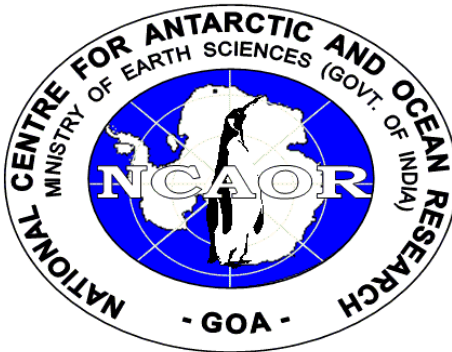


ORV SAGAR KANYA (SK-299 CRUISE)

(03-October to 03-November 2012)

Hydrothermal Studies: Exploration of Seafloor Massive Sulfide Hydrothermal Deposits in Cluster 'B' (SK-299)

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1.0 Introduction and Objectives

Deep-sea hydrothermal vents are mainly associated with seafloor spreading at mid-ocean ridges and in basins near volcanic island arcs. In order to find a new hydrothermal vent one makes guess based on the geology of the area under investigation. And bathymetry map may provide hints to locate hydrothermal fields. So the preparation of a high-resolution bathymetric map is essential in this endeavor. Even the hydrothermal plumes can be detected in seawater overlying vent fields, and beyond, because they have a distinctly different physical and chemical signature from the surrounding seawater. The heat and particle content of hydrothermal plumes are two readily measurable parameters. These parameters are usually elevated relative to unaffected seawater, and measurable differences can be detected as far as tens to hundreds of kilometers away from the vent fields. It was reported elsewhere that the 350°C hydrothermal fluids discharging from the black smoker chimneys at a water depth of about 2,600 m continuously precipitate metal sulphides in response to mixing of the high-temperature hydrothermal fluids with ambient seawater in a site. The increase in temperature from about 2°C to values >400°C is a result of conductive heating of a small percentage of seawater close to the solidified top of a high level magma chamber (International Seabed Authority, ISA). Due to the increased buoyancy at high temperatures, the hydrothermal fluid rises rapidly from the deep-seated reaction zone to the surface along major faults and fractures within the rift valley or close to the flanks of the rift. In particular the intersections of faults running parallel and perpendicular to the ridge axis are the loci of high-velocity discharge black smokers and massive sulphide mounds.

The major objective of SK-299 is to explore seafloor massive sulfide deposits in and around the hydrothermal vents in designated cluster 'B' area. In order to achieve the given objective it was planned to collect huge volume of significant geophysical and oceanographic datasets for the analysis and interpretation. The following scientific operations were carried out in SK-299 cruise.

- (a) Multibeam Echo Sounder (MBES) survey
- (b) Sub-bottom profiling
- (c) Magnetic survey
- (d) CTD and SVP casting. Besides deep water samples were collected in CTD stations for estimation of oxygen isotope composition.

For a quick-look into the SK-299 collected datasets (MBES bathymetric maps, CTD, SVP details), it is suggested to refer table-1 and figure1-4, attached at the end of this report.

2.0 Cruise itinerary

Embarkation and departure	:	Chennai – 03.10.2012 (Arrival in the study area: Cluster B –16.10.2012)
Arrival	:	Mauritius – 02.11.2012
Disembarkation	:	Mauritius – 03.11.2012

3.0 Participants

NCAOR, GOA

1. Dr. Babula Jena	Scientist ‘C’ – Chief Scientist
2. Dr. Dinesh Pandit	Research Scientist C
3. Dr. Rajesh Singh	Research Scientist B
4. Nitin Sharma	POR (TEL), (Indian Navy)
5. C.M.Goswami	POR (TEL), (Indian Navy)
6. Sandesh Dicholker	Ship Board Assistant
7. Rohit Bodnekar	Ship Board Assistant

M/S Norinco Pvt. Ltd. (AMC)

8. Mr. K. Madhusudan	AMC- Service Engineer.
9. Mr. V.C. Sarathchandran	AMC- Service Engineer.
10. Mr. Avertano Callistus Luis	AMC- Service Engineer.
11. Mr. Ganapathy Mahadevan	AMC- Service Engineer.

4.0 Study area and survey details (Figure: 1& 2)

Cluster-B

Longitude	:	69.5°E to 70.5°E
Latitude	:	24.4°S to 25.7°S
Total MBES surveyed area	:	~ 16000 km ²
Total MBES survey line length	:	~ 2727km

Total no. of SBE CTD/SVP : 12
Total no. of Idronaut CTD : 01

5. Equipments used and data collection

5.1: SB-3012 Multibeam Echosounder System

The MBES survey was carried out using standard practice with reference to the methodology given in the special publication No. 44 (S-44), International Hydrographic Organization (IHO) Standards for Hydrographic Surveys, 5th Edition (2008). SeaBeam 3012 Multibeam Echosounder onboard ORV-Sagar Kanya was used to carry out the MBES survey in cluster-B. The SB3012 is a 12 KHz, 201 beam sonar system, has a beam width of 1 degree at nadir and is capable of measuring depths ranging from 200m to 11000m.

The specifications of the system are as follows:

Make:	L3-Communications Elac-Nautik
No. of beams:	201
Swath coverage:	5 x Water Column
Frequency of operation:	12 KHz
Technology:	Full motion compensation (Sweptbeam technology)
Depth performance:	Max. 11,000 m.
Acquisition software:	Hydrostar
Data Processing software:	Eiva NaviPac

The complete Multibeam system comprises of many sub systems:

Surface Sound velocity (SSV): The surface sound velocity profiler is an underway ocean surface profiling system that can collect the water sound speed profiles continuously.

Side Scan Imagery: Online printer provided with system and annotation interval was set at 30 minutes for acquiring side scan imagery.

Gyro and Motion sensor: Multibeam system uses Octans sensor for Gyro and motion input. Octans is an IMO-compliant survey-grade gyrocompass with an integral motion sensor.

Positioning System: C-NAV DGPS subsystem is used for positioning accuracy. C-Nav GcGPS corrections are similar to other wide area DGPS system such as the Federal Aviation Administration's (FDA) wide area augmentation system (WAAS). The C-Nav GPS receiver can accept two (2) different GcGPS correction service message formats. The C-Nav, dual frequency, GPS user equipment receives either of these corrections broadcast from the communications satellite, applies them its own observed, refraction corrected C/A code, dual frequency observations, and performs a navigation solution. The resulting corrected GPS position; velocity and time (PVT) are output from the C-Nav equipment to other subsystems on the platform/vehicle/vessel to support the navigation positioning control requirements.

