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Crystalline Complexes in the Southern Parts of the Bohemian Massif and in the Eastern Alps

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(First day)

The Bohemian Massif in Austria
The Moldanubian Zone

By H. G. Scharbert

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Introduction

The Bohemian Massif is a deeply eroded cratogenic block having received its last tectonic coining during the Variscian orogeny. M. Máška (in V. Zoubek ed., 1960) subdivided the Bohemian Massif into the following two main-units: 1. the Variscian intramontane stable block and 2. the area of the intensive Variscian tectogenesis. The first unit forms the central and the southern part of the Bohemian Massif and may further be subdivided into the "Region of Moldanubic elevation" (referred to as "Moldanubian Zone" in the following) and into the "Region of Teplá Barrandien". The second main-unit consists of three sub-units: a) the Krušné Hory-Thueringen Region, b) the Železné Hory-West Sudetes Region and c) the zone of the Moravicum-Silesicum which reaches Austrian territory as the "Moravian Zone" along the eastern termination of the Bohemian Massif. The area of the intensive Variscian tectogenesis encircles the Variscian intramontane stable block in the West, North, East and Southeast.

During the first part of this excursion we shall be able to study rocks of the Moldanubian Zone which is the only sub-unit of the Variscian intramontane stable block being found on Austrian territory. The main-part of the Moldanubian Zone is situated north of the Danube River.

Recent publications suggest that a great deal of the Moldanubian Zone is older than Variscian and that only parts of this older orogenic belt were incorporated into Variscian tectogenesis. Generally, the Moldanubian Zone consists of a pre-Assyntian unit with high-grade metamorphism, migmatization and intrusion of ultrabasic and basic magmas and of a Variscian migmatization, granitization and intrusions of granodiorite and granitic magmas. Little evidence has so far been put forward distunguishing these units on Austrian territory. It is suggested, however, that the pre-Assyntian unit may be represented in parts of the Lower Austrian Waldviertel, whereas the Variscian migmatization etc. is to be met with in the Upper Austrian Mühlviertel.

Accoring to M. Máška and V. Zoubek (in V. Zoubek ed., 1960) the stratigraphy of the Moldanubian Zone is most probably earliest Proterozoic.

If we disregard the possibility of the Variscian tectogenesis influencing the pre-Assyntian unit, we roughly can divide the latter into two metamorphic phases.

The rocks in granulite facies belong to the oldest recognizable metamorphic phase in the Lower Austrian Waldviertel. They always appear as separate bodies with their own particular tectonic style which is almost steadily and entirely preserved in the central parts of these bodies. The marginal sections recrystallized under the conditions of the almandine-amphibolite facies which is characteristic of the metamorphic rocks outside the granulite facies bodies. This observation indicatęs an older age for the rocks in the granulite facies. Mineralogically they consist of quartz, alkali feldspar, plagioclase, garnet, kyanite (sillimanite), hypersthene, clinopyroxene, amphibole, biotite, pyrite, magnetite. A very outstanding accessory is graphite in places. Commonly the rocks in granulite facies are closely connected with pyrope-bearing serpentinites which may contain eclogite nodules. This paragenesis is typical for the Moldanubian granulite facies rocks.

The younger phase of metamorphism which can be found in the major parts of the Moldanubian Zone has affected a geosynclinal pile of sedimentary and igneous rocks. The most important rocks are as follows: gneisses derived from pelites, semi-pelites, quartz-rich sediments, arkoses etc., mica-schists, amphibolites, marbles, calcsilicates, serpentinites, small gabbroic intrusion, dykes. For migmatitic gneisses terms such as "Gföhl gneiss", "Spitz gneiss" etc. have been used. These rocks cover quite extensive areas in the Moldanubian Zone. In this zone of the younger metamorphic phase M. Máška and V. Zoubek (in V. Zoubek ed., 1960) distinguished between a "monotonous" and a "variegated" series. The former is mainly formed by large areas of sedimentary gneisses without noteworthy intercalations of other rocks, whereas in the latter all the rocks cited above may be found in various combinations. There is some indication that this division is also valid for the Moldanubian Zone on Austrian territory.

The sedimentary gneisses are rather uniform in composition. The main constituents are quartz, oligoclase, biotite. Garnet, sillimanite, graphite, alkali feldspar, cordierite may enter the rocks. Alkali feldspar and cordierite are mainly connected with anatectic phenomena.

Amphibolites are rather wide-spread within the variegated series. Ortho- and para-amphibolites can be distinguished. Many igneous relics have been described. Amphibolites with garnet, basic plagioclase and/ or quartz, however, have been designated as presumably derived from sedimentary rocks or tuffaceous material. In some places plagioclases prevail, thus giving rise to anorthositic amphibolites.

Marbles with varying impurities are quite common in the variegated series. Sometimes the silicate minerals prevail and calcsilicates result. The marbles proper are white or gray; yellow or reddish varieties may be found in places.

Quartzites also appear rather commonly in the variegated series, but may also be met within the sedimentary gneisses of the monotonous series as result of local quartz enrichment.

There is an other sequence of ultrabasic rocks which has no connection with the granulite facies rocks and which does not contain garnet bearing members as the ultrabasic rocks in the granulite formations do. The differences (apart from the garnet content) are not yet worked out in detail, although F. Becke stressed the occurrence of two mineralogically different kinds of ultrabasic rocks which also are paragenetically different.

In the Lower Austrian Waldviertel many light-coloured gneisses have been designated as "orthogneisses". The most famous among these is the "Gföhl gneiss" which embraces a broad variety of granitic, syenitic and aplitic gneisses which were summarized into an "Gföhl gneissification act" by M. Máška and V. Zoubek (in V. Zoubek ed., 1960), regarded as a synorogenic process in the Moldanubian Zone. All these gneisses are rather poor in plagioclase and mafic components, but rich in quartz and alkali feldspar. The migmatitic zone may contain garnet, sillimanite, kyanite etc. There are a few separate bodies of the "Gföhl gneiss" which all have been given socal names. Another variety of light-coloured gneisses is the "Spitz gneiss" with rather a granodioritic composition. As long as no regional investigations have been undertaken, all these different names remain very doubtful, especially since the "Spitz gneiss" is still an unsolved problem in the Moldanubian Zone. One thing is certain, however: all these gneisses are evidently younger than the granulites.

As mentioned above, the Variscian tectogenesis had only little influence upon the Variscian intramontane stable block. Within the Moldanubian Zone the influence of the Variscian tectogenesis is mainly restricted to the Upper Austrian Mühlviertel which will not be visited during this excursion. It has been discovered that apparently Precambrian rocks identical to those of the pre-Assyntian unit of the Lower Austrian Waldviertel have been reworked. A great deal of granitization, migmatization and intrusion of granitic and granodioritic magmas took place during the Variscian tectogenesis. The end of the Variscian tectogenesis is marked by a rather intensive dyking in some places. The dykes are mostly of syenitic, dioritic and lamprophyric character. We also

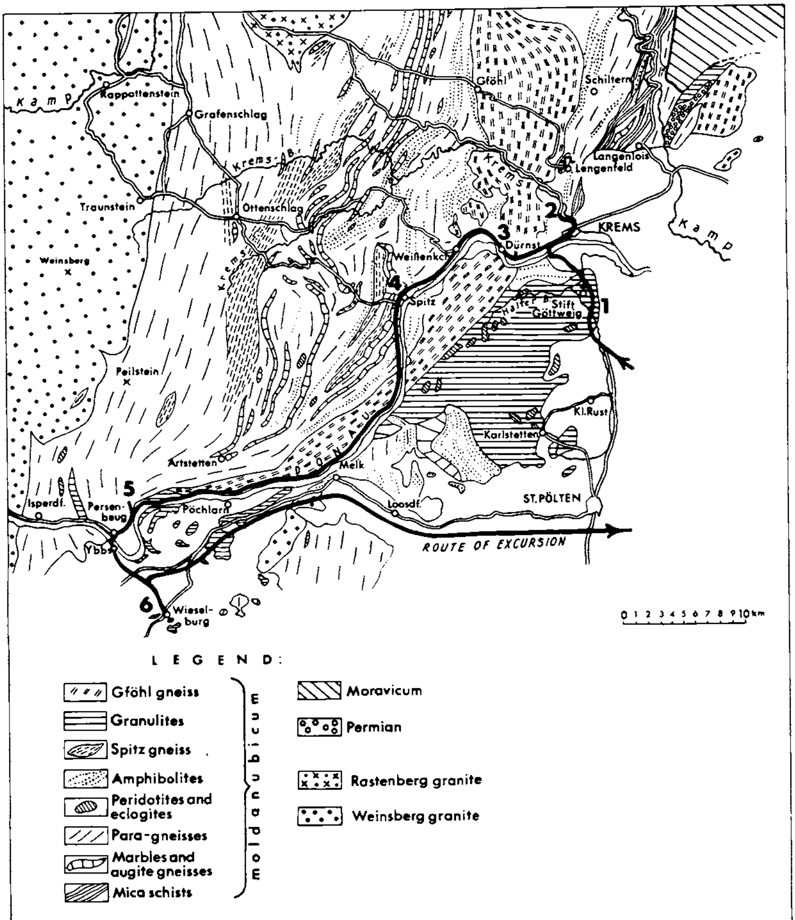

Fig. 1. Geologic sketch map of the southeastern section of the Bohemian Massif (according to L. WALDMANN 1958)

know of some dykes with alkaline affinities giving evidence for some kind of kratogenic magmatism in this area.

The "area of intensive Variscian tectogenesis" is not widely represented in Austria, i. e. the "M o r a v i a n Z o n e" which is situated east of the Moldanubian Zone. Accoring to the ideas of F. F. Suess the high-grade metamorphic rocks of the Moldanubian Zone have been thrust over the lower-grade metamorphic rocks of the Moravian Zone. Along the path of this overthrust a broad zone of mica-schists developed by retrograde metamorphism from Moldanubian sedimentary gneisses.

Important literature

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The Excursion

(Stop I/1 — stop I/6)

Stop I/1: Meidling im Tal

The two main occurrences of granulite facies rocks within the Moldanubian Zone are south of the Danube River. They must have formerly formed one single body which has later been affected by the Diendorf strike-slip fault. This fault splits this body up into the two occurences known as the Dunkelstein Forest granulite body in the northeast and the Pöchlarn—Wieselburg granulite body in the southwest.

