International Ridge-Crest Research: **Back Arc Basins**

Rift Propagation and extensive off-axis volcanic and hydrothermal activity in the Manus Basin (Papua New Guinea): MANAUTE Cruise

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The Manus basin is one of the intra-arc or back-arc basins aligned along the Australian and Pacific Plate boundary (Fig. 1). It is encircled by Manus Island to the north, New Ireland to the east, Papua New Guinea to the west and New Britain to the south. The whole domain constitutes the Bismarck plate. Structurally the Manus basin is bounded by the fossil Manus subduction zone to the north and to the south by the tectonically active system formed by the New Britain trench and the folded and over thrusting suture of Papua New Guinea. The emerged areas surrounding the manus basin constitute an ancient tertiary volcanic arc (Francis, 1988; Stewart and Sandy, 1988), part of the unique arc separating the Australian and Pacific plates at that time and dismembered during the opening of Manus basin about 4 Ma ago (Falvey and Pritchard, 1985). Different models have been proposed to explain the Manus basin creation, ranging from diffuse accretion, up to a complex system combining accretion, microplate rotation and stretching (Martinez and Taylor, 1996) , through to a simple oceanic spreading.

The present day spreading in the Manus Basin is located on 3 successive N45, N65-trending ridge segments offset by N120 transform faults, Weitin and Djaul FZ to the east and Wuillaumez to the west (Tufar, 1986; Binns *et al.*, 1993; Martinez and Taylor, 1996). Two zones of basalt-dominated seafloor spreading in the central and western portions of the basin, are both associated with hydrothermal activity (Tufar, 1986).

In 1995, a joint French-Japanese cruise (ManusFlux) explored the Manus Spreading Centre (MSC) and some sites of the South Eastern Rift (SER) in the Manus Basin with the Japanese submersible Shinkai 6500 (Auzende *et al.*, 1996; Gamo *et al.*, 1997). In the frame of the same joint project New STARMER, the French and Japanese teams recently (March-April 2000) carried out the MANAUTE cruise with the *R/V L'Atalante* and the Ifremer submersible *Nautile*. The objectives of the MANAUTE cruise were to explore and sample volcanic and

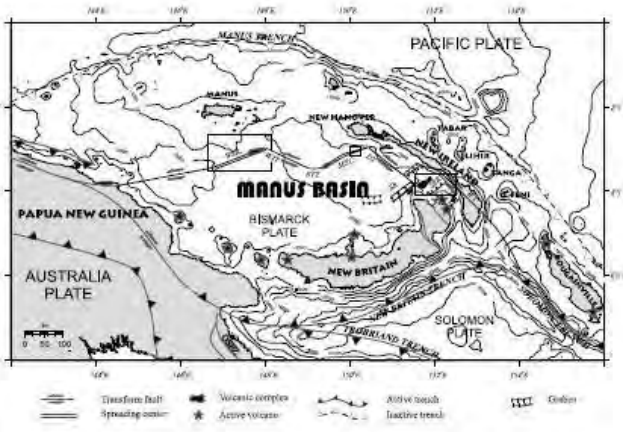

Figure 1. Geodynamical sketch of the Bismark Sea-Manus Basin area (after Martinez and Taylor, 1996)

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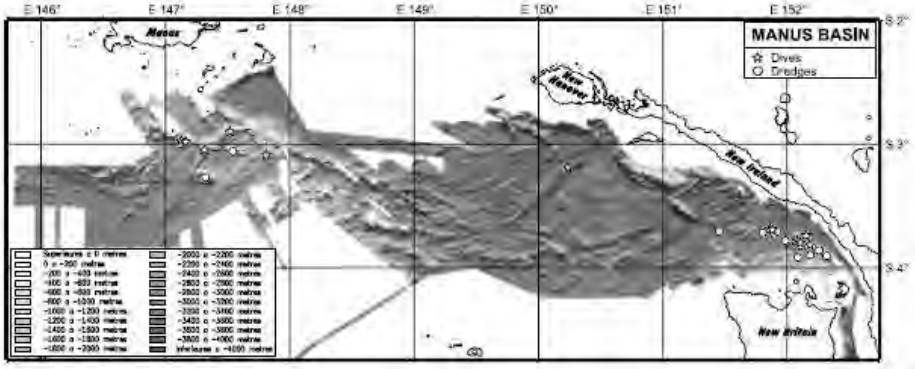

Figure 2. Synthetic swath map of the Manus Basin. Dives are indicated by stars and dredges by rings.

