IODP Proposal Cover Sheet

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Title:	**Opening of the South China Sea and its implications for Southeast Asian tectonics, climates, and deep mantle processes since the early Mesozoic**		
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Abstract: (*400 words or less)*

The South China Sea (SCS) and Huatung basins are situated at the junction of the Eurasian, Pacific, and Indo-Australian plates. The SCS has nearly undergone a complete Wilson cycle despite its relatively small size and short evolutionary history, and the Huatung Basin is a critical site linking some of the major western Pacific tectonic units. Due to the lack of drilling in oceanic crusts of these basins, key hypotheses are untested regarding Mesozoic pre-rifting tectonic background, Cenozoic rifting mechanisms, ages and sequences of seafloor spreading, and their climatic and deep mantle aftermaths.

Here we propose drilling at 4 sites in the SCS ocean basin focusing on Cenozoic spreading and oceanic crust evolution, and at 2 sites in the Huatung Basin targeting Mesozoic interactions among the East Asia, Tethys, and Paleo-Pacific. These sites are designed strategically to fulfill the following research objectives in 4 major themes:

(1) Mesozoic continent-ocean interactions and tectonic transitions leading to continental margin break-up and seafloor spreading;
(2) Cenozoic mechanisms, timings, sequences, and affiliations of seafloor spreading;
(3) Oceanic crustal evolution, and seawater circulations and rock-fluid reactions;
(4) Climatic and deep mantle aftermaths of the formation of western Pacific marginal seas.

The water depths at these sites range from about 3350 m to about 4750 m, and the penetrations are estimated to be from about 80 mbsf to about 900 mbsf. The total penetrating thickness in the overlying sediments is about 2990 m, and an additional 180 m penetration is required into the oceanic basements. The total on-site time (drilling and logging) is estimated to be 27.5 days, plus 3 days in transit.

Scientific Objectives: (*250 words or less*)

1. To better understand the Mesozoic interplay between the Tethys and the Paleo-Pacific and how they interacted with the East Asia, both geologically and climatically, prior to the development of the western Pacific marginal seas;
2. To test various hypotheses of the dynamic processes controlling the transitions from a Mesozoic active continental margin to a Cenozoic passive one, and from continental rifting and break-up to seafloor spreading, and constrain whether the forces driving the opening of the SCS were far-field (triggered by the tectonic extrusion of the Indochina block), near-field (due to back-arc spreading), or in-situ (magmatism driven);
3. To establish the complex opening history of different sub-basins and styles of oceanic crustal accretion of the SCS, and constrain the tectonic controls (such as spreading rate) on distinct magnetic contrasts among the three sub-basins;
4. To reveal deep mantle processes associated with tectonic extrusion, magmatism, magnetization, seawater infiltration and serpentinization;
5. To develop a complete 3D sedimentation model and link it to regional climatic processes in response to various tectonic events;
6. To integrate these results to add to our general understanding of the geodynamic interplay of mantle and lithosphere processes that lead to the development of continental margin basins in the geological record and at present.

Please describe below any non-standard measurements technology needed to achieve the proposed scientific objectives.

None

Proposed Sites:

Site Name	Position	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
SCS-2B	17° 16.170’ N 116° 48.4920’ E	3911	720	30	750	Mechanism of ridge jump, age correlation, crustal magnetization in E Sub-basin
SCS-3A	13° 56.8176’ N 116° 46.1418’ E	4206	596	30	626	Opening sequences and ages; basement mineralization and magnetization
SCS-4B	12° 55.137’ N 115° 2.8326’ E	4383	865	30	895	Opening sequences and ages; basement mineralization and magnetization
SCS-5A	13° 20.8480’ N 115° 45.7188’ E	3792	50	30	80	Seawater circulation and serpentinization; geochemistry
HTB-1A	21° 35.9308’ N 122° 54.9138’ E	3343	50	30	80	Crustal nature and affiliation of the Gagua Ridge
HTB-2A	21° 35.9581’ N 122° 46.1682’ E	4754	710	30	740	Crustal nature and affiliation of the Huatung Basin

Opening of the South China Sea and its implications for Southeast Asian tectonics, climates, and deep mantle processes since the early Mesozoic

1. Background and statement of the scientific problem

Since the early Mesozoic, the South China Sea (SCS) area has been at the center stage of many first-order tectonic and paleoclimatic events (Fig. 1). Mesozoic subduction of the Paleo-Pacific plate, a fragment of which developed roughly along the present-day northern SCS continental margin (Jahn et al., 1976; Hilde et al., 1977; Hamilton, 1979; Holloway, 1982; Taylor & Hayes, 1983; Hayes et al., 1995; Zhou & Li, 2000; Yang et al., 2003; Xiao & Zheng, 2004; Zhou et al., 2008; Li et al., 2008b), gradually dispelled the Paleo-Tethys and built a massive orogen in Southeast Asia that turned to have very pronounced effects on regional climates, magmatism, and sedimentation (Fig. 2) (Zhou & Li, 2000; Shi & Li, submitted). However, during the transition from the Early to Late Cretaceous, all supportive evidences of a subduction zone mysteriously disappeared, and regional extension started to prevail and eventually triggered the Cenozoic opening of the SCS (Shi & Li, submitted), via continental margin break-up and ultimately seafloor spreading from ~32 Ma to ~16 Ma (Taylor & Hayes, 1980, 1983; Briais et al., 1993).

In this overall evolutionary scenario (Fig. 2), key geological processes that are currently poorly understood in the SCS area are as follows.

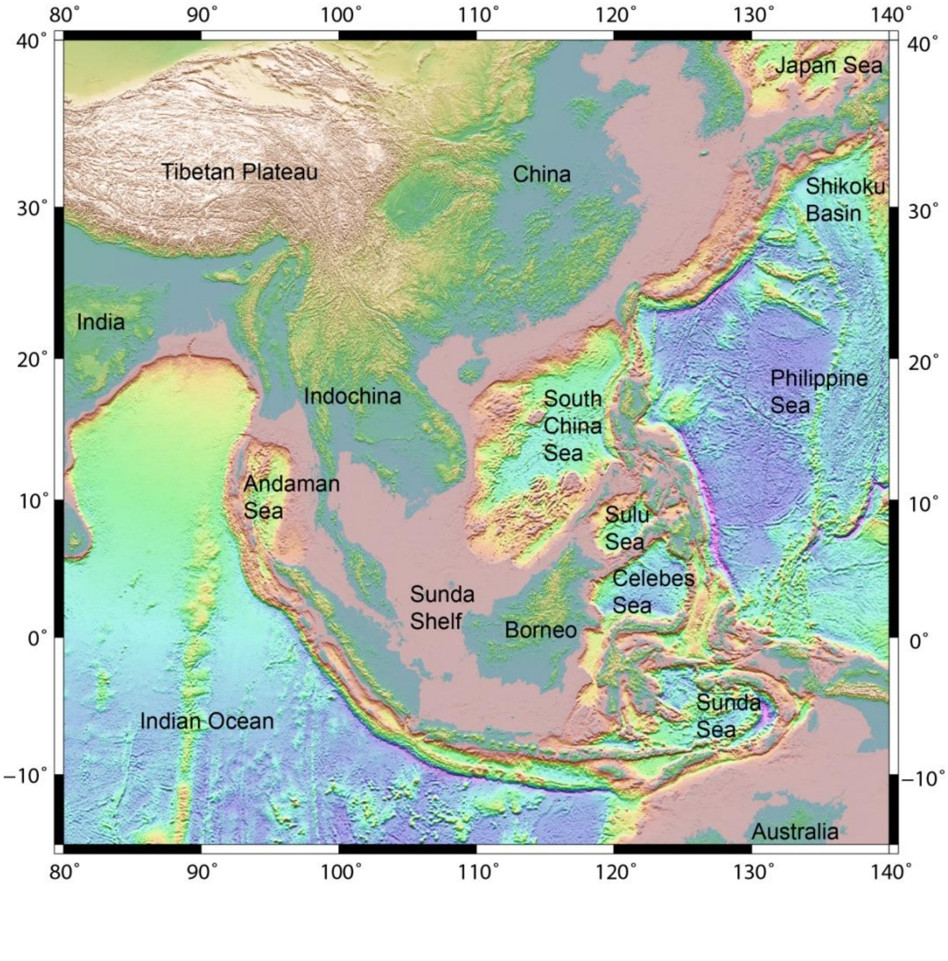


Fig. 1

Regional topography and geodynamic framework of Southeast Asia. Data based on Smith and Sandwell, 1997.

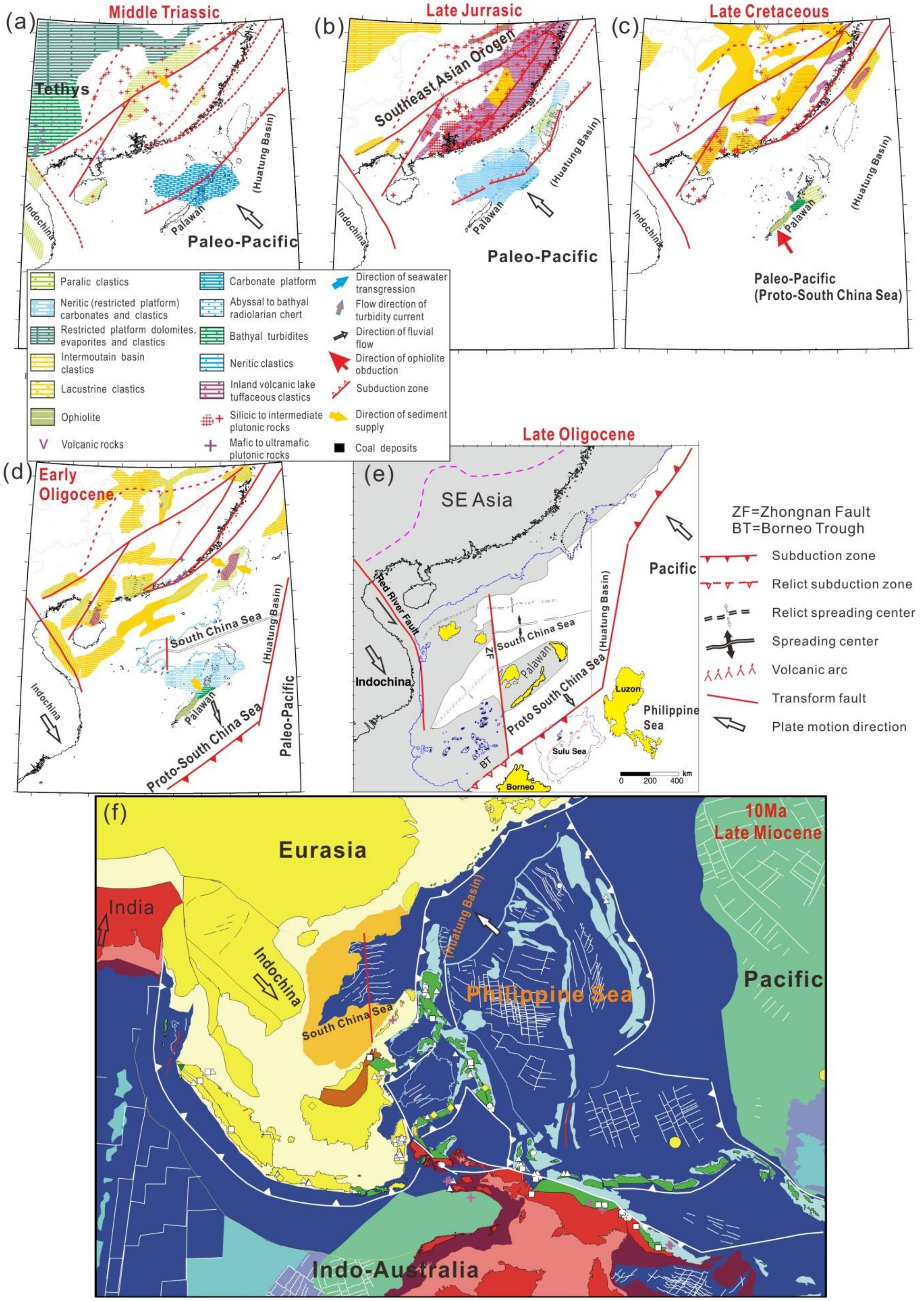


Fig. 2 Sketched evolution of the SCS area since the Early Triassic. (a), (b), and (c) shows the Mesozoic interactions among the Tethys, Paleo-Pacific, and East Asia (Shi & Li, submitted). (d) and (e) shows the hypothetical models on the opening of the SCS (Li et al., 2007b; Shi & Li, submitted). (f) Late Miocene plate reconstruction (modified after Hall, 2002). From these models it is hypothesized that the Huatung Basin is a relict of the Paleo-Pacific plate and was connected with the Proto-SCS and the northeasternmost SCS.

(1) Complicated Mesozoic interplays among the Tethys, Paleo-Pacific, and East Asia.

There are arguments that the SCS area was once situated in a transition zone between the Tethys and Paleo-Pacific (Sun et al., 1989; Liu et al., 1996; Chen et al., 1998; Zamoras & Matsuoka, 2001; Xia et al., 2004; Li, 2004; Zhou et al., 2005). Paleontological studies in the area indicate that some late Mesozoic macrofossils show closer affinity with Tethyan biota, whereas some others show characteristics more typical of the Pacific biotic province (Fontaine et al., 1983; Kudrass et al., 1986; Hutchison, 1989; Liu et al., 1996; Chen et al., 1998).

From the late Mesozoic until the end of Eocene, most of the Western Pacific marginal seas were nonexistent, and East Asia was under the direct impact of the Pacific Plate (Fig. 2). With the cessation of the Paleo-Pacific subduction and associated magmatism, and the gradual closure of the Tethys and the buildup of the Tibetan Plateau, East Asia reversed its topography from being west-tilting to east-tilting, an event exerted a profound impact on regional environments and on continent-ocean interactions (Wang, 2004). As shown by numerical modeling and geological records, the Eocene climate in the region was prevailed by a planetary wind system, and the Asian monsoon was insignificant if not absent (Chen et al., 2000; Sun & Wang, 2005)

(2) Geodynamic transition from a Mesozoic active to a Cenozoic passive continental margin and the Cenozoic opening mechanism of the SCS.

Hypotheses presented so far on the opening mechanisms differ markedly and include (1) India-Eurasia continental collision and a consequent tectonic extrusion process mainly along the Red River fault zone (Tapponnier et al., 1982; Lallemand & Jolivet, 1985; Schärer et al., 1990; Briais et al., 1993; Leloup et al., 2001; Flower et al., 2001), (2) extension related to subduction of the Pacific plate along the western Pacific margin (Taylor & Hayes, 1980; Hall, 2002) or to the subduction under Sabah/Borneo (Holloway, 1982), and (3) extension related to an upwelling mantle plume (e.g., Fan & Menzies, 1992).

The original SCS basin before subduction along the Manila Trough could be twice the size of what we see today (Sibuet et al., 2002), and it seems to be difficult to imagine that the extruding Indochina block alone could trigger the opening of a large marginal basin located primarily to the east of the extruding block. Indeed, it has been argued increasingly that only a minor amount of extension associated with the SCS spreading center was transferred to the red-river fault zone (Rangin et al., 1995; Morley, 2002; Clift et al., 2008). Regional rifting in the East Asia occurred long before the India-Eurasia collision (Fig. 2) and was associated mainly with the subduction of the Paleo-Pacific plate (Shi & Li, submitted).

Toward addressing the Mesozoic and early Cenozoic pre-rifting problems listed above, the northeasternmost part of the SCS basin and the Huatung Basin to the east of Taiwan (Fig. 3) are arguably the most promising areas. Although there are views that the northern SCS passive margin may have reached the area northeast of Taiwan about 10 Ma ago (Teng, 1990; Hall, 2002; Clift et al., 2003), Sibuet & Hsu (1997) and Sibuet et al. (2002) argued alternatively that prior to 15 Ma the Ryukyu subduction zone extended south to the northeasternmost SCS and, consequently, interpreted a sector of the northeasternmost SCS basin as comprising oceanic crust, older than that of the present-day SCS crust. Hypotheses have long been proposed regarding the existence of a proto-SCS oceanic basin (Madon et al., 1999; Haile, 1973) that began to close from ~44 Ma (e.g. Hall, 1996, 2002) in order to accommodate the opening of the SCS (Fig. 2), and are supported by the wide occurrence of Jurassic, Cretaceous and/or early Tertiary marine sediments in the present southern SCS and beyond. A large part of this proto-SCS may have been subducted into, or uplifted as part of, island arcs to the south formed in the area of Borneo/Sabah and Palawan (Hutchinson, 1996, 2004). Deschamps et al. (2000) interpreted the Huatung Basin as an Early Cretaceous oceanic block, but this interpretation is disputed (Sibuet et al., 2002). One unsolved problem is whether and how the Huatung Basin was affiliated with the southeast-verging proto-SCS (Deschamps et al., 2000; Hall, 2002; Sibuet et al., 2002), and the northwesterly subducting Paleo-Pacific plate (Fig. 2). Drilling in the Huatung Basin will reveal the nature and age of this piece of oceanic crust that will offer potentially significant information on Mesozoic evolution of the western Pacific and the connectivity between the SCS and the western part of the Philippine Sea.

(3) Climatic and deep mantle aftermaths due to the Cenozoic uplift of the Tibetan Plateau and the formation of the western Pacific marginal seas.

The India-Eurasia collision also triggered eastward lithospheric extrusion (Tapponnier et al., 1982; Briais et al., 1993; Jolivet et al., 1994; Flower et al., 2001), but the degree of mantle contamination by the extruded mantle has never been tested directly within the SCS, where the extrusion was considered to be the largest. To better examine whether and how the western Pacific marginal basins are related to the eastward mantle flow caused by the India-Eurasia collision (Flower et al., 2001), to the westward subduction of the Pacific, or the northward convergence of the Indo-Australian plate, we need to study the basement rocks of these marginal basins and find firm geochemical signatures of mantle contaminations by surrounding blocks, and this can only be achievable by deep ocean drilling. The uplift of the Tibetan Plateau redistributed regional river systems and is crucial for the establishment of the modern environmental settings in Asia, including the Asian monsoon system and formation of the boreal ice sheet (Wang, 2004). As relative small marginal basins immediately surrounded by numerous continental blocks, the SCS and the Huatung Basin are very sensitive to East Asian and western Pacific tectonic and climatic pulses and have recorded these information in the post-drifting sediments (Wang et al., 1999). However, without drilling, we remain to know little on sedimentation rate, provenance, water depths, tectonic subsidence, and facies changes within these basins, and their correlations to regional tectonic and climatic events.

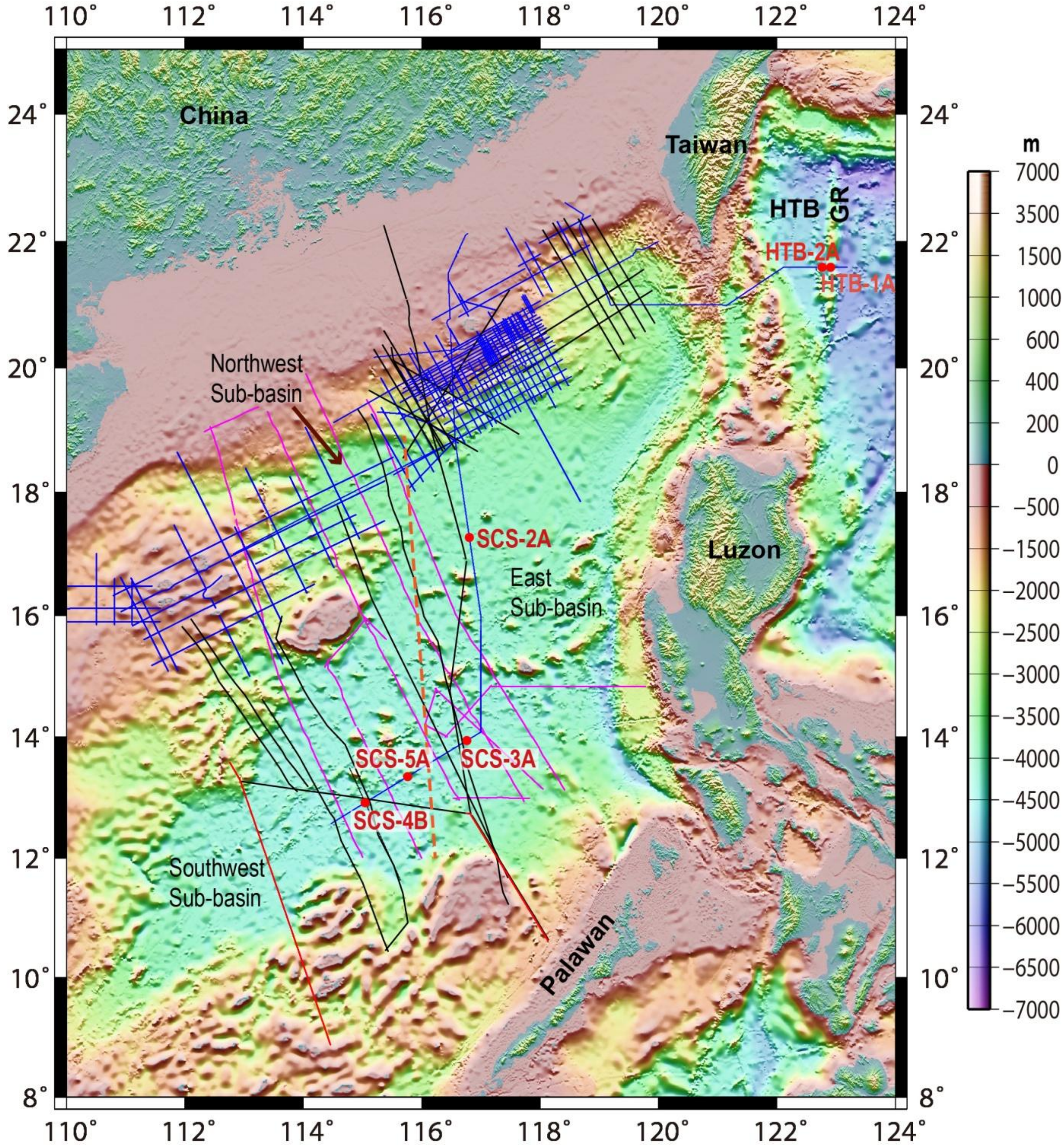


Fig. 3 Topographical and bathymetrical map of the SCS and its adjacent region. HTB = Huatung Basin; GR = Gagua Ridge. The dashed red line is the Zhongnan Fault. Red solid points are locations of the proposed drilling sites. Pink solid lines are seismic sections collected by R/V Sonne in 1987 (SO49) and in 2008 (SO197). Other solid lines are seismic data collected by Chinese research institutes and oil companies.

