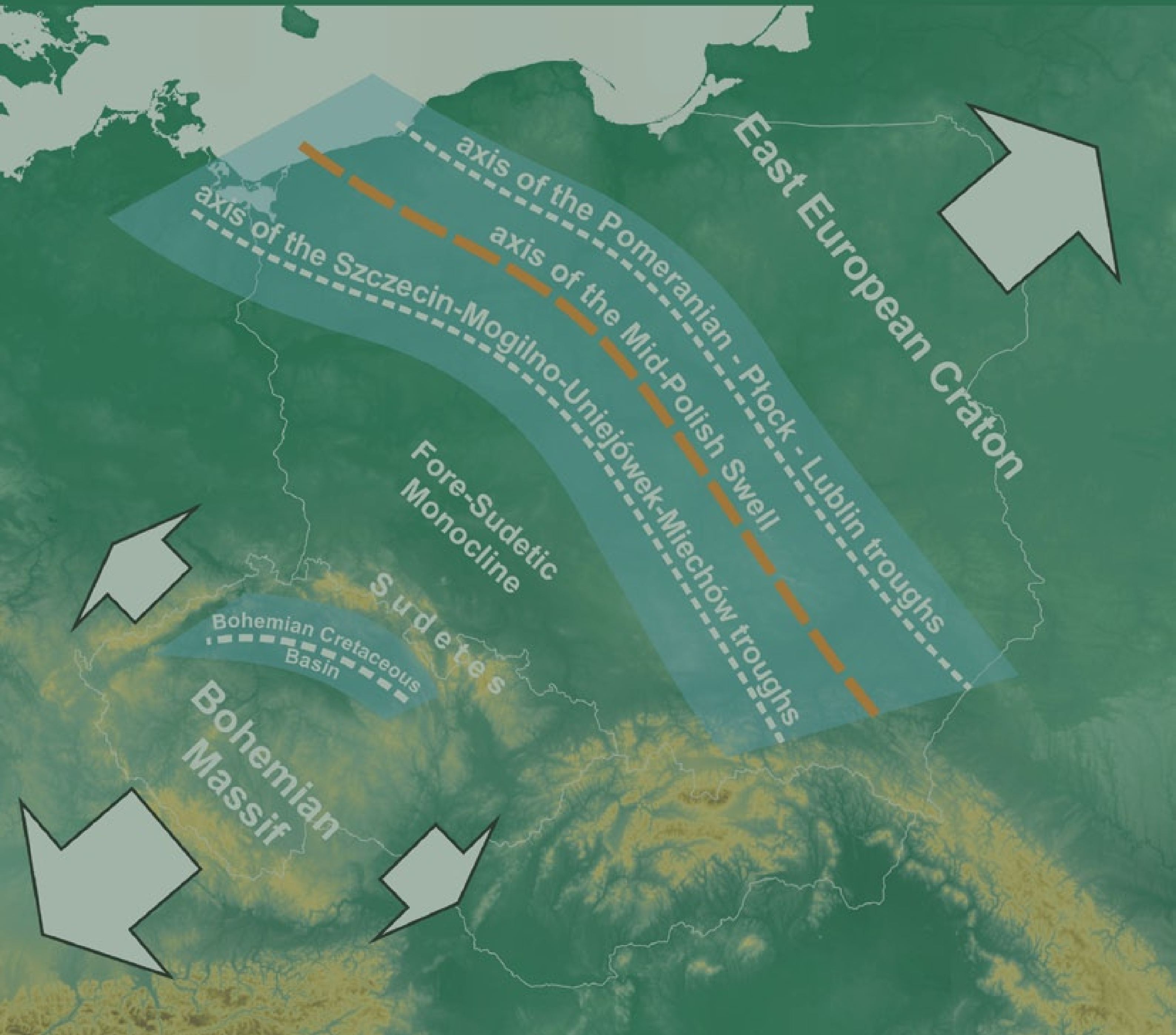
JAN KOZIAR

# Tensional origin of the inversion in the Polish Basin

## with the reference to tensional development of the Bohemian Massif

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# TENSIONAL ORIGIN OF THE INVERSION IN THE POLISH BASIN WITH REFERENCE TO TENSIONAL DEVELOPMENT OF THE BOHEMIAN MASSIF

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## EXTENDED ABSTRACT

### The Polish Basin and the views on its development

The biggest geological structure on the Polish territory is the Polish Basin. It comprises the Mid-Polish Swell (fig. 1) running NW-SE and the adjacent two rows of troughs: Pomeranian, Płock and Lublin (to the NE) and Szczecin, Mogilno, Uniejów and Miechów (to the SW). The Mogilno and Uniejów troughs turn towards SW into the Fore-Sudetic Monocline which rests against the NE margin of the Bohemian Massif. The NE structural border of the Polish Basin is determined by the margin of the East European Craton to which the NE row of troughs adjoins.

