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GEODYNAMICS AND DEFORMATIONS OF THE SUDETIC GEOLOGICAL STRUCTURAL BLOCKS

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Abstract

As generally known, the African plate pushes to European orogenic Alpine structures that transfer further the compression to Variscan structural units, including the Bohemian Massif. The Bohemian Massif squeezes into the Alpine structures, protects its continuous movement to the north and, thus, geological masses situated outside the Massif should be affected strongly and have to distinctly move with respect to the Massif structural blocks. Since the Sudety Mts. area and their Foreland cover partly kinetically quasi-effected and quasi-non-effected structural blocks, in 1997 the geodynamical network EAST SUDETEN established in this area to perform annually GPS observation campaigns for possible movement detection. All data registered within six annual campaigns (1997-2002) were processed by the Bernese software 4.2. A methodology applied to GPS satellite signal monitoring and consequent data processing did not allow errors in the horizontal direction 2 mm and in the vertical direction 5-6 mm to be exceeded. Preliminary results of geodynamical movements in the Sudety Mts. are delivered. Since time series of coordinate changes for network sites give pronounce trends, preliminary deformations among individual structural blocks were determined and an comparison to geological and geophysical materials were discussed.

1. GPS Data

In 1997 the Czech-Polish GPS network EAST SUDETEN was established in the northern-eastern part of the Bohemian Massif (Schenk et al., 1998, 1999, 2000, 2002). The regional geodynamic network in the Czech part of the East Sudeten area was built with respect of the assumption that the Sudetic faults of the NW-SE directions (e.g. the Main Sudetic, the Marginal Sudetic, the Bělá and Klepáčov faults, etc.) are active. Besides some evidences of mobility on the Sudetic fault system there have been also some mobility evidences found on a few faults of the E-W direction, e.g. on the Opavice shear zone. Selected GPS sites of the network EAST SUDETEN formed two profiles crossing the east and west marginal parts of studied area going more or less perpendicularly to the Sudetic faults in the direction SW-NE. These profiles *de facto* framed individual Sudetic geologic structural blocks. It was assumed that site configuration allows possible existing movements among the blocks to be detected and evaluated.

The joint Czech-Polish geodynamic network EAST SUDETEN in 1997 consisted of nine sites and the network extent was roughly 150 kilometres in the NW-SE direction and about 80 kilometres in the perpendicular direction. Monitoring of GPS satellite signals on the geodynamic network EAST SUDETEN has been performed mostly with the Ashtech receivers equipped by geodetic or marine antennas in two full day sessions (48 hours) and a sampling rate of 30 seconds. On some Polish sites apart from the Ashtech receivers also receivers Leica, Trimble and Spectra-Precision operated. GPS equipment availability and logistic conditions influence observation data homogeneity as well an accuracy of coordinate determinations of sites.

Preliminary GPS data processing consisted of a carrier-phase observation processing of independent vectors of triple differences. In that process different linear combinations of the carrier-frequencies L1 and L2 were tested. The main aim was to find out and eliminate cycle slips. If they cannot be eliminated, then this part of data was rejected from observation file or new ambiguity was introduced (Hugentobler et al. 2001). Coordinates and RMS errors were generated for individual sites of the network EAST SUDETEN for years 1997–2002 by connecting the daily solutions to the ADDNEQ program (Brockmann 1996, Hugentobler et al. 2001). Since 1998 the RMS values have been reduced by improvements of the field GPS observation technology and they have not exceeded 2 millimetres in the horizontal and 5-6 millimetres in the vertical coordinates.

2. Time Series and Movement Vectors

Time series of site coordinate changes with respect of the north and the east directions (Fig. 1) allowed annual movement velocities for Czech sites of the geodynamic network EAST SUDETEN to be determined.

