Anthropogenic seismicity induced by the filling of water reservoirs in Vietnam

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Anthropogenic seismicity explores the phenomenon of seismicity induced or triggered by human industrial activity. Thus, induced seismicity release seismic energy introduced by human activities, into the rock formation; while triggered seismicity are those events, where tectonic energy release is triggered by human activity. This is a special situation when the seismicity is shown to be associated with water reservoirs. Among all earthquakes accompanied by human activities, this type of seismicity causes the strongest earthquakes. The largest earthquakes triggered by water impoundment have exceeded a magnitude of 6. Occurrence of a damaging 6.3 magnitude earthquake at Koyna Dam, India, took place in December 1967 (Gupta 2002). The role of reservoir exploitation in triggering magnitude 7.9 earthquake in China 2008 is still under debate (Ge et al. 2009; Gahalaut and Gahalaut, 2010). In Vietnam the strongest case of a reservoir triggered seismic event of magnitude 4.9 took place in Hoa Binh Province, Northern Vietnam, in 1989 (Tung, 1996). In contrast to the natural seismic activity, which is practically static, anthropogenic seismicity varies with time and there are dependencies between the seismicity and human development activities. The anthropogenic seismic activity also depends on the tectonics of the area and the natural seismic processes existing there before humans came there with development. Unfortunately, very often a complete seismic survey begins when noticeable earthquakes appears, which occurs after the seismic processes have reached a maximum. The aim of just started project entitled: “Initialization and development of anthropogenic seismic processes induced by artificial surface reservoirs” is to study the anthropogenic seismicity induced by the filling of water reservoirs and the assessment of the risks related to this activity. The project is funded by National Science Centre and lead by Institute of Geophysics PAS (IG PAS). Within the framework of the project close cooperation with Institute of Geophysics Vietnamese Academy of Science and Technology (IGP VAST) is foreseen.

In Vietnam, such measurements had started before the reservoir in Lai Chau was filled up. It will allow exploration of the natural seismicity, which exists in the area of the future dam, and then determine the development of anthropogenic seismic activity associated with the impoundment of water in the reservoir. Measurements will be conducted by a dense seismic network consisting of 10 seismic stations located within 20 km from the...
reservoir. This area is characterized by tectonic seismic activity, therefore there is a high probability to collect appropriate material to study the anthropogenic seismic activity. Further measurements will continue in the region of Song Tranh 2, where joint Vietnamese-Polish seismic network recorded more than 5000 seismic events. The improving of the location of events and more accurately determination of the focal mechanisms are the main goals for this region research. This will be possible due to the development of the velocity distribution of seismic waves in the region. The cooperation with local seismic and geological team will allow to implement modern seismological methods, such as investigation of seismic source mechanisms, correlation of events with tectonic faults, or changes of static stress. Time dependent results of measurement in Lai Chau and Song Tranh 2 will be correlated with geological data and technological data related to changes in the reservoir level. We will test the new concept of a reservoir impoundment corresponding to an aseismic (slow earthquake style) main shock. In such case, the anthropogenic seismicity is treated as the aftershock sequence. The study of stationary and time-dependent seismic hazards associated with the reservoir will explore the possibilities of assessment and mitigation of seismic hazard.

Currently, the main research data and software concerning the anthropogenic seismicity is prepared within the European Plate Observing System (EPOS) project within the Anthropogenic Hazard (AH) work package (WP14). The product of this implementation will be Thematic Core Service Anthropogenic Hazard (TCS AH) for scientists working upon the anthropogenic seismicity and its hazards. IG PAS and IGP VAST provided data for this project about the Central Vietnam (Song Trahn2 reservoir), which was integrated onto the prototype of TCS AH within the national infrastructural project (IS-EPOS). All future scientific works using data and results from Central and North Vietnam are also designated to be incorporated into the TCS AH. The reservoir triggered seismicity episodes from the IS-EPOS platform may be used as a benchmark data sets for the development of the methods foreseen in the project (except the 2 Vietnamese episodes there are foreseen at least 3 other: Czorsztyn, Montenyard and Val d’Agri). Since the TCS AH will gather the most of the scientific community around the e-research platform, the results of the research project described above will be published there as data sets (one new episode and update of Song Tranh2 episode) or software developments, references to publications will be widely distributed within the community and beyond via IS-EPOS platform. Moreover, the Northern Vietnam data and future results may play a significant role as a case study for distinguishing the role of industrial operations on the changes in the seismogenic process.