

The relation of the seismicity in the eastern part of the Ukrainian Carpathians and the distribution of electrical conductivity in the Earth's crust

SVETLANA KOVÁČIKOVÁ^{1,✉}, IGOR LOGVINOV² and VIKTOR TARASOV²

¹Institute of Geophysics, Czech Academy of Sciences, Boční II/ 1401, 14131 Praha 4 – 14100, Czech Republic; ✉svk@ig.cas.cz

²Institute of Geophysics, National Academy of Sciences of Ukraine, Palladin av. 32, 03142 Kiev, Ukraine; anna_log@ukr.net

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Abstract: We present results of a study of the peculiarities of the seismicity and electrical conductivity distribution beneath the Ukrainian Eastern Carpathians. Based on the analysis of seismic data for the years 1999–2016, specific zones of concentration of earthquake sources related to the principal fault systems and their intersections have been distinguished. This paper covers two zones, one linked to the contact of the Outer Carpathians and the Carpathian Foredeep and another one linked to the fault system transverse to the Carpathians strike. Both belts of earthquake sources concentration correlate well with the geoelectric models of the studied area obtained as a result of 2D and quasi-3D inversion. Most of the seismic events occur at the intersection of the mentioned seismic zones, at shallower depths, than the main conductive structures appear, concentrated at their marginal parts. The interrelation of both phenomena suggests their common explanation by processes occurring in active fault systems: fracturing, shear deformation, migration of highly mineralized fluids, high porous pressure, accumulation and release of tectonic stress.

Keywords: Ukrainian Carpathians, seismicity, electrical conductivity.

Introduction

The Carpathian region is characterized by increased seismic activity which is irregularly distributed along the Carpathian Mts. strike. One of the areas of increased seismicity is the territory of the Ukrainian Eastern Carpathians (sources — Kostyuk et al. 1997; European-Mediterranean Seismological Centre EMSC <http://www.emsc-csem.org>; Seismological Bulletins of Ukraine 1999–2016 etc.). Currently, from 3–5 to 20–30 earthquakes with a magnitude of 0.6–0.8 and higher (reaching 4.2) are instrumentally registered during a year in the Ukrainian Carpathians; 60–75 % of them in the Transcarpathian basin, the rest in the Outer flysch Carpathians and partly in the Carpathian Foredeep and the adjacent territories of the East European platform (EEP). For the purposes of this study, we analysed data from the Seismological Bulletins of Ukraine for the years 1999–2016 and compiled a summary catalogue of the Carpathian earthquakes for these years.

Geoelectrically, the Carpathians are characterized by subsurface low resistivity sedimentary sequences of the Carpathian Foredeep and by the prominent crustal Carpathian conductivity anomaly CrCA (recently, for example, Twaróg et al. 2018; Bezák et al. 2019; Červ et al. 2019; Logvinov & Tarasov 2019). Currently, a database of the magnetotelluric (MT — natural electromagnetic field) data has been created, which includes practically 90 % of all results of the MT research in Ukraine. Using this database and on the basis of the 2D modelling through a network of 12 profiles, the areal distribution of geoelectric parameters in the depth interval of

1–16 km for the territory of the Ukrainian Carpathians was obtained (Logvinov & Tarasov 2019). The quasi-3D thin sheet inversion made it possible to model the electrical conductivity distribution in a sheet approximating the upper boundary of the electrical anomaly source.

Peculiarities in the distribution of earthquakes and increased conductivity within the Earth attract permanent interest from researchers. The results of geoelectric studies suggest narrow interrelation of the revealed conductive structures with fault tectonics and consequent geothermal and seismic activity in the whole Carpathians (e.g., Kováč et al. 2002; Toth et al. 2002; Majcin et al. 2014). Following the above mentioned course, the presented article aims to correlate the seismicity of the eastern part of the Ukrainian Carpathians with the geoelectric parameters of the Earth's crust, determined by 2D and 3D interpretational methods.

Investigated area, geoelectric and seismological data

The Carpathian region in Ukraine is traditionally subdivided into the Carpathian Foredeep, the Transcarpathian Depression and the Carpathians themselves (Fig. 1), the major part of which is here occupied by the nappes of the Outer flysch Carpathians (Glushko & Kruglov 1986). The Prealpine basement of the Ukrainian Carpathians is represented by the EEP complexes with the oldest represented by the Preriphean crystalline rocks (Archean-to-early Proterozoic with geological

