This article is published in:

Quaternary Science Reviews 23 (2004), 2049-2052

doi:10.1016/j.quascirev.2004.02.011

Response to the „Comment on 'Geoarchaeological and chronometrical evidence …' " by J.C. Carracedo et al. *(Quaternary Science Reviews 23, 2045-2049)*

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We would like to thank Carracedo *et al*. for their response to our earlier article, and shall do our best to respond to both their queries and the various other communications we have received. We would like to commence by stating that we maintain our earlier stance concerning various as-yet unexplored inconsistencies in current interpretations of Lanzarote's Quaternary geological profile and occupational history. This paper is structured to address Carracedo *et al*.'s specific comments; however, we would firstly like to clarify some issues that appear to have been misunderstood by the authors.

While Carracedo *et al*. state that we claimed a sedimentation age of 10.2±1.4 for the loess-like material of a bone-bearing horizon near Guatiza, we would like to point out that this date was obtained from a layer 2.5m below the ovicaprid bone (as clearly shown in figure 3 of Zöller *et al*. 2003). We wrote (p. 1304) that the two youngest ages from Guatiza "strongly support" the notion that the material in the ash layer originated from the nearby Corona volcano, but that this was by no means a certainty.

A large volcano such as La Corona is very unlikely to have been formed by a single eruptive event (Schmincke 2000, p 88f, and pers. comm.), and this is substantiated by evidence for several easily-distinguishable eruptive centres and lava-flows that stand out from the geomorphology of the Corona system. At present we cannot confirm the reliability of the 20.7±6.5 ka $^{40}Ar/^{39}Ar$ determination for La Corona, as data on eventual argon excess (e.g. isochrone intercept on the $^{40}Ar/^{36}Ar$ axis) are not yet published, and we are therefore – at the present time – cautious about this estimate. Nevertheless, the fact that the lava tube mentioned by Carracedo *et al*. ends on a submerged platform 80-120 m below current sea level would seem to support a pleniglacial age for this lava flow. However, it should be noted that the Guatiza basaltic ash layers may have been deposited by younger eruptions of the Corona volcanic system. The two lava flows near the villages of Ye and Guinate flow over the Famara cliff as a "lava cascade", and appear to end at the 10 m contour line below sea level, thus suggesting a Holocene age (Figure 1). While carrying out extensive volcanological and tephrostratigraphical surveys, one of us (H.B.) was able to follow this ash layer over a distance of more than 1,000m near Guatiza. We agree that some of the Guatiza ash deposits were fluvially reworked, but would point out that there is extensive evidence for fall-out deposits in many locales.

The validity of Carracedo *et al*.'s claim that: "…we revisited the location and the sections described by Zöller and co-workers…" is thrown into doubt by the fact that at least one of the sections ("Guatiza II") was destroyed by road construction works prior to February 2003 (Figure 2). The rough stratigraphy was still exposed east of the new "circunvalación" road, but the original site where we found the bone (that failed ^{14}C-dating) was no more accessible. The location of the find was exactly at the intersection of the road foundation and the outcrop.

We strongly disagree with Carracedo *et al.*'s interpretation of the horizons filling the depression of Guatiza (and of other "vegas", such as the Valle de Femés and the Valle de San José). The authors not only cloud the issue of "paleosol" definitions, but also completely disregard the results of Coudé-Gaussen *et al*. (1987), Grousset *et al*. (1992), Jahn (1988, 1995), and Mizota & Matsuhisa (1995), which conclusively prove that the majority of eastern Canarian dust components, thick soils and sediments have a Saharan origin. According to McDonald & McFadden (in Eppes, McDonald & McFadden 2003, p. 114 ff), stone pavements may form due to trapping of fine aeolian sediments. As Jahn found that up to 70% of deeply weathered pedocomplexes covering Lanzarote's plateau basalts was comprised of quartz, the authors need to explain how quartz (not present in basalts) can be enriched in the weathering process and thus be completely independent of allochtonous (aeolian) deposition processes (see semi-quantitative XRD data in Table 1). One of us (L.Z) has identified the signatures of pristine and reworked loess in the depression fills; the three light layers visible in photo Guatiza I, D of Carracedo et al. (Guatiza III in our record; data currently under investigation) are genuine desert loess in our opinion, even if local dust components stemming from volcanic material may also be present.

