საერთაშორისო სამეცნიერო კონფერენცია „დედამიწასა და მის გარსებში მიმდინარე გეოფიზიკური პროცესები“
შრომები, ISBN 978-9941-36-147-0, თბილისი, საქართველო, 16-17 ნოემბერი, 2023 წ.
International Scientific Conference "Geophysical Processes in the Earth and its Envelopes"
Proceedings, ISBN 978-9941-36-147-0, Tbilisi, Georgia, November 16-17, 2023

A NEW POINT OF VIEW AT THE DESTRUCTIVE 1827 TSAGHKADZOR EARTHQUAKE

*Haroutiunian R.A., **Asatryan A.H., ***Nazaretyan S.N., *Egnatosyan N.M.,
*Avagyan A.V.
*Institute of Geological Sciences NAS RA, Yerevan, Armenia
**Research Center for Cultural and Historical Heritage, Yerevan, Armenia
***Regional Survey for Seismic Protection. Ministry of Internal Affairs of the Republic of Armenia, Yerevan, Armenia
snaznssp@mail.ru

Abstract. *The devastating earthquake of October 8, 1827, known as the "Tsaghkadzor earthquake", was more powerful than previously imagined. As a result, not only churches in Tsaghkadzor and on the shores of Lake Sevan were destroyed, but also churches in other places in northeastern Armenia, as well as buildings in the city of Tbilisi. New estimates of earthquake parameters and a scheme of its isoseismals are presented.*

Key words: *Historical earthquake, epicenter parameters, isoseismals.*

Introduction

There is a lot of written information about strong earthquakes in Armenia over the past two thousand years. These data describe the behavior of the most significant monumental architectural structures us churches, temples, palace buildings, fortresses during natural devastating phenomena. The historical valuable information on the consequences of strong earthquakes mainly concerns the damage and destruction of church buildings built since the 4th century. Different interpretations are based on the described damages of the church buildings when determining the intensity of these earthquakes (and therefore magnitudes) [6]. The disagreement among experts, especially on the issue of assessing the parameters of the Tsaghkadzor earthquake of 1827 are significant. In this work, we have attempted to clarify the main parameters of the Tsakhkadzor earthquake in the light of the results of studying the consequences and characteristics of the 1988 Spitak earthquake.

1. Ideas about the Tsaghkadzor earthquake of 1827 before the destructive 1988 Spitak earthquake

According to chronicle sources [10], the most powerful earthquake recorded in the Caucasus in 1827 occurred on October 8, 1827 in Armenia. It affected the entire Aparan region, the village of Tsaghkadzor and the north, north-western shores of Lake Sevan. The French traveler Dubois de Montpere, who visited these regions of Armenia in 1834, writes: "The strong earthquake of 1827 shook most of Armenia and shook the Kecharis Church to such an extent that its dome collapsed. The same earthquake destroyed many churches on the shores of Sevan." Bishop Hovhannes Shakhatunyants reports: "In 1827, in the month of October, a not very strong earthquake occurred (according to V. Stepanyan, Shakhatunyants gave such an assessment in 1842 under the impression of the recently occurring catastrophic Ararat earthquake of 1840). As a result of the earthquake, only the Church of St. Sarkis monastery of Ushara (Ushi), the cathedral church of the Kecharis monastery, as well as private old houses in many places are destroed."

Piruzyan S. [9] conducted very detailed studies of the 1827 earthquake. The results of these studies are summarized as follows:

1. The earthquake caused destruction in only 2 churches of the Kecharis monastery. The Kecharis monastery includes four churches - St. Grigor, St. Nshan, St. Harutyun and Katoghike. They all have the same design; the walls were built from clean, large blocks of basalt, using very solid lime mortar. Church of St. Harutyun, the

smallest and most flexible, did not receive seismogenic destruction. Church of St. Grigor and Katoghike, the most massive ones, suffered significant damage, which, taking into account the very good quality of construction of Armenian churches, can be attributed to the intensity 9-10 points. Church of St. Nshan, which occupies a middle position in terms of rigidity (judging by its size), received minor damage (the upper outer part of the dome fell out). All the churches are located on very dense rock, on the edge of a cliff".

