Geological studies in the region of Vegarshei — Gjerstad

By

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Introduction.

The region investigated covers an area of about 700 km² on the borders of Sørlandet and Telemark. The nearest town is Arendal, 50 km southwards, while Risør lies 20 km eastwards (Fig. 1).

From a geological point of wiew, this area belongs to two classical zones: the Kongsberg-Bamble and the Telemark. These two zones are separated by a big breccia which can be followed all throug the south of Norway, from Kristiansand to the Oslo region, for about 300 km. However, in the area investigated, the breccia does not seem to play a fundamental part and the formations lying on both sides are of a similar nature, at least on the scale of a few kilometers. The big breccia represents a late episode, which may have occurred at a recent period, but it dissected an essentially homogenous region. Kongsberg-Bamble and Telemark are terms of regional geology, which can only be used on a much larger scale than the one chosen in this study.

Historical.

The South of Norway is a particularly suitable place to study granitisation and metamorphism. The conditions of exposure are good, even perfect at times. The geology however is complicated, certain facies are not classical ones and it was not easy to find a general and logical classification. The main workers in the area have been J. A. W. Bugge and T. F. W. Barth. Barth and J. A. Dons (1960) recently published a paper

1) — Present adress: E.N.S. Géologie, B.P. 452, NANCY (M. & M.) France.

in «Geology of Norway» giving the latest views on the geology of the region, to which the reader is referred.

The region of Vegarshei – Gjerstad.

The general features of the geology of Southern Norway are now fairly well known, but little had been done in the region of Vegarshei-Gjerstad itself. A few hints can be found in several publications by A. Bugge, J. A. W. Bugge and Barth. These are mainly only brief accounts and the only suitable map was published by Barth in «Geology of Norway (1960).

Thus the present work has been first and foremost a field investigation on the scale of 1/50 000, sometimes 1/20 000, constituting a form of background for further studies. The present paper deals with some results of the field work and must be considered as an «introduction».

The problem considered was primarily the genesis of augen gneisses, but it was of course necessary to study all the facies occurring in the region. We will therefore present a brief description of the main characteristics of these facies, keeping to the classification defined by J. A. W. Bugge, which corresponds, for the main features at least, to the chronological order of geological events.

The following will be studied in turn:

The old group:

The banded gneisses.
The quartzites.
The amphibolites.

The younger complex (migmatites).

The metatexites (anatexites).
The augen gneisses.
The granites (Orientated granite and normal granite).
The pegmatites.

The mylonites and the breccia.

The diabase dyke (non metamorphic).

LEGEND

The rocks

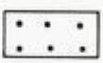
Diabase dyke (non métamorphic).

Mylonites and breccias belonging to the «Great breccia».

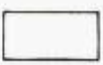
Telemark granite.

Orientated granite (tardimigmatique).

Normal augen gneisses (Types I and II).



Charnockitic augen gneisses.



Undifferentiated metatexites.

Zones, where amphibolites are predominant.

Zones, where quartzites are predominant.

The limits (*Further comments in text*).

Fault zones (corresponding to the mylonites and breccias).

Sharp petrographic limit, possibly emphazised by late tectonic movements.

Progressive transition limit between two formations of the Younger complex spesially augen gneisses and metatexites).

Petrographic limits, possibly sharp, not completely followed on the fields.

This limit only indicates zones where a rock type from the old group – i. e. quartzite or amphibolite – is particularly abundant.