Alluvial fans may have contributed to infilling in the marginal parts of the Vega de Guatiza (as is apparent from the nature and texture of the sediments, basaltic gravel and reworked caliche), while volcanic ash fall may have reached also the centre of the basin. However, the majority of the filling – particular in the central area – is of aeolian origin (either direct desert loess deposits or fluvial reworked aeolian fines). As the lava flows from many of the cinder cones delineating the eastern margin of the Vega de Guatiza proceeded to dam the vega, the cones must be older than the filling. This is also evident from a lava flow comprised of sandy biocalcarenites extending north from Las Calderas (near the Jardin de Cactus) into the Mala dune-field. This lava flow was recently exposed in the deep sand pits east of Mala below two intensively weathered reddish-brown paleosols which yielded OSL ages in the vicinity of 180-200 ka (M. Lamothe, Montreal, pers. comm. 31 October, 2003).

A serious question arises from the find of a pottery shard mentioned by Carracedo *et al*. In all our fieldwork from 2000 to 2002, no stratigraphically-secure pottery was ever recovered from the sedimentary fills of the vegas of Guatiza, Femés, and Valle de San José, despite searching kilometres of exposed sections. However, concentrations of prehispanic and post-conquest ceramics were sometimes located on the surface soils of the vegas and on neighbouring slopes. In response to Carracedo *et al.*'s challenge of: "The authors should explain how they obtain IRSL ages of 5 to 10 ka in sediments including historic (<500 years) pottery", therefore, we would instead propose that the authors (Carracedo *et al*.) should explain how historic (<500 years) pottery can appear in sediments physically dated to between 5 and 10 ka. We have already stated that our original section exposure (Guatiza II) has been destroyed since our initial investigation took place. We view the stratigraphic and contextual location of the pottery shard shown in photo "Guatiza II, G" with some suspicion, for whereas pottery shards deposited by sheet floods should lie horizontally, this example is vertically oriented. In the Guatiza I pit we observed that the high Na-saturation had led to soil swelling and shrinkage and, thus, to sliding during watering-drying cycles. We would like to discuss this possibility with Carracedo *et al*., and we believe that this difficult question merits further attention. It is of course possible that our IRSL ages are over-ageing the sediments due to insufficient optical zeroing of the mineral grains at deposition (similar to excess argon in Ar/Ar-dating), although the stratigraphic consistency of our IRSL age determinations and the long shine-down plateaus do not support this interpretation. To ensure maximum accuracy, we have undertaken to run more tests in order to preclude a residual luminescence signal at

deposition which could be responsible for age overestimates, and these tests are currently underway.

We agree that "a modification of the simple hotspot theory is out of is out of context in this paper", but would like to draw attention to a recent publication by Tarduno *et al*. (2003), which argues against the assumption of fixed and unmoving Hot Spots in the Earth's mantle (using a Hawaiian example).

We would like to emphasise that we welcome – and are actively seeking – collaborations and interdisciplinary projects with experts from the Canary Islands, and share Edwards & Meco's hope (2000, p. 182) that luminescence dating will become available for the paleosols. During our 2003 field season on Lanzarote, we found more bones below the basaltic tephra layer (that we have tentatively correlated with a Corona eruption) in the Guatiza I pit (Figure 3). In order to share these findings, and in order to foster links with local archaeologists, we immediately visited the Cabildo Insular and the Patrimonio Histórico to report our finds. While we were, most unfortunately, unable to enter as fully into dialogue with specialists as we would have liked at that time, we are anxious to foster academic and social links with specialists in the archipelago. In addition to our intention of handing over the zooarchaeological finds to a Canarian museum, we would like to join other specialists to continue and expand our sedimentological, paleopedological and chronostratigraphic work, and would like to offer our facilities and expertise for the thermoluminescence dating of ceramic shards. We are convinced that the magnificent sedimentary records of Lanzarote and Fuerteventura hold the answers to numerous fascinating research questions, and hope to contribute to the broad interdisciplinary research programmes that they so richly deserve.

The authors wish to thank Lawrence Stewart Owens (Institute of Archaeology, London), for critically reviewing an earlier draft of this response.

