Introduction

The Patomsky crater is located in east part of the Irkutsk region (Russia) (Figure 1). This geological object has anomaly appearance and is discordant placed relative to hosting geological structure. The crater has been discovered in 1949 during routine geological survey of the territory by geologist V.V. Kolpakov. The drastic investigations of Patomsky crater by modern technology have begun since 2006. Since than three geological expeditions has been done. The first electroprospecting investigations by AMT method have been carried out in 2008 by «Irkutsk Electroprospecting Enterprise». By now there is no agreement about crater origin. Two possible versions are considered: impact and endogenous, but neither of them have proper confirmation. The new attempt to shed the light on origin of this wonderful geological object has been making in august of 2010 by joint geological and geophysical expedition. The field AMT crew includes 2 geophysicists (expert in EM methods) from Saint Petersburg Mining University.

The Patomsky crater is the ring structure of central type with piled up cone. The cone size is 160x130 m. The age of the crater talus is very young (200 -500 years) and the crater breaks sediments of Proterozoic metamorphic ages. The crater is located at the synclinal flexure wing which long axis is oriented in northwest direction. Numerous faults of northwest direction are found in the area of investigation. The spatial or genetic connections of the crater location with structural features have not been established.

Figure. 1. *The location of investigation area (a) and the photo of the Patomsky crater from the helicopter*

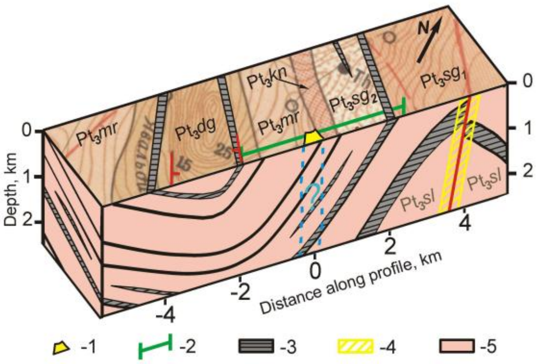

Figure 2. *Geoelectrical model of the Patomsky crater area. 1 – the Patomsky crater, 2 – the AMT profile, 3 – coaly shale, 4 – faults, 5 – hosting terrigenous and carbonate rocks.*

The geological and geophysical model constructed on the base of previous investigations data is shown in Figure 2. The hosting rocks for Patomsky structure are metamorphic and folded terrigenous and carbonate layers of early Proterozoic age, which have high resistivity (1 000 – 100 000 Ohm-m). Also several conductive thin layers (with less than 150 m thickness) represented by coaly shale and coaly sandstone are observed. Resistivity of this layers could as low as 1-10 Ohm-m. So hosting medium could be approximated as 2-D structure with strike -45 degree.

Data acquisition and processing

Five components AMT sounding [Berdichevsky M. N., Dmitriev V.I., 2009] were situated on the profile oriented in orthogonal direction to the strike of hosting rocks. Total length of the profile was 4.3 km. Average spacing between AMT stations was 200 m. Seven sets 5th generation of Multifunctional equipment MTU-5A (Phoenix Geophysics, Toronto), (Fox, et al., 2001, Fox, et al.,2008) as well as the same number of precision tripods for magnetic sensors (AGCOS, Toronto) were deployed at four days survey. Due to mountain terrain with heavy forest all equipment transportation in the survey area was done by foots. Field array is shown in Figure 3, as well as precision tripods in the working position (left) and in transportation position as back pack (right) (Ingerov, et al., 2009). Two experienced geophysicist from Saint Petersburg Mining University did all field survey and data processing. Other members of the expedition permanently helped to do transportation from field camp to profile and back. Total number of recoded sites is: 21 AMT (frequency band 10 000 - 0.3 Hz and 3 AMT + MT (10 000 Hz – 2 200 Sec.). Two grounded electric lines of 30 m each have been used for registration of two orthogonal horizontal electric components (Ex, Ey) of the natural electromagnetic field (EM). The E lines were grounded by nonpolarized low noise pots PE-4. For registration of three magnetic components (Hx, Hy, Hz) of the natural EM field the induction magnetic sensors MTC-30 (AMT) and MTC-50 (MT) have been applied. In contrast to traditional scheme of AMT/MT investigations, when magnetic coils are buried, authors have applied more progressive scheme installation of magnetic sensors using precision tripod (Figure 2b,c). The precision tripods application allows to set magnetic coils on any type of the ground including slopes up to 45 degree ensure high accuracy of sensors orientation, protection from wind noises and thermo stability. Precision tripods as well dramatically increases productivity of AMT field survey. All field data were recorded with satellite synchronization and permanent reference site.

