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RESEARCH PAPER

The Impact of Geological Processes on the Location of Shahrake Firouzeh, a Prehistoric Site from NE Iran

Mohammad Hossein Rezaei and Hassan Basafa

Today, geoarchaeological studies have turned into a useful tool in archaeological studies to explain ancient Quaternary environments. This paper examines the impact of environmental and geological conditions on location of Late Bronze Age Shahrake Firouzeh settlement. Shahrake Firouzeh settlement is located northwest of Neyshabur County with an average altitude of 1250 meters above sea level and 36°12′48″N 58°47′45″E coordinates. At the same time, geological and sedimentation outcrops based on research method of systemic comparative analysis have been used to examine the impact of these conditions on location and/or destruction of this site. Evidence suggests the occurrence of a massive climatic catastrophe in the second millennium BC in Shahrake Firouzeh site, which buried the entire plain under alluvial deposits in a short period of time. These developments occurred concurrent with the establishment of the settlement and a short while after abandonment of it. Due to the vast area of Shahrake Firouzeh, lack of water extraction techniques of qanāt and deep well digging, the conveyance of water from Somea basin through canals can be deemed. Location of Shahrake Firouzeh on floodplain deposits as well as minimum distance from the watershed outlet due to water conveyance indicates the agricultural origin of this site.

Introduction

Nowadays, archaeologists and anthropologists have no doubt that human search for food and their settlement strategy in land is related to ecological function of landscape, which is understandable for expansion of energy and foodstuff in time and space dimension in all aspects of landscape (Butzer, 1982). Therefore, understanding the geological structure and environmental context of a landscape as well as environmental data reflecting these behaviors enable better perception of choice of various strategies in different ecosystems by man in the past (Niknami 2004, 52). Geoarchaeological survey has now become an explanatory tool in archaeological studies to elucidate ancient Quaternary environments. Different criteria have been presented for recognition of ancient environments, including survey of sediments, morphology of the environment and its relationship with environmental conditions of human settlements (Maghsoudi et al. 2012: 2).

In general, geoarchaeological studies have not a long history in Iran and have been limited to archaeological excavations and research in previous years. Through survey of sediments in ancient site of Tepe Pardis in Qarchak County of Varamin in Tehran Plain, Gillmor et al. (2009 & 2011), as well as studying environmental conditions of the past, found vestiges of an artificial irrigation network, which indicated the efforts of chalcolithic man to acquire water harvesting technology. In another study, Gillmor et al. examined the ancient environmental conditions and their impact on settlement of prehistoric man in Tehran Plain (Gillmor et al. 2011). Schmidt et al. studied the sediments of ancient sites in Sagzabad cluster of Qazvin Plain to survey the rate and type of sedimentation in the studied area and attempted to express the relationship between environmental conditions and human settlement in this region (Schmidt et al. 2011). Moreover, during the excavations of Pishva city in Varamin County, Pedrami (1985) examined climatic changes using sedimentological data while reviewing the regional sediments. In his study, Maghsoudi surveyed the distribution of prehistoric settlements in alluvial plain of Jajrood (Maghsoudi, 2008). Quigley et al. studied the likelihood of the impact of tectonic movements due to active faults in Qazvin Plain on displacement or loss of prehistoric settlements (Quigley et al. 2011). In this context, Barberian and Yeats discussed the same phenomenon with a seismologic approach in two separate articles (Barberian and Yeats, 1999 & 2001). Sohbati et al. (2011) studied the Cheskin anticline in Bouin Zahra region and examined the possible influence of tectonic movements in abandonment of prehistoric settlements in Qazvin Plain. Furthermore, zooarchaeology and archeobotany studies were conducted in Qazvin Plain ancient by Mashkour et al. (1999), Mollasalehi et al. (2006) and Shirazi et al. (2006).

Research Method, Geographic Area

This article is based on compilation of library data, especially on the basis of field excavations results in Shahrake Firouzeh site as well as geoarchaeological studies. At the same time, research methodology has been based on sys-

Department of Archaeology, University of Neyshabur, IR

Corresponding author: Mohammad Hossein Rezaei (mohammad.1561@yahoo.com)

temic comparative analysis in which the impact of Environment conditions on location and/or destruction of the site has been dealt with using outcrop geology and sedimentation in the region. In other words, the aim of this study was to evaluate the effect of geomorphological features and elements on formation and site selection as well as influence of environmental conditions on displacement or loss of Shahrake Firouzeh site.

