C. R. Geoscience 348 (2016) 587–597

Contents lists available at ScienceDirect

Comptes Rendus Geoscience

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Internal Geophysics

Geophysical study of deep basement structure of NW Poland using effective reflection coefficients

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ARTICLE INFO

Article history:
Received 14 June 2016
Accepted after revision 15 June 2016

Handled by Michel Campillo

Keywords:
Trans-European Suture Zone
Deep basement
Poland
Effective reflection coefficient sections

ABSTRACT

The paper presents the possibility of applying the method of effective reflection coefficients (ERC) to recognise the deep basement structure for a case study of seismic profile GB1-III-86/89 from NW Poland. Two sectors of the seismic profile were selected in areas of occurrence of deep fractures bounding the Trans-European Suture Zone (TESZ) from the southwest and the northeast, respectively. At certain time intervals, due to transformation of the amplitude into an impulse form, seismic wave traces have been presented as effective reflection coefficients. An interpretation of the two sectors of profile GB1 provides a more detailed image of the complex geological structure of the Earth's crust in the southwestern and northeastern edges of the TESZ. The work has allowed for the identification of boundaries of reflection coefficients by distinguishing a number of layers and complexes (among others transition zones to the consolidated basement), and the determination of lines and seismic discontinuity zones, including the nature and location of the two deep tectonic fracture zones bounding the TESZ, as well as the Moho position. In particular, the southwestern sector of the profile shows cross-sections of two areas with different seismic structures, with a boundary that can be correlated with a deep fracture zone – the Trans-European Fault (TEF). The location and course of the boundary correlated with the Moho discontinuity is also defined. The northeastern sector of the profile, analysed at three time intervals, characterises the zone of deep fracture occurring in the northeastern part of the TESZ. Interpretation of the seismic section in its upper part illustrates seismic horizons that may define the Caledonian Deformation Front (CDF) and the northeastern limit of the Teisseyre–Tornquist Zone (TTZ), bounding the TESZ to the northeast. In the lower part, it represents the crustal structure and an attempt to identify areas of different structures: the lower laminated part and the upper homogenous part, as well as seismic discontinuity lines of tectonic and/or lithological origin. The applied method has delivered satisfactory results for the Lower Palaeozoic and older basement formations down to the Moho. The new form of seismic record, compared with the previously acquired wave image of profile GB1-III-86/89, significantly increases the possibility of interpretation and reliability of the results. The results confirm and justify the earlier concepts concerning the main tectonic features presented by researchers of this area. The experience and results justify the need for continuing the work using this method to verify and provide details about the extent of the structural-tectonic elements to the northwest and southeast, with reference to the research results from Poland and adjacent areas of Germany and the southern Baltic Sea.

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http://dx.doi.org/10.1016/j.crte.2016.06.003

1. Introduction

This study shows the method of using effective reflection coefficients (ERC) to recognise geophysical complexes at great depths. Data processing was aimed at finding a possibility to improve the correlation of seismic reflection boundaries. For this purpose, profile GB1-III-86/89 was selected (Białek et al., 1991) in *A project of deep regional reflection seismic surveys (GBS) using extended recording time to 18s.* That project includes the following profiles: *GB2-87/93, GB2A, GB2B-96 and 25-III-82*, the results of which were presented in many publications: Cwojdziński et al., 1995; Żelaźniewicz et al., 1997; Młynarski et al., 2000, and profile GB1-III-86/89 (GB1) (Figs. 1 and 2a – yet unpublished). The main task of this study is to obtain information about the internal structure of the Earth's crust from the interval between the base of the Permo-Mesozoic succession and the Mohorovičić discontinuity (Moho) zone, including identification of deep fracture zones.

Measurements performed on profile GB1 were the first deep seismic records in Poland obtained using the reflection method. This is a very important profile because of its course and linkage with the LT7 profile of "Deep Seismic Sounding (GSS)" (Guterch et al., 1994), and its location in relation to areas of similar investigations carried out in NW Europe, particularly in Germany (DEKORP-BA Research Group, 1999).

