Contribution to the Geology of the Area around Ober-Meisling (Krems Valley)

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With 3 figures and 2 tables

Abstract

Thirteen working days were spent in the field mapping on the scale of 1 : 10,000 and the collection of 55 rock samples from a 6.74 square kilometres of land around Ober-Meisling (Krems Valley) located on the Moldanubian Series at the southern part of the Bohemian Massive and just 18 kilometres north of Krems, Lower Austria.

The main rocks encountered here are the highly folded, garnet, biotite and sillimanite rich paragneisses which are invaded by irregularly outcropping bodies and intercalations of amphibolites, calc-silicate gneisses, marbles, dioritic intrusions, linear dykes of lamprophyre, migmatites, pegmatitic and aplictic gneisses.

The presence and the abundance of hornblende, plagioclase, garnet and sillimanite in these rocks are all pointers to the typical mode of occurrence of high grade zone of amphibolite facies.

Most of these rocks are folded on large scale but the pronounced structural feature is the marked NE-SW regional trend with dips generally towards the SE.

The age of these rocks is almost earliest Proterozoic and the origin is of metamorphosed geosynclinal basin of pelitic material with occasional limestone layers.

Emphasis has been placed on the descriptive petrography of the rocks of this area since this has been the primary aim for the mapping of this particular area.

Introduction

Purpose

The geological mapping around Ober-Meisling on the Krems, Lower Austria, was undertaken as part of an eight-month post graduate further training of geologists from developing countries in Vienna, Austria. In this particular training, the curriculum is designed to cover the study of petrology of metamorphic and intrusive rocks and related problems. The main aim of this training is for Austrian geologists to impact some of their knowledge and experience to their fellow scientists from these various countries by assisting them, not only to accurately map an area and collect

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field data, but also to help them in correct assessment and interpretation of the data so collected. Emphases are placed on laboratory work and exercises during which time, apart from the ordinary examination of rock in thin section with polarizing microscope, universal stage methods for detailed examinations of rock sections and petrofabric analytic methods are taught. The laboratory work is also supplemented by specialized lectures of such-like topics as rock-forming minerals, feldspar investigations, geochemistry, ore-microscopy. X-ray methods which are geared to assisting the participant in his training programm in Austria and the subsequent utilization of the knowledge so acquired in the participant's own work in his home country.

The present work is the final report of this eight-month course which has been prepared under the guidance of our Austrian colleagues. Even though the report on the whole concerns the geology of the Krems Valley area around Ober-Meisling, understandably, emphasis has been placed on the petrography of the rocks in this area inasmuch as the whole course has been directed to this end.

It is also hoped that this work will contribute to the geological knowledge of this part of the Bohemian Massive.

Locality

The village of Ober-Meisling, with an estimated population of 500 people, is situated directly on one of the numerous bends on the Krems stream and is located almost at the centre of the mapped area (see Fig. 1) which lies between 48° 27′ 18″ North latitude and 15° 26′ 30″ and 15° 28′ 18″ Eeast longitude. The mapped area is almost 6.74 square kilometres in area.

It is easily reached from Vienna by driving west to St. Pölten (63 km) then north to Krems-on-the Danube (28 km) and finally northwest to Ober-Meisling (18 km) through the villages of Senftenberg and Unter-Meislng.

The only settlement of any significance in the mapped area is the village of Hohenstein which is about 4 km southwest of Ober-Meisling.

Fieldwork

The geological mapping of this area was started on the 9th of October, 1969 after 2 days of introductory geological excursions in the area and its environs. The fieldwork was completed on the 23rd of October, 1969. Thirteen days were but spent in the actual field mapping and the collections of 55 rock samples (see Fig. 1).

The mapping of the area was based on the scale of 1 : 10,000 or 1 cm.: 100 metres. Rock exposures were excellent especially along road cuttings and stream valleys and good fresh rock samples could be easily collected.

Physical features

Most of the mapped area is pine-forested hilly country ranging in height from 350 to 567 metres (see Fig. 2). Prominent hills in the area include Hulm (519 metres high) Wachtberg (540 metres) and Steinberg (567 metres) (see Fig. 1). These hills are often covered with soil or weathered products of the rock and decayed vegetation and not much geology could be observed except in places which have been cut down to make way for farms.

The only stream of any significance is the Krems which enters the mapped area from the west through the village of Hohenstein, meanders eastwards through the villages of Ober-Meisling, bisecting the mapped area into almost two parts. In certain portions of its bank, it is often bounded by steep cliffs whilst in other places there are flat plains and terraces intensively cultivated for vegetables.

The valleys separating the hills are steep and sometimes contain some water. In these valley, deeply weathered rocks, mostly covered with vegetation are common and these rocks could easily be studied.

Previous work

Probably, many Austrian geologists might have worked in this area but it would suffice to mention that F. BECKE, F. REINBOLD and L. WALDMANN have done some geological work in this area.

Of late, A. MATURA has been mapping this area although his work is yet to be published.