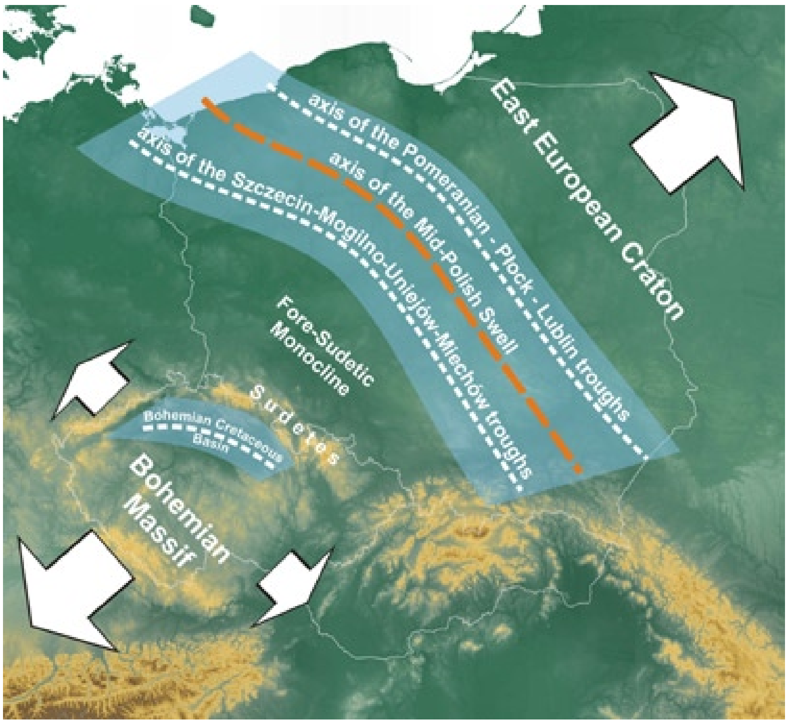


**Fig. 1. Location of the main structures under discussion and the tensional plan of their development.**

The Polish Basin is filled mainly by Permian-Mesozoic deposits. At the turn of the Mesozoic and Cenozoic the basin was rebuilt what was manifested by:

(1) uplifting of the Mid-Polish Swell,

(2) development of the two rows of troughs

(3) gradual ceasing of sedimentation.

Up to the 80s the development of the Polish Basin was treated according to traditional compressional tectonics. In particular the uplift of the Mid-Polish Swell was believed to result from compression transmitted mainly through the Bohemian Massif from the late Cretaceous Alpine-Carpathian folding. In the post-war period the syntectonic sedimentation was being recognized in many European Permian-Mesozoic basins (Voigt 1963). It became clear that the Mid-Polish Swell up to the beginning of the late Cretaceous was a trough ("the Mid-Polish Trough") with the largest subsidence and greatest thickness of deposits. In the late Cretaceous and early Paleocene the trough was being uplifted into the present swell (fig. 1) and axes of the subsidence appeared beside it, leading to creation of the two adjacent rows of the present troughs.

In 1978 McKenzie made a breakthrough in understanding of the development of sedimentary basins, pointing out their tensional origin. Soon after that the term "inversion" (Glennie & Boegner 1981) began to be used to denote the uplifting of central parts of sedimentary basins (in fact the term was already used by Hall (1859) for the process of transformation of a geosyncline into an elevated fold belt). However, the basin inversion itself is still being explained, by the mechanism of regional compression (traditional tangential compression). In the case of the Mid-Polish Trough the cause is presumed to be, as before, a hypothetical compression ("far field compression") transmitted mainly by the Bohemian Massif from the late Cretaceous Alpine-Carpathian folding. Such a view was presented recently in the papers by Krzywiec (2000, 2002, 2005) and Mazur et al. (2005) – fig.2.

