GEOPHYSICAL VERTICAL SECTION ACROSS BOGD FAULT SYSTEM ON EASTERN FOOTHILL OF CHANDMAN KHAYRKHAN MOUNTAIN IN SW MONGOLIA

Viktor Valtr[1], Pavel Hanžl[1], Kristýna Hrdličková[1]

Abstract

The Bogd fault is one of the largest intra-continental faults in Asia. In July 2006 we were committed to study the internal structure of the fault using geophysical methods of very low frequencies (VLF), vertical electrical sounding (VES), total field magnetometry (TFM), dipole electromagnetic profiling (DEMP) and induced polarization vertical sounding (VES-IP) on profile with length about 930 m. It was situated across the centreline of the fault on the eastern foothill of the Chandman Khayrkhan Uul Mt. (SW Mongolia). The main southern branch of fault zone accompanied with intensive graphitization (mylonitized graphitic limestones) caused strongest anomalies VLF, TFM and VES-IP (which proved to be most indicative for increase of graphite volume). Geophysical measurements confirmed several sub-parallel faults that are steeply dipping, mostly to the south. An imbricated structure inside the fault zone and anastomising trends of mylonitic zones were revealed by the orientation and structure of the low resistivity zones of geoelectric section.

Keywords

Bogd fault, Gobi Altay, geophysics, induced polarisation, vertical electrical sounding, VLF, DEMP, magnetometry

1. Introduction

Our geophysical terrain group of company SIHAYA Ltd. operated at Mongolian Altay within the frame of the project “Geological survey of the Mongolian Altay at a scale of 1 : 50,000 (Zamtyn Nuruu-50)” in years 2005 and 2006. This project was headed by Czech Geological Survey and organized in a frame of the Czech International Development Program. The most significant geological structure in the surveyed area is the Bogd fault, which is one of the largest intra-continental faults in Asia (Cunningham et al. 1996a, b). We were committed to study by means of applied geophysics its internal structure on 930 m long profile positioned by leading geologist from Czech Geological Survey (CGS) on the basis of the preceding terrain geological recognition. This mainline and two complementary profiles we surveyed with efficacious complex of geophysical methods. In the first step swift profiling measurements were accomplished using methods of very low frequencies (VLF), total field magnetometry (TFM) and dipole electromagnetic profiling (DEMP). Subsequently, sounding geoelectric measurements followed, we placed individual points of vertical electrical sounding (VES) and induced polarization vertical sounding (VES-IP) to characteristic sectors of the profile according to the preceding prospection results.

Fig. 1: View of the Chandman Khayrkhan Uul Mt. from East. The terraain team preparing point VES-IP along profile remarked like 100.

Geophysical measurements along the profiles on the Chandman rupture were accomplished during three days in July 2006. The main geophysical profile was situated on the eastern foothill of the Chandman Khayrkhan Uul (SW Mongolia) near the branching of the Chandman rupture. The direction of the profile is approximately perpendicular to the E-W oriented Chandman rupture of the Bogd fault's axis. Length of the profile increases towards S.

Position of all measured points and ends of geophysical profiles were acquired by GPS. In total 37 points of VES, 38 points of VES-IP, 397 points of DEMP, 498 points of TFM and 494 points by method of VLF were acquired along the geophysical cross-section profile.

The geophysical profiles (Fig. 1) in the eastern foothill of the Chandman Khayrkhan Uul Mt. were situated over small geochemical anomaly of As, Au and Bi, which coincided with a mylonitic zone on the Chandman rupture of the Bogd fault and was ascertained during the geological survey of the Zamtyn Nuruu area (Hanžl and Aichler, 2007). The geophysical manifestations and the geological interpretation of the profile through the Chandman part of the important intracontinental fault are presented in this paper.

1.1 Geographical position

The main measured profile is situated at eastern foothill of the Chandman Khayrkhan Mt. The mountain is located in the eastern part of the Gobi Altay Province of the Western Mongolia at the distance of 10 km E of the Chandman sum (local administrative centre).This mountain is an isolated mountain massif representing the junction point between the Gobi Altay and Mongolian Altay Mts. and the easternmost promontory of the Bayan Tsagaan mountain range.

1.2 Geological setting

The studied tectonic phenomenon - Bogd fault is envisaged to be a part of the so-called Main Mongolian lineament. This lineament is a regional topographic and structural boundary between mostly Precambrian and Lower Paleozoic rocks of the Lake Terrane in the north from dominantly Middle–Upper Paleozoic units of the Gobi Altay Terrane in the south (see Fig. 2a) (Marinov et al., 1973; Badarch et al., 2002). In the area of the Chandman rupture, the fault separates metamorphic rocks, Carboniferous granites and the Lower Paleozoic sediments of the Gobi Altay Terrane in the south from the Lake zone in the north. The latter includes Neoproterozoic to Cambrian metamorphic and volcano-sedimentary rocks accompanied by Cambrian granites with the Permian volcanics in the hanging wall (Hanžl and Aichler, 2007).

The scarp of the Bogd fault is nearly E–W-oriented, tracing the northern foothills of the Chandman Khayrkhan Mt. This part of the fault was designated as the Chandman rupture (Baljinnyam et al., 1993).

Variscan granites and diorites of the Chandman Massif (Economos et al. 2008) with metamorphic rocks of the Chandman Khayrkhan Crystalline Complex (Hrdličková et al., 2008) are exposed in the area of the Chandman Khayrkhan Mt. south of the master fault (Fig. 2b).

The fault splits into two branches at the eastern extremity of the Chandman Khayrkhan Uul Mt. The northern one continues towards east, the southern one deflects to SE and disappears east of Khutag Nuur Lake (Valtr and Hanžl, 2008: 194).

