Testing Hypotheses for Lithosphere Thinning During Continental Breakup: Drilling at the South China Sea Rifted Margin


Keywords
Continental Breakup, Serpentinization, COT, Rifting

Abstract

This CPP addresses the mechanisms of lithosphere extension during continental breakup. State-of-the-art, deep reflection seismic data show that the northern South China Sea (SCS) margin offers excellent drilling opportunities that can address the process of plate rupture at a non-volcanic rifted margin. The SCS margin shows similarities to the hyper-extended Iberia-Newfoundland margins, possibly including exhumed and serpentinized mantle within the Continent-Ocean-Transition (COT). However, recent modeling studies suggest that mechanisms of plate weakening other than serpentinization of the sub-continental lithospheric mantle exists. Two competing models for plate rupture (in the absence of excessively hot asthenospheric mantle) have widely different predictions for: (1) Crustal structure across the COT; (2) the time lag between breakup and formation of igneous ocean crust; (3) the rates of extension; and (4) subsidence and thermal history. The drilling proposed will be able to firmly discriminate between these models. We propose four drill holes across a 150–200 km wide zone of highly extended seaward-thinning crust with a well-imaged COT zone. Three 1423-1652 m deep holes will determine the nature of critical crustal entities within the COT, and constrain post-breakup crustal subsidence. These three holes will also help constrain how soon after breakup did igneous crust start to form. A fourth 1102 m deep hole on the continental margin landward of the COT will constrain the timing of rifting, rate of extension, and crustal subsidence. If serpentinized mantle is found within the COT, this will lend support to the notion that the Iberia-type margin is not unique, and hence, that weakening of the lithosphere by introducing water into the mantle may be a common process during continental breakup. If serpentine is not found, and alternatively, scientific drilling results for the first time are gained in support of an alternative model, this would be an equally important accomplishment. Constraints on SCS formation and stratigraphy, including industry drilling, ODP Leg 184 and IODP Expedition 349 drilling, the young (Paleogene) rifting of the margin, and absence of excessively thick post-rift sediments, allow us to effectively address these key topics by JOIDES Resolution drilling within a well-constrained setting. Initial spreading rate of ~ 2 cm/yr half-rate reduces the potential complexity of magma starved, slow-spread crust forming after breakup. The proposed drilling requires ~120 days of operations.
Scientific Objectives

1. Determine the nature of the basement within critical crustal units across the Continent-Ocean-Transition (COT) of the South China Sea rifted margin in order to discriminate between different competing models of breakup at non-volcanic rifted margins. Specifically, to determine if the sub-continental lithospheric mantle was exhumed during plate rupture.

2. To examine the scale of time-lag between plate rupture and asthenospheric upwelling that allowed decompression melting to generate igneous ocean crust.

3. To address the kinematics of breakup in terms of rate of extension and vertical crustal movements.

4. To improve the understanding of the Cenozoic regional tectonic and environmental development of the Southeast Asia margin through new as well as existing ODP/IODP sediment records from the South China Sea basin.

Non-standard measurements technology needed to achieve the proposed scientific objectives.

Proposed Sites

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Position (Lat, Lon)</th>
<th>Water Depth (m)</th>
<th>Penetration (m)</th>
<th>Brief Site-specific Objectives</th>
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<tr>
<td>SCSII-9B</td>
<td>18.14383, 116.31410</td>
<td>3880</td>
<td>Sed 1569, Bsm 100, Total 1669</td>
<td>Nature of oceanic crust: Was a robust mantle-melting regime established shortly after breakup or not? High priority for objectives 2,1.</td>
</tr>
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</table>
### Proponent list:

