—»— (1936) Geologisk exkursion till sydvästra Finland. Nordiska naturforskarmötet i Helsingfors 1936, s. 220.

ESKOLA, PENTTI, and NIEMINEN, EERO (1938) The quartzite area of Tiirismaa near Lahti. C. R. Soc. géol. Finlande 12; Bull. Comm. géol. Finlande 123, p. 29.

ESKOLA, PENTTI (1939) Die metamorphen Gesteine. BARTH—CORRENS—ESKOLA: Die Entstehung der Gesteine. Berlin.

—»— (1941) Erkki Mikkola und der heutige Stand der präkambrischen Geologie in Finnland. Geol. Rundschau 32, S. 452.

—»— (1949) The problem of mantled gneiss domes. Quart. J. Geol. Soc. London 104, p. 461.

—»— (1950) Orijärvi re-interpreted. C. R. Soc. géol. Finlande 23; Bull. Comm. géol. Finlande 150, p. 93.

—»— (1951) Around Pitkäranta. Ann. Acad. Sci. Fennicae, Ser. A, III, 27.

HIETANEN, ANNA (1938) On the petrology of Finnish quartzites. Bull. Comm. géol. Finlande 122.

—»— (1943) Über das Grundgebirge des Kalantigebietes im südwestlichen Finnland. Bull. Comm. géol. Finlande 130.

—»— (1947) Archean geology of the Turku district in Southwestern Finland. Bull. Geol. Soc. Am. 58, p. 1019.

HUHMA, A., SALLI, I. ja MATISTO, A. (1952) Suomen geologinen kartta. Geological map of Finland. Lehti — Sheet — 2122. Ikaalinen. Kallioperäkartan selitys. Explanation to the map of rocks.

HÄRME, MAUNU, (1949) On the stratigraphical and structural geology of the Kemi area, Northern Finland. Bull. Comm. géol. Finlande 147.

HÄRME, MAUNU, and SEITSAARI, J. (1950) On the structure of a tilted dome near Tampere in Southwestern Finland. C. R. Soc. géol. Finlande 23. Bull. Comm. géol. Finlande 150, p. 19.

KAHMA, AARNO (1951) On contact phenomena of the Satakunta diabase. Bull. Comm. géol. Finlande 152.

KAY, M. (1947) Geosynclinal nomenclature and the craton. Am. Assoc. Petrol. Geol. Bull. 31, p. 1289.

KRANCK, E. H. (1933) Beiträge zur Kenntnis der Svecofenniden in Finland. III. Kinetisch-geologische Studien im Schärenhof von Ekenäs (SW-Finnland). C. R. Soc. géol. Finlande 6; Bull. Comm. géol. Finlande 101, S. 30.

—»— (1937) Beiträge zur Kenntnis der Svecofenniden in Finnland. IV. Über Intrusion und Tektonik im Küstengebiete zwischen Helsingfors und Porkkala. C. R. Soc. géol. Finlande 10; Bull. Comm. géol. Finlande 119, S. 69.

KRUMBEIN, W. C., and SLOSS, L. L. (1951) Stratigraphy and sedimentation. San Francisco.

KUENEN, P. H., and MIGLIORINI, C. I. (1950) Turbidity currents as a cause of graded bedding. Jour. Geol. 58, p. 91.

LAITAKARI, AARNE (1921) Über die Petrographie und Mineralogie der Kalksteinlagerstätten von Parainen (Pargas). Bull. Comm. géol. Finlande 54.

—»— (1925) Über das Jotnische Gebiet von Satakunta. Bull. Comm. géol. Finlande 73.

LOKKA, LAURI (1934) Neuere chemische Analysen von Finnischen Gesteinen. Bull. Comm. géol. Finlande 105.

—»— (1950) Chemical analyses of Finnish rocks. Bull. Comm. géol. Finlande 151.

MAGNUSSON, N. H. (1936) The evolution of the lower Archean rocks in Central Sweden and their iron, manganese, and sulphide ores. Quart. J. Geol. Soc. London 92, p. 332.

METZGER, ADOLF A. T. (1928) Über die Tektonik des Grundgebirges um Svartå, SW.-Finnland. Fennia 50, N:o 17.

—»— (1945) Zur Geologie der Inseln Ålö und Kyrklandet in Pargas — Parainen, S.W. Finnland. Medd. Åbo Akademis Miner.-geol. Inst. 27.

—»— (1947) Zur tektonischen Stil von Palingengranit und Marmor in den Svecofenniden in Finnland. C. R. Soc. géol. Finlande 20; Bull. Comm. géol. Finlande 140, S. 183.

MIKKOLA, AIMO (1949) On the geology of the area north of the Gulf of Bothnia. Bull. Comm. géol. Finlande 146.

MIKKOLA, ERKKI (1941) Suomen geologinen yleiskartta. The general geological map of Finland. Lehdet — Sheets B 7—C 7—D 7. Muonio—Sodankylä—Tuntsajoki. Kivilajikartan selitys. Explanation to the map of rocks.

MÄKINEN, EERO (1915) Ein archäisches Konglomeratvorkommen bei Lavia in Finnland. Geol. Fören. i Stockholm Förhandl. 37, S. 385.

—»— (1915) Über Uralit aus Uralitporphyrit von Pellinge. Geol. Fören. i Stockholm Förhandl. 37, S. 638.

NEUVONEN, K. J., and MATISTO, A. S. I. (1948) Some observations on the tectonics in the Tampere schist area. C. R. Soc. géol. Finlande 21; Bull. Comm. géol. Finlande 142, p. 79.

NIGGLI, PAUL (1946) Die leukogranitischen, trondhjemitischen und leukosyenitgranitischen Magmen und die Anatexis. Schweiz. Min. Petr. Mitt. 26, S. 44.

PARRAS, KAUKO (1941) Das Gebiet der Pyroxen führenden Gesteine im westlichen Uusimaa in Südfinnland. Geol. Rundschau 32, S. 484.

—»— (1946) On the coarse-grained garnet-cordierite gneisses of South and Southwest Finland. C. R. Soc. géol. Finlande 19; Bull. Comm. géol. Finlande 138, p. 1.

PEHRMAN, GUNNAR (1931) Über eine Sulfidlagerstätte auf der Insel Attu im südwestlichen Finnland. Medd. Åbo Akademis Geol.-miner. Inst. 12.