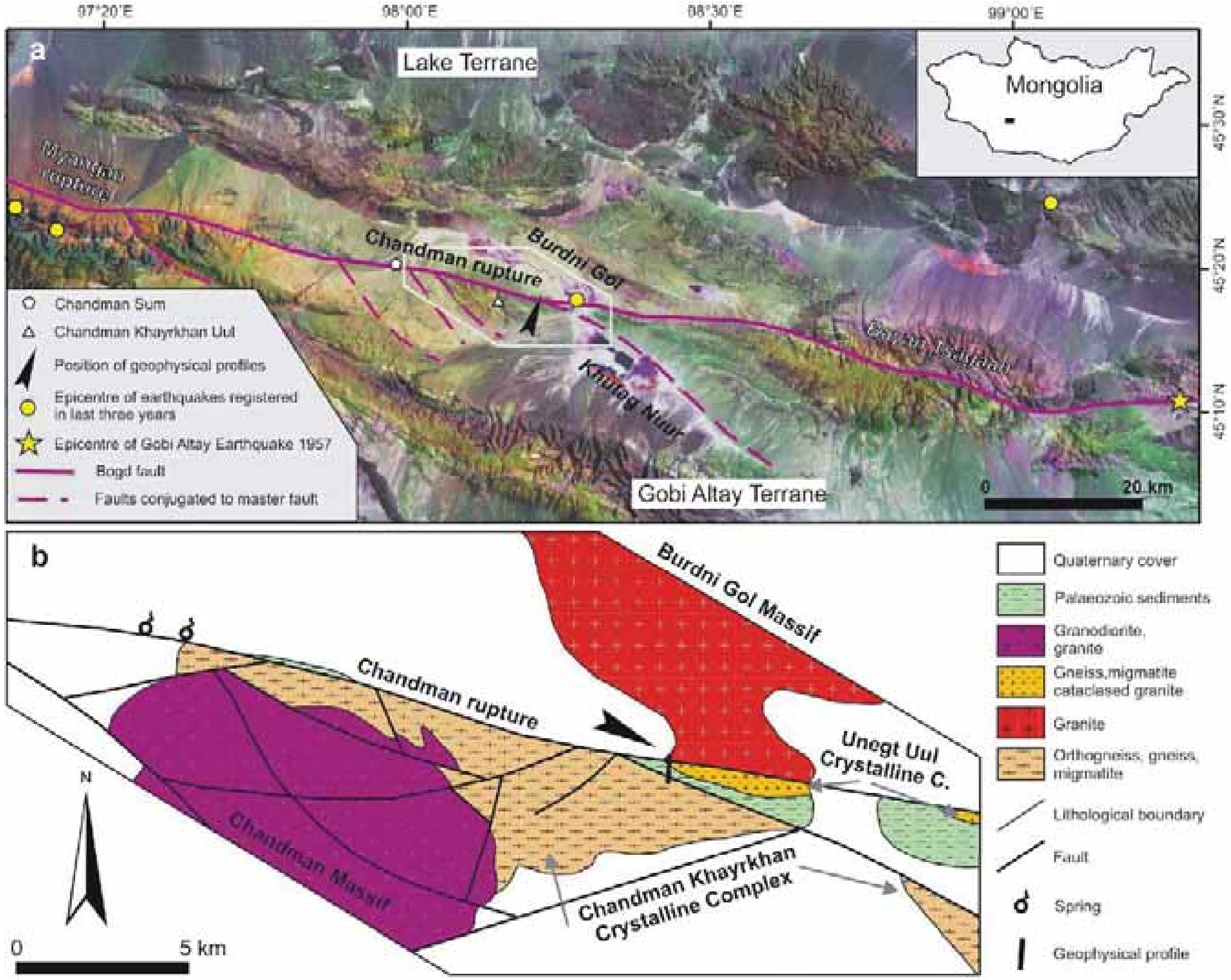

Fig. 2: Geomorphology and basic geology along the Chandman rupture of the Bogd fault: a - position of the studied area and Bogd fault on the digital elevation model combined with the Landsat ETM + (4 - 5 - 3 as RGB); b - geological sketch along the Chandman rupture.(After Valtr and Hanžl 2008:19.)

Tectonic melange composed of mylonitized granites, metamorphic rocks, serpentinites related to the Unegt Uul Crystalline Complex (Hrdličková et al., 2008) and Lower Palaeozoic sediments (Rauzer et al., 1987) including limestones is exposed in a wedge between these two fault branches. The NWN–SES-trending foliation presents a dominant feature in the metamorphic rocks south of the Chandman Mt. The foliation planes are medium to steeply dipping to the south and bear metamorphic lineations plunging variably to NW or SE. The asymmetric structures that developed locally along the feldspar porphyroblasts in the gneiss on the northern slope of the Chandman Khayrkhan Uul indicate strike slip movements sub-parallel to the strike of the Chandman rupture (Hanžl and Aichler, 2007).

2. Geophysical measurements

2.1. Geophysical methods

The parallel geophysical profiles were localized on the eastern tip of the Chandman Khayrkhan Uul, near the splitting of the master fault into two branches (see Fig. 2a). The direction of the geophysical profiles was NNE–SSW; therefore the main profile No. 100 was approximately perpendicular to the surveyed fault axis. Two auxiliary profiles (No. 110 and No. 150) were placed at the distance of 10 and 50 m of the main profile No. 100. The length of each of the profiles was 30 m.

The profile No. 150 was examined only by the method of very low frequencies (VLF) and the profile No. 110 was measured only by method DEMP, whereas on the main survey profile No. 100 the following complex of geophysical methods was applied:

- The method of **vertical electrical sounding** (**VES**) was use to determine boundaries of quasi-homogeneous blocks of rocks according to their resistivity like rough determination of the volume of conductive fine fraction in sediments, estimation of the slope of tectonic zones, estimation of rock types and state of weathering, etc.
- The method of **induced polarization vertical sounding** (time domain combined Schlumberger IPS and VES soundings) in its VES modification (**VES-IP**) were used to determine boundaries of quasi-homogeneous rock blocks according to their ability to be polarized by long-time (from 1 to 3 s) direct current charges.

The apparent chargeability of rocks was determined for various time windows: starting from 100 to 250 ms after current I_{AB} (A–B electrode current) switching-off and ending with the window: 1350 to 1500 ms after current I_{AB} switching-off. The parameter η_{app} is obtained using the following equation:

$$\eta_{app} = \frac{U_{mx}^{MN}}{U_{inTW}^{MN}} [\%]$$

U_{mx}^{MN} – *steady voltage (observed whilst the current is on) – the potential difference measured between voltage non-polarizing electrodes M and N short time before I_{AB} switching-off,*

U_{inTW}^{MN} – *magnitude of the polarization voltage – the potential difference average of discharging curve measured between M and N electrodes in given time window after* I_{AB} *switching-off.*

The positive anomaly of parameter η_{app} was used to indicate ore mineralization, or increased graphite contents in underlying quasi-homogeneous rock blocks. The decrease of this parameter can, for instance, differentiate salt water from clay materials in pores of clastic sediments (Komarov, 1980).

GEA-IV – the direct current geophysical instrument (24b A/D*2) with continuous sampling of potential electrodes voltage with rechargeable direct current source from 12 V to 400 V – was used for VES and VES-IP measurements (see Fig. 3).

Obtained VES curves and VES-IP discharge curves were interpreted by the VIS software (SIHAYA Ltd.) directly to the form of depth section (Fig. 5).

The method of **dipole electromagnetic profiling (DEMP)** was performed to subdivide efficiently the exposed rocks according to their apparent conductivity. This measurement was carried out using ground conductivity meter CM-031, with the maximum

Fig. 3: One of the VES points in Altay in steep slope.