<table>
<thead>
<tr>
<th>First name</th>
<th>Last name</th>
<th>Affiliation</th>
<th>Country</th>
<th>Expertise</th>
<th>Role</th>
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<tr>
<td>Zhen</td>
<td>Sun</td>
<td>South China Sea Institute of Oceanology</td>
<td>China</td>
<td>Marine geology (also data lead)</td>
<td>Lead Proponent</td>
</tr>
<tr>
<td>Hans Christian</td>
<td>Larsen</td>
<td>Visiting scholar at Tongji University</td>
<td>China</td>
<td>Marine geophysics, tectonics</td>
<td>Lead Proponent</td>
</tr>
<tr>
<td>Chun-Feng</td>
<td>Li</td>
<td>Tongji University</td>
<td>China</td>
<td>Geophysics, tectonics</td>
<td>Lead Proponent</td>
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<tr>
<td>Jian</td>
<td>Lin</td>
<td>Woods Hole Oceanographic Institution</td>
<td>United States of America</td>
<td>Marine geophysics</td>
<td>Lead Proponent</td>
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<tr>
<td>Pinxian</td>
<td>Wang</td>
<td>Tongji University</td>
<td>China</td>
<td>Paleoceanography and regional geology</td>
<td>Lead Proponent</td>
</tr>
<tr>
<td>Wei-Wei</td>
<td>Ding</td>
<td>The Second Institute of Oceanography of the State Oceanic Administration</td>
<td>China</td>
<td>Marine geology</td>
<td>Other Proponent</td>
</tr>
<tr>
<td>Nick</td>
<td>Hayman</td>
<td>Institute for Geophysics, University of Texas at Austin</td>
<td>United States of America</td>
<td>Marine geology</td>
<td>Other Proponent</td>
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<tr>
<td>Shu-Kun</td>
<td>Hsu</td>
<td>National Central University</td>
<td>China</td>
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<td>Other Proponent</td>
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<tr>
<td>Chi-Yue</td>
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<td>National Cheng Kung University</td>
<td>China</td>
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<td>Other Proponent</td>
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<tr>
<td>Xiao-Long</td>
<td>Huang</td>
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<td>Petrology and Geochemistry</td>
<td>Other Proponent</td>
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<tr>
<td>Chao</td>
<td>Lei</td>
<td>China University of Geosciences (Wuhan); University of California, Davis</td>
<td>China</td>
<td>Marine and petroleum geology</td>
<td>Data Lead</td>
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<tr>
<td>Charles E.</td>
<td>Lesher</td>
<td>University of California, Davis</td>
<td>United States of America</td>
<td>Petrology, geochemistry</td>
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<td>United Kingdom</td>
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<td>Xiong</td>
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<td>Joann</td>
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<td>Marine geophysics</td>
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<td>Xin</td>
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<td>Xiaodong</td>
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<td>Paleomagnetics</td>
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<td>Harm</td>
<td>Van Avendonk</td>
<td>Institute for Geophysics, University of Texas at Austin</td>
<td>United States of America</td>
<td>Marine geophysics</td>
<td>Other Proponent</td>
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<td>Shiguo</td>
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<td>Geochemistry</td>
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<tr>
<td>Name</td>
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<td>Sequence stratigraphy, marine geology</td>
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<tr>
<td>Yi-Ching</td>
<td>Yeh</td>
<td>Taiwan Ocean Research Institute</td>
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<td>Marine geophysics</td>
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<td>Xiangtao</td>
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<td>Di</td>
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<td>South China Sea Institute of Oceanology</td>
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</table>
Addendum 2

Proposal 878: Testing Hypotheses for Lithosphere Thinning During Continental Breakup: Drilling at the South China Sea Rifted Margin

The purpose of this addendum is to inform the IODP Science Evaluation Panel (SEP) and all other relevant IODP entities that we propose to slightly adjust the location of one of the 4 proposed main drill sites in Proposal 878. The location of all other proposed main and alternate drilling sites remains unchanged. The drilling objectives of the proposal also remain unchanged.