Neyshabur County is located north to Khorasan Razavi Province and is limited to Ghoochan County from north, Chenaran and Mashhad from east, Torbat-Heydarie and Kashmar from south, Sabzevar from west and Faruj County of North Khorasan Province from northwest (**Figure 1**). Neyshabur has specific natural and geographical characteristics, and has been considered by human communities from long ago due to its communication role en route communication and trade paths, especially Great Khorasan Road (Silk Road). Shahrake Firouzeh site is an important prehistoric settlement in this region, which dates back to Late Bronze Age. The absolute chronology of the Shahrake Firouzeh site was based on a charcoal sample in the Vaikato lab in New Zealand (**Figure 2**).

Shahrake Firouzeh is located northwest of Neyshabur County with average altitude of 1250 meters above sea level in 36°12′48″N 58°47′45″E coordinates. Farub Ruman is the closest water resource to Shahrake Firouzeh located in its west site (**Figure 3**). In general, based on the surveys conducted in Shahrake Firouzeh site, this site represents the culture of Bronze Age and presumably Iron Age in the region. In the meantime, the focus of cultural materials is indicative of a culture known as BMAC (Bactria–Margiana Archaeological Complex). The recovered objects (including pottery and burial practices) indicate regional and trans-regional interactions of Shahrake Firouzeh with neighboring areas such as Merv, Balkh, southern Turkmenistan and Iran (Basafa, 2014). As shown on the satellite image, the location of the Shahrake Firouzeh site is proving the origin of agriculture in this area, firstly, Located on the flood plain sediments and, second, the maximum distance to the main streams in order to avoid the effects of the overflows And, thirdly, the minimum distance to the catchment area was due to water transmissions (**Figure 4**). Farub Ruman is considered an independent river of Central Desert Basin and is flooded in the rainy season. Given the geomorphological structure of Neyshabur Plain, water currents always carry a large volume of alluvial deposits and precipitate them in lower areas (plain). Therefore, Shahrake Firouzeh is located underneath alluvial deposits with a diameter of 1.5–2.5 m. The first archaeological evidence of Shahrake Firouzeh was accidentally detected in summer of 2008 as a result of excavation conducted for construction work. Unfortunately, over 90% of the site has been destroyed (**Figure 5**). The dimensions of Shahrake Firouzeh settlement are undefined due to two reasons: 1) it was buried under alluvial deposits and 2) the bulk of it is located under residences of the people of Neyshabur on the basis of preliminary studies (Basafa 2014, 10).

The role of alluvial fan, sediments and eddy currents on Shahrake Firouzeh settlement

In general, alluvial fans in many parts of the world have provided a good opportunity for human habitats and settlements from prehistoric up to modern times due to favorable conditions such as the presence of water-rich aquifers, gentle slopes of alluvial fans, fertility due to deposition on alluvial fans by currents from upstream basins, eddy currents and canals, which provide the water needed for drinking, agriculture and handicraft (pottery production) (Gillmor et al. 2009, 2011).

Due to the slope and shape of upstream basins, most alluvial fans are of an equal size and slight change in size,

