VOL. 10, NO. 2, FEBRUARY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

SEISMIC INVESTIGATIONS OF LAKE CHEBARKUL IN THE PROCESS OF SEARCHING CHELYABINSK METEORITE

P. S. Krylov, D. K. Nourgaliev and P. G. Yasonov
Insitute of Geology and Petroleum Technologies, The Kazan Federal University, Russia
E-Mail: sprint@front.ru

ABSTRACT

High-resolution seismic investigations of Lake Chebarkul bottom was carried out in the place of meteoric fall of the biggest part of "Chelyabinsk" meteorite. The disturbance of stratification and degassing zone on seismic sections passing through the coordinates of the ice hole was found on the proposed meteorite location.

Keywords: chebarkul lake, chelyabinsk meteorite, seismic sections.

1. INTRODUCTION

On 15 February 2013 in the region of Chelyabinsk, Russia, an excessively large meteorite produced a powerful shock wave, which caused unprecedented damage to people and property. According to official news reports, glass windows were shattered in over 7300 buildings, and falling debris hurt more than 1600 people [1, 2].

The Chelyabinsk meteorite shower is a unique phenomenon, during which more than ten hundred thousands of fragments of a cosmic body fell on the surface of the Earth. The supposed area of strewn meteorite material exceeds 60-100 km length and 10-20 km width [3]. The largest piece so far recorded weighs 1.8 kg. It is believed that at least one much larger stone penetrated the ice of Chebarkul Lake is located 70 km W of Chelyabinsk [4]. On February 28th and March 11th 6,000 points of the Earth magnetic field were measured in a grid separated by 1 m, covering an area of 60 x 100 meters around the hole [5].

On July 14, 2013 the expedition was organized to carry out seismic investigations of Chebarkul Lake in the area of proposed meteorite location.

2. METHOD

Seismic profiling was carried out using specialized complex, designed and manufactured on the base of Kazan Federal University. The complex includes: a source of elastic waves, a receiver, a seismic station, a laptop, a GPS-receiver, an inflatable boat, a motor, and power supply elements. The complex allows getting seismic acoustic sections with vertical resolution at least 15 cm; depth study of various types of lake sediments at least 10 m; geodetic positioning system within several meters. It also provides the digital recording of information; portability and low power consumption and the ability to use inflatable boats for conducting a research. As a source of elastic vibrations an inductive oscillator "boomer" was used. As a source of electric power a storage battery was used. The continuous seismic monitoring was done on the basis of the principle of central beam with the use of single-channel receiver unit. The GPS receiver was used to coordinate profiles and boat location.

3. RESULTS AND DISCUSSIONS

As a result of the work 6 cross-sections of approximately length 230 meters each were done. The schematic location of these cross-sections is shown on Figure-1. The seismic section was analyzed to determine the bottom topography, the bedding layers, bedrocks and the presence of gas in sediments. On seismic section number 5 at the supposed place of a meteorite fall the depth of the lake is 9.6 m. In this place we can observe a weak reflection from the bottom of the lake caused by weakly consolidated slurry and loose silt (Figure-2), which was confirmed by underwater work carried out at bottom of the lake [6]. The thickness of these sediments reaches 2 m. below these sediments we can determine reflections typical for stratified sediment, where is the supposed place of meteorite location.

On sections number 1, 3, 4, 5 in the place of meteoric fall, there is a zone of degassing and disturbance of stratification layers. This is likely due to the mechanical meteorite impact after the fall. On section number 7, which is located 40 meters from the ice hole, we cannot observe the same thing. All the layers in this place are deposited relatively parallel, without any disturbances of stratification (Figure-3).

According to the findings of seismic investigations, the sediments of Lake Chebarkul contain a large amount of organic gas, presumably, methane, and this lake is a unique object for studying the accumulation and distribution of gas in sediments. As we can see on the seismic sections, the accumulation of gas occurs towards the center of the lake where the deposit thickness exceeds 2.5-3 m. At this point a transition zone of gassy/not-gassy sediments is formed. Chelyabinsk meteorite fell exactly in this transition zone, which led to difficulties in interpretation. Nevertheless, brought to the surface the largest Chelyabinsk meteorite fragment confirmed that the crater was formed by the mechanical impact of the meteorite.