Following the SEP review comments (June 2015) we have carefully examined all proposed drill site locations in preparations for the supplementary site survey planned for late March 2015. This survey will provide industry-quality MCS data across (cross-lines) all proposed sites within Proposal 878 prior to the JR Facility Board meeting of May 2015. Except for Site SCSII-9A, we found no reason to adjust site locations. However, in order to further optimize the chances of achieving the key drilling objective (nature of basement) of site SCSII-9A (18.14950°N, 116.35998°E), we propose to relocate it (5250m) from seismic line 08ec2696 to a new site named SCSII-9B (18.14383°N, 116.31410°E) on seismic line 08ec1555 (Figs. 1 and 2). The two sites are on the same basement structure, and with entirely similar objective as Site 9A. The original site SCSII-9A is at CDP number 9742, while the new site SCSII-9B is at CDP number 8902 (Figs. 1 and 2). The seismic reflection pattern around basement level at the relocated site (SCSII-9B) is somewhat simpler and cleaner compared to Site 9A, and most important of all avoids sitting directly on a basement fault. This will minimize the risk of potential complexities, and will therefore optimize the chances of seismic-core logging integration. Water depth at Site 9B is 10m shallower, but drilling penetration below seafloor increase about 17m than Site 9A (i.e., almost identical operations time). All the other sites of the original CPP878-Full are still active.
Figure 1. Seismic profiles for the former site 9A (black vertical line, at CDP 9742 on 15ecLW5 and CDP 4700 on 08ec2696) and new site location 9B (green vertical line, at CDP 8902 on 15ecLW5 and CDP 4134 on 08ec1555). The somewhat clearer and simpler basement reflection features of the new site SCSII-9B should minimize the risk of a complex transition into basement by avoiding a basement fault, and improve the chances of seismic-core-log integration.
Figure 2. Map view for site locations. We propose to slightly adjust the location of the original site SCSII-9A (white star) to a new location at SCSII-9B (Red star).
Curriculum Vitae for Zhen Sun

Professor / Research Scientist
CAS Key Lab of Marginal Sea Geology
South China Sea Institute of Oceanology, Chinese Academy of Sciences,
164 Xingangxi Road, Guangzhou 510301, China

Phone: 86-20-89023147 (office); 86-13544361886 (cell phone)
Email: zhensun@scsio.ac.cn

Education:
Sep. 1990-Jul. 1997, BS and MS, Department of Earth Sciences, Nanjing University, Nanjing, 210093, China
Sep. 1997-Jul. 2000, PhD, Department of Earth Exploration and Information Technology, Faculty of Earth Resources, China University of Geosciences, Wuhan, 430074 China

Working Experience:
Dec. 2001- Jan. 2009, Associate Research Scientist/ Associate Professor, South China Sea Institute of Oceanology, Chinese Academy of Sciences.
Nov. 2004- Feb. 2005, Visiting scientist in Tectonic Special Research Center of University of Western Australia.
Sep. 2009 – Now, Senior Research Scientist/Professor of South China Sea Institute of Oceanology, Chinese Academy of Sciences.
Sep. 2011-Now, Vice board chairman of Guangdong Petroleum Society
May 2013-Now, Committee board of Guangdong Geological Association
Mar. 2013-Now, Editorial board of Marine Geophysical Research
Jun. 2013-Now, Committee Board of Guangdong Geological Society

Research Interests:
(1) The structures and the corresponding sedimentation process in deep water basins;
(2) The structures of continental transition zone and the controlling dynamics for continental breakup;
(3) The dynamics for continental margin transition from subduction to passive continental margin extension;
(4) The fault orientations along slow and ultra-slow spreading ridge and its dynamics.

Graduate Students and Post-Docs advised:

Recent Publications (*means corresponding author):
(1) Zhen Sun, Ziying Xu*, Xiong Pang, Chengzhi Yan, Yuanping Li, Zhangwen Wang, Cuimei Zhang. The mechanism of post-rift fault activities in Baiyun Sag, Pearl River Mouth basin. Journal of Asian


Curriculum Vitae for Hans Christian Larsen

Education:
1977: University of Copenhagen Scientific degree (Magister Scientarium – PhD) in geology/geophysics.

