

SVERIGES GEOLOGISKA UNDERSÖKNING

SERIE C NR 732 AVHANDLINGAR OCH UPPSATSER ARSBOK 71 NR 7

PER H. LUNDEGÅRDH

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IN WESTERN CENTRAL
SWEDEN



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SUMMARY

The bedrock of Värmland county north of Lake Vänern in western central Sweden is dominated by granitoids and gneisses. The gneisses are in part homogeneous in part banded or veined. The granitoids as a rule consist of granites and granodiorites. Two principal generations can be distinguished: an older gneiss-granite group concentrated to the central part of the county, and a younger granitoid group (Rb/Sr age 1 690—1 700 Ma) located mainly to its eastern part. Microcline megacrysts are common in the latter (Fig. 1).

A broad zone of dikes and sills of black dolerite called hyperite runs parallel to the foliation right through the central gneiss-granites and associated gneisses.

During two periods of tectonization the bedrock has been foliated and folded around axes striking NNW—SSE. The younger of these tectonizations has developed as its main result a great number of thrust zones and has influenced most rocks of the county. The older tectonization has affected only the gneisses and gneiss-granites. A third tectonization has been confined to certain areas, the greatest one stretching between Hammarö south of Karlstad and Kristinehamn, immediately to the north of Lake Vänern. It has developed a very strong foliation and lineation striking ENE—WSW to E—W.

Though most sedimentary and volcanic rocks of Värmland have been altered to gneisses, there still remain rocks with recognizable primary textures, especially in the eastern and southern parts of the county. In central Värmland such rocks are sparse, however. The only metasedimentary rock worth mentioning is the Hälsjö (Horrsjö) quartzite, the only metavolcanics a couple of small boudins near the western margin of the hyperite zone in Gräsmark (Fig. 2). These metavolcanics comprise basaltic, andesitic, and dacitic lavas and tuffites in part porphyritic and in part rich in xenoliths. They have not been described earlier and will therefore be examined in this paper. They should correspond to the Småland, Amål, and Dala porphyries, Rb/Sr age 1 695—1 670 Ma.

TABLE 1. Chemical analyses of rocks from the Gräsmark—Lekvattnet area, western central Värmland

Concentrations in per cent by weight, analyst: Geochemical dept., Geol. Survey of Sweden, 1976. The contents of water and most minor elements including phosphorus have not been determined. Accordingly, all sums are lower than 99 %.

Rock	Gneiss-granite		Hyperite		Meta-splite		Meta-dacite	
	TORSBY SO	TORSBY SO	TORSBY NV	TORSBY SO	TORSBY SO	TORSBY SO	TORSBY SO	
Topographic map	66711/	667115/	66763/	6661/	66638/	666825/		
Coordinates in the Swedish net	13259	132565	13239	13348	13338-40	133145		
Analysis no.	6837—340	—341	—344	—328	—342	—345		
SiO ₂	70.0	46.6	47.7	52.2	48.7	61.3		
TiO ₂	0.53	1.2	1.4	0.80	0.69	0.67		
Al ₂ O ₃	15.0	19.1	18.5	18.0	15.3	18.9		
Fe ₂ O ₃	1.0	1.4	1.5	4.4	5.7	2.2		
FeO	1.1	9.2	8.9	4.1	3.0	1.9		
MnO	0.07	0.16	0.16	0.17	0.18	0.10		
MgO	0.54	8.5	7.3	5.0	10.5	1.5		
CaO	0.8	8.5	9.0	9.5	11.9	4.6		
BaO	0.11	0.04	0.04	0.08	0.05	0.18		
Na ₂ O	4.2	2.9	3.0	2.8	1.6	4.5		
K ₂ O	5.6	0.6	0.7	1.6	0.9	3.1		
Total	98.95	98.20	98.20	98.65	98.52	98.95		

GENERAL SURVEY OF THE BEDROCK IN VÄRMLAND

The predominant rocks of Värmland are granitoids which have most frequently been foliated. Two principal groups of granitoids can be distinguished, viz. an older and always foliated one including granite and granodiorite with or without microcline megacrysts, and a younger one comprising the same rock types but in part lacking foliation. The rocks of the older granitoid group, called gneiss-granites, are concentrated to the central parts of the county and have been foliated at least twice, while the rocks of the younger group, known as the Värmland granitoids, or the Kristinehamn—Filipstad—Hagfors granites¹, have occupied most part of eastern Värmland and have as a rule been foliated only once. They are associated with and at least in part related to scattered masses of gabbro, diorite, and monzodiorite, in most cases of minor size. In central and western Värmland still younger granitoids occur. These have been developed as granites, e.g. the Dalslandian Blomskog granite, and their areal distribution is restricted.

The basic eruptive rocks of the county are concentrated to a zone stretching SSE—NNW through central Värmland. They are there represented by numerous winding and more or less elongated bodies of black dolerite, both dikes interpreted as intrusion channels, and sills. Great part of the dolerite has been uralitized and simultaneously foliated to some extent. Occasionally it contains plagioclase phenocrysts. Garnet is a common mineral in the uralitized parts of the rock. The black dolerite has since long been known as hyperite in Swedish geological literature. (See, inter alia, A. E. Törnebohm 1891.)

The bedrock of southwestern Värmland is characterized by a complicated pattern of gneisses, some of which may have sedimentary origin. These gneisses, in part veined, in part banded, are at present studied by Roland Gorbatshev and Anders Lindh.

