Publishe

Travertinization and Holocene Morphogenesis in Armenia: A Reading Grid of Rapid Climatic Changes Impact on the Landscape and Societies Between 9500-4000 cal. BP in the Circumcaspian Regions?

Vincent Ollivier[1,2], Sébastien Joannin[3,4], Paul Roiron[5], Samuel Nahapetyan[6]
and Christine Chataigner[7]

Context and problematic

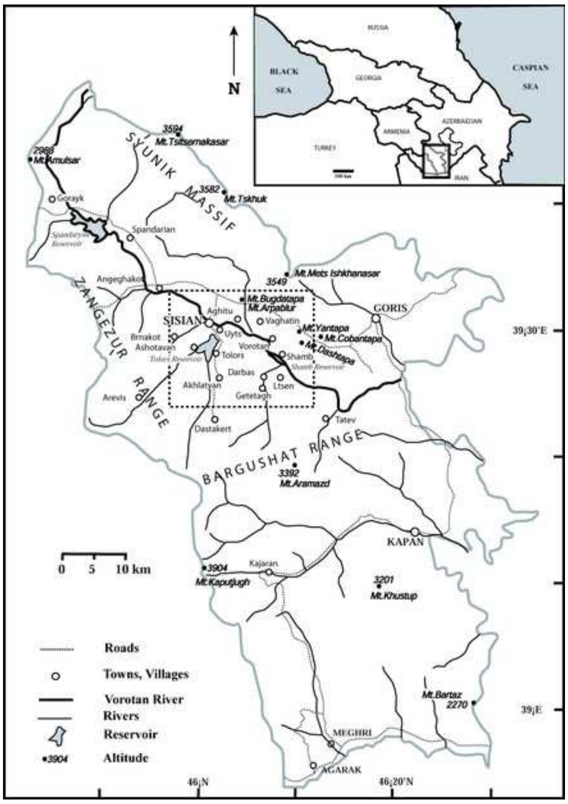

Fig. 1: Location map.

Travertine deposits are very rich paleoenvironmental and geomorphological archives. Thanks to their biosedimentary formations property with physico-chemical and biochemical origin, they are sensitive to biotope changes linked to climatic oscillations and/or anthropogenic activities (Ollivier et al. 2006). Frequently localized downstream karstic resurgence, they need temperate and humid climate with relatively forested watershed to be significantly developed. Coupled with morphosedimentary analysis, they are very useful to reconstruct landscape mutations patterns concerning long to short time period. Integrated into the 'Caucasus Mission' Program (CNRS, MAE) and the International Associated Laboratory HEMHA ('Humans and Environment in Mountainous Habitats: The Case of Armenia'), one of the objectives of our research is to define and identify the rapid climate changes and their impact on the landscape mutations (including expressions, terms, rhythms and amplitudes) and societies in the Circumcaspian regions. To answer this question we use the Quaternary travertine system development analysis in feedback with the morphogenical trend variations in a pluridisciplinary approach integrating geomorphology, paleoecology and archaeology.

The Holocene travertine systems studied are located in the Vorotan valley (Syunik region, southern Armenia, Fig. 1). This major river in Armenia rises in the Syunik mountains and is confluent with the Arax near the Iranian border. The area is dominated by lower Pleistocene diatomitic fluvio-lacustral deposits with rich palaeoecological content already analyzed (Fig. 2 and 3, Joannin et al. 2010; Ollivier et al. 2010).
A total of five major travertine formations were studied in Uyts, Shamb and Tatev localities. The most detailed analysis was performed in the Shamb 2 travertine sequence.

