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Geology of Kirchberg am Wechsel and Molz Valley Areas (Semmering Window), Lower Austria

With 1 plate, 18 figures and 2 tables

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Auszug

Diese Publikation behandelt petrographische, petrochemische und strukturelle Studien über die beiden metamorphen Serien im Semmering-Fenster. Besonderes Augenmerk wurde der Wechsel-Serie und ihren Unterteilungen zugewendet. Die Strukturuntersuchung zeigt, daß es zwei deutliche Deformationsachsen gibt, die auf die Schichten einwirkten. Die Achse des größten Drucks auf das Stress-System hat eine annähernde NNE—SSW-Orientierung mit Bewegungen in südliche Richtung. Das Bewegungsbild und der Strain haben monokline Symmetrie. Die petrographischen Untersuchungen haben ergeben, daß metamorphe Differentiation in der Entwicklung der Wechselschieferserie eine große Rolle gespielt haben. Die Art des Ursprungsmaterials, aus dem diese Gesteine unter tiefmetamorphen Bedingungen entstanden sind, wird diskutiert.

Abstract

This paper records petrographical, petrochemical and structural studies carried out on the two low-grade metamorphic series in the Semmering Window. Particular attention has been given to the Wechsel Series and its sub-members. The structural study reveals that there are two distinct axes of deformation with time lapse which have acted on the schists. The largest compressional axis of the stress system has a probable orientation of NNE—SSW with movements of southerly vergence. The movement picture and strain have a monoclinic symmetry. The petrographical studies have shown that the metamorphic differentiation has played a large part in the evolution of the Wechsel schist series. The nature of the original parent material which has given rise to these rocks under the conditions of low-grade metamorphism is also discussed.

Introduction

The area under investigation lies between the Lat. 47° 37' 13' and 47° 39' 30" North and Long. 15° 56' and 16° 01' East, in the Lower Austria (Niederösterreich). It is bounded to the north by the Otterbach and to the south by the Molzbach. This region in general is mountainous, altitude varying from 600 m at Otterbach to 1000 m at the Saurücken ridge.

The two main river valleys which traverse this region are the Otter and the Molz. The floor of the former is covered to certain extent by Tertiary and recent fluviatile sediments. Low-grade metamorphic rocks belonging to two major series, Grob Gneiss serie and Wechsel serie, account for the most of the rocks which comprise the area under study. Some outcrops of Mesozoic limestones are recorded in the northern part of the area.

This work essentially concerns itself to the study of the structure and geology of the two above mentioned series of rocks and in particular deals with the Wechsel serie. The Mesozoic and the Tertiary and the recent sediments are beside the scope of the present study.

The general geological setting of the two above series is that they belong to the Lower East Alpine elements of the Central Alpine zone.

This work is carried out at the Geological Survey of Austria and at the Petrographic Institute of the University of Vienna.

Previous Literature

There are very few detailed recordings of the Wechsel series and the area in general has not been studied in detail till now. The earlier works which deal in general with the regional study of the Semmering Window are from KOBER (1912), and MOHR (1910, 1912). The more recent investigations concern with the Grob Gneiss series around St. Jakob (Steiermark) (WIENEDER, 1932, 1960, 1961 and 1962). However, though primarily concerned with the geology around Aspang, it was RICHARZ (1911), who gave the first precise descriptions of the rocks of the region and the interrelationships between them. The first chemical analyses of the rocks are also due to him.

Nomenclature:

The Wechsel schist was first described by BÖHM (1883), who named it as albite gneiss because of the large percentage of albite present in the rock. Latter different workers have given different names in the succeeding works among whom the main were RICHARZ (op. cit.) — Wechsel gneiss; MOHR (1912) — Wechsel schist; and WIESENEDER (1960) — albite gneiss. However, the most commonly accepted nomencluture is that of BÖHM (op. cit.) — albite gneiss. But the author is in preference to call the rock as Wechsel schist (after MOHR), as the rock in general does not fullfill the characteristics required for a rock to be termed as gneiss, and the observed features are more in agreement for the term schist. It is the author's contention that the designation of a rock as a gneiss or schist is more on fabric than on the mineralogical elements (see also WINKLER, p. 210, 1965). Such a designation reflects the character of the schistose or foliated fabric present in it as the

[1]) In this respect, HARKER (p. 203, 1939) has made an attempt to distinguish schistose and foliated fabrics.

most important defining element in the mesoscopic sub-fabric [1]). Moreover, the term gneiss is generally accepted to refer to the rocks belonging to the higher grades of the metamorphic facies, and is to be adopted for

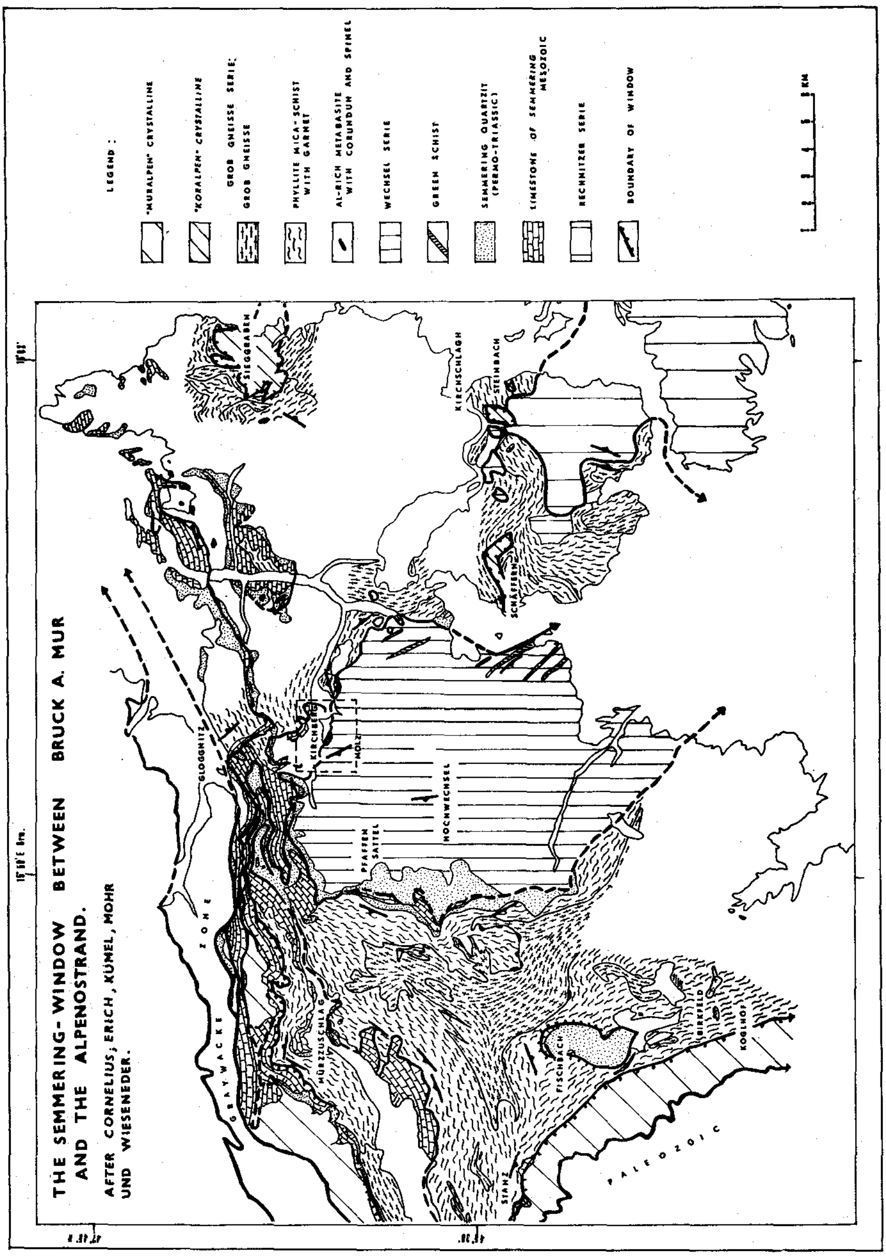

Fig. 1. Geological map of part of the Semmering Window. Outlined the area covered by this paper. After WIESENEDER (1962).

those rocks coarse grained and regularly foliated, showing an absolute preponderance of equant and stubby minerals, like quartz and feldspar, conjugated in thick well marked bands, which characterizes the development and emphasis of foliation.

The rock unit exposed in the Molz valley has well developed schistosity and belongs to the greenschist facies. The segregation layering is present only locally in certain instances, and can not be recognized as a general feature. All these further affirm the author's contention to name the rocks as Wechsel schist rather than as albite gneiss, and this nomenclature is more in agreement with the observed data.

The Grob Gneiss serie generally seems to enclose the Wechsel serie in the Semmering Window (fig. 1). It was formerly designated as Northern System (RICHARZ, op. cit.) but subsequently has been changed to Kern series after MOHR's map (1912). The Kern series comprises a suite of rocks consisting of mica and garnet-mica schists intruded by a granite, hornblende schist and garnet amphibolites. These different members of the series are not deliniated in the MOHR's map. After the studies of WIESENEDER (1960, 1961 and 1962) the meta-granite with the enclosing country rocks have been made into a separate entity called the Grob Gneiss serie. The granite itself is termed Grob Gneiss because it shows the effects of the alpine epimetamorphism. The author favours the terminology of WIESENEDER of calling these granitic rocks as meta-granite as these rocks are massive in nature, are non-foliated and the effects of the metamorphism are only related to the indirect components. The granite is regarded probably as the result of an anatectic process and its emplacement is dated as late variscian. The associated metabasites containing corundum and spinel (around St. Jacob) are explained as the resistates of the anatexis (WIESENEDER, 1961, 1962).