Acknowledgements

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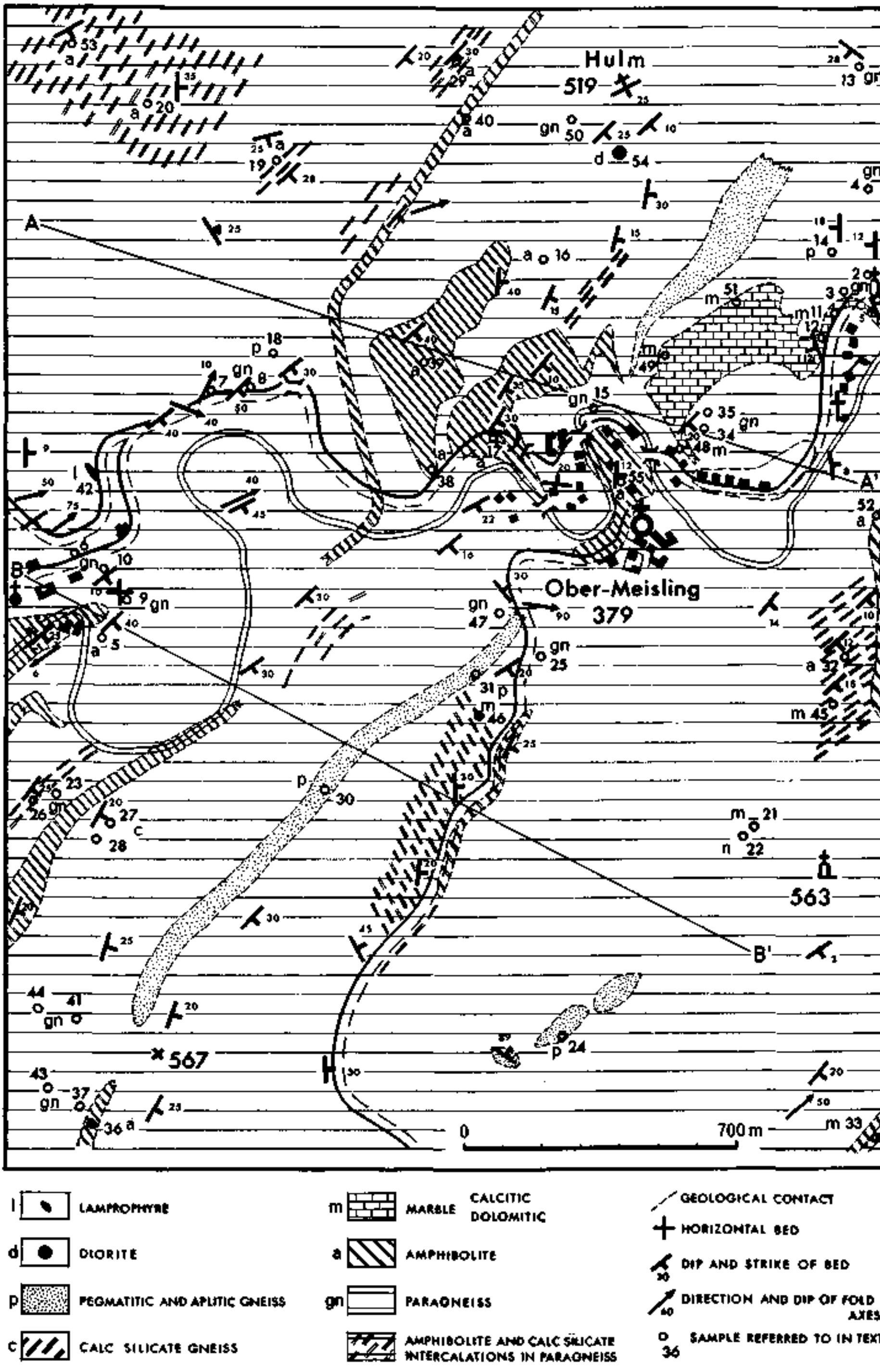

Fig. 1: Geological Map of the Area around Ober-Meisling.

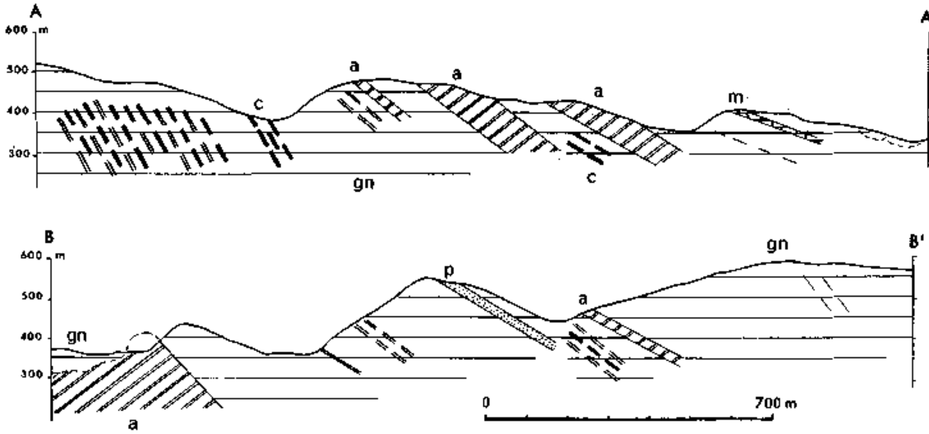

Fig. 2: Cross sections. Position see Fig. 1.