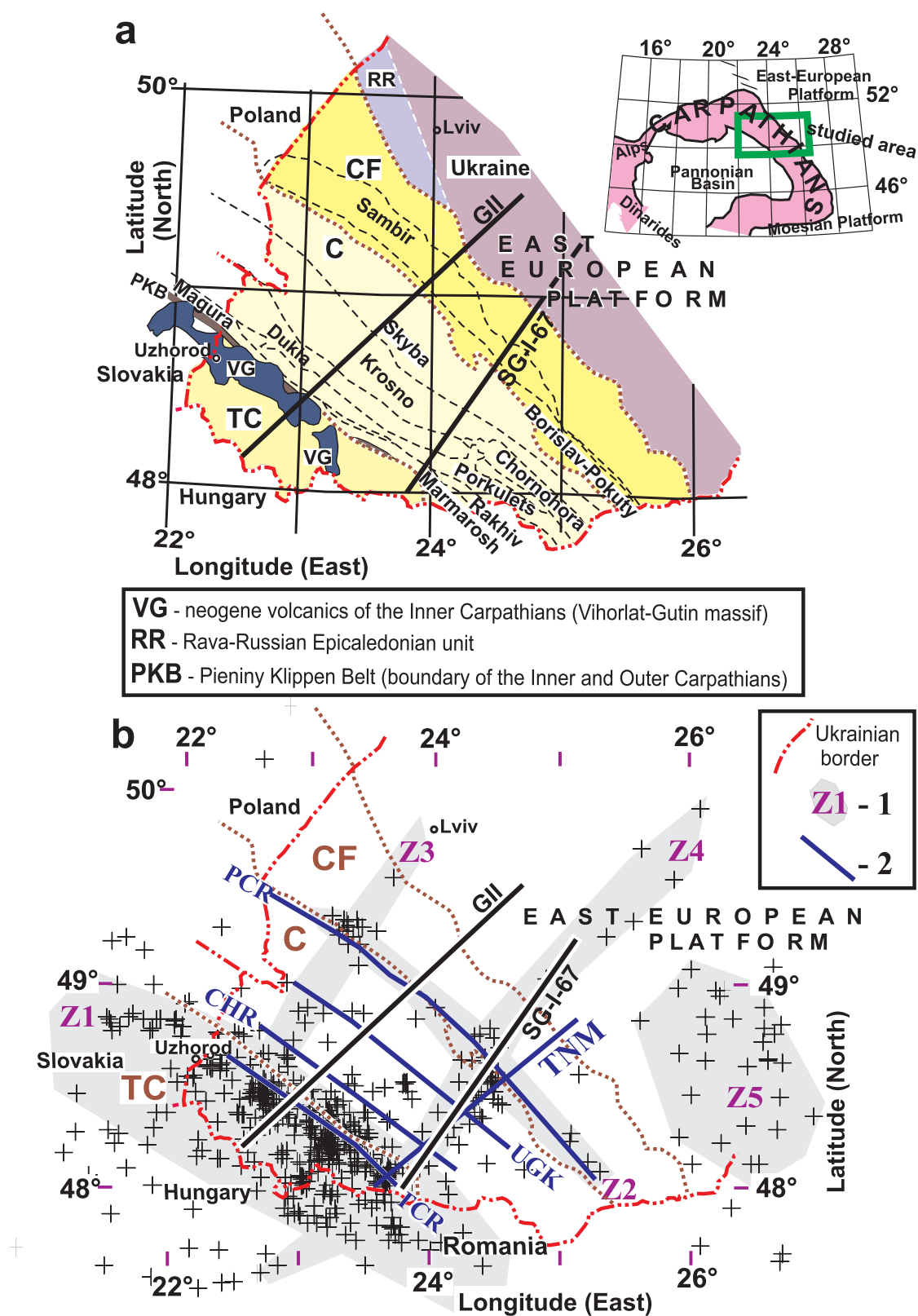


Fig. 1. a — tectonic scheme of the Ukrainian Carpathians (according to Glushko & Kruglov 1986) with individual nappe boundaries (black dashed lines); **b** — distribution of earthquakes epicentres (crosses) and (1) — areas of their concentration (grey zones), (2) — main faults intersecting the surface of the crystalline basement: TCR — Transcarpathian, CHR — Chornoholova, UGK — Uzhok, PCR — Precarpathian, TNM — Tyachev–Nadvorniansk–Monastyrets (Zayats 2013). In both subfigures: dotted lines — boundaries of main tectonic elements: TC — Transcarpathian depression, C — Carpathians, CF — Carpathian Foredeep. GII, SG-I-67 — MT profiles discussed further; rectangle in the inset — studied area.

ages more than 1650 Ma) followed by the Neoproterozoic formed during the Baikalian tectonic processes (around 850 Ma). The territory is intersected by a complicated network of faults parallel to the orogene axis and related to individual thrust zones as well as transversal faults (Verkhovtsev 2006; Zayats 2013).

Geoelectric investigations

As an input for performing the 2D and quasi-3D geoelectric modelling, the experimental MT (both electric and magnetic components of the recorded natural electromagnetic field) and

magnetovariational data (MV, only magnetic components) from the Ukrainian Carpathians in the period range 1–6400 s (Gordienko et al. 2011; Logvinov 2015 and sources therein) and the results from the international profile PREPAN (Adám et al. 1997) have been used (Fig. 2a).

For the 2D modelling performed using the REBOCC inversion algorithm (Siripunvaraporn & Egbert 2000), experimental MT sites over the area were projected on eleven profile lines (plus profile PREPAN). Geoelectric parameters of the subsurface layers were used as a priori information in the starting interpretational model. Sedimentary layers play a significant role in calculating the models of the electrical resistivity

