Petrographic analysis of eolian detrital sediments in beach-dune systems of La Graciosa Island (Canary Islands)

Análisis petrográfico de sedimentos detríticos eólicos en sistemas playa-duna de la isla de La Graciosa (Islas Canarias)

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ABSTRACT

La Graciosa island is formed by volcanic and sedimentary processes since the Middle Pleistocene, features low-lying plains where stand out volcanic cones. Approximately half of its surface is covered by aeolian sands (jables) and muddy sediments occasionally in endorheic basins. Studies were conducted on six beach-dune systems distributed across the northern, eastern, and southern sectors of the island. Only the northern systems (Las Conchas and Lambra beaches) are currently active; the others are semi-active, with no recent marine sand inputs. A total of 21 aeolian and 5 endorheic basin detrital samples were petrographically analyzed to determine the composition and relative abundance of sand grains. The predominant sands are bioclastic (average of 77.5%; σ = 8.6), mainly composed of mollusk remains (55%) and fragments of red coralline algae (22.5%). Terrigenous components (volcanic rock fragments and sedimentary intraclasts) account for 22.5%, with intraclasts being more abundant (14.5%; σ = 5.9) and in lower proportion volcanic terrigenous with 8% (σ = 1). Endorheic basin muddy sands consist almost exclusively of intraclasts (98.5%). Slight variations in abundance percentage occur both among different eolian systems and within them, influenced by sample location and, the geological and geomorphological nearby elements.

Key-words: *Aeolian sands, beach-dune systems, petrography, bioclasts, provenance analysis.*

RESUMEN

La Graciosa se formó por procesos volcánicos y sedimentarios desde el Pleistoceno Medio, presentando planicies donde destacan conos volcánicos. Aproximadamente la mitad de su superficie está cubierta por arenas eólicas (jables) y, ocasionalmente, sedimentos fangosos endorreicos. Se estudiaron seis sistemas playa-duna en sectores norte, este y sur de la isla. Sólo los sistemas del norte (playas de Las Conchas y Lambra) están activos; los otros están semiactivos, sin aportes recientes de arenas marinas. Un total de 21 muestras detríticas eólicas y 5 fangosas de cuencas endorreicas fueron analizadas petrográficamente para determinar la composición y abundancia relativa de los granos. Las arenas predominantes son bioclásticas (promedio de 77.5%; σ =8.6), compuestas principalmente de restos de moluscos (55%) y fragmentos de algas rojas coralinas (22.5%). Los componentes terrígenos (fragmentos de roca volcánica e intraclastos sedimentarios) representan el 22.5%, siendo los más abundantes los intraclastos (14.5%; σ = 5.9) y, en menor proporción, los volcánicos con un 8% (σ=1). Las arenas limosas endorreicas contienen casi exclusivamente intraclastos (98.5%). Existen ligeras variaciones en los porcentajes de abundancia tanto entre diferentes sistemas eólicos como dentro de ellos, influenciados por la ubicación de las muestras y, los elementos geológicos y geomorfológicos cercanos.

Palabras clave: *Arenas eólicas, sistemas playa-duna, petrografía, bioclastos, análisis de procedencia.*

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Introduction

La Graciosa Island, with an area of 27.05 km², is located north of Lanzarote and forms part of the Chinijo Archipelago Natural Park (Fig. 1). This protected area, which also includes Alegranza, Montaña Clara, the Roques, and the Risco de Famara, together with the island of Lanzarote was declared a UNESCO Global Geopark in 2015, recognizing its high geological and ecological value (Galindo et al., 2019).

During the Middle to Late Pleistocene, La Graciosa island emerged through strombolian and hydromagmatic phases that created volcanic cones aligned NE-SW, such as Las Agujas, Mojón and Amarilla mountains (Fig. 1). Quaternary subaerial processes have shaped its current morphology, producing deposits of alluvial, colluvial, soil, aeolian and marine origin over platforms sloping toward the sea (De la Nuez-Pestana et al., 1998; Balcells et al., 2004).

Currently, sand sheets or "*jables*" cover nearly half of the island (13 km²), associated with beach-dune systems in the northern and southern sectors, separated by NE-SW volcanic alignments. These deposits are highly sensitive to surface waters and wind actions, marine activity, and human intervention. In this sense, tourism development since the 1970s has intensified pressure on these aeolian systems, causing sediment loss, erosion, and fixation of dunes by shrub vegetation (Pérez-Chacón et al., 2012; Santana-Cordero et al., 2016). This is accompanied by a current low production of marine bioclastic sands and their complex redistribution across emerged zones (Mangas et al., 2017).

