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PRECAMBRIAN PETROLOGY, GEOCHEMISTRY AND AGE RELATIONS OF NORTHEASTERN BLEKINGE, SOUTHERN SWEDEN

WITH ONE MAP
(SCALE 1:50 000)

STOCKHOLM 1974

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CONTENTS

ABSTRACT

The present paper deals with the petrology, tectonics and chronology of the Precambrian of northeastern Blekinge in southern Sweden. Three principal groups of granitoid plutonics have been distinguished: 1, an Older granitoid complex comprising moderately to distinctly gneissic tonalites—granodiorites; 2, a Younger post-orogenic granitoid group essentially made up of massive differentiated rocks ranging from subordinate tonalite through predominant granodiorites to granites; and, 3, a Youngest granitoid group including coarse-grained megacryst-bearing granites and small-grained granites. The border zone between the Older and the Younger granitoid complexes has been subjected to strong deformation. The oldest unit in the area consists of various gneisses. This unit as well as the two earliest granitoid groups are considered to have Svecofennian age, whereas the Youngest granitoids are post-Svecofennian. Mineralogical and chemical data are given for the various rock types. Several generations of hypabyssal metabasites occur in the area.

INTRODUCTION

This paper presents information about the Precambrian petrology, geochemistry, and age relations of the northeastern part of Blekinge in the extreme southeastern Sweden. The surveying comprises the south and north sections of the Topographical Maps 4F Lessebo SO and 3F Karlskrona NO (scale 1:50 000), covering approximately 440 sq. kms. The location of the map area is shown on Plate 1 (see insets).

Because of its geographical position, the investigated region (see Plate 1 and Fig. 1) crosses the triple-junction between the Older granitoids *("Tvinggranit"),* the Younger granitoids ("*Smålandsgraniter*"), and the Youngest granitoids ("*Eringsboda granit*"), and thus forms a key area in the study of the relations between the three age-different plutonic complexes. In addition, restricted parts of the Older and Younger granitoid terrains include early gneisses (Coastal gneisses) and basic plutonics. The three plutonic periods seem to be preceded, separated and succeeded by periods of basic dike intrusion.

The age relations of the Coastal gneisses and the Older granitoids have been the subject of many discussions. According to the current time division of the Swedish Precambrian (Welin 1970) these rock units and the subsequent Younger granitoid group belong to the Svecofennian period, whereas the Youngest granitoids are post-Svecofennian.

The main purpose of the present paper has been to study the geological relations between the three chronologically different Blekinge granitoid groups. Special attention has been focused on the petrological and geochemical relations as well as the border zone between the Older and Younger granitoid complexes. In addition, the following aspects were selected for detailed investigations: 1, the compositions of the biotite and amphibole of the granitoids; 2, the coexistence of actinolite—hornblende in a metagabbro; 3, the potash feldspar megacrysts of the various granitoid groups; and, 4, the metabasite dikes of the region.

Since the regional development has been so complex, including several phases of plutonic activity, metamorphism, and tectonization, and because of lacking isotopic age data, no attempt will be made here to provide a synthesis of the Precambrian evolution of northeastern Blekinge. However, in the concluding chapter (Fig. 58 on p. 96) a tentative chronological scheme is presented. A brief geochronological review of the adjoining areas is given on p. 10.

PREVIOUS WORK

The main geological features of Blekinge are known from the pioneer work of Blomberg (with assistance of G. De Geer, Holst and Lundbohm) carried out during the years 1885—1900. The results of this general survey were presented in a report (Blomberg 1900) accompanied by a map (1:100 000).

Further investigations of the eastern and northeastern parts of Blekinge, including also southernmost Småland, were made by Holst (1879) and Hedström (Hedström and Wiman 1906) on the behalf of the Geological Survey of Sweden and resulting in maps (1:200 000) with descriptions.

In 1897, Bäckström published an eminent monograph entitled ”The Vestanå region — a study in petrogenesis”. The supracrustal complex of Västanå is mainly situated in northeastern Scania and the adjacent part of western Blekinge. According to Bäckström (1897), the rock sequence includes schists, mica-quartzites, conglomerates, and dense gneisses *(”hälleflintgnejser”).* The latter pass into the surrounding Coastal gneisses, considered as strongly metamorphosed quartz-porphyritic tuffs.

The Coastal gneisses have been treated in several other papers. De Geer (1889, p. 66) discussed the relationship between the dense gneisses *(”hälleflintgnejser”)* and the Coastal gneisses. R. Norin (1936, 1959), who has carried out detailed petrographic studies in western Blekinge (see below), arrived at the same conclusion as Bäckström (1897) concerning the boundary relations between the various gneisses. In the opinion of Asklund (1947, p. 98) no transition exists between the mentioned rock units. He considered the Coastal gneisses as metamorphic varities of the ”gneiss-granites”.

The most comprehensive petrological studies of Blekinge have been made by R. Norin (1936, 1959). In his work of 1959, he presented a scheme of the geological evolution of Blekinge and nearby areas, which will be summarized here:

1. A period of deposition of supracrustals (Västanå complex).
2. Oldest orogenesis. A period of plutonic activity (*e.g.* grey Växjö granite and Tving granite) followed by deformation.
3. A period of volcanic (Småland porphyries) and plutonic activity (red Växjö granite).
4. Youngest orogenesis. A period of migmatization (older supracrustals) and plutonic activity (*e.g.* Spinkamåla granite, hyperites).
5. A post-orogenic period of plutonic activity (*e.g.* Vånga granite, Karlshamn —Eringsboda granites).
6. Development of basic dikes (diabases).

R. Norin (1957) also presented some notes on the composition of biotite and potash feldspar in the Karlshamn granite.

Moberg (1896) has thoroughly described the diabases of western Blekinge.

I. Larsson and Stanfors (1970) have studied the magnetic properties of two diabases in western Blekinge.

Some aspects of the metamorphic historiy of the Blekinge Precambrian complex have been given by Zeck (1971).

Cohen and Deecke (1891) presented some remarks on the similarities between the Precambrian geology of Bornholm and Blekinge, and suggested possible correlations.

Investigations of the conspicuous lava-like rocks in Lake Mien at the boundary between Blekinge and Småland have been carried out by Holst (1890) and Stanfors (1973).

The tectonic features of central and western Blekinge have been treated by Habetha (1936) and I. Larsson (1954), as well as to some extent by Asklund (1947).

Isotopic age determinations on various rock types from Blekinge have been performed by Russian (in Magnusson 1960a, 1970) and Swedish geochronologists (Welin and Blomqvist 1966).

METHODS OF INVESTIGATION

FIELD WORK

A total of about eight months field work was carried out in the spring and autumn seasons 1969—1972.

During the field work the following Topographical Maps (scale 1:50 000) issued by the Geographical Survey Office of Sweden have been used: 3F Karlskrona NO and 4F Lessebo SO. Tectonic analyses in the field have been supplemented by photogeologic interpretations of aerial photos (scale 1:20 000).

As grid reference the Universal Transverse Mercator system (UTM) has been used to codify the positions (with an accuracy of ±100 m) of the sampling localities for chemical analyses listed on pp. 106—107. For localities, see Fig. 59 and the petrological map (Plate 1).

From the Official Topographic Maps only geographical names, roads and lakes necessary for readers' orientation have been transferred to the petrological map (Plate 1).

The size and frequency of metabasite dikes and/or fragments have made an accurate reproduction on a scale of 1:50 000 impossible. Approximate designations of more important occurrences have been made on the petrological map (Plate 1). The metabasite symbols on the map are thus entirely schematical. The same is valid for the diabase dikes on the petrological map.

LABORATORY WORK

In the laboratory thin and polished sections of the collected samples have been studied by means of microscopical routine methods. During the microscopical work the following manuals have been used: Deer *et al.* (1962—1963), Kerr (1959) and Tröger (1967, 1971). The feldspars have been identified and chemically analysed with the aid of a Leitz' 4-axis universal stage, X-ray methods and atomic absorption spectroscopy (see below). Most plagioclase compositions were determined according to the zone method given by Rittman (1929). Supplemental determinations as axial angles, twinning laws, refractive indicies *etc.* are sometimes presented in the text.

The X-ray powder method was used to determine the average compositions of the zoned plagioclase crystals. The 131—1$\bar{3}$1 peak intervals have been evaluated in accordance with the determination curves of Smith (1956) and Bambauer *et al.* (1966). The curve for low-temperature plagioclases was applied.

The degree of triclinicity of the potash feldspar megacrysts was determined by the method described of Goldsmith and Laves (1954). All X-ray runs have been carried out with the aid of a Philips diffractometer.

The refractive indicies were measured in monochromatic (Na$_D$) light using a set of immersion liquids, which were regularly checked by means of an Abbe refractometer. The accuracy is about ±0.002. For plagioclases this value corresponds to ±4 % An.

The modal compositions of the various rocks investigated have been determined according to the methods of Van der Plas (1959, pp. 522—531) and Van der Plas—Tobi (1965). Using a point counter these methods imply that the point distance must be larger than the diameter of the largest grains measured, in order to avoid correlated observations. Adequate sampling was the greatest problem encountered during the modal analyses of the more or less coarse-grained and megacryst-bearing rocks of Blekinge. Several authors (*e.g.* Chayes 1956, p. 93) have pointed out that one single standard thin section cannot give an adequate picture of the mineral composition of a rock with a maximum grain size exceeding 3 mm. In order to get the desired reliability of the modal results it has been necessary to produce several thin sections of each investigated rock specimen. Contents of minerals determined by modal analysis are given by per cent by volume. Semi-quantitative determinations of mineral compositions have also been made in accordance with the following classifications:

>25 %	Main minerals
5—25 %	Essential minerals
1— 5 %	Subordinate minerals
≤1 %	Accessory minerals

Whole-rock analyses have been carried out at the laboratories of the Geological Survey of Sweden (SGU) with the routine methods devised there. Samples between 2 and 5 kg have been used.

Most element analyses have been determined by quantitative spectrography *(Smältisoformering B)* with an estimated standard deviation of 1—5 %. Alkali metals were analysed by atomic absorption spectrophotometer. The rubidium content was determined by means of X-ray fluorescence analysis. The other trace elements were analysed spectrographically with an estimated accuracy of 10—30 %. Ferrous iron was determined by wet-chemical analysis, the relative error being 5—10 %.

Partial chemical analyses of the plagioclases and potash feldspars of the granitoid rocks were performed at the Geological Institute, Lund. The analytical methods are described and discussed together with the feldspar section (p. 84).

Selected mineral grains of biotites and Ca-amphiboles were analysed regarding their contents of major elements with the aid of a Cambridge Geoscan microprobe at the Geological Institute of Uppsala, applying the analytical technique and correction methods described by M. Dahl (1969). The accuracy of the microprobe method is about ±4 % of the amount analysed. As the ratio ferrous/ferric iron cannot be determined in the microprobe, all Fe is given as FeO.

Most petrochemical calculations were made on an IBM 360/75 computer at the computer centre of SGU, using the Benorm Program written by R. W. Bowen, U.S. Geological Survey, and revised at the Data-section, SGU. Supplemental calculations of the rock analyses have followed Burri (1959).

NOMENCLATURE

The classification and nomenclature of plutonic rocks used in this report follow Streckeisen (1967).

The terms plutonism and plutonic rocks are used in the sense of Buddington (1959, p. 675).

The investigated rock units are regarded by the writer as rock-stratigraphic, following the nomenclature of the International Subcommission on Stratigraphic Classification (1972). As at present the available isotopic age data from south-eastern Sweden show an incongruence and are considered too small in number, it is not yet possible to make a convenient and acceptable chronostratigraphic classification of the Precambrian basement of this part of Sweden (*cf.* p. 102).

The term granitoid is here used to refer to an igneous or pseudo-igneous rock, within the compositional interval tonalite—granodiorite—granite *(sensu stricto)*, regardless of its origin.

The term Småland granitoid is used in a more or less collective and geographical meaning, without genetical and chronological aspects.

The term metabasite was originally proposed by Hackman (1907) to denote metamorphic basic rocks, and will be adopted thus in the present paper.

Megacryst is used as a descriptive term in a non-genetical sense, including partly genuine phenocrysts, partly porphyroblasts.

Metamorphic textures are described in accordance with Spry (1969).

Classification and nomenclature of deformed rocks follow Higgins (1971)

For the study of the chemical relations between different granitoid groups, some element ratios have been plotted against corresponding. Differentiation

Indicies (DI) in the sense of Thornton and Tuttle (1960). DI is simply defined as the sum of the weight percentages of normative quartz, orthoclase, albite, nepheline, leucite and kalsilite. In addition DI is a measure of the "basicity" of the rock.

On the basis of grain-size, the rocks are divided into four groups, *viz.* coarse 5—30 mm, medium 1—5 mm, fine 0.05—1 mm, and dense (aphanitic) <0.05 mm. A subdivision into fine medium-grained *etc.* has also been used.

PRINCIPAL GEOLOGICAL UNITS OF NORTHEASTERN BLEKINGE

The Precambrian of northeastern Blekinge shows a broad chronological development. Four geological units can be recognized, which structurally, mineralogically and chronologically are distinguishable from each other: 1, the Coastal gneisses; 2, the Older granitoids; 3, the Younger granitoids; and, 4, the Youngest granitoids.

The early gneisses, which occur only in the Older granitoid terrain, are the oldest unit of the investigated region. These rocks display a wide compositional and textural variation. Folding, recrystallization and partial migmatization make it difficult to identify the origin of this rock sequence. No primary structures and textures are preserved.

The Older granitoid complex makes up the largest area of the studied region. The Older granitoids grade from tonalites to predominant granodiorites. These rocks are in general regionally foliated/lineated, but they have locally been subjected to reactivation. The presence of an "early" generation of metabasite dikes, which can be traced as aligned blocks in the granitoids, demonstrates clearly that a reactivation process has affected the Older granitoid group.

The Younger granitoids, which occupy the northeastern section of the map area, form a differentiated sequence, ranging from tonalites to granites *(sensu stricto)*. This granitoid group differs from the Older one in its chronological position and is separated from it by one or several generations of metabasite dikes.

The Youngest granitoids occur in two diapiric massifs, consisting of coarse-grained megacryst-bearing granites—granodiorites. In contrast to the earlier plutonics, they are accompanied by numerous pegmatites and lokal migmatization. The contacts against the older plutonics are prevailing intrusive and cross-cutting.

REGIONAL GEOLOGY OF SOUTHEASTERN SWEDEN, WITH SPECIAL REFERENCE TO THE AGE RELATIONS

Hitherto available isotopic age data from Blekinge include four K/Ar determinations performed by Russian geochronologists[1] (discussed and interpreted by Magnusson 1960a, 1970), one U/Pb (Welin and Blomqvist 1966) and one Rb/Sr

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[1] The decay constant used by Gerling and Polkanov (1958) and Gerling (1961) was $\lambda_e = 5.50 \cdot 10^{-11} \mathrm{yr}^{-1}$. The approximate ages given within brackets are those obtained when using the current decay constants : $\lambda_e = 5.85 \cdot 10^{-11} \mathrm{yr}^{-1}$; $\lambda_B = 4.72 \cdot 10^{-10} \mathrm{yr}^{-1}$.

determination (Magnusson 1960a). A radiometric Rb/Sr dating project of Older and Younger granitoids in Blekinge is in progress (O. Larsen and U. Wiklander).

The oldest rock dated in the Precambrian basement of Blekinge is a Coastal gneiss collected NW of Karlskrona. Magnusson (1960a) gives here 1 560 m.y. (1 510 m.y.). Another gneiss sample, W of Karlshamn, has according to Magnusson (1970) an age of 1 280 m.y. (1 240 m.y.).

A similar isotopic age, 1 460 m.y. (1 410 m.y.), was obtained in an Older granitoid *("Tvinggranit")* cropping out ESE of Rödeby.

No isotopic age determination has been made on the Younger granitoids in Blekinge, but one Småland granitoid at Torsås, situated in the eastern extension of the Younger granitoid province outside the mapped area (see inset on Plate 1), has been dated by means of the K/Ar and Rb/Sr methods (Magnusson 1960a). The figures obtained are 1 475 m.y. (1 420 m.y.) and 1 430 m.y. respectively.

A specimen of an Eringsboda granitoid, belonging to the Youngest granitoid group of Blekinge and sampled W of Holmsjö village (see Plate 1), has according to Magnusson (1960a) a K/Ar age of 1 420 m.y. (1 380 m.y.). This figure should be compared with the U/Pb datings (Welin and Blomqvist 1966) on a pegmatite at Pänseryd, associated with the Youngest granitoid plutonism, and on an aplite vein allied with the Romele granite in Scania, regarded to be contemporary with the Karlshamn—Eringsboda granitoids (Hjelmqvist 1934, p. 170), which together define an isochron of 1 455 m.y.

K/Ar determinations of two diabase dikes (Tärnö and Hoby) have given a very approximate age of 800 m.y. (I. Klingspor, personal communication).

The Västanå complex, which is situated in the northeastern part of Scania and adjoining parts of Blekinge, at the extreme southern end of the Småland granitoid province (see Fig. 1), is composed of metamorphosed quartzites, conglomerates, schists, dense gneisses of various origin and volcanic rocks (Bäckström 1897). All three polymorphs of Al_2SiO_5, andalusite, sillimanite, and kyanite, have been reported in metaquartzites from the Västanå complex (Bäckström 1897).

Structural investigations performed by W. Andersson (personal communication) have revealed that the rock complex has been deformed by at least two major folding phases.

The contact relations between the Västanå complex and the surrounding gneisses, in part Coastal gneisses, are described as transitional according to Bäckström (1897) and R. Norin (1936).

One K/Ar age determination of a mica-quartzite has given 1 240 m.y. (1 200 m.y.; Magnusson 1960a). This figure must be explained as an effect of later metamorphism which has more or less strongly influenced the area. Although the exact age of the formation of the Västanå complex is unknown, it seems to be more than 1 700 m.y.

The rock unit exposed in the northeastern part of the mapped area (see Plate

Fig. 1. Generalized geologic map of southeastern Sweden (mainly after *Carte géologique internationale de l'Europe*, Unesco 1966).

1 and Fig. 1) is actually a small portion of an extensive more or less continuous belt of granitoid rocks ("older" and "younger") which extends northwards to south central Sweden, where it reaches the boundary of the Svecofennian orogenic region (see *e.g.* Gorbatschev 1971b). The huge granitoid mass is often referred to as the "Småland granite complex". The regional geology of the region and its environs has been studied by numerous workers. The granitoid complex has a batholithic size with an approximate length of 200 km and a width of 140 km. It essentially shows the character of a post-deformational intrusion. The "younger" granitoids appear as discrete plutons, either with sharp or transitional intramassif contacts.

As to the relations between the Younger and Older granitoid units in Blekinge, the contact seems to be confined to an important, large and persistent tectonic zone (see Plate 1), with a direction somewhat deviating from the strike of the regional deformation within the older basement (see p. 22).

The "younger" granitoid complex includes a variform sequence of rocks ranging from tonalites, through predominant granodiorites to granites *(sensu stricto).* Pegmatites are mostly lacking, however. Even in one single pluton rocks frequently vary considerably. In addition, small scattered basic bodies, generally considered as forerunners of the granitoids, are widespread within the Småland region.

Petrochemically, the granitoids reveal a slightly alkaline character compared with the synkinematic Svecofennian granitoids, which belong to a trondheimitic calc-alkalic compositional trend.

Within the "younger" granitoid terrain of Småland a large number of spatially distributed varisized rock segments of different ages and origin occur, such as supracrustal rocks and foliated basement granitoids (see pp. 14—15). In previous descriptions from the region the chronology was simplified to such an extent that the "older" foliated granitoids inside the post-orogenic unit were considered as metamorphic equivalents. As is well-known, this interpretation has later turned out to be incorrect (see p. 14). On the other hand, it is probable that parts of the "older" basement have been reactivated during the emplacement of the subsequent granitoids.

Hypabyssals of metabasite, porphyry (sometimes forming composite dikes) and different kinds of (meta-)diabases are occasionally met within the Småland region.

The time emplacement of the Småland granitoids, based on available geochronological Rb/Sr data, indicates a widespread temporal distribution, ranging from *c.* 1 840 m.y. (Röshoff 1973) to *c.* 1 700 m.y. (Priem and Bakker 1973; Åberg 1973). The Rb/Sr age obtained on post-orogenic granitoids from the Strålsnäs area, Östergötland, which are contemporary with the "younger" granitoids of the Småland region, is about 1 740 m.y. (Welin *et al.* 1966; Åberg 1973), whereas K/Ar datings on similar granitoids (Magnusson 1960a) yielded younger analytical ages (see p. 14).

The continuity of the Småland granitoid complex is disturbed by metamorphosed supracrustal rocks including volcanic as well as sedimentary rocks and raised to more or less high-dipping zones striking E—W to NW—SE (see Fig. 1). The age of the metasediments is unknown. Magnusson *et al.* (1963) report observations of quartzite fragments in Småland porphyries, indicating that the metasediments are older than the latter. Rb/Sr datings of the Småland porphyries have given 1 695 ± 20 m.y. (Åberg 1972). The metavolcanics, mainly consisting of acid porphyries (to a large extent ignimbrites) with associated tuffs and agglomerates (Holst 1885; O. Nordenskjöld 1894; Munthe and Hedström 1904; Persson 1973; Röshoff 1973), are older than the surrounding granitoids *(op. cit.)*. Gradations between volcanics and granitoids are common. The porphyries may locally appear as younger than the granitoid environment (O. Nordenskjöld 1900; Munthe and Hedström; Hedström and Wiman 1906; R. Norin 1959).

The age determinations of Småland granitoids made up to date have given somewhat higher ages than the porphyries, contrary to field observations. The interpretation of the available age data from the Småland region thus still causes much trouble, as will be evident from the following text.

SE of Lake Vättern we meet with the supracrustal Vetlanda complex (see Fig. 1), represented by conglomerates, quartzites, schists, limestones, basic volcanics, tuffs and tuffites. The Vetlanda complex is intruded by Småland granitoids (*e.g.* Magnusson *et al.* 1960; Röshoff 1973). The conglomerate of Malmbäck is of a particular interest because it contains pebbles of foliated granitoids (Holst 1885; Stolpe 1892), possibly of the same age as the granitoid basement exposed at Virserum and recently described by Hjelmqvist (1969). He demonstrates a primary depositional contact of supracrustal rocks on a granitoid basement, which is exposed in a belt eastwards from Vetlanda (Magnusson *et al.* 1962). A foliated granitoid specimen from this zone has given a K/Ar age of 1 560 m.y. (1 510 m.y.) according to Magnusson (1960a). Owing to lack of Rb/Sr age determinations, the chronological position of this basement granitoid should in general be regarded as uncertain in relation to the Svecofennian evolution. Another K/Ar dating at 1 750 m.y. (1 680 m.y.), originating from a Småland granitoid collected NNW of Vimmerby (see Fig. 1), was considered by Magnusson (1960a) as being a Svecofennian relic inside the post-orogenic granitoid complex. More recent mapping and dating (Röshoff 1973) have shown that the supracrustal rocks in the Lake Nömmen area, belonging to the Vetlanda complex, were deformed by at least two tectonic phases before the intrusion of Småland granitoids. The plutonic activity has given a Rb/Sr age of about 1 840 m.y. *(op. cit.)*.

At the northeastern boundary of the Småland granitoid province, the granitoids border on the Västervik complex (see Fig. 1), a metasedimentary sequence comprising predominantly quartzites, arkoses and feldspathic greywackes (see *e.g.* S. Gavelin 1960; S. Gavelin and Lundegårdh 1960; Elbers 1971). Several investigators have since long discussed particularly the age relation between the metasediments and the so called Loftahammar granite *(sensu lato)* in the Västervik area. In the beginning of this century A. Gavelin (1904, 1905, 1910) and P. J. Holmqvist (1905a, 1905b) had a long dispute on the relations between the foliated Loftahammar granite, basic rocks, metasediments and the regional migmatization. Still different opinions remain about the mutual age relations between the Västervik quartzite and the Loftahammar granite, as well as on the tectonic positions of the various granitoid types in the regional chronological scheme (*e.g.* Magnusson *et al.* 1963; Westra *et al.* 1969; Elbers 1971; Kresten 1971, 1972). Recent Rb/Sr datings[1] of the Loftahammar granite have given an age of roughly 1 700 m.y. (Priem and Bakker 1973; Åberg 1973). Comparing this figure with the Rb/Sr and K/Ar age measurements on biotites from the metasediments and the various granitoids (”older” and ”younger”), which have given approximately 1 460 m.y.[1] (Priem *et al.* 1969), it is not impossibly that late reheatings in the Västervik area and other parts of Småland can be correlated with the events of the post-Svecofennian plutonism, roughly between 1 500 m.y. and 1 300 m.y., in the districts of Scania—Blekinge—Småland. Alternatively, but less probably, these low ages may be explained as due to the Dalslandian tectogenesis (*cf.* Welin and Blomqvist 1966), which has strongly affected southwestern Sweden.

U/Pb age determinations on radioactive minerals in pegmatites and aplites from the Västervik region have yielded 1 745 m.y. An essentially lower Rb/Sr whole-rock age on a pegmatite, *c.* 1 510 m.y.,[1] was recorded by Priem *et al.* (1969).

The Almesåkra complex (of so called Jotnian age), mainly situated within the Småland granitoid province (see Fig. 1), comprises superimposed arenitic sediments, which are intercalated with sills and intersected by dikes of diabase (S. Gavelin 1931). According to S. Gavelin (*op. cit.; cf.* Eichstädt 1885), the complex has suffered from weak folding and thrust-faulting, possibly contemporaneous with the Dalslandian tectonization (Lundegårdh 1970). The absolute age of the sedimentary sequence is not known, however, but may be considered as approximately 1 300—1 100 m.y. The widespread geographical distribution of analogous Precambrian post-orogenic sediments in Scandinavia suggests an originally very large areal extension (*cf.* p. 70), this being confirmed by the isolated occurrences of xenoliths of sedimentary origin, probably equivalent to the Almesåkra sediment, in younger diabases, *inter alia* in Blekinge (*cf.* p. 67). During the deposition of the sandstones, the crust was affected by considerable faulting, which continued intermittently throughout the time of sedimentation. Later on, repeated movements along these tectonic zones may have occurred.

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[1] Swedish and Dutch geochronologists use different decay constants. In this paper all Rb/Sr ages are referred to the constant $1.39 \cdot 10^{-11} yr^{-1}$.

SYNTHESIS

The supracrustal complexes, Västervik, Vetlanda, and Västanå, although probably more widespread once, were the result of sedimentation and lava extrusion in isolated basins, but any correlation between them and similar rocks in southeastern Sweden must be tentative, especially due to lack of absolute radiometric age data (*cf.* Lundqvist 1968, p. 161).

Considering the age evolution of the Småland granitoids, only some generalizations can be made, because no detailed information is available from the region. As mentioned before, some minor parts of the granitoid province are supposed to be intimately related to the Svecofennian orogeny (*e.g.* the Loftahammar granite), and the major part is considered post-orogenic in regard to the Svecofennian evolution though comparatively closely connected with it (Lundqvist 1968). The emplacement of the subsequent granitoid group is postulated to be span over a fairly long period, comprising several successive plutonic phases and including reactivation of older rocks in the region (*cf.* Munthe and Hedström 1904, pp. 36—38; Koark 1969, 1970). The extrusion of the Småland porphyries ($\approx$ 1 700 m.y.) is assumed to have occurred at least in part simultaneously with the intrusion of the posterior granitoids (O. Nordenskjöld 1894, p. 23).

As evident from the reviewed isotopic age data of the Blekinge region (*cf.* p. 11) and adjacent parts of Sweden, there is a distinct radiometric peak at approximately 1 450 m.y., indicating that great part of the older basement in southeastern Sweden has been updated due to thermal influences caused by the emplacement of the Karlshamn—Eringsboda—Spinkamåla granitoids and probably also to some extent by Dalslandian metamorphism and tectogenesis (between 1 100 and 935 m.y.; *cf.* Magnusson 1960a; Welin and Blomqvist 1966).

Recent radiometric dating on granites from the island of Bornholm, situated in the Baltic Sea south of Sweden, has given K/Ar ages from 1 255 to 1 340 m.y. (O. Larsen 1971). According to the interpretation by Larsen (1971), some of the Bornholm granites belong to a period of post-Svecofennian plutonism equivalent with the Youngest granitoid plutonism in Blekinge.

Correlations between post-Svecofennian plutonism in the Baltic and Ukrainian Shields have been made by Semenenko *et al.* (1968). They refer to the similar distribution of radiometric ages (1 500—1 150 m.y.). This similarity has inspired Semenenko and his co-workers to identify an extensive Gothian—Ovruchian folding belt, stretching from the Ural mountains through Poland to southern Sweden. The postulated orogeny is considered to be preceded by the Volhynian orogeny (1 700—1 500 m.y.) in Ukraina. Apart from their idea of a ”Gothian” orogeny (*cf.* p. 101), which does not seem to have existed, it should be mentioned that other Russian workers (*e.g.* Vinogradov and Tugarinov 1961) have not accepted their conception of an Ovruchian orogeny.

Correlations of this kind between isolated parts of the Baltic and Ukrainian Shields, without detailed knowledge of the geological evolution of the regions, should be avoided.

PETROGRAPHIC DESCRIPTIONS

COASTAL GNEISSES

In the Older granitoid area west of Tving village occur narrow zones of heterogeneous gneisses, which probably are correlative with the Coastal gneisses in western and southern Blekinge (see Plate 1). Different opinions have been expressed concerning the age (see p. 6) and origin of the Coastal gneisses. Bäckström (1897) and R. Norin (1936, 1959) interpreted the gneisses as a deeper, progressively stronger deformed and metamorphosed part of the Västanå supracrustal complex, whereas Asklund (1947) considered them as fine-grained varieties of the Older granitoids.

The border relations between the Older granitoids and the gneisses within the mapped region are more or less unknown in the field, but photogeological observations indicate that the larger gneiss belt is separated from the granitoids by tectonic zones, striking sub-parallel to the main regional deformation. Concerning the appearence of the small "conformable" gneiss strip close to the Eringsboda massif the reader is referred to p. 44. In the vicinity of Tving village gneiss fragments are found within the Older granitoids. They are always in structural continuity with the country rock and decrease not only in abundance but also in size when proceeding away from the gneiss area.

The gneiss complex displays well discernible variations in composition, grain-size and texture. On the basis of areal distribution, the rock sequence has been divided into two main units, *viz.*, 1, quartzo-feldspathic gneisses, and, 2, biotite- and/or hornblende-bearing quartzo-feldspathic gneisses. In the field it is not possible to trace any transition between the different units. On the other hand, transitional types occur within single units.

Average mineralogical and chemical compositions of the Coastal gneisses are presented in R. Norin's paper of 1936. Two chemical analyses of a gneiss fragment enclosed in the Older granitoid terrain are given in Table 1: nos. 45—46 (p. 117).

The predominant rock types are greyish-reddish to grey, small-grained quartzo-feldspathic gneisses, in general with a planar preferred orientation of mica crystals. Potash feldspar megacrysts of moderate size are frequently observed, but because these post-folding porphyroblasts cannot be regarded as dominant characteristic features of the rocks, they have not been marked on the petrological map (Plate 1). Locally, the gneisses are rich in thin veins and schlieren of pegmatite and granite. Amphibolitic rocks display more or less parallel bands concordantly intercalated in the gneisses. The metabasite dikes of the investi-

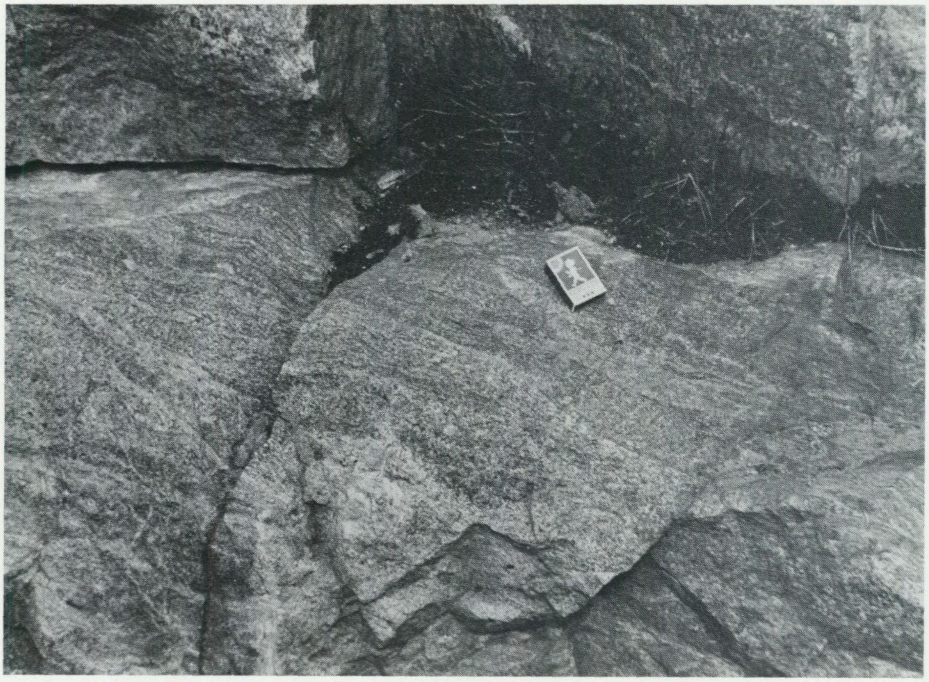

Fig. 2. Heterogeneous gneiss of banded type. Pegmatite-veining and small-folding. Hillerstorp (WC 291395).

gated area are not included in the gneiss group. Several dikes have been affected by folding (see p. 60).

The hornblende-bearing gneisses show good foliation and are often banded. The latter structure implies a more or less regular alternation of felsic and mafic bands (Fig. 2). In many of these rocks the amphibole produced during the first period of metamorphism is green hornblende, which as a result of subsequent retrograde metamorphism has been to some extent transformed into blue-green or nearly colourless amphiboles.

It has been difficult to state a sedimentary and/or volcanic origin of the gneisses, as subsequent metamorphism (see p. 95) and deformation have obliterated the primary textures and structures of the rocks. Judging from the appearence of zircons in the gneisses, it may be concluded that the rocks bear imprints of a complex history. As is well known, the shape of the zircon individuals has often been used as a criterion for the origin of their host rocks. During the microscopical studies of the gneisses, two different types of zircon have been encountered. The shapes and sizes of the zircons show considerable variations. Some of these are comparatively large (elongation ratio around 5), idiomorphic, sporadically slightly corroded, and zoned. Besides, it has been observed that several large zircon crystals enclose older irregular zircons. The elongated zircons do not show any association with biotite. The second type of zircon consists of small, more or less rounded, translucent grains, which preferentially occur within or closely connected with biotite.

At many places the gneisses show a small-folded appearance. (See Plate 1.) The whole sequence has undergone at least three folding phases, the F_2 phase producing the main regional structures dominated by NW-trending axes. F_1 folds occur as relics in the regional foliation (S_1), and F_3 folds are formed by the intrusion of the Eringsboda massif. In the western part of Blekinge, I. Larsson (1954) recognized a large-scale folding of the Coastal gneisses and the Older granitoids with N—S fold axes, plunging gently to the north. According to the same author *(op. cit.),* this folding phase ”cannot be connected with that of the Svecofennids, but must be compared with the gneiss-area of SW Sweden”.

OLDER GRANITOIDS

The large mass of plutonic rocks occupying the southern half of the map area (Plate 1), previously termed *”Tvinggranit”* and here collectively called Older granitoids, forms a small part of an extensive belt of moderately to distinctly foliated/lineated granitoids in Blekinge, which extends southwards of the Younger granitoid region from an E—W line between Flymen village in the east and to Lake St. Alljungen in the west. In the map area the medium- to coarse-grained, megacrystal Older granitoids are divisible into two main units: 1, plagioclase megacryst-bearing tonalites; and, 2, potash feldspar megacryst-bearing granodiorites. The most notable field criterion for the subdivision of the Older granitoid complex into tonalitic and granodioritic members is the distinctive reddish colouration of the potash feldspar megacrysts of the latter, in contrast to the tonalitic rocks which almost exclusively carry grey-white plagioclase megacrysts. However, the geochemical data of the granitoids demonstrate a much greater variation and heterogeneity than the mineralogy of the rocks (see p. 70). The plutonics form a differentiated sequence with predominant granodiorites. There is no sharp boundary between the different units. The tonalitic phase occupies only small parts of the Older granitoid region around the Yasjö massif (see Plate 1).

The frequency and distribution of the feldspar megacrysts are variable and seldom related to the deformation of the rocks (see below). Only one example of potash feldspathization along a mylonitic zone has been observed. It has a width of a few meters and occurs in the border granitoid (blasto-mylonite) south of Flymen village. In some places the megacrysts are very abundant, in others they are sparse or locally almost lacking.

The Older plutonics have been subjected to a threefold feldspathization. The earliest feldspar megacryst generation is plagioclase measuring 1—3 cm across

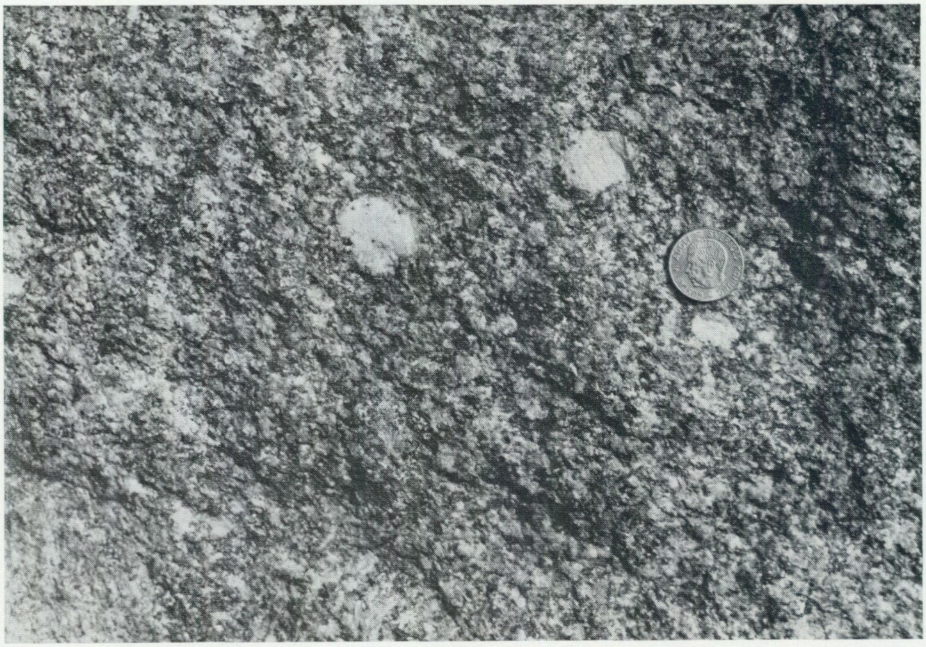

Fig. 3. Foliated Older granitoid of tonalitic composition with plagioclase megacrysts. 1.7 km ENE of Tving village (WC 303417).

Fig. 4. Foliated Older granitoid with pre-tectonic potash feldspar megacrysts. 1.7 km SE of Tving village.

Fig. 5. Foliated Older granitoid with pre- and post-tectonic potash feldspar megacrysts. Yasjön (WC 295442).

and predominantly developed in the tonalites (see Fig. 3). These megacrysts display prevailing deformation structures (see p. 27).