VOL. 10, NO. 2, FEBRUARY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

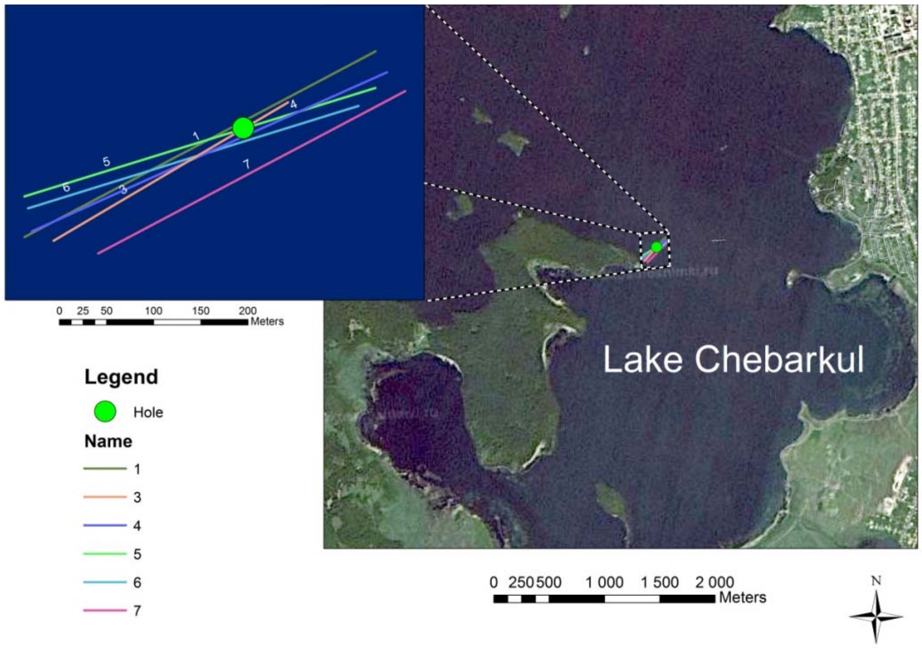

Figure-1. Schematic profiles location.

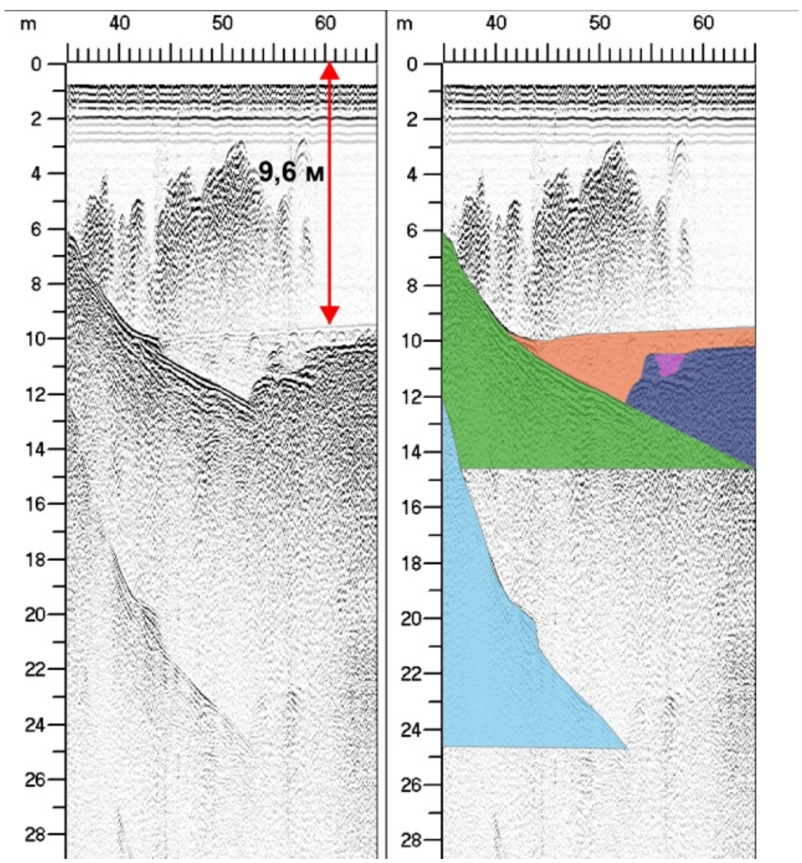

Figure-2. Seismic section number 5. Horizontal scale corresponds to the pickets of the profile. Vertical scale is the depth in meters relative to the water surface. Bedrocks are green colored, gassy sediments - dark blue colored, multiple deposition - blue colored, meteorite crater - purple colored.

