THE MOLDANUBICUM – AN OLD NUCLEUS IN THE HERCYNIAN MOUNTAIN RANGES OF CENTRAL EUROPE

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1. Introduction

For many years the Moldanubicum was accepted as the old core of the Bohemian Massif – a median mass (STILLE, 1951; ZOUBEK et al. 1960, SVOBODA et al. 1966 a. o.). For most geologists „Moldanubicum" was synonymous with Precambrian. There is a tendency now to leave this conservative view. THIELE (1976 a, b, 1984) takes the nappe structures of the Moldanubicum like those of the Moravicum as Hercynian in age. This view is supported by TOLLMANN (1982, 1985), who concludes on the observations of fold vergencies that the Moldanubian nappes are derived from 300 km to the W. Matte et al. (1985) also favour E-directed Hercynian nappes in the Moldanubicum of the Waldviertel on the basis of combined structural-geochronological studies. Siluro-Devonian microfossils discovered in the Varied Group of southern Bohemia provide a surprise: Parts of the Moldanubicum are Palaeozoic in age (ANDRUSOV & CORNA; 1976; PACLTOVA, 1980, 1986). The geochronological studies by van BREEMEN et al. (1982) bring the result that the granulite facies metamorphism, SE-directed thrusting and plutonism all occurred within the period of 345±5 and 331±4 ma.

Thus all recent research seems to support the concept of a uniform Hercynian orogene comprizing both the Moldanubicum and the Moravicum. Nappes directed ESE are the prominent structural elements in the south-eastern parts of the Bohemian Massif.

Certainly it does not mean „to be in", if one puts arguments in favour of the old view of a Moldanubicum representing a median block. However there are series of facts inconsistent with the assumption of a uniform homogeneous Hercynian mountain system in the Bohemian Massif. Therefore I contested this view in my 1986 paper. Since then the Wolfshof Syenite has been dated (pers. comm. by Prof. W. FRANK, Geol. Inst. Univ. Vienna), which provides another essential argument against the concept of Hercynian intra-Moldanubian nappe structures. In the following the problem is discussed particulary in respect to the Austrian portions of the Bohemian Massif.

2. The Moldanubian Rocks and Structures

The Variscian Moldanubian Pluton intruded a rock complex with characteristic rock associations, and orogenic zoning.

In **southern Bohemia** the zonal arrangement follows a SW-NE-strike, and the regional dip is NW. The lowest series are the monotonous Kaplice Micaschists followed by the Varied Series[1]) with its marbles, graphite schists, quartzites, paragneisses and amphibolites. Large bodies of hybrid orthogneiss resemble the Gföhl Gneiss of the Waldviertel. In the NW, thus apparently in the highest position, large granulite masses and associated ultramafites follow.

In the **Waldviertel** and **Moravia** the regional strike is SSW-NNE with dip towards the ESE. We find the same rock assemblages as in Bohemia and the same sequence of zones. The Monotonous Series is the lowest complex succeeded by the Varied Series. Then follow the Gföhl Gneisses and at the top the granulites with their associate series.

Thus in Bohemia as in the Waldviertel and Moravia we find the high-grade metamorphics, migmatites, and orthogneisses regularly overlying the metasedimentary series of lower grade of alteration. ZAYDAN & SCHARBERT (1983) found P/T conditions of ca. 630 °C/3 Kbs for the Monotonous Series, ca. 670 °C/5 Kbs for the Varied Series. HÖGELSBERGER (1987) examined the carbonates of the latter series and deduced ca. 700 °C/5.5–7.5 Kbs. PETRAKAKIS (1986) studied the gneisses of the same unit and suggested even 700–770° C/7–9 Kbs. HÖGELSBERGER (1987) notes that he did not find a change in metamorphism between the Varied Series and the overlying Gföhl Unit. The granulite series making up the upper portions of the named unit, however, were formed under > 760 °C/> 11 Kbs (SCHARBERT & KURAT, 1974). Associated with the granulites we find pyrope peridotites and garnet pyroxenites derived from the upper mantle (DOBRETSOV et al. 1984; SCHARBERT & CARSWELL, 1983).

The inversion of metamorphic complexes, no doubt, was brought about by tectonics. In form of nappes the high-grade metamorphic complexes came in superposition on less altered rocks. The importance of thrust tectonics first emphasized by F. E. SUESS (1903, 1912) was extended to the internal parts of the Moldanubicum by FUCHS (1971, 1976), MATURA (1976) and THIELE (1974, 1976, 1984). Regarding the delimitation of the units, age and vergency of thrusting the opinions of the named authors are diverging. However it is evident that the Moldanubicum is characterized by certain rock association (granulite series, Gföhl Gneiss, Varied and Monotonous Series), nappe tectonics, typical zoning and the SW-NE-to-SSW-NNE-trend of orogenic belts.

3. The Relations between Moldanubicum and Bavaricum

It was usual in Austria and Bavaria to regard the Moravicum as an individual unit in the sense of F. E. SUESS and to take the rest of the Bohemian Massif as Moldanubicum. Thus the Hercynian belt of the Mühlviertel, Sauwald and Bavarian Forest was too named „Moldanubicum". FUCHS (1976) introduced the term Bavaricum for the named belt, because it represents a new orogenic zone, which has to be distinguished from the Moldanubicum typified in the preceding chapter.