Professional Positions held:
1994-2004: Founder and director of the Danish Lithosphere Centre (DLC)
2013--2014: Visiting Professor, Key State Laboratory of Marine Geology, Tongji University, Shanghai, China

Other leadership experience relevant to Scientific Ocean Drilling
Chief or Co-chief scientists on numerous expeditions including ODP Legs 152 & 163.
Co-Chair of the international CONCORD meeting and proposal task force, Tokyo, 1997. One of 7 members of the IODP Planning Subcommittee (IPSC, 1999-2001) that prepared for the Integrated Ocean Drilling Program and its Initial Science Plan.

Major grants:
Principal proponent (1992) to form a new centre of excellence in Earth sciences, the Danish Lithosphere Centre (DLC). Grant approximately 25 million US$ over ten years.
Principal or co-proponent on several joint proposals (DLC, US NSF and NSERC for rifted margins studies (total of ~ 1.5 million USD)

Awards: Danish National Geology Price (2002)


Select Publications (since 1994):


**Chun-Feng Li**  
Tel: (86)-21-6598-8582  
E-mail: cfl@tongji.edu.cn  
http://mgg.tongji.edu.cn/space/cfl/  

School of Ocean and Earth Sciences  
State Key Laboratory of Marine Geology  
Tongji University  
1239 Siping Road  
Shanghai 200092, China

**Principal Research Interests**  
Marine Geophysics and Geodynamics

**Working Experience**  
Professor, School of Ocean and Earth Sciences, Tongji University, China, 2008-present.  
Co-Chief Scientist, IODP Expedition 349 (South China Sea Tectonics). 2014, 1-3.  
Visiting Professor, Université des Sciences et Technologies de Lille, France, 2005, 6-7.  
Assistant/Associate Prof., School of Ocean & Earth Sciences, Tongji University, 2003-2008.  
Teaching Assistant, Department of Geosciences, University of Tulsa, USA. 1999 -2002.  
Teaching/Research Assistant, Department of Geosciences, University of Houston. 1996 -1997.  

**Professional Preparation**  
Ph.D. in Geophysics, University of Tulsa, Tulsa, OK., USA, 2002.  
M.S. in Geophysics, University of Houston, Houston, TX., USA, 1999.  
M.S. in Geology, Chinese Seismological Bureau and Academy of Sciences, China, 1995.  
B.S. in Geology, China University of Geosciences, Wuhan, China, 1992.

**Professional Service**  
- Editorial Board Member, Marine Geophysical Research. 2013-
- Vice director, State Key Laboratory of Marine Geology, 2012-
- Council Member, Chinese Geophysical Society. 2012-
- Editorial Board Member, Journal of Geodynamics. 2010-
- Member, Science Planning Committee, IODP. 2010-2011
- Member, Site Survey Panel, IODP. 2007-2010
- China representative on IGCP 559 Project “Crustal Architecture and Images”, 2008-2012
- Curator, Marine Geology Library at Tongji University. 2005- 2012

**Selected Publications**  
• C.-F. Li, Zhou Z., Li J., Chen H., Geng J., Li H., 2007, Precollisional tectonics and terrain amalgamation offshore southern Taiwan: Characterizations from reflection seismic and potential field data. *Sci. China (Ser. D)*, 50(6), 897-908.

**Patent and Book**

**Courses Taught**
Specialized English in Geology and Geophysics; Plate Tectonics
Numerical Computing; Seismic Stratigraphy; Seismic Data Processing
Continental Margin Tectonics; Nonlinear Processes in Geosciences
Geodynamics; Marine Geology – tectonics and geophysics session
Integrated Geological and Geophysical Interpretation

**Thesis Advisor**
Curriculum Vitae of Jian Lin

JIAN LIN
Senior Scientist, Henry B. Bigelow Chair for Excellence in Oceanography
Dept. of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA
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EDUCATION:

PROFESSIONAL APPOINTMENTS:
Senior Scientist, Woods Hole Oceanographic Institution, 2005-; Associate Scientist with tenure, 1996; Associate Scientist, 1992; Assistant Scientist, 1988.
Chair, InterRidge International Science Program and Steering Committee, 2007-09.
Chair, WHOI Summer Student/Minority Fellowship Program Committee, 2004-07.
Member, MIT/WHOI Joint Committee in Marine Geology and Geophysics, 2002-06.