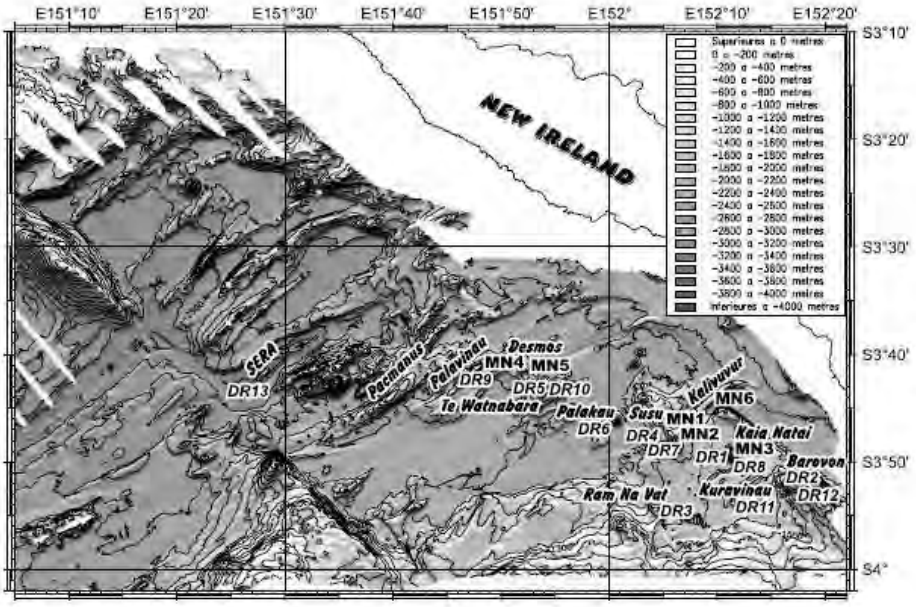

Figure 3. Swath map of the Eastern Manus Basin and location map of dives and dredges. The contour interval is 100 m.

Figure 4. Example of chimneys at the top of Kaia Natai volcano

hydrothermal sites in the eastern part of Manus Basin and on the spreading axis of the Western Ridge (WR).

The eastern Manus Basin (South Eastern Rift-SER) is characterised by a complex system constituted by spreading axes, transform fault segments and massive volcanic features represented either by isolated volcanoes or ridges. Some researchers have proposed that this part of the basin was created by streaching the the back arc crust (*e.g.* Martinez and Taylor 1996). The Western Manus rift (WR) was poorly known and omitted in previous interpretations.

The aim of the MANUATE cruise was to carry out a detailed study of both, the eastern and the western parts of the Manus Basin. Twelve new dives and 18 new dredges were carried out (Fig. 2) in addition to the dives carried out previously in this area during the ManusFlux 95, and the BioAccess 97, 98 and 99 cruises of the New STARMER French-Japanese programme.

The map in Fig. 3 shows that the eastern Manus Basin is located between two left-leral offset fracture zones, Djaul to the west and Weitin to the east. The crust of this part of the basin is about 2000 m deep. It is cut by two N45 propagating axes, the SERA and the Kalivuvur. A succession of volcanoes and volcanic ridges are aligned along the axis at an oblique N110 line. The 6 dives and 13 dredges carried out in this area provided data to confirm that SERA and Kalivuvur are both actively propagating axes. The sampled rocks will give us an answer as to the nature of the volcanism along these axes, acidic or perhaps tholeitic, as on the MSC. The study of the oblique volcanic line shows that all the volcanoes and ridges are active. They are made of acidic rocks ranging from andesites to dacites and show hydrothermal venting. The Susu site is composed of three volcanoes. At the top of the volcanoes active chimneys expel fluids with a temperature range from 50°C on the southern most volcano, to 220-280°C on the other two volcanoes. Hydrothermal deposits (sulphides and oxides) and intense alteration of the volcanic rocks are associated with these vents. The Kaia Natai volcano is covered by a thick layer of hydrothermal deposits ranging from sulphides, sulphates and iron oxides to altered and silicified volcanic rocks. Peculiar hydrothermal vents were discovered. They are characterised by low temperature fluids (38°C) and an abundance of bacterial mats, possibly associated with the acidic nature of the fluids (Fig. 4).

The western part of the Manus basin (Fig. 5) is characterised by two N45 parallel axes propagating rapidly to the SW and located at extremely shallow depth: between 200 and 600 m for the eastern one and around 800 m for the western one. The five dives and four dredges carried out in this area confirmed that the present day magmatic activity is concentrated on these two axes. The sampled rocks were very fresh, vesicular to the pumice stage. Such a type of pumitic rocks were previously observed in the Lau Basin at 1700 m depth (Fouquet *et al.*, 1993) and are thought to reflect the acidic nature of the volcanism.

All the dives have shown Manganese anomalies (detected by a new *in situ* analyser installed on the *Nautile* and developed by J.Knoery at IFREMER/Brest), thus, suggesting the presence of hydrothermal activity. Off axis, the Mata na Kul (Fig. 6) and Vat na Ingiet volcanoes show intense diffusion activity with deposits ranging from iron oxides, manganese-silica and barytine.

