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Contributions to the knowledge of metamorphic rocks of Sopron Hills (Western Hungary)

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With 1 figure

Schlüsselwörter
Western Hungary
Sopron Hills
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Summary

Between 1969—72, a detailed geological mapping and a material testing of crystalline schists of Sopron Hills were carried out. This work yielded significant new results in the field of more profound knowledge of these rocks and by this means some important conclusions connected with their origin have also been drawn. Since the rocks here are considered as belonging to the "grobgneiss" formation group of the Eastern Alps, these conclusions can reckon on a wider interest than ours. The paper deals mainly with the derivation problems of mica schists and rocks formed by horizontal movements / leucophyllites and kyanite quartzites /.

Introduction

On the area of Hungary the crystalline schists of the Sopron Hills rise from the young basin sediments in their surroundings as one larger island and as several smaller ones. A part of the largest block spreads over Austrian area, too. In all probability these rocks can be considered as belonging to the "grobgneiss" formation group of the Eastern Alps and at the same time they could be the easternmost superficial occurrences of this formation group.

The geological and petrographical relations of the Semmering-Wechsel window / in Eastern Austria / which the "grobgneiss" formation group also belongs to, haven been summarized by H. WIESENEDER / 1968, 1971 / in recent times. It is M. VENDEL / 1929, 1933, 1964, 1972, 1973 / who has dealt with the metamorphic rocks / especially leucophyllite and kyanite quartzite / of Sopron Hills for a long time. Lately a detailed geological mapping was done that area under the direction of M. VENDEL and on commission of the Hungarian State Geological Institute. The mapping and the testing of materials have been executed by the author and his colleague I. BOLDIZSÁR. Here I wish to give account of some of the most important results and conclusions of this work, hoping, perhaps, to be able to reckon on a wider interest than ours.

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Geological and petrographical relations

As regards their original rock materials and metamorphic events, the „grobgneiss" formation group is rather heterogeneous and what is more we can reckon with a significant difference in its age, too. Quite certainly the rocks of the mica schist formation, considered as geosynclinal sediments in their origin, are the most ancient and they include also kyanite quartzites of, perhaps, tectonic origin / old tectonites /. The orthogneisses which could originally intrude as masses of granite into the rocks of the mica schist formation which have been metamorphosed earlier, are younger in age. Sometimes well observable, thinner or thicker gneiss beds of injection type appear inside the mica schists, next to the large gneiss bodies, settling mainly along the planes of the schistosity. At last the youngest rocks still of metamorphic origin were formed tectonically along the zones of the most intensive horizontal movements nearer to the surface, mainly by the transformation of the material of gneisses and mica schists having existed earlier. They are called leucophyllites / young tectonites /. The regional extent of these rocks is sketched out in Figure 1.

1. Mica schists

They are the most wide-spread and most variegated representatives of the "grobgneiss" formation group. Their contact with the underlying orthogneisses is most frequently a tectonic one. The original rock materials can be supposed to have been monotonous enough: clay, silt, sand and rarely a little coarser sediments. Practically they must have originated exclusively from the erosion of silicate rocks and later they could not get contaminated by any other / e. g. carbonate / materials either. Apart from scattered traces they proved free from carbonaceous matter, too.