This study analyzes the provenance and composition of aeolian detrital sediments from different beach-dune systems on La Graciosa through petrographic observations. The geomorphological variability of the sampling points, including supratidal zones and endorheic basins, allows evaluation of active sedimentary processes, sediment sources, and possible imbalances.

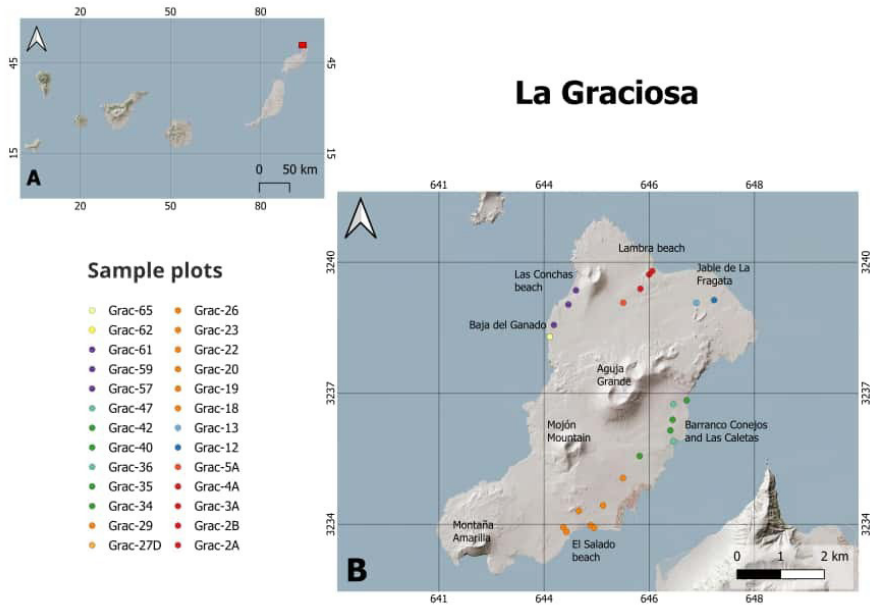

Fig. 1.- La Graciosa Island to the north of Lanzarote in the Canary Islands (light red square) (A), and location of the studied samples in circles of different colours (B). Base map: WMS LIDAR MTL, provided by Grafcan (IDECanarias).
Fig. 1.- La isla de la Graciosa al norte de Lanzarote en el archipiélago canario (cuadrado rojo claro) (A), y localización de las muestras estudiadas (círculos de distintos colores) (B). Mapa base: WMS LIDAR MTL, proporcionado por Grafcan (IDECanarias).

Materials and methods

Between May 2009 and July 2010, 26 detrital samples were collected from various sedimentary environments on the island for petrographic analysis. These samples were taken from supratidal zones and interior dune fields (foredune, nebkha, sand sheet and endorheic basin, Fig. 2).

For the mineralogical and textural characterization of the aeolian sandy sediments, thin sections were analyzed at the Geology Laboratory of the University of Las Palmas de Gran Canaria, using polarized light microscopy (Leitz-ORTOPLAN). In addition, a point-counting system was applied (200 points per sample) using an PETROG automated stage and the PetrogLite software, classifying the grains into three main groups: bioclasts (mollusc, algae, etc.), lithoclasts (volcanic rock and mineral fragments), and intraclasts (sedimentary aggregates with clay-silt matrix or carbonate cement). The treatment of petrographic data and its interpretation allow for a better interpretation of the sand provenance.

Results

Petrographic analysis of the aeolian sands of La Graciosa reveals notable compositional variability among the analyzed samples (Fig. 3). Five main groups of components were identified: mineral lithoclasts (Lmi), volcanic rock fragments (LRf), flora bioclasts (Bfl), fauna bioclasts (Bfa), and sedimentary intraclasts (INT), classified based on their optical characteristics under the microscope.

The data, processed using spreadsheets, allowed for the calculation of abundance percentages, mean values, and standard deviations by sedimentary environment, thus estimating the typical composition and its heterogeneity. For easier interpretation, the results were organized into two sectors: the northern (Fig. 4) and the central-eastern (Fig. 5).