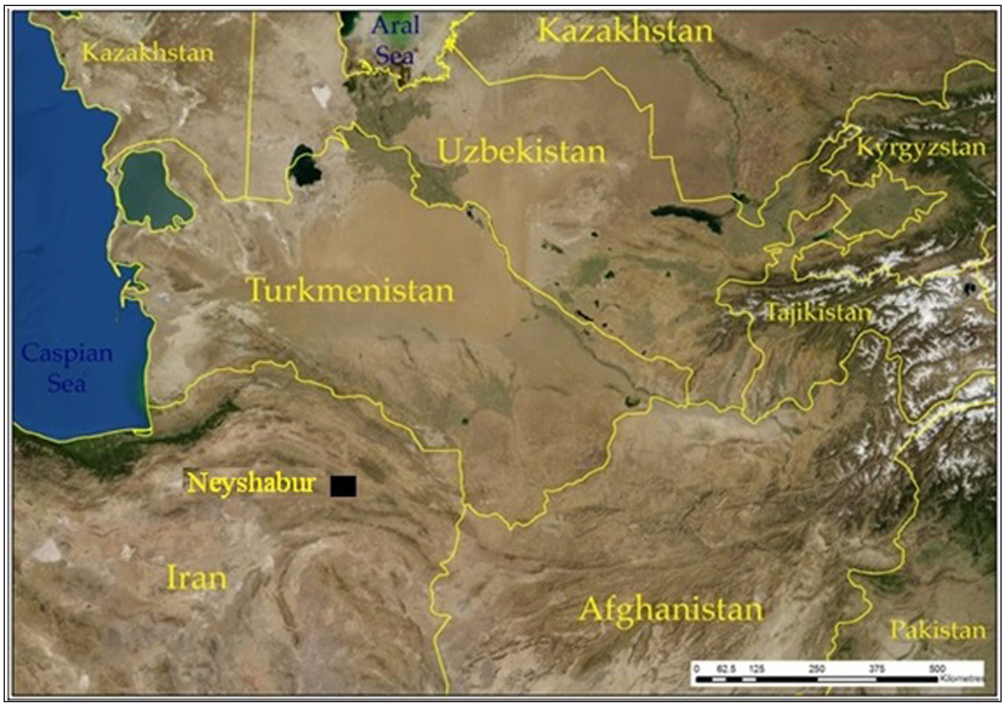

Figure 1: Location of Neyshabur County in northeastern Iran.

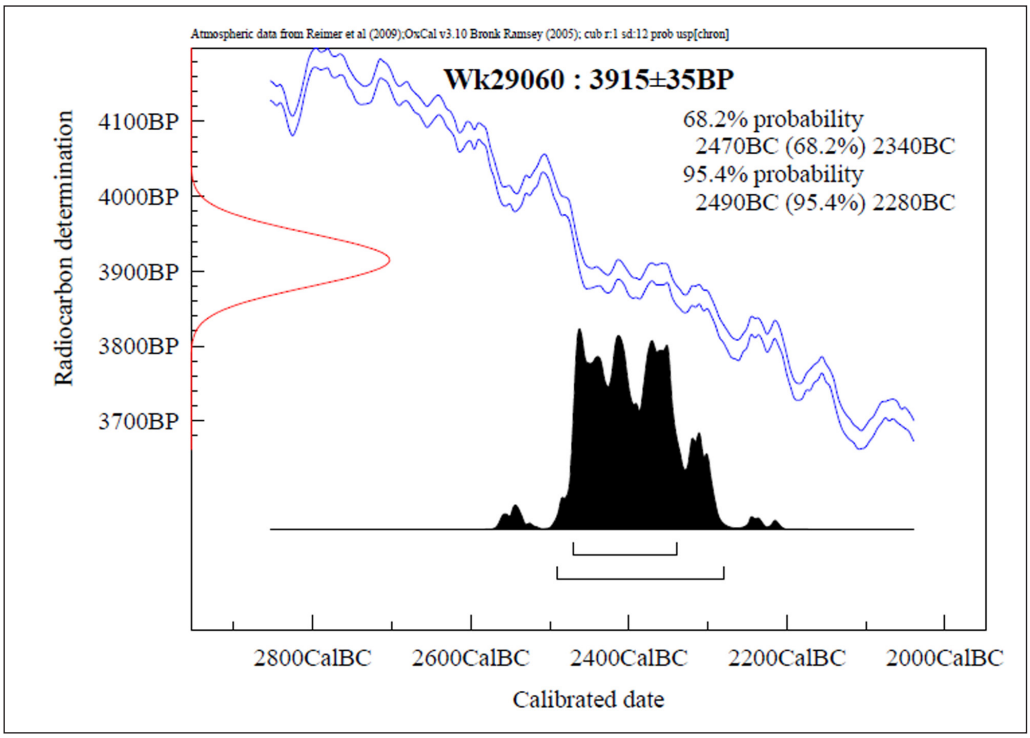

Figure 2: Calibrated Date of Shahrake Firouzeh Site.

