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Horizontal Movements on Deep Faults in the Proterozoic Basement of Moravia (Czechoslovakia)

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With 3 Figures

ČSSR
Böhmische Masse
Kristallin
Proterozoikum
Moldanubikum
Blattverschiebungen
Metamorphose

Summary

Since all radiometric methods for age determination of the metamorphosed Proterozoic rocks in the eastern part of the Bohemian Massif have been unsuccessful so far, the author has tried to determine the relative age by analysis and synthesis of regional geological data. He has come to the conclusion that sizeable horizontal block movements of several tens of km are of pre-Paleozoic age. Because the granulite massif of the Moldanubicum was displaced on the Diendorf dislocation during the Proterozoic, the metamorphism of the Moldanubicum must have taken place much ealier. The superposition of non-metamorphosed Devonian and Carboniferous rocks above the granulites, and the high-temperature metamorphosed surrounding gneisses of the Miroslav Horst, prove that high temperature and low pressure metamorphism had taken place in the Moldanubicum already by Proterozoic times and again during the Variscan tectogenesis (intrusion of plutons).

Zusammenfassung

Bisher haben radiometrische Methoden der Altersbestimmung im Gebiet des metamorphen Proterozoikums, im östlichen Teil der Böhmischen Masse, alle Erwartungen enttäuscht. Deswegen versucht der Autor, das relative Alter des Kristallins durch regional-geologische Betrachtungen zu dechiffrieren. Er kommt zum Schluß, daß die großen Blattverschiebungen (um mehrere Zehnerkilometer) in vorpaläozoischer Zeit erfolgt sein müssen. Da an der Diendorfer Dislokation ein Granulit-Massiv noch im Proterozoikum zerschert worden ist, muß auch die Metamorphose des Moldanubikums alt sein. Die Lagerung von nicht metamorphen Sedimenten des Devons und Karbons auf den Granuliten des Misslitzer Horstes und den von Hochtemperatur-Metamorphose überprägten, umgebenden Gneisen bestätigt, daß das Moldanubikum schon im Proterozoikum einer Tiefdruck- und Hochtemperatur-Metamorphose ausgesetzt war. In der Variszischen Tektogenese wurde das Moldanubikum noch einmal durch eine Metamorphose desselben Typs überprägt (Intrusion von Plutonen).

Radiometric methods are important for the determination of ages of volcanic rocks or dating of metamorphic processes influencing the sedimentary fill of geosynclines. In the case of dating of blocks of metamorphites incorporated into a younger orogene, the situation is far more complicated. If metamorphism took place in several stages, as proved by petrological methods, the age of metamorphism is not easy to determine radiometrically. We can be certain that the real age of the rocks is greater than that given by radiometric data.

In the Bohemian Massif it is quite possible that the oldest rocks are 2000–3000 Ma old (GRAUERT, et al., 1973). The Bíteš Gneiss gives a radiometric age of 800 Ma (S. SCHARBERT, 1977) which might approach the real age. All the data about 400 Ma determined from the Moldanubian rocks (Caledonian episode) cannot be supported by geological facts and are influenced by secondary, mainly Variscan, processes. The evaluation of the Rb/Sr whole rock ages of the crystalline rocks of the European Variscides is given by DORNSIEPEN (1979).

Neither the ealier, nor the later (BREEMEN et al., 1982) age determinations of the metamorphic rocks of the Bohemian Massif core by radiometric methods have been successful; on the contrary, the more individual data that are available, the more complicated becomes the situation.

Since these promising methods failed to satisfy the demand, it is necessary to analyse the area geologically and attempt to determine relative chronology. Mistakes are possible depending on the correctness of the geological interpretation. The eastern part of the Bohemian Massif may give a successful solution. It is formed by several blocks of crystalline Proterozoic basement, divided by deep faults or zones with sizeable horizontal movements. G. FUCHS & MATURA (1976) suppose that these movements took place during the youngest Palaeozoic. ARTHAUD & MATTE (1977) are of a similar opinion when explaining Permian tectogenesis of the Appalachians and the Urals.