Network Timeserver with GPS synchronized time base: LANTIME (local area network timeserver) provides a high precision time base to a TCP/IP network (stratum-1-server). The NTP (network time protocol) is used to synchronize all NTP clients with the reference. LANTIME/GPS is a set of equipment composed of a satellite controlled clock GPS167, a single-board computer with integrated network board and a power supply, all installed in a metal 19" on the single-board computer flash disk. Four push buttons and a 2 x 40 character LC display can be used configure and monitor the time server. After the network connection has been established the time server can also be configured and monitored remotely from a workstation via TELNET or FTP.

Network Time Protocol (NTP): NTP is a common method for synchronization of hardware clocks in local and global networks. Timeservers synchronize themselves by a reference time source, such as a radio controlled clock, GPS-receiver or modem time distribution. Stratum-1-

servers distribute their time to several clients in the network which are called stratum-2. A high precision synchronization is feasible because of the several time references. Every computer synchronizes itself by up to three valued time sources. NTP enables the comparison of the hardware times and the adjustment of the own clock, a time precision of 128ms, often better than 50ms, is possible.

Sound Velocity Profiler (SVP): The sound velocity profilers have a velocimeter that operate on the “sing-around” sound principle, and contain a transducer head and a reflective plate a known distance apart. The "sing-around" sound principle refers to the use of a transducer and reflective-plate pair that is a known distance apart. The device calculates the speed of sound in water by effectively dividing this known distance by one-half the time required for a signal to be transmitted by the transducer, reflected by the reflective plate and received by the transducer. The sound velocity profiler used onboard Sagar Kanya was Valeport Midas SVP. The onboard processor calculates the sound velocity every second and stores it in the inbuilt memory of the SVP. The SVP data is uploaded after retrieval using the onboard data logging software. The MIDAS SVP is one of the most accurate sound velocity profiler in the world. It used digital time of flight sound velocity sensor. It also comes with a pressure sensor with 0.01% accuracy, a fast response PRT sensor and a high accuracy temperature compensated piezo-resistive pressure sensor.

<u>Sound Velocity</u>	
<i>Range:</i>	1400 - 1600m/s (extended range on request)
<i>Resolution:</i>	0.001m/s
<i>Accuracy:</i>	±0.03m/s
<u>Temperature</u>	
<i>Range:</i>	-5°C to +35°C
<i>Resolution:</i>	0.005°C
<i>Accuracy:</i>	±0.01°C
<u>Pressure</u>	
<i>Range:</i>	300 or 600 Bar (others on request)
<i>Resolution:</i>	0.001% range
<i>Accuracy:</i>	±0.01% range

The SVP instrument was attached with CTD under-water unit to collect the sound velocity profiles at 12 stations in cluster-B with depths ranging from 2130m to 4160m.

Data acquisition and processing software: Hydrostar is the data acquisition and control system for Multibeam echosounder onboard ORV-SK. It also acts as an interface for various external sensors (position, motion, heading and sound velocity sensors). NaviPac software was used for navigation and data acquisition from various feeds such as GPS, Gyro, Motion sensor etc. NaviPac also allows the navigator to perform all phases of surface, sub-sea and remote navigation, to view all sensor data, to perform changes in navigation principles and components. The programme reads all basic information from the setup DB, present all available stations and let the navigator specify the stations wanted. All the information's is stored in the online DB file, which can be maintained by one or more online programs. NaviPac is installed in Windows NT workstation. NaviEdit, NaviModel and NaviPlot are the software to edit the data and create the bathymetric grid model. The processed multibeam datasets of cluster-B were imported, mapped and analyzed in ArcGIS 9.2 software (figure 3).

5.2: Sub Bottom Profiler

GeoAcoustics sub-bottom profiler onboard was used to collect the sub bottom profile data along all the MBES survey lines. SBP contains four units:

GeoPro data processing unit: It is the main processing unit and MacOS is the operating system. GeoPro software, which is a complete software system, installed in the main unit and software features, such as acquisition, target analysis, mosaicing and seismic processing are all part of one software application.

GeoPulse 5430A Transmitter: It is a stand-alone transmitter of 10 kW maximum power output in a frequency range of 2 KHz to 12 K HZ.

GeoPulse Receiver: The receiver is a universal amplifier/filter for use in sub bottom profiling. The receiver, combining many functions, replaces many single function boxes that would otherwise create space as well as interference problems.

5.3: Magnetic survey

The Geometrics Inc Cesium Vapour marine magnetometer (G-882) was used to collect magnetic data along survey tracks. The magnetometer fish is towed behind the ship at length three times the length of the ship.

Technical Specifications of the G-882 Marine Magnetometer

Operating Principle:	Self-Oscillating split-beam Cesium Vapour
Operating Range:	20,000 to 100,000 nT
CM-221 Counter Sensitivity:	<0.004nT/Hz rms. Up to 10 samples per second.
Heading error:	1nT (over entire 360E equatorial and polar spin)
Absolute accuracy:	< nT throughout Range
Output:	RS-232 at 1200 to 19200 Baud

Operating Temperature:	-30°F to +122°F (-35°C to +50°C)
Storage Temperature:	-48°F to +158°F (-45°C to +70°C)
Altitude:	Up to 30,000 ft (9,000 m)
Water tight:	Up to 9000 ft (2750m) depth operation
Power:	24 to 32 VDC, 0.75 amp at turn-on and 0.5 amp thereafter.

5.4: CTD operations and water sampling

SBE CTD and rosette water sample bottles were used to collect the CTD data and water samples at 12 locations (Table-1) in cluster-B. SBE-CTD unit measures conductivity, temperature and pressure. Beside multiple auxiliary sensors are attached in the SBE-CTD unit to study the physical, chemical and biological processes of the marine environment. The sensors available on SBE-CTD unit are:

- Temperature sensor (Temperature measurement)
- Conductivity sensor (Conductivity measurement)
- DO sensor (Dissolved Oxygen measurement)
- Pump
- Bottom Contact Module
- Altimeter (Depth measurement)
- Fluorometer (Fluorescence)
- Turbidity measurement
- PAR

In addition to the measurement of above parameters, deep water samples were collected in CTD stations for estimation of oxygen isotope composition i.e. $\delta^{18}\text{O}$ using IRMS.

Sampling Method: Water samples were collected as close to sea bottom with 50 meters depth intervals while up-casting CTD operation. Samples are stored in 30 ml PPT bottles. Initially, PPT bottles are 3 times rinsed with the sample seawater, filled in the bottles up to the top levels so that there should not be any air bubbles appear inside the bottles while closing. After filled

with deep seawater, bottles are air tight closed. Neck of the bottle is sealed with parafilm tape the covered with adhesive transparent cello tape. Deep seawater sample are kept at 2 degree centigrade temperature in the freezer to check evaporation.