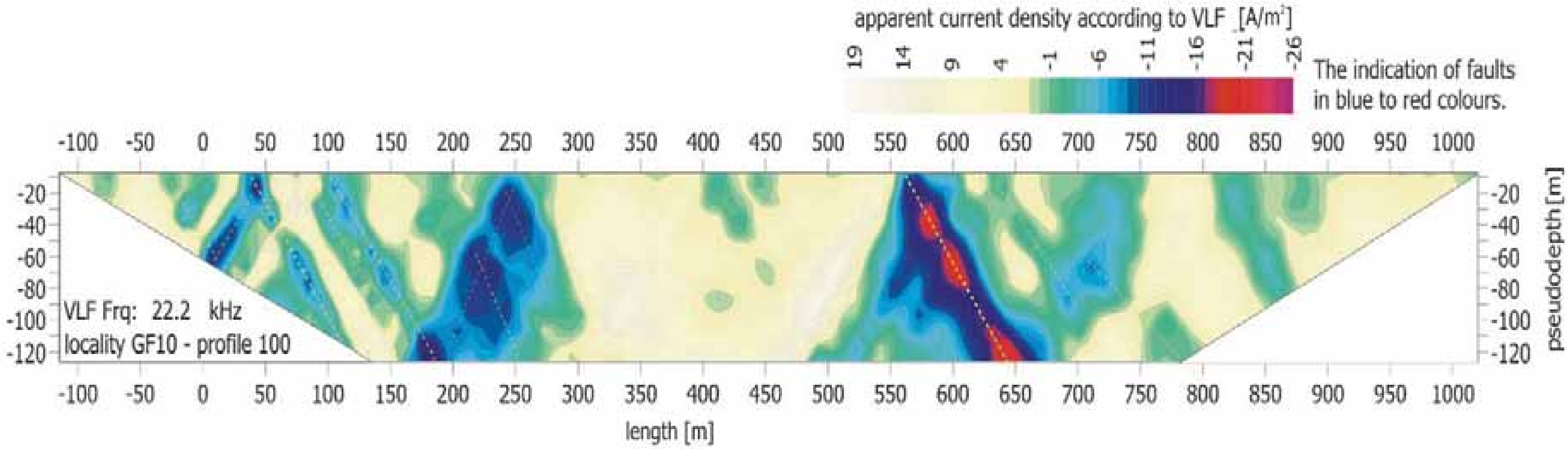

Fig.4: The pseudo-depth section of apparent current density according to VLF on profile 100, frequency 22.2kHz.

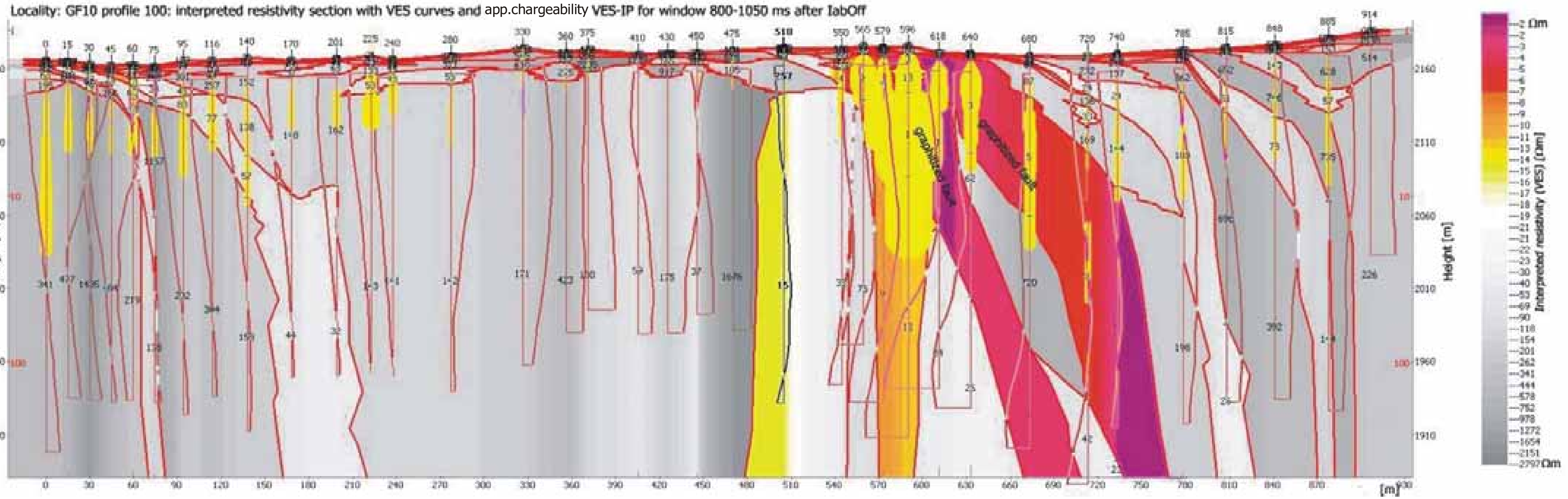

Fig.5: The vertical geoelectric section of VES and VES- IP, interpreted resistivities (in automatically interpolated color scale) with VES curves (inverse color) and with block scheme of apparent chargeability 100ms after I_{AB} off by programme remarked VIS-IP.

investigation depth of circa 6 m (depending on the ground conductivity).

The method of **very low frequencies (VLF)** was applied along both profiles (No. 100 and 150) to determine effectively the dip, shape, surface position and direction of long, deep conductors such as fault zones, graphitic zones and ore bodies, which are longer than 50 m.

The continuous wave electromagnetic equipment records perturbations in a plane-wave radio signal (15 up 30 kHz) emanating from one of distant military transmitters. We used VLF instrument of producer ENVI SCINTREX, which can measure both the primary and secondary fields in three frequencies simultaneously. The data acquired by this VLF instrument involves three separate parameters of the secondary magnetic field: the amplitude of the field, its quadrature (imaginary) and in-phase (real) components relatively to the horizontal primary field (or equivalently the elasticity and "tilt angle" of the field).

Acquired VLF data were interpreted using software remarked VDV-PH (SIHAYA, Ltd.) based on Karous and Hjelt (1983) theories of apparent current density dependence upon the measured tilt angle of the VLF signal. It enables obtaining apparent current density distribution at certain pseudo-depth levels and hence construction of pseudo-depth–apparent current density sections according to the VLF. The interpretation process is generally qualitative and subjective in each case. VLF- located anomalous areas had to be further studied in detail by using independent techniques.

The method of **single sensor magnetometry** was used to determine effectively the surface boundaries of magnetically different rocks (by measuring the total magnetic field). For total field (TF) magnetometry we used instrument PMG 1.0 ver. 1.2 – proton magnetometer and gradiometer (Satis Geo). Modern magnetometers usually measure the gradient of the magnetic field (by two sensors separated vertically by two or three feet). We measured only the total field (single sensor mode) as it was more suitable for the aim of this mapping measurement.

The resulting total field was corrected for TF variations measured by the same device in a near variation point or using variation station instrument ENVI SCINTREX - Mag. On the auxiliary profile 150 only VLF method was applied to verify the orientation of the observed anomalies.

2.2 Field geophysical measurements

Geophysical measurements along the profiles on the Chandman rupture were accomplished in July 2006. Position of all measured points and ends of geophysical profiles were acquired by GPS. In total 37 points of VES, 38 points of VES-IP, 397 points of DEMP, 498 points of MM and 494 points by method of VLF were acquired along the geophysical cross-section.