The Wechsel serie

Two main rock-types comprise the Wechsel serie domain in the Semmering Window. They are the Wechsel schist and several kinds of phyllites (quartz and graphitic phyllites). In the Molz valley only the schist is exposed. It shows local and structural and petrological variations. In general the rocks has well developed schistosity but also occasionally shows segregation layering of light minerals (quartz and albite). This segregation layering imparts a foliated character. The relative amounts of the minerals present also show marked variations — the more pronounced the segregation the more is the percentage of albite in the rock. MURTY & RAMAM (1966) have defined albite-poor, albite-rich and quartz-albite-chlorite-muscovite schists according to the varying amounts of the minerals present in the rocks. These variations are, however, not recorded in the map as they lack lateral continuity and have no utility in evaluation of the stratigraphic sequence, either. However these variations could be regarded as proof of the important role played by the metamorphic differentiation in the evo-

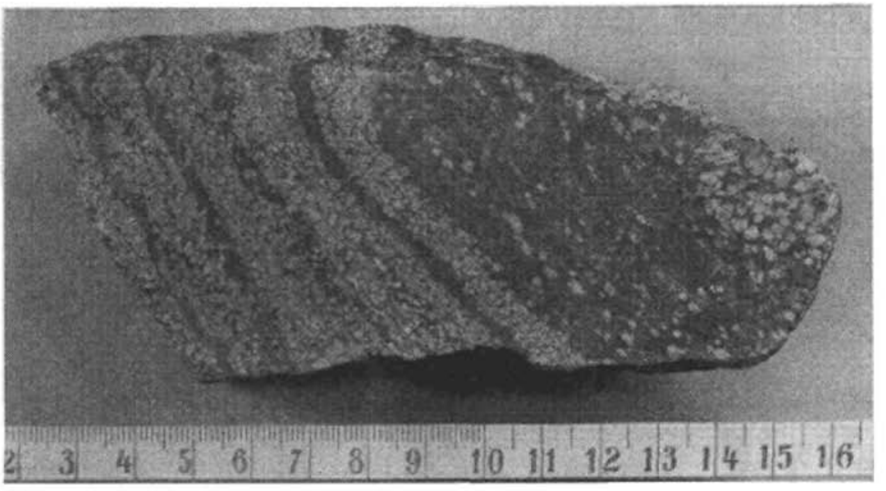

Fig. 2. Banded albite-rich schist (Wechsel schist serie). Individualization of quartz-albite layers due to the metamorphic differentiation (Saurücken, N.-Ö.).

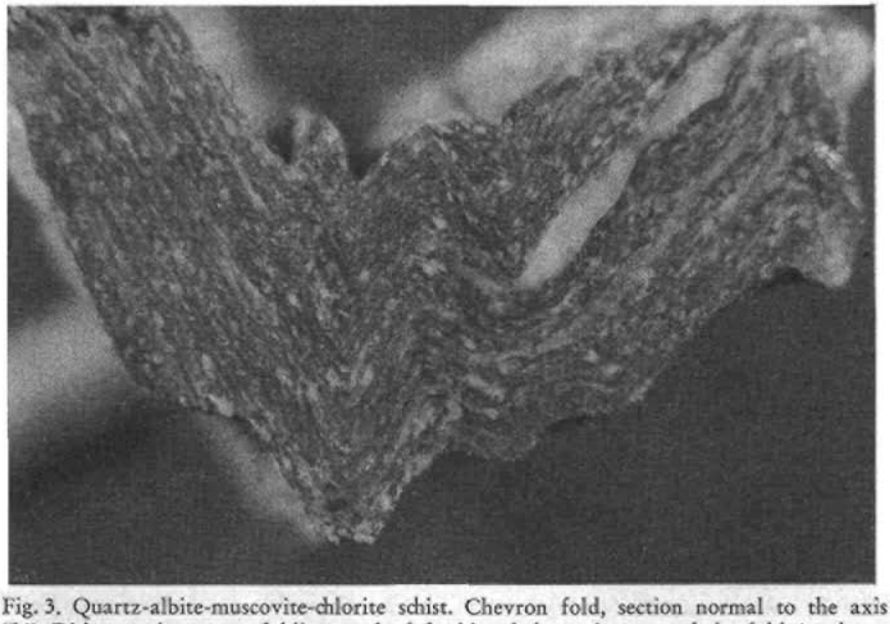

Fig. 3. Quartz-albite-muscovite-chlorite schist. Chevron fold, section normal to the axis "b". Disharmonic reverse folding at the left side of the main crest of the fold (explanation in the text) (Koglbauer, Molz valley, N.-Ö.).

lution of the Wechsel schist. Fabrics like that of the fig. 2, are a direct evidence of such differentiation on such a large scale. It also produced the fine separations of the quartz-albite layers and the micaceous layers. But the dominant fabric is that of the fig. 3, and this belongs to the sub-domain of quartz-albite-muscovite-chlorite schist, which has a fairly uniform composition and is exposed over a widespread area.

Petrography:

The Wechsel schist is a fine to medium grained, well schistose rock, locally exhibiting a coarser granulation due to the segregation layering of light minerals. The colour varies from light to dark green with eye-shaped albites along the s-planes. Quartz trains are common and the boudin-like appearance marks a well defined lineation. Mesofolding of the schistosities, with local development of latter cleavage, can also be seen especially near the stronger tectonic zones. The structural features are discussed elsewhere.

Albite is the typical mineral of the schist occuring as ballshaped porphyroblasts and are generally full of inclusions. They are, however, fresh and are unaltered. Untwinned and the single twinned grains outnumber the twinned by 10 : 1. The twinning is on the albite law and the lamellae do not run through the whole grain in certain cases. The anorthite content never exceeds 6% and the average is around 5%. Most of the porphyroblasts contain an impressive set of si-inclusions of muscovite, chlorite, quartz and graphite, which belong to the se-matrix. Due to this sieve structure the albite grains appear like poikiloblasts. In general the primary inclusions [2]) do not show any recognizable orientation to the space lattice of the porphyroblast itself. It is only a coincidence when the $\{001\}$ planes of muscovite are very nearly parallel to the $\{001\}$ or $\{010\}$ of the enclosing albite.

In most of the sections studied, it was possible to detect detrital feldspar which has an irregular shape. These show polysynthetic twinning with lamellae fading out and the anorthite content is around 13—15%. The presence of detrital feldspar is however difficult to discern as the grains are rather fine grained. But high magnification enables one to resolve them from the matrix consisting of the quartz and the porphyroblastic feldspar. Such feldspar are also reported from the rocks in Trattenbach region associated with detrital muscovite (MURTY & RAMAM, op. cit.).

Granulated quartz is abundant and shows wavy extinction. It occurs in the matrix and as lens shaped elongated aggregates with mosaic texture and interlocking saw-teethed boundaries, surrounded by the se-planes. These lenses, looking like augens, have been dragged out in the direction of the planar fabric, which is adjusted to them. The large porphyroblasts are sometimes surrounded by the granular quartz grains and also by the fragmentary albite grains derived from the porphyroblasts themselves. These cataclastic features are the imprints of a latter deformation which has affected the rocks.

The planar discontinuities which pervade the rocks are defined by the flaky minerals — muscovite and chlorite. Muscovite is colourless and shows high interference colours. It is coarsely crystalline and isobiaxial ($2\ V_X =$

[2]) This expression is used here to distinguish such inclusions from that ones of latter orogin formed by alteration of the enclosing feldspar.

20^0 to 40^0). The elongated flakes and the $\{001\}$ cleavages are parallel to the s-planes. The planar trends of muscovite and chlorite are well fitted to the porphyroblasts and show very often effects caused by the rotation of the porphyroblast. Parallel orientation of the micaceous minerals is therefore less developed in sections normal to the b-lineations. Some of the small muscovite grains observed could be detrital in nature. Chlorite tends to localise in patches or along side of the muscovites in the s-planes. The mineral is colourless to green, pleochroic from light green to dark green, interference colours are purple and brown and in some flakes Berlin blue. The $2\ V_Z$ ranges between 30° and 40°, and it is regarded as peninne as also supposed by RICHARZ (op. cit.).

Epidote is not an important mineral in the rocks of Molz valley though MURTY & RAMAM (1966) have described the mineral from Trattenbach as having inclusions of muscovite and chlorite. The minor constituents are the tourmaline (zoned basal sections), graphite (films paralleling the s-planes), zircon and apatite (detritals), pyrite, siderite and calcite.

Porphyroblastic Domains:

The most predominant characteristic of the Wechsel schist is the disposition of the porphyroblastic albite (white augen-spots in the mesoscopic sub-fabric and untwinned, unaltered grains with inclusions in the microscopic domain). Such crystalloblasts constitute a microscopic domain, within which there is an internal sub-fabric defined by inclusions of quartz, muscovite, chlorite and graphite. These inclusions define an early set of internal s-planes (si in SANDER's terminology) that can be matched in time with the external s-planes (se) of the enclosing matrix. The growth of the porphyroblasts can not be older than the s-planes. The refraction of se-planes around the porphyroblasts is the shouldring aside effect of deformation latter than the porphyroblastic growth. The geometric relations between si and se together with the general fabric of the rock allow some inferences concerning the deformation-times which had effected the fabric:

1. S-shaped and/or spiral trends of si (here mainly graphite and muscovite) within albite indicate a rotation of the porphyroblasts during its development (syntectonic crystallization), as it has been pointed by WIESENEDER (1962).

