Towards IODP deep riser stratigraphic drilling in northern Zealandia: outcomes of pre-drilling site surveys on the Lord Howe Rise continental ribbon

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The Lord Howe Rise, the backbone to northern Zealandia, is a ribbon of submerged and extended continental crust that separated from Australia during the Late Cretaceous. Sedimentary basins on the Lord Howe Rise preserve a 100 million year record of tectonics, climate and ancient microbial life. Proposal 871-CPP, approved by the International Ocean Discovery Program (IODP) in 2017, aims to drill and core a Lord Howe Rise rift basin using the riser-capable drilling vessel CHIKYU. In preparation for this proposed riser drilling, Geoscience Australia and JAMSTEC have undertaken two site surveys to acquire pre-drilling data that constrain the stratigraphic, structural, geotechnical and environmental characteristics of the sites under consideration.

Multichannel seismic reflection data acquired across proposed drill sites in 2016 provide a more detailed view of basin stratigraphy and pre-rift basement. The preferred drill sites, located in two separate depocentres, intersect syn-rift sediments with a thickness of 700–1000 m that are overlain by up to 1000 m of post-rift sediments. Seismic stacking velocities range from 2–3 km/s in the sedimentary sequence and up to 4 km/s in basement. Based on these velocities and experience from previous CHIKYU drilling operations, the anticipated rate of coring will be 40–60 m/day through syn-rift sediments and 30–40 m/day in pre-rift basement.

In one depocentre, the inferred base of the rift-fill sediments coincides with a strong reflector that is interpreted to represent a sill. As seismic penetration below high impedance contrasts is normally dramatically reduced, depth-to-basement estimates at sites in this depocentre are uncertain. In addition, gravity modelling suggests that low-density sediments are likely to be present beneath the strong reflector. In the other depocentre, the new seismic data reveal prominent sub-horizontal reflectivity within pre-rift basement beneath the syn-rift strata. Drilling in this depocentres is thus preferred because there is greater certainty that rocks recording the full rifting history of the region will be intersected.

A second site survey in late-2017 acquired high-resolution multichannel seismic data around priority drill sites. These data not only indicated the absence of any significant drilling hazards in the shallow sediments, but also provide a higher-resolution image of the sedimentary fill. Seismic refraction data recorded on closely-spaced (800 m) ocean-bottom seismometers across the preferred drill site will provide a rare, public-domain dataset that can be used to generate a high-resolution velocity model that will help to better constrain depth to key reflectors at the preferred drill site.

Piston cores acquired during the second survey penetrated to a hard layer at a depth of ~7 m below the seafloor. This layer corresponds to an extensive reflector that is evident in sub-bottom profiler data surrounding the drill sites. Constraints for planning riser top-hole construction will be derived from strength tests to be conducted on whole-round samples from the piston cores and also from rotary cores

collected from greater depths during IODP Expedition 371 in 2017.

Multibeam bathymetry data from a ship-mounted system and, at some sites, from a deep-tow system, reveal a relatively smooth seafloor around the drill sites. These data will help ensure that drill sites are not located on structures related to sediment dewatering. Imagery from the deep tow system also confirms that there are no significant biological communities on the seafloor around the proposed drill sites.

The site surveys conducted on the Lord Howe Rise demonstrate the benefits of acquiring a broad range of data that allows a detailed geological and geotechnical understanding of the area. This supports the prospect of successful IODP deep riser drilling in one of Earth’ s last remaining geoscience frontiers.

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