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OSCAR – Oceanographic and Seismic Characterisation of heat dissipation and alteration by hydrothermal fluids at an Axial Ridge

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The interdisciplinary OSCAR project is examining the heat and mass fluxes in the solid Earth and overlying ocean at the Costa Rica mid-ocean Ridge (CRR) in the Panama Basin. The 3500 m deep Panama basin is isolated from the wider Pacific Ocean below ∼2000 m by the Cocos and Carnegie Ridges except for a deep water channel along the Ecuador trench. This channel supplies cold abyssal water into the Basin at a rate of 0.35 Sv (million cubic metres per second)) at a temperature of 1.75°C. Within the basin the water is heated to ∼2°C. The energy for this heating is dominated by geothermal effects with a smaller contribution from mainly tidal induced mixing over the ridges.

The main geophysical transect for the OSCAR survey links the CRR with the ODP 504B borehole which is drilled 2111 m into 5.9 Ma oceanic crust. Changes in the solid Earth properties from the CRR to 504B are mapped using a combination of seismic 2D- and 3D-refraction and synthetic-aperture reflection, magnetics, gravity, magnetotelluric data, swath bathymetry and heat-flow. Results show that the properties of layer 2 are variable and are more likely a function of changes in magma supply at the ridge rather than the effects of ageing. Of particular note is the abrupt change at 5 Ma. Older crust has a higher velocity and lower topography when compared with younger crust. Also the heat-flow over the older crust is largely through conduction whereas in the younger crust it is largely by advection.

The physical oceanography data include conductivity temperature depth (CTD) casts, micro-structure casts, helium and other isotope data, together with seabed and moored temperature, pressure and Doppler current measurements. The inflowing water along the Ecuador trench initially mix with with the warmer water as it enters the basin. Mixing and heating continues as the water circulates into the western part of the basin where it shows no vertical density gradient for over 1000 m and an overall temperature increase of 0.25°C combined with a decrease of 0.01 psu in salinity. Evidence of hydrothermally driven plumes were also detected along the CRR but exact locations of their sources were not found.

Our best estimate from the OSCAR data show that the geothermal contribution is over 70% to the abyssal water upwelling. This is the largest contribution yet observed in abyssal basins and is in line with a growing number of studies arguing that geothermal heating plays a significant role in driving the abyssal and global circulation.