In easternmost Värmland, especially the Lesjöfors—Filipstad area contains various kinds of eruptive and altered sedimentary rocks belonging to the Svecofennides of Central Sweden. Ulf Wiklander has started a thorough examination of this area.

The older granitoids have intruded into rocks of supracrustal origin, in the first hand a red homogeneous felsic gneiss which covers large areas in southern Värmland and resembles the fine-grained felsic gneiss-granite of the county very much. Of other pre-granitoid supracrustal rocks should be mentioned the Hammarö Formation of southernmost Värmland (metamorphic basic volcanics and greywackes,

¹ See P. H. Lundegårdh 1974, further E. Welin, R. Gorbatshev, and P. H. Lundegårdh 1977. These rocks have been classed as early Gothian or post-Svecofennian.

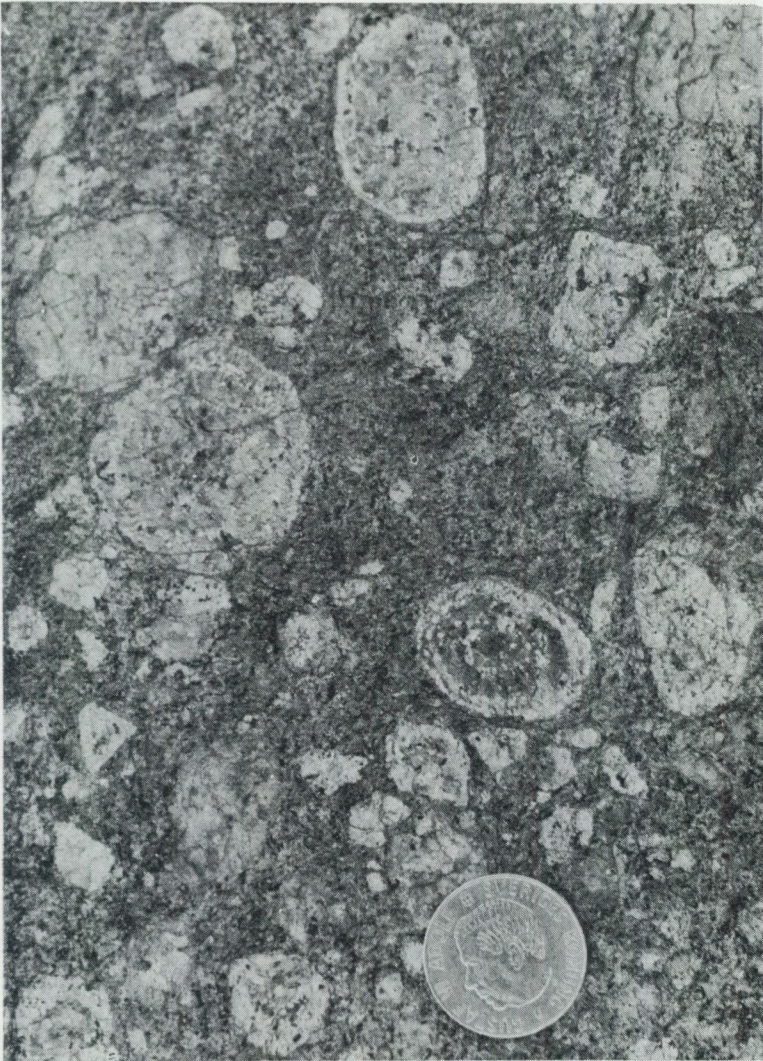


Fig. 1. Granitoid rich in microcline porphyroblasts frequently showing oligoclase mantling. Ö. Björntjärnen, 13 km east of Filipstad city. Map-sheet Filipstad SV: 66245/14209. Photo P. H. Lundegårdh 1974.

quartzite most frequently rich in felspar), further the Hålsjö (Horrsjö) and Rämberg quartzites of central and eastern Värmland.

In Gräsmark, western central Värmland, the marginal part of the hyperite zone contains a formation of metavolcanics not earlier mentioned in Swedish geological literature (Fig. 2), in the first hand porphyritic and in part spilitic metabasalt, metaandesite, and metadacite. The famous geologist A. E. Törnebohm has certainly marked a few diffuse zones of mica schists, hälleflinta, and granulite in this part of his petrological map of Värmland at a scale of 1:400 000 (1881), but

neither the map nor the accompanying description give any information regarding the metavolcanics and most of the neighbouring hyperite. The volcanics will therefore be examined in this paper. (See the next chapter.)

In a few outcrops, young granite has been seen to penetrate and brecciate hyperite and metabasalt (Figs. 3—5). The metaspilite, metaandesite, and metadacite, in turn, contain angular pieces of, *inter alia*, granite.

The older granitoids, or gneiss-granites, have been foliated once before the appearance of the doleritic hyperite magma, which has intruded along fissures striking NNW—SSE and following this early foliation. After the formation of the younger granitoids, the bedrock of Värmland was strongly affected by a final thrusting manifested by tectonic zones generally striking NNW—SSE, *viz.* the same direction as the early foliation. The dips of the late zones vary considerably, owing to folding along axes with very low plunges. The main effect of the final thrusting is a distinct foliation combined with disintegration and displaying transport lineation. The greatest zone has since long been known as the mylonite zone of central Värmland. (Cf. N. H. Magnusson 1937.) It has been re-examined from a modern petrographic-tectonic point of view by A. Lindh (1974). However, mylonite is by no means a prominent rock among the crushed and recrystallized or cemented granitoids and gneisses of the thrust zones. Mylonitization has, indeed, occurred only in certain zones, especially in those of central and western Värmland. The term mylonite zone is thus inadequate. Moreover, the conception of one broad zone as the principal result of the thrusting is erroneous. As a matter of fact, the bedrock between the Norwegian boundary in the west and central Västmanland in the east has been cut by a great number of thrust zones. Even the Hagfors—Filipstad—Kristinehamn granites of eastern Värmland have been strongly influenced by thrusting along several narrow zones, as will be evident from the new county map in preparation.

