საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, 175, №2, 2007
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, 175, №2, 2007

Geophysics

Controlling Influence of Reservoir Water Level on Local Seismic Energy Release

Vakhtang Abashidze*, Thea Khutsishvili*, Zurab Javakhishvili*, Natalya Zhukova*, Eka Mepharidze*, Tamaz Chelidze, Teimuraz Matcharashvili***

* *M. Nodia Institute of Geophysics, Tbilisi*
** *Academy Member, M. Nodia Institute of Geophysics, Tbilisi*

ABSTRACT. We present an evidence of reservoir induced controlling influence of water level periodic changes in Enguri high dam reservoir on regional seismic activity. Data sets of water level daily variations in the Enguri high dam reservoir and the seismic data sets recorded by the local network have been analyzed. Monthly frequency of earthquake occurrence has been calculated.

According to our results decrease in daily seismic energy release around Enguri high dam during water level periodic variation can be assumed as a control of seismic activity. This controlling influence may be explained as a result of phase synchronization of complex seismic process with small periodic changes in the reservoir water level.

Key words: *synchronization phase, seismicity, water reservoir, dynamics.*

In the present study the possible control of water level variation of the dynamics of local seismic activity in a large reservoir is investigated. Large reservoirs, especially those located in seismically active zones, are often considered as a source of triggered or induced earthquakes [1-5]. Therefore, the scientific and practical importance of possible mechanisms related to the influence of high dam water reservoirs on earthquakes in the surrounding territory is well acknowledged [1-6]. Since the middle of the past century reservoir-induced seismicity has been observed at many reservoirs and their geological, hydrological and physical features remain the subject of intense investigations.

During impoundment or after it with several months delay (years) the number and magnitude of earthquakes around the reservoir significantly increases. This increase is related to the complex impact of the water lake on the earth's crust under the reservoir and is explained by the changes in the ambient stress condition due to the load of the water or, respectively, to the increase of interstitial pore pressure in the rock matrix beneath the reservoir due to downward percolation of fluid [3, 7, 8]. It is also known that reservoir-induced seismicity decreases after several years down to the basic level of local seismic activity, when lesser earthquakes occur with lower magnitudes.

At present, many aspects of reservoir-induced seismicity become understandable [3, 4]. At the same time the decrease of seismic activity following the initial increase is still an open problem.

In the present study we investigated the influence of the water level variations (Fig. 1a) at the Enguri reservoir on the daily release of regional seismic energy (Fig. 1b).

As it follows from Figs. 1a and 1b, the daily emission of seismic energy at first increases under the influence of the Enguri reservoir. This increase of regional seismic activity during the first 3200-3400 days coincides with the

