Geoarchaeology of the Akrotiri Peninsula

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As part of the *Ancient Akrotiri Project*, directed by **Prof. Simon JAMES** (University of Leicester), and the ERC-RoMP-*PortusLimen Project*, directed by **Prof. Simon KEAY** (University of Southampton)

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INTRODUCTION

In September 2016, four geomorphological cores were drilled with the company Geoinvest in the Salt Lake of Akrotiri, southern Cyprus, with the financial support of the PortusLimen Project (ERC-RoMP). The authorisation was given by the Sovereign Base Areas Administration of Akrotiri (SBAA and Akrotiri Environmental Center) and the Geological Survey Department of Cyprus (Figure 1 – Peninsula of Akrotiri and location of the four new boreholes). The Honor Frost Foundation provided financial support for the multi-proxy palaeo-environmental analyses of the sedimentary cores. These cores provide important results regarding: (1) the main chronological phases of formation of the double tombolos that now join Akrotiri Island to the mainland and hence the formation of the Akrotiri Peninsula; (2) and the changing harbour potential of the Salt Lake, former lagoon through time (Blue, 1995; Leidwanger, 2005).

Figure 1 – Peninsula of Akrotiri and location of the four new boreholes

The theoretical formation of a tombolo is relatively well understood. A tombolo corresponds to a long narrow ridge of sand or pebbles (spit) deposited by a process of longshore drift which in the case of Akrotiri have joined the former island to mainland Cyprus. The spits are formed with longshore drift material transported along the coast and by wave refraction and diffraction around the island. The tombolo is formed when a spit continues to grow until it reaches the island.

The case of the double tombolos of Akrotiri is rather unusual. Usually tombolos are single, for example those in in Alexandria, Gibraltar or Tyre in the Mediterranean sea (Marriner et al., 2008). Another Mediterranean tombolo pair exists at Giens in France (Blanc, 1982; Courtaud, 2000). Even more rare are the tombolo triplets such as the one of Orbetello in Italy (Gosseaume, 1973).

The reconstruction of the palaeogeographical evolution of the Akrotiri Peninsula during the Holocene involves the reconstruction of the timing of the formation of a first tombolo, commonly considered to be the western tombolo composed of pebbles[1]. The second tombolo, composed of sand, to the east seems to have been formed later. Palaeogeomorphological analyses have been conducted and they bring new light on the different stages of evolution of the double tombolo, the processes involved in its formation and the chronology of these processes.

1. Core drilling campaign

Initially the aim was to drill in the middle of the Salt Lake when the lake was dry. The objective was to drill a single core with the best-preserved stratigraphy. However, even if the lake had been dry at the end of the summer (beginning of September 2016), the ground surface was too soft. Consequently, it was clear that it was impossible to reach the middle of the lake with the mechanical corer hired as it was sinking into the sediments. Then, we decided to drill not one but four shorter cores on the edges of the Salt Lake: in the east (Core Ak-1), in the northeast (Ak-2), in the south (Core Ak-3), and finally in the west (Core Ak-4) (Figure 1 – Peninsula of Akrotiri and location of the four new boreholes. Core Ak-4 was drilled around 500m south of the cores previously drilled and studied by the *Pluto Project* in 2002-2003 (Morton et al., 2003). The objective was to complement the work undertaken 15 years ago by the Pluto Project (new analyses, and more dates), and to provide comparable data for the four new core sequences and their analyses. Each core was drilled in relatively stable areas for the mechanical corer (Figs. 2 to 5).

Due to the technique of extraction and the softness of the sediment drilled, the sedimentary sequences were compacted. In each core drilled, the first two meters have been particularly compacted. Following the different stage of drilling with the machine, we reconstructed afterward the un-compacted sequence of the sedimentary sequence.

Each borehole was located in the field by Dimitris Damianou using a DGPS (Table 1). Heights were taken in reference to the current sea-level.

Core	X	Y	Z
Ak-1	198738.805	331450.290	-2.836
Ak-1-BIS	198862.188	331383.225	-2.533
Ak-2	199401.916	333346.020	-1.899
Ak-3	333346.020	330413.894	-2.992
Ak-4	195378.022	331110.472	-2.620

Table 2 – Location and altitude of the cores drilled

[1] http://www.southampton.ac.uk/~imw/Cyprus-Akrotiri-Lake-Coast.htm

Figure 2 – Mechanical corer (Schramm Rotadrill) from the Company GeoInvest (Cyprus) under the supervision of Andreas Shiathas (Eng. Geologist – Manager Director)

Figure 3 – Drilling (on the left) and extraction of the sedimentary core (on the right)

Figure 4 – Extraction of the sedimentary core sequence (Core Ak-1: -1.20 to -2.40 below the topographic level)

2. Laboratory analyses

A large range of analyses was conducted on the samples of the four cores drilled in 2016 (Figs. 5 and 6). Non-destructive analyses were performed (Magnetic susceptibility, Itrax core scanner) as well as destructive analyses (laser grain-size analysis, LOI, bioindicators). These analyses include:

- Laser grain-size analysis (Palaeoenvironmental Laboratory at the University of Southampton);
- Magnetic susceptibility (Palaeoenvironmental Laboratory at the University of Southampton);
- Loss-of-Ignition (Palaeoenvironmental Laboratory at the University of Southampton) ;
- Geochemical analyses – Itrax core scanner (BOSCORF, Southampton);
- Macrofauna (CNRS);
- Pollen (University of Northumbria) ;
- Radiocarbon dates (Beta Analytics and Artemis Program);
- OSL dates (Baylor University).