VOL. 10, NO. 2, FEBRUARY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

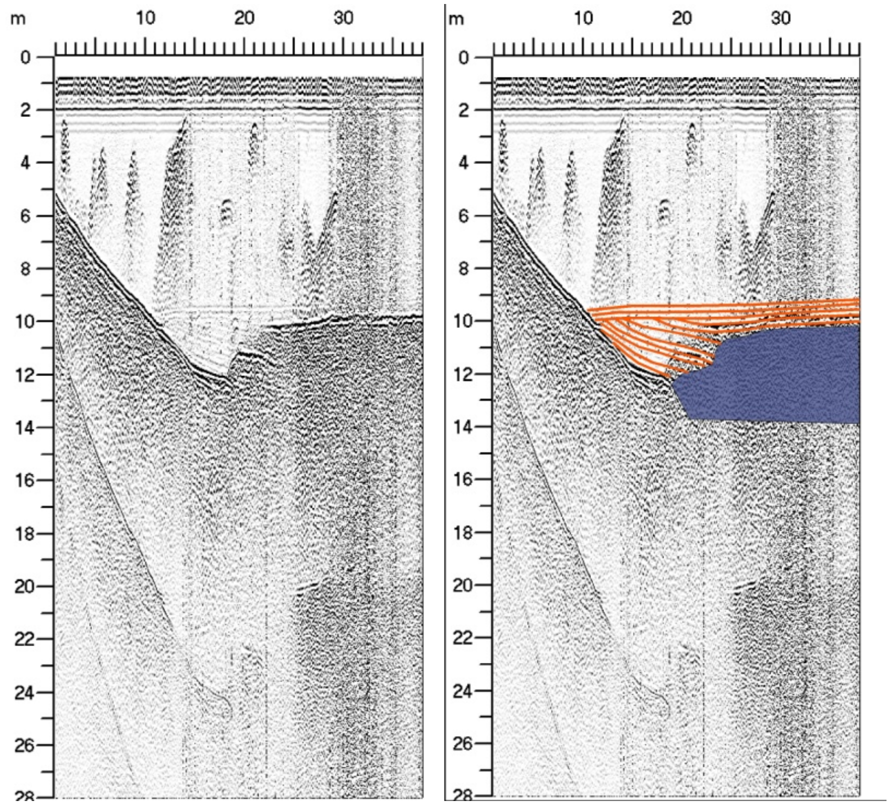

Figure-3. Seismic section number 7. Gassy sediments are blue colored, the undisturbed layers are marked by orange lines.

4. CONCLUSIONS

On October 16, 2013 from Lake Chebarkul the largest fragment of Chelyabinsk meteorite was brought to the surface by divers. Its weight was slightly over 600 kg. The work was carried out directly under the ice hole, where seismic sections showed the crater.

REFERENCES

[1] Heimann Sebastian, Álvaro González, Rongjiang Wang and Simone Cesca. 2013. Torsten Dahm Seismic Characterization of the Chelyabinsk Meteor's Terminal Explosion. Seismological Research Letters. 84(6): 1021-1026.

[2] Popova O.P. *et al*. 2013. Chelyabinsk Airburst, Damage Assessment, Meteorite Recovery, and Characterization. Science. p. 342.

[3] Badyukov D. D. and Dudorov A. E. 2013. Fragments of the Chelyabinsk Meteorite Shower: Distribution of Masses and Sizes and Constraints on the Mass of the Largest Fragment. Geochemistry International. 51(7): 583-586.

[4] Pillinger C. T., Greenwood R. C., Johnson D., Gibson J. M., Tindle A. G., Verchovsky A. B., Buikin A. I., Franchi I. A. and Grady M. M. 2013. Light Element Geochemistry of the Chelyabinsk Meteorite. Geochemistry International. 51(7): 540-548.

[5] Narkhov E. D., Sapunov V. A., Denisov A. Yu., Savelyev D. V., Galkin D. A., Yakovenko D. S. and Fedorov A. L. 2013. Magnetic prospecting and data interpretation of the Chebarkul meteorite. In: Proceedings of the International Workshop Asteroids and Comets: The Chelyabinsk event and the Chebarkul lake meteorite fall, Chebarkul, June 21-22, Kray Ra and Chelyabinsk. pp. 72-75.

[6] Kopeikin V. V., Kuznetsov V. D., Morozov P. A., Popov A. V., Berkut A. I., Merkulov S. V. and Alexeev V. A. 2013. Ground Penetrating Radar Investigation of the Supposed Fall Site of a Fragment of the Chelabinsk Meteorite in Lake Chebarkul. Geochemistry International. 51(7): 575-582.