—»— (1952) Geologische und mineralogische Beobachtungen auf der Insel Niksor, Finby, S.W. Finnland. Medd. Åbo Akademis Geol.-miner. Inst. 32.

PETTIJOHN, F. J. (1943) Archean sedimentation. Bull. Geol. Soc. Am. 54, p. 891.

—»— (1949) Sedimentary rocks. New York.

RANKAMA, KALERVO (1948) New evidence of the origin of pre-Cambrian carbon. Bull. Geol. Soc. Am. 59, p. 389.

READ, H. H. (1948) A commentary on place in plutonism. Quart. J. Geol. Soc. London 104, p. 155.

SEDERHOLM, J. J. (1891) Studien über archäische Eruptivgesteine aus dem südwestlichen Finnland. Min. Petr. Mitt. 12, S. 97.

—»— (1893) Om berggrunden i södra Finland. Fennia 8, N:o 3.

—»— (1897) Über eine archäische Sedimentformation im Südwestlichen Finland und ihre Bedeutung für die Erklärung der Entstehungsweise des Grundgebirges. Bull. Comm. géol. Finlande 6.

—»— (1907) Om granit och gneis, deras uppkomst, uppträdande och utbredning inom urberget i Fennoskandia. Bull. Comm. géol. Finlande 23.

—»— (1910) Suomen kartasto. Atlas de Finlande.

—»— (1913) Suomen geologinen yleiskartta. Lehti B 2. Tampere. Vuorilajikartan selitys.

—»— (1923) On migmatites and associated pre-Cambrian rocks of Southwestern Finland. Part I. The Pellinge region. Bull. Comm. géol. Finlande 58.

—»— (1926) On migmatites and associated pre-Cambrian rocks of Southwestern Finland. Part II. The region around the Barösundsfjärd W. of Helsingfors and neighbouring areas. Bull. Comm. géol. Finlande 77.

—»— (1931) On the sub-Bothnian unconformity and on Archaean rocks formed by secular weathering. Bull. Comm. géol. Finlande 95.

—»— (1932) On the geology of Fennoscandia. Bull. Comm. géol. Finlande 98.

—»— (1934) On migmatites and associated pre-Cambrian rocks of Southwestern Finland. Part III. The Åland islands. Bull. Comm. géol. Finlande 107.

SEITSAARI, JUHANI (1951) The schist belt northeast of Tampere in Finland. Bull. Comm. géol. Finlande 153.

SIMONEN, AHTI, and NEUVONEN, K. J. (1947) On the metamorphism of the schists in the Ylöjärvi area, C. R. Soc. géol. Finlande 20; Bull. Comm. géol. Finlande 140, p. 247.

SIMONEN, AHTI (1948 a) On the petrochemistry of the infracrustal rocks in the Svecofennidic territory of Southwestern Finland. Bull. Comm. géol. Finlande 141.

—»— (1948 b) On the petrology of the Aulanko area in Southwestern Finland. Bull. Comm. géol. Finlande 143.

—»— (1949) Suomen geologinen kartta. Geological map of Finland. Lehti — Sheet — 2131. Hämeenlinna. Kallioperäkartan selitys. Explanation to the map of rocks.

SIMONEN, AHTI, and KOUVO, OLAVI (1951) Archean varved schists north of Tampere in Finland. C. R. Soc. géol. Finlande 24; Bull. Comm. géol. Finlande 154, p. 93.

SIMONEN, AHTI (1952) Suomen geologinen kartta. Geological map of Finland. Lehti — Sheet — 2124. Viljakkala—Teisko. Kallioperäkartan selitys. Explanation to the map of rocks.

STIGZELIUS, HERMAN (1944) Über die Erzgeologie des Viljakkalagebietes im südwestlichen Finnland. C. R. Soc. géol. Finlande 17; Bull. Comm. géol. Finlande 134, p. 1.

TUOMINEN, HEIKKI V., and MIKKOLA, TOIVO (1950) Metamorphic Mg-Fe enrichment in the Orijärvi region as related to folding. C. R. Soc. géol. Finlande 23; Bull. Comm. géol. Finlande 150, p. 67.

TWENHOFEL, W. H. (1950) Principles of sedimentation. New York.

TYRRELL, G. W. (1933) Greenstones and greywackes. C. R. Réunion Internationale pour l'étude du Précambrien, etc.; Bull. Comm. géol. Finlande 102, p. 24.

VÄYRYNEN, HEIKKI (1933) Über die Stratigraphie der Karelischen Formationen. C. R. Soc. géol. Finlande 6; Bull. Comm. géol. Finlande 101, S. 54.

—»— (1939) On the geology and tectonics of the Outokumpu ore field and region. Bull. Comm. géol. Finlande 124.