Geology and Petrography

General Geology

The rocks encountered in the mapped area are part of the variegated series of the Moldanubian Zone of the southeastern part of the Bohemian massive. The most prevalent rocks are the highly folded paragneisses which in turn are invaded by irregularly outcropping bodies and intercalations of amphibolites, calc-silicate gneisses, marbles, small dioritic intrusive bodies, lamprophyric dykes, migmatites, pegmatitic and aplitic gneisses.

The paragneisses are rather uniform in composition with the main constituents being quartz, oligoclase-andesine and biotite. In certain localities, garnet, sillimanite, alkali feldspar and cordierite are present.

Greyish to dark green amphibolites are rather widespread within these gneisses and are in intimate association with the gneisses. White or greyish marbles with varying amounts of impurities are also found. Sometimes, the silica minerals prevail and calc-silicate gneisses result.

A great deal of granitization or migmatization and general intrusion of granite rocks have taken place within the paragneisses. Dykes which are lamprophyric in character, as well as dioritic intrusives, do occur.

Quarternary deposits, consisting mainly of gravel, sand and alluvium derived from weathered rocks and deposition by the meandering Krems often cover the rocks. The most interesting deposit however is a thick deposit of loess found in the neighbourhood of Ober-Meisling (see Fig. 1).

The rocks have a general trend of northeast-southwest or northsouth strike with dips to the southeast and east. Most of the rocks are foliated with minerals like mica and sillimanite conspicuously oriented in planes and lines presumably as a result of directed pressure during metamorphism. Apart from the foliation which could be observed, these rocks are also prominently folded.

According to SVOBODA (in SVOBODA et al., 1966), the age of these rocks is generally regarded as a Pre-Cambrian, most probably, Early Proterozoic or Late Archean and were affected by intense pre-Palaezoic metamorphism. Numerous bodies of Variscian igneous rocks which later intruded these rocks resulted in the formation of migmatites and also of cordierite bearing gneisses.

A geological succession for the entire area is presented in Table 1, with the youngest rocks at the top of the table.

Table 1. Geological Succession.

Recent:	Superficial deposits i. e. gravel, sand, silt, clay and loess
Intrusives:	i. Lamprophyre
	ii. Diorite
Moldanubian Zone:	i. Pegmatitic and aplitic gneisses
	ii. Calc-silicate gneiss
	iii. Marble (a) Calcitic
	(b) Dolomitic
	iv. Amphibolite
	v. Paragneiss

Petrography

Paragneiss

About 80 per cent of the mapped area is underlain by highly folded paragneiss. These rocks actually form the bulk of the hills around Ober-Meisling and its environs, excellent exposures of which can easily be seen abounding the stream in the centre of this village and also at the northern side of the road cut located at about 2.3 kilometres west of Ober-Meisling on the Ober-Meisling-Hohenstein road.

These gneisses vary from the very fine-grained to medium-grained in texture. In colour, they vary from greyish-brown to dark brown. In some places, they are weakly, but at times, strongly migmatized. These gneisses commonly show strong compositional banding i. e. have a heterogenous structure with light layers (mainly composed of plagioclase feldspar) alternating with dark bands rich in biotite.

It is possible that most banding is inherited from original banding or bedding in the sediments and have been accentuated by subsequent metamorphism. The gneisses on Steinberg at the southwestern part of the mapped area; in certain places are characterized by excellent schistosity and those on Felling road are sandy. Some of them are still massive and structureless when there is not much mica in them.

The gneisses often contain bands of amphibolites, marbles, calc-silicate gneisses and quartzo-felspathic rich bands. The amphibolites, often are stretched but some display boudinage structures.

The s-surfaces of these gneisses are not planar but irregular. They are folded both on small and large scale, and have steep dips. In some areas, they are almost sub-horizontal and have varying attitudes even in the same general area.

The main rock types are the biotite, biotite-sillimanite, biotite-garnet gneisses. In the neighbourhood of Hulm, there are concentrations of poikiloblastic garnet in these rocks.

One outstanding characteristic of these gneisses is the monotonous sameness over large areas proving that, as a rule, metamorphic processes tend toward homogenization producing rocks more or less uniform both in structure and in composition.

A typical paragneiss is specimen M. 13 derived from a road-cut at the extreme northeast corner of the mapped area. This rock can conveniently be called a biotite garnet gneiss, for in hand specimen, this greyish black, fine-grained rock is foliated with quartzofeldspathic bands alternating with garnet crystals scattered throughout the rock.

Under the microscope, it is made up mainly of biotite, quartz, plagioclase, alkali feldspar, garnet sillimanite and opaques. These minerals are in mosaic arrangement with each other except the biotite and the sillimanite which are in some sort of alignment.

The biotite (25%) which is an iron-rich one occurs as roughly hexagonal plates showing strong basal cleavage. When fresh, it is light brown in colour with intense pleochroism. The flakes are in regular leaves and are oriented parallel to each other thus imparting and confirming the foliation as observed in these rocks. In certain parts of the section, biotite is seen to be readily altered into a light green chlorite, first, along the cleavage boundaries.

Quartz (23—25%) exhibits undulose extinction. It often builds irregular shaped grains sometimes interstitial to the feldspars but at times lobed into it in a manner suggesting replacement. Inclusions in the quartz are ubiquitous and are seen to consist of trains of minute bubbles.

