



# Ten years of archaeoseismological research in Armenia (2004–2013)



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## ABSTRACT

The results of the observations made during our 2003–2013 missions in Armenia are described here:

I. Several seismic events, unknown in the written sources and the latest catalogs, were identified: A) At Erebuni, in the Ararat plain, an earthquake ruined the temple of Khaldi at the end of the Urartu period and led to the abandonment and the transformation of the quarter where it had been established, probably around the end of the 7th c. BC; B) At Benjamin, in northwestern Armenia, an earthquake caused important damage to parts of the Hellenistic settlement, in particular on the tower-porch at the east; the traces of repairs indicate that this event dates to the same period; C) The study of the bridge at Garni and the church of the village, southeast of Yerevan, have revealed a seismic event that occurred at least earlier than the earthquake of 1679, the only one mentioned in the texts, which is used as a reference for all the destruction dates in the region.

II. The observations made of the traditional rural constructions called “hazarashen” have not only enabled the dating of this building tradition to at least as early as the Hellenistic period (4th c. BC); they have also enabled identification of the lozenge-shaped deformation in these structures as a characteristic effect of the disturbances caused by the earthquake, a deformation resulting from and accompanied by compression or extension of the walls according to their position in relation to the direction of the ground motion.

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## 1. Introduction

Since 2004, within a program of the French National Centre for Scientific Research (Programmes Internationaux de Collaboration Scientifique), we have worked in collaboration with our Armenian colleagues A. Karakhanyan and A. Avagyan (Institute of Geological Sciences, Academy of Sciences of the Republic of Armenia), as well as their collaborators, on the subject of archaeoseismology. Our task has been to observe the evidence for damage and disturbances present on archaeological sites and in ancient buildings, in order to reveal past earthquakes for which we have no trace in the written sources. In this article, we present the observations and interpretations that we have carried out on different sites and monuments, at Erebuni, Benjamin and Garni, as well as analyses of recurrent phenomena of destruction and deformation in the traditional houses of Armenia, called “hazarashen” houses.

## 2. In search of unrecorded past earthquakes in Armenia

**Fig. 1** Location map for the sites studied.

### 2.1. Archaeoseismological observations at the excavations of the Franco-Armenian archaeological mission at Erebouni (temple of Khaldi)

The archaeological site of Erebuni, on the hill called Arin-Berd, south-west of the city of Erevan (**Fig. 1**), has been the object of excavations since 1950. The vestiges of a large fortified settlement have been brought to light, including monumental constructions and many other buildings considered to be storehouses. The inscriptions found in some of these constructions have shown that the foundation of this fortress should be attributed to a king of Urartu, Arghisti 1st, in 782 BC, “to the glory of the god Khaldi”, the principal god of Urartu, who had a temple there. In 2010 excavation of the temple of Khaldi was resumed by a Franco-Armenian team in order to define the conditions and chronology of the transition between the end of the kingdom of Urartu and the period of Achaemenid occupation that followed.