The most important lineament running through the Bohemian Massif and the Carpathians in Czechoslovakia (Fig. 1) is the prolongation of the Elbe zone from Dresden to the SE (DVOŘÁK & PAPROTH, 1969). In Moravia it is represented by the fracture zone of the Upper Moravian Basin separating the North Moravian block,

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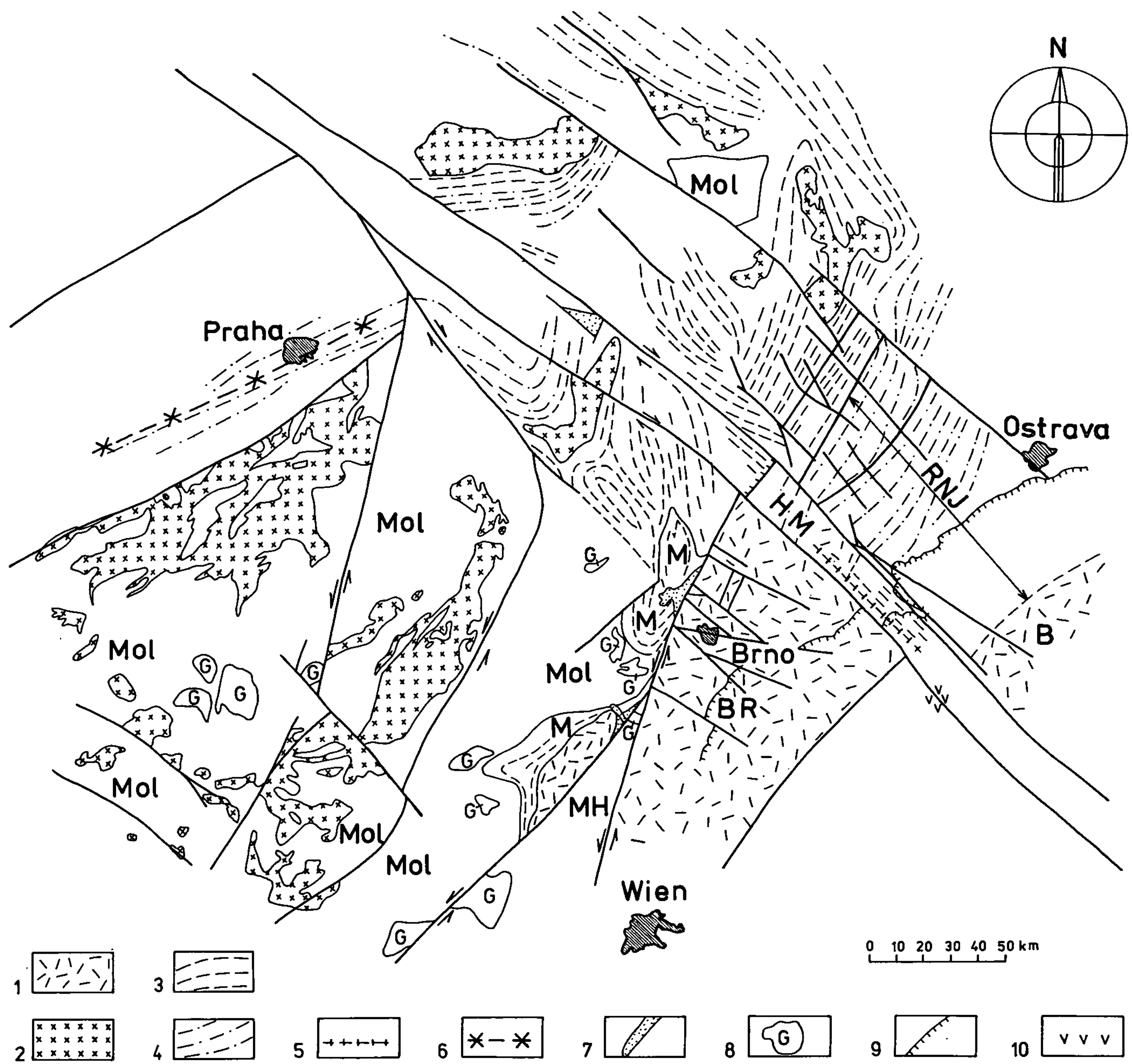