The feldspars (35—40%) are of two kinds i. e. alkali feldspar and plagioclase. The alkali feldspar-microline (7%) does not display its characteristic twinning but like the plagioclase rather seem to have undergone an extensive alteration. The amount of plagioclase (35%) in these rocks greatly exceeds the amount of potassium feldspar, a common characteristic observed in these gneisses. Universal stage method reveals that the plagioclase has an anorthite content of 35% i. e. Andesine. Some of the large plagioclase fields have inclusions of biotite and other accessories such as zoisite.

The garnet (5%) of almandine variety, appears as spongy matrix anhedra haphazardly scattered throughout the rock. It is highly poikiloblastic and porphyroblastic with many inclusions of other minerals especially quartz.

Sillimanite (7%) is irregularly distributed as fibres in small bundels concentrated in discoidal felted masses and elongated in streaks usually intergrown with quartz or biotite. Some seem to bear no relation to the direction of schistosity and look like they have been formed late, replacing biotite. In certain parts of the section, sillimanite is in the process of being altered to sericite and present a „fluffy“ outlook.

Opaque minerals include magnetite and reddish brown rutile.

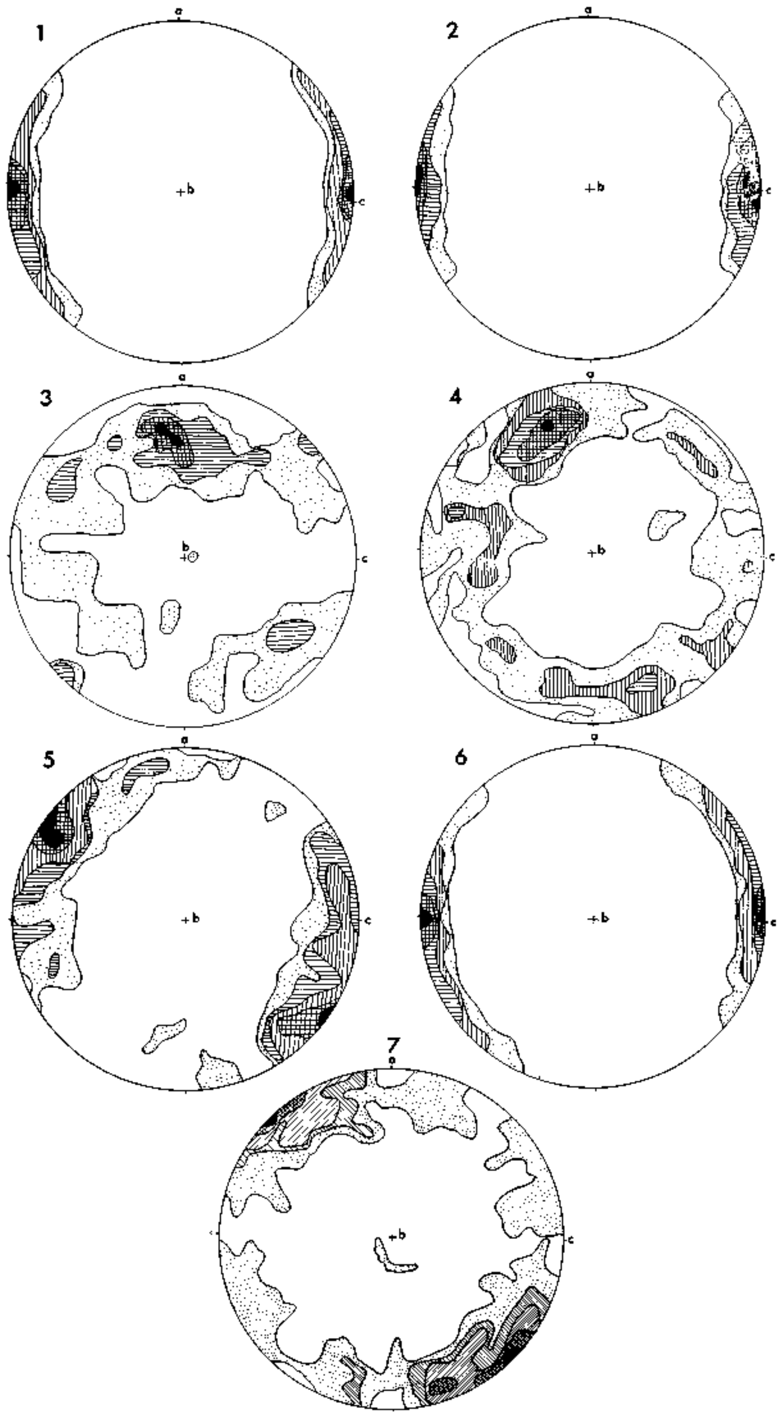

Fig. 3: Orientation diagrams. For descriptive legend see opposite page.

Specimen M. 41 also a sillimanite-biotite paragneiss taken from the southern part of Steinberg (see Fig. 1) is a fine-grained variety, greyish green in colour with sillimanite and biotite rich bands defining a foliation. The whole outcrop is intercalated with quartzofeldspathic rich bands.

The main minerals in these rocks are quartz (30%), biotite (25%), plagioclase (30%) with An 33 (i. e. andesine) alkali feldspar (6%), garnet (3%), sillimanite (5%), and accessory kyanite, rutile, zircon and graphite.

The interesting aspect of this rock is its high sillimanite content as compared with sample M. 13, and the abundance of myrmekite. The zircon present in biotite is surrounded by pleochroic "haloes" of extremely deep brown colour and intense pleochroism.

