Report on a short visit to Las Palmas University, Gran Canaria, Canary Islands, in the frame of the ESF-MedCLIVAR programme for 2011

Project title: ***Reconstruction of Mid-Late Quaternary climatic conditions in the periphery of the western Mediterranean based on Optically Stimulated Luminescence dating of loess and paleosol deposits from the Canary Islands.***

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1. Purpose of the visit

The purpose of this short visit to Gran Canaria was to initiate a scientific collaboration between my home institute, the National Centre for Scientific Research (N.C.S.R.) 'Demokritos', Greece, and the University of Las Palmas on Gran Canaria, Spain, with the view to deducing a chronology for Mid-Late Quaternary paleonvironmental events in the Canary Islands. Scientists from the Departments of Physics and Biology at the University of Las Palmas have a long record of paleoclimatic/paleoenvironmental investigations in subtropical regions such as the Canary Islands (Meco et al., 2003; Meco et al., 2002; Perez-Torrado et al., 2006; Menendez et al., 2007; Menendez et al., 2008; Menendez et al., 2009). The topic of reconstruction of past environments in mid-low latitudes concerns our working group at 'Demokritos' presently.

Consequently, my acquaintance with the scientific staff of the University of Las Palmas supplied me with useful knowledge on the topic of paleoenvironmental research. Besides, the Laboratory of Archaeometry at N.C.S.R. 'Demokritos' is well-equipped with facilities for geochronological analysis and specifically with modern instruments for Optically Stimulated Luminescence (OSL) dating. OSL from sedimentary deposits has been reputable in the dating of paleoenvironmental/paleoclimatic research events (Duller, 2004), and has the potential of providing the resolution required. The OSL signal from mineral grains can be used to estimate the time that has elapsed since the last exposure of mineral grains to sunlight. Therefore OSL dating is very effective in depositional environments where sediments have undergone sufficient exposure to daylight prior deposition. This is the case of aeolian environments. So far, OSL dating of paleoclimatic events in the Canary Islands has been limited to the eastern islands only (Zöller et al., 2003; Bouab and Lamothe, 1997). By taking advantage of this MedCLIVAR fellowship, I was given the opportunity to carry out sampling for OSL dating on the island of Gran Canaria which is situated at the geographical centre of the archipelago.

The short visit to Gran Canaria was hosted by Professor Francisco Jose Perez Torrado, 'Departamento de Física (Geología), Universidad de Las Palmas'. I was given further scientific and fieldwork support by other members of the University of Las Palmas, namely Professor Joaquin Meco from the Department of Biology, Juan Francisco

Betancort Lozano, PhD candidate, from the Department of Biology and Dr Inmaculada Menéndez from the 'Departamento de Física (Geología)'. Fieldwork on Gran Canaria was carried out between 5 -14 May 2011.

2. Relevance to the Mediterranean paleoclimate

Study of former environmental conditions in the Canary Islands can facilitate the understanding of paleoclimatic processes in the periphery of the western Mediterranean Sea. Currently, the climatic regime on the boundary of the Mediterranean Sea with the Atlantic Ocean (i.e. the Alborean Sea, the Straights of Gibraltar and the coasts of Morocco), is influenced by three types of atmospheric circulation. The first corresponds to the 'Trade Winds' which are set in motion at the equator and circulate in a loop-like pattern (being part of the Hadley circulation). The second type of wind system is represented by the 'Westerlies' or 'anti-trades' that move in an opposite direction and finally, the third type of atmospheric circulation is represented by the West African monsoon system. The Westerlies generate rainfall in the western Mediterranean during winter and the West African monsoon induces precipitation in the Sahel during summer. The Hadley circulation system stimulates drought in northern Sahara (Nicholson, 2000).

Generally, paleohumidity and past precipitation regimes are encoded in terrestrial formations more systematically than they do in marine deposits (Hooghiemstra, 1988; Dupont, 1993). However, uninterrupted terrestrial sedimentary records of the paleohumidity history of the western Mediterranean exist only on the northern coasts of the Mediterranean Sea (Pons and Reille, 1988; Narcisi, 2001). To the contrary, archives of moisture and drought are inconsequently encoded in the terrestrial record of the African side, and usually are restricted to the Holocene and the latest parts of the Pleistocene only (von Suchodoletz et al., 2010). Consequently, absence of continuous and long climatic sedimentary records in North Africa hinders paleoclimatic and paleoenvironmental reconstructions on the south-western side of the Mediterranean for older periods of the Quaternary (e.g., Cheddadi et al., 1998).