2. A closer examination of the sections reveals that the crystallization-deformation time-relationship is not so easy to be stated because the curved trending of si does not merge without breaking into the trend of similar lines of se. There is a sharp change in the trend of se at the boundaries betweeen the porphyroblasts and the matrix as well as the porphyroblasts which contain themselves si-inclusions (fig. 4). There are several features related to the subsequent rotation and deformation (post-crystalline) which are observed. These are the desintegration of albite porphyroblasts, granulation and undulose extinction in quartz grains, phenomena similar to a micro-boudinage among albite porphyroblasts with cataclasis and plastic

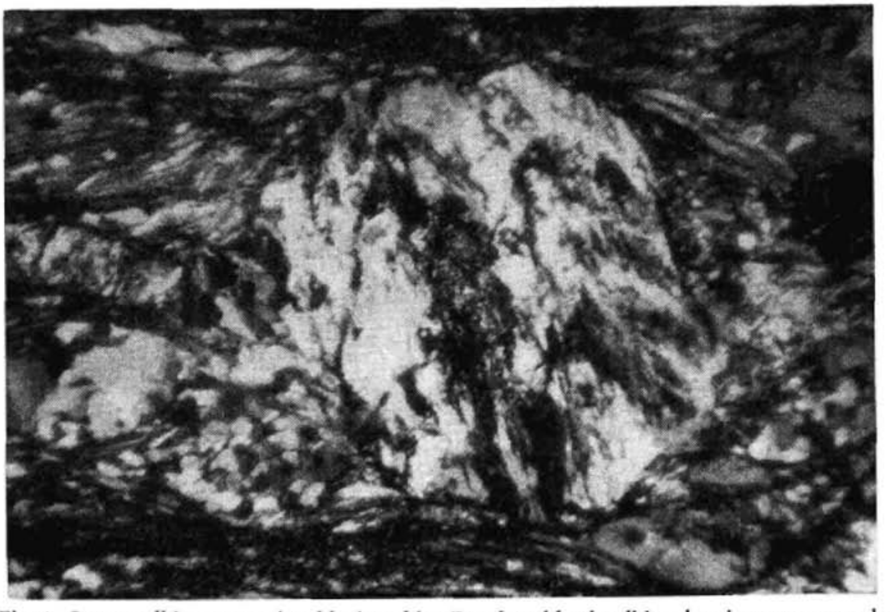

Fig. 4. Quartz-albite-muscovite-chlorite schist. Porphyroblastic albite showing post-crystalline rotation. Inclusions are mainly of graphite. Section parallel to N-S, L1-lineation (Fuchsloch, N.-Ö.).

flowage of the incompetent matrix. These above mentioned features are not feasibly explained if only para-crystalline deformation is present, as stated by earlier workers. It is possible to see that two distinct stages of deformation, with a timelapse, have been exerced on the Wechsel schist leaving their imprint on the porphyroblasts as well as on the whole fabric. The latter rotation have completely oblitered almost all the features of the earlier rotations. So arises a well marked post-crystalline rotation whose effects are better seen in sections parallel to the N-S axis, indicating that this rotation has evolved around an E-W axis. This is in conformity with the mesoscopic observations concerning the two different trends of linear structures.

The cataclasis was so intense that the schist had been transformed into a phyllonite devoid of albite porphyroblasts, which are visible in the schist fabric. Phyllonitic fabrics are best developed in the vicinity of the faults. Most of the vestiges of post-crystalline deformation have been described by RICHARZ (p. 318, op. cit.).

Petrochemistry:

The Wechsel schist is a quartz-albite-muscovite-chlorite-(epidote) schist according to the assemblage of rock-forming minerals. The mineralogical composition and the characteristics displayed by some of its crytical minerals viz., the extreme low content in An present in albite, the nature of muscovite (2 M polymorph), allied to the conspicuous absence of biotite and presence of the albite + epidote pair (WINKLER, p. 76, op. cit.) make this rock-type to be well fitted to the Barrovian Greenschist facies (quartz-albite-muscovite-chlorite subfacies). Chemical analyses of two rock-specimens from the Molz valley region (table I) have been recalculated to be plotted on ACF and A'KF diagrams, illustrated in the fig. 5.

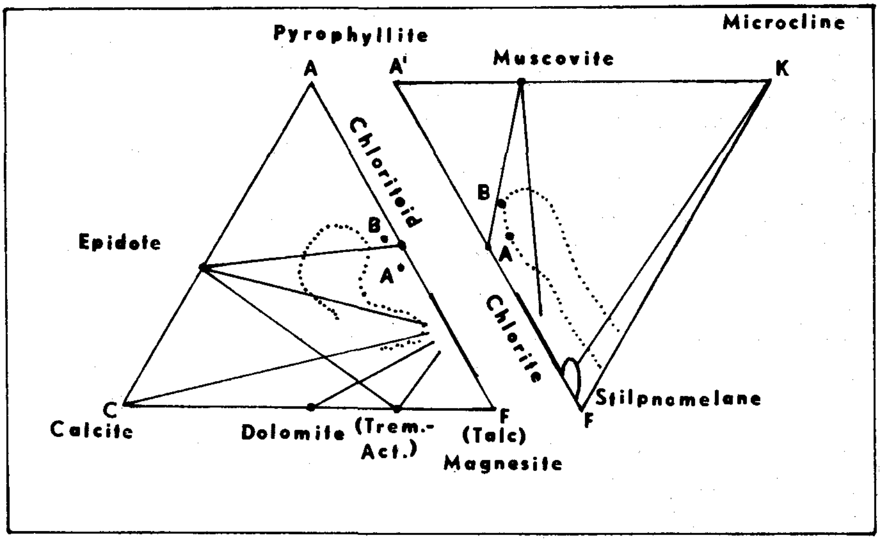

Fig. 5. Quartz-albite-muscovite-chlorite subfacies of the greenschist. Points A and B refer to the analyses of the table I. Outlined the field defined by graywacke analyses (cf. WINKLER, fig. 8, 1965). Quartz and albite are present in the paragenesis. (After WINKLER, p. 78, 1965.)

With exception of the alkalies, all the other components do not show any appreciable variation in the two chemical analyses presented here. The alkali content is variable throughout the domain of the Wechsel schist and it is the cause for the varying amounts of albite recorded in the different members of the series (cf. MURTY & RAMAM, op. cit.). The ratio FeO/MgO is more or less constant and the Al_2O_3 is equally high in both samples. This prevents the formation of stilpnomelane (stilpnomelane was not detected in thin sections though it was earlier reported by some authors). But chloritoid is a possible phase to be found in the rocks since K_2O is generally low. However, this mineral was not observed in any section. It is possible that the necessary conditions to its formation were not attained. Perhaps it requires higher temperatures or special pressure conditions then those for the usual greenschist facies (BARTH, p. 315, 1962). Absence of calcite and dolomite point out that P_{CO_2} was insufficient for the development of such minerals.

By comparing the positions of the Wechsel schist's analyses on the ACF and A'KF diagrams one can see that the plotted points fall very near the field defined by graywacke analyses (cf. WINKLER, fig. 8, op. cit.). Spectrochemical investigations presented by MURTY & RAMAM (table 1) also point towards the same conclusions in regard to the parent sedimentary material, from which the Wechsel schist was derived. The presence of detrital plagioclase with An_{15} in the schists of the Molz region and the phyllites and schists of Trattenbach is suggestive that the original sediment was a feldspar-rich and it could be a feldspathic graywacke. The albite porphyroblasts and the segregated quartz layers (with albite) are not considered to indicate a derivation from a magmatic source nor an ortho-nature of the original material. The porphyroblasts can be regarded as a resulting from the local migration of material derived intraformationally from the detrital plagioclase present in the sedimentary material, and not as a proof of introduction of soda. Albite porphyroblasts are a common feature in nonmetassomatic derivatives of graywackes (TURNER, p. 116, 1948), and along with the quartz layers are to be regarded as the most familiar resultants of metamorphic differentiation — endogenous secretion during metamorphism (TURNER & VERHOOGEN, p. 583, 1960).

Table I

Chemical Analyses			Spectrochemical analyses + (ppm)			
	A %	B %		S-83	S-21	R 612
SiO_2	70.37	71.53	K (%)	3.20	3.70	1.80
TiO_2	.61	1.09	Rb	120	170	60
Al_2C_3	14.45	14.24	Ca (%)	2.80	2.18	3.00
Fe_2O_3	1.91	2.21	Sr	180	100	176
FeO	2.23	2.59	Ti	5600	6700	5600
MgO	1.53	1.74	Mn	200	150	120
CaO	.33	.54	Cr	60	50	32
MnO	tr	tr	Ni	23	16	16
K_2O	.98	1.97	Co	18	10	12
Na_2O	4.56	1.30	V	13	38	9
H_2O-	.29	2.31	Zr	42	120	80
H_2O+	2.04		Ba	900	300	280
CO_2	.04	—	Cu	42	42	65
P_2O_5	.05	—	Sc	12	—	4
S	.02	—	Y	15	15	45
BaO	.02	—				
Cr_2O_3	tr	—				
V_2O_3	tr	—				
ZrO_2	.06	—				
Cl—	.03	—				
	99.52	99.52				

A = Wechsel schist, Waldbach, Molz valley (NÖ). Laboratory of the Geological Survey of Austria, 1966.

B = Wechsel schist, Molz valley (NÖ), after RICHARZ (1911) + after MURTY & RAMAM (1966), from the area around Trattenbach:

S-83 = Quartz-albite-muscovite schist, between Pfaffen and Ochsenhof.

S-21 = Albite schist — Trattenbach (NÖ).

R-612 = Albite schist — Trattenbach, near the post-office (NÖ).