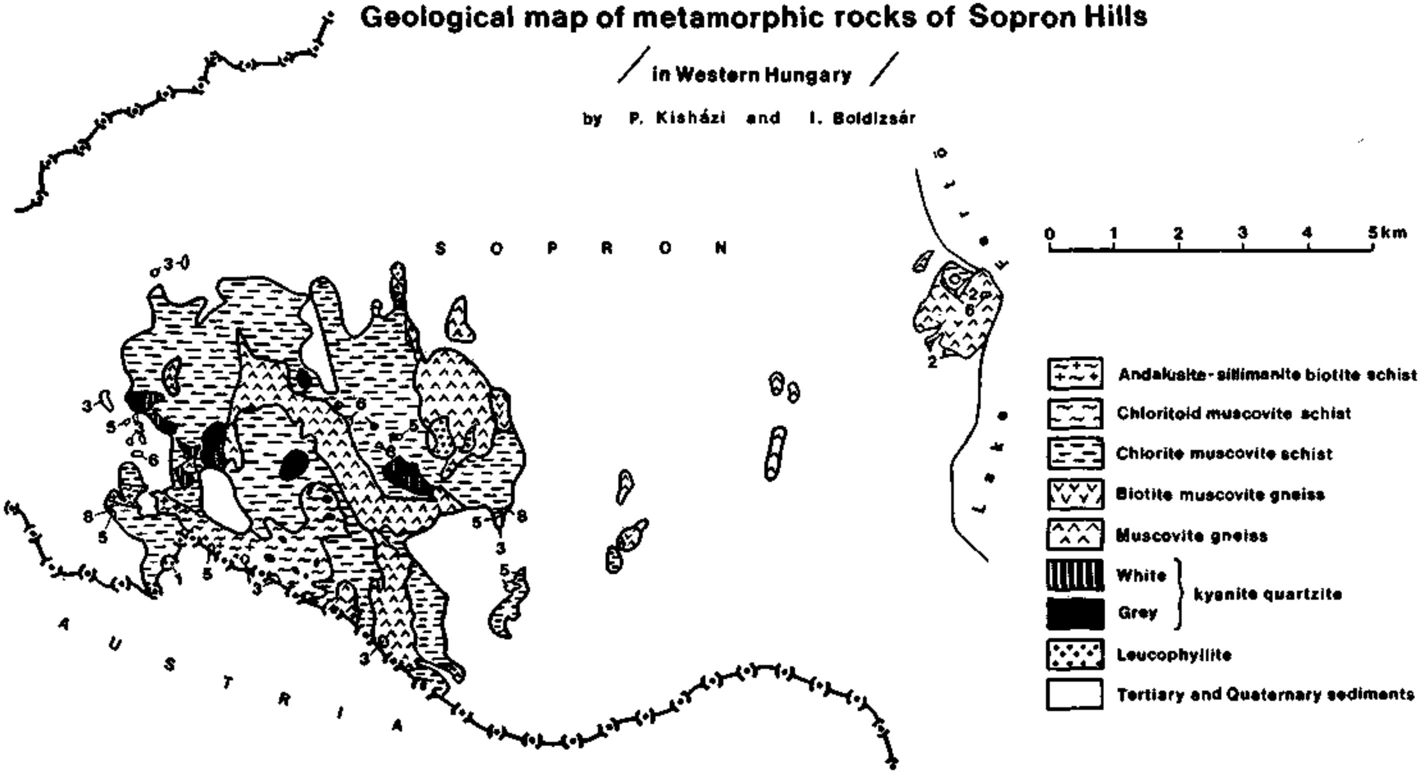
In their present state the mica schists reveal rather different metamorphic grades and on this basis we managed to distinguish four varieties among them.

It is the andalusite-sillimanite-biotite schists that were metamorphosed in the highest grade. Their most characteristic sorts of pelitic origin are dark-coloured with lighter stripes. They are foliated distinctly but not too well. They are tough and break off in lumps rather than schistose. Their psammitic sorts, of course, are lightercoloured but they, too, contain darker stripes or spots. Their original metamorphic grain size is mostly well developed and the smaller grains nearly always appear as inclusions or else they may be the products of an incipient retrogressive transformation. Their main mineralogical components are the often poikiloblastic andalusite, the sillimanite always forming a fibrous network and the brown biotite consisting of generally well developed scales. Other minerals of importance are quartz, feldpars / orthoclase and oligoclase / and muscovite / both coarse-scaly and tiny-scaly of retrogressive metamorphic origin /. Their rare components are opaque ore grains, garnet, tourmaline, zircon / or monazite /, tiny acicular kyanite / a transformation product in andalusite /, staurolite / a relic /.

