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The Temisas Carbonate Building: an example of a thermogene tufa 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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ABSTRACT

The Temisas Carbonate Building (TCB) is situated in the Temisas ravine, at the SW part of the Gran Canaria Island. Four different facies were recognised: detrital, framestone, phytoclastic and a transition between the last two facies. The carbonate is mostly calcite. The sedimentary sequence indicates that the TCB was formed in a fluvial system with different subenvironments, such as cascades, channels and bars. The studied deposits correspond to the distal part of a calcareous spring deposit. Petrologically these deposits can be included in the term tufa. The stable isotope values indicate thermal origin for the CO_2, so from the geochemical point of view the TCB should be considered a thermogene tufa.

Key-words: *Tufa, thermogene, spring deposits, volcanic setting, Canary Islands.*

RESUMEN

El Edificio carbonático de Temisas (TCB) está situado en el barranco de Temisas al SW Gran Canaria. Se pueden reconocer cuatro facies distintas: detritica, "framestone", fitoclástica y de transición, entre las dos últimas. Los depósitos carbonáticos son esencialmente de calcita. La secuencia sedimentaria indica que el TCB se ha formado en un sistema fluvial formado sobre todo por cascadas, canales y barras. Los depósitos estudiados en este trabajo corresponden a la parte distal de una surgencia carbonática y se podrían clasificar como toba. Los valores de isótopos estables sugieren un origen termal para estas aguas. Por ello el TCB puede ser considerado como una toba termogéna.

Palabras clave: *Tobas, termógeno, depósitos de surgencia, contexto volcánico, Islas Canarias.*

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Introduction

Calcareous 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 Rodríguez-Berriguete *et al*. (2012) described calcareous spring deposits at the Gran Canaria Island in the Azuaje Gorge, and Camuera *et al*. (2014) in the Berrazales area. Another example of calcareous 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. The aim of this study is to do a petrologic and stable isotope characterization in order to characterise 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

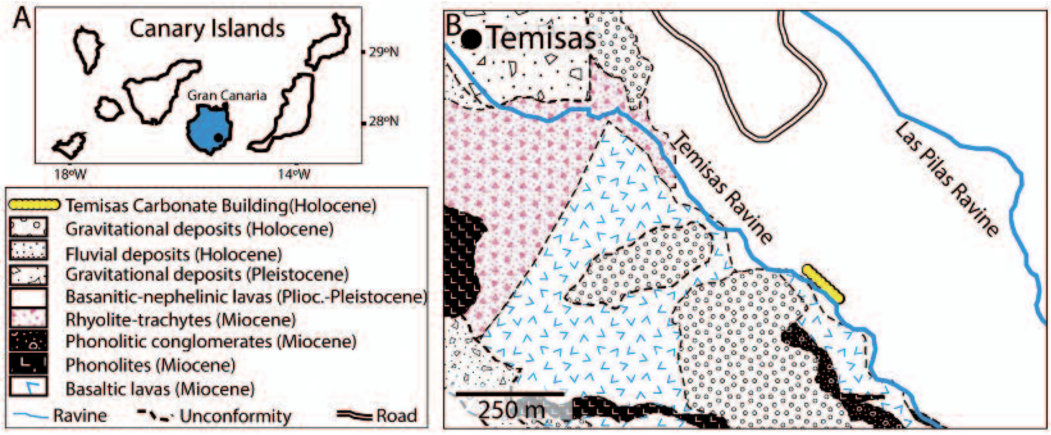

Fig. 1.- Geographic and geologic setting of the studied profiles.

Fig. 1.- Situación geográfica y geológica de los perfiles estudiados.

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.

1-*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 µm to 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).