FISCHER (1959), FISCHER & TROLL (1973), FUCHS (1962), FUCHS & THIELE (1968), a. o. describe the rotation of the NE-SW-trending structural elements of southern Bohemia into the Hercynian NW-SE-strike of the Bavarian Forest and the Mühlviertel. Parallel with the structural transformation the typical rock assemblage of the Moldanubicum is progressively overprinted by metablastesis and finally obliterated. A new crystalline formed with NW-SE orientated Hercynian granites and migmatites. In passage zones,such as the Böhmer Wald, or in the Kropfmühl area in Bavaria remains of the older complex are partly preserved.

Thus the well-dated Hercynian orogenic belt cuts the NE-SW-striking zones of a pre-existing mountain system at right angles. The old foliation and axes are rotated into the new direction and the old, very characteristic rock associations are obliterated by migmatization. Therefore it is documented that the crystalline complex of southern Bohemia – the Moldanubicum – is older than the Bavaricum, which was formed in Hercynian times. Definitely there are more than one structural and metamorphic phases (see also FISCHER & TROLL; 1973).

4. The Relations between the Moldanubicum and Moravicum[2])

A tectonic discordance is very conspicuous if two orogenic belts meet at right angles as along the Moldanubicum/Bavaricum contact. In the Waldviertel and Moravia both the Moldanubicum and Moravicum show similar regional NNE-SSW strike. There the structural unconformity is primarily expressed in the direction of dip: The rock series of the Moldanubicum predominantly dip ESE, whereas the Moravicum shows a regional plunge towards the W. The two complexes join along the Moldanubian Thrust (F. E. SUESS) a tectonic plane dipping towards the W. After thrusting this thrust plane was deformed – in culminations the Moravicum is exposed in tectonic windows (Thaya and Svratka Windows). Detailed mapping showed that the internal structures in the Moravicum are in conformity with the Moldanubian Thrust. Those of the Moldanubicum, however, are disconformable. The Moldanubian Thrust marks the western boundary of the Thaya Window. The Moravian rock series follow parallel to this line (Pl. 1). But the Moldanubian zones join the Moldanubian Thrust in a **discordant** way. The Varied Series strikes from the Jauerling via Krumau/Kamp to the area of Messern, where it comes in contact with the Moravicum. The Gföhl Gneiss meets the Moravicum at Horn. The Rehberg Amphibolites and paragneisses of the lower Kamp Valley border the Moravicum E of this valley. NW of the Messern Bow the Moravicum is approached by the Blumau Granulite from the W. Gföhl Gneisses from the NW, and the Varied Series from the N, from Drosendorf. Also in the CSSR various rock series of the Moldanubicum border the Moravicum.

When we follow the named Moldanubian series as they approach the Moravicum we observe increasing **retrogressive** metamorphism. The granulite facies rocks and series of the sillimanite zone are adapted to the kyanite or staurolite zones of amphibolite facies. There are also structural changes near to the Moldanubian Thrust: S of Messern the Varied Series shows huge recumbent folds in km-dimensions. The Gföhl Gneiss is deformed in E-directed isoclinal folds, which explain its peculiar areal extent and pseudosynclinal form in the Gföhl area. The Drosendorf Window is an E-directed antiform with overturned eastern flank. Thus the Moldanubian Thrust is followed by a zone several km wide, which is dominated by intensive E-vergent folding. It is a zone where the Moldanubian sequences are inverted (Pl 1,2). This type of deformation is accompanied by retrogressive metamorphism. The most conspicuous change is from the paragneisses to micaschists. SUESS (1908, 1912) therefore introduced the term Micaschist Zone to this belt and gave the right explanation of its origin. The retrogressive nature of the Micaschist Zone was further substantiated by KÖLBL (1922). Modern petrological studies all show two distinct metamorphic phases in the Moldanubicum (FUCHS & SCHARBERT, 1979; GÖTZINGER, 1981; ZAYDAN & SCHARBERT, 1983; HÖDL, 1985; HÖGELSBERGER, 1987).

It is evident that the internal structures of the Moldanubicum and its rock assemblages are older than the Moldanubian Thrust and the accompanying deformations and alterations. Following F. E. SUESS we may accept the latter as Hercynian in age. Though the Hercynian metamorphism affected the whole Moldanubicum, the preexisting rocks and structures remained predominantly metastable. Only in a several km wide marginal zone the rocks became adapted to the Hercynian metamorphism. This probably is due to the intensive Hercynian deformation in this marginal belt, where a new crystalline was formed.

Thus like in Bohemia there is evidence in the Waldviertel and Moravia that the Moldanubian rock associations and structures are older than the adjoining Hercynian orogenic zone.

5. The Relation of the Hercynian Intrusives to the Surrounding Crystallines

The sequence of Hercynian magmatites was investigated by WALDMANN (1951, 1958). Recently S. SCHARBERT (1987) has given geochronological dating of the main types of granitoids in the Austrian part of the Bohemian Massif. The Weinsberg Granite and Mauthausen Granite are about of the same age (349±4 resp. 353±5 m. a.). From field evidence the Weinsberg Granite always proves to be older. The Eisgarn Granite gave an age of 316±7 m. a.

In the **Waldviertel** all these granites show sharp contacts, migmatization is insignificant, and swarms of dikes occur occasionally. All evidence shows that the magmatites intruded a pre-existing crystalline complex. The rocks and the structures were already formed at the time of intrusion.