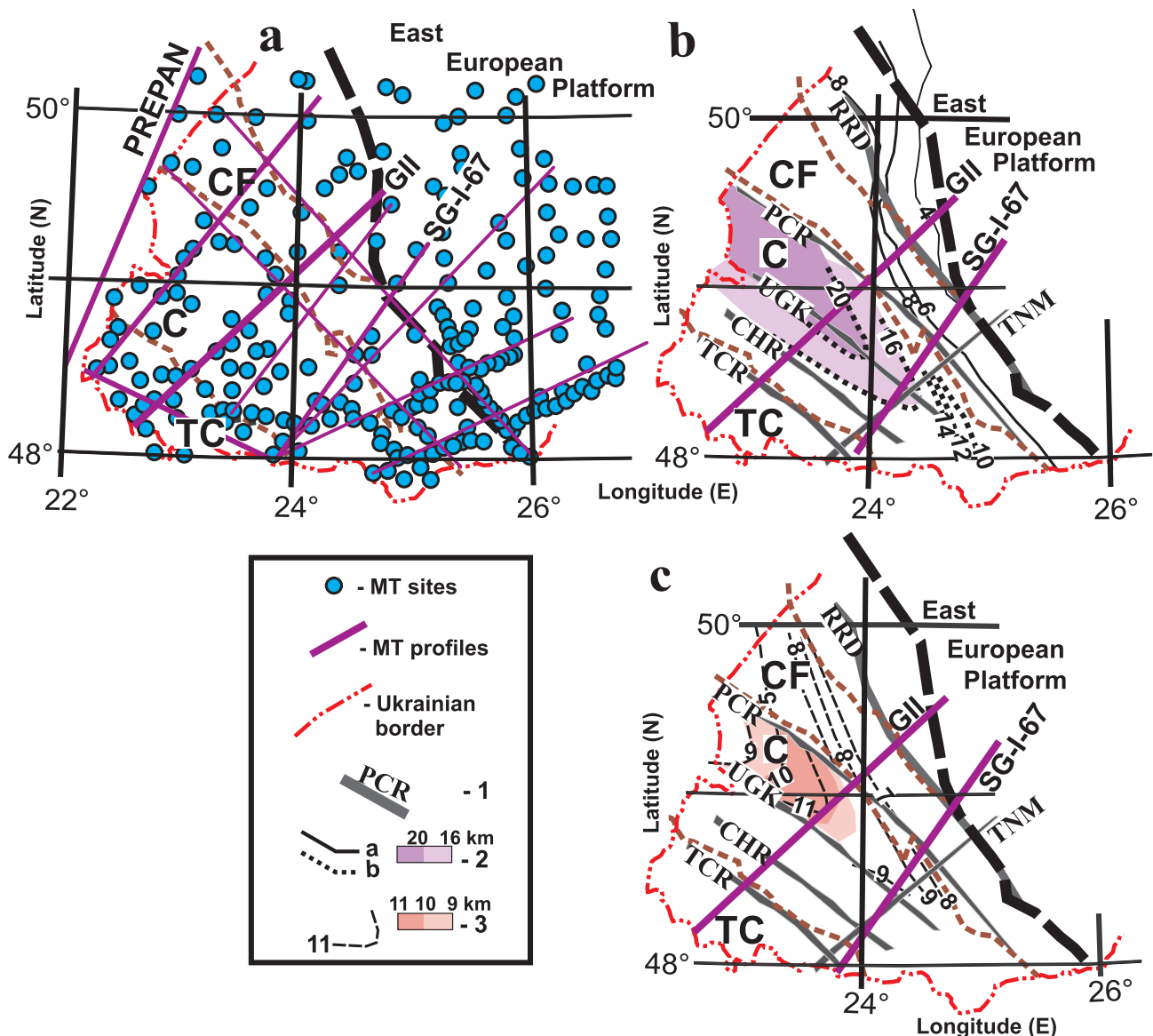


Fig. 2. a — Locations of MT field observation sites and profiles of the 2D inversion (Logvinov & Tarasov 2019); GII — along the IInd international Geotraverse and SG-I-67 — MT profiles discussed further; dashed lines: thin — boundaries of the principal units of the Ukrainian Carpathians (zones CF, C, TC — see Fig. 1), thick — the EEP boundary; b — scheme of the Preriphean crystalline basement; c — scheme of the Baikalian basement (Zayats 2013); 1 — main faults intersecting the surface of the crystalline basement (see Fig. 1), RRD — Rava-Russian-Davydenko fault (SW boundary of the Preriphean platform); 2 — contour lines of the Preriphean basement (in km): a — reliable, b — expected; 4 — contour lines of the Baikalian basement surface (in km).

(ρ) of the Earth's crust. In the Ukrainian Carpathians region, the Baikalian basement is overlain by Meso-Cenozoic sediments. Generally, according to the scheme on Figure 2c, the thickness of sedimentary rocks in the Carpathian Foredeep and the folded flysch Carpathians does not exceed 8 km (Zayats 2013). According to the logging data and the direct current methods, the rocks composing the flysch Carpathians are characterized by strongly varying values of ρ . For the Cenozoic rocks, the resistivity values are generally 10–50 ohmm. The resistivity of the Mesozoic and Paleozoic rocks varies from 15–30 ohmm to 100 or more ohmm. Mesozoic to Cenozoic deposits of the Carpathian foredeep are characterized by ρ values varying from 3–5 ohmm to 10–30 ohmm, whereas the resistivity of Paleozoic rocks varies from 30–60 ohmm to 100–150 ohmm. Details of the 2D modelling along the profiles were described in Logvinov & Tarasov (2018, 2019). Root mean square deviation rms in the inversion varied between 1.65 and 2.8.

Currently available geological and geophysical information is obviously presented in the form of horizontal and vertical sections. In this work, horizontal sections at various depths are presented (Fig. 3a–e). For joint presentation of the 2D modelling results a three-dimensional matrix was constructed. At each modelling profile, the spatial coordinates of the modelling cells were defined and a three-dimensional matrix was built (variables are: X — longitude, Y — latitude, Z — depth, ρ — electrical resistivity). With respect to the scale of the profiles network and the horizontal step of modelling on the profiles, the initial matrix for the construction of models of geoelectric parameters was transformed into a matrix with the horizontal cell size 6 km \times 6 km. The electrical resistivity (ρ) within the interval of 100–1000 ohmm was assumed as the normal resistivity value. At this normal resistivity background, plots with ρ less than 40 ohmm are shown, giving more than 90 % of contribution to the low resistivity objects (Rokityansky 1982). High resistivity structures may also be geologically interesting and features with ρ exceeding 1000 ohmm are also shown in the figures. The densest network of modelling profiles is located in the eastern part of the Ukrainian Carpathians, bounded from the west by an international geotraverse GII (Fig. 2, Kruglov & Gursky 2007). Therefore, the most conditioned results from this area are used as the resistivity distribution in the Earth's crust in the following.

The resulting resistivity distribution for the first 4 km (Fig. 3a) is in good agreement with the geoelectrical characteristics of sedimentary rocks described above. An interesting feature of the obtained distributions of ρ is the presence of an arc-shaped area in the central part bounded by a contour line of 100 ohmm. At the south-west, it appears at the intersection of geographic coordinates 23°E and 48°N, a locality in the Transcarpathian depression. Further, the structure crosses the flysch Carpathians and in the area with coordinates of about 23.5°E and 48.5°N, its strike is close to the Precarpathian fault's stretching. In the described depth interval, three anomalous objects (ρ less than 10 ohmm) are allocated in the area. Beneath 5 km, only local high conductivity (or low resistivity)

objects remain on the horizontal sections in the same areas as in the shallower depths. The highest conductivity values are observed in the central object at a depth of 5 km (with coordinates of its centre approximately 24.3°E and 48.7°N). Beneath the 8 km depth, the central conductive structure splits onto three separate high conductivity objects traced down to 16 km. Comparison of the described conductivity distribution with the fault tectonics allows us to associate individual conductive structures with faults of the Carpathians stretching and transverse (with respect to the Carpathians) faults. Such feature is quite clearly traced down to the depth of about 8 km. Another feature of this area is the presence of a high-resistivity structure located to the south of the central conductive structure. In a volumetric presentation, its position suggests encompassing of the high-resistivity block by the conductive structure. In depth, this block disappears beneath the Baikalian basement surface (Fig. 2c). The central and eastern structures (limited by contour line $\rho=40$ ohmm) can be traced through the whole depth interval presented in Figure 3, but their centres migrate, as they approach the Earth's surface. Rapid change of the anomalous object's position occurs in the depth interval of 8–10 km. This depth interval separates the conductive objects into two floors also by the conductivity value. The largest conductivity is observed at a depth of 16 km and deeper, which indicates the location of their roots in the crystalline basement rocks (Fig. 2b).

The obtained 2D models were used as a priori layered 1D structure and the source depth for the quasi-3D geoelectric modelling based on the thin sheet theory applicable at quite long periods (the range of hundreds to thousands seconds) when, in a quasi-static approach, the electromagnetic wavelength exceeds the thickness of the upper crustal layers (Schmucker 1970; Vasseur & Weidelt 1977). The upper boundary of the electrical anomaly source is then approximated by a horizontally inhomogeneous sheet buried in a layered Earth. In this case, the electrical conductivity (reverse of the resistivity) is replaced by the integrated conductance S (Siemens) distribution over the sheet and the vertical changes of the conductivity are neglected. In the procedure, only magnetic components of electromagnetic records (induction arrows) were used. The method is sensitive mainly to the horizontal conductivity gradients which makes it suitable especially for tracing regional crustal conductors that may mark significant tectonic boundaries and structures. Details of the technique were presented in Kováčiková et al. (2005). The thin sheet applied in the inversion was located in a layered medium at the depth of 8 km approximating the upper boundary of the Carpathian conductivity anomaly. Its source is presumably located in the depth interval of about 10–20 km although to the east, it approaches the surface reaching about 8 or less km in Ukraine (Logvinov 2015). Choice of the modelling parameters and results was presented in Kováčiková et al. (2016). The model consisted of 46 \times 46 cells; the cell size was 10 km \times 10 km with respect to the used period range (400 s–6400 s). Starting with the normal conductance in the thin sheet (1000 S), the inversion was performed up to 15 iterations and finished reaching

the data weight value between two iterations (0.5 with respect to the induction vectors amplitudes reaching values of 0.7). Inversion was calculated for all periods separately (400 s, 900 s, 1600 s, 3600 s and 6400 s) with the best fit of the model at the period 1600 s. The average difference in amplitude was about 0.2 (16 %) and maximum 24° in azimuths.