[1] Collège de France, PrOCauLAC-UMR 7192 du CNRS, Paris
[2] Maison Méditerranéenne des Sciences de l'Homme, LAMPEA-UMR 6636 du CNRS, Aix en Provence, France
[3] CNRS-UMR 5276 LGL TPE, Université de Lyon, Lyon, France
[4] CNRS-USR CNRS-UMR 6249 LCE, 32 rue Mégevand, Besançon, France
[5] Université de Montpellier 2, CBAE-UMR 5059 du CNRS, Montpellier, France
[6] Department of Cartography and Geomorphology, Yerevan State University, Armenia
[7] Université de Lyon 2, Archéorient, UMR 5133, Maison de l'Orient, Lyon, France

Morphosedimentary analysis, absolute dating and palynology

The morphosedimentary approach was used to correlate in a spatiotemporal dynamic scale the different facies and morphologies of the travertine formations from low to high energy sedimentary pole (sharp travertine to chalky units). The samplings for dating were performed on each facies' variations which are the expression of hydrodynamic and / or climatic changes (from dry to humid conditions) in a short time range. We used Uranium / Thorium and Radiocarbon dating methodology to better fit the morphosedimentary evolution (Poznan Radiocarbon Laboratory (Poland), IFM GEOMAR (Kiel, Germany)). Some of the travertine formation allows palynological analysis. The first samplings were collected on the silty and chalky facies of the most representative and continuous formation in Shamb 2.

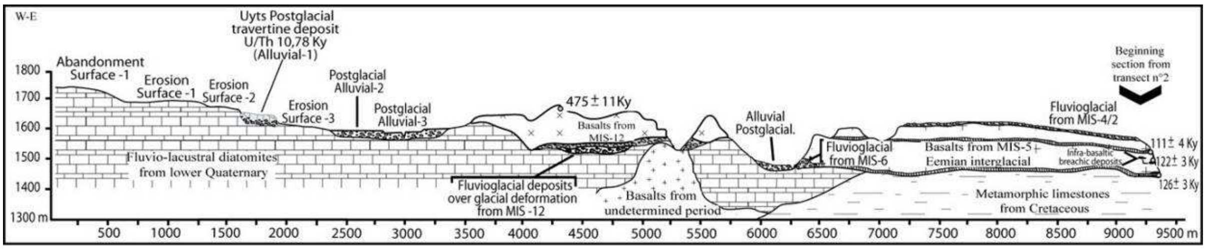

Fig. 2: Uyts-Aghitu geomorphological transect with travertine formation localization.

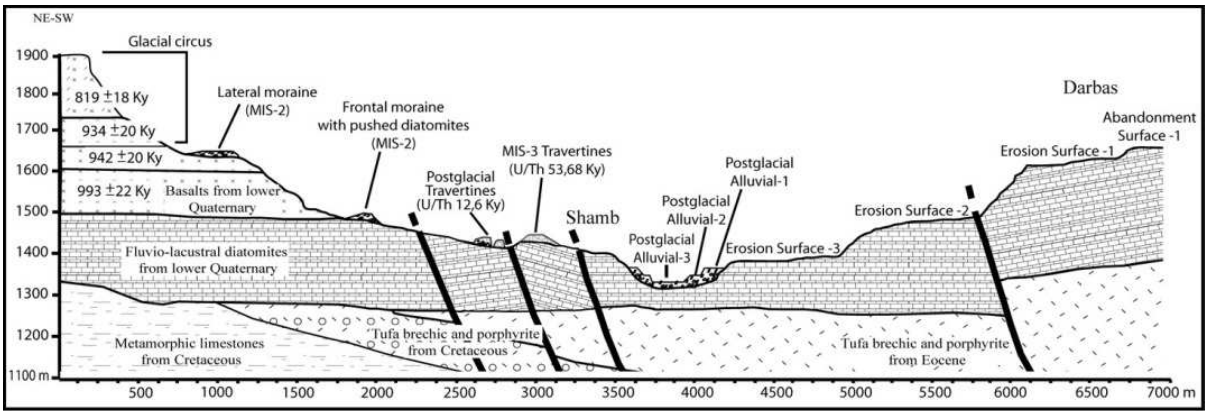

Fig. 3: Shamb-Darbas geomorphological transect with travertine formation localization

Preliminary results

The main part of the valley connected to the Vorotan River in the Sisian-Tatev localities area were quickly filled by alluvial formations (around 6 to 10 meters thickness) during the Lateglacial and the Holocene. Fire signatures can be read inside the Lateglacial silt deposits and are represented by burned levels with charcoals. This kind of record probably underline a short period of drier climate around 12,900 cal. BP corresponding to the Younger Dryas event. The first travertine formations, which often express the production of biogenic carbonate and high aquifer levels, appear from the very beginning of the Holocene in the context of the postglacial warming.

