



Forum communication

Composition and diagenesis of ancient Shali city buildings of evaporite stones (kerchief), Siwa Oasis, Egypt



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ABSTRACT

Shali is an ancient fortress, built in the XII–XX century in Siwa, Northwest Egypt. It is built on two Middle Miocene limestone and marl hills, between the wadi plain. The architecture of the fortress buildings is composed of local materials derived from the Miocene, Quaternary, and recent salt lake deposits. The framework blocks of the city are mainly composed of salt (Kerchief), limestone, and bentonite, wood particles, dry date seeds, and bones derived from ancient tombs. In this study, the modification and mineral phases that developed during the diagenetic alteration and cementation of the salt and clay mortars with different framework in the walls of the ancient houses and settlements will be followed and interpreted. Diagenesis included transportation of salt materials from the nearby Fetnas Lake and mixing with some sand and clays as mortar pressed into the voids between the frameworks (Kerchief blocks). This resulted in dehydration, gypsum crystallization, and halite cementation. The continuous crystallization through the epitaxial growth of halite in both cement and framework blocks results in strong adhesion and binding of the framework. At the end of the process the kerchief blocks and the cement will be completely homogenous to a point that they apparently no longer be distinguished.

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1. Introduction

Salt houses have been documented in a number of ancient cities all over the world. For example, one of the well-known recent salt house hotels is found in Salar de Ayuni, Colchani, Bolivia. Taghaza is an abandoned salt-mining center located in a salt pan in the desert region of northern Mali. It was an important source of rock salt for West Africa up to the end of the 17th century. At Dallol volcano located in the Danakil Depression in NE Ethiopia, ruins of potash houses are found. The volcano rises 50–60 m above the surrounding salt plains, nested on top of an almost 1000 m thick layer of evaporites.

Siwa oasis is located in northwest Egypt near the Libyan border, 300 km southwest of Mersa Matruh Governorate, covering an area about 7500 km² (Fig. 1A). The climate is extremely arid all the year except from January to June where the precipitation reaches 2 mm, and in July it reaches 9 mm. Siwa is dominated by high summer temperatures (maximum 37.7 °C in July and August and the evaporation rate varies from July to December between 16.5 and

5.5 mm/day. It is characterized by constant climatic conditions throughout the year and has monthly average temperature of 35 °C, humidity of 58% and 300 average sunshine hours per month (Gindy and El Askary, 1969; World Climate Charts, 2010).

Geomorphologically, Siwa comprises closed flat depressions bordered to north by a limestone plateau with a steep escarpment running E–W and to the south by sand dune areas (Great Sand Sea). Inland saline lakes (–20 m), rock inselbergs and cultivated land are the main features within the depressions (Fig. 1B). The relief of the cultivated land ranges between –6 and –17 m. Naturally flowing springs are confined to the floor of the depression. The spring waters are used to irrigate the palm and olive plantations, and drain into the salt lakes. In recent years, more deep wells have been drilled causing a rise of the water table close to the surface level (Hammad et al., 2000). This causes the formation of widespread salt efflorescence on the surface, walls of buildings and rock outcrops. The Siwa region is thought to be a tectonically induced depression formed through successive tectonic events, and shaped finally by topographic processes (Masoud and Koike, 2006).

2. Shali fortress

Shali is an ancient fortress, built between twelfth and twentieth century in Siwa, on two Miocene hills separated by a wadi plain

