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The conservation of the Shahr-e-Zohak archaeological site (central Afghanistan): Geomorphological processes and ecosystem-based mitigation

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ABSTRACT

The archaeological remains of Shahr-e Zohak are part of the Bamiyan valley, which has been recognized by UNESCO as World Heritage and is famous for hosting the main heritage of the Buddhist culture in Afghanistan. The site comprises the remains of the Zohak fortress, which is placed on a steep hill at the confluence of the Bamiyan and Kalu rivers. The fortress is protected by ramparts, built along the steep cliffs bounding the site, which are equipped with several watchtowers. The citadel is protected by three more orders of walls and is located on the topmost part of the hill. All the structures are made of mudbricks placed on top of stony foundations. Due to the prolonged exposure to weathering, the lack of conservation measures and the misuse during war periods, many constructions collapsed or are prone to collapse.

A new topography (1 m contour lines) of the site was produced using drone-derived 3D photogrammetry combined with GPS data. Then a detailed geomorphological survey of the whole site was carried out in order to identify the main geomorphic processes acting on the land surface and structures. GIS analysis allowed defining the internal drainage system of the studied area. The site is affected by incised erosional phenomena on the eastern side, while the hilltop is mainly hit by diffuse erosion and soil mobilization during snowmelt. Monument deterioration is coupled with the lack of an adequate drainage system to collect runoff. Ramparts located on the steep hillslopes are severely affected by gully erosion and siphoning, which cause depressions infilled by eroded and weathered building material. The access path is locally eroded or buried by debris cones. The western margin of the plateau has been rapidly retreating due to collapses, while the citadel is in danger due to diffuse or gully erosional processes developed on all its sides. A mitigation strategy with low environmental impact (ecosystem-based approach) is proposed in order to adopt sustainable, systemic and cost-effective tools for soil conservation, in order to improve the environmental resilience of the site.

1. Introduction

Contemporary history of Afghanistan has been dramatically marked by war. Since the abolishment of monarchy in 1973 the country never experienced a stable peaceful period; this chronic instability led to a continuous division of power among local or tribal authorities, resulting in widespread poverty and abandonment of common goods. Besides forcing the population to live in dramatic conditions, the constant fighting for power between different factions heavily mistreated and abused the huge cultural heritage of Afghanistan, which is nowadays in an extreme precariousness.

Many outstanding archaeological sites have been used for artillery positioning due to their strategic location, others have been used as military settlements or inhabited by displaced refugees, and finally most of them have been mined. These disastrous events culminated in the destruction of the two giant Buddha statues, deliberately acted on March 2001 by the Taliban regime due to religious belief.

After the overthrow of the Taliban regime by the international forces, occurred after the 11 September 2001 terrorist attacks, the Afghan nation was able to build democratic structures over the years, and some progress was made in key areas of governance. This resulted in a renewed attention to the Afghan cultural assets, and UNESCO put enormous efforts to provide a good conservation and restoration of such goods (Manhart, 2004). Nevertheless the severe climatic conditions, typical of this arid and mountainous country, the building techniques used in the past and the long years of carelessness represent a huge challenge in terms of monuments conservation. Discriminating the geomorphological processes acting on a site, understanding their role in shaping the landscape and in affecting the anthropogenic structures is fundamental in order to plan the proper conservation interventions. Detailed field surveys and analysis of high-resolution digital

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elevation models represent the basic tools for geomorphological studies in many different fields, from landslide risk prevention (e.g. Guzzetti et al., 2012; Frodella et al., 2014) to soil conservation (e.g. Nyssen et al., 2000; Renschler and Harbor, 2002).

The relevance of soil erosion for archaeological site conservation is well known (Casana, 2008; Margottini and Spizzichino, 2014) and affecting many sites worldwide. Some examples of soil-erosion impact on Cultural Properties can be found in Bamiyan, Afghanistan (Margottini, 2014), Easter Island, Chile (Mieth and Bork, 2005), Methana, Greece (James et al., 1994) as well as many others. Sometimes, the presence of soil erosion required important mitigation works that have generated spectacular cultural landscapes such as the terraces in Porto Venere and Cinqueterre (Italy), Machu Picchu (Peru) or Serra de Tramuntana (Spain).

This paper deals with geomorphological processes affecting the conservation of the Shahr-e Zohak archaeological site, an earthen fortified city located in the Bamiyan Valley. The valley is world famous for hosting the main heritage of the Buddhist culture in Afghanistan, whose principal record was represented by the two destroyed giant Buddhas (Margottini, 2004, 2007, 2014; Crippa et al., 2013). The final aim of the work is to propose remedial measures in order to preserve the site against future damages related to geomorphic factors. The proposed mitigation strategies are aimed at limiting the effect of runoff due to rainfall and snowmelt, through a new nature-based approach (ecosystem-based approach). The latter is intended to adopt sustainable, systemic and cost-effective tools for soil conservation, in order to improve the environmental resilience of the site.