The present exposure is situated in the eastern region of the granulite body of the Dunkelstein Forest. The schistosity of the rocks is steep or vertical almost everywhere. Axes are horizontal or gently plunging to the west. The rocks are strongly jointed, perhaps as a result of the influence of the near-by Diendorf strike-slip fault. The granulite facies rocks in this quarry mainly consist of lightcoloured granulites sensu stricto. Only a few intercalations of pyroxene-bearing granulites may be found. The light-coloured granulites sensu stricto consist of quartz, perthitic orthoclase, oligoclase, garnet; they are seldom free of biotite and may contain kyanite in many places. Sillimanite is found growing on joints, presumably in connection with slight pegmatitic veining.

In this quarry the typical combination of the granulites with pyrope-bearing ultrabasic rocks is well exposed. These have the same main structures as the granulites. They have not yet been investigated in detail, however. Eclogite nodules are situated within these serpentinites. They consist predominantely of garnet (Py 58.4, Alm 19.0, Gr 20.4) and of pyroxene (Jd 9.8, Ac 1.6, Di 50.0, En 14.6). These rocks may rather be called garnet-pyroxenites.

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Stop I/2: Rehberg, near Krems/Danube

This old quarry exposes a Moldanubian amphibolite with gabbroic relics ("gabbro-amphibolite") within the variegated series. It may originally have been a gabbroic sill which intruded into semi-pelites and pelites which have been metamorphosed into-gneisses. The strike of this series is roughly N-S, the dip toward west, underneath the main body of "Gföhl gneiss" in this area. The mineralogical composition embraces uralitized pyroxene and labradorite relics. The re-crystallized parts of the rock have hornblende, andesine and diopside as their main constituents. A little ore, sphene and calcite is added.

Reference

MARCHET, A. (1919): Der Gabbro-Amphibolitzug von Rehberg im niederösterreichischen Waldviertel. — Sitzber. Ak. Wiss., Wien, vol. 128, pp. 215—291.

Stop I/3: Dürnstein

The light-coloured "Gföhl gneiss" in its cleanest development is shown in this exposure along the Danube shore. This body of "Gföhl gneiss" was originally named "central gneiss" by F. Becke. The foliation is almost horizontal, multiple small-scale folding occurs with N-S horizontal axes. The rock consists of quartz, microcline-perthite and biotite. There is only a little oligoclase in the rock.

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KÖLBL, L. (1925): Die Stellung des Gföhlergneises im Grundgebirge des niederösterreichischen Waldviertels. — Tschermaks Miner. Petr. Mitt., vol. **38**, pp. 508—539, Wien.

Stop I/4: Spitz/Danube

One of the silicate-rich marbles of the variegated series is seen here. Only roughly 50% of the rock consist of calcite. The other components are medium to basic plagioclase, quartz, diopside, biotite and scapolite, in places. Tiny intercalations of biotite-schists can be found. On the northern termination of this old quarry one can study the different competencies of marble, amphibolite and acid veins.

Stop I/5: Loja-Valley

The three huge quarries in the Loja Valley work mainly the sedimentary gneisses of the Moldanubian monotonous series. The series is slightly dispersed by the appearance of presumably early Variscian cataclastic granite filons and by late Variscian dykes which contact-metamorphosed marble intercalations in the gneisses (formation of wollastonite, grossularite etc.). Otherwise, the main rock-type is a dark sedimentary gneiss, which is migmatitic in places. The mineralogical composition is quartz, oligoclase, biotite, garnet, sillimanite, alkali feldspar. The migmatization is presumably Variscian. The relationships have still to be worked out in detail.

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Stop I/6: Wieselburg/Erlauf

The southwestern of the two granulite bodies south of the Danube River is touched by visiting this quarry which is worked mainly in a dark-coloured pyroxene-granulite. Principally, this rock is a NW-striking vertical layer within the light-coloured granulite. The whole body has a fan-structure. The pyroxene-granulite is an acid rock (SiO_2 70.23) and contains quartz, perthitic orthoclase, oligoclase, Al_2O_3-bearing hypersthene, garnet in different amounts (sometimes absent), biotite; there is a little hornblende and diopsidic augite in the rock. Also the layers free of mafic minerals are rather dark-coloured.

Another rock-type of interest to be met with in this quarry is a light-coloured, pink granulite with a high amount of both garnet and kyanite. Late Variscian kersantite dykes are intruded into the granulite which otherwise is hardly affected by the Variscian tectogenesis.

Reference

SCHARBERT, H. G. (see exposure No. 1).

II

(Second day)

The Bohemian Massif in Austria
The Moravian Zone

By G. Frasl

With 3 figures

General Remarks

In 1901 F. E. Suess devided the Bohemian Massif into a western unit, the Moldanubicum, consisting of highly metamorphosed series with post-tectonic intrusions of several generations of granites. The eastern unit, the Moravicum as defined by F. E. Suess, is characterized by a distinctly lower grade of metamorphism (partly epi-zonal); its tectonical features are different from those of the Moldanubicum.

The western (and higher) divisions of the Moravicum, adjoining the Moldanubicum, show schuppen tectonics and nappe structures. The lower (and eastern) divisions of the Moravicum consist of a more or less autochthonous mass of granitic rocks.

The originally sedimentary rocks of the Moldanubicum and the Moravicum differ in facies and age, the Moravian para-series being probably younger. The plutonic rocks of both units also differ in age and chemical composition.

Following the theory of F. E. Suess, the Moldanubicum formed a traineau ecraseur overthrusting the Moravicum for some ten kilometres towards east. The overthrust took place in Hercynian times, causing the internal tectonic of the Moravicum and its metamorphism.

This tectonic conception of F. E. Suess offered a plain solution to the main problems but some questions remained unsolved. Therefore, in the following times, divergent ideas on the origin of the Moravian Zone have been published. Most of the problems and the various opinions have been summarized recently in "Regional Geology of Czechoslovakia", Part I, Prague 1966.

This is not the place for a lenghty discussion of the many questions of Moravian and Moldanubian Zone on which a large number of papers have been published. It is sufficient here to give a short summary of the actual geological knowledge.

The easternmost (and tectonically lowest) element of the Moravian unit is the Thaya mass, consisting of meta-granites, meta-granodiorites and meta-tonalites. In accordance with the age determination of the analogous Brünner massif, those intrusive rocks are of pre-Devonian age. In the east the Thaya mass is covered by Tertiary sediments of the Alpine Molasse Zone. Towards west it borders against a series of metamorphic sedimentary rocks in which, locally, relics of thermo-contact phenomena can be found.

This autochthonous to par-autochthonous part of the Moravian unit is overlain by some allochthonous series composed of ortho- and para-gneisses, biotite schists and phyllites, calcareous schists and limestone marbles. Some of the ortho-gneisses and schists seem to be metamorphosed aequivalents of the above mentioned granitic rocks and their pre-Devonian cover. Some other members of these series, p. e. the calcareous schists and the limestone marbles ("Moravian limestone") are taken for Devonian. (In the less metamorphic limestones of the Kvetnica Group which already have been compared with the Moravian limestones by F. E. Suess, Preclik a. o., determinable Devonian fossils were found recently [see "Regional Geology of Czechoslovakia", 1966].)

The uppermost tectonical element of the Moravian unit is the nappe-sheet of the Bittesch gneiss. Moving from west towards east it overthrusted the above mentioned Paleozoic series. (Within the Austrian territory only the western branches of those nappe structures are exposed. In Czechoslovakia, however, in the so-called Svratka dome, the complex of the Bittesch gneiss forms a huge nappe-sheet, in the center of which the lower tectonical elements of the Moravicum appear as a window structure.)

Finally the Moravian Zone borders with another thrust-horizon against the Moldanubian unit, the Moravian Zone having been overthrust by the Moldanubian Zone.

In correspondence with the ideas of F. E. Suess, L. Waldmann and K. Preclik the structural development of the Moravicum and the related phases of metamorphism can be sketched as follows:

1. Early Moravian phase ("altmoravische Phase"): Pre-Devonian (Assyntian?) movements connected with a metamorphism in amphibolite facies (?). Subsequent intrusions of granitic rocks and contact metamorphism.

2. Middle Moravian phase ("mittelmoravische Phase"): Main phase of the Hercynian movements. Formation of the slip- and nappe structures in connection with a regional metamorphism partly of greenschist facies, partly of amphibolite facies (the latter in the middle-west parts of the Thaya dome).

3. Late Moravian phase ("jungmoravische Phase", without a distinct hiatus to the preceding phase): Characterized by shearing movements in connection with retrograde metamorphism of the lower greenschist facies (zones of diaphthoresis).

