IODP Nankai Trough Seismogenic Zone Experiment Stage 1 Expedition 316 "Shallow Megasplay and Frontal Thrusts" on the *Chikyu*

The D/V *Chikyu* was delivered in July 2005. The ship is much larger than the *JOIDES Resolution* and has riser drilling capacity. It cost 60 billion yen (approximately $Aus630 million in late 2007 values). The first role of the *Chikyu* in IODP has been Stage 1 of the Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE). Stage 1 involved three expeditions off the Kii Peninsula (southwest Honshu) in the Nankai Trough: Expedition 314, which completed logging-while-drilling at five sites, Expedition 315, which cored at two sites, one in the Kumano Basin and another on the upper trench slope, and Expedition 316, which undertook coring at another two sites on the upper trench slope and at two sites at the frontal thrust at the base of the Nankai Trough accretionary prism. In Stages 2 and 3 in 2008-2009 the *Chikyu* will undertake riser drilling at several sites including a planned site with a target depth of 6000 mbsf in the forearc. The plan is to reach the seismogenic zone of the main subduction zone fault of the Nankai Trough. The drilling sites are located in an asperity along the subduction zone fault (i.e. a sticking zone along the fault). NanTroSEIZE is all about understanding the origin of subduction zone earthquakes and related tsunami. This is very pertinent to Japan but, as shown by the 2004 Boxing Day tsunami that killed over a quarter of a million people in eleven countries, is of major international significance and interest.

In late November 2007 an informal invitation was issued to AusIODP from the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) for an Australian scientist to participate in Expedition 316. This was in response to Australia's successful bid for funding to join IODP that was planned to begin from January 2008. I had participated as a sedimentologist on Leg 190 Nankai Trough of the Ocean Drilling Program. After thinking about this invitation for a couple of days I rang Neville Exon of AusIODP to sound him out and before much longer I found myself in a rush to complete the required medical examinations and book an airplane ticket. Packing was not so difficult as scientists were to be flown out to the *Chikyu* by helicopter from the helicopter base at Minami-Ise on the eastern Kii Peninsula (over 300 km west-southwest of Tokyo) and we were allowed to take on no more than 10 kilograms of luggage on the helicopter (although extra luggage could be sent on the supply boat).

The helicopter trip also meant that it was necessary to undertake Helicopter Underwater Escape Training (HUET). HUET was a day long course conducted at the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) facilities near Yokohama and involved a lecture and practical component that prepared one for the unfortunate circumstance where the helicopter has to ditch in the sea requiring escape from an overturned inundated helicopter. HUET proved to be a good bonding experience for the 12 members of the Science Party that attended my particular training session. The next day after HUET we travelled by the Shinkansen (bullet train) from Yokohama to Nagoya (317 km in 1 hour 20 minutes) and took a slower train from Nagoya to Ugata. The next day (19th December 2007) we were flown out to the Chikyu in three separate groups. Fortunately the helicopter never had to ditch at any time during the three expeditions of Stage 1 of NanTroSEIZE.

The view of the *Chikyu* from the air was truly impressive. It is a very large ship with the world's tallest drilling derrick (on both sea and land). Once on the ship you are first given induction with OH&S training. Each person on the ship has their own cabin with adjoining bathroom (shower, vacuum toilet, and hand basin). This made for a very comfortable stay on

the *Chikyu*. Laboratories are spacious and very well equipped. One of the more useful devices that were new to me in an ocean drilling context was an X-ray Computed Tomography (X-CT) scanner; these are widely used in medical imaging and are very useful for examining cores prior to splitting. On Expedition 316 the X-CT scans were very valuable as a large number of whole rounds were collected and the X-CT scans provided a way of determining whether valuable data was being lost in a whole round sample. X-CT scans were also very useful for distinguishing drilling disturbance from natural features in the cores such as sedimentary and fault breccias.

As is typical of all IODP expeditions a vast amount of data was collected and it was difficult to keep abreast of all developments. The success of these ventures depends on the cohesion of the Science Party and how well they are able to interact with technicians, drillers and others on the ship. I felt privileged to be on Expedition 316. The Expedition was very ably led by Co-Chief Scientists Gaku Kimura and Liz Screaton with very strong support from the Expedition Project Manager Daniel Curewitz. The Science Party was able to get on well with each other and interacted very professionally with other people working on the ship. HUET may well have been very useful as a bonding exercise in addition to preparing one for any mishap with the helicopter. A table tennis tournament also provided a much needed break from the full-on science activities. As well we were treated to delicious and very well presented meals at Christmas and New Year. Present-giving festivities occurred at Christmas with anonymous presents given to each member of the Science Party from other members. Sailing into port at the end of the expedition was also a highlight. Unfortunately I had to miss that as I developed a bad case of iritis in my left eye. I had to leave the ship on a routine helicopter flight on Friday 1st of February and return to Australia prior to the *Chikyu* entering Shingu (the home port of the *Chikyu*) on the 5th February 2008. I missed most of the last two days of drilling.