Two periods of potash feldspar porphyroblastic growth can be recognized in the granodiorites, *viz.* pre- and post-tectonical. The time relations between deformation and potash feldspar blastesis show interesting features. Pre-tectonical porphyroblastic growth of potash feldspar took place before the main intense deformation (Fig. 4), which resulted in an almost complete cataclasis of the granitoids. Whereas the pre-tectonic megacrysts have a preferred orientation in the plane of foliation, the post-tectonic ones are randomly oriented (Fig. 5). Post-tectonic blastesis is further shown by the existence of megacrysts in strongly deformed inclusions. This category of megacrysts is supposed to be genetically related to the potassium metasomatism operating during the emplacement of the Youngest granitoids. A more detailed description of the three chronologically different feldspar megacryst generations is given in the feldspar sections on pp. 84—95.

The tectonic position of the Older granitoids is somewhat disputable in relation to the petrogenetic and structural evolution of the Precambrian complex of Blekinge. It is to be noted that Bäckström (1897) pointed out that the granitoids in western Blekinge and adjoining parts of Scania were deformed contemporary with the supracrustal rocks of the Västanå complex.

The texture of the Older granitoids ranges from gneissic to massive with a predominance for the former development. The major deformation phase, which predates the formation of the Younger granitoids, gave rise to the dominant NW to WNW structural trends with high dips. There are considerable variations in the intensity of the regional schistosity throughout the area, and even locally differences in the degree of deformation occur. Generally, the granitoids show a progressively greater deformation but a decreasing intensity of metamorphism (retrograde metamorphism, see p. 95) when proceeding from south to north. Southwards, outside the map area, the inverse relations are found. The increasing effect of the deformation is seen particularly well in the metabasite dikes cutting the granitoids (see p. 60) and along the border of the Younger granitoid complex. It has also affected the shape of the basic inclusions. However, subsequent deformation phases have been recognized in the region. In several outcrops there are conflicting foliation directions indicating repeated tectonic movements. These refoliations are generally subparallel to the rectilinear boundary line between the Older and Younger granitoid complexes, which transects on a major scale the regional deformation. (See Plate 1.) Detailed studies of the structures along the boundary between the granitoid complexes have shown that the tectonic zones display sets of sub-parallel shear zones which become more intense and crowded when approaching the boundary. In addition the border rocks have been moderately to strongly mylonitized. The contact line proper is covered by till, which has prevented detailed studies, and it is not clear whether it is originally intrusive or tectonic. However, late tectonic activity has probably reactivated this discontinuity zone.

Along the boundaries of the Eringsboda—Yasjö massifs the Older granitoids have been plastically deformed (Fig. 6). As regards the contact relations between the Youngest and Older plutonics, the reader is referred to p. 44.

Basic inclusions are widespread throughout the granitoid region. The gradual increase of the regional deformation from south to north is also evident from the progressive variation in the shape of the basic inclusions. With increasing deformation the shape of the inclusions grades from ellipsoidal to lensoidal (see Fig. 7).

Most of the basic inclusions are supposed to be dike fragments, but some of the small mafic spots characteristical of the tonalites may be explained as remains from the partial melting of crustal material (*cf.* Piwinskii 1968).

During the emplacement of the Youngest granitoids, probably also to some extent during the formation of the Younger granitoids, parts of the Older granitoid region were subjected to considerable reactivation, resulting in strong recrystallization and remobilization, which are especially accentuated in the metabasic dikes. (See p. 60 and Fig. 30.) In the reactivated granitoid areas the planar/linear structure has become more or less obliterated. The metabasite dikes, which occur in at least six generations, have been used as chronological markers for separating different tectonic-plutonic events in the region. They will be considered in more detail on p. 58.

Fig. 6. Plastically deformed Older granitoid along the border of the Eringsboda granitoid massif. Alnaryd village.

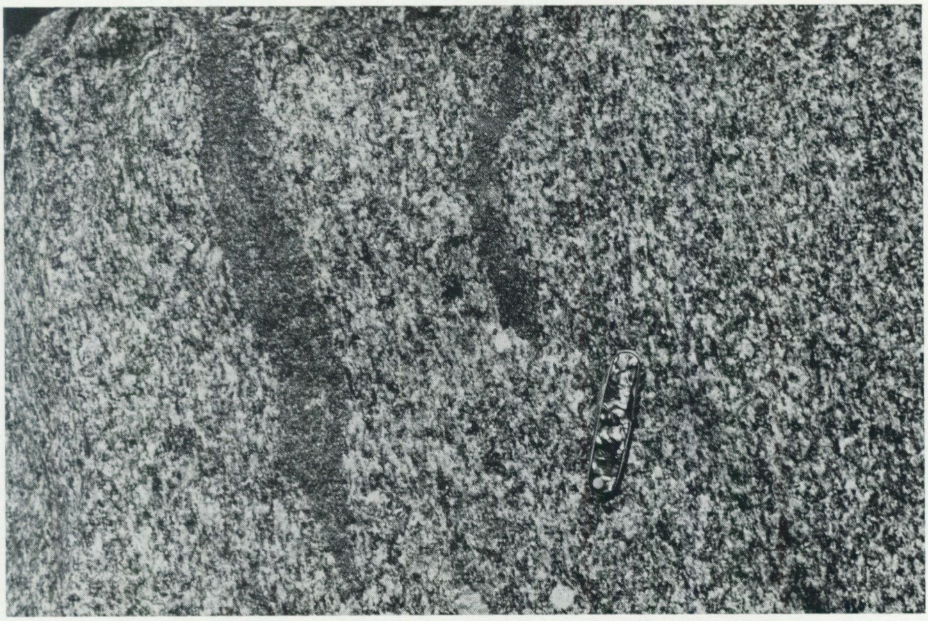

Fig. 7. Foliated Older granitoid (tonalite type) with strongly deformed basic fragments. 1.7 km ENE of Tving village (WC 303417).

Modal (see Fig. 36 on p. 71) and chemical analyses of the Older granitoids are presented in Tables 1—3: nos. 1—9.

The principal mineral assemblages are plagioclase, quartz, potash feldspar, biotite, and hornblende. Subordinate or accessory minerals are most frequently sphene, apatite, zircon, orthite, rutile, and opaque minerals. Secondary minerals are sericite, epidote, chlorite, calcite, and prehnite.

Quartz shows as a rule a variform development. It has generally been crushed/fractured (see Fig. 8) and forms aggregates. In strongly deformed rocks it is granulated and appears as lenticular agglomerated streaks. Reactivated granitoids (Fig. 9) contain rutile-bearing quartz, occasionally forming sagenitic quartz. A "secondary" quartz generation has been found as tiny, clear, subrounded grains in biotite and hornblende (see p. 81). Furthermore, quartz appears as intergrowths with biotite and/or hornblende.

Myrmekite is more prevalent in the granodiorites than in the tonalites, although it is generally not very frequent.

The coexisting plagioclases in the Older granitoids frequently show wide compositional variations. (See also chemical analyses in Table 7.) Three rather well-delimited compositional frequency maxima have been recorded in the tonalitic plagioclases: 1, An_{36-38}; 2, An_{27-28}; and 3, An_{0-5}. The optimal anorthite value refers to the megacrysts, which generally display a faint and patchy core zoning with a maximum anorthite content of 40 % (determined by means of refractive index measurements; *cf.* p. 8). The outer parts commonly show a weak normal zoning from *c.* An_{34} to An_{32}. Inverse zoning has been observed in only one of the examined rock specimens with a core of An_{22} and a marginal zone of An_{24}. Vance (1965, 1966) described so called patchy zoning and explained it as the result of a two-stage replacement process involving resorption followed by crystallization of a more sodic feldspar at lower pressure (*cf.* Raase and Morteani 1968; Raase 1969).

In this context it is worth noting that recent works of Hunahashi *et al.* (1968) as well as Kim and Hunahashi (1972) indicate that the plagioclases of Småland granitoids show a greater range ofcompositiona l variation than those of primorogenic to late-orogenic Svecofennian granitoids. In addition the Småland granitoids display a more distinct frequency maximum.

Locally, there is a distinct orientation of biotite crystals around larger plagioclases, indicating a late growth of the latter.

The plagioclases of comparatively anorthite-rich composition are moderately to highly sericitized. As already mentioned, the Older granitoids reveal a cataclastic foliation along the boundary towards the Younger granitoid complex, and this tectonization is clearly demonstrated in the deformation (see below) and alteration of the plagioclases. There is also a gradation in colouring of the plagioclases from greyish-whitish to greenish when passing from slightly to intensely deformed rocks, due to the strong epidotization of the feldspars, which

Fig. 8. Older granitoid of tonalitic composition. Deformed plagioclase megacryst (left below). 2 nic. 1.7 km ENE of Tving village (WC 303417).

Fig. 9. Reactivated Older granitoid with large secondary quartz grains. 2 nic. Spjutsbygd (WC 350406).

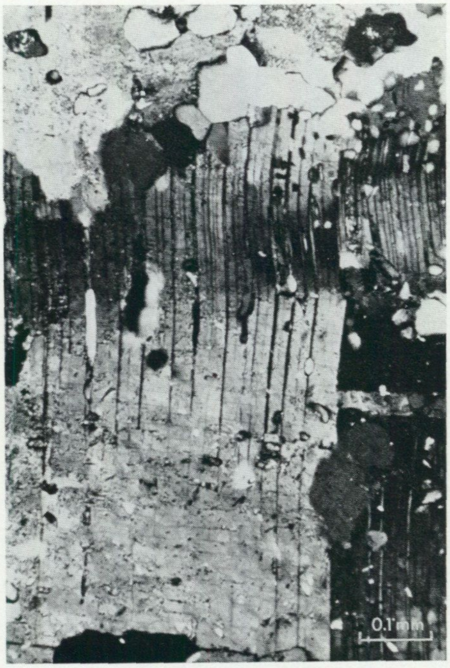

Fig. 10. Kinked plagioclase crystal in a deformed Older granitoid. 2 nic. Allsjön.

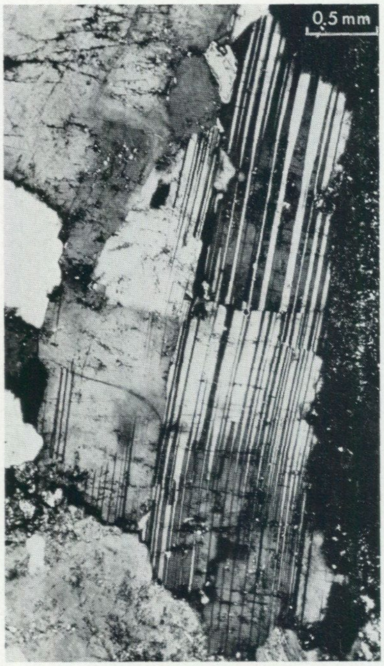

Fig. 11. Secondary albite twinning in a deformed plagioclase crystal from an Older granitoid. The plagioclase crystal shows vanishing albite lamellæ and offset structures (centre). 2 nic. S of Porsgöl.

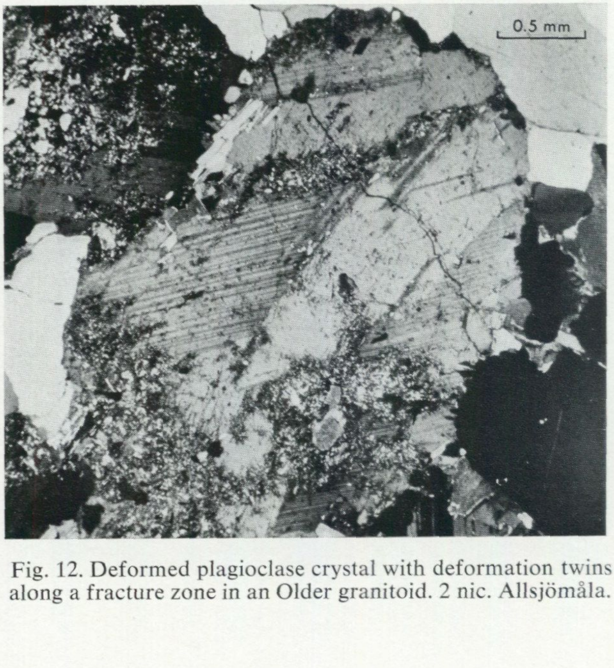

Fig. 12. Deformed plagioclase crystal with deformation twins along a fracture zone in an Older granitoid. 2 nic. Allsjömåla.

is accompanied by the formation of sericite and calcite. Many petrographers have described and discussed glide twinning (=secondary twinning, deformation twinning) in plagioclases (*e.g.* Vance 1961; Vogel and Seifert 1965; Borg and Heard 1969; Capedri 1970). Vance (1961) distinguished two types of glide twins on basis of petrographical texture criteria. Similar deformation structures have been recognized under the microscope on plagioclases of the deformed Older granitoids, especially in rocks from the tectonic zone separating the Older and Younger granitoid complexes. They are illustrated in Figs. 10—12.

The observed plagioclases generally lack zoning or are weakly zoned, and a hiatal grain-size distribution between the matrix and the porphyroclasts is typical in the strongly deformed rocks. The frequency of multiple twinning and the degree of deformation of the plagioclases are highly variable. The intensity of deformation ranges from kinking without substantial recrystallization (Fig. 10) to fracturing with subsequent development of secondary twinning (Fig. 11). However, most plagioclases display wedge-shaped vanishing twin lamellæ, indicative of secondary twinning formation and elimination of primary twinning (see Fig. 11; *cf.* also Vance 1961, p. 1110; Smithson and Barth 1967, p. 29). Fig. 11 shows a plagioclase crystal with offset structures along a fracture, where the lamellæ are terminating at the fracture and are differently distributed on both sides of the fracture. Consequently, the twinning postdates the fracture. Another kind of deformation twinning is demonstrated in Fig. 12. In this case the development of secondary twins has been controlled by a broad shear zone and is obliquely superimposed on more or less obliterated primary ones. In addition all plagioclase megacrysts in the tonalites have been deformed implying the development of granulation or secondary twinning structures. The granulated megacrysts are composed of a mosaic containing numerous small semi-equigranular grains. The interstices and the grains are filled and overgrown by potash feldspar. The microfabric of a plagioclase megacryst with secondary twinning and impregnation of potash feldspar is depicted in Fig. 8.

Many plagioclase grains have clear and sericite-free sodic rims along the contacts with potash feldspar. Comparable rims are found around inclusions of biotite, chlorite, and quartz.

Antiperthite is present only in the granodiorites.

Perthitic potash feldspar occurs in the granodiorites as irregular masses which enclose and replace plagioclase and other minerals, and as large subhedral to anhedral, mostly poikilitic megacrysts. Detailed studies of the megacrysts and their surroundings suggest that the megacrysts have been developed at a late stage in the history of the rocks, and thus may be termed porphyroblasts. Potash feldspar also occurs locally as scattered blebs with haloes of sodic plagioclase and enclosed in plagioclase individuals. The tonalites contain interstitial potash feldspar. The majority of the optically examined porphyroblasts consists of cross-hatched microcline which is confirmed by X-ray obliquity measurements (see p. 91). However, in a rock specimen collected close to the Yasjö massif (WC 308420) the recorded optical parameters of one single perthitic megacryst without cross-hatching have given values characteristic for orthoclase. Determinations of $2V_{\times}$ and $X' \wedge [100]$ on (001) fall in the range 72—77° and 6—10°.

Different generations and types of perthite are frequently met with, and the size and texture of the exsolved/replaced albite lamellæ are quite variable.

Antiperthite is present only in the granodiorites.

Biotite, pleochroic from straw-yellow to dark brown, is the principal ferromagnesian mineral in the Older granitoids.

Major element contents of four biotites are given in Table 4, and the results are discussed on p. 82.

Biotite occurs as ragged flakes, often clustering together with hornblende and sometimes replacing it. However, there is also thin section evidence indicating the reverse age relationship between coexisting biotite and hornblende (see p. 81). The biotite has in part been replaced by potash feldspar, quartz, chlorite, and prehnite. In contrast to the biotites of the Younger granitoids in the map area, these biotites lack a sagenitic pattern of rutile/sphene (see p. 33), whereas they contain numerous minute irregular grains of sphene along the cleavage planes, especially in the kinked individuals. This may be a result of titanium exsolution from biotite during cataclasis, causing the formation of sphene (*cf.* Hsu 1955, p. 253).

Moreover, the biotite contains inclusions of mainly zircon, surrounded by pleochroic haloes. Occasionally, the zircons show a zonal distribution in the basal sections of the biotites.

Common alteration products are chlorite and epidote.

Hornblende occurs as individual well-formed crystals but more frequently forms ragged aggregates, many of which poikilitically enclose grains of quartz, biotite, and opaque minerals. Larger grains display pale-coloured cores with minute quartz inclusions (Fig. 13). According to Taubeneck (1964, 1967) these textural features indicate an advanced stage in replacement of augite by hornblende (*cf.* p. 81). However, in the present case no relic pyroxene has been encountered.

Two complete hornblende analyses are given in Table 5.

Sphene is the most frequent accessory or subordinate constituent of the Older granitoids. Often it appears as megascopical grains with the characteristic acute rhomb cross-section. In general the sphene occurs in association with biotite and hornblende. The abundance of sphene in the biotite suggests the presence of a titanium-rich biotite prior to recrystallization.

Orthite has a widespread regional distribution as an accessory component of the granitoids and gneisses of Blekinge (*cf.* Bäckström 1897, pp. 5, 8, and 57; and p. 47 in this paper). Most frequently it attains remarkable sizes (Fig. 14) and is many times larger than the individual crystals of any other accessory mineral

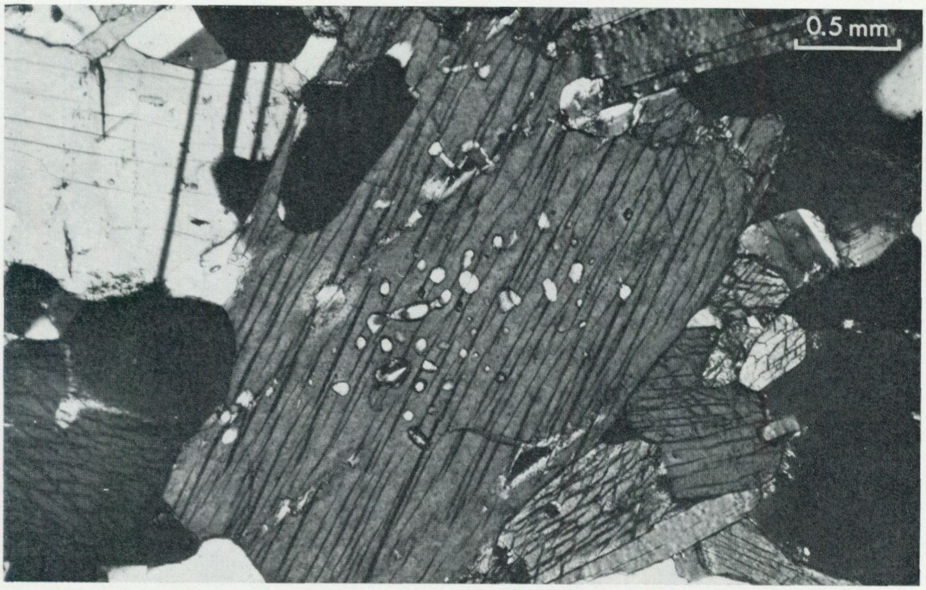

Fig. 13. Hornblende in reactivated Older granitoid. Small sub-rounded quartz grains, partly surrounded by bleached zones, lying mainly in the centre of the hornblende crystal may indicate a secondary origin for the amphibole. 2 nic. Viö.

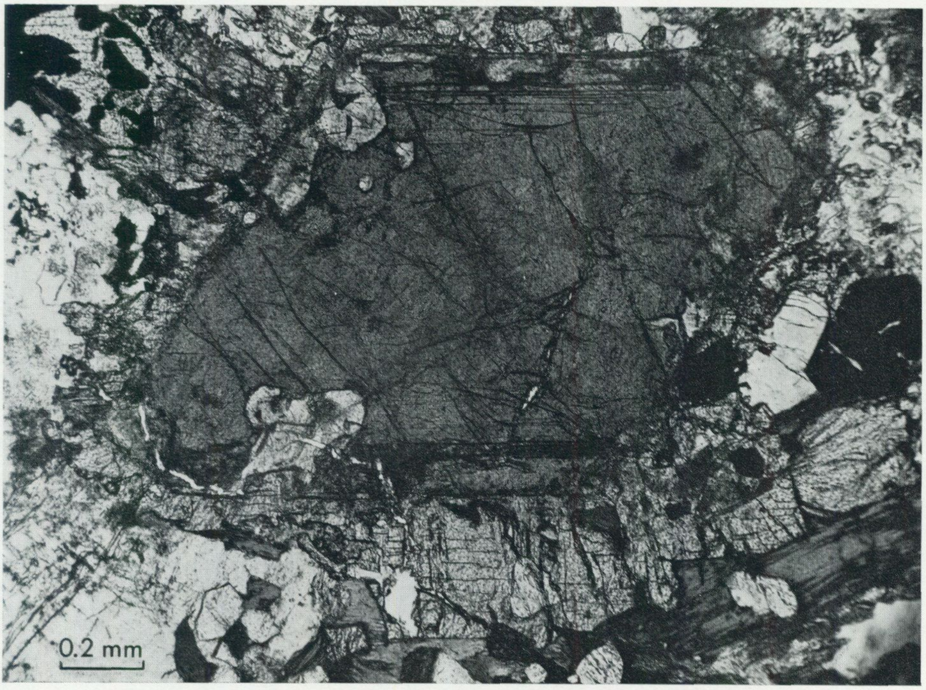

Fig. 14. Idiomorphic orthite crystal rimmed by epidote in Older granitoid. Note the zoning and cracking of the orthite. 1 nic. Gagnekulla (WC 423417).

in the same rock, with the exception of sphene. In northeastern Blekinge orthite shows a preferential association with the reactivated parts of the Older granitoid region. In thin section, orthite displays different modes of occurrence and size. Small, anhedral to subhedral orthite crystals, which make up the bulk of the orthite in the rocks, show a close association with biotite, bearing a replacement relationship to this mineral. On the contrary, large euhedral to subhedral (post-tectonic?) orthites (see Fig. 14) do not exhibit any relation to the principal rock-forming minerals. As a rule they show a well-marked zonal structure which may indicate compositional variations within the crystals.

A characteristical development is a more or less pronounced metamictization of all examined orthites.

Around or inside the orthites are found frequent rims and replacements by epidote.

No conclusive special genetic significance can be drawn from the genesis and the relative age of crystallization of the orthites during the complex history of the polymetamorphic granitoids, but some brief tentative suggestions will be made. Orthite of typical accessory-size is assumed to be genetically associated with the biotite. On the other hand, the larger orthites are believed on geological and textural grounds to have formed by late emanations from the Youngest granitoids, which are comparatively rich in RE, such as uranium and thorium (see p. 47).

YOUNGER GRANITOIDS

The northeastern part of the map area (Plate 1) is mainly occupied by various granitoids, here designated as Younger granitoids, and is considered to be an offset of the ”younger” Småland granitoids. The granitoids were emplaced after the last general deformation phase affecting the Coastal gneisses and the Older granitoids and can therefore be classified as post-tectonic. Characteristically, the granitoid group comprises many textural and compositional varieties, ranging from tonalite to leucogranite. For convenience the rock sequence has been subdivided into six sub-groups, most of these representing petrographically variable ”suites” with one predominating rock type. Although some of the sub-groups are closely associated in the field and may prove to be genetically related to the complex, it seems advisable here to consider them separately. The mutual relations between the different rock types are partly known. Some types represent individual intrusions, the contact relations of which towards the country rocks can be exactly established in the field, whereas others show complicated interrelations, such as hybridization.

Contrary to the Older granitoids, the Younger granitoids are only locally deformed, weakly metamorphosed, and recrystallized.

The internal parts of a few plutons exhibit conspicuous breccias of older rocks, where several of the sub-angular fragments do not resemble the country rocks in any respect. (See Fig. 29 on p. 57.)

Aplitic and pegmatitic differentiates are sparse members of the rock assemblage of the region.

As earlier mentioned, the extreme southern border of the Younger granitoid complex is probably in faulted contact with the Older granitoid block. However, the lack of outcrops in this critical area, which is largely covered by Pleistocene deposits, has prevented the establishment of the exact nature of the contact.

An earlier basic rock group, represented by heterogeneous gabbroids and dioritoids, occurs in varisized bodies throughout the granitoid terrain (see Plate 1 and p. 54).

The ”younger” Småland granitoids are thought to have crystallized from relatively anhydrous anatectic magmas (Lundqvist 1968; *cf.* also Sijperda 1968) developed during the Svecofennian period but erupting outside the orogenic region, where the crust was subjected to tension, resulting in fracturing and melting. This anatectic model, originally suggested by Lundegårdh (1967, Fig. 8, pp. 20—21), and the hitherto available radiometric age data of the ”younger” Småland granitoids (see p. 13) are in agreement with Middlemost's (1969, 1971) concept of syntectic magmas. He *(op. cit.)* pointed out that ”the period during which most syntectic magmas are generated does not have to coincide with the period of maximum orogenic intensity, because it takes a considerable time for the crust to adjust to a new thermal regime”.

Piwinskii (1968) as well as Piwinskii and Wyllie (1968) have summarized the major hypotheses regarding the formation of batholithic rocks by igneous processes. On the basis of their experimental works on synthetic and natural rocks of the Sierra Nevada batholith they suggested that the batholithic granitoids are the result of hybridization of a partly crystallized and differentiated gabbroic magma, with anatectic granitic magma in the lower crust derived from the melting of crustal material.

Tonalite

Dark grey, fine medium-grained tonalite constitutes two comparatively large massifs, one situated NE of Holmsjö and another W to SW of Ledja (see Plate 1). Tonalite varieties have also been discovered in small quantities around some basic plutons, *e.g.* at Sillhövda Halt. At these places the rock type appears as not mappable units. Generally, the tonalite is a homogeneous rock, and it has a massive texture.

The small elongated tonalite body cropping out NE of Holmsjö has at various places been cut by dikes of light grey, fine-grained granite and reddish aplite (see p. 42).

The irregular tonalite massif situated to the west and southwest of Ledja village

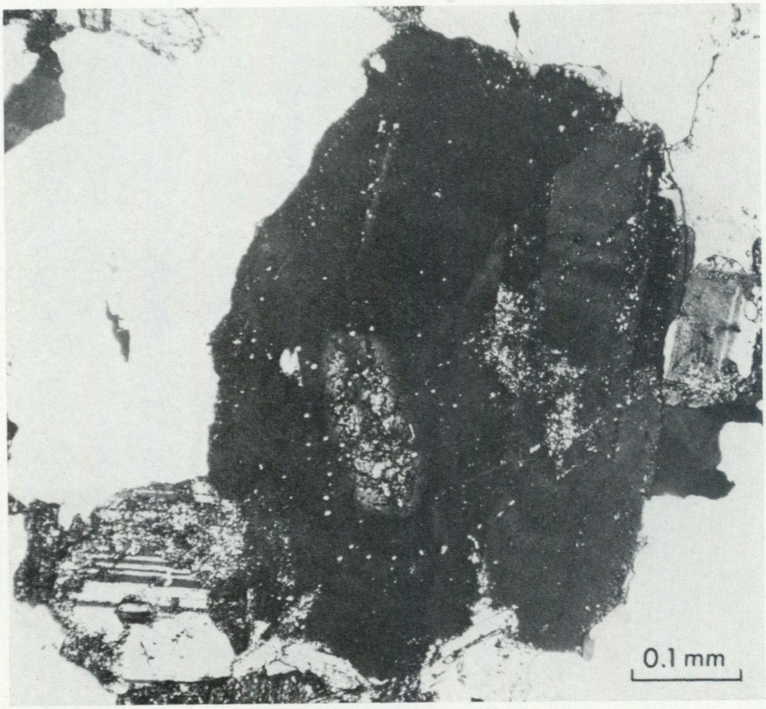

Fig. 15. Synneusis texture among plagioclases in a Younger tonalite specimen. Two attached plagioclase crystals with individual core zoning but coincided overgrowth rim zoning. 2 nic. 1 km NW of Ledja (WC 400533).

is in contact with the red-grey porphyroblastic granodiorite (see p. 35) to the east. Contacts against the reddish medium-grained granitoid complex (see p. 36) in the west are lacking. Some tonalite outcrops to the south contain potash feldspar megacrysts, probably originating from the surrounding granitoids.

The chemical and normative compositions of a tonalite specimen (no. 13) are listed in Tables 1 and 2. Modes of representative samples are given in Table 3. Differentiation Index is around 59.

The tonalite has a hypidiomorphic-granular texture and is essentially composed of plagioclase > quartz > biotite > hornblende.

Plagioclase makes up about 64 per cent by volume of the whole rock and forms subhedral to euhedral tabular, more or less unaltered crystals. It is characterized by normal zoning (*cf.* Vance 1962). The central body is in general zoned within the limits of An_{30} — An_{40}. Many individual grains are zoned within determinable limits of as much as 12 per cent An. In some specimens the plagioclase shows more than twelve zones. A few crystals display an unzoned core with patchy extinction and lacking twinning.

Twinning is abundant, and the most common twin laws in order of abundance are: albite, Carlsbad and pericline.

Synneusis textures among the plagioclase crystals (Fig. 15) are common phenomena in this rock type, indicating that the crystals have once been suspended in a melt (Vogt 1921). The attached plagioclase crystals often show irregular composition planes, which according to Vance (1968, p. 8) is due to that ”the initial planar surface of attachment is succeeded by a more irregular boundary arising from the interference of adjacent crystals as they compete for growing space”. Many of the involved crystals exhibit zonal overgrowths in the outermost parts, but each individual crystal has its own core (Fig. 15). This texture presumable resulted from the coalescence and growing together of two originally separated individuals.

Along contacts to potash feldspar, secondary sodic rims have often grown on the surfaces of the sub- to euhedral plagioclase crystals. Mostly the rims display myrmekitic intergrowths with fine quartz rods.

Quartz is anhedral and makes up *c.* 11—12 per cent by volume. It occurs either as single crystals or as crystal aggregates. The quartz is in part strongly undulatory and shows deformation textures, except for the younger quartz formed inside biotite and/or hornblende, which lacks wavy extinction and shows no evidence of strain.

Biotite amounts to 10—15 per cent by volume, as a rule forming ragged flakes with pleochroism from dark brown to light yellow. It has often been strongly corroded by plagioclase and potash feldspar. The biotite has to a minor extent been altered to chlorite minerals. Sometimes penninite with anomalous blue interference colours forms lamellæ alternating with fresh biotite in the same individual.

Sphene grains, partly oriented as strings of pearls, are common in the biotite and its alteration products. In addition, tiny needles of rutile and/or sphene with a sagenitic texture are observed in more or less chloritized flakes of biotite (see p. 35 and Fig. 16).

Locally the biotite is poikilitic, enclosing quartz.

Lensoidal aggregates of prehnite are noted as rare constituents.

Enclosed apatite and zircon may show dark pleochroic haloes.

Hornblende is of the common green type and exhibits anhedral outlines. Extinction angles (Z/c) range from 16° to 20°. The amount of hornblende varies from a few per cent up to 10 per cent. It is found either as fresh crystals, containing poikilitic inclusions of minute quartz grains, or in different stages or alteration to biotite and/or chlorite. The association with poikilitic quartz may indicate a transformation from a primary hornblende to a metamorphic one.

Intergrowths between hornblende and biotite are seldom visible.

As in the biotite, titanium minerals among the breakdown products bear evidence of a comparatively high titanium content in the amphibole.

Potash feldspar occurs in amounts less than 3 per cent and is mostly interstitial. The majority of crystals displays a microcline grid and are perthitic. The potash feldspar has affected corrosion of adjacent plagioclase and mafic minerals. It may also appear as small blebs around enclosed microlites, especially zircon, in plagioclase crystals. In this case, the microlites seem to have served as crystallization nuclei of the growing potash feldspar.

Subordinate constituents (excl. potash feldspar) are chlorite and epidote minerals.

More widely distributed and abundant accessories are sphene, apatite, rutile, opaque minerals, zircon and muscovite, whereas orthite occurs only locally.

At some localitites plagioclase and biotite display deformation textures, manifested by bending and fracturing of twin lamellæ.

Granodiorite (-tonalite)

The Younger granitoid complex also includes grey, (coarse) medium-grained, semi-equigranular granodioritic to tonalitic rocks which form one of the most important rock types of Småland, distinguished by Hummel (1877a, 1877b) and called ”grey Vexiö granite”. Several minor heterogeneous bodies of this rock type occur in the map area (see Plate 1). Characteristically, they are associated with extensive hybridization and contain numerous very fine-grained dioritic inclusions ranging up to a few decimetres in size. The transition from tonalite to granodiorite is accomplished by an increase in the amount of mafic minerals. The different rock varieties grade into each other over distances from 1 m to several hundreds of metres.

The grey granitoids of intermediate composition are evidently older than the reddish granitoids in the area, though they are cut and brecciated by the latter (*e.g.* at Nävragöl village). Along the road between Strömsberg and Ledja which traverses the Younger granitoid region, there are several outcrops showing features that indicate a distinct difference in age between the intermediate and acid granitoids. These features are subrounded tonalitic inclusions with dark margins lying in reddish more felsic granitoids.

Analysis no. 10 in Tables 1—3 gives the chemical and mineralogical compositions of a representative granitoid specimen. For discussion of the petrochemistry, see p. 70.

The rock consists of zoned antiperthitic plagioclase (An_{15}—An_{35}) sometimes with rims of more sodic composition, quartz, perthitic potash feldspar, biotite, and green hornblende. Approaching the dioritic contacts (see above) the granitoid becomes progressively enriched in hornblende. Subordinate minerals are chlorite and epidote, and accessories in common with the tonalite described on p. 31.

Granodiorite, megacryst-bearing

The coarse medium-grained granodiorite mass outcropping in the surroundings of Ledja village (see Plate 1) appears rather homogeneous on the scale of an outcrop. The rock is reddish grey to grey. Reddish potash feldspar megacrysts, averaging 0.5—2 cm in diameter, are scattered through the rock. The megacryst content varies from about 10 to 15 per cent by volume. The chemical composition of a megacryst is shown in Table 7: no. 4.

A characteristic macroscopical feature of this rock type is a faint blue-colouring of the quartz (*cf.* Ljunggren 1954, pp. 68—70).

Locally the Ledja granitoid is spotted by small clusters of mafic minerals (*cf.* Fig. 17).

Analysis no. 14 in Table 1 gives the chemical composition of the investigated rock samples.

In thin section the granitoid displays a hypidiomorphic granoblastic texture.

Quartz makes up *c.* 26 per cent by volume of the bulk. It is usually aggregated. The individual grains display micro-fractures.

Plagioclase (subhedral) is the dominant feldspar, amounting to about 44 per cent by volume. It has a maximum anorthite content of 28 %. Many plagioclase crystals contain sericite flakes, which are zonally arranged around a core section made up by epidote grains. This phenomenon indicates a primary zoning of the feldspar. Rarely a distinct zoning is observed in the plagioclase grains examined. Part of the plagioclase has often been replaced by potash feldspar. The degree of replacement varies from grain to grain.

Antiperthite is as a rule less frequent.

Potash feldspar is present as megacrysts and in the groundmass. The total content amounts to about 18 per cent by volume. The mineral is always slightly perthitic. The megacrysts contain inclusions of plagioclase and biotite. The border zones of the plagioclases have usually been albitized and myrmekitized.

The recorded obliquity value is intermediate (Table 7: no. 4).

Biotite is in part the only dark mineral present (*c.* 10 % by vol.). Hornblende, if present, is a subordinate constituent in the rocks exposed around Ledja village. The biotite has a brownish-greenish colour, indicating a high total Fe content (see p. 84). One biotite analysis (no. 4) is presented in Table 4. Alteration of the biotite to chlorite is frequently met with. During this alteration process, titanium has been exsolved and crystallized as rutile and/or sphene. The basal sections of the biotites and chlorites exhibit a conspicuous sagenitic texture, forming a triangular lattice of slender crystals of rutile and/or sphene intersecting at angles of 60° as illustrated in Fig. 16. Generally, sagenitic texture is referred to rutile, but detailed studies of sagenitic inclusions in biotites by microprobe technique have proved that in many cases these inclusions are not rutile but sphene (Niggli 1965). In the present case (see Fig. 16), two generations

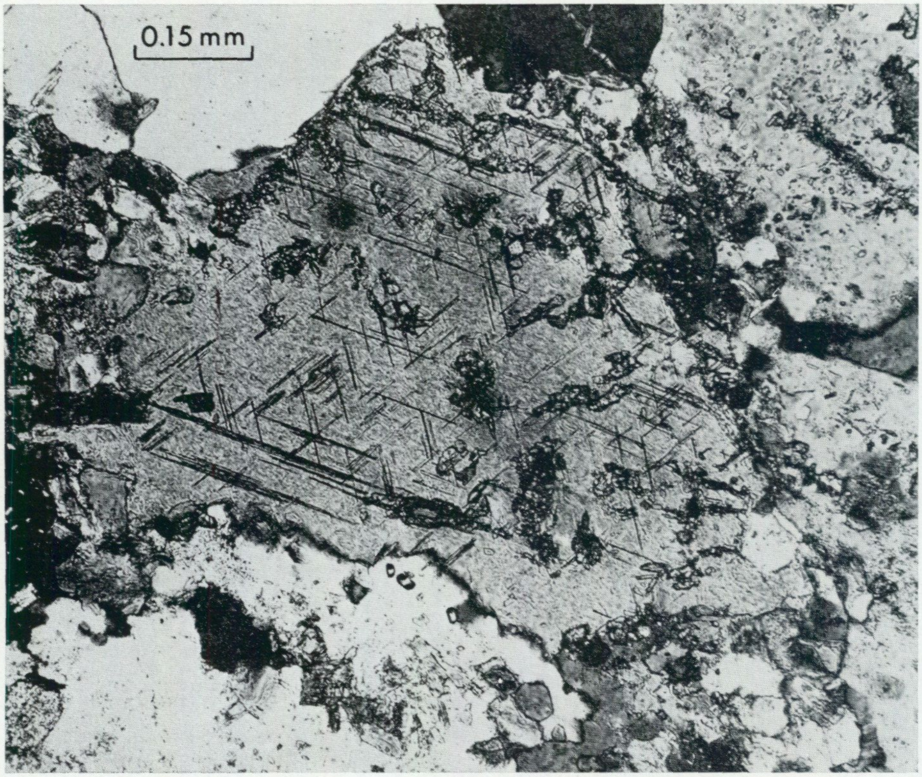

Fig. 16. Basal section of biotite with sagenitic texture in a Younger granitoid. Note the two generations of Ti-minerals. 2 nic. Ledja (WC 407527).

of Ti-minerals are coexisting. The first generation consists of tiny reticulated crystals with oblique extinction or lack of complete extinction. The latter feature may probably by interpreted as an interference phenomenon. The optical data virtually suggest that the first exsolved mineral is sphene (*cf.* Niggli 1965), but positive identification must await a chemical analysis, whereas the second generation of inclusions has been verified to consist of sphene.

Accessories are epidote minerals, sphene, rutile, zircon, apatite, prehnite, pumpellyite, orthite and metallogenic opaque minerals.

Granite—granodiorite, mostly porphyritic

The main part of the Younger granitoid area is occupied by red granites showing moderate development of megacrysts (Fig. 17). These granites occasionally give place to medium-grained granitoids lacking potash feldspar megacrysts.