FIVE OTHER SIGNIFICANT PUBLICATIONS:
SYNERGISTIC ACTIVITIES:
Advisory Board, AGU Natural Hazards Focus Group, 2010-; Advisory Committee, Key Laboratory of Marginal Sea Geology, South China Sea Institute of Oceanology, CAS, 2012-; AGU Tectonophysics Meeting Committee, Chair, 1992-93; Maurice Ewing Medal Committee, 1996-98; History of Geophysics Committee, 1999-00; AGU Index Committee, 2003-05; AGU Western Pacific Geophysics Meeting, Tectonophysics, Co-Chair, 2006.

GRADUATE STUDENTS AND POST-DOCS ADVISED:

AWARDS AND RECOGNITIONS:
Henry B. Bigelow Chair for Excellence in Oceanography, Woods Hole Oceanographic Institution, awarded 2009.
Fellow, American Association for Advancement of Science, elected 2008.
Fellow, Geological Society of America, elected 2007.
Faculty Co-Author, AGU Outstanding Student Paper Awards, w/ students Van Ark, 2003; Behn, 2000; Ito, 1995; Ruth & Paul Fye Best Student Paper Award w/ student Ito, MIT/WHOI, 1996.
Charles E. Culpeper Young Scientist Award, Culpeper Foundation and WHOI, 1989.

SEA EXPERIENCE:
Co-Chief Scientist, Geophysics, eastern flank of the Mid-Atlantic Ridge, R/V Ewing, 1996.
Co-Chief Scientist, OBS seismic refraction/MCS, Mid-Atlantic Ridge, R/V Ewing, 1996.
Logging Scientist/Geophysicist, ODP Leg 184, South China Sea, R/V JOIDES Resolution, 1999.
Co-Chief Scientist, TV grab/MAPR hydrothermal studies, Equatorial East Pacific Rise, R/V Dayang 1, 2005.
U.S. Lead PI, ABE autonomous underwater vehicle/TV grab; Southwest Indian Ridge, R/V Dayang 1, 2007.
U.S. Lead PI, ABE AUV/TV grab; Equatorial East Pacific Rise, R/V Dayang 1, 2008.
Co-Chief Scientist, EdgeTech sonar mapping of submarine seismic faults and marine archaeology, Greece, 2013.
Curriculum Vitae of Pinxian Wang

Education:
1955-1960 Moscow State University, Dept. of Geology

Professional Experience:
1972-1981 Dept. of Marine Geology, Tongji University, Shanghai.
1981-1982 Geologisch-Palaontologisches Institut, Universitat Kiel, Germany, Alexander von Humboldt Research Fellow
1986 School of Pacific Studies, Australian National University, Visiting Research Fellow
1982- Dept. of Marine Geology, Tongji University, Shanghai, Professor

Outside Professional Activities:
President, Chinese Committee on Ocean Research (1994-2002)
Vice-President, Scientific Committee on Ocean Research (SCOR), ICSU (1994-1998)
PAGES Global Monsoon Working Group (2007-)
Vice-Chairman, PAGES Scientific Steering Committee (2004-2007)
ODP-andIODP-China Scientific Committee (1998-2014)
Department of Earth Sciences, Chinese Academy of Sciences (1997-2002)

Honours
Fellow, American Association for the Advancement of Science (2006-)
Geological Society of India (2006-)
Member, Chinese Academy of Sciences (1991-)
Third World Academy of Sciences (2001-)
Milutin Milankovitch Medal, European Geoscience Union (2007)

Selected Publications:
Pinxian Wang, Qingyu Li, Jun Tian, 2014. Pleistocene paleoceanography of the South China Sea: Progress over the past 20 years. Marine Geology, 352: 381-396
Pinxian Wang and Qianyu Li (Eds.), 2009. The South China Sea—Paleoceanography and Sedimentology. Springer, 506p


Pinxian Wang W. Prell, P. Blum, et al., 2000. Proceeding, Ocean Drilling Program, Initial Reports, 184. ODP, Texas A&M, College Station, USA
Section A: Proposal Information

Title of Proposal: Testing Hypotheses for Lithosphere Thinning During Continental Breakup: Drilling at the South China Sea Rifted Margin

Date Form Submitted: 2015-03-24 21:30:42

Site Specific Objectives with Priority (Must include general objectives in proposal)

Nature of oceanic crust: Was a robust mantle-melting regime established shortly after breakup or not? High priority for objectives 2,1.

