Expedition 380 Mini-Prospectus

February 2017

NanTroSEIZE Stage 3: Frontal Thrust Long-Term Borehole Monitoring System (LTBMS)

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Summary of Planned Operations

At the time of this writing, NanTroSEIZE Stage 3 drilling is planned to extend the NanTroSEIZE Long-Term Borehole Monitoring System (LTBMS) network to the frontal thrust region of the Nankai Accretionary prism at Site C0006. Recent geological studies at Nankai (Sakaguchi et al., 2011; Yamaguchi et al., 2011) and direct observational evidence from the 2011 Tohoku earthquake (e.g., Ito et al., 2011) suggest strongly that slip to the toe region during megathrust earthquakes is much more common than formerly accepted. Additionally, VLF (very low frequency) earthquakes, tremor, and slow slip under the outer accretionary wedge have now been detected (e..g, Sugioka et al., 2012). Monitoring of this region is therefore a high priority to detect interseismic strain accumulation and release to better understand outer wedge megathrust processes.

The LTBMS sensors will include: seafloor reference and formation pressure sensors, broadband seismometer, tiltmeters, volumetric strainmeter, geophones, and accelerometers. There will be a congruent “NanTroSEIZE Workshop at Sea”, which will convene researchers aboard D/V *Chikyu* to re-examine, with the latest techniques and equipment, cores, and shipboard measurement data (including XCT scans) and logging while drilling data, all collected during NanTroSEIZE Stage 1 in 2007. The expedition will be completed in 40 days.

IODP Site C0006 is located at the toe of the accretionary prism (**Figure F1**) near the trench axis. Previous drilling here includes Integrated Ocean Drilling Program (IODP) Stage I NanTroSEIZE logging-while-drilling (LWD) to 885.5 meters below seafloor (mbsf) during Exp 314 (Expedition 314 Scientists, 2009) (**Figure F2**), and coring to 603 mbsf during Exp 316 (Expedition 316 Scientists, 2009) (**Table T1**).

Planned operations during Expedition 380 include:

- Riserless drilling to ca. 520 mbsf and setting 9-5/8-inch casing to ca. 350 mbsf;
- Running and setting the Site C0006 LTBMS;
- Conducting an on-board "NanTroSEIZE Workshop at Sea".

Further background information about the NanTroSEIZE drilling transect and the goals for the observatory network can be found in IODP Proposal 603D-Full2.

Primary plan: Site C0006 Operations

The primary drilling plan for Expedition 380 is to drill and case a new riserless hole at Site C0006 for the LTBMS installation. Previous LWD logs, coring records, and seismic images will be used to determine casing shoe depth, and identify a suitable lithological interval for setting and cementing the sensor carrier and related instruments. There are no plans for either new coring or LWD logging during this expedition.

Scientific background & Objectives

This expedition is part of the larger Nankai Trough Seismogenic Zone Experiment's (NanTroSEIZE) complex drilling program (CDP) (Tobin, et al., 2009, Tobin and Kinoshita, 2006). Specifically, IODP Expedition 380 is part of a greater effort establishing a subsea network of borehole observatories to monitor the seismogenic zone in real time via a connection to the DONET undersea cabled network. This will be the third long-term borehole monitoring system (LTBMS) installed under NanTroSEIZE; one is in Hole C0002G (Expedition 332: Kopf, et al., 2011) (shallow monitoring of the plate boundary/megasplay fault interface), and the other in Hole C0010A (Expedition 365: Kopf, et al., 2016), monitoring the shallow section of the megasplay fault just below the seafloor. Site C0006 is located at the toe of the Nankai accretionary complex, with the main frontal thrust located ca. 700 meters below sea floor. The main fault zone was identified from logging while drilling (LWD) data from IODP Exp 314 (Expedition 314 Scientists, 2009) and in core samples from IODP Exp 316 (Expedition 316 Scientists, 2009). The formation in the interval of interest for the LTBMS is composed of turbiditic sequences interbedded with hemipelagic sediments and hosting numerous small faults and fractures (**Fig F3**). An updated version of the seismic image with formation interpretation is in **Figure F4**.