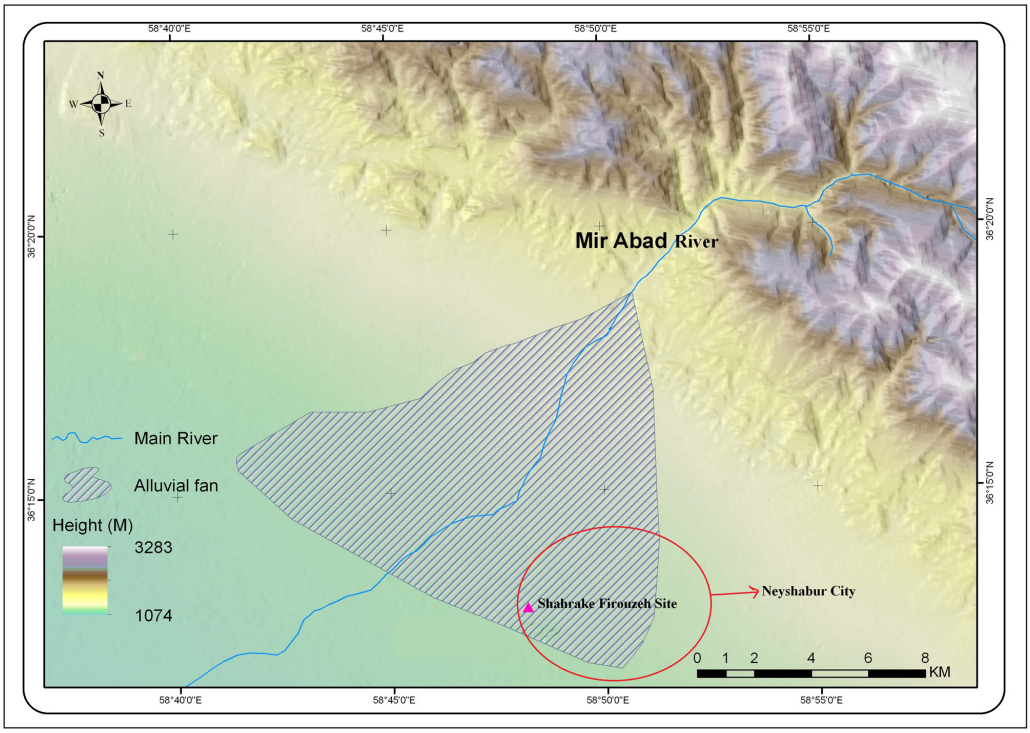

Figure 3: Location of Shahrake Firouzeh in Neyshabur Plain.

height or shape of the basin causes fundamental change in alluvial fan as well as presence of coarse precipitate matters. alluvial fan deposits are usually a good basis for detection of Weather conditions, because alluvial fans are small with steep slope in dry weather but are large with gentle slope in wet weather. In addition, other factors such as drainage systems, water content, difference in height and type of rocks affect the origin and size of the fan. Alluvial fans are the accumulation and feeding centers of groundwater within the sedimentary basin as well as water input to the whole downstream compression units. Special features of alluvial fans) flood and water flow (have resulted in virtual lack of villages on alluvial fans and nearly all the villages have appeared in the border between two alluvial fans. geological fault is a factor with indirect effect upon past and present human settlements, which controls the alluvial fans. Equal extent of alluvial fans and orientation of their trails in a line despite the difference in size and height of river basins is an evidence for this claim.

Figure 4: Location of Shahrake Firouzeh in relation to alluvial fan.

Figure 5: Shahrake Firouzeh site and the condominiums built on the site.

In a canal near the alluvial fan called Nanova next to sand washing plant, a thickness of Alluvial deposits at least 5 meters was created by flood And it visible in section. A topographic break can be seen at the end of alluvial fan near the steel plant, which leads to deposition of silt. This border has been the limit of settlement life in the past and present, so that development of human life above this break line (silt deposits) has been practically impossible. The characteristics of alluvial deposits in alluvial fan can be analyzed through survey of existing sections as well as archaeological studies. In the examined sections, alluvial deposits of different thickness, granularity and general characteristics were observed. Obviously, layers with various thicknesses, homogeneous or heterogeneous, coarse or fine constituent grains with fine layering of different colors indicate diverse conditions of depositional environment. The presence of fine-grained fertile deposits provides good materials and building blocks for agriculture, pottery and other economic activities, creating good conditions for development of settlements in parts of alluvial plans.

Neyshabur Plain is located between alluvial fans to Kalshour (**Figure 6**). The alignment of alluvial fan trails along a hidden fault, difference in sediment types and sudden shift of alluvial fan deposits to silt represent a topographic break. The type and volume of deposits is a function of the extent of sedimentary basin, sediment and highland type as well as orientation of mountains. In alluvial fan of Mir Abad village, deep gullies perpendicular to the stream bed can be seen, which are not only the main source of sand and gravel of floods but have played an important role for several reasons, including their role in feeding groundwater resources, critical minerals, coverage of sites and human settlements as well as being the main cause of vertical movement of plains. Geomorphologically, alluvial fan sands have played an important role in the elimination of consecutive morphological steps. Evidence of these sands with a thickness of more than one mater can be seen in Shahrake Firouzeh site (second millennium BC) and Shadiyakh site (early Islamic period).