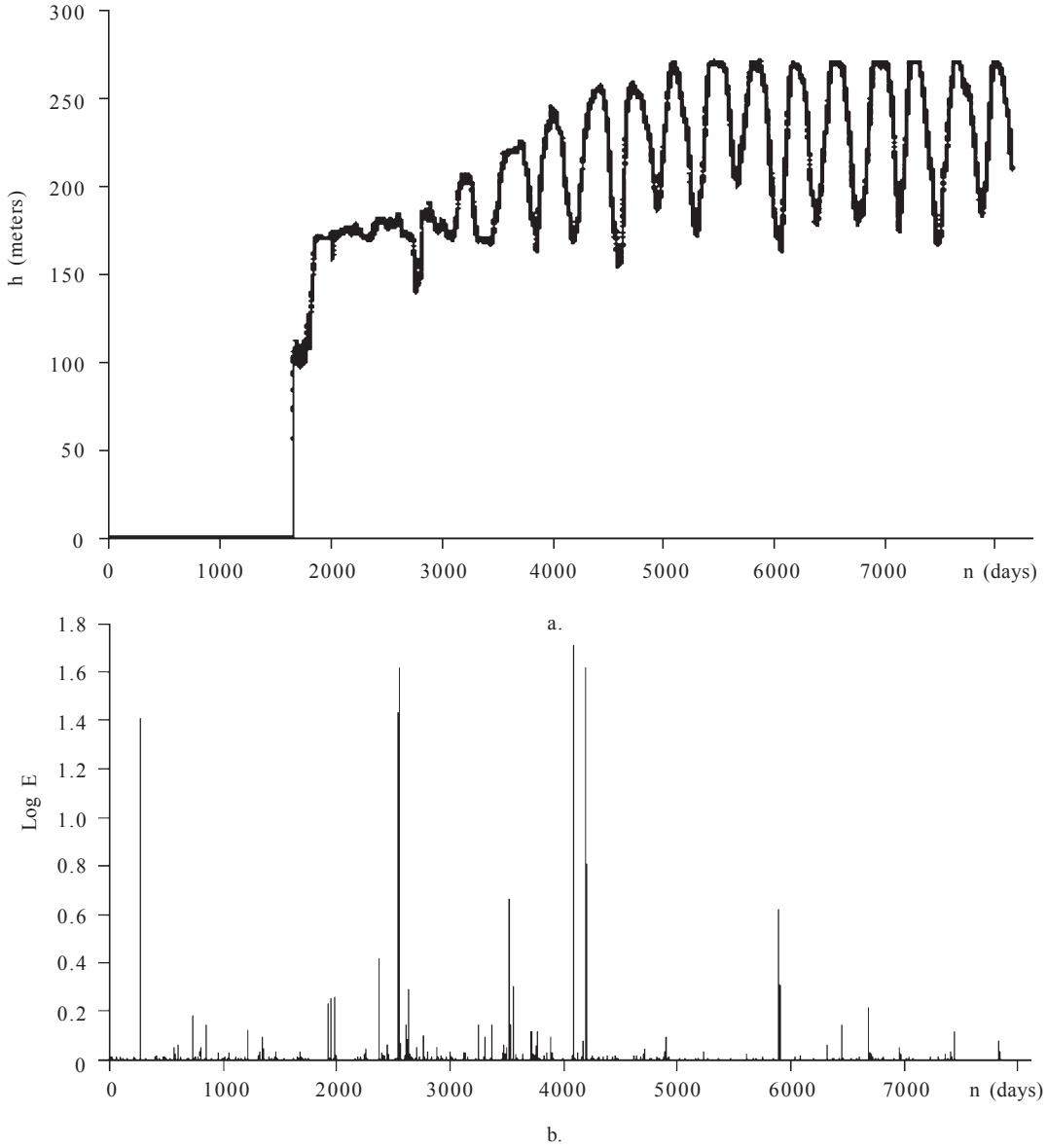

Fig. 1. a) Record of the daily water level in the lake of Enguri dam from 1975 to 1993, b) Log of normalized daily released seismic energy.

period of impoundment and reservoir filling. This is in good agreement with other observations [3, 4] and represents a clear example of reservoir induced seismicity.

Commonly, the initial period of increase is followed by a period when seismic activity gradually decreases [3, 8]. In the case of the Enguri reservoir the amount of daily released seismic energy and number of earthquakes decreases even to a smaller absolute level than that before impoundment (Fig. 1b). As is evident from Fig. 1, this decrease coincides with the interval of (seasonal) periodic changes of water level.

In order to test the reliability of this assumption we proceed from the analysis of the dependence of earthquakes monthly distribution on reservoir water level (Fig. 2). Here the monthly frequency of earthquake occurrence (MFEO) was calculated as a ratio of the monthly number of earthquakes that occurred during the last 8 years of water level periodic variation, normalized to the total amount of earthquakes for the same period. Similar calculation was carried out for the first five years of observation, when seismicity was not influenced by water level variation. As it follows from Fig. 2, when water level variation is periodic, earthquake occurrence appears unimodally distributed with maximal frequency of earthquakes occurring at reservoir discharge periods. At the same time without reservoir influence, the distribution of earthquakes was almost uniform. This means that the dynamics of water level variation may indeed affect local energy release.

