PROCEEDINGS, Thirty-Third Workshop on Geothermal Reservoir Engineering
Stanford University, Stanford, California, January 28-30, 2008
SGP-TR-185

STRUCTURE FEATURES OF SUBSURFACE CHANNELS OF ANOMALOUS THERMAL SPRINGS (MUTNOVSKY VOLCANO, SOUTH KAMCHATKA)

Manstein Yu.A., Bortnikova S.B., Manstein A.K.

Trofimuk Institute of Petroleum Geology and Geophysics, SB RAS
Bld.3, Koptyuga street
Novosibirsk, 630090, RUSSIA
e-mail: mansteinya@ipgg.nsc.ru

ABSTRACT

Hydrogeochemical research of thermal springs in active volcanoes areas can help to study the fluid-magma systems and sources of elements in solutions. Mathematic simulation of fluid transport up to the surface can clarify the diversity of magma fluids in the surface. However, the geometry of subsurface fluid channels was not studied directly. Subsurface media structure and hydrogeochemical zoning of internal pore fluids is the crucial problem. The problem solving could explain the thermal springs origin. The electromagnetic frequency induction soundings were effected at Mutnovsky volcano at 2007 with NEMFIS (Near surface EM Frequency Induction Sounding) technique, developed in IPGG SB RAS (see Fig.1). The physical property of the media to be studied is the distribution of low electric resistance areas caused by highly mineralized waters

Figure. 1. NEMFIS operation at Donnoe field, Mutnovsky volcano.

into more resistive accommodating rocks. Such a geophysical task can be solved using NEMFIS technique (Manstein et al., 2000, Manstein et al., 2006). The aim of the work is to explore the structure of electric resistance up to the 6 m depth to study the geometry of subsurface channels of water transport up to the mud pots and fumaroles at the Donnoe field.

THE STUDY SUBJECT

The Donnoe Field (north-eastern crater of the Mutnovsky Volcano) is the lake bottom which has been existing until 1950. Then it has disappeared and the fumarolic field formed in this place. There are three sulfur fumaroles, big mud pot Cherny and a great number of small thermal springs. Their temperature, color and consistence (water-rock ratio) vary in a wide range.

The studying area of the Donnoe Field is divided on the sounding stations of the grid 1x1 m. Sounding is made using 14 frequencies in the 2.5-250 kHz range. The obtained information is processed using Isystem software that is the part of NEMFIS.

EM SOUNDING DATA

The geoelectric cross-sections are made along the 9 observation lines. The lines are 29 m long, the distances between them are 1 m. Each cross-section reflects apparent resistivity distribution in the ground. The geoelectric cross-sections along observation lines are shown at the Fig.2. The lines are numbered at the left. Mud pots were located at the lines 7-9.

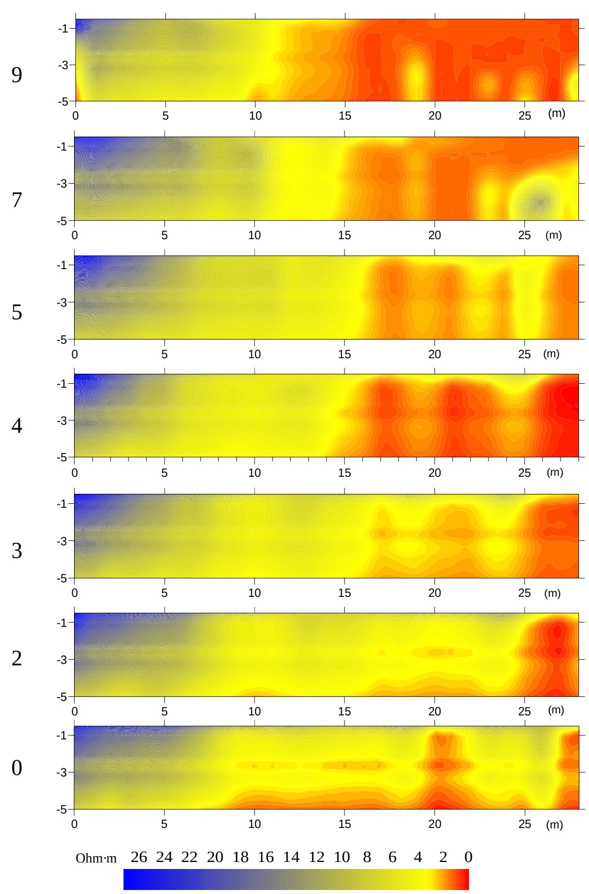

Figure. 2. Geoelectric cross-sections.