The LTBMS will be deployed into a cased borehole (no screened intervals), with the main sensor carrier and strainmeter (**Fig F5**) positioned below 400 mbsf in a zone

that LWD data (**Fig F2**) indicates is relatively homogeneous. The LTBMS will be fitted with an acoustic modem for data transmission until the observatory is linked to the DONET network in a future JAMSTEC cruise.

Scientific Staffing Needs

Scientific specialties that will likely be required for the shipboard science party include borehole observatory specialists and possibly downhole logging specialists.

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Figure captions

Figure F1. Map of Site C0006 (in red), shown in relation to Sites C0002 and C0010 (outlined in red), where other NanTroSEIZE long term borehole monitoring systems are installed. The inset map shows the region in relation to Japan. The yellow arrows = computed far-field convergence vectors between Philippine Sea plate and Japan (Seno, 1993; Heki, 2007). GPS = Global Positioning Satellite.

Figure F2. Summary Logging while drilling diagram from IODP Exp 314 at Site C0006. LSF = LWD depth below seafloor. VE = vertical exaggeration. Black tadpoles = bedding, red tadpoles = fracture, tadpole line = dip direction of plane.

Figure F3. Results from coring, Site C0006 summary results. Holes C0006C–C0006F. CSF = core depth below seafloor, LWD = logging-while-drilling, WR = whole-round.

Figure F4. Interpreted seismic reflection depth section of Inline 2435 around Site C0006 and C0007, based on integrated interpretation of core and log data from the boreholes with the seismic imaging. P/P = Pleistocene-Pliocene boundary, P/M = Pliocene-Miocene boundary.

Figure F5. Diagram of the Site C0006 long term borehole monitoring system (LTBMS), annotated with depth targets for total depth, sensors, and casing.

Table captions

Table T1. Summary of lithological units, Holes C0006E and C0006F, from IODP Exp 316.

Table 1. Summary of lithological units, Holes C0006E and C0006F, from IODP 316.

Unit	Hole, core, section, interval (cm)		Depth CSF (m)		Thickness (m)	Stratigraphic age	Lithologic description	Processes of formation
	Top	Bottom	Top	Bottom				
	316-	316-						
I	C0006E-1H-1, 0	C0006E-4H-3, 20	0	27.23	27.2	Pleistocene	Nannofossil-bearing mud, interbedded sand layers, and a volcanic ash layer near the base	Hemipelagic settling, turbidites, and a volcanic ash layer
IIA	C0006E-4H-3, 20	C0006E-12H-2, 10	27.23	72.06	44.8	Pleistocene	Thick to thin sands with thin interbedded nannofossil-bearing mud layers and a volcanic ash layer	Turbidites, hemipelagic settling, and a volcanic ash layer
IIB	C0006E-12H-2, 10	C0006E-24X-1, 0	72.06	163.33	91.3	Pleistocene	Sands interbedded with nannofossil-bearing mud, rare volcanic ash layers	Turbidites, hemipelagic settling, and rare volcanic ash layers
IIC	C0006E-24X-1, 0	C0006E-48X-1, 0	163.33	391.33	228	Pleistocene	Mud with sand/silt layers and rare volcanic layers	Hemipelagic settling, thin-bedded turbidites, and rare volcanic ash falls
IID	C0006E-48X-1, 0	C0006F-7R-CC, 33.5	391.33	449.67	58.3	Pleistocene	Mud with volcanic ash layers and rare thin silt layers	Hemipelagic settling, volcanic ash layers, and rare thin-bedded turbidites
III	C0006F-7R-CC, 33.5	C0006F-23R-CC, 21	449.67	603	153.3	Pleistocene to Miocene	Mud with tuff layers	Hemipelagic settling and rare volcanic ash layers