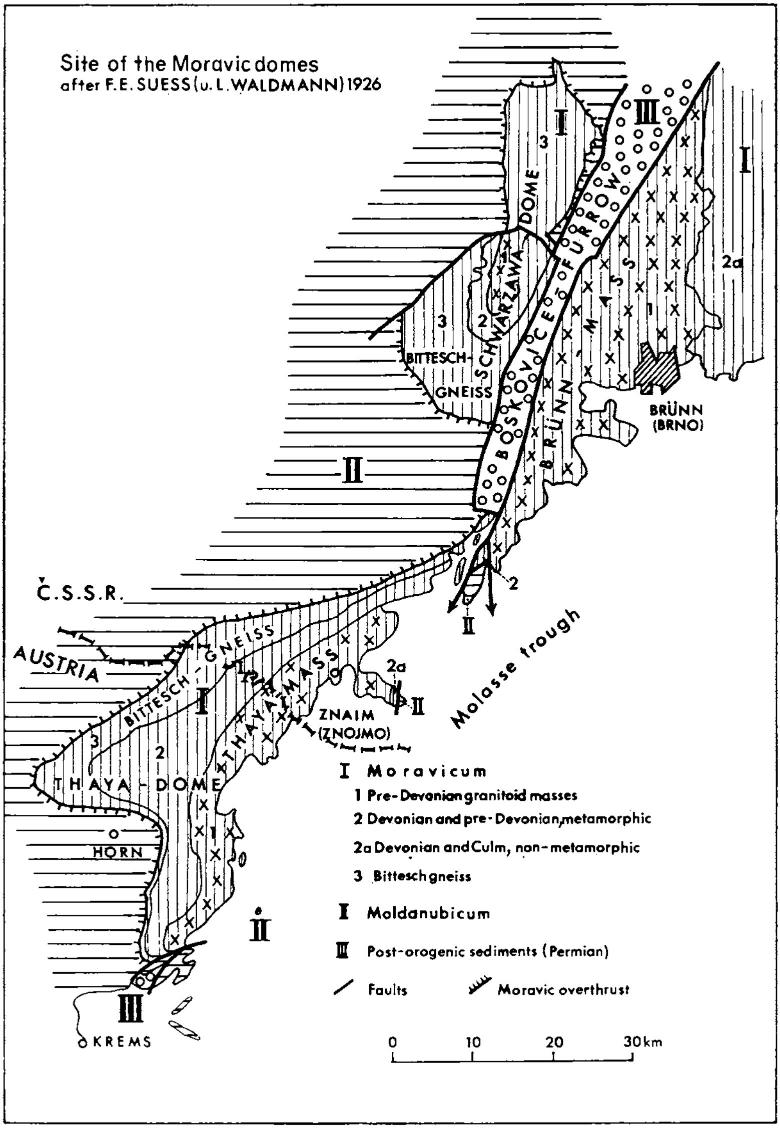
Site of the Moravic domes
after F.E. SUESS (u. L. WALDMANN) 1926
DOME
SCHWARZAWA
BITTESCH-
GNEISS
BOSKOVICE FURROW
BRÜNN MASS
BRÜNN
(BRNO)
Č.S.S.R.
AUSTRIA
BITTESCH-GNEISS
THAYA-MASS
THAYA-DOME
ZNAIM
(ZNOJMO)
Molasse trough
HORN
KREMS
I Moravicum
1 Pre-Devonian granitoid masses
2 Devonian and pre-Devonian, metamorphic
2a Devonian and Culm, non-metamorphic
3 Bitteschgneiss
II Moldanubicum
III Post-orogenic sediments (Permian)
Faults
Moravic overthrust
0 10 20 30km

Fig. 1.

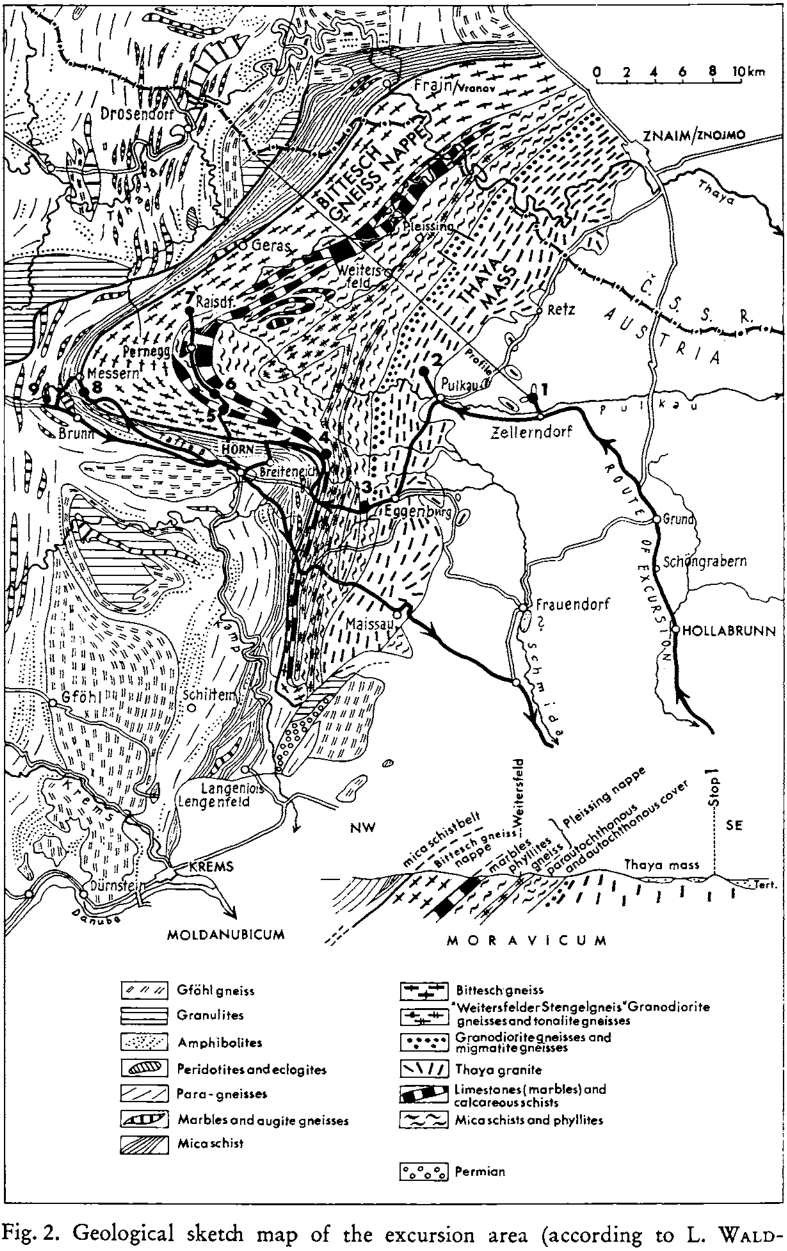

Fig. 2. Geological sketch map of the excursion area (according to L. WALDMANN 1958)

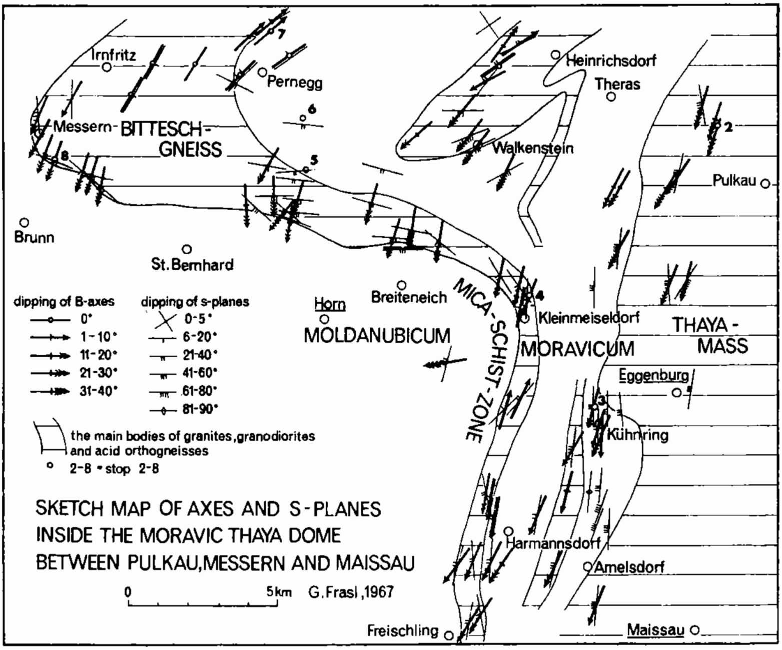

Fig. 3.

After these orogenic phases, fault tectonics and formation of the graben structures (Boskovice furrow, Diendorf fault) took place.

For the regional position of the Moravian series in Austria in respect to those situated in the southern part of the CSR we refer to fig. 1. A schematic cross section and a sketch-map of the Moravian unit as exposed in Austria (fig. 2 and 3) complete the basic information.

The excursion presents a cross-section, beginning in the lower (more or less autochthonous) parts of the Moravian unit and proceeding towards the higher (overthrusted) divisions of the Moravicum.

The Excursion

(Stop II/1 — stop II/9)

Vienna — Hollabrunn — Zellerndorf — Pulkau — Eggenburg — Kleinmeiseldorf—Horn (Lunch)—Mödring—Pernegg—Messern— (eventually Dietmannsdorf a. d. Wild)—Horn—Vienna (see also fig. 2 and 3).

Stop II/1: Quarry Wartberg N of Zellerndorf.

Fine grained granodiorite to granite of the Thaya mass. It is an aequivalent of the Brünn mass and thus of pre-Devonian ("Assyntian"?) age.

This inner part of the Thaya mass is only moderately affected by tectonisation and recrystallisation. According to microscopical examinations the primary biotites have preserved their original shape. Their colour is mainly reddish-brown. Only along cleavage fractures and at the borders of the biotite the colour changes slightly to olive-brown and it is only there that tiny microlites of epidote and Ti-minerals can be noted. Fine grained biotite which belongs to a second generation is scarce. The plagioclases show normal zoning from An_{27} to An_{17} with narrow albite rims. Only exceptionally, extremely small microlites of sericite and clinozoisite indicate the very beginning of instability.

The granitic rock of the quarry is cut by some decimeter thick veins of pegmatite and by an about 5 m thick dike of porphyrite which crosses the quarry from N to S.

At Pulkau we reach the region in which the Moravian Zone is exposed continously.

At the western end of Pulkau there is an outcrop of pink acid granite which has been metamorphosed under conditions of the greenschist facies. Here we find albite instead of oligoclase and dark greenish biotite instead of the brownish one. The texture of the rock, however, is nearly irregular (granite of Maissau-type).

Stop II/2: Haidberg, NW of Pulkau, Biotite-rich granite to flaser granite.

We are now in the marginal zone of the Thaya mass. Here the igneous rocks ranging in their composition from granites to granodiorites and even tonalites underwent a progressive tectonisation and metamorphism. Locally the originally idiomorphic and 3 to 7 mm sized primary biotites were stretched to parallel stripes of very fine grained, foliated biotite. The other minerals, too, were visibly deformed. During and after the deformation, however, a recrystallisation occurred (Frasl, 1968). The numerous newly grown flakes of fine grained biotite which derived from the triturated particles of the primary idiomorphic biotite show no signs of instability. In contrary to the center of the primary biotite having a brownisch colour and residues of sagenite, its margin and the secondary biotite-flakes are olive-brown in colour.

