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A reappraisal of the stratigraphy and chronology of Early Pliocene palaeontological sites from Lanzarote Island containing fossil terrestrial animals

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ABSTRACT

The Famara massif, in the north of Lanzarote Island, constitutes the remains of a former island inhabited by the oldest known vertebrate fauna of the Canary archipelago off the coast of Africa. In this study, new ages are offered for the underlying and overlying basaltic lava flows of two paleontological sites. The island's three major palaeontological sites, which contain remains of this ancient fauna (Valle Grande, Valle Chico and Fuente de Gusa), are intercorrelated according to their lithologies, sedimentology, palaeontological content and geochronology. The new K/Ar age interval for the fossiliferous sedimentary deposits ranges between 4.3 ± 0.7 and 3.78 ± 0.71 Ma, within the Early Pliocene, and shows that the first known terrestrial animals in Lanzarote were present on the island for about 500 ka. The principal component of the deposits is a bioclastic calcarenite of aeolian origin (sand sheet deposits), which is present in all three sites and constitutes 65% of the beds. The remaining 35% is of fluvial-aeolian origin (mainly stream deposits). All the beds contain the same fossils (insect egg pods, land snails, avian eggshells and tortoise eggshells). The local palaeogeography and the formation of the deposits were conditioned by a flat plain, larger than 16 km^2, over which aeolian sands moved freely with a prevailing NNE-WSW wind direction. In agreement with previous investigations, the palaeoclimate in this interval (ca. 4.3 to 3.8 Ma) must have been mainly dry with some rainy episodes.

1. Introduction

The aim of this paper is to define the geological and chronostratigraphic context of sites in Lanzarote (Canary Islands, Spain) which contain fossil eggs of land vertebrates (Fig. 1). The publication of papers assigning fossil remains found at these sites to flightless running birds on an island 140 km from the African continent has generated some debate (Rothe, 1964; Sauer and Rothe, 1972; García-Talavera, 1990; Sánchez Marco, 2010, Schmincke and Sumita, 2010). Consequently, since 2011, we have undertaken a series of research campaigns to provide a geological study of the sites, which is the subject of the present paper, as well as to perform detailed analyses of their fossil content and palaeoecological significance.

Fossil remains from Lanzarote have been the subject of previous studies. Avian eggshells were identified as ratites (Rothe, 1964), a group of large flightless birds (with the exception of Kiwis), and alternatively to Pelagornithidae, an extinct group of flying seabirds, by García-Talavera (1990). Gittenberger and Ripken (1985) found five species of terrestrial gastropods, four of them new. Eggshells of a large terrestrial tortoise were attributed by Hutterer et al. (1997) to an indeterminate species within *Geochelone*. Previously, Rothe