As ESKOLA (1932) has pointed out, the high solubility of quartz and albite is the main factor that facilitates segregation of these minerals in layers and veins. In fact, albite and quartz are very susceptible to be readily dissolved and redeposited, to be segregated in veins or layers in the conditions of low-grade metamorphism. Also it is possible for albite to have attained the porphyroblastic shape under the conditions of the low-grade metamorphism by means of concretionary growth. The primary source for the development of porphyroblastic albite (An_5) were the detrital plagioclasis (An_{15}), which became unstable under the operating metamorphism and underwent solution conducting to the further redeposition and enrichment in the stable minerals albite + epidote. Some lime might also be removed by the circulating solutions. This can explain the very low content in CaO.

Along with the chemical factors, deformation has also played an important role throughout the whole process. The indirect and direct componental movements have acted synchronously. The former facilitates the transport of the material by solution and further redeposition, and the latter the stress. The shearing stress created pressure gradients. The high pressure zones were the sources where the unstable material went into solution, and the low pressure zones functioned as receptacles for the material that was being redeposited. The differences between rock and open fissures and voids may also account (together with solution and redeposition) for the segregation and formation of quartz-rods and boudins-like quartz trains.

Since these linear elements are parallel to the N-S mesoscopic fold axes, they may be regarded as syngenetic lineations (L_1) with the cylindrical folds (chevron). These are produced by flexural-slip mechanism on the planes of schistosity which had been developed parallel to the surfaces of shear. Schistosity planes became the main channels by which the solutions percolated as it witnessed by the presence of both quartz layers (with or without albite) and by the porphyroblastic albite studding such planes.

Mesoscopic Structural Analysis

Penetrative Elements:

Schistosity (S_1 and S_2) is the most important penetrative structure recognized. In the Wechsel schist these represent a pervasive system of a family of statistically defined parallel or sub-parallel surfaces. Another important planar element regarded as penetrative is a late strain-slip cleavage (S_X). The non-penetrative discontinuities can be divided into two groups, as per scale of observation (the domain amplitude). All the faults are categorized under major, macroscopically non-penetrative features, since they bound unlike domains (the Wechsel and the Grob Gneiss series); the minor, meso and microscopically non-penetrative planes are the kink zones affecting the folds.

The penetrative linear elements are: a) the lines of intersection of planar elements (S_1, S_2 and S_X); b) regular mesofolding of S_1 penetrative plane, defining fold axes **B**, and c) elongated domains of boudin-like quartz trains. Quartz-rods, which are present only locally, are the linear non-penetrative features.

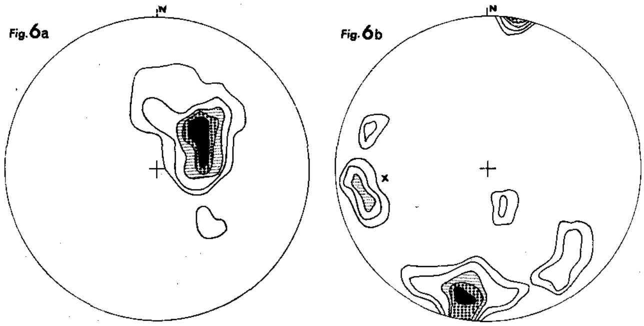

Fig. 6. Structural data from the Molz region. Quartz-albite-muscovite-chlorite schist. a) 50 poles to the schistosities S_1 and S_2. Contours, 20%, 15%, 10%, 5%, 1%, per 1% area. b) 40 lineations. X are L_2-lineations (see text). Contours, 30%, 20%, 12%, 4%, 1%, per 1% area. Molz valley. Lower Austria.

Schistosity:

The Wechsel schist as exposed in the Molz valley and adjacent regions, has as the most conspicuous element in the mesoscopic subfabric two sets of sub-parallel s-planes. The spatial behavior is NNW-SSE tending to NNE-SSW, and dipping towards W (Fig. 6 a). After HARKER (p. 203, op. cit.) these planes are considered to represent true schistosity rather than foliation. These s-planes are analogous with the slaty-cleavage, distinguished only by the larger size of the component minerals but resulting from the same process. The S_1 and S_2-planes are defined by a state of preferred orientation due to the external shape of the recrystallized flaky minerals — sub-parallel disposition of $\{001\}$ planes of muscovite and chlorite. A general feature is the presence of graphitic films along them, imparting a blackish luster to the schistosity surfaces.

The schistosity extends through all the layers that build up the rock, and there appears to be very little variation in the perfection of it. The few excriptions noticed are in reponse to local lithologic changes due to segregation layering. The bedding was totally obliterated by the recrystallization of the minerals, and it is not observed in the Molz region. Such planar elements are developed parallel to the surfaces of shear. The slipping along them, which followed subsequently gave rise to a rock that looks like (in cross section) as a „augen-schist". This rock consists of white albitic spots („Feinkörniger albit", BÖHM, op. cit.), and boudins-shape mesoscopic quartz trains, with the matrix surrounding them. There is ample evidence to suppose that these features are mostly due to the process of deformation synchronously with the lowgrade metamorphic recrystallization. All the mesoscopic features and the rotated albite porphyroblasts bear witness to the microslipping on such planes. Furthermore, such could not be considered as fractures but only as slip-planes (HILLS, p. 290, 1963) since the plastic deformation has not destroyed the coherence of the rock.

The schistosity shows widespread evidence of mesofolding and associated corrugation is observed on the microscopic scale. The folding is of the type angular (chevron) produced by flexural-slip.

Metamorphic Segregation Layering:

Certain structures which could be mistaken for original relict bedding are observed at some locals. These are the quartz layers (more than 2 cm) and laminae (less than 2 cm thick) sometimes with albite Fig. 2). Such structures are always parallel to the „ab"-plane of the mesocopic fabric, and are considered to be of metamorphic origin. The parallelism of such layers to the latter strain-slip planes was never observed.

The alternation of these layers with the micaceous layers reflects the inhomogenity in the development of schistosity. The author believe that the original pre-metamorphosed rock was a non-layered one and the present banding was controled by the S_1 and S_2-planes of metamorphic origin. The individual layers on a close examination are a rather discontinuous lenses. These when involved in a folding process show a neat inhomogeinity.

Strain-slipcleavage:

Strongly developed strain-slip cleavage (S_X) appears to be restricted to a narrow zone at the northern boundary of the Wechsel schist paralleling, and in all probability related to the Kreuzbauern-Wilhelmshof upthrust. Such S_X-planes are surfaces of transposition dislocating the S_1 and S_2-planes. They are mechanically induced and independent of any planar orientation of muscovite and other minerals, which are present in the schist. The development of strain-slip cleavage shows closely spaced (0.5 cm) narrow slip-zones, in which the schistosity is seen to fold in the vicinity of the slip-planes.

Fig. 7. Phyllonitic quartz-albite-muscovite-chlorite schist. S_1 folded with the strain-slip cleavage (S_X) parallel to the axial surfaces of the folds. North of Fuchsloch, Molz valley. Lower Austria (section normal to "b"-axis).

They define sliced domains compressed between and extended parallel to the slip-planes (Fig. 7) — these are the so called microlithons (DE SITTER, p. 97, 1956). These features show that movement (transposition) of S_1 between the slips was strong enough to produce folds ($B_{S1}/_{SX}$), whose style is completely different from that of chevron folds. The folds with cleavage are formed by slip-folding process (fracture-cleavage folding, DE SITTER, p. 185, op. cit.).

The development of S_X-planes has produced a preferrential parting-planes parallel to them, which show a silver shadow surface luster. Very often (near the upthrust) the S_X-planes are so closely spaced that they could be mistaken for S_1-planes. In this zone the schist becomes a real phyllonite due to the intense shearing produced by the faulting. The strain-slip cleavage always cut the older planes (schistosity). However, they die out without any refraction when they came across a competent quartz layer.

The S_1- and S_X-planes are easily identified. The S_X-planes, however, tend to dominate towards the fault zone and elsewhere in the region are weakly developed. Their presence in such places are only due to the local disturbances accompanying the upthrust. The following criteria are offered to enable one to classify the S_1 and S_X with certain limitations: strain-slip cleavage is always unrelated to chevron folds: graphit is never present on these planes and; the orientation (strike ESE-WNW, and dip towards S, is in antithetic relation with the upthrust which dips towards NNE) is in complete divergence to the schistosity S_1. This last criterion should never be used alone The S_1- and S_2-planes of the region in general have parallel quartz layers or laminae and cleave in graphitic dirty surfaces (the rock-parting is parallel to the S_X-planes where present). In the microscopic sub-fabric no preferred mineral orientation with the S_X is seen (present only as kink zones).

Linear Elements:

Uniformly oriented, sub-horizontal lineations are present in the Wechsel schist along the Molz valley. It was possible to distinguish two different trends in the linear elements, each one having its own zone of dominance. The lineations have in general a N-S trend and plunge towards S (5—20°). The mesofold axes B_{S1}, the boudins-like quartz trains, which occur in association with the traces of the intersection of S_1- and S_2-planes and quartz-rods, constitute the different elements of N-S lineations. These are here labelled L_1 to distinguish from the L_2, which symbolize the nearly E-W trend of the latter lineations (Fig. 6 b).