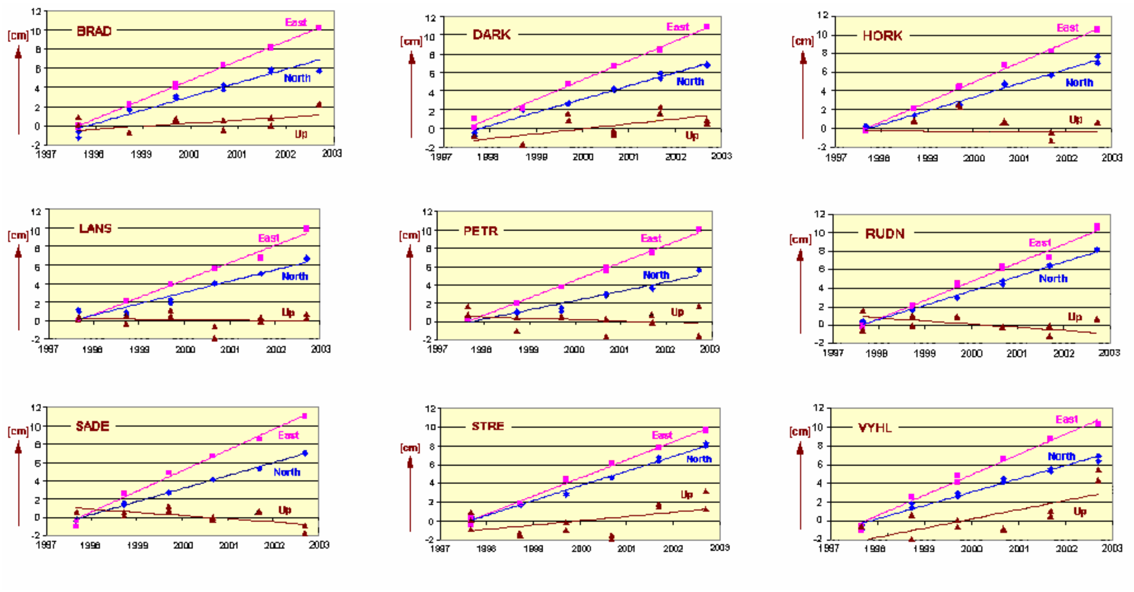

Fig. 1. Time series of the Czech sites of the geodynamic network EAST SUDETEN, 1997-2002

In Figure 2 movement velocity vectors were displayed for 14 sites of the Czech-Polish EAST SUDETEN network into a schematic geological map of the Sudeten area. Maximum annual movement velocities reached values of 5 mm/year for 4 network sites (KLOD, MECI, STRZ, LANS). At the first moment these values seemed to be relatively high. However, when we take into account a fact that rock masses of Central Europe are under permanent pushing to the north towards the bulky East European Platform, which is a relatively huge and stable body of crystalline rocks, then movement velocities round 5 mm/year are acceptable.

