Public Response to Two Rare Earthquakes: Crowdsourcing Constraints on Crustal Structure in South Bohemian Massif

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Abstract. We analysed two rare earthquakes that occurred near Mirotice in south Bohemian Massif (Czechia) in March 2024 (M_L 3.5) and April 2025 (M_L 3.1), integrating seismological analyses with crowdsourced macroseismic observations. Both events originated at unusually large depths for the region (24.5 km) and were widely felt across southern and central Bohemia, attracting significant public attention. Independent of low population density, macroseismic effects were documented through extensive citizen participation, with over 1,500 questionnaires for each event collected by the Institute of Geophysics, Czech Academy of Sciences. Maximum macroseismic intensities reached IV; however, the spatial distribution of observations was distinctly non-circular, forming a pattern controlled by major tectonic structures. Areas underlain by granitoids of the Central Bohemian Pluton exhibited dense and far-reaching macroseismic responses, consistent with low seismic energy attenuation of the Moldanubian, whereas regions dominated by early Palaeozoic sedimentary rocks of the Teplá–Barrandian showed sparse observations, indicating higher attenuation. Focal mechanisms indicated normal faulting on a NW–SE striking fault plane, consistent with regional stress field. The unusually large focal depths may be attributed to low geothermal gradient in the area suggesting deep-seated structural controls on earthquake nucleation. The results delineate two sub-vertical geological structures within the Bohemian Massif. They demonstrate that crowdsourced macroseismic data provide valuable constraints on earthquake effects and deep geological controls on seismic wave propagation, even in regions with sparse seismicity, and effectively complement instrumental observations.

Short Summary

Two rare earthquakes in the Bohemian Massif in 2024 and 2025 were analysed from crowdsourced macroseismic and seismological data. Both events occurred at large depths (~24 km) and were widely felt. Non-even distribution of observations reflects contrasting attenuation and control on geology in the Bohemian Massif. Results show that crowdsourced data can effectively constrain deep geological structures and complement instrumental observations in regions with sparse seismicity.

Introduction

Involving citizens in science related to natural hazards helps people better understand risks and prepare for them. It also supports disaster management and improves decision-making. Crowdsourcing uses information shared by many individuals, providing valuable ground-level insights that strengthen scientific understanding and emergency response. In seismology, citizen involvement has been especially effective in gathering and sharing important information, significantly contributing to seismic risk mitigation (e.g., Guan and Chen, 2014; Hao and Wang, 2020; Kryvasheyeu et al., 2016).

Macroseismic questionnaires, pivotal in this context, gather information on ground shaking and its effects on buildings, infrastructure, and populations. Online macroseismic questionnaires, supported by widespread internet access, have further enhanced this process by enabling rapid, cost effective, and geographically extensive data collection (e.g., Kankanamge et al., 2019). Compared to traditional paper-based methods, online approaches improve the efficiency, accuracy, and comprehensiveness of macroseismic data.

Macroseismic data not only support the assessment of earthquake impacts but also offer valuable constraints on the character of geological features. Their applicability to geological investigations depends on data quality, the representativeness of the surveyed population, and the methodologies used for data collection and analysis. Crowdsourcing, facilitated by online platforms, mobile applications, and widespread smartphone use, enables broad public participation and rapid data acquisition. This methodology is particularly effective in regions with sparse seismic instrumentation or low seismicity, where instrumental seismic data are often unavailable. In such settings, crowdsourced macroseismic observations offer a cost-effective means of acquiring large volume datasets that reflect geological controls on seismic wave propagation (e.g., Toshinawa et al., 1997; Cifelli et al., 1999). This approach is especially relevant for the Bohemian Massif, one of the largest exposures of the European Variscan orogenic belt situated at its eastern periphery (Fig 1), where present-day seismicity is low.

In this study, we focus on crowdsourcing-based macroseismic analysis of two unusual earthquakes (M_L 3.5 in 2024 and M_L 3.1 in 2025) near Mirotice in southern Bohemian Massif, Czechia (Figs 1 and 2). Located in the deep crust, both events were widely felt across southern and central Bohemia, providing opportunity to examine the spatial distribution of macroseismic effects and their relation to regional geological structure. Studies of the deep European Variscan crust show that pre-Permian thrusts exposed at the surface are rooted in the lower crust, at the Moho or within the upper mantle (Meissner and Wever, 1986). This highlights the importance of investigating deep structure of the Bohemian Massif to better constrain the past tectonic evolution and delineate deep subvertical tectonic boundaries otherwise difficult to establish. Our results demonstrate the potential of crowdsourced data to reveal deep-seated geological structures that control seismic wave propagation in a region of sparse seismicity with limited instrumental observation.