Seawater samples are label as SK299/S01/W01 to W12 for one vertical profile. W01 to W12 represent 12 bottles along the vertical profile. Bottom most sample represent W01 and top most one is W12.

6. Diary of Events

Date 03.10.2012

11.00: Sign-on is completed for 11 participants.

12.00: All participants were boarded/materials loaded and vessel set to sail at 20.00hrs.

20.30: Pilot reached and sailed at 21.00hrs for generator trial which may take 12 hours.

Date 04.10.2012

10.30: After completion of generator trail, two workshop persons were disembarked at Chennai port limit.

10.40: Multibeam system was checked and found to be functional including SSV sensor. The problem associated with SSV sensor was rectified on 03/10/2012.

10.40: WP1 (70.30°E; -24.20°S) was given to Master. Vessel approaching towards WP1.

11.30: Safety familiarization meeting called by Master.

16.30: Safety drill was carried out for all the participants mustered at boat deck.

Vessel Position @ 0800 (IST) 05.10.2012 ;(081.23°E; 10.20°N)

Date 05.10.2012

08.30: The Multibeam was working fine till 0830hrs (05.10.2012).However it stopped tracking the bottom with a message “Sensor Seabeam 3012 (ID 18) SB 3000 permanently shut down amplifier: E16”. MBES system is pinging but number of beams are zero. While pinging, the voltage, current etc are within limits. After stopping and restarting the system, the PPC Rx, Tx, DGPS, TSS, SSV, XSE server and Seabeam sensor completes the start up procedure properly but while going to pinging mode, system tracks the bottom with around 40 active beams but after few more pings the number of becoming zero and stops showing the bottom. AMC engineers are working to rectify this problem.

01.30: There was a meeting with all participants reg. our planned activities.

Vessel approaching towards WP1.

Vessel Position @ 0800 (IST) 06.10.2012 ;(082°27.39'E; 07°13.12'N)

Date 06.10.2012

06.45: The MBES problem observed yesterday was rectified and the system is now working/recording the data. One of the UPS's is showing battery fault indication but still functional. It is planned to shut down the system tonight for keeping the UPS on charge.

01.30: There was a meeting with all participants reg. our planned activities.

Vessel approaching towards WP1.

Vessel Position @ 0800 (IST) 07.10.2012 ;(081°32.79'E; 04°34.46'N) Sea state:calm

Date 07.10.2012

The UPS is put on charge till 8/10/2012(10am) and further the MBES system will be started.

Vessel approaching towards WP1.

Vessel Position @ 0800 (IST) 08.10.2012 ;(080°18.15'E; 01°34.04'N) Sea state: calm

Date 08.10.2012

0800 MBES data acquisition system was put ON and found working well.

0900 MBES data files of transit were processed and the PP system is set ready for processing of MBES data in the cluster 'B'.

Vessel approaching towards WP1.

Vessel Position @ 0800 (IST) 09.10.2012 ;(079°10.26'E; 01°17.39'S)

Sea state: CR6 (cloudy, rain, moderate visibility)

Date 09.10.2012

2000: Planning of survey lines/time required to complete the survey is under progress.

Vessel approaching towards WP1.

Vessel Position @ 0800 (IST) 10.10.2012 ;(078°00.99'E; 04°27.62'S)

Sea state: BC7 (Partly cloudy, good visibility, Slight sea 1.5mtrs swell height)

Date 10.10.2012

10.00: Planning of survey lines/time required to complete the survey is completed.

Vessel approaching towards WP1.

Vessel Position @ 0800 (IST) 11.10.2012 ;(076°49.34'E; 07°52.83'S)

Sea state: OR6 (Moderate, visibility, Rain, 2.2mtrs swell height)

Date 11.10.2012

00.00: Multibeam stopped working due to blown of fuses of capacitor bank.

06.00: replaced the defective fuses with the new ones, started pinging with -3db power and started acquiring bottom. The number of total beams are 173 and active beams are below 100.

Vessel approaching towards WP1.

Vessel Position @ 0800 (IST) 12.10.2012 ; (075°32.95'E; 11°13.15'S)

Sea state: CR6 (Cloudy, Moderate sea, moderate visibility, Rainy, 2.5mtrs swell height)

Date 12.10.2012

17.00: Generated survey way points based upon existing MBES data and Plotted in helsman's display.

Vessel approaching towards WP1.

Vessel Position @ 0800 (IST) 13.10.2012 ;(074°25.19'E; 14°19.67'S)

Sea state: BC7 (Good visibility, Slight sea, 3.0mtrs swell height)

Date 13.10.2012

Vessel approaching towards WP1.

Vessel Position @ 0800 (IST) 14.10.2012 ;(073°11.50'E; 17°31.97'S)

Sea state: BC6 (Moderate visibility, partly cloudy, moderate sea, 2.0mtrs swell height)

Date 14.10.2012

Vessel approaching towards WP1.

Vessel Position @ 0800 (IST) 15.10.2012 ;(071°53.82'E; 20°50.82'S)

Sea state: BC7 (Moderate sea,1.5mtrs swell height, partly cloudy,Good visibility)

Date 15.10.2012

Survey line Coordinates given in the bridge.

Vessel approaching towards WP1.

Vessel Position @ 0800 (IST) 16.10.2012 ;(070°33.58'E; 24°15.40'S)

Sea state: BC7 (Moderate sea, 1.5mtrs swell height, partly cloudy, Good visibility)

Date 16.10.2012

0804: Magnetometer deployed (070°33.45'E; 24°15.77'S; Depth-2284).

1100: Vessel reached at WP1 (070°30.00'E; 24°38.55'S; Depth-3542) i.e. Start of line (SOL)-B7. First six survey lines were skipped due to paucity of time. These lines (B6 to B1) can be surveyed while on way back to Mauritius provided if time is available after dredging and sediment coring operations. It is planned to undertake the survey with a vessel speed of 8-8.5knts.

1800: End of line (EOL) - B7 (069°30.18'E; 24°38.24'S; Depth-2583).

1830: SOL- B8 (069°29.58'E; 24°41.84'S; Depth 2575). Correction signals were not available in C-NAV differential GPS since start of this line. Raw datasets were checked for overlapping coverage and found to be within the acceptable limit.