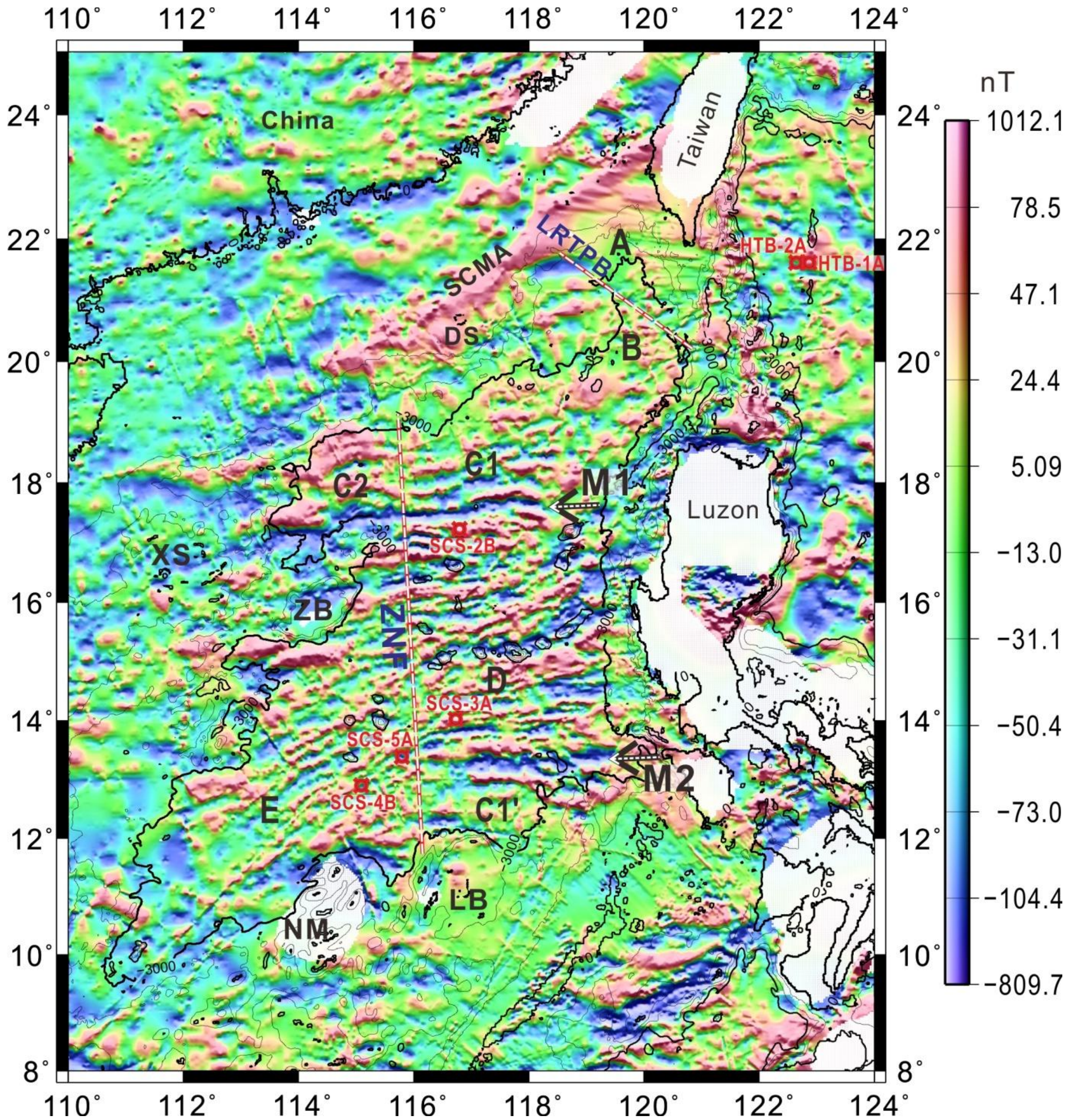


Fig. 4 Total field magnetic map showing major magnetic zones (A, B, C1, C1', C2, D, and E). M1 and M2 are two major magnetic anomalies in the East Sub-basin. ZNF = Zhongnan Fault; LRTPB = Luzon-Ryukyu Transform Plate Boundary; DS = Dongsha Rise; SCMA = offshore south China magnetic anomaly; XS = Xisha; ZB = Zhongsha (Macclesfield) Bank; LB = Liyue (Reed) Bank; NM = Nansha Massif (Dangerous Grounds). Dashed lines mark transform faults. (After Li et al., 2008a).

(4) Timings and episodes of the Cenozoic opening of the SCS.

Magnetic and seismic data suggest that the SCS Basin can be divided into five magnetic zones (Figs. 3 & 4), each with a characteristic magnetic pattern. In particular, the magnetic patterns in the Southwest Sub-basin (magnetic zone E) differ significantly from those in the East Sub-basin (magnetic zone D), not only in magnetic amplitudes, but also in orientations. These two sub-basins are sharply divided by the Zhongnan Fault (Figs. 3 & 4), which is a transform boundary (Yao, 1995; Jin et al., 2002; Li et al., 2007b, 2008a). This magnetic contrast may support either a model of episodic rifting of the SCS (Ru & Pigott 1986), or can be attributed to different crustal types with the two sub-basins evolving independently. Pautot et al. (1986) suggested that the East Sub-basin developed within an older, pre-existing oceanic crust, whereas the Southwest Sub-basin resulted from continental rifting that led to seafloor spreading. Within the East Sub-Basin, two distinct negative magnetic anomalies (M1 and M2 in Fig. 4), suspected of the same age, further divide the sub-basin into one central part with high magnetic strengths and two separated parts with slightly weaker magnetization (C1 and C1', respectively) near the two conjugate continental margins. The magnetic pattern of the Northwest Sub-basin (Figs. 3 & 4) also differs from its adjacent segment in the East Sub-basin.

There are other contrasts between the East and Southwest sub-basins in water depths, heat flow, seismicity, free-air gravity anomalies and Curie depths (Table 1). Some of the contrasts are rather perplexing; for example, the relatively older crustal ages of the Southwest Sub-basin inferred from larger water depths (Ru & Pigott, 1986; Yao et al., 1994; Li et al., 2008a) contradict with the younger ages inferred from higher heat flow and shallower Curie-point depths there (Ru & Pigott, 1986; Li et al., 2010). Recent heating from magmatic activities could have contributed to the high heat flow in the Southwest Sub-basin (Ru & Pigott, 1986; Li & Song, submitted), but this hypothesis has to be confirmed with drilling.

Table 1 Differences between the East and Southwest Sub-basins

Attributes	**East Sub-basin**	**Southwest Sub-basin**
Water depths	shallower on average	deeper on average
Basement depths	close（deepen to the margins）	close（deepen to the west）
Heat flow	lower	higher
Magnetic strikes	east-west	northeast-southwest
Magnetic amplitudes	stronger	weaker
Magnetic spectra	preferentially low in high-wavenumber components	preferentially high in high-wavenumber components
Free-air gravity anomalies	higher	lower
Curie depths	mostly deeper	mostly shallower
Seismicity	stronger	weaker

Any tectonic reconstruction model of the opening of the SCS must explain the observed differences between sub-basins (Table 1). There have been a number of Cenozoic tectonic models proposed but it remains uncertain whether the SCS basin experienced primarily a single episode or multiple episodes of extension and seafloor spreading and, if multiple, in what sequence the three sub-basins evolved (e.g., Taylor & Hayes, 1980; Pautot et al. 1986; Ru & Pigott, 1986; Briais et al., 1993; Yao et al., 1994; Hayes & Nissen 2005; Li et al., 2007b, 2008a). It has been suggested, for example, that the opening of the East and Northwest sub-basins predated, or at least synchronized with, that of the Southwest sub-basin (Talor & Hayes, 1983; Briais et al., 1993; Lee & Lawver, 1994; Tongkul, 1994; Honza, 1995; Zhou et al., 1995; Schlüter et al., 1996; Hall, 2002; Hall & Morley, 2004; Hayes & Nissen, 2005; Sun et al., 2008), a model contrasting with some others in which an earlier opening in the Southwest Sub-basin is preferred (Fig. 2e) (e.g., Ru & Pigott, 1986; Yao et al., 1994; Li et al., 2007b). The latter group of models considers the sharp contrasts between the East and the Southwest sub-basins and the important roles of the Zhongnan Fault (Figs. 3 & 4), which the first group often ignores.

These large margins of uncertainties arise largely from our inabilities in accurately dating oceanic crust from geophysical data alone. Up till now all age controls on the oceanic crust of the SCS basin are from magnetic anomaly correlations and empirical relationships between ages and bathymetry and/or heat flow (Table 2). Furthermore, it has been difficult to have a direct age correlation between seismic reflectors in the central basin and those from the continental margins, because most exploration wells are located far from the central basin and massive post-drifting magmatic activities and faulting in the continent-ocean transition zone often block us from making direct stratigraphic correlations. To ultimately resolve these age problems, we need to drill into the oceanic basement and retrieve basaltic rocks at various sub-basins of the SCS basin.

Table 2 Various age estimates of the South China Sea Basin

Authors	**Ages (Ma)**	**Area of study**	**Year of publication**	**Data used**
Taylor & Hayes	32－17	East Sub-basin	1980, 1983	magnetic anomaly
Briais et al.	32－16	Central SCS basin	1993	magnetic anomaly
Yao et al.	42－35	Southwest Sub-basin	1994	magnetic anomaly
Barckhausen & Roeser	31－20.5	Central SCS basin	2004	magnetic anomaly
Hsu et al.	37－15	Central SCS basin and northeastern SCS	2004	magnetic anomaly
Ru & Pigott	~55 35－36 ~32	Southwest Sub-basin Northwest Sub-basin East Sub-basin	1986	heat flow and bathymetry

(5) Oceanic crustal accretion and upper lithospheric architecture of the SCS in particular and of the western Pacific marginal seas in general.

The enigmatic zonation in the magnetic anomalies as well as the existence of numerous seamounts in the SCS basin indicate peculiar evolutionary paths of the oceanic crust and upper mantle. Ridge jump is a mechanism proposed to explain the apparent geophysical differences between different sub-basins (Briais et al., 1993), but the exact sites, ages and mechanisms for ridge jumps are very much disputed (Li and Song, submitted). The anomalous feature of M1 and M2 (Fig. 4) and the different magnetic zones they divide lead to a good reasoning that they are associated with a significant event during the oceanic crustal accretion. According to the magnetic reversal time scale of Cande & Kent (1995) and the early dating of magnetic anomalies (Taylor & Hayes, 1980; Briais et al., 1993), M1 and M2 correspond most likely to magnetic anomaly C8, whose age is about 26 Ma. This timing is in line with the age of a major regional unconformity and a slump zone roughly along the Oligocene-Miocene boundary (Wang et al., 2000; Li et al., 2004). Magnetic anomaly C8 also seems to correlate with a regional episode of magmatism (Su et al., 2010; Li & Song, submitted). It is therefore argued that magnetic anomaly C8, rather than C7 suggested by Briais et al. (1993), represents a major event in the oceanic crustal accretion.

Our further 2D spectral analyses on magnetic anomalies found that (1) Curie depths are correlated with post-drifting magmatism within the SCS basin, and (2) Curie isotherm is located underneath the Moho, hence implying that the uppermost mantle here is also magnetized (Li et al., 2010). An impelling explanation for uppermost mantle magnetization is in-situ serpentinization caused possibly by infiltration of seawater through large transform faults (Li & Lee, 2006). With a proper selection of drilling sites to be discussed later, we may be able to test the hypothesis that in-situ upper mantle serpentinization can occur due to infiltration of seawater through large transform faults.

2. Drilling and research objectives

2.1 Specific scientific objectives

We propose at 6 sites drilling into the basement of the SCS basin and the Huatung Basin to date accurately the basement volcanic, and/or Mesozoic sedimentary rocks and overlying Cenozoic sedimentary rocks, measure physical properties (e.g., magnetic susceptibility) of basement rocks, examine post-rift sedimentary environments, and analyze both element and isotope geochemistry. With these studies we seek to

(1) better understand the Mesozoic interplay between the Tethys and the Paleo-Pacific and how they interacted with the East Asia, both geologically and climatically, prior to the development of the western Pacific marginal seas;

(2) test various hypotheses of the dynamic processes controlling the transitions from a Mesozoic active continental margin to a Cenozoic passive one, and from continental rifting and break-up to seafloor spreading, and constrain whether the forces driving the opening of the SCS were far-field (triggered by the tectonic extrusion of the Indochina block), near-field (due to back-arc spreading), or in-situ (magmatism driven);

(3) establish the complex opening history of different sub-basins and styles of oceanic crustal accretion of the SCS, and constrain the tectonic controls (such as spreading rate) on distinct magnetic contrasts among the three sub-basins;

(4) reveal deep mantle processes associated with tectonic extrusion, magmatism, magnetization, seawater infiltration and serpentinization;

(5) develop a complete 3D sedimentation model and link it to regional climatic processes in response to various tectonic events;

(6) integrate these results to add to our general understanding of the geodynamic interplay of mantle and lithosphere processes that lead to the development of continental margin basins in the geological record and at present.

2.2 Proposed drilling sites

All proposed sites in this proposal are located within areas floored by oceanic crust. This makes our proposed sites differ distinctly from previous ODP 184 sites (Wang et al., 2000) and sites proposed by the active IODP proposal 618-Full3, which are all located on the continental shelf and slope and are primarily targeting scientific problems related to sedimentation and paleoenvironment.

Site 1: SCS-2B

As mentioned above, the SCS basin shows a complicated magnetic zonation despite its small size. Two striking magnetic anomalies M1 and M2 in the East Sub-basin further divide the sub-basin into a central part of strong magnetic strengths bounded by M1 and M2 and two slightly weakly magnetized parts (C1 and C1', respectively) near the two conjugate continental margins (Fig. 4). Based on the traditional interpretations (Taylor & Hayes, 1980, 1983; Briais et al., 1993), these two anomalies correspond to magnetic anomaly C8 (~26 Ma), which is possibly linked to large-scale transforms in magmatism and compression all along the Chinese continental margin (Wang et al., 2000; Li et al., 2004; Su et al., 2010; Li & Song, submitted). Ridge jump is another favorable explanation but Briais et al. (1993) suggested that a minor ridge jump occurred after magnetic anomaly C7 rather than on C8.

This site is located near the magnetic anomalies C7 and C8 (Figs. 4 & 5). With this site we will test various hypotheses here regarding the age and mechanism of the presumed ridge jump through an integrated age calibration with magnetic anomalies, fossil records, radioactive dating, and magnetostratigraphy, and test alternative hypotheses on regional transforms in magmatism and stress field (consequently in spreading rate). Magnetization measurements will help answer the sharp increase in strengths in magnetic anomalies of C8.

This proposed drilling site is a little less than 200 km south of ODP site 1148, which was located in the continent-ocean transition zone and revealed detailed Cenozoic lithological information (Wang et al., 2000; Li et al., 2004; Wang & Li, 2009). However, along the northern margin of the SCS basin, nearly ubiquitous igneous bodies (e.g., around shot point 8000 in Fig. 5) and deep crustal faults separate the Cenozoic strata in the continent-ocean transition zone from those in the SCS basin. Therefore it has been highly problematic to extrapolate the Cenozoic stratigraphy obtained at ODP1148 or other exploration wells on the continental shelf to the deep basin (Li et al., 2008a). Indeed, the lack of detailed stratigraphic correlation within the SCS Basin is one of the reasons why the Cenozoic opening history of the SCS remains so controversial.

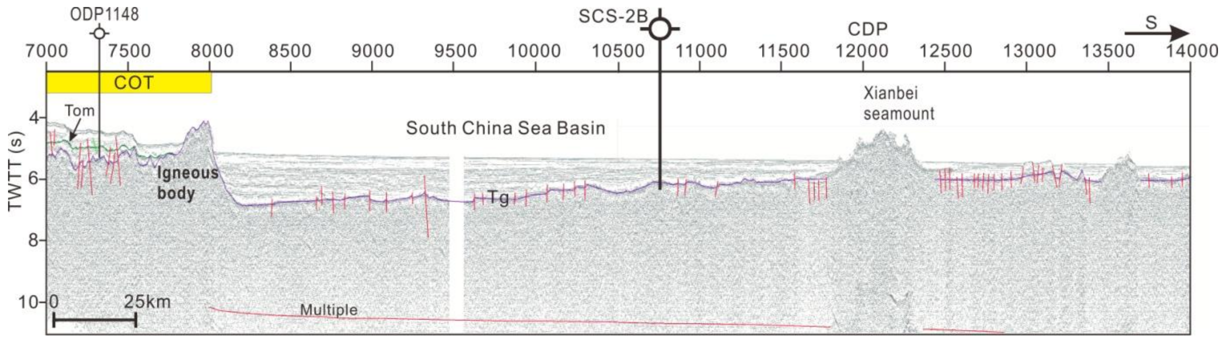


Fig. 5 Seismic section showing the continent-ocean transition zone (COT), and the deep see basin. Tg is the Cenozoic basement. Horizon Tom represents the unconformity between the Oligocene and Miocene. (After Li et al., 2008a)

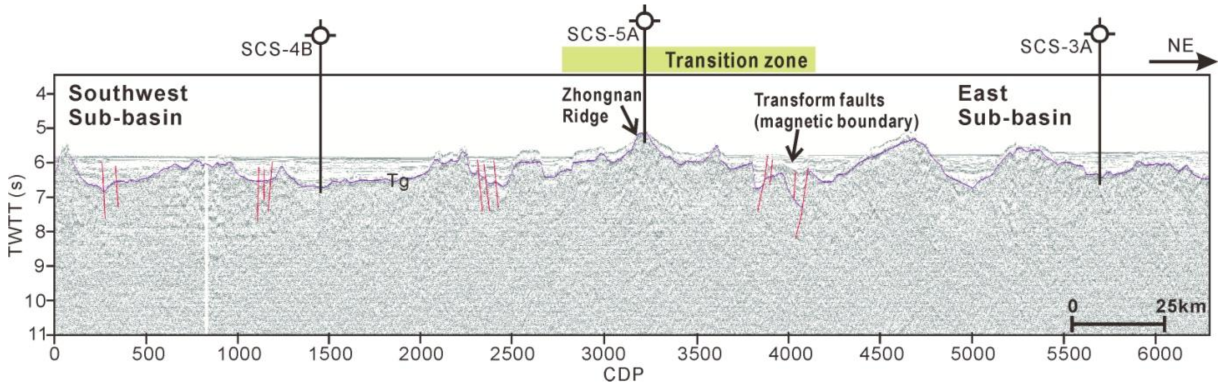


Fig. 6 Seismic section showing the structures of the Southwest Sub-basin and the East sub-basin, as well as the transition zone in between. Tg is the Cenozoic basement. (After Li et al., 2008a)

<u>Site 2: SCS-3A</u>

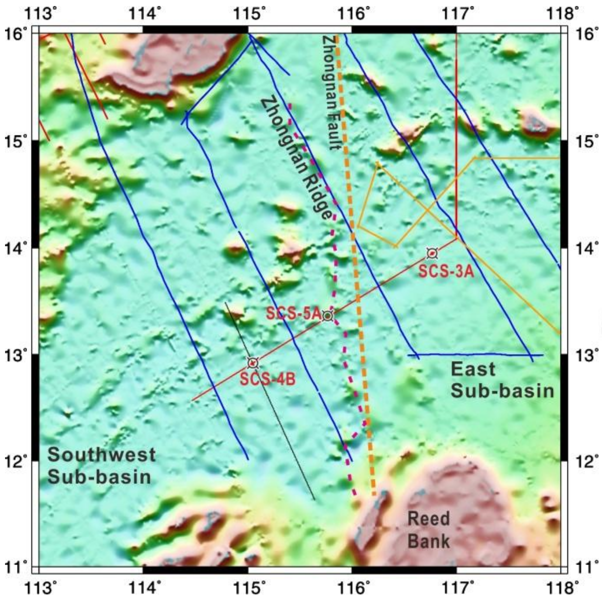
Magnetic patterns in the Southwest Sub-basin differ significantly from those in the East Sub-basin, not only in amplitudes, but also in structural trend (Fig. 4). The two sub-basins are sharply divided by the Zhongnan Fault (Figs. 3 & 4) (Yao, 1995; Jin et al., 2002; Li et al., 2007b). Owing to the marked contrast, it is justifiable to ask whether rifting and drifting within these two sub-basins are synchronous or diachronous, and how these two sub-basins evolved in comparison to the Northwest Sub-basin.