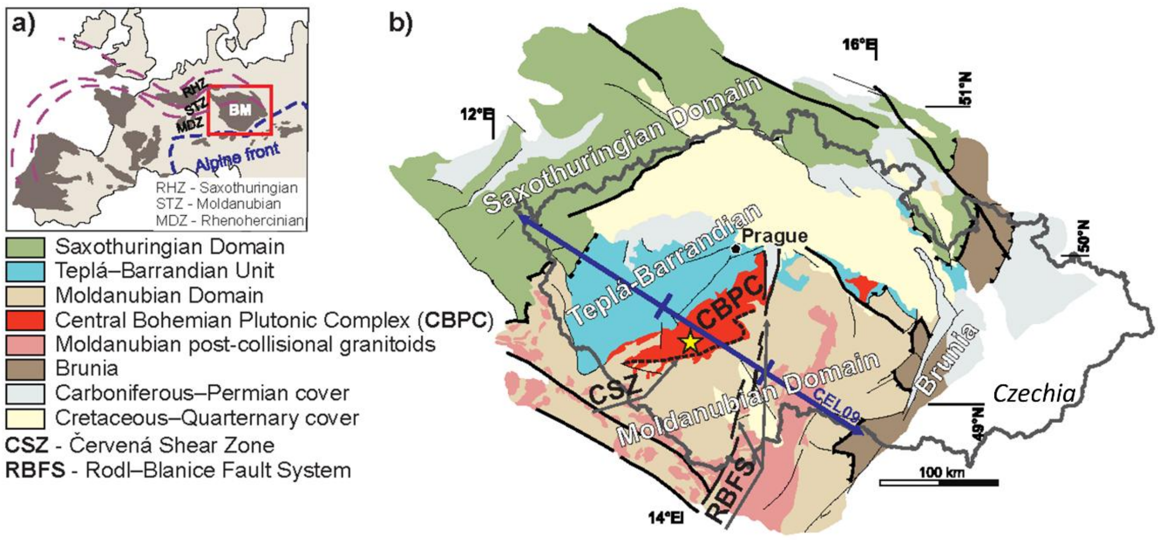

Figure 1. a) Schematic sketch of the European Variscides with the Bohemian Massif (red box) in the eastern edge. b) Simplified geological map of the Bohemian Massif with individual tectonic units (modified after Machek et al., 2022). The Mirotice earthquakes are marked by a yellow star; the violet line marks the CEL09 seismic profile from the CELEBRATION 2000 experiment (Hrubcová et al., 2005). The Czechia border is indicated by a grey curve.

Seismicity in the Bohemian Massif

Present-day seismicity within the Bohemian Massif is low, dominated by weak intraplate earthquakes, mostly confined to the upper crust (<12 km), and concentrated mainly along the massif margins (CZEQ catalogue, 2024; Fig. 2). In central and southern Bohemia, no seismotectonicaly active structures has been documented and only very few seismotectonic structures were observed in SW Bohemian Massif (Málek et al., 2018). More significant seismicity is limited to western Bohemia/Vogtland, where earthquake swarms are linked to the ascent of mantle-derived fluids migrating along deep crustal structures (Fischer et al., 2014), and to the eastern Sudetes (Fig. 2). Consequently, large parts of the internal structure of the Bohemian Massif remain seismically inactive. For this reason, seismic stations within the Bohemian Massif (excluding the above active regions) primarily serve as part of regional seismic monitoring networks.

2024 and 2025 Mirotice Earthquakes

On 7 March 2024, shortly before noon local time (10:41:41 GMT), an earthquake of magnitude M_L 3.5 occurred in southern Bohemia (Czechia). The epicentre (49.42° N, 14.05° E) was located southeast of Mirotice town with the hypocentral depth of 24.5 km ±1.5 km. Subsequent analysis identified four minor aftershocks with M_L 0.5 occurring within one hour of the main shock, followed by a very weak event (M_L −0.1) about 12 hours later. The latest aftershock (M_L 0.4) was recorded more than three weeks later, on 29 March 2024 at 17:51 GMT.