References:

Carracedo, J.C., Meco, J., Lomoschitz, A., Perera, M.A:, Mallester, J. & J.-F. Betancor (2003): Comment on "Geoarchaeological and chronometrical evidence of early human occupation on Lanzarote (Canary Islands)", by L. Zöller, H. von Suchodoletz and N. Küster.- Quat. Sci. Rev. (this volume).

Coudé-Gaussen, G., Rognon, P., Bergametti, G., Gomes, L., Strauss, B., Gros, J.M. & M.N. le Coustumer (1987): Saharan dust on Fuerteventura island (Canaries): Chemical and mineralogical characteristics, air mass trajectories, and probable sources. Journal of Geophysical Research 92, D8, 9753-9771.

Grousset, F.E., Rognon, P., Coudé-Gaussen, G. & P. Pedemay (1992): Origins of peri-Saharan dust deposits traced by their Nd and Sr isotopic composition. Palaeogeography, Palaeoclimatology, Palaeoecology 93, 203-212.

Edwards, N. & Meco J. (2000): Morphology and palaeoenvironment of brood cells of Quaternary ground-nesting solitary bees (Hymenoptera, Apidae) from Fuerteventura, Canary Islands, Spain. Proceedings of the Geologist´s Association 111, 173-183.

Eppes, M.C., McDonald, E.V. & McFadden, L.D: (2003): Soil geomorphological studies in the Mojave Desert: Impacts of Quaternary tectonics, climate, and rock type on soils, landscape and plant-community ecology. In: D. J. Easterbrook (ed.), The Quaternary of the United States. INQUA 2003 Field Guide Volume, Desert Research Institute, Reno, 105-122.

Jahn, R., 1988. Böden Lanzarotes. Vorkommen, Genese und Eigenschaften von Böden aus Vulkaniten im semiariden Klima Lanzarotes (Kanarische Inseln). Univ. Stuttgart-Hohenheim (PhD thesis), Hohenheimer Arbeiten (Ulmer).

Jahn, R., 1995. Ausmaß äolischer Einträge in circumsaharischen Böden und ihre Auswirkungen auf Bodenentwicklung und Standortseigenschaften. Hohenheimer Bodenkundliche Hefte 23, Stuttgart.

Mizota, C. & Y. Matsuhisa (1995): Isotopic evidence for the eolian origin of quartz and mica in soils developed on volcanic materials in the Canary Archipelago. Geoderma 66, 313-320.

Schmincke, H.-U. (2000): Vulkanismus. 264 p, Darmstadt (Wissenschaftliche Buchgesellschaft).

Tarduno, J.A., Duncan, R.A., Scholl, D.W., Cottrell, R.D., Steinberger, B., Thordarson, T., Kerr, B.C., Neal, C.R., Frey, F.A:, Torii, M. & Carvallo, C. (2003): The Emperor Seamounts: Southward Motion of the Hawaiian Hotspot Plume in Earth's Mantle. Science 301, 1064-1069.

Zöller, L., von Suchodoletz, H. & Küster, N.: Geoarchaeological and Chronometrical Evidence of Early Human Occupation on Lanzarote (Canary Islands).- Quat. Science Rev. 22, 1299-1307.

Tables

Table 1 Semi-quantitative XRD mineralogical analysis results for sediment and soil samples from “Femes” and “Guatiza” (analysed by W. Smykatz-Kloss, Institute of Mineralogy, University of Karlsruhe)

depth of horizon	quartz	calcite	plagioclase	kali feldspars	hematite	goethite	mica (illite)	chlorite	smectite	palygorskite	gypsum
Femés											
15-55	XXX	XX	II	I	I		X	II	II		
55-74	XXX	II	XX	I	I	I	X	II	II	I	
74-120	XXX	I	II	II		I	X	II	II	I	I
120-165	XXX	XX	II	I	I		X		II	I	I
165-200	XXX	XX	II	II		I	X	II	I	II	
200-240	XX	XX	I	I			X	X	II	X	I
240-270	XXX	II	I	X	I		X	I	II	X	
275-340	XX	XX	II	II	I		X	II	I	I	I
340-360	XXX	I	I	II	I		X	I	I	I	
440-460	XXX		II	II	I		X	II		I	I
470-485	XXX	I	II	I		I	II	II	I	II	
485-555	XXX	II	II	II			X	II	X	I	
555-570	XX		I	I		I	XX	II	II	II	I
595-670	XXX		II	I	I	I	X	II	I	I	
Guatiza											
60	XXX	XX	II	II	II		II	II	I	I	I
280	XXX	XX	I	I	I	I	II	I	I	II	
550	XX	XX	II	I		I	II	X	II	II	
650	XXX	X	II	I		I	X	II	I	I	
750	XXX		X	II		I	II	I		I	II