Some thrust zones have allowed solutions and perhaps even gases to rise from the depths and to alter the foliated and crushed rocks. South of Lake Mängen in Gräsmark, western central Värmland, a sulfide ore mineralization and a simultaneous development of micaceous orthoquartzite ('ore quartzite') has thus occurred.

According to the age determinations reported by Eric Welin (E. Welin, R. Gorbatshev, and P. H. Lundegårdh, in print 1977), the granitoids of eastern Värmland have been developed $1\ 689 \pm 30$ — $1\ 700 \pm 37$ Ma (million years) ago. The final regional thrusting and folding have occurred much later, as indicated by various age determinations no more than about 1 100 Ma ago. (See p. 16.) They should thus have Dalslandian age and ought to be included in the Sveconorwegian tectogenesis.

As mentioned, the intrusion of the hyperite magma has been controlled by early fissures striking NNW—SSE. Furthermore, the great masses of Värmland and

Småland granitoids have the same general orientation. The boundary between the Värmland granitoids and the gneiss-granites to the west is, however, rather diffuse, indicating an increasing regeneration of the latter towards the contact. In addition, separate masses of Värmland granitoids occur within the gneiss-granites, and microcline porphyroblasts with oligoclase mantling (Fig. 1) have been developed locally even in the western parts of the gneiss-granite complex. It seems thus probable that great masses of Värmland granitoids underlie the gneiss-granites, a conception recently supported by gravimetric and magnetometric investigations (S. Aaro and M. Lagmanson, personal communications 1976 and 1977), as well as by Rb/Sr whole rock determinations of the age of the gneiss-granites giving preliminary values about 1 700 Ma, possibly a regeneration age (E. Welin, personal communication 1976).

Many of the microcline porphyroblasts developed by the Värmland granitoid magmas have been disintegrated during the Sveconorwegian tectogenesis, especially in the late thrust zones. Some of these porphyroblasts have been regenerated once again in Dalslandian time, as a result of a regional migmatization at the end of the Sveconorwegian tectogenesis. Other effects of this migmatization will be reported at the end of this chapter.

Though NNW—SSE is the dominant tectonic and areal orientation of the Precambrian rocks in Värmland, remarkable exceptions from this trend have been found. In the first hand the Hammarö Formation at Lake Vänern should be mentioned. This formation stretches from the neighbourhood of Kristinehamn in the east to Skoghall south of Karlstad in the west. It has been subjected to intense folding around flat-lying or horizontal axes striking ENE—E or WSW—W. Accordingly, it cuts the general tectonic pattern of Värmland at right angles. Remnants of similar folding have been traced northwards, such as in Gräsmark and ENE of Torsby. The E—W folding is older than the Sveconorwegian thrusting and folding but has proved to be younger than the first tectonization that has produced NNW—SSE structures. In Gräsmark it has been traced in the meta-volcanics described in the next chapter. In other parts of Värmland much of the hyperite, and locally the gneiss-granites, too, have been influenced by this folding. It has developed complicated tectonic patterns in some hyperite bodies which have afterwards been thrust and folded in Dalslandian time. Such a two-fold tectonization is very well displayed by a hyperite outcrop to the north of Degerberget, in the easternmost part of Hammarön near Karlstad.

The Sveconorwegian tectogenesis comprises a regional synorogenic metamorphism followed by serorogenic migmatizations of variable strength in various parts of Värmland. A widespread formation of magnetite is characteristic of the Sveconorwegian metamorphism in especially the southern and central parts of the county. In areas lacking magnetite, black hastingsitic hornblende is a common secondary mineral.

The migmatization has been rather strong in the northern vicinity of the Hammarö Formation and seems to have been facilitated there by the meeting between two structures, viz. the ENE—WSW trend of the Hammarö Formation and the NNW—SSE trend of the Sveconorwegian tectonization. Even secondary fine-grained granite resembling the Bohus granite of the northern Swedish west coast occurs in this area. The Bohus granite and allied granites in southern Norway have since long been classed as Late Dalslandian.

PETROGRAPHY OF THE GRÄSMARK METAVOLCANICS

To the north of Lakes Kymmen and Rottnen, in Gräsmark, western central Sweden, the predominant red or reddish, mostly felsic gneiss-granite (chemical analysis in Table 1) does not only contain numerous boudinated dikes of black, in part foliated and uralitized dolerite called hyperite, but also elongated bodies of metavolcanics, viz. porphyrite, porphyritic metaspilite, metaandesite, and metadacite. The foliation of the gneiss-granite and its inclusions have the same strike, i. e. N—NNW (Fig. 2). Conformable thrust zones are common in this part of Värmland and contain both mylonite and micaceous orthoquartzite grading into mica schist. To the south of Lake Kymmen the Mängen copper mines are located to tectonic mica schist and micaceous orthoquartzite near a lake bearing the same name.

