The Temisas Carbonate Building: an example of a thermogene tuff system in Gran Canaria Island

El Edificio carbonático de Temisas: un ejemplo de un sistema tobáceo termógeno en la isla de Gran Canaria

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Introduction

Calcereous spring deposits are common in volcanic settings and can be found in many places around the world in places such as the active rift system of the Kenya Rift Valley (Renaut and Jones, 1997) or the volcanic areas of Iceland (Pentecost, 2012). Even though they have been described in volcanic settings before, they are rarely seen at the Canary Islands, which are made mostly of volcanic rocks. Mangas et al. (2004) and Rodriguez-Berriguete et al. (2012) described calcereous spring deposits at the Gran Canaria Island in the Azuaje Gorge, and Camuera et al. (2014) in the Berazales area. Another example of calcereous deposits occurs in the Temisas ravine (barranco in local toponomy) and it is the object of this study. The Temisas carbonate building (TCB) is located within a fluvial system entrenched in volcanic rocks. This study is to do a petrologic and stable isotope characterization in order to characterize this building and understand the processes involved in its formation.

Geological-geographic setting

The Gran Canaria Island is in the central part of the Canary Islands and its development and evolution are related to the African plate movement over a mantle plume (Carracedo et al., 2002). Gran Canaria can be classified as a volcanic island in an advanced rejuvenated stage. There were periods of low volcanic activity when various sedimentary deposits accumulated and entrenching of ravines occurred (Carracedo et al., 2002; Guillou et al., 2004; Menéndez et al., 2008). The Island has a nearly circular shape, with a dense network of deeply incised ravines. The Temisas barranco is one of these ravines, located in the southeastern part of the island (Fig. 1). This area is situated near the humid-arid limit of the island and has low water supply.

The Temisas Carbonate Building (TCB)

The Temisas Carbonate Building (TCB) is located approximately 6 m above the present Temisas Barranco floor. TCB is an outcrop about 3 m high and has 50 m of...
lateral continuity. Two different profiles have been studied and are referred here as Profile 1 and Profile 2 (Fig. 2).

Profile 1 consists essentially of six different beds. The first and second beds are composed of imbricated gravels and coarse sands mostly of volcanic fragments embedded in micritic matrix and partially cemented by calcite/aragonite. The third bed contains phytoclastic deposits that are overlain by various sequences of large calcified vertical oriented stems, corresponding to the framestone facies that passes to coarse sands at the top of the interval. The fifth bed of the profile is formed by coarse gravels overlayed by 25 cm of phytoclastic facies that are situated inside small grooves.

Profile 2 is composed mostly by carbonate deposits. The lower bed is made of phytoclastic facies that changes to detrital sands at the top. The second bed is composed of gravels that laterally pass to coarse sands, overlaid by an alternation between coarse sands and phytoclastic facies. The third bed consists of successive small sequences composed of phytoclastic facies with larger amount of detritic clasts. The fourth bed consists of two sequences of coarse sands and framestone facies.

Facies/microfacies description

Detrital facies

The clast size varies from medium sands to coarse gravels and the clasts are of volcanic composition. Matrix is micrite, and cements are either mosaic or fibrous calcite cement. Locally some diatoms can be found. In some cases it is possible to identify volcanic clasts with laminated coatings of µm thickness (Fig. 3A), composed of fibrous calcite crystals aggregates. Furthermore, small-calciﬁed plant remains are often found. The mineralogy of this facies includes mostly volcanic components and calcite (Table I).

Carbonate facies

Three main carbonate facies, all of them calcitic, have been recognized: phytoclastic, framestone and transitional. The framestone facies mainly consists of calcified stems or roots, which are vertically oriented. The stems are not preserved, so this facies is seen as composed of circular or oval pores coated by laminated carbonate (Fig. 3B). The diameter of the overall pore varies from 1 mm to 13 mm (average 10 mm). The coatings are formed by laminated and wavy shaped carbonate of dark to light brown alternating laminae that are 10 µm to 1 mm thick (Fig. 3C). The matrix is micritic and it is often recrystallized to pseudosparite. Fibrous calcite cement can also be seen. The mineralogy of this facies is 65% Calcite, 5% Aragonite, 15% Phyllosilicates, 10% Feldspars and 5% of other minerals (Table I).