Figure F1

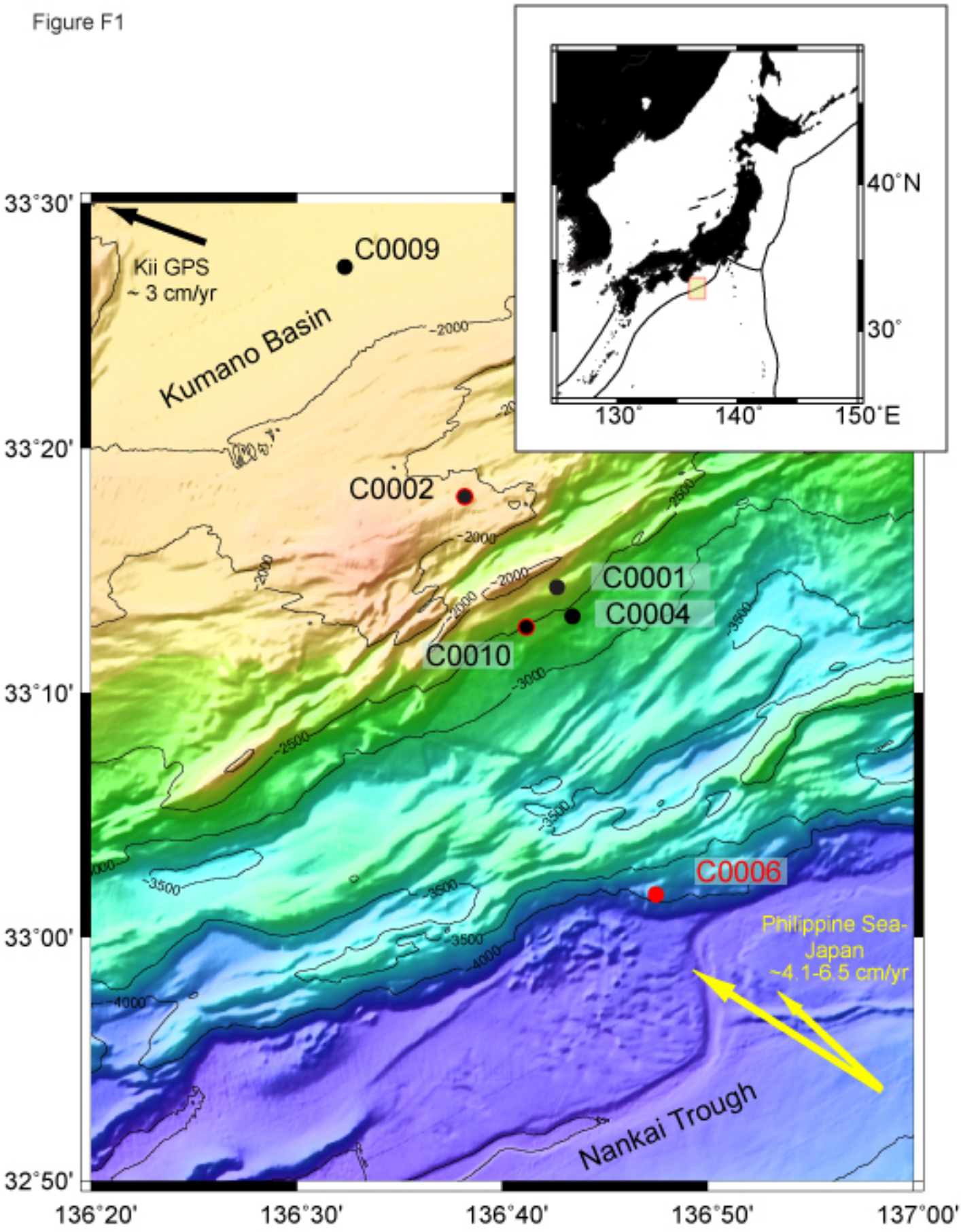