This site is located in the East Sub-basin near magnetic anomaly 6b (Taylor & Hayes, 1980; Briais et al., 1993) (Figs. 4 & 6). Coring at this site will help determine the age of the East Sub-basin and correlate ages from magnetic anomalies with fossil, magnetostratigraphic, and radioactive ages. Composition and magnetic susceptibility measurements from basement rocks will explain the sharp differences in magnetic amplitudes and strikes between the East and Southeast Sub-basins. Furthermore, this site will allow testing of the hypothesis that the

East Sub-basin formed in an area already floored by oceanic crust (Pautot et al., 1986).

Site 3: SCS-4B

This site is located in the Southwest Sub-basin, near the magnetic anomaly 6 of Briais et al. (1993) (Figs. 4 and 6). Coring will help determine the age of this sub-basin and correlate ages from magnetic anomalies with fossil, magnetostratigraphic, and radioactive ages. Together with site SCS-3A, this site can explain the sharp differences in magnetic amplitude and strike between the East and Southeast sub-basins and test the hypothesis that the Southwest Sub-basin was initiated by continental rifting, a formation mechanism that might be in sharp contrast to that of the East Sub-basin (Pautot et al., 1986). The apparent weak magnetizations in basement rocks will be examined via studies on chemical compositions and magnetic susceptibility measurements. Sites SCS-3A and SCS-4B together will answer in what sequences these two sub-basins opened, and how deep mantle processes influenced their evolutions.



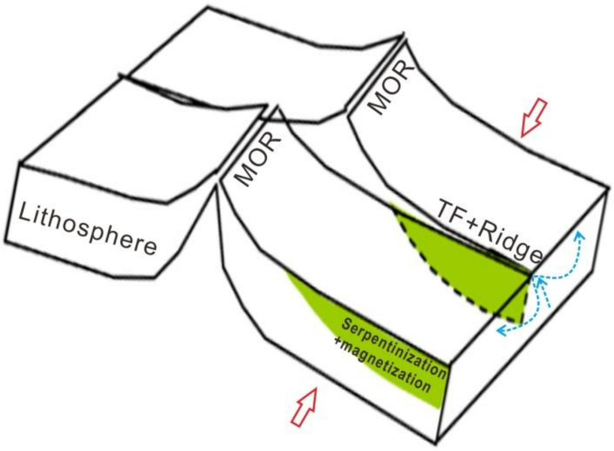


Fig. 7 (Left) Topographic map showing the Zhongnan Ridge; (Right) Hypothesized model of serpentinization within oceanic lithospheric mantle due to the infiltration of seawater via transform faults (modified after Li & Lee, 2006). TF=Transform fault; MOR=Mid-ocean ridge.

Site 4: SCS-5A

Many interesting features exist roughly along the transition zone between the Southwest and East Sub-basins (Figs. 3, 4 & 6); from the east to the west they are identified as the Zhongnan Fault, the Zhongnan Ridge, and the Zhongnan Seamounts. The Zhongnan Ridge is subparellel to the Zhongnan Fault and appears as a low rise in a zigzag shape (Fig. 7). On the magnetic anomaly map (Fig. 4), the Zhongnan Fault seems to be correlated with a magnetic weak belt although this correlation is not definite and a high-resolution magnetic survey that we are currently planning is necessary to confirm this. On the gravity anomaly map, the Zhongnan Ridge appears clearly as a gravity high belt. Seismic data show that the Zhongnan Ridge has a V-shaped crest (Fig. 6), like that on the Gagua Ridge that are interpreted as being formed from a compressed fault zone (Deschamps et al., 1998; Li et al., 2007a). Also considering the deeply dipping strong reflections within the Zhongnan Ridge, we interpret that the ridge formed by compression along a structurally fractured or weak zone. Cenozoic sediments are almost absent at the crest of the ridge and basement volcanic rocks can be easily recovered. Hypotheses we will test here are whether strong fluid activities deep from the mantle have accompanied with fracturing and whether there developed serpentinized mud volcanoes near the top of the Zhongnan Ridge. This information to be gleaned by drilling will put important constraints on seawater circulation within the oceanic crust and in-situ serpentinization and magnetization in the lower crust and upper mantle caused possibly by infiltration of seawater through large transform faults (Li & Lee, 2006).

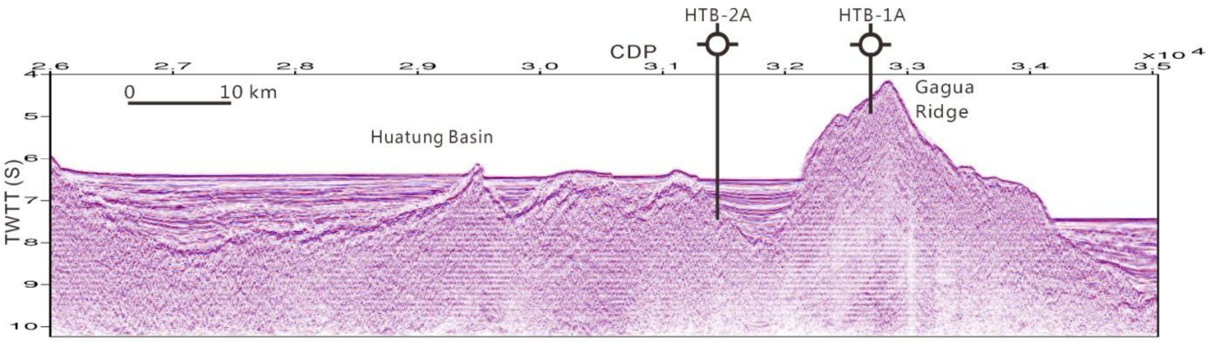


Fig. 8 Seismic reflections in the Huatung Basin (Li et al., 2007b). TWTT = two way travel time. CDP = common depth point.

Site 5: HTB-1A

The Huatung Basin is located to the westernmost of the Philippine Sea Basin and is bounded by the Gagua Ridge, and the Ryukyu, Taiwan, and Luzon islands (Figs. 3, 8 & 9). The Early Cretaceous age and the tectonic affiliation of the Huatung Basin proposed by Deschamps et al. (2000) is currently disputed (Sibuet et al., 2002). This site is located on the west flank of the Gagua Ridge (Figs. 8 & 9) and is designed to verify whether the Huatung Basin is of Cretaceous in age (Deschamps et al., 2000; Yeh & Cheng, 2001) and whether or not it once belonged to the proto-SCS and/or was affiliated with the Paleo-Pacific, and whether it was once connected with the northeasternmost SCS (Sibuet et al., 2002). In addition, this site will be used to test the hypothesis that the Gagua Ridge is formed by oceanic crustal compression along a major fracture zone (Fig. 9) (Deschamps et al., 1998). There are fairy continuous dipping seismic reflections within the Gagua Ridge, and a shallow penetration at this site will easily reveal the nature of the Gagua Ridge and its rock formations, since Cenozoic sedimentary cover at this site appears virtually absent. This is also a potential site for studying incipient development of subduction zones, as geophysical data indicate that strong compression here may cause the Philippine Sea plate start to subduct beneath the Huatung Basin (Fig. 9) (Deschamps et al., 1998; Li et al., 2007a).

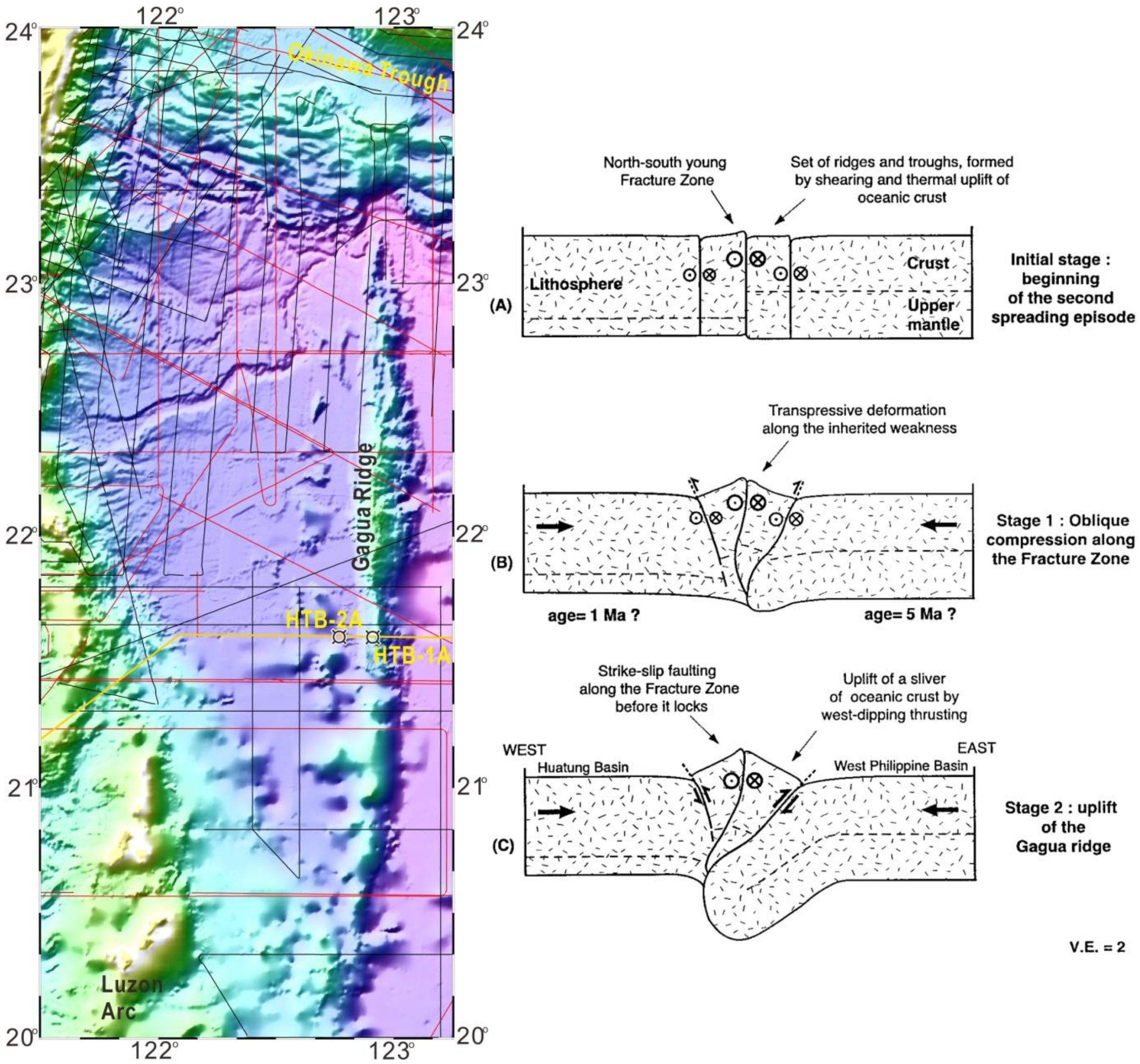


Fig. 9 (Left) Available seismic surveys in the Huatung Basin; (Right) Model of formation of the Gagua Ridge (Deschamps et al., 1998)

<u>Site 6: HTB-2A</u>

This site (Figs. 3, 8 & 9) is located in the Huatung Basin and is also designed to verify whether the basin is of Cretaceous in age and whether or not it once belonged to the proto-SCS (which might be affiliated with the Paleo-Pacific crust according to Xia et al. 1997) and connected with the northeastern part of the SCS (Deschamps et al., 2000; Sibuet et al., 2002). Since all known western Pacific marginal seas formed during the Cenozoic, the verification of a Mesozoic relict in the Huatung Basin will open a window into Mesozoic evolution of the western Pacific and the connectivity between the SCS and the western part of the Philippine Sea. The northeasternmost SCS is also the most likely place to preserve Paleo-Pacific crust (Xia et al. 1997; Sibuet et al., 2002; Li et al., 2007b, 2008a,b). There seismic sections show lateral continuous but folded reflections beneath the Cenozoic sequences, suggesting the existence of deformed Mesozoic sedimentary rocks. Regional magnetic studies also support this view (Li et al., 2007b, 2008a,b; Shi & Li, submitted). Critical questions like whether and how the Tethys or the Paleo-Pacific interplayed, and how East Asian was in contact with the Paleo-Pacific plate, can be answered by paleontological and geochemical analyses on the recovered rocks with precise age and lithology controls at this site.

Sediments to be recovered from this site are expected to have at least three major sequences: Cretaceous radiolarian cherts at the bottom, Cenozoic red clays and pelagic muds in the middle, and late Cenozoic orogenic turbidites in the upper part. Since the middle Miocene, the SCS oceanic crust has been subducting eastward beneath the Huatung Basin to form the Luzon arc. Chert xenolith blocks with radiolarian fossils of 115 Ma were found in the Miocene andesitic volcanic island within the Luzon arc (Yeh & Cheng, 2001). This indicates that the Luzon arc magma could have passed through a Mesozoic radiolarian chert layers above the oceanic crust of the Huatung Basin. In this context, we expect to find Mesozoic radiolarian chert layers in the lowest part of the sedimentary sequences. Today most sediments in the Huatung Basin are transported eastward from the Miocene accretionary prism (Central Range, uplifted above sea-level: 6.5-4 Ma) and the Luzon arc-forearc (Coastal Range, uplifted above sea-level in 1.5 - 0 Ma) of Taiwan (Huang et al., 2006) through some submarine canyons (Liu et al., 1998; Schnürle et al., 1998). Therefore, the sedimentary sequence here could show a transition from pelagic sediments in an open sea environment to an orogenic-sediment dominant unit un-roofed from the Taiwan due to the active collision between the Luzon arc and the Asian continental margin starting from 6.5 Ma.

2.3 Overarching testable hypotheses

With the six drilling sites all penetrating into the basement, we aim at testing the following overarching hypotheses:

(1) <u>The Tethys and the Paleo-Pacific had strong interactions in the present-day northeasternmost SCS and the Huatung Basin, and the latter two basins were once connected before the formation of western Pacific marginal seas.</u>

Seismic and magnetic data in the northeasternmost SCS suggest the presence of thick Mesozoic sediments (Li et al,, 2007b, 2008a), and previous paleontological studies from wells on the continental shelf and onshore indicate strong signatures of mixing in Tethyan and

Pacific biota (Fontaine et al., 1983; Kudrass et al., 1986; Hutchison, 1989; Liu et al., 1996; Chen et al., 1998). The Huatung Basin has also been interpreted as of Early Cretaceous based on $^{40}Ar/^{39}Ar$ dating and Radiolaria (Deschamps et al., 2000; Yeh & Cheng, 2001) and is thought to be connected with the northeasternmost SCS basin based on magnetic anomalies and regional geodynamic reconstruction (Sibuet et al., 2002). By drilling into the basement here we will be able to examine closely the true nature and affiliation of the crust of the Huatung Basin. Meanwhile we will have a chance testing the presumed proto-SCS and its relationships with the Tethys and the Paleo-Pacific. Both sedimentary and volcanic rocks will reveal processes on the direct interaction between the East Asia and the Paleo-Pacific, and paleo-environmental evolutions associated with Paleo-Pacific subduction and magmatism, Southeast China orogeny, and the incipient rifting leading to the opening of western Pacific marginal seas. The closure of the Tethys and the subduction of the Paleo-Pacific formed zones of lithospheric weakness that appear to be inherited by the Cenozoic continental margin rifting and break-up here (Shi & Li, submitted). This links naturally to the next hypothesis.

(2) <u>The incipient opening of the SCS was fostered and driven primarily by the cessation or eastward retreats (jumps) of the Paleo-Pacific subduction zone.</u>

In-situ synrifting magmatic activities are rather weak in the area and the northern continental margin of the SCS is often classified as a magma-poor (non-volcanic) margin despite increasing evidences of underplating to the northeast (Clift et al., 2003; Yan et al., 2006). The likelihood of continental margin break-up driven by in-situ magmatism here has yet to be better documented. Although the extrusion of the Indochina block northerly bounded by the Red River Fault Zone has been suggested as the driving force (e.g., Briais et al., 1993), this idea has been increasingly disputed (Morley, 2002).

The presence of so many widespread western Pacific marginal seas needs to be deciphered from a more regional perspective, although the decisive mechanisms for different marginal seas differ significantly. In the SCS area, all evidences supporting a Paleo-Pacific subduction zone disappeared during the Early to Late Cretaceous transition, and then prevailing rifting succeeded well into the early Cenozoic (Shi & Li, submitted). From basement coring, we will have the opportunities to trace the magma sources forming the crust and mantle of the SCS basin and examine its possible affiliations with, or contaminations from, either Eurasian or Pacific plates or both. Similarly, geochemical analysis of oceanic crust at proposed sites could place constraints on the location of the boundary between Indian and Pacific mantle. The proposed drilling sites have most focuses on the basement rocks and have been so selected that careful examination on the basement rocks have maximum chance of success in studying the regional mantle processes and mantle flow regime.

(3) The opening of the SCS experienced multiple stages of rifting, seafloor spreading and ridge jumps that induced peculiar magnetic zonations.

There are sharp boundaries (such as the Zhongnan Fault) and contrasts between different magnetic zones in the SCS basin (Fig. 4) that can be taken as strong evidences supporting the multiphase opening model of the SCS (Ru & Pigott, 1986; Yao et al., 1994; Li et al., 2007b). The sharp contrasts in observed magnetic anomalies and calculated 3D analytical signals between the East and Southwest Sub-basins (Fig. 4) cannot be easily reconciled by a single episode of rifting. It appears that the basement rocks in the East Sub-basin is more mafic than those from other sub-basins, a deduction conformable to the speculation of Pautot et al. (1986) that the East Sub-basin developed within a pre-existing oceanic crust, whereas the Southwest Sub-basin evolved from continental rifting that ultimately led to seafloor spreading. It is hypothesized that the Northwest and Southwest Sub-basins formed in an early stage of rifting either simultaneously or sequentially, before the formation of the East Sub-basin. This hypothesis is to be tested with the four proposed drilling sites in the SCS. The accurate timings to be estimated from each of these different sub-basins will be for the first time quantitatively correlated to the timings of regional tectonic events such as the India-Asia collision, and the causes for this part of continental margin rifting will be better understood. Meanwhile, the timing and mechanism of a possible ridge jump around the magnetic anomaly C8 or C7 will be studied at Site SCS-2B.

(4) Pervasive seawater circulations throughout the SCS oceanic crust bear signatures of in-situ lower crust and uppermost mantle magnetization and serpentinization.

The unique tectomorphological feature of the Zhongnan Ridge sets it in an ideal spot to test the existence of hydrothermal activities and serpentinized mud volcanoes. Magnetic spectral inversion reveals that the uppermost mantle of the SCS is magnetized (Li et al., 2010), and magnetic filtering analyses together with satellite magnetic observations also confirm lower crust and upper mantle contributions to surface magnetic anomalies (Li & Song, submitted). One possible explanation is that in-situ serpentinization within lower crust and upper mantle due to seawater infiltration along fracture zones (Li & Lee, 2006) elevated rock susceptibilities (Fig. 9).

2.4 Regional and global significance of drilling in the SCS and Huatung basins

The SCS and Huatung Basins are geologically unique: the SCS is a classical representative of western Pacific marginal seas that developed from continental margin rifting and is floored with oceanic crust; they are located at the junction of the Eurasian, Pacific, and Indo-Australian plates (Figs. 1 & 2), and thereby sensitive to their tectonic and climatic changes; the relatively small size of the SCS facilitates easy tectonic comparisons between the two conjugate continental margins, accessible through one single IODP leg; the SCS has nearly undergone a complete Wilson cycle from continental break-up and seafloor spreading to subduction despite its short evolutionary history and, therefore it is also well suited for studying various plate boundary activities, such as continental margin rifting (e.g., Hayes & Nissen, 2005) and geodynamics of continental margin basin formation (e.g., Yamasaki & Stephenson, 2009), oceanic subduction (the Manila Trench; e.g., Li et al., 2002; Li et al., 2007a), strike slip faulting (the Red River fault; e.g., Clift & Sun, 2006), as well as active orogenic processes (Taiwan; e.g., Huang et al., 2001, 2006) (Fig. 1).

All these attributes make the SCS and Huatung Basin ideal natural laboratories for studying continental break-up, basin formation, deep mantle evolution, and land-ocean interactions. The afore-mentioned problems to be answered and hypotheses to be tested are by no means only specific to the SCS area. The efforts in answering these fundamental questions will require knowledge of, and thereby enlighten our views on, mechanisms of continental margin break-up and basin formation, and deep lithospheric dynamics of marginal seas and their connections to surface processes globally.