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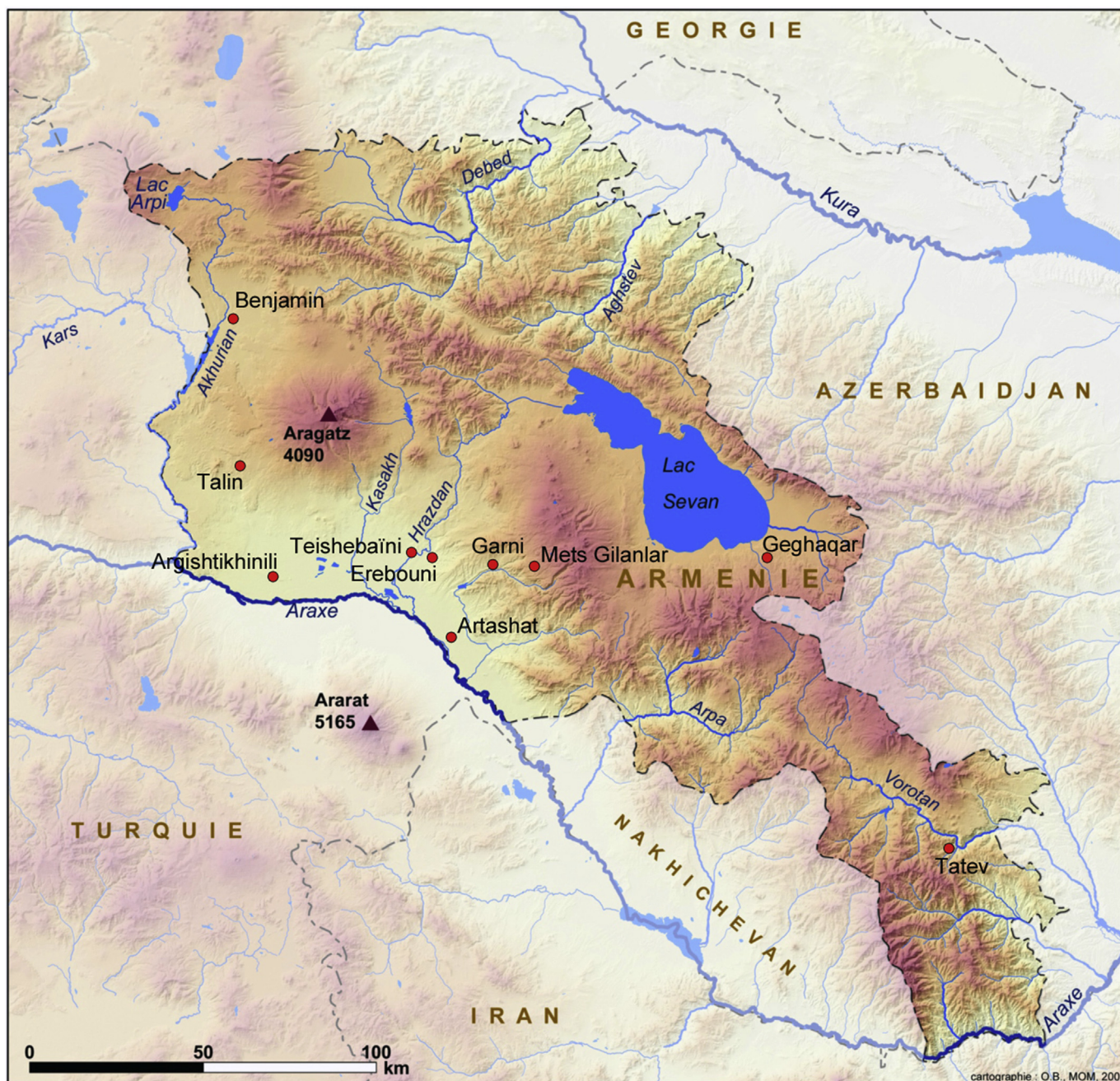


Fig. 1. Map of Armenia with the sites mentioned in the text.

The observations made during the course of the excavation (Fig. 2) have enabled the discovery that an earthquake ruined the temple of Khaldi at the end of the Urartu period and led to the abandonment and the transformation of the quarter where it had been established, probably around the end of the 7th c. BC.

#### 2.1.1. Typology of the disturbances observed

2.1.1.1. 1. Temple of Khaldi, wall 1133. The examination of wall M 1133 revealed evidence for characteristic disturbances which are also visible all around the temple: conchoid flakes resulting from displacements and vertical and horizontal shocks, fracturing of stone blocks, rotations and tilting of certain blocks (such as the one carrying the inscription of Arghishti, which moreover fragmented at the lower angle), horizontal thrust towards the north, of which

the effects are found throughout the monument and the site (Fig. 3).

2.1.1.2. 2. Temple of Khaldi, north wall, gate-niche 1198 (Fig. 4). On the left door-jamb of the gate-niche are blocks that have rotated (R), fractured blocks (F) with traces of conchoid flakes (EC), as well as a bulge resulting from a displacement towards the north–northeast (Fig. 4b).

On the right door-jamb are fractured and displaced blocks, also with bulges. The mud brick wall is probably an added buttress (Fig. 4c).

On the right door-jamb of the niche (Fig. 4d), we have confirmation for a thrust towards the north, associated with manifestations of vertical shocks (conchoid flakes or fracturing and

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