

On the connection of fractures with clays and fluids in the accretionary prism of the Nankai Trough at Site C0002, NanTroSEIZE IODP Expedition 338/348. Borehole images and log interpretation results

Sobre fracturas, arcillas y fluidos en el prisma de acreción de Nankai en el Site C002 de NanTroSEIZE, Expediciones de IODP 338 y 348. Interpretación de imágenes y diagráfias de sondeo

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Abstract: International Ocean Discovery Program IODP has extensively used the D/V *Chikyu* to drill the Kumano portion of the Nankai Trough. (IODP) Expeditions 338 and 348 of the NanTroSEIZE project drilled deep into the inner accretionary prism south of the Kii Peninsula collecting a suite of LWD data, including natural gamma ray, electrical resistivity logs and borehole images, suitable to characterize structures (fractures and faults) inside the accretionary prism. Both expeditions drilled into the accretionary prism at Site C0002: Hole C0002F (Expedition 338) was drilled down to 2004.5 mbsf, Hole C0002P (Expedition 348) reached a depth of 3058.8 mbsf. Structural interpretation and analysis of logging-while-drilling data in the deep inner prism revealed intense deformation of a generally homogenous bedding that dips steeply and are intersected by faults and fractures. The interpretation of the images of both Hole C0002F and Hole C0002P reveals distinct areas of intense fracturing and faulting within a very clay-dominated lithology. Faults are undoubtedly interpreted on C0002P images. The relationship between fractures, faults and the changes in clay mineralogy from cutting sample analyses is analyzed to characterize potential connection between these features in the accretionary prism.

Key words: IODP, Nankai accretionary prism, LWD logging while drilling, resistivity borehole images, structural interpretation.

Resumen: El International Ocean Discovery Program (IODP) ha realizado numerosas perforaciones mediante el buque de perforación *Chikyu* en la zona de Kumano de la fosa de Nankai. Las Expediciones de IODP 338 y 348 perforaron en la zona interna del prisma de acreción, al sur de la península de Kii y, durante las mismas, se adquirieron datos con sondas de testificación geofísica de tipo logging-while-drilling (LWD). Las medidas realizadas en los sondeos incluían perfiles de radiactividad natural, de resistividad, e imágenes orientadas, entre otros que se han revelado como idóneos para la caracterización de las estratificación y estructuras (fracturas y fallas) dentro del prisma de acreción de Nankai. Durante ambas expediciones realizaron numerosas perforaciones en el Site C0002, entre ellas el sondeo C0002F (Expedición 338), que se perforó hasta 2004.5 mbsf y en el sondeo C0002P, que se perforó hasta los 3058.8 mbsf. La interpretación estructural y el análisis de los datos e imágenes LWD revela una intensa deformación de los materiales de prisma de acreción con estratificación homogénea y elevado buzamiento, afectados por numerosas fallas y fracturas. La interpretación de las imágenes adquiridas tanto en tanto del sondeo C0002F como del sondeo C0002P, muestra zonas específicas con deformación intensa de los materiales predominantemente arcillosos que constituyen el prisma de acreción. En las imágenes del sondeo C0002P se identifican fallas con claridad. Se presenta el análisis de la relación entre fracturas, fallas y cambios en la mineralogía de las arcillas (obtenida sobre muestras de ripios de sondeo) que tiene por objeto evaluar la posible conexión de estos elementos en el prisma de acreción.

Palabras clave: IODP, prisma de acreción de Nankai, LWD logging-while-drilling, imágenes de resistividad de sondeo, interpretación estructural.