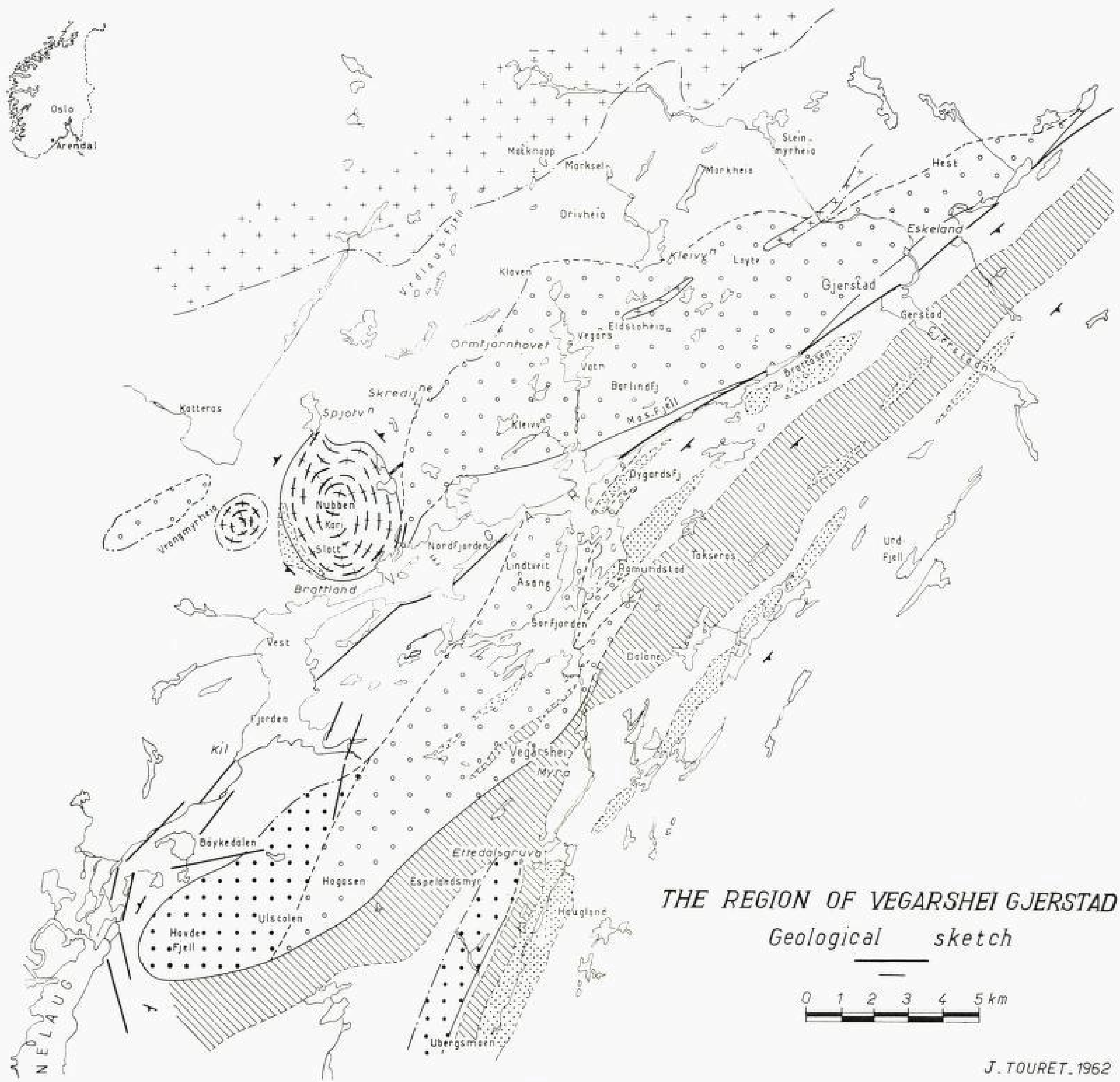

THE REGION OF VEGARSHEI GJERSTAD
Geological sketch
0 1 2 3 4 5 km
J. TOURET_1962
Oslo
Arendal
Gjerstad
Eskeland
Hest
Vegarshei
Nubben
Brattland
Ormtjarnhovet
Skredi
Spjotv
Katteros
Vrangmyrheia
Nordfjorden
Lindtveit
Åsang
Sørfjorden
Vest
Fjorden
Kil
Bøykedalen
Hogasen
Ulscolen
Hovde Fjell
Ettedalsgruva
Espelandsmyr
Ubergsmoen
Myra
Dalane
Takseros
Romundstad
Dygardsfj
Berlindfj
Vatn
Vegars
Eldsteheia
Kloven
Orivheia
Marksel
Markheis
Kleivv
Løyte
Gerstad
Urd Fjell
Nelaug
Hauglane

Fig. 1

The old group.

The banded gneisses.

In the area as a whole a few typical banded gneisses, with undisturbed structure, occur.

Most of them, however, were mobilized during the second period of metamorphism and now belong to the migmatites. Nevertheless, as for instance in the region of Lunde, rather important patches of typical banded gneisses may still be observed.