Vessel Position @ 0800 (IST) 17.10.2012 ;(069°36.56'E; 24°44.35'S)

Sea state: BC7 (Slight sea, 1.5mtrs swell height, partly cloudy, Good visibility)

Date 17.10.2012

0133: EOL- B8 (070°30.49'E; 24°41.55'S; Depth 3676. Correction signals were not available in C-NAV differential GPS in EOL- B8.

0140: SOL- B9 (070°30.57'E; 24°42.62'S; Depth 3841).

0430: Correction signals were acquired in C-NAV differential GPS in line B9 (070°06.53'E; 24°44.75'S; Depth 2664).

0849: EOL- B9 (069°29.99'E; 24°45.22'S; Depth 3598).

0858: SOL- B10 (069°30.39'E; 24°47.50'S; Depth 3559).

1110: Magnetometer on deck before arrival of CTD/SVP station (CTD-B1_1, SVP-B1_1)

1200: DP attempted for CTD/SVP operation (069°51.42'E; 24°47.10'S; Depth-3253).

1247: DP achieved.

1320: The probe is tripping while lowering Idronaut CTD.AMC engineers are working on this problem and detail report will be submitted by AMC.

1415: Seabird CTD and attached SVP was casted up to 3100m.

1600: CTD/SVP on deck. Data acquired successfully. Profiles were checked with the climatological data and found to be matching. Water samples were collected at different depths ranging from 2550-3100m (50m intervals).

1610: Magnetometer was deployed (069°51.42'E; 24°47.10'S; Depth-3253).

1630: Continuation of line-B10 (069°51.50'E; 24°46.79'S; Depth-3314).

1800: Magnetometer on deck before arrival of CTD/SVP station (CTD-B1_2, SVP-B1_2)

1827: DP attempted for CTD/SVP operation (070°03.25'E; 24°47.03'S; Depth-2340).

2000: DP achieved.

2005: Seabird CTD/SVP was casted up to 2200m.

2100: CTD/SVP on deck. Data acquired successfully. Water samples were collected at different depths ranging from 1650-2200m (50m intervals).

2224: Continuation of line-B10 (069°51.50'E; 24°46.79'S; Depth-3314).

1610: Magnetometer was deployed (070°03.06'E; 24°47.32'S; Depth-2380)

Vessel Position @ 0800 (IST) 18.10.2012 ;(069°44.39'E; 24°49.08'S)

Sea state: BC7 (Slight sea, 0.5mtrs swell height, partly cloudy, Good visibility)

Date 18.10.2012

Continuation of line - B10 (070°13'28.83"E; 24°47'05.98"S; Depth-2860).

0200: EOL- B10 (070°28'59.1"E; 24°47'24.61"S; Depth 3058).

0205: SOL- B11 (070°29'59.96"E; 24°47'53.66"S; Depth 3019).

0930: EOL- B11 (069°30'20.20"E; 24°49'48.05"S; Depth 3584).

0945: SOL- B12 (069°29'42.31"E; 24°51'21.53"S; Depth 3463). Correction signals were not available in GPS.

1330: Magnetometer on deck before arrival of CTD/SVP station (CTD_B12, SVP_B12)

1340: DP attempted for CTD/SVP operation (069°57'29.15"E; 24°52'31.2"S; Depth-3635).

1340: DP achieved.

1400: Seabird CTD and attached SVP was casted up to 3400m.

1539: Seabird CTD/SVP on deck. Data acquired successfully. Water samples were collected at different depths ranging from 2850-3400m (50m intervals).

1550: Idronaut CTD was down-casted up to 3150m for testing.

1954: Idronaut CTD on deck and data acquired successfully. A comparative analysis to be carried out between Idronaut and Seabird measured profiles.

2015: Magnetometer was deployed (069°57'08.32"E; 24°52'14.98"S; Depth-3655).

2030: Continuation of line-B12 (069°57'08.32"E; 24°52'14.98"S; Depth-3655).

Vessel Position @ 0800 (IST) 19.10.2012 ;(069°31.23'E; 24°55.23'S)

Sea state: BC7 (Slight sea, 0.5mtrs swell height, partly cloudy, Good visibility)

Date 19.10.2012

0020: EOL- B12 (070°30'00.52"E; 24°52'33.42"S; Depth 2666).

0025: SOL- B13 (070°30'00.70"E; 24°52'58.94"S; Depth 2682).

0800: EOL- B13 (069°30'34.05"E; 24°55'13.59"S; Depth 3330).

0804: SOL- B14 (069°29'45.27"E; 24°55'20.53"S; Depth 3313).

1121: Magnetometer on deck before arrival of CTD/SVP station (CTD-B14_1, SVP-B14_1)

1135: DP attempted for CTD/SVP operation (069°51'33.70"E; 24°57'38.42"S; Depth-2895).

1150: DP achieved.

1155: CTD/SVP was casted up to 2600m.
1320: CTD/SVP on deck. Data acquired successfully. Water samples were collected at different depths ranging from 2050-2600m (50m intervals).
1330: Continuation of line-B14 (069°51'43.43"E; 24°57'57.84"S; Depth-2860).
1550: Arrival of CTD/SVP station (CTD-B14_2, SVP-B14_2)
1555: DP attempted for CTD/SVP operation (069°51'33.70"E; 24°57'38.42"S; Depth-3691).
1600: DP achieved.
1606: CTD/SVP was casted up to 3450m.
1742: CTD/SVP on deck. Data acquired successfully. Water samples were collected at different depths ranging from 2850-3400m (50m intervals).
1751: Continuation of line-B14 (070°03'37.39"E; 24°57'59.57"S; Depth-3691).
1830: Magnetometer deployed (070°04'51.56"E; 24°57'59.13"S; Depth-3363).
2112: EOL- B14 (070°27'45.74"E; 24°58'01.42"S; Depth 2900).
2118: SOL- B15 (070°27'52.04"E; 24°58'32.57"S; Depth 3059).
Vessel Position @ 0800 (IST) 20.10.2012 ;(069°48.28'E; 25°03.44'S)
Sea state: BC7 (Slight sea, 2.0mtrs swell height, partly cloudy, Good visibility)

Date 20.10.2012

0402: EOL- B15 (069°29'58.45"E; 25°00'42.71"S; Depth 3380).
0530: SOL- B16 (069°29'46.85"E; 25°02'58.93"S; Depth 2967). Correction signals were not available in GPS receivers for 2 hours and received afterwards.
1301: EOL- B16 (070°30'01.49"E; 25°03'41.43"S; Depth 4052).
1323: SOL- B17 (070°30'00.16"E; 25°04'58.53"S; Depth 4239).
2024: EOL- B17 (069°29'53.99"E; 25°06'10.71"S; Depth 2975).
2038: SOL- B18 (069°29'35.63"E; 25°07'47.19"S; Depth 3103).
2326: Magnetometer on deck before arrival of CTD/SVP station (CTD-B18_1, SVP-B18_1)
Vessel Position @ 0800 (IST) 21.10.2012 ;(070°21.05'E; 25°08.88'S)
Sea state: BC7 (Slight sea, 2.0mtrs swell height, partly cloudy, Good visibility)