Also the habitus of the plagioclases is of petrogenetic interest. It should be studied on less deformed specimens of granodioritic to tonalitic rocks. Here the plagioclases appear as so-called "filled plagioclase" (an oligoclase matrix filled by numerous microlites of sericite and/or clinozoisite). This kind of feldspar shows close affinity to certain plagioclase types of the meta-tonalites of the Zillertaler and Venediger massif of the Tauern window (Central Alps) which have been studied by E. Christa, Dal Piaz & Bianchi, F. Karl and others. In the latter case, the igneous rocks underwent a regional metamorphism under the conditions of the "Tauernkristallisation" ranging from epizonal conditions to those of the beginning mesozone.

In the northern part of the Haidberg so-called porphyroids of several meter thickness are exposed. They are epi-metamorphic rocks with relics of phenocrysts of quartz and feldspar lying in a more or less schistose matrix with striae of biotite and chlorite. One can assume that those rocks originally have been intrusive veins of granite-porphyries, connected with the granitic rocks.

Both, the "porphyroids" and the schistose meta-granites strike NNE-SSW and dip nearly vertically.

On our way to the next stop we pass the medieval town Eggenburg and the village Kühnring. Here we cross the original thermo-contact zone of the Thaya mass.

Generally the granitic rocks of the Thaya mass border against a series of "biotite phyllites" with rare intercalations of quartzites and "porphyroids". This group is considered to be the autochthonous to par-autochthonous cover of the Thaya mass. In some places pseudomorphs of muscovite + biotite after cordierite were found. From other places calc-silicate hornfelses have been described by Becke, Reinhold, Mocker and Waldmann. The rocks of these series, however, seem to have suffered not only from a thermo-contact metamorphism but also from a regional metamorphism which ranges in its intensity from the greenschist facies to the lower amphibolite facies (oligoclase, olive-brown biotite). The latter is related to the so-called Middle Moravian movements.

Stop II/3: Rock exposure situated approximately 200m N of Kühnring

Parts of the above mentioned biotite phyllites were additionally affected by a retrograde metamorphism and changed to clorite-muscovite schists. Those rocks are characteristic products of the Late Moravian movements (Waldmann) which, in connection with a selective diaphthoresis influenced the respective Moravian series along certain zones of weakness which run about parallel to the border of the Thaya mass.

In this area the crystalline rocks are widely covered by loess and Tertiary sediments. Therefore we cannot study the various rocks which are developed between the Thaya mass and the Bittesch gneiss, as there are: biotite schists, ortho-gneisses, calcareous schists and phyllites, limestone marble etc. (Some of them will be shown at stop 5, 6 and 7.) The most characteristic rock of the Moravian Zone, the Bittesch gneiss, which is quarried in several dozen places because of its platy structure is shown next:

Stop II/4: Quarry near Kleinmeiseldorf (500 m N of the railway viaduct)

The Bittesch gneiss is of granitic to granodioritic composition. Its texture ranges from slightly schistose to linear- or plane parallel schistose. Platy texture, however, is predominant. The s-planes of the gneiss dip at a low angle towards west, the B-axes run in direction SSW.

The texture of the rock points to an enormous lamination which is in connection with slip tectonics and nappe structures of this higher division of the Moravian unit.

The fine grained rock contains aboundantly augen of potash feldspar and often remarkable big flakes of muscovite. Additionally along certain shear planes sericite can be found. The biotite is extremely ruptured and stretched out in "B". It is re-crystallized to very fine grained biotite-flakes of an olive-brown colour. The quartz grains, too, were strongly deformed and then re-crystallized.

The relictic primary feactures of the augen-feldspars as well as the crystallographic shape of the accessory zirkones prove the normal "magmatic" origin of the primary rock (Frasl, 1954 and 1963).

The main deformation and the re-crystallisation of the Bittesch gneiss can be attributed to the middle Moravian phase. Most parts of the Bittesch gneiss however were affected by a second, post-crystalline deformation. The latter can be correlated with the late Moravian phase.

Continuing our trip we cross the so-called mica schist belt which is taken for the border zone of the overlying Moldanubian unit. Then we enter the Tertiary basin of Horn. (Lunch in Horn).

After lunch we drive towards north. Near Mödring we enter the Moravian unit again. After passing through the zone of Bittesch gneiss some types of the underlying metamorphic series can be studied:

Stop II/5: Quarry in the Mödring valley near the inn "Waldschänke"

The quarry exposes grey, fine grained, biotite-bearing limestone marbles which locally change to calcareous mica schists. They represent the so-called "Moravian limestone" (F. E. Suess a. o.). The dip is approximately 30° towards south. Dip and strike are rather conformable to those of the overlying Bittesch gneiss.

Under the microscope it can be noted, that the marbles contain oligoclase and andesine (up to 45% An) with an inverse zoning. The biotites are of a reddishbrown colour (Frasl, 1967).

Especially the composition of the plagioclases gives strong evidence that in this part of the Thaya dome the Moravian series including the Moravian limestone were metamorphosed under mesozonal condition (according to the almandine-amphibolite facies of Turner-Verhoogen, H. G. F. Winkler a. o.). Obviously this metamorphism outlasted the main deformation (Middle Moravian phase).

It should be pointed out, that the Moravian limestone marbles are considered to be aequivalents of the less metamorphic fossiliferous Devonian limestones of the Kvetnice series in Czechoslovakia (the latter overlie the granitoid mass which forms the center of the Svratka dome). If this correlation (F. E. Suess, Waldmann, Preclik a. o.) is correct, the metamorphism and the main tectonic structures of the Moravian unit are related to the Variscian (= Hercynian) orogeny.

Stop II/6: Exposures at mile stone (km 8) of the road leading from Mödring to Pernegg

We are now in the westernmost part of the sedimentogenous group inside the Thaya-Dome. Compared with the vicinity of stop 3 (Kühnring) a considerable higher grade of regional metamorphism can be noted here, the sedimentogenous schist being developed as garnet- and staurolite-bearing biotite schists.

The garnets and the staurolites are comparatively well preserved. Therefore the author considers this crystallisation to be related to the Middle Moravian phase i. e. the main phase of movement in this area.

This assumption is supported by the fact that the metamorphic facies of these rocks does correspond with that of the marbles we saw at stop 5.

We are now driving about 3.5 km towards north-northwest. We cross the so-called "Pernegg partial dome" and come to the north-west dipping flank of this structure.

Stop II/7: Raisdorf, small quarry in the south-western slope of the Halter-Berg

Here the "Fugnitzer Kalksilikatschiefer" (calc-silicate shists) are exposed. They are fine grained, slightly banded rocks which contain bluish-green amphibole, diopside-like pyroxene, clinozoisite, quartz, plagioclase, potash feldspar, calcite, titanite, etc.

The plagioclases show an intensive inverse zoning (oligoclase to andesine and even labradorite). There are no signs of instability nor any contact phenomena against the blue-green amphiboles which grew distinctly parallel to the regional B-axes (i. e. NE-SW). Therefore we can assume that both minerals are af Middle Moravian age. Here too, the grade of metamorphism corresponds to the amphibolite facies. It is only little stronger than that of the above mentioned Moravic limestone (see stop 5).

Stop II/8: Quarry "Hattey", situated in the valley 1 km south-southeast of Messern

This locality is one of the westernmost outcrops of the Bittesch gneiss. Here too, the gneiss shows its characteristic platy structure (see also stop 4). In this exposure, however, we are able to study the uppermost parts of the gneiss mass in which basic intercalations are fairly abundant.

Besides it should be noted that in this westernmost parts of the Thaya dome, the Bittesch gneiss shows a higher grade of metamorphism (p. e. in comparison with that type of Bittesch gneiss we studied at stop 4).

According to microscopical investigations the plagioclase of the gneiss is oligoclase (approximately An_{22}). In a biotite-amphibolitic intercalation a representative plagioclase grain (bordering biotites orientated in "s") shows an inverse zoning from An_{17} (core) to An_{37} (border). In an amphibolite intercalation of about 10 cm thickness inverse zoned plagioclases have been found ranging from An_{30} to An_{60}. In none of these three samples any indication of instability of the plagioclases has been observed, neither acidic rims nor any microlitic unmixing. In all three samples the biotites were found to be of a homogeneous reddish-brown colour. They show no traces of unmixing (neither Ti-minerals nor epidote). Moreover, in the basic intercalations common hornblende is a stable mineral component.

Therefore, it can be taken for granted that in this area the Bittesch gneiss underwent a mesozonal metamorphism resembling the almandine-amphibolite facies.

Stop II/9:

If there is any time left, a quarry 1 km east-southeast Dietmannsdorf an der Wild can be visited to study the tectonic style and the type of metamorphism of the Moldanubian unit (which, as mentioned in the beginning, are quite different from those of the Moravian series).

An amphibolite of several meter thickness is folded together with a coarse grained, banded marble. Boudinage structures and — locally — reaction rims can be observed. Both rocks border against a peculiar spotted calc-silicate gneiss.

These rock types belong to the so-called varied group ("-variegated series", see the contribution by H. G. Scharbert, pag. 5 ff.).

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III

(Third and fourth day)

The Eastern End of the Central Alps

By H. WIESENEDER

With 3 figures

General geology of the area

In the eastern part of the Alps deeper elements of the Central Alps are exposed forming the Semmering-Wechsel window. The northwestern frame of the window is formed by a small band of Mesozoic rocks. The upper tectonic unit (Middle Austro-Alpine) consists of biotite- and muscovite schists, biotite- and aplite gneisses, amphibolites and pegmatites. The southwestern rim of the window is formed by limestone, dolomite and rauhwacke lenses of probable Mesozoic age. The overlying metamorphic formation is composed of coarse-grained garnet-micaschists, aplite gneisses, amphibolites and "garbenschiefer". This association corresponds in its metamorphism to the northwestern frame of the window.

East of the Wechsel mountain metamorphic schists of the described type occur in several isolated "Klippen" (Schäffern, Kirchschlag, Steinbach, Sieggraben) together with kyanite gneisses, marbles, amphibolites and amphibol-eclogites. These occurrences of high grade metarmorphic rocks are considered as erosional relicts of the eastern frame of the Semmering-Wechsel window. Further to the east the metamorphic zone is covered by Tertiary sediments.

