CRUISE REPORT

ORV SAGAR KANYA
CRUISE 195
(28 July to 30 August, 2003)

राष्ट्रीय समुद्र विज्ञान संस्थान
NATIONAL INSTITUTE OF OCEANOGRAPHY
ORV SAGAR KANYA
CRUISE 195
(28 July to 30 August, 2003)

NATIONAL INSTITUTE OF
OCEANOGRAPHY
(Council of Scientific and Industrial Research)
Dona Paula, Goa 403004
CONTENTS

1. Summary
2. Cruise track
3. Introduction
4. Itinerary
5. Participants
   5.1 Scientific component
   5.2 Ship’s compliment
6. Objectives
7. Work accomplished
   7.1 Survey plan and equipment used
   7.2 Geology & Geophysics
   7.3 Physical oceanographic observations
   7.4 Chemical oceanographic observations
   7.5 Biological oceanographic observations
8. Performance of equipment used
9. Performance of the ship
10. Conclusions
11. Recommendations
12. Acknowledgements

Annexure - Details of operations carried out during the cruise.
1. SUMMARY

The SK-195 cruise onboard ORV Sagar Kanya is the second of the four cruises proposed for the joint CSIR-DOD Network Program titled "Tectonic and Oceanic processes along the Indian ridge system and the backarc basins". The main objectives of the cruise were to acquire Multibeam swath bathymetry (Hydrosweep), Geophysical data and to carry out CTD observations, collect water, sediment, and rock samples at select locations for geological, biological, physical and chemical oceanographic studies. These studies are aimed at characterizing the ridge axis in terms of the tectonic segmentation and to delineate the hydrothermal mineralization zones based on the geological, chemical and biological signatures. A total number of 39 sampling operations were carried out; these consist of 23 deep CTD casts, 14 dredge operations with Chain bag dredge and 2 Spade core operations. The CTD casts are selected within the rift valley zone and on the off-axis highs. The entire rift valley as revealed by the swath bathymetric map was sampled at about 10 to 15 miles interval. These operations were aimed to study the near seabed chemical signatures and the CTD was lowered and suspended to about 5 m above the seafloor with the help of altimeter. Out of the 14 dredge operations 9 operations were successful, the recovery varied from 5 kg to 900 kg and a variety of rocks were recovered. There was no recovery in the 2 spade core operations. The multibeam and geophysical observations were planned primarily to cover the ridge crest region from the axis to about 30 miles on either side. The survey lines are planned at 3-mile interval to achieve 100% coverage of the seafloor.

About 19757 sq. km area covering the ridge axis between 04°30'S and 07°55'S latitudes and 67°30' and 69°10'E longitudes was mapped. About 3440 line km of magnetics 5040 line km of gravity and sub-bottom profiler data were acquired within the survey area. The ADCP data was acquired along the survey tracks.
Fig. 1. Cruise track of the voyage.
Fig. 2. Seafloor image generated from the swath bathymetry data. Station locations are superimposed.
3. INTRODUCTION

Mid-oceanic ridges are the primary sites of volcanic activity and generation of new crust. They exert major influence on the evolution of the solid earth, affect the composition of the ocean waters and support unique forms of life. It is estimated that about 25% of the Earth’s total heat flux is transferred to the hydrosphere through thermal convection related to volcanic and hydrothermal activity associated with mid oceanic ridges.

Ocean crust formation is a multi-dimensional process, as is clear from the variations that occur even at constant spreading rate. Problems such as the linkages between the surface manifested characteristics and the causative processes deep within the mantle are global in scale, and have wavelengths longer than any regional study can encompass. These aspects could be addressed by contributing to build a global database. At segment scale investigations, there is inherent value in the exploration of unknown terrain: every ridge segment that has been investigated thus far has yielded surprises that did not conform to our preconceptions, thereby stressing the importance of exploring every segment of the ridge system. Exploration remains necessary to know the variability and to generate the global database to address problems of local and global nature.