Descriptive legend for Fig. 3:

Diagram 1.

Sample M. 13. Paragneiss (Biotite Garnet Gneiss).
Orientation diagram for biotite: poles of (001) cleavage in 200 crystals.
Contours at 15%, 12%, 9%, 6%, 3% per 1% area.

Diagram 2.

Sample M. 43. Paragneiss (Garnet Cordierite Gneiss).
Orientation diagram for biotite: poles of (001) cleavage in 150 crystals.
Contours at 7.5%, 5%, 2.5%, 1% per 1% area.

Diagram 3.

Sample M. 1. Paragneiss (Biotite Gneiss).
Orientation diagram for quartz. Optic axes of 300 grains.
Contours at 4%, 3%, 2%, 1% per 1% area.

Diagram 4.

Sample M. 13. Paragneiss (Biotite Garnet Gneiss).
Orientation diagram for quartz. Optic axes of 250 grains.
Contours at 5%, 4%, 3%, 2%, 1% per 1% area.

Diagram 5.

Sample M. 43. Paragneiss (Garnet Cordierite Gneiss).
Orientation diagram for quartz: Optic axes of 200 grains.
Contours at 5%, 4%, 3%, 2%, 1% per 1% area.

Diagram 6.

Sample M. 46. Calc-Silicate Gneiss.
Orientation diagram for biotite: poles of (001) cleavage in 150 crystals.
Contours at 20%, 15%, 10%, 5%, 1% per 1% area.

Diagram 7.

Sample M. 46. Calc-Silicate Gneiss.
Orientation diagram for quartz. Optic axes of 200 grains.
Contours at 5%, 4%, 3%, 2%, 1% per 1% area.

Under the ore-microscope, traces of pyrite, often altered to limonite, could be observed. Ilmenite is a common occurrence is both twinned and involved in a "myrmekitic" intergrowth with garnet. Graphite occurs in laths and is also intimately associated with garnet. Magnetite is also present.

Specimen M. 43 is from th southwestern part of the field sheet. The rock is fine- to medium grained in texture, greyish brown in colour and contains transparent anhedral grains of cordierite showing alteration probably to muscovite. It occurs inconspicuously among the other constituents which, as usual, are quartz, alkali feldspar, plagioclase, biotite, garnet, sericite and accessory rutile, sphene and iron oxides.

Universal stage method used in the determination of the amount of Anorthite content in the plagioclase of some of these gneisses is set in Table 2.

Table 2. Anorthite content in paragneisses.

Sample No.	Anorthite content
1	33%
2	36%
13	33%
23	32%
35	35%
43	40%
	Average: Approximately 35% i. e. Andesine

The Table indicates that the characteristic plagioclase in these rocks is mainly andesine with an anorthite content of about 35% or An_{35}.

Orientation diagrams for biotite (0001)-poles in samples M. 13 and 43 (see Fig. 3/1 and 2) show that these poles form a well developed girdle of monoclinic symmetry with distinct singular maxima indicating the average position of the s-plane-pole. These diagrams proved that the micas are microfolded and confirms the well developed schistosity displayed by the biotite in these gneisses.

Orientation diagrams for quartz axes in samples M. 1, M. 13 and M. 43 (see Fig. 3/3, 4 and 5) show that the symmetry of the broadgirdle around B-axes is triclinic. There is a general under-population around B-axes co-ordinate in alle the samples, with the maxima near the A-axes. In sample M. 43 the under populated region in the B-axes is somewhat inclined to the AB plane.

In conclusion, it could be said that since these samples came from not too much distant areas, they have a tendency to develop the same mineralogical features with very minor local variations.

Amphibolites

These rocks occupy about 10 per cent of the mapped area outcropping mainly in the central and at the eastern parts of Hohenstein and in many other localities (see Fig. 1). These are greyish black, fine-grained rocks which represent the most frequent interlayers and are often in intimate association with the paragneisses. They form thin and up to several metres thick bodies in the gneisses and are often stretched or ruptured into pieces with respect to each other mainly by dilatation.

On top of Wachtberg, the amphibolites are fine-grained, greyish black rocks and finely lineated with the B_L 060/20. They also form boudinage structures within the paragneisses. Some of these rocks display a crude foliation but are mostly poorly foliated or hardly at all. They are peculiar rocks in that they sometimes carry biotite or at least altered product of biotite. In these biotite carrying rocks, the plagioclase content changes and although all these amphibolites are in intimate association two main types can be distinguished. These would be designated as (a) Amphibolite (in the true sense of the word) and (b) Biotite hornblende gneiss.

(a) Amphibolites

Specimen M. 39 taken from the centre of the mapped area (see Fig. 1) is a typical amphibolite. It is fine-grained, greyish green in colour, massive and structureless rock in hand specimen.

Under the microscope, however, it is seen to consist mainly of hornblende, diopside, plagioclase, chlorite, sphene, apatite, and opaques.

Hornblende (50%) is the greenish-brown variety, pleochroic from greenish to brownish green. Some of the grains are pseudomorphic after pyroxene but for the most part form characteristic prismatic grains with the grains interfering with each others.