The Gräsmark hyperite (Fig. 4) is a genuine dolerite containing both olivine and pyroxene. Great part of it has been uralitized, however. Two chemical analyses are given in Table 1. The uralitized hyperite has in part become foliated and, in zones of thrusting, schistose. Most or all amphibole of the schistose meta-hyperite has been changed to minerals with more water, chlorite essentially. Simultaneously, the plagioclase has been strongly altered. Part of the uralite-hyperite contains almandite.

Xenoliths are rare in the Gräsmark hyperite. Only a big lenticular inclusion of gneiss-granite and a few fragments of tonalite have been met with.

Contrary to the hyperite, part of the Gräsmark volcanics are rich in xenoliths. This is especially true for the metaandesite and metadacite, whereas the porphyrite as a rule lacks fragments.

The porphyrite is black or greenish, with a very fine-grained or aphanitic groundmass of uralite, plagioclase, and a little quartz. Ore grains are common. Most phenocrysts have been interpreted as altered mafic minerals, in the first hand clinopyroxene. They consist of a mixture of uralite, epidote, and chlorite, frequently with ore impregnations. Other phenocrysts display a mass of epidote, calcite, and clinozoisite. These are probably secondary after calcic plagioclase. Still other, though rather sparse, phenocrysts contain preserved clinopyroxene. The regenerated plagioclase shows An c. 40 %.

Like the other metavolcanics of Gräsmark, but contrary to the neighbouring hyperite, the porphyrite is very rich in trivalent iron (Table 1).

The metaspilite is black to greyish with a groundmass consisting of a very fine-grained network of uraltite, epidote, some ore, and a plagioclase mostly changed to sericite, epidote, and clinozoisite. Accessoric grains of apatite and sphene have also been observed in the groundmass. The rock is crowded with aggregates of epidote measuring up to 15 cm across (Fig. 6) and apparently secondary after carbonate minerals, calcite and/or dolomite especially, which have never been preserved, however. Numerous phenocrysts also occur, chiefly plagioclase crystals measuring up to 5 cm in length and strongly or wholly changed to sericite, epidote, and clinozoisite. The plagioclase phenocrysts are irregularly distributed and have a xenolithic character. Sparse small amygdules of quartz bear witness of the lava character of the rock.

The metaspilite contains scattered angular pieces of metarhyolite (reddish quartz porphyry; see Fig. 7) and occasionally fragments of red granite, too.

As could be expected from its high content of epidote, the metaspilite is very rich in CaO and MgO (Table 1). Its chemical composition differs markedly from that of the hyperite regarding, *inter alia*, the high oxidation degree of its iron. Contrary to the porphyrite, the metaspilite is restricted to one elongated inclusion in the gneiss-granite and is not associated with other metavolcanics, or hyperite. In the centre of the inclusion, the metaspilite shows primary bedding. The beds have been folded around flat-lying axes striking E—W. Accordingly, their own strike has the same orientation (Fig. 2). Marginally, the metaspilite has become strongly affected by the regional thrusting and is at present schistose along planes striking N 10° W.

The metaandesite and metadacite have the greatest areal distribution of the Gräsmark metavolcanics. They appear as grey green black to greenish or reddish dark grey, metatuffitic conglomeratic rocks with numerous phenocrysts and xenoliths. Probably their matrix represents some kind of crystal tuff developed by volcanic explosions. It displays a very fine-grained, mostly granoblastic mixture of plagioclase, quartz, epidote, biotite, and sericite in variable proportions. Sparse grains of apatite also occur. Phenocrysts and porphyroblasts of aggregated biotite and penninite associated with epidote, some quartz, and a little sphene appear frequently in the rock, whereas aggregates built up exclusively of epidote are rare. Scattered phenocrysts of plagioclase and quartz should further be reported. The plagioclase, an andesine, is in many crystals zonal. Late microcline has grown at various places in the rock, commonly in connection with plagioclase, and also forms grains of considerable size.

The xenoliths comprise small fragments of black or dark, basic metavolcanics (metabasalt and altered carbonate lumps originating from metaspilite, metaandesite, and metadolerite; see Fig. 8), as well as large pieces (≤ 6 dm in length) of