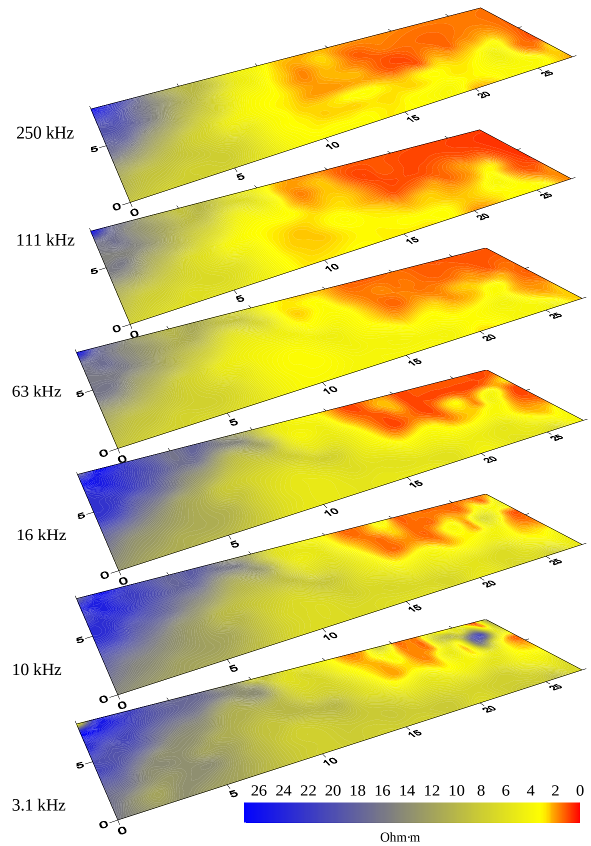

Figure. 3. Geoelectric maps.

Data visualization as the set of geoelectric maps is presented at the figure 3. The quazi-3D presentation includes maps in perspective view at the sequence corresponding to the signal penetration depth. The signal frequency is shown at the left. The shape of quite sharp anomalies of low resistivity can be seen.

DATA INTERPRETATION

According to the measurements, the apparent specific resistance of the grounds in the studying area varies from 0.1 to 27 Ohm·m. Obviously the low resistance is caused by high mineralized thermal waters saturation of the ground, while the high resistance is caused by the ground washed by melted snow. The geometry of low resistance zones is vertical. Their top parts are connected to the mud pots at the surface. The interpretation of these zones as fluid transport paths becomes more consistent while the parallel cross-sections are examined going apart of the mud pots (lines 5-0). Low resistance zones becomes to be less obvious, they are not touching the top of cross-section. It means that in this area mineralized waters are not flowing on the surface (and it's true! There's no mud pots). It should be noted that channels structure is quite complicate and they are connected with zoning of variously mineralized fluids in the Donnoe field subsurface media.

CONCLUSION

The geometry of thermal spring fluids transport channels were studied by examination of low electric resistance areas distribution. The study proves the hypothesis of fluids transportation by open cracks. The hydrogeochemical zoning of pore fluids is discovered. The zoning is caused by transported brines and meteo water mixture at various ratios. It is the cause of thermal sources (mud pots) of various composition, color, physical and chemical properties appearance at the small spot.

As per our experience, NEMFIS technology is the most convenient for crater study, taking into consideration its mobility, high data acquisition speed and real-time visualization.

Acknowlegements. Funding for this investigation was obtained from RFBR (grants NN 07-05-00910, 06-05-96002).

REFERENCES

Manstein ,Y.A. and Balkov, E.V. et al. (2006),. "Electromagnetic frequency sounding for archaeologic prospection", *Geophysica*, N 1, 43-50 (in Russian).

Manstein, A.K., Epov, M.I., Voevoda, V.V. and Sukhorukova, K.V. (2000), "*Russian Federation patent* № 2152058 C1, G 01 V 3/10, dated on 24.06.98" Induction frequency sounding technique". Russian patents band trademarks agency. Bul. № 18.