2. A survey of the epicentral zone showed that there were no destruction of seismic origin in other church buildings near Tsaghkadzor: Makravan (2 km), Bjni (10 km), Arzakan (13.5 km) villages, on the three churches in Sevan Peninsula (22 km), etc.

3. It was established that during the earthquake there was no mass destruction of rural houses, both in Tsaghkadzor itself and in nearby settlements (Makravan, Solak, Qakhsi, Ddmashen, etc.). This suggests that the intensity of the earthquake of 1827 did not exceed 6-7 points.

4. The destruction of churches in Tsaghkadzor is associated with the phenomenon of resonance of short-term high-frequency (15-16 Hz) seismic vibrations in the structures themselves.

5. The 1827 earthquake of an intensity 6-7 points occurred in the immediate vicinity of Tsaghkadzor, at a very shallow depth (probably no more than a few kilometers).

The following parameters were given in the scientific literature (coordinates of the epicenter, depth of the hypocenter (H), magnitude (M) and intensity (I0), characterizing the earthquake of October 8, 1827:

φN=40 °36', λE=44 °24', H=6 km , M = 4.5, I_0=6-7 [9],

φN=40 °33', λE=44 °42', H=10 km , M= 5.0, I 0 =7-8 [3].

These ideas persisted until the devastating 1988 Spitak earthquake, which occurred, according to the then existed seismic zoning map of Armenia, in the seven-point intensity zone.

2. Representations of the 1827 Tsaghkadzor earthquake after 1994 research.

In 1994 research was carried out at the initiative of the newly created National Service for Seismic Protection (NSSP) of Armenia, scientific work was carried out to researsh the seismic hazard in the area around the Armenian Nuclear Power Plant. Unfortunately, the report on these studies (Haroutiunian R.A., Karakhanian A.S., Assatrian A.H. (1994) ''Study of the impact of historical earthquakes on the territory within a radius of 25 km from the Metsamor NPP site'', in NSSP funds) was not published, the part of the obtained results were presented only in the collection of materials of the NATO workshop on historical earthquakes in the Caucasuss [2].

Historical chronicles have revealed irrefutable evidence of the destruction of churches in remote places from Tsaghkadzor village: on the shore of Lake Sevan (20 km to the east), in the village of Ushi (36 km to the southwest). Based on this, Piruzyan's opinion was questioned that the hypocenter of the earthquake was in the immediate vicinity of Tsaghkadzor at a depth of 6 km and the intensity of seismic vibrations at the epicenter did not exceed 6-7 points, since in this case it is impossible that such an earthquake could destroy an Armenian church 36 km from the epicenter.

In connection with this issue, additional research was undertaken to identify new data on the destruction of Armenian churches during the earthquake of October 8, 1827. As a result of studies of historical, chronicle and data on the destruction of historical monuments, new, previously unknown information was obtained about the destruction or damage of Armenian churches in 6 points in the northeast of Armenia [2]: the Church of St. Astvatsatsin in Vanadzor, Tekhenyats monastery complex in the village of Buzhakan, St. Grigor in the village of Ohanavan, Church of St. Zoravor in Haghpat, Dsevank Church in the Kayan fortress. In the destruction zone of this earthquake, other destroyed church buildings were discovered without indicating the time of destruction, but restored in the period 1830-1840. The latter allowed to attribut these destructions to the earthquake of 1827. The data obtained made it possible to outline the areas of 9-point and 8-point earthquakes, based on from an assessment of the degree of destruction of churches on the following scale:

- Intensity 9 and more - complete destruction,
- Intensity 8 - partial collapse of walls, and destruction of the dome.

The obtained 9-point isoseismal is a NNW elongated ellipse along the Garni active fault [2]. Thus, the epicenter of the earthquake of October 8, 1827 is located at the junction of the Garni and Alavar segments of the Garni active fault and has the following characteristics:

φN=40 °37', λE=44 °32'; M =6.5 ±0.5; I_0=8-9 points [2]

3. Results of new research.

In 2022, an article was published [5], rejecting our estimates of the Tsaghkadzor earthquake, considering them overestimated, and accepting the opinion of S. Phiruzyan [9] - the destruction of some church buildings was only in the Kecharis monastery, located in Tsaghkadzor, due to the phenomenon of vibration resonance in them, rural houses in Tsakhkadzor and neighboring villages did not collapsed, the intensity of seismic vibrations at the epicenter of the earthquake was of 6-7 points.