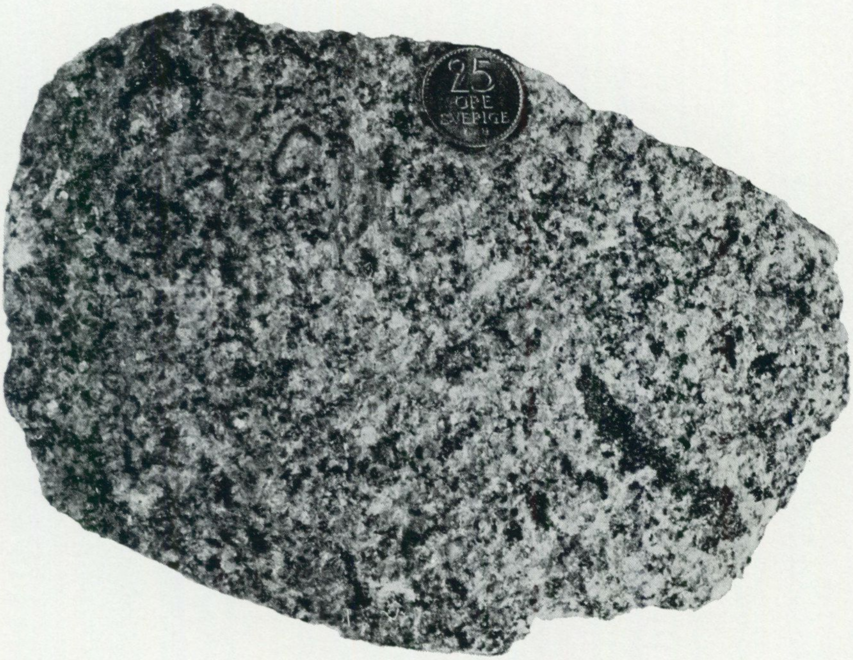

Fig. 17. Younger granodiorite with zoned feldspar megacrysts and mafic spots. Nävragöl village (WC 348482).

The rock is equivalent to the Småland granitoids and was called ”red Vexiö granite” by Holst (1879). The colour of the granite is red to red-grey. Its texture is mostly porphyritic to pophyroblastic, with a fine- or medium-grained matrix. The potash feldspar megacrysts are macroscopically subhedral to euhedral and most frequently between 0.5 to 2 cm in diameter. Thin-section study of the potash feldspar megacrysts was supplemented by X-ray diffraction studies and partial chemical analyses (Table 7: nos. 5, 6 and 7). The recorded obliquity (Δ) values are between 0.77 and 0.82. The low content of dark minerals is characteristic. In general the porphyritic (to porphyroblastic) granite exhibits a massive structure although there are several exceptions from this rule. Especially along the contact against the Older granitoid unit (see p. 22). Preferred deformation zones of restricted areal extension are found, leaving other parts of the Younger granitoid complex more or less intact. On the whole, deformation and metamorphism of the Younger granitoids decrease from south to north. The post-crystalline zones are accompanied by cataclastic crushing and partial recrystallization of the rock. On fresh surfaces, the granitoid often has a reddish brown colour caused by iron oxides. Under the microscope the deformational structure

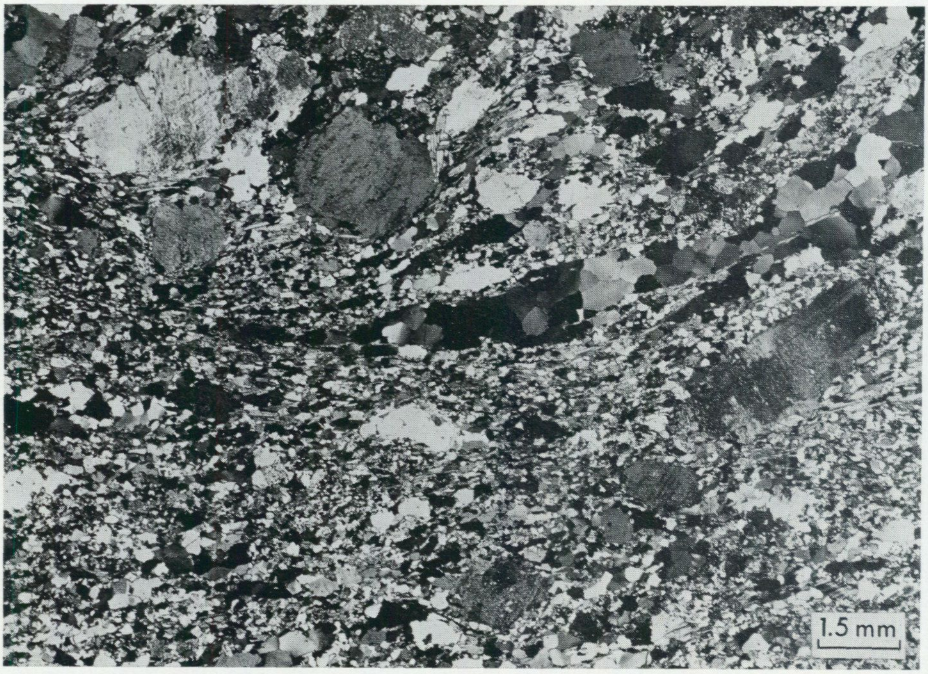

Fig. 18. Deformed Younger granitoid with lenses of quartz and feldspar porphyroclasts in a fine-grained matrix. 2 nic. S of Flymen village.

is easily discernible as sparsely distributed narrow strain zones (Fig. 18). Quartz has been crushed in part and frequently forms granulation zones within the feldspars. The latter display mortar texture. The biotite is strongly bent. Mineral degradation as well as formation of new minerals, are observed all through the rock. Epidote and chlorite alteration is frequent, but is largely confined to the shear zones.

Basic xenoliths of variable shape, size and frequency are found in the granitoid pluton (see p. 30).

Chemical and modal analyses of two representative granite samples are given in Tables 1 and 3 (nos. 12 and 15).

The granite is mainly made up of quartz, plagioclase and potash feldspar.

The quartz displays in part fairly normal irregular crystals showing undulatory extinction, though granular aggregates are much more frequent. In deformed rocks the mineral has a cataclastic appearence which predates a recrystallization to a number of subindividuals. Recrystallized quartz penetrates the potash feldspar.

Plagioclase forms an essential constituent. It is generally subhedral, but when appearing as inclusions in potash feldspar it displays anhedral outlines. Zoning has now and then been observed. The twinning is most common according to the albite law. Primary albite twinnig prevails in the less deformed grains, whereas in strongly deformed grains such twinning is lacking. Secondary albite twinning has been recognized in bent and broken crystals (see p. 27 and *cf*. Fig. 11).

The composition is mostly in the oligoclase range. However, many rims lap over to albite, and plagioclase remnants within potash feldspar grains have most frequently clear sodic rims.

The plagioclase ranges from fresh to highly altered grains rich in sericite and epidote-zoisite. The cores of many plagioclases are clouded, because of the presence of secondary minerals and microlites. The clouding is believed to be the result of a migration of iron and other elements into the crystal after its formation.

Plagioclase grains bordering on potash feldspar may show myrmekitic intergrowths with quartz.

Potash feldspar occurs as a main or essential constituent. It is present as megacrysts and as irregular masses in the matrix. The megacrysts form subhedral to anhedral grains, while most of the groundmass feldspar is interstitial to quartz and plagioclase. Microcline grid twinning, sometimes with a patchy occurrence, is visible in many of the potash feldspar grains.

Most of the potash feldspar crystals are perthitic, and the size and texture of the albite intergrowths are quite variable. Concerning the perthite development, there is evidence for both replacement and exsolution origin.

In many of the thin sections examined, two ”generations” of potash feldspar megacrysts occur. According to the author, the oldest megacrysts should be interpreted as phenocrysts and the younger megacrysts as porphyroblasts (see p. 94). In deformed rocks, the megacrysts are pigmented and surrounded by granulated rims.

Microscopic determinations reveal that the potash feldspar megacrysts are optically triclinic. With regard to their X-ray properties, they have a somewhat intermediate symmetry, with obliquities in the range 0.77—0.82. (Compare the obliquity values of potash feldspar phenocrysts from the post-orogenic Rätan granite determined by Lundqvist 1968, p. 152.)

Biotite is a subordinate mineral in this kind of granitoid. In part it has been chloritized. Hexagonally oriented needles of rutile and/or sphene are common in the chloritized biotite (*cf*. p. 35). Where the rock has been deformed, the biotite displays preferred orientation and kink-band texture.

One microprobe analysis (Table 4: no. 6) shows that the biotite is comparatively rich in iron.

Chlorite and muscovite are frequently observed as subordinate or accessory minerals.

Epidote, sphene, apatite, zircon, orthite, calcite and opaque minerals are the most abundant accessories. Prehnite occurs as a minor accessory mineral. Tourmaline has been identified in trace amounts.

Granite—granodiorite, mostly porphyroblastic

Porphyroblastic granite—granodiorite, in general foliated, is predominantly exposed in a belt along the eastern border of the Eringsboda massif. Most of the granitoid is medium-grained, even if variations from medium- to coarse-grained occur. Its composition may also vary to some extent. According to Streckeisen's classification (1967), the rock corresponds to granite and granodiorite.

One chemical and modal analysis is presented in Tables 1 and 3: no. 11. Differentiation Index is around 84 (see Table 2).

The colour of the granitoid is usually reddish grey. The intensity of the red-colouring depends on the content of potash feldspar megacrysts.

A foliation is marked by the orientation of the dark minerals, the potash feldspar megacrysts and the inclusions. The foliation generally strikes NW to NNW with vertical dips.

The potash feldspar megacrysts are definitely younger than the other constituents of the granitoid, and form genuine porphyroblasts. The shape of the porphyroblasts may vary, but usually they display rather well-developed crystal habits. Locally they are somewhat rounded, showing an augen form, and suggesting an origin contemporaneously with the development of the folation or before that. They are on average 1 to 2 cm in length and have a pinkish colour. The megacryst content is about 10—15 per cent by volume.

The texture of the groundmass is hypidiomorphic granoblastic.

Quartz, which is colourless to faint bluish, occurs both as single individuals and as crystal aggregates consisting of granulated and highly undulatory grains. Occasionally grains rich in microlites, especially apatite and rutile, have been observed.

Myrmekite is only present in small quantities.

Plagioclase appears as subhedral to anhedral crystals, measuring about 1.5 mm in diameter (max. 6.5 mm). The maximum anorthite content is estimated to 25 mol. %.

Sericitization and saussuritization are common phenomena, particularly in the cores. Highly sericitized parts lack twinning or show vanishing twinning. This indicates that an original twin pattern has been eliminated, probably during metamorphism. Normally the plagioclase is twinned according to the albite law, occasionally to the Carlsbad law. The twin lamellæ are often bent and/or displaced along cleavage planes.

A few grains exhibit patchy zoning or diffuse normal zoning. Along contacts with potash feldspar the larger sericitized plagioclase grains have a dust-free albitic rim.

Partial potassium-feldspathization of the plagioclase has been observed in several stages.

The plagioclase cores enclose small biotite flakes, partly chloritized. Sometimes these are arranged around the contours of the plagioclase cores.

Antiperthite is in general a sparse constituent, though it may locally be present in considerable quantities.

Potash feldspar occurs as abundant, large porphyroblasts and as anhedral grains in the groundmass. Microscopically, the megacrysts often exhibit anhedral to subhedral outlines. A tendency to formation of euhedral crystals is now and then present. The potash feldspar is as a rule perthitic and can be referred to string, vein and patch types according to Alling's (1938) nomenclature. Some of the perthites seem to be of replacement origin.

The megacrysts are rich in remnants of replaced plagioclase.

Biotite is pleochroic in brown to yellow colours. The crystals have often clustered together as swarms of small and large flakes. At several places the agglomerations form rosettes of radiating platy crystals. Most frequently the biotite has been ragged and corroded by plagioclase and potash feldspar. Moreover, it has been more or less chloritized. This process seems to have been accompanied by release of titanium and formation sphene, which occurs as numerous tiny grains along the cleavage planes (*cf.* p. 35). Sphene-bearing biotite may contain small lens-shaped grains of potash feldspar.

Rarely lenticular aggregates of prehnite are visible. Lenses of fluorite have sporadically been found between the cleavage planes of the biotite.

In foliated granitoids the biotite shows kink-band textures.

Common hornblende is sometimes present in amounts between 2 and 3 per cent by volume. In part it forms small anhedral grains, somewhat biotitized, within biotite flakes, in part it occurs as single poikilitic individuals enclosing small rounded quartz grains.

Subordinate minerals are chlorite and epidote.

Accessories are opaque minerals, sphene, apatite, zircon, calcite, muscovite, rutile and orthite. Fluorite and prehnite are found in minute amounts.

Fine- to medium-grained granites

Several types of fine- to medium-grained granites are met within the Younger granitoid complex. They have predominantly a massive texture. Most of the granites form veins, dikes and small massifs, generally with sharp intrusive contacts against the surrounding rocks. The intrusive character of the dikes is shown by the presence of country rock inclusions. Exceptionally gradational contacts between fine-grained granites and medium- to coarse-grained granitoids have been observed. Hedström and Wiman (1906, p. 40) noted that fine-grained granites are mainly found as transitional types between red, medium-grained granites (”Red Växjö granite”) and grey granodiorites-tonalites (”Grey Växjö granite”).

The small- to medium-grained granites represent the youngest granitoid generation inside the Younger rock suite. But it is still a problem if these granites belong to the Younger granitoid clan, or if they are still younger, *i.e.* contemporaneous with the Spinkamåla granites in the western part of Blekinge. According to the writer the granites should be referred to the Younger granitoid group. This supposition is only based on field experiences.

No chemical analysis is available.

Only two principal granite types will be described in this report, a grey fine-grained one NE of Holmsjö and a medium-grained two-mica granite in Holmsjö village.

Grey fine-grained granite

In the northeastern surroundings of the Holmsjö region the older plutonic rocks, especially the tonalite massif, are traversed by two aplite-granite generations of different age. They form numerous dikes and irregular bodies with satellitic dikes. Light grey, fine-grained, equigranular granite constitutes the bulk mass. Generally the texture is massive. The dikes contain inclusions of the above-mentioned tonalite. The granite which has a simple mineralogical composition, is sometimes flanked by narrow zones showing a coarser inequigranular texture.

Besides small dike occurrences of reddish aplite-granite, with a relatively younger age, have been found in road cuttings NE of Holmsjö.

The grey granite appears to be compositionally uniform. Generally the texture is granoblastic to xenomorphic. Essential minerals are quartz, potash feldspar and plagioclase. Biotite occurs in subordinate amounts (<5 vol.-%). Accessories are opaque minerals, chlorite, muscovite, calcite, sphene, epidote, zircon and orthite.

Quartz displays variformed individuals most frequently occupying interstices between the other chief minerals in a characteristic manner. Usually it displays undulatory extinction.

Plagioclase occurs as subhedral to anhedral crystals, often with myrmekitic borders. It exhibits moderate to comparatively strong normal zoning from calcic oligoclase to albite. The cores of several plagioclase grains are sericitized and weakly epidotized.

Potash feldspar is perthitic and forms anhedral grains with poikilitic textures. Cross-hatching occurs to a variable extent.

Biotite is pleochroic from greenish brown to light yellow. The biotite flakes often exhibit ragged outlines. Partial replacement by potash feldspar and plagioclase is a common phenomenon. Irregular aggregates of sphene are generally associated with the biotite, part of which has occasionally been chloritized.

Two-mica granite

At Holmsjö village a small massif of two-mica granite crops out. The granite is medium-grained and has light pinkish grey colour. The age relations between the aforementioned grey fine-grained granite and the two-mica granite could not be established in the area investigated.

Numerous amphibolite dikes (fifth generation; see p. 64) striking NNW cut the granite body. The dikes have apophyses in shear zones parallel to the dike direction. Locally transverse shears associated with offsets are visible, but they have not displaced the apophyses. This tectonization process is also recognized microscopically in the granite. Under the microscope the granite exposes a granoblastic texture. Plagioclase and mica are bent by the slight deformation of the rock.

The essential minerals are quartz, plagioclase and potash feldspar. Biotite and muscovite form subordinate constituents. Accessories include apatite, zircon, sphene, calcite, epidote and opaque minerals.

Quartz has prominent position in the rock. It is always anhedral and occurs as single grains, as well as crystal aggregates. Undulatory extinction is common. At some places the mineral has suffered from pronounced granulation. Moreover, it seems to have been later formed than potash feldspar.

The plagioclase is an albite—oligoclase displaying more or less irregular grains. Two plagioclase generations have been traced, but it is very difficult to distinguish between early and late plagioclase except when the older generation is enclosed in the younger (see below). The plagioclase is often zoned, and in part the zoning is patchy. When twinning is present, albite twins are most common, whereas twins according to the Carlsbad and pericline laws are less frequent. Significant of this granite is a widespread alteration of the plagioclase to muscovite. The cores of many plagioclases contain, indeed, a multitude of minor muscovite flakes, produced by sericitization of the more calcic central portions of the grains. The albitic border zones lack sericitization. Plagioclase crystals enclosed within potash feldspar exhibit decalcified rims.

As mentioned above, two plagioclase generations have been recognized. In a few cases the older plagioclase crystal, twinned according to the albite law, is obliquely enclosed in later plagioclase twinned according to the pericline law. The latter twin pattern has been superimposed on the earlier plagioclase, the composition of which is comparatively more sodic.

Antiperthite textures are frequently met in the coexisting plagioclases. The potash feldspar blebs, often spindle-shaped, are elongated parallel to the twin-plane traces of the host crystal. Sometimes potash feldspar intergrowths cross the boundaries and enter the older plagioclase crystal.

Potash feldspar is an essential component. Most crystals are strongly perthitic. Occasionally the mineral has grown to porphyroblasts, enclosing and replacing plagioclase and other minerals. In turn the potash feldspar may be replaced by muscovite.

A few large potash feldspar individuals display faint zoning. In some cases this development is also reflected by the distribution of tiny albite crystals in concentric zones, parallel to the crystal faces of the host (*cf.* p. 52 and Fig. 25).

Biotite is present in very subordinate quantities. The colour of the biotite is yellowish-brown. Generally it has been penetrated by muscovite. The amount of biotite replacement by muscovite varies strongly.

Muscovite is always present, but as a secondary constituent. The relative proportions of muscovite and biotite vary throughout the granite massif. As mentioned, muscovite replaces biotite and plagioclase on a large scale, and potash feldspar to a less extent.

YOUNGEST GRANITOIDS

The Youngest granitoids (post-Svecofennian age) form two massifs in the western half of the map area (Plate 1) dominated by coarse megacryst-bearing granitoids ranging in composition from granodiorite to granite. Owing to lack of detailed examinations, no subdivision of the investigated grantoids has been made, and thus only some general considerations of the rock group will be presented here. The larger plutonic mass constitutes the easternmost part of the huge Eringsboda massif (see Fig. 1), as well as the elongated granitoid body situated SE of Yasjön, referred to as the Yasjö massif and somewhat different in composition and texture from the former. The Youngest granitoid group also includes scattered minor masses and dikes of small- to medium-grained granites *(sensu stricto)* of Spinkamåla type (named after the type locality in western Blekinge). Similar granites appear in the Holmsjö region (Plate 1), but according to their field relations they have been referred to the Younger granitoid group (see p. 42). Contrary to the pre-existent granitoid suites of the map area, the Youngest plutonics are accompanied by aplites and pegmatites but not associated with basic forerunners. The country rocks are often cut by satellitic dikes of granitic material.

The main part of the Youngest plutonics displays a massive texture, indicating that they were emplaced under conditions subsequent to major deformations. These granitoids cut the older rock units sharply, sometimes brecciating, and on a regional scale they behave discordantly. However, their contacts may sometimes be controlled by local structures. The contacts often show high dips, and the contact effects are highly variable. The coarse granitoids show only small grain-size variations when approaching the contacts. The occurrence of cordierite and sillimanite reported by Hedström and Wiman (1906, p. 9) within the small concavo-convex septum of quartzo-feldspathic gneiss at the southern contact of the Eringsboda massif (see Plate 1) may indicate contact metamorphism (*cf.* p. 99). It must be emphasized, however, that in most cases of this kind it is not possible to distinguish contact effects from regional ones (*cf.* Miyashiro 1973, p. 116).

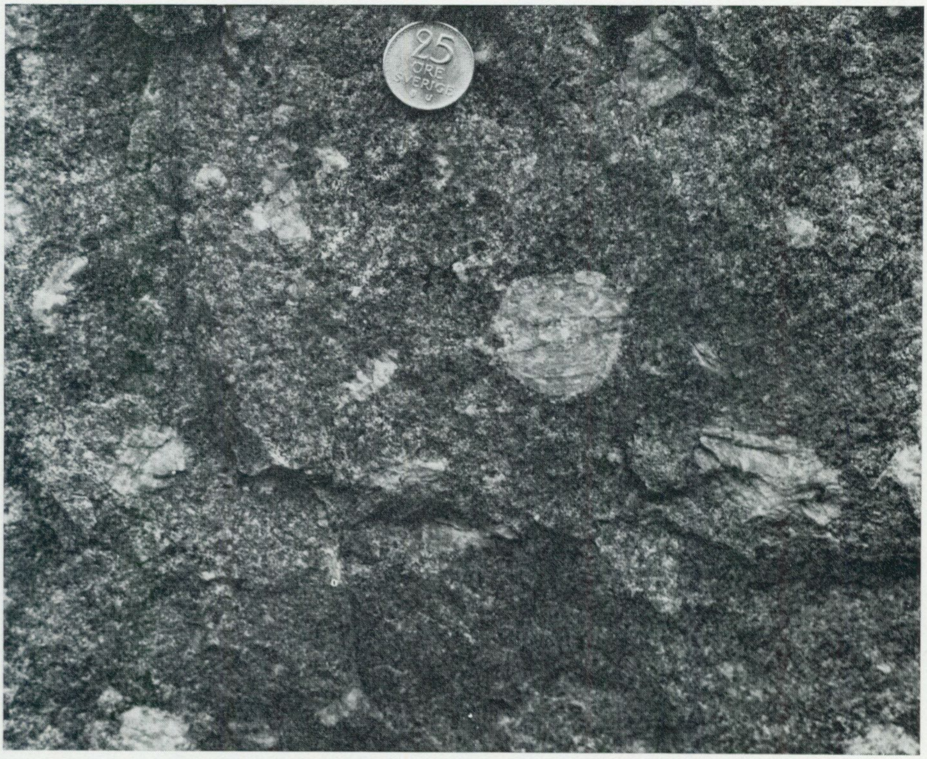

Fig. 19. Zoned potash feldspar porphyroblasts in a dioritic xenolith within the Eringsboda granitoid massif. Guttamåla.

The gneiss segment mentioned above has probably been dragged upward in connection with the diapiric intrusion of the Eringsboda granitoid. This postulation is based merely on its disconformable appearence in relaton to the general regional strike, especially the trend of the gneiss belt situated immediately to the west of Tving village (see Plate 1). The vertical drag features along the contact of the Eringsboda massif may in this case be an evidence of diapirism movement in a solid or partly solid state.

Porphyroblastic development of potash feldspar megacrysts is very common in the contact aureole around the Eringsboda massif, but less pronounced around the Yasjö massif, which in part borders on rocks of the tonalitic phase of the Older plutonics. Here only the Older granodiorites contain both pre- and post-tectonic potash feldspar megacrysts. The latter are most probably genetically associated with the Youngest granitoid plutonism (see p. 94). Potash feldspar megacrysts often display a strong preference to xenoliths in the Youngest granitoids (Fig. 19). Xenoliths are, however, rare in these granitoids, except for a zone west of Alnaryd (see Plate 1).

In addition to the development of porphyroblasts it is assumed that the intrusion of the Youngest granitoids may have caused the recrystallization and reactivation locally observed in the Older granitoid unit of the map area. Southwards, outside the investigated region, extensive migmatization and potash feldspar blastesis have affected substantial parts of the older basement. As mentioned on p. 16, the emplacement of the Youngest plutonics (approximately 1 450—1 380 m.y.) seems to have caused a large regional thermal influence of great parts of the Blekinge region. Older plutonics and Coastal gneisses have been updated, giving K/Ar ages ranging from 1 510 to 1 240 m.y. (corrected figures from Magnusson 1960a) which may indicate a period of cooling after a post-Svecofennian plutonism and also some later thermal events in the region. The latter may possibly be related in time of the Dalslandian period, 1 100—935 m.y. according to Welin (1966a).

Eringsboda granitoid

The Eringsboda granitoid (Fig. 20) differs somewhat in texture and grain size from the time-equivalent Karlshamn granitoid. According to Blomberg (1900), the former granitoid type usually lacks recognizable preferred orientation of the

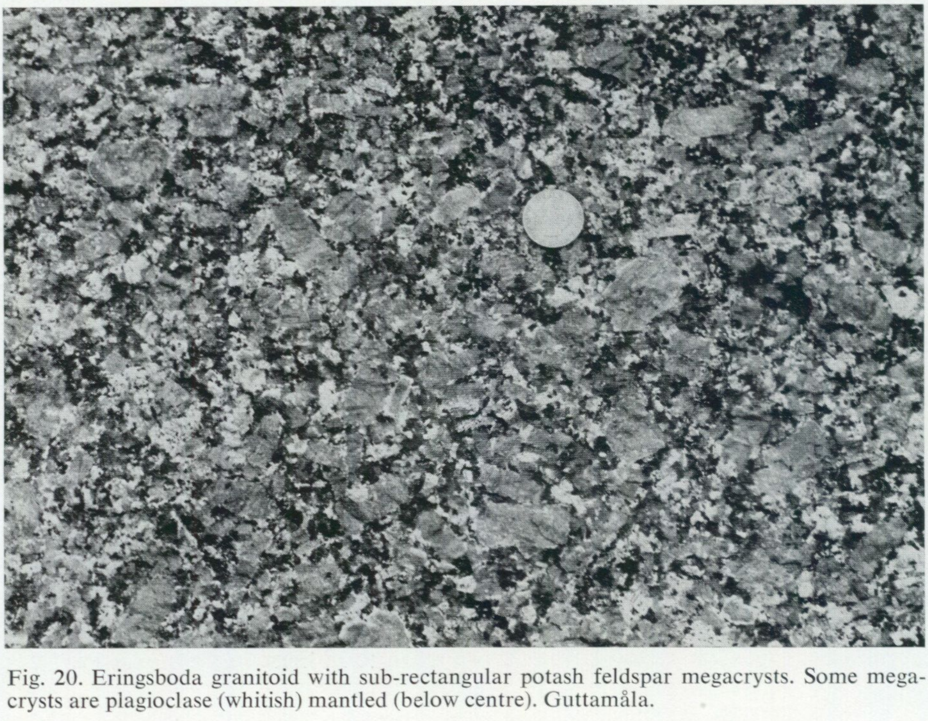

Fig. 20. Eringsboda granitoid with sub-rectangular potash feldspar megacrysts. Some megacrysts are plagioclase (whitish) mantled (below centre). Guttamåla.

macrotexture and contains larger potash feldspar megacrysts as compared with the Karlshamn granitoid, which also often has a gneissic texture. The mineralogy and petrography of the Karlshamn massif is thoroughly treated in papers by R. Norin (1936, 1937) and Asklund (1947). Tectonical analyses of the Karlshamn massif have been presented by Habetha (1936) and I. Larsson (1954).

The Eringsboda pluton has been examined only in reconnaissance by the writer, and it is thought that a detailed mapping of the massif certainly should reveal several rock variants. The typical rock type of the Eringsboda massif is a very coarse-grained, megacryst-bearing, massive granodiorite to granite showing greyish red or red colour, thanks to numerous red potash feldspar megacrysts. Locally the granitoid becomes as rich in large megacrysts and simultaneously as coarse to be classed as a pegmatitic granitoid. The matrix of the rock has a granodioritic composition. The megacrysts, often macro-perthitic, occur in considerable but varying amounts. Generally they constitute more than 30 per cent by volume of the rock. The euhedral to anhedral megacrysts range from 1 cm to 10 cm in length. In most outcrops of the massif the megacrysts are randomly arranged but they exhibit slight preferred orientation at a few localities, especially along the marginal zone of the massif.

The potash feldspar megacrysts are often rimmed by plagioclase making the rock look like a rapakivi granite (Fig. 21), especially in the more ”basic” varieties. Plagioclase crystals mantled by potash feldspar have also been frequently observed (Fig. 22). These normally and inversely mantled feldspar crystals have been found to occur together with non-mantled potash feldspar megacrysts in a single outcrop. Many megacrysts also contain zone-wise orientated inclusions of biotite flakes (Fig. 21; see also p. 95). On p. 95 will be given evidence suggesting that the potash feldspars continued to grow during a considerable time after the initial emplacement of the granitoid. X-ray obliquity determinations of a few potash feldspar megacrysts have shown that these are close to maximum microcline with obliquities above 0.8 (see Table 7). Partial chemical analyses of potash feldspar megacrysts are listed in Table 7.

No whole-rock chemical analysis of the Eringsboda granitoid has been made.

The above-mentioned perthitic megacrysts constitute the main mineral phase, while the matrix essentially consists of plagioclase varying in composition from albite to andesine, quartz, biotite, and, in rare cases, hornblende (Fig. 23). Biotite often bears signs of deformation. Sphene is the dominant accessoric mineral, not seldom forming macroscopically well-developed crystals. Locally, orthite has been found to be a significant constituent of the granitoid.

In this context it is worth mentioning that measurements of the total intensity of gamma-ray in western Blekinge have given abnormally high concentrations of radioelements in the Youngest granitoids as compared with the surrounding rocks (personal communication, G. Åkerblom, SGU).

Fig. 21. Eringsboda granitoid with plagioclase (whitish) mantled potash feldspar (greyish) megacryst. The outer part of the potash feldspar megacryst contains concentric zones of biotite crystals. W of Lake St. Alljungen.

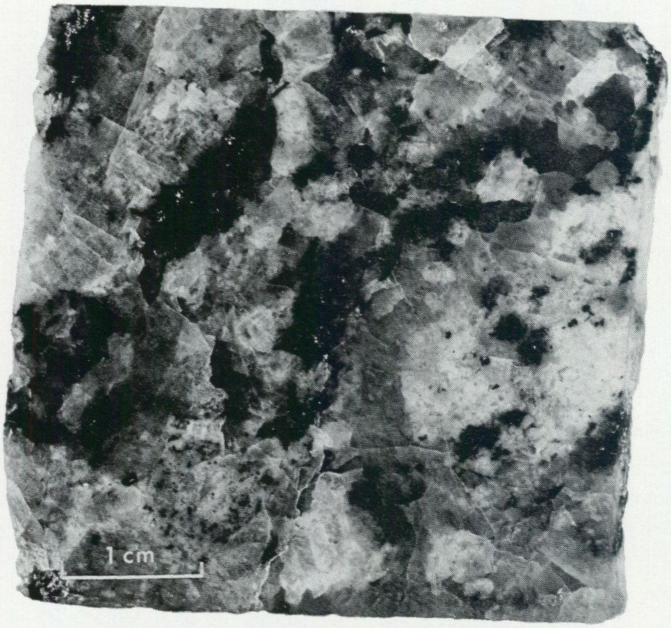

Fig. 22. Eringsboda granitoid with potash feldspar (greyish) mantled plagioclase (whitish) megacryst (right). W of Lake St. Alljungen.

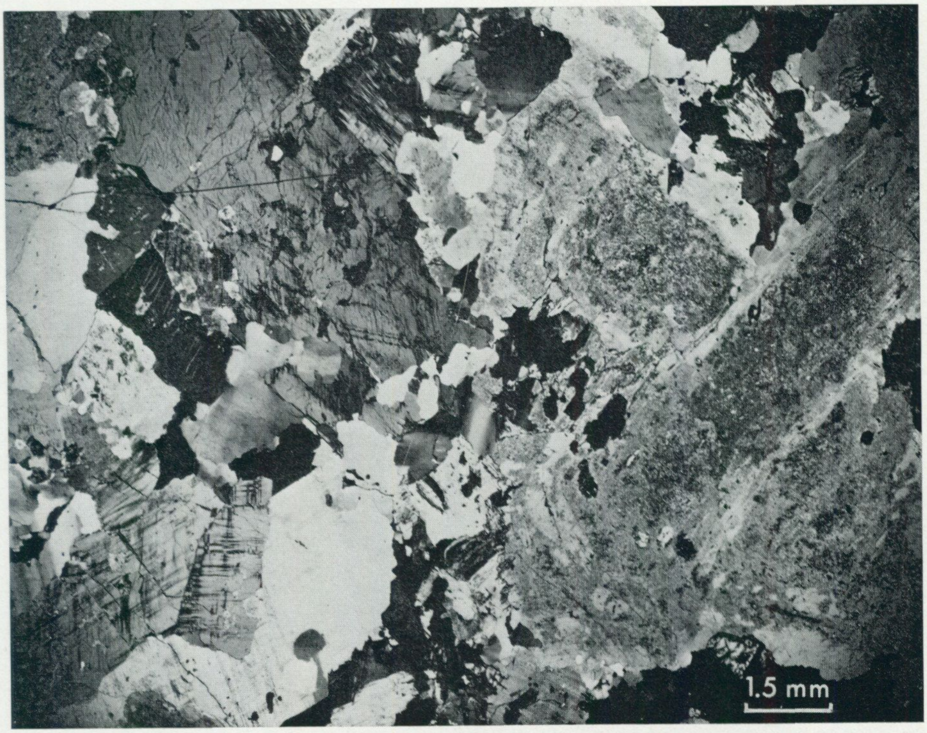

Fig. 23. Eringsboda granitoid. Corroded plagioclases and zoned potash feldspars. 2 nic. E of Lake St. Alljungen.

Yasjö granitoid

This rock appears to be an equivalent of the Eringsboda granitoid. The main granitoid of Yasjö is a coarse-grained reddish to greyish red granodiorite to granite characterized by the presence of large ovoid potash feldspar megacrysts, frequently rimmed by plagioclase (Fig. 24). The fundamental difference regarding the composition of the matrices of the Eringsboda and Yasjö granitoids is the higher amounts of biotite and hornblende contained in the latter variety. Moreover, the Yasjö granitoid has locally been subjected to cataclastic deformation restricted to narrow zones of foliation with a NW—SE trend parallel to the adjacent, more or less prevailing deformation trend of the Older granitoid area. This tectonization is younger than the regional deformation of the map area and is manifested by the presence of crushed lensoid megacrysts, elongated and strained quartz grains or aggregates, deformed plagioclase crystals, and kinked biotite flakes.

Fig. 24. Yasjö granitoid with sub-rounded potash feldspar megacrysts, frequently mantled by plagioclase. Yasjön.

According to Plate 1 the Yasjö massif displays a highly regular and elongated body. However, Plate 1 fails to inform that the granitoid is discordant on a local scale, although there are several examples of contacts parallel to the foliation of the surrounding country rocks. Near the contact the Older granitoids show signs of flowage (see Fig. 6) and potash feldspar blastesis. The distribution of potash feldspar megacrysts is, however, very irregular and sparse (see Fig. 5).

There is a noticeable lack of inclusions in the Yasjö granitoid. The few xenoliths observed are composed of dark fine-grained basic rocks, containing potash feldspar megacrysts mantled by plagioclase. This observation may be an evidence of solid state growth of potash feldspar megacrysts.

The Yasjö granitoid is composed essentially of quartz (32—38 %), microcline (48—56 %), plagioclase (8—14 %), biotite (1—3 %), and hornblende (<1 %).

The microcline is highly perthitic, the sodium-rich phase being developed as strings, rods, and veins. It occurs generally as poikiloblastic crystals, in which the typical cross-hatched twinning may be uniformly distributed over the whole crystal or variable and in patches. The megacrysts contain groundmass inclusions. Large plagioclase crystals are often strongly replaced by potash feldspar in the centre, which may indicate a replacement origin for some of the mantled potash feldspar megacrysts. There is, however, no conclusive evidence of such an origin for the observed mantling phenomenon.

The plagioclase is oligoclasic in composition (An_{15}—An_{25}), and is well-twinned, bent twin lamellæ being present in specimens from deformation zones. The crystals regularly have rims of clear albite and are often zoned in the cores.

Biotite is generally chloritized, either completely or along cleavages and margins.

Hornblende is a scanty component, partly chloritized.

The most widespread accessories are sphene, apatite, zircon, orthite, epidote, rutile, fluorite, and opaque minerals.

Partial wet-chemical analyses of potash feldspar megacrysts and chemical analyses of whole-rock samples are shown in Table 7 (nos. 9 Y and 11 Y) and Table 1 (nos. 16—17).

Fine- to medium-grained granites, pegmatites and aplites

Within the map area two principal types of unfoliated small- to medium-grained granite *(sensu stricto)* have been identified: 1, grey to red, fine- to medium-grained, slightly potash feldspar megacryst-bearing granite, and 2, grey, fine-grained, spotted granite.

Fine- to medium-grained granite (Spinkamåla type)

This rock type, which seems to be identical with the Spinkamåla granite in western Blekinge (see R. Norin 1936), displays an overall simple granitic composition. It occurs in small irregular masses and as cross-cutting dikes, especially within or near the Eringsboda massif (see Plate 1). The granite dikes are occasionally flanked by narrow zones which are more coarse-grained. These granites are thought to be genetically related to the Eringsboda granitoid, as indicated by the fact that the dike frequency increases when approaching the Eringsboda massif. R. Norin (1936, p. 559) postulated the reverse relative age relation between the Spinkamåla granite and the Karlshamn granite in western Blekinge. In the opinion of the same author *(op. cit.)*, the Spinkamåla granite has originated from Coastal gneisses by palingenetic reactions.

On microscopical examination the granites reveal a xenoblastic texture. They are mainly composed of quartz, microcline and plagioclase. Subordinate minerals are biotite and muscovite, accessories are apatite, sphene, rutile, zircon, epidote, chlorite, calcite, orthite, and ore minerals.

The quartz contains as a rule considerable amounts of microlites (a.o. rutile)

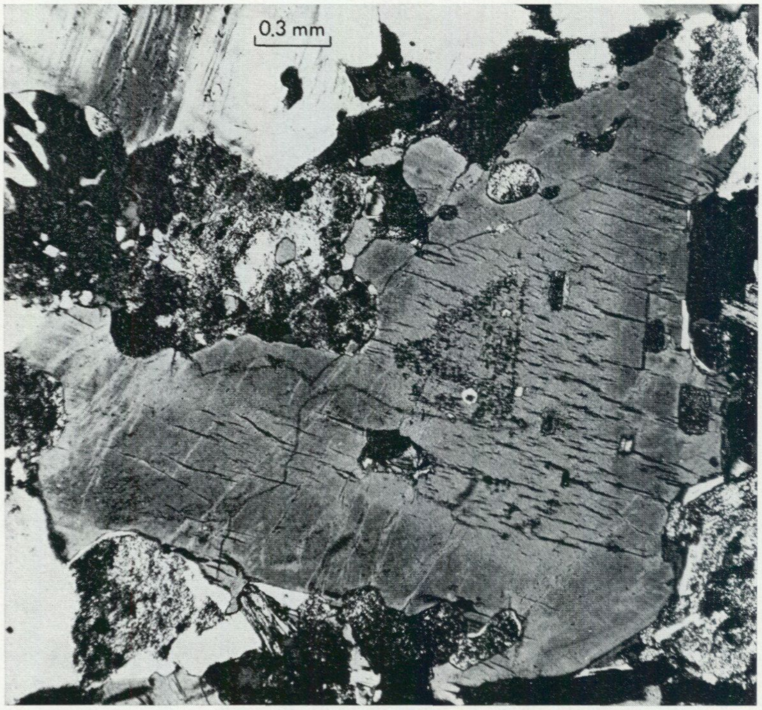

Fig. 25. Zoned potash feldspar megacryst with two generations of perthite. Small-grained granite belonging to the Youngest granitoid group. E of Tving village.

and sub-microscopical liquid inclusions, concentrated to well-defined central parts of the crystals. This texture may indicate a secondary growth of the quartz.