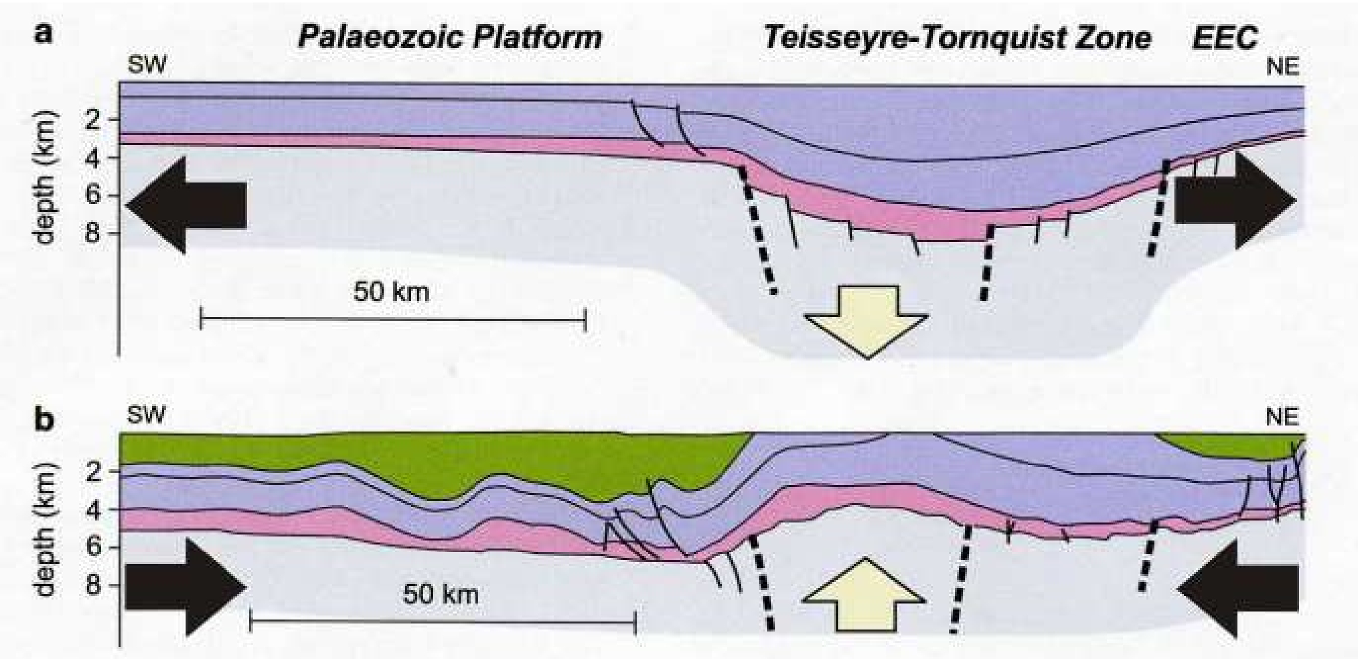


**Fig. 2. Development of the Polish Basin**
after Mazur et al. 2005 (horizontal arrows J.K.); a – tensional stage (subsidence of the Mid-Polish Trough), b – compressional stage (inversion of the Mid-Polish Trough).

However, I will demonstrate that the inversion of the Mid-Polish Trough should be explained as an effect of an isostatic response to stretching of a basement. While the signs of compression – should be explained as an effect of gravitational spreading (Bucher 1956, Ramberg 1981) of a sedimentary prism, being uplifted and losing lateral support (fig. 3).