Northern beach–dune systems

If we consider the petrographic data associated with the abundance values of the main types of sand grains (volcanic lithoclasts of minerals-Lmi and rock fragments-LRf; bioclasts of flora-Bfl and fauna-Bfa; and sedimentary intraclasts-INT) in the sand samples of various eolian deposits (supratidal, nebkha, sand sheet, and endorheic basin) from N beach-dune system (Fig. 4), we observe that in the supratidal zone of Las Conchas, Lambra, La Fragata, and Baja del Ganado, Bfa dominate with values ranging from 47 to 66.5%, followed by Bfl with 24.5 and 33.5%. The grains of fauna are mainly mollusks, and the ones from flora are coralline red algae (rodoliths). Grains of sand made up of mineral (Lmi) is elevated in Las Conchas with data below 13% but scarce in Lambra

Fig. 2.- Littoral photographs from La Graciosa Island: Active beach-dune systems of Las Conchas (A) and Lambra (B) (NW and N, respectively) with foredunes, nebkhas, and sandy sheets. (C) Nebkhas and sand sheets semi-stabilized by shrub vegetation in the Caletas coast (E sector). (D) Inactive supratidal zone of Salado Beach without sand input (S sector).
Fig. 2.- Fotografías litorales de la Isla de La Graciosa: sistemas playa-duna activos en las playas de Las Conchas (A) y Lambra (B) (sectores NO and N, respectivamente) con foredunas, nebkhas y mantos eólicos. (C) Nebkhas y mantos eólicos semiestabilizados por la vegetación arbustiva en la costa de Caletas (sector E). (D) zona supramareal inactivae en la playa de Salado, sin entrada de arena (sector S).

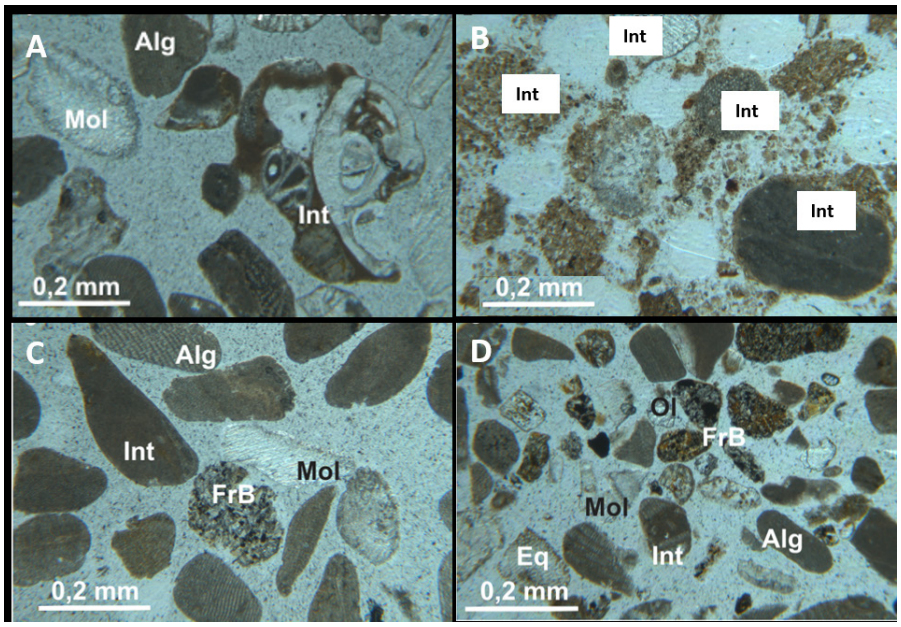

Fig. 3.- Microphotographs (PPL, 40X) of aeolian deposits from different beach-dune system in La Graciosa Island: (A) foredune sands in Lambra; (B) endorheic basin aggregates in Lambra; (C) grains of sand sheet in Las Conchas; (D) foredune in Salado. Mol: mollusk, Alg: algal mesh, Eq: echinoderm, For: foraminifer, FrB: basaltic rock fragment, Ol: olivine, Pir: pyroxene, Int: intraclast.