The plagioclase crystals have often altered to sericite. The composition generally ranges from albite to oligoclase (An_5—An_{16}). In addition, thin albite rims and myrmekite are occasionally found between plagioclase and perthitic microcline. The latter mineral occurs in the megacrysts and the matrix. Many microcline megacrysts lack well-developed cross-hatching, and several display in the outer parts a more or less distinct zoning and in the inner parts a zonal arrangement of perthite following crystallographic surfaces, indicating zonal growth of the megacrysts (see Fig. 25). Moreover, Fig. 25 illustrates a second generation of perthite distributed all over the microcline megacryst. Biotite has frequently clustered into aggregates. It has often changed to chlorite and sometimes to muscovite.

Spotted granite

A rather conspicuous structure has been developed in the spotted granites (Fig. 26), which occur at a few localities within the investigated area (indicated with

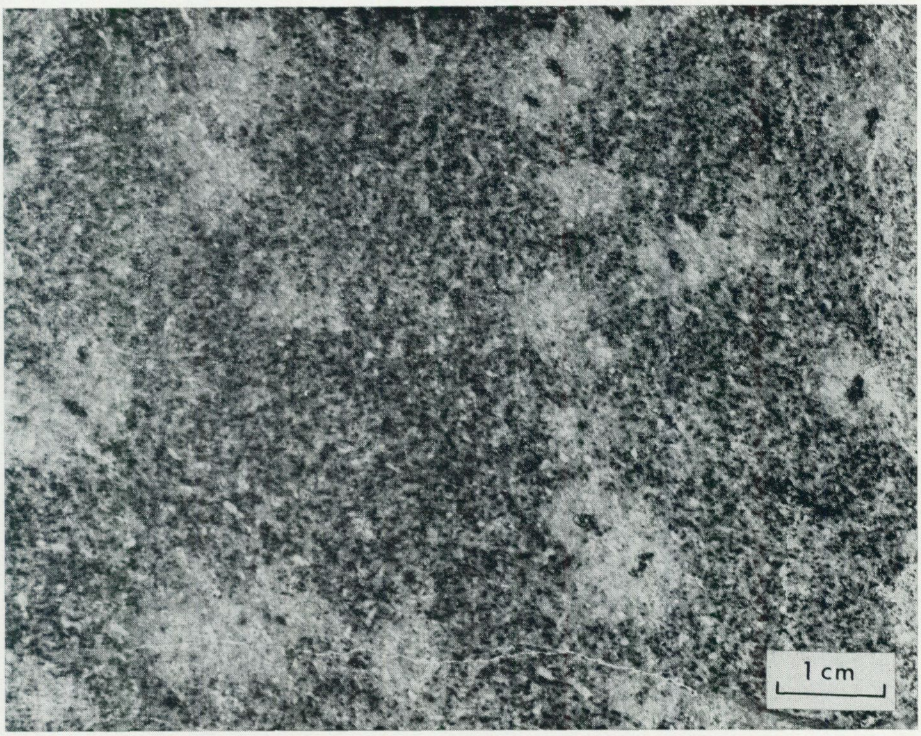

Fig. 26. Sphene-spotted granite. The xenoblastic sphene crystals are surrounded by leucocratic haloes. Yasjön (WC 302441).

T in Plate 1), *e.g.* at Yasjön and in the Tving region. They appear as thin crosscutting dikes in the Yasjö granitoid and in the Older granitoids.

The spots contain a core of a xenoblastic sphene crystal with inclusions of quartz and feldspar, especially potash feldspar. The core is surrounded by a biotite-free quartzo-feldspathic mantle bordering on a matrix of quartz, feldspar and biotite.

The rock type is similar to the spotted granites (German: *Titanitfleckengesteine*) found in *e.g.* the Stockholm granite, Sweden (Geijer 1908, 1913; Fromm 1943; Stålhös 1969, the last-mentioned work gives a complete list of known occurrences in the Stockholm region), and in other parts of the world (*e.g.* Osann 1923; Fischer 1926; Troll 1964; Windley 1965).

As regards theories about the origin of the flecky granites, the reader is referred to the above-mentioned authors and Drescher—Kaden (1969, pp. 428—429). The writer will not at present (work in progress) enter into any discussion concerning the genetic explanation of the fleck structure.

Pegmatite and aplite

Abundant pegmatites and aplites are associated with the Youngest granitoids. They occur as dikes and veins and are mainly concentrated along the margin of the Eringsboda massif. Several generations of pegmatite have been observed within the map area.

BASIC PLUTONICS WITHIN THE YOUNGER GRANITOID REGION

The basic plutonics of the northeastern granitoid region form more or less heterogeneous mixtures of gabbro, diorite—monzodiorite and tonalite. Locally, small not mappable areas of hybrid granitoid rocks occur within the basic plutons. North of Sällemålla farm granitic and basic rocks have been mixed intimately (*cf*. Hedström and Wiman 1906, p. 43). Contacts between gabbro and diorite vary from sharp to gradational. Some contact relations, *e.g*. NE of Sillhövda, indicate that gabbro was solid when diorite magma intruded (see below).

Contacts between diorite, monzodiorite and tonalite are mostly transitional.

Granitoid veins and dikes penetrate the basic plutons, locally forming net-veined bodies. The contact zones of the basic rocks have often been invaded by granitoid apophyses from the surrounding rocks.

Basic massif of Holmsjö village

The basic massif east of Lake Sillhövden is composed of predominantly fine-grained hybrid dioritic rocks and small irregular masses of coarse- to medium-grained actinolite-bearing gabbroic rocks. The basic complex is undoubtedly older than the surrounding granitoid terrain. The dioritic suite ranges widely in composition and texture.

The dioritic phase shows clear-cut intrusive relations with the gabbroic phase. The latter is cut by fine-grained dioritic dikes, showing a tendency to chilled margins against the gabbro. This intrusive relation of the dioritic rocks indicates that the gabbro was solid when the diorite magma intruded it.

The gabbro (see Table 1: no. 22) is rather high in chromium (860 ppm) and nickel (330 ppm), whereas the dioritic rocks (see Table 1: nos. 20—21) are low in these elements (Cr 5—55 ppm and Ni 10—40 ppm). The following order of trace element distribution has been observed:

gabbro	$Cr > Ni > V > Co$
dioritic rocks	$V > Cr > Ni > Co$ or $V > Co > Ni > Cr$

A comparison of the data presented above and the major element distribution between the two phases gives reason to interpret, although there is no conclusive proof available, the gabbroic phase as an early differentiate, while the dio-

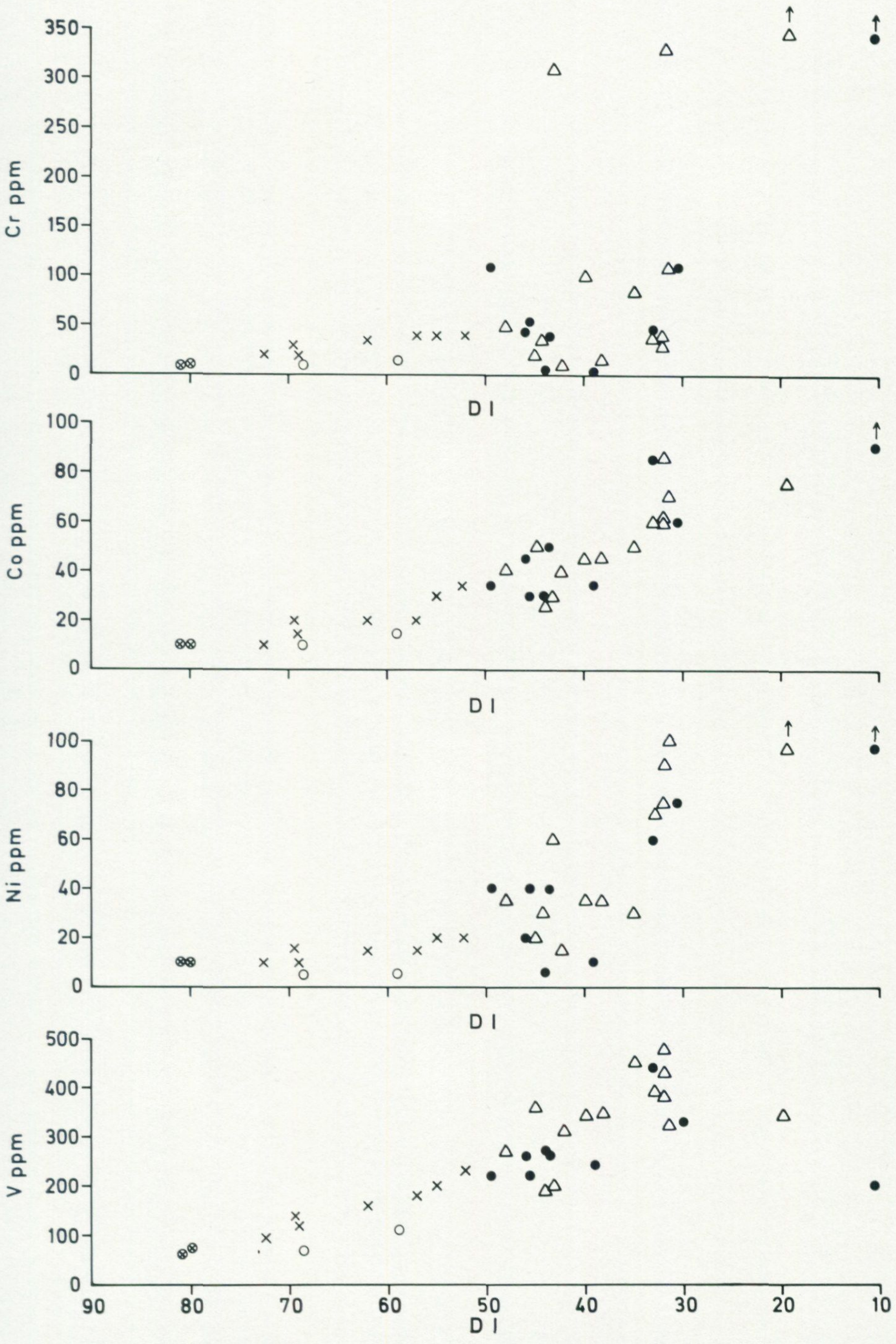

Fig. 27. Plots of Cr, Co, Ni and V contents (ppm) *versus* Differentiation Index (after Thornton and Tuttle 1960). Symbols: inclined crosses—Older granitoids, open circles—Younger granitoids, circles with inclined crosses—Youngest granitoids, filled circles—basic plutonics within the Younger granitoid area, and triangles—metabasites. Arrows indicate samples with trace element contents higher than permitted by the scales.

ritic rocks belong to a rather late stage of differentiation (*cf*. Lundegårdh 1950) and have thus a younger relative age.

Summing up, the basic plutonics (excluding metabasites) within the Younger granitoid area show a scattered trace element (Cr, Co, Ni and V) distribution when plotted against DI (see Fig. 27). No regular differentiation trends are apparent from Fig. 27, possibly with the exception of the relationship V—DI. These irregular trace element distributions can be interpreted in several ways.

Chromium and nickel, especially the former element, are enriched in early magmatic minerals by fractional crystallization of basic magma. Thus, the absolute concentration of chromium is a very useful indicator of basic and ultrabasic parentages. The Ni/Co ratio diminishes during fractionation and is consequently a very good index of fractionation, since both elments are divalent. Besides, the vanadium content and the Cr/V ratio are useful indicies of fractionation in basic rocks (Taylor 1965).

Coexisting actinolite—hornblende

Zoned Ca-amphiboles, associated with plagioclase, biotite, epidote, and chlorite, are essential constituents of the basic rocks, especially the metagabbro at Holmsjö village, within the Younger granitoid area. Green hornblende, blue-green to faint green hornblende, and colourless actinolite coexist in zoned amphibole grains of the Holmsjö gabbro. Actinolite occurs as rims around hornblende cores, sometimes as irregular patches within the hornblende crystals. The hornblende cores show abundant inclusions of opaque minerals and biotite, probably due to unmixing. Preliminary data of a few electron probe analyses on a zoned

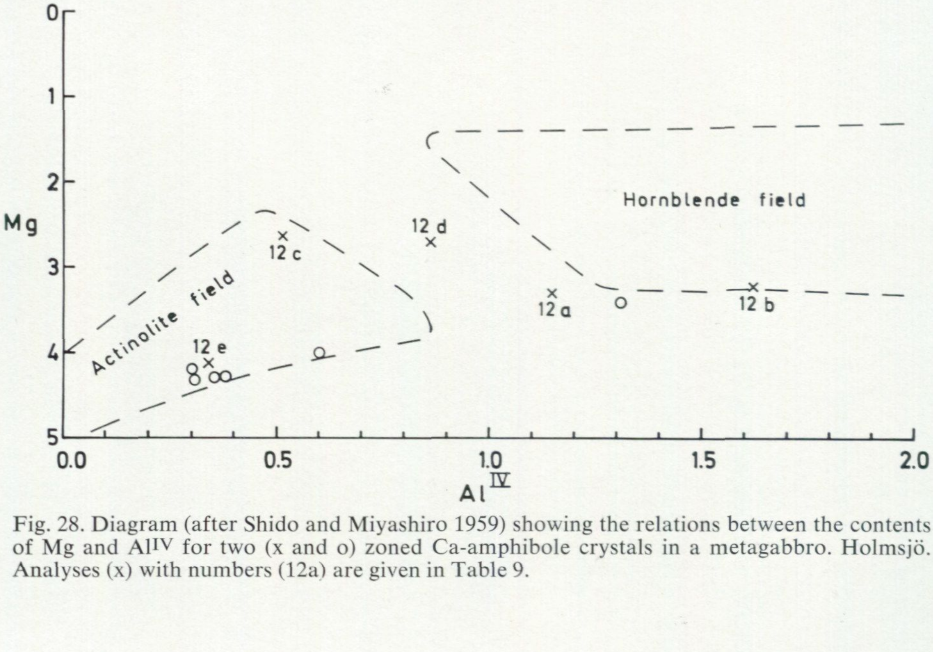

Fig. 28. Diagram (after Shido and Miyashiro 1959) showing the relations between the contents of Mg and Al^{IV} for two (x and o) zoned Ca-amphibole crystals in a metagabbro. Holmsjö. Analyses (x) with numbers (12a) are given in Table 9.

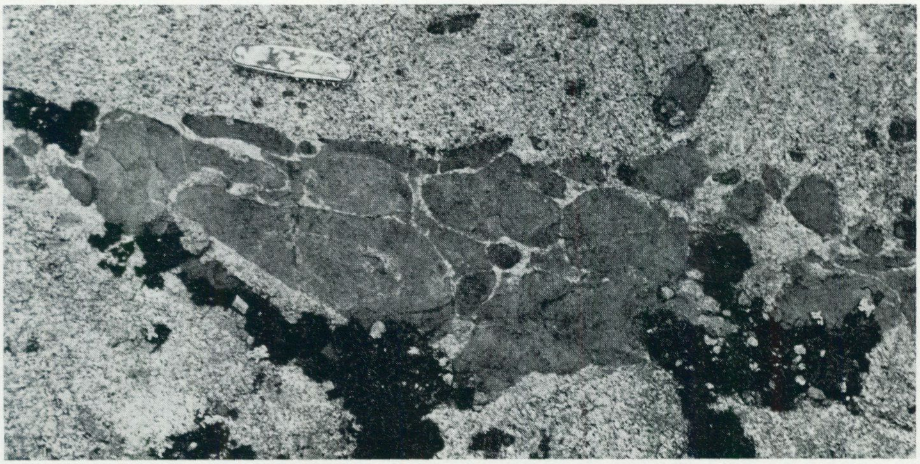

Fig. 29. Breccia. Younger granitoid with metabasite fragments. Höjemåla.

Ca-amphibole grain of the gabbro at Holmsjö are given in Table 9. (Additional chemical and optical data will be presented and discussed in a forthcoming paper.) No detailed nomenclature distinctions were made in the hornblende or actinolite analyses. The boundaries between the green hornblende core, the faint greenish transition zone, and the colourless actinolite rim, respectively, are optically rather sharp, but they are not separated optically by a Becke Line. Continuous electron microprobe scans for Ca, Fe, and Mg content across the analysed zoned amphibole grain did not show any abrupt compositional variations between core and rim.

Much discussion has taken place concerning the problematical existence of a miscibility gap between actinolite and hornblende. If all available chemical analyses of Ca-amphiboles are considered, the curve representing the frequency of occurrence shows a marked minimum about Si = 7.2 for 24 (O, OH, F) according to Leake (1968). The significance of this minimum is in dispute. Several workers interpret it as a result of a probable miscibility gap between actinolite and hornblende (*e.g.* Hallimond 1943, p. 74; Miyashiro 1958, p. 249; Shido and Miyashiro 1959, p. 94; Klein 1969, p. 233; Cooper and Lovering 1970, p. 11). However, Miyashiro (1958, p. 249) states that at higher metamorphic grades the miscibility gap disappears and hornblende becomes the stable amphibole.

In Fig. 28 (including plots of unpublished data), representing the amounts of Al^{IV} and Mg respectively in different zones of the analysed Ca-amphiboles (diagram and boundary areas after Shido and Miyashiro 1959, Fig. 2), a few plots fall between the fields of actinolites and common hornblendes. The available data do not support theories of a miscibility gap in the calciferous amphibole solid solution series, but it must be emphasized that there is no conclusive evidence for such an assumption.

HYPABYSSAL METABASITES

Review of basic dike activity in southeastern Sweden

Ever since Sederholm (*e.g.* 1912, 1926) in his classical investigations in SW Finland demonstrated the application of basic dikes to solving problems of the episodic evolution and relative chronology of Scandinavian orogenic plutonites, this approach has been employed in numerous parts of the shield area. Substantial contributions concerning the Precambrian terrains of SE Sweden are given by several workers (*e.g.* A. Gavelin 1909; Lundegårdh 1946, 1960; Lundqvist 1959, 1962; S. Gavelin 1960; Stålhös 1964, 1969, 1972; Elbers 1971; Kresten 1971, 1972).

In the Västervik area (see Fig. 1), Elbers (1971) recognized two periods of emplacement of basic dikes, which are primorogenic and intraorogenic in relation to the Svecofennian orogenic evolution. Kresten (1972) confirmed that basic magmatism in the Västervik region has been active during the whole course of the orogeny, and moreover, discerned seven different periods of activity, where dikes of the youngest period are intersecting ”younger” Småland granitoids. From the Linköping area further north, Gorbatschev (1971b) reported basic dikes having a similar chronological position in regard to analogous granitoids. The numerous occurrences of basic dikes in the Svecofennian basement of the Stockholm region and its surroundings have an intraorogenic status (Stålhös 1964, 1969, 1972), and there is no evidence of synorogenic dike intrusions.

In addition, the existence of metabasite dikes within the Småland province (excl. the Västervik area) are occassionally documented in some of the descriptions accompanying the petrological maps of the area (*e.g.* Holst 1885, 1893; Munthe and Hedström 1904; Hedström and Wiman 1906; A. Gavelin 1907; Hedström 1917; Geijer *et al.* 1951).

Concerning informations of the basic dike activity in Blekinge and its border areas towards Scania, there are only scanty contributions available from the literature. According to R. Norin's (1936) investigation of western Blekinge, the metabasites are restricted to the older ”basement”, where they occur as conformable intrusions and are assumed to be genetically linked with the Older granitoid suite (”gneiss-granites” according to Norin's terminology). When proceeding westwards to the Västanå region numerous metabasites are met with. In the opinion of Bäckström (1897), these rocks were intruded before the main folding phase of the supracrustal complex.

Metamorphosed basic dikes in northeastern Blekinge

The rocks treated belong to the more or less ”orogenic” stages of the evolution and do not comprise the last series of unaltered diabase dikes which are later and, as it appears entirely foreign to the preceding ”orogenic” evolution.

Numerous metamorphosed basic dikes of varying relative ages and compositions are found in the investigated area. Many dikes appear as brecciated fragments in the granitoids or small outcrops, where the relations to the surrounding rocks are uncertain. Also due to reactivation processes it is sometimes not possible to confirm a dike character. In spite of these difficulties, on the basis of field relations and geochemistry, at least six generations of metabasites can be distinguished in the area. Consequently, field evidence indicates a relatively long duration of Precambrian basic magmatic activity in northeastern Blekinge.

Details of the proposed dike chronology are preliminary and need confirmatory additional mapping and chemical work.

Metabasite dikes have been observed in almost the whole area mapped, except for the massifs of the Youngest granitoids.

Most of the dikes are foliated and show steep dips. Strikes vary according to age. Dikes within the Older granitoid unit trend in general towards NW to WNW, *i.e.* parallel to the regional deformation pattern. A few minor dikes in the same area are discordant, but have later been affected by weak deformation. Basic dikes cutting the Younger granitoids run NNW and E—W.

The present mineral assemblage of the basic dike rocks is brown to (bluish) green hornblende, actinolitic hornblende, plagioclase (oligoclase), biotite and epidote and suggests that the stage of metamorphism responsible for the present mineral associations was close to the boundary between greenschist and amphibolite facies. Pyroxene and garnet are absent in all specimens examined. The absence of garnet may be due to combination of relatively low P and T.

The localities of the chemical samples considered in this paper are shown on the map Fig. 59 (pp. 108—109).

The different groupings will be considered below.

Generation I

The first generation of metabasites occurs within a restricted part of the basement gneisses in the SW, and is supposed to be older than the Older granitoid group. These metabasites form elongated lens-shaped fragments, which are folded and sheared. The foliation is parallel to that of the country rock. This suggests an original concordance, and involvement of the metabasitic rocks in the same deformation phase as the gneisses. Both the basic layers and the surrounding gneisses carry thin veins of quartz and feldspar.

Petrographically, these basic rocks are amphibolites *(sensu lato)* according to the nomenclature of Cannon (1963). Their main minerals are hornblende (>50 %), plagioclase and biotite. The rocks are fine-grained and have dark grey colour.

The oldest metabasites differ chemically from successive generations in having *inter alia* very high Cr/V och Ni/Co ratios, and low DI (Table 2: no. 40).

The problem of distinguishing between para- and ortho-metabasites has concerned geologists during many years. There are several papers dealing with the chemical distinction of para- and ortho-amphibolites (*e.g.* Evans and Leake 1960; Walker *et al.* 1960; Leake 1963, 1964; Janda *et al.* 1965; Shaw and Kudo 1965; Preto 1970; Misra 1971).

In order to interpret the origin of the rocks in terms of para- or ortho-amphibolite origin, the chemical analysis was compared to analyses of metabasites of known origin from the literature *(op. cit.)*. Definitive conclusions cannot be drawn from this comparison, but it is possible that some of the oldest metabasites have been derived from originally sedimentary rocks. In that case, of course, these basic rocks would fall outside the proposed dike chronology.

Generation II

The second generation of metabasite dikes occurs in the gneiss and Older granitoid areas. The composition is essentially hornblende > biotite > plagioclase. The dikes are 0.5 to 1 m across and have throughout their area of distribution a predominant NW—SE strike. All dikes are moderately to distinctly foliated. In strongly reactivated granitoid areas they have been split up into numerous blocks separated by the reactivated granite material. An instance of a dike which has been folded and disrupted by the surrounding Older granitoid is shown in Fig. 30. Locally, within the Older granitoid region, the second generation dikes have been affected by metasomatic alterations. The degree of replacement by granitic material is highly variable from place to place. A few of the dikes have been penetrated by leucogranitic material, which is finer-grained than the surrounding Older granitoid *(cf.* Chapman 1955; Wattersson 1965, p. 67). Fig. 31 illustrates an advanced stage of replacement of a second generation basic dike by fine-grained granite. It is noted that the late granite material is not found outside of the original limits of the dike. The rocks have later been intruded by clearly younger aplite-granite dikes. The replacement described here permits different interpretations which is due to its complex geological history.

The dike margins are often granitized by quartz plus feldspar material. The central and marginal zones of one of the granitized dikes, east of Tving village, have been analysed chemically (Table 1: nos. 29—30) in order to examine the changes caused by the granitization. As evident from Table 1, the dike margin (no. 30) has been relatively enriched in Si, Al, Na and K, and impoverished in Ca, Fe_{tot}, Mg, Ti, Mn, Cr, Co, V and Ni. These results are in agreement with those of Ogura (1958) from similar granitized basic rocks (*cf.* Härme 1959).

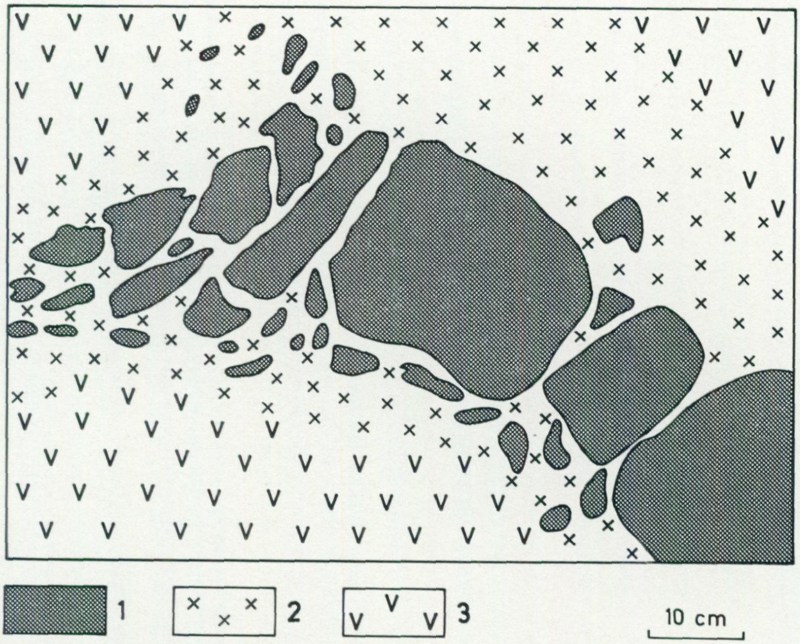

Fig. 30. Folded and broken metabasite dike (second generation) in reactivated Older granitoid. N of Perstorp. Symbols: 1 — metabasite, 2 — medium-grained leucocratic granitic material, and 3 — Older granitoid.

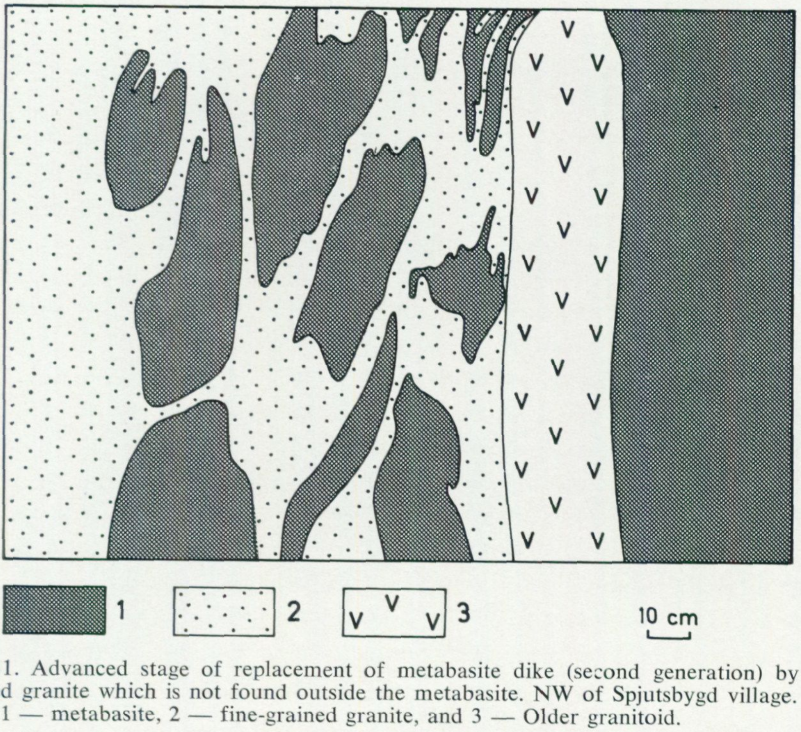

Fig. 31. Advanced stage of replacement of metabasite dike (second generation) by fine-grained granite which is not found outside the metabasite. NW of Spjutsbygd village. Symbols : 1 — metabasite, 2 — fine-grained granite, and 3 — Older granitoid.

Generation III

Only a few dikes of this group have been found. They are all within the Older granitoid area in the neighbourhood of Tving village.

The basic dikes of the third generation are discordant in regard to the general direction of the regional deformation of the Older plutonic rocks. The dikes show, however, weak signs of shearing and internal deformation coincident with the direction of the regional deformation pattern. Again, the deformation has never proceeded so far that the dikes have become broken and separated into fragments. The dike foliation is thus supposed to have developed later than the primary granitoid foliation. This assumption is mainly based on the fact that the dikes display a much weaker internal deformation than the country rock.

Granitized dike margins are fairly common. The dike rocks are petrologically classed as amphibolites. One discordant metabasite dike (Tables 1—2: no. 31) at Tving village has been analysed chemically and shows much lower Cr/V and Ni/Co ratios than the other dike generations.

Generation IV

The occurrences of metabasite dikes belonging to the fourth generation are restricted to the Older granitoid area. They are the most frequent dikes in this area. In contrast to previous dike generations, they do not seem to have been affected by the regional deformation phase attributed to the Older granitoid complex. Field evidence shows that the fourth generation of metabasites is older than the emplacement of the Youngest granitoids, as these split the dikes at the contact between the Older and the Youngest rock complexes (*e.g.* at the south-eastern part of Lake St. Alljungen). Furthermore, since these metabasites are neither transecting the border between the Older and the Younger plutonics nor found within the latter rock suite, their intrusion seems to be prior to the development of the Younger rock unit. Thus the fourth metabasite generation seems to have intruded after the regional deformation but before the introduction of the Younger plutonic rocks.

The rocks are predominantly of amphibolite type, with normative olivine and modal quartz (Tables 1—2: nos. 33, 35—36, 42—44).

The dikes vary in thickness from a few decimeters to about 3 m.

In the southern and central parts of the Older granitoid area the dikes strike approximately NW—SE with persistent vertical dips conformable with the direction of the regional deformation. As mentioned they have not been influenced by the granitoid deformation, but on the other hand they may at some places display deformation structures due to later tectonization phases of cataclastic nature (see p. 63). A few dikes show internal displacement features, while no corresponding breaks are visible in the country rock granitoid. This appearance can be interpreted as being due either to faulting with subsequent recrystallization of the granitoid or to intrusions of basic magma into original irregular fissures (*cf. e.g.* Kaitaro 1952; Roddick and Armstrong 1959, p. 606).

In these parts of the region the metabasites are less metamorphosed and always show better preserved original textural features than the basic rocks of earlier generations. In several dikes relics of the original ophitic texture remain, and in one case, at the railway crossing of Spjutsbygd village, the original chilled dike margin, which has a width of about 1 dm, has been preserved. This dike borders upon an Older reactivated granitoid, where the reactivation process is either almost equivalent in age or, more probably, predating the fourth generation dike activity. At Spjutsbygd village the emplacement of the basic magma seems to have produced mobilization of the wall rock, resulting in transverse reomorphic pegmatoid veins in the basic dike (*cf. e.g.* A. Laitakari 1928; Kahama 1951; Frankel 1967; I. Laitakari 1969). The acid veins start at the contacts of the basic dike but show no apophyses into the wall rock. The back-veining may indicate that the basic intrusion has taken place in a pre-heated rock complex (*cf.* Wager and Bailey 1953; Walker and Skelhorn 1966). The chemical relations of the dike at Spjutsbygd village are discussed below.

Northwards in the Older granitoid district the strike of the dikes of the fourth generation changes from NW—SE to WNW—ESE. Along the border zone against the Younger rock complex the strike is almost E—W. Simultaneously the metabasites become increasingly affected by cataclastic tectonization. In the irregularly distributed tectonic zones the metabasites as well as the granitoids have been converted into mylonite rocks, while between the zones folation of moderate intensity has developed (see p. 22). It is also suggested that subsequent movements have occurred along the border zone between the Older and the Younger igneous blocks, making use of this preexisting tectonic discontinuity zone.

Chemical analyses of six representative samples of metabasites (nos. 33, 35—36, 42—44) belonging to the fourth dike generation will be found in Table 1.

The dike at Spjutsbygd village was selected for more detailed chemical investigation in order to investigate whether metasomatic alterations had occurred between the dike margin (no. 36) and the central zone (no. 35). The results of the two analyses are very similar and do not thus support the assumption of large-scale metasomatic alterations of the fourth metabasite generation, as contrasted to be second dike generation (see p. 60). The minor chemical variations from margin to center, the increase of elements such as K and Sr, and *status quo* between the distribution of Cr, Co and Ni, are instead suggesting a differentiation within the dike when proceeding inwards from the chilled margin.

Generation V

This category of basic hypabyssals has only been found immediately east of the Eringsboda massif, within the Younger plutonic district, and forms dike swarms (see Plate 1). Most of them occur along the eastern border zone of the Eringsboda massif in a tectonic discontinuity zone. This indicates a relatively late origin in relation to the evolution of the igneous rocks of northeastern Blekinge. The dikes are aligned irregularly in NNW—SSE directions and with undulating moderate to steep dips. Their width is mostly about 0.5 m. The pronounced shift in dike direction from the Older granitoid area to the Younger appears to reflect changes in the tectonic regime in connection with the Youngest plutonic activity.

The majority of the investigated dike rocks is composed essentially of hornblende and plagioclase, and these two minerals often make up more than 80 per cent of the bulk composition.

Preserved intrusive features such as apophyses and *en échelon* structures occur now and then. A minor part displays offset structures, but the displaced pieces of the dikes are still connected with each other.

Generation VI

Members of the sixth metabasite generation were found at two localities in road cuttings about 2.5—3.5 km ENE of Holmsjö village within the area of the Younger rock suite. They form small (<0.3 m) steep-dipping dikes, striking E—W to WNW—ESE.

Petrologically, they are very fine-grained (altered) diabases, showing great mineralogical similarities with the uralite diabases in the province of Småland, previously described by Eichstädt (1882, 1884) and Hedström (1906). Also similarities of dike orientation (Hedström and Wiman 1906, pp. 54—55) suggest that the sixth metabasite generation is related to the uralite diabase group in southeastern Sweden.

The chemical composition of a sample (no. 38), taken from a dike about 2.5 km ENE of Holmsjö village, is given in Table 1. This analysis differs from most of the others in having a high-alumina to tholeiitic basalt composition, normative quartz, hypersthene, and no olivine (Fig. 32).

Chemical characteristics of the metabasites

The chemical compositions of the metabasites are only treated provisionally in order to give a general idea of the chemistry. Their petrochemical characters are best demonstrated by a number of diagrams of synopsis nature.

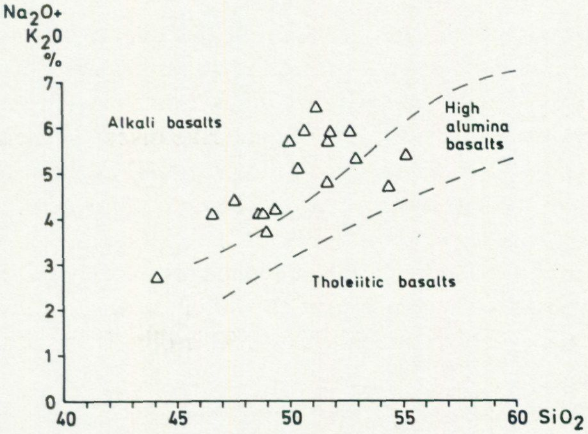

Fig. 32. Diagram showing the relation between alkalies and silica in metabasitic rocks from northeastern Blekinge. Boundary lines after Kuno (1968).

By plotting the analyses in a variation diagram (Fig. 32; boundary lines are from Kuno 1968) showing the relation between alkalies and silica, it can be seen that the majority of the samples reveals alkalic affinities. Three samples (Table 1: nos. 32 and 37 are of unknown relative age, and no. 38 belongs to the sixth metabasite generation) plot just under the boundary line between the alkalic and high alumina basalt fields.

In Fig. 39 (p. 73) the presently available analyses are projected into an AFM diagram, where the alkalies Na_2O+K_2O, the total iron as FeO, and MgO are represented in the three apicies. From this diagram it is evident that the metabasites plot to form an alkalic trend, which more or less follows the general differentiation trend of the rest of the plutonic rocks in the investigated area.

Plots of the Differentiation Indices (DI) of the metabasites (on p. 75) *versus* their respective atomic ratios K/K+Na (Fig. 42), Ca/Ca+Na (Fig. 40) and Mg/Mg+Fe (Fig. 44) exhibit scattered distribution patterns, except for the diagram DI *versus* Ca/Ca+Na (Fig. 40), which fits the "normal" trend observed. However, it can be noted how the above element ratios generally vary with increasing differentiation. DI ranges from 19.7 to 49.1 in the successive dike generations, but not in a regular manner.

DIABASES

The diabases are the youngest rocks of the Precambrian in the Blekinge region. They form dike swarms striking approximately NNE—SSW. In the area studied there are at least five dikes, but they have not been systematically mapped. Preliminary K/Ar datings on two diabase dikes in western Blekinge (Tärnö and

Hoby) have given approximately 800 m.y. (I. Klingspor, personal communication.) In the western part of the province the writer has found sandstone fissure fillings, probably of Cambrian age, in the diabase dike passing near the centre of Karlshamn. Previously, occurrences of ”sandstone dikes” in Blekinge have only been reported from the eastern section of the region (Mattsson 1964).

The diabases of western Blekinge have been thoroughly described by Moberg (1896) and are mostly olivine-bearing. In his description of the bedrock geology of eastern Blekinge, Hedström (1906) mentioned several xenolith-bearing diabase dikes. One of these occurrences is situated within the mapped area at Sällemåla farm, about 3 km SW of Nävragöl village. This dike is described in the next chapter.

I. Larsson and Stanfors (1970) have compared two diabase dikes in western Blekinge in regard to their magnetic properties.

In the area investigated the width of the diabase dikes varies between less than 1 and 20 m. The dikes are schematically indicated in the petrological map (Plate 1). A few dikes can be traced over distances of several kilometers.

Photogeological studies indicate a close relationship between the dike strikes and the lineaments of the landscape. The regional development of fractures *versus* dike intrusions seems to be complex, and probably there is more than one dike generation in the area. I. Larsson (1954) has analysed the fracture pattern in western Blekinge in terms of modern views on fracture formation.

No chemical analysis has been made of the diabases in the area investigated. The chemical compositions of two diabase dikes from western Blekinge have, however, been published by I. Larsson and Stanfors (1970).

Petrography

A detailed study of the diabases is beyond the scope of this paper. Petrographically, the diabases examined seem to be very uniform.

In fresh cuttings the diabases have greyish block colour. The grain size varies with the dike width.

Under the microscope the plagioclase crystals are lath-shaped. They are often zoned and the composition ranges from about An_{48} in the centre to An_{25} at the rim. Most crystals are twinned according to the albite and Carlsbad-albite laws.

Augite is the most abundant mafic mineral. It occurs interstitially between the plagioclase individuals. Optical determinations of the augite (sample from the dike outcrop about 5.5 km NE of Tving village) have $2V_z = 48°$ and $c/Z = 42°—44°$. A few crystals display faint zoning. Part of the augite has altered to minerals such as biotite, chlorite and epidote.

Olivine is not found in all examined dikes and when originally present has generally been pseudomorphosed by green fibrous chlorite minerals, carbonates, and skeletal grains of ilmenite and magnetite.

The principal accessory mineral is apatite. It forms hexagonal crystals and needles.