The Wechsel unit

The deepest tectonic part within the Semmering window is the Wechsel area forming a culmination. The rock association of this unit is monotonous and clearly different from the overlying Grobgneiss formation. The western border of the Wechsel schists is represented by a north-south extended zone of Mesozoic quartzites and marbles overlying the west-diping Wechsel schists. In the north the Wechsel formation is overlain by the Mesozoic rocks of the Sonnwendstein syncline. On the eastern border, west-dip predominates, probably caused by secondary complications. Only two small occurrences of Mesozoic beds mark this boundary. The petrographic composition of the Wechsel formation may be studied in a west-east cross-section between the Pfaffensattel and the village Mönichkirchen. Below the Permotriassic quartzites of the "Pfaffen" there follow graphite-phyllites, phyllites and greywacke phyllites. In the greywacke phyllites polysynthetic twinned oligoclases are embedded in a matrix of quartz grains, sericite and clinozoisite. The irregular shaped plagioclases show numerous carbonaceous inclusions and are probably of detritic origin.

The most characteristic rock of the Wechsel formation is an albite gneiss which forms the central and eastern part of the Wechsel area. This rock has been described by several authors (A. Böhm, 1883, S. Richarz, 1911, H. Mohr 1912, H. Wieseneder, 1962). The albite gneiss consists of 30—60% mostly untwinned albite grains. Muscovite, chlorite, clinozoisite, epidote and quartz are additional components, apatite and sphene accessories. Sometimes small layers of greenschists are intercalated in the albite gneisses. The typical mineral assemblage is chlorite, epidote, albite; spindle-shaped grains of sphene and apatite are minor components. A chemical analysis of the albite gneiss is given in the field guide. The S-shaped lines of inclusions in many albites of the above described rocks point to a synkinematic crystallisation. Proofs for a postcrystalline deformation within the Wechsel formation are generally lacking. The geology of the southern part of the Wechsel area is not completely clear and needs further investigations.

The "grobgneiss" formation

Coarse-grained granite gneisses occur west, east and north of the Wechsel area and are forming bodies of different sizes. North of the Mürz river, a 20 km long, northeast-southwest elongated grobgneiss body is forming the Mürz nappe. The frame of the Semmering window begins beyond this nappe and is separated by a belt of Mesozoic rocks. Another grobgneiss body forms the central part of the Pretul nappe, southwest of the Mürz nappe. It is separated from the latter also by Mesozoic rocks.

As already stressed by R. Schwinner (1932), the grobgneiss shows little variation. Pegmatites, aplites, lamprophyric dikes are rare. Inclusions of country rocks and the wellknown pictures of migmatisation are almost completely lacking. The inner parts of the gneiss body have a more granitic structure whereas the boundary zones are strongly foliated.

The rock consists of 2.5 cm perthitic microclines often twinned after the Karlsbad law. The plagioclases are filled with sericite- and clinizoisite microlites but, nevertheless, the twin lamellae (mostly albite and pericline law) are sharp. Microlites of the described type are very common in alpine gneisses and their origin has been discussed intensively in the literature. It seems reasonable to assume that the microlites have been formed out of the anorthite component of the plagioclases because this mineral is not stable under the conditions of low grade metamorphism.

During deformation the sericite microlites grew and recrystallized as muscovites predominantly along s-planes. Therefore the plagioclases filled with microlites are to be found in the less deformed parts of the "grobgneiss" whereas the strongly deformed parts are characterized by newly formed muscovites.

Absolute age determinations of the "grobgneiss" have not been done because of the lack of suitable unaltered samples.

Together with the grobgneiss, especially in the south and southeast of map-sheet Birkfeld, a medium grained gneiss consisting of microcline, oligoclase, quartz and muscovite is found. In contrary to the "grobgneiss" this rock does not show any sign of relictic plutonic structures. Therefore we suppose that this rock is older than the emplacement of the "grobgneiss". A granitic rock younger than the "grobgneiss" is occuring near Stubenberg. This granite is described under stop 8. The country rocks of the "grobgneiss" are phyllitic micaschists grading in the southern part of the area into quarzitic micaschists.

The phyllitic micaschists are composed of muscovite, quartz, chlorite and some albite or oligoclase, and contain frequently garnet and tourmaline. In some places black tourmaline rocks in the size of 1 cubic meter or less occur within the mica schists; they may have been formed by lateral secretion. Near the boundary to the "grobgneiss", microcline porphyroblasts can be observed in the micaschists. All geologists working in this area agree that this alkalifeldspar aureoles around the "grobgneiss" bodies are to be explained by metasomatic action during the emplacement of the "grobgneiss". East and southeast of Birkfeld the phyllitic micaschists are replaced by biotite schist, biotite gneisses and migmatic biotite gneisses. R. Schwinner (1935) intruduced the names "Tommer schists" and "Strahlegger gneiss". Detailled mapping in this area made it clear that the migmatisation of the "Strahlegger gneiss" is older than the emplacement of the "grobgneiss". Sericite aggregates are frequent in the biotite schists. As staurolite is sometimes found in the cores of these aggregates, it is probable that the biotite schists are partly derived from staurolite-bearing rocks by retrograde metamorphism. In the low grade metamorphic schists of this area chloritoid is present too. We believe that this mineral is formed from originally staurolite-bearing rocks during diaphthoresis. Garnet is a common mineral in all described rocks.

Together with the biotite schists and biotite gneisses long stretched bodies of quartzites and kyanite quartzites occur. These rocks are well known as "Kornstein" in the talc deposits Rabenwald. Their genesis is discussed under stop 9.

Permo-Mesozoic

Several authors most recently E. Kristan and A. Tollmann (1957) have contributed to our knowledge of the geology of the Mesozoic of the Semmering region. Fossils pointing to a Mesozoic age have been found for the first time by F. Toula (1877). The stratigraphic section begins with white or light green metaquartzites, metaconglomerates and metaarkoses (Semmeringquarzit).

A Permotriassic age is assumed for these rocks. The quartzites consist of quartz, muscovite, sometimes altered feldspars or newly formed albites, tourmaline and small zirkon crystals. Red quartz pebbles are characteristic in many places. The pebbles of the metaconglomerates are embedded in a matrix of quartz grains. The medium grained quarzites and metaarkoses are composed of a network of xenomorphic quartz grains which show mostly wavy extinction. The thickness is variable and amounts to 400 m.

Normally the quartzites are overlain by porous limestones (rauhwackes). Rauhwackes are very characteristic for the Mesozoic strata of the Central Alps. They occur in different stratigraphic positions and are of different origin. The Rauhwackes overlying the Semmering-quartzites are mostly calcarenites containing grains of detritic quartz, feldspar and gneiss. At places, newly formed siderite and albite has been described. By weathering the rocks become porous. The limonite derived from the weathered siderite gives a characteristic yellow colour to the rocks.

In unreduced cross sections, the Middle Triassic starts with light or dark grey coloured limestones, seldom with thin bedded white or pink marbles. Fossils (*Encrinus liliiformis?*, gastropoda) have been described. Cherty limestones and dolomite breccias are associated with this stage of the Triassic. The next higher element in the stratigraphic section is a bedded or massive dark grey dolomite: "Semmeringdolomite" which composes the Otter-Sonnwendstein range and parts of the Myrthengraben. Crinoidea and *Gyroporella* are known from this dolomite. Near Göstritz and on the Semmering road variagated coloured shales are exposed. E. Kristan and A. Tollmann (1957) compare this rock association with the Upper Triassic (Keuper) of the western Carpathians. The uppermost stage in this stratigraphic column are blue grey platy limestones and slates. The age is prooved by *Pentacrinus*, *Thecosmilia*, *Mypohoria inflata*, gastropoda and bivalva.

Within the Semmering Mesozoic, E. Kristan and A. Tollmann (1954) distinguish the following tectonic units from north to south:

1. A d l i t z s c h u p p e : well developed on both sides of the Adlitz Graben, consisting of quartzites, rauhwackes and Lower Triassic marbles.

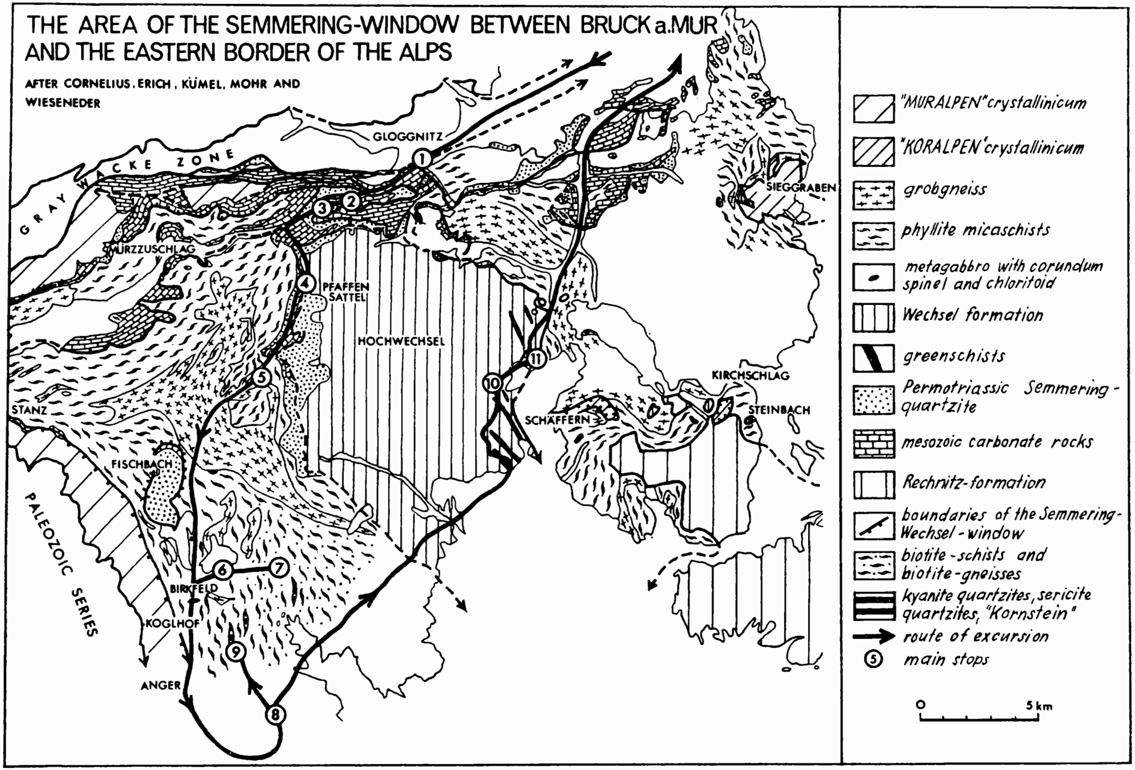

THE AREA OF THE SEMMERING-WINDOW BETWEEN BRUCK a.MUR AND THE EASTERN BORDER OF THE ALPS
AFTER CORNELIUS. ERICH. KÜMEL, MOHR AND WIESENEDER
GRAY WACKE ZONE
GLOGGNITZ
MÜRZZUSCHLAG
PFAFFEN SATTEL
HOCHWECHSEL
SIEGGRABEN
KIRCHSCHLAG
STEINBACH
SCHÄFFERN
STANZ
FISCHBACH
PALEOZOIC SERIES
BIRKFELD
KOGLHOF
ANGER
"MURALPEN" crystallinicum
"KORALPEN" crystallinicum
grobgneiss
phyllite micaschists
metagabbro with corundum spinel and chloritoid
Wechsel formation
greenschists
Permotriassic Semmering-quartzite
mesozoic carbonate rocks
Rechnitz-formation
boundaries of the Semmering-Wechsel-window
biotite-schists and biotite-gneisses
kyanite quartzites, sericite quartzites, "Kornstein"
route of excursion
main stops
0
5 km

Fig. 1.

