Remote sensing at D. João de Castro bank: tools for biology and conservation studies

Santos, R.S. [1], A. Pascoal [2], P. Dando [3], F. Cardigos [1], F. Tempera [1], P. Oliveira [2], C. Silvestre [2] & M. Cardew [4]

[1] Departamento de Oceanografia e Pescas, University of Azores, Horta, Portugal;
[2] Institute for Systems and Robotics / Instituto Superior Técnico, Lisbon, Portugal;
[3] School of Ocean Sciences, University of Wales Bangor, Anglesey, United Kingdom;
[4] System Technologies, Ulverston, United Kingdom.

Abstract

The description of hydrothermal vents ecosystems is of interest both to ecological studies and nature conservation management of those unusual environments. In the D. João de Castro offshore bank (Azores, Portugal), one of the sites proposed as a Special Area for Conservation (Natura 2000 network), hydrothermal activity is a frequent feature between -13 and -45m deep. Under the EU-MAST III project ASIMOV, several methods and technologies have been brought together to initiate the study of habitats and biological communities in the area. That study is now being continued with funding from the Portuguese Foundation for Science and Technology, under the MAROV project.

A side-scan unit and a mechanically scanned pencil beam echosounder were used to draw geo-referenced 3-D maps that include the positioning, intensity, and density of venting activity. The maps produced show that the venting activity concentrates in the northeastern part of the volcanic cone. Imaging (photo and video) tools operated by UW-scooter-powered scuba divers have been employed to survey the bottom topography and identify conspicuous epibenthic species. The communities are mainly divided into three groups: sandy, rocky, and rocky with venting activity. The sandy communities develop after 40 meters of depth and are very species-poor. The rocky habitats develop between –20 to –45 metres and are dominated by an algal mosaic of *Sargassum* sp., *Coralina* sp. and *Halopteris* sp. in the shallower area, and *Zonaria tournefortii* in the deeper zones. The communities on rocky substrata near vents are dominated by filamentous termophyle bacteria and a dense mosaic of different algae (e.g., *Cladostephus spongiosus*, *Codium elisabethae* and *Padina pavonica*).

Water sampling along the water column allowed for large-scale surveys of methane plumes (indicator of hydrothermal activity). The data collected with the later technique suggest the occurrence of hydrothermal activity at depths ranging between -150 and -250m. Hydrothermal fields at such depths are poorly known and D. João de Castro should be a suitable site for the development of future studies that make use of Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs).

Introduction

The D. João de Castro Bank is an isolated seamount located between S. Miguel and the Terceira Island, in the Azores archipelago (Figure 1A), at a Latitude of 38º13.3'N and a Longitude of 26º36.2'W. The Bank is located 36 nautical miles away from Terceira Island and 40 miles away from São Miguel. The shallower part of the bank is probably

the result of several submarine eruptions that occurred during a period of two weeks in December of 1720. The eruptions took place at 100 meters depth and projected ashes and water vapour that were clearly visible from S. Miguel and Terceira islands. The ashes accumulated, forming a small island that the winter storms completely destroyed two years later (Agostinho, 1934, 1960; Weston, 1964; Machado, 1967).

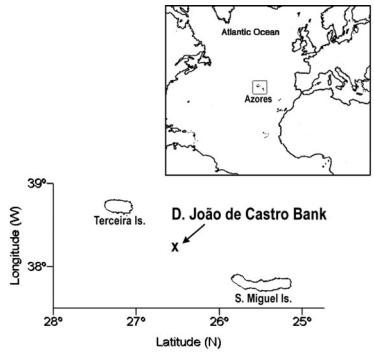

Figure 1 – D. João de Castro Location.

The D. João de Castro bank is the upper part of a volcanic cone, like those that are present in most of the Azorean Islands. The cone is circular, with the base located at 50m depth, the shallowest part being at -13m. Inside the cone, the depth is 45m. In the North-South direction the cone is 300 meters long and in the East-West direction 600m (Figure 1B). What makes the D. João de Castro bank unique in the Atlantic Ocean is the fact that it has exhuberant hydrothermal activity at shallow depths (Figure 2) (Santos *et al*., 1996). A small area at the bottom (100x50m), between 16 and 45m water depth, in the western part, exhibits release of gas (mainly CO_2, according to V. Forjaz pers. commn). This gas has its source in a magmatic chamber located between 1 and 5 km under the seafloor (Machado & Lemos, 1998). Recently, a second area with hydrothermal activity was discovered, at around 200m depth southeast of the shallowest part (Pascoal *et al*., 2000).