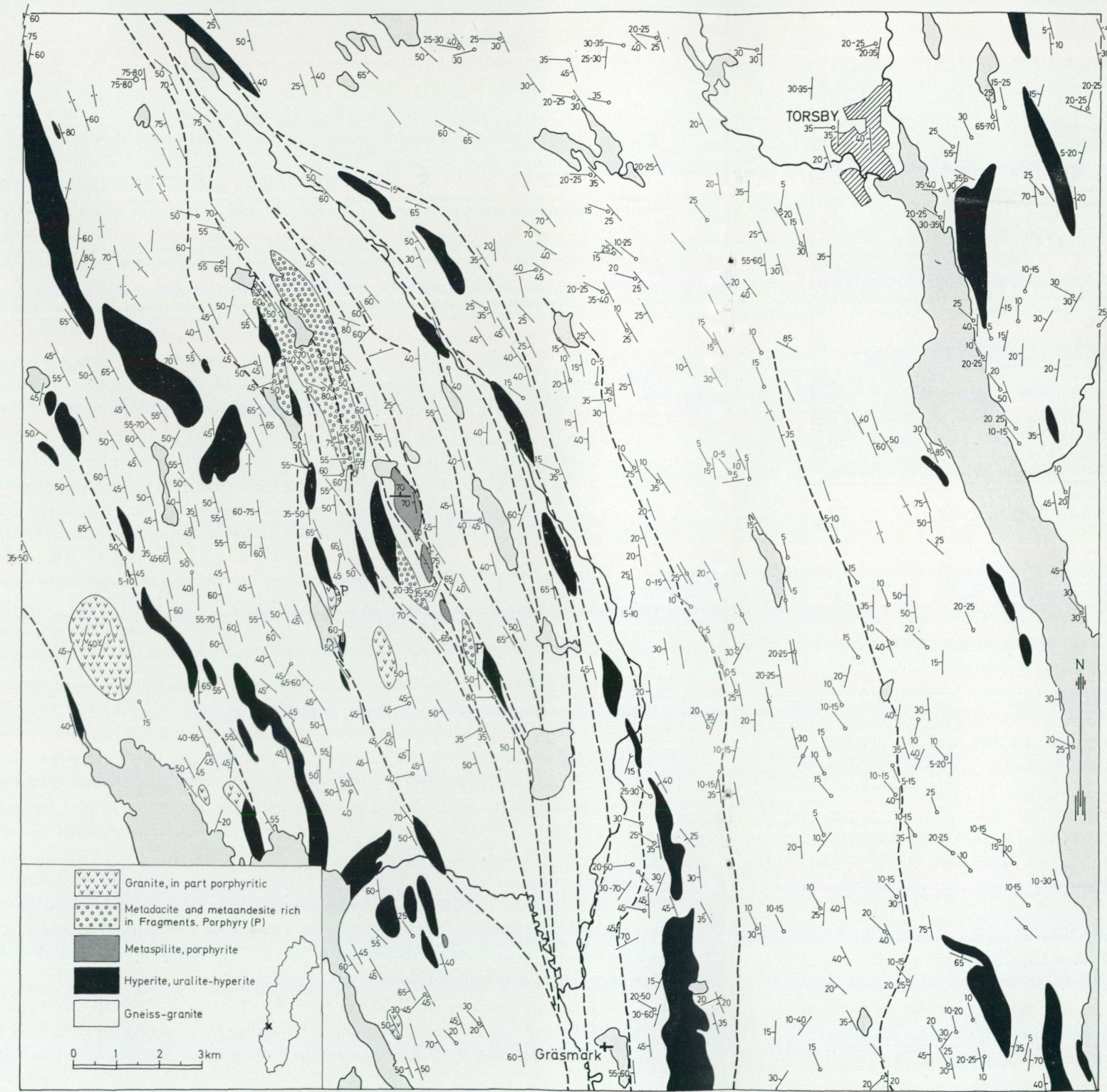


Fig. 2. Petrological map of northern Gräsmark and adjacent parts of western central Värmland. Scale 1 : 125 000.

From the Swedish topographic map-sheet Torsby SO. Foliation and lineation marked by conventional thin symbols, bedding by thick symbol, central parts of thrust zones by broken lines.

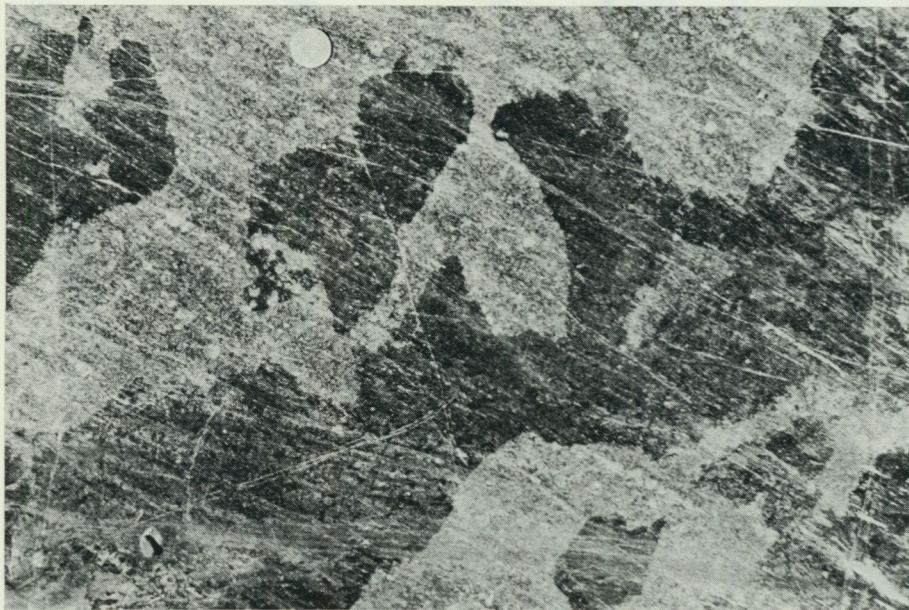


Fig. 3. Uralite hyperite brecciated by marginal Filipstad granite. Outcrop now covered by Europe way 18 south of Ö. Fågelvik church, east of Karlstad. Photo P. H. Lundegårdh 1976.

metarhyolithe (Fig. 8: red or reddish quartz porphyry), reddish or red granite and, occasionally, dark grey quartz diorite or tonalite. The granite is in part slightly porphyritic and contains in a few cases mantled augen of the main mineral, which is microcline-perthite. As mantled megacrysts have never been observed in the ordinary gneiss-granite of central and western Värmland, younger granitoids ought to occur at deeper levels of the crust in Gräsmark and to have contributed to the volcanic ejecta. This conception coincides with the statements regarding the distribution of the Värmland granitoids given in the first chapter (p. 7). Besides, metamorphic gneiss-granite with mantled porphyroblasts occur immediately to the west of the xenolith-bearing metavolcanics (Fig. 2).