2. The next deeper unit is the Grasbergschuppe: well exposed near the road between Baufelsen and Grasberg.

3. The quartzite of the Hirschenkogel is the basement of the Göstritzschuppe in which variegated coloured slates (Keuper) predominate. The deepest tectonic element is the Sonnwendstein-Otter syncline, overlying the Wechsel schists.

Metamorphism in the Semmering-Wechsel area

The metasediments of the Wechsel unit are probably Paleozoic of age and have been metamorphosed during the Alpine orogenesis. In the next higher tectonik unit, "the Lower Austro-Alpine", a low grade metamorphism of Alpine age is observable too because of the fact that tremolite and muscovite have been crystallized in the Mesozoic marbles of Fischbach. It has been mentioned already that the metamorphism of the "grobgneiss" took place during Alpine orogenesis. The metamorphism of the grobgneiss-mantle, however, may be divided into two stages: the pre-Alpine metamorphism is characterized by the staurolite-amphibolite subfacies of the amphibolite-facies whereas the Alpine metamorphism never exceeds the green schist facies. In Mesozoic sediments, this metamorphism is progressive. Rocks of higher grade metamorphism from older (probable Variscian) cycles underwent retrograde metamorphism by diaphthoresis.

The Excursion

(Stop III/1 — stop III/11)

Stop 1: Gloggnitz, Riebeckite gneiss

The town is situated at the southern edge of the Vienna Basin; here we enter the west-east striking "Greywacke Zone". Its Paleozoic age is proved by fossils. The Zone which has an average thickness of 7 km is composed of slates, phyllites, quartz-greywackes, conglomeratic phyllites, greenschists porphyroids, limestones, dolomites and lydites. The most important ore deposits (siderite) and mineral deposits (magnesite) of the Alps are situated in this Zone. In the eastern part an upper unit (Norische Decke) and a lower unit (Veitscher Decke) are separated by the "Norische Linie".

The Silbersberg-formation (the name is derived from the Silbersberg north of Gloggnitz) consists of phyllites, quartz-greywackes phyllites, greenschists, porphyroids and riebeckite gneisses. The largest of the 14 occurences of the latter is situated of the southern end of Gloggnitz. Here, the gneiss body has a length of 1 km and is approximately 100 m thick. In the fine-grained matrix of the foliated rock bluish-green patches of riebeckite are visible. The local name of the rock is "Forellenstein" (trout stone). According to the studies of H. Graf Kayserling (1903) and J. Zemann (1954) the rock is composed of alkalifeldspar, albite, quartz, riebeckite and aegirine. Accessories are hematite, magnetite, rutile and leukoxene. New chemical analyses were given by J. Zemann (1951).

Analyses of the riebeckite gneiss of Gloggnitz

J. Zemann

	I	II
SiO_2	76.03%	76.60%
TiO	0.10%	0.09%
Al_2O_3	11.74%	10.75%
Fe_2O_3	2.44%	2.42%
FeO	0.65%	1.10%
MnO	0.04%	0.03%
MgO	0.04%	0.08%
CaO	0.11%	0.19%
Na_2O	4.74%	4.68%
K_2O	4.07%	4.06%
K_2O+	0.28%	0.27%
H_2O-	0.04%	0.06%
	100.28%	100.33%

II

optical integration analyses

quartz and feldspars	92.2
riebeckite	4.2
aegirine	2,7
accessories:	
leucoxene	
magnetite	0,9
hematite	
rutile, limonite	

calculated mineralogical composition

quartz	34.1 vol. %
albite	32.8 vol. %
alkalifeldspar	25.2 vol. %
riebeckite	4.7 vol. %
aegirine	3.0 vol. %
sphen	0.2 vol. %

The chemical composition points to alkaligranitic "magma". The author considers the rock to be metacomenditic.

Stop 2: Göstritz, Upper Triassic shales, old gypsum mine

Variagated shales, gypsum, anhydrite, black limestones and white quartzites are found on the dump of a gipsum mine, abandoned several years ago. The environment of Göstritz and the terrain of the road to the Semmering pass is composed of the same rock association belonging to the "Göstritzschuppe". Near Göstritz, within the shales, the previously mined gypsum deposit consists of a dome-shaped anhydrite body with gypsum-cover of variable thickness. Similar deposits are mined at the adjacent Haidbachgraben. At the locality Bärenwirt, a big landslide was caused by the water retaining effect of the shales and the mining activity underground. The association of anhydrite and red shales demonstrate clearly the conditions of sedimentation under a dry climate. The pigment of the red shales is made up by flakes of hematite in newly formed micas being visible under the microscope. The green colour of the shales is caused by small pyrite crystals in the micas; the reduction of the iron is an effect of diagenesis.

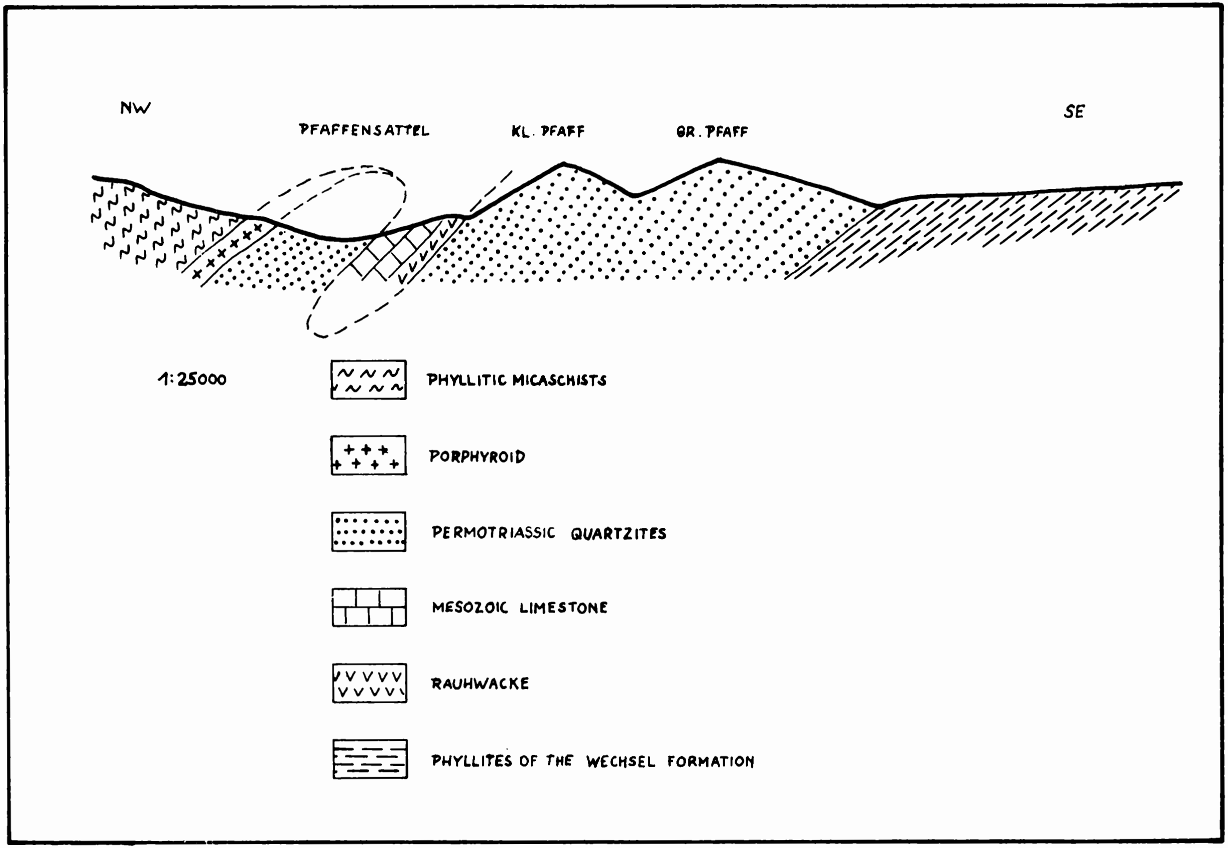
Stop 3: Maria Schutz. For the general geology of the area, see first part of this text.

Stop 4: Pfaffen Sattel, 1344 m, Mesozoic schists of the "Pfaffen syncline"

The cross section from the Pfaffen montain across Pfaffen Sattel to point 1508 gives a good impression of the Mesozoic schists separating the higher Pretul nappe from the deeper Wechsel unit. The quartzites from a west dipping syncline with a core of grey, blue-grey and white marbles and limestones. So far, fossils have not been found here. Therefore, the stratigraphy is based on lithologic correlation only. Between the marbles and the quartzites rauhwackes occur. This fact points to an Early Triassic age of the marbles West of the Pfaffen Sattel the quartzite is underlain by porphyroids. The contact between the Wechsel schists and the quartzites is not exposed, but it seems reasonable to consider the Wechsel phyllites as the stratigraphic base of the quartzite.