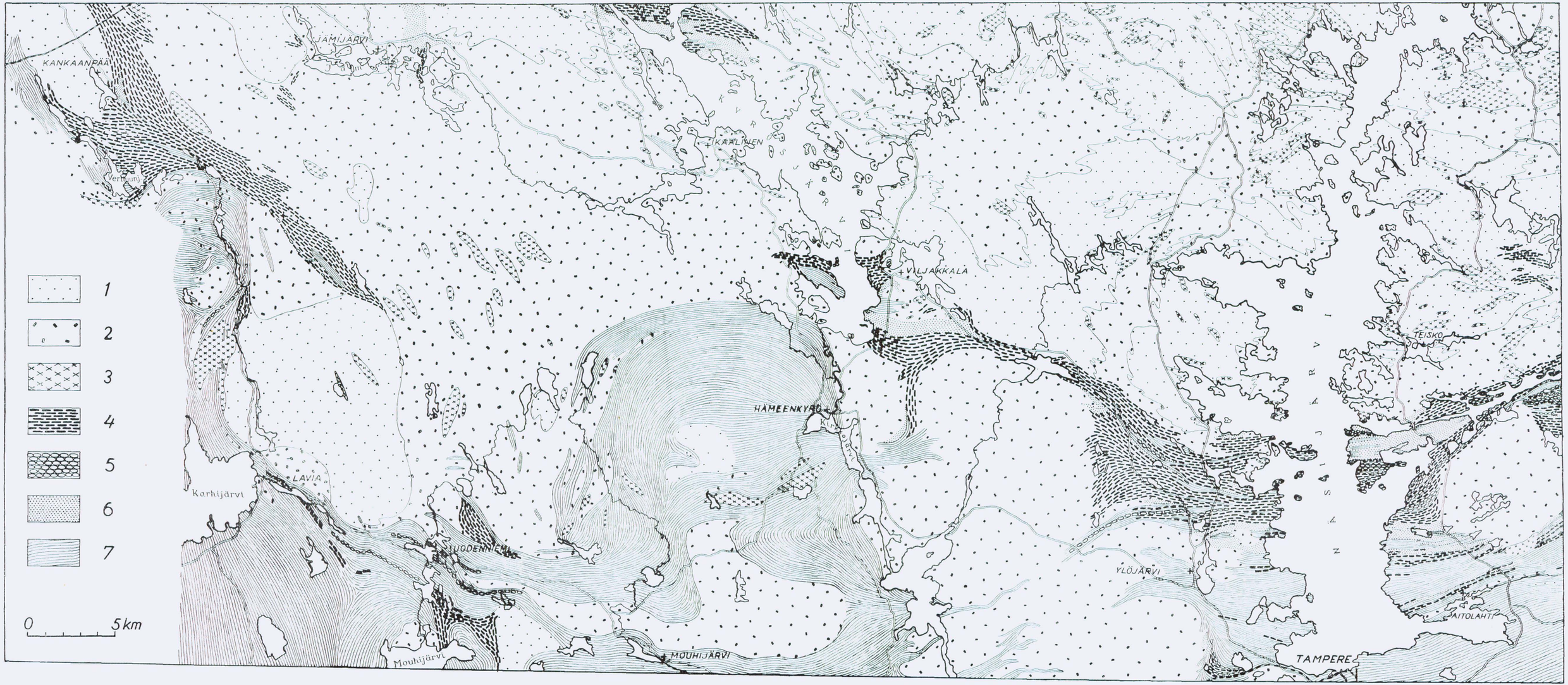
WAHL, WALTER (1936) The granites of the Finnisch part of the Svecofennian Archaean mountain chain. C. R. Soc. géol. Finlande 9; Bull. Comm. géol. Finlande 115, p. 489.

WEGMANN, C. E. (1928) Über die Tektonik der jüngeren Faltung in Ostfinnland. Fennia 50, No 16.

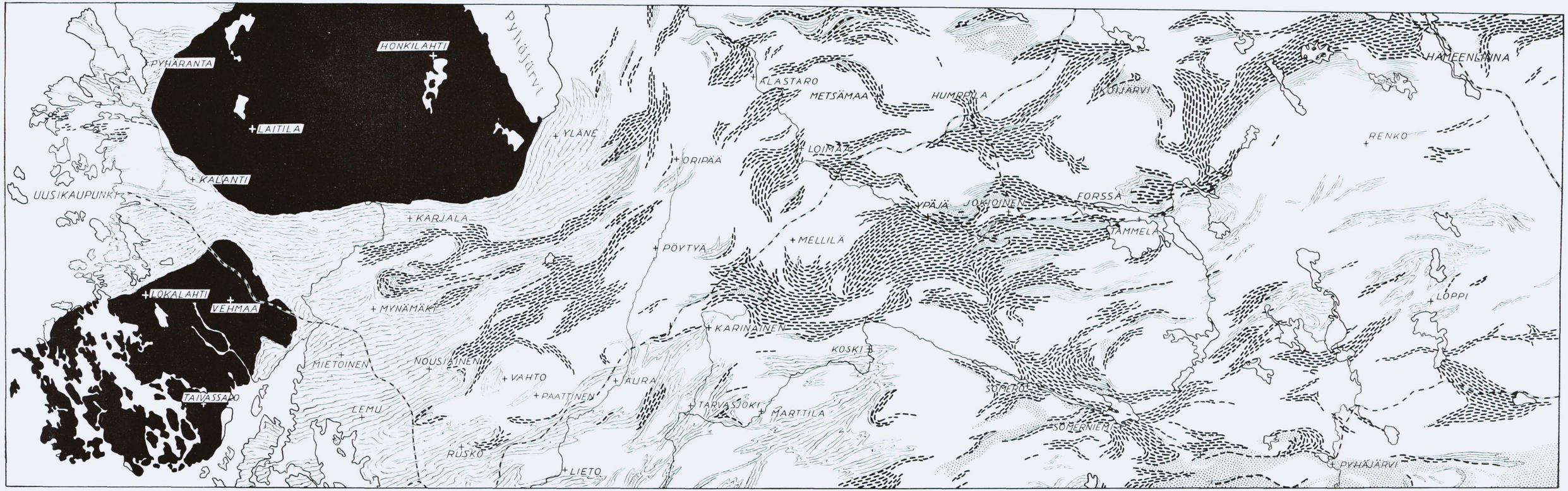
WEGMANN, C. E., und KRANCK, E. H. (1931) Beiträge zur Kenntnis der Svecofenniden in Finnland. Bull. Comm. géol. Finlande 89.

WILKMAN, W. W. (1936) Über archäische vulkanische Gesteine in Saarijärvi im mittleren Finnland. C. R. Soc. géol. Finlande 9; Bull. Comm. géol. Finlande 115, S. 121.

ÖDMAN, OLOF H., Härme, M., MIKKOLA, A. och SIMONEN, AHTI (1949) Den svensk-finska geologiska exkursionen i Tornedalen sommaren 1948. Geol. Fören. i Stockholm Förhandl. 71, s. 113.



Map. I. Geological map of the Tampere schist zone. 1, microcline granites; 2, granodiorites and quartz diorites; 3, diorites and gabbros; 4, basic and intermediate volcanics; 5, conglomerates; 6, quartz-feldspar rocks; 7, varved schists and mica schists.



Map II. Geological map of the Uusikaupunki—Hämeenlinna zone in Southwestern Finland. 1, mica gneisses; 2, mica schists; 3, quartz-feldspar schists; 4, basic and intermediate volcanics; 5, Svecofennidic infracrustal rocks; 6, rapakivi granites.

Bulletin de la Commission géologique de Finlande.