Conversely, the Canary Islands are located on southernmost perimeter of 'the westerly-influenced Mediterranean climate zone' (von Suchodoletz et al., 2010), and at the same time, the archipelago is prone to the desert processes of the hyperarid western Sahara. Fortunately, a very well preserved and continuous record of paleohumidity exists in the Canary Islands, which not only captures the latest parts of the Quaternary, but extends further back in the Pleistocene (e.g. Meco et al., 2003; Meco et al., 2002; Menendez et al., 2008; Menendez et al., 2009).

Regional paleohydrological history has been well documented in terrestrial sedimentary deposits such as paleosols and loess formations. Although paleoclimatic processes have been studied systematically in the easternmost islands of Lanzarote and Fuerteventura (e.g. Petit–Maire et al., 1987; Damnati et al., 1996; Alonso-Zarza and Silva, 2002; Meco et al., 2002;), similar investigations on Gran Canaria are limited. Through the OSL analysis will be able to date events of drought or humidity that occurred on Gran Canaria during the Quaternary. Assuming that atmospheric circulation induced moisture (or drought) not only to the Canaries but to the western Mediterranean, OSL results from Gran Canaria could account for the climatic variability that took place in the western Mediterranean over the Mid-Late Quaternary. Forthcoming data could be further analyzed so as to detect long-range trends in the climate of the western Mediterranean.

3. Description of the work carried out during the short visit

Study of literature relevant to sites with paleoenvironmental interest (Meco et al., 2003; Meco et al., 2002; Perez-Torrado et al., 2006; Menendez et al., 2008; Menendez et al., 2009) preceded sample collection. It was the scientists from Las Palmas who indicated appropriate sample sites in the field. Fieldwork involved depiction of stratigraphic sequences by means of scaled drawings, measurement of layer thicknesses, description of basic macropscopic characteristics (colour, macrofossil content, texture, size of clasts, degree of cementation) as well as measurement of the attitude (strike and dip) of the sampled layers. Samples were extracted from representative layers. Sampling for the purposes of luminescence dating included extraction of blocks and cores by penetrating horizontally small aluminium tubes in natural and artificial sections. OSL results will be combined with fieldwork observations with the aim of reconstructing a Mid-Late Quaternary paleoclimatic framework for Gran Canaria.

4. Description of the main results obtained

Figure 1 illustrates the archipelago in the Atlantic Ocean as well as the sample sites on Gran Canaria. The area of Galdar, in the north part of Gran Canaria, constitutes a basin in which a sedimentary sequence, represented by silt-sized deposits, was studied. Fine deposits are intercalated by dense calcrete laminations. Calcrete horizons divide the outcrop in 4 distinct layers, namely G1, G2, G3, G4 (nomenclature after Menendez et al., 2009) and are shown in Figure 2. The silt deposits overlay a conglomerate made up of basaltic clasts and the entire sequence is capped by a topsoil (Figure 2). Menedez et al. (2009) suggested the aeolian origin of these silt deposits and characterised them as ‘loessoid’ because they are considered to have been accumulated with rates smaller than those estimated for the formation of typical loess (Menendez et al., 2009).

Although the term ‘loess’ typically refers to aeolian silt accumulation in periglacial environments, the same term today stands for windblown silt and clay accretion in arid or semi-arid regions (Muhs and Bettis, 2003). The main source of windblown silt caught in the basin of Gadar has been the Sahara Desert (Menendez et al., 2009). In addition, this volume of dust deposited in Galdar bears evidence of some degree of fluvial reworking, due to episodic washings of the basin (Menendez et al., 2009). Presence of paleosols intercalating the loess deposits in Galdar indicates periods when dust accumulation was outweighed by pedogenesis.

Provided that dust accumulation is favoured by dry conditions, weathering of parent sediment (pedogenesis) implies occasional wettening in the paleoclimate (Muhs and Bettis, 2003). This pattern is indeed observed in the deposits of Galdar, suggesting alternate periods of humidity and drought in the paleoclimate of the archipelago. Hence, the loess sequences of Galdar are significant paleoenvironmental indicators, and at the same time, suitable material for OSL dating.

Apart from the assumed Mid-Late Quaternary age (Menendez et al., 2009) nothing else is known about the precise chronology of these deposits. With the intention of providing a chronological control on the environmental events encoded in the sequence of Galdar, two samples were extracted from layers G2 and G3 respectively in order to be submitted for OSL dating.

Figure 1. Left: location of the Canary Islands in the Atlantic Ocean. Right: sample sites on Gran Canaria during the MedCLIVAR project.

