Solid Earth Discussions

Solid Earth Discuss., referee comment RC2
https://doi.org/10.5194/se-2021-99-RC2, 2021

Comment on se-2021-99

Andrzej Solecki (Referee)

Referee comment on "Late Cretaceous – early Palaeogene inversion-related tectonic structures at the NE margin of the Bohemian Massif (SW Poland and northern Czechia)" by Andrzej Głuszyński and Pawel Aleksandrowski, Solid Earth Discuss., https://doi.org/10.5194/se-2021-99-RC2, 2021

Figures enclosed in pdf version

General Comments

The assessed paper preprint constitutes a concise, deliberately selective review of effects of the Late Cretaceous – Early Palaeogene deformation in the Sudetes and their foreland at the NE margin of the Bohemian Massif. The review is enriched with new data yielded by newly reprocessed archival seismics of 1970s to 1990s. Most of the described structural examples come from SW Poland, while some others - from northern Czechia.

The topic is appropriate for the special issue of the Solid Earth devoted to the Late Cretaceous -Early Palaeogene inversion in central Europe. The paper seems to partly fill the gap consisting in the lack of a holistic approach and easily accessible information on the „Laramide" or „Saxonian" tectonics affecting the Sudetic fragment of the Variscan belt. The paper is, in general, well written and nicely illustrated and presents well-suited tectonic examples, some of which come from the authors' own collection of data and the others are borrowed from the literature, though each time with critical discussion on their interpretation. The hitherto state of the knowledge is complemented with new seismic structural interpretations supplied by the authors. The presented examples are shortly explained and discussed as to their origin, mostly in a reasonable way and to the extent possible in a relative short publication.

The work of the past generations of geologists on the post-Variscan deformation structures in the Sudetes is rather decently acknowledged, in the right proportion to the modest size of the paper. Some completion in this respect seems, nevertheless, to be adviced, which has been indicated on the text below. Similarly, the paper would benefit from being completed with information on such interesting tectonic structures as the Late Cretaceous deformation bands that were described from the area of interest of the paper.

Specific Comments

Taking into account the abundance of published works, it was nearly impossible for the authors to avoid some simplifications and omissions. In this respect, I would like to point out four issues.

The first is the existence of a Triassic-Upper Cretaceous stratigraphic gap . The deposition of Late Cretaceous sandstones on substratum of various age caused long-term discussion on the Cimmerian phase of deformation. The most far-fetched interpretation was expressed by Beyer (1934), assuming the existence of the Cimmerian basemen folds transverse to the present North-Sudetic synclinorium structure.

The second issue is the possible role of salt tectonics especially in the north-eastern margin of the Sudetes in the transition zone to the Fore-Sudetic Homocline described by Markiewicz and Becker (2009). The presence of casts after halite crystals in the Zechstein deposits in the southernmost part of the North-Sudetic Synclinorium (WleÅ□ Graben) described by Kowalski et al. (2019) indicates that not only anhydrite (mined in the central part of the North Sudetic Synclinorium) but also rock salt may influence its deformation. One should take into account that according to Kley (2013) both extensional and contractional Saxonian" structures are often strongly modified by salt movement

The third is description of historical concepts of North Sudetic synclinorium development. In lines 193-196 authors point out "the necessity for reinterpretation of the hitherto widely held concept of the internal structure for the North-Sudetic Synclinorium, assuming the dominance of high-angle block tectonics. In a new concept, the significance of low-angle thrust faults, of compressional down-warping of the top basement surface, and of the well-developed detachment folding pattern should be taken into account."

It would be nice to mention, that the author's new concept confirms ideas of Solecki (1986, 1994) who contradicted the then dominant views and wrote in his 1994 paper at page 37:

"Deformation process of the North Sudetic Synclinorium was connected with reactivation of ancient faults which have been at least active in Permian (northern fault of Å□wierzawa Graben) or Triassic-Cretaceous times (Jerzmanice Fault) … In the pre-Cenomanian times

the northern limb was the downthrown one, while during Laramian phase …was ovethrusted on the Cretaceous strata. These facts support J.A. Jackson (1980) model where the basin develops due to extension of the listric faults of basement and next due to basement compression the sedimentary cover is deformed in Saxonian style. As a result the North Sudetic Synclinorium may be described as an inverted basin (P.A. Ziegler 1987 and references contained therein)".

In my opinion, the discussion section suggested by Kley (https://doi.org/10.5194/se-2021-99-RC1), in his recent comments to the reviewed paper by GÅ□uszyÅ□ski and Aleksandrowski, would be a good solution to tackle the four issues mentioned above.

The forth problem is the paragraph on joints in the reviewed paper, which I, in contrast to Kley, appreciate. It is true as claimed byKley, (https://doi.org/10.5194/se-2021-99-RC1) that the authors rely entirely on matching orientations but in my his opinion this approach does not seem to be mechanically problematic. Although "joints are opening-mode fractures that form with the smallest principal [effective] stress being tensile", one should remember that the opening is but the last phase formation of joints, which takes place during decompression of a rock massif. The orientation of joints is determined by the evolutionary history of a given rock, that often includes accumulation of residual stresses (cf. Price 1959,1966) and/or preferentially oriented chains of microcracks developed well before the decompression, during earlier compressional phases. Therefore, the Polish traditional mining term "cios" (Eng. blow, stroke) used for the joints rightly emphasizes a tendency of apparently intact rock to break and form fractures in regular way when hit, thus reflecting the presence of a hidden mechanical anisotropy acquired by the rock under (usually horizontal) compression during the initiation of a joint network, as opposed to their opening during the late phase of decompression (usually related to regional uplift).

