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# Reaction of Georgian Wells to Remote and Nearby Earthquakes. Similarities and Differences

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## *ABSTRACT*

*The behavior of two wells located in Georgia is compared: Oni and Nakalakevi. A stable relationship (coupling coefficient) between the reactions of water in these wells to earthquakes is found. It is indicated that the coupling coefficients are different for remote and nearby earthquakes.*

***Key words:*** *coupling coefficient, resonance period, hydrodynamic anomalies, seismic event precursors.*

## 1. Introduction

*Well coordinates.* Oni well: 42.573° N 43.437° E. Nakalakevi well: 41.424° N 43.317° E.
The distance between the wells is 125 km.
*Well parameters.* Oni well: length 255 m, screen 70-250 m. Confined sub-artesian aquifer; fractured shale and basalts. Nakalakevi well: length 600 m, screen 255-367 m. Confined sub-artesian aquifer; fractured andesite-basalts.
The water level was recorded every 1 minute.

## 2. Data Analysis

If there is a reaction of water to an earthquake in the Oni and Nakalakevi wells, then:
1. The result of dividing "amplitude of water in Oni" / "amplitude of water in Nakalakevi" is 2.7-2.8 provided: a) remote earthquake (distance ≥1000 km); b) earthquake depth ≤ 40 km.
2. "Amplitude of water in Oni" / "Amplitude of water in Nakalakevi" is 5.7-6.2 if the earthquake is close (distance ≤600 km).

### Remote earthquakes

The table and the graph based on it make it possible to assert that under certain conditions the "amplitude of water in Oni" / "amplitude of water in Nakalakevi" is 2.7-2.8.

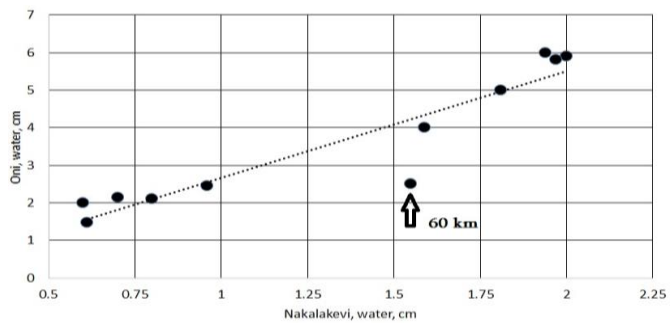


Fig.1. Amplitude ratio of Nakalakevi & Oni water as a reaction to remote earthquakes in 2020-2021.

Table 1. Remote earthquakes

| Date | Magnitude | Distance, km | Depth, km | Place | Nakalakevi, water, cm | Oni, water, cm |
|---|---|---|---|---|---|---|
| 14/05/2019 12:59 | 7.5 | 11876 | 10 | New Britain Region, P.N.G | 0.7 | 2.15 |
| 28/01/2020 19:10 | 7.7 | 11013 | 10 | Cuba Region | 0.6 | 2 |
| 25/03/2020 02:49 | 7.5 | 8094 | 60 | East Kuril Islands | 1.55 | 2.5 |
| 02/05/2020 12:51 | 6.6 | 1742 | 10 | Crete, Greece | 0.8 | 2.1 |
| 23/06/2020 15:29 | 7.4 | 12368 | 10 | Oaxaca, Mexico | 2.0 | 5.9 |
| 22/07/2020 06:12 | 7.8 | 9079 | 30 | Alaska, Peninsula | 1.94 | 6 |
| 19/10/2020 20:54 | 7.5 | 9103 | 40 | South of Alaska | 1.59 | 4 |
| 30/10/2020 11:51 | 7.0 | 1460 | 10 | Dodecanese Islands, Greece | 1.81 | 5 |
| 11/01/2021 21:32 | 6.7 | 4326 | 10 | Russia-Mongolia border | 0.61 | 1.48 |
| 13/02/2021 14:07 | 7.1 | 4866 | 60 | Near East Coast of Honshu, Japan | 0.96 | 2.45 |
| 04/03/2021 19:28 | 8.1 | 16123 | 29 | Kermades Islands, New Zealand | 1.97 | 5.82 |

**Nearby earthquakes**

Water response (or lack thereof) to earthquakes in Turkey at a distance <= 600 km from the well.
Conclusion for close earthquakes at a distance of ≤ 600 km

- If the magnitude is M = 5.0-5.5, then there is no reaction of water to earthquakes.
- If the magnitude is M ≥ 6, then the water reaction is observed and Oni / Nakalakevi is 5.73 or 6.12, which is twice the expected 2.7-2.8.