The N-S fold axis B_{S1} is the most important lineation and it defines a chevron style of folding on the planes of schistosity (Fig. 8). The main features of the folds are the very straight limbs and the sharply curved sometimes pointed crests. The axial plane cleavage and the crumpling of the s-planes are lacking. Though the folds are similar in form, a few dishar-

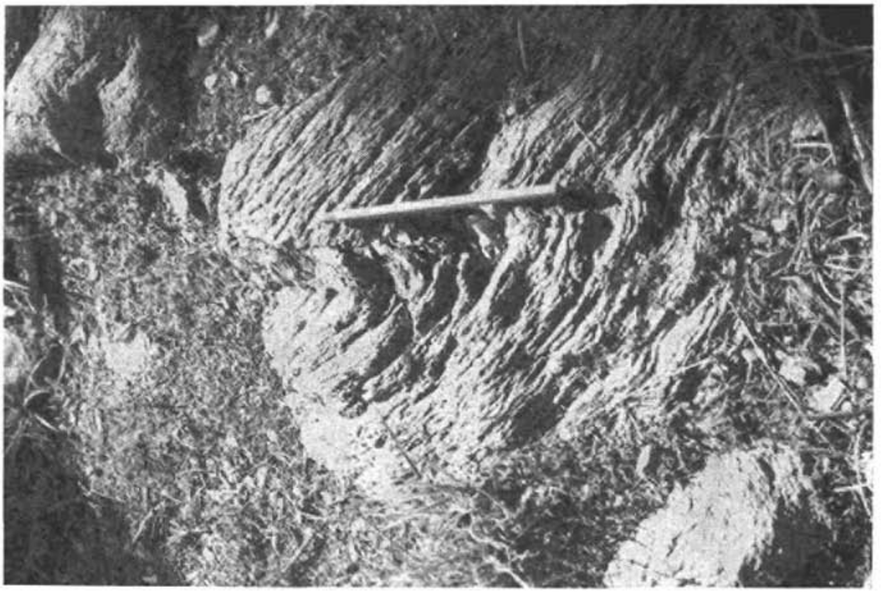

Fig. 8. Synformal and antiformal chevron folds. The pencil parallels the fold axis, which plunges towards south. Qzr = quartz-rods. Saurücken, Lower Austria.

monic features are present at some places. Fig. 3 illustrates a disharmonic pattern where a neat reverse folding is developed in respect to the underlying layers. The thin quartz laminae, as a competent body, has prevented the obliteration of the individual identity of the fold. The porphyroblasts of albite lie with their longest axes (0.2 cm) oriented in the plane of schistosity ("ab") and subparallel to the "a"-axis of the fabric. This pattern of orientation for the porphyroblasts is present elsewhere, too. They are bilaterally asymmetric, plunging normal folds, monoclinic in symmetry and are produced by flexural-slip mechanism.

The quartz trains (Fig. 9) are a very important lineation parallel to the chevron fold axis. Although such structures do not resemble boudins in shape, they are the typical competent elements enclosed in an incompetent rock. The term "competent bed" is not used here because these monomineralic trains were formerly not real beds, as it is possible to observe in undisturbed regions outside the Molz valley. These structures were primarily monomineralic stringes or strips of quartz, which have been formed by the same process responsible for the development of the segregation layering. More or less synchronously with the segregation of the quartz stringes, deformation caused the bulging and the thinning due to stretching. The more mobile host-rock has squeezed on either sides into the spaces so formed. The pinched intersections between the competent segments show incipient recrystallization of quartz.

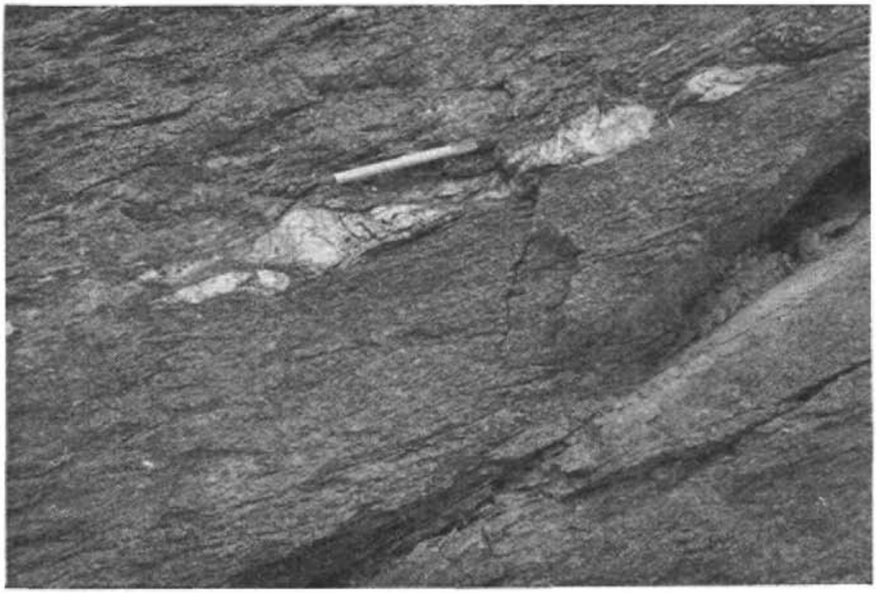

Fig. 9. Boudins-like quartz trains in quartz-albite-muscovite-chlorite schist. Koglbauer, Molz valley, Lower Austria.

Quartz-rods parallel to the chevron fold axis occur only locally near the hinges of certain folds (Fig. 8), and they are not a common linear feature in the region. They belong to the group of the "segregated rods" from the host-rock itself.

Lineations L_2, trending nearly E-W, have a plunge either towards E or W. They are defined by sub-parallel orientation of mesofold axes $B_{S1}/_{SX}$ of the cleavage folds. These fold-types are restricted to a narrow zone bordering the upthrust of Kreuzbauern-Wilhelmshof region, and one of the best places to study them is around Fuchsloch. The prime cause for the formation of these folds are the strain-slip cleavage planes. The schistosity is almost completely obliterated on small scale between the cleavages. These are thin domains of very intense strain. The obliterated schistosity is apressed between the S_X-planes and extended parallel to them, maintaining the same dimensions along the lines paralleling the slip-planes. The hinges are thickened in relation to the limbs (Fig. 7) which are attenuated and slipped out. S_1-planes were clearly the passive elements, which have undergone folding due to a laminar gliding on periodically constant active surface of strain-slip cleavage. When involved in this style of folding the normal schist was transformed to a phyllonite. These folds are bilaterally asymmetric, horizontal inclined and planar cylindrical. The fold symmetry is monoclinic.

The E-W direction for L_2-lineations is also very well observed in the microscopic sub-fabric, where it constitutes an axis of rotation around which the albite porphyroblasts have undergone a post-crystalline rotation.

The Grob Gneiss Serie

A major non-penetrative fault surface demarcates the boundary between the Grob Gneiss serie an the Wechsel schist. This fault runs E-W, through Wilhelmshof and Kreuzbauern and dips more than 50° towards NNE, and it is called here as Kreuzbauern-Wilhelmshof upthrust. From the upper block of this fault, the Grob Gneiss series extends towards the NE corner of the region. The Kreuzbauern area, however, is a very important one for the understanding of the tectonic relations between these series, as it was stated by MOHR (1912). He was the first to recognize the thrust nature of the Grob Gneiss unit against the Wechsel schist. Moreover, the contacts between the former unit and the mesozoic limestones (Semmering Mesozoic) are also tectonic in nature. In this respect another upthrust fault was mapped near St. Wolfgang and it is very probable that this fault continues through Hermannshöhle und Eigenberg.

The Grob Gneiss serie is made up by a meta-granite named Grobgneiss and the enclosing country-rocks — phyllitic mica schists. The latter were observed as feldspathized inclusions (roofs) near Kreuzbauern and around Kirchgraben. Xenoliths are also noted in an old quarry near St. Wolfgang. Fabric variations in the meta-granite occurs along the fault zones. At these zones the deformation caused the metagranite to have a flaser and even gouged fabric. Slickensides are quite common.

Megascopically the meta-granite is a massive, almost porphyritic rock, where 3 cm long pink microcline, quartz, biotite and muscovite may be discerned. The mineralogical composition is similar to WIESENEDER's description (1960) from the Grob Gneiss around St. Jakob, in the western part of the Wechsel region (table II). Microcline is always twinned on Carlsbad law, and vein-perthites are well developed in it. Microcline is, however, altered to sericite. Plagioclase (An_{12-16}) generally shows a core crowded with secondary inclusions of clinozoisite and sericite (the so called "filled" plagioclase). The edges are otherwise clear and unaltered. Twinning is on albite or Manebach laws. The alteration when restricted to the core of the plagioclase points out the zoned nature of it. But "unfilled", unaltered albite (An_{2-6}) where present, shows twin lamellae on albite law. Xenomorphic quartz appears in the annular spaces among the feldspars. Generally it is granular and show undulose extinction. In the flasertype the situation is rather different: the first stage of cataclasis is demonstrated by undulatory extinction in both quartz and feldspar, and also by microshearing and rounding of those minerals by granulation. In the flaser-fabric quartz shows a well-marked preferred orientation of (0001) axes.

The common mafic mineral is brown biotite, often altered to chlorite. Inclusions of zircon and, to less extent, apatite can be present in biotite. Muscovite occurs in small flakes. Both micas are non- oriented in the massive meta-granite, but become strongly so in the flaser-fabric, paralleling the surfaces of slip. Clinozoisite appears only as a secondary inclusion in the plagioclase.

Table II

	A	B
Quartz	35%	33%
Alkalifeldspar	27%	27%
Plagioclase	25%	24%
Biotite	8%	12%
Muscovite	3%	2%
Accessories	2%	2%

A = Massive meta-granite, quarry near St. Wolfgang (NÖ).
B = Grob Gneiss, around St. Jakob (Steiermark), WIESENEDER (1960).

There is a close similarity in the mineralogical compositions of the meta-granite of Kirchberg am Wechsel and the one near St. Jakob. The original character of it may be regarded as a normal granite (WIESENEDER, 1960). "Unfilled" albite, clinozoisite, muscovite and chlorite are clearly of more recent formation, related to the alpine age. The albite (and clinozoisite) is formed from the plagioclase, while chlorite by the retrograde alteration of biotite. It seems that the alpine effects on the granite are characterized by neomineralization, in which the indirect components greatly outweigh the direct. These are expressed in the development of locally strained fabrics, but could not transform the granite as a whole into a real gneiss according to the fabric requirements.