A record of Rapid Climate Change and major landscape mutation around the 8th millennium BC identified through the Shamb 2 travertine

The Shamb 2 travertine formation (Fig. 4) is the most representative of the rapid climate change affecting the first part of the Holocene. In terms of sedimentary facies, our results clearly show the progression of temperate and humid conditions since the Last Glacial Maximum with an optimum ranked around 9000-9500 cal. BP. These conditions are expressed through the progressive development of various travertine facies, from chalky units to sharp carbonated deposits that underline the growth of hydrodynamic conditions in the valley. The major phase of carbonated accumulation highlighted at this time indicates an

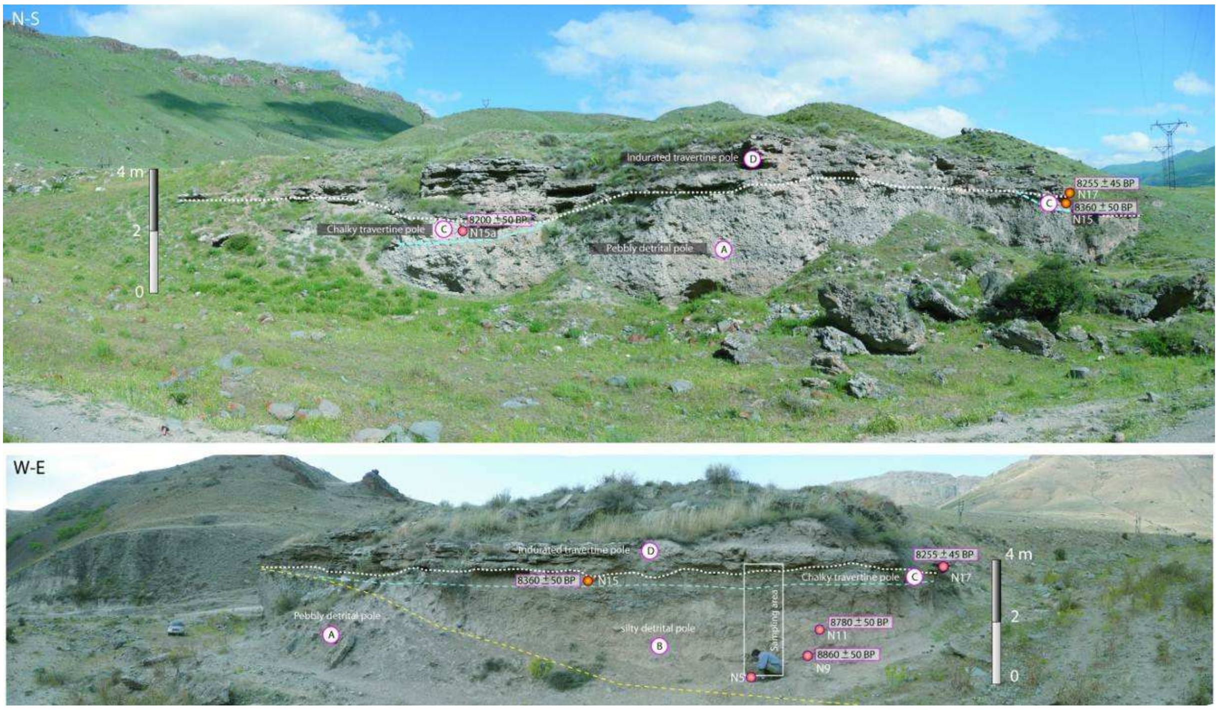

Fig. 4: Shamb 2 holocenic travertine formation.

important environment changing with the appearance of attractive humid zone for the Neolithic populations in this area. The pollen analysis gives more paleoenvironmental detail on these results. Thirteen samples provided enough pollen grains for pollen analysis (Fig. 5). On this short-time record (1000 years), herbs and steppe mainly composed an open-vegetation landscape where only few temperate trees (*Quercus* and *Carpinus* mainly) probably developed in the valleys. Thanks to a high temporal sampling resolution (80 yrs/sample on average), a more woody phase, and therefore a more humid phase is recorded from around 10,000 to 9500 cal. BP in accordance with the sedimentological analysis.