The metadacite analysed in Table 1 has a chemical composition characterized by a rather high content of alumina. This indicates weathering of the original rock. The fragment-bearing metadacite and metaandesite should thus be characterized as volcanic conglomerates.

Most part of the metarhyolite occurs as xenoliths in the metadacite and metaandesite. Only two separate bodies of metarhyolite have been found in the mapped area. These have been marked with 'P' (porphyry) in Fig. 2. The eastern body has been strongly foliated and to some extent mylonitized, whereas the western body is in part better preserved. The metarhyolite here displays a red porphyry with several feldspar phenocrysts measuring up to 6 mm in length. This porphyry

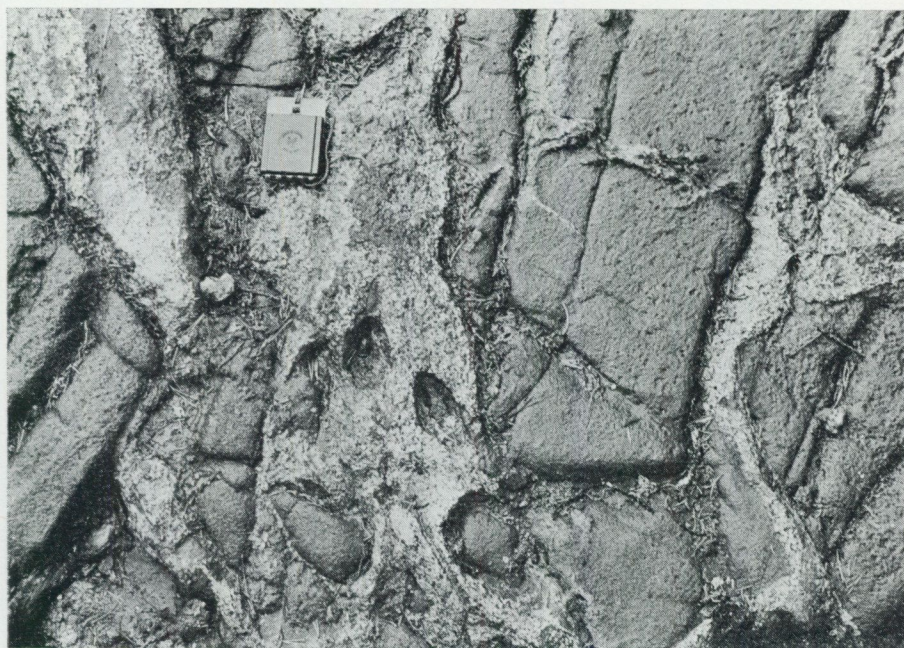


Fig. 4. Uralite hyperite brecciated by reddish granite. East of Kymsberg, Gräsmark. Map-sheet Torsby SO: 665455/13343. Photo P. H. Lundegårdh 1976.

has been intruded by a porphyritic Värmland granitoid which also contains hyperite xenoliths.

The metarhyolite of the xenoliths commonly displays a red or reddish quartz porphyry with a very fine-grained granoblastic groundmass composed of microcline, quartz, and plagioclase in the first hand, further some aggregated biotite and a little epidote, as well as apatite, zircon, ore, garnet, and leucoxene (the minerals starting with apatite given in order of decreasing frequency). The phenocrysts consist mainly of inhomogeneous microcline-perthite, quartz, and sericitized inhomogeneous plagioclase. Moreover should be reported sparse aggregates of ore, chlorite, and apatite, as well as of biotite or garnet, epidote, and ore. A few plagioclase phenocrysts contain minute garnet grains. Rare garnet porphyroblasts should also be reported.

The presence of garnet in the rock is remarkable as all xenolith-bearing metavolcanics of the area are rich in epidote and thus belong to a rather low metamorphic facies. The garnet, an almandite, has apparently grown secondarily and indicates a metamorphic degree corresponding to the amphibolite facies which characterizes most part of the surrounding bedrock.

The outermost parts of the microcline-perthite phenocrysts have frequently grown secondarily and contain minute fragments of the matrix.