These rocks are very similar to the gneisses of the Randesund area, which have been studied recently in great detail by R. Dietrich. An important point which Dietrich mentioned and which is also evident here, is that the banded structure is not only an alternation of quartzitic and amphibolitic layers, but all kinds of intermediate composition may occur, amphibolite and quartzite being the two extreme poles.

No cyclic or regular sequence can be found and the conclusions reached by Dietrich concerning this rock type, i. e. recristallisation controlled by supracrustal sedimentation, seem definitely to be the most acceptable.

As no limit exists to the thickness of the layers, the rocks considered below, quartzites and amphibolites, belong in fact to the banded gneisses. But field evidence suggest that they may be distinguished and studied separately. They may therefore form important occurences, sometimes several hundred meters thick and are very typical rocks of the group. Besides, their chemical composition and mineral evolution are patricularly interesting.

The quarzites.

Numerous exposures of quartzites and quartzitic rocks are to be found over the whole of the Vegarshei-Gjerstad region.

As appears on the map, most of these rocks lie south of the breccia and are disposed in two different belts, striking roughly N. 60., parallel to the main strike of all the formations in the district. One of them is close to the breccia and the body of augen gneisses and runs from Romunstad to the banks of lake Gjerstavatn. In the area close to the augen gneisses, there are numerous patches of quartzites that will be considered later.

The second belt is roughly parallel to the first. It lies more to the south and is mostly apparent in the region of Ubergsmoen.

North of the breccia, it is not possible to recognize any belts. However, the region of Brattland is remarkable for very pure quartzites, some of them lying curiously above orientated granite.

Mode of exposure.

The mode of exposure is interesting. The rocks consist of elongated layers, which seem to be concordant with the strike of the migmatites. The beds are very thick at times – a hundred meters or so – but more often they are thin, even very thin. It is possible to follow some fairly thin layers over several kilometres, but, generally speaking, only a series of elongated patches displayed at intervals following a common strike can be observed. As Bugge and Barth have already observed, this general outline suggest the remains of an ancient formation which, in the past, was much more important. The study of the mineralogical composition further supports this view.

Mineralogical composition.

The quartzites may be composed of a single mineral, i. e. quartz, as for instance near Brattland. This is not very common and rocks of this type never make important exposures. There are generally present micas, whose parallel orientation emphasizes the structures, while, feldspars are often noticeable under the microscope. However the total quantity of these two latter minerals never exceeds a few %, so the name of quartzite is perfectly justified.

The main associations are the following ones:

– Quartz-muscovite: This is the most common association. The quartz, occurs as crystals with interlocking boundaries, frequently showing an undulatory extinction. The crystals are generally elongated in a direction which can be different from the one indicated by the muscovites. At some distance from the body of augen gneisses, these rocks hold no feldspars, but, as we come nearer, they contain larger and larger quantities of microcline.

– Quartz-biotite and quartz-biotite-muscovite: These varieties are also frequently found. The contrast between the shape of biotite and muscovite crystals is striking. While the muscovites are highly corroded and indented, the biotites remain absolutely sound, free from any corrosion. Pleochroism is obvious, showing a dark brown hue, except for a few varieties, according to their characters, could be compared to ferrimusco-

vites. They may hold garnets, which are always surrounded by a rim of biotite crystals.

– Quartz-muscovite sillimanite and quartz-muscovite-sillimanite-microcline. Sillimanite is not abundant in the Vegarshei district, but in the second belt near Ubergsmoen, there are quartzites holding large quantities of sillimanite, sometimes associated with muscovite and microline. These rocks are very similar, and probably related, to the well known sillimanite bearing rocks from Søndeled.

The amphibolites

As with the quartzites, the outline of the amphibolite suggests the remains of an older formation in the midst of the migmatites. However they are much more abundant. The rocks which were changed into amphibolites may have been initially more important or they may have resisted the granitization processes better.

They occur everywhere in the region of Vegarshei-Gjerstad, but they are mostly found in a wide belt immediately to the south of the augen gneisses of Vegarshei. The orientation is similar to that of the quartzites and of the migmatites, i. e. N.N.E. The most striking exposures occur in the region of Takserås-Kvisli, where the very coarse grained amphibolites may hold garnets 10 cm in size.