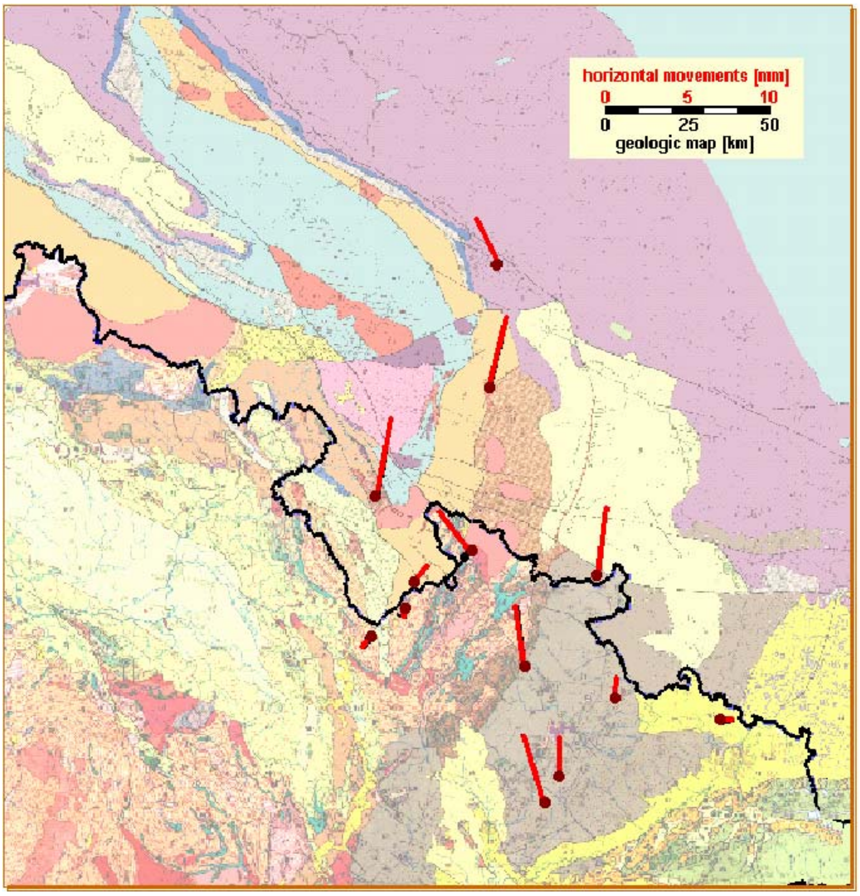

Fig. 2. Movement vectors determined for the GPS network sites

3. Geodynamics and deformations of the Sudetic blocks

The eastern part of the Bohemian Massif has been geologically and geophysically investigated by many authors. Buday et al. (1995) analyzed regional motions of geological structures mainly along the Sudetic fault zones and found for them one common feature: if a structural block has an uplifting tendency with respect to its neighbouring blocks, then its relative motion with respect to these blocks heads to south-east. Similarly, if a structural block has a subsiding tendency with respect to neighbouring ones, its motion with respect to these blocks heads to north-west.

To compare and verify the GPS movement vectors with the geological conclusions mentioned above, the GPS vectors were spread to vector components of two fault systems: the Sudetic one (Fig. 3a) and the Moravo-Silesian one (Fig. 3b). On the first system mainly strike-slip movements occur and on the later one, because of normal and reverse faults, the uplifted and subsided trends are activated.

The fact that the individual movement vector components faithfully correspond to structural block motions gives clear evidence on a high accuracy of the GPS realized in all six campaigns on the geodynamic network EAST SUDETEN (see Paragraph 1).