In conclusion, the MANAUTE cruise allowed us to determine the spreading pattern of the Manus Basin and also to evaluate the local magmatic and hydrothermal activity.

The newly created crust in the eastern part of the basin is restricted to two small size areas flanking the SERA and Kalivuvur axes. These axes are propagating through the ancient back arc basin crust.

In the western part of the basin the present-day accretion is localised on two axes propagating rapidly to the SW.

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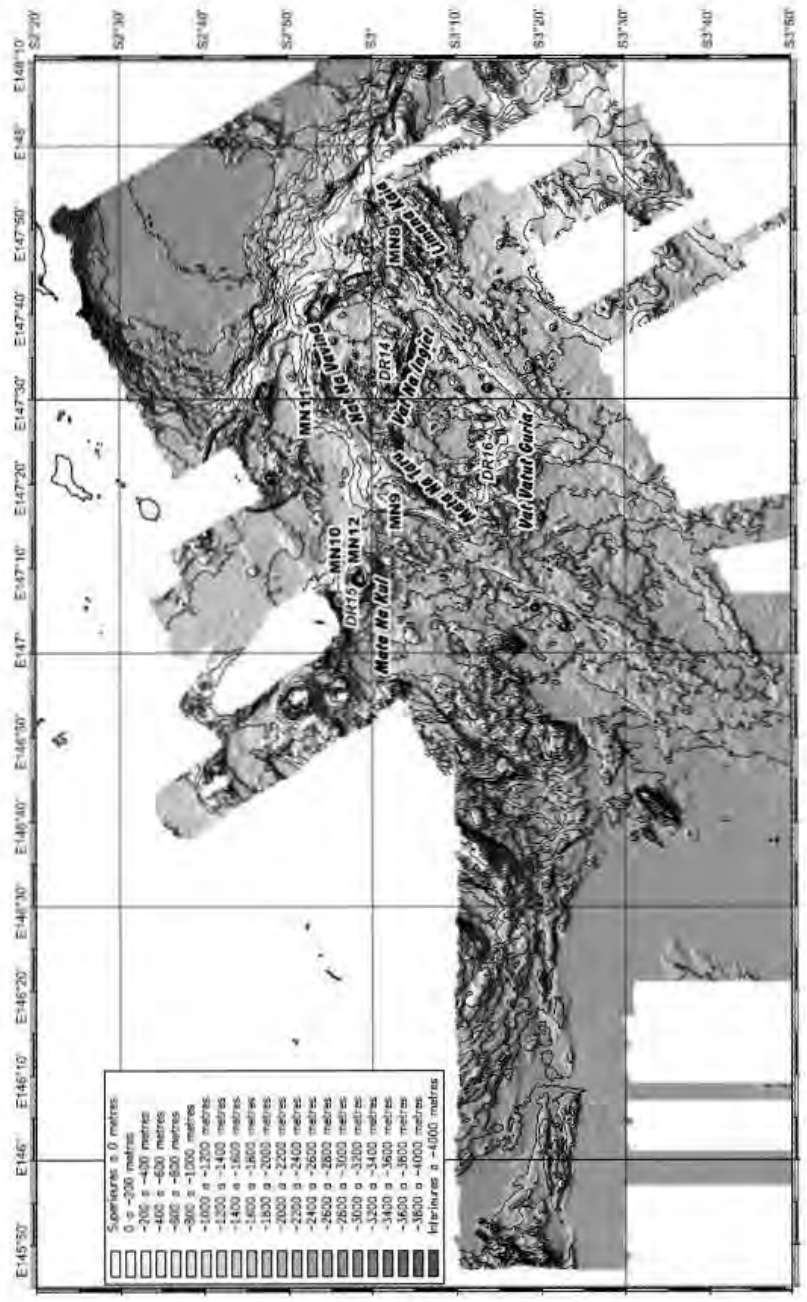

Figure 5. Swath map of the Western Manus Basin and location map of dives and dredges. Contour interval is 100 m.

Figure 6. A 3D view of the western axis Mata na Taru (Red eye in Tolai language, PNG) and of the Mata na Kul volcano (Eye of devil in Tolai language)

In both, the eastern and the western domains the magmatic activity is robust on the axes but the nature of the erupted rocks is still considerably influenced by the effect of the New Britain subduction zone. Off axis, the magmatic activity is also related to subduction.

The hydrothermal activity seems to be more intense on the off axis features. The expelled fluids and the deposited products are strongly influenced by the acidic nature of the rocks constituting the manus Basin basement. They are relatively low temperature fluids (50 to 290°C) with a very acidic pH. The hydrothermal deposits cover a variety of compositions, ranging from manganese to sulfides and passing through iron oxides, sulfates and silica.

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