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The active Moresby Seamount Detachment Fault, Woodlark Basin: insights into structure and mechanics from high-resolution submarine mapping and sampling

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Moresby Seamount Detachment, located east of Papua New Guinea in the Woodlark Basin, is arguably the best-exposed active extensional detachment fault in the world. It forms the northern slopes of Moresby Seamount, a 3000 meter high east-west trending tectonic horst separating two extensional basins. Fault zone dip is about 30°, and total horizontal stretch accumulated in the past 3.5 Ma is about 8 km. The detachment surface is exposed on the sea floor over an area of about 30 square kilometers. Denudation is almost absent, and sedimentation is apparently suppressed by strong bottom water currents, providing a unique opportunity to analyze the tectonic geomorphology and structure of the fault zone, and sample the fault rocks.

R/V SONNE Expedition 203 first mapped the area with about 20 m spatial resolution by ship-based multi-beam bathymetry operating at 12 kHz. Most of the detachment surface was subsequently surveyed by AUV fitted with a 200 kHz multibeam echosounder, a CTD and a water column turbidity sensor. Map resolution is about 2 m. Samples were dredged from the detachment, and in basement and sediment sites in the footwall block.

In the uppermost part the detachment zone cuts through an approximately 500 m thick sequence of Pliocene clastic sediments. Topography there is rugged, with erosional gullies, and areas of slope failure. Below, an upper smooth zone of the detachment is made up by a slope-parallel belt of cataclasites, generated from metamorphic basement rocks of Paleogene or older age, mainly gabbro, metadiabase and psammo-pelitic schists. Structurally and topographically below the cataclasites is a lower rugged zone mainly exposing cataclasites and mylonites. Topography is due to localized slope failure and a major sinistral strike slip fault scarp transecting the detachment with a 320° azimuth. Below the rugged zone is a lower smooth zone of cataclasites and mylonites. The most spectacular feature here are several north-south trending, extremely straight grooves hundreds of meters long, probably megascopic slickensides. At the foot of the detachment we discovered a km-sized temperature (0.01 °C) and turbidity (2 x background) anomaly in the oceanic bottom water.

Our main interpretations from these observations are: (1) Exhumation (minimum 3 km at 100°C/km geothermal gradient) in the lower smooth zone has progressed far enough to bring pristine ductile fault rocks to the Earth´s surface. (2) Deformation is partitioned into dip-slip normal and sinistral strike-slip faulting. (3) The nature of the faulting imposes an important upper bound on ductile flow strength of the detachment at depth (about 100 MPa). (4) The detachment zone is a pathway for hydrothermal fluids from depth, possibly at a large scale.