In the **Bavaricum** the older magmatites – the Weinsberg Granites and the Diorites I – are synorogenic (FUCHS, 1962). They are foliated and show elongate forms concordant to the surrounding gneisses. The Weinsberg Granite passes into the accompanying migmatites (Grobkorngneiss; Schlierengranite, FINGER, 1986). All observations point to syntectonic intrusion during regional metamorphism. The younger magmatites, Diorites II, Mauthausen Granite, and Eisgarn Granite exhibit predominantly sharp discordant contacts and insignificant migmatization. It is obvious that the crystalline was already cooling at the time of their intrusion.

The different appearance of the Weinsberg Granites in the Waldviertel and the Bavaricum indicates that at the time of regional metamorphism and tectogenesis in the Hercynian belt the Moldanubian complex was already existing.

6. The Age of the Moldanubian Rocks and Structures

In the preceding chapters it was documented that the Moldanubicum formed before the Hercynian zones of the Bavaricum and Moravicum. Therefore it shows imprints of polymetamorphism and several tectonic phases. Now the question arises whether these phases occurred in one orogeny (TOLLMANN, 1982) or may be attributed to different orogenies (FUCHS, 1976)?

6.1. Radiometric Data

S. SCHARBERT compiled the existing geochronological data in 1980: The characteristic Moldanubian rocks – the granulites and Gföhl Gneisses – gave ages of 485±11 (ARNOLD & SCHARBERT, 1973) and 491±24 m. a. (ARNOLD pers. comm.). Anatectic gneiss in Bavaria was dated 487±20 m. a. by GRAUERT et al. (1974). The age of the granulite metamorphism is dated with 446±36 m. a., and biotite ages indicate the cooling at the end of the Hercynian metamorphism. Also the Gföhl Gneiss indicates Hercynian alteration at 325±7 m. a. and the above named anatexites at 324±15 m. a.

These data document a strong Caledonian regional metamorphism and the activity of Hercynian metamorphism, which however was not able to homogenize the pre-existing rocks. Caledonian radiometric ages were found by various authors in different parts of the European Variscides (DAVIS & SCHREYER, 1962; GRAUERT et al. 1971; GEBAUER & GRÜNENFELDER, 1976; SCHMID, 1976; DORNSIEPEN, 1979; GEBAUER et al. 1981; BLÜMEL, 1982 a. o.).

ZWART & DORNSIEPEN (1979) and DORNSIEPEN (1979) discuss the problem of a Caledonian thermic event or regional metamorphism without contemporaneous folding in the suprastructural series. They are inclined to explain the Caledonian ages as a rejuvenation in Hercynian times. In my view the subfluence model (BEHR, 1978) provides a reasonable solution of this problem (see chapter 8).

Recently the **Wolfshof Syenite** of the eastern Moldanubicum has been dated (pers. comm. by Prof. Dr. W. FRANK, Geol. Inst. Vienna University), and a petrological study of this magmatite is under way by H. ALIASGARI. After my mappings in that area I pointed out that the geochronological examination of the Wolfshof Syenite would elucidate the age of the intra-Moldanubian nappe tectonics. This because of the following facts:

1) The syenite-gneiss occurs as one respectively few rather continuous, concordant layers in the huge syncline of St. Leonhard/HW. Its position is within the paragneisses and amphibolites between the Gföhl Gneiss below and the granulite at the top.

