

# Late orogenic extension in the Bohemian Massif: petrostructural evidence in the Hlinsko region

## *Extension tardi-orogénique dans le Massif de Bohême : arguments pétrostructuraux dans la région de Hlinsko*

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**ABSTRACT.** - The tectonic contact between low-grade metasedimentary series and high-grade rocks in the Hlinsko region (Bohemian Massif) is commonly interpreted as a thrust of the Barrandian sediments over the upper Moldanubian nappe.

The sediments occur in an E-facing synform that contains a tonalitic laccolith on its eastern boundary with the Moldanubian, and is truncated by a granodiorite pluton to the west. The synform represents a late deformational folding event related to the granodiorite intrusion. NW-oriented normal shear in the tonalite is indicated by S-C microstructures. Kinematic criteria associated with the major foliation and lineation development in the metasediments also indicate a north-westward, normal shear. In addition, Moldanubian gneiss display late shear bands due to north-westward, normal shear. Consequently, the presumed thrust is a low-angle, normal shear zone.

Low-pressure type metamorphism ( $3 < P < 4 \times 10^2$  MPa) coeval with the major deformational phase in pelites of the Hlinsko synform is attributed to both the tonalite aureole and the extensive HT metamorphism (under  $P > 6 \times 10^2$  MPa) that has affected the underlying Moldanubian.

The possibly polyphase normal fault is consistent with the metamorphic pressure jump between the metasediments and the Moldanubian.

We suggest that the tonalite intruded syntectonically within the normal ductile shear zone active during waning stages of the Variscan orogeny.

**Key words:** Bohemian Massif, late orogenic extension, Variscan.

**RÉSUMÉ:** Le contact tectonique entre les séries métasédimentaires de bas degré et les roches de haut grade a été interprété comme le chevauchement du Barrandien sur le Moldanubien.

Dans la région de Hlinsko, les séries sédimentaires forment une synforme déversée vers l'Est qui comprend une lame tonalitique sur sa bordure Est, avec le Moldanubien, et est recoupée par un pluton granodioritique à l'Ouest. Le développement de la synforme régionale est lié à la mise en place tardive de l'intrusion granodioritique. Les microstructures S-C indiquent un cisaillement en faille normale au niveau de la tonalite.

Les critères cinématiques associés aux foliations et linéations majeures des métasédiments indiquent également un cisaillement vers le NW, en faille normale que l'on retrouve encore dans les gneiss du Moldanubien.

Un métamorphisme de basse pression ( $3 < P < 4 \times 10^2$  MPa), synchrone de la déformation majeure dans la synforme de Hlinsko, est attribué à l'intrusion de la tonalite et au métamorphisme de HT qui a affecté le Moldanubien sous-jacent ( $P > 6 \times 10^2$  MPa).

Le contact entre le Barrandien et le Moldanubien peut être polyphasé, mais la structure actuelle résulte d'une faille normale, ductile. Cette interprétation est cohérente avec la saute de pression métamorphique relevée au niveau du contact entre le Moldanubien et les métasédiments de Hlinsko. Nous proposons que la tonalite soit un laccolite syntectonique intrusif dans la faille normale ductile. Cet événement est tardif dans l'histoire orogénique de la chaîne varisque.

**Mots clefs :** Massif de Bohême, extension post orogénique, chaîne Varisque.

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## I. INTRODUCTION

The importance of extensional structures and their interplay with shortening tectonics has been emphasised in the last years through many examples from several orogens (e.g. Wernicke, 1981; Dewey, 1988; Friedman and Armstrong, 1988; Van den Driessche and Brun, 1992). Yet, the dynamics and mechanical constrains of orogenic extension are not fully understood. Among many questions, deep seated processes and interaction between metamorphism, deformation and plutonism require more information. We aim to show that syntectonic laccoliths may be intrusive within major ductile contacts and can enhance the gravitational collapse of a part of an orogen.

Two major blocks have been recognised in the central part of the Bohemian massif (Fig. 1) : 1) the Barrandian, consisting of upper-Proterozoic to middle Devonian sediments is characterised by low grade metamorphism and shallow type fold tectonics and 2) the Moldanubian represented by high grade sequences containing relics of HP metamorphites (e.g. Kossmat, 1927). Tollmann (1982) subdivided the Moldanubian into two large scale nappes: the lower Drosendorf nappe and the upper Gföhl nappe that differ by their lithological content and their metamorphic evolution (cf. also Thiele, 1976; Fuchs, 1976). The nappe pile is essentially Variscan in age (e.g. Van Breemen *et al.*, 1982).

East-verging folding of sedimentary strata is frequently used as indicating eastward thrusting of the Barrandian over the Moldanubian (e.g. Tollmann, 1982). Hence, the contact between Late-Proterozoic to Early-Palaeozoic Barrandian sediments of the Hlinsko region and the Variscan Moldanubian nappe pile

assumes a key role in the interpretation of the Bohemian Massif. This contact is usually interpreted as a flat lying thrust zone (Ulrich, 1930; Sachsel, 1933; Vachtl, 1962; "Hlinsko thrust" of Franke, 1989).