Among the migmatites, the ampibolitic layers are often deformed, broken into boudins and agmatites. But the most important layers – sometimes many meters thick – seem to have been but little altered during the phase of migmatitisation. These rocks apparently resist the processes of granitization very easily.

Mineralogical composition.

The mineralogical composition, appearence and structure of the rocks vary. Their study is more difficult than in the case of the quartzites, as the only determinative criteria are a very dark coloration and, under the microscope, a total amount of dark mineral exceding 50 %; these minerals may be amphiboles, micas or pyroxenes.

However it is possible to identify a few main types:

– The most common amphibolite is a rock containing 45 to 50 % amphibole (common green hornblende with sometimes a bluish coloration) and 40 to 45 % plagioclase. The plagioclase is normally rather calcic (An 30 to 40); but in some cases a different kind of feldspar, more albitic

and frequently untwinned, may be noticed. The rest of the rock, i. e. 5 to 10 %, consist of apatite, epidote, ore minerals and now and then a little quartz. Sphene, wich is often lacking, may in a few cases appear in rather large quantities. In addition pyrope-almandine garnets, sometimes of considerable size, may be present.

– Another type is very similar to the above, but the amphiboles are associated with biotite crystals and it is often possible to notice as common orientation of the crystallographical elements in both minerals.

– The third type is different. In addition to amphiboles, micas and feldspars, it contains monoclinic pyroxenes belonging to the diopside-hedenbergite series. The plagioclases are more calcic (An 40), but the accessory minerals are similar to those of the preceeding types.

The structure is rather peculiar. The planar orientation is sometimes unnoticeable and the shape of the pyroxenes and amphiboles reminds us of a gabbroic tructure. These rocks can certainly be compared with the «hyperites», gabbroic rocks well known in the south of Norway through the publications of Brøgger.

– The last type is not an amphibolite, but a true pyroxenite. The only minerals are plagioclase and monoclinic pyroxene, without any traces of uralitisation. In the field, this type can be distinguished from amphibolites by its very dark colour and its fine grain size.

Conclusion.

Now, the question of the origin of the rocks belonging to the «old group» is no longer controversial. They are rests of an ancient formation and have apparently suffered very little change in their bulk composition during metamorphism. This phase of metamorphism is thus «topochemical», without any significant metasomatism.

Concerning the region of Vegarshei-Gjerstad, it can be noted that all the mineralogical associations met with belong to the amphibolite facies.

The younger complex.

During a second phase of metamorphism, all the rocks we have just considered were transformed into units belonging to the «Younger complex». Here the phenomena of anatexis, palingenesis, metasomatism play a fundamental part. The structure, which had been preserved till then, became completely disturbed. All these rocks are now migmatites.

Unfortunately, the term migmatite has assumed so broad a signifi-

cance that it is hardly possible to use it: all the rocks in the south of Norway are in fact migmatites, even the rocks of the old group which constitute their paleosome.

Thus the different types of migmatites will be studied from a purely descriptive point of view, without any petrogenitic consideration:

- The metatexites.
- The augen gneisses.
- The granites.
  Normal granites.
  Orientated granites.
- The pegmatites.

The metatexites.

Under the heading of metatexites will be examined rocks whose general features do not differ basically from those of the old group. However the general structure becomes more complex and layers of quartzofeldspathic material can be noticed which tend to cut the general plane of foliation. This notion of intersection is fundamental, as it is simply impossible to distinguish concordant layers produced by migmatitisation from layers of similar composition but resulting from the ectinitic recristallisation of an appropriate sediment (for instance a metaarkose). Besides, the total amount of granitic material is not sufficient to produce important bodies, so that the thickness of granitic beds never exceeds some meters.

As regards their shape and appearance the metatexites can be considered as intermediate steps between rocks from the old group and the more advanced products of granitization as, in the region of Vegarshei, augen gneisses, orientated granites and granites.

Description.

From what has just been said, it is obvious that the most interesting features of the metatexites are structural ones. The hard task of describing completely these structures will not be attempted – this work is ably done in Bugge's publication (1943) and in «Geology of Norway», (see specially the drawing by Schaer and Wegmann). Here only a few comments concerning the region of Vegarshei-Gjerstad will be made.