The development of flaser fabrics and zones of gouged rock is directly related to the faulting. The flaser granite retains the nature of the parent

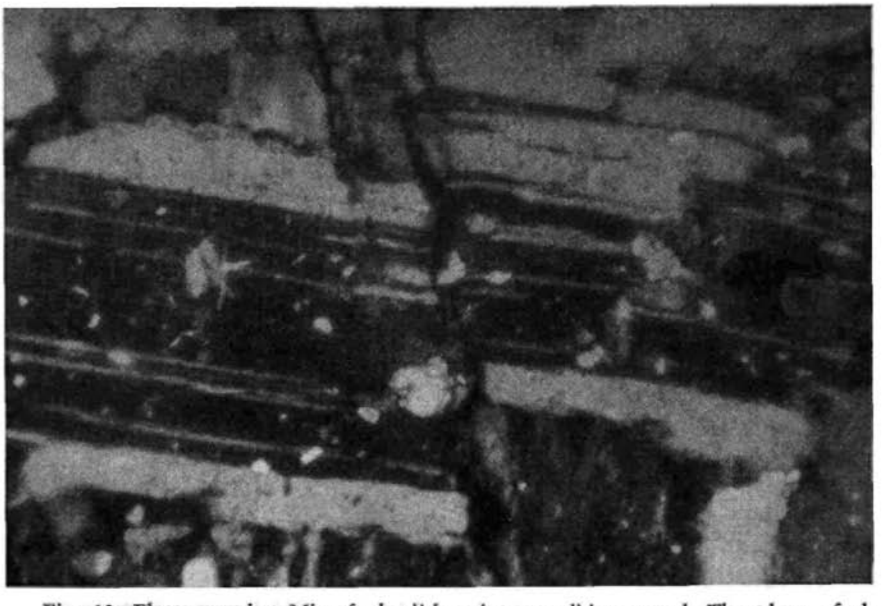

Fig. 10. Flaser granite. Microfault dislocating an albite crystal. The plane of the microfault strikes E-W. (Wilhelmshof, NÖ).

rock, where fine-grained aggregates devoid of clastic structure wander irregularly between the large crushed crystals of feldspar. The latter are frequently dislocated by microfaults paralleling the macroscopic ones. The effects of these penetrative elements can be easily observed by the dislocation of twin lamellae in the crystals (Fig. 10). Development of foliation, in the flaser-fabric, is always parallel to the fault surfaces, and the deformed and disrupted tabular crystals of feldspar are oriented in a b-lineation trending E—W. The two main important zones of flaser-fabric are near Wilhelmshof and south of Kirchgraben. Gouged rock is mostly developed in minor fault planes. It is a greyish and loosely compacted material of very fine granulation, containing sometimes relicts of quartz and feldspar. Slickensides are very common around the fault zones, mainly in the vicinity of St. Wolfgang. They are plenty of striae, which trend 5°—15°, plunging with a high angle. They are parallel to the "a"-axis of the fabric.

Large inclusions (roofs) of phyllitic mica shists showing widespread evidences of feldspathization outcrop around Kreuzbauern and Kirchgraben. This rock is here called as "augen-migmatite". It is a rather foliated rock with numerous eye-shaped porphyroblasts of feldspar. These are well oriented in a conspicuous E—W, b-lineation. The mesoscopic fabric shows two sets of s-planes. S_1 is the older, inherited planar surface already present in the almost unmetamorphosed country-rock, along which the porphyroblasts have grown. S_2 is an imposed foliation and it is related to the thrust movements caused during the faulting. The porphyroblasts bear the effects of the deformation. They show perfect orientation and a post-crystalline rotation around an E—W axis. The sense of rotation as observed is from the NNE towards SSW.

Microcline occurs as porphyroblasts and it is sericitized. The grains are untwinned and perthite-free. Albite from the parent rock (very similar in features with that one of the Wechsel schist) occurs either as inclusions in microcline or as fragments in the matrix. Also frequent are the zoned inclusions of biotite andn muscovite in the porphyroblasts. Quartz in elongated and undulant aggregates parallels the s-planes, showing a strong preferred orientation. Biotite and muscovite define the s-planes. Some epidote is also present along with chlorite, but aluminium silicates, which are common for contact metamorphism, are missing. Quartz and feldspar occur also in the matrix as fragments derived from the breaking up of the coarser grains.

Near Kreuzbauern a sequence of metamorphic changes, starting from the almost non-metamorphosed schist to the meta-granitic body could be followed. First are the fine-grained phyllitic mica schist, well laminated with diminute porphyroblasts (0.3 cm.). Nearer the metagranite the porphyroblasts become more numerous. The increase in size, together with the more pronounced recrystallization of the matrix, causes the rock to be coarser corresponding to the "augen-migmatite". Growth of porphyroblasts of microcline in the country-rocks around the mega-granitic bodies has been reported from several localities (RICHARZ, op. cit.; WIESENEDER, 1960, etc.). Pegmatites are not observed, but a small quartz vein is exposed at Kreuzbauern, cutting in a discordant way the "augen-migmatite".

Development of microcline in porphyroblasts is a very characteristic feature of the enveloping schists which have been affected by K-metasomatism through solutions supplied from the granite. As a matter of fact, feldspathization is a process of metasomatic origin, where the determining factor was the availability of K in the solutions. However, it is unlikely that the feldspar (microcline porphyroblasts) has been built up as a result of a simple molecular rearrangement of the host-rock, as is seen from the composition of the porphyroblasts.

Xenoliths of the country-rock has also been observed in an old quarry near St. Wolfgang. The xenoliths have a hornfelsic texture with a sugary arrangement of the equant, recrystallized quartz grains. Microcline porphyroblasts are developed, and the original s-planes remain undestroyed but somewhat obliterated.

The general features of the "augen-migmatite" point out that the metamorphism was not strong enough to destroy the s-planes of the parent rock. Muscovite and biotite remain stable with their preferred orientation — $\{001\}$ in sub-parallel orientation to the original schistosity. This was intensified during the metamorphism resulting in a well defined foliation. The presence of both micas as stable minerals points out to a low temperature. In fact, the mineral assemblage muscovite, biotite, albite, microcline, epidote and chlorite is typical of the albite-epidote contact facies, the pair albite + epidote being the diagnostic (WINKLER, p. 59, 1965). The relations between the granite and the country-rocks, as they are observed around Kirchberg am Wechsel region, affirm WIESENEDER's view concerning the same features in the area around St. Jakob. Hence it is surmised here that the granite emplacement must have occurred during a latter stage of the variscian orogeny (WIESENEDER, 1962) at a somewhat high level of the crust (WIESENEDER, 1960). Supposition of a Mesozoic or even younger age for the intrusion seems to be unjustified, as the mesozoic rocks of the Semmering Window do not show any related and compatible evidences due to the granite intrusion and consequent metamorphism. The Mesozoic age can not be claimed in absence of concrete proofs.

Petrofabric Investigations

Wechsel Schist:

Microscopic work on recrystallized muscovites shows that the flakes tend to align with $\{001\}$ planes parallel to the schistosity (S_1). Petrofabric diagrams for muscovite show that the $\{001\}$ maxima commonly lie in complete or partial peripheric girdles whose axis coincide with the visible lineation L_1. Most of the sub-fabrics bear homotactic relations with the allied mesoscopic elements. The symmetry is perfectly monoclinic. Fig. 11 illustrates a common example where a conspicuous schistosity S_1 and a late strain-slip cleavage S_X intersect in a common lineation, which is also the girdle axis of the peripheral mica girdle. The single strong maximum coincides with S_1, and it is expressed by the orientation of large muscovites. The bent micas reflect the latter influence of S_X. The plane of symmetry is that of the figure. Patterns of axial and near axial symmetry are also found. The important thing, however, that arises from the muscovite sub-fabric patterns is the perfect homotactic relations with the mesoscopic elements, which have their monoclinic symmetry duplicated on muscovite diagrams.

Quartz [0001] axes sub-fabric, on the other hand, bears a completely discordant relation with both mica and mesoscopic sub-fabrics. The only homotactic quartz sub-fabric found is that of Fig. 12, from the high slopes of the Waldbach. The four, well-developed maxima fall in a nearly E—W (70°) monoclinic quartz girdle, developed around L_1, which is parallel to the girdle axis. All the sub-fabrics have monoclinic symmetry and the plane of it is shared by all together. The overall fabric is homotactic and monoclinic.

The general picture is, however, by far different. While the quartz sub-fabrics have monoclinic, N—S oriented girdles, which are parallel to L_1-lineations (Fig. 13). The girdle axis, in this case, is nearly E—W, i. e., paralleling L_2-lineations. Such situation gave rises to a triclinic symmetry for the whole fabric. The plane of symmetry shared by the mica and the mesoscopic sub-fabrics is nearly normal to that one present in the quartz diagrams. These heterotactic relations are found elsewhere in the Molz valley (the unique exception being the case of Fig. 12). Triclinic quartz sub-fabric, though very seldom, were also found (Fig. 14).

Grob Gneiss Serie:

Petrofabric work carried on [0001] quartz axes in the "augen-migmatite" and in the flaser granite, have shown patterns similar to those illustrated in the Figs. 15, 16 and 17. Investigations on a slickenside mylonite showed a common pattern of orientation displayed by quartz axes, usually described in the literature for such domains. A strong populated maximum lies in the "ab"-plane of the fabric (foliation) and it is still parallel to the "a"-axis, and, of course, normal to a visible b-lineation. Besides, the orientation of the axial maximum is parallel to the striae that dominate the quartz slickensides of the area around. The symmetry is perfectly axial and the maximum trends NE, plunging 50° (Fig. 15).