Seismological data

The summary catalogue of the Ukrainian Carpathians earthquakes for the years 1999–2016, mentioned in the introduction, contained data from eighteen Seismological Bulletins of Ukraine for the years 1999–2016 issued by the Institute of

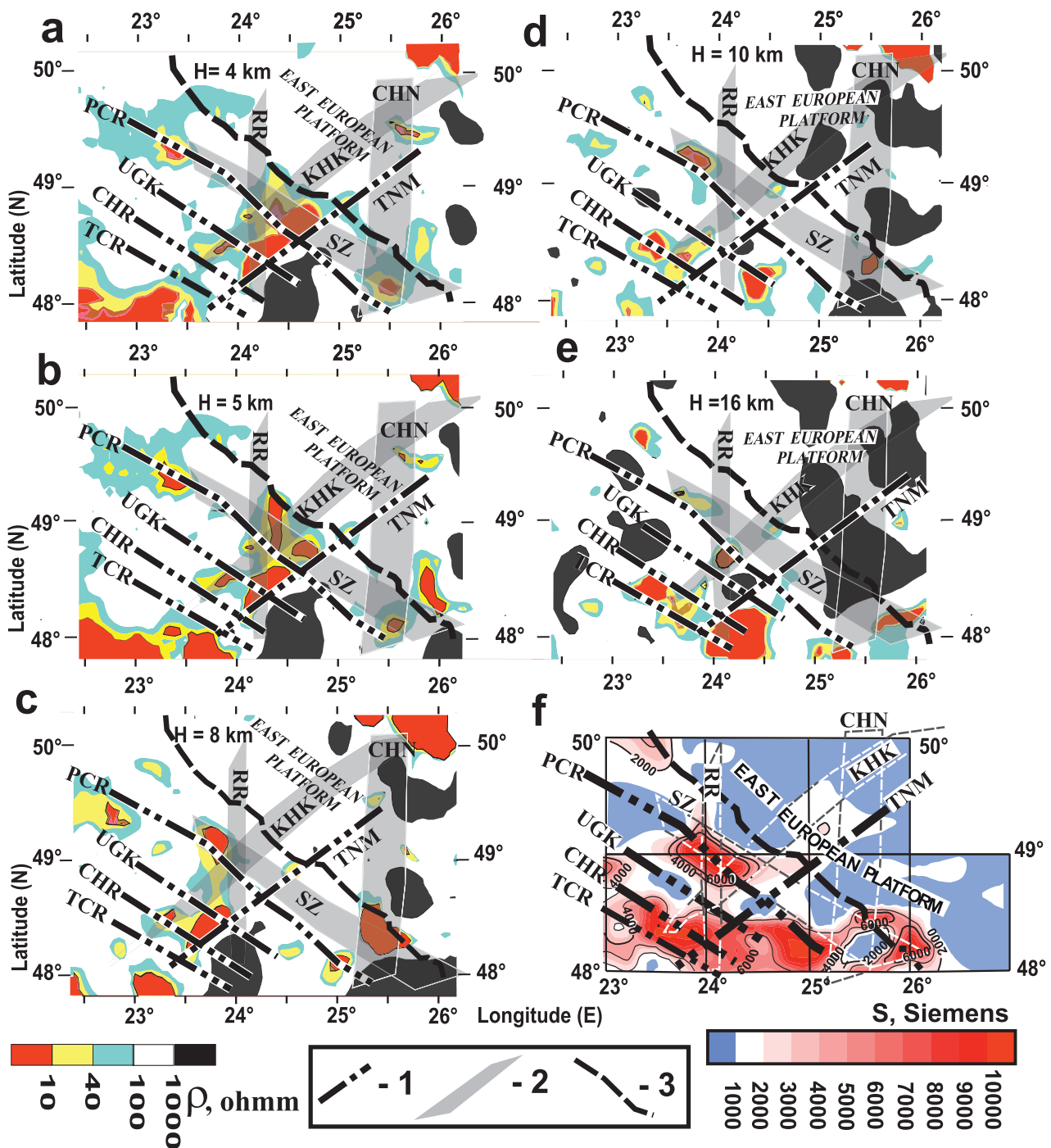


Fig. 3. a–e — Distribution of the electrical resistivity in the upper part of the Ukrainian Carpathians crust from the 2D inversion at different depth levels; f — distribution of the integrated conductivity within the thin sheet at 8 km (result of the quasi 3D inversion for the period $T=1600$ s); 1 — main faults intersecting the surface of the crystalline basement (see Fig. 1); 2 — faults active during last 3 Ma (Verkhovtsev 2006); SZ — Starosambir-Zmynnyi, RR — Ratnov-Rakhiv, KHK — Khust-Korets, CHN — Chertkov-Novoluts'k; 3 — EEP boundary.

Geophysics NAS Ukraine, Simferopol. It listed data on 949 events limited by coordinates 21–26.8°E and 47.5–50°N (Fig. 1b) their source times, epicentre coordinates, focal depths, magnitudes M_{SH} (horizontal component magnitude) and M_D (earthquake duration magnitude) and classification according to the K-class system (Rautian et al. 2007). Five zones of concentration of earthquake epicentres can be distinguished within the Ukrainian Carpathians region. They are related to: the Transcarpathian Depression (Z1); Precarpathian fault (Z2); a belt stretching approximately from 22,5°E and 48°N to 24°E and 50°N (Z3); another belt stretching from 23°E and 47.8°N to 26°E and 50°N (Z4); an area limited by the longitudes 26–26.8°N and latitudes 48–49°N (Z5). Of course, the selection of the zones is relative and conventional and further research will help to make more reliable conclusions. Characteristics of the Transcarpathian earthquakes are described in many studies (e.g., Malytsky 2006; Gnyp 2009; Lozynyak et al. 2011; Maksymchuk et al. 2011; Nazarevych et al. 2016). The zones Z3 and Z5 practically do not fall into the area of geoelectric parameters obtained by the 2D modelling. Therefore, in this paper we consider characteristics of earthquakes concentrated along the Precarpathian fault and in the belt Z4. The area of the most conditioned geoelectric 2D modelling results is located east of the Geotransverse II line (GII in Fig. 2, Zverev & Kosminskaya 1980). According to the above mentioned database of the Ukrainian Carpathians earthquakes for the years 1999–2016, in the area of the most conditioned 2D modelling results, the earthquake epicentre coordinates were defined at 280 points, 273 of them belonging to the energy class K_p (Rautian et al. 2007). At 243 points, not only the depth intervals but, specifically, the focal depths (with average δh varying for individual years from 1.62 to 0.3) have been defined since the year 2000. The magnitude M_{sh} (horizontal component magnitude) was defined for the periods 1999–2003 and 2013–2016 (a total of 107 earthquakes), and the magnitude M_D (earthquake duration magnitude) — for 232 earthquakes since the year 2002.