This travertinization optimum around 9500-9000 cal. BP corresponds to a period of humidity identified in Anatolia, in the north-western Iran and more generally in the Caucasus (Kvadadze and Connor 2005; Morteza et al. 2008; Turner et al. 2008; Wasylikowa et al. 2008; Wick et al. 2003). After this episode, the travertine growth records an abrupt interruption. Around 4000 cal. BP, the permanent antagonism between the sedimentation budgets (erosion/sedimentation), main parameter controlling the travertine formations development, is again positively balanced in favor of carbonate accumulation as we can be observe with the Tatev travertine formation in the downstream part of the Vorotan valley. The Tatev travertine (4140 cal. BP) contains numerous leaf imprints that allow us to reconstruct the local vegetation (Figs 6 and 7). This travertine is the last testimony of the Holocene carbonatogenesis in the Vorotan Canyon. Its lower position in the valley show the major impact of cutting phases related to climate but also to the local tectonic evolution.

Between 9000-4000 cal BP. an important cutting of the valleys occurs (ca. 40 m depth). According to the dating and the geometry of the Shamb (9500-9000 cal BP.) and Tatev (4140 cal. BP) travertine formations, this incision can be connected to the

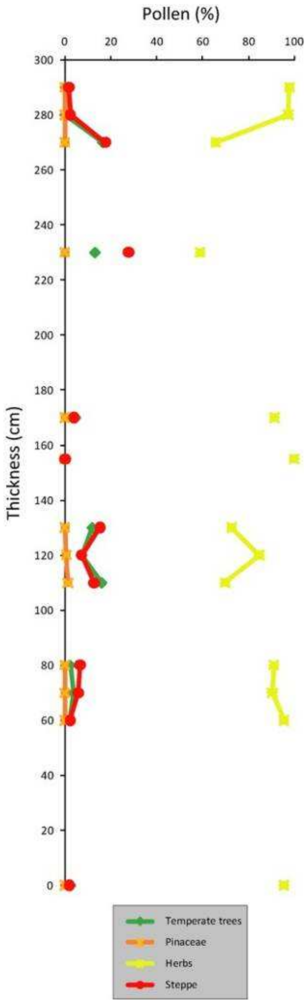

Fig. 5: Palynological diagram of the Shamb 2 holocenic travertine formation.

cumulative effect of the river sedimentary budget variation balance and to the uplifting of the Lesser Caucasus range. The interpolation of our results allows us to calculate the tectonic impact on the landscape mutation in this area and to propose an uplift rate situated ca. 8 mm/year.

