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Active tectonics research using trenching technique on the south-eastern section of the Sudetic Marginal Fault (NE Bohemian Massif, central Europe)

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ABSTRACT

The NW–SE striking Sudetic Marginal Fault (SMF) is one of the most conspicuous tectonic structures in central Europe. It controls the pronounced morphotectonic escarpment of the Sudetic Mountains for a length of 130 km. This paper presents the results of trenching on the SMF, undertaken in order to assess activity of the fault. The trenching technique has not hitherto been applied on either this particular fault system or elsewhere in the Bohemian Massif. However, it is the most effective tool for near-surface fault investigation in areas that are well vegetated and therefore devoid of fault outcrops. Moreover, the study area is situated in an intraplate region with a low displacement rate, which is exceeded by an erosion rate and does not favor the preservation of fault scarps.

The trench sites were selected from prior DEM analyses, geomorphological fieldwork, and geophysical sounding. The trenches exposed a range of lithologies of Variscan crystalline rocks and Caenozoic sediments. At least four phases of faulting have been distinguished based on structural data, succession and age of the deformed sediments. Reverse faulting (N160°E), which displaced the Miocene sediments over the crystalline rocks, post-dates their deposition (15 Ma) and pre-dates Late Glacial gelifluction. Horizontal movements that have affected the Miocene deposits along a structure striking N35°E have the same wide time constraint. Younger reverse faulting, which caused a co-seismic relief step, post-dates the Late Glacial gelifluction but preceded the early Holocene colluvium deposition (10,940 ± 140 cal yrs BP). Normal faults striking N145°E, which cut the Miocene unit, might have been reactivated after the early Holocene colluvial sedimentation but before the buried soil (430 ± 120 cal yrs BP). Moreover, based on the identified prehistoric earthquake, respective minimum moment magnitude *M* 6.3 and slip rate 0.03 mm/year were estimated.

1. Introduction

The study area is situated in the north-eastern part of the Bohemian Massif and comprises the Czech portion of the Sudetic Marginal Fault zone (SMF). The SMF represents one of the most prominent tectonic zones in central Europe. The fault is more than 200-km long and controls the pronounced morphotectonic escarpment of the Sudetic Mountains front for a distance of 130 km (Fig. 1).

Despite the topographic expression of the morphotectonic escarpment (Fig. 2), no historic earthquake event is considered to have been of sufficient magnitude to have generated relief within the Sudetic Mountains. Paleoseismological studies demonstrate that in order to generate a topographic expression, an earthquake event must have a moment magnitude in excess of M 5 (e.g. McCalpin, 2009). By contrast, local historic earthquake intensities have been estimated to reach only $I_0 = 4–7$ MSK (Guterch and Lewandowska-Marciniak, 2002). In order to discover whether prehistoric faulting has indeed been responsible for generating the morphology of the mountain front, a near-fault investigation was undertaken from exposures seen within artificially dug trenches (Fig. 3).

As the region belongs to an intraplate area of central Europe, only low to moderate seismicity would be anticipated (see panel discussion in Mohammadioun, 1995), although also evidence for the occurrence of large earthquakes in such a stable continental regions exist (Camelbeeck and Meghraoui, 1996, 1998). Moreover, the climate and exodynamic processes in the studied area during Pleistocene has not favored good preservation of a fault scarp neither depositional bodies related to an earthquake, since mass wasting during cold periods removed all older Quaternary deposits from steep slopes along the SMF. We have a good control of removal of Pleistocene sediments from this area which were deposited by continental glaciation and covered wider area in the middle Pleistocene (e.g. Prosová, 1981; Sikorová et al., 2006); but