Geological map of metamorphic rocks of Sopron Hills

/ in Western Hungary /

by P. Kisházi and I. Boldizsár



A close connection seems to be between the former rocks and the kyanite-chloritoid-muscovite/sericite/schists both in field and petrographically. Megascopically they are also often similar to each other, although the structure of the latter ones is already slightly more foliated. These are lacking in andalusite and sillimanite and initially their places were occupied by tiny kyanite and sericite aggregates. Later chloritoid aggregates of appearance similar to those of kyanite present themselves at the expense of those. The quantity of biotites decreases a little, that of the feldspars does so even more. All these increase the part of sericite. Coloured chlorite does not yet generally appear and the colourless one / leuchtenbergite / tends to appear only in the rocks of tectonic origin / see later /.

By the further decrease, then by the disappearance of kyanite we get the next member, which can be named chloritoid-muscovite/sericite/schists. When observed microscopically the simultaneous transformation of kyanite and biotite seems to have conduced to the formation of chloritoid. The other main transformation product is sericite. Larger and smaller, contiguous sericite fields, in their middle with loose aggregates of tiny chloritoid laths being so characteristic in thin sections, could form in this manner. The quantities of biotites and feldspars keep on decreasing. In turn the part of quartz increases rather than decreases in the course of the changes. The significance of the garnets also seems to augment in comparison with the former rock types. Coloured chlorite does not normally appear. We can find these fairly wide-spread on the surface and although they can be variegated enough, in their typical appearance they still look like biotite schists. Their structure is frequently not very well foliated and they break off in lumps.

The most intensively reformed / diaphthoresed / rocks are characterized by chloritization in addition to the well foliated structure and lepidoblastic texture. The chlorite is usually penninite, more rarely clinochlore. The other most characteristic mineral is muscovite / sericite /. Thus this member can be designated as chlorite-muscovite/sericite/schists. The part of quartz is generally significant, while that of the feldpars is not, except, of course, in the injection zones. Here garnet / almadine / reaches its most frequent occurrence. The biotites are not rare here either, although they are often about to change to chlorites and are more frequently green than brown. In one or another bed of these rocks chloritoid can be found, too. The rare minerals are as follows: ilmenite, goethite, pirite, rutile, sphene, zircon, monazite, tourmaline, apatite. This type is the widest-spread of mica schists and they are called „phyllitic mica schists", too, because of their considerable phyllonitization.

2. Orthogneisses

The gneisses of the Sopron Hills are comparatively not very variegated. As for their grain size they are not typical "grobgneisses". They are mostly medium- or fine-grained rocks. Their schistosity varies from mass structure to a strongly foliated one. The former type shows a metagranitic appearance and the rock is a muscovite-biotite gneiss, while that of the latter type is a muscovite gneiss.

Their main minerals are quartz and feldspars / microcline and albite /. Not only the original plagioclases could become albite, but newly formed albites also came into existence. There occur aplite-like gneisses in which the only feldspar is albite. The sericitization of feldspars is a common phenomenon. Among the micas the quantity of muscovite / sericite / increases, while that of biotite decreases with growing foliation. The change of biotite to chlorite cannot be observed at all. Accessory minerals: garnet, epidote, clinozoisite, sphene, rutile, apatite and ilmenite.

The mineralogical composition of the gneiss injections is the same as that of orthogneisses occurring in the large bodies and two types are easily distinguishable: one of them is coarse-grained / pegmatitic / and the other is fine-grained / aplitic). Apart from the injections other contact phenomena cannot be recognized thinking about the overlying schists having been metamorphosed earlier.

3. Tectonites

In the history of the development of the metamorphic schists the tectonic movements had to play an important part. Especially the horizontal movements can be considered as of great importance in bringing about the dislocation metamorphic effects of different intensity. These effects have shown themselves in extensive phyllonitization. Along the zones of the most intensive movements — supposing migrant solutions — rocks of new type have come into being that are named tectonites.

It is M. Vendel who has conducted the detailed study of leucophyllites as rocks formed by horizontal movements. Normally they are snow-white in colour. They could be derived from any sort of the rocks mentioned, but we can most frequently find them in the contact zones between mica schists and orthogneisses. Leucophyllites have three main mineralogical components: quartz, muscovite / sericite / and leuchtenbergite. The latter may be lacking, especially in the transitional zones towards the gneisses. The leuchtenbergite of leucophyllites coming from mica schists is not quite colourless. Apatite, rutile, ilmenite and a phlogopite-like mica are the accessory minerals. The problem of the magnesium metasomatism connected with the origin of leuchtenbergites will be discussed later.