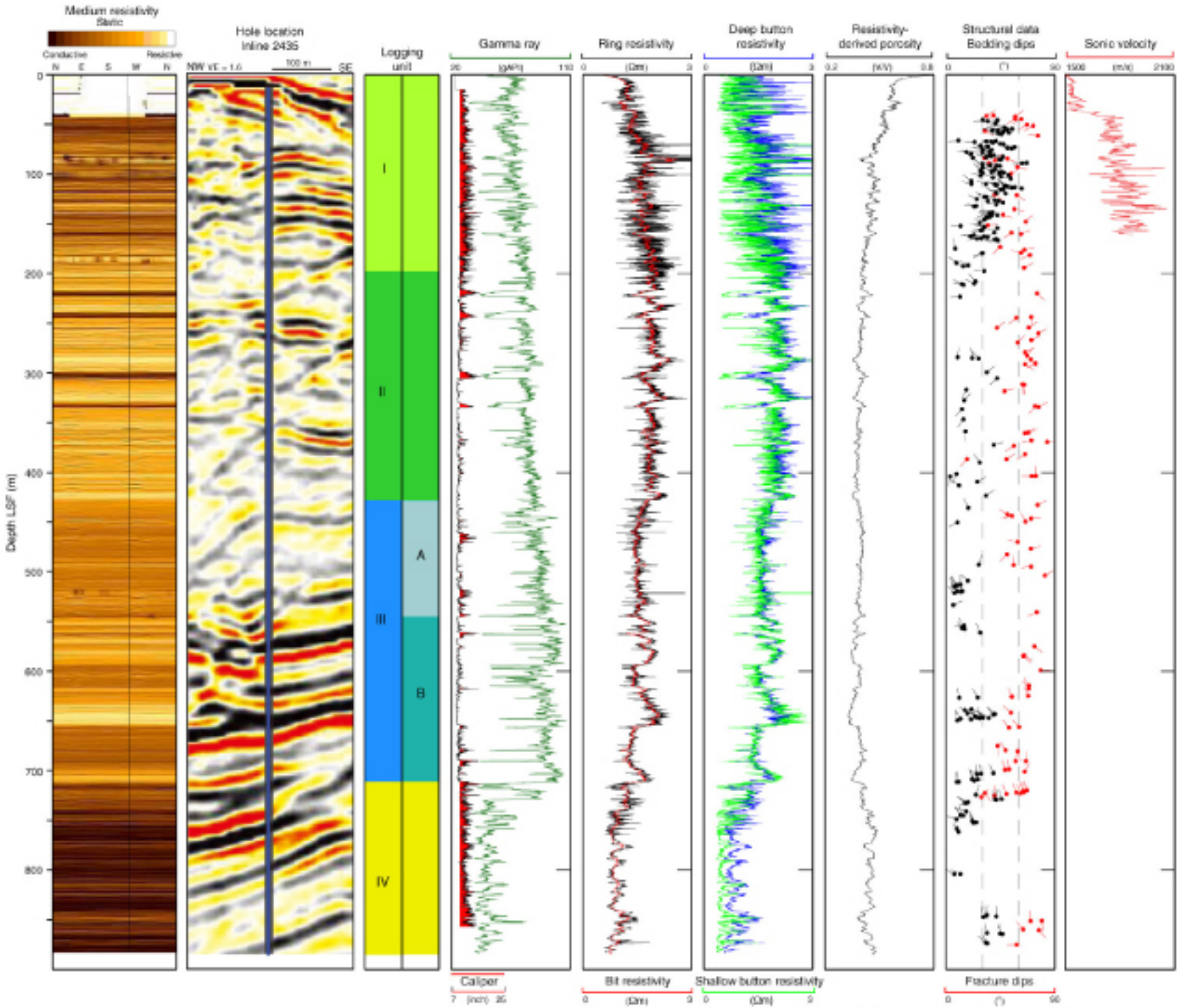
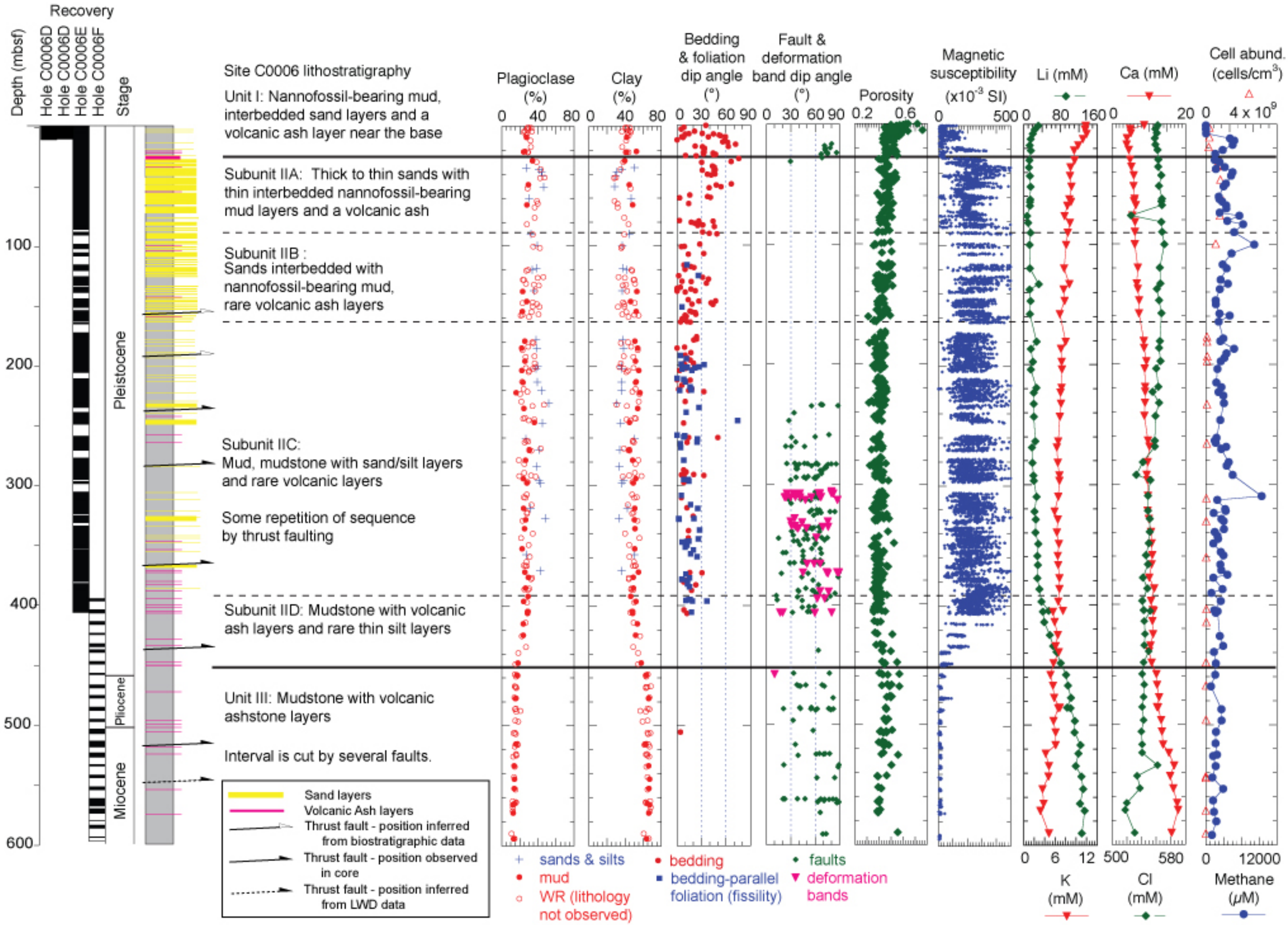