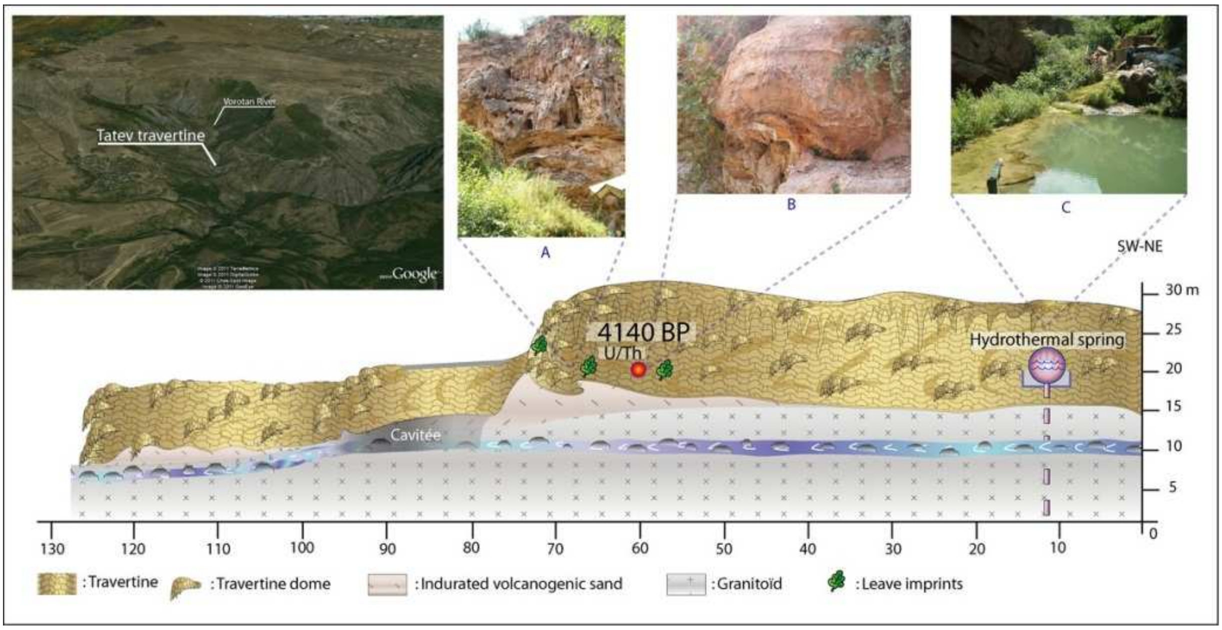

Fig. 6: Tatev holocenic travertine formation.

Rapid Climate Change and tectonic data, the travertine as a reading grid of Neolithic/Chalcolithic landscape mutations in Circumcaspian regions?

The analysis of the morphosedimentary travertine system development in Lesser Caucasus, allow to identify and characterize the rapid Postglacial climate changes and their potential impact on the landscape mutations and societies of this bioclimatic and cultural croassroad area between Africa, Asia and Europe. The sensitivity and responsiveness of the travertine formations are an efficient recording of the rapid and short term (inferior to 1 Ky) climate changes. The generalized and synchronized travertine system development in the valleys illustrates a major landscape mutation with the apparition of alluvial/marshy environment in a prior context dominated by dry and steppic valleys. The cumulative effects of alluvial incision and tectonic elevation on the valleys physiography between the beginning and the end of the Holocene underline the importance and the rhythmicity of the landscape mutations (Fig. 8). Such Holocene landscape changes variability must have influenced the human group mobility and/or occupation modes.

Few Neolithic sites are known in Armenia (Tsaghkunk, Aratashen, Verin Khatunarkh / Aknashen, Teghut, Ada-Blur, Masisi-Blur, Artashat) and the fragmentary character of the information available has not allowed the establishment of a precise chronological sequence for the material culture within the 7th/6th to the middle of the 4th millennium BC (Badalyan et al. 2010). The widespread use of the landscape reading grid provided by the geomorphological study of the travertine systems could be useful to have a better knowledge about the relationship between environmental fluctuations and the evolution of the Neolithic societies but also to lead differently the prospecting for new archaeological sites or to understand their absence in some areas.

In the zone of the studied travertine formations the correlation between environmental and archaeological data is under progress and will be also available for the Chalcolithic period with the site of Godedzor (4th millennium BC) excavated in the framework of the Caucasus Mission. At last, the wide dissemination of travertine formations context allow to work on local and extra-regional scale but also diachronically on the whole Quaternary period.