Discussion

Neyshabur Due to the vast plains and weather conditions and strategic location provides a perfect habitat with at an altitude of 1200 meters above sea level, average precipitation of 14 degrees as well as 300 mm rainfall. Binalud is the highest mountain range of Neyshabur with Shirbad pinnacle of 3420 meters located north to Bojan village (North east of Neyshabur). Binalud ridge is connected to conic line with a steep slope. Due to the proximity of ridge to conic line, type and orientation of mountains (placement of Binalud) virtually holds no rural settlement. Orientation of old Neyshabur (Kohandej), New Neyshabur and high density of villages around this site from East, West and South reflects the natural capacity of this range. Satellite images and topographic maps specify at least three distinctly demonstrable structural morphologic steps. These steps play settlement roles, and conic line as well as Kalshour can be added to the mentioned morphologic steps as the main natural factors that play an indirect role. Both internal (faults and earthquakes) and external (flooding and climate change) factors have been involved in a fierce battle to show off during the last few centuries of human settlement.

The slope of this area is calculated 2% to 4%. It is obvious that this region has had a morphologic step due to passage of fault in the first millennium, and a much lower slope can be calculated for primary settlement plain. Preliminary view seems to indicate that the height of deposits is decreased while moving towards lower areas (Kalshour) and the likely sites lie in a lower depth. However, this is partially true, and drawing the profile shows that the settlement is a function of steepness. The historical settlement sites have been essentially formed in topographic break sites and in places where the slope has steeply changed, almost all of which have been buried under deposits due to severe floods. In this way, the collection of historical sites (cultural and natural sedimentary layers) have been a factor for leveling and elimination of these natural steps. Most likely, these breaks have been an example of active fault demonstration in the plain, which if true, they will be very young.

In the study of age of walls and adobe layers of upstream villages of Shahrake Firouzeh, it was shown that due to higher rainfall and lack of soil cohesion in foothill modern villages (Eysh Abad and Somea) relative to Shahrake Firouzeh site, the lifetime of adobe structures is nearly 3 to 4 decades, wear marks and curves are formed in buildings due to corrosion and right angles virtually disappear in structures. However, the lifetime of these structures is increased due to presence of higher amounts of clay and