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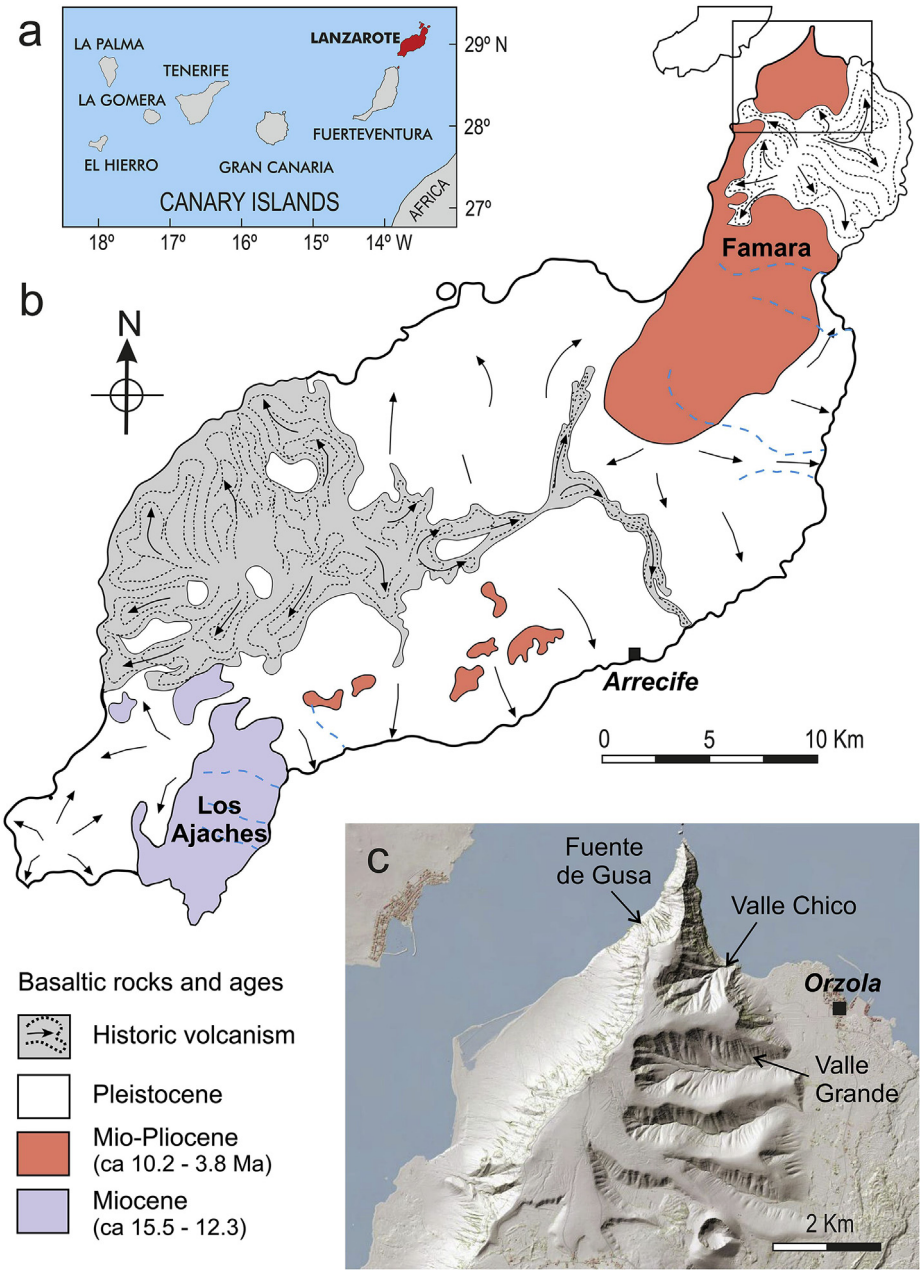

Fig. 1. **a** Lanzarote location in the Canary Islands; **b** Schematic geological map of Lanzarote with its two Neogene volcanic edifices: Los Ajaches and Famara. Ages from Abdel-Monem et al. (1971) and Coello et al. (1992); **c** Locations of the fossiliferous sites (square area in b).

and Klemmer (1991) studied fossil eggs of terrestrial tortoises from Pliocene calcarenites of Fuerteventura Island.

Sauer and Rothe (1972, 1974) proposed two alternative hypotheses to explain the presence of flightless birds on Lanzarote. One considers a land connection through a volcanic island chain between the eastern Canaries and Africa. These volcanic structures would have subsequently been eroded, but during the Late Miocene would have facilitated the passage of the birds to Lanzarote by short inter-island jumps. The other explanation these authors envisage is based on the possibility of a continental origin of the eastern Canaries (Lanzarote and Fuerteventura), as indicated by Dietz and Sproll (1970), with the presence of ratites thus being attributed to the detachment of the eastern Canaries from Africa. However, both hypotheses contradict present knowledge of the regional geology. The possible presence of ancient land bridges between the eastern Canary Islands and Africa, as postulated by Sauer and Rothe (1972, 1974), faces some serious geological problems (Schmincke and Sumita, 2010).

Different ages have been attributed to Valle Chico (Fig. 1c), one of the three palaeontological sites in the Famara edifice considered in the present study: (a) Rothe (1966) includes it in the Tortonian (11.6–7.2 Ma); (b) Sauer and Rothe (1972) placed it in the interval 12-6 Ma; (c) Coello et al. (1992), taking lava flow samples from immediately above and below the fossiliferous sedimentary bed, included it in the Messinian after dating it at 6.0–5.3 Ma; and (d) the Balcells et al. (2004) geological map draws the fossiliferous bed ("aeolian sands with fossil eggs") between the lower and middle units of the Famara edifice; that is, they indirectly assign it an age of between 8.3 and 7.2 Ma. In addition, Sauer and Rothe (1972) partially studied Valle Grande site and García-Talavera (1990) mentioned Fuente de Gusa as a new site (Fig. 1c).

Because of the uncertainties in ages of the fossil localities on