Thus, the results of the present investigation, to-

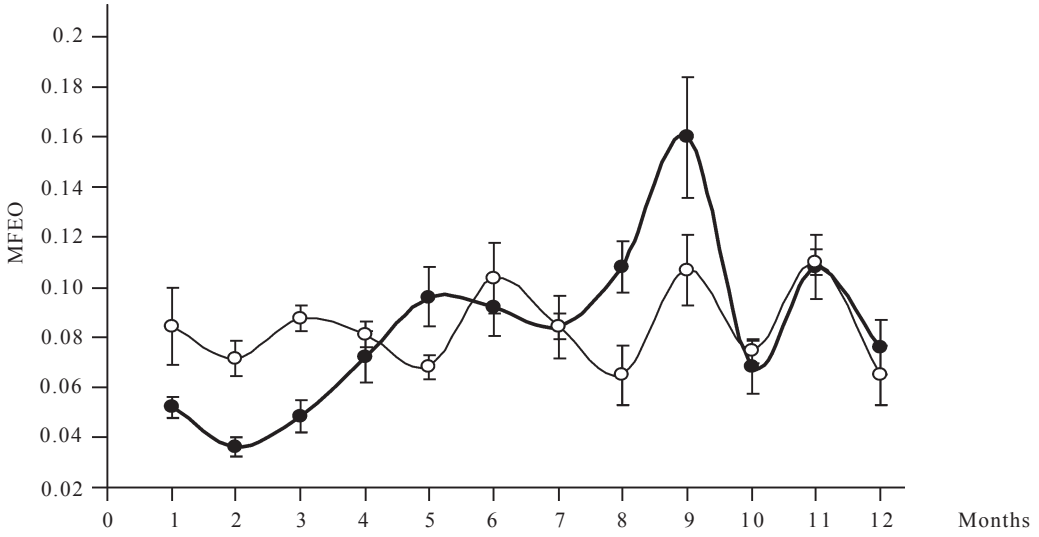

Fig. 2. Monthly frequency of earthquake occurrence before (open circles thin line) and during water level periodic variation (dark circles bold line).

gether with earlier findings on the synchronizing influence of reservoir water level variation [9], may be considered as evidence of the controlling influence of reservoir on related regional seismic activity.

გეოფიზიკა

წყალსაცავის გავლენით განპირობებული გამოთავისუფლებული ლოკალური სეისმური ენერგიის კონტროლი

ვ. აბაშიძე*, თ. ხუციშვილი*, ზ. ჯავახიშვილი*, ნ. ჟუკოვა*, ე. მეფარიძე*, თ. ჭელიძე, თ. მაჭარაშვილი***

* *მ. ნოდიას გეოფიზიკის ინსტიტუტი, თბილისი*
** *აკადემიის წევრი, მ. ნოდიას გეოფიზიკის ინსტიტუტი, თბილისი*

სტატიაში განხილულია წყალსაცავის გავლენით განპირობებული ლოკალური სეისმური აქტივობის კონტროლის შესაძლებლობის საკითხი ენგურჰესის წყალსაცავში წყლის დონის პერიოდული ცვლილების ზეგავლენის მაგალითზე.

შესწავლილ იქნა ენგურის მაღლივი კაშხლის წყალსაცავში წყლის დონის ყოველდღიური ცვლილებისა და ლოკალური სეისმური ქსელის მეშვეობით ჩაწერილი მონაცემები. გამოთვლილ იქნა მიწისძვრათა ყოველთვიური სიხშირე.

მიღებულ შედეგებზე დაყრდნობით ვასკვნით, რომ ყოველდღიური გამოთავისუფლებული სეისმური ენერგიის ცვლილება ენგურის მაღლივი კაშხლის ირგვლივ წყალსაცავში წყლის დონის პერიოდული ცვლილების დროს შეიძლება განხილულ იქნეს როგორც ლოკალური სეისმური აქტივობის შესაძლო კონტროლი.

REFERENCES

1. *D. W. Simpson*. (1986), Ann. Rev. Earth Planet. Sci., 14: 21-42.
2. *H. K. Gupta*. (1992), Reservoir induced seismicity, developments in geotechnical engineering, Elsevier.
3. *P. Talwani*. (1997), Pure and Appl. Geophys., 150: 473-492.
4. *C.I. Trifu* (Ed). (2002), The mechanism of induced seismicity. 623p; Special Volume, Pure & Applied Geophysics, 159.
5. *M. Assumpзo, V.I. Marza, L.V. Barros, C.N. Chimpliganond, J.E.P. Soares, J.M. Carvalho, D. Caixeta, A. Amorim, E. Cabral*. (2002), Pure Appl. Geophys., 159: 597–617.
6. *D. Simpson, W. Leith, C. Scholz.* (1988), Bulletin of Seis. Soc. America, 78, 2025-2040.
7. *M. Saar, M. Manga*. (2003), Earth and Planetary Sci. Letts. 214.
8. *A.F. Nascimento, P.A. Cowie, R.J Lunn., G. Pearce*. (2004), Geophys. J. Int., 158, 1041-1052.
9. *J. Peinke, T. Matcharashvili, T. Chelidze, J. Gogiashvili, A. Nawroth, O. Lursmanashvili, Z. Javakhishvili*. (2006), Physics of the Earth and Planetary Interiors, 156/1-2: 130-142.

Received December, 2006