Deep-Sea Research II 98 (2013) 7–23

Contents lists available at ScienceDirect

Deep-Sea Research II

journal homepage: www.elsevier.com/locate/dsr2

Condor seamount (Azores, NE Atlantic): A morpho-tectonic interpretation

Fernando Tempera [a,*], Ana Hipólito [b], José Madeira [c], Sara Vieira [a], Aldino S. Campos [d], Neil C. Mitchell [e]

[a] Centre of IMAR of the University of the Azores, DOP & LARSyS, Rua Prof. Dr. Frederico Machado, no. 4, PT-9901-862 Horta, Açores, Portugal
[b] Centro de Vulcanologia e Avaliação de Riscos Geológicos, Universidade dos Açores, Complexo Científico, 3° Piso – Ala Sul, Rua da Mãe de Deus, 9500-321 Ponta Delgada, Açores, Portugal
[c] Departamento de Geologia da Faculdade de Ciências & Instituto Dom Luiz (Laboratório Associado), Universidade de Lisboa, C6, Campo Grande, 1749-016 Lisboa, Portugal
[d] Portuguese Task Group for the Extension of the Continental Shelf (EMEPC), Rua Costa Pinto 165, 2770-047 Paço de Arcos, Portugal
[e] School of Earth, Atmospheric and Planetary Sciences, University of Manchester, Williamson Building, Oxford Road, Manchester M13 9PL, UK

ARTICLE INFO

Available online 21 September 2013

Keywords:
Condor
Seamounts
Multibeam
Volcanism
Tectonics
Erosion features
38°24′N–38°38′N
29°16′W–28°51′W

ABSTRACT

High-resolution datasets collected by multibeam and acoustic backscatter surveys were used to produce fine-scale seafloor nature and morpho-tectonic interpretations of the Condor seamount. Condor constitutes an elongated volcanic ridge that extends for 39 km and rises more than 1800 m from the surrounding seafloor. Constructive morphologies include (i) linear eruptive centres, (ii) volcanic cones with or without summit depressions, (iii) lava flows and (iv) hummocky sectors. Eruptive type is interpreted to vary with depth. On the deeper seamount extremities, the predominance of highly acoustically backscattering volcanic cones and hummocky terrain is interpreted to result from effusive eruptions not yet covered by sediment deposits. In contrast, the smoother relief of the central seamount flanks is interpreted as draping and infilling of the underlying effusive relief by (i) primary volcaniclastic deposits produced by explosive eruptions on the shallowest parts of the ridge, together with (ii) secondary volcanigenic sediments resulting from truncation of the seamount top by swell erosion and (iii) sediments resulting from biogenic production.

A set of WNW–ESE to NW–SE trending volcano-tectonic structures are shown to control most of the fissural volcanism that formed the ridge. A network of NNW–SSE trending faults is identified on the seafloor around Condor but they show little relation with the distribution of volcanic edifices or with post-emplacement dismantling of the seamount. These fault sets are related to the transtensional regime acting on the Azorean segment of the Eurasia–Nubia plate boundary.

Erosional features include (i) palaeo wave-cut platforms on the seamount summit, (ii) landslide scars produced by lateral collapses of the NE and SW-facing flanks, (iii) gullies and turbidity current channels and (iv) mass-wasting deposits. Iceberg drag and bump marks are also identified on the seamount upper flanks, representing the first reference to such features in the Azores and an additional low latitude record.

Given the lack of major erosional and tectonic dismantling, Condor is suggested to be a relatively young seamount. A revised factoring of eustatic, erosional and isostatic processes does not exclude that the summit may have been eroded as late as the Last Glacial Maximum.

1. Introduction

Seamounts are some of the most ubiquitous landforms on Earth and their time-averaged generation may represent 10–20% of the global cumulative magmatic extrusive budget (Wessel, 2007). They occur at ridge-transform fault intersections, overlapping spreading centres, in intraplate regions and hotspots (*e.g.*, Iyer et al., 2012). The most recent desktop extraction of seamounts from a global bathymetric grid at 30″ resolution (Yesson et al., 2011) identified 33,452 seamounts (*i.e.*, height ≥ 1000 m) plus 138,412 smaller elevations (200 m ≤ height < 1000 m).