Fig. 1: Schematic structural map of the eastern part of the Bohemian Massif.
1 = Proterozoic granitoids; 2 = Variscan granitoids; 3 = trends of structures in the Proterozoic metamorphic rocks; 4 = trends of structures in the Palaeozoic sediments; 5 = axial trend of a pronounced positive magnetic anomaly in the Upper Moravian Basin (cf. fig 2); 6 = the axis of the Barrandian; 7 = outcrops of nonmetamorphosed Devonian and Lower Carboniferous sediments along the Diendorf dislocation, in the Boskovice Furrow and near Hradec Králové along the Elbe lineament; 8 = granulites; 9 = the margin of the Carpathian Flysch nappes; 10 = neovolcanics of Nezdenice in the Carpathians; M = Moravicum; Mol = Moldanubicum; BR = the Brunnia (Brno granitoid massif); HM = zone of the Upper Moravian Basin; MH = the Miroslav (Misslitzer) Horst; RNJ = gneisses of the Nízký Jeseník Mts.; B = granitoid massif below the Beskydy Mts. Palaeozoic rocks of Moravia omitted. The map shows only the Proterozoic basement.

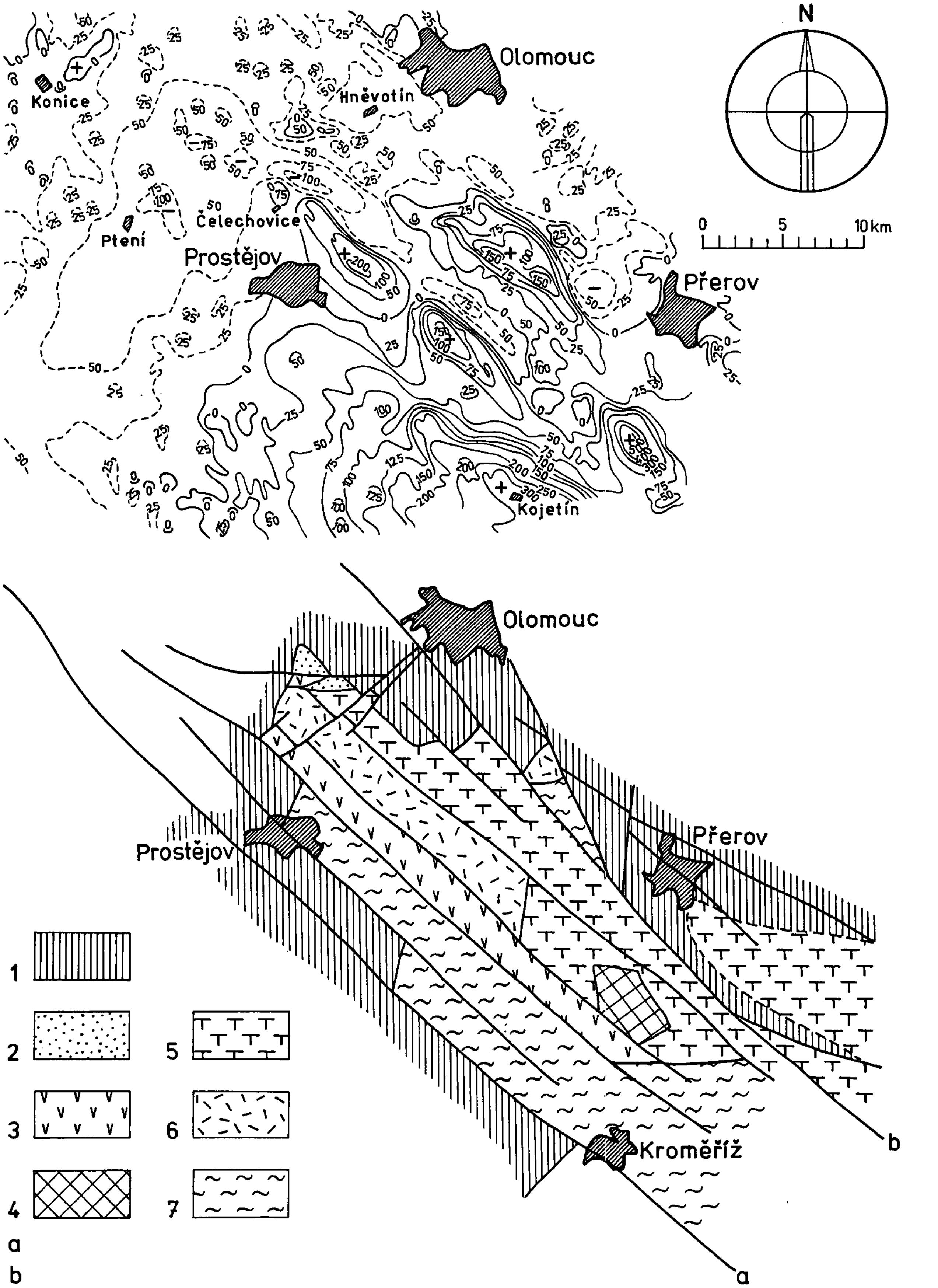

Fig. 2
A – Total Magnetic Field △T map.
B – Structural outline of rocks of Proterozoic age (segment of the Elbe lineament). 1 = nonmetamorphosed Devonian and Lower Carboniferous sediments; 2–7 = Proterozoic rocks (2 = sandstones and slates of the Zábřeh Complex, 3 = metabasites, 4 = ultrabasites, 5 = granodorites and diorites, 6 = granites and pegmatites, 7 = gneisses); a = the Nectava–Konice dislocation; b = the Litovel–Přerov dislocation (after K. Šalanský et al., 1970).

formed mostly by gneiss, from the South Moravian Brunnia (Brno granitoid massif – BLÍŽKOVSKÝ et al., 1977). The fracture zone of the Upper Moravian Basin was consolidated by intrusions of granitoid rocks, basic and ultrabasic rocks in proterozoic times (DUDEK, 1980). The origin of the NW–SE elongated system of crustal blocks with their related magnetic and gravimetric anomalies (Fig. 2) is due to consolidation of a 20 km – wide mobile zone. During Devonian and Carboniferous times, mobile zones followed the margin: in the north-east the system form dislocations, part of which is the Litovel – Přerov fault, the Bušín dislocation etc. On the south-western margin there is a very prominent Nectava-Konice dislocation and its prolongation SE of Kroměříž (gap of the river Morava through the flysch Carpathians to the Vienna Basin – Fig. 2). Non-metamorphosed Devonian sediments with a rich fauna lie horizontally on the metamorphic rocks of the Upper Moravian Basin fault zone.