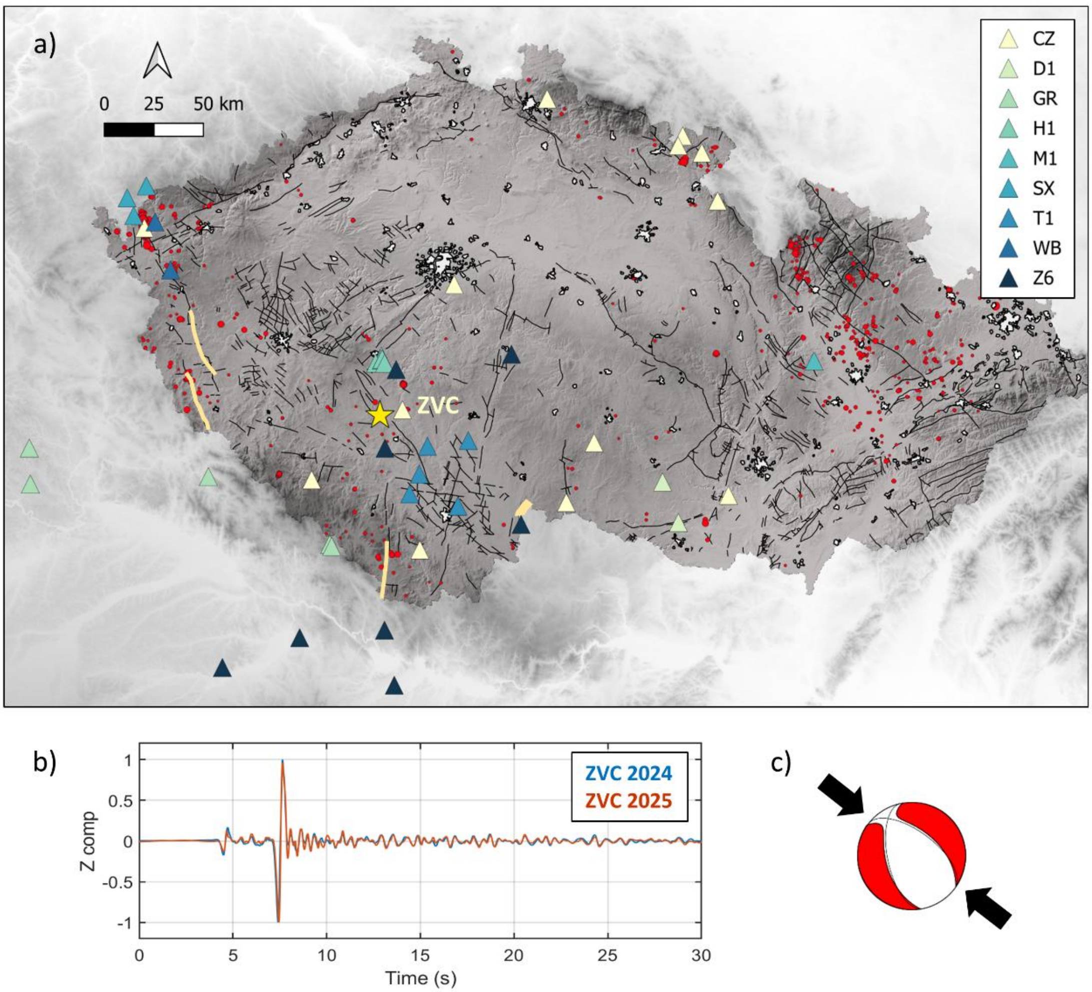

Figure 2. a) Seismicity in Czechia with M_L in range 0.5–4.8 during the 2000–2024 period (CZEQ catalogue, 2024; red circles scaled by magnitude); Mirotice earthquakes denoted by yellow star. Triangles indicate seismic stations used for earthquake location and focal mechanism calculations color-coded by network (for network codes see text). Orange lines indicate seismotectonic lines in central and southern Bohemia (after Málek et al., 2018). b) Seismic waveforms (filtered 0.5–2.0 Hz and scaled to maximum amplitude) of the Mirotice earthquakes in 2024 (M_L 3.5) and 2025 (M_L 3.1) recorded by station ZVC. Note similar waveform shape that suggests a similar source location and focal mechanism for both events. c) Source mechanism of the Mirotice earthquakes; the arrows indicate the orientation of the regional maximum horizontal stress (SHmax; after Heidbach et al., 2016).

The second earthquake (magnitude M_L 3.1) occurred on 24 April 2025 at 17:32:47.3 GMT. This event originated essentially at the same location (49.42° N, 14.04° E) and at a comparable hypocentral depth of 24.5 km ±1.5 km. The main shock was followed by four weak aftershocks (maximum M_L 0.3), two occurring immediately after the main shock and two recorded one day later.

Due to sparse seismicity and limited seismic stations, the earthquake locations and focal mechanisms (Fig. 2) were calculated from stations belonging to various networks: the Czech Regional Seismic Network (CZ), Saxon Seismic Network (SX), German Regional Network (GR), and two Czech local seismic networks (WB and M1). Additionally, we incorporated data from temporary station network (Z6) from the ongoing AdriaArray experiment (Kolínský et al., 2025; Vecsey et al., 2025), as well as stations from local industrial networks (D1, H1, and T1).

The epicentral coordinates of both events were obtained from the bulletin of the Institute of Physics of the Earth (IPE, 2025). Hypocentre locations were determined using the Hypo3d program (Firbas and Werl, 1988), based on the arrival times recorded at 23 stations. The calculations used a simple 1D gradient velocity model, regionally calibrated using observed travel times from deep seismic refraction experiments (Hrubcová et. al, 2005) and quarry blasts. The reliability of the depth estimates was further assessed by comparing the observed travel times of the depth phase (sP) at epicentral distances of 140–210 km with theoretical travel times derived from several alternative velocity models. Additional support for the accuracy of the depth determination was provided by the consistency of the optimal focal mechanism solutions derived from both full-waveform and first-arrival inversions.