Xenolithic diabase dikes

Some of the diabase dikes of southeastern Sweden comprise localities with more or less rounded xenoliths of quartzitic rocks occasionally accompanied by other rock types. These xenolith-bearing dikes, which in Sweden are often named "diabase conglomerates", have been investigated and discussed by several geologists (Nycander 1884; Eichstädt 1885; Holst 1885, 1893; Bäckström 1890; Stolpe 1892; Moberg 1896; Hedström 1906, 1910, 1917; Blomberg 1907; Sederholm 1927; Berg-Lembke 1970). The best known occurrences are found at Brevik (Hedström 1917) and Rödja (Eichstädt 1885) in the province of Småland.

Special attention has been paid to the xenolithic diabase dikes on account of the problems concerning the origin and the age of the quartzitic fragments and the mechanism of the diabase intrusion. Two contrary hypotheses have been advanced regarding the age of the inclusions. Most investigators have correlated the quartzitic xenoliths with the Jotnian Almesåkra quartzite and conglomerate (*e.g.* Eichstädt 1885; Holst 1885; Stolpe 1892; Hedström 1906, 1910, 1917). The Almesåkra complex is situated SE of Lake Vättern, in the province of Småland. The stratigraphy of the Almesåkra area is from bottom to the top as follows (S. Gavelin 1931): granitic arkose deposited on a granite, white quartzite, pale sandstone, slate, sandstone, quartzite, and a discordantly superimposed polymict conglomerate. The sedimentary complex is intercalated with sills and intersected by dikes of diabase.

K/Ar age determinations of slates from the Almesåkra complex are between 848 m.y. and 964 m.y. (Magnusson 1960a).

Eichstädt's (1885, p. 22) petrogenetic theory of the "diabase conglomerates" considers that the Almesåkra conglomerate was disintegrated by rivers following large fault zones. The matrix of the conglomerate was destroyed and the quartzite pebbles regained their original status. Later, diabase magma intruded along these tectonic zones and enclosed the pebbles.

Different opinions on the age and origin of the fragments were advocated by Moberg and Sederholm. Moberg (1896, p. 45) held that the xenolithic dikes in western Blekinge were friction breccias. He noted that the larger xenoliths are sharp-edged and the smaller subrounded and supposed that the fragments derive their origin from a deeper part of the crust. It must, however, be noted that the Almesåkra complex is not represented in the province of Blekinge. Sederholm (1927, p. 415) discussed the age of the quartzite fragments (pebbles) in the "diabase conglomerates". On the basis of a comparison between quartzite samples from Brevik and from the Västervik complex (Svecofennian) he assumed that the quartzite pebbles are older than the "younger" Småland granitoids and even the Loftahammar granite. Thus Sederholm (1927, p. 416) postulated a sedimentary formation older than the Almesåkra complex. A similar type of quartzite xenolith-bearing diabase dike in Häme, Finland, has been described by Laitakari (1969), who points out that: "It is not possible to assume that the quartzite was derived from the country rocks because no quartzite of this type is known anywhere in the area, at least at the present erosion level". Further he writes (p. 47): The author has come to the conclusion that the typical quartzite xenoliths are derived from quartzite occurrences below the present erosion level".

Some general characteristic data on the quartzite xenolith-bearing diabase dikes in southern Sweden will be briefly summarized here. Hedström (1917, p. 48) writes about the Rödja dike: "Quartzites derived from the Almesåkra complex are predominant among the enclosures; besides, granites, leptites and other pre-Cambrian rocks are represented". Later on he mentions: "pebbles are found to which portions of the original matrix are still attached". The inclusions are more or less rounded. Berg-Lembke (1970) reports the following distribution of rock types among about 200 pebbles in the Brevik dike: sandstone and feldspar quartzite 78 %, pure quartzite 12 %, porphyry 6 % and granite 4 %.

The xenoliths are restricted to well-defined zones within the diabase dikes, and never occur along the dike margins (Nycander 1884, p. 404; Eichstädt 1885, p. 5). The size of the fragments varies from less than 1 cm to more than 10 cm in diameter. Even the xenolith content shows great variation and exceptionally exceeds 50 %.

Xenolith-bearing diabase dike at Sällemåla

The xenolith-bearing diabase dike at Sällemåla farm is poorly exposed, which prevented detailed investigation and neither the width of the dike nor the dike orientation could be determined.

The main petrographical characteristics of the diabase rock agree with those described previously (p. 66).

A conspicuous feature of the Sällemåla dike are the numerous packed and in part cracked quartzitic fragments with diameters between approximately 2—4 cm. The largest may exceed 10 cm. The inclusions consist exclusively of greyish (on weathered surfaces whitish grey) quartzitic rocks. The frequency of the fragments is usually 30—40 %. Their shape is generally variformed (Fig. 33).

The subrounded quartz grains in the fragments have a grain size between 0.03 and 0.25 mm, on average 0.1 mm (Fig. 34). Many of the grains are traversed by micro-fractures, ceasing at the contact against the diabase. The fractures are filled with chlorite minerals. In a few specimens, thin diabase apophyses penetrate the fragments, probably due to the disintegration of larger xenoliths.

The interstices between the quartz grains consist of a very fine-grained mass of quartz—feldspar and chlorite—serpentine—calcite aggregates.

Fig. 33. Diabase crowded with sub-angular cracked quartzite-sandstone fragments. Sällemåla.

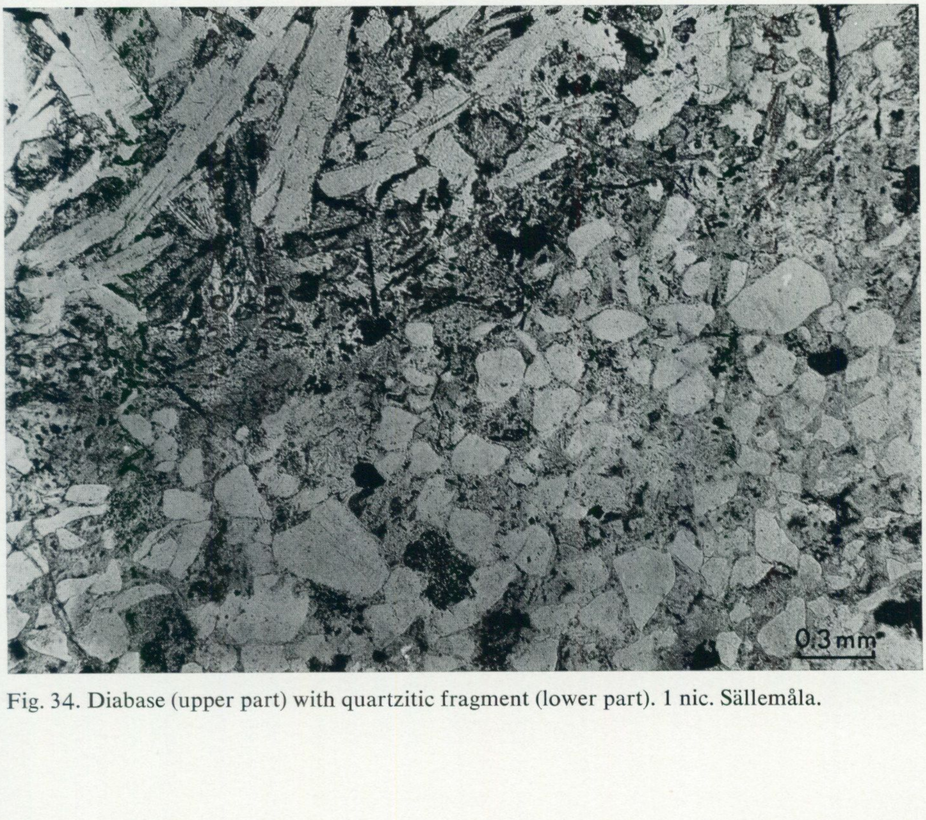

Fig. 34. Diabase (upper part) with quartzitic fragment (lower part). 1 nic. Sällemåla.

The diabase in contact with the xenoliths is slightly chilled and this is taken to evidence that the inclusions were only subjected to moderate preheating. Parenthetically it may be noted, that the concentration of pyroxene and apatite increases when moving from unaffected rock to the margins of the fragments. Thermal influences on the quartzitic xenoliths, such as partial melting caused by the crystallizing basalt magma are absent or very restricted. Because the fragments do not seem to have been subjected to considerable thermal metamorphism it is assumed that the Earth's surface was not very distant and the sedimentary cover not very thick at the time of dike intrusion.

In regards to the age and origin of the quartzitic inclusions, no substantiated opinion can be given because there are no quartzite occurrences in the vicinity. However, it seems most reasonable to correlate them with the Almesåkra complex situated SE of Lake Vättern. This would indicate a large original areal extent of the Almesåkra complex.

CHEMICAL RELATIONS BETWEEN THE VARIOUS GRANITOID GROUPS, WITH SPECIAL REFERENCE TO THE OLDER AND YOUNGER GRANITOIDS

Seventeen samples of granitoid rocks, representing the three age-different granitoid complexes in northeastern Blekinge, were analysed chemically for major and minor elements. For localities, see list on p. 106 and Fig. 59 (pp. 108—109).

The results of the analyses and the norms and modes of the rocks are given in Tables 1—3. Although few data are available concerning the chemical compositions of the various granitoid provinces, several chemical parameters are discriminating between the three rock groupings. Some chemical features are shared by the Older and Younger granitoid groups. Figs. 35—45 have been used to give a diagramatic survey of the major chemical characteristics of the investigated granitoid rocks.

Fig. 35 gives normative Q—Or—(Ab + An) compositions (weight proportions) of the various plutonics in the map area. As evident from Fig. 35, there is no discrimination between the Older and Younger granitoid groups respectively.

The modal compositions (Fig. 36) of the plutonics reveal calc-alkalic affinities. The Older granitoids are for the most part confined to the granodiorite field, whereas the Younger granitoids are equally distributed between the granodiorite and the granite fields respectively.

Normative weight proportions Q—Ab—Or of the analysed plutonic rocks are shown in Fig. 37. As expected most of the Older granitoids are found outside the granite maximum of Tuttle and Bowen (1958), the rocks actually trending from an albite-rich field into the eutectoid granite compositional area.

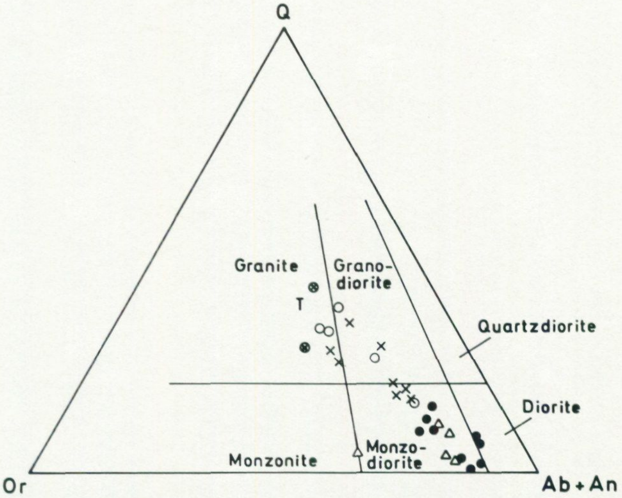

Fig. 35. Diagram showing normative Q—Or—(Ab+An) compositions in plutonic rocks in northeastern Blekinge. Terminology according to Streckeisen (1967). Symbols: inclined crosses—Older granitoids, open circles—Younger granitoids, circles with inclined crosses—Youngest granitoids, filled circles—basic plutonics within the Younger granitoid area, and triangles—metabasites.

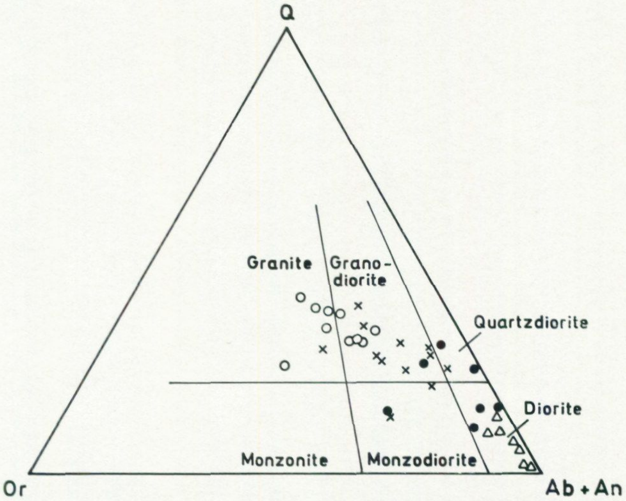

Fig. 36. Diagram showing modal quartz—alkali feldspar—plagioclase compositions in plutonic rocks in northeastern Blekinge. Terminology according to Streckeisen (1967). Symbols: inclined crosses—Older granitoids, open circles—Younger grantioids, circles with inclined crosses—Youngest granitoids, filled circles—basic plutonics within the Younger granitoid area, and triangles—metabasites.

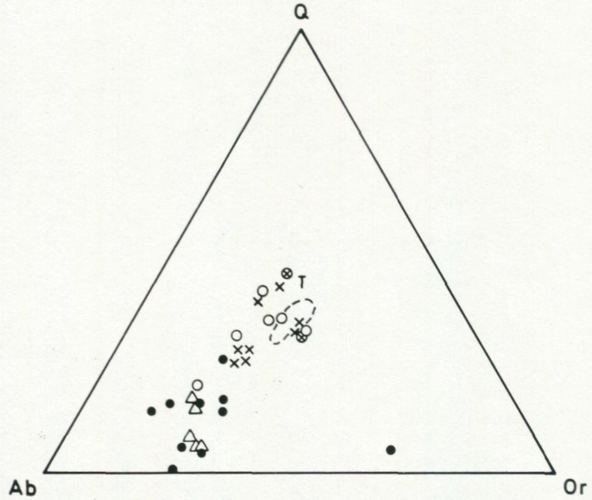

Fig. 37. Diagram showing normative weight proportions Q : Ab : Or in plutonic rocks in northeastern Blekinge. Symbols : inclined crosses—Older granitoids, open circles—Younger granitoids, circles with inclined crosses—Youngest granitoids (coarse-grained), T—spotted granite, filled circles—basic plutonics within the Younger granitoid area, and triangles—metabasites. Broken lines indicate area of max. concentration of world granite analyses (Tuttle and Bowen 1958).

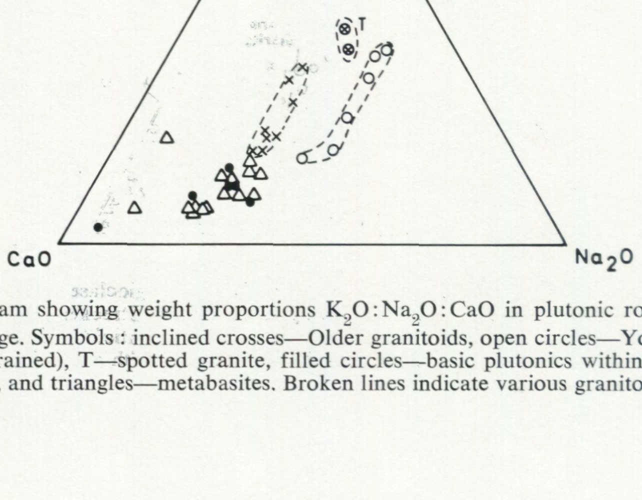

Fig. 38. Diagram showing weight proportions $K_2O:Na_2O:CaO$ in plutonic rocks in northeastern Blekinge. Symbols : inclined crosses—Older granitoids, open circles—Younger granitoids (coarse-grained), T—spotted granite, filled circles—basic plutonics within the Younger granitoid area, and triangles—metabasites. Broken lines indicate various granitoid groups.

The above characteristics consequently do not render different trends for the two granitoid groups. However, they indicate different positions on the trend lines, provided the number of analyses be held sufficient to indicate the average chemical compositions of the two groupings.

When a distinction between the various granitoid provinces is desired, chemical characteristics such as the weight proportions K_2O—Na_2O—CaO depicted in Fig. 38 will be more significant. This plot displays distinctly a threefold grouping of the granitoid analyses. Moreover, it is evident that the Younger granitoids have an alkalic nature, especially due to high Na contents, as compared with the Older granitoids. The Youngest granitoid group deviates from the other granitoid groups in having a high content of potassium.

In Fig. 39, which is a ternary diagram for alk ($\Sigma\, Na_2O+K_2O$), F ($\Sigma\, FeO$), and M (MgO), all available plutonic rock analyses from the investigated area plot close to an alkaline trend. Not surprisingly, the Older granitoids differ in chemistry from the Younger granitoids in having higher MgO and lower FeO_{tot} contents. However, this diagram is not generally applicable to acid granitoids because the amounts of Fe+Mg are normally so low that slight differences

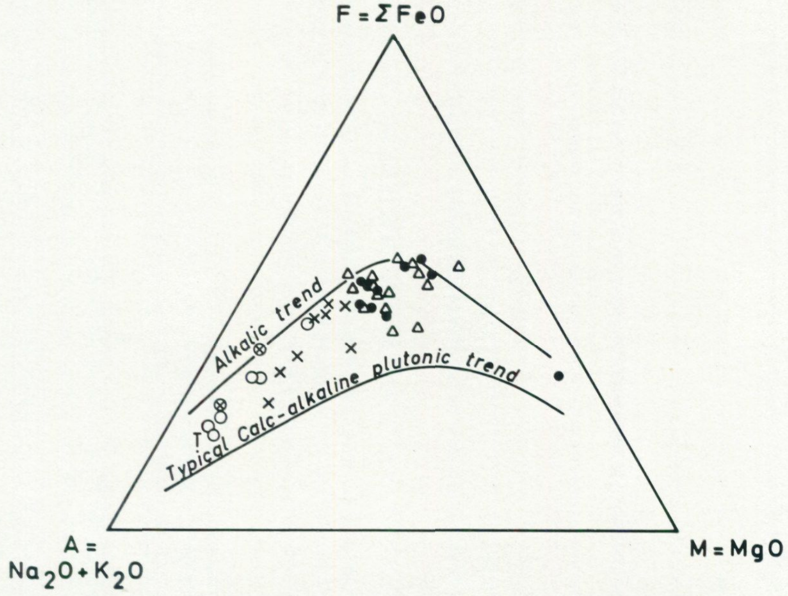

Fig. 39. AFM diagram (weight proportions) for plutonic rocks in northeastern Blekinge. Symbols: inclined crosses—Older granitoids, open circles—Younger granitoids, circles with inclined crosses—Youngest granitoids (coarse-grained), T—spotted granite, filled circles—basic plutonics within the Younger granitoid area, and triangles—metabasites. Curves are trends of fractional crystallization of calc-alkalic (after Hess 1960) and alkalic (after MacDonald and Katsura 1960) suites, respectively.

cause comparatively large step-like changes of the granitoid plots. In addition, it must be emphasized that the Blekinge granitoids do not probably belong to any mantle-differentiation, but are thought to have an anatectic origin (*cf.* p. 31).

In order to find out other significant chemical relations between the analysed plutonics, particularly the Older and the Younger granitoids, the atomic ratios Ca/Ca+Na, K/K+Na and Mg/Mg+Fe (Table 2) have been plotted *versus* Differentiation Index (per cent of normative quartz+orthoclase+albite; after Thornton and Tuttle 1960) respective silica percentage in Figs. 40—45. Some of these parameters are discriminating between the Older and the Younger granitoid groups.

The most significant and interesting plots are those of Ca/Ca+Na *vs.* DI and SiO_2 (Figs. 40—41) respectively, showing exceedingly two well-defined separate trends for the Older and Younger granitoid groups. Calculating the regression lines for these two granitoid complexes in the plot of Ca/Ca+Na *vs.* DI (see Fig. 40) show that the Ca/Ca+Na ratio decreases systematically with increasing DI within each rock grouping and that the decrease is more pronounced in the Younger granitoid sequence. The Yasjö plutonics can be seen to plot near the Younger granitoid trend. Older granitoids have higher Ca/Ca+Na ratios *vs.* DI than Younger granitoids of corresponding DI. Ca/Ca+Na ratios for Older granitoids range from 0.39 to 0.50, and corresponding average values for Younger granites and granodiorites are 0.20 and 0.29 respectively. The calc-alkalic character of the former rock suite is chemically reflected in the calcium content.

Also in the plots of K/K+Na *versus* DI and SiO_2 (Figs. 42—43), respectively, systematical differences between the various granitoid groups are evident. The data render marked trend differences between the Older and Younger rock sequences. Older granitoids reveal higher K/K+Na ratios than Younger plutonics of corresponding DI respective SiO_2-content. It should be noted, however, that Gorbatschev (1971b, p. 41) found the reverse relation between Svecofennian gneissic granitoids and younger ("Gothian") plutonics in the Linköping area, when plotting the corresponding element ratio *versus* Niggli *si*. Figs. 42—43 visualize the slightly more alkalic nature of the Younger granitoids compared with the Older plutonics, mainly due to relatively higher contents of sodium (*cf.* Fig. 38).

Figs. 44—45 illustrate the atomic ratio Mg/Mg+Fe *versus* DI and SiO_2 respectively. Most of the granitoid plots exhibit some scattering, especially in lateral direction, with exception for the Youngest granitoid group. The Older granitoids are characterized by relatively higher Mg/Mg+Fe ratios than the Younger granitoids (*cf.* Table 2). It may be observed from Fig. 44 that the Mg/Mg+Fe ratios of the Older and the Younger granitoids do not decrease significantly with increasing DI (*cf.* Gorbatschev 1971b, p. 43). These observations disagree with the normal trend of differentiation established for calc-alkali and alkali series ranging from gabbro to granite. Generally, there is a

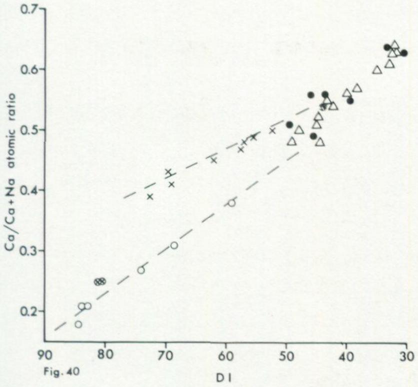

Fig. 40

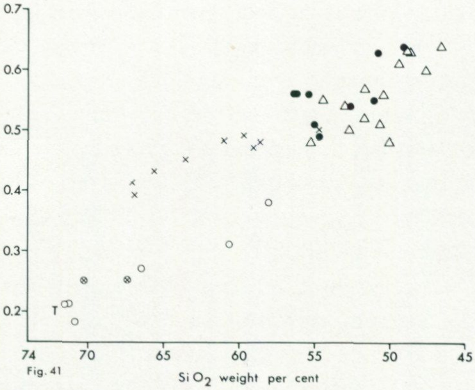

Fig. 41

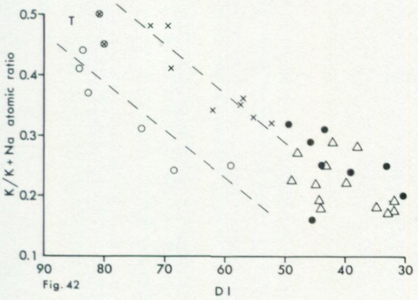

Fig. 42

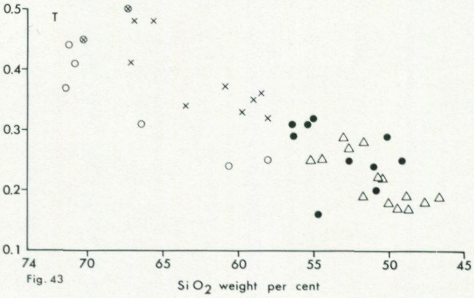

Fig. 43

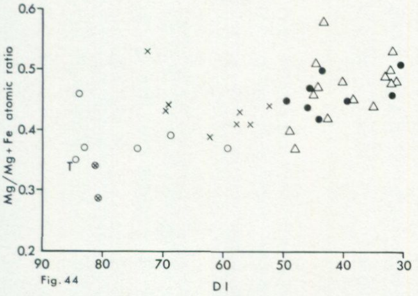

Fig. 44

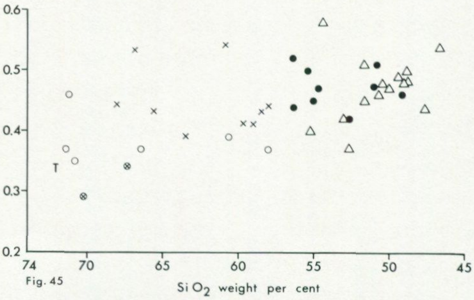

Fig. 45

Figs. 40—45. Plots of the atomic ratios Ca/Ca+Na, K/K+Na, and Mg/Mg+Fe *versus* Differentiation Index (after Thornton and Tuttle 1960) and weight per cent SiO_2 for different plutonic rocks in northeastern Blekinge. Symbols: inclined crosses—Older granitoids, open circles—Younger granitoids, circles with inclined crosses—Youngest granitoids, T—spotted granite, filled circles—basic plutonics within the Younger granitoid area, and triangles—metabasites. In Fig. 40 broken lines show regression trends according to the following equations: Older granitoids—Ca/Ca+Na=–0.005 DI+0.771 (r=–0.982), and Younger granitoids—Ca/Ca+Na=–0.007 DI+0.814 (r=–0.994). In Fig. 42 broken lines show regression trends according to the following equations: Older granitoids—K/K+Na=0.008 DI – 0.105 (r=0.913), and Younger granitoids—K/K+Na=0.007 DI – 0.154 (r=0.912).

steady decrease in the Mg/Mg+Fe proportion with progressive differentiation, which also finds expression in the systematic variation of Mg/Mg+Fe of the ferromagnesian minerals (see p. 82).

Summing up, the Older and the Younger plutonic groups appear both related or unrelated chemically depending on what chemical parameters of major elements are considered. On a Q—Ab—Or diagram (Fig. 37), or on a normative (Fig. 35) respective a modal plot of Q—Or—[Ab+An] (Fig. 36) there appear to be a single differentiation trend. This single trend vanishes on a K_2O—Na_2O—CaO diagram (Fig. 38). More diagnostic in discriminating between the various granitoid groups are chemical parameters such as the atomic ratios Ca/Ca+Na and K/K+Na plotted against Differentiation Index and silica percentage (Figs. 40—43) respectively. The separate variation trends for the Older and the Younger granitoid groups suggest that there may be a common rock composition from which the two groups diverge by different processes, thereby giving rise to different styles of variation. Concerning the Youngest granitoids, it is concluded on the basis of the data presented above, that they are chemically unrelated to the older rock suites in the investigated region.

K—Ba

In Fig. 46 the K/Ba weight ratio is plotted against the weight percentage of silica. Plots of the Older granitoid analyses reveal a great scattering, indicating that this rock unit has been affected by metamorphic-metasomatic processes (*cf.* Fig. 47). On the contrary, the plots of the Younger granitoids tend to define a single trend within a rather narrow field. This confirms that the Younger granitoids have escaped a large-scale K—Ba redistribution in comparison with the Older granitoids.

Considering the Older granitoids, there is a visual positive correlation between Ba and K in Fig. 47, which suggests that late potassium-metasomatism has been a rather important process in the development of these rocks (see p. 78). In the Younger granitoids the reverse trend is found, which means that Ba is depleted relative to K with progressive differentiation. This relation is well-pronounced in alkalic suites, because of the early crystallization of potash feldspar, which readily accepts Ba in its structure.

In this context it should be noted that plots of the basic rock analyses in Fig. 46, including amphibolites and gabbroic—(monzo-)dioritic rocks, exhibit an irregular distribution pattern, as may be expected with regard to the heterogeneous compositional variations and the various ages of these rocks. Moreover, no relation between the basic rocks and the granitoids within the Younger complex seems to exist.

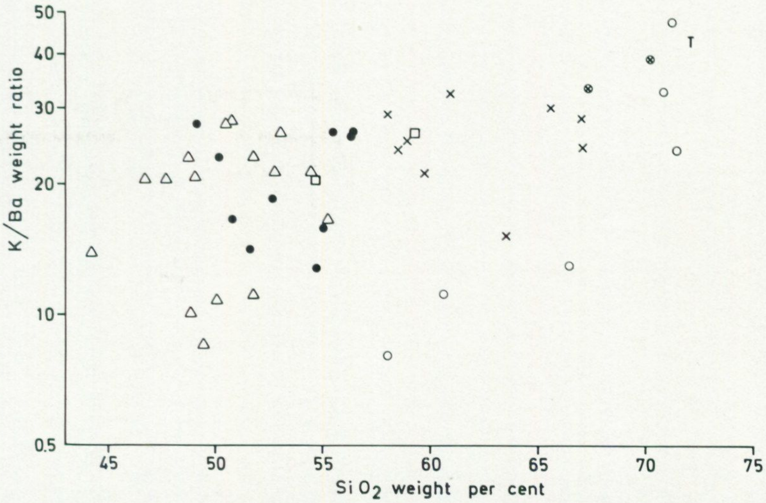

Fig. 46. Diagram showing the relations between the weight ratio K/Ba and the silica percentage in various rock types in northeastern Blekinge. Symbols : squares—Coastal gneisses, inclined crosses—Older granitoids, open circles—Younger granitoids, circles with inclined crosses—Youngest granitoids (coarse-grained), T—spotted granite, filled circles—basic plutonics within the Younger granitoid area, and triangles—metabasites.

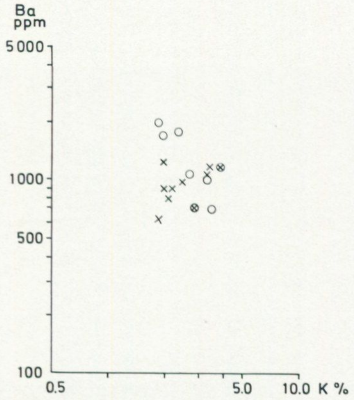

Fig. 47. Diagram showing the relations between the contents of Ba and K of whole-rock samples from various granitoid groups in northeastern Blekinge. Symbols: inclined crosses—Older granitoids, circles—Younger granitoids, and circles with inclined crosses—Youngest granitoids.

K—Rb

The K/Rb ratio is generally used as a geochemical indicator of magmatic differentiation. According to Shaw (1968), unaltered igneous rocks have fairly constant K/Rb ratios, and the ratio depends on the total K content of the rock.

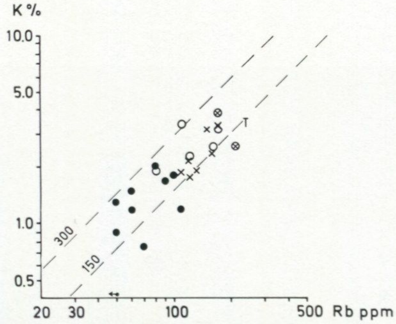

Fig. 48. Diagram showing the relations between the contents of K and Rb in various rock types in northeastern Blekinge. Symbols: inclined crosses—Older granitoids, open circles—Younger granitoids, circles with inclined crosses—Youngest granitoids, T—spotted granite, and filled circles—basic plutonics within the Younger granitoid area. Dashed lines indicate ”normal” area according to Taylor (1965).

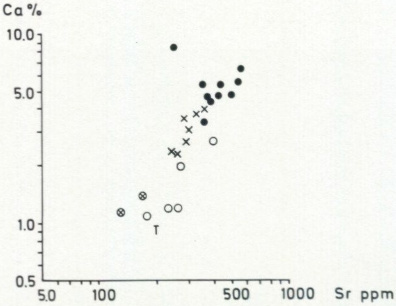

Fig. 49. Diagram showing the relations between the contents of Ca and Sr in various rock types in northeastern Blekinge. Symbols: inclined crosses—Older granitoids, open circles—Younger granitoids, circles with inclined crosses—Youngest granitoids, T—spotted granite, and filled circles—basic plutonics within the Younger granitoid area.

Taylor (1965) gave an average K/Rb ratio of 230 in rocks, and the ”normal” ratios vary from 150 to 300.

Fig. 48 shows K/Rb ratios of various rock types from the investigated area, and the broken lines correspond to a K/Rb ratio of 150 and 300 respectively. The obtained K/Rb ratios range from 107 to 309. The anomalous values, outside the range of 150—300, exhibit a slight enrichment of Rb. In this connection it can be mentioned that Gorbatschev (1971b) reported high K/Rb ratios (280—620) in Småland granitoids from the Linköping area.

There is a tendency to positive correlation between the Rb and K contents of the analysed rocks (Fig. 48). The small spread of some plotted values can be explained by post-magmatic potassium enrichment. Beus and Oyzerman (1965) have shown that the degree of K/Rb correlation in granitic rocks may serve as a criterion of the intensity of post-magmatic activity. Then it is obvious that the K/Rb ratio can not be used as an indication of the differentiation in post-magmatic altered rocks. It is also evident from Fig. 48 that there is an overlapping in the plots of the K/Rb ratios between various types of granitoids and a scattering among the plots of the basic rocks.

Ca—Sr

Sr/Ca ratios in igneous rocks have been given by several workers. Turekian and Kulp (1956) found an obvious geochemical relation between Ca and Sr in granitic rocks. Moreover, they observed an increase of the ratio Sr/Ca with progressive differentiation. It should be noted, however, that when potash feldspar starts crystallization, Sr is depleted relative to Ca. The following data are quoted from Turekian and Kulp (1956).

	Sr content (ppm)
Granitoids containing 0.1—1 % Ca	100
Granitoids containing 1—5 % Ca	440

The very few analytical data (Table 1) available plotted in Fig. 49 show a positive correlation between Sr and Ca, in agreement with observations on Rätan granite made by Lundqvist (1968). When comparing the trend of the Older granitoids with that of the Younger granitoids in Fig. 49, it is found that the former rock suite shows lower Sr/Ca ratios. The Youngest granitoid group has values intermediate between the two other groups.

Cr, Co, Ni and V

The contents of Cr, Co, Ni and V in the analysed granitoid rocks are listed in Table 1. The variations of these trace elements are plotted against respective Differentiation Indicies in Fig. 27 (on p. 00). Generally, the contents of Cr, Co, Ni and V decrease with increasing DI in the granitoid groupings. The following order of distribution of Cr, Co, Ni and V has been observed in the Older granitoid group: V > Cr > Co > Ni (average 161 ppm > 32 ppm > 23 ppm > 16 ppm).

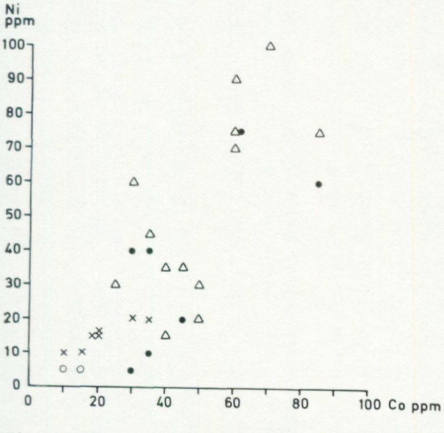

Fig. 50. Diagram showing the relations between the contents of Ni and Co. Symbols : inclined crosses—Older granitoids, open circles—Younger granitoids, filled circles—basic plutonics within the Younger granitoid area, and triangles—metabasites.

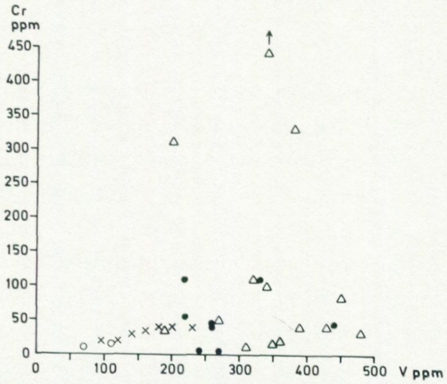

Fig. 51. Diagram showing the relations between the contents of Cr and V. Symbols : inclined crosses—Older granitoids, open circles—Younger granitoids, filled circles—basic plutonics within the Younger granitoid area, and triangles—metabasites. Arrow indicates sample with higher trace element than permitted by the scale.

Chromium and vanadium show a steeper slope of trend than the other elements. The high vanadium contents and the low nickel values in the Older granitoids are in agreement with the typical and characteristic feature of calc-alkaline geochemistry (see *e.g.* Taylor *et al.* 1969).

Two available analyses of Younger granitoids exhibit pervaiding lower trace element contents than Older granitoids of corresponding DI. Further conclusions regarding the Cr, Co, Ni and V distribution in the Younger granitoid group can not be drawn, on account of the restricted number of analyses available.

Ni/Co and Cr/V ratios are illustrated in Figs. 50 and 51. Notable are the Older granitoid plots in the Cr—V diagram (Fig. 51), showing a regular decrease in the Cr/V ratio with increasing differentiation.

CHEMICAL ANALYSES OF BIOTITE AND CALCIC AMPHIBOLE IN VARIOUS GRANITODS

The distribution of major elements has been studied in coexisting biotite—hornblende from two representative samples of the Older granitoid group, *viz.* a tonalite (whole-rock analysis no. 8 in Table 1 — mineral analyses nos. 2a+2b in Tables 4—5) respective a granodiorite (whole-rock analysis no. 6 in Table 1 — mineral analyses nos. 3a+3b in Tables 4—5). Furthermore, biotite compositions from two Younger granitoids (whole-rock analyses nos. 4 and 6 in Table 1) are presented. One biotite analysis from a coarse-grained Karlshamn granitoid, representing the Youngest granitoid group, is quoted from R. Norin (1957).

For localities, see Fig. 59 (pp. 108—109) and the list on p. 107.

Chemical analyses of coexisting feldspars are given in Table 7.

The analyses were made with an electron microprobe at the Geological Inst. of Uppsala, Sweden. Corrections have been applied for atom number and absorption (M. Dahl 1968).

The results of the microprobe analyses are presented in Tables 4 and 5. Ionic values have been calculated on the basis of 22 and 23 oxygens for biotite and Ca-amphibole respectively. Mg/Mg+Fe ionic ratios were calculated and the distribution coefficient (Table 6) is given as

$$K_{D_{Mg}} = \frac{X_{Mg}^{Bi}}{X_{Fe}^{Bi}} \cdot \frac{X_{Fe}^{A}}{X_{Mg}^{A}}, \text{ where } X_{Mg} = \frac{Mg}{Mg+Fe} \text{ and } X_{Fe} = \frac{Fe}{Fe+Mg}$$

represent the ionic fractions in biotite = Bi and Ca-amphibole = A.

The microscopic characters of the Fe-Mg—silicates are given in the petrographical descriptions of the examined granitoid groups and also to some extent below.

Textural relations between biotite and Ca-amphibole in Older granitoids

In most of the investigated Older granitoid samples biotite and calcic amphibole appear to be in textural disequilibrium with each other. In several samples biotite seems to replace hornblende. Again, there are in some cases mineralogical features indicating a reverse reaction (biotite → hornblende). Hornblende contains poikilitic inclusions of quartz and biotite. The boundaries of the biotite inclusions are surrounded by small irregular crystals of potash feldspar and sphene. As observed by Büsch (1965, p. 258) and Mehnert (1968) this is a criterion for biotite replacement by hornblende, whereby potash feldspar and sphene are reaction products (*cf.* also Karamata 1956).

Other complex textural relations have been found in a few hornblende crystals, which exhibit bleached cores, especially around small inclusions of quartz (Fig. 13). According to Taubeneck (1964, p. 295; 1967, p. 15) these relations point to replacement of pyroxene, where silica has been liberated during the alteration of the pyroxene to hornblende. It may be observed, however, that there are no relics of pyroxene in any of the inspected thin sections of the Older granitoids. If pyroxene really once had existed in the rock, the present state must represent an advanced stage of alteration. However, further investigations are needed before this assumption can be proved.

Coexisting biotite—hornblende in the Older granitoids

Compositional data of the analysed Fe-Mg—silicates are listed in Tables 4—6. As mentioned before, analysis no. 2 comes from a tonalite, and analysis no. 3 represents the granodioritic phase of the Older granitoid group.

