Com os melhores cumprimentos,
Carlos Marques da Silva

PALEOENVIRONMENTAL AND TAPHONOMICAL INTERPRETATION OF MIOCENE RHODOLITHS FROM PORTO SANTO (MADEIRA ARCHIPELAGO, PORTUGAL). PRELIMINARY DATA

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A common feature to most of the Miocene marine units that outcrops in the volcanic island of Porto Santo, is the presence of large rhodoliths, locally called "*laranjas*". They occur associated with shallow marine sedimentary units in the transition between two major volcanic complexes: (1) the trachytic to basaltic submarine basal volcanic complex with ages ranging between 18.8 and 13.5 Ma (Ferreira, 1985) and (2) subaerial alkali basaltic to hawaiitic complex formed between 14 and 10.2 Ma (Ferreira, 1985). Previously assigned to an age interval between 19.3 and 15.2 Ma (Ferreira, 1996), the fossiliferous layers were restricted to *circa* 14 Ma based on calcareous nannofossils (biozone CN4 of Okada & Bukry; Early Serravalian; Cachão *et al.*, 1998) confirmed by recent $^{40}Ar/^{39}Ar$ age dating (Geldmacher *et al.*, 2000). Silva (1995) already referred the presence of these calcareous algae in the Miocene of Porto Santo, which he attributed to the species *Lithothamnium* aff. *magnum* CAPEDER 1900.

The present study while resuming and updating the taxonomical identification of the calcareous algae that produced these rhodoliths aims a paleoecological and taphonomical interpretation of the Porto Santo Miocene marine facies in which the rhodoliths can be found, mainly around the area occupied by the present day islet "Ilhéu de Cima" located near the SE end of Porto Santo island.

At the islet of "Ilhéu de Cima" two distinct types of fossil rhodolith assemblages can be found. One type is located at the "Pedra do Sol", on the SW side of the islet. Here two distinct marine layers can be identified, separated by 8 meters of an ash unit followed by a thick basaltic flow. In the lower marine layer the rhodoliths are fossilized together with *Clypeaster* echinoids, *Spondylus* bivalves and rare balanids in a bioclastic calcareous sandstone layer filling an irregular basaltic surface. The topmost regular and flat limit of this sedimentary unit corresponds to the original seafloor fossilized by the irregular ash layer that can reach 2.4 m thick. Above this fossilized seafloor the basaltic rock surfaces have *in situ* coral carpets that can reach 0.11 m thick. These coral covered surfaces extend vertically 7.5 meters above the sediment top (the minimum water depth) having also been fossilized by the explosive volcanic event that produced the ash layer. Rhodoliths are dominated by at least two species of *Lithothamnion*, many encrusting bryozoans, some serpulide wurm tubes, and rare peyssonneliacean algae. Growth forms are mostly columnar. Rare crustose forms occur formed by *Lithoporella melobesioides*, another not identified coralline alga, and peyssonneliacean algae.

The second rhodolith assemblage type outcrops at "Cabeço das Laranjas" on the eastern side of the NW tip of the islet. Here the rhodoliths constitute the major component of the fossil content of these marine sediments with densities of more than 80 rhodoliths per square meter. *Clypeaster* are rare as well as pectinids and other bivalves. Some of the rhodoliths exhibit corals that grew directly over them occupying generally less than half of their visible surface. The rhodolith layer has around 6 meters having intercalated a sedimentary lens of volcanic debris (maximum thickness 2.4 m) with sedimentary structures produced by coastal currents and biorturbation on the top. Rhodoliths are formed by the two genus *Sporolithon* and *Lithothamnion*.

There are no significant changes of growth forms within the particular species the rhodolith growth (but not the sphericity) is only caused by the contributing taxa and do not indicate the frequency of turning of the rhodolith.

The main purpose of rhodolith morphometrics was to determine which of the rhodolith assemblages, if any, was *in situ* and which had been subjected to transport. For both fossil assemblages favourable outcrops were selected with a significant number of rhodoliths with less than half of its volume inside the sedimentary matrix. Because morphometrics were performed without removing the rhodoliths from the outcrop, the study of their shape was simplified by determining only the major and minor visible axes of their elliptical contour. Frequency distributions for the major and minor axis revealed that the "Pedra do Sol" rhodoliths assemblage had an almost perfect uni-modal normal distribution while the "Cabeço das Laranjas" rhodoliths assemblage had a multi-modal positively skewed distribution (dominance of smaller specimens). These results suggest that the "Cabeço das Laranjas" assemblage was produced *in situ* while the "Pedra do Sol" assemblage was subjected to transport. In fact, analysis of rhodoliths from the "Pedra do Sol" assemblage showed that corals, although overspread throughout the outcrop, did not contribute to the rhodoliths (neither by serving as a nucleus, nor by encrustations) supporting the interpretation that they were probably transported into this environment prior to fossilization.

The analysis of the features of the external surface of the rhodolith also allows taphonomic characterization and further paleoenvironmental interpretations. Rhodoliths found in several of the Miocene outcrops of Porto Santo can be distinguished by their external surfaces into several types: (1) "fresh" lumpy surfaces with swollen protuberances; (2) abrasioned surfaces and (3) surfaces with epibiontic organisms (corals, serpulids, bryozoans, etc.). These features may be interpreted as follows (respectively): (1) *in situ* living algae; (2) rhodoliths subjected to shore wave abrasion and eventually emersion; and (3) having passed by stage 2 algae structures were partially or totally dead after which they were resubmitted to the infratidal environment and colonized prior to burial. This seems to have occurred in certain areas such as the "Lombinhos de Cima" ("Serra de Fora") outcrop in the Island of Porto Santo. However, even high-energy rhodoliths can be estabilized long enough to serve as a stable substrate for coral growth. Parts of the rhodolith tissue can be damaged and corals can grow over there without the whole rhodolith stop growing. This seems to better explain features found in certain rhodoliths at "Cabeço das Laranjas".

The study of the Miocene rhodoliths of Porto Santo allowed to better understanding the paleoenvironments in which they evolved. Two distinct situations were detected: (1) *in situ* rhodolith assemblages ("Cabeço das Laranjas") and short-term transport rhodolith assemblages ("Pedra do Sol").

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