Focal mechanisms were determined through full waveform moment tensor inversion using the Bayesian ISOLA method (Vackář et al., 2017), based on waveform data from 12 broadband seismic stations at epicentral distances of 11–70 km. The inversion employed velocity model derived from nearby CEL09 refraction and wide-angle reflection profile (Fig. 1) of the CELEBRATION experiment (Hrubcová et al., 2005), which improved the waveform fit. The results indicate that both events were characterized by normal faulting on a NW–SE striking fault plane with strike 160° and dip 59° (Fig. 2c). Similar focal mechanism was obtained from P-wave first-motion polarities recorded at 47 stations with slightly different velocity model (strike 164°, dip 51°; see Table 1).

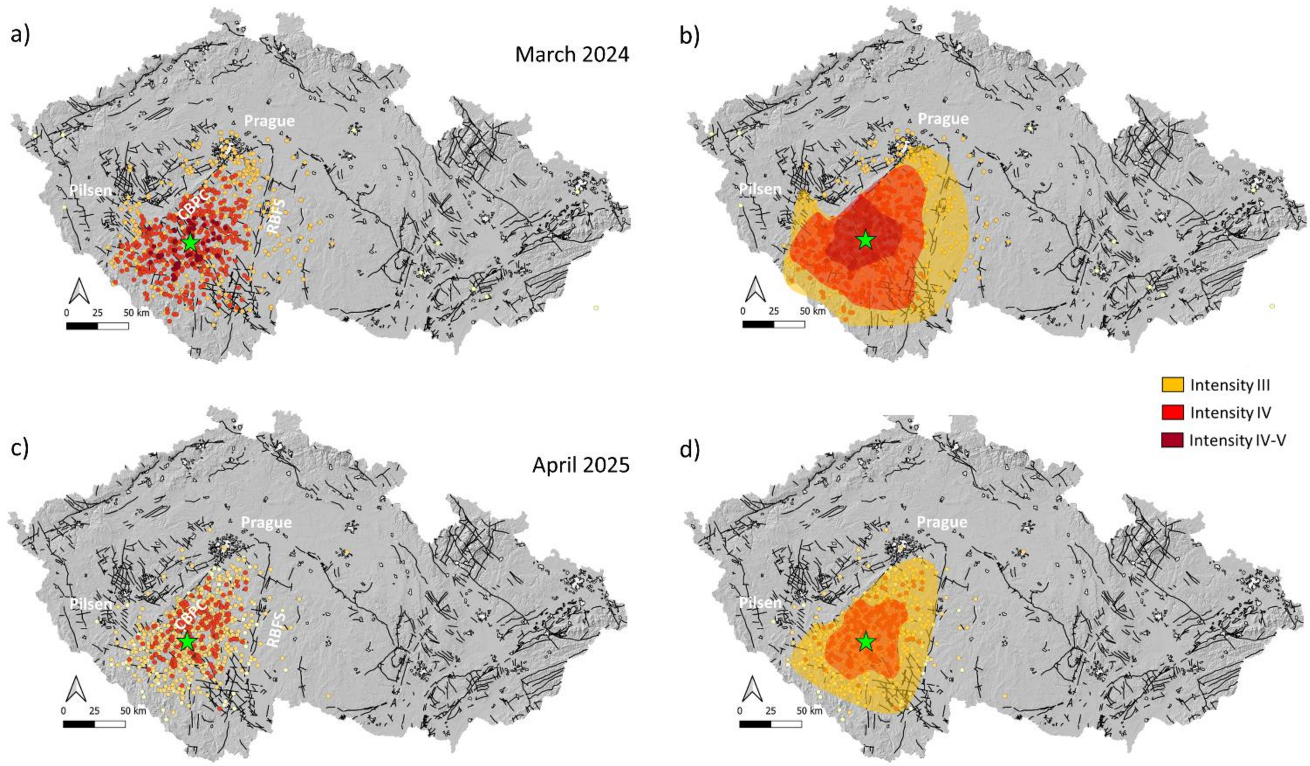

Figure 3. The Mirotice earthquakes. (a,b) The M_L 3.5 event in March 2024; (c,d) the M_L 3.1 event in April 2025. (a,c) Spatial distribution of macroseismic observations (color-coded by individual intensities) collected by IG CAS. (b,d) macroseismic intensity according to the EMS–98 scale. The epicentres are marked in green; CBPC, Central Bohemian Plutonic Complex; RBFS, Rödl–Blanice Fault System.

Macroseismic Observations

The earthquakes that occurred near Mirotice in 2024 and 2025 were unusual for the region in terms of their location, depth, and felt intensity, and therefore attracted considerable scientific interest as well as public attention. Macroseismic effects were documented through 1,512 questionnaires for the 2024 event and 1,679 questionnaires for the 2025 event, collected via online forms or smartphone application provided by the Institute of Geophysics of the Czech Academy of Sciences (IG CAS) (*https://www.ig.cas.cz/makroseismicky-dotaznik/*). In both cases, observations were submitted voluntarily. The public participation was encouraged through media interviews regularly following stronger or unusual events in Czechia, in which people are invited to complete this questionnaire. The approach supports the reliability of the dataset, as evidenced by the even higher reporting rate for the weaker 2025 event.