List Previous Drilling in Area: ODP Leg 184: Asian Monsoon; IODP Exp. 349: South China Sea Tectonics.

Section B: General Site Information

Site Name: SCSII-9B
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#: no
Latitude: Deg: 18.14383
Longitude: Deg: 116.31410
Coordinate System: WGS 84
Priority of Site: Primary: yes Alt: 

Area or Location: The north South China Sea basin
Jurisdiction:
Distance to Land: (km) 420
Water Depth (m): 3880
### Section C: Operational Information

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**General Lithologies:**

- Mudstone, siltstone, sandstone
- Serpentinite or Basalt

**Coring Plan:**
- APC
- XCB
- MDCB
- PCS
- RCB
- Re-entry

**Wireline Logging Plan:**

- Standard Measurements:
  - WL
  - LWD
  - Porosity
  - Density
  - Gamma Ray
  - Resistivity
  - Sonic (\(\Delta t\))
  - Formation Image (Res)
  - Check-shot (upon request)
- Special Tools:
  - Magnetic Susceptibility
  - Magnetic Field
  - Borehole Temperature
  - Nuclear Magnetic Resonance
  - Geochimical
  - Side-Wall Core Sampling
  - Formation Image (Acoustic)
  - Formation Fluid Sampling
  - Formation Temperature & Pressure
  - VSP
  - Others:

**Max. Borehole Temp.:**

<table>
<thead>
<tr>
<th></th>
<th>°C</th>
</tr>
</thead>
</table>

**Mud Logging:**

- (Riser Holes Only)

<table>
<thead>
<tr>
<th>Cutting Sampling Intervals</th>
<th>from</th>
<th>to</th>
<th>m intervals</th>
<th>from</th>
<th>to</th>
<th>m intervals</th>
</tr>
</thead>
</table>

**Estimated Days:**

- Drilling/Coring: 22.9
- Logging: 2.0
- Total On-site: (Not in Monsoon season (June to October))

**Observatory Plan:**

- Longterm Borehole Observation Plan/Re-entry Plan

**Potential Hazards/Weather:**

- Shallow Gas
- Hydrocarbon
- Shallow Water Flow
- Abnormal Pressure
- Man-made Objects (e.g., sea-floor cables, dump sites)
- H₂S
- CO₂
- Soft Seabed
- Landslide and Turbidity Current
- Currents
- Fracture Zone
- Fault
- High Dip Angle
- High Temperature
- High Pressure
- Sensitive marine habitat (e.g., reefs, vents)

**Other:**

- Preferred weather window Not in Monsoon season (June to October)
neighbored profiles collected by SCSIO and the SIO (Zhao et al., 2011; Wei et al., 2011).

CDP 4134

SCSII-9B

2015-03-24 21:30:42

OBS1993 by SCSIO and Tokyo University (Yan et al., 2001); OBS2006-3 and other neighbored profiles collected by SCSIO and the SIO (Zhao et al., 2011; Wei et al., 2011).

The data is collected and provided by GMGS.

Available at ODP Leg 184 and IODP349 sites. Also Piston cores by R/V Vema and R/V Conrad (Damuth, 1980).

No ice in this region.

Provided by CNOOC. The original navigation data for line 08ec1555 will upload in the format of linename.p190. The navigation data after stacking were listed in column 2 of relative seg-y files. The seg-y file for seismic line 15ecLW5 contains navigation information along with seismic data.