Remark. In [1, Fig. 1.5], coseismic jumps are noted at a distance from earthquakes ≤ 400 km, if the magnitude is Mw> 6, as well as their absence at a lower magnitude.
**Example 1** (distance ≤ 600 km)

1. 24/01/2020 17:55, M=6.8, D=587 km, H=15 km, Eastern Turkey. Oni/Nakalakevi=**5.73**.
2. 25/01/2020 16:30, M=5.1, D=599 km, H=7 km, Eastern Turkey. No water reaction.
3. 23/02/2020 05:53, M=5.7, D=346 km, H=10 km, Turkey-Iran Region, Oni=0.22 cm, Nakalakevi=0.0 cm.
4. 23/02/2020 16:00, M=6.0, D=471 km, H=10 km, Turkey-Iran border, Oni=3 cm, Nakalakevi=0.49 cm. Oni/Nakalakevi=**6.12**.
5. 15/06/2020 06:51, M=5.5, D=423 km, H=5 km, Eastern Turkey. No water reaction.
6. 25/06/2020 10:03, M=5.4, D=457 km, H=10 km, Turkey-Iran border. No water reaction.
7. 03/12/2020 05:45, M=5.0, D=529 km, H=14 km, Eastern Turkey. No water reaction.
8. 27/12/2020 06:37, M=5.5, D=577 km, H=2 km, Eastern Turkey. No water reaction.

**Example 2** (distance ≥ 1000 km)

1 26/06/2017 12:28, M=6.3, D=1498 km, Az=254°, H=9 km, Near the Coast of Turkey, Oni=1.22 cm, Nakalakevi=0.6 cm. Oni/Nakalakevi=1.22/0.6=**2.03**.

**Remark for nearby earthquakes at a distance of ≤ 600 km**

When comparing the reaction of wells Oni and Nakalakevi under the condition: distances <= 600 km and Oni/Nakalakevi> 5.5, note that the well Oni, reacting more strongly, is at the same time further down the well Nakalakevi per 100 km for earthquakes in Turkey.

## 3. Conclusion

**Well resonance period as a possible cause of different well response to remote/nearby earthquakes**

Let us calculate the resonance period *P* of the well, but previously simplify the calculations.

The formula for the resonance frequency of a pendulum is $f = \frac{1}{2\pi}\sqrt{\frac{g}{H}}$. Since $\frac{\sqrt{g}}{\pi} \approx 0.996 \approx 1$ and period $P = \frac{1}{f}$, then numerically (!) resonance period $P = 2\sqrt{H}$, where *P* is measured in seconds and pendulum's length *H* is in meters. For wells *H*=Hsolid+3/8*Hscreen, [1, p.96].

For well Oni *H*=138 m, for Nakalakevi *H*=530 m. Consequently, Oni have a resonance period *P*=23.5 sec. and for Nakalakevi *P*=46 sec.

For comparison, the sensitive well YuZ-5 located in Kamchatka [1] has a resonance period of 44.6 sec.

The length of the period of the incoming wave from remote earthquakes can be 13-30 sec. Nearby earthquakes have a shorter period of waves. Since the well Oni resonance period is 2 times less than Nakalakevi, then Oni react more noticeably. This difference sharply manifests itself at short distances from earthquakes, but affects differently at distant ones.

Remark. The length of the incoming wave's period was estimated based on the data of the TBLG, Delisi, Georgia seismic station, given in http://ds.iris.edu/wilber3, Station Monitor.

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# საქართველოს ტერიტორიაზე განლაგებული ჭაბურღილების რეაქცია მახლობელ და შორეულ მიწისძვრებზე. მსგავსება და განსხვავება


გ. კობზევი, გ. მელიქაძე, თ. ჯიმშელაძე



### რეზიუმე

ხდება საქართველოს ტერიტორიაზე განლაგებული ორი ჭაბურღილის, ონისა და ახლქალაქის რეაქციის შედარება. ვლინდება მჭიდრო კავშირი, მიწისძვრაზე ამ ორი ჭაბურღილის რეაქციებს შორის. აღმოჩნდა, რომ რომ მათ შორის კორელაციის კოეფიციენტი მახლობელი და შორეული მიწისძვრებისათვის განსხვავებულია.


# Реакция скважин Грузии на далекие и близкие землетрясения. Сходства и различия


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### Резюме

Сравнивается поведение двух скважин, расположенных в Грузии: Они и Накалакеви. Выявлена устойчивая связь (коэффициент связи) между реакциями воды этих скважин на землетрясения. Указывается, что для дальних и близких землетрясений коэффициенты связи разные.