NECESSITY OF LOCAL SEISMIC MONITORING IN THE AREA OF MUTNOVSKY GEOPOWER PLANTS

Yu. Kugaenko, V. Chebrov
Kamchatkan Seismological Department, Geophysical Service, RAS
Petropavlovsk-Kamchatsky, Russia

In this report data about seismic situation in the Mutnovsky steam-hydrothermal field are present. Verkhne-Mutnovsky GeoPP (12 MW) began to work in this area in 1999, and Mutnovsky GeoPP (50 MW) – in 2001. Development of geothermal energy production is vital issue for Kamchatkan population. Problems connected with hydrothermal field exploitation are quite actual. Estimation of seismic risk in area of Mutnovsky GeoPP is smaller than really one. It was made in the beginning of 80-th by paleoseismic data and analysis of 1962-82 region seismicity. But during next years new data and facts were collected. Summarizing of all available data allows us to evaluate seismic hazards and its negative consequences.

Drilling in the Mutnovsky hydrothermal field began in 1978. Now there are more then 90 wells with the depth from 250 to 2500 m. We can say that Mutnovsky and Verhne-Mutnovsky GeoPP are really ecological clean for atmosphere and hydrosphere due to used technology excepted thermal liquid contact with environment. Reinjection is carried out for hydrothermal reserve reconstruction. In future power of GeoPP will be increased to 300 MW. It may cause disturbance of the hydrothermal system balance and probable increasing of man-caused seismicity.

MGeoPP are in high seismic risk zone. According to the seismic risk zoning map Mutnovsky hydrothermal field belongs to an area having seismic intensity 9. By long-term seismic prediction strong earthquake may happen near southern part of Kamchatka (in focal zone) in nearest years. So possibility of strong earthquake now is higher than long-term average estimation by seismic risk zoning. Strong earthquakes that can cause strong ground motions with intensity 7 or more in GeoPP area take place in seismic focal zone that crops out along east coast of Kamchatkan peninsula, but strong crust seismic events were observed within peninsula too.

Hydrothermal field is close to 2 active volcanoes: Mutnovsky volcano (last eruption was in 2000) and Gorely volcano (last eruption was in 1985-1986). During last 200 years explosions of this volcanoes were explosive in the main. Seismic station GRL works on Gorely volcano from 1982. Volcanic hazard in the area of Power Plants is: ash falls, lahars, electro-magnetic phenomenon in ashes clouds triggering death of electric equipment. Eruptions of Mutnovsky and Gorely volcanoes are attended with seismic activity: local earthquakes and volcanic tremor. Seismic monitoring allows to estimate the volcano state and the volcano danger before eruption beginning. It may decrease damage caused by eruptions.

The special attention in the report is focused on local seismicity in Mutnovsky hydrothermal field directly. By analysis of Kamchatkan earthquakes catalogue it was show that from 1996 small surface earthquakes are registered from the area of exploited hydrothermal field (fig.1). But earlier it was presumed than local seismicity is absent in this area. So we can propose that seismic processes in this region may be connected with intensive man-caused influence on the environment. This activity may destruct natural balance of hydrothermal system and initiate seismicity.

As far as we know industry activity may trigger earthquakes. Earthquakes can be induced by reservoir impoundment, fluid injection, mining, or oil, gas and thermal water extraction. Induced quakes create a risk of personal injury and damage to property. In many exploited hydrothermal field of the word induced seismicity was found. Induced seismicity can be used for seismic monitoring of hydrothermal fields. Small earthquakes and induced seismic emission associated with stress in and around reservoir, also can be used to image the reservoir dynamics. Microseismicity can be used to monitor rock mass deformation that can cause well failure. Some else applications on induced microseismicity: tracking of injection water front, fault mapping,
mapping of the orientation, height, length, complexity and temporal growth of the induced fractures.

Examples of man-caused seismicity in the world exploited hydrothermal fields and its seismic monitoring used increasingly are given in the report. Some results of passive seismic monitoring caring out by seismic array and use of endogen microseismic emission are present. Authors of this report realized this study in Mutnovsky hydrothermal field in 1998.

In Russia first GeoPP was build on the south extremity of Kamchatka in Pauzhetsky geothermal field in 1967. One of the first Kamchatkan seismic stations is working in this area from 1961. By data of this station region of Pauzhetsky geothermal field from 1961 till 1972 was characterized as very seismic quiet. But from 1973 seismic activization begin in the vicinity of hydrothermal system. A lot of shallow earthquakes were registered. Some of them were perceptible. Ground motions in seismic station building had intensity about 6. It is first example of induced seismicity appearance in hydrothermal field in Russia. Triggered earthquakes can appear later than exploitation of deposit begins. Activization in Pauzhetsky geothermal field began 6 years after exploitation start. Such seismic events are registering in resent years too.

![Figure 1](image)

**Figure 1** Map of shallow earthquakes epicenters for different periods of time:
- **A** - 1962-1987,
- **B** - 1988-1995,

**Description of periods of time:**
- **A** - time from beginning of seismic observations on kamchatka (1962) till second nearest station rus building (december of 1987). it is important moment because of this station improved eq registration and increased accuracy of hypocentres determination. in 1980-th this area was enough active: we can see seismic swarm under viliuchinsky (1981) volcano and (in left down corner) part of swarm under asatcha volcano (1983) that is nearest neighbour of mutnovsky volcano from south-west. last activity of gorely volcano associated with this period of time too.

- **B** - time from 1988 till 1995. in 1996 first small earthquake were registered in the region of mytnovsky hydrothermal field. region is very quite.

- **C** - time from 1996 to May, 2004. We can see epicentres of small shallow earthquakes in the central part of the map. Such seismic events were not registered here yet.

At present, the techniques for estimating induced seismicity have not been elaborated yet, whereas damage caused by relatively weak induced earthquakes is becoming more and more significant.

Kamchatkan seismic stations network is oriented on registration of regional seismicity. It does not intent for local seismic control of Mutnovsky hydrothermal field. It is necessary to set up additional seismic stations for reliable registration of seismicity from deposit area directly for monitoring of hydrothermal system and nearest volcanoes and GeoPPs safety.