In the southern part of Moravia the Brunnia is separated from the west Moravian crystalline massif by the fracture zone of the Boskovice Furrow trending NNE–SSW. The Brunnia reaches as far as the gravimetric depression below the Carpathians in the east and the Alps in the south. Between the West Moravian block, formed by the Moravicum and the Moldanubicum, and the Brunnia there is the wedged-in triangular block of the Miroslav-Misslitzer-Horst and its southern continuation, mostly re-covered by Tertiary sediments which are developed mostly in Austria. The boundary between the Miroslav Horst block and the West Moravian block is formed by the Diendorf dislocation; that of the Miroslav Horst block and the Brunnia is formed by the southern continuation of the Boskovice Furrow.

Horizontal block movements of tens or hundreds of kilometres can be regarded as proved (FIGDOR & SCHEIDEGGER, 1977). The direction of their movements along the deep faults is clear from the map (Fig. 1). It conforms to the general trend of block movements in Europe (GAÁL et al., 1978; STRÖMBERG, 1976; STETTNER, 1971; SCHÖNENBERG, 1975; WATSON, 1980). The age of these movements has not been demonstrated yet. Horizontal movements along the NW–SE trending faults (STETTNER, 1971) are evidently relatively younger. Proterozoic foliation of the Zábřeh complex on the NW margin of the Upper Moravian Basin zone is also parallel to this direction. Movements cannot be younger than the Permian fill of the Boskovice Furrow. Devonian and Lower Carboniferous rocks could not be mutually displaced more than several kilometres (DVOŘÁK, 1973). The Diendorf dislocation is covered by Devonian sediments near Znojmo, and by Devonian and Lower Carboniferous rocks near Miroslav (DUDEK, 1960, 1963). These sediments are not disturbed by dislocations and joints with traces of horizontal movements. Horizontal movements of considerable extent on both fault systems (NNE–SSW and NW–SE) are obviously pre-Devonian, most probably Proterozoic. Small horizontal movements (up to 1 km) during the Carboniferous are proved SE of Olomouc (surroundings of Grygov and Přerov; (DVOŘÁK & FREYER, 1968). It is also possible to think about pre-Palaeozoic horizontal movements within the Jeseníky block because of displacement of magnetic anomalies (Fig. 3). Horizontal movements which took place along the NNE–SSW running Vrbno zone and the Šternberk–Hroní Benešov zone are conformable to the system of the Boskovice Furrow, though their extent is smaller, 10–30 km.