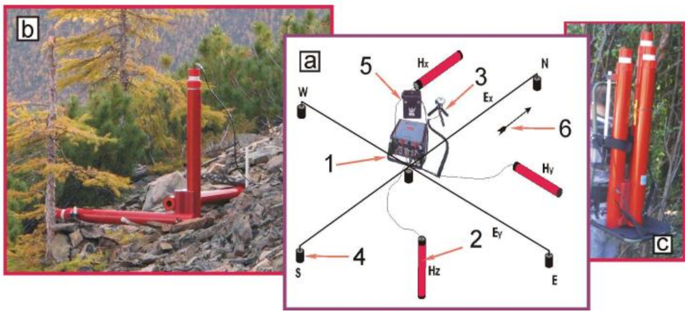

Figure 3. *The scheme of AMT/MT station setting. a – scheme of setting for measurements, b – view of magnetic sensors installed on precision tripod, c- one of way of tripod and magnetic sensors transportation. 1 – MTU-5a station, 2 – magnetic sensors, 3 – GPS receiver, 4 – nonpolarized electrode, 6 – azimuths of setting.*

Data processing and editing is provided in field camp to control data quality. More processing and editing were done in Saint Petersburg. Phoenix software SSMT-2000 was used to obtain AMT/MT (impedance tensor) as well as MVP function (tipper, induction vectors). Data processing was finished by exporting impedance and tipper data in international (SEG) format for further data analyses and interpretation.

Data analyses and interpretation

On this stage the processed data were imported popular WinGLink data base. For data analyses some pseudo sections and map had been created. As well regularities in AMT curves form changes along profile were analyzed. In Figure 4 the AMT curves from southwest (left), central (including curve obtained inside Patomsky crater) and northeast part of the profile are shown. The main feature is high level resistivity at the top of the section (frequency band 10 000 – 1 000 Hz). Other common feature is long descending branches at lower frequencies which reflected presence of low resistive layers at bigger depth (several hundred meters). Resistivity curves at southwest part of the profile shows one order less resistivity level at the high frequency compare with central and northeast part as well as in southwest part we see significant tipper anomalies at frequency range 10 000 – 1 000 Hz. There are the biggest in the profile differences in resistivity and phase curves form station to station at the central part of the profiles (Figure 4). And the sounding curves obtained at station 3 (inside Patomsky crater) are very different especially for TE mode. As TE mode for 2-D inversion component XY (azimuth -45 degree) was chosen. Accordingly component YX (azimuth 45 degree) was chosen as TM. It takes attention that TM mode phase curves after 30 Hz leave their quadrant (Figure 4.B2). This fact is very clear signal about presence here 3-D situation. At northeast part the resistivity as well as phase curves has similar form at neighbor stations and main changes are in the level of the curves.

In the vertical section of real induction arrows (Figure 5), where arrows presented in Parkinson convention (Rokityansky, 1982), it means what real arrow pointed toward conductive anomaly or back from resistive anomaly. Such situation is observed near Patomsky crater. In frequency range 10 000 – 300 Hz at stations 03, 04, 05,12 situated to the right from Patomsky crater real induction vectors directed to northeast, as to the left from the crater at stations 02, 01, 06, 07 they oriented in opposite direction (to southwest). This real induction arrows behavior strongly shows that Patomsky crater is high resistive body situated at less resistive background at least first several hundred meters from the top. Also we have to admit that bright sub vertical conductive anomaly is situated at