*N:o 1. Ramsay, Wilhelm und Nyholm, E. T. Cancrinitsyenit und einige verwandte Gesteine aus Kuolajärvi. S. 1—12. 4 Fig. 1895 .... —

*N:o 2. Sederholm, J. J. Ueber einen metamorphosirten praecambrischen Quarzporphyr von Karvia in der Provinz Åbo. S. 1—16. 12 Fig. 1895 —

N:o 3. Ramsay, Wilhelm, jemte Bihang 1 af Hackman, Victor och 2 af Sederholm, J. J. Till frågan om det senglaciala hafvets utbredning i Södra Finland. S. 1—44. 1 tarta. Résumé en français: La transgression de l'ancienne mer glaciaire sur la Finlande méridionale. 1896 ..... 100: —

*N:o 4. Frosterus, Benj. Ueber einen neuen Kugelgranit von Kangasniemi in Finland. S. 1—38. 11 Fig. 2 Taf. 1896 ..... —

*N:o 5. Berghell, Hugo. Bidrag till kännedomen om Södra Finlands kvartära nivåförändringar. S. 1—64. 16 fig. 1 plansch. 1 karta. Deutsches Referat: Beiträge zur Kenntniss der quartären Niweauschwankungen Süd-Finlands. 1896 ..... —

*N:o 6. Sederholm, J. J. Über eine archäische Sedimentformation im südwestlichen Finland und ihre Bedeutung für die Erklärung der Entstehungsweise des Grundgebirges. S. 1—254. 97 Fig. 5 Taf. 2 Karten. 1897 —

*N:o 7. Ailio, Julius. Über Strandbildungen des Litorinameeres auf der Insel Mantsinsaari. S. 1—43. 8 Fig. 1898 ..... —

*N:o 8. Andersson, Gunnar. Studier öfver Finlands torfmossar och fossila kvartärflora. S. 1—210. 21 fig. 4 tafl. Deutsches Referat: Studien über die Torfmoore und die fossile Quartärflora Finlands. 1898 —

N:o 9. Sederholm, J. J. Esquisse hypsométrique de la Finlande. P. 1—17. 1 carte. 1899 ..... 100: —

N:o 10. Sederholm, J. J. Les dépôts quaternaires en Finlande. P. 1—28. 2 fig. 1 carte. 1899 ..... 100: —

*N:o 11. Hackman, Victor. Neue Mitteilungen über das Ijolithmassiv in Kuusamo. S. 1—45. 7 Fig. 1 Taf. 2 Karten. 1899 ..... —

*N:o 12. Ramsay, Wilhelm und Borgström, L. H. Der Meteorit von Bjurböle bei Borgå. S. 1—28. 20 Fig. 1902 ..... —

*N:o 13. Frosterus, Benj. Bergbyggnaden i sydöstra Finland. S. 1—168. 18 fig. 8 tafl. 1 karta. Deutsches Referat: Der Gesteinsaufbau des südöstlichen Finland. 1902 ..... —

*N:o 14. Borgström, Leon. H. Die Meteoriten von Hvittis und Marjalahti. S. 1—80. 8 Taf. 1903 ..... —

N:o 15. Hackman, Victor. Die chemische Beschaffenheit von Eruptivgesteinen Finlands und der Halbinsel Kola im Lichte des neuen amerikanischen Systemes. S. 1—143. 3 Tab. 1905 ..... 120: —

*N:o 16. Sundell, I. G. On the Cancrinite-Syenite from Kuolajärvi and a Related Dike Rock. P. 1—20. 1 plate. 1905 ..... —

*N:o 17. Fircks, Curt. On the Occurrence of Gold in Finnish Lapland. P. 1—35. Frontispiece. 15 fig. 1 map. 1906 ..... —

*N:o 18. Tanner, V. Studier öfver kvartärsystemet i Fennoskandias nordliga delar. I. Till frågan om Ost-Finmarkens glaciation och nivåförändringar. S. 1—165. 23 fig. 6 tafl. Résumé en français: Études sur le système quaternaire dans les parties septentrionales de la Fenno-Scandia. I. Sur la glaciation et les changements de niveau du Finmark oriental. 1906 ..... —

*N:o 19. Trüstedt, Otto. Die Erzlagerstätten von Pitkäranta am Ladoga-See. S. 1—333. 80 Fig. 19 Taf. 1 Karte. 1907 ..... —

N:o 20. Tanner, V. Zur geologischen Geschichte des Kilpisjärwi-Sees in Lappland. S. 1—23. 3 Fig. 2 Taf. 1 Karte. 1907 ..... 60: —

---

*) Loppuunmyyty.
Out of print.

N:o 21. Tanner, V. Studier öfver kvartärsystemet i Fennoskandias nordliga delar. II. Nya bidrag till frågan om Finmarkens glaciation och nivåförändringar. S. 1—127. 10 fig. 6 tafl. Résumé en français: Études sur le système quaternaire dans les parties septentrionales de la Fenno-Scandia. II. Nouvelles recherches sur la glaciation et les changements de niveau du Finmark. 1907 ..... 200: —

N:o 22. Borgström, L. H. Granitporphyr von Östersundom. S. 1—20. 3 Fig. 1 Taf. 1907 ..... 60: —

*N:o 23. Sederholm, J. J. Om granit och gneis, deras uppkomst, uppträdande och utbredning inom urberget i Fennoskandia. S. 1—110. 11 fig. 8 tafl. 1 planteckn. 1 karta. English Summary of the Contents: On Granite and Gneiss, their Origin, Relations and Occurrence in the Pre-Cambrian Complex of Fenno-Scandia. 1907 ..... —

*N:o 24. Sederholm, J. J. Les roches préquaternaires de la Fennoscandia. P. 1—39. 20 fig. 1 carte. 1910 ..... —

N:o 25. Tanner, V. Über eine Gangformation von fossilienführendem Sandstein auf der Halbinsel Långbergsöda-öjen im Kirchspiel Saltvik, Åland-Inseln. S. 1—13. 5 Fig. 2 Taf. 1911 ..... 60: —

*N:o 26. Mäkinen, Eero. Bestimmung der Alkalien in Silikaten durch Aufschliessen mittelst Chlorkalzium. S. 1—8. 1911 ..... —

N:o 27. Sederholm, J. J. Esquisse hypsométrique de la Finlande. P. 1—21. 5 fig. 1 carte. 1911 ..... 80: —

*N:o 28. Sederholm, J. J. Les roches préquaternaires de la Finlande. P. 1—27. 1 carte. 1911 ..... —

*N:o 29. Sederholm, J. J. Les dépôts quaternaires de la Finlande. P. 1—23. 5 fig. 1 carte. 1911 ..... —