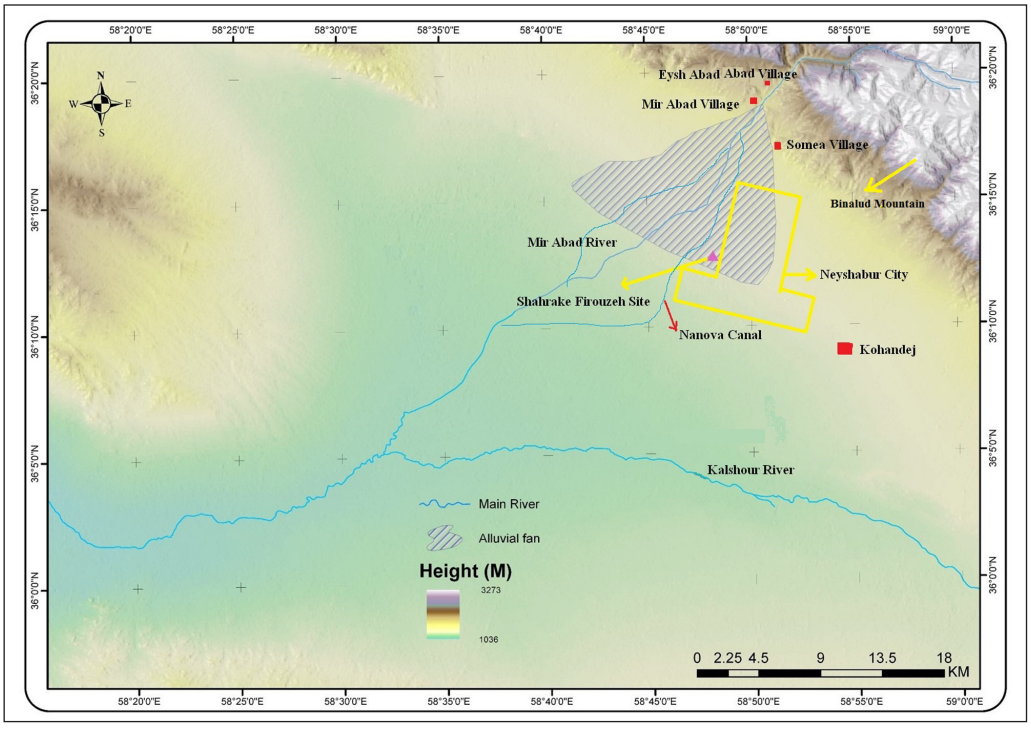

Figure 6: Location of New Neyshabur, Kohandej and Kalshour River.

the resulting increase in stickiness. In other words, there is correlation between degree of slope and type of sediment with stability, and in lower slopes the soil is more clayey and the clay is more resistant than silt. The presence of sharp corners in exploration layers shows that in principle, such residences are not subject to degradation and erosion (**Figure 7**).

As already stated, the initial coverage of the area is a silt layer on sand and gravel layer with a thickness of approximately 30 cm in Shahrake Firouzeh site, which has been demonstrated to belong to the second millennium BC. According to these layers, enormous changes should have occurred during Holocene in Neyshabur plain, especially in urban area of Neyshabur, which is incredibly dynamic and energetic in terms of climate, and this is a function of geological type of basin, steep slope between mountain and plain, weather systems and in particular the position of Binalud.

The presence of massive river rocks in Faizabad, despite the fact that most of the erosion of the mountain, due to its genus, is micro-degradation (small crushing) erosion. The strength of the flood events can be estimated, the lack of tofony, the phenomenon of verni and the location of the rocky site, only in the current river bed indicates that this very young event originated after Holocene. The presence of gravel and sandy layers on the archaeological site reveals various discontinuities of these climatic events in at least three different phases of flooding with different energies. Based on archaeological evidence and evidence of the upper and lower layers of the sandy and gravel, one can consider the near-reality chronology for these layers. With regard to the absolute date on the charcoal sample in the pottery container, it shows the burial on the Context 15 of 3915 years ago. And according to the history of the charcoal sample of the Context 2, shows the date 3788. This indicates that the flood occurred approximately 120 years after the burial, and this indicates the time of occurrence of the flood. As it is seen in the stratigraphy profile, it seems that in the later periods (probably Islamic period) new floods have occurred and its evidence is visible in the layers of the site (**Figure 8**). The burial in the Shahrake Firouzeh site at a depth of 3 meters can reflect the depth of the catastrophe that occurred in the central areas.

Conclusion

The Geological fault is a linear structure associated with movement that has significantly affected tectonic developments as well as formation of structural sedimentary basins in Iran, especially Neyshabur. In general, the faults have played an important role in this civilization center

Figure 7: The existence of burial in the layer of early bronze age and the presence of flood layers.