Fig. 3.- Microfotografías (PL, 40X) de depósitos eólicos de diferentes sistemas playa-duna en la isla de La Graciosa: (A) arenas de foredune en Lambra; (B) detríticos endorreicos en Lambra; (C) arenas de mantos eólicos en Las Conchas; (D) duna costera en Salado. Mol: molusco, Alg: malla de algas, Eq: equinodermo, For: foraminífero, FrB: fragmento de roca basáltica, Ol: olivino, Pir: pyroxeno, Int: intraclasto.

below 4%. Rock fragments (LRf) appears occasionally in these samples with values ≤2.5%, and intraclasts (INT) ranges between 16.5% and 6.5%.

The nebkhas show greater heterogeneity. Thus, in Lambra, Bfa ranges from 55.5% to 61%, followed by Bfl (23.5–29%) and INT (11–13%). In La Fragata, notable values include 63% Bfa, 15% Bfl, 4% Lmi, and 4.5% LRf. Samples from Las Conchas are internally variable: one contains 41.6% Bfa, 33.7% Bfl, and 13% Lmi, while another is strongly dominated by Bfa (89.5%). In Baja del Ganado, there are high proportions of Lmi (23%) and LRf (7.5%), with moderate Bfa (36.5%) and Bfl (23%).

In the sand sheets of La Fragata, Bfa reach 74.5% and Bfl 15.5%, with moderate LRf (5.5%) and low INT (4.5%) contents.

The endorheic basins of Lambra and Baja del Ganado present sediments composed almost entirely of intraclasts (99.5–100%), with abundant silty-clayey matrix (Fig. 4).

Central–eastern beach–dune systems

If we take into account the petrographic data obtained in this sector Central-eastern (Fig. 5), it is noted that in the supratidal zones of Playa El Salado, the fauna bioclasts are the most abundant (51.6-52%), and they are followed by those of flora (19.5-25.2%), rock fragments (6.5-16.1%), minerals (up to 8%), with low intraclast (2.5%).

The nebkhas of Conejos-Caletas are also dominated by Bfa (51.7–59.5%) and Bfl (24.5–29.6%), with low levels of Lmi and LRf (1.5–4%) and moderate INT (10.5–15.5%).

The sand sheets show relatively homogeneous compositions. In El Salado, Bfa (46–55.9%) and Bfl (26–29.5%) dominate, with Lmi (1–2%), LRf (4–6%), and INT (12–18.5%). In Conejos and Caletas, Bfa reach up to 73.5% and Bfl 23%, with virtually no Lmi or LRf.

In the coastal dunes of Conejos–Caletas, INT reaches 47.5%, while Bfa decreases (31.5%). In the El Salado, composition is more varied: Bfa (42.4–47.8%), Bfl (24%), LRf (12.9–14.3%), INT (11.5–13.9%), and Lmi (1.4–7.8%).

Discussion

La Graciosa Island presents an extensive coverage of coastal sedimentary systems, mainly composed of loose bioclastic sands distributed across subtidal, intertidal, and supratidal zones (Figs. 1 and 2). These systems are grouped into two main domains: a northern one (4.4 km²) and a central-eastern one (8.7 km²), separated by Upper Pleistocene volcanic cones.

Subtidal sands are transported by marine dynamics to intertidal areas, where wave and current action introduce new detrital sediments through the erosion of rocky substrates. These materials are then carried inland by NE-SW trade winds, forming various aeolian deposits such as du-