Palaeo-hydrodynamics are reconstructed using grain-size data. In order to reconstruct the depositional processes, a C/M diagram (coarsest percentile versus the median of the of the grain-size analysis) will be proposed for the Salt Lake based on grain-size data (Passega, 1964; Bravard and Peiry, 1999). This diagram gives an idea of the maximum competence of the depositional process (D99) and the capacity of transport (D50). Geochemical analyses (Croudace and Rothwell, 2015) along with bioindicators (shells, pollen) provide information about the depositional context (salinity, water oxygenation etc.). Age-depth models of each core will be based on both radiocarbon and OSL dates.

Figure 5. - Multisampling of Core Ak-2 (U-channels for the core scnner + individual samples for laser grain-size analysis, LOI, pollen etc.). Photo: Salomon, Ferreol

Figure 6. - Itrax core scanner (BOSCORF, Southampton, photo: Charidemou, Miros S.J.)

3. Initial results and interpretations

Preliminary interpretations suggest that we drilled through two stages of the formation of the double tombolo of Akrotiri (Fig. 7). The initial radiocarbon dates available for the four cores range between the 5th and the 1st millennium BC. Older dates were obtained in the core drilled to the west and more recent dates were mainly recorded in the cores drilled in the east.

At the base of each core, well sorted yellow sand with scarce small pebble might correspond to pre-Holocene deposits. Marine shells were identified in these units.

Brown clayey silts drilled in Core Ak-4 and the dark grey / bluish silty sands identified in each stratigraphic sequence, reflect sediments that were deposited in sheltered to semi-sheltered environments with mixed fluvial and marine influences. Shells, pollens and geochemical analyses show some variations in the salinity through time.

Finally, the upper level of brown silty sand with a high content of ostracods and foraminiferae relate to a second phase of evolution of the tombolo, leading to the current enclosed Salt Lake of Akrotiri.

A publication for a scientific journal is in preparation. It will present the detailed analyses performed for each core.

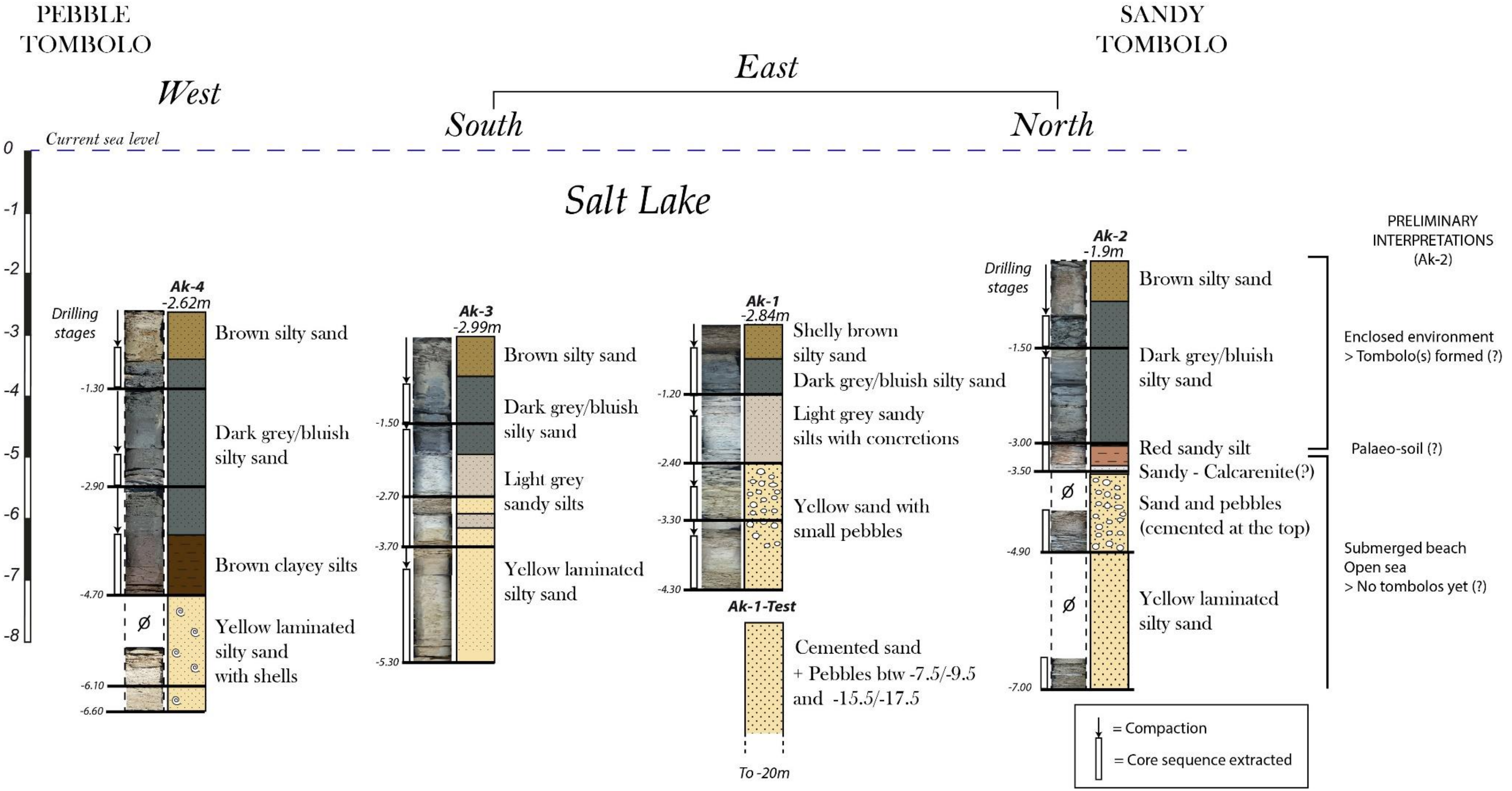

Figure 7 – Cross-section on the edges of the Salt Lake of Akrotiri

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