In Figure 4, the epicentres and depths of earthquake hypocentres, typical for the Z2 and Z4 zones and the position of the main fault zones are presented. The zone Z2 is linked to the contact of the flysch Carpathians and the Carpathian Foredeep and is characterized by a change of the earthquake hypocentre depths along its strike. The zone Z4 is located between the Tyachev–Nadvornyansk–Monastyrets (TNM) and Khust–Korets (KHK) fault zones along its whole length. The normal value of hypocentres depth varies within the interval of 2–4 km. At the same time, two nodes can be seen, where the hypocentres are observed in the depth interval of 2–16 km. One of the nodes (with approximate size 60×60 km) is located at the intersection of the Transcarpathian fault (TCR) and TNM (zone “n1” in Fig. 4a), the second one (with approximate size 50×20 km) — at the intersection of the Uzhok fault (UGK), the Precarpathian fault (PCR) and TNM (zone “n2” in Fig. 4a and detail in Fig. 4b). From the analysis of the epicentres distribution presented in Figure 4a, another zone of earthquake concentration associated with the KHK fault can be

identified — at the KHK line between its intersections with TCR and PCR (“z” in Fig. 4a).

The normal value of the hypocentre depths in this zone corresponds to the depth of about 6 km, which is deeper than in surrounding areas. Regionally, it should be noted that the zone Z4 divides the territory of the flysch Carpathians into eastern and western parts. In the eastern part, the number of earthquakes is significantly lower than in the western part and the hypocentre depth exceeds 6 km. As was mentioned above, the M_{sh} magnitude was defined for the half number of earthquakes compared with the M_D magnitude. Therefore, in order to characterize the distribution of the zones of earthquake epicentre concentration Z2 and Z4, the magnitude M_D was used. Both zones were divided into cells with a size of 30×30 km (Fig. 5a), in which the magnitudes (Fig. 5b) were defined, with the Z2 cell No. 5 completely coinciding with the Z4 cell No. 6. The Transcarpathian node of earthquake concentration is characterized by the cells 2 and 3. The node at the intersection of the UGK, PCR and TNM can be characterized by the distribution of the M_D magnitude in the cells 5 and 6. Although at this time, it is difficult to provide a serious correlation, as in the vicinity of the second node, the earthquake parameter estimation is complicated by the absence of the required quality network of seismic stations (a list of the Carpathian seismic stations is given, for example, in Verbitsky et al. 2013). A significant difference of the folded Carpathians earthquake parameters west of Z4 from the eastern part is also evident in the distribution of released seismic energy. A fast decrease of earthquake parameters during transition from the flysch Carpathians to the Carpathian Foredeep can be visible in zone Z4 (difference between sections 1–6 and 7–12). In zone Z2 we can see decrease of folded Carpathians earthquake parameters west and east of Z4 (Z2 sections 1–5 and 6–8).

Discussion

With respect to the earthquake distribution in depth, horizontal sections reflecting the main peculiarities in distribution of both parameters were selected for comparison of geoelectric and seismological data (Fig. 6). The difference between the models resulting from the 2D and 3D geoelectric modelling methods can be explained by more smooth distribution of magnetic responses applied in the quasi-3D modelling.

A slice representing a depth interval of 4–6 km (Fig. 6b) demonstrates a regional change in conductivity anomalies: above the depth of 4 km, a good conductivity of the rocks of the Carpathian Foredeep in the south-east is visible, disappearing at a greater depth. At depths between 2 and 7 km, the number of seismic events is about 100, whereas at greater depths their number rapidly decreases to 14–15 within the depth intervals of 7–9 km and 9–11 km, 6 events within the depth interval of 11–13 km and 4 earthquakes within the depth interval of 13–17 km. In a depth interval of 2–11 km, most of the hypocentres are located outside the contours of the most conductive parts of the anomalous structures (less than

10 ohmm). The belt of earthquake epicentre locations within the Z4 zone correlates well with the conductive structure strike, and the decrease of the earthquake numbers with depth is accompanied by a decrease in the number of local conductive structures as well as decrease of their integrated conductivity.

Correlation of the conductivity distribution with the number of earthquakes is clearly visible in the thin sheet modelling results (Fig. 6h,i). Above the sheet located at a depth of 8 km, 93 seismic events within the depth interval of 5–7 km are observed, and only 17 earthquakes are observed within the depth interval of 7–9 km. According to the thin-sheet modelling results, it can be also seen, that earthquakes occur mostly in the marginal parts of the conductive structures.

As was mentioned above, the sedimentary cover of the Ukrainian Carpathians is represented by the Meso- to Cenozoic rocks of variable thickness, lithology, and level of dia-

cata- and metagenetic stages of transformation of the carbon-bearing material. Paleozoic rocks occurring in the Carpathians are transformed under the high temperature and pressure conditions to a degree that makes their classification as sedimentary rocks doubtful. General knowledge about the changes in the properties of primary sedimentary formations under the influence of high pressure and temperature when immersed in deep sedimentary basins suggests, that during heating, which corresponds to their deep sections, the late katagenesis can be reached at the depth of 3.5–7.5 km with the temperatures of 100–200 °C; below the depth of 10 km and with temperature of 300 °C the rocks transform into metamorphic rocks and cannot be assumed to belong to sediments (Gordienko et al. 2011).