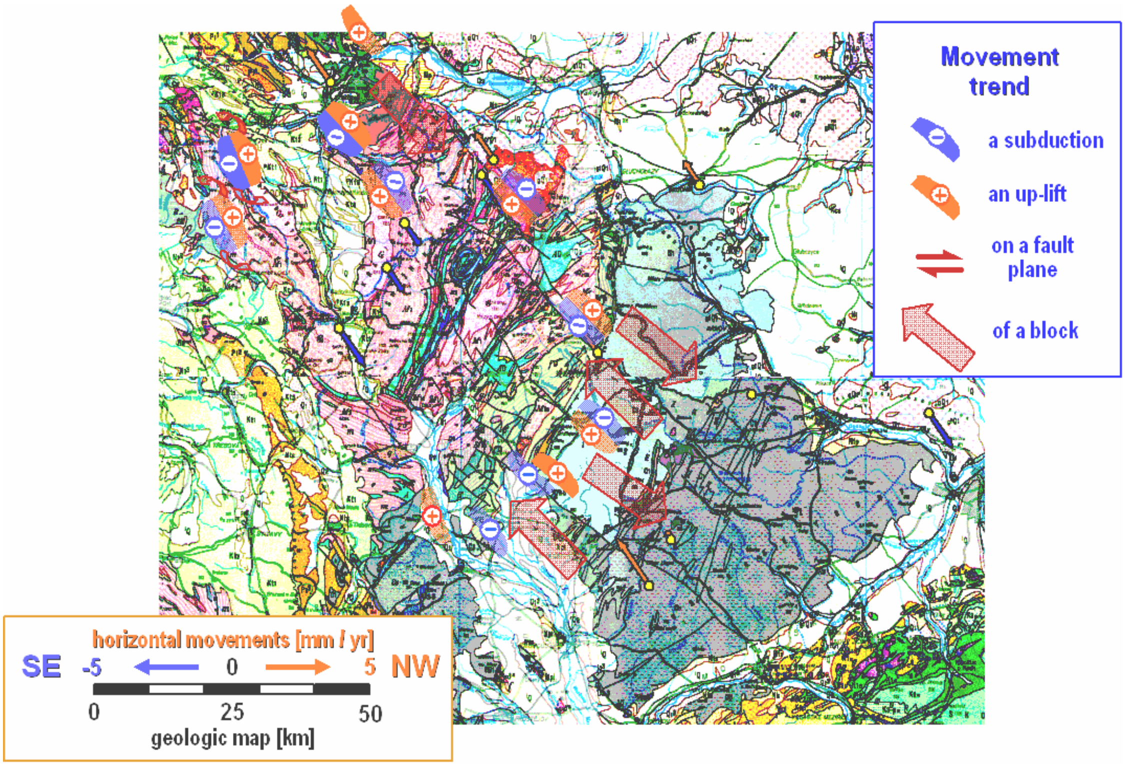

Fig. 3a. Components of the movement vectors of the Sudetic direction

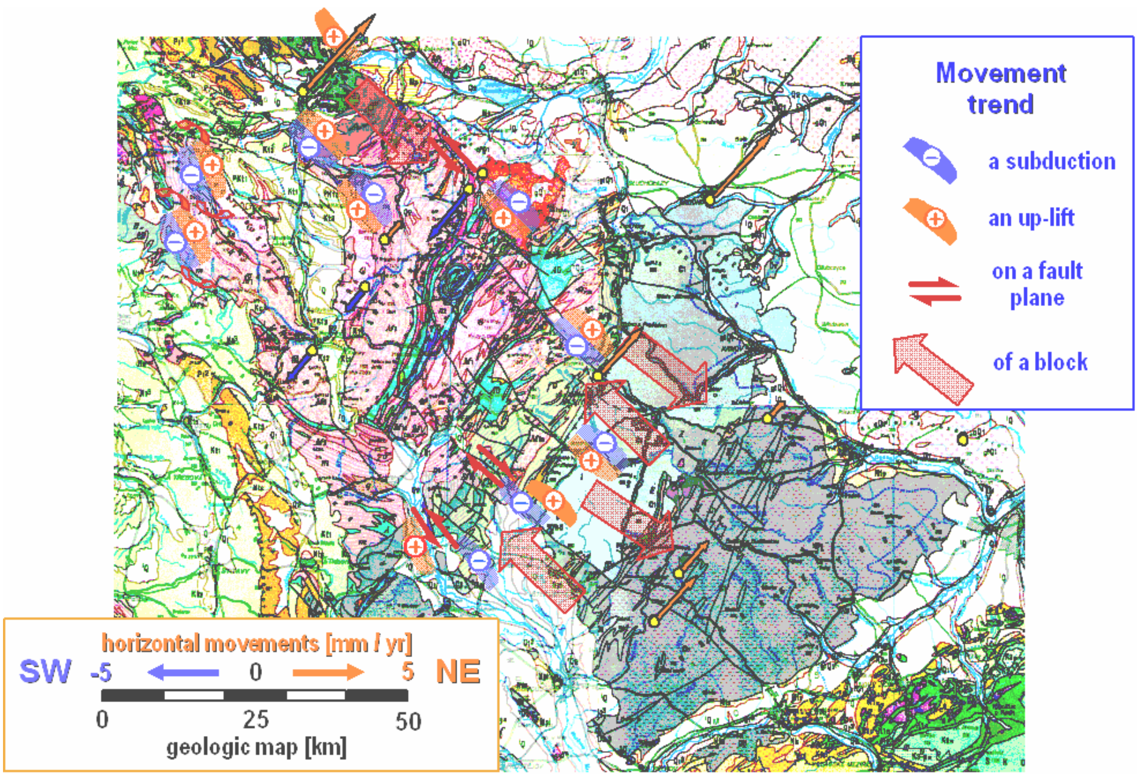

Fig. 3b. Components of the movement vectors of the Moravo-Silesian direction

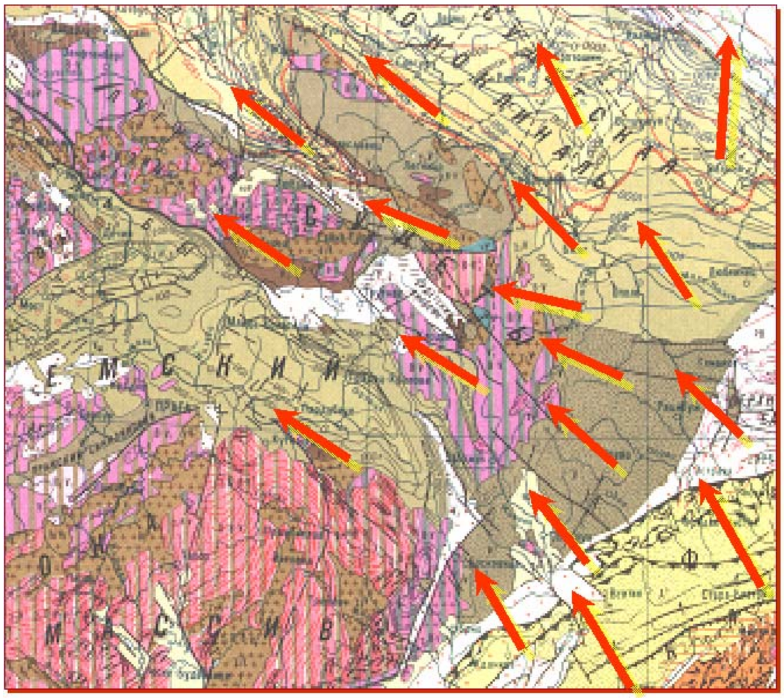

Fig. 4a. Preliminary stress field for the NE part of the Bohemian Massif

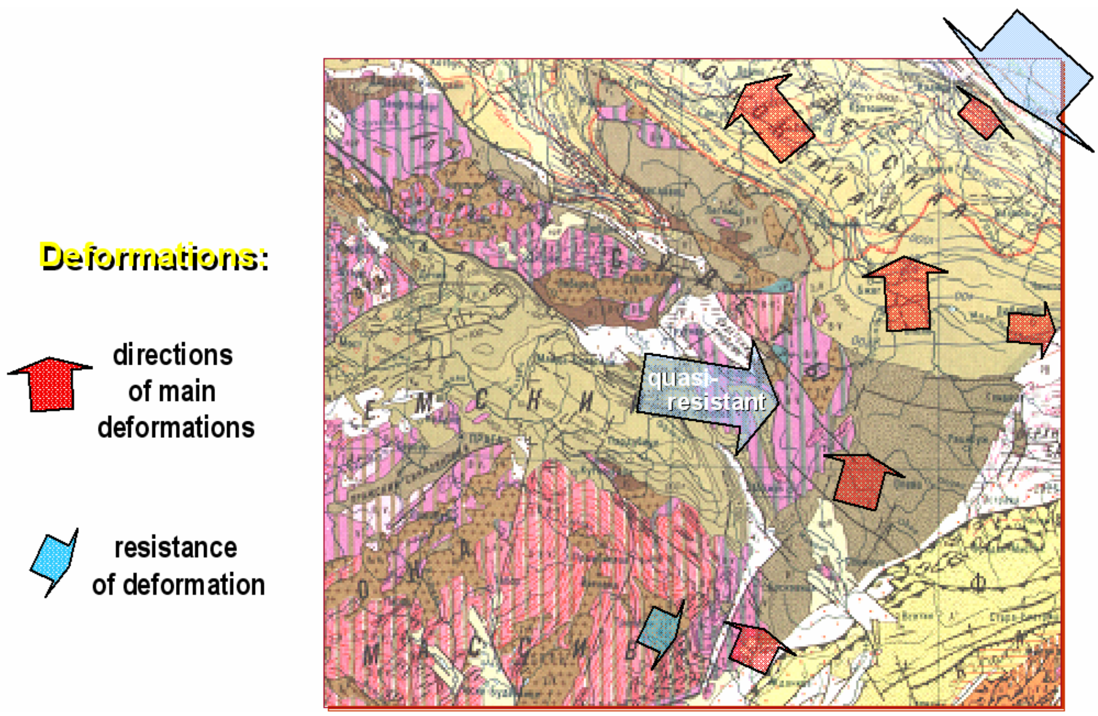

Fig. 4b. Preliminary strain (deformation) field for the NE part of the Bohemian Massif

The preliminary stress and strain fields were drawn on the basis of all available geological and geophysical materials. Two anomalous features were identified:

a) an existence of zone that affects contrariwise to the surrounding regional movement trends (see below a geodynamic terrane B). With the highest probability its mobility resistence is caused by its deep seating (its MOHO is round 5 km deeper neighbouring blocks) and by types of regional structures (thrusting tectonic faults). In past along these fault zones the western blocks (Lugicum) thrusted over the eastern blocks (Moravo-Silesicum) and, thus, the eastern blocks moved deeper to the Upper mantle and pushed the MOHO to higher deep too.

b) a movement analysis of the network sites located in its eastern part displayed in annual velocity azimuths and rates a turning to NE and small decrease of velocity rates. These effects should to be investigated latter if no any geodynamic *motionshed*. In positive case it could divide structural movements in the east part of the Bohemian Massif to two main directions: into the north and northwest direction and to northeast one.