2.3 Results of geophysical measurements

The VLF result – pseudo-depth section of apparent current density according to the VLF method (22.2 kHz) is shown in Fig. 4. One strong manifestation of a deep long intensive conductor appears on this section. Its outstanding anomaly (marked in red colour) reaches apparent current densities down to -26. This anomalous structure crops out at length 560 m. It is steeply dipping to the south and is probably caused by a graphitized zone along the major rupture zone. It is possible to find also several smaller anomalies of less intense manifestation. The second largest anomalous structure is the one surfacing around length 250 m (current density extends only to -11, shown in blue) with sense of dip towards N.

VES and VES-IP measurements were processed by the programme VIS-IP and results were presented in form of vertical geoelectric sections, pseudo-depth isoohmic sections of the measured apparent resistivity and pseudo-depth sections of the measured apparent chargeability. The isoohmic section of the apparent resistivities measured by VES (Fig. 4, 8) correlates well with the VLF results. The zone of very low resistivities is obvious – representing a manifestation of the main fault zone (red, violet colours, for particular values see the hatch legend on figure) – even using raw measured apparent resistivity data (length from 550 m to 630 m).

The VES-IP-resulting chargeability (0.8 sec after I_{AB} off) correlates with the modal ore and graphite contents in the rock marking the active fault zone by an yellow, red to violet area (η_{app} from 3.0 up to 7,4 %; Fig. 7). The strongest anomaly (chargeability almost 7.5 %) was detected around the length 590 m (from 555 to 610 m). The highly prolonged discharging curves in this area imply graphitization (see Fig.6). A smaller anomaly is evident also around length 250 m, correlating well with the second strongest VLF anomaly (Fig. 11).

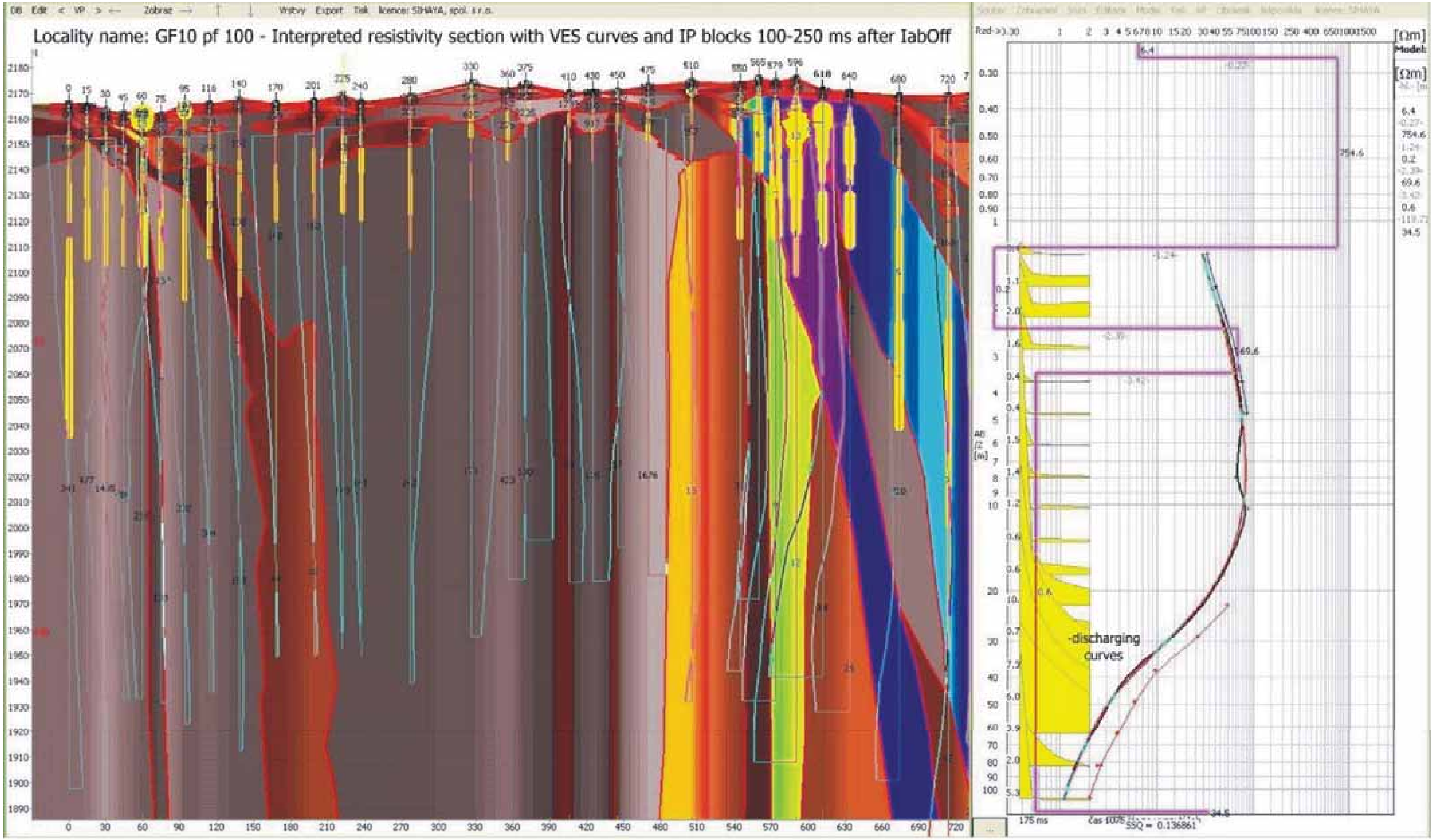

Fig. 6: Copy of working screen of programme VIS-IP with discharging curves, VES curves and IP scheme (yellow blocs).

The resulting interpreted resistivity section according to VES with VLF conductive axis and with resulting geological interpretation is presented in Fig. 12, diagrams of total field magnetometry (violet line graph) and apparent resistivities according to DEMP (green and blue line graphs) are shown in Fig. 11. In those pictures, summarizing results of all used methods, the fault boundary is far more precisely demarcated.

There is also a notable decrease in apparent resistivities according to DEMP, accompanied by magnetometry total field (TF) increase at length 510 – 610 m. The shape of TF diagram in this anomalous sector is also significant for the fault dip to the south. The TF diagram is much more variable in the area between lengths 180 m to 510 m than in the area from length 600 m upwards. Similarly, the highest apparent resistivities by DEMP have been reached in between length 280 m to 500 m and from 850 m upwards.