Even the date of the earthquake was questioned by critics [5]. To confirm the accuracy of the date, it is appropriate to mention the diary entry of E. Lachinov [4]: "I forgot to say before that during the occupation of Erivan on October 8, there were several rather strong shocks of earthquake repeated for about five days, reaching even Tiflis...". And also, "There was an earthquake on October 8, 1827, at 12.35 midnight in Tiflis and in all cities and provinces of Georgia" [1]. Note at that time Georgia (Kartli-Kakheti) included modern eastern Georgia and northern Armenia (regions of Gori, Dusheti, Telavi, Skhnakhi, Lori).

S. Phiruzyan's opinion that during the earthquake there were no massive destructions of rural houses, both in Tsakhkadzor itself and in nearby settlements (Makravan, Solak, Qakhsi, Ddmashen, etc.) [9] contradicts historical evidence. Let us cite one of them, dating back to 1829 [1]: "At the plant in Darachichak (Tsaghkadzor) there are now 6 small houses of stone belonging to the ore miners... Near the plant there are still the ruins of the Armenian Church and traces of a small village that was here in ancient times".

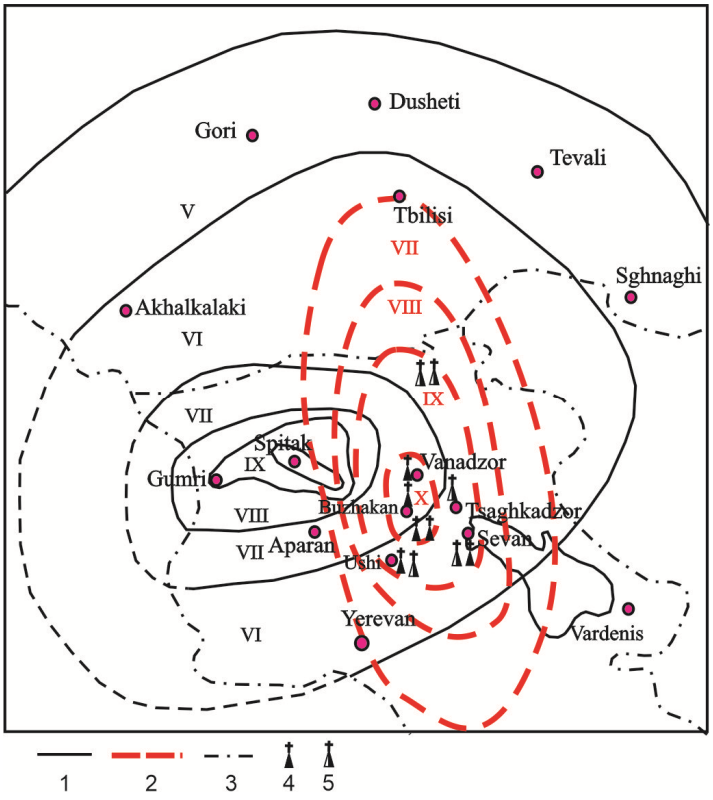

Fig. 1. Isoseismals of 1988 Spitak [7] and 1827 Tsaghkadzor earthquakes: 1 – isoseismals of the 1988 Spitak earthquake, 2 – isoseismals of the 1827 Tsaghkadzor earthquake, 3 – country borders. Consequences of the 1827 earthquake: 4 – destroyed churches, 5 – half-destroyed churches.

In 1994, when it became known that the Church of St. Nicholas, the Narikala fortress and residential buildings in the city were completely destroyed in Tbilisi. An assumption arose - since the 9-point seismic