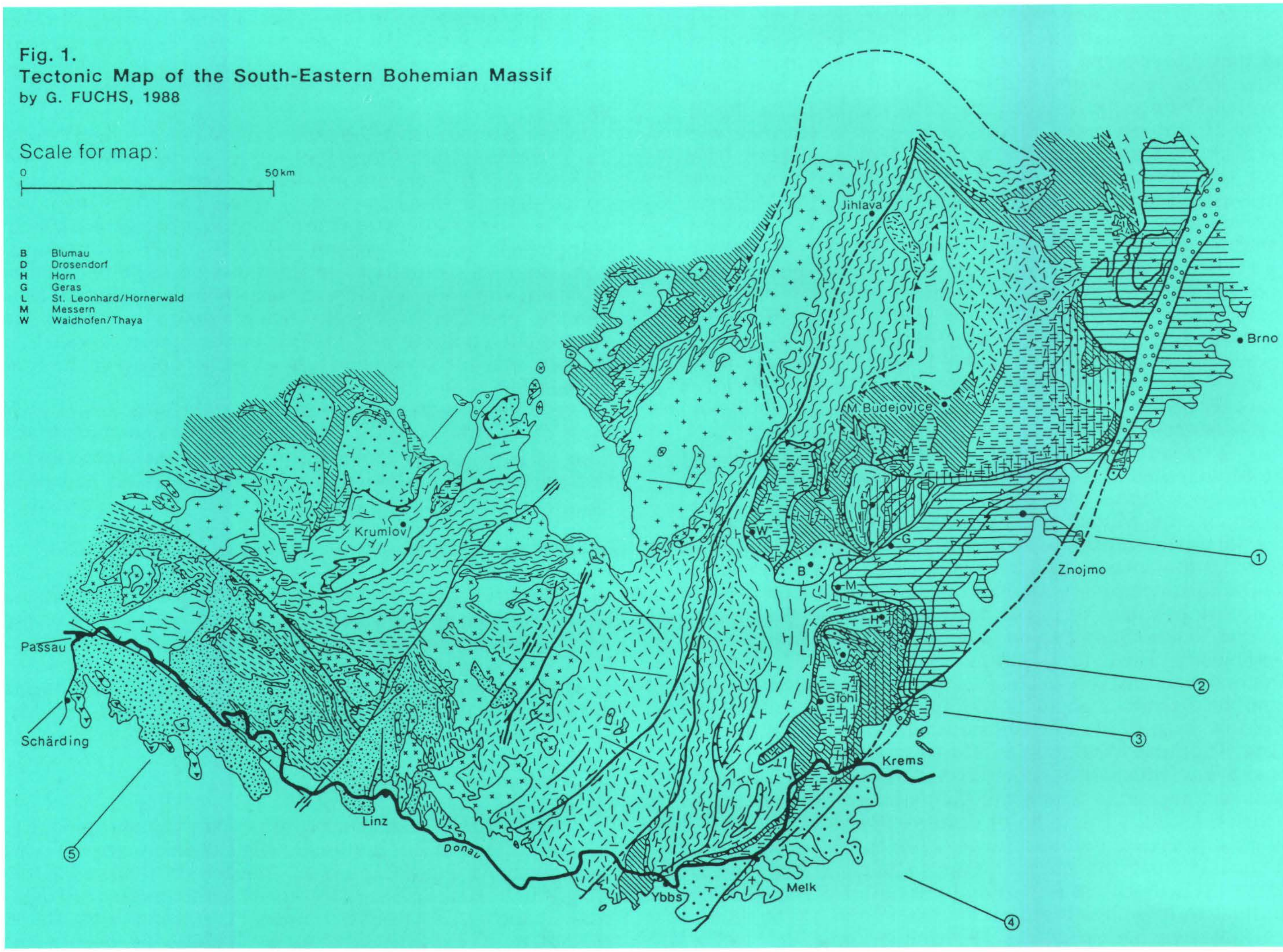


Fig. 1.
Tectonic Map of the South-Eastern Bohemian Massif
by G. FUCHS, 1988

2) The faint parallel structures and massive character of the syenite-gneiss contrasts to the schistosity of the intruded rocks. This is also observed in cases where the thickness of the syenite-gneiss is reduced to a few meters.
3) Inclusion of the country rock in the syenite and branching sills document the magmatic contact.

Consistent with these observations there is only the conclusion that the syenite intruded during the nappe tectonics and not yet in a solid state was sandwiched between the Gföhl Gneiss and the overthrust granulite series. Thus the age of the magmatite gives the age of the intra-Moldanubian thrusting.

The Wolfshof Syenite was examined by whole rock Rb/Sr method (8 samples) by FRANK (pers. comm.) and gave a good isochrone of 430 ± 15 m. a. (Silurian).[3]).

Contrary to the above indications of a Caledonian orogenesis van BREEMEN et al (1982) propose a basement formed in the Cadomian orogeny and rejuvenated in Hercynian times. In the very small time interval of ca. 15 m. a. the granulites formed at 345 ± 5 m. a., SE-to ESE-directed thrusting occurred at 338 ± 3 m. a., and granite plutonism took place at 331 ± 4 m. a. In the Visean Culm conglomerates of the Moravo-Silesian Zone we find already boulders of granulite.

It is very unlikely that all these processes occurred in such close succession. Between the formation of the granulite series with its associated rocks from the Mantle and the Hercynian plutons the conditions must have changed fundamentally. S. SCHARBERT (1987) dated the Weinsberg Granite with 349 ± 4 m. a., the Mauthausen Granite with 353 ± 5 m. a. which means that these intrusives formed earlier or approximately at the same time as the granulites! Again it should be stressed that the Bohemian SW-NE-trending zone containing granulites is cut and obliterated by the Bavaricum with its NW-SE-striking synorogenic intrusions of Weinsberg Granite-gneiss. Further South Bohemian granulites are penetrated by Rastenberg Granitoid (durbachite, FIALA et al. 1987, p. 11) which is generally accepted as earliest Hercynian intrusive. This indicates a pre-Hercynian age of the granulites. My interpretation of the geochronological data by van BREEMEN et al is that they show the cooling towards the end of the Hercynian metamorphism. Doubts concerning the results of van BREEMEN et al are also advanced by SUK (1986, p. 231).

6.2. Palaeontological Evidence

ANDRUSOV & CORNA (1976) claimed the discovery of microfossils in the Varied Group of southern Bohemia. PACLTOVA (1980, 1986) confirmed this by describing fragments of acritarchs, chitinozoans, and tracheid tissues belonging probably to vascular plants. These microfossils suggest Silurian and Devonian age. They were recovered from marbles, graphitic marbles and quartzites, erlans, paragneisses, and micaschists. Certainly Silurian and Devonian age of the Varied Series would prove the Hercynian age of the Moldanubian nappe structures. But the figured fossils are far from convincing. Further I doubt that the organic structures can be preserved in graphitized form in the rock series altered under conditions of the sillimanite zone The marbles and erlans show all signs of plastic flow, and the graphitic rocks are extremely deformed because of the gliding facilities of graphite. Though PFLUG & REITZ (1987) found doubtless spores in garnetiferous micaschists, it should be emphasized that the metamorphism of the Varied Group is much stronger. In this context it is to note that the fossils discovered in the Lam-Bodenmais area in Bavaria are derived from Hercynian metamorphites of the Bavaricum and not from the Moldanubicum as understood here.

