“Splitting a continent: Insights from submarine high resolution mapping of the Moresby Seamount Detachment, offshore Papua New Guinea”

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DATA ACQUISITION

Multibeam echo-sounding data of Moresby Seamount and surroundings were collected on R/V SONNE Expedition 203 (Devey et al., 2009). A Kongsberg EM120 system with 191 beams in the range 11.25-12.75 kHz was used for ship-based mapping. Beam ray paths and seafloor depths were calculated utilizing sound velocity profiles derived from conductivity-temperature-depth casts on the same SONNE Expedition. The resulting bathymetric map, with average pixel size of 25x25 m (Fig. 1b and Fig. DR1), is a substantial advance over existing bathymetric data (Taylor et al., 1995). Together with backscattered signals it formed an excellent base for dredging, and for high-resolution AUV mapping, using a RESON Seabat 7125 multibeam (200/400 kHz) system, a CTD and a water column turbidity sensor. Map resolution of the detachment surface (Fig. 3) is about 2 m relative horizontally and ≤ 0.5m absolute vertically.

PRINCIPAL ROCK TYPES AWAY FROM THE EXTENSIONAL DETACHMENT ZONE

The quaternary talus to the NNE of Moresby Seamount (Fig. 1c) is defined by ODP Sites 1108, and 1110-1113, the so-called „Talus Sites“ (cf. Roller et al., 2001). Gravels of mylonites and other faulted and fractured basement rocks (Taylor et al., 1999) document progressive exhumation of the detachment surface since the Upper Pleistocene. A thin (up to 6.6 m) Pleistocene cover of foraminifer-bearing ooze and clay, containing calc-alkaline volcanic silt-sized components was documented above an unconformity at ODP Site 1114 (Taylor & Huchon, 2002; Roller et al., 2001). This Pleistocene cover has not been mapped out in Fig. 1c as an independent lithological unit, but is represented as the thin Pleistocene cover of Pliocene clastic sediments.

Quaternary basin sediments and slide deposits (Fig. 1c) north and south of Moresby Seamount are outlined by areas of hummocky topography and low multibeam backscatter intensity.

Variably lithified siltstones and mudstones with interbedded volcanics of Pliocene age (Taylor & Huchon, 2002) have extensive outcrops on the crest and upper flanks of Moresby Seamount. They were recovered along with basement rocks in Dredges (DR) DR39, DR40, DR42 and DR43 (Fig. 1c). These
correspond to a layer of Pliocene clastics several hundred meters thick that was cored at ODP Site 1114 (Taylor & Huchon, 2002). DR44 (Fig. 1c), from the southern slope of the seamount, contained exclusively coarse clastic Pliocene sandstones and microconglomerates. On the northwestern slope interbedded mudstones with a cleavage discordant to the sedimentary layering were recovered in DR63 (Fig. 1c).

Basement rocks of the footwall block immediately below the Moresby Seamount detachment (MSD) were recovered from DR105, DR42, and DR41 (Fig. 1c). These are mostly coarse-grained, plagioclase-clinopyroxene-bearing gabbros with variable alteration to epidote, amphibole, and chlorite, and no deformation apart from fracturing.

Basement away and structurally below the MSD (DR69; Fig. 1c) consist of two groups of rock types. First, there are greenschists and meta-gabbros. The latter are fine grained, and undeformed or slightly foliated, with slight or more pervasive retrogressive alteration of primary minerals to albite, epidote and chlorite. Second lithology is quartzo-feldspathic gneisses and schists, which are foliated and tightly folded, and have a well-developed stretching lineation. More mica-rich varieties exist as well, with intense foliation fabric.

FLOW STRESS ESTIMATION

Infiltrated quartz veins were plastically deformed, which can be derived from a strong crystallographic preferred orientation indicated by predominantly blue interference-colors when inserting a gypsum plate in crossed polarized light in the optical microscope. For one of these quartz mylonites (sample DR40-2B) from the MSD the flow stress was determined using the experimental piezometer calibration of Stipp and Tullis (2003), which is independent of the water content of the samples (Stipp et al., 2006). Resulting stress data are corrected for the Griggs rig apparatus distortion ($\sigma_{\text{Gas apparatus}} = 0.73 \times \sigma_{\text{Griggs MSC}}$, +/- 10 MPa, where differential stress $\sigma = \sigma_1 - \sigma_3$; Holyoke and Kronenberg, 2010). For DR40-2B two quartz-dominated sample areas with a minimum of impurities were selected. For each of these areas micrographs in three different rotation positions of the polarizer and in circular polarization were taken and stacked together. On the basis of this stack grain boundary outlines were drawn and recrystallized grains distinguished from porphyroclasts (Fig. DR3). The size of each grain was measured using the public domain software NIH Image (US National Institute of Health, http://rsbweb.nih.gov/nih-image/about.html). The diameter of each recrystallized grain is defined as the diameter of a circle with the same area, and the average two-dimensional grain diameter (= recrystallized grain size) for the sample was calculated as the root mean square diameter from all measured recrystallized grains in that sample.

REFERENCES CITED


SUPPLEMENTARY FIGURE CAPTIONS

Figure DR1. Bathymetric map of the continent-ocean transition east of Moresby Seamount generated from R/V SONNE 203 multibeam echo-sounder data. Topographic features of sub-100m size can be clearly identified, forming an excellent base for site selection regarding the dredging and for high-resolution mapping using the Autonomous Underwater Vehicle. Successful dredge stations (recover of rock material) are shown, “on bottom” locations by red dots and “off bottom” locations by violet square. The area of the geological map of Moresby Seamount is marked by the white rectangle; the area of the AUV-dive is marked by the white polygon. The supposed locations of ridge axes 1A and 1B (Taylor et al., 1999) are marked with dashed black lines.

Figure DR2. Foliation-parallel anastomosing hydrofractures with crack-seal structures in a lower greenschist facies metabasite (DR105-1A). The crack-seal structures consist of cyclically grown calcite fibres indicating intermittent hydraulic fracturing. This structural feature is most commonly observed in fault rocks reflecting metamorphic grades up to upper greenschist facies (cf. Ramsay, 1980).

Figure DR3. Grain boundary maps and related 2D-recrystallized grain size distributions of two areas from sample DR40-2B. Recrystallized grains were distinguished from porphyroclasts based on microstructural evidence. Recrystallized grains are marked in white, porphyroclasts in grey and other minerals in black. The mean recrystallized grain size of 11.3±3.6 µm and 10.9±2.9µm corresponds to a flow stress (σ) of 71+25/-14 MPa and 73+23/-10 MPa, respectively.
Figure DR1

WOODLARK BASIN
Moresby Seamount

Mercator projection (WGS 84)

Speckbacher et al., GSA DR - Figure 1, ai. file (Vers. CS4)
Figure DR3

Speckbacher et al., GSA DR - Figure 3, ai. file (Vers. CS4)