2. Regional setting

2.1. Description of the archaeological site

Due to its strategic location, the Bamiyan region represented a crucial meeting place for travellers, pilgrims and cultures, representing one of the major Buddhist centres of Central Asia until the Islamic occupation of the 9th century. The valley rests along the famous Silk Road and was a fundamental part of the trade route connecting China to the West. In 2003 the Cultural Landscape and Archaeological Remains of the Bamiyan Valley, which comprise a serial property consisting of eight separate sites within the Valley and its tributaries, were recognized by UNESCO as World Heritage (UNESCO, 2003). Unfortunately most of these outstanding monuments are at risk of collapse, due to the action of weathering processes coupled with the damages produced by repeated war periods, and the lack of adequate maintenance; for these reasons they were included in the Danger list of World Heritage (UNESCO, 2003). The Shahr-e Zohak fortress represents the easternmost of the Bamiyan Valley archaeological remains. The fortress rises on a hilltop at the confluence of the Kalu and the Bamiyan rivers, about 15 km east of the city of Bamiyan and 115 km west-northwest of Kabul (Fig. 1). The hill has a peculiar triangular shape and is bounded by steep cliffs moulded by the erosion of the Bamiyan and Kalu rivers and their minor tributaries. The site is thought to have been founded during the Buddhist period, in the 6th–7th century A.D., but the present fortification remains are dated to the Islamic period and are those that tried in vain to oppose to the advance of the Mongol army, that invaded the region in 1221 A.D. Due to its strategic position, providing excellent measures of natural defence, Shahr-e Zohak was once the principal fortress protecting the entrance to the city of Bamiyan, during the reigns of the Shansabani Kings in the 12th–13th centuries A.D. (Minorsky, 1943; Dupree, 1977), though archaeological evidence testify the existence of a fort on this site since the times of the White Huns (6th century A.D.). After the Mongol invasion and the subsequent destruction and abandonment, the citadel was never rebuilt, and only the extremely dry climate of the region preserved the mud walls from a total ruin. The fortress is made of three main sectors: the bounding escarpments and an Upper and Lower Citadel (Fig. 2). The whole complex is protected by crenelated ramparts built along the steep cliffs bounding the hilltop, and equipped with several watchtowers. Towers typically lack of any entrance, since they were accessible only using ladders. The access to the fort, located on the hill eastern flank, is characterized by a steep path ascending on the slope with a zig-zag trend, which leads to the residential area through a tunnel excavated into the rock. The living quarters, which once could host up to 3000 people, rest on a triangular plateau enclosed within defensive walls. The fort comprises the royal quarters and is placed on the southern side of the hilltop. It is separated from the plateau by an E–W oriented valley and it is protected by three more orders of walls. These defensive walls lay along the southern flank of the minor valley and are punctuated by a number of watchtowers used as surveillance posts.

The buildings of Shahr-e Zohak are made of mud bricks placed on top of stony foundations and are covered with mud plaster (Fig. 3). Bricks are made of sun-dried red clay resulting from the weathering of the local terrain, consisting of conglomerates and marls. Stones used for the foundations mainly consist of pebble- to cobble-sized rounded clasts of fluvial origin, probably deriving from the local riverbeds.

2.2. Geographic and climatic setting

Afghanistan is mostly mountainous. About 27% of the country has a semi-arid/steppe or arid climate with low precipitation. Winters are very cold and snowy, while summers are hot and dry. Precipitations are concentrated in a wet season between winter and early spring (Delmonaco and Margottini, 2014).

Within the whole country the central highlands experience the most severe climate. This region covers about two-thirds of the country and is crossed by important mountain ranges, of which the principal is the Hindu Kush. The Bamiyan Valley, located in the middle of the Hindu Kush ridge, is a 50 km long and 15 km wide SSW–NNE oriented depression laying at about 2500 m a.s.l. (Fig. 1B). The region is characterized by a cold semi-arid climate. The available meteorological data for the Bamiyan area (Fig. 4) report a mean annual temperature of 6.9 °C and a mean annual precipitation of about 133 mm, mainly falling as snow (Peel et al., 2007; Cook, 2011). In spring and early summer, snow melting from the surrounding mountains increases air moisture and river discharge in the valley bottom.

2.3. Geological setting

The study site is located at the south-western reaches of the Hindu Kush orogenic belt, formed by the collision of the Eurasian and Indian continental plates that began about 50 Ma ago. The Hindu Kush region is still actively deforming and represents one of the most active seismic zones in the world. Structurally, the Hindu Kush is bounded to the south by a right lateral strike–slip fault, known as the Herat fault (Ambraseys and Bilham, 2003; Mohadjer et al., 2010), while its northern margin is less well defined. The main faults and mountain ranges have an NNE–SSW trend.

The Bamiyan valley is hosted in a wider Tertiary intermountain basin bounded to the south by the Koh-e-Baba Mountains and by the Khwaja-Ghar and Koh-e-San Chaspan Ranges to the north (Lang, 1972). The basin was filled with an about 1500 m thick succession of continental deposits. This succession, laying unconformably over the mainly igneous Precambrian to Cretaceous bedrock, can be subdivided in four main units, that are, from bottom to top (Fig. 5):

- The Zohak Formation (Eocene), a more than 1000 m thick succession of alternating red conglomerate and marl, deposited by huge en-masse flows.
- The Qal'acah Formation (Oligocene), a complex of angular violet conglomerates with volcanic debris.
- The Buddha Formation (Oligocene), consisting of more than 70 m thick interbedded yellow to brown mudstone, sandstone and conglomerate with some volcanic material.