Two different types of deformation are noticeable:

1) A plastic style, which is the general case. The structures, at the scale of the exposures, look very much deformed, faulted. The orientation of the faults seems to vary very rapidly; but, at least in the region of Vegarshei, this complexity does not subsist on a larger scale. Here the structure of the rocks belonging to the old group is very simple; general strike N. 60 E., dip East. Plotting the orientation of faults axes the metatexites on a stereographic net, a similar direction clearly appears. Moreover, on the aerial photographs, a single orientation comes out, either in the «old group» or in the metatexites. As a conclusion, it seems that the complexity of deformation for the metatexites is much greater at the scale of 10 or 20 metres that at the scale of a kilometer or so.

As Barth many times pointed out, it is also clear that feldspars tend to develop in fields where the pressure is comparatively weak. This is particularly visible in the picture shown in figure 2.

2) A cataclastic style is sometimes noticeable. It may be amphibolitic layers apparently broken to give agmatites. These shapes may occur at the hinge of an anticline.

It is possible to relate these cataclastic features to a quartzofeldspatic network generally occuring in the amphibolites. The veins are very thin (a few cm) and straight. They could correspond to a primitive stage of migmatitisation and might be venites according to the definition of Scheumann.

Mineral Facies of the metatexites.
Degree of evolution.

From a petrographical point of view, the mineralogical associations of the neosome correspond to the assemblages found in the rocks of the paleosome: the neosome consists of quartz, feldspars – plagioclases and microcline, – occasionally a few micas or amphiboles. All these associations are typical of the amphibolite facies. Excepting certain local phenomena of retromorphosis, which generally correspond to the phase of mylonitisation, nowhere has there been found any traces of rocks belonging to another facies. It will be interesting to compare this fact with those concerning the augen gneisses.

This uniformity does not avoid the necessity of defining a «degree of evolution» of the metatexites; this notion is a very subjective one and depends only on the relative amount of granitic material in the metatexi-

Fig. 2: The «metatexites».

Fig 3: The «sharp contact» of the augen gneisses near Vegarshei.
Note the system of joints.

tes. It can hardly be denoted by any number but is probably familiar to any geologist having worked in the Precambrian. In the region of Vegarshei-Gjerstad, it is clear that there is no discontinuity at the breccia, but that this «degree» is higher northwards than southwards. South of the breccia, it increases the west. It must be noted that this «degree of evolution» is utterly independant of the mineral fecies.

The «augen gneisses».

The «augen gneisses» form the most interesting and typical rocks in the Vegarshei-Gjerstad district. Of course the facies «augen gneisses» is not rare in the south of Norway, but the gneisses of Vegarshei are more widely distributed than in any other part of Sørlandet. Moreover, they are remarkable for very large feldspar porphyroblast, whose size can reach ten centimeters or more. Thus they are similar to the «Riesen Augengneisse» in the Hohe Tauern.

The gneissic structure is often obvious; it may be less distinct at times, so that it has been possible to apply the term «granite» to these rocks. But too many features are different from real granites for this term to be retained.

Mode of exposure.

The gneisses appear in two different elongated bodies of comparable size occuring on either side of the breccia. The gneisses of Vegarshei, which are the only augen gneisses mentioned in the litterature, occur to the south of the breccia, while the very similar gneisses of Gjerstad lie to the north. The two bodies are not in direct contact with the breccia, except at one point ,northeast of Gjerstad. Here it can be seen that the augen gneisses are themselves brecciated and mylonitizated. It is thus clear that at least the last movements came after the «mise en place» of the gneisses. This point will be dicussed further below.

The gneisses of Vegarshei.

As regards the general shape of the body, the important point to notice is a striking difference between the southern and northern boundaries.

The southern boundary, which runs from Hovdefjell to Vegarshei sta-

tion, is very sharp. The contact with the metatexites is emphasized by a topographical depression which has been used for the railway line, so that it can be followed meter after meter for a distance of ten kilometers (Fig. 3).

Traces of movements are noticeable along the plane of contact and the question is whether this contact is only tectonic or whether it has a more petrographical origin. This problem is difficult to answer, but two arguments support the petrographical view.