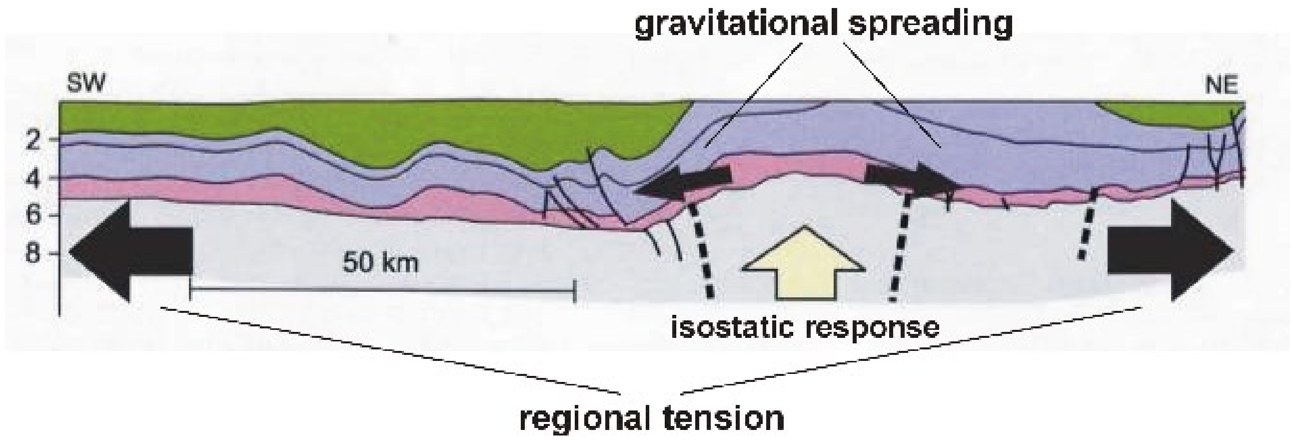


**Fig. 3. Inversion of the Mid-Polish Trough and the gravitational spreading as an effect of stretching of the basement and its isostatic response** (on the basis of fig. 2a, Mazur et al. 2005).

### Reasons for the tensional mechanism of the inversion

First, I will show that the inversion being a result of an assumed regional compression (fig. 2b), is impossible. In particular:

(I) The hypothetical far-field tangential compression generated by the late Cretaceous Alpine fold belt did not exist.

(II) The action of any tangential compression through the Polish Basin is impossible, because of its structure and the structure of its basement.

**Explanations:**

Ia) Post-war investigations revealed that under the frontal part of fold belts and under their fore-deeps, the deep basement is stretched (fig. 4). It means that the compression caused by overthrusted rock series is only a superficial phenomenon that is not indicative of the deformation of the deep basement which develops in a quite opposite manner.

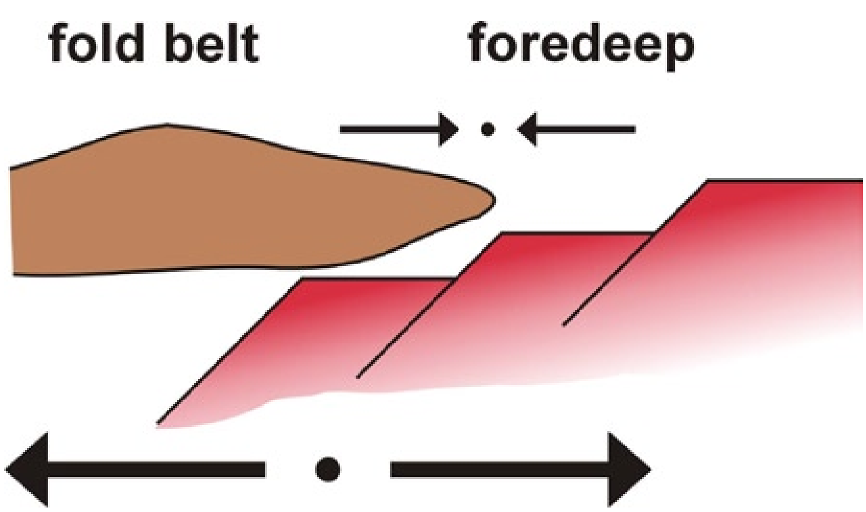


**Fig. 4. Juxtaposition of superficial overthrust compression with deep tension under the frontal part of a fold belt and its fore-deep.** (Koziar 2005a).

Ib) A flysh geosyncline still existed between the developing late Cretaceous Alpine orogen and the Bohemian Massif. What is more, it begun to be more active in the late Cretaceous. And we know, since the investigations of the Alpine geologists of the 40s and 50s, that geosynclines are tensional structures.

IIa) The hypothetical tangential compression was supposed to be perpendicular to almost vertical inversion uplifting (see fig. 2b) which makes the uplifting mechanically unrealistic.

IIb) Both rows of troughs adjoining the Mid-Polish Swell constitute a mechanical "void", unable to transmit the hypothetical tangential compression. The compressional structures, existing here, should be explained by inward gravity tectonics (e.g. Reyer 1888; Van Bemmelen 1954; fig. 5).