7. The Intra-Moldanubian Nappes

FUCHS (1971, 1976) and SCHARBERT & FUCHS (1981) designate three major tectonic units in the Waldviertel (from bottom to top):

1) The **Ostrong Unit** is composed by the Monotonous Series (anatectic sillimanite-cordierite paragneisses) and very subordinate leucocratic orthogneisses, eclogitic rocks, and erlans. In the W the unit is intruded by the Hercynian granites. Towards the SSW the unit plunges beneath the Varied Series of the Drosendorf Unit, which overrides the Ostrong Unit in the E.
2) The **Drosendorf Unit** follows the Ostrong Unit tectonically. In the centre of a shear zone a thin layer of granulite formed along the thrust plane (FUCHS & SCHARBERT, 1979). This dm to a few meters thick granulite lamella was traced for approximately 30 km. The Drosendorf Unit is composed of the Dobra Orthogneiss and the succeeding Varied Series consisting of marbles, calcsilicate rocks, quartzites, graphite schists and amphibolites in a paragneiss matrix.
3) The **Gföhl Unit** rests as nappe on the above unit as documented by the Drosendorf Window. The Gföhl Unit is characterized by the Gföhl Gneiss, granulite, ultramafitites, migmatitic paragneiss often containing graphite quartzite, the banded Rehberg Amphibolite and anorthosite amphibolite. The lower boundary of the unit is not well-defined as amphibolites border on both sides and the migmatization of the Gföhl Unit influenced the uppermost portions of the Varied Series too. Within the Gföhl Unit we observe the following succession (from bottom to top):
   a) amphibolites, serpentinites and paragneisses
   b) Gföhl Gneiss (hybrid orthogneiss)
   c) amphibolites and paragneisses showing tendency towards granulite facies with the concordant intrusion of the Wolfshof Syenite
   d) Granulite and ultramafitites

This sequence represents at least two structural subunits: The Gföhl Gneiss and associated rocks and the Granulite Series. Thin layers of granulite along shear planes (e. g. at the base of the Gföhl Gneiss in the Taffa Valley) and granulite tendency in highly deformed portions of the Gföhl Gneiss indicate regional metamorphism of highest amphibolite facies close to granulite facies. This and the granulite lamella at the base of the Drosendorf Unit are evidence that the nappe movements occurred under strong amphibolite facies to granulite facies conditions. Also the migmatization reaching down across the Gföhl and Drosendorf Units boundary proves thrusting under „hot" conditions of regional metamorphism. These facts are the reason why FUCHS (1971, 1976) takes the eastern Waldviertel and Moravia as the root zone of the nappes. In the frontal position, as assumed by THIELE (1976, 1984) and TOLLMANN (1982, 1985), the above phenomena are not easy to understand. After a transport of ca. 300 km, as accepted by TOLLMANN, a crystalline nappe will be cool and no granulites will be produced along the thrust plane.

This brings us to the problem of the **direction of thrusting** and provenance of the nappes. As I accept the belt marked by Gföhl Gneiss and Granulite in the eastern Waldviertel and Moravia as the root zone and the Blumau-Waidhofen thrust mass as an outlier, the conclusion is W-directed tectonic transport (FUCHS, 1971, 1976). This was contested by THIELE (1976, 1984) and TOLLMANN (1982, 1985). TOLLMANN studied the dm– to decametric folds in various parts of the Waldviertel and found them all directed E or SE. This vergency is thought as caused by the overriding „Gföhl Nappe".

In the whole region W of the Gföhl Gneiss from the Danube to Waidhofen/Th, my mappings revealed W-vergent kilometric folds, unrealized by TOLLMANN. These huge, often isoclinal folds proved to be younger than the emplacement of the nappes, because they deform the ready pile of nappes (FUCHS & FUCHS, 1986).

Thus in the Waldviertel farther W from the Moldanubian/Moravian boundary there are W-directed km-folds younger than the nappe tectonics and the dm-to decametric folds directed E according to TOLLMANN. In the eastern marginal parts of the Moldanubicum all structures are uniform directed E.

In the dispute about the direction of the nappe movements I hesitated to use the small to medium scale folds as an argument, because they are not unequivocal as claimed by TOLLMANN. Further there are wide areas where the folds uniformly trend across the regional NNE-SSW-strike (e. g. around Spitz, where TOLLMANN (1982, p. 10 – 15) also claims SE-vergency).

It is the problem now whether the observed vergencies are related to the nappe movements? Most of the E-directed folds referred by TOLLMANN and shown in the figures are in marbles. In these rocks we find the most conspicuous fold patterns. However, in rocks so ready to plastic flow, can we expect there the preservation of older structures? It is a fact that the Moldanubicum is polyphase deformed, whether we accept early and late Hercynian phases (TOLLMANN, 1982) or different orogenies (FUCHS, 1976). Anyhow, the intra-Moldanubian nappes formed in the earlier phase. In my view TOLLMANN's E-directed folds are Hercynian like those dated by MATTE et al (1985) 323±7 m. a. (39 Ar/40 Ar), but they are not related to the earlier intra-Moldanubian nappe tectonics. These older structures would not have survived the younger deformation in marbles.

What is now the **age** of the Intra-Moldanubian nappes? Granulites and Gföhler Gneiss dated. ca. 480 m. a. are integrated parts of the nappes, which therefore can not be older. On the other hand the Moldanubian structures are deformed and obliterated along the contacts to adjoining Hercynian fold belts (Bavaricum and Moravicum, see chapters 2, 3), and thus are older. As the thrusting occurred under conditions of high-grade regional metamorphism (sillimanite zone, granulite facies) it is very suggestive that the tectonics immediately followed the formation of the large granulite masses. All that indicates Caledonian age (FUCHS, 1976, 1986) wich is now proved by the 430 m. a. age of the Wolfshof Syenite. TOLLMANN (1982, 1985) accepts early Hercynian (Bretonic) Moldanubian nappe tectonics overprinted by the late Hercynian Moldanubian Thrust. This is very unlikely because in the Bavaricum two orogenic belts meet at right angles and the older is overprinted and obliterated. It is hard to believe that such a fundamental change in the tectonometamorphic pattern may occur within one orogeny.