In Figure 7, geological sections of the upper part of the Carpathian crust along two profiles bounding the studied area (Figs. 1, 2) are presented. Profile A–B (practically coinciding

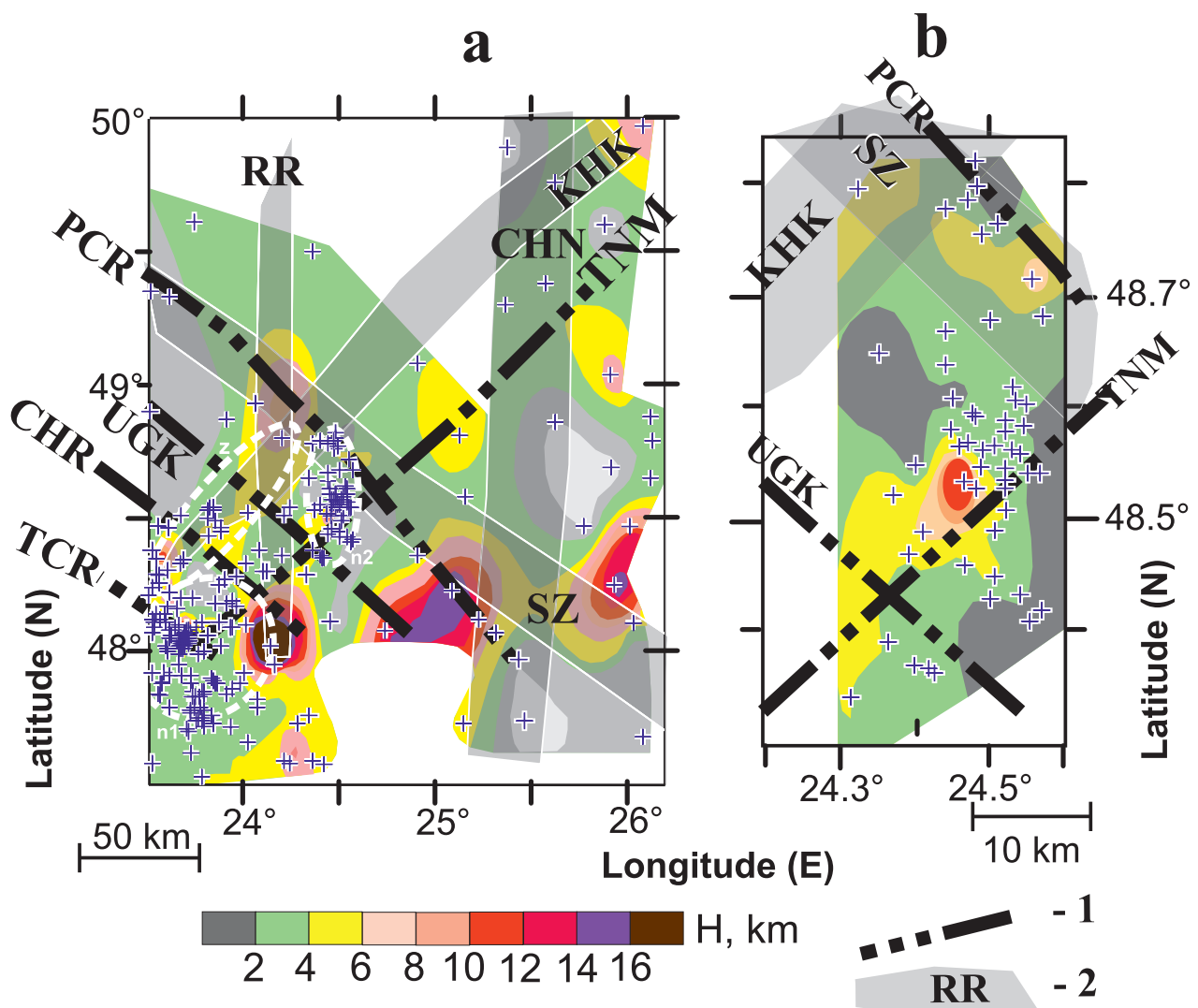


Fig. 4. **a** — distribution of epicentres (crosses) and depths of hypocentres H (km) of the Ukrainian Carpathians earthquakes for the years 1999–2016 (see introduction); 1 — main faults: TCR, CHR, UGK and TNM (see Fig. 1); 2 — faults active during last 3 Ma (see Fig. 3); areas z , $n1$, $n2$ bounded by white dashed lines — zones of earthquake concentration; **b** — detailed seismicity image in the zone of intersection of the UGK, PCR and TNM fault zones.

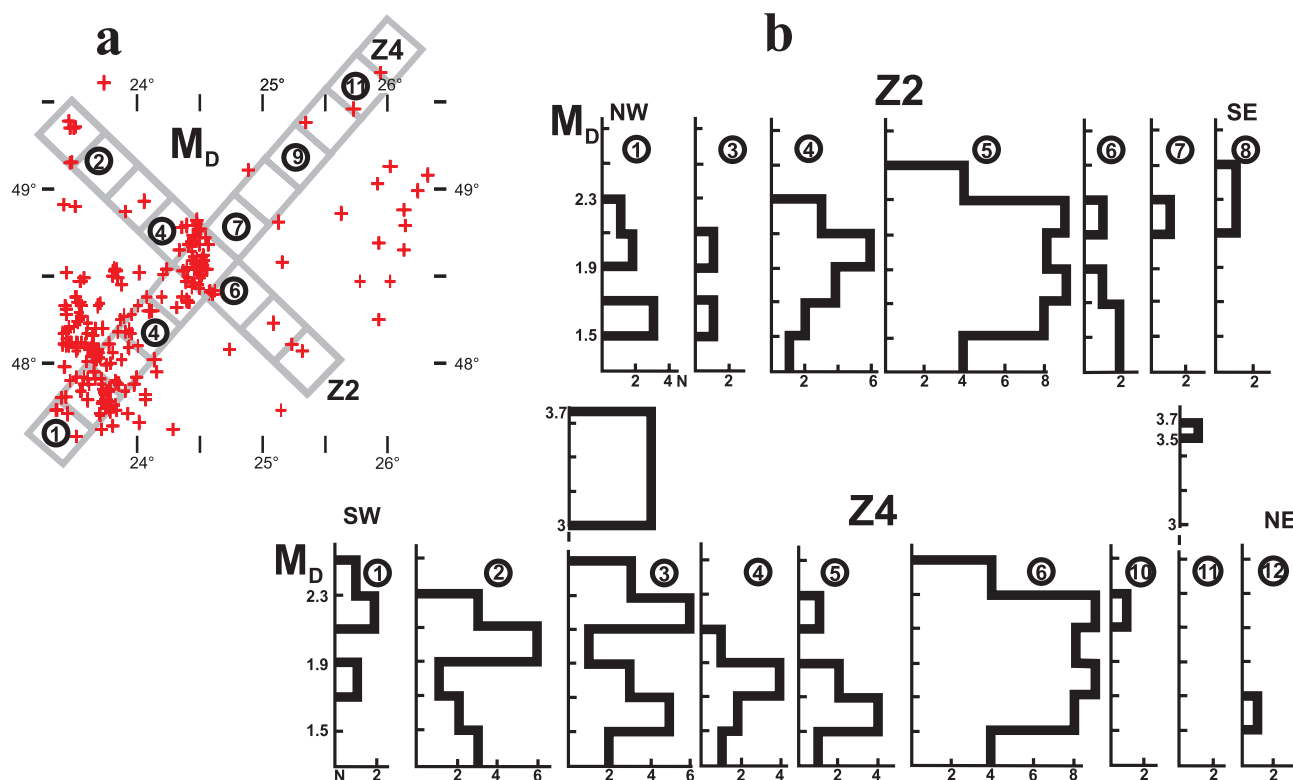


Fig. 5. **a** — Distribution of the earthquake epicentres (crosses), in which the magnitudes M_D were defined; **b** — relation of the magnitudes M_D for Z2 and Z4 and the earthquakes number N ; numbers in circles — the cell numbers.