The shaking was reported over distances of several tens of kilometres. Responses were collected up to 70–100 km from the epicentre, including Písek, Strakonice, and Tábor regions, as well as the Šumava Mountains (Fig. 3a,c). Respondents reported ground shaking of varying intensity (strong shaking in 17% of cases and light shaking in 66% for the 2024 event; light shaking in 58% of cases for the 2025 event), swaying of lightweight objects, and clinking of dishes (30% in 2024; 18% in 2025), and, in some cases, hairline cracks in walls or plaster, particularly near the epicentre (2.5% in 2024; <1% in 2025). The shaking was frequently accompanied by rumbling to booming sounds, many residents also reported sounds resembling the passage of heavy vehicles or an explosion (~90% of cases both in 2024 and 2025). Earthquake-related sounds are commonly perceived near epicentres, even for very small events (e.g., Tosi et al., 2012). In our case, the large number of reports across the wide area where these sounds were detected suggests unusually efficient seismic wave propagation.

Individual questionnaire responses were converted into macroseismic intensities according to the EMS–98 scale criteria (Grünthal, 1998). Intensities were initially assigned to individual reports and subsequently evaluated for localities. Qualitative terms such as “few”, “many”, and “most” were quantified using three percentage not-overlapping ranges (0–20%, 20–60%, and 60–100%), enabling a more quantitative assessment (Tosi et al., 2015). No correction for surface conditions like sedimentary effects was applied, as the area is generally underlain by crystalline rocks. Although the area is sparsely populated (~20–50 persons/km²; see Fig. 4), the population distribution is relatively uniform; therefore, no correction for population density was considered necessary. Questionnaires lacking sufficient diagnostic information, containing inconsistent timing, duplicates, or those reporting effects not clearly attributable to the earthquake were excluded from the analysis (after Tosi et al., 2024). On average, only ~2% of the questionnaires were discarded, which demonstrates the reliability of the data provided by citizens.

Reports indicating light shaking felt by few persons at rest, but without movement of objects, were assigned intensity III (“weak”). Reports of strong shaking felt by many indoors, accompanied by rattling of windows, doors, or dishes and slight movement of lightweight objects, were assigned intensity IV (“largely observed”). An intensity of IV–V was assigned in areas with numerous reports indicating clear movement of unsecured objects, overturning of small items, or rare non-structural damage (e.g., hairline cracks in plaster), but without fully satisfying the criteria for intensity V (“strong”). Reports indicating that the earthquake was “not felt” are particularly valuable for estimating macroseismic intensity at lower intensity levels, where the assessment is commonly based on the proportion of people perceiving the shaking (e.g., Grünthal, 1998; Tosi et al., 2015). In our case, the “not felt” reports were associated with the perception of sounds resembling transport heavy vehicles (in 13% of all cases) and were assigned an intensity of III. When multiple effects were reported, intensities were assigned conservatively, based on object or damage-related indicators. The final locality intensity was taken as the modal value of all retained responses.

The maximum macroseismic intensity, assessed according to the EMS–98 scale (Grünthal, 1998), reached IV–V for the stronger 2024 earthquake and IV for the weaker 2025 event. The spatial distribution of macroseismic intensities is illustrated in the corresponding intensity maps (Fig. 3b,d). However, the most notable feature was not the intensity level itself but the spatial pattern of the reported observations. The stronger 2024 event was observed farther to the west than the 2025 earthquakes; nevertheless, in both cases, the distribution of observations was distinctly non-circular. Importantly, the uneven spatial pattern was not controlled by population density (Fig. 4). Notably, the weaker 2025 event was reported more frequently, and in addition, both events were widely accompanied by reported sound effects.

