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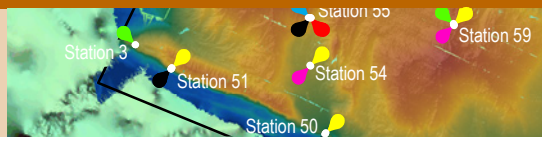
Revealing the Wallaby Plateau

Recent survey delivers geophysical, geological and biophysical data



Gabriel Nelson, Michael Hughes, Rachel Przeslawski, Scott Nichol, Bridgette Lewis, and Kane Rawsthorn

The Wallaby (Cuvier) Plateau was the focus of the third leg of the recent Geoscience Australia Southwest Margin marine reconnaissance survey. The plateau is a large bathymetric high, lying in water depths from 2000 to 4000 metres approximately 500 kilometres west of Carnarvon, Western Australia. Satellite-derived gravity data and initial seismic interpretations indicate a portion of the plateau comprises continental crust with sedimentary depocentres. This submarine plateau has been recently added to Australia's extended continental shelf under the United Nations Convention on the Law of the Sea (*AusGeo News 93*), and is one of the frontier areas being focussed on by Geoscience Australia's Offshore Energy Security Program.

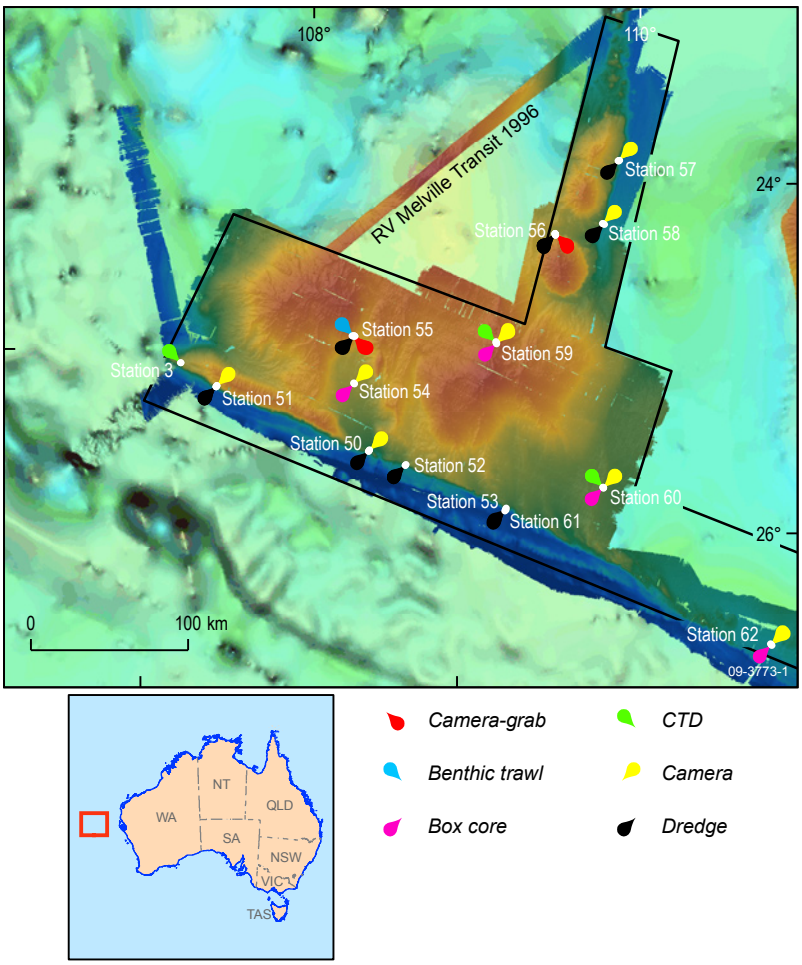


Figure 1. New swath bathymetry acquired during the Southwest Margin marine reconnaissance survey on the Wallaby Plateau overlain on satellite-derived bathymetric image. The station locations and type of sampling done at them during the survey are also shown.

Approximately 65 000 square kilometres of the Wallaby Plateau were surveyed over 29 days (figure 1). Key datasets collected during this time include multibeam swath bathymetry and about 8000 line kilometres of high resolution gravity, magnetic and Acoustic Doppler Current Profiler measurements. Additional data were collected with 11 rock dredges, three sediment grabs, four box cores, one benthic (sea floor) trawl, eight camera tows as well as 10 temperature, conductivity (salinity) and depth profiles through the water column. These complementary datasets will continue to contribute to a better geologic, sedimentologic, oceanographic and biologic understanding of this frontier region of Australia's continental shelf.