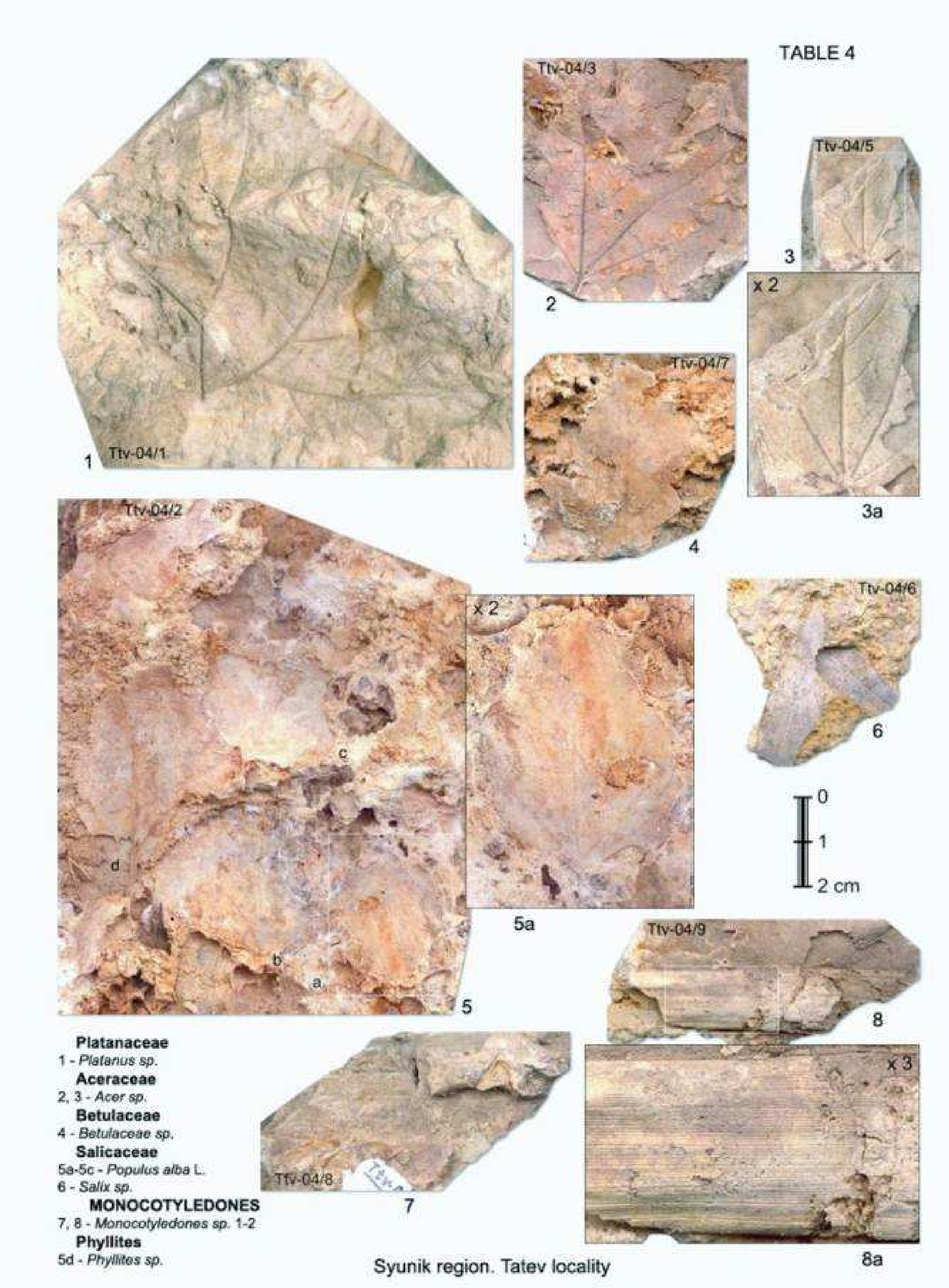

Fig. 7: Leave imprints of the Tatev travertine formation.

Fire is a key ecological factor at different scales of space and times. In addition with palynological analysis, studies about fire frequencies using microcharcoal distribution in Armenian chalky travertine or detrital sequences (were fire signatures are frequently recorded) will also be provided in the context of the International Associated Laboratory HEHMA to reconstruct Holocenic bioclimatic oscillations as well as anthropogenic landscape impact of the Neolithic occupation modes. Many multidisciplinary (geomorphology, archaeology and paleoecology) research opportunities focused on circumcaspian travertine system environment are open.