The aim of this paper is to describe and to compare the structural and metamorphic evolution of the Palaeozoic sediments with that of the underlying high-grade metamorphites in the Hlinsko area. We will argue that the best interpretation implies that the "Hlinsko thrust" zone is actually a normal shear zone. This zone includes a late Variscan tonalite forming a laccolith between the supposedly Barrandian sediments and the underlying Moldanubian gneisses. Its geodynamic significance is discussed in the light of the late evolution of the Variscan orogen in the Bohemian Massif.

## II. GEOLOGICAL SETTING

The Hlinsko Palaeozoic sediments ascribed to the Barrandian block form a N-S elongated outcrop limited by the Nasavrky plutonic complex to the west and the high-grade metamorphites of the Svatka crystalline unit to the east. Three Early-Palaeozoic metasedimentary units are identified (Vachtl, 1962), from the bottom to the top (Fig 2): 1) the pelites and greywackes Hlinsko series that cap a pelite and metavolcanic sequence (Vítanov series), 2) the pelitic Mrákotín series containing lydite and quartzite beds and 3) the mostly greywackes Rychmburk series.

The Silurian age (Late Llandovery - Early Wenlockian) of the Mrákotín series is warranted by graptolites (Wurm, 1927; Horny, 1956). The age of the

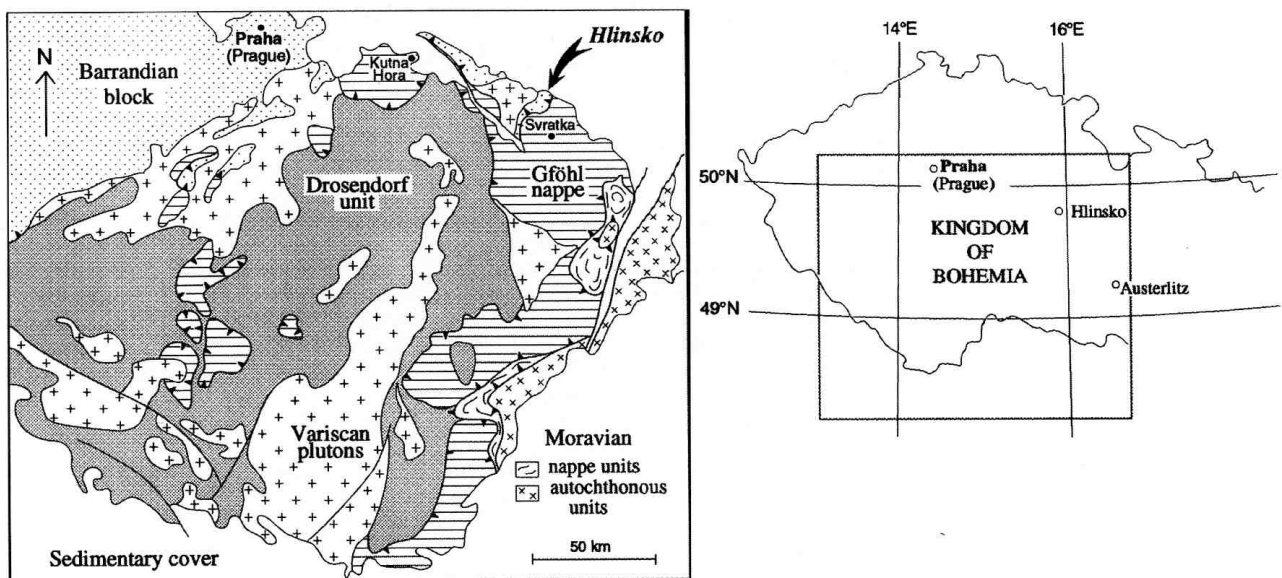


Fig. 1 - Sketch map of the central part of the Bohemian Massif (modified after Tollmann, 1982) with location of the Hlinsko region.  
 Fig. 1. - Partie centrale du Massif de Bohême avec localisation de la région de Hlinsko (modifié d'après Tollmann, 1982).

Hlinsko (Ashgill ?) and Rychmburk series (Early-Devonian and/or Carboniferous ?) is inferred in the light of their lithological similarities with other regions of the Bohemian Massif and according to their stratigraphic position above and below the Mrákotín series, respectively (e.g. Sachsel, 1933; Vachtl, 1962). Imperfect micropaleontological evidence (Konzalová and Vachtl, 1976) supports the Silurian to Early-Devonian age of the uppermost Rychmburk layers (Ulrich, 1930; Sachsel, 1933; Vachtl, 1950; Svoboda, 1956; Konzalová and Vachtl, 1976) although the Early-Carboniferous (Kodym, 1927; Cháb, 1973) cannot be excluded since coal lenses with fossil plants occur in place (Vachtl, 1950).