The western Pacific is hallmarked by a series of marginal sea basins, whose formations are more or less related to the subduction of the west Pacific Plate. However, their specific local opening mechanisms and styles seem to vary significantly. While some (e.g., Shikoku basin) can be easily attributed to back-arc spreading, the SCS in particular is not a typical back-arc basin, at least seen from its present configuration. Some of the western Pacific marginal basins and oceanic crusts (Sulu Sea, Celebes Sea, Japan Sea, Philippine Sea etc.) have already been drilled in the early stages of deep sea drillings for tectonic studies, and important discoveries regarding their ages and crustal evolutions have been found (e.g., DSDP legs 6 and 31; ODP Legs 124, 127 and 128). Given the unique characteristics of the SCS, a dedicated drilling program will fill in important gaps in our understanding of the regional formation of western Pacific marginal seas, and of global continental margin rifting and basin formation in places such as the Gulf of California, the Japan Sea, and the Andaman Sea.

Pre-existing weak zones in the continental lithosphere are often host places fostering rifting (Wilson 1966; Delvaux et al. 1995, 1997; Lesne et al. 2000; Tommasi & Vauchez 2001; Harry & Huerta 2002). This proposal is also set to study these fundamental pre-rifting problems including (1) the transfer of Mesozoic pre-existing structures into the triggering of Cenozoic rifts and marginal seas, and (2) complex history of Paleo-Pacific subduction and its tectonic and climatic interactions with the Tethys and East Asia.

The present configuration of the SCS and the Huatung Basin is closely related to the rotation history of the Philippine Sea Plate to the east and the ongoing subduction and collision of the Indo-Australian Plate to the south of the Sunda Shelf and the Sunda and Java Arcs (Packham, 1996; Pubellier et al., 2003). However, the tectonic and deep mantle interactions, if there is any, between the SCS and the subduction processes along the Sunda Trench are the least known. The relic spreading ridge of the SCS basin is nearly perpendicular to the Sunda Trench, making it an unlikely candidate being a back-arc basin behind the Sunda Arc. The subducted Indian oceanic plate may have influences on the deep mantle of the SCS, but again, this has to be studied by deep sea drilling and coring with the benefit of directly measuring geochemical compositions of basaltic rocks and dating them.

2.5 Scientific significance of sampling oceanic crust in the western Pacific

While dating is key to geodynamic reconstructions that are currently only loosely constrained in the area, the merits of sampling basement crustal rocks in the marginal sea basins go far beyond. The magnetic patterns in the SCS is particularly intriguing with sharp contrasts between different zones (Li et al., 2008a), and their causes have to be better understood. We need to scrutinize whether it is differences in rock magnetizations and compositions or other factors (such as ages, metamorphism, heat flow, spreading rates, cooling rates, magma supplies, magma assimilations, reheating, magnetic orientations, or thicknesses of the magnetized layer) that cause the sharp contrast between the east and southwest sub-basins. The efforts to better understand seafloor magnetic anomalies and magnetization processes date back to the earliest phase of deep sea drilling and has remained continuously to be one of the main themes. As stated in the Initial Science Plan of IODP referring the 21st century Mohole, "… the source of marine magnetic anomalies will be much better understood when a complete section of the lower oceanic crust is available for analysis". Before the implementation of the proposed mega-project Mohole, basement sampling and rock analysis will put much needed experiences and apprentices into place.

Geochemical analysis is needed to trace deep mantle processes and study crustal affiliations or mantle contaminations by adjacent blocks. A recent assessment of the Nd–Sr isotopic compositions of the Japan Sea basalts from ODP legs 127/128 indicates eastward asthenospheric flow and depleted mantle (Nohda, 2009). Drilling into the basement is the only means of direct assessment of chemical budget, heat flow, deep biosphere, magmatic differentiations during the cooling, and sub-seafloor hydrothermal activities that could bear deep mantle signatures on magnetization and serpentinization. Shallow basaltic rocks near the surface of the basement could bear information related to these magmatic processes and mantle flow behaviors. Some of the proposed drilling sites of this proposal are ideal places for these types of studies.

There have been several DSDP/ODP/IODP sites (332, 395, 418, 504, 735, 801, 1256, U1309) with basement penetrations close to or deeper than 500 m in thickness, and the thickest one is reaching 1800 m. However, none of these are from the western Pacific marginal basins. A few shallow basement recoveries in the Sulu Sea, Celebes Sea, Japan Sea, and Philippine Sea from early DSDP/ODP/IODP expeditions have helped decipher the complicated tectonic history in the area (DSDP legs 6 and 31; ODP Legs 124, 127 and 128) (Karig et al., 1975; Rangin et al., 1990; Ingle et al.,1990; Tamaki et al., 1990), but western Pacific marginal seas have had a variety of origins and histories (Rangin et al., 1990), which can only be better understood with added knowledge from a full leg of ocean drilling in the SCS. In the recent IODP Thematic Review prepared by Larsen et al. (2009), it is stated that "… the final activities of ODP and initial IODP activities in the study of oceanic crustal formation and structure … proves that it is a field where new and surprising scientific results of first-order significance still can be made…". Seafloor spreading and mantle melting linked to ocean crustal architecture continues to be one of the challenges listed in the new IODP science plan for 2013-2023.

3 Interpretation of expected results

3.1 Accurate dating strategy

Accurate age estimates on the opening duration and phase of the sub-basins of the SCS can be correlated with the uplift history of the Tibetan Plateau to further advance our understanding on the possible links between extrusion tectonics (Tapponnier et al., 1982; Briais et al., 1993; Clift et al., 2008) and the proposed continental break-up leading to the formation of the SCS.

Age controls in the overlying sedimentary rocks will be made from routine microfossil analysis, measurements on magnetic susceptibility, and isotope geochemistry analysis. This can be further constrained by correlating seismic reflections around different drilling sites. Since we will have four drilling sites within the SCS, we can build a detailed 3D post-spreading model of seismic stratigraphy that will offer invaluable insights into the deep-water sedimentary process and how it evolve with time. This sedimentary model will be further coupled with regional paleo-environment and paleo-oceanography to single out major geological events.

Basement volcanic rocks will be dated with ^{40}Ar–^{39}Ar and other high resolution zircon dating techniques with Uranium-series isotopes (Goldstein et al., 1991, 1994, 1994; Goldstein, 1995). These techniques have been progressing remarkably.

3.2 Mineralogical and geochemical analyses

One major question is what has caused the difference in magnetic strengths between the East and the Southwest Sub-basins. Susceptibilities of extrusive basalts normally decrease with increasing degree of alteration that reduces their content of titanomagnetite (e.g., Bleil & Petersen, 1983). Serpentinization of gabbros and peridotite at deeper depths also smears surface magnetic anomalies (e.g., Dyment et al., 1997). Detailed mineralogical studies are essential to understand these processes.

Geochemistry analyses on basement rocks will offer new insights into crustal affinity and evolution, and deep mantle processes. Element and isotope compositions such as Sr and Nd isotopes and other geochemical systems will provide insights into the material influx and deep crustal and mantle formations. The opening mechanism of the SCS can be constrained by the Nd-Sr system. Temporal variations in εNd values and Sr isotopic compositions gained at different sites will tell how the mantle evolved with time and how the crust interacted with, and thereby was altered by, seawater. The $^{87}Sr/^{86}Sr$ in particular is sensitive to changes in spreading rates and in the connectivity of the SCS with an open sea.

3.3 Physical property and fluid measurements

Routine physical measurements on the cores will provide information on current state of stress and rheology in the deep basin. These kinds of data are currently badly missing in the region. Due to the intriguing patterns of magnetic anomalies, careful measurements on magnetic susceptibility are needed to constrain models, e.g., of tectonic settings or spreading rates (Dyment & Arkani-Hamed, 1992), that can explain the distinct differences in magnetic patterns between different sub-basins, and their crustal affinities. Magnetization measurements from core measurements are also vital in setting up a reasonable initial model for magnetic modeling and inversion in order to better understand the observed magnetic anomalies.

Current heat flow measurements in the central SCS are very sparse, and this has limited our ability to interpret the cooling process and the ages of the sub-basins. Geothermal gradient and thermal conductivity measurements at the 6 proposed drilling sites will be a step forward toward improving the current situation. Fluid geochemistry studies will reveal how and if seawater reacted with uppermost mantle and thereby bear signatures of mantle.

3.4 Logging

Porosity, density, gamma ray, and sonic logs are essential products of deep sea drilling and logging. Gamma ray data will be used to infer lithology and provenance. Porosity, sonic and density logs together are critical to constraining the tectonic subsidence and opening history of the SCS basin, which has not yet been possible to do previously. ODP184 provided data for studying the subsidence history at the continent-ocean transition zone (Wang et al., 2000), but not in the oceanic basin. A time-depth curve (Fig. 10) at ODP Site 1148 can be built and used for estimating sediment thicknesses and depths in the SCS ocean basin before more accurate time-depth relationships become available (Li et al., 2008a).. Through backstripping and tectonic subsidence analysis using new sonic and porosity data and time constraints, we will assess the subsidence and rifting parameters in the deep basin, which will offer new views on the proposed episodic opening and subsidence history of the SCS.

With Formation MicroScanner (FMS) logging, we will gain high-resolution quasi-2D images (electrofacies) of borehole wall and the structural orientation of rock formations. These data together will put much needed constraints on volcanostratigraphy and crustal accretion processes (Tominaga et al., 2009).

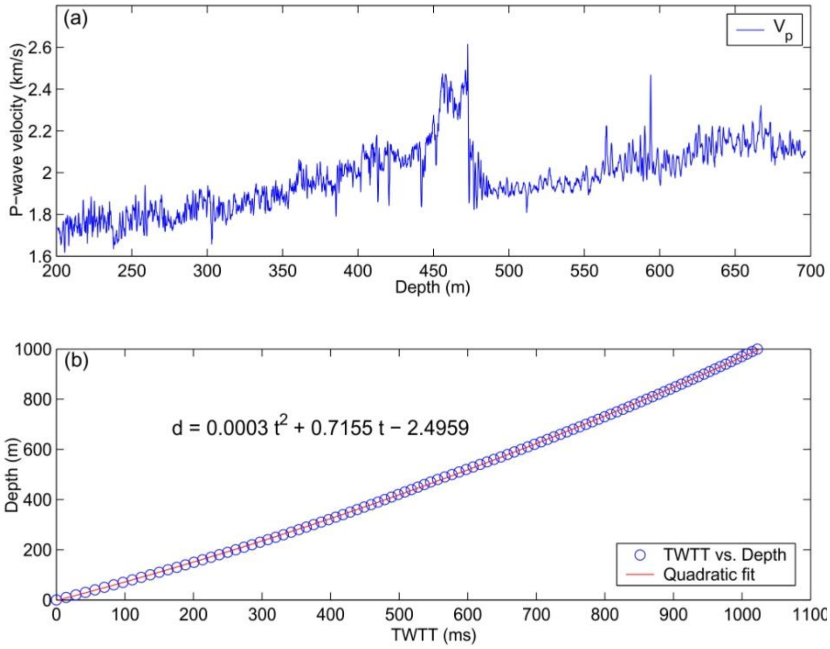


Fig. 10 (a) P-wave sonic logging velocity from the Ocean Drilling Program (ODP) Site 1148 (Wang et al., 2000).

(b) Calculated relationship between depth (m) versus two way travel time TWTT (ms). In the quadratic polynomial fit $d = 0.0003t^2 + 0.7155t - 2.4959$, t stands for the two-way travel time (ms) and d is the depth (m) beneath the seafloor (Li et al., 2008a).

3.5 Interpretation of cored sediments

As relative small marginal basins immediately surrounded by numerous continental blocks, the SCS and the Huatung Basin are very sensitive to East Asian and western Pacific tectonic and climatic pulses and have recorded these information in the post-drifting sediments. With coring, detailed information on sedimentation rate, provenance, water depths, tectonic subsidence, and facies changes will be faithfully revealed and will be correlated to known tectonic and climatic events onshore. By correlating drilling and coring information with regional seismic sections, detailed 3D sedimentation models will be built.

4 Site descriptions and drilling strategy

Table 2 summarizes the site information for the six proposed drilling sites. The water depths range from about 3350 m to about 4750 m, and the penetration thicknesses are estimated to be from about 80 mbsf to about 900 mbsf. We propose basement penetrations of 30 m at all proposed sites to guarantee the amount of samples necessary for studying microfossils, lithology, geochemistry, physical properties, and provenances and/or affiliations of basement rocks.

Assuming an average cruising speed of 11 knots for the JOIDES Resolution, the total time for ship movement between the proposed drilling sites is about 3 days. Excluding the transit time, a total of 27.5 days of drilling and logging are estimated for the six sites with non-riser drilling.

Basement sills have been found in a few ODP sites (e.g., ODP Legs 170, 205, 210), and on seismic sections they appear as relatively flat-lying, high-amplitude, and laterally continuous seismic reflectors near the basement. These types of seismic reflectors have not been identified near the proposed sites of this proposal, and therefore the chances of meeting sills are very low. In case of encountering volcanic sills, they are unlikely to be very thick and the true basement can still be reachable. Detailed dating and geochemical studies on sill samples alone would provide key information on late-stage magmatism in the area, or provide proxy information regarding the nature of the underlying basement as is the case at ODP Site 1276 in Newfoundland margin (Hart & Blusztajn, 2006).

Table 2. Site descriptions and estimated drilling and logging time

Site	Position	Water depth (m)	Sediment (m)	Basement (m)	On-site time (day)*
SCS-2B	17°16.170' N 116°48.4920' E	3911	720	30	6.0
SCS-3A	13°56.8176' N 116°46.1418' E	4206	596	30	5.0
SCS-4B	12°55.137' N 115°2.8326' E	4383	865	30	6.5
SCS-5A	13°20.8480' N 115°45.7188' E	3792	50	30	2.0
HTB-1A	21°35.9308' N 122°54.9138' E	3343	50	30	2.0
HTB-2A	21°35.9581' N 122°46.1682' E	4754	710	30	6.0

* Estimations based on riserless penetration rate: sediments=8.9 m/hr; basalt=1.2 m/hr

5 Site survey data

Site SCS-2B:

Multichannel seismic data and magnetic data were collected near this proposed site by R/V Vema in 1980, and by R/V Conrad and R/V Haiyang IV in 1985 (Taylor & Hayes, 1980; 1983; Yao et al., 1994; Hayes et al., 1995) (Fig. 3). Three cruises with the German R/V Sonne were carried out in the years 1987 (SO-49, SO-50B), 1990 (SO-72A) and 1994 (SO-95), and over 6,600 km of multi-channel reflection seismic data and high-resolution 3.5 kHz echograms were collected (Lüdmann et al., 2001, 2005; Lüdmann & Wong, 1999). In 2001, SCSIO carried out an integrated multichannel seismic, bathymetric, gravimetric and magnetic survey along a transect passing through this proposed site SCS-2B (Figs. 3 & 5) (Li et al., 2008a). An OBS experiment was conducted very close to this proposed drilling site by Yan et al. (2001). In 2006, three OBS profiles were shot by The second Institute of Oceanography, SOA, one on the northern continental margin and the other two crossing the Northwest Sub-basin.

A large set of industrial seismic data and gravity and magnetic data are also available near site SCS-2B. Some of these data accessible to the lead proponent are also shown in Fig. 3.

Early 2011, The South China Sea Deep, a comprehensive 8-year research program steered by Prof. Pinxian Wang, was proved by the National Science Foundation of China (NSFC). With a total budget of ~ 23M in US Dollar, this program will fund coincident refraction/reflection surveys and deep-tow magnetic surveys in the SCS basin, among other research activities.

Sites SCS-3A, SCS-4B and SCS-5A:

These three sites are located in the center part of the SCS ocean basin. Geophysical surveys of single-channel seismic reflection profiles, and wide-angle reflection and refraction data from sonobuoys in the central SCS basin started in the 1960s by R/V Vema and R/V Conrad (Ludwig et al., 1967; Ludwig, 1970; 1979; Taylor and Hayes, 1980). Two stages of Sino-US cooperation in the early 1980s added a more dense data coverage, which includes bathymetry, gravity and magnetic anomalies, single and multi-channel seismic reflections, sonobuoy measurements, two ship expanding spread profile, and piston cores (Taylor and Hayes, 1983; Yao et al., 1994; Hayes et al., 1995). R/V Sonne collected additional 2D multi-channel seismic data of a little over 10,000 km in total length by two expeditions, one in 1987 (SO49), and another very recently in 2008 (SO197) (Franke et al., 2011) (Fig. 3). A very large of amount of additional data has also been collected by The second Institute of Oceanography of SOA, SCSIO, and GMGS over the last 30 years. One of the SCSIO geophysical transects passing through these three proposed sites is shown in Fig. 6. Coincident refraction/reflection surveys and deep-tow high-resolution magnetic surveys are either just done or in the planning stage under the South China Sea Deep program sponsored by NSFC.

High resolution total field magnetic data (Fig. 4) covering all proposed drilling sites are compiled by Geological Survey of Japan and Coordinating Committee for Coastal and Offshore Geoscience Programmes in East and Southeast Asia (CCOP) in 1996. This compilation offers a remarkable coverage and accuracy (Fig. 4). Our recent analyses on this dataset have yield many new insights into the dynamic opening process of the SCS (Li et al., 2007b, 2008a, 2010). 3D deep crustal and mantle structures in the area have also been mapped with surface wave tomography (Wu et al., 2004)

Sites HTB-1A and HTB-2A:

Recent geophysical studies in this region included reflection seismic, gravimetric and magnetic surveys, ocean-bottom seismograph (OBS) experiments, bathymetric sounding, and earthquake hypocenter relocations (Fig. 9). A 24-channel seismic reflection transect from the Chinese continental shelf, passing through the Luzon Arc, to the western Philippine Sea was obtained in 1987 by the South China Sea Institute of Oceanology (SCSIO) (Xia et al. 1994; Wang et al. 2000; Huang et al., 2001). In 2001, Guangzhou Marine Geological Survey (GMGS) carried out an integrated multichannel seismic, bathymetric, gravimetric and magnetic survey along a transect spatially very close to the 1987 line (Li et al., 2007a).

During the TAICRUST experiment with the R/V Maurice Ewing from Columbia University in 1995 (Reed et al., 1996; Liu et al., 1997; Moore et al., 1997), a multichannel seismic survey was also conducted offshore southern Taiwan (Chi, 2003). More recently in the TAIGER project (Wu et al., 2007), multichannel seismic reflection and OBS surveys have also been carried out in the proximity of the proposed drilling sites. Velocity controls are also available from some of the earliest OBS experiments in the area (Chen & Jaw, 1996; Nakamura et al., 1998) and various earthquake hypocenter relocations and tomographic studies (Wu et al., 1997; Cheng et al., 1998; Kao et al., 2000). On potential field data, Hsu et al. (1998) updated the free-air gravity anomaly and magnetic anomaly maps around Taiwan by incorporating newly obtained data sets. Further, Hsu et al. (2004) compiled a new bathymetric map of the northernmost SCS based on newly collected multi-beam bathymetric data and that collected during the ACT cruise (Lallemand et al., 1997).

6 Description of third party financial commitment

After a detailed discussion with the Ministry of Science and Technology of China (MOST), a project recommendation book has already been submitted to MOST for final approval and the initial response from MOST is encouraging. This proposed budget will cover 70% of the estimated platform operating costs for finishing the 6 proposed sites. In addition, the South China Sea Deep program sponsored by NSFC and directed by Prof. Pinxian Wang is committing an extra funding of ~ 23M USD for additional site surveys and for post-cruise research activities. International workshops on the SCS geology will be organized in the coming years.

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Zhou, D., Sun, Z., Chen, H.-Z., Xu, H.-H., Wang, W.-Y., Pang, X., Cai, D.-S., Hu D.-K., 2008. Mesozoic paleogeography and tectonic evolution of South China Sea and adjacent areas in the context of Tethyan and Paleo-Pacific interconnections. Island Arc 17, 186–207.

Zhou, X. M., Li, W. X., 2000. Origin of late Mesozoic igneous rocks in southeastern China: implications for lithosphere subduction and underplating of mafic magmas. Tectonophysics 326, 269–287.

Proponents:

Proponent	Affiliation	Specialty
Bochu Yao	Guangzhou Marine Geological Survey, Chinese Ministry of Land and Resources, Guangzhou	Marine geology and geophysics
Chi-Yue Huang	National Cheng Kung University, Tainan	Marine geology, paleooceanography
Chun-Feng Li	Tongji University, Shanghai	Geophysics, tectonics
Dieter Franke	Federal Institute for Geosciences and Natural Resources, Germany	Tectonics, geophysics
Gaku Kimura	The University of Tokyo, Japan	Tectonics, structural geology
Jiabiao Li	2nd Institute of Oceanography, State Oceanic Administration, Hangzhou	Marine geology, tectonics
Jianhua Geng	Tongji University, Shanghai	Reflection seismology
Liaoliang Wang	Guangzhou Marine Geological Survey, Chinese Ministry of Land and Resources, Guangzhou	Marine geology
Nengyou Wu	Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences, Guangzhou	Marine geology
Peter Michael	University of Tulsa, USA	Igneous Petrology, geochemistry
Pin Yan	South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou	Marine geophysics
Pinxian Wang	Tongji University, Shanghai	Paleoceanography
Qianyu Li	Tongji University, Shanghai	Paleoceanography
Randell Stephenson	University of Aberdeen, UK	Tectonics, geodynamics
Shiguo Wu	Institute of Oceanology, Chinese Academy of Sciences, Qingdao	Marine and petroleum geology
Shu-Kun Hsu	National Central University, Jhongli City	Geophysics, tectonics
Xinong Xie	China University of Geosciences, Wuhan	Marine and petroleum geology
Xuelin Qiu	South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou	Marine geophysics
Yongjian Yao	Guangzhou Marine Geological Survey, Chinese Ministry of Land and Resources, Guangzhou	Marine geology
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Principal Research Interests

Tectonophysics and Geodynamics, Marine Geology and Geophysics, Seismology, Geophysical Data Processing and Interpretation, Nonlinear Processes in Geosciences

Working Experience

Professor, School of Ocean and Earth Sciences, Tongji University, China, 2008-present.
Shipboard Scientist, IODP Expedition 316 (NanTroSEIZE). 2007, 12-2008, 2.
Visiting Professor, Université des Sciences et Technologies de Lille, France, 2005, 6-7.
Assistant/Associate Professor, School of Ocean and Earth Sciences, Tongji University, China, 2003-2008.
Teaching Assistant, Department of Geosciences, University of Tulsa, USA. 1999 -2002.
Geophysicist, Carrizo Oil & Gas, Inc. Houston, TX., USA. 1998 -1999.
Teaching/Research Assistant, Department of Geosciences, University of Houston, USA. 1996 -1997.
Research Assistant/Associate, Institute of Crustal Dynamics, Chinese Seismological Bureau, Beijing, China, 1993 - 1996.