The offset can be determined exactly only on the Diendorf dislocation where the granulite massif of the moldanubicum was displaced a distance of 22 km. Displacement on the dislocation system of Boskovice Furrow is estimated to be 80 km. These movements are relatively older with regard to the movements on dislocations of the NW–SE direction. The data indicating the offset have not been published yet. Flexures of the proterozoic complexes at the fault zone of the Elbe lineament allow an inferred displacement of several tens of kilometres. Magnetic anomalies similar to those of Brno granitoid massif are found in the eastern part of the Beskydy Mts. in NE Moravia. Clastic quartz transported in carboniferous times comes from the granitoids (DVOŘÁK, 1982). Thus it is possible to suppose that the Proterozoic basement, today deeply buried under the Magura flysch of the Carpathians, is formed by granitoid rocks which may correspond with the Brno massif. I estimate the horizontal displacement along the Elbe lineament at c. 80–100 km. The weakly metamorphosed Proterozoic rocks of the Barrandian-Teplá block were shifted from the proterozoic structures on the eastern margin of the Giant Mts. by the same distance. This horizontal sigmoid is followed also by the Lower Palaeozoic of the Barrandian, the Železné Mts. and the Giant Mts. (HAVLÍČEK, 1980).

From the interpretation of the material presented here it is evident that:

1) In the proterozoic considerable horizontal movements of blocks took place in Moravia (and in the whole Europe, too).
2) The older horizontal movements of large extent occurred on the NNE–SSW faults, the younger ones on the NW–SE faults. Their extent was about the same.
3) The Moldanubicum in Austria, being also incorporated into the older horizontal displacements is evidently of Lower Proterozoic age. If a nappe structure exists in the West Moravian and Austrian crystallinicum (G. FUCHS & MATURA, 1976), it could not originate later than in the proterozoic.
4) In Europe, fault systems of NW–SE and NNE–SSW direction have been continously rejuvenated and both vertical and horizontal movements have continued on a smaller scale to the present (A. LUDWIG & R. MEIER, 1978).

The considerable age of the Moldanubicum metamorphism is evidenced by the results of NĚMEC (1980) from the granulite area of the Miroslav Horst. He found sillimanite in the surrounding granulite gneisses but only disthene in granulites. Gneisses are supposed to originate by recrystallisation and migmatitization of granulites. In the area of the Miroslav Horst this high temperature metamorphism (sillimanite) is undoubtedly pre-Variscan because of the cover of non-metamorphosed Devonian and Lower Carboniferous sediments. In the Moldanubicum itself this metamorphism is thought to be of Variscan age. The chemical composition of garnets from the granulites of the Miroslav Horst shows that they approach more the granulites of Waldviertel in Austria than those of the Moldanubicum in Czechoslovakia. This fact speaks in favour of more extensive horizontal movements.

The occurrence of pebbles of Moldanubian rocks in the Lower Carboniferous conglomerates of the Drahany

