A leap in seamounts geo-characterization: using a multi-technical approach for origin, nature and evolution of Amanay, Banquete and Conception Bank (Canary Islands). LIFE+ INDEMARES (2009-2013)

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Abstract

Seamounts are unique places of increasing scientific interest; although being abundant and exhibiting a global distribution [3], most of them are still showing a lack of research. Besides the physical (i.e.: deep-sea circulation) and biochemical implications (i.e.: as pelagic biodiversity hotspots), there is likewise a greater interest in geological terms, in order to understand origin, nature and evolution of the constituent materials from these submerged edifices, as well as to investigate potential mineral resources [1].

The LIFE+ INDEMARES (2009-2013) national project (http://www.indemares.es) leaded by the 'Fundación Biodiversidad' (http://www.fundacion-biodiversidad.es) has allowed achieving a deeper knowledge of the biodiversity from several marine areas of the Spanish seas, with the potential to be included in the Natura 2000 network and thus become protected. In addition, selected marine areas in the Canary Islands archipelago focused research aims on particular seamounts, including 'Conception Bank' (70 km northeast of Lanzarote I.), as well as 'Amanay' and 'El Banquete' seamounts (20 km southwest of Fuerteventura I.). The 'Instituto Español de Oceanografía' (IEO), as part of the project team, has leaded the oceanographical campaigns collecting a wide variety of bio- and geological samples. The research group 'Geología Aplicada y Regional' (GEOGAR), attached to the 'Instituto de Oceanografía y Cambio Global' (IOCAG), at the 'Universidad de Las Palmas de Gran Canaria' (ULPGC) has conducted a geological research collaboration in order to broadly characterize, for the first time, about 300 samples of igneous rocks (i.e.: plutonic, subvolcanic and volcanic rocks), sedimentary rocks (i.e.: carbonate clastic rocks and ferromanganese crusts) and unconsolidated sediments.

In regards to the geological objectives for this work, we used a multi-technical approach comprising several disciplines: (i) sediments geo-characterization (i.e.: grain-size, provenance, carbonate, organic matter, microscopy, mineralogy, petrography, geochemistry); (ii) igneous rocks and (iii) sedimentary rocks geo-characterization (petrography, mineralogy, geochemistry). Hence, a number of methods was required for these purposes (e.g.: dry sieving, calcimetry, petrographic microscopy, scanning electron microscopy (SEM), electron microprobe analysis (EMPA), powder X-ray diffraction (XRD) procedures, Raman spectroscopy, ICP/ICP-MS, etc.). Thereby, the foremost objective for this work is to characterize an evident geological diversity, through analyzing textural, mineral and geochemical data, and later combining these results to understand origin, nature and evolution of the seamounts involved. In summary, here we show the main results we have obtained and we discuss the most relevant findings.

Firstly, a set of about 100 igneous rocks confirms a volcanic origin, so as expected, for Amanay, Banquete and Conception seamounts, and therefore, being originated from intraplate (hotspot) volcanism, also responsible of the neighboring islands and seamounts belonging to the 'Canary Island Seamount Province' [2]. Further, a petrography study and some geochemical analysis show typical ocean island alkaline basalts series, comprising a wide range of plutonic, subvolcanic and volcanic (lava flows and pyroclasts) rock varieties (e.g.: basalts, trachy-basalts, gabbros) where phenocrysts are typically characterized by the presence or absence of olivine, clinopyroxene, plagioclase and amphibole. Furthermore,

volcanic and diabase-like rocks reveal a considerable geological alteration and mineral neoformation caused by the action of seawater. Hence, they show mineral alterations on edges (e.g.: Fe-, Mn- and Fe-Mn-oxides coatings), as replacements of phenocrysts but mostly filling rocks vesicles and cracks (e.g.: micritization, zeolitization, phosphatization), as observed from microscopic studies (i.e.: SEM) and confirmed by mineral identification (i.e.: EMPA and Raman spectra).

Secondly, close to 150 samples show a great diversity of sedimentary rocks, comprising mainly carbonated rocks and ferromanganese crusts, but also conglomerates and sandstones. Sedimentary rocks are reflecting both oceanic and geological processes: (i) carbonate rocks are mostly described by a variable fraction of bioclasts (mainly planktonic foraminifera), apart from a varying degree of compaction and porosity (e.g.: mudstone, packstone, grainstone) whereas cementing matrix is characterized by calcite minerals (i.e.: micrite and sparite), in some samples phosphatized too; (ii) ferromanganese crusts appear typically as layered oxides with botryoidal, isopachous and druzy textures (up to 3-4 cm in thickness), where mineralogical analysis (i.e.: XRD and Raman spectra) allow to affirm they are commonly constituted by iron and manganese minerals (i.e.: todorokite, goethite, hematite).

Thirdly, a set of 60 non-consolidated sediment samples was also taken into research. A mineral identification of significant amounts of allochthonous (i) quartz and dolomite; volcanic-related augite and plagioclase, as well as further calcium-magnesium minerals within the silty-clayey fraction, (ii) high levels of carbonate content (close to 90% on average), owing to high ratios of relative contents of bioclasts (up to more than 60% of planktonic foraminifera) and lastly, (iii) the lowly concentrations of REE (by a few tens of ppm) detected in selected samples, are some of the most relevant results concerning the deep-sea sediments.

In conclusion, a seamount-based geological research has provided new geological and extensive data from igneous rocks, sedimentary rocks and sediments; reflecting altogether the volcanic origin and the underwater evolution of these edifices. Hence, these geological features are undoubtedly a record of the bio-geo-physico-chemical processes occurred since both early and late submarine stages. Thereby, the resulting data from this work suggest new goals and chances for further studies, whether for geological purposes (e.g.: combining with geophysical data), as well as for interdisciplinary proposals (e.g.: considering additional layers for statistical modeling of species distribution, specially for such marine protected areas).

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