Stop 5: Klaffenegg-Graben, Feistritz Valley. Metagabbros, biotite-metagabbro with corundum, spinel and chloritoid.

In the Klaffenegg-Graben, a right tributary of the Feistritz river, between the phyllitic micaschists and the overlying grobgneiss a 500 m north-west striking metagabbro in a thickness of 80 m can be studied in detail. In general, no parallel arrangement of the components in the coarse-grained rocks is visible. The non-altered parts of the metagabbro are composed either of biotite, pale green amphibole, plagioclase (anorthite content 50—60%) or of amphibole and plagioclase. Diopsidic pyroxene occurs rarely. Accessories are quartz, apatite, pyrrhotine and calcopyrite. In some places within the metagabbros corundum and spinel are found as accessories. Decimeter-sized, irregular shaped, pure corundum-spinel rocks containing the above mentioned ore minerals have been found. For the host-rock, we use the name metagabbro because in almost all samples traces of a low grade metamorphism can



Fi. 2. Cross section through the border line Wechsel formation Lower Austro Alpine at the Pfaffen Sattel.

be observed. The gabbroidic types grade into chloriteamphibolites. During metamorphism, the plagioclases have been replaced by sericite and albite or oligoclase. The biotites were leached out and contain irregular patches of iron-titanium oxide as dissolution products. In the altered types, chloritoid seems to be derived from spinel. According to observations on samples of the studied area, the author considers the spinel to be not stable under the conditions of low grade metamorphism. Concerning the origin of the described rock having a very unusual composition, several interpretations are possible. The author believes that these rocks are relics of an anatectic process brought up to higher niveaus by the rising granite (now metamorphosed to grobgneiss). A second proposal is that a gabbroidic magma has assimilated aluminous-rich metasediments. The opinion that these rocks are metamorphosed bauxites is not valid because of the mineralogical and chemical compositions which point to an igneous origin.

Chemical analysis of metagabbro, Klaffenegg-Graben

	I	II
SiO_2	45.55%	47.65%
TiO_2	3.04%	3.50%
Al_2O_3	23.00%	21.65%
Fe_2O_3	1.92%	6.22%
FeO	8.35%	5.70%
MnO	0.17%	0.20%
CaO	6.00%	4.80%
MgO	3.25%	4.00%
Na_2O	0.65%	1.40%
K_2O	3.30%	1.04%
CO_2	1.69%	1.75%
P_2O_5	0.57%	0.15%
H_2O+	1.76%	1.81%
H_2O-	0.11%	0.07%
S	0.61%	0.27%
SO_3	—	0.11%
	99.97%	100.32%

Analyzed by Dr. I. Janda, Bundesversuchs- und Forschungsanstalt Arsenal.

Stop 6: Miesenbachtal, grobgneiss

In Birkfeld we turn to east and enter the Miesenbach valley. In the outer part of the valley quartzitic micaschists are cropping out. Near the farm Schreihofer, grobgneiss is quarried occasionally. Here, the microclines reach a length of 10 cm, their triclinicity varies between 0.8 and 0.9, their albite content averages 15%. Viewed with the naked eye, the plagioclases show parallel orientation to the crystal faces of the microclines. The anorthite content of the plagioclases filled with sericite and clinozoisite microlites is 10—15%. Newly formed albites (anorthite content 0—10%) are free of inclusions. The brown biotites are generally altered to green biotites and contain sagenites. Around small euhedral zirkons, pleochroitic haloes are developed. Almadine as acessory mineral is scattered through the rock. The quartz content amounts to 25%.

The metamorphism of the rock is described in the first part of this paper.

grobgneiss Birkfeld Miesenbachtal		ppm		calculated mineralogical composition:	
SiO_2	69.80%	Sr	150	quartz	29.5 vol. %
TiO_2	0.39%	Ba	700	albite	24.2 vol. %
Al_2O_3	15.90%	V	20	anorthite	7.9 vol. %
Fe_2O_3	1.07%	Pb	20	potassium feldspar	19.0 vol. %
FeO	1.71%	Ni	50	altered biotite	7.6 vol. %
MnO	0.05%	Cr	200	muscovite	11.8 vol. %
CaO	1.81%	Ga	20		
MgO	0.81%	Co	8		
Na_2O	2.74%	Be	4		
K_2O	4.66%				
CO_2	0.12%				
P_2O_5	0.05%				
H_2O+	0.72%				
H_2O-	0.06%				
S	$<$ 0.03%				
	99.92%				

"Leucophyllites" are white glittering phyllitic and quartz-phyllitic rocks occuring as small intercalatons in the grobgneiss bodies, predominantly in their outer parts. A colourless chlorite (leuchtenbergite) belonging to the clinochlore group is a typical mineral of this rock. Muscovite, quartz, microcline, and tourmaline are the other components. The occurence of leucophyllites in this region is correlated with stress zones. The formation of leuchtenbergite has been studied by M. Vendl (1929) in detail and is explained by a metasomatic supply of magnesium.

Stop 7: SchlofferECK, kyanite-quartzite

In a big quarry, a northeast dipping kyanite-quartzite is exploited for road construction. The rock is underlain by an amphibolite con-

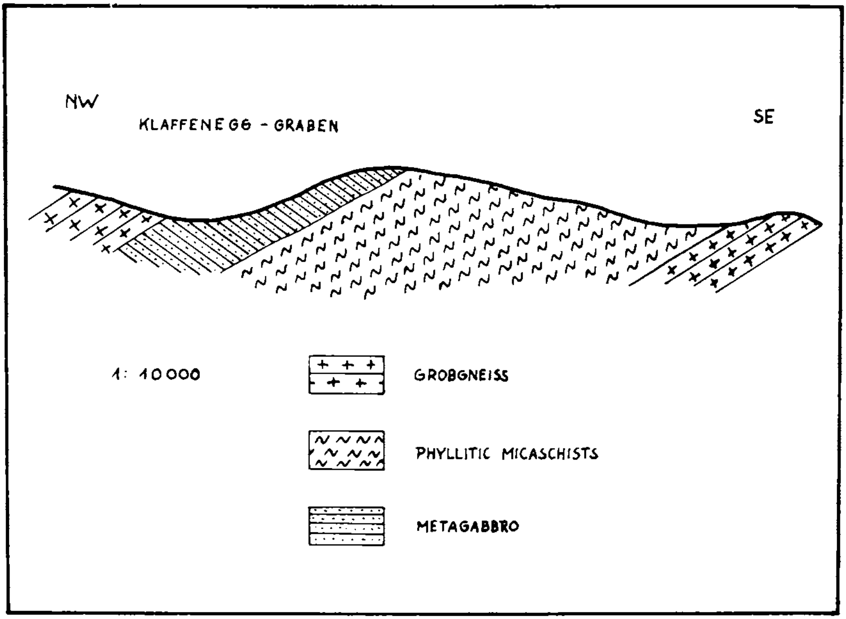


Fig. 3. Cross section through a "metagabbro" and its country rocks along the Klaffenegg Graben.

taining a core of metagabbro. The quartzite is composed of quartz, muscovite, chlorite and varying quantities of kyanite up to 40%. The rock is considered to be the northern continuation of the sericite quartzites of the talc deposit Rabenwald, because rocks of this deposit contain also kyanite of places. This proves that the occurence of kyanite is not caused by metasomatic processes. It is an inheritage of the sedimentary rocks from which the kyanite quartzite originated. In the authors opinion only quartz sands, rich in high aluminous minerals like kaolinite can provide the source material of the quartzites. This means a terrestrial origin of these rocks which were originally sediments derived perhaps from a peneplained landscape deeply weathered under the conditions of kaolin weathering. The kyanite quartzite may be a good marker horizon within the described metamorphics.

Stop 8: Stubenberg, granite quarry

A medium grained granite is exposed in a big quarry in the Feistritz valley near Stubenberg. Pegmatites (lacking generally in the "grobgneiss" association) occur frequently in this rock. A single beryll crystall and amethyst have been described from here by W. Tufar (1961). In this granite, alkalifeldspars, quartz and biotite are recognicable with the naked eye. Microscopic studies reveal that graphic structures predominate. Quantitative mineralogical and chemical composition is given below.

The albite content of the alkalifeldspars averages to 15%. The plagioclases are filled with sericite but nevertheless the anorthite content amounts to 30%. Sphene and small, mostly euhedral garnets are accessories. The amount of garnets surpasses the quantity of zirkon by several times. Though the rock has suffered alteration, the granitic texture is completely preserved. From this fact arose the suspicion that the granite of Stubenberg is emplaced after the Alpine orogenesis. The Bundesanstalt für Bodenforschung, Hannover, Germany, has provided an absolute age determination according to the potassium-argon method. The analyses have been performed on a pegmatite muscovite from the quarry. Preparation has been done by Dr. G. Müller, analytical work by Dr. W. Harre. The potassium argon age has been found to be 153×10^6 y., which corresponds to a Jurassic age. But dating after the potassium argon method needs a careful interpretation because in general the data correspond to the last metamorphism and the

Chemical analyses of Stubenberg granite

SiO_2	72.56%
TiO_2	0.40%
Al_2O_3	15.15%
Fe_2O_3	0.52%
FeO	0.97%
MnO	traces
CaO	0.28%
MgO	0.37%
K_2O	4.54%
Na_2O	3.25%
H_2O-	0.31%
H_2O+	1.68%
CO_2	0.02%
P_2O_5	0.04%
Ges.-S.	0
BaO	0.01%
Cr_2O_3	traces
V_2O_3	0
ZrO_2	0.05%
Cl	traces
	100.15%

calculated mineralogical composition:

quartz	31.3 vol. %
albite	32.6 vol. %
anorthite	2.0 vol. %
potassium feldspar	12.0 vol. %
muscovite	16.5 vol. %
biotite	5.6 vol .%

Analyzed by Dr. W. PRODINGER, Geologische Bundesanstalt, Vienna actual rock ages are higher. Therefore we think that the emplacement took place before the Alpine orogenesis, probably in Upper Carboniferous.

Talc and actinolite schists have been found in the deepest part of the quarry. The mode of occurence of these interesting rocks is not known.