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, Graduate School, Chinese Seismological Bureau and Chinese Academy of Sciences, Beijing, China, 1995.
B.S. in Geology, China University of Geosciences, Wuhan, China, 1992.

Five Relevant Publications

Li, C.-F., X. Shi, Zhou, Z., Li, J., Geng, J., Chen, B., 2010. Depths to the magnetic layer bottom in the South China Sea area and their tectonic implications. *Geophysical Journal International,* 182, 1229-1247.

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Five Other Significant Publications

Li, C.-F., 2011. An integrated geodynamic model of the Nankai subduction zone and neighboring regions from geophysical inversion and modeling. *Journal of Geodynamics*, 51, 64-80.

Li, C.-F., Zhou, Z., Ge, H., Mao, Y., 2009. Rifting process of the Xihu Depression, East China Sea Basin. *Tectonophysics,* 472, 135-147.

Li, C.-F., Liner, C., 2008. Wavelet-based detection of singularities in acoustic impedances from surface seismic reflection data. *Geophysics*, 73, V1-V9.

Li, C.-F., 2004. Information passage from acoustic impedance to seismogram: perspectives from wavelet-based multiscale analysis. *Journal of Geophysical Research*, 109, DOI:10.1029/2003JB002883.

Li, C.-F., 2003. Rescaled-range and power spectrum analyses on well-logging data. *Geophysical Journal International,* 153, 201-212.

Patent and Book

US Patent 6745129 B1. Inventor: Li, C.-F., Liner, C., University of Tulsa. Patent title: Wavelet-based analysis of singularities in seismic data. Int. Cl7: G01V 1/28. U.S. Cl: 702/17. June 01, 2004.

Zhou, Z., Li, C.-F., 2008. Continental Margin Geodynamics. Science Press, p. 314. (in Chinese)

Professional Service

• Editorial Board Member, Journal of Geodynamics. 2010-

• Member, Science Planning Committee, IODP. 2010-

• Member, Site Survey Panel, IODP. 2007-2010

• China representative on IGCP 559 Project “Crustal Architecture and Images - Structural controls on landscapes, resources and hazards”

• Curator, Marine Geology Library at Tongji University. 2005-

Courses Taught

Specialized English in Geology and Geophysics
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

Shaowu Zhang, Tongji University, 2008- 2011, M.S.
Taoran Song, Tongji University, 2011- , M.S.
Jian Wang, Tongji University, 2011- , Ph.D.

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Professional Preparation:

1955-1960 Moscow State University, Dept. of Geology

Professional Experience:

1960-1972 Dept. of Geography, The Normal University of East China, Shanghai.
1972-1981 Dept. of Marine Geology, Tongji University, Shanghai.
1981-1982 Alexander von Humboldt Research Fellow, Geologisch-Palaontologisches Institut, Universitat Kiel, Germany.
1986 Visiting Research Fellow, School of Pacific Studies, Australian National University.
1982- Professor, Dept. of Marine Geology, Tongji University, Shanghai.
1982-1990 Department Head, Dept. of Marine Geology, Tongji University, Shanghai.
1993-2005 Director, Key Laboratory of Marine Geology, Tongji University
1999 Co-Chief Scientist, ODP Leg 184 (South China Sea)
2005 Co-Chief Scientist, IMAGES XII/MD 147 (South China Sea)

Academic Honours

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

Current Research Activities

Major Project Leader, Chinese NSF, “The South China Sea Deep” (2011-2018)
Co-Chair, PAGES Working Group on Global Monsoon (2007-)

Recent Selected Publications

Wang, PX., Tian, J., Lourens, L.J., 2010. Obscuring of long eccentricity cyclicity in Pleistocene oceanic carbon isotope records. Earth and Planetary Science Letters, 290 : 319–330

Wang, PX., Li, QY. (Eds.), 2009. The South China Sea-- Paleoceanography and Sedimentology. Springer, 506 p.

Wang, PX., 2009. Global monsoon in a geological perspective. Chinese Science Bulletin, 54 (7) : 1113-1136

Wang PX, Clemens S, Beaufort L, et al., 2005. Evolution and variability of the Asian monsoon system: state of the art and outstanding issues. Quaternary Science Reviews, 24(5-6): 595-629

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Wang PX, 2004. Cenozoic deformation and the history of sea-land interactions in Asia. In: P. Clift at al. (Eds): Continent-Ocean interactions in the East Asian Marginal Seas. Geophysical Monograph 149, American Geophysical Union, 1-22.

Wang PX, Tian, J., Chen, X., et al., 2003. Carbon reservoir changes preceded major ice-sheet expansion at Mid-Brunhes Event. Geology, 31(3): 239-242

Wang, PX., Zhao, QH, Jian Z, et al., 2003. A 30-million-year deep sea record in the South China Sea. Chinese Science Bulletin, 48(23): 2524-2535

Wang, PX., Chappell, J.,2001. Foraminifera as Holocene environmental indicators in the South Alligator River, Northern Australia. *Quaternary International*, 83/85: 47-62.

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

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Working Experience
Research Assistant, Federal Institute for Geosciences and Natural Resources, BGR, 1996-1999
Permanent position as scientific employee at BGR, Germany – Marine seismics group, 2000-2008
Team Leader - Oil and Gas Geology at BGR, Germany, 2009-present

Professional Preparation
Doctorate in Geosciences at the Free University of Berlin, Germany. 2000
Diploma in Physics at the Friedrich Alexander University, Erlangen, Germany, 1996

Main Research Projects
Russian high arctic: Laptev Sea & East Siberian Sea
South Atlantic: offshore Argentina, offshore South Africa
South China Sea: offshore NW Borneo & NW Palawan

Five Relevant Publications
Franke D., U, Barckhausen, N Baristeas, M. Engels, S. Ladage, R. Lutz, J. Montano, N. Pellejera, E.G. Ramos, M. Schnabel **(**2011). The continent-ocean transition at the southeastern margin of the South China Sea. *Marine and Petroleum Geology*, 28: 1187–1204.

Franke, D., Barckhausen, U., Heyde, I., Tingay, M., Ramli, N., (2008). Seismic images of a collision zone offshore NW Sabah/Borneo, *Marine and Petroleum Geology* 25, doi:10.1016/j.marpetgeo.2007.11.004, 606-624.

Hesse, Susanne, Back, Stefan, Franke, Dieter (2008). The deep-water fold-and-thrust belt offshore NW Borneo: gravity-driven versus basement-driven shortening. *Geological Society of America Bulletin* 121 (5-6), 939-953.

Franke, D., Neben, S., Ladage, S., Schreckenberger, B., Hinz, K. (2007). Margin segmentation and volcano-tectonic architecture along the volcanic margin off Argentina/Uruguay, South Atlantic, *Marine Geology*, Vol. 244/1-4, pp. 46-67, doi:10.1016/j.margeo.2007.06.009.

Franke, D. & Hinz, K., (2005). The structural style of sedimentary basins on the shelves of the Laptev Sea and the western East Siberian Sea, Siberian Arctic, *Journal of Petroleum Geology* 28(3), 269-286.

Five Other Significant Publications

Franke, D., Schnabel, M., Ladage, S., Tappin, D.R., Neben, S., Djajadihardja, Y.S., Müller, C., Kopp, H., Gaedicke, C., (2008). The great Sumatra–Andaman earthquakes—Imaging the boundary between the ruptures of the great 2004 and 2005 earthquakes, *Earth and Planetary Science Letters*, Volume 269, Issues 1-2, doi:10.1016/j.epsl.2008.01.047, 118-130

Franke, D., Reichert, C., Damm, V., Piepjohn, K., (2008). The South Anyui suture, northeast Arctic Russia reveald by offshore seismic data, *Norwegian Journal of Geology* 188 (4), 189-200.

Franke, D., Hinz, K. & Oncken, O. (2001). The Laptev Sea Rift. *Marine and Petroleum Geology*, 18(10), 1083-1127.

Franke, D., Neben, S., Schreckenberger, B., Schulze, A. Stiller, M. & Kravczyk, C. (2006). Crustal structure across the Colorado Basin, offshore Argentina. *Geophysical Journal International* 165 (3), 850-864. doi: 10.1111/j.1365-246X.2006.02907.x

Franke, D., Reichert, Chr. & Hinz, K. (2004). Geology of the East Siberian Sea, Russian Arctic from seismic images: Structures, evolution and implications for the evolution of the Arctic Ocean Basin, *J. Geophys. Res*., Vol. 109, No. B7, B07106, 10.1029/2003JB002687, 1-19.

Course Taught

Reflection seismics – What is real? RWTH Aachen University, Germany

Thesis Advisor

Susanne Hesse, 2007 – present, PhD

Kathrin Becker, 2009 – present, PhD

IODP Site Summary Forms:

Form 1 - General Site Information

Please fill out information in all gray boxes

New ☐ **Revised** ☑

Section A: Proposal Information

Title of Proposal:	**Opening of the South China Sea and its implications for Southeast Asian tectonics, climates, and deep mantle processes since the early Mesozoic**
Date Form Submitted:	July, 2011
Site Specific Objectives with Priority (Must include general objectives in proposal)	1. To test the hypothesis that a ridge jump occurred around 26 Ma by coring and dating the sedimentary and volcanic rocks. 2. To measure the magnetization, mineralization, and geochemical compositions of basement rocks and reveal the causes of the sharp magnetic contrast between different sub-basins and around the magnetic anomaly C8. 3. To correlate the ages from magnetic anomalies to fossil, magnetostratigraphic, and radioactive ages. 4. To reveal the sedimentary and climatic responses to the opening of the South China Sea.
List Previous Drilling in Area:	ODP Leg 184: Asian Monsoon

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**SCS-2B**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	The East Sub-basin of the South China Sea
Latitude:	Deg: 17	Min: 16.170	Jurisdiction:	
Longitude:	Deg: 116	Min: 48.492	Distance to Land:	333 km
Coordinates System:	WGS 84,	Other ( )		
Priority of Site:	Primary: Yes	Alt:	Water Depth:	3911 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	720 What is the total sed. thickness? 720 m	30
		Total Penetration: **750** m
General Lithologies:	Mudstone, siltstone, sandstone	Basalt

Coring Plan: *(Specify or check)*

1-2-3-APC, XCB, RCB.

1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ☐ RCB ☐ Re-entry ☐ HRGB ☐

** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	■	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	■	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma Ray	☐
Gamma Ray	■	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	■	Side-Wall Core Sampling	☐				
Acoustic	■						
Formation Image	■			Others ( )		Others ( )	

Max.Borehole Temp. : *Expected value (For Riser Drilling)* ________ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from ________ m to ________ m, ________ m intervals

from ________ m to ________ m, ________ m intervals

Basic Sampling Intervals: 5m

Estimated days:

Drilling/Coring: 4.4	Logging: 1.6	Total On-Site: 6.0

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Methane Hydrate	☐
Abnormal Pressure	☐	Fractured Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☐
CO_2	☐				

What is your Weather window? (Preferable period with the reasons)

Not in monsoon, (June to September)

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New [X] *Revised* [ ]

Proposal #: 735-CPP	Site #: SCS-2B	Date Form Submitted: July, 2011

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s) :Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) 973SCSIO_1C SP: 10730 Crossing Lines(s): Not yet available
3	Seismic Velocity†			Stacking and interval velocities
4	Seismic Grid			Nearby seismic lines from GMGS, and from cruises by R/V Vema in 1980, R/V Conrad and R/V Haiyang IV in1985, and R/V Sonne in the years 1987 (SO-50B), 1990 (SO-72A) and 1994 (SO-95). One additional transect from SCSIO. (Fig. 3)
5a	Refraction (surface)			Profiler-Sonobuoy measurements (Ludwig et al., 1979)
5b	Refraction (near bottom)			OBS1993 (Yan et al., 2001); New OBS measurements in 2010 and 2011 by SCSIO and The second Institute of Oceanography.
6	3.5 kHz			Location of Site on line (Time) None
7	Swath bathymetry			Available and accessible to proponents at GMGS and The second Institute of Oceanography.
8a	Side-looking sonar (surface)			None
8b	Side-looking sonar (bottom)			None
9	Photography or Video			None
10	Heat Flow			Regional compilation by Shi et al. (2003) and Li et al. (2010), including in particular the heat flow data from Taylor and Hayes (1983) and Nissen et al. (1995) that are from sites very close to SCS-2B. Heat flow are also available from the nearby sites of ODP Leg 184 (Wang et al., 2000)
11a	Magnetics			Data grids from Geological Survey of Japan and Coordinating Committee for Coastal and Offshore Geoscience Programmes in East and Southeast Asia (CCOP). New magnetic data from SCSIO.
11b	Gravity			1’ free-air gravity grid (V. 16.1) from Sandwell and Smith (1997)
12	Sediment cores			Available at ODP Leg 184 sites. Also Piston cores by R/V Vema and R/V Conrad (Damuth, 1980)
13	Rock sampling			None
14a	Water current data			
14b	Ice Conditions			None
15	OBS microseismicity			None
16	Navigation			Available for numerous 2D lines on or near the drilling site.
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

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.

IODP Site Summary Forms:

Form 3 - Detailed Logging Plan

New ☐ *Revised* ☒ X

Proposal #: 735-CPP	Site #: SCS-2B	Date Form Submitted: July, 2011
Water Depth (m): 3911	Sed. Penetration (m): 720	Basement Penetration (m): 30

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ■

Are high temperatures expected at this site? Yes ☐ No ■

Are there any other special requirements for logging at this site? Yes ☐ No ■

If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be: 1.6 days

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Decompaction, backstripping, and subsidence analysis in order to better understand the rifting episodes. Also critical for seismic interpretation.	1
Litho-Density	Seismic interpretation. Basic information required for better gravity modeling/inversion such that the regional tectonics can be better inferred.	1
Natural Gamma Ray	Seismic interpretation of lithology. Also compensation for poor core recoveries.	1
Resistivity-Induction	Seismic interpretation of lithology and structures. Also compensation for poor core recoveries.	1
Acoustic	For time-depth conversion, and for estimating porosities, and for identifications of lithological boundaries or unconformities.	1
FMS	For mapping fractures, faults, foliations in both basement and overlying sediment. Will provide important constraints on tectonic evolution and emplacement history of basement.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility	For magnetic modeling and inversion, and for correlations of magnetic anomalies. Important for interpretations of the basement.	1
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	Temperature probe to estimate heat flow.	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

Form 4 – Pollution & Safety Hazard Summary

IODP Site Summary Forms:

Please fill out information in all gray boxes

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: SCS-2B	Date Form Submitted: July, 2011

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Triple-APC to refusal, XCB to 250 m, RCB to target depth. Log as shown on form 3.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	Sites of ODP Leg 184 to the north have no hydrocarbon occurrences of greater than background levels
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	No commercial drilling within the oceanic basin of the South China Sea. Producing wells are located far north on the continental shelf in the Pearl River Mouth Basin, and on the continental slope in the Baiyun Depression.
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What "special" precautions will be taken during drilling?	Continuous monitoring under IODP safety standards.
7	What abandonment procedures do you plan to follow:	Per IODP standard operating procedure.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	
9	Summary: What do you consider the major risks in drilling at this site?	Ocean currents

IODP Site Summary Forms:

Form 5 – Lithologic Summary

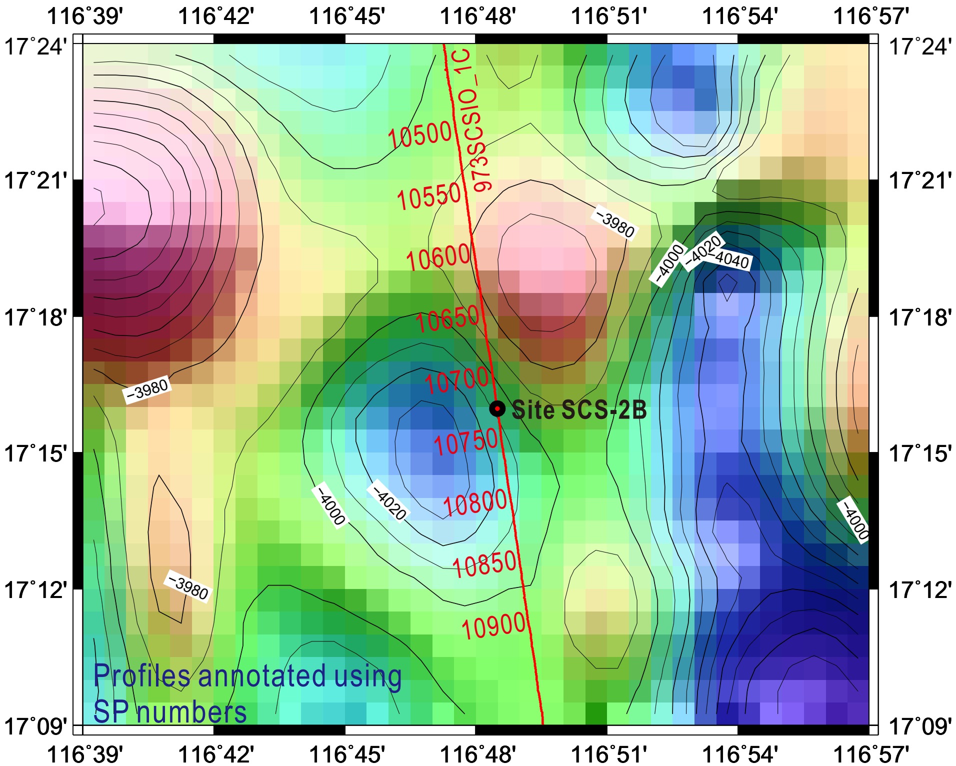
New [ ] *Revised* [X]

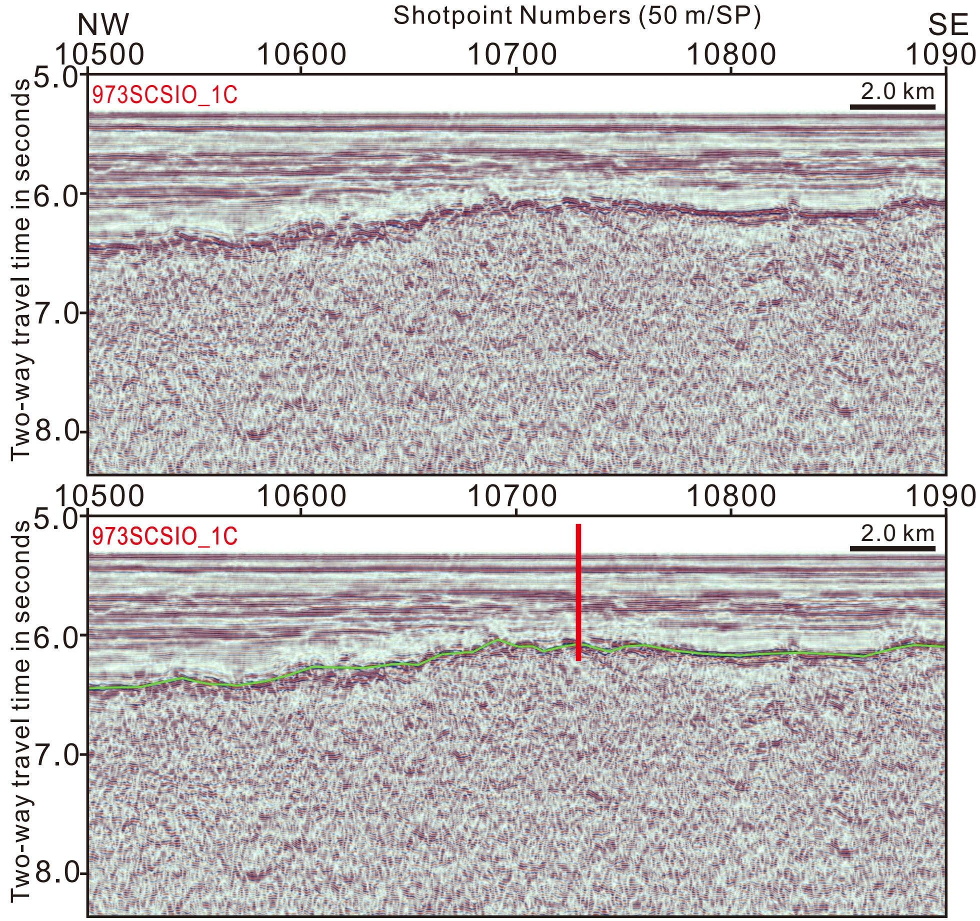
Proposal #: 735-CPP	Site #: SCS-2B	Date Form Submitted: July, 2011

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0~720		0~26 Ma	2.4	Siltstone and sandstone	Shallow to deep marine	27.7	Ages and lithology are estimated from published data, and from correlations of seismic facies.
	Top Basement						
720-750		~26 Ma	3.9	Basalt	Oceanic crust		Sedimentary rates are only very rough estimates.