With the development and widespread use of high-resolution acoustic systems such as multibeam echo-sounders and sidescan sonars over the last few decades, detailed morphological analyses of seamounts were made possible. Seamounts were revealed to

* Corresponding author. Tel.: +351 292 200400; fax: +351 292 200411.
E-mail addresses: tempera@uac.pt (F. Tempera), ana.rc.hipolito@azores.gov.pt (A. Hipólito), jmadeira@fc.ul.pt (J. Madeira), amscampos@emepc-portugal.org (A.S. Campos), neil.mitchell@manchester.ac.uk (N.C. Mitchell).

0967-0645/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.dsr2.2013.09.016

range from flat-topped conical elevations with and without summit craters or collapse pits to dome-shaped structures and linear ridges. Important insight on how tectonic and volcanic processes control the constructional and erosional processes responsible for shaping seamounts was provided by Fornari et al. (1987), McPhie (1995), Smoot (1995), Mitchell (2001), Johnson et al. (2008) and Passaro et al. (2010).

With only a small extent of the Azores geology being accessible on the subaerial parts of the islands, knowledge of the seafloor is critical to understand the geodynamic processes acting around the Azores oceanic plateau.

Linear volcanic ridges (LVRs) have been shown to be the most common geomorphological feature in the Azores region, Northeast Atlantic (Lourenço et al., 1998). LVRs are composite volcanic constructions built by basaltic fissural volcanism which in the Azores is favoured by the transtensional tectonic environment.

Condor is a large LVR located in the vicinity of Azorean island of Faial. It has been the target of an intense scientific programme for the last 4 years, aiming to improve our understanding of seamount structure and functioning from the sea surface down to the seafloor (see Giacomello et al., this issue).

Although having been surveyed with the Towed Ocean Bottom Instrument (TOBI) during the AZZORRE'99 cruise (Ligi et al., 1999), the earliest published information on the geomorphology of Condor can only be found in Lourenço et al. (2008). In their analysis of the main volcano-tectonic structures found around Faial, Condor was identified as a LVR and a brief illustrated description of its backscatter patterns was provided. More recently, Tempera et al. (2012) presented an overview of the seamount's geological and biological landscape based on new high resolution multibeam mapping of the seafloor and benthic surveys.

Using the multibeam compilation of Tempera et al. (2012) along with new groundtruth information, the current paper details a geomorphological interpretation of Condor, providing (i) a morpho-structural map of the area and (ii) a seafloor facies map. Tectonic structures, volcanic and erosional forms and seabed nature are mapped in fine scale supported by groundtruthing provided by remotely operated vehicles (ROVs) and drop-down cameras.

1.1. Geological background of the area

The Azores archipelago lies about the boundaries between the North America (NA), Eurasia (Eu) and Nubia (Nu) plates at the Azores Triple Junction (ATJ; Fig. 1). The Azores portion of the Eu–Nu plate boundary is expressed as a wide dextral transtensional zone (*e.g.* Lourenço et al., 1998; Madeira and Ribeiro, 1990; Madeira and Brum da Silveira, 2003), where hyper-slow oblique expansion occurs (Vogt and Jung, 2004), accommodating the differential