INTRODUCTION

Our study is focused on the characterization of structures of the accretionary prism of the central Nankai Trough, off Japan. Multiple seismic surveys and Integrated Ocean Drilling Program (IODP) scientific drilling and logging data were acquired in the

last decade. IODP has extensively used the D/V *Chikyu* to drill the Kumano portion of the Nankai Trough, including two well sites within the Kumano Basin. Site C0002 is located in the Kumano forearc basin above the seismogenic, and presumably locked, portion of the plate boundary thrust. IODP Expeditions 338 and 348 drilled deep into the inner accretionary prism at Site

C0002 (Fig. 1), south of the Kii Peninsula collecting a suite of Logging While Drilling (LWD) data (natural gamma ray, electrical resistivity logs and images and full wave sonic data. IODP) Expeditions 338 and 348 of the NanTroSEIZE project were analyzed. Both expeditions drilled into the accretionary prism at Site C0002. Hole C0002F (Expedition 338) was drilled down to 2004.5 mbsf, Hole C0002P (Expedition 348) down to 3058.8 mbsf into Miocene age mainly hemipelagic mudstone and sand/silt sediments (Moore et al., 2014; Tobin et al., 2015).

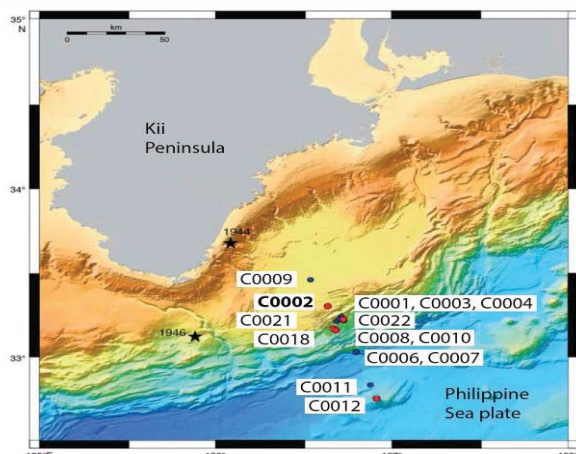


FIGURE 1. Site C0002 location. At this site Hole C0002F (Expedition 338) and Hole C0002P (Expedition 348) were drilled. After Tobin et al. (2015).

Hole C0002F (Expedition 338) and Hole C0002P (Expedition 348) LWD resistivity oriented images have been processed and analyzed to characterize bedding dips and structures (fractures and faults) inside the accretionary prism and to infer the internal accretionary prism structures intersected at Site C0002 and detection of active structures.

We used Techlog Schlumberger software for logging data and image processing and interpretation. We present structural constraints on this setting and a preliminary work on identifying relationships between clay mineralogy changes and structures inside the prism.

BOREHOLE LWD IMAGE GEOLOGICAL INTERPRETATION: STRUCTURES WITHIN THE ACCRETIONARY PRISM

Logging data and LWD images (Fig. 2, Fig. 3) allowed us to characterize the different types of structures and the fault zones identified on 338 and 348 Expeditions. Fractures and faults interpreted on Logging While Drilling (LWD) oriented images and data are used to outline the features of internal deformation within the prism.

Structural interpretation and analysis of logging-while-drilling data in the deep inner prism revealed

intense deformation of a generally homogenous lithology characterized by bedding that dips steeply (60-90°) predominantly to the NW (Fig. 2), and intersected by faults and fractures (Fig. 3). Also folds were intersected at both Hole C0002F and Hole C0002P. Steeply dipping beds with an average dip of ~70°, and a range from ~30°-90°, with bedding strike are perpendicular to the convergence direction (Boston et al., 2016). Faults were picked where clear offsets were observed (Fig. 3).

The structural interpretation of borehole images illustrates the deformation within the fractured and faulted sections of the accretionary prism. The interpretation of the images of both Hole C0002F and Hole C0002P reveals distinct areas of intense fracturing and faulting within a very clay-dominated lithology. Faults are undoubtedly interpreted on C0002P images.

Expedition 348 LWD images are used to further investigate the internal geometries and structures of the Nankai Trough accretionary prism and relationships to clay mineralogies and as potential fluid paths. On Figure 3 changes in clay composition can be associated with the main fault zone characterized by the geometries and deformation characterized on oriented resistivity images and petrophysical properties defined by log response (resistivity and sonic logs).