Site Summary Form 6

Proposal 735-CPP
Site SCS-2B





SSDB locations of these graphics and supporting data

Will be submitted soon after the submission of this CPP proposal

Site SCS-2B
SP 10730 on 973SCSIO_1C

Interpretation

Green-Top basement

IODP Site Summary Forms:

Form 1 - General Site Information

Please fill out information in all gray boxes

New [ ] **Revised** [✓]

Section A: Proposal Information

Title of Proposal:	**Opening of the South China Sea and its implications for Southeast Asian tectonics, climates, and deep mantle processes since the early Mesozoic**
Date Form Submitted:	July, 2011
Site Specific Objectives with Priority (Must include general objectives in proposal)	1. To determine the ages of the East Sub-basin, and correlate the ages from magnetic anomalies to fossil, magnetostratigraphic, and radioactive ages. 2. To measure the magnetization, mineralization, and geochemical compositions of basement rocks and reveal the causes of the sharp magnetic contrast between different sub-basins. 3. To test the hypothesis that the East Sub-basin formed in an area already floored by an older oceanic crust. 4. To reveal the sedimentary and climatic responses to the opening of the South China Sea.
List Previous Drilling in Area:	None

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**SCS-3A**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	The East Sub-basin of the South China Sea
Latitude:	Deg: 13	Min: 56.8176	Jurisdiction:	
Longitude:	Deg: 116	Min: 46.1418	Distance to Land:	371 km
Coordinates System:	WGS 84,	Other ( )		
Priority of Site:	Primary: Yes	Alt:	Water Depth:	4206 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	596 What is the total sed. thickness? 596 m	30
		Total Penetration: **626** m

General Lithologies:	Mudstone, siltstone, sandstone	Basalt
Coring Plan: *(Specify or check)*	1-2-3-APC, XCB, RCB. 1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ☐ RCB ☐ Re-entry ☐ HRGB ☐ ** Systems Currently Under Development*	

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	■	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	■	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma Ray	☐
Gamma Ray	■	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	■	Side-Wall Core Sampling	☐				
Acoustic	■						
Formation Image	■			Others ( )		Others ( )	

Max.Borehole Temp. : *Expected value (For Riser Drilling)* ____________°C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from ________ m to ________ m, __________ m intervals

from ________ m to ________ m, __________ m intervals

Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring: 3.8	Logging: 1.2	Total On-Site: 5.0

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Methane Hydrate	☐
Abnormal Pressure	☐	Fractured Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☐
CO_2	☐				

What is your Weather window? (Preferable period with the reasons)

Not in monsoon, (June to September)

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: SCS-3A	Date Form Submitted: July, 2011

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s) :Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) 973SCSIO_2A SP: 606 Crossing Lines(s):
3	Seismic Velocity†			Stacking and interval velocities; OBS velocities
4	Seismic Grid			2D multi-channel seismic line from R/V Sonne in 1987 and 2008. One additional transect from SCSIO.
5a	Refraction (surface)			Wide-angle reflection and refraction data from sonobuoys in the central SCS basin by R/V Vema and R/V Conrad (Ludwig et al., 1967; Ludwig, 1970; 1979; Taylor and Hayes, 1980). Two stages of Sino-US cooperation in the early 1980s that have sonobuoy measurements and two ship expanding spread profile.
5b	Refraction (near bottom)			New OBS measurements in 2010 and 2011 by SCSIO and The second Institute of Oceanography.
6	3.5 kHz			Location of Site on line (Time) None
7	Swath bathymetry			Available and accessible to proponents at GMGS and The second Institute of Oceanography.
8a	Side-looking sonar (surface)			None
8b	Side-looking sonar (bottom)			None
9	Photography or Video			None
10	Heat Flow			Regional compilation by Shi et al. (2003) and Li et al. (2010)
11a	Magnetics			Data grids from Geological Survey of Japan and Coordinating Committee for Coastal and Offshore Geoscience Programmes in East and Southeast Asia (CCOP). New magnetic data from SCSIO
11b	Gravity			1’ free-air gravity grid (V. 16.1) from Sandwell and Smith (1997)
12	Sediment cores			Piston cores by R/V Vema and R/V Conrad (Damuth, 1980)
13	Rock sampling			None
14a	Water current data			
14b	Ice Conditions			None
15	OBS microseismicity			None
16	Navigation			Available for numerous 2D lines on or near the drilling site.
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

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.

IODP Site Summary Forms:

Form 3 - Detailed Logging Plan

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: SCS-3A	Date Form Submitted: July, 2011
Water Depth (m): 4206	Sed. Penetration (m): 596	Basement Penetration (m): 30

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ■

Are high temperatures expected at this site? Yes ☐ No ■

Are there any other special requirements for logging at this site? Yes ☐ No ■

If "Yes" Please describe requirements:______________________________

____

What do you estimate the total logging time for this site to be:___1.2 day___

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Decompaction, backstripping, and subsidence analysis in order to better understand the rifting episodes. Also critical for seismic interpretation.	1
Litho-Density	Seismic interpretation. Basic information required for better gravity modeling/inversion such that the regional tectonics can be better inferred.	1
Natural Gamma Ray	Seismic interpretation of lithology. Also compensation for poor core recoveries.	1
Resistivity-Induction	Seismic interpretation of lithology and structures. Also compensation for poor core recoveries.	1
Acoustic	For time-depth conversion, and for estimating porosities, and for identifications of lithological boundaries or unconformities.	1
FMS	For mapping fractures, faults, foliations in both basement and overlying sediment. Will provide important constraints on tectonic evolution and emplacement history of basement.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility	For magnetic modeling and inversion, and for correlations of magnetic anomalies. Important for interpretations of the basement.	1
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	Temperature probe to estimate heat flow.	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

Form 4 – Pollution & Safety Hazard Summary

IODP Site Summary Forms:

Please fill out information in all gray boxes

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: SCS-3A	Date Form Submitted: July, 2011

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Triple-APC to refusal, XCB to 250 m, RCB to target depth. Log as shown on form 3.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	No previous DSDP/ODP/IODP drilling
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	No commercial drilling within the oceanic basin of the South China Sea.
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What “special” precautions will be taken during drilling?	Continuous monitoring under IODP safety standards.
7	What abandonment procedures do you plan to follow:	Per IODP standard operating procedure.
8	Please list other natural or manmade hazards which may effect ship’s operations: (e.g. ice, currents, cables)	
9	Summary: What do you consider the major risks in drilling at this site?	

IODP Site Summary Forms:

Form 5 – Lithologic Summary

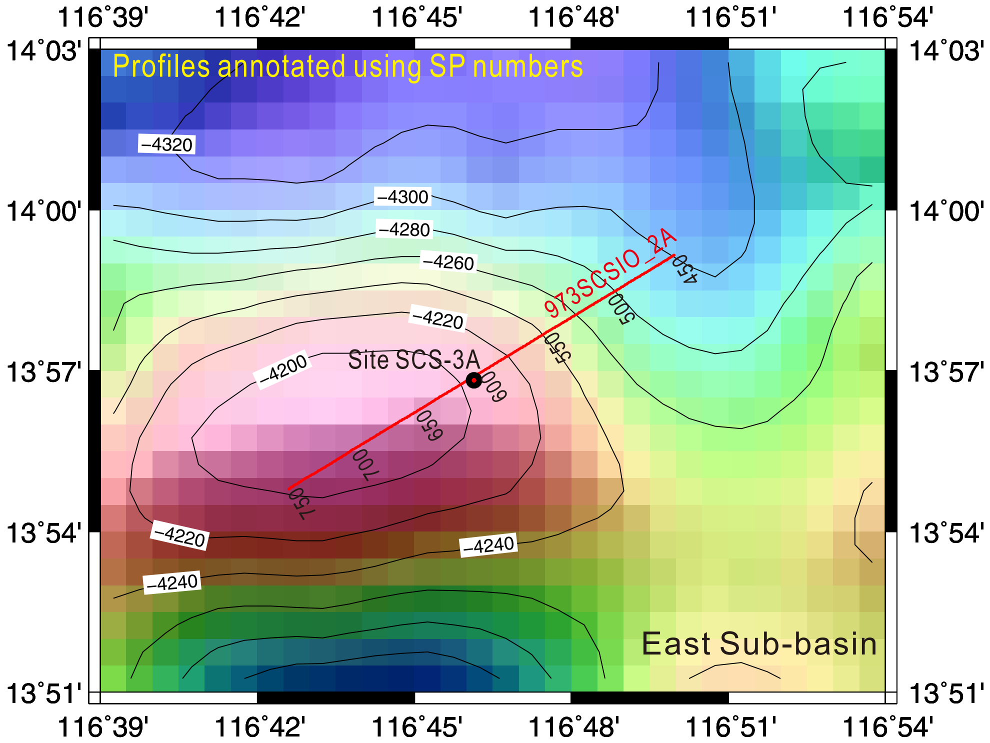
New [ ] *Revised* [X]

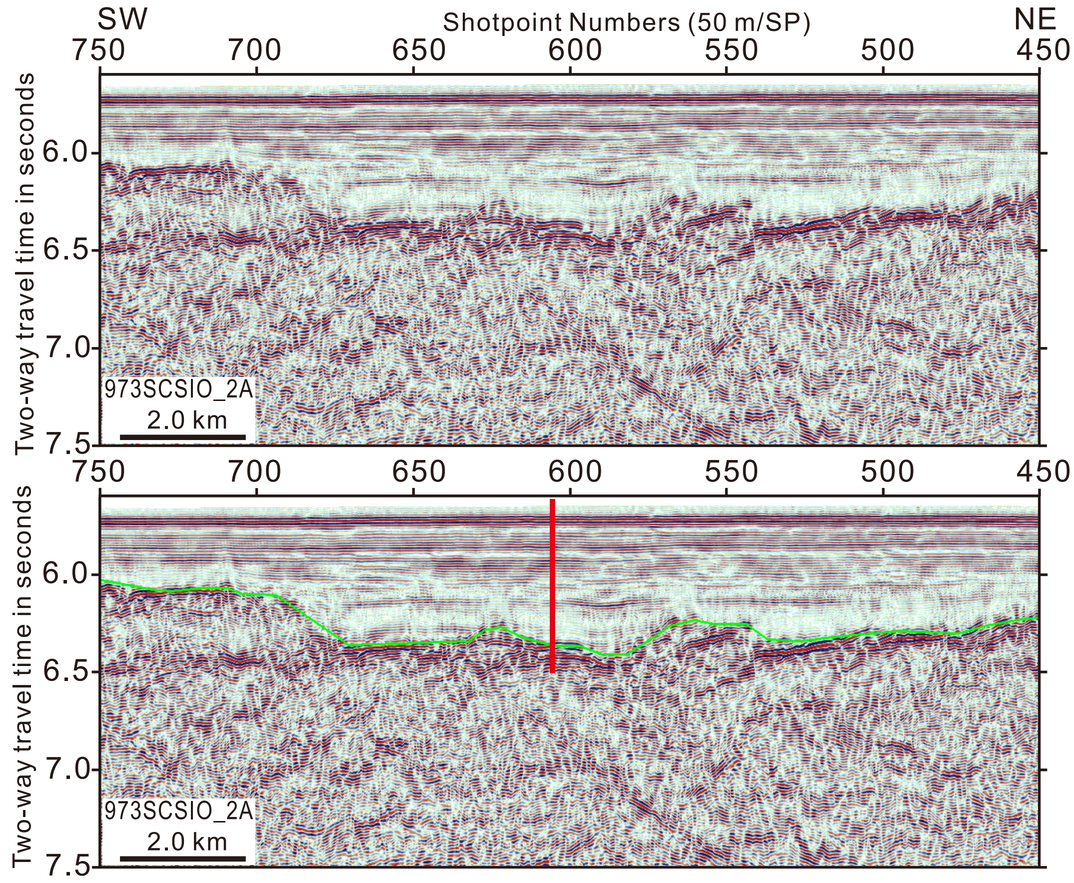
Proposal #: 735-CPP	Site #: SCS-3A	Date Form Submitted: July, 2011

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0~596		0~22 Ma	1.7	Siltstone and sandstone	Shallow to deep marine	27.1	Ages and lithology are estimated from published data, and from correlations of seismic facies.
	Top Basement						
597-696		~22 Ma		Basalt	Oceanic crust		Sedimentary rates are only very rough estimates.

Proposal 735-CPP
Site SCS-3A

Site Summary Form 6





Site SCS-3A
SP 606 on 973SCSIO_2A

Interpretation

Green-Top basement

SSDB locations of these graphics and supporting data

Will be submitted soon after the submission of this full proposal

IODP Site Summary Forms:

Form 1 - General Site Information

Please fill out information in all gray boxes

New [ ] **Revised** [✓]

Section A: Proposal Information

Title of Proposal:	**Opening of the South China Sea and its implications for Southeast Asian tectonics, climates, and deep mantle processes since the early Mesozoic**
Date Form Submitted:	July, 2011
Site Specific Objectives with Priority (Must include general objectives in proposal)	1. To determine the age of the Southwest Sub-basin, and correlate the ages from magnetic anomalies to fossil, magnetostratigraphic, and radioactive ages. 2. To measure the magnetization, mineralization, and geochemical compositions of basement rocks and reveal the causes of the sharp magnetic contrast between different basins. 3. To test the hypothesis that the Southwest Sub-basin evolved within a continental crust by continental margin rifting. 4. To reveal the sedimentary and climatic responses to the opening of the South China Sea.
List Previous Drilling in Area:	None

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**SCS-4B**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	The Southwest Sub-basin of the South China Sea
Latitude:	Deg: 12	Min: 55.137	Jurisdiction:	
Longitude:	Deg: 115	Min: 2.8326	Distance to Land:	515 km
Coordinates System:	WGS 84,	Other ( )		
Priority of Site:	Primary: Yes	Alt:	Water Depth:	4383 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	865 What is the total sed. thickness? 865 m	30
		Total Penetration: **895** m
General Lithologies:	Mudstone, siltstone, sandstone	Basalt

Coring Plan: *(Specify or check)*

1-2-3-APC, XCB, RCB.

1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ☐ RCB ☐ Re-entry ☐ HRGB ☐

** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	■	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	■	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma Ray	☐
Gamma Ray	■	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	■	Side-Wall Core Sampling	☐				
Acoustic	■						
Formation Image	■			Others ( )		Others ( )	

Max.Borehole Temp. : *Expected value (For Riser Drilling)* ____________°C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from ________ m to ________ m, __________ m intervals

from ________ m to ________ m, __________ m intervals

Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring: 5.1	Logging: 1.4	Total On-Site: 6.5

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Methane Hydrate	☐
Abnormal Pressure	☐	Fractured Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☐
CO_2	☐				

What is your Weather window? (Preferable period with the reasons)

Not in monsoon, (June to September)

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: SCS-4B	Date Form Submitted: July, 2011

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s) :Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) 973SCSIO_2B SP: 4847 Crossing Lines(s): SIOSOA_NDS3 CMP: 23521
3	Seismic Velocity†			Stacking and interval velocities; OBS velocities
4	Seismic Grid			2D multi-channel seismic line from R/V Sonne in 1987 and 2008. One additional transect from SCSIO.
5a	Refraction (surface)			Wide-angle reflection and refraction data from sonobuoys in the central SCS basin by R/V Vema and R/V Conrad (Ludwig et al., 1967; Ludwig, 1970; 1979; Taylor and Hayes, 1980). Two stages of Sino-US cooperation in the early 1980s that have sonobuoy measurements and two ship expanding spread profile.
5b	Refraction (near bottom)			New OBS measurements in 2010 and 2011 by SCSIO and The second Institute of Oceanography.
6	3.5 kHz			Location of Site on line (Time) None
7	Swath bathymetry			Available and accessible to proponents at GMSG and The second Institute of Oceanography. (Li et al., 2002)
8a	Side-looking sonar (surface)			None
8b	Side-looking sonar (bottom)			None
9	Photography or Video			None
10	Heat Flow			Regional compilation by Shi et al. (2003) and Li et al. (2010)
11a	Magnetics			Data grids from Geological Survey of Japan and Coordinating Committee for Coastal and Offshore Geoscience Programmes in East and Southeast Asia (CCOP). New magnetic data from SCSIO
11b	Gravity			1' free-air gravity grid (V. 16.1) from Sandwell and Smith (1997)
12	Sediment cores			Piston cores by R/V Vema and R/V Conrad (Damuth, 1980)
13	Rock sampling			None
14a	Water current data			
14b	Ice Conditions			None
15	OBS microseismicity			None
16	Navigation			Available for numerous 2D lines on or near the drilling site. (Fig. 3)
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

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.

IODP Site Summary Forms:

Form 3 - Detailed Logging Plan

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: SCS-4B	Date Form Submitted: July, 2011
Water Depth (m): 4383	Sed. Penetration (m): 865	Basement Penetration (m): 30

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ■

Are high temperatures expected at this site? Yes ☐ No ■

Are there any other special requirements for logging at this site? Yes ☐ No ■

If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be: 1.4 days

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Decompaction, backstripping, and subsidence analysis in order to better understand the rifting episodes. Also critical for seismic interpretation.	1
Litho-Density	Seismic interpretation. Basic information required for better gravity modeling/inversion such that the regional tectonics can be better inferred.	1
Natural Gamma Ray	Seismic interpretation of lithology. Also compensation for poor core recoveries.	1
Resistivity-Induction	Seismic interpretation of lithology and structures. Also compensation for poor core recoveries.	1
Acoustic	For time-depth conversion, and for estimating porosities, and for identifications of lithological boundaries or unconformities.	1
FMS	For mapping fractures, faults, foliations in both basement and overlying sediment. Will provide important constraints on tectonic evolution and emplacement history of basement.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility	For magnetic modeling and inversion, and for correlations of magnetic anomalies. Important for interpretations of the basement.	1
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	Temperature probe to estimate heat flow.	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

Form 4 – Pollution & Safety Hazard Summary

IODP Site Summary Forms:

Please fill out information in all gray boxes

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: SCS-4B	Date Form Submitted: July, 2011

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Triple-APC to refusal, XCB to 250 m, RCB to target depth. Log as shown on form 3.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	No previous DSDP/ODP/IODP drilling
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	No commercial drilling within the oceanic basin of the South China Sea.
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What “special” precautions will be taken during drilling?	Continuous monitoring under IODP safety standards.
7	What abandonment procedures do you plan to follow:	Per IODP standard operating procedure.
8	Please list other natural or manmade hazards which may effect ship’s operations: (e.g. ice, currents, cables)	
9	Summary: What do you consider the major risks in drilling at this site?	

IODP Site Summary Forms:

Form 5 – Lithologic Summary

New [ ] *Revised* [X]

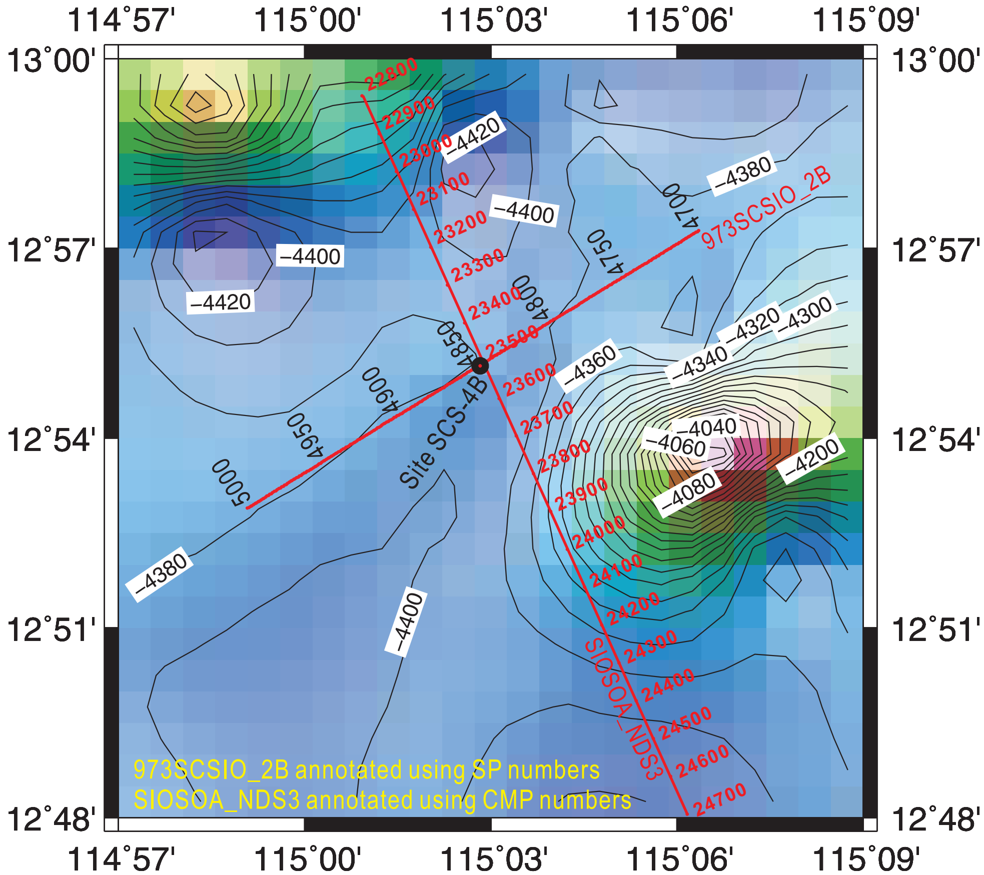
Proposal #: 735-CPP	Site #: SCS-4B	Date Form Submitted: July, 2011

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0~865		0~22 Ma	1.95	Siltstone and sandstone	Shallow to deep marine	39.3	Ages and lithology are estimated from published data, and from correlations of seismic facies.
	Top Basement						
865-895		~22 Ma	3.9	Basalt	Oceanic crust		Sedimentary rates are only very rough estimates.