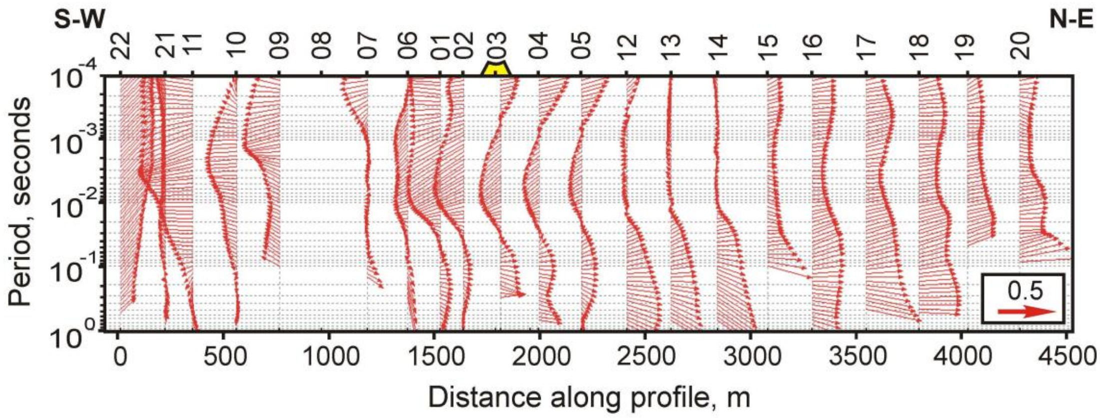

Figure 5. *Vertical section of real induction arrows*

southwest part of the profile. There is opposite picture for station 21. From left and right stations real induction vectors directed to station 21, it means they directed toward conductive anomaly.

Based on that facts and preliminary geological section (Figure 2), as well as 1-D estimation of invariant resistivity and phase, 2-D resistivity start model has been created. Also the estimation of parameters of local heterogeneities has been implemented according to tipper vertical sections (Ingerov, et al, 2009, Ingerov and Ermolin, 2010). Authors apply R. Makki 2-D smooth inversion. As we have problem with phase leaving their quadrant we were forced to limit frequency bend for resistivity and phase as 10 000 – 100 Hz, and used full AMT band (10 000 – 0.3 Hz) for tipper.

Results

The result of 2-D inversion is shown in Figure 6. The obtained for this model RMS value was 3.5 %. Authors didn't try to reduce the error more because in our situation is not really 2-D structure. Three layers of low resistivity values (units – first hundreds Ohm-m) are allocated among of the high resistivity (about 10000 Ohm-m) section. The layers of high resistivity represent metamorphic terrigenous and carbonate rocks of Proterozoic age. The conformity conductive layers are represented by coaly shale and coaly sandstone the same age.

The syncline flexure with low dip of rocks in the central and northeastern parts of the profile and the anticline flexure in the southeastern part of the profile with a high dip of the rocks are observed. The contrast conductive anomalies (units Ohm-m) are located in curve of fold (stations 21 and 22) at the elevations 400 and -500 m. Not sow bright anomaly is mapped at the northeast part of the profile near the stations 16 and 17. The distortions of geoelectric section are observed directly in Patomsky crater area (stations 02, 03 and 04) and also near stations 13-15. The Patomsky crater is located over the sub vertical (dip angle about 80 deg.) object of high resistivity. This object is separated from host medium by two conductive sub vertical zones (with resistivity first hundred Ohm-m) with width about 250 m, which are connected with high fractured zones. The object of high resistivity can not be part of metamorphic terrigenous-carbonate hosting rocks according to all geological and structural indications. The anomaly appearance of this structure allows to choose the endogenous hypothesis of the Patomsky crater origin as the most possible, but in investigated 3 000 depth section there is not sing of magma channel.