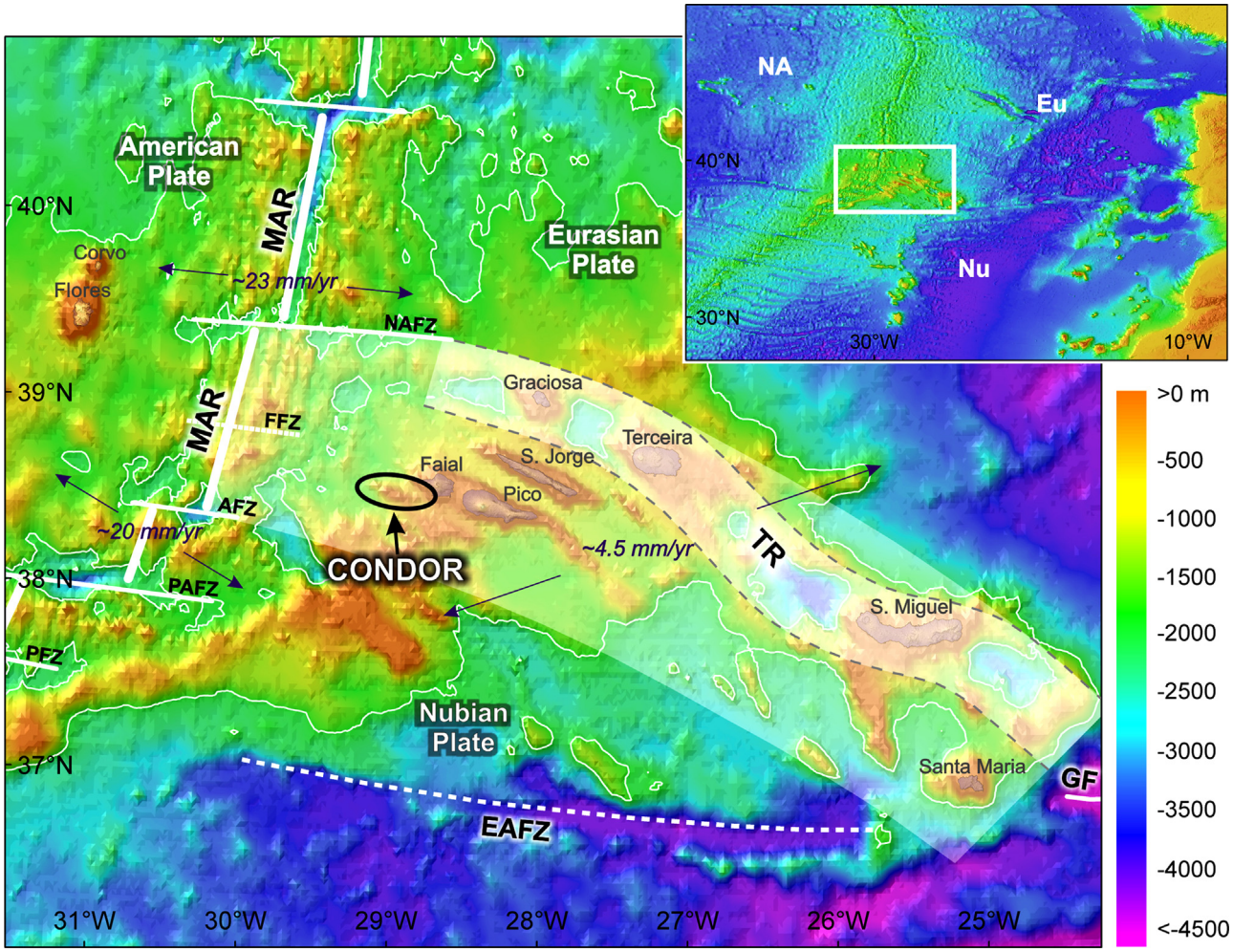

Fig. 1. Location of Condor seamount in the general frame of the Azores. White lines define approximately the morphological expression of each structure; white shaded area represents the sheared western segment of the Eurasia–Nubia plate boundary; white shaded area limited by a dotted grey line represents its main structure, the Terceira Rift (TR). Tectonic structures: MAR–Mid-Atlantic Ridge; EAFZ–East Azores Fracture Zone; NAFZ–North Azores Fracture Zone; GF–Gloria Fault; FFZ – Faial Fracture Zone; AFZ–Açor Fracture Zone; PAFZ–Princesa Alice Fracture Zone; PFZ–Pico Fracture Zone. Azores bathymetry sourced from Lourenço et al. (1998) and GEBCO 08. Datum: WGS 1984.