Hornblende

The composition of the amphiboles is uniform. Mg/Mg+Fe ratios are about 0.40—0.41 (Table 6). The corresponding ratio for whole-rocks is 0.44. The two analysed amphiboles plotted in the diagrams presented by Deer *et al.* (1962) fall within the hornblende field. Referring to the system of Leake (1968), the analysed amphiboles are tschermakitic hornblendes ($Ca+Na+K>2.5$ and $Na \leq 0.38$).

Biotite

The ionic ratio Mg/Mg + Fe is between 0.49 and 0.51 in Older granitoid micas, whereas it ranges from 0.38 to 0.42 in biotites from Younger granitoids (Table 6). In general, the biotites of the Younger granitoids show greater similarity with whole-rock composition than those of the Older granitoids. A feature which stands out clearly in Table 6 is that the ionic ratios Mg/Mg + Fe are higher in biotite than in the coexisting hornblende, which is in agreement with the trend observed in many other igneous suites (*e.g.* Larsen and Draisin 1948).

The Fe-Mg distribution between biotite and calcic amphibole appears to be unaffected by temperature and total pressure (*e.g.* Kretz 1959; Saxena 1966, 1968; Gorbatschev 1970b). The Mg/Mg + Fe ratio is dependent on factors as the oxygen and water fugacities. Decreasing fugacity of oxygen may result in lower Mg/Mg + Fe for biotites crystallizing from magmas.

The distribution coefficient $K_{D_{Mg}}^{Bi\text{-}A}$ ranges from 1.44 to 1.56 (Table 6). The deviation does not seem to be correlated with the distribution of iron and magnesian or with the distribution of tetrahedrally coordinated ions (*cf.* Gorbatschev 1969, 1970b, 1972a), but it may be explained by the high Al content in the hornblende (*cf.* Kretz 1960). But it is possible that a more regular distribution would been obtained if $Mg + Mg/Fe^{2+}$ rather than $Mg + Mg/Fe_{tot}$ ratios were employed. The oxidation level of iron can not be determined using microprobe techniques.

Characteristic of calcic amphiboles is the concentration of iron in coexisting biotite during the crystallization process. This is due to the later crystallization of biotite in relation to hornblende during igneous fractionation. In the present case the biotites have somewhat lower concents of FeO_{tot} and higher of MgO as compared to the coexisting hornblendes.

In this context it might be of interest to look upon the distribution of anions among coexisting biotite—amphibole of Swedish Precambrian granitoid rocks, which has been studied by M. Gillberg (1964). She has examined the distribution of chlorine, fluorine and hydroxyl between micas and some coexisting amphiboles from granitic rocks of Svecofennian and ”Gothian” ages. The results did not demonstrate consistent differences between granitoids of different age, but it appeared ”. . . that the content and distribution of volatiles are affected by the tectonic and chemical history of a petrographic province” (M. Gillberg 1964, p. 495). The distribution of fluorine between coexisting Ca-amphiboles, biotites, apatites, and sphenes from some Swedish apatite-bearing iron ores has been investigated by Ekström (1972), and is considered to be a potential geothermometer.

Biotite in granitoids

Studying differences in chemical compositions of biotites from different types of rocks, Gokhale (1968) proposed biotite as a guide to the knowledge of the petrogenesis of granites (*cf.* Peikert 1963). By plotting chemical data from biotites in a MgO—Al_2O_3—FeO_{tot} diagram (after Nockolds 1947), he thought he could distinguish between magmatic and metamorphic-metasomatic granites, as indicated by the dashed line MgO=15 in Fig. 52. Fig. 52 shows that the biotites analysed here fall in the metamorphic field, as well as the biotite analysis quoted from R. Norin (1957). Gorbatschev (1969, 1970a) obtained the same result for biotites from Late Svecofennian (Revsund granitoids) and post- to late-orogenic granitoids (Rätan and Graversfors granitoids) considered to be of intrusive origin. On the basis of theoretical and empirical observations, Gorbatschev (1970a, p. 30) concluded that ". . . the chemical composition of biotites is no good general indicator of granite formation by either "igneous" intrusion or metamorphism".

The analyses available from Blekinge have been plotted in Fig. 52 and reveal a distinction between different granitoid groups. Biotites from Older granitoids, plotting in a very small field, show a tendency to have higher MgO and lower FeO_{tot} contents as compared to biotites in Younger granitoids. Moreover, higher

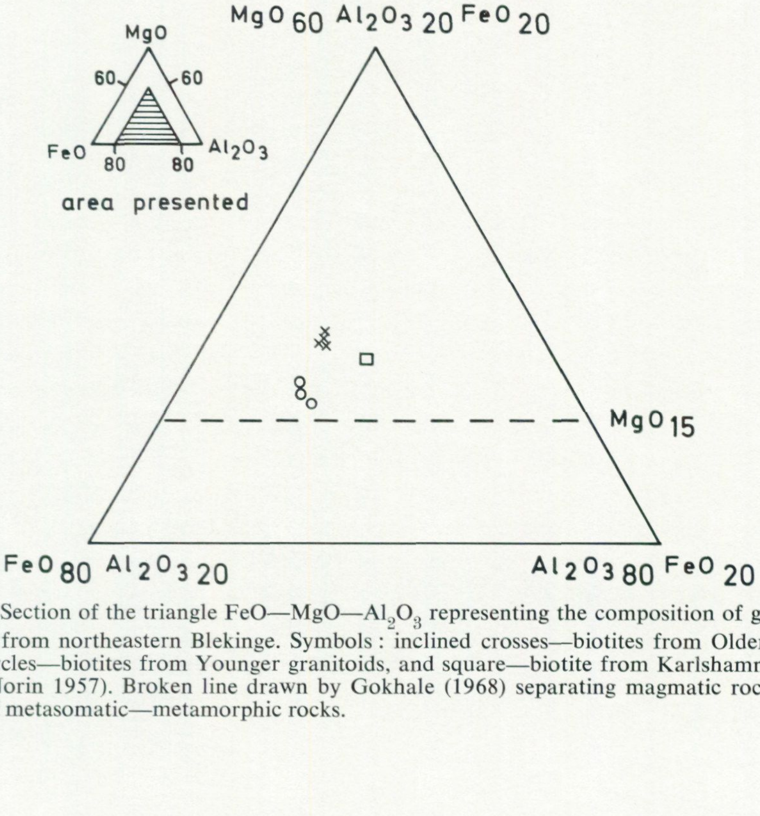

Fig. 52. Section of the triangle FeO—MgO—Al_2O_3 representing the composition of granitoid biotites from northeastern Blekinge. Symbols: inclined crosses—biotites from Older granitoids, circles—biotites from Younger granitoids, and square—biotite from Karlshamn granite (after Norin 1957). Broken line drawn by Gokhale (1968) separating magmatic rocks from those of metasomatic—metamorphic rocks.

Al+Mn and lower Ti contents distinguish the latter biotites from those of the Older granitoids (Table 4). The contents of Mn appear to be highest in the biotites of the felsic rocks, *e.g.* analyses nos. 4 and 6 (*cf.* DI in Table 2). TiO_2 of the Older granitoid biotites varies between 1.8 and 2.6 (average 2.2) weight per cent, while the micas in the Younger granitoid rocks show a narrower range, *viz.* 1.7—2.1 (average 1.8) weight per cent. As mentioned, biotites from Younger and Older granitoids have greenish-brownish and brown colours, respectively, and chemically the Younger granitoid micas are comparatively richer in iron. Furthermore, these biotites have been rutilized and/or sphenized. This exsolution of titanium minerals in the biotites indicate that at the time of the original crystallization, the biotites were considerably richer in titanium.

Hall (1941) discussed the relation between colour and composition of biotites. He advocated that the Ti content is responsible for brown colours, whereas high total Fe contents give green colours. Recently Gorbatschev (1972b) investigated varicoloured biotites in migmatitic rocks and concluded that the principal controls of brown biotite colour are trivalent Fe and Ti, the latter ”obviously being the dominant colouring element in low-oxidized environments” (Gorbatschev 1972b, p. 5).

In the Younger granitoids the whole-rock oxidation ratios ($Fe^{3+}/Fe^{3+}+Fe^{2+}$) are between 0.30 and 0.32, whereas the corresponding ratio is 0.33—0.34 in the Older granitoids.

CHEMICAL ANALYSES OF POTASH FELDSPARS IN VARIOUS GRANITOIDS

In order to obtain more detailed information about the relationships between the various granitoid groups in northeastern Blekinge, eleven potash feldspar megacrysts, representing the three chronologically different granitoid groups, were analysed for Ca, K, Na, Ba, Rb and Sr. The specimens, selected from representative granitoid types, were purified by means of heavy liquids and a magnetic separator. The contents of Ca, K and Na in the samples were determined by atomic absorption spectroscopy (Perkin—Elmer AAS model 306). Ba, Rb and Sr were analysed by X-ray fluorescence (Philips PW 1540 X-Spectrometer). The analyses were carried out at the Geological Inst. of Lund by Dr. Z. Solyom and in co-operation with the writer. The following rock standards were available as reference samples: GM, BM, WL-1, AGV-1, BCR-1, GSP-1 and T-1. The standard deviations for the applied analytical technique are as follow: CaO—0.06; K_2O—0.1; Na_2O—0.13; Ba—3.3; Rb—3.3; and Sr—2.3.

Because of the small number of analytical data the interpretations and conclusions are not entirely compelling.

The results of the chemical analyses of potash feldspars are summarized in Table 7 and recalculated to Ab + Or + An = 100 mol.%.

Analyses nos. 1—3 of the analysed potash feldspars are megacrysts from the Older granitoid group, and analyses nos. 4—7 are from Younger granitoids. Analyses nos. 8—11 are from the Eringsboda and Yasjö massifs respectively.

Sampling localities (and corresponding whole-rock analyses numbers) are given on p. 107 and shown in Fig. 59 (pp. 108—109).

Microscopical studies of the potash feldspars will be found in the petrographical descriptions on the individual rock groups.

MAJOR ELEMENTS (Ca, K and Na)

The investigated potash feldspars are normal perthitic microclines (obliquity values in Table 7) with a composition varying from 77 Or/21 Ab to 90 Or/9.5 Ab (Table 7). As far as CaO and K_2O are concerned there appears to be no visible systematic variation between the various granitoid groups (Table 7). The feldspars contain very little CaO, which except in analysis no. 2 does not exceed 0.4 weight per cent. Again, the Na_2O contents are highly variable ranging from 1.10 per cent in the Older granitoids to 2.46 per cent in the Youngest granitoids. The latter group has higher average content of Na than the others (Table 7). For comparison, it can be mentioned that R. Norin (1957) reported 3.02 weight per cent Na_2O in an analysed potash feldspar from coarse-grained Karlshamn granite, which probably is equivalent in age with the Eringsboda—Yasjö granitoids. A detailed study of the potash feldspars from the Youngest granitoids is lacking, and thus it is at present not possible to draw petrogenetic conclusions from their high Na_2O contents.

The parent granites to the feldspar analyses nos. 6—11 have more than 80 per cent normative quartz + albite + orthoclase (see p. 70 and Table 2), and can thus be referred to the system of Tuttle and Bowen (1958). This classification is based on the distribution of sodium between the plagioclase and potash feldspar phases of igneous rocks having compositions within or near ”petrogeny’s residual system”. According to this classification the Younger and Youngest granitoids are grouped in the subsolvus category, which means that the rocks are characterized by two feldspars, perthitic potash feldspar and plagioclase. On the basis of the albite content of the potash feldspar Tuttle and Bowen (1958) made a further division of subsolvus granites into three subgroups, II A, II B and II C.

With the exception of analyses nos. 8 and 11, the analysed granitic potash feldspars have less than 15 weight per cent albite molecule and are therefore placed in group II C, indicating that the rocks completed crystallization or recrystallization at low temperatures, probably under metamorphic conditions. This group includes granites of metasomatic origin. A large number of experimental investigations (*e.g.* Tuttle 1952; Tuttle and Bowen 1958; Seck 1971a, 1971b and several others) strengthened the conclusions of Tuttle (1952) that potash feldspar (Or_{60-80}) and albite (Or_{5-15}) in subsolvus granites owe their origin to recrystallization, even if these studies also showed that simultaneous primary crystallization of coexisting feldspars with such compositions is not impossible in principle.

Analyses nos. 8 and 11 which represent the Youngest granitoids contain more than 15 weight per cent albite. These feldspars are thus in group II B ($30 > \text{albite} > 15$). Rocks of group II B can be considered to have (re-)crystallized at higher temperature than rocks of group II C. In this connection, it is interesting to note that Marmo (1971) pointed out that post-kinematic and late-kinematic granites containing perthitic microcline and oligoclase, but no orthoclase, belong to group II B, and late-kinematic microcline-albite granites can be referred to group II C.

TRACE ELEMENTS

Theoretical aspects of trace element distribution are considered by a.o. Turkein (1963), Tauson (1965), Taylor (1965), Nockolds (1966), Burns and Fyfe (1966, 1967) and Burns (1970). A review by Heier (1962) summarizes the general rules of element distribution in feldspars.

Rubidium

Rubidium contents are between approximately 150 and 450 ppm (Table 7). A small difference in Rb contents is observed between the potash feldspars from various granitoid groups. Older granitoids are poorer in Rb than younger granitoids. The Younger granitoids and the Eringsboda—Yasjö granitoids exhibit similar average values of Rb, of 350 ppm and 340 ppm respectively.

Strontium

Strontium is more than two times higher in potash feldspars from the Older granitoids than in this mineral from the younger granitoids. Sr ranges between 171 ppm in the Younger granitoids and 616 ppm in the Older granitoids, whereas the Sr contents within single granitoid groups vary little.

Barium

Barium contents of the potash feldspars range between 1 900 ppm and 7 400 ppm. High contents of Ba are found in the Older granitoid group (average 5 520 ppm). The Younger granitoids (excl. analysis no. 4) and Youngest granitoids have Ba averages of 2 685 ppm and 2 525 ppm respectively.

Potash feldspars are the most important Ba carriers. The distribution of this element in potash feldspars has been investigated by several workers. Compared to the Ba values given by Heier (1962), Hertz and Dutra (1966)[1], Kowalski (1967), Emmermann (1969)[2] and Rhodes (1969)[3] for granitic potash feldspars, the Ba contents in the Older granitoid potash feldspars are above average.

K—Rb

Taylor (1965) reported an average K/Rb ratio of 230 for various rocks and minerals, the range being between 150 and 300. These "normal" limits are shown by broken lines in Fig. 53, which gives the relations between the contents of K and Rb in potash feldspars and in parent rocks. Obviously the absolute Rb content is independent of the K content in the potash feldspars. The majority of analysed potash feldspars has high K/Rb ratios (>300), which especially applies to potash feldspar megacrysts belonging to the Older granitoids and analysis no. 4 of the Younger granitoids (>400). There is no correlation between the K/Rb ratios of the whole-rock samples and the potash feldspars in the Older granitoids, which suggests that the Rb concentration in coexisting biotites is a dominant factor. It has been noted by several workers, that biotite takes up Rb more readily than other potassium-bearing minerals (see *e.g.* Taylor 1964). Comparing the Rb distribution between the potash feldspars and the whole-rock samples of the Older granitoids, we find that only a minor proportion (>25 per cent) of all available Rb is in the potash feldspars.

Ba—Rb

The Ba-Rb relationship reveals a significant difference between the Older and the Younger granitoid potash feldspars (Fig. 54). Generally, the Ba/Rb ratio is regarded as a critical indicator of fractionation. Fig. 54 shows the inverse relations of Rb and Ba, which agrees well with the data of Heier and Taylor

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[1] average 2 765 ppm

[2] average 4 700 ppm

[3] average 2 125 ppm

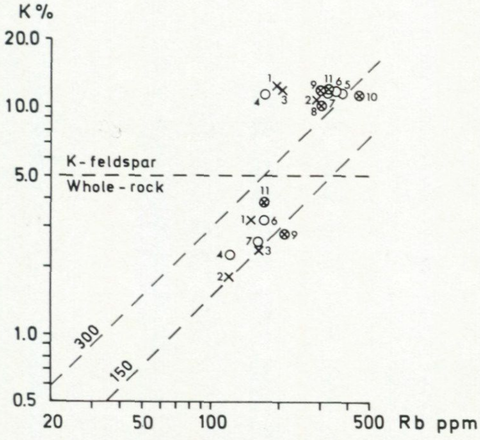

Fig. 53. Diagram showing the relations between the contents of K and Rb of whole-rock samples and corresponding potash feldspar megacrysts from Older granitoids—inclined crosses, Younger granitoids—open circles, and Youngest granitoids—circles with inclined crosses. Numbers of the separate samples refer to Table 7. Inclined dashed lines indicate "normal area" according to Taylor (1965).

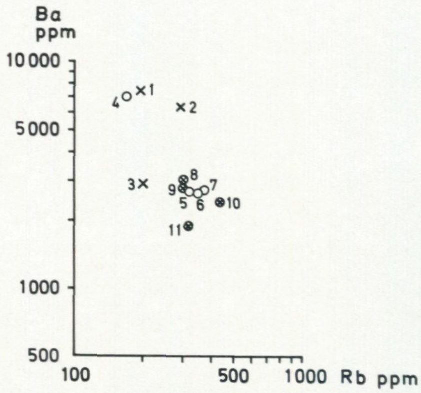

Fig. 54. Diagram showing the relations between the contents of Ba and Rb of potash feldspar megacrysts from Older granitoids—inclined crosses, Younger granitoids—open circles, and Youngest granitoids—circles with inclined crosses. Numbers of the separate samples refer to Table 7.

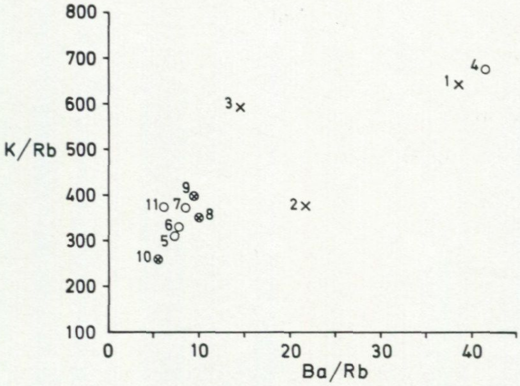

Fig. 55. Diagram showing the relationships between K/Rb and Ba/Rb of potash feldspar megacrysts from Older granitoids—inclined crosses, Younger granitoids—open circles, and Youngest granitoids—circles with inclined crosses. Numbers of the separate samples refer to Table 7.

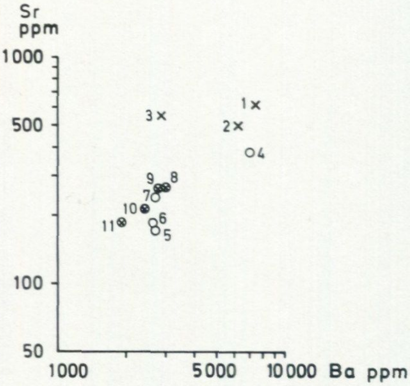

Fig. 56. Diagram showing the relations between the contents of Sr and Ba of potash feldspar megacrysts from Older granitoids—inclined crosses, Younger granitoids—open circles, and Youngest granitoids—circles with inclined crosses. Numbers of the separate samples refer to Table 7.

(1959). The Younger granitoids exhibit a smaller range of variation than the Older granitoids.

Hertz and Dutra (1966) investigated the distribution of trace elements in Brazilian potash feldspars from pre- or syntectonic *vs.* post-tectonic granitoids, and found important differences between the tectonic rock-groupings. Rb was concentrated in post-tectonic granite (720 ppm) and was lowest in pre- or syntectonic granodiorite (85 ppm). The latter group had the highest Ba, Ca and Sr values, and showed the highest Ba/Rb and K/Rb ratios. The plot Ba/Rb *versus* K/Rb was found to be most suitable for separating the samples genetically. For comparison with the results by Hertz and Dutra (1966), the presently available ratios, Ba/Rb *versus* K/Rb, are plotted in Fig. 55. Potash feldspars from Older granitoids show similar high K/Rb and Ba/Rb ratios, and the Younger granitoids clustering nearest the origo. The diagram reveals a clear distinction between the Older and Younger granitoid groups. However, this is a general function of composition and while defining two groups it fails to define two trends. Moreover, these ratios appear to change in a regular manner (Fig. 55), and there is an obvious and expected geochemically, regulated correlation between Ba, Rb, K and DI (see Table 7).

Ba—Sr

As can be predicted from geochemical theory, Heier and Taylor (1959) found that Sr in potash feldspars shows a close association with Ba. Similarly, Fig. 56 indicates a positive correlation between Sr and Ba. The distribution of Ba and Sr permits a significant geochemical distinction between potash feldspars from Older and Younger granitoids.

Summary of the trace element contents and element ratios in potash feldspars from the chronologically different granitoid groups:

Older granitoids	Younger granitoids[1]	Youngest granitoids
highest Ba, Sr	low Ba; lowest Sr	lowest Ba; low Sr
lowest Rb	highest Rb	high Rb
highest K/Rb, Ba/Rb	lowest K/Rb; low Ba/Rb	low K/Rb; lowest Ba/Rb
lowest Ba/Sr, K/Ba, Ca/Sr, Rb/Sr	highest Ba/Sr, Ca/Sr, Rb/Sr; high K/Ba	high Ba/Sr, Ca/Sr, Rb/Sr; highest K/Ba

[1] excl. analysis no. 4

FELDSPAR THERMOMETRY

Two plagioclase samples from the Older granitoids, coexisting with potash feldspar megacrysts, have been analysed for Na, K and Ca in order to estimate the temperature of (re-)crystallization. Sample no. 2 represents coexisting megacrysts of plagioclase and potash feldspar. The host-rock of sample no. 3 lacks plagioclase megacrysts, and the analysed plagioclase is from the matrix. The chemical data are given in Tables 7—8.

The results of the chemical analyses of the plagioclases agree roughly with the values obtained from X-ray powder patterns and optical determinations (see p. 00). According to Smith (1956) the difference between 131 and 131 gives the best estimate of the chemical composition for plagioclases of between 20 % and 40 % An. Using Smith's diagram, samples nos. 2 and 3 render 32 % and 35 % An respectively (*cf.* Table 7).

The use of the "two feldspar thermometer" of Barth (1951, 1956, 1962, 1968) is based on the temperature dependence of the distribution of sodium between coexisting potash feldspar and plagioclase. Barth (*op. cit.*) defined a distribution constant

$$k_{(P,T)} = X_{Ab}^{Or} / X_{Ab}^{Plag}.$$

Moreover, he *(op. cit.)* proposed that this ratio varies linearly with the inverse of absolute temperature, but hitherto available information reveals that the ratio is not a constant, even at constant temperature. The distribution of Ab in coexisting potash feldspar and plagioclase varies with temperature, pressure and composition (see *e.g.* Seck 1971a, 1971b), and this indeed reduces the potential use of Barth k-values as a relative temperature indicator. Tests of the geothermometer by experimentally determined coexisting feldspar compositions did not coincide with the curve proposed by Barth (*e.g.* Winkler 1961; Luth and Tuttle 1966; Seck and Tuttle 1966; Piwinskii 1967, 1968; Luth *et al.* 1970; Seck 1971a, 1971b, 1972). According to Dietrich 1961, (p. 16), however, the obtained temperatures reflect only "the most recent lowest temperature at which equilibrium existed between the feldspar phases" and not an original temperature of formation.

Chemical data of coexisting feldspars, k-values, and estimated temperatures of origin are listed in Table 8.

Simonen (1961) used the feldspar method to estimate the temperature of crystallization of some Precambrian plutonic rocks of Finland. Pegmatite granites and late-kinematic microcline granites rendered temperatures about 580°—630°C and 450°C respectively. Barth (1956) obtained a similar temperature (450°C) for Norwegian "anatectic granite". For granodiorite and tonalite, he calculated values of 530°C and 600°C respectively.

By using the geothermometer compiled by Saxena (1973, p. 143), which is based on Seck's experimentally determined data on composition of coexisting feldspar between 500 bars to 1 kb and 650° to 900°C, the estimated feldspar-equilibrium temperature of the Older granitoids can be established as ranging approximately between 825° and 900°C.

In sample no. 2, the contents of Sr in coexisting potash feldspar and plagioclase were determined (Table 7) to obtain the (re-)crystallization temperature. The presently available data for these coexisting mineral phases indicate that Sr replaces K more readily than Ca. Heier (1960, 1961, 1962) found that the distribution of Sr between coexisting feldspars is dependent of temperature and also indicated that Sr is present in the two feldspars in more or less equal amounts. Barth (1961; *cf.* also Hall 1967; Virgo 1968) suggested that the distribution ratio of Sr (Sr in potash feldspar/Sr in plagioclase) increases with temperature, the contents of Sr in coexisting feldspars being equal at 450°C.

The Sr distribution obtained here is close to unity, and using Barth's diagram (1961), the recorded temperature is just below 450°C.

Iiyama (1968) studied the distribution of Ba, Rb and Sr between potash feldspar and plagioclase experimentally by hydrothermal runs at 600°C and 1 kb. Concerning the Ba distribution his results contradict the observations in natural rocks as he found higher Ba contents in the plagioclases than in the coexisting potash feldspar. The distribution coefficient of Sr varied around 0.80, which agrees with the presently obtainable value (0.80) for sample no. 2. On the contrary, the Rb distribution of sample no. 2 does not coincide with his data.

Comparing the estimated temperatures of (re-)crystallization to the contents of Ba, Rb and Sr in the potash feldspars (Table 7), it is found that the absolute Ba content and the Ba/Rb and Ba/Sr ratios decrease with decreasing temperature.

OBLIQUITY DETERMINATIONS

It has been claimed that the degree of ordering in feldspars has petrogenetical significance. To test whether the structural states of potash feldspars are discriminating between various granitoid groups from northeastern Blekinge, some potash feldspar samples were subjected to X-ray obliquity (Δ) determinations. The potash feldspars studied are those chemically analysed (see p. 84).

The powdered feldspar samples were X-rayed on a Philips diffractometer unit at the Dept. of Geology in Lund by the writer. CuK$_{\alpha}$ radiation with Ni-filter was used. Scanning speeds were 0.25 degrees per minute. Diffractometer patterns were run over a 2 θ-range of 29.0°—31.5°. Peak positions were measured as described according to Goldsmith and Laves (1954) using their expression $\Delta = 12.5\,(d_{131} - d_{1\bar{3}1})$.

This index depends in a complicated way on the degrees of Si—Al order in the lattice. Many factors such as temperature of formation, growth rate, volatile content, metamorphism and radiation are known to affect the ordering process (Marmo 1959; Karamata 1961; Nilssen and Smithson 1965; Shmakin and Afonina 1967). Experimental studies by Martin (1969) show that the two most important kinetical variables appear to be temperature of (re-)crystallization and the presence or absence of peralkaline fluid.

Investigations by Lundqvist (1968), Kornfält (1969) and Gorbatschev (1972c) from northern central Sweden demonstrated that in that area differences exist in the structural states of potash feldspars from orogenic, early post-orogenic, and late post-orogenic plutonics. Similar observations have been made by Vorma (1971, 1972) in the Finnish Precambrian. These differences in feldspar mineralogy appear to reflect different kinetics of (re-)crystallization. Orogenic and early post-orogenic granitoids were emplaced under relatively higher pressure in a rather hot environment. Late post-orogenic granitoids, on the contrary, represent high level intrusions of relatively dry nature.

The following results which are based on very few samples are of preliminary character. Fig. 57 gives the diffraction diagrams for Older (I), Younger (II) and Youngest (III) granitoid rocks. Some specimens show very sharp reflections (*e.g.* Youngest granitoids), others exhibit subsidiary peaks and/or broadened peaks. These variations may be due to the presence of small amounts of microcline with either higher or lower obliquities (*cf.* Steiger and Hart 1967).

The Δ-values are given in Table 7. It is seen that there are differences in the Δ-values between the different granitoid groups, but additional determinations are needed to indicate the precise magnitude of these differences.

In the Older granitoids the potash feldspar megacrysts form two generations of porphyroblasts, pre- and post-tectonic, which are close to maximum microcline. With the exception of sample no. 1, the obliquities range from 0.80 to 0.85. In sample no. 1 (see Table 7), collected from a strong deformation zone, the obliquity is 0.64. This result contradicts the well-known rule that deformation promotes triclinization (see *e.g.* Dietrich 1962). It may be noted, however, that it appears to be a correlation between the Ba contents and the obliquities of the investigated Older granitoid feldspars (see Table 7), *viz.* that a high Ba content may counteract the ordering process (*cf.* also Shmakin and Afonina 1967), but there is at present no conclusive evidence for such an assumption.

In the Younger granitoids the potash feldspars seem to be characterized by somewhat lower obliquity values than in the other examined granitoid groups. In the samples nos. 5—7, Δ-values are between 0.69—0.82 (average 0.76). These results are in agreement with the obliquity data for similar post-orogenic granitoids published by Lundqvist (1968). Potash feldspars from ”younger” Småland granitoids of the Västervik area were investigated by Budding (1968) and had high Δ-values, even if in some cases he found indications of a monoclinic ancestry.

The granitoids of the Eringsboda—Yasjö massifs contain potash feldspar megacrysts of almost maximum obliquity (0.80 to 1.00; average 0.88).

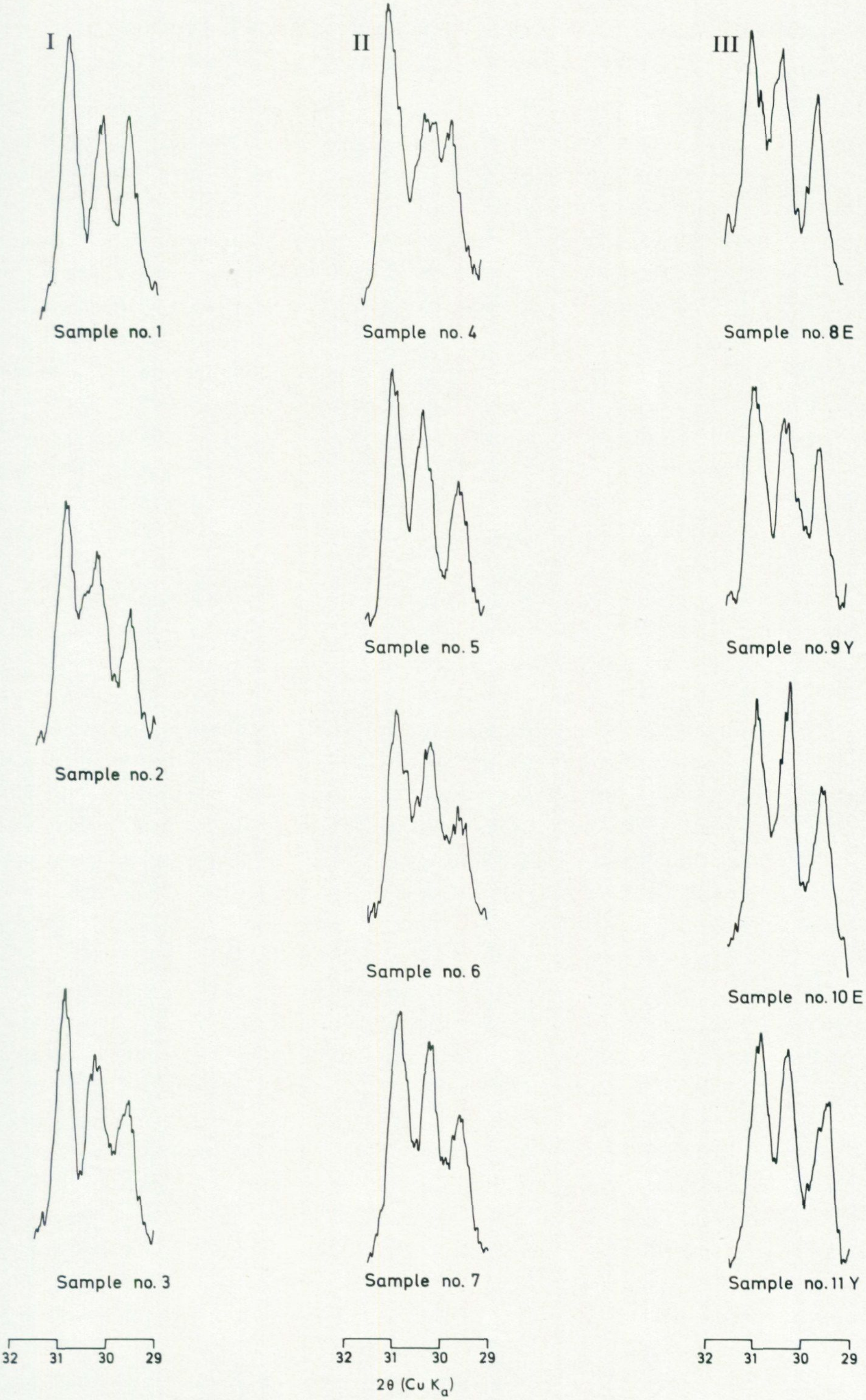

Fig. 57. X-ray powder diffraction diagrams for potash feldspar megacrysts of various granitoid groups from the northeastern part of Blekinge. I. Older granitoids. II. Younger granitoids. III. Youngest granitoids.

DISCUSSION AND CONCLUSIONS REGARDING THE ORIGIN OF POTASH FELDSPAR MEGACRYSTS

The development of potash feldspar megacrysts in the Older granitoid rocks appears to have a complex history. The field relations show that there are two generations of megacrysts (see p. 21) and that these periods of porphyroblast growth are separated by a regional deformation phase predating the emplacement of the Youngest granitoids (Eringsboda—Yasjö granitoids). Consequently the oldest megacryst generation, represented by analyses nos. 1 and 2, cannot be connected with the intrusion of these granitoids. There exist, however, indications that some of the first generation megacrysts have grown after the deformation had taken place. The late growth may be explained by local reactivation which has affected the Older granitoid province. This reactivation process is assumed to have transformed foliated granitoids into more or less massive rock types. Further evidence of reactivation is provided by the state of some basic dikes within the regenerated granitoid areas (see p. 60), and southwards, outside of the mapped area, the plutonics and the gneisses have been affected by migmatization.

The primary age of the pre-deformation potash feldspar megacrysts is difficult to determine. Their growth is assumed to have occurred in a magmatic stage followed by post-magmatic blastesis and accompanied by an isochemical recrystallization *in situ*. Among other things the high Ba and Sr contents, and the low Rb content of these feldspars support this hypothesis, but compelling evidence is lacking. These relations may show the effect of the chemistry of environment on the feldspars. An exclusive post-magmatic blastesis is not advocated here, because this would imply an enrichment of Ba from potassium-rich fluids of high Ba contents. Such fluids cannot be correlated to any known processes in the area, which could have caused a separate period of blastesis. However, evidence of a large-scale metasomatic Ba addition in a pluton was found in the Albtal granite, Germany (Emmermann 1968, 1969).

The post-deformative potash feldspar blastesis, represented by sample no. 3, is assumed to be genetically linked with the intrusion of the Youngest granitoids and the accompanying migmatization or, less probably, with a separate reactivation period of the Older granitoid rocks.

The potash feldspar megacrysts of the Younger granitoids, with reservations for the granodiorite in the vicinity of Ledja village (represented by feldspar sample no. 4) and the granitoid rocks along the border zone against the Eringsboda pluton, are supposed to have a magmatic to late-magmatic origin. This suggestion is mainly based on micro-textural details of the potash feldspars (see p. 39). Feldspar megacrysts from the other mentioned granitoids have a porphyroblastic nature. Moreover, it should be noted, that the potash feldspar megacryst sample (no. 4) from Ledja village shows a close chemical relationship, especially concerning the Ba and Sr contents, to the pre-tectonic (or syntectonic) megacrysts in the Older granitoids. In addition the petrochemistry and the macroscopical features of the Ledja granodiorite reveal great similarities with the latter rock sequence. It is thus possible that the Ledja granodiorite is a strongly recrystallized Older granitoid relic inside the Younger plutonic province (*cf.* Lundqvist 1973, p. 25).

Because detailed studies are lacking, the formation of potash feldspar megacrysts in the Youngest granitoids is only briefly treated here. As mentioned before, the Youngest granitoids often display a mantling of the potash feldspar crystals. Development of ovoid shapes is, however, not so frequent as in the typical Finnish rapakivi. The Eringsboda—Yasjö granitoids also contain mantled plagioclases and are accompanied by aplites and pegmatites.

The greater part of the potash feldspar megacrysts of the Eringsboda massif has at present a porphyroblastic character, even if it seems reasonable to suggest a primary origin of some of them. This is indicated by the occurrence of concentric zones of mafic minerals (see Fig. 21 on p. 48) in the microcline megacrysts, which may suggest a growth in a semi-solid to mobile state (*cf.* Kerrick 1969, p. 847). Evidence of solid state growth of potash feldspar megacrysts is present in basic inclusions within the Yasjö granitoid, which contain mantled potash feldspars. It is thought that the genesis of the potash feldspar megacrysts in the Youngest granitoids has implied a two-stage development with a magmatic and a post-magmatic, metasomatic stage.

OUTLINES OF THE POST-INTRUSIVE AND METAMORPHIC HISTORY

The nature of the metamorphism of the plutonic rocks and the quartzo-feldspathic to hornblendic gneisses, which are of doubtful origin and commonly called Coastal gneisses, has not been studied in detail. Nevertheless, some general considerations will be given here. Fig. 58 lists the essentials of rock evolution in NE Blekinge.

It must be emphasized that the interpretation of the metamorphic relationships within and between the granitoid groups of different age is very complicated, which is due to the effects of superimposed igneous, tectonic and metamorphic events. During the metamorphic evolution of the rock complex the PT-conditions have changed gradually in corformance with various metamorphic episodes. The available data on the mineral associations of the polymetamorphic granitoids do not always allow a distinction between magmatic and metamorphic parageneses. Furthermore, it proved impossible to establish exactly the number and relative ages of metamorphic events still traceable in the mineral associations. In many of the studied thin sections, the textural relations are either ambiguous or contradictory and not suitable for determination of the relative ages of the various paragenetic developments. (See p. 81 concerning textural disequilibrium.)

	Major events recognizable over large areas	Isotopic age m.y.
POST—SVECOFENNIAN	Retrograde metamorphism?	
	Intrusion of diabases	*c*. 800
	Deposition of sandstones (contemporaneously with the formation of the Almesåkra complex)	
	Local deformation, metamorphism	
	Reactivation, migmatization, formation of aplites and pegmatites	1 380—
	Intrusion of Youngest granitoids	1 500
SVECOFENNIAN	Intrusion of basic dikes (uralite diabases)	>1 500
	Intrusion of Younger granitoids and basic plutonics?	
	Faulting and mylonitization (and reactivation of earlier gneisses and Older granitoids?)	
	Intrusion of basic dikes	
	Deformation, metamorphism, and intrusion of basic dikes	
	Intrusion of Older granitoids and associated basic plutonics	
	Intrusion of basic dikes	
	Deformation, amphibolite facies metamorphism, and reworking of the Coastal gneisses	
	Intrusion of basic dikes (and sills?)	
	Formation of Coastal gneisses (from supracrustal rocks?)	

Fig. 58. Generalized Precambrian chronology of the northeastern part of Blekinge.

In the northeastern part of Blekinge the metamorphic associations belong to the amphibolite, greenschist and prehnite—pumpellyite facies. The principal mineral assemblage development in the area reflects PT—conditions of the amphibolite facies. One of the last metamorphic events in the area was a widespread low-grade regional metamorphism at the greenschist—prehnite—pumpellyite level. This event caused a retrogressive alteration of higher grade minerals.