Diopside (15%) is the commonest pyroxene. It is usually roughly equidimensional and may be subhedral to anhedral in form. Its association with the hornblende shows clearly that the hornblende follows the pyroxene or at least there is a replacement for one kind taking place, i. e. a clear case of uralitization in these rocks.

Plagioclase (20%) occupies large inter-spaces between the other minerals. It is mostly untwinned and forms even-grained mosaic pattern with other minerals. This particular specimen has a high anorthite content of 67% i. e. Labradorite but these amphibolites on the average contain about 45% Anorthite i. e. Andesine.

Chlorite (6%) probably as a retrograde product after biotite, occurs in erratically disposed flakes and is intergrown with the hornblende and/or pyroxene. Some of the chlorite could be determined as penninite.

Sphene (5%) in spindle and wedge-shaped forms is irregularly distributed in the specimen. Some of the large sphene crystals contain large inclusions of apatite, are pleochroic from brown to dark greenish brown and twinned.

Apatite (3%) is a abundant occurring as euhedral prismatic grains and also as six-sided prisms. It may be colourless but is often bluish and the crystals are often fractured across by a basal parting.

Under the ore-microscope, specimen M. 17, also a garnet amphibolite from the central part of the mapped area contains pyrite, magnetite, ilmenite, and limonite as products after pyrite.

(b) Hornblende gneiss

Specimen M. 5 taken from the southern part of Hohenstein is a typical example of these foliated amphibole-plagioclase rich rocks. It shows banding with alternating layers of hornblende (50%) and diopside (5%) versus plagioclase (35%) quartz (8—10%). The diopside is often concentrated in patches and streaks.

Summary: Near Hohenstein the amphibolites are folded (see Plate 6) with the fold axis measuring 06° towards the southwest.

The age relationship between the paragneisses and the amphibolites is not always clear in that they are in very intimate association.

Marble

X-ray analyses of the marble specimens collected during the field work showed that two main types of marbles occur in the area. The first type is mainly calcitic which is found outcropping at the northeastern part of Ober-Meisling and the second type (Specimen M. 33) is a dolomitic one found at the extreme southeastern corner of the mapped area. The marbles occur interbedded with the paragneisses and the amphibolites.

(a) Calcitic marbles

Specimens M. 11, 12, 48, 49 and 51 represent the calcitic marbles. Some of these marbles can be seen in a small quarry at the northern side of the road and about 100 metres from the cross at the extreme eastern part of the mapped area on Unter-Meisling—Ober-Meisling road. This outcrop is about 4 metres thick, has a strike of N 15° W and a dip of 12° towards the west. It is cut in places by thin bands of amphibolite and calc-silicate rocks. Ptygmatic veins of quartzofeldspathic material also cut the marble.

In hand specimen, the marble is massive, greyish white in colour but sometimes is cut by alternating light brown and reddish bands. The marble has a sugary or granular texture.

Under the microscope it consists mainly of mosaic pattern of calcite (90%) grains which are traversed by minute cracks appropriate to the rhombohedral cleavage of the calcite. In specimen M. 49 which appears slightly crushed, the grains show twin lamella.

Other mineral associated with the calcite are dolomite (2%), feldspar (2%), which is altered, quartz (2%), white or pale green diopside (3%), muscovite (1%) and scapolite. Accessory minerals include magnetite, sphene and iron-ores.

(b) Dolomitic marble

Specimen M. 33 consists predominantly of dolomite (90%) with minor amounts of calcite (2—3%) and other minerals such as quartz (3%). feldspar (2%), tremolite (1%), some few crystals of zoisite iron oxides opaque minerals. The dolomite crystals resemble the calcite crystals both in hand specimen and under the microscope.

Calc-silicate gneiss

These gneisses are not confined to one locality but are seen often as scattered boulders especially in the minor stream valleys and also as disjointed series of rocks both within the amphibolites and the paragneisses.

In general, these gneisses are commonly fine- to medium-grained, banded and vary from greyish green to deep green in colour. This banding is due to inhomogenous, anisotropic distribution of minerals but not to preferred orientation of these minerals.

Specimen M. 19 derived from the northwestern part of the map is a diopside-plagioclase rock with a granoblastic texture under the microscope, it is made up mainly of diopside, plagioclase, carbonate, quartz, chlorite, epidote which is altered to pistacite.

Diopside (30%) may be white or pale-green in colour and frequently contains rhombohedral crystals of sphene inclusions.

Plagioclase (35%) is often twinned and shows undulose extinction when not twinned. Some of the tabular prismatic crystals are partly corroded as a result of recrystallization of other minerals. Some of the untwinned crystals have been altered to sericite and kaolinite. Universal state method revealed that the plagioclase had an Anorthite content of 63% i. e. Labradorite.

The carbonate (10%) is twinned, rhombohedral in form and is often distorted or bent. This means that the rock has undergone some cataclastic effect.

Quartz (15%) forms large composite grains, has undulose extinction and carries some inclusions.

Most of the chlorite (8%), probably derived from biotite, is the penninite variety whilst the epidote group is represented by pistacite.

Accessory minerals include sphene, zircon, apatite, and poikiloblastic garnet. The ore-microscope shows abundant pyrite and limonitic alterations after pyrite. There are traces of chalcopyrite and ilmenite inclusions in the garnet.

Specimen M. 46 taken 2 kilometres in the valley just south of Ober-Meisling—Lechnerkreuz road contains quartz, biotite, plagioclase, garnet, alkali feldspar. The predominantly quartz grains are set in a mosaic of other minerals present.