1) The body of augen gneisses ends near Vegarshei station. In the direction of the contact, no traces of deformation are noticeable among the migmatites. Moreover, fine exposures in the station enable the contact between the augen gneisses and the migmatites to be studied accurately. The transition is sharp, but progressive.. Patches of augen gneisses appear in the metatexites, giving the impression of scattered wisps apparently bearing no relation to one another. The rocks are but little deformed, and no signs of tectonic movements are visible.

2) In the region of Hovdefjell the metatexites surround the body of augen gneisses. The contact here is particularly sharp and the surface of the contact becomes more and more curved. The structure of the migmatites remains parallel to the contact and goes around the augen gneisses. These features are very similar to those of some diapyric granites.

The northern contact is very different from the southern one. The transition is very progressive, occuring in a broad zone which always exceeds several hundred meters. Different processes can be observed:

– The total amount of feldspar porphyroblasts decreases regularly within a single horizon. The gneissic structure often disappears at the same time (Fig. 4).

– Some other beds retain a typical augen gneissic appearence, but are surrounded by considerable thicknesses containing no feldspars porphyroblasts. The thickness of these beds gradually decreases, but the features of the augen gneisses are still noticeable when they are a few centimeters thick. This kind of augen gneiss is common in the whole Sørlandet and in the region of Randesund we visited an exposure kindly indicated by Dietrich which was absolutely similar to those of Vegarshei.

To sum up, the limits of the body of augen gneisses seem to present intermediate features between those of common migmatite formation and those of typical granites.

Fig. 4: The «progressive limit» of the body of augen gneisses.
An example.

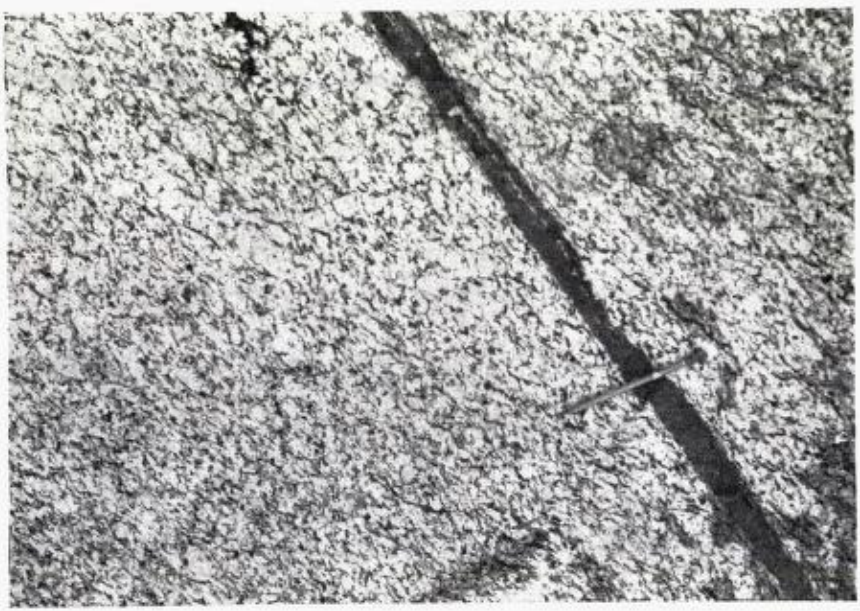


Fig. 5: Amphibolitic xenolith in the augen gneisses (Gjerstad).

The gneisses of Gjerstad

The features of the body are very similar to those of the Vegarshei gneisses. There is again a sharp southern limit and a much more gradual northern one. The sharp limit occurs very close to the big breccia but is usually separated by a thin layer of metatexites, as can nicely be seen near lake 207, between Mo and Gjerstad. As has been mentioned, the gneisses are themselves brecciated where in contact with the breccia.

Petrographical study of the gneisses.

Only a few details about the augen gneisses will be given here, as a more important paper will be devoted to this question. Generally speakking, three different types can be distinguished.

– Two types can be called «normal», as they belong to the same mineral facies as the metatexites. They appear in the two bodies of Vegarshei and Gjerstad, and are very similar in both districts: Considering a hand specimen, it is impossible to say wether it comes from one region or from the other.