vibrations that destroyed the church in Tbilisi could not have occurred during the Tsaghkadzor earthquake, it means there was another earthquake, the epicenter of which was to north of Tbilisi. Therefore, research in this direction was then stopped in 1994. Recently it turned out that there is another version of the reason for the destruction of the church and the fortress in which the church was located. A powder warehouse for the Russian army was built in the church, the explosion of which led to the destruction of the church and fortress. There is an assumption that earthquakes and explosions are interconnected (https://marshruting.com/2022/08/18/). It is very likely, since it resembles the situation in Yerevan, when during the 1988 Spitak earthquake, which manifested itself in Yerevan (as well as in Tbilisi) with 6-point fluctuations. After the second strong shock, a few minutes after the first, all IGS employees and visitors to the Geological Museum, located in the city center, hastily left the 2-story building, built in the 19th century. In this way one can imagine the situation in the powder magazine in the Church of St. Nicholas. Of course, a 7-point fluctuation could not destroy the church, but it could cause severe panic among the warehouse staff, which could leave the church building immediately after the first shock. And such vibrations, possible during the Tsaghkadzor earthquake, could well have knocked over the candlesticks, which could have caused a fire, a subsequent explosion of the gunpowder warehouse and the destruction of the church.

In 1994 was assessment intensity at the epicenter of Tsaghkadzor earthquakes of 9 points and it is believed that the collapse of domes and other significant destruction of churches are possible with fluctuations of 8 points [2]. Therefore, it is assumed that the earthquake of October 8, 1827 was weaker than Spitak. Now that all the data on the destruction zone of the Spitak earthquake has been summarized [6,7] and it turned out that the complete destruction of Armenian churches occurs with 10-point fluctuations, the fall of domes and other significant destruction occurs with 9-point fluctuations. Taking these parameters into account, a new isoseismals scheme of the 1827 earthquake was constructed and, judging by the more extensive isoseismals for 7-10 points, it was much more powerful than the Spitak earthquake of 1988 (Fig.1).

Thus, the Tsaghkadzor earthquake of 12:35 p.m., October 8, 1827, which shocked the all territory of modern Armenia and eastern Georgia and had the following characteristics:

$$\varphi N=40\ ^\circ 37',\ \lambda E=44\ ^\circ 32';\ M=7.1\pm 0.2;\ I_0=10 \text{ points}.$$

References

[1] Acts, collected by the Caucasian Archeographic Commission.// Volume VII, Tiflis, 1878, 954 p., (in Russian).

[2] Haroutiunian R.A., Karakhanian A.S., Assatrian A.H. Strong Historical Earthquakes in the Armenian Upland: new data and elaboration of a technique. // (in Proceedings of the NATO Advanced Research Workshop on Historical and Prehistorical Earthquakes in the Caucasus, Yerevan, Armenia, Vol. 28, July 11-15, 1996, pp. 375-382.

[3] Karapetyan N.K. The mechanism of occurrence of earthquakes in the Armenian Highlands. // Yerevan. Pub house Academy of Sciences of the Armenian SSR, 1986, 228 p. (in Russian).

[4] Lachinov E.E.'s diaries and records. // In Collection of documents and materials - Decembrists in Armenia and Transcaucasia, Yerevan, 1985 (in Russian).

[5] Melik-Adamyan H.U., Krbekyan V.G., On the issue of the strength, intensity and destructive effect of the Tsaghkadzor earthquake of 1827. // In the journal "Crisis Management and Technologies", 2022, N 1, pp. 204-214 (in Russian).

[6] Nazaretyan S.N., Mkhitaryan K. A., Mughnetsyan E.A., Tigranyan M.T. Principles of compiling a special macroseismic scale for damage to Armenian churches to assess the intensity of historical earthquakes. // Materials of the International Conference dedicated to the 100th anniversary of Yerevan State University "Modern problems of geography and geology". Pub. house of Yerevan State University, 2018, pp. 204-208. http://www.ysu.am/files/3-1573628784-.pdf

[7] Nazaretyan S. The 1988 Spitak Earthquake in Photos, Facts and Comments. // Pub. house ANAS. Pub. house Gitutyun, Yerevan, 2018, 140 p. http://www.mes.am/files/docs/3199.pdf.

[8] Nazaretyan S.N. Seismic hazard and risk of the territory of the cities of the Spitak earthquake zone of 1988. // Pub. house "Gitutyun" ANA,. Yerevan, 2013, (in Russian).

[9] Phiruzyan S.A. A detailed study of seismic activity and seismotectonics of the Greater Yerevan region. // In the book Geology of the Armenian SSR, vol. X, Geophysics, 1972, pp. 154-157, (in Russian).

[10] Stepanyan V.A. Earthquakes in the Armenian Highlands and surrounding areas. // Pub. house "Hayastan", Yerevan, 1964, (in Armenian).