8. The Moldanubicum in the Hercynides of Europe

TOLLMANN (1982, Pl. 2) shows the Bohemian Massif in the context of the Hercynian belts of Europe. The Moravicum is envisaged as the continuation of the Rhenohercynian Zone and thus belongs to the N-directed branch of the Hercynian orogene. The Moldanubicum represents the S-vergent branch. The ENE-striking divide between these branches bends to the S in Moravia. Thereby the vergency of the northern branch changes from NNW to NE and finally to ESE. Similarly it may be expected that in the southern branch the SE-vergency of Bohemia should swing around to the W in Moravia and the Waldviertel (like in the Ibero-

Amorican arc.) Contrary TOLLMANN accepts SE-vergency also in the Waldviertel.

The arc connecting the analogous zones of Bohemia with those of Moravia and the Waldviertel is explained by TOLLMANN (1982, Fig. 16) as the result of the axial NE-plunge of the anticlinorium of the Moldanubian Pluton. There the frontal portions of the „Gföhl Nappe" are connected with those parts of the nappe nearer to the roots. This view is **inconsistent with the bending of the whole orogene** (see above). FUCHS (1986) stresses that in accordance with the bending of the whole orogene the Moldanubian Zone swings around from the NE-strike in Bohemia to the S-to SSW-strike in Moravia and the Waldviertel. In this sharp bend the vergency changes from SE in Bohemia to W in the Waldviertel. There is no necessity to assume a thrust distance of 300 km (TOLLMANN, 1982, 1985).

It seems very suggestive to me that the Palaeozoic mountain building in Europe was a process of very long duration. It started with the Cadomian orogeny and persisted through the Caledonian to the Hercynian orogeny (BEHR, 1978, BEHR & WEBER, 1980). The Cadomian crust was rejuvenated along subfluence zones in the sense of BEHR's ensialic orogene model (1978). But in my view it is necessary to distinguish between subfluence zones active at different times. In the southern Bohemian Massif **Caledonian** subfluence zones are characterized by the Varied Series overthrust by the Gföhl Gneiss-granulite complexes. BEHR's Granulite-Garnet Peridotite-Migmatite Belts 5 and 6 (in 1978, Fig. 1, p. 289) seem to join up in the area N of Jihlava (Iglau). In Bohemia the subfluence is towards the NW (vergency of thrusting towards the SE), in Moravia-Waldviertel it is towards the ESE (vergency towards the WNW). The Caledonian subfluence zones and relictic Cadomian crust together formed a seed nucleus. Such consolidated masses acted as more or less rigid cores during the succeeding Hercynian orogeny. Their position in the Hercynian orogene is near the „Narbe" dividing the N-respectively S-directed belts. The Caledonian subfluences affected mainly the lower crust. In the suprastructure tectonics active during the sedimentation of the Ordovician-Devonian beds of the Prague Basin (HAVLICEK, 1981) are a synchronous phenomenon.

The **Hercynian** subfluence zones follow the margins of the Moldanubian nucleus. They cut the internal structures of this block discordantly and the subfluence is directed beneath the Moldanubicum. The **Moldanubian Thrust** represents a subfluence zone in its upper levels involving slightly altered sedimentaries (Devonian of the Moravian Windows). The metamorphism along the thrust was of the staurolite-to kyanite grade of amphibolite facies and is represented in the „Micaschist Zone".

The **Bavaricum** is a subfluence zone eroded to a deeper level. It is also of amphibolite facies grade, but with much anatectic mobilization and migmatization. These phenomena indicate rich supply in H_2O. In the Bavarian — as well as in the Moldanubian/Moravian subfluence belt no granulite or derivatives thereof have been found. The granulites of the Waldviertel and Moravia crop out close to the latter belt, but are not the products of this subfluence zone; they formed along the older E-dipping subfluence belt, which is cut by the W-heading Moldanubian Thrust. Granulites which may be attributed to the post-Caledonian subfluence are to be expected at deeper depth.

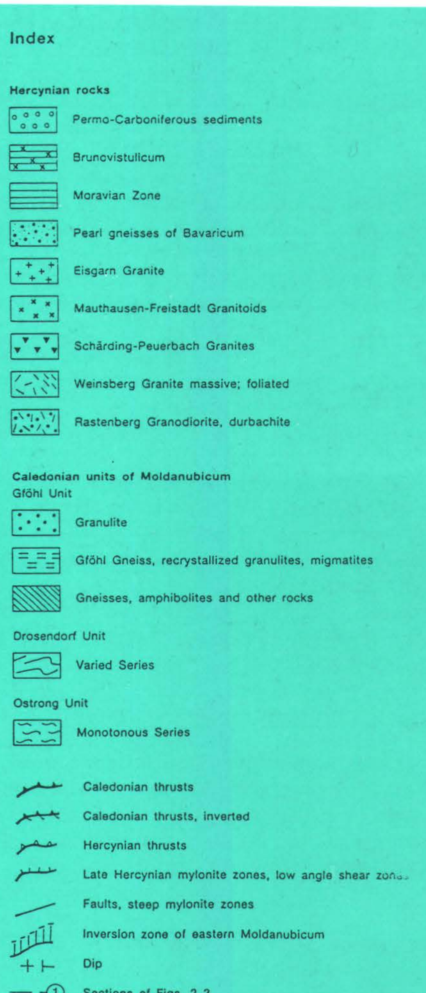


Fig. 2.
Sections across the South-Eastern part of the Bohemian Massif.
Index same as for map Fig. 1.