3. Geological interpretation of the geophysical data

Dominating trends of geophysically detected boundaries and anomalies along the profile on the eastern foothill of the

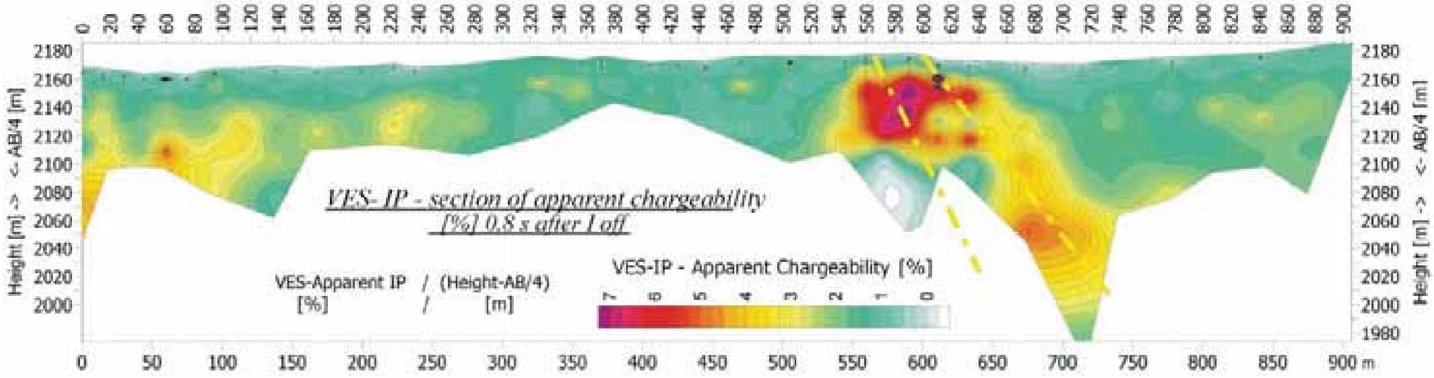

Fig. 7: The pseudo-depth section of apparent chargeability by VES-IP-indication of faults in red to violet colours, yellowdash-dotted lines are are axes of interpreted faults.

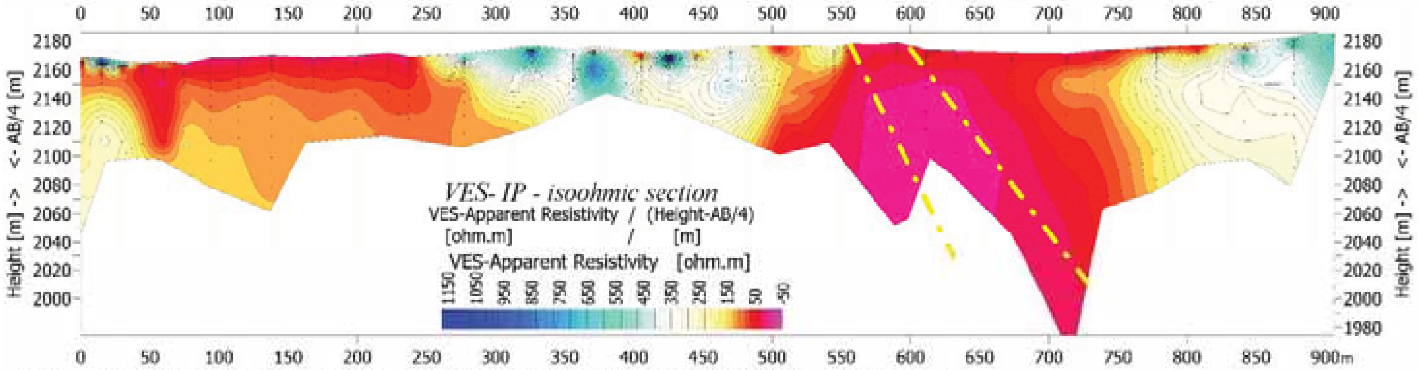

Fig. 8: The pseudo-depth section of apparent resitivity by VES

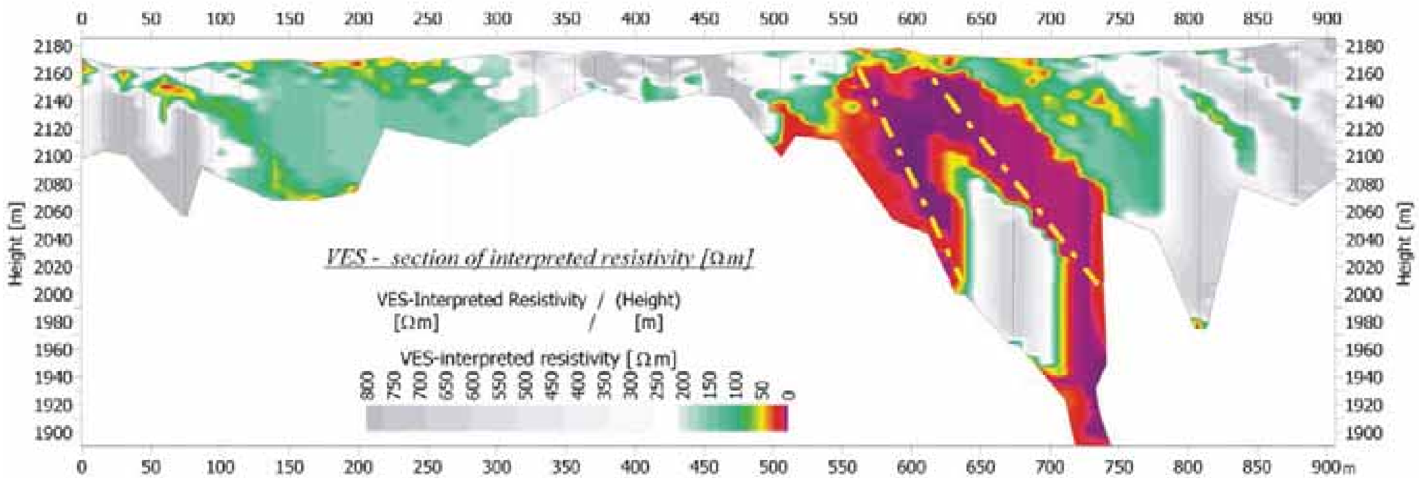

Fig.9: The depth section of interpreted resistivity by VES.

Chandman Khayrkhan Uul Mt. are characterized by a homogeneous orientation. Geophysical anomalies are steeply dipping towards the south (Fig.12), which is in accordance with the orientation of foliation, bedding and mylonitized zones observable on the surface (Valtr and Hanžl, 2008). Generally, the Chandman rupture of the Bogd fault zone separates the Cambrian granites of the Burdni Gol Massif (Hanžl and Aichler, 2007) in the N from the metamorphic rocks in the roof of the Variscan Chandman Massif (Economos et al., 2008) in the area of the eastern foothill of the Chandman Khayrkhan Uul Mt. Paleozoic sediments are enclosed by the branching faults in this zone (Fig. 10).