Movement velocity vectors determined for selected sites of the geodynamic network EAST SUDETEN allowed more detailed delineation of possible geodynamic terranes of the Sudetic structural blocks to be done (Fig. 5). The following terranes were delineated:

A. Moravo-Devonian terrane,
B. the thrusting zone terrane,
C. Lower Silesian-Opole terrane,
D. Lower Sudeten terrane and
E. the Kłodsko furrow.

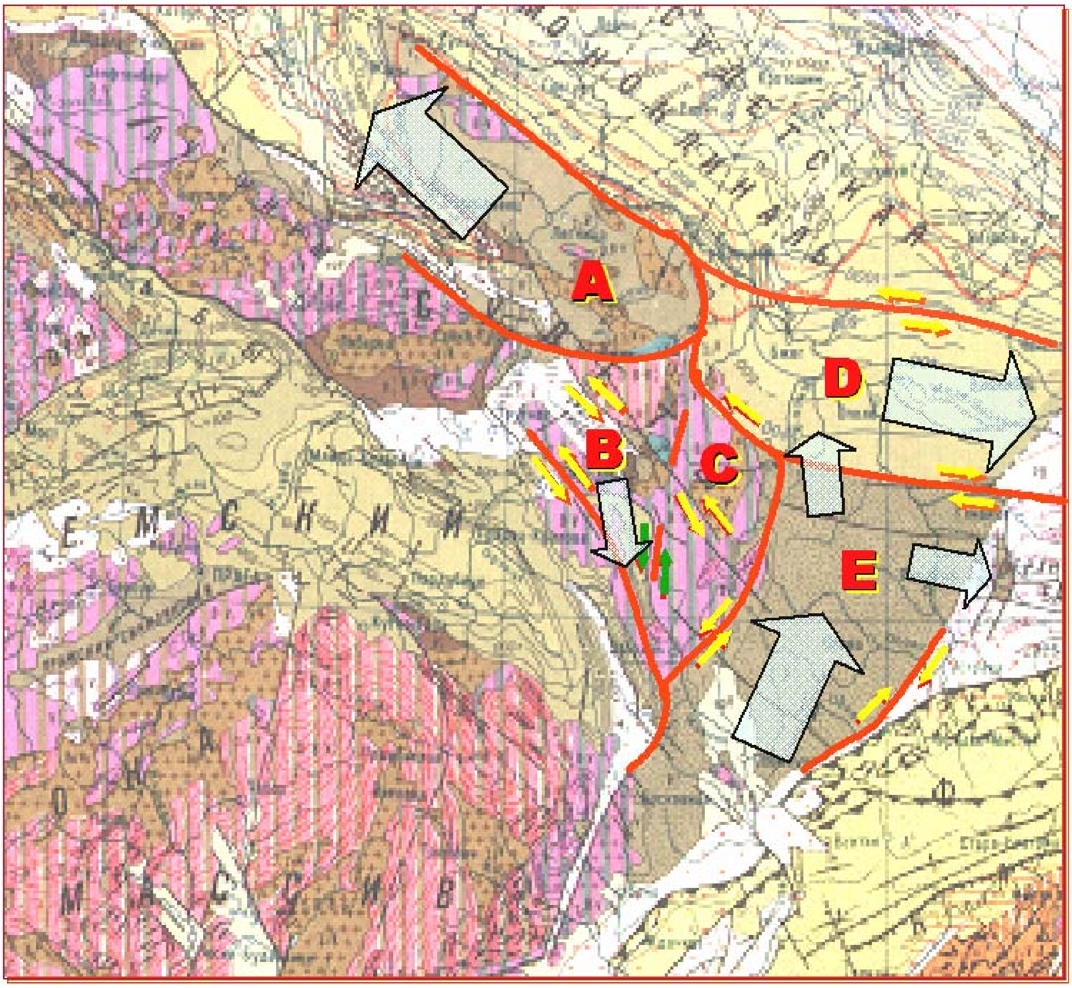

Fig. 4. Possible geodynamic terranes for the NE part of the Bohemian Massif

4. Outlook and conclusion

Even if six annual GPS campaigns were realized and movement trends for individual sites of the geodynamic network EAST SUDETEN were more or less defined, still some open questions exist. In near future the problem of the thrusting zone effects (terrane B) to regional geodynamic field has to be explained. If the geodynamic network will be extended eastward to the Beskydy Mts. in future, then motion effects between the Carpathian nappes (upper units) and the Bohemian Massif structures (lower units) could be assessed. Such activities will clarify a question if any geodynamic motionshed exists in the area under study.

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