The relationship between fractures, faults and the changes in clay mineralogy for Hole C0002P shown on Figure 3 reveal that the integration of logging data and cutting sample analyses is a valuable tool for characterization of petrophysical and mineralogical changes associated to structures of the Nankai accretionary prism (Jurado and Schleicher, 2015 and work in progress). This is critical for our understanding clay-fluid interaction and mechanical properties during fault displacements and seismogenesis.

CONCLUSIONS

LWD oriented images and geophysical logs. LWD image interpretation results indicate strong tectonic deformation of the accretionary prism sediments. Deformation features are characterized by steep bedding, and a large number of fractures and faults.

LWD oriented images show the structures and allows to define the 3D structure at Site C0002 drillsites within the Nankai accretionary prism. Integration of image interpretation with geophysical logs and cutting sample analyses is a basis to advance on the characterization of active structures and the relationship between clay mineralogy and fluid flow at this Nankai location.

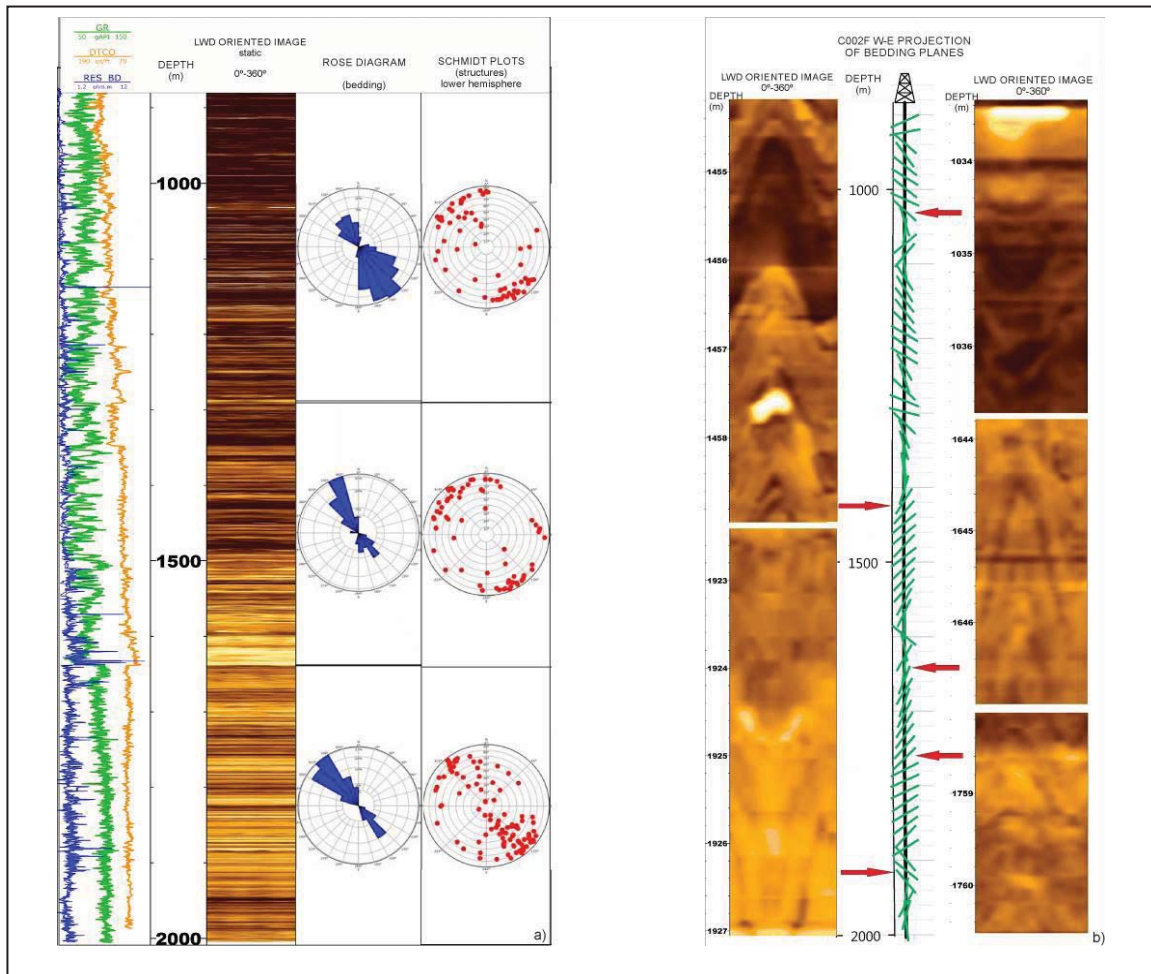