Orientation diagrams for the biotite and quartz (see Fig. 3/6 and 7) reveal similar orientations for these two minerals as seen in the paragneisses (refer to Fig. 3/1—5). The only conclusion that can be drawn from these figures is that since all these rocks come from the same general area, there is little wonder that they have undergone similar metamorphic effects in their mineral orientations.

Pegmatitic and aplitic gneisses

Within the paragneisses and usually on top of some of the hills such as Steinberg, Buchberg and at the southeastern part of Hulm are found these fine- to medium-grained gneissic rocks which occur in two distinct forms. Firstly, as aplictic and migmatic quartzo-feldspathic rocks injected into the paragneisses as cross-cutting dikes, ptymatic or convoluted veins. Secondly, they occur as huge boulders with some measuring 2 or 3 metres in diameter on higher elevations but smaller boulders obviously derived from the huge ones, haphazardly scattered at lower elevations around and down-hill. Some of these boulders can conveniently be seen on the north-east trending trail from Lechnerkreuz near the top of Buchberg towards the cross at the eastern part of the area at an elevation of 563 metres.

Some of these rocks are gneissic in outlook but others are massive, coarse-grained, greyish white in colour, heterogenous and megascospically composite rocks, composed of magmatic portions as well as metamorphic parts. They usually consist of quartz, feldspar and few dark minerals, in which biotite predominates and seem to have preferred orientation. It is possible that these rocks intruded into the paragneisses absorbing some inclusions of the latter rock within them.

Within the paragneisses, these rocks are often folded into ptygmatic folds with strongly contorted structures and local enrichments often paralleling these s-planes of the paragneiss.

A typical aplictic gneiss is sample M. 14 taken from the northeastern part of Hulm.

In hand specimen, this rock is slightly foliated, light greyish yellow in colour, fine- grained with the mica grains defining the foliation.

Under the microscope, it is seen to be made up of mainly quartz, plagioclase, alkali-feldspar, muscovite, biotite and accessory garnet, apatite, zircon and epidote. Myrmekitic structures can also be observed. It has an allotriomorphic-granular texture.

Quartz (20%) some of which grow in the feldspar occurs as anhedral grains filling spaces between the feldspar and other minerals. It shows signs of recrystallization especially along adjacent grain boundaries.

Plagioclase (20%) occurs as both twinned and untwinned crystals with some appearing highly cloudy due to alteration to both sericite and kaolinite. Universal stage method proves 30% anorthite content for the plagioclase i. e. Oligoclase-Andesine. Alkali-feldspar (45%) mostly micro-cline is abundant. They occur as big individuals some of which are altered. There are also oriented inclusions in these feldspars.

The biotite (10%) is reddish-brown in colour and strongly pleochroic slightly aligned and defining some foliation. Some of the biotite have been altered to chlorite and penninite.

Muscovite (2%) occurs as an alteration product of potassium feldspar.

Apatite (1%) is seen as minute prismatic crystals.

Accessory minerals include zircon, poikiloblastic garnet and epidote which occurs as a vein mineral indicative of its late formation in this rock.

Sample M. 31 from the middle part of the mapped area has almost the same mineral composition as M. 14. The only difference between these two rocks is that M. 31 is massive, medium-grained, greyish green in colour with abundant myrmekite.

Diorite

This basic rock (sample M. 54) outcrops as an intrusive within the paragneiss at about 150 metres south of Hulm. It is but a small outcrop measuring only about one square metre in area and 0.6 of a metre high.

In hand specimen, it is a medium-grained, equiangular rock with greyish green colour.

Under the microscope, it has a hypidiomorphic texture and is seen to be made up mainly of hornblende, plagioclase, epidote, tremolite, apatite and accesory zoisite and pyrite.

Hornblende (45%) is the brown variety some of which have partly been altered to chlorite variety of penninite.

Plagioclase (45%) occurs as large individuals with some of the plagioclase twinned. Saussuritization in the plagioclase can be recognized by the greasy lustre, green colour, absence of cleavage and twinning in some of the plagioclase fields. Zoisite crystals are also seen embedded in the plagioclase. The plagioclase variety is oligoclase-andesine with an anorthite percentage of about 30% (An_{30}).

Apatite (5%) occurs as minute euhedral crystals of prismatic habit.

Alkali feldspar (3%), epidote and tremolite occur.

Under the ore-microscope, the rock is seen to be low in opaques. Only a few idiomorphic grains of altered pyrite can be observed.

Lamprophyre

Only one specimen (M. 42) of this rock-type is seen at the western part of the mapped area cutting the paragneiss as a narrow dyke, and measuring less than half a metre in width. It trends in a northwest-southeast-direction and has a steep dip to the northeast. In this area the paragneiss have been highly weathered, deformed and is sandy in places.

The dyke rock, in hand specimen, is a melanocratic, greyish green, fine-grained, massive and homogenous rock.

Under the microscope, it exhibits a panidiomorphic-granular (lam-(prophyric) tecture and consists mainly of subheral laths of plagioclase (50%), biotite (24%), anhedral quartz (10%), hornblende (15%), apatite with accessory iron ores and magnetite.

Examination under the ore-microscope reveals only tiny grains of pyrite with alterations to limonite and a few grains of magnetite.