– A third type appears chiefly southwest of the Vegarshei body, in the region of Hovdefjell. It shows similarities with rocks belonging to the granulite facies, which are well known in the south of Norway and are numerous in the region of Arendal. It will be termed the «charnockitic augen gneisses».

Normal gneisses.

These gneisses make a continuous series between two types, one acid and the other basic.

The acid variety (Type I) contains big porphyroblasts of microcline, small crystals of plagioclase and one dark mineral: biotite. Quartz is abundant. Few accessory minerals, except some ore minerals and apatite.

The basic variety (Type II) contains porphyroblasts of microline, but it also contains porphyroblasts of plagioclase. The dark minerals are not only biotite, but also amphiboles in larger quantities. Accessory minerals are more abundant: sphene, apatite, epidote, allanite, ore minerals. Quartz, if present, is obviously secondary.

Fig. 6: Skialith (near Öygardslia).

Fig. 7: Quartzitic xenoliths in normal augen gneisses near Barlindfjell.

Both varieties hold xenoliths, consisting solely of quartzites and amphibolites similar to those belonging to the old group (Fig. 5, 7). Numerous amphibolitic xenoliths more or less «digested» (skialiths) are also found (Fig. 6). Quartzites are mostly found in places where gneisses of type I are particularly abundant. As appears on the map, these places correspond to the prolongation of one of the quartzitic belts we have already mentioned in this paper. In the same way, basic gneisses of type II are very typical in the prolongation of the amphibolitic belt.

Though the petrographical composition suggest similarities with the rocks of the old group, it is impossible to find any continuous boundary between the gneisses of type I and those of type II, as between the quartzites and the amphibolites of the old group. It seems that, during the feldspathisation processes, the old structure were completely deformed. This important point will also be the subject of a later paper.

Charnockitic gneisses.

These curious rocks appear mainly in the region of Hovdefjell. In addition, a rather important band, separate from the body of Vegarshei, is found south of the Vegarshei gneisses, in the region of Ubergsmoen.

The rocks look very dark, nearly black. The colour however is not due to any dark minerals, but to feldspars, which have a typical «malgachitic» coloration. Under the microscope, are found porphyroblasts of feldspar, which can be plagioclase (An 35) or microcline, but also typical Carlsbad twinned orthoclase. Dark minerals are present: biotite, amphibole, but also monoclinic and orthorhombic pyroxenes and garnets. Biotite is very often associated with hypersthene and garnets.

From their appearence and mineral composition, these rocks definitely belong to the granulite facies.

It is not possible to distinguish in these gneisses different varieties similar to the types I and II. But many xenoliths can be found which can be paralled with the amphibolitic and quartzitic xenoliths in the normal gneisses.

Thus it is thought that the charnockitic gneisses are not genetically different from the normal gneisses: they are similar rocks which have undergone different conditions of metamorphism. These rocks must be compared to the «arendalites», for which Bugge reached similar conclusions.

Structure of the gneisses

All the gneisses, the normal ones as well as the charnockitic ones, are highly deformed rocks. The typical structure is that of a «harnischmylonite», with veinlets of recristallized quartz around the feldspar porphyroblasts. Many features, e.g., curved twinning planes of the feldspars, undulatory extinction of quartz or even feldspars, prove that the rocks have suffered postcrystalline deformation. In some cases however, microcline porphyroblasts seem to be much less deformed than the rest of the rock: so the growth of the feldspars was a true recristallisation after a first period of deformation.

Thus the augen gneisses at least seem to have gone through several stages of deformation, the last period being that of the «great breccia». But as Wegmann (in Geology of Norway, 1960, p. 6), for instance, has pointed out, the movements of the great breccia are but the last episodes of a much older tectonic activity.

Conclusion

The different observations that have been presented concerning the augen gneisses are not conclusive. However, certain points can be made:

The general direction of the gneissic bodies are more or less parallel to the structure of the rocks belonging to the old group. Thus if one considers the gneisses as a simple recristallisation of a potassium rich unit of the paleosome, tuffs for instance, it must be admitted that there is a lateral variation of facies. On the other hand, this lateral change does not agree very well with the similarities found between the gneisses and the surrounding rocks; specially noteworthy is the fact that the gneisses hold many quartzitic xenoliths in the prolongation of the belts where quartzites are particularly abundant and many amphibolitic xenoliths in the prolongation of the amphibolites.