The objectives of Expedition 316 are given in detail in the scientific prospectus.
http://publications.iodp.org/scientific_prospectus/316/index.htm
The plan was to drill and collect core at one site through a shallow portion of the megasplay fault. The megasplay has been highlighted in recent publications (e.g. Greg Moore et al. Science, volume 318, p. 1128-1131, 2007) as playing a critical role in earthquakes and devasting tsunami such as the 1944 Tonankai event (moment magnitude 8.1). Additionally it was also planned to drill and collect core through the frontal thrust at the toe of the Nankai Trough accretionary prism. This is an important site and has been targeted by ODP drilling further west in the Nankai Trough in Legs 131, 190 and 196. A three-dimensional seismic survey has been conducted over the area containing all sites drilled in Stage 1 (see Moore et al. 2007, Science 318, p. 1128-1131). In addition to numerous other seismic surveys, dredge sites, deep-sea submersible dives and detailed bathymetry, the 3D seismic survey has provided a superb framework for drilling. Many excellent seismic profiles are available (see Moore et al. 2007 and the Stage 1 Expeditions 314, 315 and 316 Scientific Prospectuses and the Expedition 314 and 315 Preliminary Reports, see below). This effort in addition to previous work in the Nankai Trough, including ODP Legs 131, 190 and 196, means that the Nankai Trough is the most intensively studied subduction zone.

On Expedition 316 we drilled four sites: two associated with the megasplay fault (Sites C0004 and C0008) and two associated with the frontal thrust (Sites C0006 and C0007). The first site C0004 was drilled through the megasplay and was noteworthy for the abundance of fault breccia and wide use of the C-XT scanner to help resolve just what we were seeing in the cores. We started drilling on the 20th December and we intersected the megasplay fault on

Christmas Day with total depth of 400 m reached later that day. Site C0008 was drilled from the 27th January until late on 2nd February 2008 through a slope basin to provide information on the activity of the megasplay fault. In the lower part of hole C0008A flow-in of exotic materials into the cores was observed with the development of intense layering parallel to the core liner and disruption of sand and ash beds in the lower half or so of the cores.

Most of the Expedition was spent on the frontal thrust sites which are marked by structural complexity with abundant faults in trench-wedge turbidites and mud. Drilling at Site C0006 began on the 28th December 2007 and continued until the 13th January 2008 down to a total depth of 603 m. Many fault zones were encountered at this site along with the possibility of duplication of parts of the succession along thrust faults. Drilling began at Site C0007 on the 14th January and continued until the 24th January 2008. A total depth of 494 m was reached. At Site C0006 we failed to reach the frontal thrust but we just managed to get across it at Site C0007 although with very low recovery from the footwall. As at Site C0006, Site C0007 also had several major fault zones with possible duplication of the succession. A more detailed account of the drilling with an outline of preliminary findings is given in the press release provided after the finish of Exp 316. See
http://www.jamstec.go.jp/e/about/press_release/20080205/

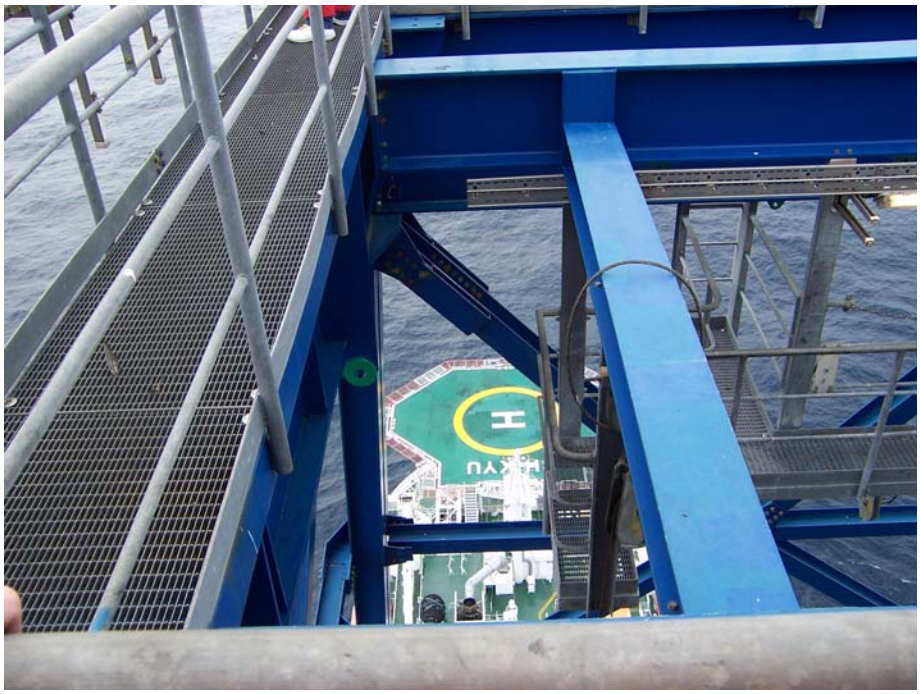
The Preliminary Reports for Expeditions 314, 315 and 316 are available on the IODP web site:
http://www.iodp.org/scientific-publications/
http://publications.iodp.org/preliminary_report/316/index.html