*N:o 30. Sederholm, J. J. Sur la géologie quaternaire et la géomorphologie de la Fennoscandia. P. 1—66. 13 fig. 6 cartes. 1911 ..... —

N:o 31. Hausen, H. Undersökning af porfyrblock från sydvästra Finlands glaciala aflagringar. S. 1—34. 9 fig. Deutsches Referat. 1912 ..... 80: —

N:o 32. Hausen, H. Studier öfver de sydfinska ledblockens spridning i Ryssland, jämte en öfversikt af is-recessionens förlopp i Ostbaltikum. Preliminärt meddelande med tvenne kartor. S. 1—32. Deutsches Referat. 1912 ..... 80: —

N:o 33. Wilkman, W. W. Kvartära nivåförändringar i östra Finland. S. 1—40. 9 fig. Deutsches Referat. 1912 ..... 100: —

N:o 34. Borgström, L. H. Der Meteorit von St. Michel. S. 1—49. 1 Fig. 3 Taf. 1912 ..... 100: —

N:o 35. Mäkinen, Eero. Die Granitpegmatite von Tammela in Finnland und ihre Minerale. S. 1—101. 23 Fig. 1913 ..... 120: —

N:o 36. Eskola, Pentti. On Phenomena of Solution in Finnish Limestones Finland. P. 1—13. 1 fig. 1921 ..... 60: —
and on Sandstone filling Cavities. P. 1—50. 15 fig. 1913 ..... 100: —

N:o 37. Sederholm, J. J. Weitere Mitteilungen über Bruchspalten mit besonderer Beziehung zur Geomorphologie von Fennoskandia. S. 1—66. 27 Fig. I Taf. 1913 ..... 140: —

N:o 38. Tanner, V. Studier öfver kvartärsystemet i Fennoskandias nordliga delar. III. Om landisens rörelser och afsmältning i finska Lappland och angränsande trakter. S. 1—815. S. 1—815. 139 fig. 16 tafl. Résumé en français: Études sur le système quarternaire dans le parties septentrionales de la Fennoscandia. III. Sur la progression et le cours de la récession du glacier continental dans la Laponie finlandaise et les régions environnantes. 1915 ..... 600: —

N:o 39. Hackman, Victor. Der gemischte Gang von Tuutijärvi im nördlichen Finnland. S. 1—41. 9 Fig. 1914 ..... 80: —

*N:o 40. Eskola, Pentti. On the Petrology of the Orijärvi region in Southwestern Finland. P. 1—277. 55 fig. 6 plates. 2 maps. 1914 ..... —

N:o 41. Borgström, L. H. Die Skapolithlagerstätte von Laurinkari. S. 1—30. 7 Fig. 1913 ..... 60: —

N:o 42. Hackman, Victor. Über Camptonitgänge im mittleren Finnland. S. 1—18. 3 Fig. 1914 ..... 60: —

N:o 43. Wilkman, W. W. Kaleviska bottenbildningar vid Mölönjärvi. S. 1—36. 11 fig. Résumé en français. 1915 ..... 80: —

---

*) Loppuunmyyty.
Out of print.

N:o 44. Eskola, Pentti. Om sambandet mellan kemisk och mineralogisk sammansättning hos Orijärvitraktens metamorfa bergarter. S. 1—145. 5 fig. English Summary of the Contents. 1915 ..... 120: —

N:o 45. Ailio, Julius. Die geographische Entwicklung des Ladogasees in postglazialer Zeit und ihre Beziehung zur steinzeitlichen Besiedelung. S. 1—158. 51 Abbild. 2 Karten. 1915 ..... 200: —

N:o 46. Laitakari, Aarne. Le gisement de calcaire cristallin de Kirmonniemi à Korpo en Finlande. P. 1—39. 14 fig. 1916 ..... 80: —

N:o 47. Mäkinen, Eero. Översikt av de prekambriska bildningarna i mellersta Österbotten i Finland. S. 1—152. 25 fig. 1 karta. English Summary of the Contents. 1916 ..... 200: —

*N:o 48. Sederholm, J. J. On Synantetic Minerals and Related Phenomena (Reaction Rims, Corona Minerals, Kelyphite, Myrmekite, &c.). P. 1—148. 14 fig. in the text and 48 fig. on 8 plates. 1916 ..... —

N:o 49. Wilkman, W. W. Om en prekalevisk kvartsitformation i norra delen af Kuopio socken. S. 1—18. 7 fig. Résumé en français. 1916 ..... 60: —

N:o 50. Sauramo, Matti. Geochronologische Studien über die spätglaziale Zeit in Südfinnland. S. 1—44. 5 Abbild. 4 Taf. 1918 ..... 120: —

N:o 51. Laitakari, Aarne. Einige Albitepidotgesteine von Südfinnland. S. 1—13. 5 Abbild. 1918 ..... 60: —

N:o 52. Brenner, T. H. Über Theralit und Ijolit von Umptek auf der Halbinsel Kola. S. 1—30. 4 Fig. 1920 ..... 60: —

N:o 53. Hackman, Victor. Einige kritische Bemerkungen zu Iddings' Classifikation der Eruptivgesteine. S. 1—21. 1920 ..... 60: —

N:o 54. Laitakari, Aarne. Über die Petrographie und Mineralogie der Kalksteinlagerstätten von Parainen (Pargas). S. 1—113. 40 Abbild. 3 Taf. 1921 ..... 120: —

N:o 55. Eskola, Pentti. On Volcanic Necks in Lake Jänisjärvi in Eastern Finland. P. 1—13. 1 Fig. 1921 ..... 60: —

N:o 56. Metzger, Adolf A. Th. Beiträge zur Paläontologie des nordbaltischen Silurs im Ålandsgebiet. S. 1—8. 3 Abbild. 1922 ..... 60: —

*N:o 57. Väyrynen, Heikki. Petrologische Untersuchungen der granitodioritischen Gesteine Süd-Ostbothniens. S. 1—78. 20 Fig. 1 Karte. 1923 —

*N:o 58. Sederholm, J. J. On Migmatites and Associated Pre-Cambrian Rocks of Southwestern Finland. Part I. The Pellinge Region. P. 1—153. 64 fig. 8 plates. 1 map. 1923 ..... —

N:o 59. Berghell, Hugo und Hackman, Victor. Über den Quartzit von Kallinkangas, seine Wellenfurchen und Trockenrisse. Nach hinterlassenen Aufzeichnungen von Hugo Berghell zusammengestellt und ergänzt von Victor Hackman. S. 1—19. 19 Fig. 1923 ..... 60: —