* Key to SSP Requirements
X=required; X* may be required for specific sites; Y=recommended; Y* may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>In SSDB</th>
<th>SSP Req.</th>
<th>Details of available data and data that are still to be collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a High resolution seismic reflection (primary)</td>
<td>no</td>
<td></td>
<td>Location:</td>
</tr>
<tr>
<td>1b High resolution seismic reflection (crossing)</td>
<td></td>
<td></td>
<td>Location:</td>
</tr>
<tr>
<td>2a Deep penetration seismic reflection (primary)</td>
<td>yes</td>
<td>08ec1555</td>
<td>Location: CDP 4134</td>
</tr>
<tr>
<td>2b Deep penetration seismic reflection (crossing)</td>
<td>yes</td>
<td>15ecLWS</td>
<td>Location: CDP 8902</td>
</tr>
<tr>
<td>3 Seismic Velocity</td>
<td>yes</td>
<td></td>
<td>Stacking velocity data for 08ec1555 and 15ecLW5 as well as the stacking velocity image profile for them have been uploaded to the SSDB. Sonic velocity from ODP1148.</td>
</tr>
<tr>
<td>4 Seismic Grid</td>
<td>yes</td>
<td>CNOOC 2004 and 2008 long-channel multi-channel seismic lines.</td>
<td></td>
</tr>
<tr>
<td>5a Refraction (surface)</td>
<td>no</td>
<td></td>
<td>Refraction(surface) Profiler-Sonobuoy measurements by Ludwig et al. (1979).</td>
</tr>
<tr>
<td>5b Refraction (bottom)</td>
<td>yes</td>
<td>OBS1993 by SCSIO and Tokyo University (Yan et al., 2001); OBS2006-3 and other neighbored profiles collected by SCSIO and the SIO (Zhao et al., 2011; Wei et al., 2011).</td>
<td></td>
</tr>
<tr>
<td>6 3.5 kHz</td>
<td>no</td>
<td></td>
<td>No such data presently.</td>
</tr>
<tr>
<td>7 Swath bathymetry</td>
<td>yes</td>
<td></td>
<td>The data is collected and provided by GMGS.</td>
</tr>
<tr>
<td>8a Side looking sonar (surface)</td>
<td>no</td>
<td></td>
<td>No such data in hand.</td>
</tr>
<tr>
<td>8b Side looking sonar (bottom)</td>
<td>no</td>
<td></td>
<td>No such data in hand.</td>
</tr>
<tr>
<td>9 Photography or video</td>
<td>no</td>
<td></td>
<td>No such data in hand.</td>
</tr>
<tr>
<td>10 Heat Flow</td>
<td>yes</td>
<td></td>
<td>Regional compilation by Shi et al. (2003) and Li et al. (2010). Heat flow data are also available from the nearby sites of ODP Leg 184 (Wang et al., 2000) and U1432 of IODP349 (Li and Lin et al., 2014).</td>
</tr>
<tr>
<td>11a Magnetics</td>
<td>yes</td>
<td></td>
<td>Data grids from Geological Survey of Japan and Coordinating Committee for Coastal and Offshore Geoscience Programmes in East and Southeast Asia (CCOP).</td>
</tr>
<tr>
<td>12 Sediment cores</td>
<td>no</td>
<td></td>
<td>Available at ODP Leg 184 and IODP349 sites. Also Piston cores by R/V Vema and R/V Conrad (Damuth, 1980).</td>
</tr>
<tr>
<td>13 Rock sampling</td>
<td>no</td>
<td></td>
<td>No such data in hand.</td>
</tr>
<tr>
<td>14a Water current data</td>
<td>no</td>
<td></td>
<td>No such data in hand.</td>
</tr>
<tr>
<td>14b Ice Conditions</td>
<td>no</td>
<td></td>
<td>No ice in this region.</td>
</tr>
<tr>
<td>15 OBS microseismicity</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 Navigation</td>
<td>yes</td>
<td></td>
<td>Provided by CNOOC. The original navigation data for line 08ec1555 will upload in the format of linename.p190. The navigation data after stacking were listed in column 2 of relative seg-y files. The seg-y file for seismic line 15ecLW5 contains navigation information along with seismic data.</td>
</tr>
<tr>
<td>Data Type</td>
<td>In SSDB</td>
<td>SSP Req.</td>
<td>Details of available data and data that are still to be collected</td>
</tr>
<tr>
<td>-----------</td>
<td>---------</td>
<td>----------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>17 Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