40°N
30°
130°
140°
150°E
33°30'
33°20'
33°10'
33°00'
32°50'
136°20'
136°30'
136°40'
136°50'
137°00'
Kii GPS
~ 3 cm/yr
C0009
Kumano Basin
C0002
C0001
C0004
C0010
C0006
Philippine Sea-
Japan
~4.1-6.5 cm/yr
Nankai Trough
-2000
-2500
-3000
-3500
-4000

Figure F2



From IODP Exp 314 Proceedings, Site C0006 Figure F1

Figure F3



From IODP Exp 316 Proceedings, Figure F6

Figure F4

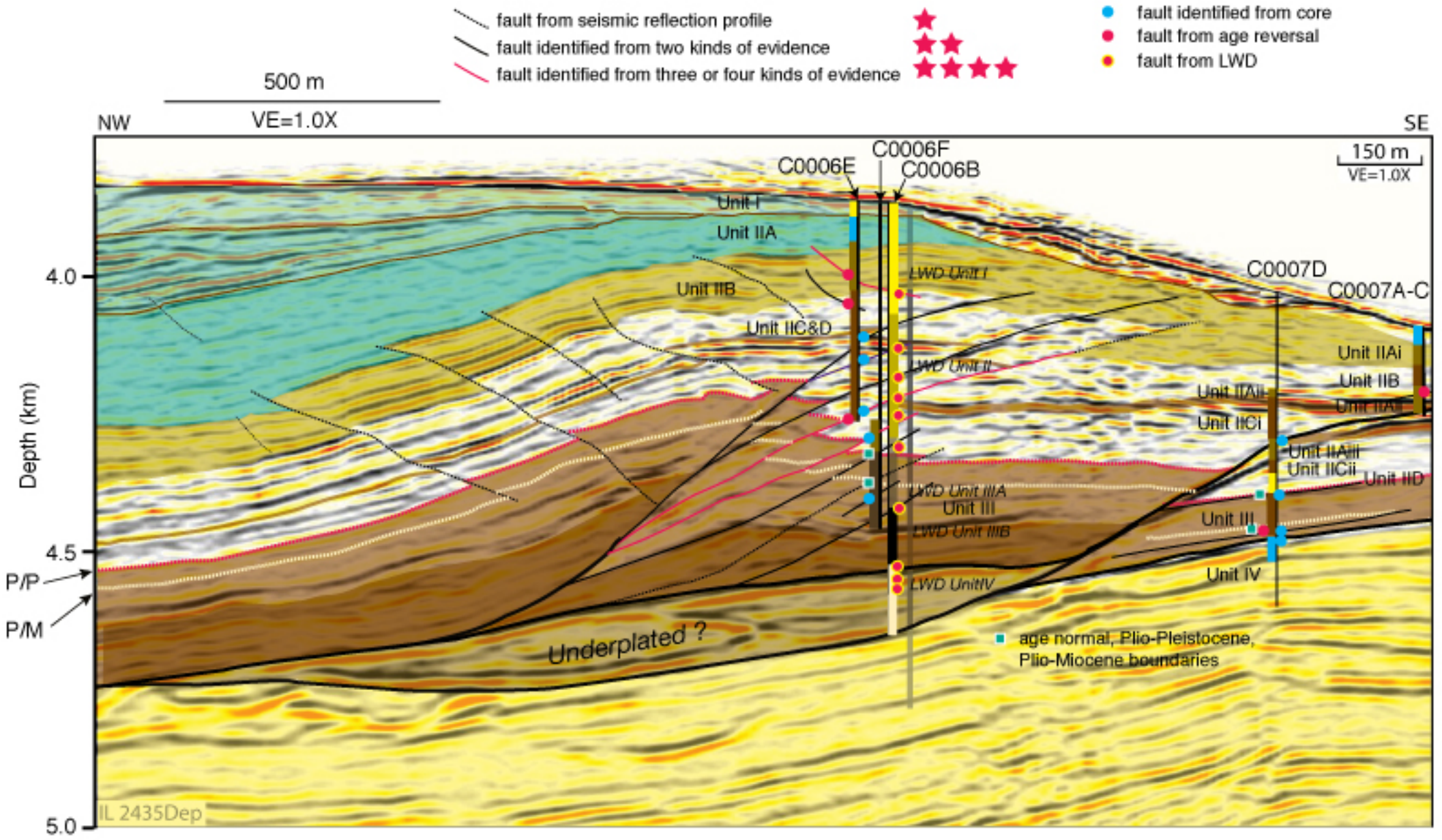
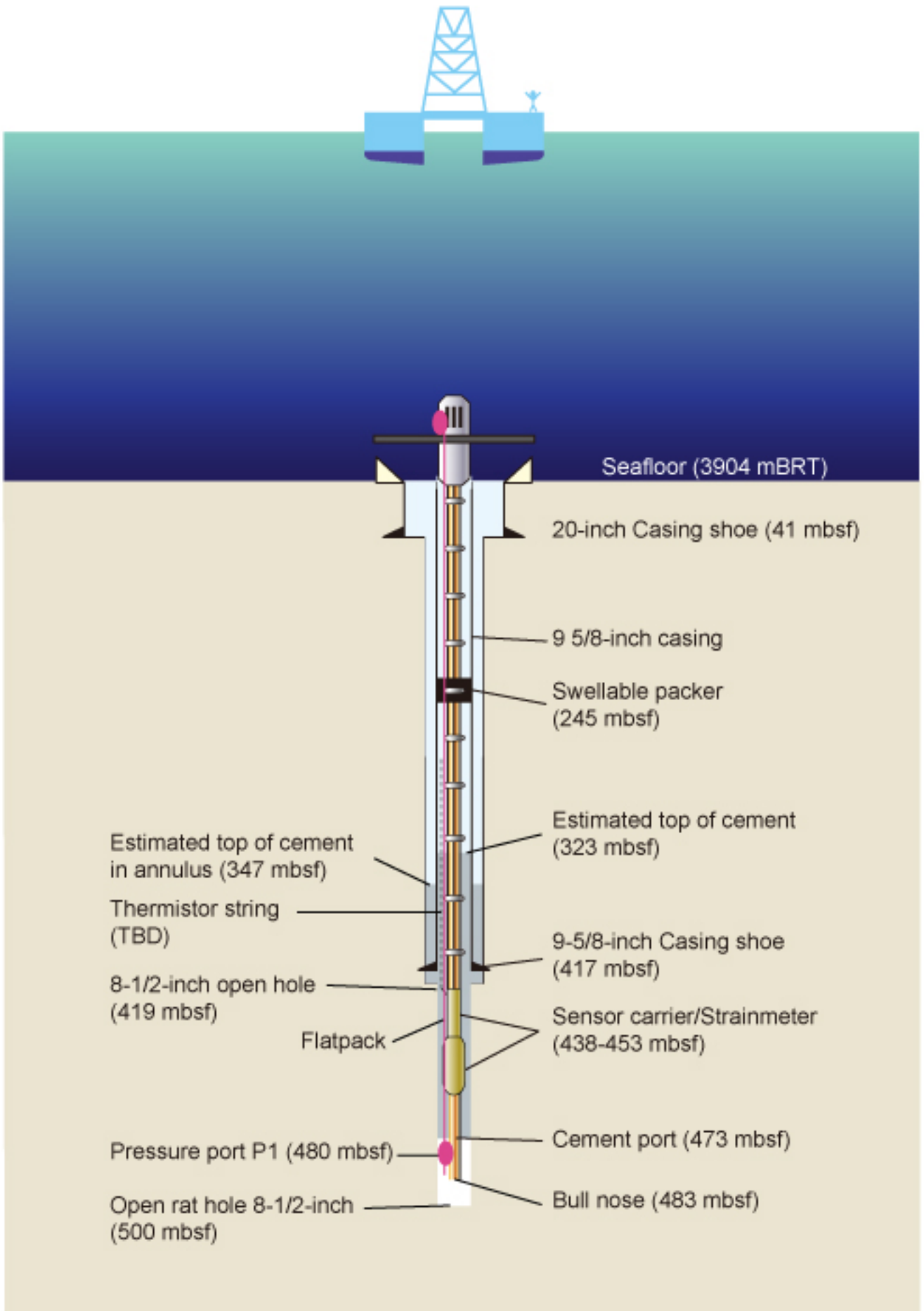