2-*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-

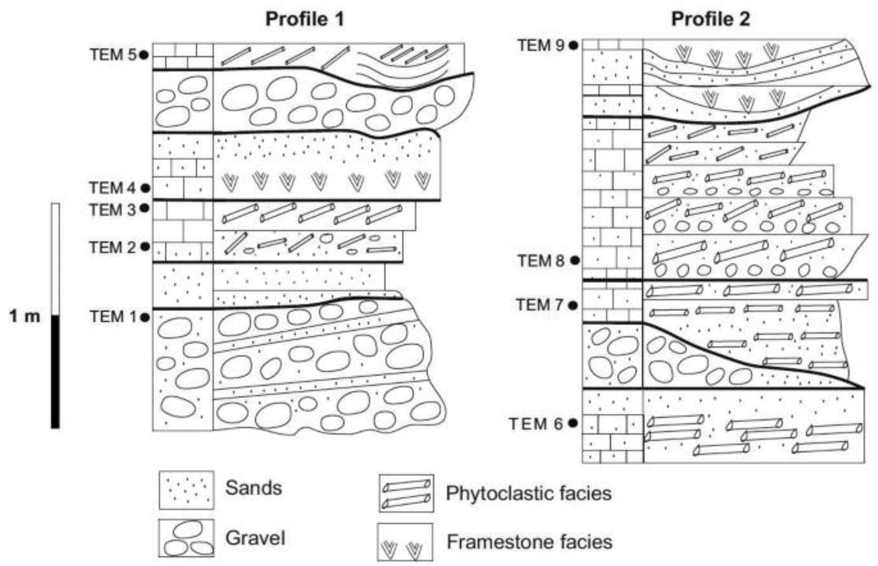

Fig. 2.- Temisas Carbonate Building profiles showing the main facies and their general arrangement.

Fig. 2.- Perfiles del Edificio Carbonático de Temisas indicando sus facies principales.

Sample	Facies	Mineralogy (%)								Stable Isotopes	
		Cal	Ar	Phy	Fel	Ol	Hor	Tre	Ot	$\delta^{18}O$	$\delta^{13}C$
TEM 1	Detrital	20		15	15	15	15	10	10	-3.03	-2.93
TEM 2	Detrital	20		15	20	20	5	10	10	-4.49	1.47
TEM 3	Transition	70		10	15				5	-3.93	3.88
TEM 4	Framestone	65	5	15	10				5	-3.78	3.2
TEM 5	Phytoclastic	50		15	25				10	-4.26	3.21
TEM 6	Phytoclastic	35	>5	25	30				5	-3.53	3.58
TEM 7	Phytoclastic	35	10	25	25				5	-3.85	3.1
TEM 8	Transition	40	5	20	30				5	-4.24	3.89
TEM 9	Transition	20	>5	30	35				10	-3.8	1.2

Table I.- Mineralogy and stable isotope composition of the TCB samples. Cal= Calcite, Ar= Aragonite, Phy= Phyllosilicates, Fel= Feldspars, Ol= Olivine, Hor= Hornblende, Tre= Tremolite, Ot= other minerals. The stable isotopes are in % PDB.

Tabla I-. Mineralogía y composición isotópica de las muestras del TCB. Cal= Calcita, Ar= Aragonito, Phy= Filosilicatos, Fel= Feldespatos, Ol= Olivino, Hor= Hornblenda, Tre= Tremolita, Tra= Trazas. Los datos de isótopos estables están en %PDB.

morphized 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.