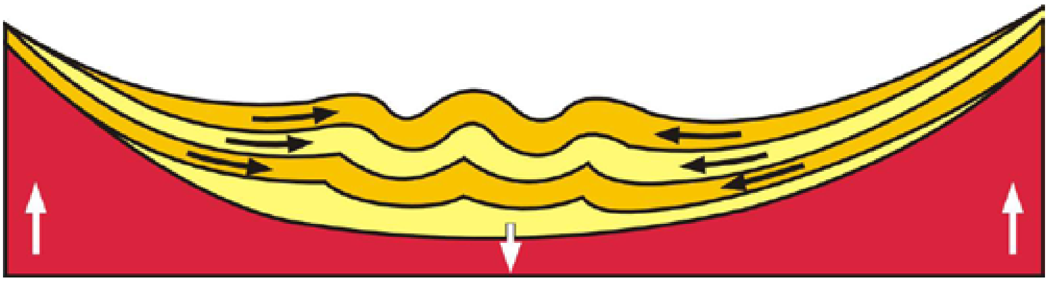

**Fig. 5. Inward gravitational tectonics in a sedimentary basin**
(after Van Bemmelen 1954).

IIc) The basement of the Polish Basin is also unable to transmit the alleged tangential compression because it is weakened by the stretching which produces the so called "neck", visible in the seismic cross-section LT-7 – fig. 6 (Guterch at al. 1999; Stephenson at al. 2003).

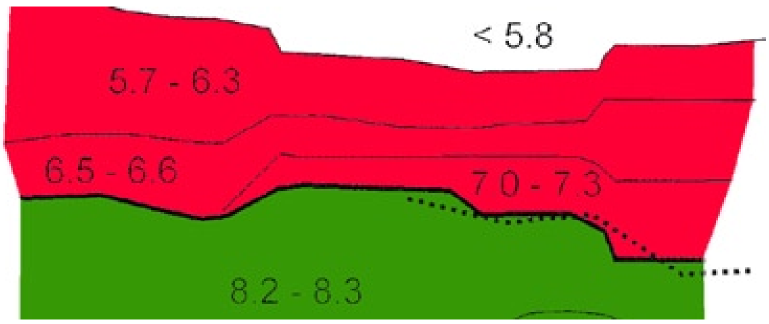


**Fig. 6. Necking of the crust under the Polish Basin**
(profile LT-7, after Stephenson et al. 2003).

Let us return now to the scheme presented in fig. 3. It refers to the well known isostatic response of deep basement to stretching which can achieve the diapiric stage (fig. 7).

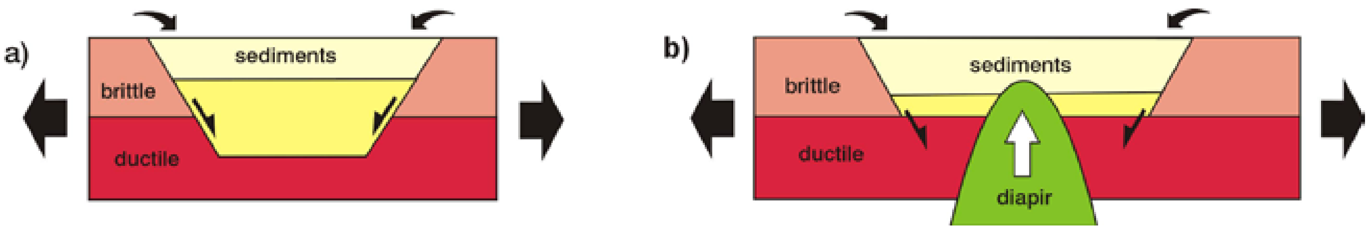


**Fig. 7. Stages of the tensional destruction of the lithosphere,** (according to Ollier & Koziar 2007)
a - development of a sedimentary basin (supracrustal indicator of tension)
b – diapiric reaction of the deep basement (infracrustal indicator of tension)