There is another special rock type on the area. It is the kyanite-leuchtenbergite-quartzite that joins the mica schists in form of larger and smaller lenses or bed remains. Besides the three components mentioned it can also contain more and less of muscovite / sericite /. The types poorer or richer in muscovite were called "white" or "grey" quartzites respectively. In the latter type sometimes certain minerals bearing rare elements / as fore example florencite and monazite / as well as lazulite enter bedside kyanite and leuchtenbergite. Tourmaline, apatite, rutile and tiny ore grains are scarcely noticeable.

The derivation of these rocks gives rise to some controversies. H. Wieseneder supposes quartz sands, rich in high aluminous minerals like kaolinite as source materials. M. Vendel also accepts this, adding that the source materials also had to contain montmorillonite or chlorite in addition to kaolinite, or else a subsequent magnesium metasomatism had to take place accounting for the considerable magnesium content. In my opinion a possibility for their tectonic origin must be considered, too. Their certain similarity to the leucophyllites, first of all in the leuchtenbergite content, can indicate this. So the matter in question is that the leucophyllites and the kyanite quartzites might be the products of horizontal tectonic movements in the same way but under different conditions: the former would have been connected with younger movements, nearer to the surface, and the latter with older movements that took place deeper under the surface.

Notes on genesis

As mentioned above, the grade of crystallinity of the mica schists varies from the epimetamorphic members to the mesometamorphic ones. As explanation three possibilities emerge: 1. the whole formation is not the same from the beginning; 2. the whole formation is the same, but later inequal contact metamorphism affected it; 3. the whole formation is the same, but later inequal regional or dislocation metamorphic effects happened on its different parts. In my opinion the third possibility seems to be the most probable one and the earlier, in greater depth more strongly metamorphosed rocks could be exposed to retrogressive metamorphic effects of locally different intensity in the course of their gradually arriving at the surface. On the other hand the phyllitic mica schists of the Eastern Alps are considered as diaphthoresed products by Austrian geologists, too.

The uniformity of the mica schist formation can be indicated by the petrographical building up of the same type / e. g. the lack of carbonates and carbonaceous matter / and the gradual transitions among the rock varieties mentioned. While stressing the original uniformity of the mica schist formation, we cannot exclude the possibility that parts, originally not belonging together, could get near each other in the present positions as a consequence of inequal movements.

The andalusite-sillimanite-biotite schist could represent the mica schist of the highest metamorphic grade which has practically remained in its original state. This rock of amphibolite facies could form next to the migmatite zone. It can be put between the facies series of Abukuma- and Barrow-type, nearer to the former / perhaps of Eastern Pyrenees-type; see H. G. F. Winkler, 1965 /. Consequently the progressive metamorphism could take place under relatively undisturbed conditions. At the beginning of the horizontal tectonism the stress must have increased and the metamorphism must have changed into Barrow-type. The first products of this change are the kyanite-chloritoid-muscovite / sericite / schists. Although such a change is not a typically retrogressive phenomenon, for the sake of the uniformity of the subsequent changes the retrogressive metamorphic effects might be dated from this period, so much the more because it is a case of metamorphism decreasing gradually / at least regarding the temperature conditions /. Accordingly the retrogressive metamorphism might already start in the amphibolite facies, but the greater part of the changes has happened in the greenschist facies.

An important negative side of the first phase of the changes is the lack of coloured chlorites. Obviously the conditions were not yet suitable for their formation. The Fe and Ti released from the change of biotites have remained for the most part in place in the form of tiny mineral grains. A major share of the released Mg has been consumed by the chloritoid formation, but its smaller part could migrate to cause metasomatism elsewhere. Nearer to the surface coloured chlorites could also appear and from this stage onwards a direct change of biotites to chlorites can be clearly observed.