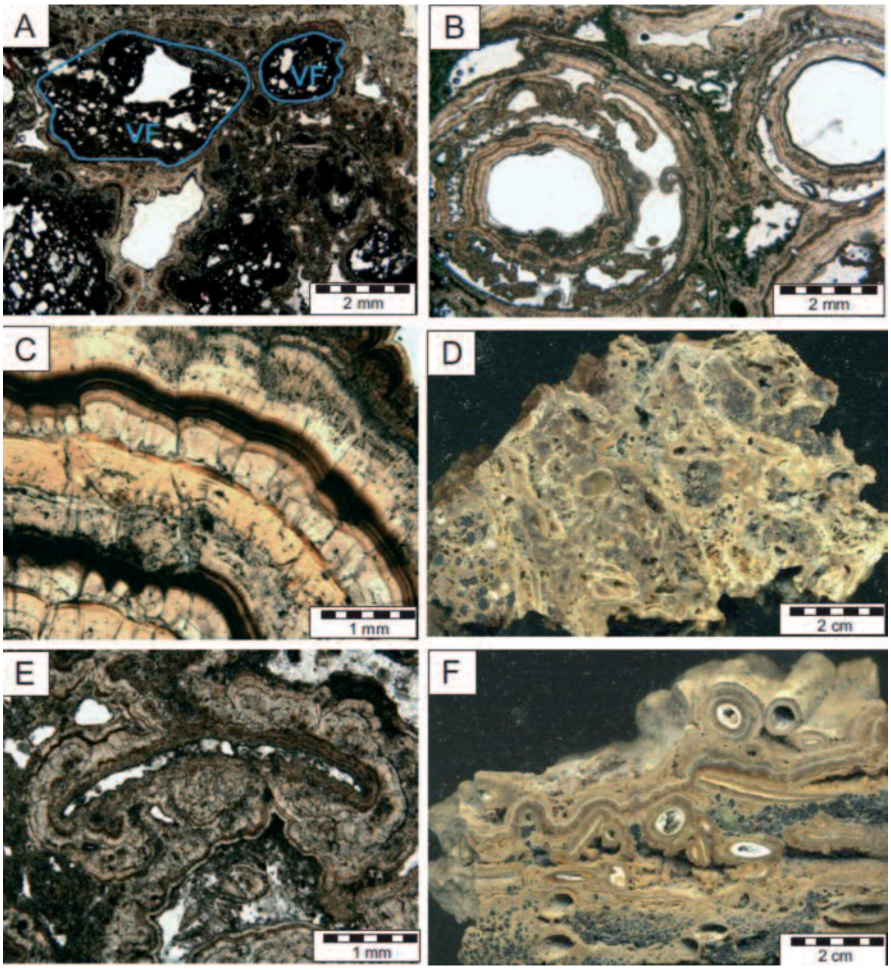

Fig. 3.- A) Detrital microfacies. Carbonate coatings around volcanic fragments (VF). B) Framestone microfacies consisting on coated stems. C) Detail of coated stems formed by coarse crystalline and micritic calcite. D) Hand sample of the Phytoclastic facies. E) Phytoclastic microfacies composed by fragments of coated stems. F) Hand sample of transitional facies composed of detrital, phytoclastic and framestones facies.

Fig. 3.- A) Microfacies detrítica. Recubrimiento sobre los fragmentos volcánicos. B) "Framestones" de tallos. C) Detalle de las cubiertas de los tallos formadas por calcita cristalina gruesa y micrita. D) Muestra de mano de la facies fitoclástica incluyendo los clastos detríticos. E) Microfacies fitoclástica compuesta por fragmentos de tallos. F) Muestra de mano de la facies de transición compuesta por las facies detritica, fitoclástica y de bioconstrución.

The carbonates of the detrital facies have also negative values of $\delta^{18}O$ and lighter $\delta^{13}C$ values than the carbonate facies. These lower values of $\delta^{13}C$ 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 are common in fluvial environments with enough space for plants to grow as well as intense calcium carbonate precipitation, such as cascades or river´s edges (Arenas-Abad *et al.*, 2010). The phytoclastic facies 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 spring deposits whereas tufa forms at ambient temperatures (cool water) (Pedley, 1990). Pentecost (2005) divides travertines into meteogene and thermogene. Meteogene travertines and tufas form from groundwater recharged from meteoric supplies and their $\delta^{13}C$ 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 $\delta^{13}C$ 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 CO_2 due to its relatively heavy $\delta^{13}C$. The positive carbon

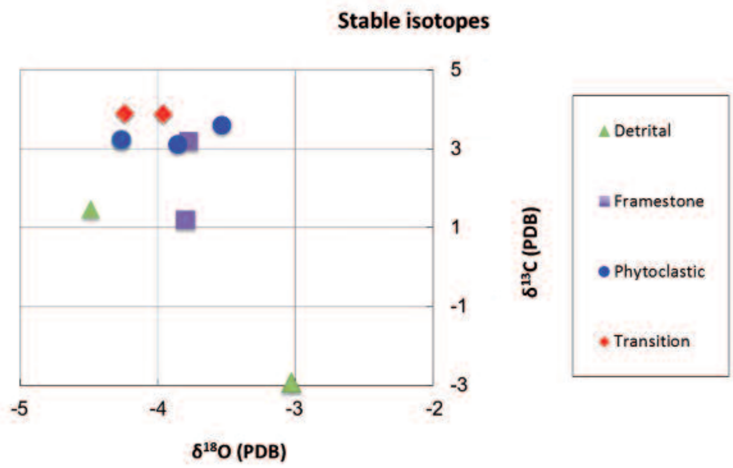

Fig. 4.- Stable carbon and oxygen isotope composition of TCB samples according to facies.

Fig. 4- Relaciones isotópicas de las muestras del TCB y su distribución para las diferentes facies.

isotopic signature suggests an endogenous origin for the CO_2 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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