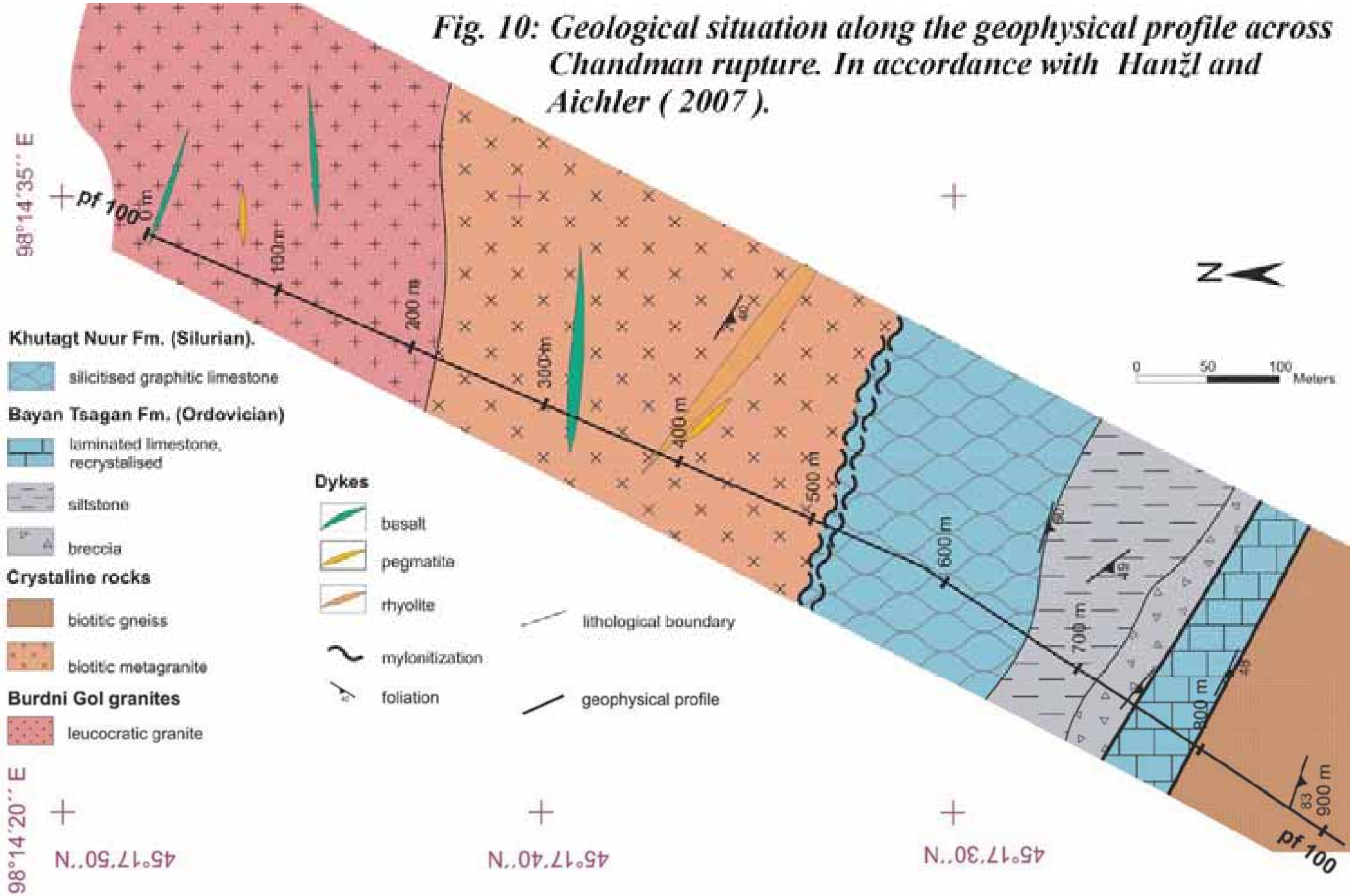

Fig. 10: Geological situation along the geophysical profile across Chandman rupture. In accordance with Hanžl and Aichler (2007).

The homogeneous fabric of the Burdni Gol Massif situated north of the fault is disturbed by a system of faults dipping to the south, as documented at profile length 50–250 m (Fig. 12). The zone of opposite dip (length 200–280 m) could be interpreted as an older fault zone or as a relic of wall rocks (mica schists) mapped in granites more to the north (Hanžl and Aichler, 2007). A relatively homogeneous, tectonically restricted block composed of orthogneisses and migmatites of the Unegt Uul Crystalline Complex continues to length 500 m (Valtr, Hanžl, 2008). The zone of extremely low resistivities at length 520–650 m corresponds to exposures of silicified, mylonitized and graphitic limestones. These can be related to Lower-Paleozoic sedimentary and volcano-sedimentary formations exposed more towards east (Rauzer et al., 1987).

Limestones are brecciated, and tectonically bound boulders of adjacent rocks are incorporated in the fault zone. The zone is steeply dipping to the south and is approximately 150 m wide. In the hanging wall of limestones, grey cataclastic siltstones are exposed. The geophysical data indicate N vergent duplex like structures in Lower Paleozoic slice between Cambrian granites in the N and metamorphic rocks in the S. The master fault adjoins to the crystalline rocks along the S boundary of fault zone and it is steeply dipping to the N.

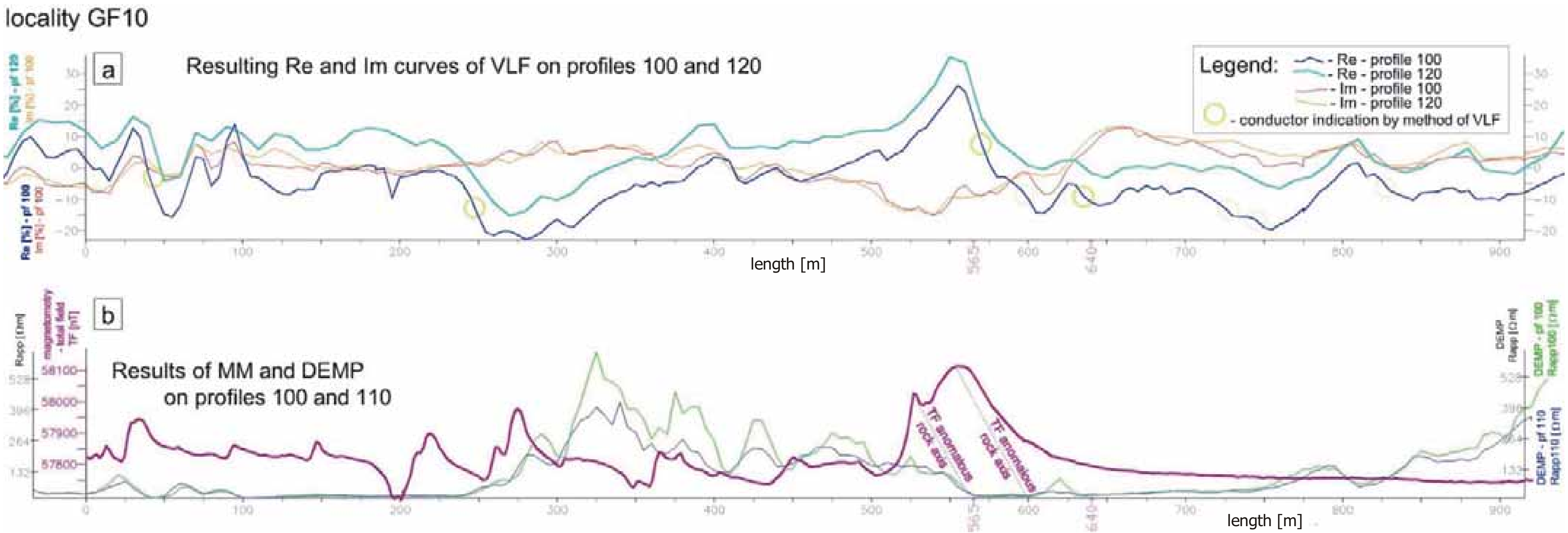

Fig.11: Summary of geophysical data of profile measurements: a- graphs of VLF measured data; b- TF magnetometry on profile 100, RappDEMP on profiles 100 and 110; c- interpreted vertical section according to resistivities VES and VLF results.