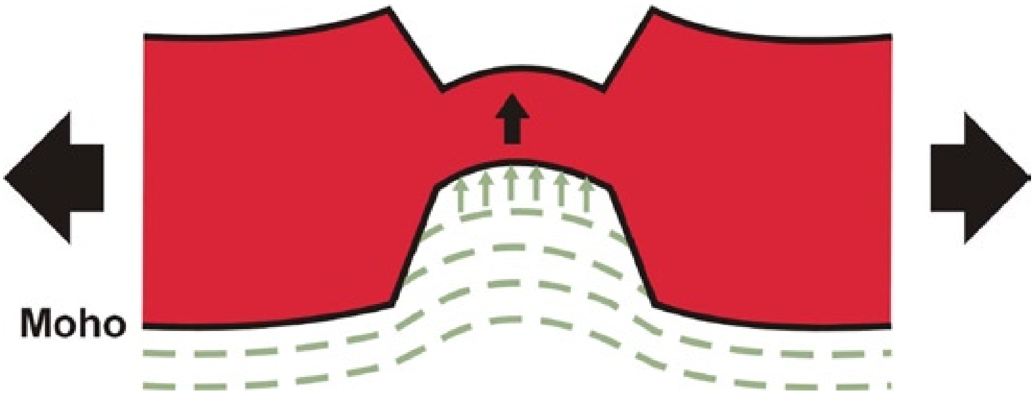


**Fig. 8. Upwelling of a rift neck by isostatic response of unchanged upper mantle**
(after Kooi & Cloethingh 1992).

The response, at the initial stage, can take on different forms. It can be an isostatic upwelling of the rift neck by unchanged mantle (Kooi & Cloethingh 1992). In this case the Moho is upwelling too (fig. 8). It can be also an upwelling of the neck caused by thinned mantle i.e. by a rift pillow (e.g. Illies 1969; Saltus 1993; Swain et al. 1994; O'Reilly et al. 1996; Koziar 2005a). In this case the Moho is downwelling and creates a "root" (fig. 9). The pillow can be hot or cool (sub-rift supersaturation of the mantle with juvenile fluids, serpentinization).

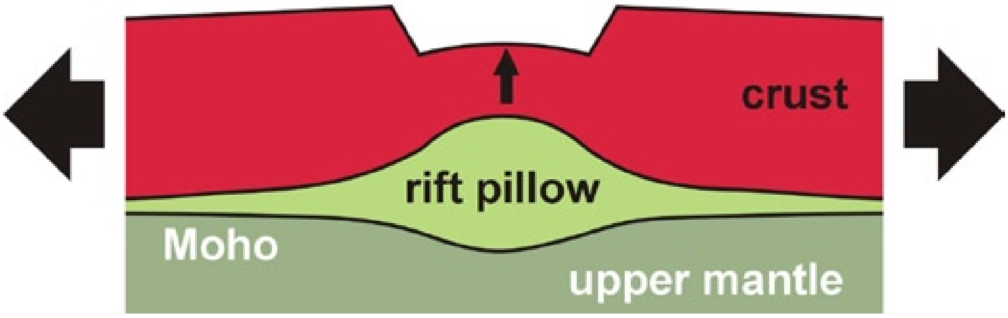


**Fig. 9. Upwelling of a rift neck by the thinned upper mantle (rift pillow).**

The tensional mechanism presented here is in accordance with an accelerated subsidence prior to the inversion (Dadlez et al. 1995; Stephenson et al. 2003). The acceleration shows that the inversion is caused by the escalation of the factor causing the subsidence which is tension. The mechanism is also in accordance with escalation of the salt diapirism which is also connected with tension (e.g. Nalpas & Brun 1993).

The inversion of the Mid-Polish Trough caused the inversion (reversion) of the former gravitational faults, connected with its former subsidence. However, the compression on such faults is not an effect of the assumed regional compression but of gravitational lateral spreading which appears at the stage of the basin inversion. The former inward gravitational tectonics is now replaced by the outward gravitational tectonics.

## Tensional development of the Bohemian Massif

The arguments presented above show that the Bohemian Massif was not subjected to the alleged compression transmitted from the late Cretaceous Alpine folding. The tensional Permian – Mesozoic plan of development of the Polish Basin reaches across the Sudety basins up to the Bohemian Cretaceous Basin (fig.1 and 10).