Date 21.10.2012

2326: Magnetometer on deck before arrival of CTD/SVP station (CTD-B18_1, SVP-B18_1)
2350: DP attempted for CTD/SVP operation (069°51'21.35"E; 25°08'47.98"S; Depth-2345).
0003: DP achieved
0005: CTD/SVP was casted up to 2130m
0127: CTD/SVP on deck. Data acquired successfully. Water samples were collected at different depths ranging from 1150-2100m (50m intervals).
0144: Continuation of line-B18 (069°51'10.95"E; 24°08'55.53"S; Depth-2268).
0230: Arrival of CTD/SVP station (CTD-B18_2, SVP-B18_2)
0236: DP attempted for CTD/SVP operation (069°57'14.50"E; 25°08'51.61"S; Depth-3187).
0242: DP achieved.
0244: CTD/SVP was casted up to 3040m.
0448: CTD/SVP on deck. Data acquired successfully. Water samples were collected at different depths ranging from 2350-2900m (50m intervals).
0456: Continuation of line-B18 (069°57'14.50"E; 25°08'51.61"S; Depth-3187).
0500: Magnetometer deployed (069°57'12.95"E; 25°08'52.01"S; Depth-3722)

0900: EOL- B18 (070°29'52.49"E; 25°08'54.59"S; Depth 3996).
0928: SOL- B19 (070°29'41.99"E; 25°08'54.01"S; Depth 2687).
1523: EOL- B19 (069°30'09.43"E; 25°11'37.21"S; Depth 2541).
1642: SOL- B20 (069°29'49.39"E; 25°14'03.96"S; Depth 3247).
2030: Magnetometer on deck before arrival of CTD/SVP station (CTD-B20, SVP-B20)
2050: DP attempted for CTD/SVP operation (070°03'40.78"E; 25°44'26.51"S; Depth-2755).
2055: DP achieved.
2100: CTD/SVP was casted up to 2740m.
2252: CTD/SVP on deck. Data acquired successfully. Water samples were collected at different depths ranging from 1950-2500m (50m intervals).
2305: Continuation of line-B20 (070°03'40.78"E; 25°44'26.51"S; Depth-2753).
2318: Magnetometer deployed (070°03'37.99"E; 25°14'21.30"S; Depth-2767).
Vessel Position @ 0800 (IST) 22.10.2012 ;(069°47.17'E; 25°17.07'S)
Sea state: BC7 (Slight sea, 2.0mtrs swell height, partly cloudy, Good visibility)

Date 22.10.2012

0225: EOL- B20 (070°30'01.83"E; 25°14'22.96"S; Depth 3339).
0228: SOL- B21 (070°30'00.49"E; 25°14'37.27"S; Depth 3388).
0810: MBES system went on standby mode and got shutdown.
0840: Magnetometer on deck.
0858: System was restarted centre depth was set manually and started pinging (069°44'05.18"E; 25°17'04.48"S; Depth-2527).
0910: Magnetometer deployed (069°45'30.06"E; 25°17'02.95"S; Depth-2421)
1100: EOL- B21 (069°29'51.58"E; 25°17'04.57"S; Depth 3893).
1120: SOL- B22 (069°30'05.39"E; 25°19'48.25"S; Depth 3463).
1355: Arrival of CTD/SVP station (CTD-B22_1, SVP-B22_1)
1400: DP attempted for CTD/SVP operation (069°51'06.98"E; 25°19'47.55"S; Depth-3663).
1419: DP achieved
1423: CTD/SVP was casted up to 3500m

1629: CTD/SVP on deck. Data acquired successfully. Water samples were collected at different depths ranging from 2750-3300m (50m intervals).
1637: Continuation of line-B22 (069°51'06.98"E; 25°19'47.55"S; Depth-3663).
1818: Arrival of CTD/SVP station (CTD-B22_2, SVP-B22_2)
1820: DP attempted for CTD/SVP operation (069°58'16.03"E; 25°19'47.34"S; Depth-4172).
1824: DP achieved.
1826: CTD in water
18.36: CTD on deck (communication problem)
1915: CTD/SVP was casted up to 4160m.
2230: CTD/SVP on deck. Data acquired successfully. Water samples were collected at different depths ranging from 3600-4160m (50m intervals).
2250: Magnetometer deployed (069°57'19.87"E; 25°19'49.50"S; Depth-4235)
2300: Continuation of line-B22 (069°58'08.15"E; 25°19'47.72"S; Depth-4192).
Vessel Position @ 0800 (IST) 23.10.2012 ;(069°51.47'E; 25°22.53'S)
Sea state: BC7 (Slight sea, 2.0mtrs swell height, partly cloudy, Good visibility)

Date 23.10.2012

0255: EOL- B22 (070°30'00.65"E; 25°20'15.01"S; Depth 3108).

0300: SOL- B23 (070°30'00.69"E; 25°20'31.42"S; Depth 3021).

1035: EOL- B23 (069°29'58.01"E; 25°22'32.02"S; Depth 3584).

1057: SOL- B24 (069°30'00.02"E; 25°25'16.99"S; Depth 3318).

1800: EOL- B24 (070°30'56.15"E; 25°27'47.76"S; Depth 3388).

1820: SOL- B25 (070°29'56.15"E; 25°27'47.76"S; Depth 3421).

2330: B07 to B23 Post Processing is over.

Vessel Position @ 0800 (IST) 24.10.2012 ;(070°21.08'E; 25°30.70'S)

Sea state: BC7 (Slight sea, 2.0mtrs swell height, partly cloudy, Good visibility)

Date 24.10.2012

0140: EOL- B25 (069°30'00.85"E; 25°28'00.69"S; Depth 3076).

0200: SOL- B26 (069°30'00.85"E; 25°18'00.69"S; Depth 3129).

0900: EOL- B26 (070°30'08.73"E; 25°30'44.70"S; Depth 2929).

0915: SOL- B27 (070°30'25.90"E; 25°32'39.06"S; Depth 3156).

1648: EOL- B27 (069°29'56.15"E; 25°30'26.32"S; Depth 3836).

1700: SOL- B28 (069°30'38.06"E; 25°36'09.74"S; Depth 3209).