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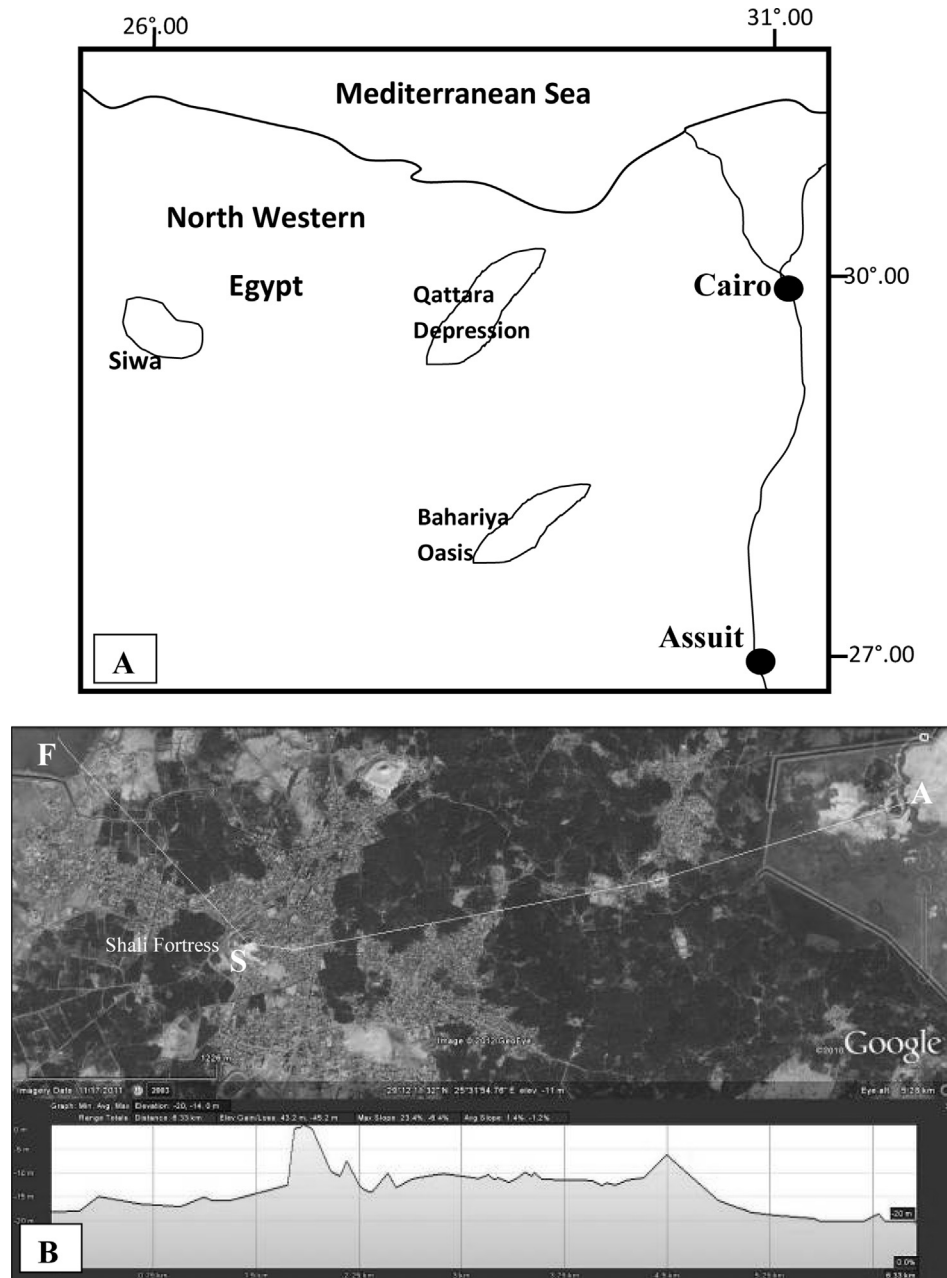


Fig. 1. A) Location map of the study area. B) Satellite image of Siwa city clear the position of Shali fortress (S) in relation to Lake Aghormi (A) and Lake Fetnas (F). The cross section FSA show the maximum elevation of Shali Fortress is 0 m while the lowest point is -20 m (the data is adopted from Google earth).

(Fig. 2A, B). It resembles an ancient castle whose rough ramparts tower above the forests of waving palm trees, and the rich green gardens. The houses are built of mud, mixed with salt, with occasional large blocks of stone from the temples let into the walls. The vast thickness of the walls makes the houses cool in the high temperature summer period, and warm in winter when cold winds sweep down from the high desert plateau. The windows are very low. The ceilings are made of palm trunks covered with rushes and a layer of mud. The ends of the trunks are long, projecting outside the walls, and serve as dowels on which to hang bundles of bones to avert the “Evil Eye” (Fig. 2C, Belgrave, 1923). Palm trunks constitute the supporting structure of the floors at different levels and by other wood insertions (some olive wood) to form connections. One

architectural peculiarity is that the builders worked without a line, gradually adding to the wall, sitting across the part which they have completed, so few of the walls are straight (Belgrave, 1923; Cassandra, 2000). Another architectural peculiarity is that, owing to the need of building walls thicker at the bottom (about 2 m thick) than at the top (30–60 cm thick) most of the houses, especially the minarets of the mosques, become narrower towards the top (Fig. 2D, E). The houses are built one above the other against the face of the rock (Fig. 2D), and the external walls form one distinct line of battlements, penetrated by little groups of square windows, encompassing the town, and rising sheer above the ground, in some places to a height of almost 60 m (Belgrave, 1923). Today, the heights of the buildings do not exceed 35 m. As the inhabitants

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