with the geotraverse GII) is adopted from the Tectonic map of Ukraine, 1:1000000 (Kruglov & Gursky 2007), profile SG-1-67 — according to Zayats (2013). The profiles are aligned along the S-W border of the Borislav-Pokuty nappe (Fig. 1a). Along both profiles, variations of thickness of formations of various ages in the Carpathians tectonic units (Krosno zone, Skyba and Borislav-Pokuty nappe) associated with seismicity within the zones Z2 and Z4 can be seen. Below the depth of 2–4 km, the information about the geological structure of these tectonic zones is not clear due to the absence of boreholes and detailed areal seismic investigations. According to the geological sections, to the S-E of the GII within the rock strata beneath the Cretaceous deposits, the Paleogene rocks contribution rises. From the point of view of geoelectrics, an important characteristic of the sections is distribution of well-conductive Neogene sediments of the Sambir nappe beneath the overlying Cretaceous deposits of the whole Skyba nappe.

Deeper, metamorphic rocks of either Hercynian (at the profile SG-1-67) or even older age (Profile A–B) occur. According to the Preperian basement scheme (Fig. 2b), the TNM fault is located within the zone of rapid change in the thickness of sedimentary rocks above the Baikalian basement, and of the entire thickness of the Preperian rocks. To the N-W from the fault, the gradient of increase of the thickness of deposits is smaller than to the S-E of it. This conclusion is confirmed also in the presented sections (Fig. 7). As was mentioned above,

abrupt changes of the geoelectrical parameters can be observed. The resistivity of structures within the Skyba zone increases with depth down to the depth of 8 km (Figs. 3, 7), what confirms a conclusion about the sedimentary character of deposits of the Prebaikalian tectogenesis.

Distribution of low resistivity structures and location of seismic events outside the area of anomalous conductivity suggests possible geological mechanisms. We can suppose that seismicity is associated with stress occurring at the margins of the low resistivity structures, which are conditioned by rocks saturated with fluids. Fluid inflow may occur from both the Neogene sediments immersed under the Cretaceous ones and from deeper horizons of the Earth's crust, what is suggested by the existence of conductive structures at depths exceeding 10 km. A complex of factors, such as rheological stratification of the crust, the high-temperature fluids pressure and differential tectonic stresses, leads to stress accumulation and brittle deformation at the margins of such areas, while inside, the stress is redistributed with respect to the equivalent rheology of the medium and the hydrodynamics of the fluids (Ellsworth 2013; Nazarevych & Nazarevych 2013). Another, a more controversial factor that can be responsible for location of seismic events on the margins of electrically anomalous objects in the studied area is the possible existence of fragmentary zones of partial melting (where elastic energy cannot be accumulated) related to thermal activation at the intersection of deep fault systems (Korchin et al 2013; Kováčiková et