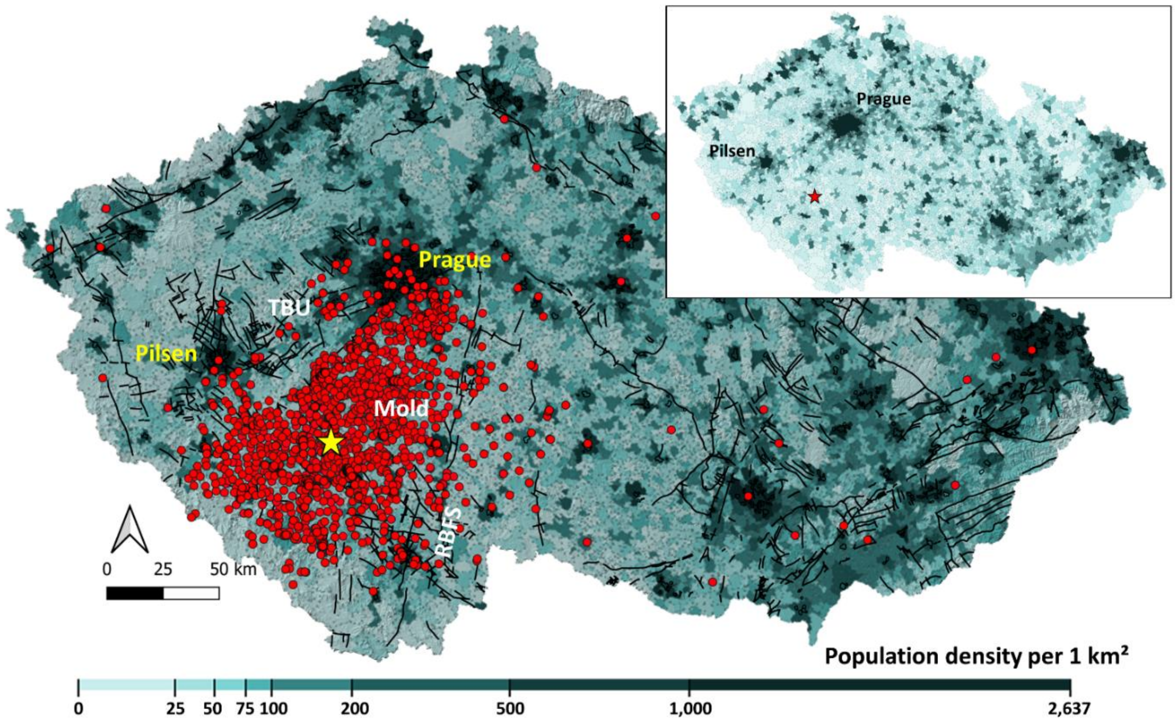

Figure 4. Spatial distribution of macroseismic observations (red points) for both 2024 and 2025 Mirotice earthquakes (yellow star), superimposed on map of population density (people per km²; *https://geoportal.gov.cz/*). Note trapezoidal patter of the observations delimited from the west by the Teplá–Barrandian (TBU) / Moldanubian (Mold) boundary and from the east by the Rödl–Blanice Fault System (RBFS) independent of population distribution. Inset shows population density without observations (public source: *https://data.gov.cz/*). Note generally low population density in southern Czechia, as well as slightly higher population density west of the area where observations terminate.

Tectonic and Structural Context

The earthquakes occurred in the southern Bohemian Massif, which formed between 500–250 Ma during the convergence of Gondwana and Baltica. Its development was shaped by Neoproterozoic active margin of the northern Gondwana, Cambro-Ordovician extension, Devonian subduction, and the Carboniferous underthrusting of the Saxothuringian microcontinent (Edel et al., 2018; Schulmann et al., 2014; Soejono et al., 2020). The Bohemian Massif is divided into four west-to-east lithotectonic units: the Neoproterozoic to Palaeozoic Saxothuringian Domain, the Ediacaran to Lower Palaeozoic Teplá–Barrandian Unit (TBU), the Variscan crustal Moldanubian Domain, and the Neoproterozoic to Palaeozoic Brunovistulicum (Hajná et al., 2017; Hanžl et al., 2019; Schulmann et al., 2014). The closure of the Saxothuringian ocean and subsequent continental underthrusting created the Central Bohemian Plutonic Complex (CBPC) magmatic arc at the TBU–Moldanubian boundary (Schulmann et al., 2014; Žák et al., 2014).

The earthquake epicentral area is located within the Central Bohemian Plutonic Complex (CBPC), specifically in the Mirotice complex, near the NE–SW trending boundary (~25 km east), between the Teplá–Barrandian Unit and the Moldanubian Domain (Fig. 1). The evolution of CBPC is characterized by the intrusion of Late Devonian plutons of magmatic arc affinity and voluminous syntectonic early Carboniferous arc plutons during regional vertical transpression into Neoproterozoic and Early Palaeozoic metasedimentary successions of subhorizontal structural record (Žák et al., 2014; Tomek et al., 2015). This resulted in deep-seated steeply dipping NE–SW oriented boundary separating CBPC in the east from contrasting lithologies of the Teplá–Barrandian Unit in the west.

The transpression regime was later replaced by ductile normal shearing along the Červená Shear Zone, which facilitated exhumation of high grade Moldanubian Domain and formed eastern boundary of CBPC (Žák et al., 2014; Fig. 1). In the study area, the Moldanubian is characterized by mostly shallow to subhorizontal structures and lithological contacts (Schulmann et al., 2014). The eastern margin of the region is further disrupted by the large scale NNE–SSW trending Rödl–Blanice Fault System, which developed during late Variscan tectonic evolution and was subsequently reactivated during the Cretaceous and Miocene (Prachař, 2022).

The deep crustal structure of the Bohemian Massif has been investigated by several active seismic profiling (e.g., Tomek et al., 1997; Růžek et al., 2003, 2007; Hrubcová et al., 2005; Vavryčuk et al., 2004), which revealed higher P-wave velocities with lower vertical gradient in the Moldanubian crust due to its crystalline rocks exposed at the surface. The Moho beneath this unit forms a sharp first-order discontinuity reaching maximum depths to 39 km (Hrubcová et al., 2005), coinciding with minimum surface heat flow (< 50 mW m^{-2}; Čermák, 1977) and suggesting cold and mechanically strong Moldanubian lithosphere (Babuška and Plomerová, 2000).