Stop 9: Rabenwald, talc deposit

The largest talc deposit of Austria is situated at Rabenwald. O. M. Friedrich (1947) studied in detail the geology of the deposit and presented a map of its vicinity. The tectonic structure is unusually complicated. Detailed mapping is difficult because outcrops are rare. According to the general geologic situation, the mines are located near the boundary of the Semmering-Wechsel window. Therefore it is to be expected that the "grobgneiss" formation is overthust by the higher unit (Muralpen). But, according to the studies of Friedrich, the tectonic situation is reversed in the deposit and in its neighborhood. At the surface, mostly rocks of the grobgneiss formation are exposed, whereas in the mines pegmatites, metasomatic altered marbles, dolomites and gneisses occur which are characteristic for the higher unit. Additional difficulties arise from diaphthoresis which has party obscured the differences of the metamorphic formations. The reversement of the general tectonics in the Rabenwald area is not completely understood and might be explained to be caused additional tectonic compliations (schuppen structures).

The most striking rocks of the Rabenwald area are sericite quartzites grading into leucophyllites which have already been described at stop 6. These rocks are called by the miners "Kornstein". The mineralogical composition of these rocks uniform: quartz, muscovite and leuchtenbergite are regular components, kyanite, microcline, turmaline and apatite occur occasionally. In the opinion of the author the "Kornsteins" are of different origin. Partly they are derived from sandstones partly they are formed from granitoids by the combined action of stress and metasomatism. But as the quartzites have suffered deformation and metasomatic alteration too, it is cumbersome to trace the origin of these rocks and in cases it is impossible to do that.

In the mines, the "Kornsteins" are in close connection with the talc schists. According to M. O. Friedrich (1947) the metasomatic transformation of marbles, dolomites, gneisses and pegmatites to talc-schists is bound to the overthrust plane. Big crystals of tremolite and actinolite, occasionally of apatite are found in the talc schists. O. M. Friedrich (1947) supposes that the occurence of lazulithe in the Semmering quartzite of Fischbach (H. Meixner, 1937) and of big crystals of apatite in the talc schist can be explained by an regional supply of phosphoric acid during metasomatism. It seems to the author that it is possible to explain this process by lateral segregation too. Kyanite, rutile, zirkone occur in the "Kornsteine" and also in talc schists in microscopic size. Magnesite and breunerite porphyroblasts in the talc schists are weathered to limonite. The limonite-filled cavities are called in the miners language "Wurm".

H. Heritsch (1967) states that the chemical equilibrum during crystallisation of talc was reached in different parts of the deposit, with reference to available experimental datas. He estimates the temperature during the formation of the deposit as 450—500° C, perhaps 550 C. This is in accordance with the facts of the Alpine metamorphism in this area.

The talc schists occur in 3 flat lying undulated layers, thickening and thinning out. Parts of extremely deformed folds are forming cylindric rock masses of a diameter of 1—2 m, representing the B-axes of the system.

Stop 10: Wechsel road, south of Mönichkirchen, albite gneiss.

In a quarry the uniform albite gneiss can be studied in detail. Cross-cutting quartz dikes can be seen and are characteristic for the albite gneiss area. The medium grained albite gneiss contains variable quantities of albite, muscovite, chlorite and quartz. The chlorite is Fe-rich ($n = 1.61$, angel of optical axis 15°, birefrigence very low). Accessories are sphene and apatite. Some remarks concerning this rock have been made in the first part of this paper.

The chemical composition and the calculated mineralogical composition is given below:

Concerning the genesis of this rock there are two possible ways of explanation: The rock may have originated from tuffites. Another possible explanation is a strong sodium metasomatism influencing phyllitic mica schists during the Alpine orogenesis. The occurence of greenschists in small layers within the albite gneiss seems to point to a basic initial volcanism during a geosyncline sedimentation. However, if the high albite content derives from a basic volcanic rock, the low Ca-content as shown by the analysis is hardly to explain. Moreover, there is also another serious objection against the metatuffite-hypothesis. Alrealy H. Mohr (1912) has presented some facts from which is becomes probable that the green schists are diaphthorites derived from amphibolites.

SiO_2	70.37%	quartz	39.3 vol. %
TiO_2	0.61%	albite	41.1 vol. %
Al_2O_3	14.45%	muscovite	8.6 vol. %
Fe_2O_3	1.91%	chlorite	9.7 vol. %
FeO	2.23%	anorthite	0.8 vol. %
MnO	traces	rutile	0.4 vol. %
CaO	0.33%	apatite	0.1 vol. %
MgO	1.53%		
K_2O	0.98%		
Na_2O	4.56%		
H_2O-	0.29%		
H_2O+	2.04%		
CO_2	0.04%		
P_2O_5	0.05%		
Ges. S	0.02%		
BaO	0.02%		
Cr_2O_3	traces		
V_2O_3	traces		
ZrO_2	0.06%		
Cl	0.03%		
	99.52%		
— O f. Cl	0.01%		
	99.51%		
s = 2.71			

Analyzed by Dr. PRODINGER, Geologische Bundesanstalt, Vienna.

Stop 11: Ausschlag-Zöbern, "Weißerde"

Near Aspang on the eastern boundary of the Wechsel unit, a striking occurrence of "leucophyllite" or "Weißerde" has been described by G. Starkl (1883) for the first time. Since many decades the material is exploited and used as fill in paper manufacturing and for other industrial purposes. The sequence from base to top (eastwest) is described by P. Wieden, 1958. The deepest part of the sequence consists of Semmering quartzite and is underlain by phyllitic mica schists of the "grobgneiss" formation.

The "Weißerde" occurs between the quartzite and bluegreen phyllites. The deposit orientated is north-south, following the eastern boundary of the Wechsel unit. The contact of the phyllites and the albite gneisses is not exposed. The "Weißerde" consists of sericite and quartz with small quantities of tourmaline, pyrite, chlorite, limonite and psilomelane (P. Wieden, 1958). Quartz is forming lenses of different size up to 50 cm diameter. Though leuchtenbergite, the typical mineral of leucophyllite has not been found untill now in considerable quantities in the deposit, there is little doubt that the "Weißerde" has been formed in the same way than the leucophyllites: that means by the combined action of stress and metasomatic action. Phyllites and Semmering quartzites may have been the source material of the "Weißerde".

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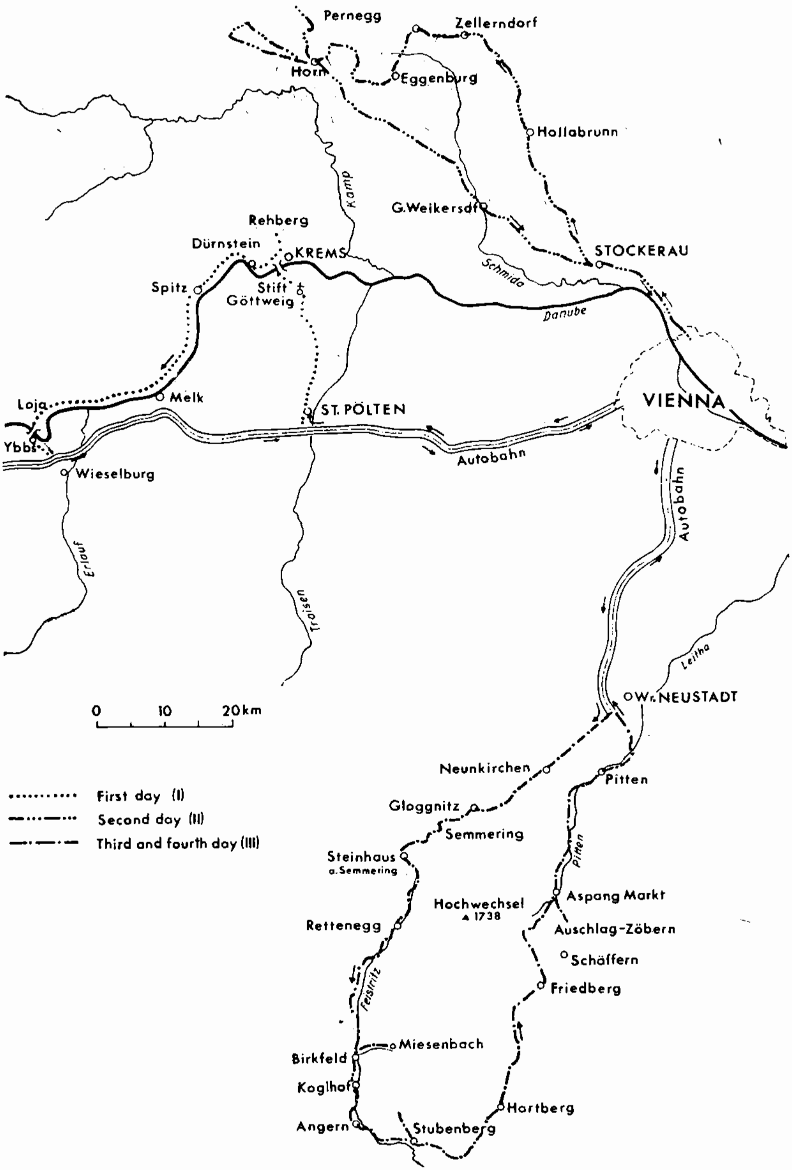
Topographic

Österreichische Karte 1 : 25.000, 104/4, Spital am Semmering.
Österreichische Karte 1 : 50.000, 135, Birkfeld.
Österreichische Karte 1 : 50.000, 105, Neunkirchen.
Sonderausgabe 1 : 25.000, Semmeringgebiet, Freytag & Berndt.


Pernegg
Zellerndorf
Horn
Eggenburg
Hollabrunn
Kamp
G.Weikersdf
Rehberg
Dürnstein
KREMS
STOCKERAU
Spitz
Stift
Göttweig
Schmida
Danube
Melk
Loja
Ybbs
ST. PÖLTEN
VIENNA
Autobahn
Wieselburg
Erlauf
Traisen
Autobahn
Leitha
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Neunkirchen
Pitten
First day (I)
Second day (II)
Third and fourth day (III)
Gloggnitz
Semmering
Steinhaus
a. Semmering
Pitten
Hochwechsel
▲ 1738
Aspang Markt
Rettenegg
Auschlag-Zöbern
Schäffern
Feistritz
Friedberg
Miesenbach
Birkfeld
Koglhof
Hartberg
Angern
Stubenberg