IODP Site Summary Forms:

Form 3 – Detailed Logging and Downhole Measurement Plan

<table>
<thead>
<tr>
<th>Proposal #:</th>
<th>5</th>
<th>Site #:</th>
<th>SCSII-9B</th>
<th>Date Form Submitted:</th>
<th>2015-03-24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Depth (m):</td>
<td>3880</td>
<td>Sed. Penetration (m):</td>
<td>1569</td>
<td>Basement Penetration (m):</td>
<td>100</td>
</tr>
</tbody>
</table>

Are high temperatures or other special requirements (e.g., unstable formations), anticipated for logging at this site?

Estimated total logging time for this site: 2.0

<table>
<thead>
<tr>
<th>Measurement Type</th>
<th>Scientific Objective</th>
<th>Relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check Shot Survey</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Nuclear Magnetic Resonance</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Geochemical</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Side-wall Core Sample</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Formation Fluid Sampling</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Borehole Temperature</td>
<td>To constrain the heat flow.</td>
<td>1</td>
</tr>
<tr>
<td>Magnetic Susceptibility</td>
<td>To know the magnetic properties of relative sediments and rocks</td>
<td>1</td>
</tr>
<tr>
<td>Magnetic Field</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>VSP</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Formation Image (Acoustic)</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Formation Pressure &amp; Temperature</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Other (SET, SETP, …)</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Pollution &amp; Safety Hazard</td>
<td>Comment</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>1. Summary of Operations at site.</td>
<td>RCB from 200m above basement till target depth.</td>
<td></td>
</tr>
<tr>
<td>2. All hydrocarbon occurrences based on previous DSDP/ODP/IODP drilling.</td>
<td>Sites of ODP Leg 184 and IODP Leg 349 to the north and east have no hydrocarbon occurrences of greater than background levels.</td>
<td></td>
</tr>
<tr>
<td>3. All commercial drilling in this area that produced or yielded significant hydrocarbon shows.</td>
<td>No.</td>
<td></td>
</tr>
<tr>
<td>4. Indications of gas hydrates at this location.</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>5. Are there reasons to expect hydrocarbon accumulations at this site?</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>6. What “special” precautions will be taken during drilling?</td>
<td>Continuous monitoring under IODP safety standards.</td>
<td></td>
</tr>
<tr>
<td>7. What abandonment procedures need to be followed?</td>
<td>Per IODP standard operating procedure.</td>
<td></td>
</tr>
<tr>
<td>8. Natural or manmade hazards which may effect ship’s operations.</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>9. Summary: What do you consider the major risks in drilling at this site?</td>
<td>Weather, not in Monsoon season (June to October)</td>
<td></td>
</tr>
<tr>
<td>Subbottom depth (m)</td>
<td>Key reflectors, Unconformities, faults, etc</td>
<td>Age</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>0-1269</td>
<td>Top Early Miocene</td>
<td>0-23</td>
</tr>
<tr>
<td>1269-1569</td>
<td>Top breakup unconformity (BU)</td>
<td>23-33.9</td>
</tr>
<tr>
<td>1569-1669</td>
<td>Basement</td>
<td>&gt;33.9Ma</td>
</tr>
</tbody>
</table>
Site Summary Figure

Files in SSDB
Location map
basemap.jpg
new-9B-9A-bathymetry

Seg-y data
08ec1555_cdp4900-3300.sgy
seg.dat_15ecLW5_final.pstm

Seismic profiles and their interpretation
9B-mainline.jpg
9B-crossline.jpg

Interpretation
- Cenozoic basement
- Top Eocene (about 33.9 Ma)
- Top Oligocene (about 23 Ma)
- Faults

Well Location
CDP4134 on Line 08ec1555
CDP8902 on Line 15ecLW5
Latitude: 18.14383
Longitude: 116.31410