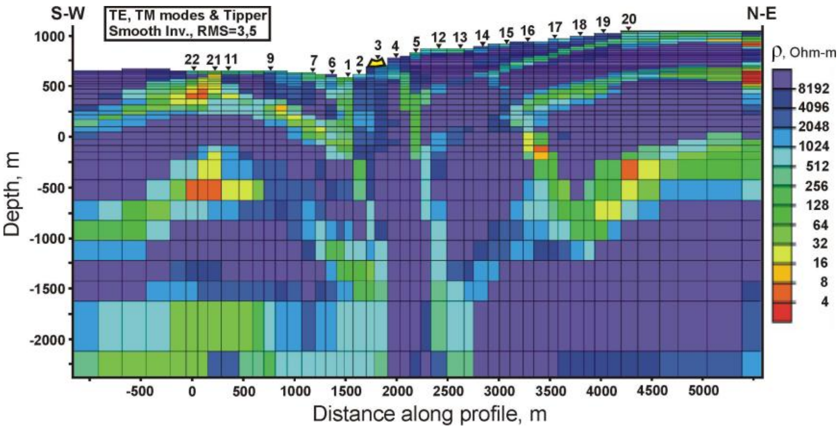

Figure. 6. *Geoelectric model for the profile crossing the Patomsky crater (2-D inversion of AMT data result).*

Conclusions

According to AMT interpretation results Patomsky crater shows up as the high resistive body which dipping in southwest direction breaking folded metamorphic sediments of Proterozoic age. Tipper and induction arrows using allowed us to create reliable model for this area with complicated geological structure. Some more 2-D modeling and inversion of AMT data has to be done to test different geological ideas. As the high resistivity of Patomsky crater body is the fact more geologists take side endogenous hypothesis of Patomsky crater origin, but in section there is not sing of magma channel. The obtain 3-D model of Patomsky crater looks reasonable to do 2 more AMT profiles with same field technique situated from on sides from first one. As well as some MT sites have to be done to investigate idea of magma body presence.

Acknoledgements

The authors acknowledge the Metropol group for financial supporting of investigation and also the Prof. of ISU A.V. Pospeev for data of previous investigations.

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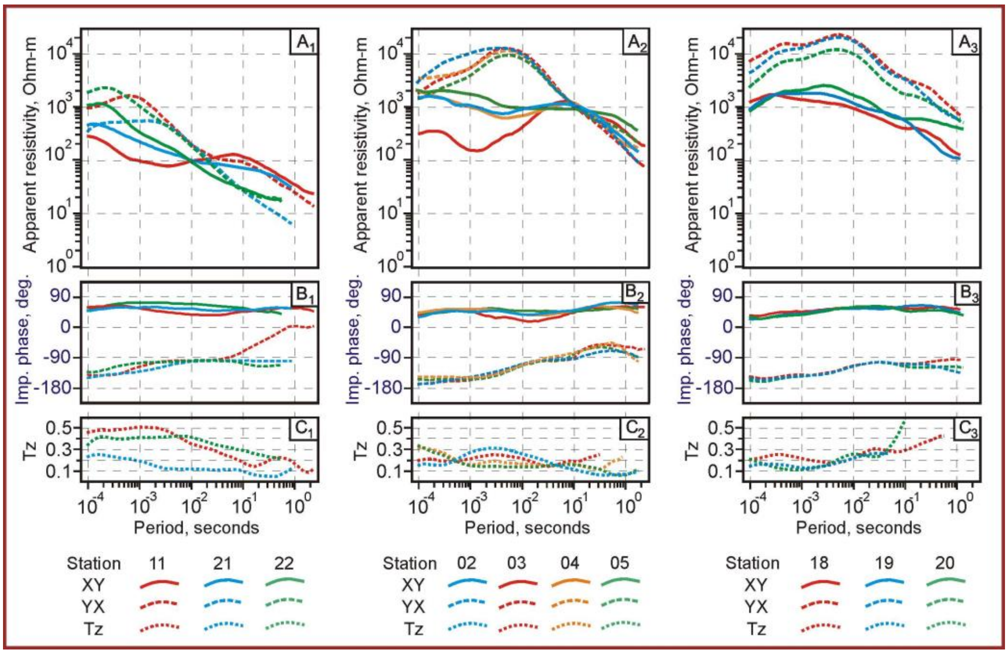

Figure 4. *Typical (A)MT curves and tipper frequency responses. The impedance tensor is rotated on 45 degree. A – apparent resistivity (XY – solid line, YX – dotted line); B – impedance phase.*