# Features of fluid dynamic processes in a seismically active region (on example of Kamchatka)

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Formation of earthquakes sources with emission of elastic seismic waves, is associated with the occurrence and development of fluid-dynamic processes in water-saturated rocks in the crust of seismically active regions. The formation of disruptions causes a redistribution of static stress state of fluid-saturated rocks, which manifests in steps of fluid pressure with amplitudes proportional to the magnitude of volume strain. Propagation of seismic waves causes dynamic deformation of rocks and accompanied by effects in surface and underground waters. Observations of water level variations make it possible to distinguish hydrogeoseismic effects due to earthquakes (HGSE) and to study fluid-dynamic processes in the «well – water-bearing rock» system at formation of seismic sources.

The report presents the HGSE study in the YuZ-5 well, Kamchatka, by 19 earthquakes with Mw = 6.8-9.1 at epicentral distances of 80-14600 km. Taking into account morphological features and duration of development, four types of HGSE were identified: I – water level oscillations during hours; II – oscillations with level rise from minutes to hours; III – level rise during hours - up to one day; IV – long (months) water level lowering.

Manifestation of HGSE types was established depending on earthquake parameters - ratio of magnitude and epicentral distance, and seismic wave parameters - specific energy density in the seismic wave and maximum horizontal velocity of soil movements according to records at seismic station. The manifestation of different types of HGSE is determined by the degree of seismic impact, the amplitude-frequency composition of maximum phases of soil movements, as well as occurrence and development of specific hydrogeodynamic processes in the «well – water-bearing rock» system.

The increase of seismic intensity, determined by values of specific density energy in seismic wave and its maximum velocity, is accompanied by a change of the GGSE manifestations from type I to type IV. Low-frequency and low-amplitude seismic signals cause water level oscillations. With an amplitude increase short-term level rises are superimposed on the oscillations. With an increase in the frequency and amplitude of the seismic signal, short-term water level rises are more pronounced. In cases of local strong earthquakes with intensity of $\geq$5-6 on MSK-64 scale appears prolonged water level lowering.

For some examples, the formation processes of HGSE I-IV types are considered. Water level oscillations occur as a result of the amplification of harmonic pressure variations in the well (Cooper et al, 1965) during the passage of surface waves with a period of 44 s. Short-term water level rises reflect a pressure step and non-linear filtration effects in water-bearing rocks (Kocharyan et al., 2011) near the wellbore. The amplitude of water head rise does not exceeded of first cm of water column with a pressure pulse relaxation time of no more than first tens of minutes. Long-term water level lowering is caused by a drop of the water head with amplitudes from tens of cm to 1 m at distances up to hundreds of meters from the well due to improvement in filtration properties of water-bearing rocks during intense shocks.