New geology from swath bathymetry

Detailed bathymetry acquired over the Wallaby Plateau area showed new seafloor features interpreted as volcanic in origin, as well as structurally-controlled valleys, scarps and ridges. Five interpreted volcanic features have been identified on the plateau; four from the new bathymetric

data and one from a pre-existing multibeam swath track. Three large volcanic complexes with amorphous perimeters and relatively flat tops were identified in the southwest, southeast and north. Two smaller, steeper and more cone-shaped volcanic features were identified in the northeast. A steep sided, 5.5 to 23 kilometre-wide valley extending to the north from the southwest edge of the Wallaby Plateau has also been identified.

The edge of the plateau is defined by a scarp that extends about 360 kilometres and up to two kilometres high. Several offset ridges, 50 to 800 metres tall and 125 to 200 kilometres long, are at acute angles to the southwestern edge of the Wallaby Plateau. These ridges are the morphological expression of the Wallaby-Zenith Fracture Zone. Northeast of the plateau more than 30 closely spaced possible volcanic hills (270 to 400 metres tall) are visible in the new swath bathymetry data. These appear to be an extension of the Sonne Ridge on the Cuvier Abyssal Plain.

Regionally, the main phase of volcanism is related to the break up of Australia and Greater India about 130 million years ago. Many of the volcanic features on the plateau are likely to correspond to regional volcanism during break-up, and the variable morphology may indicate multiple episodes of volcanic activity. Other volcanic features, including those located on the abyssal plain, are probably a result of volcanism during seafloor spreading after break-up. The southern margin of the plateau may have developed with a transtensional component, shown by the series of *en echelon* offset ridges within the Wallaby-Zenith Fracture Zone. The steep sided submarine valley in the central area of the plateau is the surface expression of extensional faults observed in 2D seismic lines. Relatively recent movement of these faults is suggested by the distinct nature of the valley sides despite extensive modern sedimentation.

Geological sampling

Geological samples were collected at nine stations (or locations) from 11 dredges, one grab sample, and one benthic trawl. There are 10 samples of sedimentary rocks, 14 volcanic samples, and seven samples with a high degree of alteration and secondary mineral development. Most volcanic samples are vesicular with a fine grained groundmass and likely to be basaltic in composition. Three volcanic samples from different parts of the plateau appear more siliceous, potentially indicating variations in magma composition in the area (figures 2a, 2b). Of the 10 sedimentary samples two contain abundant bivalve fossils and other macrofossil fragments (figure 2c, 2d). These fossil rich samples are predominantly made up of terrigenously derived grains.

Rock samples collected on the Wallaby Plateau are mostly igneous, reflecting a predominantly volcanic origin of the bathymetric features.

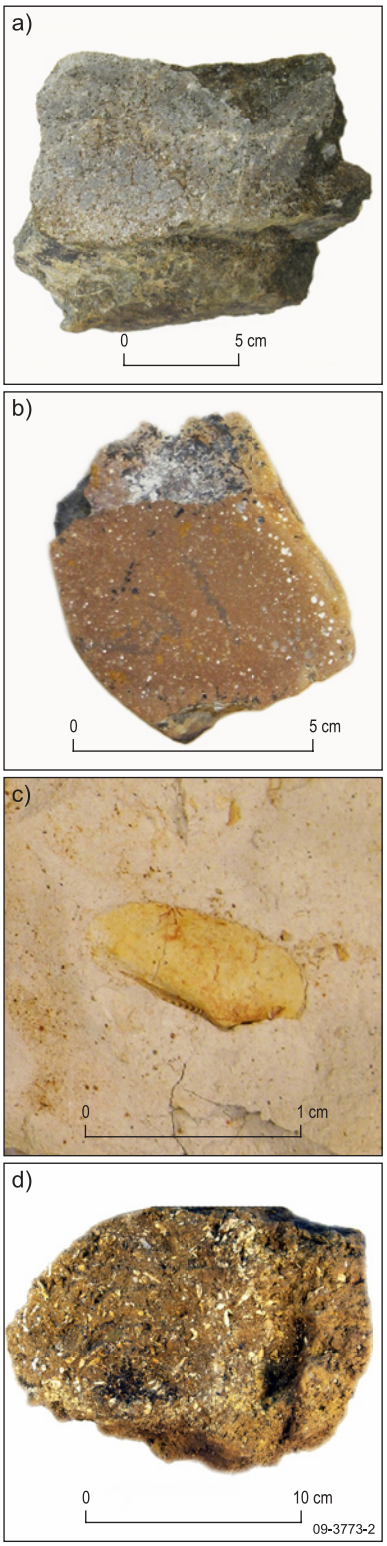


Figure 2. Geological samples recovered from the Wallaby Plateau: a) possibly evolved (more siliceous) volcanic sample; b) possibly evolved volcanics with very fine crystals and no evident olivine; c) disarticulated bivalve with evident dentition; d) very fine grained sandstone with bivalve fragments, echinoderm spines, bryozoan fragments, and other carbonate bioclasts.