In search of additional paleoenvironmental evidence, a paleosol outcrop was detected at Punta de Arucas, on the north coast of Gran Canaria. There, we studied an 80 cm-thick paleosol which incorporates landsnails and fossils of acridian ootheca (Meco et al., 2002; Meco et al., 2010). It is bracketed by marine deposits from above and below (Figure 3). The paleosol has a brown-reddish appearance and a low degree of cementation. This buried soil may represent the advent of a more humid period immediately after a regression event. Pedogenesis was supervened later by a transgression event as hinted by the overlaying marine deposit.

The whole sedimentary sequence is inserted between two phonolitic lava layers dated to 0.421 Ma and 0.151 Ma respectively (Meco et al., 2002). That time interval constraints only broadly the age of the paleosol. With the aim of providing a chronological framework for the paleosol sequence at Punta de Arucas, samples PDA-1 and PDA-2 were collected (Figure 3) in order to be submitted for OSL dating. Dating results from Punta de Arucas will be associated with those acquired from Galdar in order to deduct a sequence of paleoclimatic changes on the island.

A basic result acquired during this fieldwork is the verification of alternate phases of humidity and aridness that the paleoclimate of the Canaries sustained during recent geological periods. These paleoclimatic oscillations are today seen in the form of successions of sedimentary deposits (i.e. loess and paleosols capping or being capped by marine deposits). This evidence is mainly concentrated at the sites of Galdar and Punta de Arucas. Correlation of these climatic episodes with the widely accepted timescale of the Oxygen Isotopes and the global climatic framework that these stages denote will be feasible once OSL dating of collected samples has been completed. Possibly, the climatic change seen in the paleosol of Punta de Arucas could have a contemporaneous expression in the Galdar section. Yet, supralocal paleoclimatic correlations will be realistic once OSL dates have been estimated.

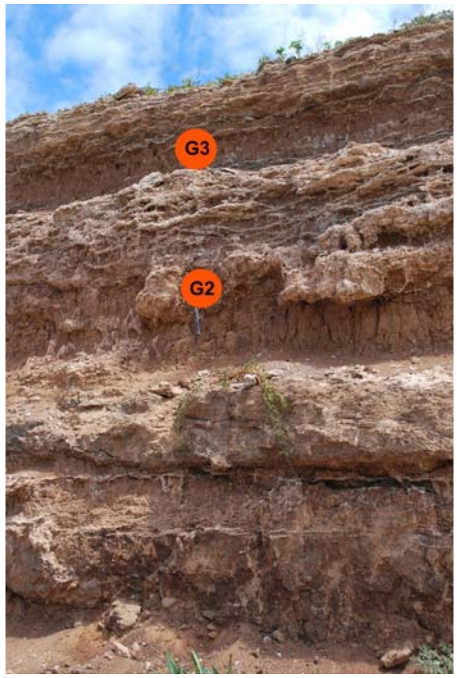

Figure 2. Section at Galdar. A sequence of silt-sized deposits, intercalated by laminar calcretes, outcrops on the highway to the town of Galdar (Mendendez et al., 2009).

Aside from the paleoclimatic evidence at Galdar and Punta de Arucas, we encountered several outcrops of windblown sand deposits that might be of paleoenvironmental importance. Indeed, colleagues from the University of Las Palmas (and other Canarian geoscientific institutions) have recently developed a strong interest in aeolianites and moving sand deposits that appear across the entire archipelago.

Although they are lacking of straightforward paleoclimatic indicators, aeolianites and active dunes from Gran Canaria have been related to past environmental contexts to some extent. For example, the presence of rhizolites in aeolianites at Tufia, on the east coast of Gran Canaria (Figure 1), has been associated with more humid stages that once intermediated an overall arid climate (Alonso-Zarza et al., 2008). Wetter conditions would have favoured soil development in a more stable landscape (Alonso-Zarza et al., 2008). Similarly, in the dune field of Maspalomas, on the south coast of Gran Canaria (Figure 1), abrupt breaks in the stratigraphy of the aeolian sequence (expressed by the intercalation of calcarenites in deposits of stabilized sand) could intimate changes in the regional paleoenvironmental conditions.

Nevertheless, the paleoenvironmental/paleoclimatic interpretation of the aeolianites and sand dunes of Gran Canaria is yet to be investigated. Taking advantage of this MedCLIVAR visit, we collected samples from the dune fields of Tufia and Maspalomas (Figure 4) in order to test their OSL properties, before we carry on with more extensive geochronological and paleoenvironmental studies.