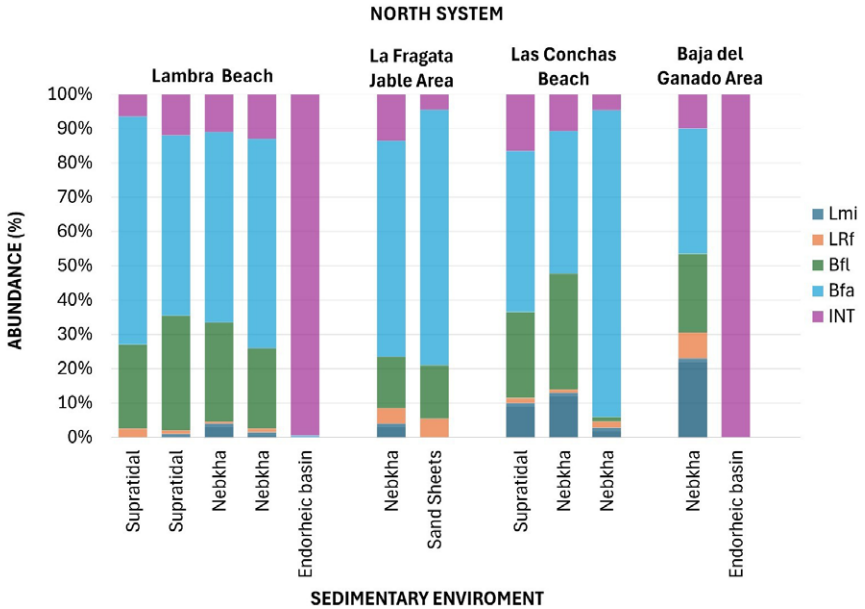

Fig. 4.- Relative abundance (%) of main types of grains (Lmi, LRf, Bfl, Bfa, INT) from supratidal zone, foredune nebkhas, sand sheets, endorheic basin within the North System (Lambra beach and Jable de La Fragata in the north, and Las Conchas beach and Baja del Ganado in the north western.

Fig. 4.- Abundancia relativa (%) de los principales tipos de granos (Lmi, LRf, Bfl, Bfa, INT) de zona supramareal, duna costera, nebkhas, mantos eólicos y cuenca endorreica, en el sistema playa-duna Norte (playa Lambra y jable de la Fragata en la zona norte, y playa de Las Conchas y Baja del Ganado en el noroeste.

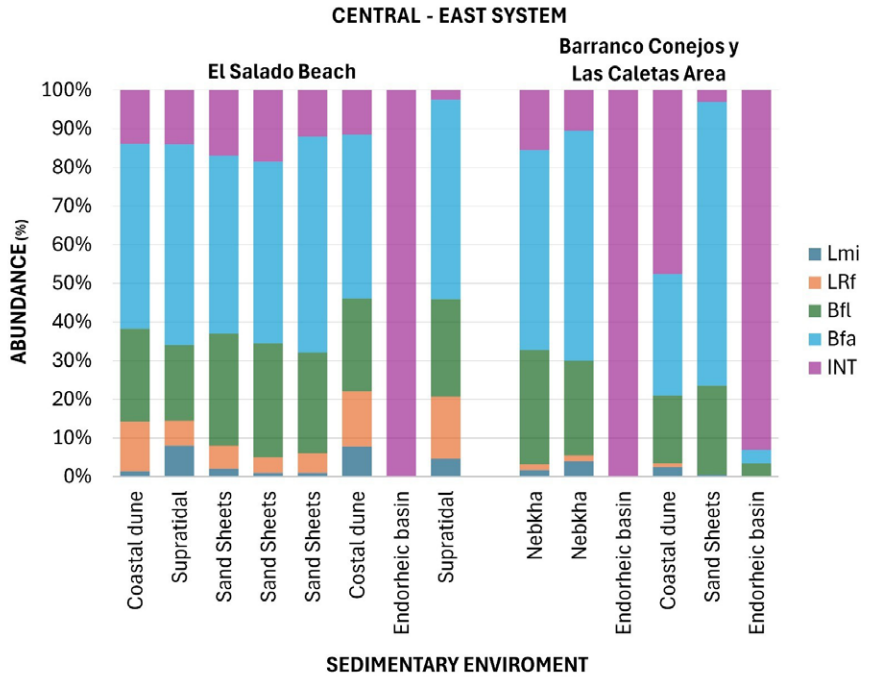

Fig 5.- Relative abundance (%) of major grain components (Bfa, Bfl, Lmi, LRf, INT) in sediment samples from supratidal zone, coastal dune, and sheets mantle, endorheic basin across the El Salado Beach and Barranco Conejos–Las Caletas area, inside of the Central–Eastern beach-dune system.

Fig.5.- Abundancia relativa (%) de los principals componentes definidos (Bfa, Bfl, Lmi, LRf, INT) en las muestras sedimentarias de la zona supramareal, duna costera, mantos eólicos y cuencas endorreicas, en la playa El Salado y Barranco Conejos–Las Caletas, en el sistema playa-duna Central–Este.

nes and sand sheets, and supplemented by runoff and gravity during rainfall events.