Proposal 735
Site SCS-4B

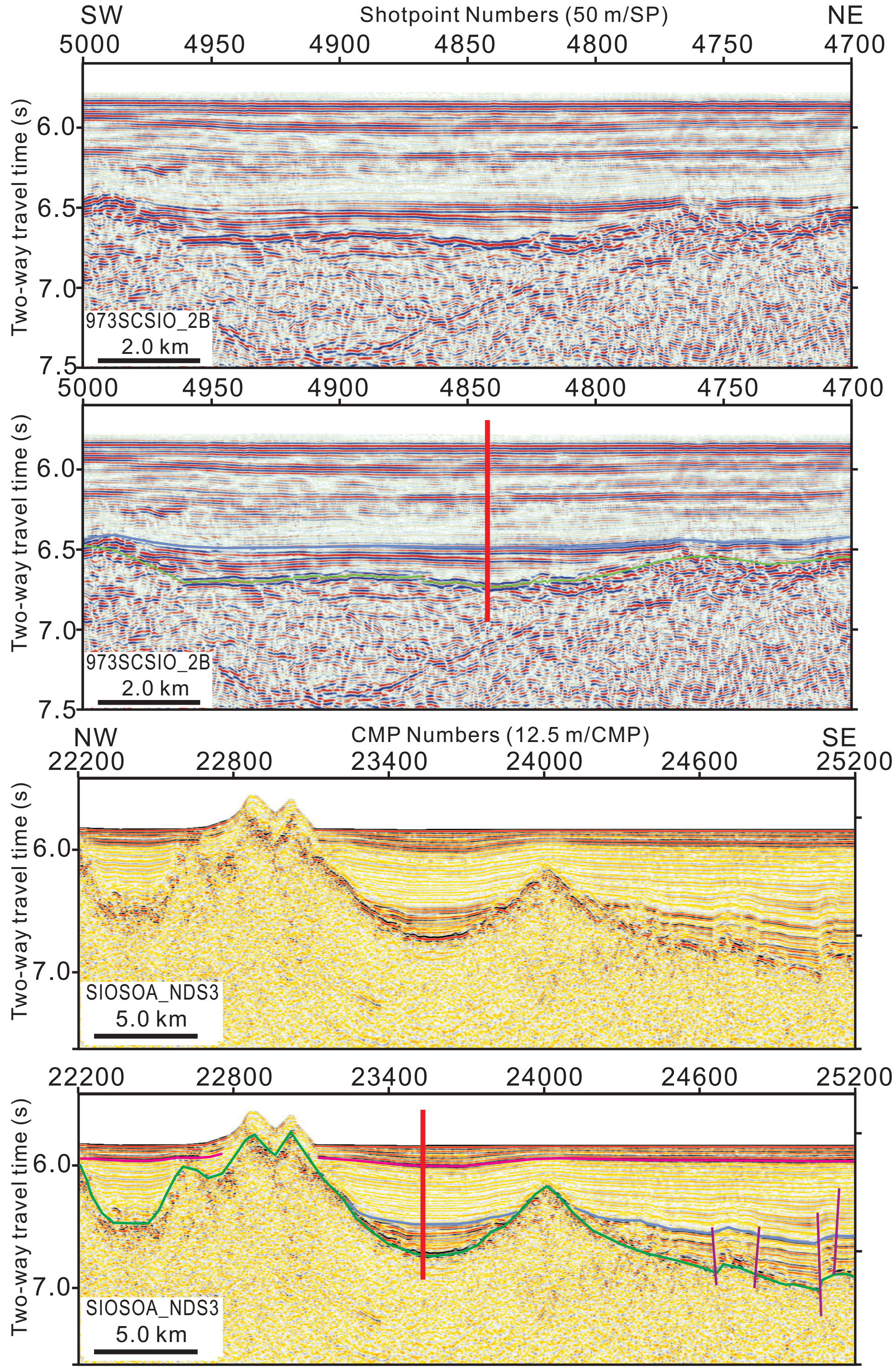
Site Summary Form 6

Site SCS-4B
SP 4847 on 973SCSIO_2B
CMP 23521 on SIOSOA_NDS3



SSDB locations of these graphics and supporting data

Will be submitted soon after the submission of this full proposal



Interpretation

Pink-Top Pliocene ?
Blue-uncertain
Green-Top basement
Purple-Fault

IODP Site Summary Forms:

Form 1 - General Site Information

Please fill out information in all gray boxes

New ☐ **Revised** ☑

Section A: Proposal Information

Title of Proposal:	**Opening of the South China Sea and its implications for Southeast Asian tectonics, climates, and deep mantle processes since the early Mesozoic**
Date Form Submitted:	July, 2011
Site Specific Objectives with Priority (Must include general objectives in proposal)	1. To test the hypothesis that the Zhongnan Ridge evolved from a transform fault under compression. 2. To test whether strong fluid activities deep from the mantle have accompanied with fracturing and 3. To examine whether there developed serpentinized mud volcanoes and in-situ serpentinization and magnetization in the lower crust and upper mantle 4. To determine the age of the oceanic crust, and correlate the ages from magnetic anomalies to fossil, magnetostratigraphic, and radioactive ages. 5. To measure the magnetization, mineralization, and geochemical compositions of basement rocks and reveal the causes of the sharp magnetic contrast between different basins.
List Previous Drilling in Area:	None

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**SCS-5A**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	South China Sea
Latitude:	Deg: 13	Min: 20.848	Jurisdiction:	
Longitude:	Deg: 115	Min: 45.7188	Distance to Land:	509 km
Coordinates System:	WGS 84,	Other ( )		
Priority of Site:	Primary: Yes	Alt:	Water Depth:	3792 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	50 What is the total sed. thickness? 50 m	30
		Total Penetration: **80** m
General Lithologies:	Mudstone, siltstone, sandstone	Basalt

Coring Plan: *(Specify or check)*

1-2-3-APC, RCB.

1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ☐ RCB ☐ Re-entry ☐ HRGB ☐

** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	■	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	■	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma Ray	☐
Gamma Ray	■	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	■	Side-Wall Core Sampling	☐				
Acoustic	■						
Formation Image	■			Others ( )		Others ( )	

Max.Borehole Temp. : *Expected value (For Riser Drilling)* ____________°C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from ________ m to ________ m, __________ m intervals

from ________ m to ________ m, __________ m intervals

Basic Sampling Intervals: 5m

Estimated days:

Drilling/Coring: 1.3	Logging: 0.7	Total On-Site: 2.0

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Methane Hydrate	☐
Abnormal Pressure	☐	Fractured Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☐
CO_2	☐				

What is your Weather window? (Preferable period with the reasons)

Not in monsoon, (June to September)

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: SCS-5A	Date Form Submitted: July, 2011

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s) :Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) 973SCSIO_2A SP: 3064 Crossing Lines(s): Not yet available
3	Seismic Velocity†			Stacking and interval velocities; OBS velocities
4	Seismic Grid			2D multi-channel seismic line from R/V Sonne in 1987 and 2008. One additional transect from SCSIO.
5a	Refraction (surface)			Wide-angle reflection and refraction data from sonobuoys in the central SCS basin by R/V Vema and R/V Conrad (Ludwig et al., 1967; Ludwig, 1970; 1979; Taylor and Hayes, 1980). Two stages of Sino-US cooperation in the early 1980s that have sonobuoy measurements and two ship expanding spread profile.
5b	Refraction (near bottom)			New OBS measurements in 2010 and 2011 by SCSIO and The second Institute of Oceanography.
6	3.5 kHz			Location of Site on line (Time) None
7	Swath bathymetry			Available and accessible to proponents at GMSG and The second Institute of Oceanography. (Li et al., 2002)
8a	Side-looking sonar (surface)			None
8b	Side-looking sonar (bottom)			None
9	Photography or Video			None
10	Heat Flow			Regional compilation by Shi et al. (2003) and Li et al. (2010)
11a	Magnetics			Data grids from Geological Survey of Japan and Coordinating Committee for Coastal and Offshore Geoscience Programmes in East and Southeast Asia (CCOP). New magnetic data from SCSIO
11b	Gravity			1' free-air gravity grid (V. 16.1) from Sandwell and Smith (1997)
12	Sediment cores			Piston cores by R/V Vema and R/V Conrad (Damuth, 1980)
13	Rock sampling			None
14a	Water current data			
14b	Ice Conditions			None
15	OBS microseismicity			None
16	Navigation			Available for numerous 2D lines on or near the drilling site. (Fig. 3)
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

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.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: SCS-5A	Date Form Submitted: July, 2011
Water Depth (m): 3792	Sed. Penetration (m): 50	Basement Penetration (m): 30

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ■

Are high temperatures expected at this site? Yes ☐ No ■

Are there any other special requirements for logging at this site? Yes ☐ No ■

If "Yes" Please describe requirements:______________________________

What do you estimate the total logging time for this site to be: 0.7 days

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Decompaction, backstripping, and subsidence analysis in order to better understand the rifting episodes. Also critical for seismic interpretation.	1
Litho-Density	Seismic interpretation. Basic information required for better gravity modeling/inversion such that the regional tectonics can be better inferred.	1
Natural Gamma Ray	Seismic interpretation of lithology. Also compensation for poor core recoveries.	1
Resistivity-Induction	Seismic interpretation of lithology and structures. Also compensation for poor core recoveries.	1
Acoustic	For time-depth conversion, and for estimating porosities, and for identifications of lithological boundaries or unconformities.	1
FMS	For mapping fractures, faults, foliations in both basement and overlying sediment. Will provide important constraints on tectonic evolution and emplacement history of basement.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility	For magnetic modeling and inversion, and for correlations of magnetic anomalies. Important for interpretations of the basement.	1
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	Temperature probe to estimate heat flow.	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: SCS-5A	Date Form Submitted: July, 2011

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Triple-APC to refusal, RCB to target depth. Log as shown on form 3.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	No previous DSDP/ODP/IODP drilling
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	No commercial drilling within the oceanic basin of the South China Sea.
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What “special” precautions will be taken during drilling?	Continuous monitoring under IODP safety standards.
7	What abandonment procedures do you plan to follow:	Per IODP standard operating procedure.
8	Please list other natural or manmade hazards which may effect ship’s operations: (e.g. ice, currents, cables)	
9	Summary: What do you consider the major risks in drilling at this site?	

IODP Site Summary Forms:

Form 5 – Lithologic Summary

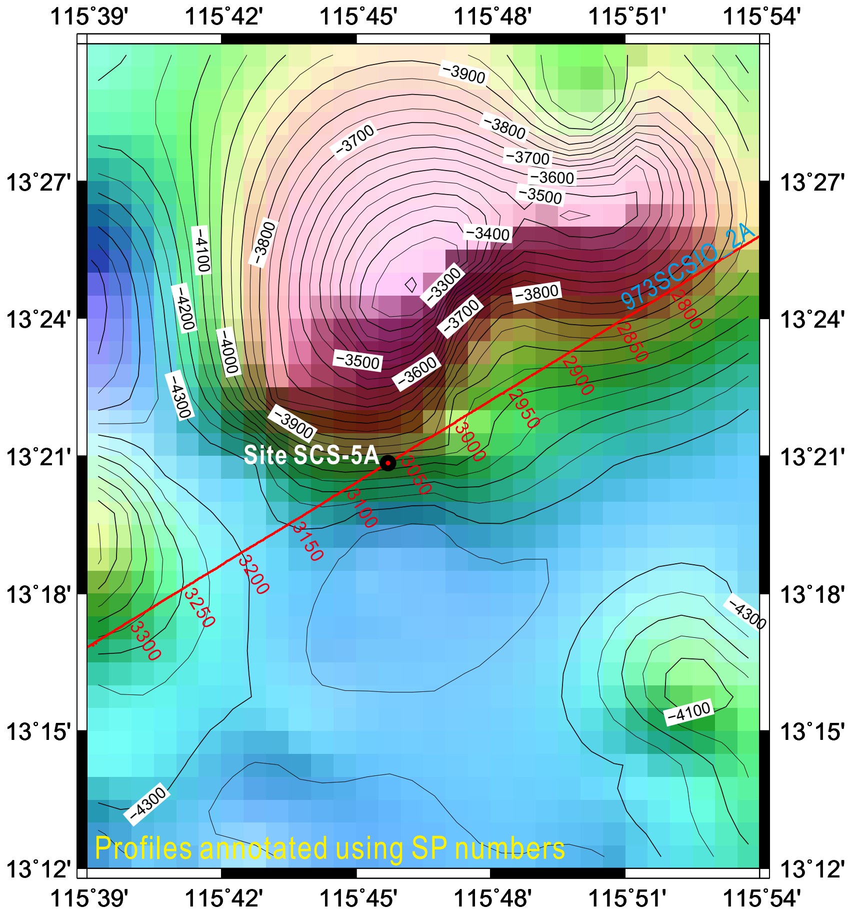
New [ ] *Revised* [X]

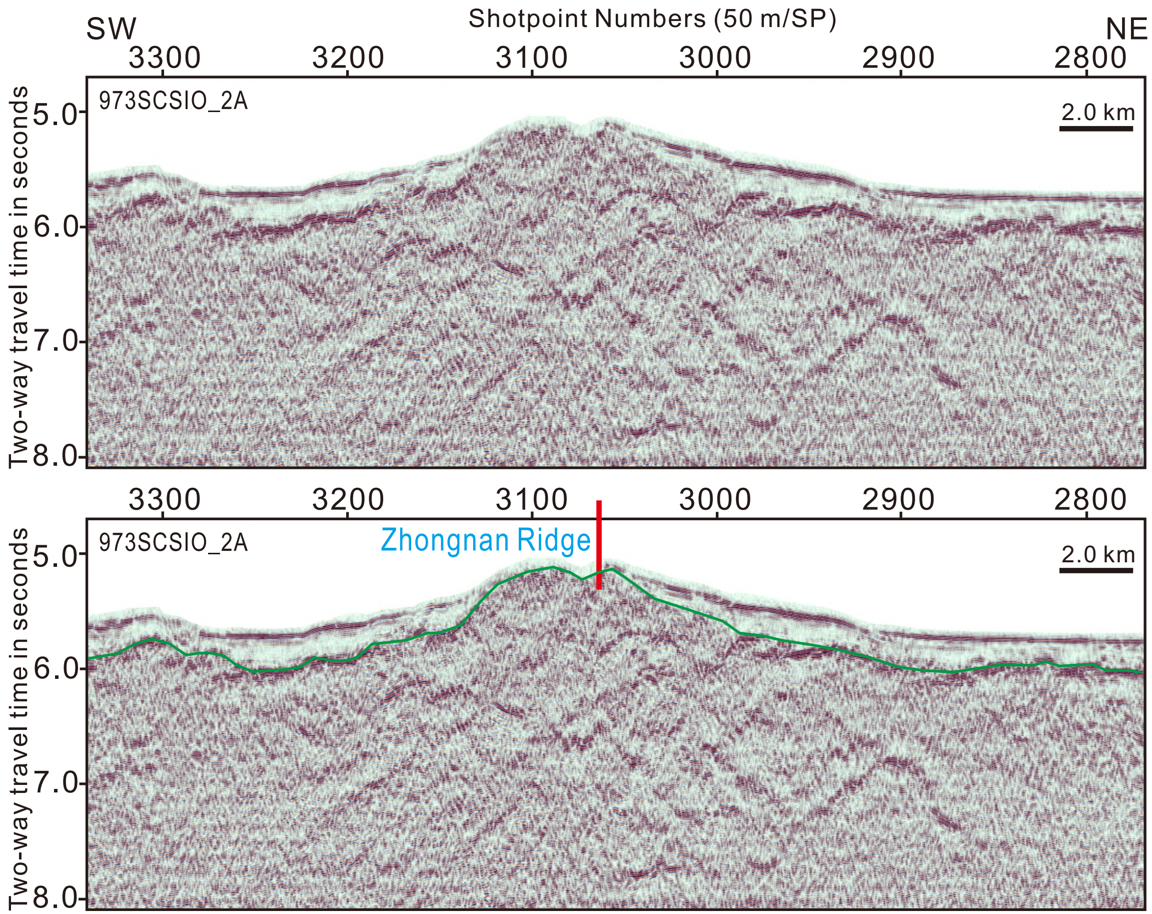
Proposal #: 735-CPP	Site #: SCS-5A	Date Form Submitted: July, 2011

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0~50		0~15 Ma	1.6	Mud and Silts	deep marine	3.3	Ages and lithology are estimated from published data, and from correlations of seismic facies. Sedimentary rates are only very rough estimates.
	Top Basement						
50-80		~22 Ma	3.9	Basalt	Oceanic crust		

Site Summary Form 6

Proposal 735-CPP
Site SCS-5A





SSDB locations of these graphics and supporting data

Will be submitted soon after the submission of this CPP proposal

Site SCS-5A
SP 3064 on 973SCSIO_2A

Interpretation

Green-Top basement

IODP Site Summary Forms:

Form 1 - General Site Information

Please fill out information in all gray boxes

New [ ] Revised [✓]

Section A: Proposal Information

Title of Proposal:	**Opening of the South China Sea and its implications for Southeast Asian tectonics, climates, and deep mantle processes since the early Mesozoic**
Date Form Submitted:	July, 2011
Site Specific Objectives with Priority (Must include general objectives in proposal)	1. To verify whether the Huatung Basin is of Cretaceous in age and whether or not it once belonged to the proto-SCS and/or was affiliated with the Paleo-Pacific, and whether it was once connected with the northeasternmost SCS. 2. To test the hypothesis that the Gagua Ridge is formed by oceanic crustal compression along a major fracture zone. 3. To study potential incipient development of a subduction zone.
List Previous Drilling in Area:	None

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**HTB-1A**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Huatung Basin and the Gagua Ridge
Latitude:	Deg: 21	Min: 35.9308 N	Jurisdiction:	
Longitude:	Deg: 122	Min: 54.9138 E	Distance to Land:	214 km
Coordinates System:	WGS 84,	Other ( )		
Priority of Site:	Primary: Yes	Alt:	Water Depth:	3343 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	50 What is the total sed. thickness? 50 m	30
		Total Penetration: **80** m
General Lithologies:	Mudstone, siltstone, sandstone	Basalt and gabbro

Coring Plan: *(Specify or check)*

1-2-3-APC, RCB.

