Looking Beneath the Seabed

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In recent years, ODP has devoted considerable time and effort to looking deeper into the Earth's crust and studying active dynamic systems. Some of these systems occur in subduction zones, regions that are characterized by the world's largest earthquakes. Recent studies of the processes occurring at subduction zones have established that fluids play a major role in their physical and chemical evolution. During Leg 193 in the Manus Basin near Papua New Guinea, ODP attempted to determine how fluids and metals derive from underlying magmatic sources and from the leaching of wall rocks by circulated water. Scientists also aimed to identify probable fluid pathways and chemical gradients within the hydrothermal system and establish a hydrological model (Binns *et al.,* 2002). During Leg 196 in the Nankai Trough offshore Japan, the scientific objectives focused on understanding the structural and hydrological evolution of the plate-boundary fault and determining the geographical extent and timing of progression of deformation (Mikada *et al.,* 2002). In both of these cases, logging while drilling (LWD) techniques helped in understanding the extent and geometry of subsurface structures.

The introduction of LWD techniques into ODP have brought to bear a critical technology on the collection of continuous geophysical records where, in the past, core recovery has been notoriously poor and wireline logging nearly impossible. As of April 2002, ODP had devoted seven legs to drill 22 LWD holes. Technological advancements have also provided more options for the type of the data being acquired during LWD operations. Recent deployments have used the borehole-imaging Resistivity at Bit (RAB) tool. This tool provides images of the borehole close to the bit with a vertical resolution of a few inches. Three, 1-inch button electrodes provide shallow, medium, and deep resistivity measurements as well as images, using the Earth's magnetic field as a reference while the drill string and RAB tool rotate. Processing of LWD images requires accurate timing and conversion of the raw electrical resistivity values into a continuous image.

Figure 1 shows images obtained through LWD and the type of information they provide. Leg 193 delineated probable fluid pathways within the system and provided constraints for a hydrological model using the fracture patterns observed in the LWD images. The images also show the relationship between volcanological, structural, and hydrothermal features in the PACMANUS hydrothermal system. In comparison to similar hydrothermal systems at mid-ocean ridges, Leg 193 results show distinct structural relationships associated with magmatic events and provide a basis for interpreting ancient ore environments. Leg 196 LWD results provided constraints on the distribution of physical properties and stress near the toe of the Nankai accretionary prism. The observation of the regional stress regime directly from LWD images corroborates, and perhaps quantifies, models for sediment accretion at plate boundaries. This information may also help to guide the selection of future drilling in the Nankai Trough. Our ability to use improved LWD techniques in active systems has proven essential for understanding environments where coring and wireline logging operations have been limited in the past.

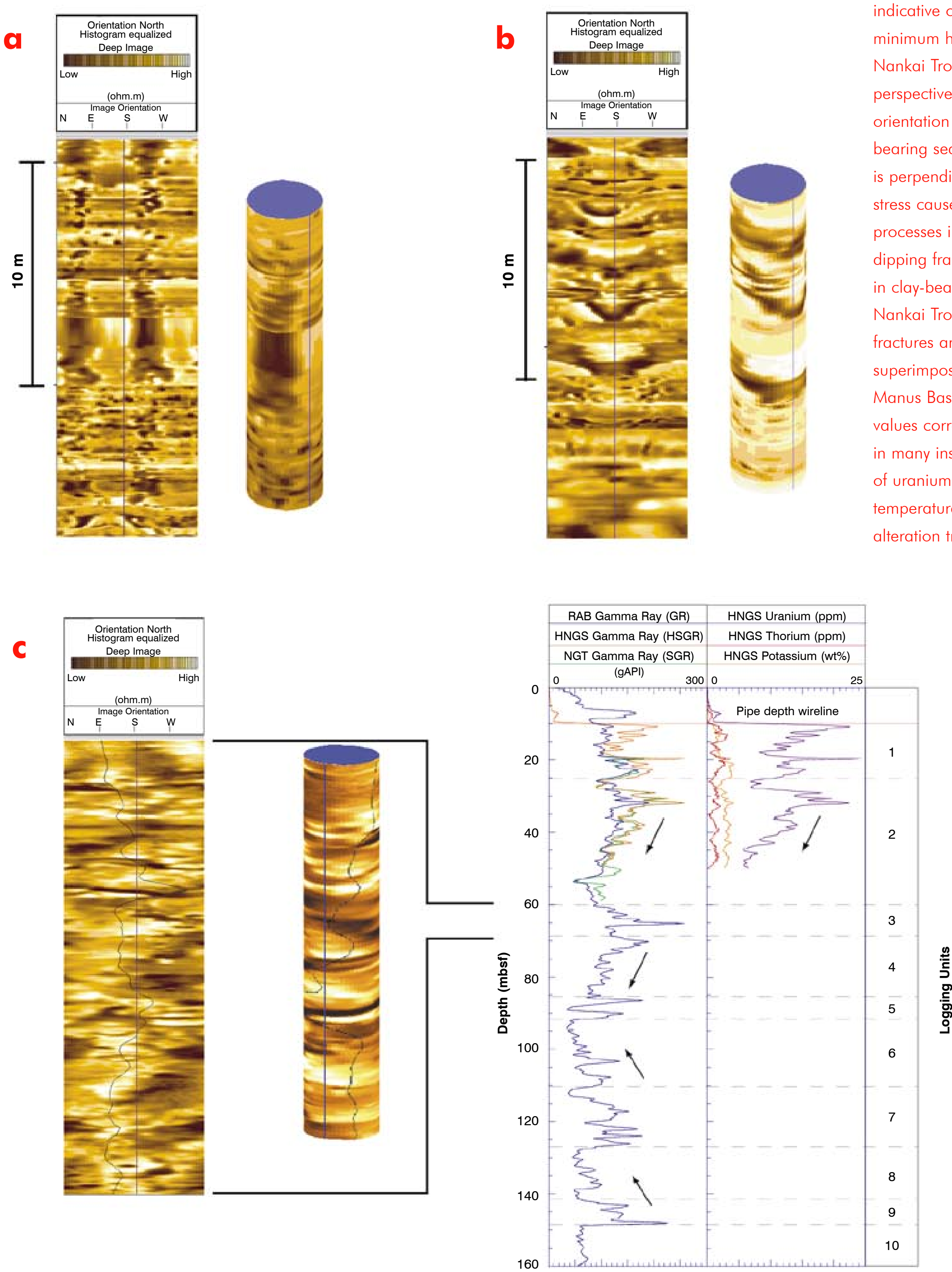

Figure 1. A series of Logging While Drilling (LWD) images obtained with the Resistivity at Bit (RAB) tool. **a)** Borehole breakouts indicative of the direction of minimum horizontal stress in the Nankai Trough. Both 2D and 3D perspectives illustrate their NE-SW orientation in consolidated clay-bearing sediments. This orientation is perpendicular to the maximum stress caused by the subduction processes in this area. **b)** Open dipping fractures near a fault zone in clay-bearing sediments from the Nankai Trough. **c)** A series of fractures and a gamma-ray curve superimposed on images from the Manus Basin. High gamma-ray values correlate with fractures and in many instances are indicative of uranium anomalies and high temperature fluid flow. Arrows show alteration trends.