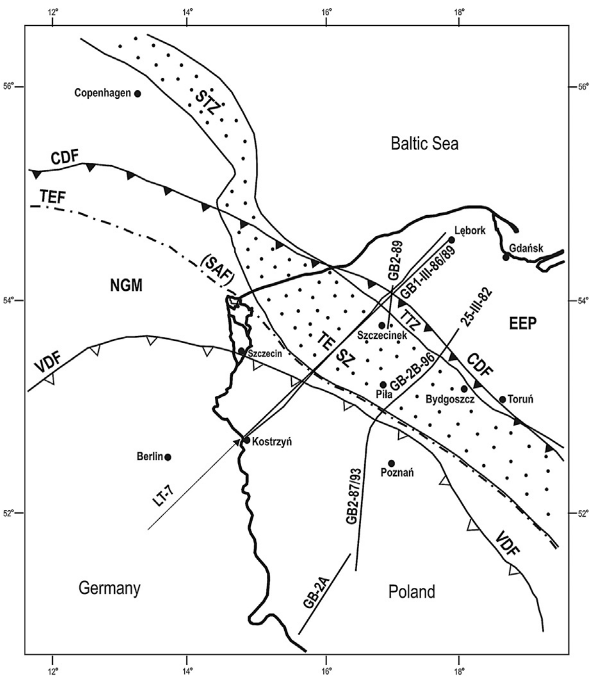

Fig. 1. Sketch map of major tectonic elements (after Dadlez et al., 2005; Petecki, 2008, supplemented) with locations of profiles of the deep seismic research project (GBS) and profile LT7; CDF: Caledonian Deformation Front; VDF: Variscan Deformation Front; TESZ: Trans-European Suture Zone; TTZ: Teisseyre–Tonquist Zone; STZ: Sorgenfrei-Tonquist Zone; TEF: Trans-European Fracture; SAF: Stralsund–Anklam Fracture; NGM: North German Massif; EEP: East European Platform.

Over several years and in several sectors, the implementation of fieldwork along profile GB1 proved to be unfavourable from the point of view of research results. The quality of basic materials and the developed seismic wave section is variable (Białek et al., 1991; Fig. 2b), both horizontally along the profile and vertically in individual complexes of crustal rocks. The reason for this variability is most probably the impact of surface conditions and the relationship between the recorded wave image and the elements of deep geological structure, especially tectonic zones, both in the sedimentary formations and deeper. The Permo-Mesozoic sedimentary rocks are dominated by seismic reflections correlative in a continuous mode. The distinctness and continuity of reflections in the sub-Zechstein rocks are definitely deteriorating. In the seismic section, the interface separating the complex of sedimentary rocks from the crystalline basement is drawn conventionally and ambiguously on the basis of the overall seismic reflection pattern image. Seismic reflections occur sporadically under the complex of sedimentary rocks to a depth of 20–25 km. The depth interval of 25–45 km is characterised by increased reflectivity and a marked increase in the energy of reflections.

Field records from the profile were subjected to processing at the stage of report development (for archiving), using a wide range (different variants) of processes; however, they failed to provide sufficiently clear seismic sections. The drawback is the lack of identifiable, distinct dynamic features of specific reflection groups, making it difficult to unequivocally distinguish the depth intervals associated with the geological complexes.

In this situation, an attempt to transform the traditional wave section into effective reflection coefficients (ERC) sections was made, using the field materials reprocessed at the Geophysics Institute of the University of Karlsruhe (Germany) (Młynarski, 1993). The analysis was made on two selected sectors of the profile from depths of 104.8–148 km and 202–246 km, at appropriate time intervals (Fig. 2a and b), in zones of occurrence of deep fractures bounding, from the southwest and northeast, one of the most important structural elements of Europe, which is the TESZ (Trans-European Suture Zone). This zone is identified with an elongated crustal block where the Palaeozoic structures of western and central Europe are in contact with the Precambrian structures of eastern Europe (Pharaoh, 1999). It is covered by a thick Permian–Mesozoic succession of the Polish basin, and by a thin Cenozoic cover (Dadlez et al., 2005).

The first deep fracture zone situated in the southwest is correlated with the TEF (Trans-European Fault) zone, which is the continuation of the NW–SE-trending Stralsund–Anklam Fault (SAF) running along southern Rügen, and is probably connected with the TESZ in Poland (Hoffmann and Franke, 1997). The second deep fracture zone located in the NE part is correlated with the southwestern edge of the East European Platform (EEP) and the NE boundary of the TTZ (Teisseyre–Tornquist Zone) covering the area of Caledonian Deformation Front (CDF). These are also gradient zones associated with a rapid change in magnetic field nature, presented in the map of magnetic anomalies (Petecki, 2008).