Petrographic analysis reveals a dominance of bioclastic grains (average value of 77.5%, σ=8.6), primarily faunal remains (55.9%) such as mollusks, and in minimal percentages bryozoans, echinoderms, and foraminifera, and floral fragments (22.6%) of coralline red algae. Terrigenous components average 22.5%, comprising carbonate intraclasts (14.5%, σ=5.9) and volcanic lithoclasts (8%, σ=1). These results align with submerged sand data (Mangas et al., 2017), which report similar bioclast proportions (averages of 82% in the subtidal areas of the island), but lower intraclast values (5%) and higher volcanic content (17.5%) in the eastern and southern sectors.

These differences suggest more intense erosion of coastal volcanic substrates and areas within the island, especially in the south and east (Mangas et al., 2017). Our results, lithoclasts content in the north is higher (13%, σ=1.9), particularly in Baja del Ganado (30.5%), where runoff transports basaltic pyroclasts into the supratidal zone (Fig. 4). In contrast, Lambra and Conejos-Caletas systems show very low volcanic input (2.9% and 3.4%, respectively), reflecting a lack of nearby volcanic sources (Fig. 5).

Field observations indicate that only Las Conchas and Lambra are currently active systems, receiving direct marine sand input (Figs. 2A and 2B). Others, like Baja del Ganado, La Fragata, El Salado, and Las Caletas, are semi-active dependent solely on wind transport of inherited sands and increasingly disconnected from marine sources (Fig. 2D). Pedro Barba system located in the NE of the island, with no active aeolian transport today, exemplifies this trend (Pérez-Chacón et al., 2012).

Recent studies confirm this progressive sand deficit in many systems (Pérez-Chacón et al., 2012; Santana-Cordero et al., 2016; Mangas et al., 2017), highlighting the vulnerability of La Graciosa's *jables* under current environmental and anthropogenic pressures.

Conclusions

Petrographic data indicate that the aeolian sands of La Graciosa are predominantly of marine origin, with a clear dominance of bioclasts, while volcanic and sedimentary components constitute significant secondary inputs. The variability of the abundance percentages in the main types of sand grains, both in the different beach-dune systems and in the varied wind deposits of each system, reflects the combined influence of local geological, geomorphological, and anthropogenic factors in the beach-dune systems of La Graciosa.

The endorheic basins exhibit a distinct sedimentary pattern, dominated by fine intraclasts derived from combined aeolian and surface transport processes.

These results provide a solid basis for understanding coastal sedimentary dynamics in volcanic contexts and represent a relevant contribution to the conservation of these ecosystems amid increasing natural and anthropogenic pressures.

Acknowledgments

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References

Balcells, R., Barrera, J.L. & Gómez, J.A. (2004). *Mapa geológico de España, Escala 1:25.000, hoja 1080 I-IV (La Graciosa)*. IGME. Madrid.

De la Nuez Pestana, J., Álvarez, M. L. Q., & Blanco, J. J. A. (1998). *Los volcanes de los islotes al norte de Lanzarote: Islas Canarias*. Fundación Cesar Manrique Lanzarote. 223 p.

Galindo, I., Vegas, J., Romero, C, Llorente, M., Martín-González, E., Rubio, J.C., Díaz, G.A., Mangas, J., Mateo, E. & Sánchez, N. (2019). In: E. Mateo et al. (Eds.), *Lanzarote and Chinijo Islands Geopark: From Earth to Space, Geoheritage, Geoparks and Geotourism*. Springer, Nature Switzerland AG, 31-45. https://doi.org/10.1007/978-3-030-13130-2

Mangas, J., Casado, J. F., Pérez-Chacón Espino, E., García Romero, L., & Menéndez González, I. (2017). *Geo-Temas*,17, 295–298.

Pérez-Chacón, E.; Hernández-Calvento, L.; Fernández Negrín, E.; Mayer, P.; Cabrera, L. Cruz, N.; Fernández E.; Peña, C.; García-Romero, L.; Hernández-Cordero, A.; Santana-Cordero, A.; Mangas, J. and Rodríguez, S. (2012). *Evolución reciente del sistema sedimentario eólico de La Graciosa (archipiélago canario): claves para su diagnóstico ambiental*. Informe final. Centro "Isla de La Graciosa" (OAPN, Ministerio de MAMRM). ULPGC. 151 p.

Santana-Cordero, A., Monteiro-Quintana M.L., Hernández Calvento, L., Pérez-Chacón, E., & García-Romero, L. (2016). *Land Degradation Development,* 27: 479-489. https://doi.org/10.1002/ldr.2369