Vessel Position @ 0800 (IST) 25.10.2012 ;(069°31.53'E; 25°38.89'S)

Sea state: BC7 (Slight sea, 2.0mtrs swell height, partly cloudy, Good visibility)

Date 25.10.2012

0021: EOL- B28 (070°30'01.26"E; 25°36'18.22"S; Depth 3175).

0025: SOL- B29 (070°29'59.05"E; 25°36'41.28"S; Depth 3134).

0809: EOL- B29 (069°29'59.12"E; 25°38'53.14"S; Depth 2758).

0830: SOL- B30 (069°30'03.71"E; 25°41'38.26"S; Depth 2381).

1555: EOL- B30 (070°29'99.36"E; 25°41'37.59"S; Depth 3215).

1620: SOL- B31 (070°29'41.45"E; 25°44'06.41"S; Depth 2948).

2300: EOL- B31 (069°29'58.09"E; 25°44'20.83"S; Depth 4008).

2320: SOL- B32 (069°29'39.76"E; 25°45'32.74"S; Depth 4181).

Vessel Position @ 0800 (IST) 26.10.2012 ;(070°30.36'E; 25°47.35'S)

Sea state: BC7 (Slight sea, 2.0mtrs swell height, partly cloudy, Good visibility)

Date 26.10.2012

0712: EOL- B32 (070°30'05.30"E; 25°47'10.69"S; Depth 2877).

0714: Magnetometer on deck before arrival of CTD/SVP station

0720: DP attempted for CTD/SVP operation (070°30'11.89"E; 25°47'23.23"S; Depth-2883).

0734: DP ACHIEVED

0744: CTD/SVP was casted up to 2700m.

0941: CTD/SVP on deck. Data acquired successfully. Water samples were collected at different depths ranging from 2150-2700m (50m intervals).

1000: Vessel heading towards next way point.

1445: DP attempted for CTD/SVP operation at known hydrothermal field (070°1.55'E; 25°18.63'S; Depth-2575)

1500: DP achieved.

1550: Idronaut CTD/SVP was casted up to 500m.

1625: CTD/SVP on deck. Data was not acquired successfully. At 500m of depth there was a problem with probe, suspected water seepage in sea cable. AMC is working on the problem.

1636: SBE CTD/SVP was casted up to 2570m for the second time.

1803: CTD/SVP on deck. Data acquired successfully.

1814: DP off. Vessel heading towards sediment coring / dredging near existing HT vent field.

Sea is quite rough to carry out any scientific operation onboard-SK. Just waiting for normal sea state to carry out sediment coring/dredging operations.

Vessel Position @ 0800 (IST) 27.10.2012 ;(070°02.04'E; 25°59.55'S)

Sea state: C6 (Rough sea, 3.5mtrs swell height, partly cloudy, Moderate visibility)

Date 27.10.2012

Post-processing of all survey lines (E7-E32) in cluster 'B' is completed.

Sea was too rough to carry out any scientific operation onboard-SK. Since the severe rough weather condition could not improve till 14.00 (27.10.2012), so proceeding for N-S MBES survey lines.

16.30 Start of N-S MBES survey line_01.

Vessel Position @ 0800 (IST) 28.10.2012 ;(069°57.36'E; 24°54.39'S)

Sea state: C7 (Rough sea, 3.5mtrs swell height, partly cloudy, Moderate visibility)

Date 28.10.2012

0053: EOL_NS_TIE_01 (070°03'32.33"E; 24°45'42.10"S; Depth 2224).

0709: SOL_NS_TIE_02 (069°57'07.07"E; 24°45'56.54"S; Depth 3017).

1248: EOL_NS_TIE_02 (069°57'17.59"E; 25°18'55.24"S; Depth 4190).

1251: SOL_NS_TIE_03 (069°56'56.25"E; 25°19'01.05"S; Depth 4295).

2003: EOL_NS_TIE_03 (069°27'31.22"E; 24°45'37.45"S; Depth 3793). The MBES N-S survey is completed.

After completion of N-S survey, it was planned to go ahead for survey of B6-B1 lines. However the weather condition was improving slowly and planned to carryout grab and dredging near Kairei HT field (inside the pre-defined block). We are hoping for favorable weather condition in next 6 hours but it is always unpredictable in space and time.

Master suggested to complete the work before 12.00 (29-10-2012) in order to reach before ETA at Mauritius.

Vessel Position @ 0800 (IST) 29.10.2012 ;(070°07.66'E; 25°18.58'S)

Sea state: C7 (Rough sea, 3.5mtrs swell height, partly cloudy, Moderate visibility)

Date 29.10.2012

We came back all the way to dredging area but there was no hope for any scientific operation. The weather was very rough till yesterday and vessel is heading towards Port Luis, Mauritius.

Vessel Position @ 0800 (IST) 30.10.2012 ;(066°49.969'E; 24°09.853'S)
Sea state: BC7 (Slight sea, 1.5mtrs swell height, partly cloudy, Good visibility)

Date 30.10.2012

Vessel is heading towards Port Luis, Mauritius.

Vessel Position @ 0800 (IST) 31.10.2012 ;(066°49.969'E; 24°09.853'S)

Sea state: BC7 (Slight sea, 1.5mtrs swell height, partly cloudy, Good visibility)

Date 31.10.2012

Vessel is heading towards Port Luis, Mauritius.

Vessel Position @ 0800 (IST) 01.11.2012 ;(059°47.735'E; 21°40.077'S)

Sea state: BC7 (Slight sea, 1.5mtrs swell height, partly cloudy, Good visibility)

Date 01.11.2012

Vessel is heading towards Port Luis, Mauritius.

Vessel Position @ 0800 (IST) 02.11.2012 ;

Sea state:

Date 02.11.2012

Vessel arrived at Port Luis, Mauritius.

Date 03.11.2012

Disembarkation of Dr. Babula Jena and Dr. Dinesh Pandit at Port Luis, Mauritius. Other participants were expected to continue in SK-300 cruise.

7. Summary

Scientific operations were carried out to collect various geophysical and oceanographic datasets in SK-299 cruise. The high-resolution sea floor geomorphic features were mapped (Figure 3 & 4) and analyzed to identify the potential sites of sulfide hydrothermal deposits. In addition geophysical and chemical parameters were collected uniformly throughout the study area (Figure 2) to understand the marine ecosystem in and around the hydrothermal vents. In the end of the cruise the sea was quite rough which led us to avoid dredging activities and planned to carry out in the next HT cruise (SK-300).