Retrogressive metamorphism demonstrated by minerals of the prehnite—pumpellyite and greenschist facies has been observed in many different units of the Precambrian basement of southern Sweden (*e.g.* Elbers 1971; Zeck 1971; Zeck *et al.* 1971), including the Coastal gneisses and the various granitoid groups in Blekinge. Moreover, the occurrence of prehnite in high metamorphic plutonics and supracrustal rocks has been reported from south central Sweden (*e.g.* Hjelmqvist 1937; Lundqvist 1968; Lundegårdh *et al.* 1972).

As far as the Older granitoids in NE Blekinge are concerned, the relation between deformation and metamorphism is obscured by an unevenly distributed metamorphic—tectonic reworking of the region. However, the main retrograde mineral alteration appears to associate with a zone of intense deformation along the border against the Younger plutonic province.

The following minerals and intergrowths are important in evaluating the post-intrusive—regressive processes of the granitoids and plurifacial metamorphic history of NE Blekinge.

Quartz occurs both in the shape of individual grains and grain aggregates. Sometimes there are different generations of quartz.

Albitization of the plagioclase, in connection with epidotization, is common and has mostly generated clear marginal zones along the boundaries against potash feldspar. These decalcified zones may be interpreted as a new mineral facies formed under low temperature conditions.

In addition, fresh secondary albite rims around plagioclase and perthite lamellæ in potash feldspar are always present in the granitoids.

Several explanations of the origin of intergranular albite have been suggested, *e.g.* unmixing of alkali feldspar (Tuttle 1952; Ramberg 1962) and replacement origin (*e.g.* Schermerhorn 1956).

Myrmekitization is a rather widespread phenomenon in most examined granitoids. Myrmekite has frequently been developed in polymetamorphic rocks. According to Eskola (1956) there is a close connection between myrmekite formation and potassium metasomatism. However, an exsolution origin of myrmekite seems to be the best explanation at present (see *e.g.* Widenfalk 1969). The exsolution temperature is assumed to have been somewhat higher than that of secondary albite formation (see above).

Antiperthite is abundant in the Coastal gneisses, but less frequent in the various examined granitoids.

The formation of antiperthite is mostly described as a result of either exsolution (*e.g.* Sen 1959; Hubbard 1965; Carstens 1967) or replacement (*e.g.* Smithson 1963; Drescher—Kaden 1948, 1969; Griffin 1969; Ekström 1973). The replacement process is mainly considered to be related to alkali metasomatism.

On the basis of textural evidence, it seems most probable that the majority of the antiperthites observed here are of replacement origin.

The following observed criteria indicate a replacement origin of the antiperthite:

(*i*) Several antiperthitic plagioclases (>5 % CaO; see Table 7) contain very large amounts of potash feldspar (>20 %), more than plagioclase can take into solid solution (*cf. e.g.* Sen 1959, p. 493).

(*ii*) The potash feldspar blebs and patches often show irregular shapes and have a heterogeneous distribution inside the plagioclases.

Potash feldspar is a major constituent of the granitoids. Textures in the Older granitoids suggest that a substantial proportion of the ferromagnesian minerals and plagioclase have been altered to epidote and chlorite after the formation of the second generation of potash feldspar megacrysts. The potassium metasomatism is thus assumed to belong to the high-temperature region of the amphibolite facies (*cf. e.g.* Tuttle 1955).

Biotite is as a rule the principal mafic mineral of the granitoids, although hornblende may be abundant locally and dominates occasionally. It is frequently altered to chlorite minerals. Also, biotitization of hornblende is a common feature in several rock types. In thin sections, the granitoid biotites vary in colour from brown to green (p. 84).

Muscovite has repeatedly been observed in the gneisses and granites, often in close association with plagioclase.

Calcic amphibole assemblages in the basic rocks reveal a retrogressive mineralogical trend, which is illustrated by the coexistence of green or brown hornblende, blue-green hornblende, and actinolite. Zoning is common in the investigated amphiboles of the basic plutonics (p. 56).

In regionally metamorphosed rocks common hornblendes are stable within a temperature range of 900—500°C (Kostyuk and Sobolev 1969).

Actinolite is mainly confined to dioritic and gabbroic rocks within the Younger plutonic province. This mineral is characteristic of greenschist facies rocks that formed at temperatures below 550°C (see *e.g.* Hashimoto 1972). Its stability field in natural rocks ranges from the higher grade part of the prehnite—pumpellyite facies (Coombs 1960; Hashimoto 1966) to the main part of the greenshist facies. Reactions producing actinolite in basic metamorphic rocks have recently been discussed by Hashimoto (1972).

Epidote minerals are common accessories throughout the various plutonic rocks, especially in the border zone of the Older granitoids towards the Younger plutonics. Under the microscope, epidote has often been observed together with biotite and amphibole, and in plagioclase cores. Besides, orthite is frequently rimmed by epidote minerals.

It is assumed that most of the epidote minerals have been formed through the saussuritization of the anorthite component of the plagioclase, and as a reaction product of the alteration of hornblende into biotite. In both cases the epidotization is believed to have taken place in connection with potassium metasomatism. But it is also possible that some epidote has crystallized during a late intrusive stage.

Stability relations of Al-Fe—epidotes have been determined experimentally by a.o. Strens (1965). The assemblage clinozoisite—epidote is stable below 550°C at 2 kb.

Chlorite is one of the most prominent and abundant subordinate minerals in the various rock types studied. It is chiefly found as an alteration product of biotite.

Major compositional changes and the reactions involved in the process of chloritization of biotite have been discussed by Chayes (1955) and MacNamara (1966).

As mentioned before, there is a close association of sphene with chloritization of biotite in the Younger granitoids, which indicates the higher Ti content in biotite compared with chlorite (*cf.* Nickel 1954).

Sphene is the principal accessoric mineral of all rock types in the region. It occurs both as segregated grains and as intergrowths (sagenite) in biotite and chlorite (*cf.* Niggli 1965). The latter type (see pp. 33 and 35, Fig. 16), which is of importance in this context, is a result of titanium exsolution and implies that the rocks bear the imprint of a stage of retrogressive metamorphism. Parenthetically, sagenite pattern is lacking in the biotites and chlorites of the Older plutonics. It is well-known that as metamorphic grade decreases, the titanium content in biotite also decreases (see *e.g.* Engel and Engel 1960).

Cordierite and sillimanite have been reported from a restricted part of the quartzo—feldspathic gneiss area in the neighbourhood of Tving village (Hedström and Wiman 1906, p. 9). This locality was sampled by the writer, byt the occurrence of the reported minerals could not be confirmed. The recorded mineral assemblage of this special kind of gneiss: quartz, microcline, muscovite, biotite, cordierite, and sillimanite, reflects pressure conditions which are somewhat higher than those usually recognized within the gneiss region.

In this context it is of interest to note that andalusite and kyanite are important constituents, though of very local occurrence, in the quartzitic metasediments of the Västanå region (Bäckström 1897). The occurrence of kyanite, however, needs not necessarily have a significant relation to the regional metamorphism of the region and can possibly be related to local tectonic environments. It is worth noting that all hitherto reported occurrences of kyanite (Dicksberget, Hållsjöberget, Björnåsen on Hökenås, and Värmlandsnäs), with the single exception of the pegmatite occurrence of Gothenburg (Bergström 1969), show a close spatial association with the "mylonite zone" of Magnusson (1937) in SW to S Sweden (*cf.* Gorbatschev 1971a).

A number of experimental studies have been carried out to establish the P-T values of the triple point of Al_2SiO_5 minerals. Recent investigations by *e.g.* Althaus (1967) and Richardsson *et al.* (1969) indicate that the position is around 600°C and 6 kb.

Prehnite occurs in minute amounts and is closely associated with biotite, forming lenticular inclusions in this mineral. Biotite lamellæ surround the prehnite lenses as if the growing prehnite had pushed them aside. The identification of prehnite was made optically. The axial angle was measured on an universal stage and $2\,V_Z$ was found to vary between 58° and 63°. Determinations of the refractive indices gave the following values:

$$n_X = 1.617 \text{ to } 1.619$$
$$n_Y = 1.622 \text{ to } 1.626$$
$$n_Z = 1.639 \text{ to } 1.643$$

Pumpellyite has not been identified with certainty. Additional investigations are required to demonstrate its identity. However, this mineral has been shown by Zeck (1971) to occur in the three age-different granitoid groups and the Coastal gneisses of the Blekinge region.

The data given above suggest overall retrogressive and/or post-intrusive—regressive parageneses ranging from amphibolite over greenschist to prehnite—pumpellyite facies. The latter facies is estimated to be stable at pressures exceeding 2 kb in a temperature range between 250° and 380°C (Liou 1971). However, it has been demonstrated that the youngest metamorphic episodes had been preceded by a higher-grade metamorphic stage having such effects as *e.g.* local reactivation and potassium metasomatism. As mentioned earlier (p. 16), the K/Ar age determinations on the Older granitoids and Coastal gneisses (Magnusson 1960a) reflect a strong thermal influence upon the recorded isotopic ages. These recorded metamorphic ages may be correlated with a period of igneous activity occurring approximately between 1 500 and 1 380 m.y. (Welin 1966a; *cf.* O. Larsen 1971).

One of the youngest retrogressive metamorphic phases which has affected the whole area appears to display a regional metamorphic character and is supposed to be correlated with the Dalslandian period of metamorphism and tectogenesis (the Sveconorwegian period, 1 100—935 m.y., according to Welin 1966a), which has influenced large parts of SW Sweden and S Norway (*cf.* a.o. Magnusson 1963; Lundegårdh 1964, 1966; Gorbatschev 1971a; Zeck 1971; Zeck *et al.* 1971).

ASPECTS OF THE PRECAMBRIAN TERMINOLOGY, WITH SPECIAL REFERENCE TO BLEKINGE

In this context the present writer wishes to consider some aspects of the terminology of the Precambrian as applied to the Blekinge region (*cf.* p. 9). The reason is that the terminology of Precambrian geological and tectonic units in Sweden is in a state of transmutation. The chronological positions of the "oldest" plutonic rocks of intermediate composition and the Coastal gneisses in Blekinge in regard to the Svecofennian evolution have for a long time been a matter of discussion. In earlier geological descriptions of Blekinge (*e.g.* Blomberg 1900; Hedström and Wiman 1906) and in R. Norin's investigations (1936, 1959) the "oldest" plutonics were called *"urgraniter"* and/or *"gnejsgraniter"*. (Concerning R. Norin's interpretation of the stratigraphic relations in Blekinge and S Småland, the reader is referred to p. 00.) In the opinion of the present writer these terms should be avoided in the Precambrian terminology of Blekinge because the former term is used in Swedish literature to denote gneissic primorogenic Svecofennian plutonics, and the latter corresponds to the term "granite-gneiss" of international usage. Such implicit correlations with the Svecokarelian fold belt are of questionable value pending a complete remapping of Blekinge and its neighbourhood and pending detailed radiometric dating. Besides, the "oldest" plutonics in Blekinge have earlier received local geographical names such as *"Farabolgranit"*, *"Fridaforsgranit"* and *"Tvinggranit"*. However, since the *"Tvinggranit"*, which is making up a large part of the mapped area, has turned out to comprise granitoids of various compositions, the neutral denomination Older granitoid seems to be more appropriate.

The Blekinge granitoids, which are chronologically intermediate between the Older granitoids and the Eringsboda—Yasjö granitoids (Youngest granitoids), in the present study called Younger granitoids, have usually been classified as belonging to the "Gothian" granitoids and/or the Småland granitoids. In this paper the term "Gothian" has been avoided, because it may cause confusion in view of the circumstance that it has been given different scopes by different workers. The name Småland granitoid is retained, but it is used in a more or less collective and geographical sense not involving genetical and chronological implications. The term "Gothian" was originally introduced as a cycle name (Wahl 1936). However, lately, the cycle concept in Swedish Precambrian geology has been reestimated. Wahl (1936) subdivided the Precambrian rock complex of Fennoscandia into three successive orogenic cycles: the Svecofennian, Gothian and Karelian. As late as 1960 Magnusson still reckoned with four different orogenic cycles in southern Sweden which were the Pregothian, Svecofennian, Gothian and Dalslandian (Magnusson 1960a). On the basis of radiometric age data, Welin (1966a) considered that ". . . the Gothian cycle must be disregarded, which conclusion is stated by the fact that there is no definite indication that the supracrustal rocks in southeastern Sweden are younger than the Svecofennian sediments and volcanics". In his classification of the Swedish Precambrian, Welin (1966a) proposed a subdivision into three periods of igneous activity and, consequently, abandoned the cycle concept and the term "Gothian". The three main time periods of igneous activity are as follows: 1, the Svecofennian period, 1 810—1 680 m.y., comprising the formation of late-kinematic Svecofennian and Karelian granites, Småland—Värmland granites as well as sub-Jotnian granites and volcanics; 2, a period of igneous activity between 1 500—1 380 m.y., including *inter alia* the Youngest granitoid group in Blekinge; and 3, the Sveconorwegian period, 1 100—935 m.y., comprising the Bohus granites and pegmatites in SW Sweden.

The oldest and youngest of these periods represent two major orogenies.

In a later paper by Welin (1970), treating the development of the Svecofennian orogenic zone in northern Sweden, the following subdivision is made: 1, a period of deposition of supracrustals between 2 100? and 1 900 m.y.; 2, a period of intrusion (*e.g.* of Haparanda—Arvidsjaur—Revsund granitoids) and deformation between 1 900 and 1 775 m.y.; and, 3, a period of deposition and intrusion (of Lina—Sorsele granitoids) from 1 775 to 1 540 m.y. Lundqvist

(1968), in his investigation of the Los—Hamra region in central Sweden, avoided the use of the term "Gothian" (*cf.* W. Larsson 1947). Instead, he described the igneous events in the area in terms of an orogenic complex (Svecofennian) and a post-orogenic complex (sub-Jotnian and Jotnian) respectively. Lundegårdh, in his description to accompany the map of the Pre-Quaternary rocks of the Gävleborg County (1967), reintroduced the term "Gothian" within the frame of the concept of a "Gothian era". In a later paper, Lundegårdh (1971) proposed that the terms Svecofennokarelian and "Gothian" as time concepts should be considered as provisional. Koark (1970) maintained the idea of a "Gothian" cycle, and postulated that a period of large-scale regeneration had caused the similarity of recorded isotopic ages from various granitoid rocks of SE Sweden. The latest proposal of a time-stratigraphic subdivision of the Precambrian in Norden was presented by the IUGS Subcommission of Precambrian Stratigraphy of Norden (Rankama and Welin 1972). The following tentative subdivision of the Precambrian in Norden is recommended in that paper:

Late Precambrian	570—1 400 m.y.
Middle Precambrian	1 400—2 500 m.y.
Early Precambrian	older than 2 500 m.y.

In the present author's opinion the term "Gothian" should, as far as the Precambrian terminology of the Blekinge region is concerned, be discarded or suspended pending a future redefinition of the relations between the plutonic episodes of the Svecofennian period and the subsequent post-orogenic period. Also, a revision of this concept should be based on not yet available radiometric datings of these episodes. The presently available radiometric age pattern of Blekinge suggests a repeated reworking of the older basement complex. In order to evaluate the duration and areal extent of the tectonic-metamorphic overprints (see p. 11), a large number of multimethod isotopic age determinations is required.

The diabases in Blekinge are generally considered to be of "Jotnian" age (*e.g.* Asklund 1923). The suitability of using the chronologic term "Jotnian" as currently defined for the Blekinge diabases, which have an approximate age of 900—800 m.y. (see p. 95), is at present questioned by the writer (*cf.* Gorbatschev 1972d, p. 43), because of the possibility of confusing them with the diabases ascribed as "Jotnian" in Finland and Sweden and with a probable age of 1 400—1 100 m.y. (see *e.g.* Magnusson 1960a; Welin 1966b). Future polymethod isotopic datings of the different generations of the Blekinge diabases will probably provide definite answers to these correlation problems.

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TABLES 1—9

LOCATION MAP AND LISTS OF ANALYSED ROCKS AND MINERALS

List of analysed rocks in Tables 1—3. For localities, see Fig. 59 and Plate 1. Coordinate system: UTM.

Analysis	Sample	Rock type (acc. to normative Q—Or—[Ab+An] composition and Streckeisen's terminology)	Locality
		OLDER GRANITOIDS	
1	119	Monzodiorite	1.7 km ENE of Tving, WC 303417
2	120	Monzodiorite	1.7 km ENE of Tving, WC 303417
3	121	Granodiorite-monzodiorite	2.2 km ENE of Tving, WC 308420
4	123	Granite	0.6 km E of Sällemåla, WC 331458
5	133	Granodiorite	Höryda, WC 327396
6	135	Granodiorite	Gagnekulla, WC 423417
7	151	Monzodiorite	2 km WSW of Spjutsbygd, WC 350406
8	154	Monzodiorite	Yasjön, WC 295442
9	156	Granite-granodiorite	1.7 km SE of Tving, WC 298395
		YOUNGER GRANITOIDS	
10	125	Monzodiorite	Nävragöl, WC 348482
11	126	Granite	Nävragöl, WC 348482
12	131	Granite	Krogsmåla, WC 399469
13	138	Monzodiorite	1 km NW of Ledja, WC 400533
14	139	Granodiorite	Ledja, WC 407527
15	150	Granite	3 km WNW of Flymen, WC 431546
		YOUNGEST GRANITOIDS	
16	122	Granite (Yasjö)	2.5 km NE of Tving, WC 310422
17	153	Granite (Yasjö)	Yasjön, WC 296441
18	136	Granite, sphene-spotted	Yasjön, WC 302441
		BASIC PLUTONICS WITHIN THE YOUNGER GRANITOID AREA	
19	134	Diorite	Buggamåla, WC 398489
20	142	Diorite	Sillhövda Halt, WC 344510
21	143	Diorite	1 km ENE of Sillhövda, WC 347524
22	144	Monzodiorite	1.2 km NE of Sillhövda, WC 346528
23	148	Monzodiorite	Krogsmåla, WC 400466
24	149	Monzodiorite	Krogsmåla, WC 400466
25	152	Gabbro	Mästaremåla, WC 414446
26	157	Monzodiorite	1.3 km NNW of Bjurabygget, WC 431521
27	158	Monzodiorite	Brändahall, WC 437484
28	159	Monzodiorite	Bökegöl, WC 457487
		METABASITES	
29	114	Amphibolite1) (central zone)	0.9 km ENE of Tving, WC 344510
30	115	„ (marginal zone)	0.9 km ENE of Tving, WC 344510
31	118	„ (discordant appearance)	1.3 km ENE of Tving, WC 347524
32	124	„	2.2 km SW of Nävragöl, WC 334465
33	127	„	Bostorpssjön, WC 347417
34	128	„	0.8 km NW of Alnaryd, WC 263452

1) According to mineralogical composition

Analysis	Sample	Rock type (acc. to normative Q—Or—[Ab+An] composition and Streckeisen's terminology)	Locality
35	129	Amphibolite1) (central zone)	Spjutsbygd, WC 367413
36	130	„ (marginal zone)	Spjutsbygd, WC 367413
37	132	„	Ängstorpet, WC 358423
38	137	„ (uralite diabase)	Hageltorp, WC 358543
39	140	„ (within the gneiss area)	Hillerstorp, WC 291395
40	141	„ (within the gneiss area)	0.8 km SW of Hillerstorp, WC 285387
41	145	„	Skäravattnet, WC 307460
42	146	„	E of St. Alljungen, WC 311466
43	147	„	E of St. Alljungen, WC 311466
44	155	„	1 km SW of Höryda, WC 317380
		GNEISS (xenolith)	
45	116	Xenolith (central zone) in Older granitoid	1.3 km ENE of Tving, WC 299414
46	117	Xenolith (marginal zone) in Older granitoid	1.3 km ENE of Tving, WC 299414

List of chemically analysed minerals in Tables 1—2 and Tables 4—9. For localities, see Fig. 59 and Plate 1. Numbers of rock analyses correspond to those of Table 1. Coordinate system: UTM

Mineral sample1)	Rock analysis		Minerals	Locality
1	Older granitoids	9	potash feldspar	1.7 km SE of Tving, WC 298395
2		8	biotite, amphibole, plagioclase, potash feldspar	Yasjön, WC 295442
3		6	biotite, amphibole, plagioclase, potash feldspar	Gagnekulla, WC 423417
4	Younger granitoids	14	biotite, potash feldspar	Ledja, WC 407527
5		—	potash feldspar	0.8 km S of Flymen, WC 459434
6		12	biotite, potash feldspar	Krogsmåla, WC 399469
7		15	potash feldspar	3 km WNW of Flymen, WC 431456
8 E	Youngest granitoids	—	potash feldspar	Skäravattnet, WC 307464
9 Y		17	potash feldspar	Yasjön, WC 296441
10 E		—	potash feldspar	St. Mo, WC 257482
11 Y		16	potash feldspar	2.5 km NE of Tving, WC 310422
12	Gabbro	22	zoned amphibole (hornblende-actinolite)	1.2 km NE of Sillhövda, WC 346528

1) E=Eringsboda and Y=Yasjö

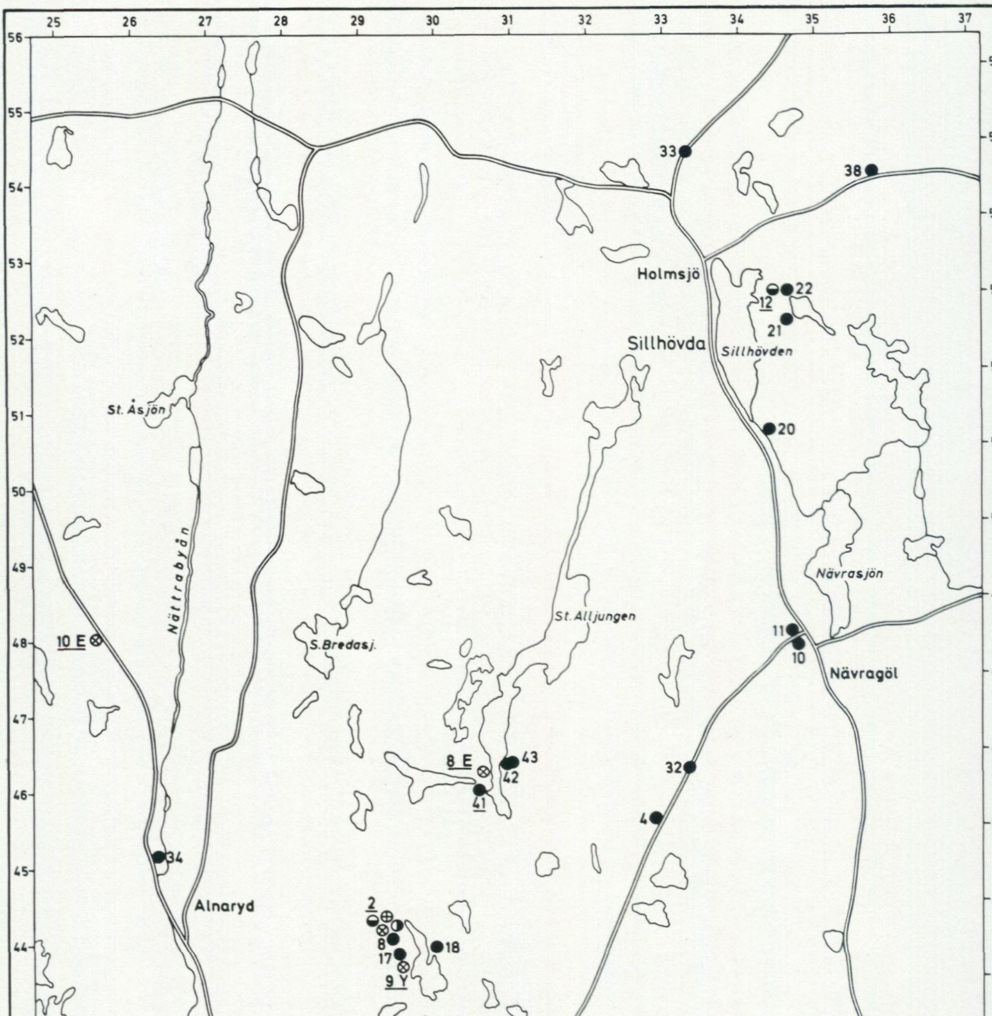

Fig. 59. Localities of sampling for chemical whole-rock analyses and mineral analyses. Numbers correspond to those of Tables 1—9. Coordinate system: UTM.

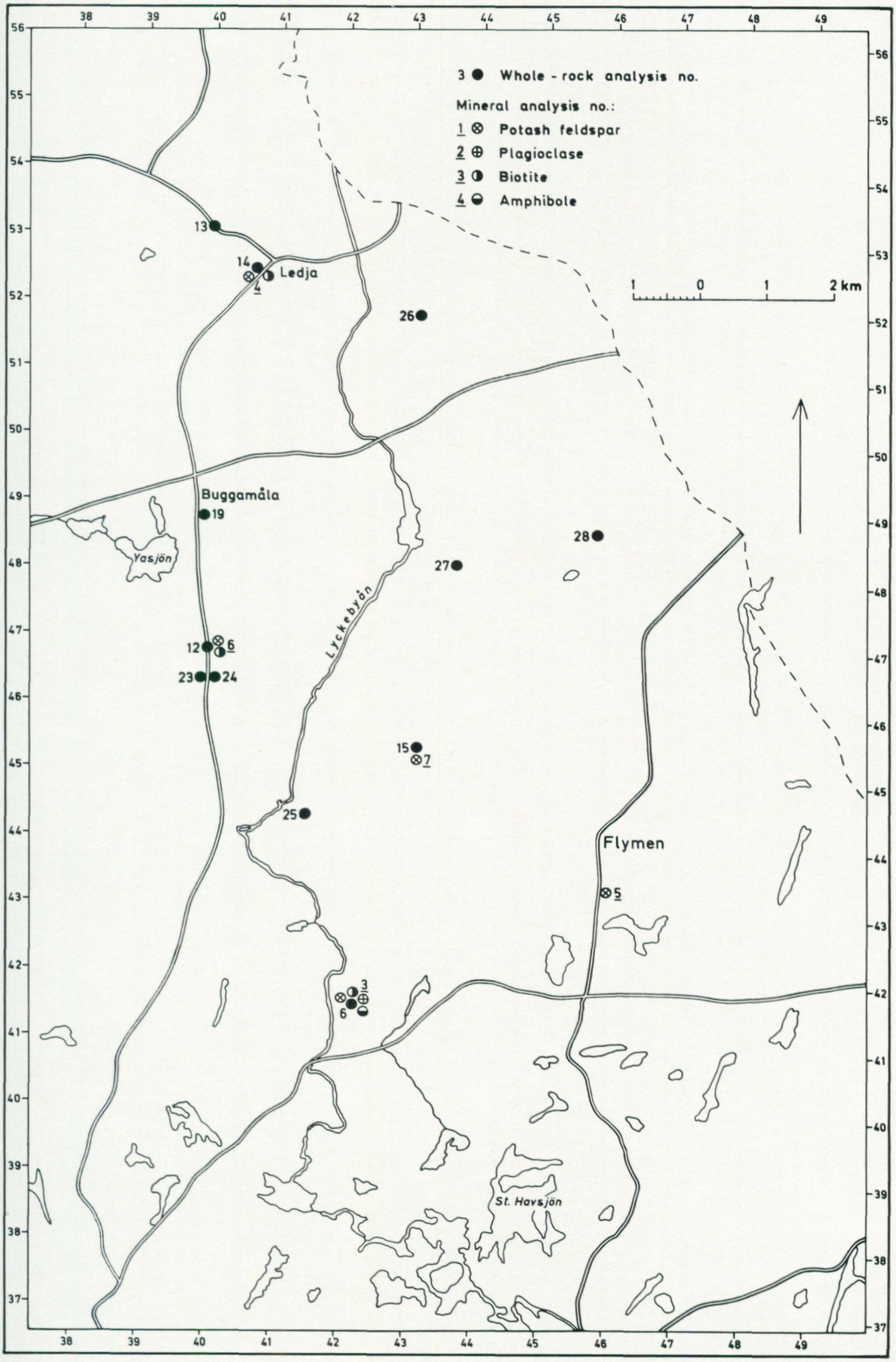
3 ● Whole-rock analysis no.
Mineral analysis no.:
1 ⊗ Potash feldspar
2 ⊕ Plagioclase
3 ◑ Biotite
4 ◒ Amphibole
1 0 1 2 km
Ledja
Buggamåla
Yasjön
Lyckebyån
Flymen
St. Havsjön
13
14
4
26
19
28
27
12
6
23
24
15
7
25
5
3
6

Table 1. Chemical analyses (contents of major elements in weight per cent and contents of trace elements, except for Ba, in ppm), cation percentages and anion contents of rocks from northeastern Blekinge. A list of the analysed rocks is given on p. 106. For localities, see Fig. 59 (pp. 108—109) and Plate 1.

Analysis	1	2	3	4	5	6
SiO_2	60.9	58.5	59.0	66.9	63.5	67.1
TiO_2	0.74	0.73	0.68	0.41	0.56	0.48
Al_2O_3	16.6	18.0	18.1	15.8	18.0	15.9
Fe_2O_3	6.2 1)	1.8	1.5	0.5	1.9	1.5
FeO	—	4.1	4.4	2.4	3.6	2.8
MnO	0.09	0.09	0.08	0.04	0.07	0.06
MgO	3.6	2.4	2.2	1.8	1.9	1.8
CaO	5.2	5.1	4.9	3.2	4.3	3.4
Na_2O	3.1	3.1	3.0	2.8	2.9	2.7
K_2O	2.8	2.6	2.5	4.0	2.3	2.9
P_2O_5	—	0.22	0.22	0.11	0.20	0.14
$H_2O > 105°$	—	1.2	1.1	0.9	1.1	1.1
$H_2O > 105°$	—	0.3	0.2	0.2	0.2	0.2
Total	99.23	98.14	97.88	99.06	100.53	100.08
V	—	180	—	95	160	120
Cr	—	40	—	20	35	20
Co	—	20	—	10	20	15
Ni	—	15	—	10	15	10
Sr	—	280	—	230	300	240
BaO	0.08	0.10	0.09	0.13	0.14	0.11
Rb	—	120	—	170	130	160
Si	—	56.4	57.0	63.7	60.0	63.8
Ti	—	0.5	0.5	0.3	0.4	0.3
Al	—	20.5	20.6	17.8	20.0	17.8
Fe^{3+}	—	1.3	1.1	0.4	1.4	1.1
Fe^{2+}	—	3.3	3.6	1.9	2.8	2.2
Mn	—	0.1	0.1	0.0	0.1	0.0
Mg	—	3.4	3.2	2.6	2.7	2.6
Ca	—	5.3	5.1	3.3	4.4	3.5
Na	—	5.8	5.6	5.2	5.3	5.0
K	—	3.2	3.1	4.9	2.8	3.5
Total	—	99.8	99.9	100.1	99.9	99.8
O	—	160	161	165	164	166
OH	—	7.7	7.1	5.7	6.9	7.0

1) Fe_{tot}

Table 1 (continued)

Analysis	7	8	9	10	11	12
SiO_2	59.7	58.0	65.6	60.6	71.2	70.8
TiO_2	0.76	0.80	0.50	0.39	0.25	0.21
Al_2O_3	18.5	18.7	16.2	20.0	15.2	15.3
Fe_2O_3	2.0	2.6	1.3	1.8	0.8	0.8
FeO	4.6	4.6	2.8	2.1	1.3	1.5
MnO	0.10	0.11	0.06	0.08	0.05	0.06
MgO	2.5	3.0	1.7	1.3	0.95	0.67
CaO	5.3	5.6	3.8	3.8	1.7	1.5
Na_2O	3.1	3.1	2.8	4.7	3.5	3.7
K_2O	2.3	2.2	3.9	2.3	4.1	3.9
P_2O_5	0.23	0.23	0.13	0.19	0.10	0.09
$H_2O > 105°$	1.3	1.4	0.8	0.6	0.5	0.8
$H_2O < 105°$	0.2	0.2	0.2	0.2	0.2	0.1
Total	100.59	100.54	99.79	98.06	99.85	99.43
V	200	230	140	70	—	—
Cr	40	40	30	10	—	—
Co	30	35	20	10	—	—
Ni	20	20	15	5	—	—
Sr	330	360	290	400	260	180
BaO	0.10	0.07	0.12	0.19	0.08	0.11
Rb	110	120	150	80	110	170
Si	56.3	54.7	62.1	57.2	66.9	66.9
Ti	0.5	0.6	0.4	0.3	0.2	0.1
Al	20.6	20.8	18.1	22.3	16.8	17.0
Fe^{3+}	1.4	1.8	0.9	1.3	0.6	0.6
Fe^{2+}	3.6	3.6	2.2	1.7	1.0	1.2
Mn	0.1	0.1	0.0	0.1	0.0	0.0
Mg	3.5	4.2	2.4	1.8	1.3	0.9
Ca	5.4	5.7	3.9	3.8	1.7	1.5
Na	5.7	5.7	5.1	8.6	6.4	1.5
K	2.8	2.6	4.7	2.8	4.9	6.8
Total	99.9	99.8	99.8	99.9	99.8	96.5
O	160	158	165	162	169	168
OH	8.2	8.8	5.1	3.8	3.1	5.0

Table 1 (continued)

Analysis	13	14	15	16	17	18
SiO_2	58.0	66.4	71.4	67.3	70.2	72.1
TiO_2	0.91	0.49	0.24	0.49	0.66	0.22
Al_2O_3	19.8	17.4	14.9	14.9	13.6	14.6
Fe_2O_3	2.3	1.2	0.6	0.7	1.9	0.6
FeO	4.2	2.5	1.6	2.3	2.4	1.3
MnO	0.11	0.07	0.05	0.05	0.08	0.03
MgO	2.1	1.2	0.72	0.87	0.93	0.53
CaO	4.8	2.8	1.7	1.9	1.6	1.3
Na_2O	4.3	4.1	3.5	3.1	2.7	2.9
K_2O	2.2	2.8	3.1	4.7	3.4	4.2
P_2O_5	0.34	0.15	0.07	0.13	0.11	0.05
$H_2O > 105°$	1.2	0.9	0.6	0.7	0.7	0.6
$H_2O < 105°$	0.2	0.2	0.2	0.2	0.2	0.2
Total	100.46	100.21	98.68	97.34	98.48	98.63
V	100	—	—	65	75	—
Cr	15	—	—	10	10	—
Co	15	—	—	10	10	—
Ni	5	—	—	10	10	—
Sr	360	270	230	170	130	200
BaO	0.25	0.20	0.12	0.13	0.08	0.09
Rb	100	120	160	170	210	240
Si	54.1	62.1	68.2	65.2	68.1	69.1
Ti	0.6	0.3	0.2	0.4	0.5	0.2
Al	21.8	19.2	16.8	17.0	15.6	16.5
Fe^{3+}	1.6	0.8	0.4	0.5	1.4	0.4
Fe^{2+}	3.3	2.0	1.3	1.9	1.9	1.0
Mn	0.1	0.1	0.0	0.0	0.1	0.0
Mg	2.9	1.7	1.0	1.3	1.3	0.8
Ca	4.8	2.8	1.7	2.0	1.7	1.3
Na	7.8	7.4	6.5	5.8	5.1	5.4
K	2.6	3.3	3.8	5.8	4.2	5.1
Total	99.6	99.7	99.9	99.9	99.9	98.8
O	158	165	170	166	170	171
OH	7.5	5.6	3.8	4.5	4.5	3.8

Table 1 (continued)

Analysis	19	20	21	22	23	24
SiO_2	50.8	54.7	51.0	50.1	56.4	55.4
TiO_2	0.73	0.65	0.76	0.36	0.71	0.67
Al_2O_3	18.9	20.5	20.8	8.5	18.0	18.7
Fe_2O_3	3.9	2.8	3.5	2.5	8.2[1]	2.6
FeO	6.8	4.6	5.4	5.3	—	5.4
MnO	0.17	0.11	0.14	0.16	0.13	0.13
MgO	6.1	3.6	4.0	15.3	4.4	4.4
CaO	7.5	6.7	7.8	12.1	6.7	6.7
Na_2O	2.4	3.9	3.5	0.8	2.9	2.9
K_2O	0.9	1.1	1.7	0.5	2.0	2.0
P_2O_5	0.19	0.24	0.52	0.08	—	0.24
$H_2O > 105^\circ$	2.1	1.6	2.1	2.6	—	1.5
$H_2O < 105^\circ$	0.1	0.2	0.3	0.2	—	0.2
Total	100.59	100.70	101.52	98.50	99.44	100.84
V	330	220	240	200	—	260
Cr	110	55	5	860	—	40
Co	60	30	35	140	—	50
Ni	10	40	10	330	—	40
Sr	240	500	550	250	—	430
BaO	0.05	0.08	0.11	0.02	0.07	0.07
Rb	160	50	60	50	—	90
Si	48.2	51.1	47.6	47.8	—	51.9
Ti	0.5	0.5	0.5	0.3	—	0.5
Al	21.1	22.6	22.9	9.6	—	20.7
Fe^{3+}	2.8	2.0	2.5	1.8	—	1.8
Fe^{2+}	5.4	3.6	4.2	4.2	—	4.2
Mn	0.1	0.1	0.1	0.1	—	0.1
Mg	8.6	5.0	5.6	21.7	—	6.1
Ca	7.6	6.7	7.8	12.4	—	6.7
Na	4.4	7.1	6.3	1.5	—	5.3
K	1.1	1.3	2.0	0.6	—	2.4
Total	99.8	100.0	99.5	100.0	—	99.7
O	151	155	151	144	—	155
OH	13.3	10.0	13.1	16.5	—	9.4

[1] Fe_{tot}

Table 1 (continued)

Analysis	25	26	27	28	29	30
SiO_2	49.1	55.0	56.3	52.6	46.6	50.4
TiO_2	0.92	0.89	0.70	0.94	0.79	0.73
Al_2O_3	18.0	18.2	17.9	19.4	16.7	18.3
Fe_2O_3	3.8	3.5	3.1	3.7	3.1	2.8
FeO	7.5	4.8	5.2	5.1	7.6	6.6
MnO	0.18	0.13	0.13	0.16	0.20	0.18
MgO	5.3	3.6	3.6	3.5	6.7	4.8
CaO	9.3	6.1	6.5	7.7	9.7	8.4
Na_2O	2.9	3.3	2.8	3.6	3.0	3.6
K_2O	1.5	2.4	1.7	1.8	1.1	1.5
P_2O_5	0.22	0.46	0.18	0.41	0.20	0.19
$H_2O < 105°$	1.6	1.4	1.5	1.2	1.6	1.2
$H_2O < 105°$	0.2	0.2	0.2	0.2	0.2	0.2
Total	100.52	99.98	99.81	100.31	97.49	98.90
V	440	220	260	270	380	340
Cr	45	110	45	5	330	100
Co	85	35	45	30	60	45
Ni	60	40	20	5	90	35
Sr	560	390	370	440	390	—
BaO	0.05	0.14	0.06	0.09	0.05	0.05
Rb	50	80	110	60	60	—
Si	46.4	52.0	53.7	49.4	45.0	47.8
Ti	0.7	0.6	0.5	0.7	0.6	0.5
Al	20.0	20.3	20.1	21.5	19.0	20.4
Fe^{3+}	2.7	2.5	2.2	2.6	2.3	2.0
Fe^{2+}	5.9	3.8	4.1	4.0	6.1	5.2
Mn	0.1	0.1	0.1	0.1	0.2	0.1
Mg	7.5	5.1	5.1	4.9	9.6	6.8
Ca	9.4	6.2	6.6	7.7	10.0	8.5
Na	5.3	6.1	5.2	6.6	5.6	6.6
K	1.8	2.9	2.1	2.2	1.4	1.8
Total	99.8	99.6	99.7	99.7	99.8	99.7
O	150	156	157	154	148	152
OH	10.1	8.8	9.5	7.5	10.3	7.6

Table 1 (continued)