In contrast, the Teplá–Barrandian Unit is characterized by higher near-surface velocity gradients, consistent with its Palaeozoic volcano-sedimentary sequences. The Moho beneath this unit is shallower as documented along the refraction CEL09 profile

(Hrubcová et al., 2005, 2017). In addition, two middle crustal reflectors, characterized by modest velocity contrasts (~0.15–0.3 km s^{-1}), are identified along CEL09 at depths of ~7–13 km and 17–20 km across much of the region.

Discussion

When interpreted in a geological framework, the spatial distribution of macroseismic observations from the 2024 and 2025 earthquakes provides insight into the deep structure of the Moldanubian and its contact with the Teplá–Barrandian (Fig. 1). Macroseismic observations were unevenly distributed around the epicentre, forming a trapezoidal pattern (Fig. 3) bounded by the boundary between the Teplá–Barrandian Unit and the Moldanubian Domain to the west and the Rödl–Blanice Fault System to the east. The enclosed area is dominated by intrusive felsic rocks, mainly granites and granodiorites of the Central Bohemian Plutonic Complex (CBPC) and high-grade metamorphic Moldanubian rocks, which are characterized by low seismic energy attenuation, allowing efficient seismic wave propagation and serving as a seismic resonator.

In contrast, areas located west of the contact exhibit a markedly low density of macroseismic observations. This corresponds to the geological character of the Teplá–Barrandian Unit, which is dominated by early Palaeozoic sedimentary formations. Moreover, at the boundary with the Central Bohemian Plutonic Complex, the Teplá–Barrandian Unit is characterized by steeply oriented, highly anisotropic deformation structures (Fig. 5). The sharply reduced number of observations suggests increased seismic energy attenuation within this geological unit. The contrasting lithologies along the NW–SE trending contact are also expressed in gravity and particularly in geomagnetic data pointing to the deep character of this zone (Bucha and Blížkovský, 1994; Švancara et al., 2021). The Rödl–Blanice Fault System is a N–S trending structure extending across the Moldanubian Domain, and the observed attenuation of seismic energy along this zone suggests the presence of a deep crustal fault (Fig. 5). In this way, macroseismic observations delineate subvertical structures within the Bohemian Massif that are not otherwise detected by deep-sounding seismic methods.

Interpreting the contrasting macroseismic characteristics across the Teplá–Barrandian/Moldanubian contact as a consequence of wave reflections from this zone is unlikely given the geometric constraints. The earthquakes originated at depths of ~24 km, with the horizontal distance to the contact of ~25 km. The subvertical geometry of the contact is unfavourable for generating strong shear-wave reflections back to the surface from such nearby sources. Instead, the non-circular distribution of macroseismic observations outlines two major crustal structures: the Teplá–Barrandian/Moldanubian contact in the west expressed as a deep-seated lithological boundary, and the Rödl–Blanice Fault System in the east expressed as a crustal-scale fault zone (Fig. 5). The observed distribution pattern can be partly explained by the radiation pattern of seismic waves, particularly S waves radiating in the SW and NE directions. However, the sharp cut-off of observations along boundaries defined by two old tectonic structures, independent of population density, indicate a strong structural control on seismic wave propagation.

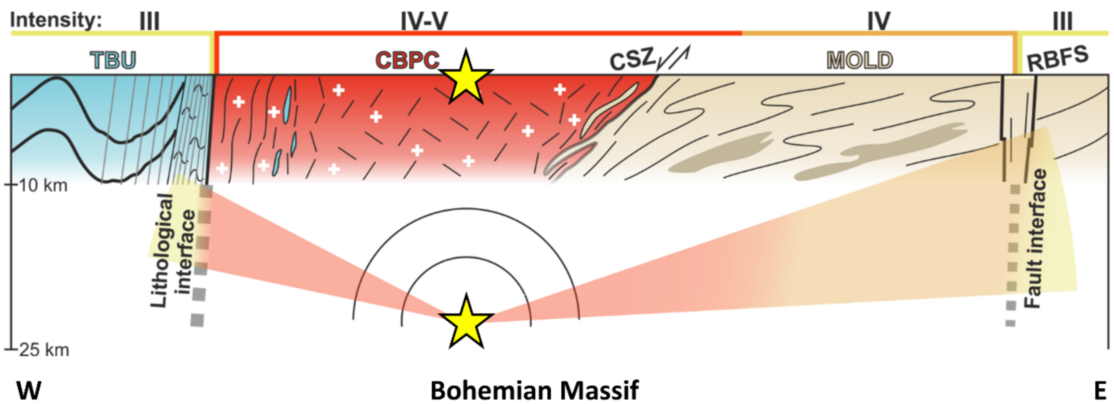

Figure 5. Schematic cross-section along a segment of the CEL09 profile (see Fig. 1) showing principal geological structures of the Bohemian Massif (modified after Deiller et al., 2021; Žák et al., 2014) with spatial distribution of 2024 macroseismic intensity (on top) of the Mirotice earthquakes (yellow stars). Note two interpreted subvertical, crustal scale tectonic boundaries affecting seismic-wave propagation and attenuation: the lithological contact between the Teplá–Barrandian Unit (TBU) and the Moldanubian Domain (Mold) in the west, and the deep Rödl–Blanice Fault System (RBFS) in the east. CBPC, Central Bohemian Plutonic Complex; CSZ, Červená Shear Zone.