FIGURE 2. Hole C0002F log and borehole resistivity LWD oriented images. A) Gamma ray, sonic slowness, deep button resistivity on the left track, LWD 0°-360° resistivity oriented image, bedding dips interval rose diagrams and Schmidt lower hemisphere projection of interpreted fractures and faults. b) On the middle track 270°-90° section displaying bedding dips projection. On the left and right track of borehole images displaying folded beds and steep bedding that define the structure within the accretionary prism section.

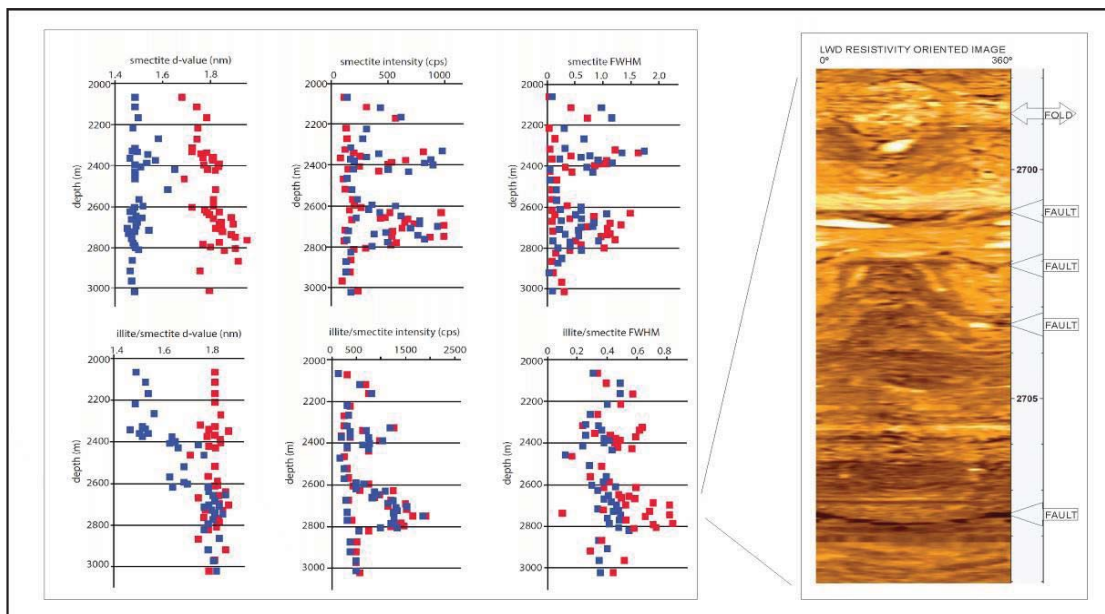


FIGURE 3. Hole C0002P cutting clay mineralogy analyses indicate changes at fault zones defined on borehole resistivity LWD oriented images.

Main clay minerals are smectite and illite. We observe a correlation between tectonic deformation as defined by bedding dips and clay mineralogy changes.

Other questions are being addressed in the frame of ongoing research on IODP Expedition 348 related to: increased water layer capacity in fractured zones, increased smectite in fracture zones, increase of smectite at depth, role of structures and dips as major control for sealing conduits and or fluid flow.

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