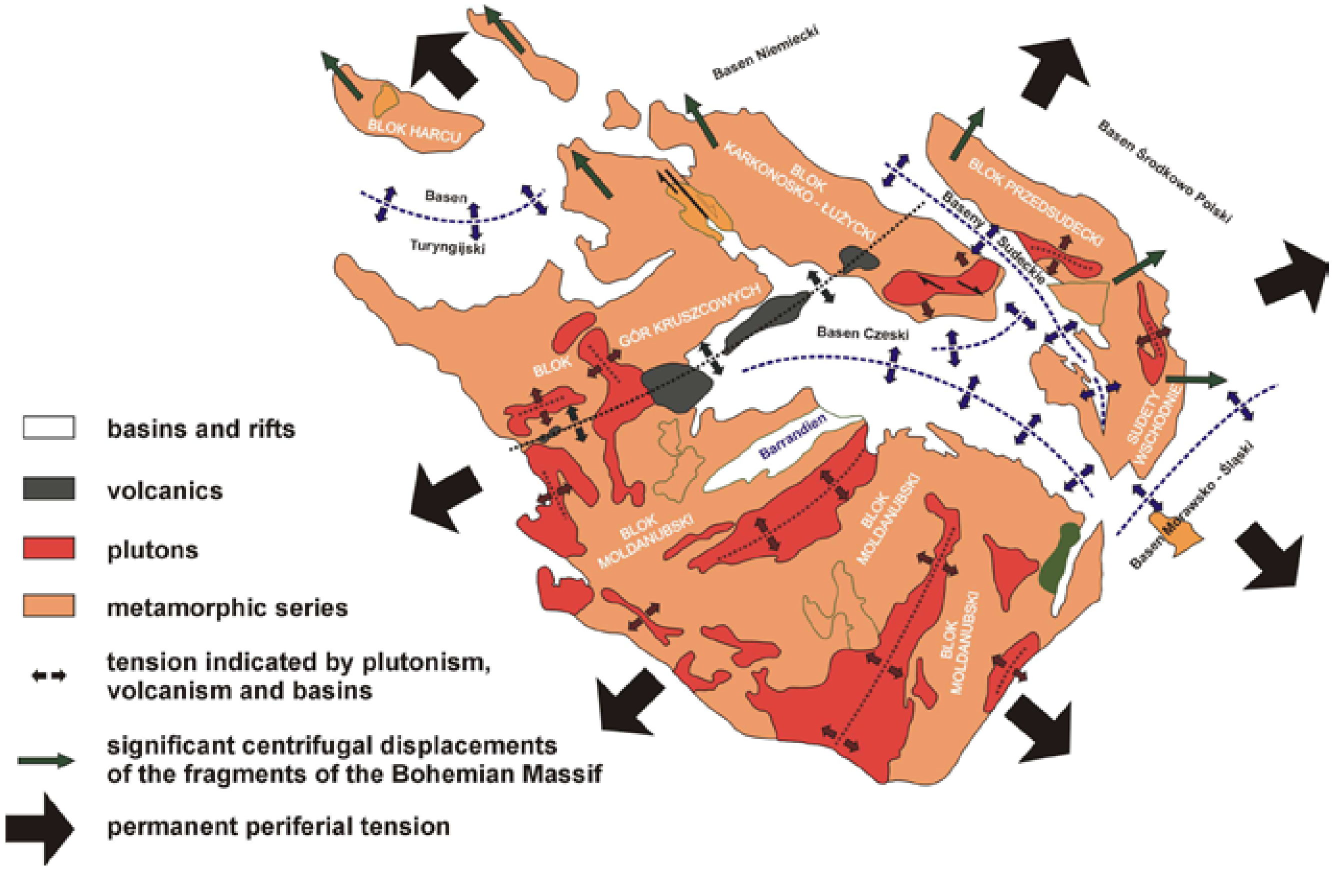


**Fig. 10. Scheme of the tensional development of the Bohemian Massif**
(after Koziar 1993 and Koziar & Wojewoda 1995)

The Bohemian Massif is a basement structure with many linear granitoid intrusions. They are also, as Bohemian basins, indicators of tension. Such indicators are also volcanic zones as e.g. Tertiary volcanic Ohře rift. The set of all these indicators creates for the Bohemian Massif a scheme of radial tension, acting at least since the Variscan epoch up to now (fig. 10). It shows that the driving mechanism of the deformation of the Massif is a radial stretching of the laying below mantle.

The tensional plan of the development of the Polish Basin and the Bohemian Massif is an element of the broader plan of the tensional disintegration of the European Variscides (Koziar 1993; Koziar & Wojewoda 2002; Koziar 2005b, 2006).

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