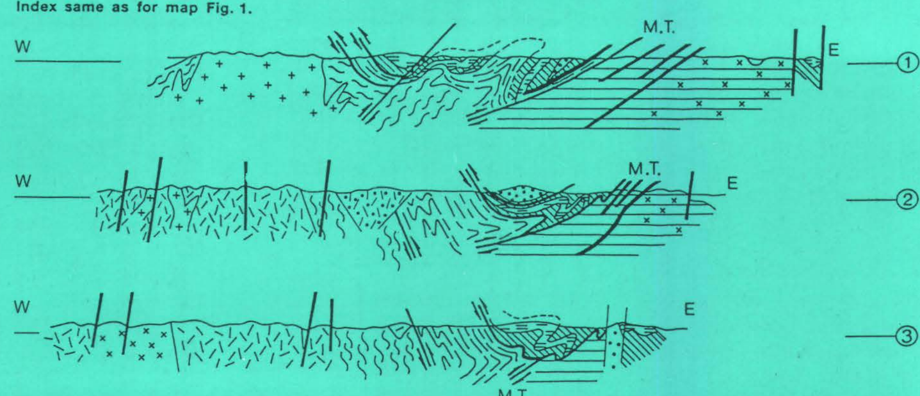
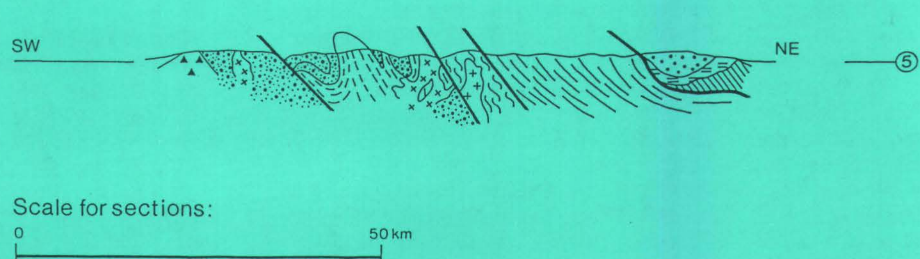


Fig. 3.
Section across the Bavaricum in Upper Austria.
Index same as for map Fig. 1.



MAGMATISM AND METAMORPHISM

The mobile Hercynian belts surround the Moldanubian block, but transformed only its marginal parts („Micaschist Zone", Mühl Zone, Böhmerwald Zone). The vast central portions of the Moldanubicum were invaded by the Hercynian granitoids accompanied by a wave of heating, but the rock assemblages and structures remained metastable. Along the margins of the Moldanubicum progressive structural overprinting and adaption to the new metamorphic conditions are observed.

Thus I come to the conclusion that the Moldanubicum formed by the reactivation of the Cadomian crust in Caledonian times. In agreement with BEHR (1978) and BEHR & WEBER (1980) this rejuvenation took place along subfluence zones in the internal zones of the Palaeozoic ensialic orogene. I explain the intra-Moldanubian nappe structures as Caledonian subfluence zones.

In Hercynian times the Moldanubicum was a consolidated core. New subfluence zones developed along its margins, their orientation however is different from the older ones. Though subfluence was a long lasting continuous process in the sialic crust of Europe (BEHR, 1978), successive thrust belts may be discerned.

The Palaeozoic orogeny of Central Europe affected the infracrust first, later the supracrust was involved (BEHR & WEBER, 1980). The orogeny started with the central zones of the mountain belt which grew outwards by the accretion of younger zones.

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[1]) I do not use the terms Monotonous and Varied Group of the Czechoslovakian geologists, because I am excluding the granulites, Gföhl Gneisses and their accompanying series from the Varied Group.

[2]) The term Moravicum is used in the sense of F. E. SUESS, who designates the Bitesch Gneiss as Moravicum, the Micaschist Zone as Moldanubian. JENCEK & DUDEK (1971) took eastern portions of the Moldanubicum (e. g. Vratenin Series = Varied Series of Drosendorf) as Moravicum, a view I can not follow.

[3]) Recently Prof. FRANK suspects that this age might be a mixed one.

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Abstrakt

Řada současných publikací interpretuje moldanubikum jako integrální část hercynského orogénu. To znamená, že vnitřní příkrovová stavba moldanubika je hercynská, stejně jako vnitřní stavba moravika.

Na rozdíl od tohoto názoru autor předkládá doklady, že moldanubikum představuje intramontánní blok evropských hercynid.

1. Moldanubická pásma v j. Čechách o průběhu SV-JZ jsou v pravém úhlu uťata bavarikem s celkovým trendem SZ-JV. V tomto hercynském pásmu jsou moldanubické struktury smazány a rotovány do nového směru.
2. Ve Waldviertlu a na Moravě je moldanubikum nasunuto na moravikum podél přesmyku hercynského stáří, upadajícího k Z.Tato plocha utíná vnitřní struktury moldanubika, upadající k V, diskordantně. V této okrajové části je moldanubikum postiženo retrográdní metamorfózou a převrásněním.
3. Starší intruzíva moldanubického plutonu jsou vůči moldanubickému komplexu posttektonická, v hercynském bavariku jsou synorogenní.
4. Granulity, které vznikly jako tektonity podél intramoldanubických střižných ploch, naznačují, že tyto pohyby probíhaly bezprostředně po vzniku velkých těles granulitů a gföhlských rul, které jsou datovány jako kaledonské.
5. Wolfshofský syenit byl zakliněn podél intramoldanubických přesmykových ploch v době, kdy nebyl ještě ve zcela pevném stavu. V současnosti byl datován 430 ± 15 miliόny let, což dokumentuje kaledonské stáří příkrovové tektoniky.