8. Acknowledgement

I acknowledge Dr. S. Rajan, Director (NCAOR), Dr. John Kurian, Dr. Anil Kumar, Dr. Avinash Kumar, Mr. M. M. Subramaniam and all SK-299 participants for excellent support. Master and his navigational officers/crews extended their support and were very cooperative in all scientific activities. I acknowledge all of them for their contribution to SK-299 cruise. I greatly acknowledge NORINCO team led by Mr. K. Madhusudan for their hard work and problem

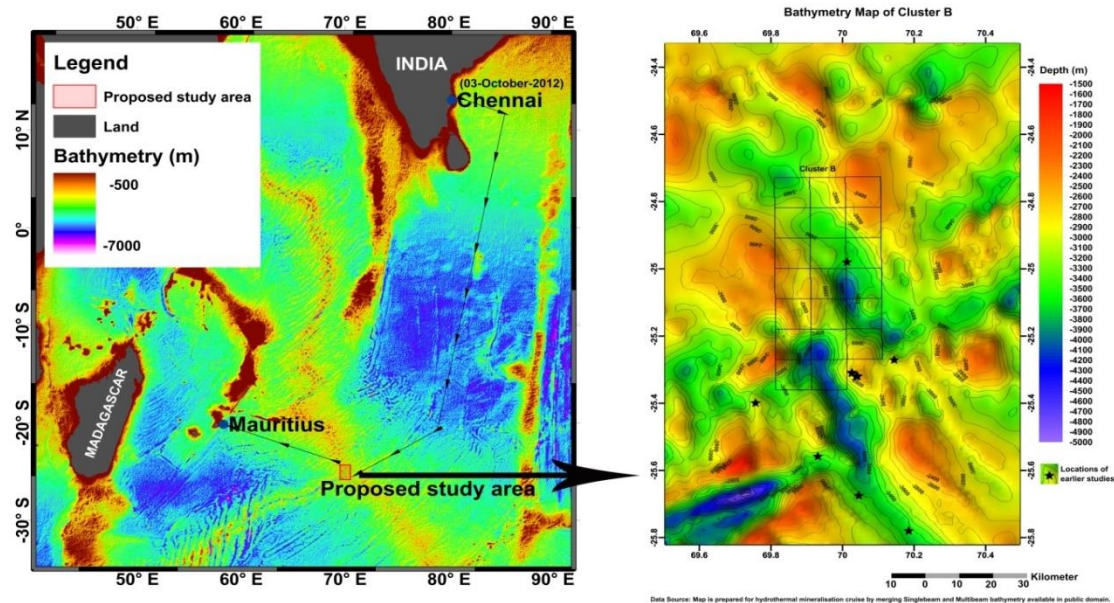
solving skills on scientific instrument which made it possible to collect huge amount of

S. No	Longitude	Latitude	Date	Time (UTC)	CTD file name	SVP file name	Casted depth (Total depth) in meter	SVP to be applied for survey line
01	69° 51.72' E	24° 47.07' S	Oct 17 2012	08:50:41	CTD_B10_01	SVP_B10_01	3100 (3253)	B7,B8,B9, B10
02	70° 03.58' E	24° 47.08' S	Oct 17 2012	20:12:02	CTD_B10_02	SVP_B10_02	2200 (2340)	

geophysical and oceanographic datasets.

03	69° 57.49' E	24° 52.52' S	Oct 18 2012	13:58:26	CTD_B12	SVP_B12	3400 (3635)	B11, B12, B13
04	69° 51.56' E	24° 57.64' S	Oct 19 2012	11:57:44	CTD_B14_01	SVP_B14_01	2600 (2895)	B14, B15, B16, B17
05	70° 03.44' E	24° 57.64' S	Oct 19 2012	15:57:54	CTD_B14_02	SVP_B14_02	3450 (3691)	
06	69° 51.35' E	25° 08.81' S	Oct 21 2012	00:21:49	CTD_B18_01	SVP_B18_01	2130 (2345)	B18, B19
07	69° 57.32' E	25° 08.69' S	Oct 21 2012	03:01:19	CTD_B18_02	SVP_B18_02	3040 (3187)	
08	70° 03.68' E	25° 14.44' S	Oct 21 2012	21:04:24	CTD_B20	SVP_B20	2740 (2755)	B20, B21
09	69° 51.50' E	25° 19.74' S	Oct 22 2012	14:23:06	CTD_B22_01	SVP_B22_01	3500 (3663)	B22, B23, B24, B25, B26, B27
10	69° 58.26' E	25° 19.79' S	Oct 22 2012	19:00:12	CTD_B22_02	SVP_B22_02	4160 (4172)	
11	70° 30.07' E	25° 47.07' S	Oct 26 2012	02:15	CTD_B32	SVP_B32	2700 (2883)	B28, B29, B30, B31, B32
12	070°1.559'E	25°18.63'S	Oct 26 2012	02:45	CTD_HT_TE ST	SVP_HT_TE ST	2570 (2575)	NA

Table 1: CTD/SVP operations carried out in SK-299



Activities (SK-299): Multibeam survey, CTD, sound velocity profile, sediment coring, dredging, etc.

Figure 1: The transit track and area of investigation (Cluster-B).