4. Conclusions

The geophysical cross-section on the eastern tip of the Chandman Khayrkhan Uul Mt. was situated near the branching of the Chandman rupture, which is a part of a large intracontinental tectonic zone – the Bogd fault. Geophysical measurements confirmed a steep dip to the south and its splitting into two branches east of the Chandman Khayrkhan Uul Mt. The zone inside the northern block showing opposite dip could be interpreted as an older fault. Geophysical data indicate imbricated structure inside the fault zone and anastomosing trends of mylonitic zones (see Fig. 12).

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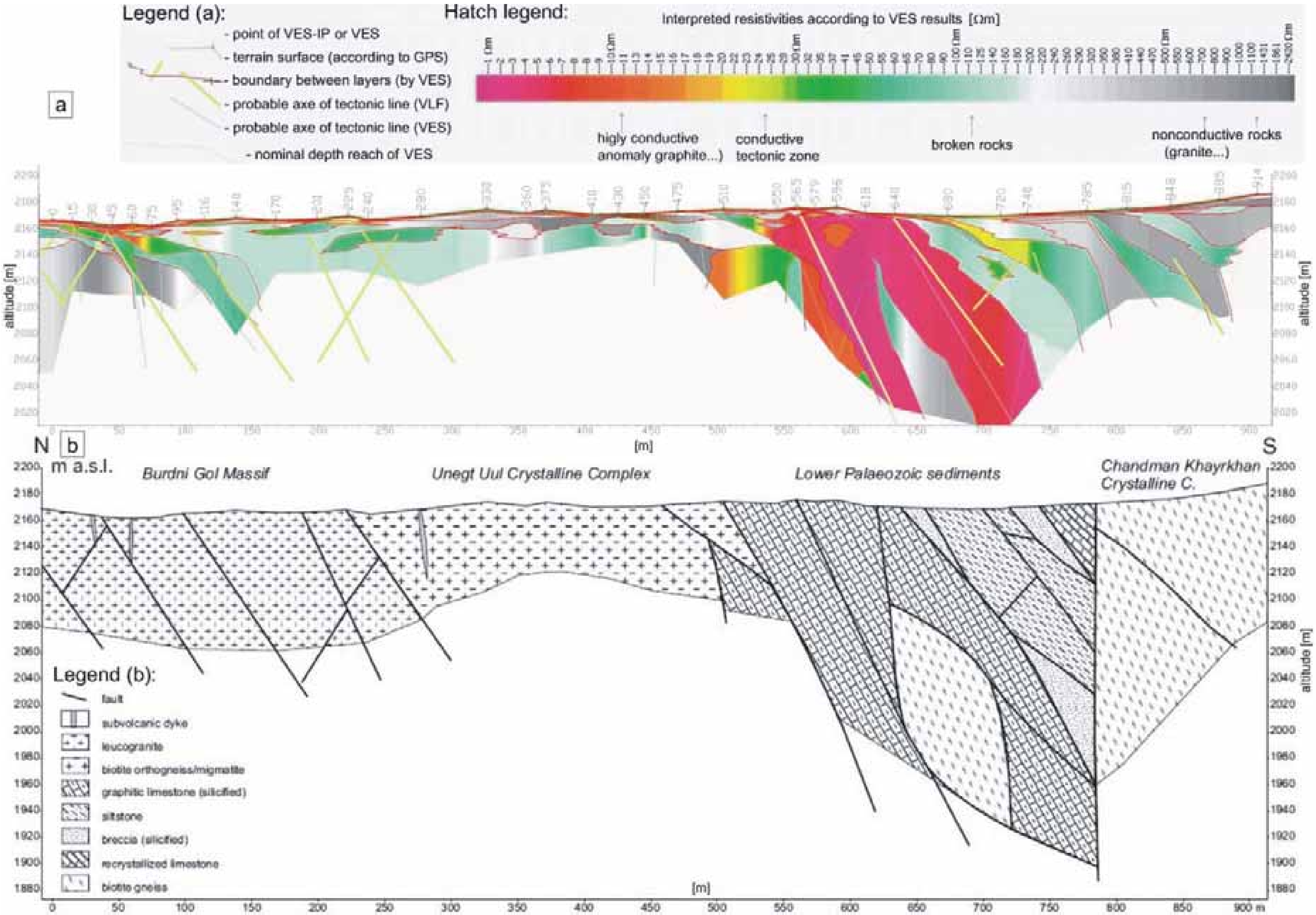

Fig.12: Summary of geophysical data and geological interpretation: a- vertical section according to VES and VLF results; b- geological interpretation og the geophysical profile across the Chandman rupture of the Bogd fault zone.

Geophysical data indicate imbricated structure inside the fault zone and anastomosing trends of mylonitic zones (see Fig. 12). The more distinct fault zone is related to the layer of graphitic limestones. The increased graphitization was best indicated by the method of VES-IP (see Fig.7).

The graphitized zones were characteristically distinguished by slowly declining, relatively long discharging curves of VES-IP with relatively high apparent chargeability. The orientation of geophysical anomalies together with geological and structural data from the surface implies thrusting of the southern over the northern block along the Chandman rupture.

Based on the field structural data and orientation of conjugated faults as seen from the satellite imagery, the origin of the Chandman Khayrkhan Uul Mt. can be interpreted as a restraining bend evolved on the left-lateral Bogd fault (Cunningham et al 2005). The strong asymmetry in geomorphology of the Chandman Khayrkhan Uul Mt. is in accordance with a rapid uplift during the Quaternary. The seismic activity in the area is confirmed by the position of recent earthquake epicenters along the segments of the Bogd fault as registered by the National Earthquake Information Center of the U.S. Geological Survey.

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References

BADARCH, G., CUNNINGHAM, W.D., WINDLEY, B.F.: *A new terrane subdivision for Mongolia: implications for the Phanerozoic crustal growth of central Asia*, Journal of Asian Earth Sciences 21, 2002, pp. 87 – 110.

BALJINNYAM, I., BAYASGALAN, A., BORISOV, B. A., CISTERNAS, A., DEM'YANOVICH, M. G., GANBAATAR, L., KOCHETKOV, V. M., KURUSHIN, R. A., MOLNAR, P., PHILIP, H., VASHCHILOV, Y. Y.: RUPTURES *of major earthquakes and active deformation in Mongolia and its surroundings*, Boulder: Geological Society of America, 1993.

CUNNINGHAM, W. D.: *Active intracontinental transpressional mountain building in the Mongolian Altai: Defining a new class of orogen*, Earth and Planetary cience Letters 240, 2005, pp. 436 – 444.