Contents of the mineral:

XXX > 40%,
XX 20-40%
X 10-20%
II 5-11%
I > 5%

Figures

Figure 1: Monte Corona and the Risco de Famara cliff. Lava flows originating from the Corona group built up a costal plain on the foot of the cliff between Punta de Lorno Blanco and El Embarcadero. The lava flows' likely submerged extent is marked by thick lines along the -10 m contour line, suggesting a Holocene age. Map from “Canarias Interactiva” CD-ROM, Volume 2, 1998.

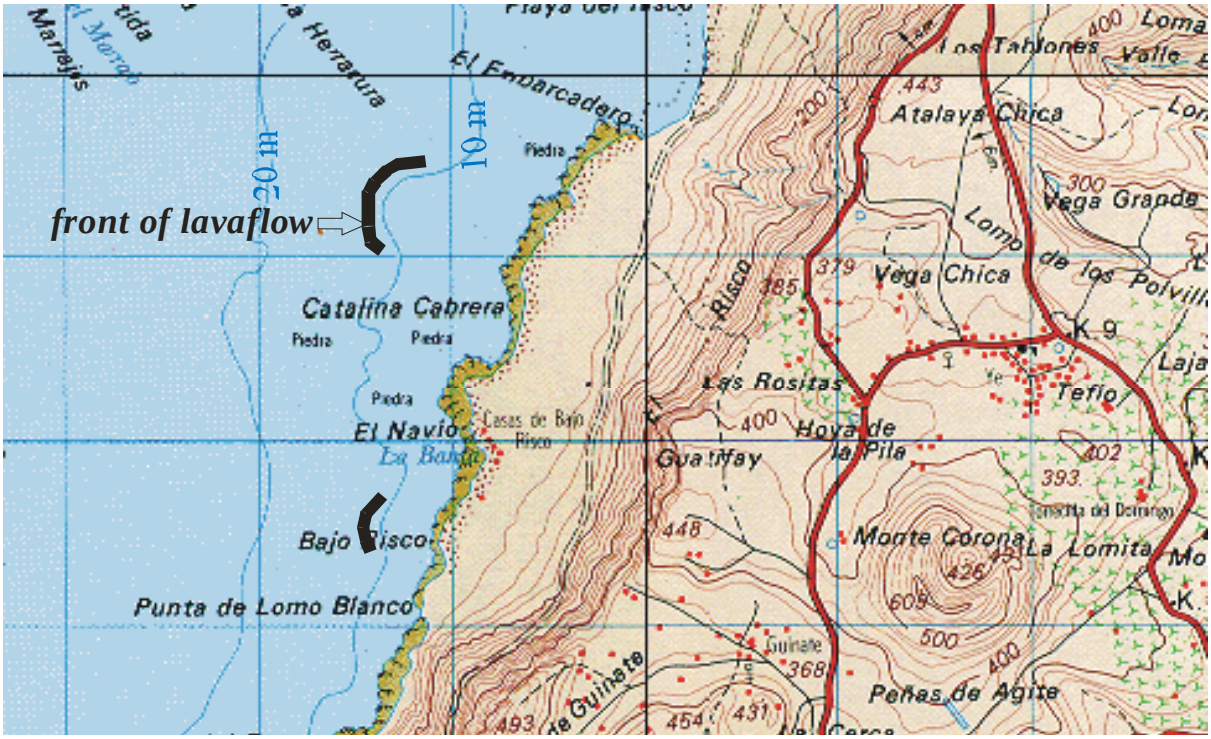

Figure 2: View of the “Guatiza II” exposure. The profile in which the ovicaprid bone was found is now masked by the road dam. By February 2003, the site had already been destroyed (photo: H. v. Suchodoletz).

Figure 3: Large bone detected in the southern wall of the Guatiza I exposure, February, 2003 (photo: L. Zöller).