The potential variability in the silica content of igneous samples suggests variable evolution of the magmatic system(s) spatially and/or temporally. Of particular importance is the recovery of several terrigenous clastic rocks. They are the first physical evidence confirming the previously inferred sedimentary depocentres on the Wallaby Plateau. The various terrigenous clastics were likely deposited during a time when a portion of the plateau was near or above sea-level.

Sedimentology

Seafloor sediments collected from 12 stations at 2050 to 4650 metres water depth represent scarps, valleys and volcanic features (figure 1). Most sediment samples were collected from pipe buckets attached to the rock dredge. Samples were also collected using a grab at three stations and a box core at three other stations, with the latter providing undisturbed sediment samples.

Visual observations of samples indicate seafloor sediments on the Wallaby Plateau comprise unlithified sandy mud that forms an extensive deposit of cohesive, poorly sorted ooze. In all samples, the sand fraction is calcareous and dominated by foram tests (or shells). Some samples also included small amounts of gravel, derived from rock outcrops that were observed by camera in the vicinity of the sample site.

The uniformity of surface sediment type across the Wallaby Plateau is consistent with a gradual accumulation of pelagic material from the water column, dominated by calcareous foram tests. Where outcrops of volcanic rock occur, the ooze is mixed with gravel clasts but these deposits appear to be of limited extent. Based on the available samples, there does not appear to be any variation in sediment type as a function of water depth or between the different geomorphic environments of the Plateau.

Oceanography

Water properties over the Wallaby Plateau were sampled at ten stations (figure 1). The general pattern observed was a three layer water-column. Within the surface layer, which is about 40 to 50 metres deep, the salinity and temperature did not vary significantly because of mixing by surface waves and currents. Below this were seasonal and permanent thermocline layers that extended down to a depth of 850 metres (figure 3). Through this depth range both the temperature and salinity decreased markedly. Below the permanent thermocline water temperatures decreased slowly with depth. Bottom water temperatures were only 1 to 2° C, considerably cooler than a typical domestic refrigerator which is about 4° C.

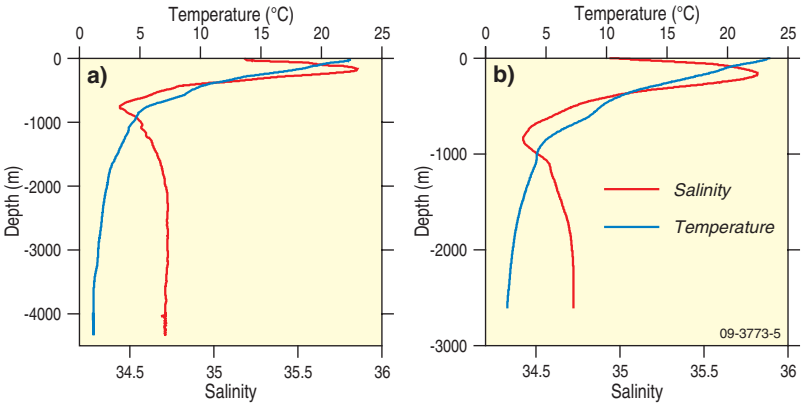


Figure 3. Depth-profiles of water temperature and salinity at Stations 50 and 59 (see Figure 1 for station locations).

Ocean current data collected using an Acoustic Doppler Current Profiler provided current speed and direction at intervals of 24 metres through the first 800 metres of the water column. Thus the measurements extended to the base of the permanent thermocline. Surface currents observed over the Wallaby Plateau at the time of the survey were typically 0.25 metres per second (or m s^{-1}) and reached up to 0.4 m s^{-1}. The pattern of flow was consistent with a clockwise-rotating eddy (figure 4). It is not known whether such an eddy is usually centred on the plateau, if so, then vertical currents within the clockwise-rotating eddy are expected to be directed towards the sea surface. This would limit the connectivity between the surface and deep water masses.

Biology

In order to characterise the biodiversity on the sea floor of the Wallaby Plateau, nine video transects were undertaken on

the plateau and slope. In addition, three grabs and three box cores were deployed to investigate deep sea animal communities that live beneath the sea floor (infauna) out of video view. In addition, surface zooplankton was sampled to compare pelagic (in the water column) and benthic (on the sea floor) biodiversity in the region.