N:o 60. Sauramo, Matti. Studies on the Quaternary Varve Sediments in Southern Finland. P. 1—164. 22 fig. in the text. 12 fig., 1 map and 2 diagrams on 10 plates. 1923 ..... 200: —

N:o 61. Hackman, Victor. Der Pyroxen-Granodiorit von Kakskerta bei Åbo und seine Modifikationen. S. 1—23. 2 Fig. 1 karte. 1923 ..... 60: —

N:o 62. Wilkman, W. W. Tohmajärvi-konglomeratet och dess förhållande till kaleviska skifferformationen. S. 1—43. 15 fig. 1 karta. Deutsches Referat. 1923 ..... 80: —

N:o 63. Hackman, Victor. Über einen Quarzsyenitporphyr von Saariselkä im finnischen Lappland. S. 1—10. 2 Fig. 1923 ..... 60: —

N:o 64. Metzger, Adolf A. Th. Die jatulischen Bildungen von Suojärvi in Ostfinnland. S. 1—86. 38 Abbild. 1 Taf. 1 Karte. 1924 ..... 120: —

N:o 65. Saxén, Martti. Über die Petrologie des Otravaaragebietes im östlichen Finnland. S. 1—63. 13 Abbild. 5 Fig. auf 1 Taf. 2 Karten. 1923. 120: —

N:o 66. Ramsay, Wilhelm. On Relations between Crustal Movements and Variations of Sea-Level during the Late Quaternary Time, especially in Fennoscandia. P. 1—39. 10 fig. 1924 ..... 80: —

N:o 67. Sauramo, Matti. Tracing of Glacial Boulders and its Application in Prospecting. P. 1—37. 12 fig. 1924 ..... 80: —

N:o 68. Tanner, V. Jordskredet i Jaarila. S. 1—18. 2 fig. 10 bild. Résumé en français. 1924 ..... 60: —

N:o 69. Auer, Väinö. Die postglaziale Geschichte des Vanajavesisees. S. 1—132. 10 Fig. 10 Taf. 11 Beil. 1924 ..... 200: —

---

*) Loppuunmyyty.
Out of print.

N:o 70. Sederholm, J. J. The Average Composition of the Earth's Crust in Finland. P. 1—20. 1925 ..... 80: —

N:o 71. Wilkman, W. W. Om diabasgångar i mellersta Finland. S. 1—35. 8 fig. 1 karta. Deutsches Referat. 1924 ..... 80: —

N:o 72. Hackman, Victor. Das Gebiet der Alkaligesteine von Kuolajärvi in Nordfinnland. S. 1—62. 6 Fig. 1 Taf. 1925 ..... 120: —

N:o 73. Laitakari, Aarne. Über das jotnische Gebiet von Satakunta. S. 1—43. 14 Abbild. 1 Karte. 1925 ..... 120: —

N:o 74. Metzger, Adolf A. Th. Die Kalksteinlagerstätten von Ruskeala in Ostfinnland. S. 1—24. 9 Abbild. 2 Karten. 1925 ..... 80: —

N:o 75. Frosterus, Benj. Ueber die kambrischen Sedimente der karelischen Landenge. S. 1—52. 1 Fig. 1925 ..... 120: —

N:o 76. Hausen, H. Über die präquartäre Geologie des Petsamo-Gebietes am Eismeere. S. 1—100. 13 Fig. 2 Taf. 1926 ..... 120: —

N:o 77. Sederholm, J. J. On Migmatites and Associated Pre-Cambrian Rocks of Southwestern Finland. Part II. The Region around the Barösundsfjärd W. of Helsingfors and Neighbouring Areas. P. 1—143. 57 fig. in the text and 44 fig. on 9 plates. 1 map. 1926 ..... 240: —

N:o 78. Väyrynen, Heikki. Geologische und petrographische Untersuchungen im Kainuugebiete. S. 1—127. 37 Fig. 2 Taf. 2 Karten. 1928 160: —

N:o 79. Hackman, Victor. Studien über den Gesteinsaufbau der Kittilä-Lappmark. S. 1—105. 23 Fig. 2 Taf. 2 Karten. 1927 ..... 160: —

N:o 80. Sauramo, Matti. Über die spätglazialen Niveauvershiebungen in Nordkarelien, Finnland. S. 1—41. 8 Fig. im Text. 11 Fig., 1 Karte und 1 Profildiagr. auf 7 Taf. 1928 ..... 60: —

N:o 81. Sauramo, Matti und Auer, Väinö. On the Development of Lake Höytiäinen in Carelia and its Ancient Flora. P. 1—42. 20 fig. 4 plates. 1928 ..... 60: —

N:o 82. Lokka, Lauri. Über Wiikit. S. 1—68. 12 Abbild. 1928 ..... 120: —

N:o 83. Sederholm, J. J. On Orbicular Granite, Spotted and Nodular Granites etc. and on the Rapakivi Texture. P. 1—105. 19 fig. in the text and 50 fig. on 16 plates. 1928 ..... 200: —

N:o 84. Sauramo, Matti. Über das Verhältnis der Ose zum höchsten Strand. S. 1—17. 1928 ..... 40: —

N:o 85. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, I. P. 1—88. 1 stéréogramme. 1929 ..... 160: —

N:o 86. Sauramo, Matti. The Quaternary Geology of Finland. P. 1—110. 39 fig. in the text and 42 fig. on 25 plates. 1 map. 1929 ..... 240: —

N:o 87. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, II. P. 1—175. 48 fig. 8 planches. 1929 ..... 280: —

N:o 88. Tanner, V. Studier över kvartärsystemet i Fennoskandias nordliga delar. IV. Om nivåförändringarna och grunddragen av den geografiska utvecklingen efter istiden i Ishavsfinland samt om homotaxin av Fennoskandias kvartära marina avlagringar. S. 1—589. 84. fig. 4 tavl. 1 karta. Résumé en français: Études sur le système quaternaire dans les parties septentrionales de la Fennoscandie. IV. Sur les changements de niveau et les traits fondamentaux du développement géographique de la Finlande aux confins de l'océan Arctique après l'époque glaciaire et sur l'homotaxie du quaternaire marin en Fennoscandie. 1930 ..... 600: —