The metabasite of the xenoliths is commonly non-porphyritic. Some fragments

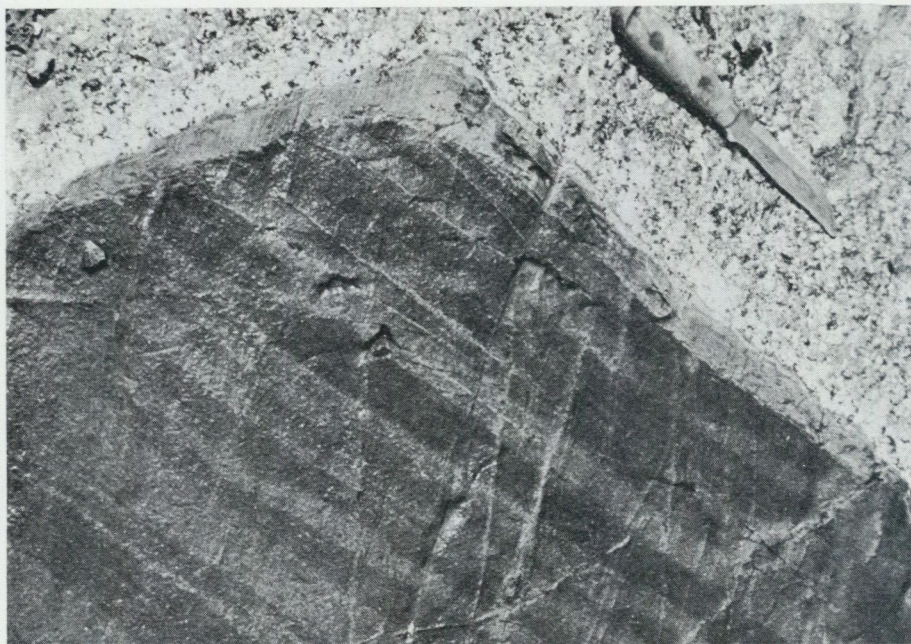


Fig. 5. Banded basic metatuffite intruded by red granite of Dala type. Långetjärn, Gräsmark. Map-sheet Torsby SO: 6658/13317. Photo P. H. Lundegårdh 1976.

are metadoleritic and probably originate from the hyperite. Most fragments display, however, very fine-grained or dense rocks, in part similar to the one shown in Fig. 5, viz. a tuffitic metabasalt or metaandesite, in part distinctly banded.

The non-porphyrific metabasite itself never contains xenoliths, and seems to be closely related to the porphyrite. Only one considerable mass of non-porphyrific metabasite has been met with during the mapping, viz. the metabasite containing the locality of Fig. 5. The delicate banding here manifested not necessarily ought to be primary, however. It might also be interpreted as a selective alteration caused by solutions penetrating the rock along planes of bedding or schistosity. The intrusive granite bordering upon the banded metabasite in Fig. 5 is red, felsic, and rather coarse. It resembles very much certain varieties of Dala granite. (Cf. S. Hjelmqvist 1966.)

TECTONICS AND AGE OF THE GRÄSMARK METAVOLCANICS

The tectonization of the Gräsmark metavolcanics is normally Sveconorwegian, of Dalslandian age, and has been concentrated to the marginal parts of the rocks. Characteristic of the conglomeratic metavolcanics is a foliation bending around



Fig. 6. Metaspilite. Northwest of Knutfallet, Gräsmark. Map-sheet Torsby SO: 66638/1334. Photo P. H. Lundegårdh 1976.

phenocrysts and xenoliths. An intense transport lineation has been developed in thrust zones and has re-worked the rocks all through, as illustrated by Figs. 8 and 9.

The occasional E—W folding encountered in the metaspilite has been cut by the Sveconorwegian foliation and should be compared with similar tectonic trends in other parts of southern and southern central Sweden. Among these ought to be mentioned an E—W structure in the Vånga granite, northeastern Scania, Rb/Sr age about 1 500 Ma (regeneration age). Even here the E—W structure has been cut by Sveconorwegian tectonization.

The metaspilite, metaandesite, and metadacite do not only contain fragments of the pre-volcanic rocks but also pieces of older beds of the volcanic formation itself, *inter alia* metarhyolite and tuffitic metabasite. The volcanic activity seems thus to have been very much extended in time.

The absolute age of the Gräsmark metavolcanics have not yet been determined radiometrically. However, the xenoliths in and intrusions into the metavolcanics permit valid conclusions regarding their stratigraphic position. The xenoliths bear witness of repeated volcanic eruptions through a bedrock of granites, some of which contain mantled porphyroblasts, and of basic eruptive rocks. This bedrock is in the present surface composed of gneiss-granite, hyperite, and a granite carrying mantled microcline porphyroblasts. The latter seem to have been de-



Fig. 7. Fragment of quartz porphyry in metaspilite. Locality etc., see Fig. 6.

veloped under the influence of Värmland granitoid magma intruded at deeper levels of the crust, a conception supported by the preliminary radiometric ages of the gneiss-granite determined by Eric Welin and reported earlier in this paper. (See p. 7.) As the Rb/Sr whole rock age of the Värmland granites and allied rocks is $1\,700 \pm 37$ — $1\,689 \pm 30$ Ma (E. Welin, R. Gorbatshev, and P. H. Lundegårdh, in print 1977), the xenolith-bearing metavolcanics in Gräsmark should be younger than $1\,690 \pm 30$ Ma.

The granite intrusive in the basic metavolcanic shown in Fig. 4 has for petrographic reasons been interpreted as a Dala granite, with a probable age of c. 1 670 Ma, or less. (Cf. E. Welin and Th. Lundqvist 1970.) The Sveconorwegian thrusting and final metamorphism of the bedrock have a radiometric age between 1 110 and 925 Ma. Six Russian K/Ar determinations on foliated Värmland rocks reported by N. H. Magnusson (1960, 1970) have given values between 1 068 and 975 Ma. When recalculated in accordance with the U.S. constant of electron capture for Ar^{40} (E. Welin and G. Blomqvist 1964), the radiometric ages become lower, viz. 1 020—925 Ma. The K/Ar ages of mica and amphibole separated from the Bamble area in southern Norway, another area metamorphosed in Dalslandian time, range from $1\,114 \pm 32$ to 970 ± 30 Ma (R. K. O'Nions, R. D. Morton, and H. Baadsgaard 1969).