1-2-3-APC [ ] VPC* [ ] XCB [ ] MDCB* [ ] PCS [ ] RCB [ ] Re-entry [ ] HRGB [ ]

** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	[x]	Borehole Televiewer	[ ]	Formation Fluid Sampling	[ ]	Density-Neutron	[ ]
Litho-Density	[x]	Nuclear Magnetic Resonance	[ ]	Borehole Temperature & Pressure	[ ]	Resistivity-Gamma Ray	[ ]
Gamma Ray	[x]	Geochemical	[ ]	Borehole Seismic	[ ]	Acoustic	[ ]
Resistivity	[x]	Side-Wall Core Sampling	[ ]				
Acoustic	[x]						
Formation Image	[x]			Others ( )		Others ( )	

Max.Borehole Temp. : *Expected value (For Riser Drilling)* ____________°C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from ________ m to ________ m, __________ m intervals

from ________ m to ________ m, __________ m intervals

Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring: 1.3	Logging: 0.7	Total On-Site: 2.0

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas	[ ]	Complicated Seabed Condition	[ ]	Hydrothermal Activity	[ ]
Hydrocarbon	[ ]	Soft Seabed	[ ]	Landslide and Turbidity Current	[ ]
Shallow Water Flow	[ ]	Currents	[ ]	Methane Hydrate	[ ]
Abnormal Pressure	[ ]	Fractured Zone	[ ]	Diapir and Mud Volcano	[ ]
Man-made Objects	[ ]	Fault	[ ]	High Temperature	[ ]
H_2S	[ ]	High Dip Angle	[ ]	Ice Conditions	[ ]
CO_2	[ ]				

What is your Weather window? (Preferable period with the reasons)

Not in monsoon (June to September)

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: HTB-1A	Date Form Submitted: July, 2011

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s) :Location of Site on line (SP or Time only) Crossing Lines(s): Not yet available
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) 973GMGS_2 SP: 2683 Crossing Lines(s): Not yet available
3	Seismic Velocity†			Stacking and interval velocities. OBS velocity.
4	Seismic Grid			Seismic lines from the ACT cruise, and other groups in Taiwan. Two additional transects from SCSIO and GMGS. (Figs. 8 & 9)
5a	Refraction (surface)			None
5b	Refraction (near bottom)			OBS studies in the TAIGER project; Early OBS experiments in the area (Chen and Jaw, 1996; Nakamura et al., 1998)
6	3.5 kHz			Location of Site on line (Time) None
7	Swath bathymetry			Multi-beam bathymetric data from Hsu et al. (2004) and that collected during the ACT cruise
8a	Side-looking sonar (surface)			None
8b	Side-looking sonar (bottom)			None
9	Photography or Video			None
10	Heat Flow			Regional compilation by Shi et al. (2003) and Li et al. (2010)
11a	Magnetics			Data grids from Geological Survey of Japan and Coordinating Committee for Coastal and Offshore Geoscience Programmes in East and Southeast Asia (CCOP). New magnetic data from Hsu et al. (1998; 2004) and from GMGS
11b	Gravity			1’ free-air gravity grid (V. 16.1) from Sandwell and Smith (1997)
12	Sediment cores			None
13	Rock sampling			Piston cores and dredges by R/V Vema and R/V Conrad (Damuth, 1980)
14a	Water current data			
14b	Ice Conditions			None
15	OBS microseismicity			None
16	Navigation			Available
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

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.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New ☐ *Revised* ☒ X

Proposal #: 735-CPP	Site #: HTB-1A	Date Form Submitted: July, 2011
Water Depth (m): 3343	Sed. Penetration (m): 50	Basement Penetration (m): 30

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ■

Are high temperatures expected at this site? Yes ☐ No ■

Are there any other special requirements for logging at this site? Yes ☐ No ■

If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be: 0.7 days

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Decompaction, backstripping, and subsidence analysis in order to better understand the rifting episodes. Also critical for seismic interpretation.	1
Litho-Density	Seismic interpretation. Basic information required for better gravity modeling/inversion such that the regional tectonics can be better inferred.	1
Natural Gamma Ray	Seismic interpretation of lithology. Also compensation for poor core recoveries.	1
Resistivity-Induction	Seismic interpretation of lithology and structures. Also compensation for poor core recoveries.	1
Acoustic	For time-depth conversion, and for estimating porosities, and for identifications of lithological boundaries or unconformities.	1
FMS	For mapping fractures, faults, foliations in both basement and overlying sediment. Will provide important constraints on tectonic evolution and emplacement history of basement.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility	For magnetic modeling and inversion, and for correlations of magnetic anomalies. Important for interpretations of the basement.	1
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	Temperature probe to estimate heat flow.	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

Form 4 – Pollution & Safety Hazard Summary

IODP Site Summary Forms:

Please fill out information in all gray boxes

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: HTB-1A	Date Form Submitted: July, 2011

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Triple-APC to refusal, RCB to target depth. Log as shown on form 3.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	No Previous DSDP/ODP drilling near this site. No hydrocarbon occurrences of greater than background levels in the South China Sea and Philippine Sea from previous DSDP/ODP legs.
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	No commercial drilling in the Huatung Basin and the Philippine Sea Basin.
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What "special" precautions will be taken during drilling?	Continuous monitoring under IODP safety standards.
7	What abandonment procedures do you plan to follow:	Per IODP standard operating procedure.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	No
9	Summary: What do you consider the major risks in drilling at this site?	No

IODP Site Summary Forms:

Form 5 – Lithologic Summary

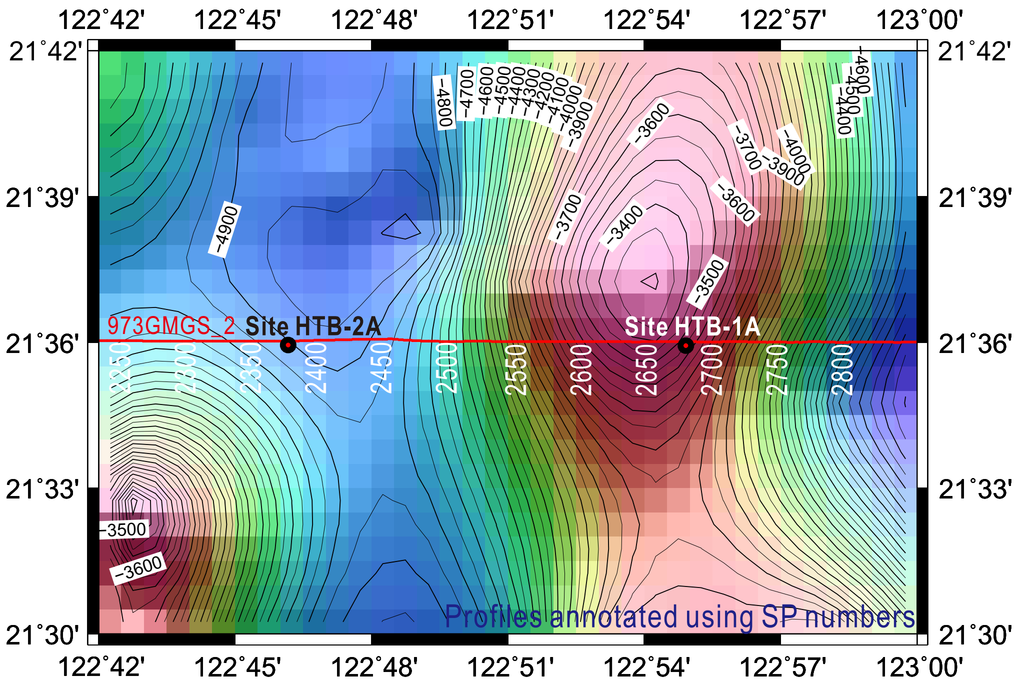
New [ ] *Revised* [X]

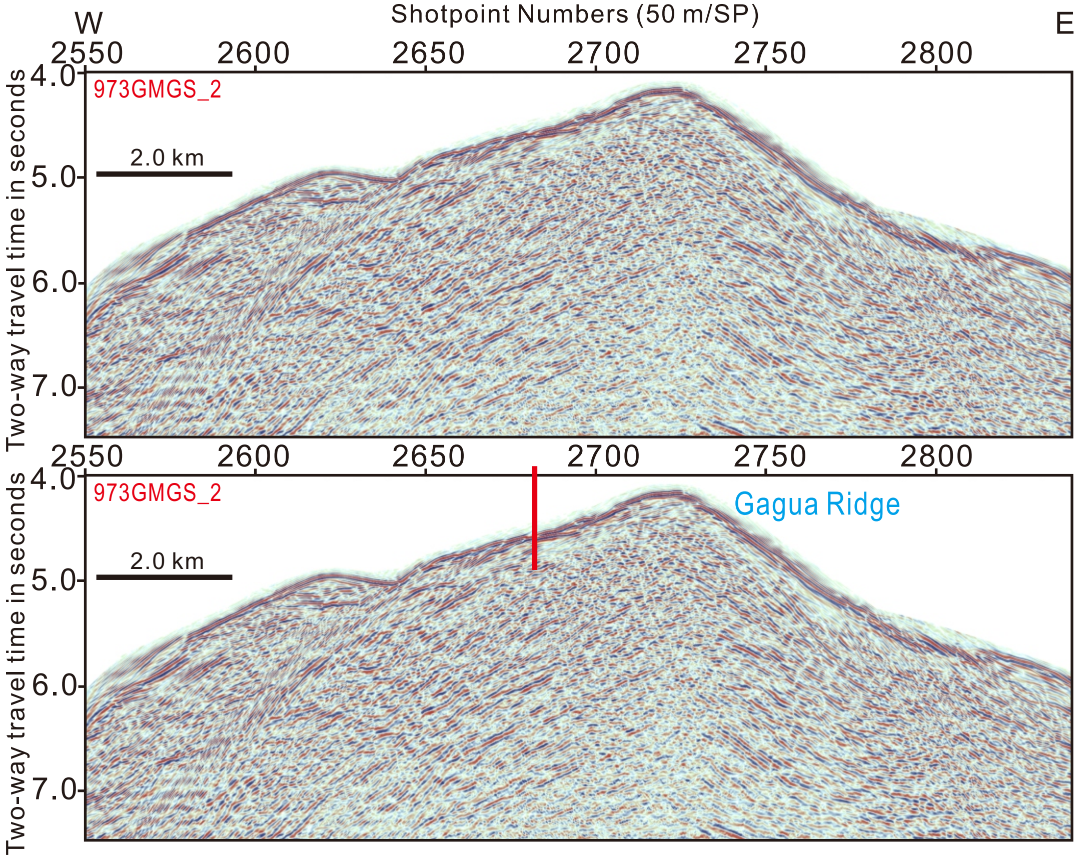
Proposal #: 735-CPP	Site #: HTB-1A	Date Form Submitted: July, 2011

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0~50	Top Basement	0-45 Ma	1.6	Muds and silts	Deep marine	1.1	The ages and sedimentary rates are only very rough estimates.
50~80		>50 Ma	3.9	Basalt and gabbro	Oceanic crust		

Proposal 735-CPP
Site HTB-1A

Site Summary Form 6





SSDB locations of these graphics and supporting data

Will be submitted soon after the submission of this CPP proposal

Site HTB-1A
SP 2683 on 973GMGS_2

IODP Site Summary Forms:

Form 1 - General Site Information

Please fill out information in all gray boxes

New [ ] Revised [✓]

Section A: Proposal Information

Title of Proposal:	**Opening of the South China Sea and its implications for Southeast Asian tectonics, climates, and deep mantle processes since the early Mesozoic**
Date Form Submitted:	July, 2011
Site Specific Objectives with Priority (Must include general objectives in proposal)	1. To verify whether the Huatung Basin is of Cretaceous in age and whether or not it once belonged to the proto-SCS and/or was affiliated with the Paleo-Pacific, and whether it was once connected with the northeasternmost SCS. 2. To reveal Mesozoic tectonic and climatic interplays between adjacent blocks. 3. To examine the Cenozoic sedimentary records of continental margin rifting, marginal basin subsidence, and Taiwan exhumation.
List Previous Drilling in Area:	None

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**HTB-2A**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Huatung Basin
Latitude:	Deg: 21	Min: 35.9581 N	Jurisdiction:	
Longitude:	Deg: 122	Min: 46.1682 E	Distance to Land:	200 km
Coordinates System:	WGS 84,	Other ( )		
Priority of Site:	Primary: Yes	Alt:	Water Depth:	4754 m

Section C: Operational Information

	Sediments		Basement
Proposed Penetration: (m)	710		30
	What is the total sed. thickness? 710 m		
		Total Penetration:	**740** m
General Lithologies:	Mudstone, siltstone, sandstone		Basalt
Coring Plan: *(Specify or check)*	1-2-3-APC, XCB, RCB.		
	1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ☐ RCB ☐ Re-entry ☐ HRGB ☐		** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	■	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	■	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma Ray	☐
Gamma Ray	■	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	■	Side-Wall Core Sampling	☐				
Acoustic	■						
Formation Image	■			Others ( )		Others ( )	

Max.Borehole Temp. : *Expected value (For Riser Drilling)* ____________°C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from ________ m to ________ m, ________ m intervals

from ________ m to ________ m, ________ m intervals

Basic Sampling Intervals: 5m

Estimated days:

Drilling/Coring: 4.5	Logging: 1.5	Total On-Site: 6.0

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Methane Hydrate	☐
Abnormal Pressure	☐	Fractured Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☐
CO_2	☐				

What is your Weather window? (Preferable period with the reasons)

Not in monsoon (June to September)

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: HTB-2A	Date Form Submitted: July, 2011

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s) :Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) 973GMGS_2 SP: 2380 Crossing Lines(s): Not yet available
3	Seismic Velocity†			Stacking and interval velocities. OBS velocity.
4	Seismic Grid			Seismic lines from the ACT cruise, and other groups in Taiwan. Two additional transects from SCSIO and GMGS. (Figs. 8 & 9)
5a	Refraction (surface)			None
5b	Refraction (near bottom)			OBS studies in the TAIGER project; Early OBS experiments in the area (Chen and Jaw, 1996; Nakamura et al., 1998)
6	3.5 kHz			Location of Site on line (Time) None
7	Swath bathymetry			Multi-beam bathymetric data from Hsu et al. (2004) and that collected during the ACT cruise
8a	Side-looking sonar (surface)			None
8b	Side-looking sonar (bottom)			None
9	Photography or Video			None
10	Heat Flow			Regional compilation by Shi et al. (2003) and Li et al. (2010)
11a	Magnetics			Data grids from Geological Survey of Japan and Coordinating Committee for Coastal and Offshore Geoscience Programmes in East and Southeast Asia (CCOP). New magnetic data from Hsu et al. (1998; 2004) and from GMGS
11b	Gravity			1' free-air gravity grid (V. 16.1) from Sandwell and Smith (1997)
12	Sediment cores			None
13	Rock sampling			Piston cores and dredges by R/V Vema and R/V Conrad (Damuth, 1980)
14a	Water current data			
14b	Ice Conditions			None
15	OBS microseismicity			None
16	Navigation			Available
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

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.

IODP Site Summary Forms:

Form 3 - Detailed Logging Plan

New ☐ *Revised* **X**

Proposal #: 735-CPP	Site #: HTB-2A	Date Form Submitted: July, 2011
Water Depth (m): 4754	Sed. Penetration (m): 710	Basement Penetration (m): 30

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ■

Are high temperatures expected at this site? Yes ☐ No ■

Are there any other special requirements for logging at this site? Yes ☐ No ■

If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be: 1.5 days

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Decompaction, backstripping, and subsidence analysis in order to better understand the rifting episodes. Also critical for seismic interpretation.	1
Litho-Density	Seismic interpretation. Basic information required for better gravity modeling/inversion such that the regional tectonics can be better inferred.	1
Natural Gamma Ray	Seismic interpretation of lithology. Also compensation for poor core recoveries.	1
Resistivity-Induction	Seismic interpretation of lithology and structures. Also compensation for poor core recoveries.	1
Acoustic	For time-depth conversion, and for estimating porosities, and for identifications of lithological boundaries or unconformities.	1
FMS	For mapping fractures, faults, foliations in both basement and overlying sediment. Will provide important constraints on tectonic evolution and emplacement history of basement.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility	For magnetic modeling and inversion, and for correlations of magnetic anomalies. Important for interpretations of the basement.	1
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	Temperature probe to estimate heat flow.	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

Form 4 – Pollution & Safety Hazard Summary

IODP Site Summary Forms:

Please fill out information in all gray boxes

New [ ] *Revised* [X]

Proposal #: 735-CPP	Site #: HTB-2A	Date Form Submitted: July, 2011

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Triple-APC to refusal, XCB to 250 m, RCB to target depth. Log as shown on form 3.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	No Previous DSDP/ODP drilling near this site. No hydrocarbon occurrences of greater than background levels in the South China Sea and Philippine Sea from previous DSDP/ODP legs.
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	No commercial drilling in the Huatung Basin and the Philippine Sea Basin.
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What "special" precautions will be taken during drilling?	Continuous monitoring under IODP safety standards.
7	What abandonment procedures do you plan to follow:	Per IODP standard operating procedure.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	No
9	Summary: What do you consider the major risks in drilling at this site?	No

IODP Site Summary Forms:

Form 5 – Lithologic Summary

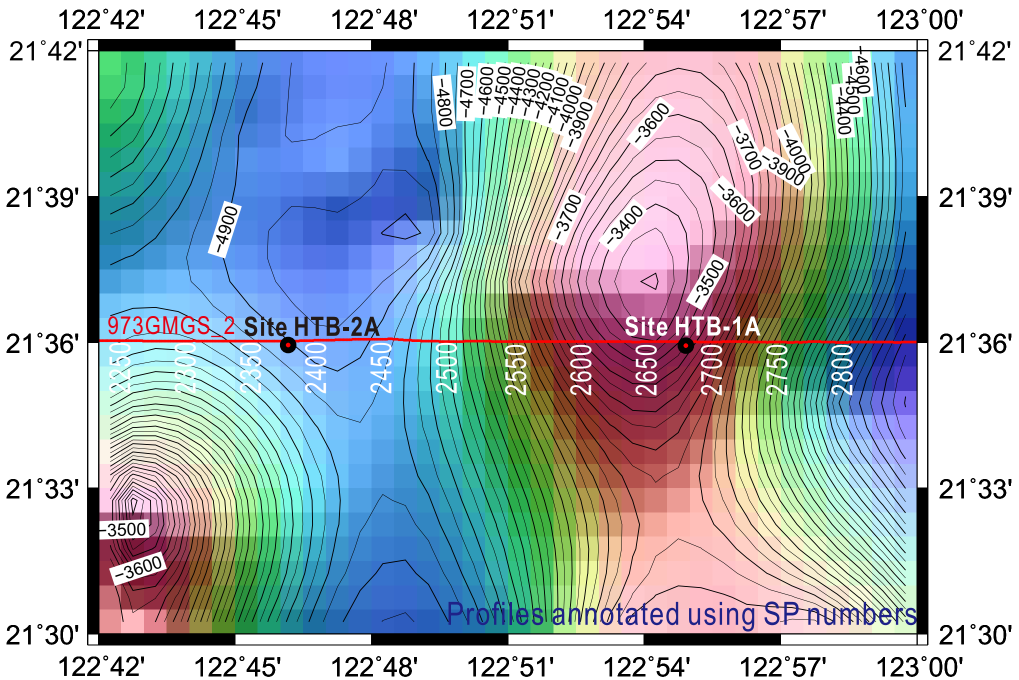
New [ ] *Revised* [X]

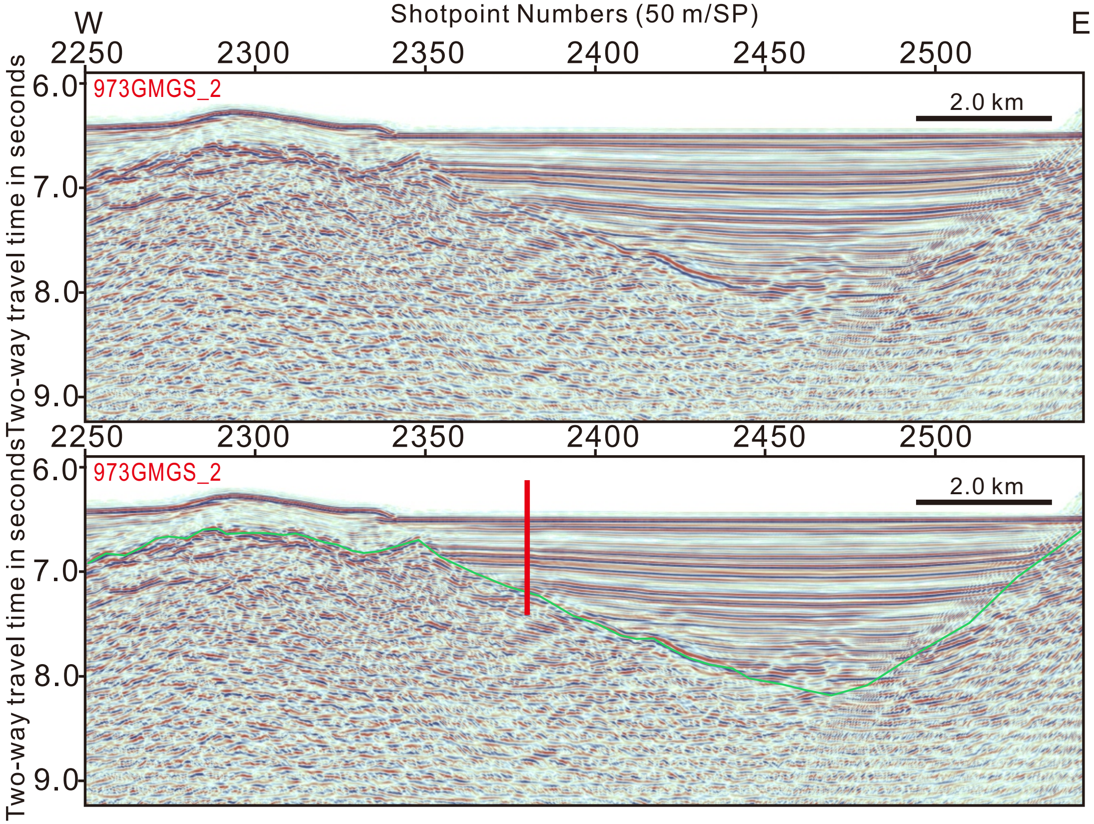
Proposal #: 735-CPP	Site #: HTB-2A	Date Form Submitted: July, 2011

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0~250	Top Miocene	0-6.5 Ma	1.7	Mudstone, siltstone and sandstones	Deep marine	38.5	The ages and sedimentary rates are only very rough estimates.
250~690		6.5-40 Ma	2.5	Mudstone, siltstone and sandstones	Deep marine	13.1	
	Top Cretaceous						
690~710		100-150 Ma	3.0	Radiolarian chert	Deep marine	0.4	
	Top Basement						
710~740			3.9	Basalt	Oceanic crust		

Site Summary Form 6

Proposal 735-CPP
Site HTB-2A





SSDB locations of these graphics and supporting data

Will be submitted soon after the submission of this CPP proposal

Site HTB-2A
SP 2380 on 973GMGS_2

Interpretation

Green-Top basement