Všechna tato fakta vedou k závěru, že moldanubikum představuje staré jádro, pouze okrajově přepracované v průběhu hercynské orogeneze. Domnívám se, že ve smyslu Behra (1978) byla kadomská kůra rejuvenována podél kaledonských zón subfluence, což vedlo ke vzniku moldanubika. To tvořilo zárodečný nukleus, pod který se ze všech stran podél okrajů podsunula mobilní hercynská pásma. Kaledonské subfluence se omezily na infrakrustální komplexy, kdežto hercynská orogeneze postihla i suprakrustální komplexy. Orogenní pásmo jeví akreci z vnitřních a starších částí přikládáním vnějších a mladších zón.

Zusammenfassung

In einer Reihe neuerer Arbeiten wird die Meinung vertreten, daß der interne Deckenbau des Moldanubikums variszisch wäre wie der des Moravikums.

Im Gegensatz dazu argumentiert der Autor dafür, daß das Moldanubikum eine Zwischengebirgsmasse in den europäischen Varisziden bildet:

1. Die NO-SW-streichenden Zonen des Moldanubikums Südböhmens werden von dem NW-SO-verlaufenden Bavarikum im rechten Winkel geschnitten. In dieser variszischen Zone wird der moldanubische Gesteinsbestand aufgelöst, umgewandelt, und die älteren Strukturelemente in die neue Richtung umgeregelt.
2. Im Waldviertel und in Mähren überschiebt das Moldanubikum das Moravikum an einer gegen W abtauchenden variszischen Bewegungsfläche — der moldanubischen Überschiebung. Diese Bewegungsfläche schneidet die ostfallenden internen Strukturen des Moldanubikums diskordant. Im Randbereich wird dabei das Moldanubikum umgefaltet und von rückschreitender Metamorphose betroffen.
3. Die älteren Intrusiva des variszischen moldanubischen Plutons erweisen sich als posttektonisch gegenüber dem moldanubischen Gneiskomplex. Im variszischen Bavarikum sind sie hingegen synorogen.
4. Entlang innermoldanubischen Bewegungsflächen bildeten sich Granulite als Tektonite. Dies spricht dafür, daß die Bewegungen während hochgradiger Regionalmetamorphose, wohl unmittelbar nach der Bildung der großen Granulit- und Gföhler Gneismassen erfolgten. Diese Gesteine wurden als kaledonisch altersbestimmt.
5. Der Wolfshofer Syenit wurde an innermoldanubischen Überschiebungen eingeschlichtet, als er noch nicht in festem Zustand war. Er wurde kürzlich mit 430 ± 15 m. a. datiert, woraus ein kaledonisches Alter der Überschiebung folgt.

Alle diese Tatsachen führen zu dem Schluß, daß das Moldanubikum einen älteren Kern darstellt, der während der variszischen Orogenese nur randlich überprägt wurde. Im Sinne von BEHR (1978) bin ich der Meinung, daß cadomische Kruste durch kaledonische Subfluenzzonen reaktiviert wurde, was zur Bildung des Moldanubikums geführt hat. Dieses bildete einen Kern in den Varisziden, der an seinen Rändern durch die mobilen variszischen Zonen unterschoben wird. Die kaledonischen Subfluenzen haben zunächst die Unterkruste betroffen, während die variszische Gebirgsbildung auch die Oberkruste erfaßt hat. Das Orogen wuchs von seinen inneren, älteren Teilen nach außen durch die Angliederung neuer, äußerer Zonen.

Rb-Sr SYSTEMATICS OF INTRUSIVE ROCKS FROM THE MOLDANUBICUM AROUND JIHLAVA

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We report here about the work of the last years that was performed in cooperation of GEOINDUSTRIA Jihlava with the Geologische Bundesanstalt. The study is the continuation of research work that has been started on the Austrian part of the Moldanubian pluton (SCHARBERT 1987, 1989). The area around Jihlava was of special interest because in its vicinity the Monotonous and Varied Groups are cropping out, accompanied by magmatites of very contrasting composition, which are the topic of this paper. The Jihlava and Třebíč Massifs are composed of melanocratic biotite, amphibole, and pyroxene rich rocks and the Central Moldanubian Pluton of light coloured biotite-muscovite bearing granites. Fig. 1 shows the situation of the massifs as well as the sample localities from which Rb-Sr data are presented below.

The Central Moldanubian Pluton (Eisgarn Massif)
The part of the pluton as shown in Fig. 1 extends over a distance of approximately 100 km in NE — SW direction. The maximun width of more than 20 km at the boundary between Austria and Czechoslovakia diminishes to the south and to the north to attain there the shape of apophyses not more than 3 km broad (Fig. 6). It crops out as a body of greater width (Massif of Melechov) NW of Havlíčkův Brod. According to MOTTLOVÁ (1982) the granite is of relatively small thickness in its central parts dipping to