fault from seismic reflection profile
fault identified from two kinds of evidence
fault identified from three or four kinds of evidence
fault identified from core
fault from age reversal
fault from LWD
500 m
VE=1.0X
NW
SE
150 m
VE=1.0X
C0006E
C0006F
C0006B
C0007D
C0007A-C
Unit I
Unit IIA
Unit IIB
Unit IIC&D
LWD Unit I
LWD Unit II
Unit IIAi
Unit IIAii
Unit IIAiii
Unit IICi
Unit IICii
Unit IID
LWD Unit IIIA
Unit III
LWD Unit IIIB
Unit IV
LWD UnitIV
Underplated ?
age normal, Plio-Pleistocene, Plio-Miocene boundaries
Depth (km)
4.0
4.5
5.0
P/P
P/M
IL 2435Dep

Figure F5


Seafloor (3904 mBRT)
20-inch Casing shoe (41 mbsf)
9 5/8-inch casing
Swellable packer
(245 mbsf)
Estimated top of cement
(323 mbsf)
Estimated top of cement
in annulus (347 mbsf)
Thermistor string
(TBD)
9-5/8-inch Casing shoe
(417 mbsf)
8-1/2-inch open hole
(419 mbsf)
Sensor carrier/Strainmeter
(438-453 mbsf)
Flatpack
Cement port (473 mbsf)
Pressure port P1 (480 mbsf)
Bull nose (483 mbsf)
Open rat hole 8-1/2-inch
(500 mbsf)