From a biological point of view, areas with hydrothermal activity, dominated by chemosynthesis, have an enormous interest for taxonomic and ecological reasons. Species linked to hydrothermal areas might be different from those occurring at light dominated ecosystems (Ballard, 1977; Grassle, 1985) or have adaptations that allow them to survive in extreme environments due to chemical contamination (Grassle at al., 1979) and/or extreme high temperatures (Jollivet *et al*., 1995). Determining if the D. João de Castro has these characteristics and adaptations is a topic of current research that is being actively pursued by a few scientists who are investigating the area. Several areas with shallow water hydrothermal vents were already the target of detailed scientific peer reviewed papers (Tarasov & Zhirmunskaya, 1989; Kharlamenko et al., 1995, Cronan et al., 1995, Southward et al., 1997; Morri et al., 1999; Bianchi & Morri, 2000; Cocito et al., 2000, Southward et al., 1996). Nevertheless, the D. João de Castro Bank is still very poorly known (Santos *et al.*, 1996, Ávila, 1997).

Methods

Bathymetric maps and a general characterization of the area were obtained using a sidescan sonar and a mechanically scanned pencil beam echosounder. In some experiments, the latter was operated off the DELFIM craft, an autonomous surface

equipped wit advanced systems for precise path following. The vehicle´s navigation system includes a Doppler log and a DGPS system with a land station located approximately 45 km away from the Bank. Habitats were surveyed by direct observations by SCUBA divers or using photo and video imaging. For the larger transects, scooters with scooter-deployed video cameras were used. A Remotely Operated vehicle was used, but with reduced coverage due to strong currents. The studies conducted have paved the way for the later use of the INFANTE AUV, which will carry out surveying missions at the Bank, in close cooperation with the DELFIM surface craft (the ASIMOV team, 2000).

Results

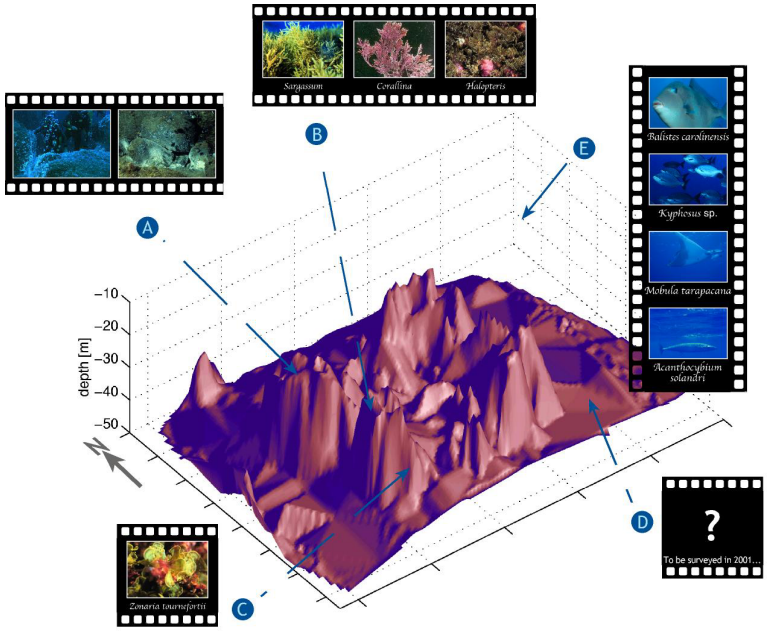

Figure 2 - Habitats in D. João de Castro Bank.

Discussion

Five different assemblages were identified. Assemblages A and B are new for the Azores, although isolated species were already registered for this area. Further studies will be carried out in the near future using technologies developed in the scope of the ASIMOV Project.

References

The ASIMOV TEAM, 2000 - Instituto Superior Técnico / Institute for Systems and Robotics (PT), École Nationale Superieure des Études et Techniques de l'Armement - ENSIETA (FR), Groupe d'Études Sous Marines de L'Atlantique - GESMA (FR), IMAR / University of the Azores (PT), Instituto Superior Técnico / Institute for Systems and Robotics (PT), ORCA Instrumentation (FR), System Technologies (UK), University of Bangore (UK), **"***Robotic Ocean Vehicles for Marine Science Applications: the European ASIMOV Project,***"** Proc. OCEANS 2000 MTS /IEEE, Providence, Rhode Island, USA, Sept. 11-14.