Observations revealed very few animals on the Wallaby Plateau compared to other locations sampled during the Southwest Margin reconnaissance survey. In the deep sea, hard substrates are often colonised by scattered suspension feeders such as sponges, gorgonians, and crinoids, however videos showed almost no such organisms on the rocky habitats. Soft sediment habitats are usually dotted with distinct tracks, burrows, and mounds from deposit-feeding infauna: but again, there was little evidence of biological activity, with few fresh tracks seen. The only animals that occurred regularly were deposit-feeding sea cucumbers and scavenging prawns (figure 5). The box core and grab samples corroborated the video, with only a few marine worms and crustaceans collected.

The comparative barrenness of the Wallaby Plateau may be the result of an abrupt decrease in oxygen availability on the sea floor. However, the only dissolved oxygen profile collected during the survey showed that the oxygen gradient in the water column was normal for deep sea habitats and did not explain the apparent lack of animals. An alternative explanation is that the ocean currents above the Wallaby Plateau drive the biological patterns observed, such that food and larvae bypass the area and never make it to the sea floor to nourish, establish, and perpetuate populations. Indeed, the Wallaby Plateau had less zooplankton than the nearby Houtman Sub-basin, suggesting that the amount of nutrients and propagules reaching the Wallaby Plateau sea floor is less than for other benthic habitats in the region.

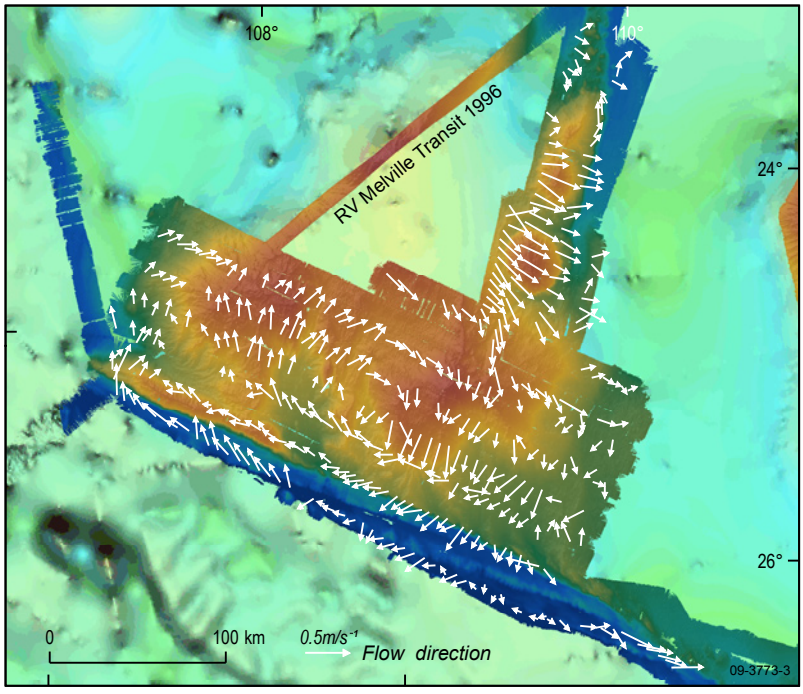


Figure 4. A sample of the surface ocean currents measured over the Wallaby Plateau showing evidence of a clockwise-rotating eddy.

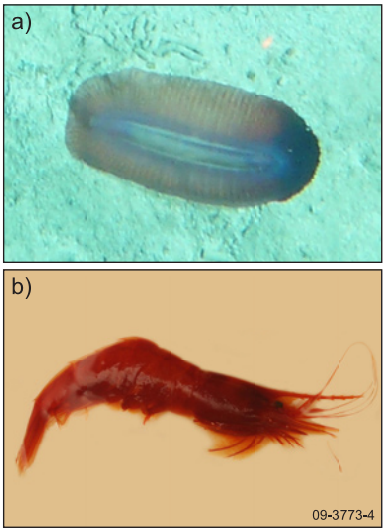


Figure 5. Sea cucumbers (top panel, video screenshot photograph from ~3950 metres) and prawns (bottom panel, collected from ~3820 metres) found regularly on the sea floor of the Wallaby Plateau.

Conclusions

The successful marine reconnaissance survey of the Wallaby Plateau resulted in several new datasets that have already revealed new geologic, sedimentologic, oceanographic and biologic discoveries. Further work is in progress to refine this understanding and place it in a regional context. This research includes detailed analysis of the bathymetry and geophysical datasets as well as the geological samples. Future analysis will provide an understanding of volcanic and depositional evolution, as well as the geomorphic and biologic state of the Wallaby Plateau.

For more information

phone Gabriel Nelson on +61 2 6249 9621
email gabriel.nelson@ga.gov.au