Finally, scattered outcrops of marine conglomerates in Agaete Valley drew our attention. They are attached to the valley's walls (Figure 5) and distributed hypsographically at variable heights, ranging between 41 and 188 m asl. At all sites the contact of the conglomerates with the background could be identified and it is represented by a sharp erosional surface (paleorelief).

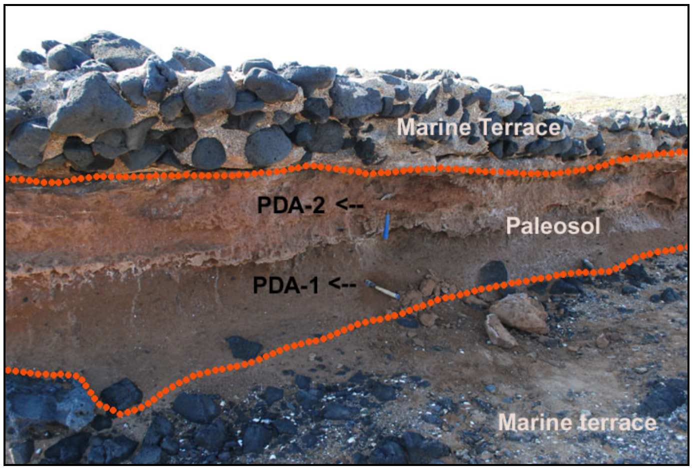

Figure 3. Section at Punta de Arucas. A paleosol interposes two marine deposits.

Figure 4. Two units of aeolianite deposits at Tufia (left). Samples TUF-1 and TUF-2 were collected from both units. Sample collection from a stabilized horizon within a moving dune in the dune field of Maspalomas (right).

Agaete conglomerates consist of heterogeneous clasts of variable size and shape (angular to round), fossils (both fragmented and intact) as well as blocks from the underlying soil, all strewn into a fine matrix. This formation exhibits internal stratification but lacks lateral continuity. Shorting of clasts is very poor.

Peréz-Torrado et al. (2006) considered these marine conglomerates as tsunami deposits, generated by giant tidal waves resulted from an immense flank collapse in the Guimar coastal area of Tenerife, opposite the Agaete Valley. The age of that enormous landslide on the side of Tenerife was dated to 0.8 Ma ago (Ancochea et al., 1990). Were the conglomerate formation on the slopes of Agaete Valley caused by the landslide on the opposite coast of Guimar, a similar age for the Agaete marine deposits should be expected.

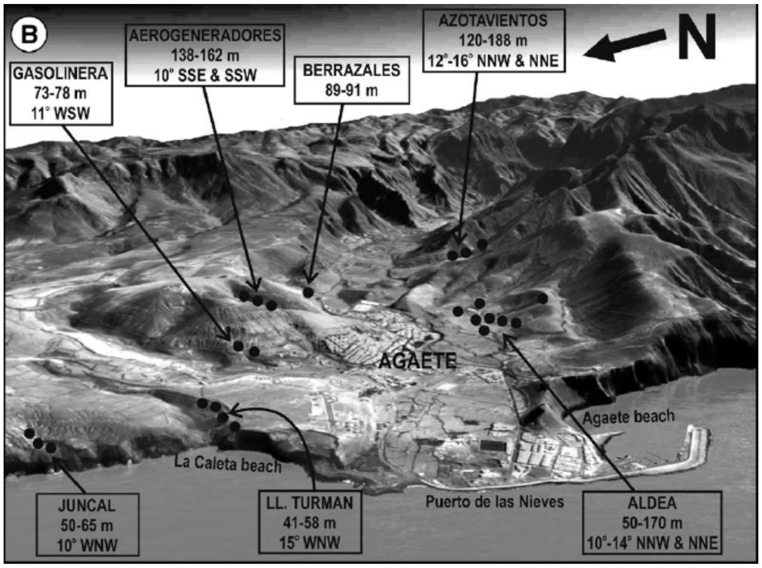

Figure 5. Sites in Agaete Valley where tsunami-related conglomerates have been detected. From Peréz Torrado et al. (2006).