So, from some field observations only, it seems that the most logical interpretation of the genesis of the augen gneisses is to admint a local introduction of potassium during the second phase of metamorphism. This hypothesis will be further developed in a later paper.

The granites.

North of the breccia occur different granites, which cut all the other formations, even those belonging to the younger complex.

A) Telemark granite:

The whole northern part of the area investigated is covered by a granite which certainly belongs to the «Telemark granite». This rock is a very typical potassic granite, holding plagioclase (An 20), much microcline, and a little biotite as the only dark mineral. The main granitic body occurs far from the augen gneisses, but several dykes of a very similar rock, large enough to be plotted on the map, occur near Gjerstad in the augen gneisses. This granite very clearly cuts the foliaion of the «augen gneisses», thus coming after the «mise en place» of the gneisses.

B) Oritentated granite:

Another type of granitic rock occurs very close to the breccia, near the northern bank of lake Vegår.

It appears on the map as several circular bodies, one of them being specially important. This regular shape is visible on the aerial photographs and clearly suggest a «diapyric» »mode of occurence. But, contrasting with many diapyric granites described by Wegmann, the «granites» and the surrounding migmatites are *concordant*. Near the contacts of a body, the «granite» thus shows a strong foliation, which is absolutely parallel to that of the migmatites. The orientation of this plane changes regularly and follows the circular outline of the contact. The foliation progressively disappears and the rock becomes more ad more massive near the middle of the body. At the same times the mineralogical composition varies: dioritic on the border (only amphiboles, a few micas, and relatively calcic plagioclases (An 35–40 %), it holds microcline and becomes more and more potassic near the middle. These interesting granite bodies, very similar to Eskola's «mantled domes», have not yet been completely investigated but it could be seen that they look like a text book example of Raguin's «granites tardimigmatiques».

The pegmatites.

Only a few words will be said concerning the pegmatites, which constitute a problem in themselves. They occur in every kind of rock, whether it belongs to the old group or to the younger complex. Statistically the largest occurences are found in amphibolites, which is the general rule in the south of Norway. In the augen gneisses, many examples are met with of a fact mentioned by Barth, which can have a major genetical importance: the complete similarity and the progressive passage between the augen and certain dykes of pegmatite.

The «great breccia» and the mylonites.

It is clear from our description of the augen gneisses that the great breccia was the last episode of a tectonic activity in the region of Vegarshei-Gjerstad. Typical breccia is rare, but does occur in the district between Mo and Gjerstad. The cement of the breccia is allways very pure quartz. The rocks brecciated and mylonitisated belong to all the formations of the region: amphibolites and quartzites, metatexites, even augen gneisses at the end of the body of Gjerstad. The rocks are often so crushed and transformed that it is hardly possible to recognize the original facies, bue generally speaking, it seem that the major change has been a general quartzification of the rocks. Dykes of hydrothermal quartz, which must not be confused with sedimentary quartzites, are abundant in and near the breccia. All the mylonites hold much quartz and there can even be seen, in the region of Brattlan, «quartzified» quartzites, with drops and veinlets of secondary quartz in a matrix of quartz.

The outcrop of the «great breccia» is easily recognizable by the abundant occurence of mylonites. But the mylonites are not restricted to this zone and many thin horizons, generally parallel to the direction of the breccia, occur all over the district.

The diabase dykes

Mention will be made of only two dykes of diabase occuring north of the breccia, in the gneisses of Gjerstad. The two dykes are very straight, 500 meters long, 20 to 50 centimeters thick, and they occur very close each other. However while one is massiv, the other exhibits a strong orbicular texture. The rock is a typical diabase, holding many thin crystals of pyroxene in a vitreous matrix. No sign of the slightest metamorphism is noticeable. Rocks of this type are common along the coast of Sørlandet but are rarely found so far inland.

Epilogue.

This very brief description clearly establishes that much more work is necessary to give a satisfactory answer to many problems Nevertheless, the district of Vegarshei-Gjerstad, seems to be a particularly convenient place to study the sequence of migmatitic metamorphism and to elucidate the condition of formation of the augen gneisses which, by their intermediate characteristics, are very important links of this sequence.

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