N:o 89. Wegman, C. E. und Kranck, E. H. Beiträge zur Kenntnis der Svecofenniden in Finland. I. Übersicht über die Geologie des Felsgrundes im Küstengebiete zwischen Helsingfors und Onas. II. Petrologische Übersicht des Küstengebietes E von Helsingfors. S. 1—107. 4 Fig. 16 Taf. mit 32 Fig. 1 Übersichtskarte. 1931 ..... 160: —

N:o 90. Hausen, H. Geologie des Soanlahti-Gebietes im südlichen Karelien. Ein Beitrag zur Kenntnis der Stratigraphie und tektonischen Verhältnisse der Jatulformation. S. 1—105. 23 Fig. im Text und 12 Fig. auf 4 Taf. 1930 ..... 200: —

N:o 91. Sederholm, J. J. Pre-Quaternary Rocks of Finland. Explanatory Notes to accompany a General Geological Map of Finland. P. 1—47. 40 fig. 1 map. 1930 ..... 120: —

N:o 92. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, III. P. 1—140. 29 fig. 3 planches. 1930 ..... 200: —

N:o 93. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, IV. P. 1—68. 12 fig. 6 planches. 1931 ..... 160: —

N:o 94. Brenner, Thord. Mineraljordarternas fysikaliska egenskaper. S. 1—159. 22 fig. Deutsches Referat. 1931 ..... 280: —

N:o 95. Sederholm, J. J. On the Sub-Bothnian Unconformity and on Archæan Rocks formed by Secular Weathering. P. 1—81. 62 fig. 1 map. 1931 ..... 200: —

N:o 96. Mikkola, Erkki. On the Physiography and Late-Glacial Deposits in Northern Lapland. P. 1—88. 25 fig. 5 plates. 1932 ..... 200: —

N:o 97. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, V. P. 1—77. 15 fig. 1932 ..... 160: —

N:o 98. Sederholm, J. J. On the Geology of Fennoscandia. P. 1—30. 1 map. 1 table. 1932 ..... 120: —

N:o 99. Tanner, V. The Problems of the Eskers. The Esker-like Gravel Ridge of Čahpatoaiv, Lapland. P. 1—13. 2 plates. 1 map. 1932 ..... 60: —

N:o 100. Sederholm, J. J. Über die Bodenkonfiguration des Päijänne-Sees. S. 1—23. 3 Fig. 1 Karte. 1932 ..... 200: —

N:o 101. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, VI. P. 1—118. 17 fig. 5 planches. 1933 ..... 200: —

N:o 102. Wegmann, S. E., Kranck, E. H. et Sederholm, J. J. Compte rendu de la Réunion internationale pour l'étude du Précambrien et des vieilles chaînes de montagnes. P. 1—46. 1933 ..... 120: —

N:o 103. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, VII. P. 1—48. 2 fig. 1933 ..... 100: —

N:o 104. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i iFnland — Comptes Rendus de la Société géologipue de Finlande, VIII. P. 1—156. 33 fig. 7 planches. 1934 ..... 220: —

N:o 105. Lokka, Lauri. Neuere chemische Analysen von finnischen Gesteinen. S. 1—64. 1934 ..... 120: —

N:o 106. Hackman, Victor. Das Rapakiwirandgebiet der Gegend von Lappeenranta (Willmanstrand). S. 1—82. 15 Fig. 2 Taf. 1 Analysentab. 1 Karte. 1934 ..... 140: —

N:o 107. Sederholm, J. J. † On Migmatites and Associated Pre-Cambrian Rocks of Southwestern Finland. Part III. The Åland Islands. P. 1—68. 43 fig. 2 maps. 1934 ..... 160: —

N:o 108. Laitakari, Aarne. Geologische Bibliographie Finnlands 1555—1933. S. 1—224. 1934 ..... 200: —

N:o 109. Väyrynen, Heikki. Über die Mineralparagenesis der Kieserze in den Gebieten von Outokumpu und Polvijärvi. S. 1—24. 7 Fig. 1 Karte. 1935 ..... 80: —

N:o 110. Saksela, Martti. Über den geologischen Bau Süd-Ostbothniens. S. 1—35. 11 Fig. 1 Titelbild. 1 Taf. 1 Karte. 1935 ..... 100: —

N:o 111. Lokka, Lauri. Über den Chemismus der Minerale (Orthit, Biotit u. a.) eines Feldspatbruches in Kangasala, SW-Finnland. S. 1—39. 2 Abbild. 1 Taf. 1935 ..... 100: —

N:o 112. Hackman, Victor. J. J. Sederholm. Biographic Notes and Bibliography. P. 1—29. With a vignette. 1935 ..... 80: —

N:o 113. Sahama (Sahlstein), Th. G. Die Regelung von Quarz und Glimmer in den Gesteinen der finnisch-lappländischen Granulitformation. S. 1—110. 5 Fig. 80 Diagr. 3 Taf. 1936 ..... 160: —

N:o 114. Haapala, Paavo. On Serpentine Rocks in Northern Karelia. P. 1—83. 21 fig. 2 maps. 1936 ..... 120: —

N:o 115. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, IX. P. 1—505. 83 fig. 20 planches. 1936 ..... 400: —

N:o 116. Väyrynen, Heikki. Petrologie des Nickelerzfeldes Kaulatunturi —Kammikivitunturi in Petsamo. S. 1—198. 71 Abbild. 36 Tab. 1 Karte. 1938 ..... 200: —

N:o 117. Kilpi, Sampo. Das Sotkamo-Gebiet in spätglazialer Zeit. S. 1—118. 36 Abbild. 3 Beil. 1937 ..... 200: —

N:o 118. Brander, Gunnar. Ein Interglazialfund bei Rouhiala in Südostfinnland. S. 1—76. 7 Fig. im Texte u. 7 Fig. auf 2 Taf. 1937 ..... 160: —

N:o 119. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, X. P. 1—170. 30 fig. 4 planches. 1937 ..... 200: —

N:o 120. Hyyppä, Esa. Post-Glacial Changes of Shore-Line in South Finland. P. 1—225. 57 fig. 21 tab. 2 append. 1937 ..... 200: —

N:o 121. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XI. P. 1—166. 47 fig. 8 tab. 2 cartes. 1938 ..... 200: —

N:o 122. Hietanen, Anna. On the Petrology of Finnish Quartzites. P. 1—118. 20 fig. 8 plates. 3 maps. 1938 ..... 200: —