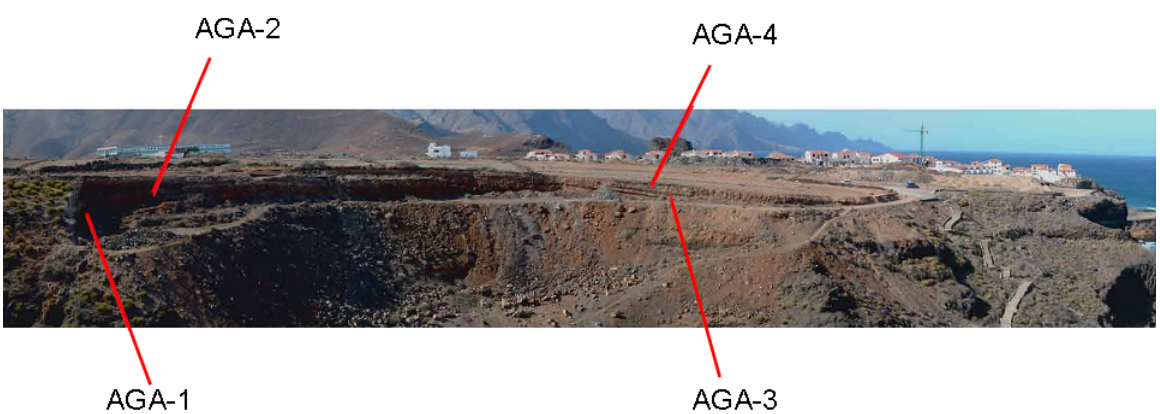

Figure 6. Sampled conglomerate outcrops at Llanos de Turman, Agaete Valley.

Although not directly related to paleoclimatic processes, a paleo-tsunami event on Gran Canaria was considered of high paleoenvironmental importance and hence samples from the Agaete conglomerates were also collected in order to be submitted for OSL dating (Figure 6). Nevertheless, the assumed age of those deposits exceeds conventional OSL dating capabilities (~ 100 ky; Athanassas 2011). Recent progress in OSL dating techniques (Wang et al., 2006a,b; Wang et al., 2007; Tsukamoto et al., 2008; Pagonis et al., 2008; Porat et al., 2010; Stevens et al., 2010, Kim et al., 2010; Adamiec et al., 2010) can enhance the age range of OSL dating by engaging other luminescence signals which give rise to the thermally-transferred OSL signal (TT-OSL). TT-OSL has higher saturation levels than conventional OSL and therefore maybe suitable to calculate ages for the conglomerate deposits of Agaete.

Optically stimulated luminescence (OSL) dating of sediments is a long-lasting, labour-intensive, and time-consuming method, and as with most dating techniques, adequately processed samples provide more precise ages while insufficiently laboratory-treated sediments yield less reliable dates. Due to the nature of the procedure practised, OSL dating of sediments cannot be accomplished adequately in less than five weeks. Taking also backlog into consideration, analysis will usually last somewhat longer. Publication on the dating results and their paleoclimatic/paleoenvironmental implications will then be submitted to peer-reviewed journals. Reprint of these publications will be forwarded to the MedCLIVAR Programme Co-ordinator also.

4. Future collaboration with the host institution

This MedCLIVAR grant made feasible an official visit to the University of Las Palmas in Gran Canaria- an aspiration that had been long ago visualized. My short stay in Las Palmas initiated a collaboration between the Greek and Spanish institutes that will probably remain effective in the long run. Our mutual and long-term interest in paleoclimatic and geochronological research in subtropical areas guarantees partnership in the future. Particularly, both sides are currently searching for new funds to support a second visit to the archipelago. Forthcoming sampling will be extended to the islands of Fuerteventura and Lanzarote in the East and Tenerife in the West. There are also plans to extend this joint research beyond the Canary archipelago, to the opposite coasts of Morocco, Western Sahara and the Capo Verde Islands in the south. A geochronological-paleoenvironmental study of that scale would permit a more thorough comprehension of the paleoenvironmental changes that occurred in West Africa and the eastern Atlantic Ocean during the Middle-Late Quaternary.

5. Projected publications/articles to result from the grant

We aim to summarize the outcome of this MedCLIVAR project in three individual peer-reviewed publications. The first will account on the chronology and the paleoclimatic implications of the loess and paleosol deposits from Galdar and Punta de Arucas. This work is planned to be submitted to ‘Quaternary Science Reviews’. The second paper will involve the TT-OSL dating of the so-called ‘tsunami deposits’ of Agaete Valley and it is planned to be submitted to ‘Quaternary Science Reviews’. Finally, the third paper will include the description of the results from OSL tests on sand dune sediments from Tufia and Maspalomas and their potential to assist paleoenvironmental reconstructions on the coastal areas of Gran Canaria. This paper is planned to be submitted to ‘Quaternary Geochronology’.

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