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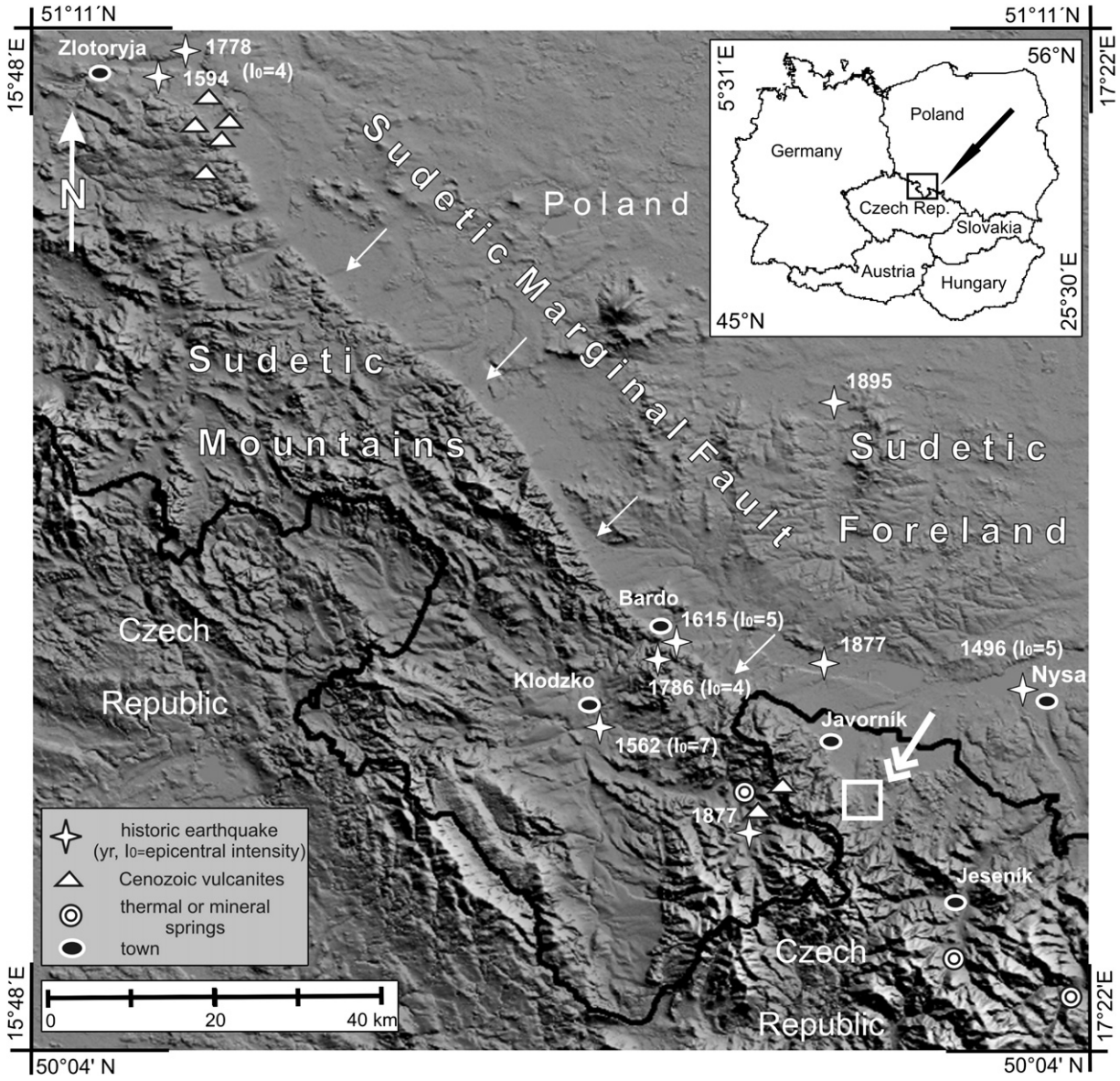

Fig. 1. Topographic situation of the morphologically well-pronounced Sudetic Marginal Fault that divides the Sudetic Mountains from the Sudetic Foreland (SRTM, 90 m resolution). Data on historic earthquakes compiled by Kárník et al. (1958); Olczak (1962); Pagaczewski (1972); and Guterch and Lewandowska-Marciniak (2002). Study area marked by white double arrow.

glacigenic sediments are mostly preserved on flat low-lying areas NE of the fault, with only relic patches in the Rychlebské hory (Mts.) SW of the SMF (Žáček et al., 1995, Pecina et al., 2005). In addition, the fully vegetated area along the SMF lacks outcrops of the fault. Thus, excavating artificial trenches was thought to be the most appropriate method with which to study the SMF in detail.

This elaborate trenching technique has not hitherto been applied on either this particular fault system or elsewhere in central Europe (Štěpančíková and Hók, 2009; Štěpančíková et al., 2009). A detailed study such as this contributes to the definition of fault characteristics, the sense of movement, the history of faulting, and the fault slip rate. Moreover, estimating the magnitude and frequency of paleoearthquakes related to a single slip event has a special importance for hazard assessment in highly populated areas (Petley, 1998). It is therefore pertinent to note that dams in the adjacent Paczków Graben have been geodetically monitored and studied in terms of neotectonic and recent crustal movements, which could be a potential hazard for this region (Cacoń and Dyjor, 1995).

2. Geological setting

The north-eastern front of the Rychlebské hory (Mts) is associated with the NW–SE trending SMF, which separates the mountains of the Sudetic Block to the southwest from the Žulovská pahorkatina (hilly land) in the Fore–Sudetic Block to the northeast (Fig. 2). The Sudetic Block is composed of various types of Paleozoic metamorphic and magmatic rocks of the Staré Město Group, Orlice–Śnieżnik Complex, Stronie Śląskie Group, Velké Vrbno Unit, Branná Group, and Keprník Unit; these rocks comprise gneisses, ortogneisses, phyllonites, marbles, mica schists, metagabbros, erlans, amphibolites, and granodiorites (Fig. 4) (Žáček et al., 1995). In contrast, the down-thrown Fore–Sudetic Block is composed of the late-Variscan Žulová granite pluton dated as 304 Ma (Pecina et al., 2005), which represents an apical part of a vast granitic body (Cháb and Žáček, 1994). To the southeast, the metamorphosed Devonian cover of the pluton comprises gneisses, amphibolites, quartzites, and marbles. The adjacent Vidnava Basin, of Neogene age, is a part of Pazcków Graben and has been filled with Miocene strata