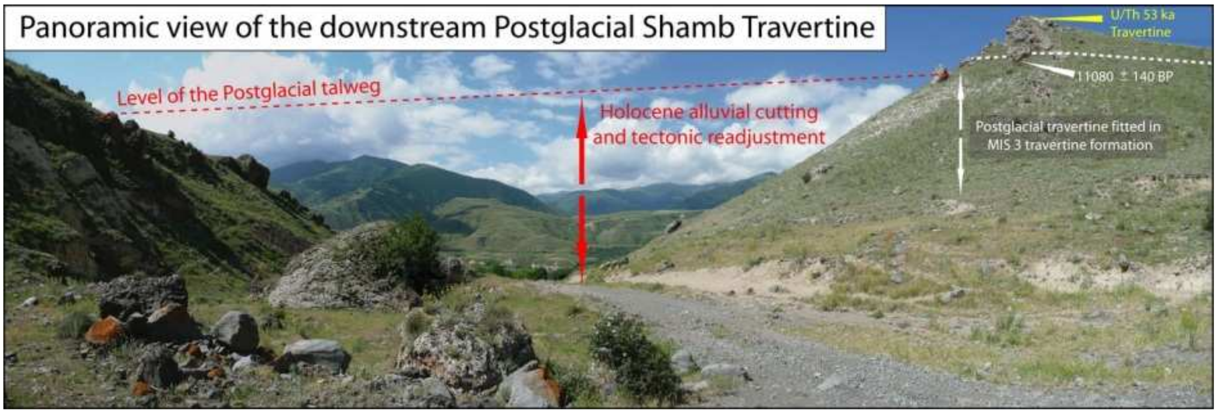

Fig. 8: Holocene alluvial cutting and tectonic readjustment around Shamb travertines.

References

BADALYAN S. R., HARUTYUNYAN A. A., CHATAIGNER C., LE MORT F., CHABOT J., BROCHIER J. E., BALASESCU A., RADU V., HOVSEPYAN R. 2010. The settlement of Aknashen-Khatunarkh, a Neolithic site in the Ararat plain (Armenia): excavation results 2004-2009, *Tüba-Ar*, 13: 185-218.

KVADADZE E.V., CONNOR S.E. 2005. *Zelkova carpinifolia* (Pallas) K. Koch in Holocene sediments of Georgia—an indicator of climatic optima. *Review of Palaeobotany and Palynology* 133 : 69–89.

OLLIVIER V., GUENDON J.-L., ALI A., ROIRON P., AMBERT P. 2006. Evolution postglaciaire des environnements travertineux provençaux et alpins : nouveau cadre chronologique, faciès et dynamiques morphosédimentaires, *Quaternaire* vol. 17 (2) : 51-67.

OLLIVIER V., NAHAPETYAN S., ROIRON P., GABRIELYAN I., GASPARYAN B., CHATAIGNER C., JOANNIN S., CORNEE J.-J., GUILLOU H., SCAILLET S., MUNCH P. AND KRIJGSMAN W. 2010. Quaternary volcano-lacustrine patterns and paleobotanical data in South Armenia, *Quaternary International* 223-224: 312-326.

JOANNIN S., CORNÉE J.-J., MUNCH P., FORNARI M., VASSILIEV J., KRIJGSMAN W., NAHAPETYAN S., GABRYELIAN Y., OLLIVIER V., ROIRON P., CHATAIGNIER C., SUC J.-P. 2010. Early Pleistocene climatic cycles in continental deposits of the Lesser Caucasus of Armenia inferred from palynology, magnetostratigraphy, and 40Ar/39Ar dating of volcanic tufs, *Earth and Planetary Science Letter*, 149-158.

TURNER R., ROBERTS N., JONES M.D., 2008. Climatic pacing of Mediterranean fire histories from lake sedimentary microcharcoal. *Global and Planetary Change* doi: 10.1016/j.gloplacha.2008.07.002.

WASYLIKOWA K., VAN ZEIST W., WRIGHT H.E. JR, STEVENS L., WITKOWSKI A., WALANUS A., HUTOROWICZ A., ALEXANDROWICZ S.W., LANGER J.J. 2008. The Lake Zeribar palaeoecology: a synthesis. In: Wasylikowa, K., Witkowski, A. (eds), The palaeoecology of Lake Zeribar and surrounding areas, Western Iran, during the last 48,000 years. *Diatom Monographs* 8, 303-321. A.R.G. Gantner Verlag K.G., Ruggel.

WICK L., LEMKE G., STURM M., 2003. Evidence of Lateglacial and Holocene climatic change and human impact in eastern Anatolia: high resolution pollen, charcoal, isotopic and geochemical records from the laminated sediments of Lake Van, Turkey. *The Holocene* 13, 665-675.