The rose diagrams in the paper's figure 20, derived from Fig. 9 of Solecki (2011) (see Fig.1 below) are welcomed. Their more detailed description and interpretation supporting their Late Cretaceous-Paleogene age can be found in Solecki (2011, in Polish), whereas the English description can be found in Solecki's (1994) paper.

Fig. 1. Strikes of joints (all), derived from Fig. 9 Solecki (2011).

P1–T2 – Permo–Triassic strata orientation; K2 – Cretaceous strata orientation; WG – WleÅ□ Graben; SG – Å□wierzawa Graben; LS – Leszczyna Syncline; BS – BolesÅ□awiec Syncline; TB – Tertiary basalts; PV – Permian volcanites; Pz – epimetamorphic basement; P1 – Rotliegend sediments; P2 – Zechstein sediments; T1 – Buntsandstein sediments; T2– Roet and Muschelkalk sediments; Cr2 – Late Cretaceous sediments.

More details of joints running transverse to the folds are visible in rose diagram Fig. 10 of Solecki (2011), where only vertical joints were included, (see Fig.2 below).

Fig. 2. Strikes of joints (vertical only), derived from Fig. 10 Solecki (2011).

Other explanations as in Fig.1.

Fig. 3. Orientation of strata (contours of plane poles, upper hemisphere) and deformation bands (circles ,upper hemisphere); derived from Fig. 2 Solecki (2011).

Other explanations as in Fig.1.

It would be nice to have your paragraph about the joints completed with information about deformation bands described by Solecki (2011) (cf. Aydin 1978, Fossen et al. 2007).

A comparison of the cataclastic bands orientation (Fig.3) with that of the faults and strata indicates their original relationship with the main North-Sudetic synclinorium compressive deformation during the Late Cretaceous – Early Paleogene. N-S system of joints seems to be related with north-south Paleogene age compression near significant fault lines as described by Cobal (1990) from the Bohemian Cretaceous Basin.

Recommendation

Irrespective of the above disputable issues and remarks, in much part addressed to the reservations expressed by the other reviewer of this paper, the paper itself deserves to be published in the Solid Earth.

References

Aydin A.: Small faults formed as deformation bands in sandstone. Pageoph., 116, 913-930, 1978.

Beyer K.: Zur kimmerischen Faltung in den Nordsudeten. Zeitschr. d. deutsch. Geol. Ges.. 86, 702-702, Berlin,1934.

Coubal M.: Compression along faults: example from the Bohemian Cretaceous Basin Mineralia slovaca (1990), 139-1444, 1999.
Centrum24.pl/centrum24-web/multi/dashboard

Fossen H., Schultz R.A., Shipton Z.K. and Mair K.: Deformation bands in sandstone: a review. Journal of the Geological Society, London, Vol. 164, pp. 755–769, 2007.

Jackson J.: Reactivation of basement faults and crustal shortening in orogenic belts. Nature 283, 343–346, 1980. https://doi.org/10.1038/283343a0

Kley J.2013 , "Saxonian tectonics" in the 21st century. Zeitschrift der Deutschen Gesellschaft für Geowissenschaften Band 164 Heft 2 (2013), p. 295 - 311published: Jun 1, 2013

Kowalski A., Durkowski K. and RaczyÅ□ski P.: Zechstein marine deposits in the WleÅ□ Graben (North Sudetic Synclinorium, SW Poland)– new insights into the palaeogeography of the southern part of the Polish Zechstein Basin. Annales Societatis Geologorum Poloniae (2018), vol. 88: 321–339,2018.

Markiewicz A. and Becker R.: The original extent of the Oldest Halite (Na1) in the southern part of the Fore-Sudetic Monocline (SW Poland) GEOLOGIA 2009 Tom 35 Zeszyt 3 327–348,2009.

Price N.J.: Mechanics of Jointing in Rocks. Geological Magazine , Volume 96 , Issue 2 , April 1959 , pp. 149 – 167, 1959 DOI: https://doi.org/10.1017/S0016756800060040

Price N.J.: Fault and joint development in brittle and semibrittle rocks. Pergamon Press, Oxford-London. 176 pp, 1966.

Solecki A.T.: Tektonika dysjunktywna i jej wpÅ□yw na warunki wystepowania kopalin w synklinorium pólnocnosudeckim, PhD thesis, University of WrocÅ□aw, 1-152 (in Polish), 1986.

Solecki, A.: Tectonics of the North Sudetic Synclinorium, Acta Universitatis WratisIaviensis No 1618, Prace Geologiczno-Mineralogiczne, 45, 1-60, University of Wroclaw, 1994.

Solecki, A.: Rozwój strukturalny epiwaryscyjskiej pokrywy platformowej w obszarze synklinorium póÅ□nocnosudeckiego (Structural development of the epi-variscan cover in the North Sudetic Synclinorium area). In: Å»elaÅºniewicz, A. et al. (eds), Mezozoik i kenozoik Dolnego Å□lÄ ska, Polskie Towarzystwo Geologiczne, WrocÅ□aw, 19-36, (in Polish with English summary), 2011.

Ziegler P.A.: Compressional intraplate deformations in the Alpine foreland. Introduction. Tectonophysics V. 137, Issues 1-4, Pages 1-5,1987.

Please also note the supplement to this comment:
https://se.copernicus.org/preprints/se-2021-99/se-2021-99-RC2-supplement.pdf