Monoclinic, heterotactic and homotactic girdles are also shown in the quartz sub-fabric. In the latter (Fig. 17) five strong maxima fall in a vertical N—S girdle normal to a visible E—W, b-lineation characterized by the sub-parallel disposition of eye-shaped porphyroblasts. The lineation conforms, in this instance, with the girdle axis. The overall fabric symmetry

Fig. 11

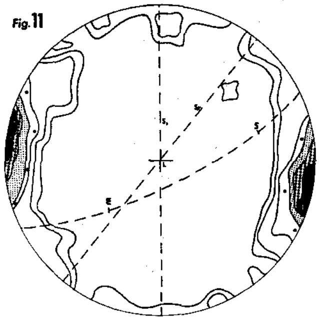

Fig. 12

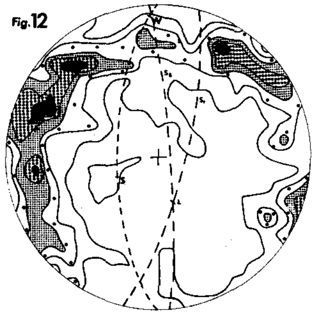

Fig. 13

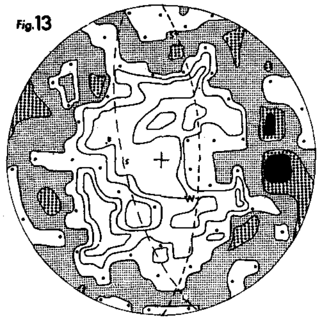

Fig. 14

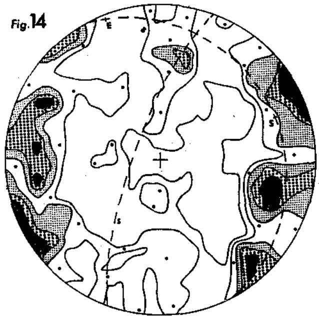

Fig. 15

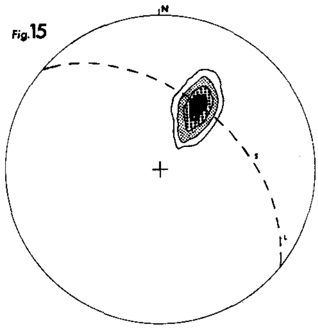

Fig. 16

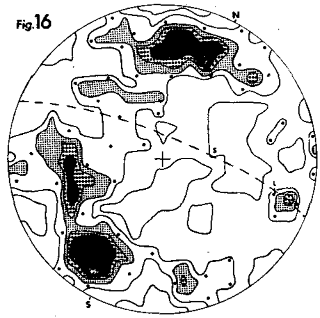

Fig. 17

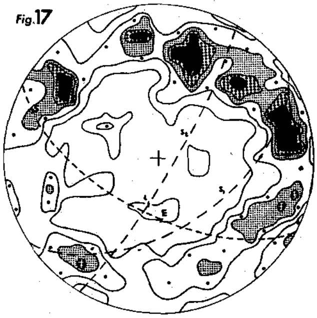

Fig. 18

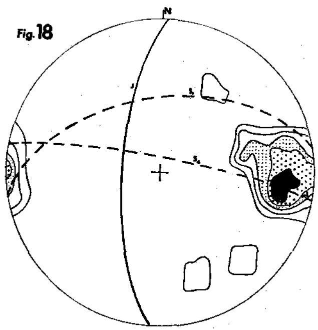

Fig. 11. Orientation diagram for [001] in muscovite. Quartz-albite-muscovite-chlorite schist. 200 [001] poles. Contours, 16%, 12%, 8%, 4%, 1%, 0,5%, per 1% area. S_1, S_X = visible s-planes, L = visible lineation. Fuchsloch, Lower Austria.

Fig. 12—14. Orientation diagrams for [0001] in quartz. Quartz-albite-muscovite-chlorite schist. Fig. 12: 200 axes. Contours, 4,5%, 3,5%, 2,5%, 1,5%, 0,5%, per 1% area (Waldbach). Fig. 13: 320 axes. Contours, 2,5%, 2%, 1%, 0,5%, 0,25%, per 1% area (Molzbach, road, km 1). Fig. 14: 400 axes. Contours, 2,5%, 2%, 1,5%, 1%, 0,5%, per 1% area (Saurücken). S_1, S_2 = visible s-planes; L = visible lineation; B = girdle axis. Molz valley, Lower Austria.

Fig. 15—17. Orientation diagramm for [0001] in quartz. Fig. 15: Slickenside mylonite in flaser-granite, 150 axes. Contours, 15%, 10%, 5%, 1%, per 1% area (near Kirchgraben); Fig. 16 Flaser-granite. 332 axes. Contours, 3%, 2,5%, 2%, 1%, 0,3%, per 1%area (near Wilhelmshof); Fig. 17: Augen-migmatite. 350 axes. Contours, 3%, 2,5%, 2%, 1%, 0,5%, per 1% area (Kreuzbauern). S = visible s-plane, L = visible lineation. Lower Austria.

Fig. 18. Joint diagram. 50 joints. Contours, 30%, 15%, 10%, 5%, 1% per 1% area. Kreuzbauern, Lower Austria.

is monoclinic. In the same locality, joint measurements define a well developed set marking an angle of approximately 90° to the lineation (Fig. 18). They are the true cross or "ac" joints. These are widespread over the Grob Gneiss series.

Overall triclinic symmetry appears when a monoclinic quartz girdle is obliquely inclined to the symmetry plane of the mesoscopic and mica sub-fabrics. This is the situation presented in the Fig. 16, where three well populated maxima lie in a N—S girdle, oblique to L and S.

Discussion:

The overall triclinic symmetry of the Wechsel schist's fabric arises through the non-coincidence of the geometric elements of sub-fabrics, each having a monoclinic symmetry. As a matter of fact, the strong triclinicity is characterized by the presence of two groups of mesoscopic and microscopic geometrically concordant fabric elements:

1. quartz sub-fabric; E—W, L_2-lineations, and strain-slip cleavage (S_X),
2. muscovite sub-fabric; N—S, L_1-lineations, and schistosity (S_1).

Related elements of each group share closely geometric concordant relations among themselves, but the relations between individual groups are completely discordants. The L_1-lineations, also the axes of chevron folds, B_{S1}, are conform with the girdle axes of $\{001\}$ muscovite patterns. The monoclinic $\{0001\}$ girdles in quartz diagrams are obliques (nearly parallel) to L_1, imparting a strong heterotactic picture to the whole fabric. Where the strain-slip cleavage has crumpled the former schistosity, cleavage (slips) folds, with a well defined E—W, L_2-lineations, are produced. These lineations are also the axes of mesofolding $B_{S1}/_{SX}$, and bear concordant geometric relations with the N—S quartz girdles, as the girdle axis. Far away from the Kreuzbauern—Wilhelmshof upthrust, quartz patterns still maintain the N—S girdles whose axis is then a non-visible lineation.

The completely different fabric picture showed in the Fig. 12 has a homotactic monoclinic symmetry, where L_1 parallels the axis of the E—W quartz girdle. This is regarded, with some confidence, as a particular case, in which the quartz was prevented to undergo the latter strain. However, this is only an assumption and it needs further confirmation.

The triclinity is the result of two different episodes of strain — an asymmaetric overpint of a latter fabric upon a primitive one. After the investigations carried on the Molz region, it was found that the final fabric of the Wechsel schist is composed by two wholly discordant sub-fabrics: a) a sub-fabric consisting of active imposed elements, which include the ones belonging to the first group cited formerly; and b) a sub-fabric composed by inherited passive elements, which correspond to the structural elements formerly placed in the second group above mentioned. This last sub-fabric portrays the kinematically passive elements, which are referred to the initial fabric related to the earlier strain. Probably the passive L_1-

lineation was normal to the symmetry plane of the movement picture prevailing during the para-crystalline deformation, which is recorded in the homotactic combination of S_1, L_1 and muscovite sub-fabric. If the supposition already placed on the overall fabric of the Fig. 12 is correct, the earlier movement picture might have had a E—W symmetry plane, with a monoclinic symmetry. But this needs confirmations in zones proved to have undergone only the para-crystalline deformation.

The kinematically active and imposed elements bear direct and important relations with the latter, post-crystalline deformation. They may be resumed as:

1. L_2-lineations have the properties of a mesofold axis $B_{S1}/_{SX}$ and it is parallel to the kinematic axis b. Therefore, it is normal to the symmetry plane of the cleavage folds, and to the plane of symmetry of the latter movement picture. L_2 is an imposed active element that reflects the movement picture and the geometry of strain.

2. Strain-slip cleavage is a post-crystalline planar element that cuts the earlier schistosity, and it takes the form of an axial plane cleavage. The laminar domains formed are a rather common feature in triclinic fabrics, arising due to asymmetrically superposed deformations (Turner & Weiss, p. 463, 1963). They represent the formation of slip-planes at high angles to the largest compressional stress σ_1 and they can be progressively rotated towards the normal to σ_1 (see Turner & Weiss, fig. 12-8, op. cit.). The last rotational stage is found in the vicinity of the Kreuzbauern-Wilhelmshof upthrust, as it can be seen in the compressed microlithons (Fig. 7). The strain-slip surfaces are the prime cause for the development of cleavage (slip) folds on the S_1-planes, through a shortening normal to them. The movements on the slip domains are like small scale thrust faults, where the N block moved upward in relation to the S one. They are antithetic slip-planes.