The attenuation of seismic energy, particularly within the TBU unit, resembles patterns previously observed at a larger regional scale in deep-sounding studies investigating wave propagation and attenuation across the Bohemian Massif and the Pannonian Basin (Beránek and Zátopek, 1981; Hrubcová et al., 2005, 2010). These studies demonstrated efficient wave propagation from surface sources toward the NW through the crystalline rocks of the Bohemian Massif, whereas strong attenuation was observed toward the SE within the Tertiary sedimentary sequences of the Pannonian Basin.

The Mirotice earthquakes, rare in the region and unusual in large depth (~24 km) for the Bohemian Massif, possibly reflect low geothermal gradient (Čermák, 1977). Their hypocentres coincide with a reflective interface identified along the CEL09 seismic profile of the CELEBRATION 2000 experiment (Hrubcová et al., 2005), situated close to the epicentral area (Fig. 1). This interface may represent a structural feature that influences the earthquake nucleation.

Although smaller in magnitude, the 2025 earthquake (M_L 3.1) was reported more frequently than the 2024 event (M_L 3.5). Together with the frequently reported acoustic phenomena for both earthquakes, this indicates efficient seismic wave transmission from depth. Such behaviour supports deep-seated origin of the activated structures and implies a relatively homogeneous crustal medium in the Moldanubian (and the Central Bohemian Pluton specifically) that facilitates both propagation of seismic waves and generation of acoustic signals.

Both focal mechanism solutions are identical, as confirmed by shape-identical waveform recordings on nearby stations (Fig. 2b), and show normal faulting on a NW–SE striking plane (Fig. 2c; Table 1). The region is influenced by far-field stresses from the ongoing Africa–Eurasia convergence, which transmit compressional stresses from the Alpine belt into the Bohemian Massif. Despite local stress heterogeneity, the maximum horizontal compressive stress (SHmax) is consistently oriented NW–SE in central Europe (Heidbach et al., 2016; Müller et al., 1992). The focal mechanisms reflect a normal faulting stress regime, with a vertical maximum principal stress, a NW–SE oriented intermediate horizontal stress, and a minimum horizontal stress perpendicular to the fault strike. This faulting geometry is consistent with the regional stress field, in which the maximum principal stress in vertical direction is dominated by lithostatic pressure at focal depth and horizontal stress retains the regional NW–SE orientation.

Conclusions

The 2024 and 2025 Mirotice earthquakes provide valuable insight into the deep crustal structure of the Bohemian Massif and demonstrate the potential of crowdsourced macroseismic observations for investigating intraplate seismicity. The analysis brings two major achievements. (1) Despite occurring in a region generally considered seismically non-active and characterized by relatively low population density, both earthquakes attracted significant public attention, resulting in a high number of completed questionnaires. (2) The spatial distribution of macroseismic observations proved highly informative and showed a clear correlation with major geological structures.

The earthquakes occurred within the Moldanubian crystalline basement, slightly west of the deepest Moldanubian root, inside the Central Bohemian Plutonic Complex (CBPC), approximately 25 km east of its contact with the Palaeozoic sedimentary sequences of the Teplá–Barrandian Unit. Their unusually large focal depths of ~24 km, normal faulting mechanisms, and efficient seismic wave propagation are consistent with the low geothermal gradient and deep-seated crystalline rocks of the CBPC within Moldanubian. The sharply delimited pattern of macroseismic observations delineates deep crustal contact of the Teplá–Barrandian with Moldanubian as a lithological boundary west of the epicentral area. To the east, it outlines the crustal scale Rödl–Blanice Fault System. Together, these observations reveal deep sub-vertical structures within the Bohemian Massif that are not otherwise resolved by conventional seismic investigation. The results demonstrate that major crustal-scale tectonic boundaries strongly influence seismic wave propagation and attenuation. They also underline the value of crowdsourced macroseismic data as a complementary source for investigating deep crustal processes in regions with sparse intraplate seismicity.

Table 1: Focal mechanisms of the 2024 and 2025 Mirotice earthquakes

Earthquake	Strike 1	Dip 1	Rake 1	Strike 2	Dip 2	Rake 2
2024/03	169°	50°	-60°	307°	49°	-121°

2025/04	169°	67°	-55°	288°	42°	-144°

Author contributions

Conceptualization: PH; Data curation: PH, JV, AP, HKE, PS, and JZ; Formal analysis: PH, JV, AP, and PS; Funding acquisition: PH; Writing original draft and visualisation: PH and MM; Writing review and editing: PH, MM, JV, HKE, PS, and JZ.

Competing interests

We declare no potential conflicts of interest.

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Data availability

Macroseismic questionnaires related to this paper are in Czech and available at request from the authors.

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