ロシア・バイカル湖における電磁気モニタリング

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Electromagnetic monitoring of the Lake Baikal

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Being the deepest lake in the World, a unique active rift structure - a nascent ocean, the Lake Baikal is a huge natural laboratory for different studies. The vertical component of electric field Ez in the hydrosphere can be free from telluric interference and therefore it is of particular interest for monitoring purposes. This idea has been implemented in the long-term Baikal experiment. This experiment is aimed at the studies of the water transport, the hydrosphere segment of the Global Electric Circuit (GEC) and the earthquake precursors. The monitoring of Ez on the basis surface-to-floor started in the southwestern part of the Lake Baikal in 2003. In 2012 a novel setup, providing the facilities to control the self-potentials of electrodes and other possible noise sources, has been put into operation. This setup in the configuration, includes, besides Ez, the measurements of sea currents and magnetic field (and its gradient) on the shore.

The experiment has confirmed absence of the telluric component in Ez. Fig. 1 shows an example (2013/2014) of comparison of the spectrum Ez and magnetic field modulus B received by simultaneous measurements by the nearest magnetometer. Clear and large first and second harmonics of the diurnal variations in the spectrum of B do not have any response in the spectrum of Ez. On the contrary, the characteristic features of the Ez spectrum have no correlation in the B spectrum.

The characteristic features of the Ez spectrum reflect the strongest (synoptic) sea currents in the Baikal within a period of 2-10 days with a random spectrum and the sole periodic sea current with a period of about 15 hours. Due to the fact that Ez, measured on a long base, does not depend on either the geoelectric section or on the flow structure, it’s attractive for the monitoring of the integrated sea currents velocity, important for hydrology, but rarely practiced because of its highly cumbersome implementation by direct methods.

At the periods longer than 10 days the sea currents in the Lake Baikal are very weak. However, unexpected strong Ez variations were discovered at the periods 100-160 days, which could not be motionally induced. We interpret it as manifestation of the GEC current on its hydrosphere segment: the X-ray variation influents on the ozone layer, which slowly causes the convective current variation in the troposphere and then the conductive current variation in the hydrosphere.

On August 27, 2008, 1h 35m UT the earthquake of magnitude M=6.4 happened near the setup. The depth of the hypocenter was 17 km; the distance from epicenter was 16.4 km. The fast amplification of negative Ez began 15 hours ahead of the earthquake. The amplification of the field by 25 microV/m ends with the extremely sharp separate splash, which is induction effect of tsunami wave, emerged exactly at the earthquake instant. The magnitude of the splash 9 microV/m corresponds to the magnitude of the water velocity about 50 cm/s, which is a quite real estimation of emerged small tsunami. Thus we observed the results of two different field excitation mechanisms: 15-hours precursor caused obviously by electrokinetic mechanism (at amplification of deep underground water filtration before the earthquake), and practically instantaneous induction tsunami effect.

Considering the complex character of electromagnetic monitoring, with planned extension of the observation network, detailed knowledge of the geoelectric cross-section over entire Baikal Rift is required. Therefore a preliminary detailed 3D geoelectric model of Baikal and the entire surrounding land has been constructed on the base of all available geoelectric and other geophysical and geological data. This model has helped to clarify some geological views by Ez monitoring and can serve as a basis for future areal regional and detailed magnetotelluric studies.