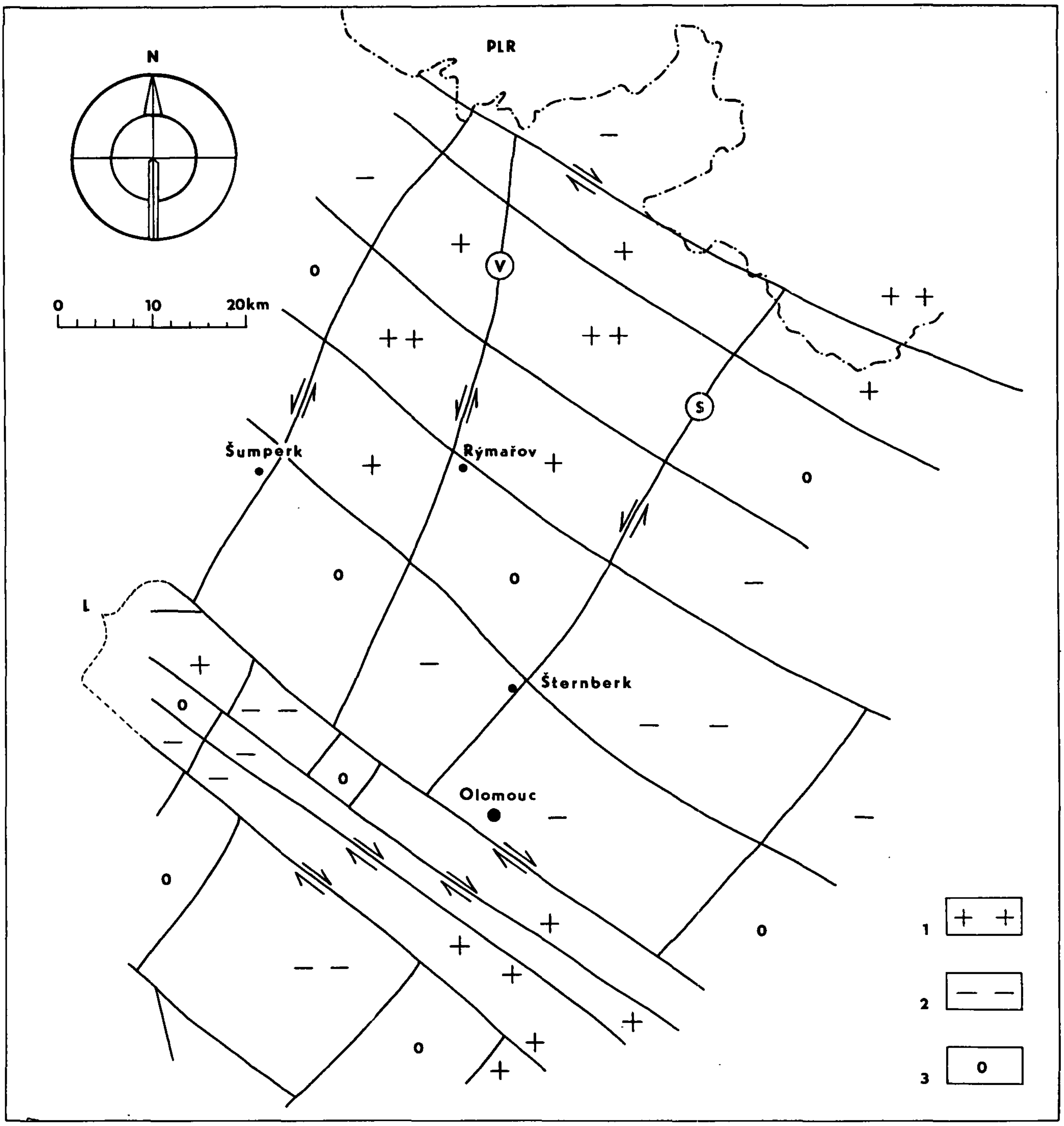

Fig. 3: Schematic map of the block structure of the Northern Moravian Basement, plotted on the basis of aeromagnetic data. 1 = block with pronounced positive magnetic field; 2 = block with pronounced negative magnetic field; 3 = block with normal magnetic field; L = Elbe lineament zone (Upper Moravian Basin); V = the Vrbno zone; S = the Šternberk–Horní Benešov zone. The offset of blocks along the dislocations trending NNE–SSW may be between 10–30 km.

Upland NE of Brno (ŠTELCI, 1960) is one of the arguments for the Variscan age of Moldanubian metamorphism. Pebbles of sillimaite gneiss occur at the base of a ca. 3.000 m thick conglomerate sequence. The Rozstání Formation with maximum thickness 1.000 m (Lower to the base of Upper Visean shales and greywackes) occurs below the conglomerates. Because of the relatively small areal extent of this formation on the Drahany Upland, no intensive denudation of the meso- and epizonal rocks in the Moldanubicum comes in question. Therefore in Devonian and Carboniferous times the Moldanubicum was not covered by weakly metamorphosed overlying rocks.

Special attention should be given to the radiometric dating of the Moldanubian granulites (after BREEMEN et al., 1982, 345±5 Ma – according to U-Pb zircon ages). This radiometric dating must be doubtful if the occurrence of the pebbles of these granulites (up to 2 m in diameter) in Upper Visean conglomerates (i. e. 320–330 Ma old – after ODIN, 1982) is taken into account. Intensive denudation within this time gap bringing these granulites to the surface can be excluded because no stratigraphically corresponding clastic sediments are known from the surrounding areas.

High temperature and low pressure metamorphism of the Moldanubicum is possibly not only Variscan but also Cadomian in age (e. g. migmatitization of the Gföhl gneiss in Moravia – DUDEK et al., 1974). That is why relatively oldest high pressure Moldanubian metamorphism is most probably older than the Cadomian. All the results of radiometric dating should be interpreted very carefully.

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