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Development of prediction technologies for dangerous geological processes and relevant destructive tsunami waves with application of onshore complex geophysical units

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1. Theoretical reasons of tsunami generation Waves - inundations, provoked by underground earthquakes, volcanic eruptions, landslides and other occurrences, are the most terrible natural calamities due to high speed of the water inflow to the coast and comprehensive character of destructions and human victims caused by flow. The most often cause of tsunami generation is a sharp vertical displacement of bit squares of the ocean bottom during underground earthquakes. In some cases tsunami form resulting a sudden horizontal fault of the underwater slopes (Chili, 1960), and/or during vibration (without displacement) of definite forms of the bottom relief by underground landslides (Sagami Bay, Japan, 1923), fall of mighty masses of soil (Lituja Bay, USA, 1958). So-called meteorological tsunamis have slightly different nature; lifting of the sea level provoked by the atmospheric pressure in centers of strong cyclones considered as their source. Velocity of tsunami spreading in the open ocean can be defined by equation , where - depth of water, - acceleration of gravity. It is almost impossible to notice tsunami in the open ocean because with height 1-2 m tsunami waves have length of few kilometers. Some explorers think that periods of waves continue from 2 to 200 minutes. Removing from the source, amplitude of tsunami waves decreases in inverse proportion to the square root of the distance. This circumstance, as well as effect of the waves energy' focusing that appears resulting sphere forms of the Earth and bottom relief, make dangerous even tsunami waves provoked by rather remote sources. The underwater ocean bottom relief exerts a significant influence upon tsunami propagation, moreover, not only on velocity of the waves, but also on distribution of amplitudes along the front. In particular, the underwater ridges serve as

waveguides where the energy concentrates. Velocity of waves sharply decreases when tsunami reach shallow waters. Simultaneously the amplitudes increase and reach their maximal volumes near the water surface. Limitation of free space aside, for example during enter the narrow bays, entail the waves' height that is much more intensive. Owing to refraction, plots near the capes are also dangerous. All these causes entail extremely uneven distribution of altitudes along the coast. We can expect that tsunami-genetic earthquakes provoke 'rupture' of the water environment' integrity, i.e. appearance of steam-gas bubbles pulsation of which cause chemical reactions, luminescence, radiation of sound in wide frequency diapason. All these events have a name "cavitations". Formation of cavitation zones results in changes of electromagnetic field of the Earth, i.e. in generation of electromagnetic radiation. Spectrum of the acoustic field radiated by cavitation cavity is analogous to the explosive source of the sound Besides, motion of the seawater within magnetic field of the Earth, waves of Rely, propagated along the bottom, processes on the border bottom-water and surface water-atmosphere entail changes of electromagnetic field in a wide range of frequencies. For example, detection of long-period variations of magnetic field of the Earth on tsunami area in the Pacific Ocean and in the Sea of Okhotsk in the 80-ies, according to magnetometer-gradient meter (with distances between sensors 500 m). Formation of acoustic and electromagnetic emission happens simultaneously with smooth change of the Earth magnetic field in a wide range of frequencies, from dozens of Hertz to dozens of Kilohertz. For all that, success of tsunami prediction depends (according to opinion of Dr. V.K.Palamarchuk) mainly (up to 95%) upon choice of the place onshore where sensors of geophysical monitoring systems are installed.

1. Technical facilities 1.1.Marine complexes 1.2. Application of hydro-acoustic complexes purposed for navigation convoy, is not useful for prediction of tsunami due to following reasons: - very high cost and big sizes of the devices themselves (both American and Russian ones); - complication of installation in a proper place; - complication of the device's repair; - shortage of hydro-acoustic information for tsunami' prediction (information about changes of electromagnetic field demanded as well). Therefore, the simplest hydro-acoustic facilities are more applicable for acceptance of hydro-acoustic information.

1.3.Onshore complexes Complex Geophysical Mobile Seismic Observatory consists of geophysical complex that includes: - precision sensors of the magnetic field of the Earth' mode (MFE) and its vector (MFE components - X, Y, Z) and onshore magneto-variation stations of MM-60M1 type, - receivers of electromagnetic radiation for a quantity of wide and narrow frequency intervals of VLF-signals, - receivers of natural and artificial electromagnetic radiation spread in the space (8-sensors registration system) in VLF-signals diapason, - three-component receivers of electromagnetic

radiation in ULF-ELF and VLF-VLFW diapasons based on three-component induction magnetometers purposed for measures of three components of magnetic field of electromagnetic radiation (EMR) in diapasons 0.1-40 Hz and 0.3-30 kHz correspondently, - mobile seismic station with 3-component sensors and hydrophones, - three-component seismic station based on piezo sensors, - georadar for radio-location sounding of the upper part of the section, - installation for measurement of natural electric fields and seeming resistance on different scatters, - multi-functional electric research station of 'Era-Trassa' type for detection in the Earth crust of the objectives with anomalous electric conductivity by stimulation of constant and alternating magnetic fields with help of earthen and not earthen feeding and receiving lines, - analyzer of radon in soil air, - gamma-spectrometer for studies of the rocks' radioactivity on gamma-radiation and concentration of radioactive elements (U, Th, radioactive isotope K). Complex geophysical mobile seismic observatory contains, for the purposes of acoustic emission studies, - 15-channel acoustic system based on piezo sensors in frequency interval 1 Hz -20 kHz, - devices for registration of the acoustic and electromagnetic emission for complex geophysical study of geo-dynamic processes of the upper part of the section, evaluation of the faults and landslides activity, short-term earthquakes predictions, - related methods and means of data processing and interpretation.

Conclusion The goal of the present article is substantiation and detection, basing on contemporary demands, of the ways to develop technical measures of the system for prediction of tsunami waves' generation, development of technologies for monitoring of geophysical fields for tsunami waves prediction and providing security for human being and economy of the country. Structure of local two-level station for prediction of tsunami waves worked out and devised for processing of geophysical and other data in two regimes: waiting regime and operating regime. Control of geophysical fields' condition in the neighboring and distant zones of the water area carried out in the regime of waiting for unfavorable event. After detection of the anomalous change of the of the water area' stable condition the system turns to the operating regime when it evaluates probability of tsunami wave origin, frontal periods of coming wave and border of the flood zone. The article shows a range of problems solved by the local station, and list of geophysical devices that compound the local station. Model of the mobile observatory elaborated in VNIIOkeangeologia used as prototype of the system of destructive tsunami waves' prevention. Application of local stations for tsunamis detection at the account of complex measures and processing of geophysical information increases reliability of the operative tsunamis prediction, lower number of false alarms and gives a time advantage for making decisions about tsunami genesis of the happened earthquake. Further development of the local stations for tsunamis detection must follow the way of creation of multi-functional devices for measurements of

geophysical fields and optimize algorithms of the problems solved by the local station.