3. The quartz sub-fabric has mostly a well patterned, monoclinic, N—S oriented quartz girdle, whose axis may coincide with L_2-lineation wherever they are present. As the quartz sub-fabric has a kinematically active nature, directly related with the movement picture, its symmetry is a very important element in the whole fabric. It guards the same monoclinic symmetry as the movement picture of the latter (post-crystalline) deformation overprinted upon the fabric.

The N—S orientation for quartz girdles are also found in the diagrams constructed for rocks of the Grob Gneiss series. Both "augen-migmatite" and flaser granite have well developed monoclinic girdle patterns in homotactic and heterotactic combinations with the mica and the mesoscopic subfabrics, respectively. In the former quartz fabric, E plunging b-lineation, due to the elongation and parallel disposition of eye-shaped porphyroblasts, coincide with the axis of the [0001] girdles. The monoclinic symmetry of the latter movement picture is also present in the rocks studied from the Grob Gneiss series.

The suggestion that the σ_1 axis of the stress system lie somewhere in the plane of the well marked quartz girdles, regardless of the fabric being homotactic or not (TURNER & WEISS, p. 432, op. cit.), is completely consistent with the tectonic elements observed in the region, either in the Wechsel or in the Grob Gneiss series. This situation is in favour of the supposed mechanism responsible for the development of the strain-slip cleavage (TURNER & WEISS, p. 465; DE SITTER, p. 182, op. cit.). It has undergone a rotation till the normal to the largest compressional axis σ_1, with a vertical dilatation and a lateral compression. This process has caused the cleavage folds in the region. Cross, "ac" joints, which are very abundant, are usually parallel to and normal to one of the remaining stress axes. In monoclinic homotactic fabrics of the "augen-migmatite" one of these may coincide with the direction of grain elongation, i. e., the b-lineation.

The axial maximum of the Fig. 15, and the orientation of a-lineations, represented by the striae from the slickensides, point out to the vergence of the latter and post-crystalline deformation. This has caused the faulting and the superimposed strain on the Wechsel schist, and very probably was developed through southerly vergence of movements. This is also in coincidence with the antithetic dip of the strain-slip cleavage.

Conclusions

The Wechsel schist domain, which extends from the Molz valley towards south occupying a surface of nearly 300 sq. km., still poses a number of unanswered problems, while the Grob Gneiss series is under study continuously since 1932 by WIESENEDER. The present work offers certain conclusions in regard to the two episodes of deformation, and also some observations on the mutual inter-relationship of the different members of the Wechsel schist series.

The presence of two approximately normal tectonic axes is evident in both mesoscopic and microscopic domains of the Wechsel schist in the area around the Molz valley.

The N—S axis characterizes the earlier deformation, which is only recorded in the Wechsel schist. It was para-crystalline in nature as stresses have evolved synchronously with the low-grade metamorphism. Metamorphic differentiation has played an outstanding role in the development of the porphyroblastic albite and in the segregation layering of quartz and albite. Development of porphyroblastic albite is considered as a "in situ albitization" derived intraformationally from the detrital plagioclase already present in the parent sedimentary material, without the influence of any external supply of soda. The porphyroblasts are therefore much more older than the alpine age. Structurally, the homotactic combination of L_1-lineations, S_1-planes (schistosity), muscovite sub-fabric and the flexural-slip folding are parts of the observable fabric. These passive elements are inherited from the earlier strain.

Concerning the para-crystalline movements little can be said with certainity. However, it is clear that S_1 surfaces are connected with the earlier lateral stresses that have produced chevron folds. The muscovite sub-fabrics show patterns about the fold axis B_{S1}, which also happens to be one of the L_1-lineations having a constant N—S trend. These features rule out a static load metamorphism. The para-crystalline deformation may probably be related to the variscian age.

The post-crystalline deformation is characterized by an E—W axis and it is well recorded in both series, being clearly related to the upthrust faults. This phase was accomplished by epi-metamorphic neo-mineralization that has affected only the Grob Gneiss series. In the Wechsel schist the features related with the latter movements are the strain-slip cleavage, L_2-lineations, quartz sub-fabrics and slip folding. These reflect the superimposition of the latter strain.

The structural elements that compose the actual fabric of the Wechsel schist and the Grob Gneiss series are consistent with strain and movement picture, both having a monoclinic symmetry. The plane of symmetry has a N—S orientation. This post-crystalline strain was superimposed on the already folded Wechsel schist, whose fabric had kinematically passive elements asymmetrically oriented with the latter movements. This accounts to the triclinic fabric. The post-crystalline deformation can be correlated with the alpine age, and its main axis of stress was probably NNE—SSW oriented. The prevailing movements have evolved through a southerly vergence.

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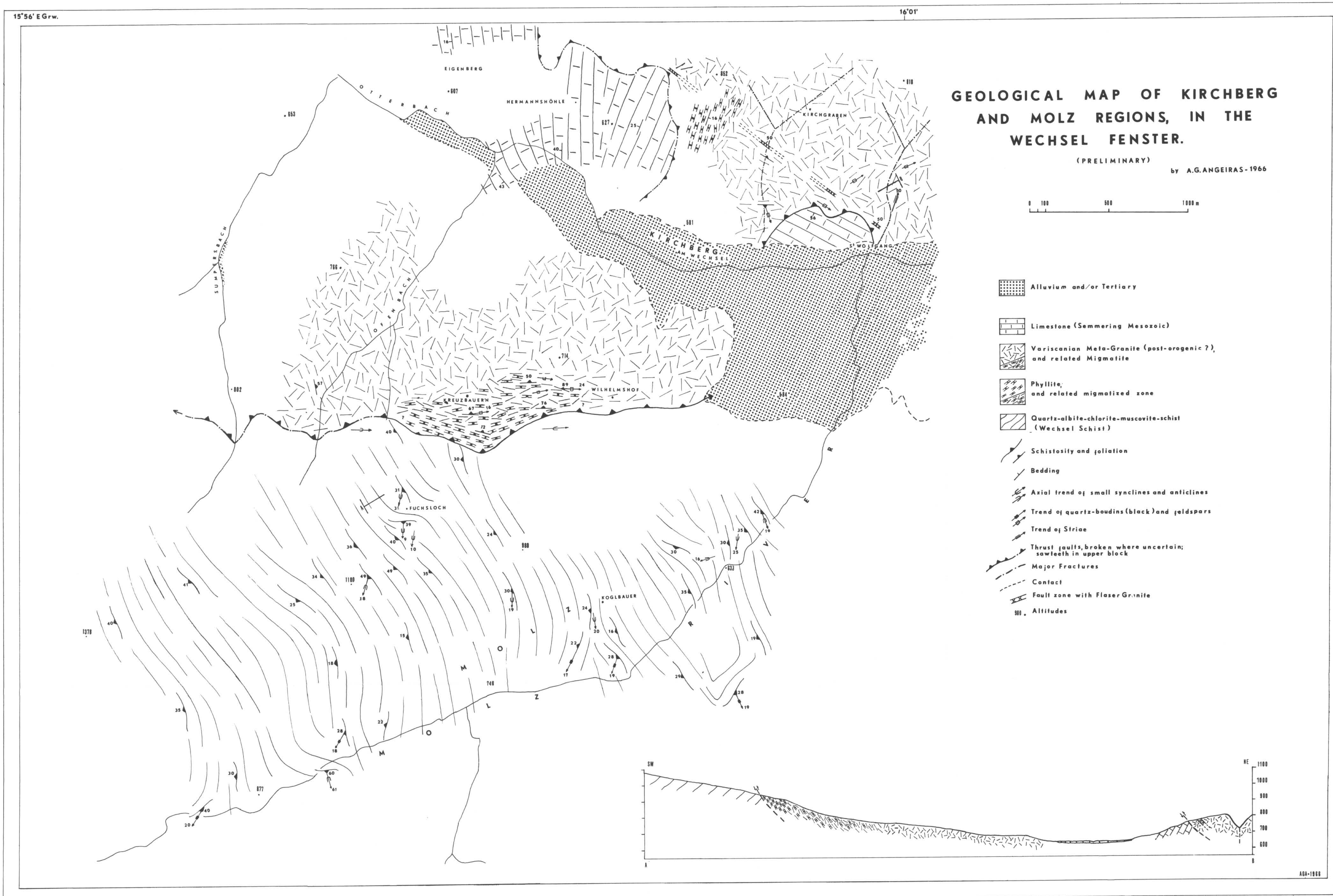

GEOLOGICAL MAP OF KIRCHBERG AND MOLZ REGIONS, IN THE WECHSEL FENSTER.
(PRELIMINARY)
by A.G.ANGEIRAS-1966
0 100 500 1000 m
Alluvium and/or Tertiary
Limestone (Semmering Mesozoic)
Variscanian Meta-Granite (post-orogenic ?), and related Migmatite
Phyllite, and related migmatized zone
Quartz-albite-chlorite-muscovite-schist (Wechsel Schist)
Schistosity and foliation
Bedding
Axial trend of small synclines and anticlines
Trend of quartz-boudins (black) and feldspars
Trend of Striae
Thrust faults, broken where uncertain; sawteeth in upper block
Major Fractures
Contact
Fault zone with Flaser Granite
Altitudes
15°56' E Grw.
16°01'
47°37'13" N
47°34'30"
EIGENBERG
HERMANNSHÖHLE
OTTERBACH
KIRCHGRABEN
KIRCHBERG AM WECHSEL
ST. WOLFGANG
SUMPERSBACH
OFENBACH
KREUZBAUERN
WILHELMSHOF
FUCHSLOCH
KOGLBAUER
MOLZ RIVER
MOLZ
SW
NE
A
B
AGA-1966

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