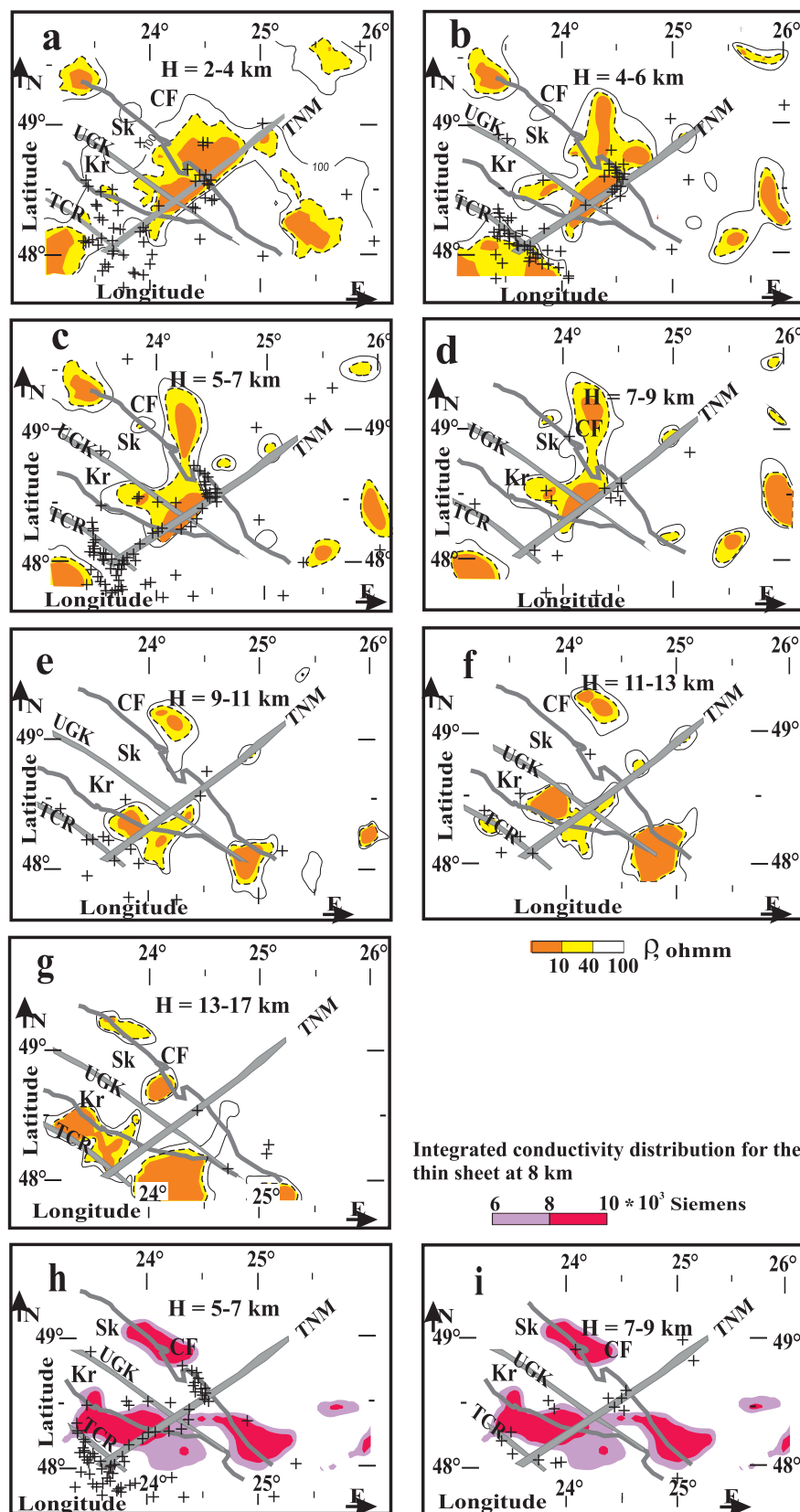


Fig. 6. Compilation of geoelectric results and seismicity in the Ukrainian Carpathians; **a–g** — distribution of the electrical resistivity obtained as a result of the 2D modelling at depths of 3 (a), 5 (b), 6 (c), 8 (d), 10 (e), 12 (f) and 15 km (g); **h, i** — integrated conductivity (S) distribution in a thin sheet calculated for the electromagnetic variations period $T=1600$ s at a depth of 8 km (h, i); crosses — hypocentres (H) of earthquakes at different depth intervals. Sk — Skyba nappe, Kr — Krosno nappe, CF — Carpathian Foredeep; deep faults — UGK, TCR, TNM — see Figs. 1, 2.

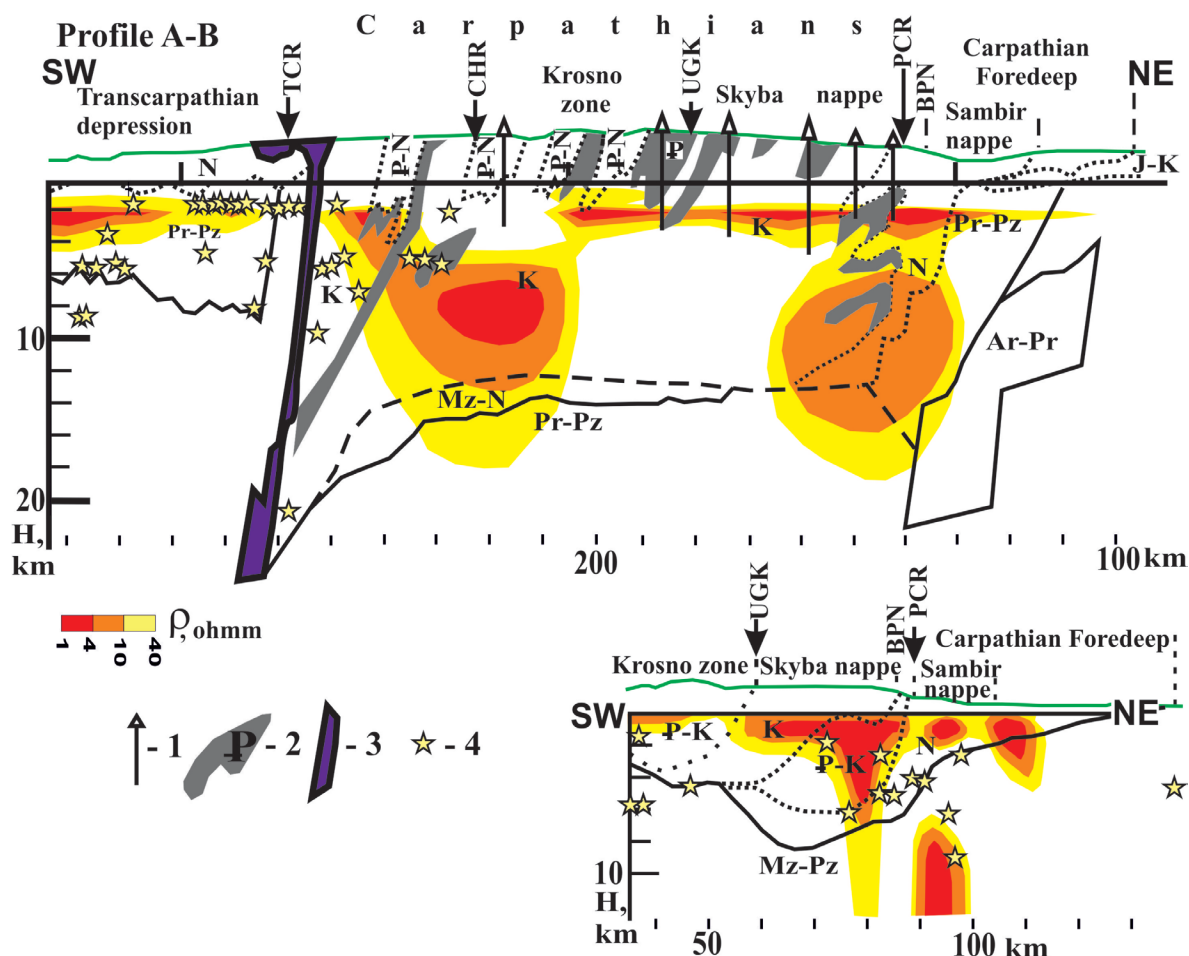


Fig. 7. Schematic geological cross-sections of the Carpathians region along the seismic profiles A-B (GII in Kruglov & Gursky 2007) and SG-1-67 (Zayats 2013) and 2D resistivity models and seismic events along both profiles: 1 — boreholes, 2 — Palaeogene deposits, 3 — Neogene basaltic rocks, 4 — earthquake hypocentres; N — Neogene, K — Cretaceous, Mz — Mesozoic deposits, Pz — Paleozoic, Pr — Proterozoic, Ar — Archean; TCR, CHR, UGK, PCR — deep faults (see Figs. 1, 2), BPN — Borislav-Pokuty nappe.

al. 2016). In this case the seismicity occurs outside zones of partial melting where elastic energy cannot accumulate.

Conclusion

The analysis of the distribution of low resistivity structures and seismicity in the Ukrainian Carpathians allows us to make conclusions about their narrow correlation. In the geoelectric models, both conductive sediments of the Carpathian Foredeep and structures corresponding to the crustal CrCA can be distinguished. Distribution of the conductive structures suggests their relation to faults parallel to the Carpathians strike as well as transversal faults (the TNM zone).

Comparison of the 2D and quasi-3D geoelectric models with earthquakes distribution indicates concentration of most hypocentres outside the conductive zones and suggests association of both phenomena with fluid migration conditioned by a complex of factors. Of course, specification of the nature of the seismicity and geoelectric characteristics of rocks in the studied area requires further research, nevertheless, the

achieved degree of correlation of the geoelectric data and the seismicity makes it possible to recommend the use of geoelectric data in combination with other geological and geophysical information in construction of seismic zonation maps.

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