The problem of the colourless chlorites / leuchtenbergites / is worth particular attention. M. VENDEL has dealt especially with the study of these and he stated that their character / e. g. birefringence / varies a little according to the rock-types genetically related to them. Practically the colourless varieties of clinochlore and sheridanite can be included in them. As is know, the formation of these chlorites, poor in iron and rich in aluminium as well as in magnesium, can take place under the conditions of higher temperature and pressure than the formation of the coloured chlorites, that is the first phase of the changes mentioned before could be already suitable for them. But one more of the essential conditions seems necessary to their formation: an environment relatively poor in iron. This can be the explanation why they are of more general prevalence. At the same time it is striking that the chlorite of leucophyllite derived from mica schists is not fully colourless clinochlore.

The zone of the most intensive horizontal movements, in addition to the strongest phyllonitization, is characterized by powerful migrations of elements. Among them the most significant ones are becoming poor in iron and growing rich in magnesium. Also the alkalis emigrate, especially sodium that could go away already under conditions of the formation of leucophyllites, while potassium, either in part or as a whole, could depart only under the circumstances of the formation of kyanite quartzites. Silicon and aluminium did not migrate and so they get relatively enriched.

The derivation of the magnesium content of leucophyllites and kyanite quartzites can cause certain problem especially in the case of leucophyllites coming from gneisses. M. VENDEL takes magnesium metasomatism into consideration and he supposes that the magnesium-bearing solutions could come from deeper horizons. The leuchtenbergite of kyanite quartzites could be considered as derived from original magnesium-bearing components, too. In my opinion there was magnesium metasomatism beyond all question and it seems as if the stress zones characterized by a high pressure could be favourable to the magnesium enrichment even in the absolute sense. But I think that this source supplying magnesium does not seem to be too distant. As mentioned above, coloured chlorite formation has not yet taken place in the first phase of the retrogressive metamorphism and a part of the magnesium released on the transformation of some biotites could not probably be consumed on the spot.

Some more words about the staurolite must be added. It can be scarcely found in the andalusite-sillimanite-biotite schichts and kyanite-chloritoid-muscovite /

sericite / schists. On microscopic examination this staurolite always looks simple, free from inclusions, lightcoloured. As to its derivation it seems likely that it formed in an earlier phase of the progressive metamorphism and a part of it has remained as a relic. The retrogressive metamorphic effects could keep on decreasing its quantity and some of it has changed to chloritoid. However, the greater part of chloritoids could not form in this way but by the simultaneous transformation of kyanite and biotite.

As to the history of the development of crystalline schists, in lack of reliable age data it is hard to say certain anything about it, therefore we present here only a hypothesis. The deposition of the original sediment materials of mica schists could take place rather early: we may reckon with an, at least Paleozoic but perhaps Precambrian, geosynclinal. The ancient era may be made likely by certain petrographical marks: almost entire exemption from carbonates and carbonaecous materials, moreover migmatization and polymetamorphic character. The progressive metamorphism of the sediments could take place during their gradual, long-continued sinking which could happen when arriving at the migmatic zone.

In the course of Variscan orogeny a slow elevation could start with movements of a subhorizontal path. This has brought about the beginning of the retrogressive metamorphic effects at the same time and has led to the formation of kyanite quartzites in the most intensive movement zones. The intrusion of granite could take place in a later phase of the same orogeny.

The Alpine orogeny must have sustained the moving of the rock body upwards — together with the granite masses — mostly along new paths as long as arriving at or near to the surface. In the course of these movements the rock body could cover a long horizontal distance and at the same time an overthrusting system could develop. The phyllonitization of mica schists has kept on and then the change of granites to gneiss has taken place. The formation of leucophyllites can be considered as having happened in an early phase of the same orogeny. Finally younger Alpine movements have brought about vertical movements and gravitation slidings down of the rock body already in the present place. These near the surface movements have caused an extensive breaking up, too.

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Anmerkung: Infolge eines technischen Versehens sind bei der Abbildung auf S. 37 die mit der Legende korrespondierenden Ziffern entfallen. Die Legende wäre, von oben nach unten, mit den Ziffern 1 (Andalusite-sillimanite biotite schist) bis 9 (Tertiary and Quaternary sediments) zu versehen!