Analysis	31	32	33	34	35	36
SiO_2	47.6	54.4	50.0	51.7	48.8	49.4
TiO_2	0.92	0.50	0.84	0.82	0.87	0.86
Al_2O_3	18.2	18.0	22.6	18.5	17.4	17.6
Fe_2O_3	4.0	1.9	3.2	3.4	3.0	3.5
FeO	7.7	4.6	5.0	6.7	7.6	7.4
MnO	0.23	0.11	0.05	0.20	0.17	0.17
MgO	4.9	4.8	4.0	4.5	5.7	5.6
CaO	8.9	6.8	7.3	7.3	9.1	9.0
Na_2O	3.3	3.1	4.3	3.0	3.0	3.2
K_2O	1.1	1.6	1.4	1.8	1.1	1.0
P_2O_5	0.24	0.17	0.35	0.18	0.22	0.19
$H_2O > 105^\circ$	1.5	1.5	1.6	1.9	1.9	1.7
$H_2O < 105^\circ$	0.2	0.2	0.2	0.2	0.3	0.2
Total	98.79	97.68	100.84	100.20	99.16	99.82
V	450	200	190	350	430	390
Cr	85	310	35	15	40	40
Co	50	30	25	45	60	60
Ni	30	60	30	35	75	70
Sr	340	270	550	330	470	390
BaO	0.05	0.07	0.12	0.15	0.10	0.11
Rb	60	—	60	120	80	70
Si	45.7	52.3	46.2	49.1	46.7	46.9
Ti	0.7	0.4	0.6	0.6	0.6	0.6
Al	20.6	20.4	24.6	20.7	19.6	19.7
Fe^{3+}	2.9	1.4	2.2	2.4	2.2	2.5
Fe^{2+}	6.2	3.7	3.9	5.3	6.1	5.9
Mn	0.2	0.1	0.0	0.2	0.1	0.1
Mg	7.0	6.9	5.5	6.4	8.1	7.9
Ca	9.1	7.0	7.2	7.4	9.3	9.1
Na	6.1	5.8	7.7	5.5	5.6	5.9
K	1.3	2.0	1.7	2.2	1.3	1.2
Total	99.8	100.0	99.6	99.8	99.6	99.8
O	150	155	151	152	149	150
OH	9.6	9.6	9.9	12.0	12.1	10.8

Table 1 (continued)

Analysis	37	38	39	40	41	42
SiO_2	55.2	49.0	52.7	44.1	53.0	50.7
TiO_2	0.91	1.2	1.4	0.98	0.86	0.78
Al_2O_3	19.7	17.8	18.5	17.1	18.5	18.7
Fe_2O_3	3.2	6.3	5.0	5.4	3.1	3.6
FeO	5.3	5.8	5.0	7.1	6.8	6.5
MnO	0.16	0.21	0.16	0.34	0.17	0.17
MgO	3.1	5.8	3.2	8.1	3.9	4.6
CaO	6.0	7.7	7.0	12.1	6.9	7.7
Na_2O	3.6	1.0	3.8	1.5	3.3	4.1
K_2O	1.8	2.7	2.1	1.2	2.0	1.8
P_2O_5	0.48	0.55	0.82	0.44	0.18	0.16
$H_2O > 105°$	1.4	2.7	1.5	2.1	1.5	1.7
$H_2O < 105°$	0.2	0.4	0.3	0.2	0.1	0.2
Total	101.05	101.16	101.48	100.66	100.31	100.71
V	—	320	270	340	310	360
Cr	—	110	50	680	10	20
Co	—	70	40	75	40	50
Ni	—	100	35	280	15	20
Sr	—	390	450	310	350	470
BaO	0.10	0.12	0.09	0.08	0.07	0.06
Rb	—	120	130	100	100	110
Si	51.7	47.4	49.4	41.9	50.0	47.3
Ti	0.6	0.9	1.0	0.7	0.6	0.5
Al	21.7	20.3	20.4	19.2	20.6	20.6
Fe^{3+}	2.3	4.6	3.5	3.9	2.2	2.5
Fe^{2+}	4.1	4.7	3.9	5.6	5.4	5.1
Mn	0.1	0.2	0.1	0.3	0.1	0.1
Mg	4.3	8.4	4.5	11.5	5.5	6.4
Ca	6.0	8.0	7.0	12.3	7.0	7.7
Na	6.5	1.9	6.9	2.8	6.0	7.4
K	2.1	3.3	2.5	1.5	2.4	2.1
Total	99.4	99.7	99.2	99.7	99.8	99.7
O	156	150	154	146	153	150
OH	8.7	17.4	9.4	13.3	9.4	10.6

Table 1 (continued)

Analysis	43	44	45	46
SiO_2	51.7	48.7	54.6	59.2
TiO_2	0.81	0.91	1.1	0.7
Al_2O_3	17.4	18.2	17.5	17.6
Fe_2O_3	2.3	3.5	3.0	2.4
FeO	6.7	7.7	6.5	3.4
MnO	0.17	0.18	0.21	0.14
MgO	5.0	5.6	2.6	1.3
CaO	8.2	9.6	4.6	2.3
Na_2O	4.2	3.1	4.8	5.0
K_2O	1.5	1.4	3.3	4.6
P_2O_5	0.15	0.21	0.55	0.30
$H_2O > 105°$	1.7	1.4	1.0	0.7
$H_2O < 105°$	0.3	0.2	0.1	0.2
Total	100.13	100.30	99.86	97.84
V	—	480	160	50
Cr	—	30	10	5
Co	—	85	25	10
Ni	—	75	10	5
Sr	—	580	200	340
BaO	0.06	0.04	0.15	0.17
Rb	—	70	110	130
Si	48.4	45.9	51.1	56.0
Ti	0.6	0.6	0.8	0.5
Al	19.2	20.2	19.3	19.6
Fe^{3+}	1.6	2.5	2.1	1.7
Fe^{2+}	5.2	6.1	5.1	2.7
Mn	0.1	0.1	0.2	0.1
Mg	7.0	7.9	3.6	1.8
Ca	8.2	9.7	4.6	2.3
Na	7.6	5.7	8.7	9.2
K	1.8	1.2	3.9	5.8
Total	99.7	99.9	99.4	99.7
O	150	150	154	158
OH	10.6	8.8	6.2	4.4

Table 2. Summary of some chemical parameters of the analysed rocks.

Analysis	1	2	3	4	5	6
Differentiation Index (DI):	—	57	58	72	62	69
Weight norm:						
quartz	—	14.6	16.5	24.7	24.2	29.2
orthoclase	—	15.7	15.1	23.9	13.5	17.1
albite	—	26.8	26.0	23.9	24.4	22.8
anorthite	—	24.6	23.6	15.5	20.2	16.2
corundum	—	1.3	2.1	1.2	3.3	2.4
leucite	—	—	—	—	—	—
nephelite	—	—	—	—	—	—
wollastonite	—	—	—	—	—	—
enstatite	—	6.1	5.6	4.5	4.7	4,5
ferrosilite	—	5.1	6.0	3.4	4.2	3.2
forsterite	—	—	—	—	—	—
fayalite	—	—	—	—	—	—
ilmenite	—	1.4	1.3	0.8	1.1	0.9
apatite	—	0.5	0.5	0.3	0.5	0.3
Niggli values:						
si	—	200	206	289	236	283
qz	—	36	43	98	73	107
al	—	36	37	40	39	39
fm	—	29	28	22	27	26
c	—	19	18	15	17	16
alk	—	16	16	23	16	19
k	—	0.35	0.35	4.08	0.34	0.41
mg	—	0.42	0.40	0.52	0.38	0.43
ti	—	1.9	1.8	1.3	1.6	1.5
p	—	0.3	0.3	0.2	0.3	0.2
Atomic ratios:						
Ca/Ca+Na	0.48	0.48	0.47	0.39	0.45	0.41
K/K+Na	0.37	0.36	0.35	0.48	0.34	0.41
Mg/Mg+Fe	0.54	0.43	0.41	0.53	0.39	0.44
$Fe^{3+}/Fe^{3+}+Fe^{2+}$	—	0.28	0.24	0.16	0.32	0.33
Weight ratios:						
K/Ba	32	24	26	29	15	24
K/Rb	—	180	—	195	147	151
Cr/V	—	0.2	0.2	0.2	0.2	0.2
Ni/Co	—	0.7	1	1	0.8	0.7

Table 2 (continued)

Analysis	7	8	9	10	11	12
Differentiation Index (DI):	55	52	69	69	84	84
Weight norm:						
quartz	15.7	13.2	22.5	14.2	29.8	29.6
orthoclase	13.5	12.9	23.1	13.9	24.3	23.2
albite	26.1	26.1	23.8	40.6	29.7	31.5
anorthite	24.9	26.3	18.3	18.3	7.9	7.1
corundum	1.8	1.5	0.7	3.3	2.1	2.4
leucite	—	—	—	—	—	—
nephelite	—	—	—	—	—	—
wollastonite	—	—	—	—	—	—
enstatite	6.2	7.4	4.2	3.3	2.4	1.7
ferrosilite	5.7	5.2	3.4	1.9	1.4	1.9
forsterite	—	—	—	—	—	—
fayalite	—	—	—	—	—	—
ilmenite	1.4	1.5	1.0	0.8	0.5	0.4
apatite	0.5	0.5	0.3	0.5	0.2	0.2
Niggli values:						
si	197	182	265	224	357	360
qz	38	27	81	35	136	137
al	36	35	39	44	45	46
fm	30	33	24	19	16	15
c	19	19	17	15	9	8
alk	15	14	21	22	30	31
k	0.32	0.31	0.47	0.24	0.43	0.40
mg	0.40	0.43	0.42	0.37	0.44	0.34
ti	1.9	1.9	1.5	1.1	0.9	0.8
p	0.3	0.3	0.2	0.3	0.2	0.2
Atomic ratios:						
Ca/Ca+Na	0.49	0.50	0.43	0.31	0.21	0.18
K/K+Na	0.33	0.32	0.48	0.24	0.44	0.41
Mg/Mg+Fe	0.41	0.44	0.43	0.39	0.46	0.35
$Fe^{3+}/Fe^{3+}+Fe^{2+}$	0.28	0.34	0.29	0.44	0.36	0.32
Weight ratios:						
K/Ba	21	29	30	11	47	33
K/Rb	174	153	216	239	309	191
Cr/V	0.2	0.2	0.2	0.1	—	—
Ni/Co	0.7	0.6	0.8	0.5	—	—

Table 2 (continued)

Analysis	13	14	15	16	17	18
Differentiation Index (DI):	59	74	83	81	80	86
Weight norm:						
quartz	9.8	22.9	34.1	25.5	36.7	35.5
orthoclase	12.9	16.5	18.6	28.6	20.4	25.2
albite	36.2	34.6	30.0	27.0	23.2	24.9
anorthite	21.9	13.2	8.3	9.1	7.5	6.4
corundum	2.3	2.8	2.8	1.5	2.8	3.0
leucite	—	—	—	—	—	—
nephelite	—	—	—	—	—	—
wollastonite	—	—	—	—	—	—
enstatite	5.2	3.0	1.8	2.2	2.4	1.3
ferrosilite	4.5	2.9	2.2	3.0	1.9	1.6
forsterite	—	—	—	—	—	—
fayalite	—	—	—	—	—	—
ilmenite	1.7	0.9	0.5	1.0	1.3	0.4
apatite	0.8	0.4	0.2	0.3	0.3	0.1
Niggli values:						
si	187	277	377	326	361	403
qz	15	81	164	110	163	180
al	38	43	46	43	41	48
fm	27	20	15	18	25	13
c	17	13	10	10	9	8
alk	18	24	28	29	25	31
k	0.25	0.31	0.36	0.49	0.45	0.48
mg	0.36	0.36	0.36	0.34	0.28	0.33
ti	2.2	1.5	1.0	1.8	2.6	0.9
p	0.5	0.3	0.2	0.3	0.2	0.1
Atomic ratios:						
Ca/Ca+Na	0.38	0.27	0.21	0.25	0.25	0.20
K/K+Na	0.25	0.31	0.37	0.50	0.45	0.49
Mg/Mg+Fe	0.37	0.37	0.37	0.34	0.29	0.34
$Fe^{3+}/Fe^{3+}+Fe^{2+}$	0.33	0.30	0.25	0.22	0.42	0.29
Weight ratios:						
K/Ba	8	13	24	34	39	43
K/Rb	183	193	161	229	134	145
Cr/V	0.1	—	—	0.2	0.1	—
Ni/Co	0.3	—	—	1	1	—

Table 2 (continued)

Analysis	19	20	21	22	23	24
Differentiation Index (DI):	30	46	39	11	—	43
Weight norm:						
quartz	4.9	6.3	0.1	0.6	—	7.4
orthoclase	5.3	6.5	9.9	3.0	—	11.7
albite	20.2	32.8	29.2	6.9	—	24.4
anorthite	35.9	31.6	35.0	18.4	—	31.6
corundum	0.8	1.2	0.2	—	—	0.1
leucite	—	—	—	—	—	—
nephelite	—	—	—	—	—	—
wollastonite	—	—	—	17.6	—	—
enstatite	15.1	8.9	9.8	38.8	—	10.9
ferrosilite	8.3	5.2	6.0	7.5	—	6.9
forsterite	—	—	—	—	—	—
fayalite	—	—	—	—	—	—
ilmenite	1.4	1.2	1.4	0.7	—	1.3
apatite	0.4	0.6	1.2	0.2	—	0.6
Niggli values:						
si	127	155	133	104	—	156
qz	–2	5	–14	–5	—	10
al	28	34	32	10	—	31
fm	45	32	34	61	—	37
c	20	20	22	27	—	20
alk	7	13	12	2	—	12
k	0.19	0.15	0.24	0.29	—	0.31
mg	0.50	0.47	0.45	0.77	—	0.49
ti	1.4	1.4	1.5	0.6	—	1.4
p	0.2	0.3	0.6	0.1	—	0.3
Atomic ratios:						
Ca/Ca+Na	0.63	0.49	0.55	0.89	0.56	0.56
K/K+Na	0.20	0.16	0.24	0.29	0.31	0.31
Mg/Mg+Fe	0.51	0.47	0.45	0.78	0.52	0.50
$Fe^{3+}/Fe^{3+}+Fe^{2+}$	0.34	0.35	0.37	0.30	—	0.30
Weight ratios:						
K/Ba	17	13	14	23	26	26
K/Rb	107	182	235	—	—	184
Cr/V	0.3	0.3	—	4.3	—	0.2
Ni/Co	1.3	1.3	0.3	2.4	—	0.8

Table 2 (continued)

Analysis	25	26	27	28	29	30
Differentiation Index (DI):	33	49	46	44	32	40
Weight norm:						
quartz	—	7.2	11.9	2.7	—	—
orthoclase	8.8	14.2	10.1	10.6	6.7	9.0
albite	24.4	27.9	23.8	30.4	24.4	30.8
anorthite	31.6	27.5	31.3	31.4	29.6	29.7
corundum	—	0.1	—	—	—	—
leucite	—	—	—	—	—	—
nephelite	—	—	—	—	—	—
wollastonite	5.5	—	—	1.8	7.7	4.7
enstatite	8.4	9.0	9.0	8.7	4.5	6.5
ferrosilite	6.0	4.7	6.1	5.0	2.8	4.9
forsterite	3.4	—	—	—	8.8	3.9
fayalite	2.6	—	—	—	6.1	3.2
ilmenite	1.7	1.7	1.3	1.8	1.5	1.4
apatite	0.5	1.1	0.4	1.0	0.5	0.5
Niggli values:						
si	118	161	168	143	109	129
qz	–18	6	23	–7	–25	–17
al	26	31	31	31	23	28
fm	41	35	36	34	44	38
c	24	19	21	23	24	23
alk	9	14	11	13	8	11
k	0.25	0.32	0.28	0.24	0.19	0.21
mg	0.45	0.44	0.44	0.42	0.52	0.47
ti	1.7	2.0	1.6	1.9	1.4	1.4
p	0.2	0.6	0.2	0.5	0.2	0.2
Atomic ratios:						
Ca/Ca+Na	0.64	0.51	0.56	0.54	0.64	0.56
K/K+Na	0.25	0.32	0.29	0.25	0.19	0.22
Mg/Mg+Fe	0.46	0.45	0.44	0.42	0.54	0.48
$Fe^{3+}/Fe^{3+}+Fe^{2+}$	0.31	0.40	0.35	0.39	0.27	0.28
Weight ratios:						
K/Ba	28	16	26	19	20	28
K/Rb	250	249	128	248	152	—
Cr/V	0.1	0.5	0.2	0	0.8	0.3
Ni/Co	0.7	1.1	0.4	0.2	1.5	0.8

Table 2 (continued)

Analysis	31	32	33	34	35	36
Differentiation Index (DI):	35	43	44	38	32	33
Weight norm:						
quartz	—	6.8	—	2.3	—	—
orthoclase	6.6	9.7	8.2	10.6	6.6	5.9
albite	28.3	26.9	36.1	25.3	25.7	27.2
anorthite	32.0	31.2	33.9	31.6	31.1	30.8
corundum	—	—	1.5	—	—	—
leucite	—	—	—	—	—	—
nephelite	—	—	—	—	—	—
wollastonite	4.7	1.0	—	1.5	5.5	5.4
enstatite	4.8	12.3	1.7	11.2	9.6	10.0
ferrosilite	3.8	6.4	0.9	8.5	7.0	6.9
forsterite	5.3	—	5.8	—	3.3	2.8
fayalite	4.7	—	3.3	—	2.7	2.1
ilmenite	1.8	1.0	1.6	1.6	1.7	1.6
apatite	0.6	0.4	0.8	0.4	0.5	0.5
Niggli values:						
si	116	158	129	136	119	120
qz	–22	11	–23	–6	–16	–16
al	26	31	34	29	25	25
fm	41	36	32	40	42	42
c	23	21	20	21	24	24
alk	9	12	13	11	9	9
k	0.17	0.25	0.17	0.28	0.19	0.17
mg	0.43	0.57	0.47	0.44	0.49	0.48
ti	1.7	1.1	1.6	1.6	1.6	1.6
p	0.2	0.2	0.4	0.2	0.2	0.2
Atomic ratios:						
Ca/Ca+Na	0.60	0.55	0.48	0.57	0.63	0.61
K/K+Na	0.18	0.25	0.18	0.28	0.19	0.17
Mg/Mg+Fe	0.44	0.58	0.47	0.45	0.50	0.49
$Fe^{3+}/Fe^{3+}+Fe^{2+}$	0.32	0.27	0.37	0.31	0.26	0.30
Weight ratios:						
K/Ba	20	21	11	11	10	8
K/Rb	152	—	193	124	141	119
Cr/V	2	1.6	0.8	0.1	0.1	0.1
Ni/Co	0.6	2	1.2	0.8	1.3	1.2

Table 2 (continued)

Analysis	37	38	39	40	41	42
Differentiation Index (DI):	49	32	48	20	42	45
Weight norm:						
quartz	8.4	7.3	4.1	—	2.7	—
orthoclase	10.5	15.8	12.3	7.1	11.8	10.6
albite	30.2	8.4	31.8	12.6	27.8	33.8
anorthite	26.6	34.5	26.9	36.2	29.7	27.1
corundum	2.0	0.5	—	—	—	—
leucite	—	—	—	—	—	—
nephelite	—	—	—	—	—	0.4
wollastonite	—	—	1.0	8.7	1.4	4.1
enstatite	7.6	14.3	7.9	7.2	9.7	2.3
ferrosilite	5.8	3.8	3.0	2.7	8.8	1.6
forsterite	—	—	—	9.0	—	6.3
fayalite	—	—	—	3.7	—	4.9
ilmenite	1.7	2.3	2.6	1.9	1.6	1.5
apatite	1.1	1.2	1.9	1.0	0.4	0.4
Niggli values:						
si	161	123	145	93	144	128
qz	–7	–4	–10	–26	–4	–24
al	34	26	30	21	30	28
fm	34	46	35	47	38	38
c	19	21	21	27	20	21
alk	14	7	14	5	12	13
k	0.24	0.63	0.26	0.34	0.28	0.22
mg	0.39	0.46	0.37	0.53	0.41	0.45
ti	2.0	2.3	2.9	1.5	1.8	1.5
p	0.6	0.6	1.0	0.4	0.2	0.2
Atomic ratios:						
Ca/Ca+Na	0.48	0.81	0.50	0.82	0.54	0.51
K/K+Na	0.25	0.64	0.27	0.35	0.29	0.22
Mg/Mg+Fe	0.40	0.48	0.37	0.55	0.42	0.46
$Fe^{3+}/Fe^{3+}+Fe^{2+}$	0.35	0.49	0.47	0.41	0.29	0.33
Weight ratios:						
K/Ba	17	21	22	14	26	28
K/Rb	—	187	134	100	166	135
Cr/V	—	0.3	0.2	2	0.1	0.1
Ni/Co	—	1.4	0.9	3.7	0.4	0.4

Table 2 (continued)

Analysis	43	44	45	46
Differentiation Index (DI):	44	32	—	—
Weight norm:				
quartz	—	—	—	4.1
orthoclase	8.9	5.9	19.5	28.9
albite	35.6	26.2	40.7	43.2
anorthite	24.2	32.7	16.5	10.0
corundum	—	—	—	0.6
leucite	—	—	—	—
nephelite	—	—	—	—
wollastonite	6.5	5.6	1.3	—
enstatite	3.9	7.1	4.3	3.3
ferrosilite	3.0	5.1	5.4	3.4
forsterite	6.0	4.8	1.5	—
fayalite	5.0	3.8	2.1	—
ilmenite	1.5	1.7	2.1	1.4
apatite	0.4	0.5	1.3	0.7
Niggli values:				
si	132	115	180	215
qz	–19	–19	–18	—
al	26	25	31	38
fm	38	42	35	24
c	23	24	15	9
alk	13	9	20	29
k	0.19	0.17	0.31	0.38
mg	0.49	0.47	0.32	0.28
ti	1.6	1.6	2.4	1.9
p	0.2	0.2	0.7	0.5
Atomic ratios:				
Ca/Ca+Na	0.52	0.63	0.35	0.20
K/K+Na	0.19	0.17	0.31	0.39
Mg/Mg+Fe	0.51	0.48	0.34	0.29
$Fe^{3+}/Fe^{3+}+Fe^{2+}$	0.24	0.29	0.29	0.39
Weight ratios:				
K/Ba	23	23	20	26
K/Rb	—	119	249	306
Cr/V	—	0.1	0.1	0.1
Ni/Co	—	0.9	0.3	0.5

Table 3. Modal analyses (vol. %) of different granitoids from northeastern Blekinge. Older granitoids — nos. 1—9 and Younger granitoids — nos. 10—15. A list of the analysed rocks is given on p. 106. For localities, see Fig. 59 (pp. 108—109) and Plate 1.

Analysis	1	2	3	4	5	6	7
Mineral /							
Quartz	22.1	21.0	27.1	32.4	26.2	33.1	22.6
Plagioclase	43.2	45.6	42.5	34.0	47.2	39.1	36.9
Potash feldspar	8.5	10.1	12.6	16.0	11.8	15.4	5.9
Biotite	11.6	14.3	11.8	8.7	4.3	3.7	11.8
Ca-amphibole	10.7	6.8	3.6	0.5	2.5	0.1	3.7
Chlorite	0.7	0.5	0.4	3.6	2.9	2.1	0.7
Sericite	1.0	0.8	0.6	3.2	3.5	2.6	13.8
Muscovite	+	+	+	0.2	+	+	+
Epidote	0.4	0.5	0.4	2.6	0.1	1.5	1.0
Prehnite	+	+	—	—	—	0.1	+
Calcite	+	+	+	+	—	+	—
Opaque	0.2	0.1	0.3	0.2	+	0.3	1.1
Sphene	0.4	0.2	0.4	0.5	1.1	1.7	2.0
Orthite	+	+	+	+	+	+	+
Rutile	+	+	+	+	+	+	+
Apatite	0.1	+	+	+	+	0.2	0.2
Zircon	+	+	+	+	+	0.1	+
Fluorite	—	—	—	—	—	—	+

8	9	10	11	12	13	14	15
18.5	27.2	22.8	22.7	34.2	11.2	26.4	28.0
45.9	32.5	57.5	34.9	38.8	55.8	42.8	40.1
5.1	33.7	9.3	35.0	20.1	3.0	17.6	20.5
9.2	5.4	4.7	5.8	2.8	13.4	9.8	7.6
3.6	+	0.3	+	—	5.0	—	—
3.0	+	1.9	0.4	0.9	3.0	1.0	1.2
8.0	0.4	0.2	0.4	2.0	6.3	1.0	0.9
+	0.1	+	0.1	0.3	0.2	0.2	0.5
0.1	0.3	1.2	0.2	0.3	1.0	0.1	0.2
+	+	+	+	+	—	+	+
—	+	—	+	—	—	+	0.1
0.5	0.1	0.9	0.1	0.2	0.2	0.1	0.3
1.5	0.1	0.3	0.1	0.3	0.2	+	+
+	+	+	+	+	+	+	+
+	+	+	+	+	+	+	+
0.1	+	+	+	+	+	+	+
0.1	+	+	+	+	+	+	+
—	—	—	+	+	—	+	—

Table 4. Microprobe analyses of biotites. Nos. 2a, 2b, 3a and 3b coexisting with hornblende (see Table 5). A list of the chemically analysed minerals is given on p. 107. For localities, see Fig. 59 and Plate 1.

Sample	Older granitoids				Younger granitoids		
	2a	2b	3a	3b	4a	4b	6
				Weight %			
SiO_2	36.2	36.1	36.8	37.0	35.8	36.8	37.2
TiO_2	2.6	2.3	1.8	2.0	2.1	2.1	1.7
Al_2O_3	15.2	15.4	15.1	15.2	17.0	15.7	15.5
$Fe_{tot}=FeO$	20.4	21.1	20.1	20.3	23.7	23.2	23.0
MnO	0.4	0.4	0.5	0.4	0.7	0.7	0.9
MgO	11.3	11.8	11.9	11.1	8.3	8.5	9.3
CaO	—	—	—	—	—	—	—
K_2O	9.6	9.6	10.0	10.0	9.9	9.9	9.9
Na_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	95.8	96.8	96.3	96.1	97.6	97.0	97.6
			Number of ions calculated on the basis of 22 0				
Si	5.55	5.49	5.61	5.65	5.47	5.64	5.66
Ti	0.30	0.26	0.21	0.23	0.24	0.24	0.19
Al_{tetr}	2.45	2.51	2.39	2.35	2.53	2.36	2.34
Al_{octr}	0.29	0.25	0.32	0.48	0.53	0.47	0.44
Fe	2.61	2.68	2.56	2.59	3.03	2.97	2.92
Mn	0.05	0.05	0.06	0.05	0.09	0.09	0.12
Mg	2.58	2.67	2.70	2.52	1.89	1.94	2.11
Ca	—	—	—	—	—	—	—
K	1.88	1.86	1.94	1.95	1.93	1.93	1.92
Na	0.03	0.03	0.03	0.03	0.03	0.03	0.03

Table 5. Microprobe analyses of hornblendes coexisting with biotite. A list of the chemically analysed minerals is given on p. 107. For localities, see Fig. 59 and Plate 1.

Sample	Older granitoids 2a+2b	3a+3b
	Weight %	
SiO_2	42.0	42.3
TiO_2	0.9	0.7
Al_2O_3	10.9	10.8
$Fe_{tot}=FeO$	21.5	21.8
MnO	0.6	0.6
MgO	8.4	8.1
CaO	12.0	12.0
K_2O	1.3	1.5
Na_2O	1.2	1.3
Total	98.8	99.1
	Numbers of ions calculated on the basis of 23 0	
Si	6.42	6.46
Ti	0.10	0.08
Al_{tetr}	1.58	1.54
Al_{octr}	0.38	0.40
Fe	2.75	2.78
Mn	0.08	0.08
Mg	1.91	1.84
Ca	1.96	1.96
K	0.25	0.29
Na	0.36	0.38

Table 6. Fe-Mg distributions and Mg distribution coefficients in biotite and hornblende from Older and Younger granitoids.

	Sample	Whole-rock			Biotite	Hornblende	Biotite-Hornblende
		$Fe^{3+}/Fe^{3+}+Fe^{2+}$	$Mg/Mg+Fe_{tot}$	$Mg/Mg+Fe^{2+}$	$Mg/Mg+Fe$	$Mg/Mg+Fe$	$K_{D_{Mg}}^{Bi-A}$
Older granitoids	2a	0.34	0.44	0.54	0.41	0.50	0.41
	2b	0.34	0.44	0.54	0.41	0.50	0.41
	3a	0.33	0.44	0.53	0.40	0.51	0.40
	3b	0.33	0.44	0.53	0.40	0.49	0.40
Younger granitoids	4a	0.30	0.37	0.46	0.38	—	—
	4b	0.30	0.37	0.46	0.39	—	—
	6	0.32	0.35	0.44	0.42	—	—

Table 7. Chemical analyses and obliquity determinations of feldspars from various granitoid rocks in northeastern Blekinge. Nos. 2 and 3 represent coexisting potash feldspar—plagioclase. A list of the chemically analysed minerals and the corresponding rock analyses is given on p. 107. For localities, see Fig. 59 and Plate 1.

Rock type	Plagioclase from Older granitoids		Potash feldspar from Older granitoids			Potash feldspar from Younger granitoids				Potash feldspar from Youngest granitoids (E = Eringsboda; Y = Yasjö)			
Sample	2	3	1	2	3	4	5	6	7	8 E	9 Y	10 E	11 Y
DI	52.3	69.2	69.4	52.3	69.2	74.1	—	84.3	82.7	—	80.3	—	81.5
K_2O wt.%	2.04	2.28	14.90	13.13	14.45	13.82	14.06	14.05	14.22	12.80	14.40	13.94	14.38
Na_2O	5.28	5.59	1.10	1.70	1.24	1.57	1.29	1.59	1.50	2.46	1.43	1.62	2.00
CaO	5.01	5.82	0.11	0.57	0.24	0.27	0.14	0.24	0.23	0.31	0.15	0.19	0.18
Or mol.%	14.8	15.0	89.9	81.9	88.0	84.8	87.8	85.0	85.9	77.2	86.9	84.9	82.7
Ab	54.8	52.8	9.5	15.2	10.8	13.8	11.5	13.8	13.0	21.2	12.3	14.1	16.4
An	30.4	32.2	0.6	2.9	1.2	1.4	0.7	1.2	1.1	1.6	0.8	1.0	0.9
Ba ppm	—	—	7 400	6 250	2 900	7 000	2 700	2 650	2 700	3 000	2 800	2 400	1 900
Rb	63	—	192	288	202	169	373	349	322	306	301	442	318
Sr	618	—	616	496	544	378	171	185	238	273	254	216	185
Δ	—	—	0.64	0.80	0.85	0.69	0.82	0.77	0.77	0.88	0.85	0.80	1.00
K/Ba	—	—	1.7	1.7	4.1	1.6	4.3	4.4	4.4	3.5	4.3	4.8	6.3
K/Rb	—	—	644	378	594	679	313	334	367	347	397	262	375
Rb/Sr	0.10	—	0.3	0.6	0.4	0.5	2.2	1.9	1.4	1.1	1.2	2.1	1.7
Ba/Rb	—	—	38.5	21.7	14.4	41.4	7.2	7.6	8.4	9.8	9.3	5.4	6.0
Ba/Sr	—	—	12.0	12.6	5.3	18.5	15.8	14.3	11.3	11.0	11.0	11.1	10.3

Fig. 8. Chemical data of coexisting feldspars, k-values and estimated temperatures of (re-)crystallization.

Older granitoids		Potash feldspar	Plagioclase	Potash feldspar	Plagioclase
Sample		2	2	3	3
Na_2O	wt.%	1.70	5.28	1.24	5.59
K_2O	„	13.13	—	14.45	—
CaO	„	—	5.01	—	5.82
Ab	mol.%	15.6	64.3	10.9	62.1
Or	„	84.4	—	89.1	—
An	„	—	35.7	—	37.9
k		0.24		0.18	
T C°		530		450	

Table 9. Microprobe analyses of coexisting actinolite and hornblende in a gabbro. For locality, see Fig. 59 (pp. 108—109).

Sample 12	Core		Transition zone		Rim
			Weight %		
SiO_2	46.7	44.8	50.5	47.0	55.5
TiO_2	0.1	0.1	0.3	0.3	0.1
Al_2O_3	10.3	14.3	7.4	9.4	3.1
$Fe_{tot}=FeO$	10.4	10.4	8.9	8.9	7.2
MnO	0.2	0.2	0.2	0.2	0.2
MgO	15.1	15.1	12.0	12.0	19.8
CaO	12.4	12.4	12.6	12.6	12.8
K_2O	0.04	0.5	0.3	0.3	0.1
Na_2O	0.5	1.7	1.3	1.3	0.6
Total	95.74	99.5	93.5	92.0	99.4
			Number of ions calculated on the basis of 23 0		
Si	6.85	6.38	7.49	7.14	7.66
Ti	0.01	0.01	0.03	0.03	0.01
Al_{tetr}	1.15	1.62	0.51	0.86	0.34
Al_{octr}	0.63	0.78	0.78	0.82	0.16
Fe	1.27	1.24	1.10	1.13	0.83
Mn	0.02	0.02	0.02	0.03	0.02
Mg	3.30	3.20	2.65	2.71	4.07
Ca	1.95	1.89	2.00	2.05	1.89
K	0.01	0.09	0.06	0.06	0.02
Na	0.14	0.47	0.37	0.38	0.16
$Mg/Mg+Fe_{tot}$	0.72	0.72	0.71	0.71	0.83
$Fe_{tot}/Fe_{tot}+Mg$	0.28	0.28	0.29	0.29	0.17
Ca/Ca+Na	0.93	0.80	0.84	0.84	0.92
S/Si+Al	0.79	0.73	0.81	0.85	0.94

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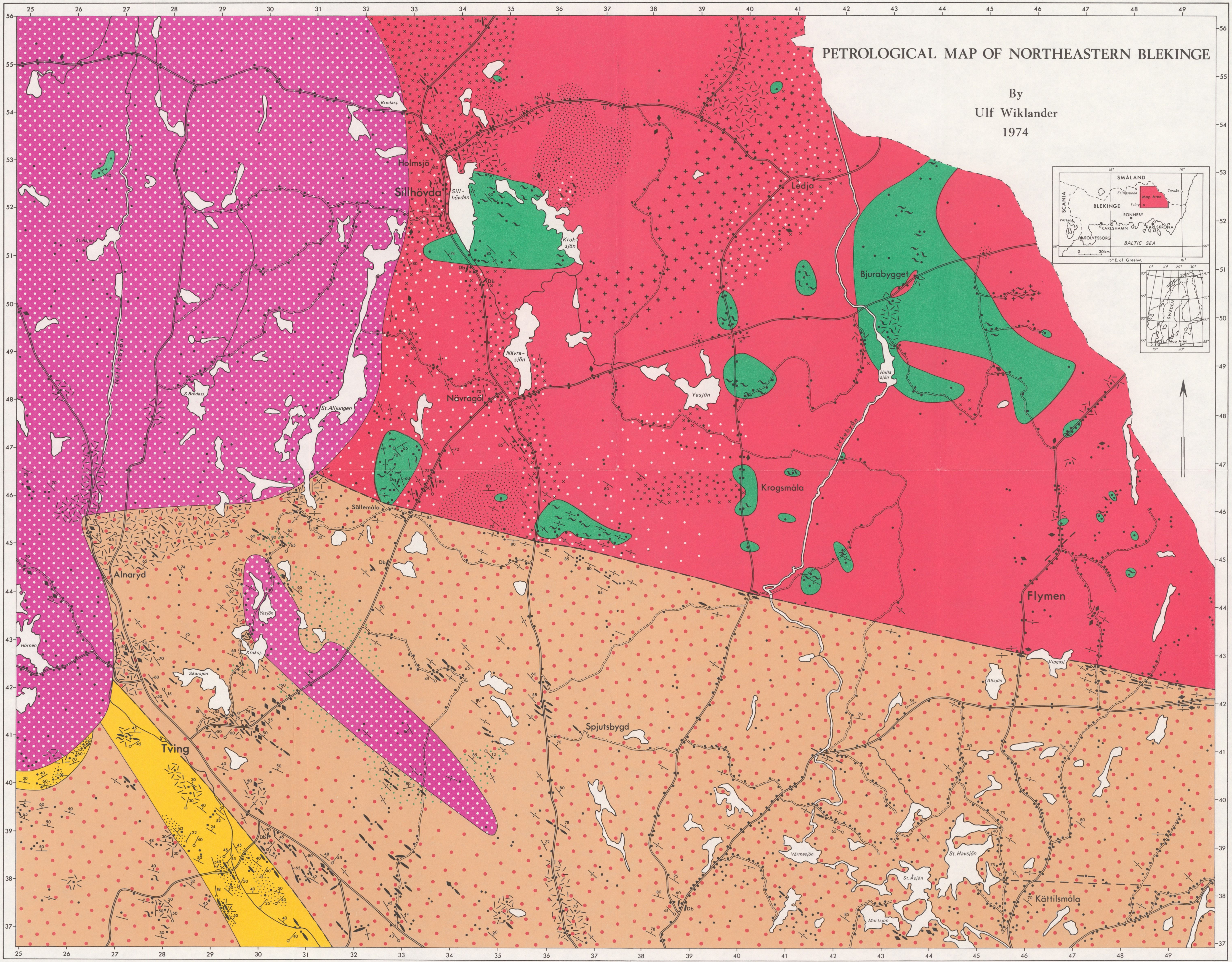
PETROLOGICAL MAP OF NORTHEASTERN BLEKINGE

By
Ulf Wiklander
1974



Universal Transverse Mercator (UTM) system

Siri Bergström

- • Locality for bedrock observation
- Tectonic zone (breccia, mylonite etc.)
- Foliation, dip in degrees
- Foliation, high dip
- Foliation, vertical dip
- Foliation, unknown dip
- Lineation, plunge in degrees
- Lineation, horizontal
- Lineation, vertical
- Fold axis, plunge in degrees
- Fold axis, horizontal
- Fold axis, vertical
- Diabase (Db); with fragments of quartzite (Dq)
- Uralite diabase (U)
- Metabasite
- Xenoliths
- Dikes of granite, aplite and pegmatite
- Veins and schlieren of do.

YOUNGEST GRANITOID GROUP

- Granite, small-grained, red—grey. T = Spotted do.
- Granite-granodiorite, coarse-grained, megacryst-bearing (potash feldspar), red—grey

YOUNGER GRANITOID GROUP

- Granite, fine-grained to medium-grained, red—grey
- Granite-granodiorite, mostly porphyroblastic, red—grey
- Granite-granodiorite, mostly porphyritic, red—grey
- Granodiorite (-tonalite), porphyroblastic, mostly reddish grey
- Granodiorite (-tonalite), mostly grey
- Tonalite, dark grey

OLDER GRANITOID GROUP

- Granodiorite-tonalite (most frequently foliated), megacryst-bearing (mostly potash feldspar), reddish grey — grey
- Tonalite-granodiorite (most frequently foliated), megacryst-bearing (mostly plagioclase), grey

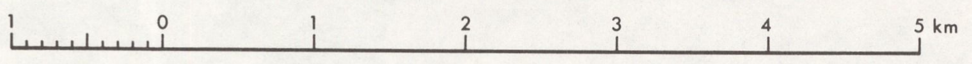
GNEISS GROUP (COASTAL GNEISSES)

- Gneiss, acid to intermediate, red—grey
- Gneiss, intermediate to basic, grey

BASIC PLUTONICS OF VARIOUS AGES

- Gabbro
- Diorite, monzodiorite

Scale 1 : 50 000



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