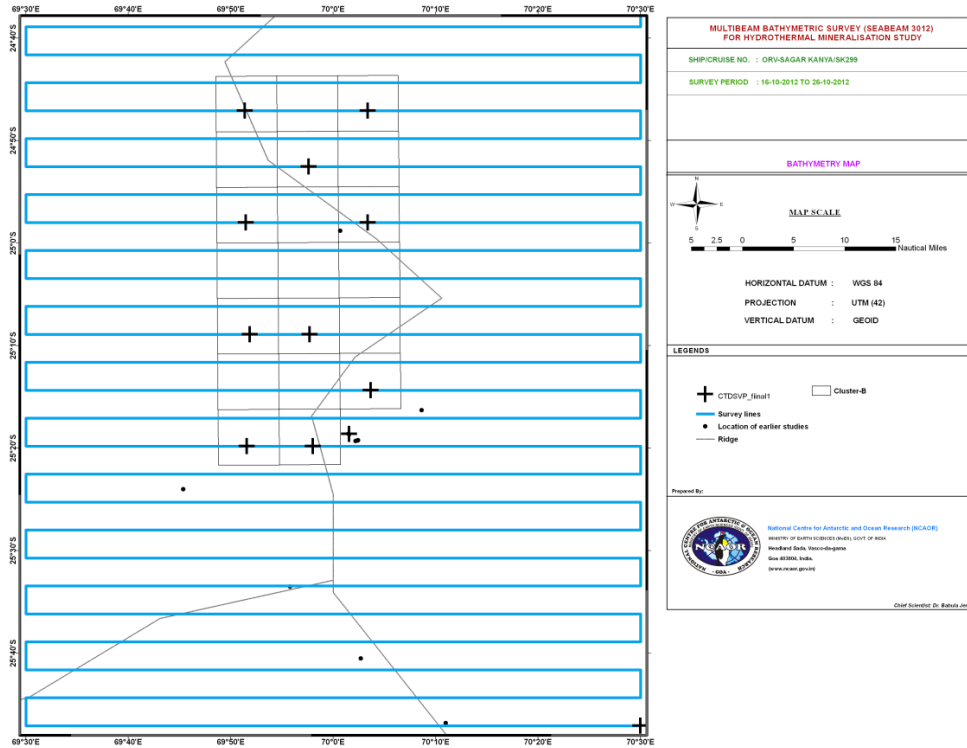


Figure 2: Shows the MBES survey lines B7-B32 with 5km spacing (blue color lines), CTD/SVP locations (+), ridge axis (black color line), and earlier reported studies (dots).

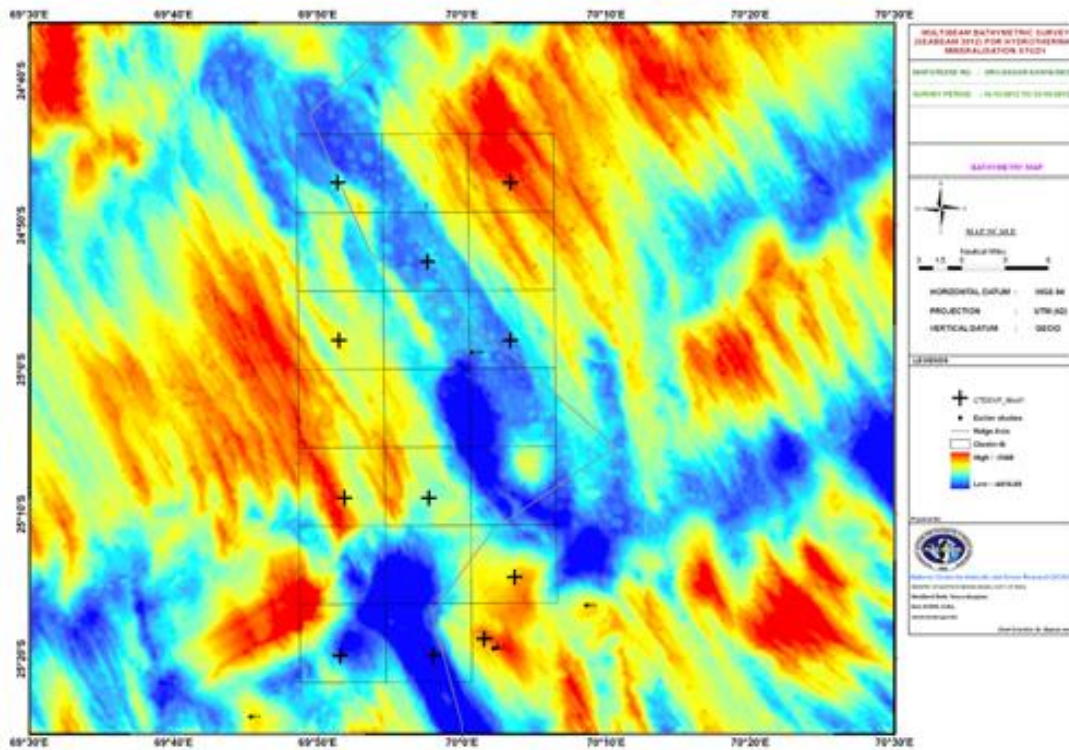


Figure 3: High resolution 2-D MBES map of cluster-B using B7-B23 survey lines.

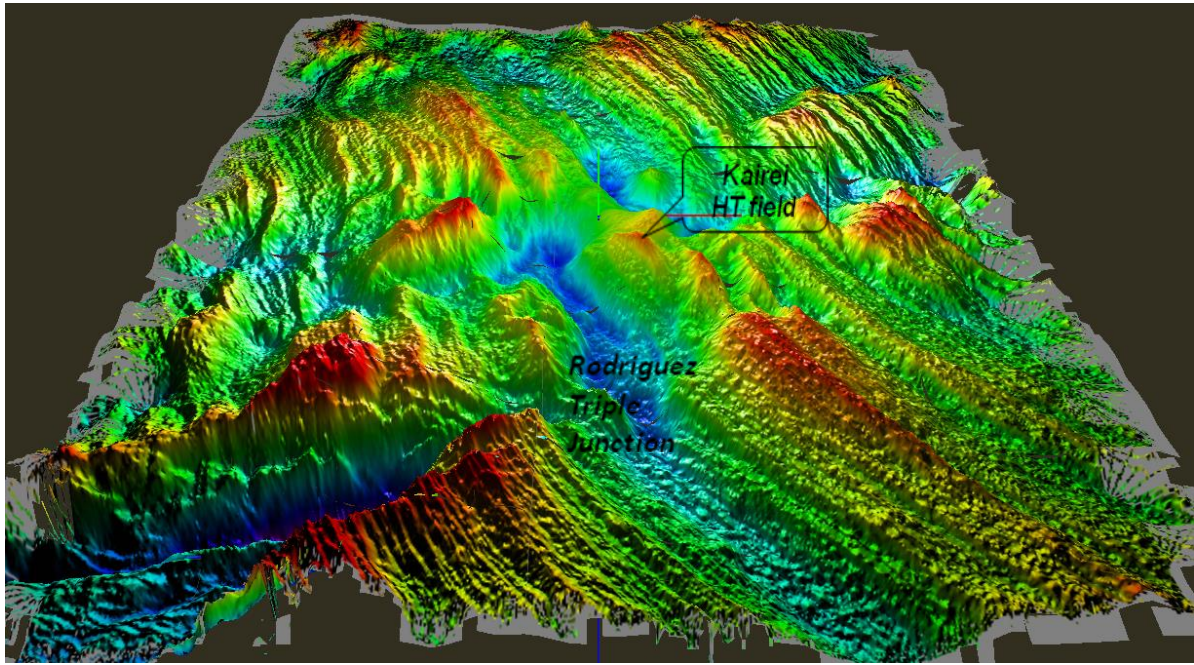


Figure 4: High resolution 3-D MBES map of cluster-B using B7-B32 survey lines. MBES datasets are 5times vertically exaggerated.

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