The Nasavrky plutonic complex is essentially composed of granodiorites dated by Smejkal (1960, 1964) at 360 - 366 My (K/Ar, whole rock). However, recent datings at  $320 \pm 4$  My (Scharbert, 1987, Rb-Sr whole rock) suggest a younger age for the associated granites.

The Svatka crystalline unit is attributed to the Moldanubian Gföhl nappe (e.g. Tollmann, 1982; Franke, 1989; Matte *et al.*, 1990). However, on the basis of lithological differences, some authors consider the Svatka as a separate unit that does not belong to the Moldanubian proper (e.g. Kodym, 1948; Svoboda, 1966). It comprises orthogneisses and migmatites with minor micaschist beds, lenticular bodies of amphibolites and skarns parallel to the main foliation. A tonalite laccolith occurs within the contact with the Hlinsko Palaeozoic sediments.

### III. STRUCTURAL AND KINEMATIC DATA

Mapping of the Hlinsko Palaeozoic sediments shows that they are folded by a large, E-verging synform with a NNE plunging axis (Vachtl, 1962, Benés, 1963). The eastern, west-dipping limb includes the tonalitic laccolith and the underlying Svatka crystalline unit. A granodiorite of the Nasavrky complex intrudes the subvertical to reverse western limb. Detailed structural analysis shows that polyphase deformation has taken place in the Hlinsko sediments. We first describe the superposed microstructures. Then we show that the tonalite laccolith has recorded shear deformation during its emplacement (Fig. 3).

#### A. Polyphase structures of the metasedimentary units

Three deformation events (D1-3) are regionally distinguished. Their development is heterogeneous and depends mostly on the distance from either the granodioritic complex or the tonalitic laccolith.

First generation structures D1 include an S1 cleavage subparallel to bedding S0 (Ph. 1). S1 is marked by the alignment of quartz, chlorite, muscovite, chloritoid and ilmenite crystals in the lowermost pelites. No associated lineation and fold have been recognised. S1 is hardly discernible in the greywackes-rich upper levels and wes-

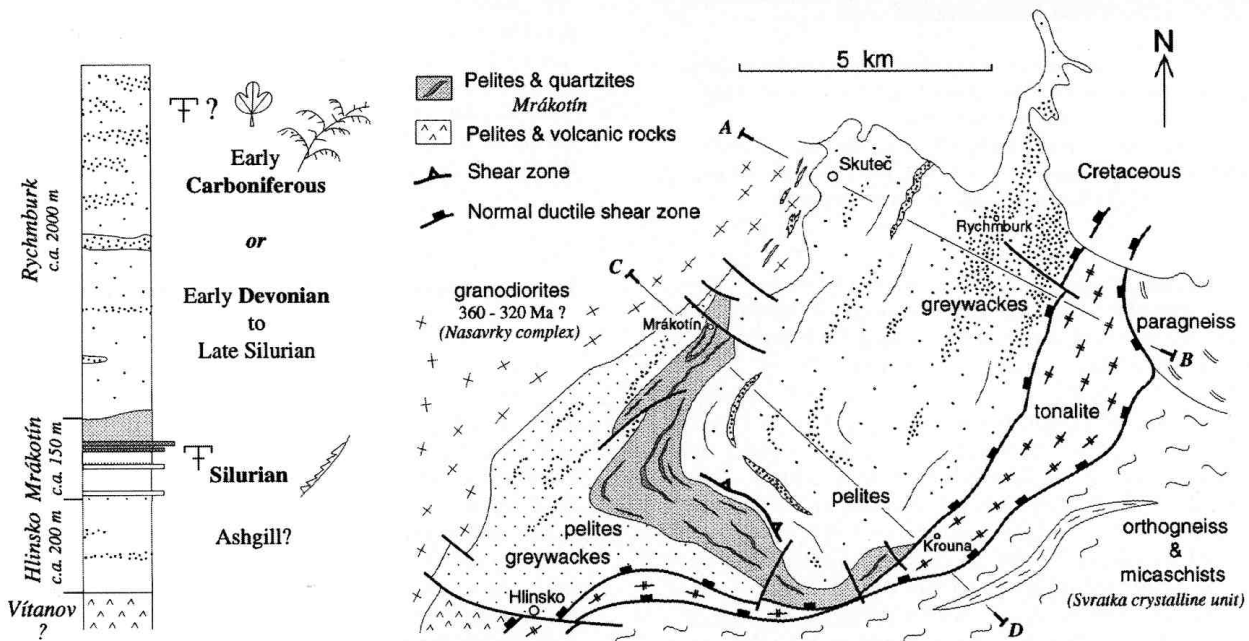


Fig. 2. - Sketch map and stratigraphy of the Hlinsko region. AB and CD = cross sections of figure 3.

Fig. 2. - Carte géologique simplifiée et log stratigraphique de la région de Hlinsko. AB et CD = trace des coupes de la figure 3.