N:o 123. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XII. P. 1—107. 20 fig. 3 planches. 1938 ..... 200: —

N:o 124. Väyrynen, Heikki. On the Geology and Tectonics of the Outokumpu Ore Field and Region. P. 1—91. 11 fig. 2 maps. 1939 ..... 200: —

N:o 125. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XIII. P. 1—119. 45 fig. 1 planche. 1939 ..... 120: —

N:o 126. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XIV. P. 1—140. 60 fig. 4 planches. 1941 ..... 150: —

N:o 127. Mölder, Karl. Studien über die Ökologie und Geologie der Bodendiatomeen in der Pojo-Bucht. P. 1—204. 7 Abbild. 1 Karte. 14 Diagr. 14 Tab. 1943 ..... 200: —

N:o 128. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XV. P. 1—183. 43 fig. 2 planches. 1943 ..... 200: —

N:o 129. Lokka, Lauri. Beiträge zur Kenntnis des Chemismus der finnischen Minerale Glimmer, Pyroxene, Granate, Epidote u. a. Silikatminerale sowie melnikowitähnliches Produkt und Shungit. S. 1—72. 48 Tab. 1943 150: —

*N:o 130. Hietanen, Anna. Über das Grundbebirge des Kalantigebietes im südwestlichen Finnland. S. 1—105. 55 Fig. 8 Tafeln. 1 Karte. 1943 .. —

N:o 131. Okko, V. Moränenuntersuchungen im westlichen Nordfinnland. S. 1—46. 12 Abb. 4 Tab. 1944 ..... 90: —

N:o 132. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XVI. P. 1—196. 41 diagr. 9 tabl. 3 cartes. 3 fig. 1944 .... 200: —

N:o 133. Rankama, Kalervo. On the Geochemistry of Tantalum. P. 1—78. 1 fig. 8 tables. 1944 ..... 150: —

N:o 134. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XVII. P. 1—91. 59 fig. 1 carte. 1944 ..... 150: —

N:o 135. Sahama, Th. G. Spurenelemente der Gesteine im südlichen Finnisch-Lappland. S. 1—86. 12 Fig. 29 Tab. 1945 ..... 150: —

N:o 136. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XVIII. P. I—XXXVIII; 1—67. 3 diagr. 11 tabl. 2 cartes. 11 fig. 2 planches. 1945 ..... 200: —

N:o 137. Rankama, Kalervo. On the Geochemical Differentiation in the Earth's Crust. P. 1—39. 18 tables. 1946 ..... 100: —

N:o 138. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XIX. P. 1—120. 7 diagr. 13 tabl. 9 fig. 1 planche. 1946 .... 200: —

N:o 139. Brenner, Th. Om mineraljordarternas hållfasthetsegenskaper. S. 1—77. 11 fig. Summary in English. 1946 ..... 120: —

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*) Loppuunmyyty.
Out of print.

N:o 140. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XX. P. 1—302. 37 tabl. 103 fig. 6 planches. 2 cartes. 1947 300: —

N:o 141. Simonen, Ahti. On the Petrochemistry of the Infracrustal Rocks in the Svecofennidic Territory of Southwestern Finland. P. 1—18. 7 tabl. 5 fig. 1948 ..... 25: —

N:o 142. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XXI. P. 1—129. 45 fig. 1 planche. 4 tabl. 3 cartes. 1948 200: —

N:o 143. Simonen, Ahti. On the Petrology of the Aulanko Area in Southwestern Finland. P. 1—66. 25 fig. 6 tabl. 1 map. 1948 ..... 100: —

N:o 144. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XXII. P. 1—165. 70 fig. 3 planches. 4 cartes. 1949 ..... 200: —

N:o 145. Salmi, Matti. Physical and Chemical Peat Investigations on the Pinomäensuo Bog, SW. Finland. P. 1—31. 12 fig. 1 table. 1949 ..... 50: —

N:o 146. Mikkola, Aimo. On the Geology of the Area North of the Gulf of Bothnia. P. 1—64. 20 fig. 10 tabl. 1 map. 1949 ..... 100: —

N:o 147. Härme, Maunu. On the Stratigraphical and Structural Geology of the Kemi Area, Northern Finland. P. 1—60. 29 fig. 4 tabl. 1 map. 1949 100: —

N:o 148. Edelman, Nils. Structural History of the Eastern part of the Gullkrona Basin, SW-Finland. P. 1—48. 16 fig. 2 tabl. 8 plates. 1949 90: —

N:o 149. Lokka, Lauri. Contributions to the Knowledge of the Chemistry of the Radioactive Minerals of Finland. P. 1—76. 7 fig. 33 tabl. 1950 .. 150: —

N:o 150. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XXIII. P. 1—111. 27 fig. 7 planches. 5 tabl. 2 cartes. 1950 250: —

N:o 151. Lokka, Lauri. Chemical Analyses of Finnish Rocks. P. 1—75. 1950 150: —

N:o 152. Kahma, Aarno. On Contact Phenomena of the Satakunta Diabase. P. 1—84. 22 fig. 10 tabl. 5 plates. 1951 ..... 200:—

N:o 153. Seitsari, Juhani. The Schist Belt Northeast of Tampere in Finland. P. 1—120. 53 fig. 9 tabl. 2 maps. 1951 ..... 300: —

N:o 154. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XXIV. P. 1—241. 95 fig. 3 planches. 24 tabl. 1951 ..... 400: —

N:o 155. Virkkala, K. Glacial Geology of the Suomussalmi area, East Finland. P. 1—66. 26 fig. 1 plate. 1951 ..... 150: —

N:o 156. Marmo, Vladi — Mikkola, Aimo. On Sulphides of the Sulphide-bearing Schists of Finland. P. 1—44. 7 fig. 4 plates. 1951 .. 90: —

N:o 157. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XXV. P. 1—148. 35 fig. 28 tabl. 1952 ..... 350: —

N:o 158. Neuvonen, K. J. Thermochemical Investigation of the Åkermanite — Gehlenite Series. P. 1—57. 7 fig. 12 tabl. 1952 ..... 100: —

N:o 159. Painossa.

N:o 160. Simonen, Ahti. Stratigraphy and Sedimentation of the Svecofennidic Early Archean Supracrustal Rocks in Southwestern Finland. P. 1—64. 17 fig. 8 tabl. 2 maps. 1953 ..... 150: —