AGOSTINHO, J., 1934. The volcanoes of the Azores. *Bulletin Volcanologic*, 8: 123-138.
AGOSTINHO, J., 1960. Actividade vulcânica nos Açores. *Açoreana*, 5: 362-478.
ÁVILA, S.P., 1997. Moluscos marinhos recolhidos no Banco "D. João de Castro". *Açoreana*, 8(3): 331-332.
BALLARD, R.D. 1977. Notes on a major oceanographic find. *Oceanus*, 20(3): 35-44.
BIANCHI, N. & C. MORRI 2000. Serpuloidea (Annelida: Polychaeta) from Milos, an island in the Aegean Sea with submarine hydrothermalism. *Journal of Marine Biology Association of the United Kingdom*, 80: 259-269.
COCITO, S., C.N. BIANCHI, C. MORRI & A. PEIRANO 2000. First survey of communities on subtidal rocks in an area with hydrothermal vents: Milos Island, Aegean Sea. *Hydrobiologia*, 426: 113-121.
CRONAN, D.S., S. VARNAVAS & C. PERISSORATIS 1995. Hydrothermal sedimentation in the caldera of Santorini, Helenic Volcanic Arc. *Terra Research*, 7: 289-293.
GRASSLE, J.F. 1985. Hydrothermal vent animals: distribution and biology. *Science*, 229: 713-717.
GRASSLE, J.F., C.J. BERG, J.J. CHILDRESS, J.P. GRASSLE, R.R. HESSLER, H.J. JANNASCH, D.M. KARL, R.A. LUTZ, T.J. MICKEL, D.C. RHOADS, H.L. SANDERS, K.L. SMITH, G.N. SOMERO, R.D. TURNER, J.H. TUTTLE, P.J. WALSH & A.J. WILLIAMS, 1979. Galapagos '79: initial findings of a deep-sea biological quest. *Oceanus*, 22(2): 2-10.
JOLLIVET, D., D. DESBRUYERES, C. LADRAT & L. LAUBIER, 1995. Evidence for diferences in the allozyme thermostability of deep-sea hydrothermal vent polychaetes (Alvinellidae): a possible selection by habitat. *Marine Ecology Progress Series*, 123(1-3): 125-136.
KHARLAMENKO, V.I., N.V. ZHUKOVA, S.V. KHOTIMCHENKO, V.I. SVETASHEV & G.M. KAMENEV 1995. Fatty acids as markers of food sources in a shallow-water hydrothermal ecosystem (Kraterna Bight, Yankich Island, Kurile Islands). *Marine Ecology Pregress Series*, 120: 231-241.
MACHADO, F. & R. LEMOS, 1998. Sobre uma possível erupção submarina no Banco D. João de Castro em 1997. *Açoreana*, 8(4): 559-564.
MACHADO, F., 1967. Active volcanoes in the Azores. *In*: NEWMAN VAN PADANG, M., A. F. RICHARDS, F. MACHADO, T. BRAVO, E. BAKER & W. LE MAITRE. *Catalogue of the Active Volcanoes of the World*, Part 21: 7-52. International Association of Volcanology, Roma.
MORRI, C., C.N. BIANCHI, S. COCITO, A. PEIRANO, A.M. DE BIASI, M. PANSINI, M. BOYER, F. FERDEGHINI, M. PESTARINO & P. DANDO 1999. Biodiversity of marine sessile epifauna at an Aegean island subject to hydrothermal activity: Milos, eastern Mediterranean Sea. *Marine Biology*, 135: 729-739.
PASCOAL, A., P. OLIVEIRA, C. SILVESTRE, L. SEBASTIÃO, M. RUFINO, V. BARROSO, J. GOMES, G. AYELA, P. COINCE, M. CARDEW, A. RYAN, H. BRAITHWAITE, N. CARDEW, J. TREPTE, N. SEUBE, J. CHAMPEAU, P. DHAUSSY, V. SAUCE, R. MOITIÉ, R. SANTOS, F. CARDIGOS, M. BRUSSIEUX & P. DANDO, 2000. Advance system integration for managing the coordinated operation of robotic ocean vehicles (ASIMOV). Paper presented at EuroOCEANS 2000.
SANTOS, R. S., J. GONÇALVES & F. CARDIGOS, 1996. D. João de Castro Bank. Report to the European Community under contract INTAS-94-0592: 5pp.

SOUTHWARD, A.J., E.C. SOUTHWARD, P.R. DANDO, J.A. HUGHES, M.C. KENNICUTT II, J. ALCALÀ-HERRERA & Y. LEAHY 1997. Behaviour and feeding of the nassariid gastropod *Cyclope neritea*, abundant at hydrothermal brine seeps off Milos (Aegean Sea). *Journal of the Marine Biology Association of the United Kingdom*, 77: 753-771.

SOUTHWARD, A.J., M.C. KENNICUTT, J. ALCALÀ-HERRERA, M. ABBIATI, L. AIROLDI, F. CINELLI, C.N. BIANCHI, C. MORRI & E.C. SOUTHWARD 1996. On the biology of submarine caves with sulphur springs: Apraisal of 13C/12C ratios as a guide to trophic relations. *Journal of the Marine Biology Association of the United Kingdom*, 76: 265-285.

TASAROV, V.G. & A.V. ZHIRMUNSKY 1989. Coastal volcanism of the ecosystem of Kraternaya Bight (Kurile Islands). *The Soviet Journal of Marine Biology*, 15: 139-148.

WESTON, F.S., 1964. List of recorded volcanic eruptions in the Azores with brief reports. *Boletim do Museu e Laboratório Mineralógico e Geológico da Universidade de Lisboa*, 10: 3-18.