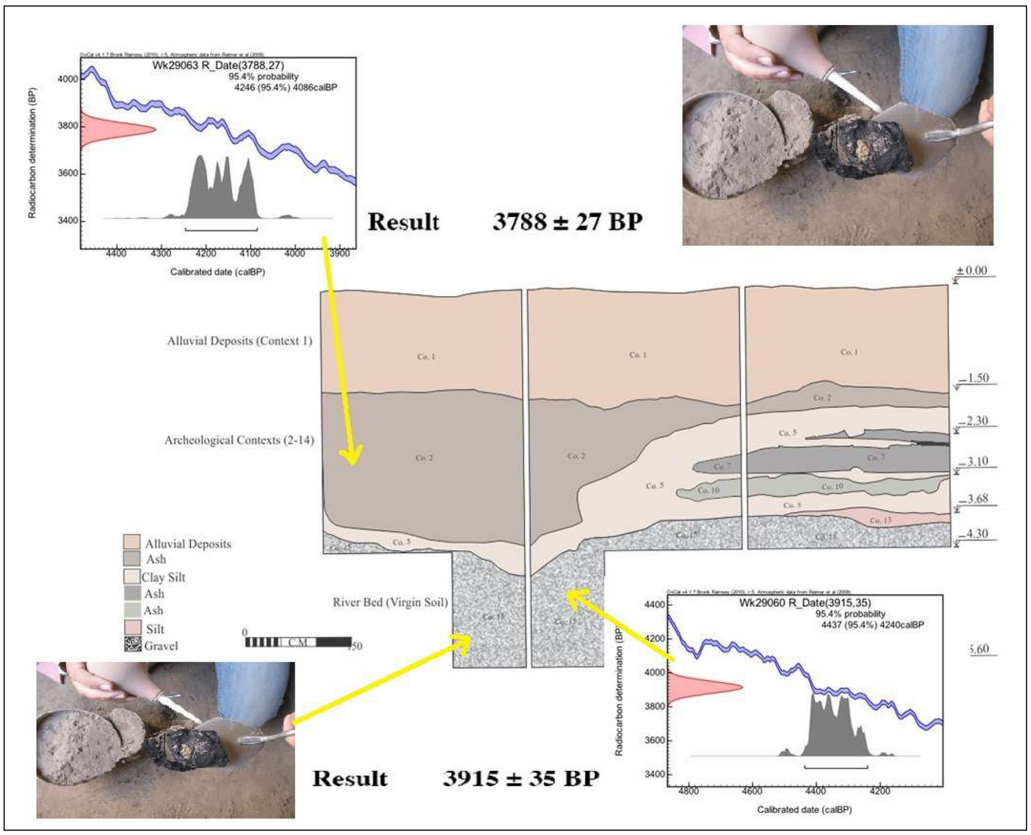

Figure 8: Stratigraphy profile and chronology of the ancient and flood layers.

in mountains, orogenesis, subsidence of plains, control of alluvial fans, determination of sediments' boundary and consequently culture, civilizational mobility, storage and maintenance of groundwater, pediment of villages, perennial and main springs, drainage of surface and deep water from mountain to plain and from Neyshabur plain outward, conduct of deposition and most importantly indirect mineral drainage from Neyshabur plain due to Kalshour fault as well as several functions with a pivotal role in the stability of Neyshabur Plain and the resulting stability of the civilizations.

New or Timurid Neyshabur is located on a surface with a slope of 6% and has been delimited by two topographic breaks to the north and south. Demonstration of the fault function, which has been partially covered today, is the reason for topographic break of Shahrake Firouzeh site and Shadiyakh in parallel to it, which encompasses Kohandej in the same direction. The morphological difference of this step has been in such a level that even the sedimentation rate of at least 1 meter per year in Shahrake Firouzeh up to 2.5 meters in Shadiyakh has not managed to neutralize the results of parallel faults, which is thus reflected in drawing the topographical map profile. The important points that can be deduced from drawing the profile is that the primary settlements were located in steepness of foothill profile up to Kal, with changing slope causing significant variation of sediment type, water conveyance from upstream Shahrake Firouzeh site (second millennium BC) and optimal utilization of qanāts (Qanat is a subterranean excavated canal through which the water flows) in Shadiyakh and Kohandej. Location of sites is a fundamental factor affecting demolition level during earthquake or burial of sites at the time of flooding. Therefore, the fault step has been important in destruction due to the above-mentioned forces while resulting in the development of human and animal life.

There is evidence of massive ecological catastrophe in the second millennium BC in Shahrake Firouzeh site and in a short time the whole plain has been buried under alluvial river deposits. These developments have occurred simultaneous with and a short while after abandonment of the site. Water conveyance by canals from Somea basins can be deemed given the vast size of this site, lack of water extraction techniques of qanāt and deep well digging, which is indicated by satellite images. This location proves the agricultural origin of this site for three reasons: 1) it is located on floodplain sediments, 2) it has kept maximum distance from main watercourses to avoid the effects of flooding, and 3) it maintains minimum distance from the watershed outlet due to water conveyance. Burial of this site at a depth of 3 meters can remind the catastrophic tragedy that happened in the central region. The biggest concern of residents in flat plains has been formidable flooding from upstream basins. Moreover, it shows that the viewpoints on human settlements around Neyshabur should be revised. In case of continued research in this area and detection of the plain slope, i.e. calculation of the paleomorphic plain level (initial slope), the depth of settlements in the same horizon can be specified. Due to the presence of upstream fault sources, relative balance of erosion, presence of hills with fertile soils (silt) and distance from flooding, this area is potentially pre-historic sites in the margin of foothills.

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Competing Interests

The authors have no competing interests to declare.

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