CUNNINGHAM, W. D., WINDLEY, B. F., DORJNAMJAA, D., BADAMGAROV, J., SAANDAR, M.: *Late Cenozoic transpression in southwestern Mongolia and the Gobi Altai–Tien Shan connection*, Earth and Planetary Science Letters 140, 1996, pp. 67 – 81.

CUNNINGHAM, W. D., WINDLEY, B. F., DORJNAMJAA, D., BADAMGAROV, J., SAANDAR, M.: *A structural transect across the Mongolian Altai: active transpressional mountain building in central Asia*, Tectonics 15, 1996, pp. 142 – 156.

CUNNINGHAM, W. D., DIJKSTRA, A., HOWARD, J., QUARLES, A., BADARCH, G.: *Active intraplate strike-slip faulting and transpressional uplift in the Mongolian Altai*, In STORTI, F., HOLDSWORTH, R. E., SALVINI, F. (eds.): *Intraplate Strike-Slip Deformation Belts*, London: Geological Society 2003, pp. 65 – 87.

ECONOMOS, R., HANŽL, P., HRDLIČKOVÁ, K., BURIÁNEK, D., SAID, L. O., GERDES, A.: *Geochemical and structural constraints on the magmatic history of the Chandman Massif of the eastern Mongolian Altay Range*, SW Mongolia, Journal of Geosciences 1, 2008, pp. 335 – 352.

Florensov, N. A., Solononko, V. P.: *The Gobi-Altay Earthquake*, Moscow: Akademiya Nauk USSR, 1963 (in Russian).

Hanžl, P., Aichler, J. (eds.): *Geological survey of the Mongolian Altay at a scale of 1: 50,000* (Zamtyn Nuruu – 50). Final report of the InternationalDevelopment Cooperation project of the Czech Republic. Brno: Czech Geological Survey & Ulaanbaatar: MPRAM, 2007, pp. 1 – 376.

Hrdličková, K., Bolormaa, K., Buriánek, D., Hanžl, P., Gerdes, A., Janoušek, V.: *Petrology and age of metamorphosed rock in tectonic slices inside the Palaeozoic sediments of the eastern Mongolian Altay, SW Mongolia*, Journal of Geosciences 2008, pp. 139 – 165.

Karous, M., Hjelt, S. E. (1983) Linear filtering of VLF dip-angle measurements, *Geophysical Prospecting* 31, 2006, pp. 782 – 794.

Komarov, V. A. *Elektrorazvedka metodom vizvannoy polyarizatsii*, St. Petersburg: Nedra USSR, 1980 (in Russian).

Kurushin, R. A., Bayasgalan, A., Olzybat, M., Enhtuvshin, B., Molnar, P., Bayarsayhan, C., Hudnut, K. W., Lin, J. *The surface rupture of the 1957 Gobi-Altay, Mongolia, earthquake*, Boulder: The Geological Society of America 1977, pp. 1 – 143.

Marinov, N. A., Zonenshain, L. P., Blagonravov, V. A. (eds.): *Geologija Mongolskoi narodnoi respubliky*, Moskva: Nedra 1973 (in Russian).

Rauzer, A. A., Zhanchiv, D. I., Golyakov, V. I., Ykhina, I. F., Ivanov, I. G., Tsukernik, A. B., Afonin, V. V., Smirnov, I. G., Bykhover, V. I., Kravtsev, A. V., Baatarkhuyag, A., Skoryukin, M. I., Khodikov, I. V., Mantsev, N. V., Okaemov, S. V., Mischin, V. A., Enkhsajkhan, T. : *Otchot o rezultatach gruppovoy geologitscheskoy syomki mashtaba 1 : 200 000 provedennoy v yugo-vostočnoy časti Mongolskogo Altaya Mongolskoy Narodnoy Respubliki v 1983-1986 g. g.*, Moscow: Tekhnoexport, 1987 (in Russian).

Tapponier, P., Molnar, P.*: Active faulting and Cenozoic tectonics of the Tien Shan, Mongolia and Baykal region*, Journal of Geophysical Research 84, 1979, pp. 3425 – 3459.

Valtr, V., Hanžl, P.: *Geophysical cross-section through the Bogd fault system in the area of the Chandman rupture*, SW Mongolia, Journal of Geosciences 53 2008, pp. 193 – 200.

Vassallo, R., Ritz, J.-F., Braucher, R., Jolivet, M., Carretier, S., Larroque, C., Chauvet, A., Sue, C., Todbileg, M., Bourlès, D., Arzhannikova, A.,Arzhannikov, S.: *Transpressional tectonics and stream terraces of the Gobi-Altay, Mongolia*, Tectonics 26, 2007, p. TC5013,doi: 10.1029/2006TC002081.

Kurushin, R. A., Bayasgalan, A., Olzybat, M., Enhtuvshin, B., Molnar, P., Bayarsayhan, C., Hudnut, K. W., Lin, and J.: The *surface rupture of the 1957 Gobi-Altay, Mongolia, earthquake*, Boulder: The Geological Society of America 1977, pp. 1 – 143.

Marinov, N. A., Zonenshain, L. P., Blagonravov, V. A. (eds.): *Geologija Mongolskoi narodnoi respubliky*, Moskva: Nedra 1973 (in Russian).

Rauzer, A. A., Zhanchiv, D. I., Golyakov, V. I., Ykhina, I. F., Ivanov, I. G., Tsukernik, A. B., Afonin, V. V., Smirnov, I. G., Bykhover, V. I., Kravtsev, A. V., Baatarkhuyag, A., Skoryukin, M. I., Khodikov, I. V., Mantsev, N. V., Okaemov, S. V., Mischin, V. A., Enkhsajkhan, T.: *Otchot o rezultatach gruppovoy geologitscheskoy syomki mashtaba 1 : 200 000 provedennoy v yugo-vostočnoy časti Mongolskogo Altaya Mongolskoy Narodnoy Respubliki v 1983-1986 g. g.*, Moscow: Tekhnoexport, 1987 (in Russian).

Tapponier, P., Molnar, P.: *Active faulting and Cenozoic tectonics of the Tien Shan, Mongolia and Baykal region*, Journal of Geophysical Research 84, 1979, pp. 3425 – 3459.

Valtr, V., Hanžl, P.: *Geophysical cross-section through the Bogd fault system in the area of the Chandman rupture, SW Mongolia*, Journal of Geosciences 53 2008, pp. 193 – 200.

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[1] *Autoři:*

Mgr. Viktor VALTR, Sihaya, Ltd., Veleslavínova 6, 612 00 Brno, Czech Republic; *sihaya@sihaya.cz*; mob: +420 605265963; *valtr@sihaya.cz*

RNDr. Pavel HANŽL, Dr., Czech Geological Survey, Leitnerova 22, 658 69 Brno, Czech Republic; mob: +420 606873203; *pavel.hanzl@geology.cz*

Mgr. Kristýna HRDLIČKOVÁ, Czech Geological Survey, Leitnerova 22, 658 69 Brno, Czech Republic; phone: +420 543429233;
kristyna.hrdlickova@geology.cz