Obviously, all data at present available point at a Dala porphyry age of the

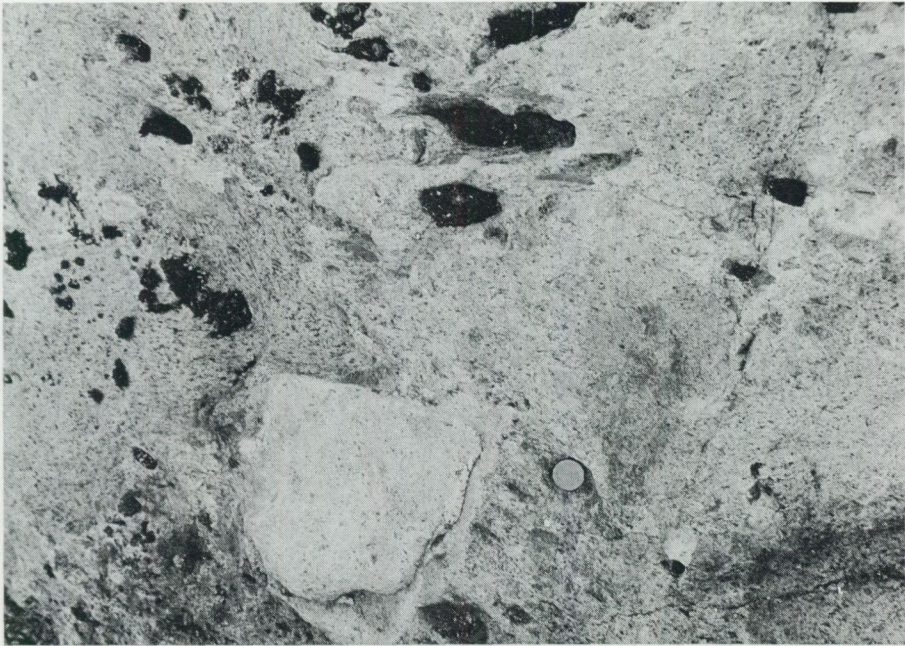


Fig. 8. Metadacite with fragments of quartz porphyry and cavities after weathered basic rocks. Outcrop perpendicular to the lineation. South of Gäddtjärn, Gräsmark. Map-sheet Torsby SO: 6665/13328. Photo P. H. Lundegårdh 1976.

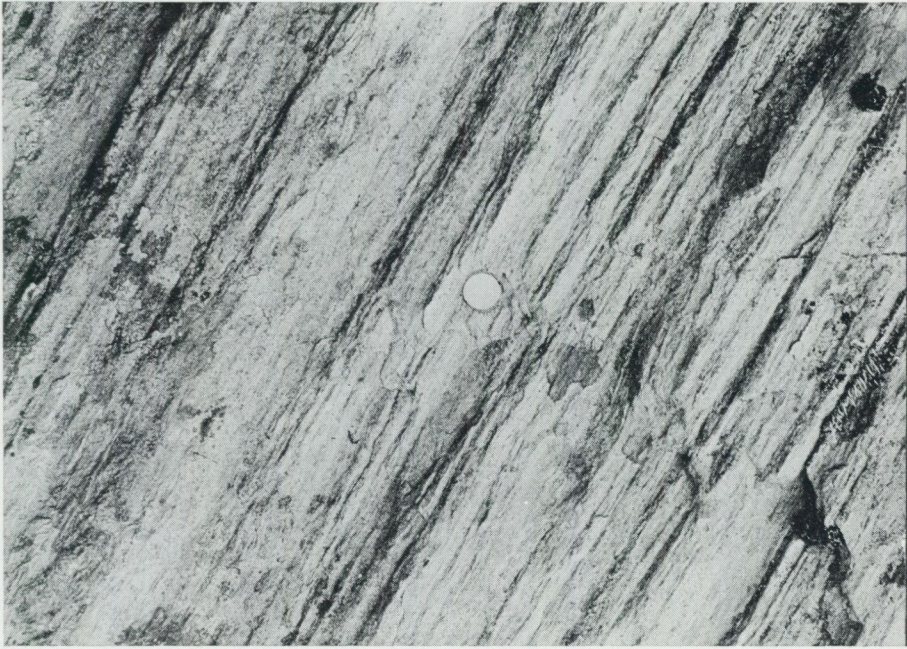


Fig. 9. The same rock as in Fig. 8. Outcrop parallel to the lineation.

xenolith-bearing Gräsmark metavolcanics, viz. about 1669 ± 32 Ma (E. Welin and Th. Lundqvist 1970). Petrographically, these rocks might very well correspond to the Småland and Åmål porphyries, however. The Småland metavolcanics have been investigated radiometrically by Göran Åberg (1972), who reports a Rb/Sr age amounting to 1695 ± 20 Ma.

Metavolcanics similar to those in Gräsmark do not occur in adjacent parts of central and western Värmland, but have been observed in the Norwegian Hedmark Fylke in the west. The Kongsvinger Group there distinguished by Ö. Gvein, H. Skålvoll, and T. Sverdrup (1974) comprises a metarhyolite similar to the one appearing as fragments in the Gräsmark Formation. (However, its areal distribution has been greatly overestimated in the Norwegian map-sheet Torsby.) The Kongsvinger Group has been classed as early Gothian, though older than the hyperite as well as the Värmland granitoids.

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