Loess and other superficial deposits

A 7-metre thick deposit of loess is seen at the northern part of the road just at the eastern outskirts of Ober-Meisling. This material is soft, porous, pale yellow in colour with small capillary tubules. It is laminated in places and riddled with white calcitic material imparting to the outcrop an effervescene with dilute acid.

Examination with the handlens reveals that the minerals in the loess consist mainly of angular grains of quartz, mica flakes, calcite and minor felspathic grains.

It is most likely that this loess is of eolian origin.

The wide valleys near the Krems in particular, and the flat plains at the entrance to some of the valleys, are often covered by Recent or Tertiary deposits consisting in the main of quartz, gravel, brownish looking cobbles, soil and alluvium all mixed up together.

On top of the hills, superficial deposits of soil and alluvium usually serve as a mantle covering the rocks underneath.

Conclusions

The detailed study of these rocks, both in the field and under the microscope has shown that the main rock type in the mapped area is the paragneiss which is the oldest rock with intercalations of amphibolites, calc-silicate rocks, marbles, aplitic and pegmatitic rocks, cut in certain places by dioritic and lamprophyric dykes.

These rocks are hetrogenous, differing widely amongst themselves in composition, structure, texture and in distribution. They vary from the very fine-grained to medium-grained and pegmatite rocks.

They have a marked tendency to follow a northeast-southwest trend with dips generally towards the southeast.

Sometimes, contacts between the different rock types could be observed. At times, the contacts were so transitional and indefinite.

The paragneisses are more uniform in character and foliated types predominate over massive ones. The main constituents are quartz oligoclase-andesine, biotite. Garnet, sillimanite, alkali feldspar, cordierite may be found in the rocks.

Amphibolites are rather widespread within these rocks. Garnet, basic plagioclase and/or quartz have been seen in these rocks and presumably, the amphibolites were derived from sedimentary rocks or possible tuffaceous material. In some cases, these rocks are foliated and are then designated as hornblende gneisses.

Two types of marbles occur, i. e. calcitic and dolomitic. X-ray methods were used in separating these two groups. In these particular area, the calcitic marbles prevail over the dolomitic ones.

It seems likely that these rocks have resulted from a prolonged sedimentation in an unstable shallow geosyclinal basin.

The paragneisses then have developed as a result of regional metamorphism under increasing temperature and pressure during the Moldanubian Orogeny. It is likely that the sediments recrystallized according to the rules of several mineral facies, the complete sequence of events being a progressive change of the sediment by deformation, recrystallization and alteration through the greenschist facies — epidote-amphibolite facies and finally amphibolite facies. The limestone in the original sediments have now been turned to marble; the marls and clays to amphibolites. The calc-silicate rocks represent concretions enriched in carbonate. An intense metamorphism of the Moldanubian folding was accompanied by the penetration or mobilization of quartz feldspar solutions which gave rise to pegmatites, migmatites and aplitic dykes of metasomatic or anatectic origin. It is even possible that they formed synorogenically with the paragneisses.

The presence and abundance of green hornblende, plagioclase, garnet (almandine variety) and sillimanite in these rocks are all pointers to the typical mode of occurrence of the amphibolite facies which is in the high grade zone of progressive regional metamorphism. In these rocks derived from clastic sediments, almandine is widely distributed.

Epidote continues to remain stable through this facies however, not with albite but in paragneisses with oligoclase-andesine as the plagioclase in the paragneisses vary from about An_{30}—An_{40}. Saussuritization, chloritization and mylonitization could all be observed in these rocks.

A great deal of migmatization and intrusion of granite material has taken place in the rocks. The end of this period is marked by the intrusion of lamprophyric and dioritic dykes into the paragneisses.

Structure

A few words would be said about the geological structure of this area. The structure in the area has been dependent on the interaction of forces with operated during the Moldanubian metamorphics and its subsequent compressional effects on the paragneisses and its enclosing bodies of rocks. Due to these forces, the paragneisses and the amphibolites usually, in most places are extensively folded.

Although local variations exist, these rocks generally have a NE-SW or N-S regional trend with moderate dips towards the southeast or east. It is to be expected that these rocks have undergone, not one, but two or more periods of regional folding, which have resulted in the formation of anticlinal structures one of which could be observed in the locality just south of Hohenstein. This particular anticline has a fold axis in N 45° E direction and with a plunge of 6° towards the southwest.

The B_F or the direction and dip of fold axis in these rocks varies from 030/00 to 060/00 and two fold axes, at right angles to each other could also be observed.

The most complicated structure involved the relationship of the amphibolites and the paragneisses in the central part of the mapped area for these two rock types are in such an intimate relation that it was not easy to decipher the geology within the limited time on hand.

No major fault was observed but the possibility that some discordant faults are cutting these rocks cannot be ruled out in that mylonitized and slickensided rocks which are indicative of mobilized zones near these faults occur. The abrupt changes in dip and strike of the rocks at the northeast part of the mapped area, the elongated and streched habit of the quartz in the rocks taken from this area e. g. in samples M. 1, M. 2 and M. 3 were all indicative of a possible faulting in this area.

Jointing in the rocks is common. Whilst some joints are perpendicular to the foliation planes (i. e. cross joints) others are sub-parallel to the s-planes with the production of sheeting structure in the rocks.

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