Expedition 316 was a great experience for me. I cannot think of anything in the earth sciences that compares with the thrill of seeing new deep-sea cores. Expedition 316 restored my faith in core as it is clear that sampling is required to enable a fuller understanding of what is happening in the subsurface. At Sites C0004 and C0006 we had access to all the logging results from Expedition 314; as valuable as those results are, a much clearer picture emerges with the collection of cores. Much post-cruise data-collection, re-analysis of results and hard thinking are required to make full use of the drilling from NanTroSEIZE Stage 1. I look forward greatly to this and encourage Australian and New Zealand scientists to become involved in Stages 2 and 3 of NanTroSEIZE.

Chris Fergusson and the Expedition 316 Scientists

Several photographs taken on Expedition 316 are included below. Other photographs from Expedition 316 are available at:
http://www.jamstec.go.jp/chikyu/eng/Expedition/NantroSEIZE/exp316_pg.html

Christmas Day 2007 on the *Chikyu* with Co-Chief Scientist Liz Screaton (left) and Sedimentologists Michi Strasser, Kitty Milliken and Uisdean Nicholson (left to right).

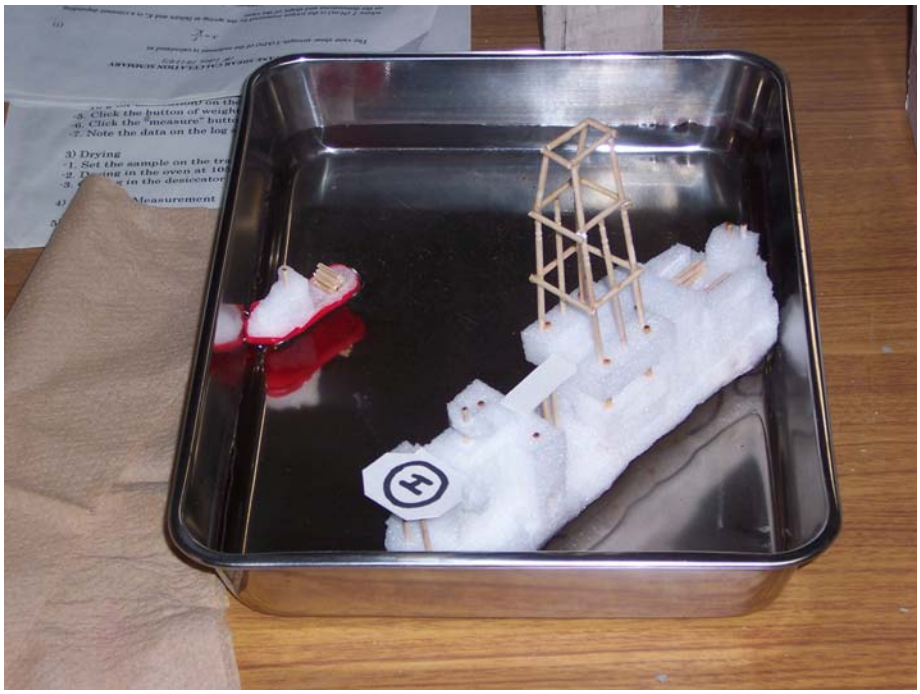


Helicopter deck on the *Chikyu* from near the top of the drilling derrick (I found it difficult to look down here).

New Year celebrations in the Core Processing Laboratory, just before midnight 31st December 2007 on the *Chikyu*. (From left to right scientists in foreground are: Matt Knuth, Daniel Curewitz, Chun-Feng Li with back to camera, France Girault and Fred Chester.)

Visual Core Description "finished" foam model car driven by "Driver Dan" Expedition 316 EPM (Daniel Curewitz). This car was placed on the core once sedimentologists had finished

their core description and alerted the technicians that the core needed to be moved to the next stage in the Core Description Laboratory.



Foam models of the *Chikyu* and the red supply boat (constructed by Matt Knuth).

Supply boat (*Kaiyu*) along side the *Chikyu*. Thanks to this boat we were kept supplied with fresh vegetables and fruit throughout the cruise.