

Precursory anomalies before Karymsky seismo-volcanic crisis on January 1-2, 1996 in Kamchatka by multi-scale seismicity and hydrogeochemical data

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Karymsky seismo-volcanic crisis (KSVC) is the series of paroxysmal seismic and volcanic events occurred in Kamchatka East Volcanic Belt on January 1-2, 1996: summit eruption of Karymsky volcano, freatomagmatic eruption in the lake in the Academia Nauk caldera, a significant earthquake swarm with largest event on January 1, 1996 with $M_w=6.8$ (Karymsky earthquake, the most strong crust earthquake recorded in Kamchatka during time of instrumental observation).

Significant hydrogeochemical anomalies and anomalies in parameters of seismicity in different levels of energy were detected before KSVC. In addition, swarms of weak low-frequency earthquakes (LFE) were detected under Karymsky volcano during last 8-9 months before KSVC.

Hydrogeochemical anomalies were markedly observed in the variations of water composition in two boreholes (N1 with the depth 600 m and N2 with the depth 2540 m) at the distance near 125 km from KSVC. Observations at borehole N1 revealed the impulsive increase (duration of about 15 days) of the concentration of calcium-, sulfate- and sodium-ions and the impulsive decrease of hydrocarbonate-ions concentrations. Similar variations of these parameters were observed prior to other large earthquakes. On the contrary, measurements in borehole N2 showed long-standing changes (up to 4 months) in concentration of hydrocarbonate-ions and ions of Ca, sulfate, Cl and Na. However alternatively to the variations observed at N1, the concentration of hydrocarbonate-ions increased and the concentration of other ions decreased.

As a multi-scale seismicity we use earthquakes of Kamchatkan regional seismic catalog and microseismicity (lowamplitude seismic noise with the frequency band within first decades of Hz). We calculated the spatial distribution of RTL parameter and Z-function for detection of dynamics of seismic process. For microseismicity analysis the original method, based on seismic noise response to tidal influence was used. Precursory seismic quiescence, detected by two independent methods (RTL and Z) are synchronous in time and demonstrate spatial agreement. Duration of detected anomaly is about 4 years.

Anomaly in seismic noise response to tidal influence was detected on the distance about 140 km from Karymsky earthquake epicenter. Duration of anomaly is about 1 month. Parameters of anomaly detected before crust Karymsky earthquake are differ from ones for subduction earthquakes 1992-2012 attended with similar effects.

Anomalies in hydrogeochemical data, seismic noise and LFE were detected in real time before KSVC. Seismic quiescence by RTL parameter and Z-function were found retrospectively.