1-Phytoclastic facies consists of fragments of the framestone facies (Fig. 3D). The fragments are composed of carbonate coatings around plant molds (Fig. 3E). The coatings present laminations which show the same pattern as the framestone facies. Micrite and fibrous cements occupy the space between the fragments, but also diatoms. Some areas of micrite are neo-
morphed to pseudosparite. Sand-sized grains mostly of volcanic fragments are common. Some samples have up to 20% of detritic grains, whereas others have lower contents. The mineralogy of this facies is shown in Table I and consists of 35-50% Calcite, 0-10% Aragonite, 15-25% Phyllosilicates, 25-30%, Feldspars and 5% of others.

3- The transition facies between the framestone and the Phytoclastic facies consists on fragments coated in situ by laminated carbonate (Fig 3F). Micrite, fibrous calcite cement and diatoms occupy the space between the fragments. The micrite is often recrystallized to pseudosparite. The mineralogy of this facies is 20-70% Calcite, 10-30% (?) Phyllosilicates, 15-35% Feldspars and 5% of others (Table I).

Stable isotopes

Stable isotopes analysis revealed that all the carbonate facies have negative values of $\delta^{18}$O, and positive values of $\delta^{13}$C (Table I) what was also observed by Rodríguez-Berriguete et al. (2012) and Camuera et al. (2014) in other carbonate spring deposits from Gran Canaria Island. These carbon values seem to be typical of deposits related to hot water springs of hydrothermal or volcanic origin (Valero-Garcés et al., 2001; Rainley and Jones, 2009), but could also be related to evaporation and/or biological effects (Chafetz and Folk, 1984; Riding, 2000; Fouke, 2011). According to Pentecost (2005) the $\delta^{18}$O values are similar in meteogene and thermogene travertines whereas the $\delta^{13}$C values are commonly negative in meteogene tufas, and travertines and -1% to 10% in the thermogene travertines. Arenas-Abad et al. (2010) show that the carbonates formed in fluvial systems have negative values of $\delta^{18}$O and $\delta^{13}$C, which are very distinct from the values observed in the Temisas deposits.
The carbonates of the detrital facies have also negative values of δ18O and lighter δ13C values than the carbonate facies. These lower values of δ13C could be explained by a larger influence of meteoric water.

Discussion and conclusions

The Temisas Carbonate Building (TCB) is a special case of fluvial carbonate deposit in Gran Canary Island. The sedimentary sequence of the TCB begins with coarse detrital deposits which indicate high-energy events that may be associated with periods when the fluvial systems were incisive, depositing coarse clasts at bars or at the bottom of the channels. The detrital facies formed at times of high water input, when the carbonate factory was minimal or null. The framestone facies represents a bioconstruction where the plants structures were coated by carbonate. These bioconstructions formed in the channel associated to the main watercourse and represent the breakage of the bioconstructions.

Several articles have focused on the definition of tufas and travertines. Thus, most authors considered travertines as warm to hot water carbonate springs whereas tufa forms at ambient temperatures (cool water) (Pedley, 1990). Pentecost (2005) divides travertines into meteogene and thermogene. Meteogene travertines and tufa form from groundwater recharge from meteoric supplies and their δ13C signatures are commonly negative. On the other hand, in thermogene travertines its carbon dioxide is sourced from thermal processes within or below the Earth’s crust and the δ13C is heavier (typically -3 to +8%) than meteogene water, although thermogene water can lose temperature in the surface and become cool. Thermogene deposits are often associated with regions of recent volcanic or tectonic activity like the Gran Canary Island (Rodríguez-Berriguete et al., 2012; Camuera et al., 2014).

The isotopic values of the TCB indicate thermal origin for the CO₂ due to its relatively heavy δ13C. The positive carbon isotopic signature suggests an endogenous origin for the CO₂ of the waters in the TCB, so from the geochemical point of view the TCB should be considered a thermogene travertine. However, the facies characteristics and arrangements fits more with the term tufa. Thus, although it may be controversial, the TCB should be considered as a thermogene tufa, representing probably the distal facies of a thermogene carbonate spring. A similar situation has been described in the Berrazales area also in Gran Canaria (Camuera et al., 2014).

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