The mid-ocean ridge systems in the Indian Ocean comprise of Carlsberg Ridge (CR), Central Indian Ridge (CIR), South West Indian Ridge (SWIR), South East Indian Ridge (SEIR). The backarc spreading system in the Andaman Sea region is an illustration of the spreading systems in the backarc basins. The CIR, SWIR and SEIR meet at the Rodriguez Triple Junction (RTJ) in a inverted Y shaped junction. These ridge systems together with the backarc spreading system in the Andaman Sea provide us an opportunity to study a broad range of characters related to the global ridge systematics. Among these ridge systems the SWIR and a part of the SEIR are comparatively better explored than the CR, CIR and Andaman backarc systems.

A 240 km long segment of the CR extending to about 60 km off-axis has been surveyed with multibeam bathymetry and other geophysical data. The swath bathymetric data and few geological samples have given good insight into the Carlsberg Ridge tectonic framework. The CIR spreading axis north of the Vema fracture zone has been mapped. In the Andaman backarc basin (ABB) the backarc spreading center has been mapped and the studies provided new insights into the evolution of the Andaman back-arc basin. The data were acquired during 1997 and 2000.

The ridge program aims to concentrate on CR-CIR and Andaman backarc spreading systems by launching an inter-disciplinary exploration program to understand the tectonic and oceanic processes that are occurring at these dynamic plate boundaries. A joint CSIR-DOD Network program has been formulated to undertake the ridge research.

The SK-195 cruise onboard ORV Sagar Kanya is the second of the four cruises that were proposed for the joint CSIR-DOD Network Program titled “Tectonic and Oceanic processes along the Indian ridge system and the backarc basin”.

4. ITINERARY

<table>
<thead>
<tr>
<th>Departure</th>
<th>Arrival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male, Maldives, 28 July 2003</td>
<td>Tuticorin, 30 August 2003</td>
</tr>
</tbody>
</table>
5. PARTICIPANTS

5.1 Scientific component

1. Dr. K.A. Kamesh Raju, Chief Scientist NIO, Goa
2. Dr V. Subrahmanyam -do-
3. Dr. Sridhar Iyer -do-
4. Dr. R. Banerjee -do-
5. Dr. Damodar Shenoy -do-
6. Mr. J. Ravindran -do-
7. Mr. Durbar Ray * -do-
8. Mr. Desmond Gracias -do-
9. Mr. P. Ganesan -do-
10. Mr. K.P. Krishnan -do-
11. Mr. Dwijesh Ray -do-
12. Mr. Anoop M. -do-
13. Mr. Imran Mirza -do-
14. Mr. Sandeep Kadamb * -do-
15. Ms. Sini Pavithram -do-
16. Ms. Sonal Kamat -do-
17. Dr. R.K. Drolia NGRI
18. Mr. Anoop K.V. * -do-
19. Mr. Shaji Mathews * -do-
20. Dr. Dr. Saumitra Mishra IIT Kharagpur
21. Mr. Sandeep Bagul ELCOME
22. Mr. P.K. Singh -do-
23. Mr. A. Luis -do-
24. Mr. Sahoo -do-
25. Mr. Bisht N. Singh -do-
* Continued from SK-194 cruise

5.2 Ship’s compliment

1. Sanap/Mahendra/Damodar Master 27. Khalasi/Babubhai/Vishrambhai
6. Mascarenhas/ Peter Paul R/O 32. Kondekar/Alisab/Sk/Dawood E/Srg
7. D’silva Rommel Gregorio S P/O 33. Pawar/Suresh/Mahadeo D/G
8. P. Jayakumar CEO 34. Anarkar/Rajamiya/Gaphur D/G
9. Lakanpal/Vijay Kumar 2EO 35. Wavgharkar/Jakir/Kadir D/G
10. Ramaiya/Mahesh Kumar 4EO 36. Tandel/Damabhai/Kesharbhai ERR2
12. Kamalan/Rajesh/Partharha Parambil 4EO 38. Moraes Tiago William ERR2
15. Rodrigues/Macario/Filomeno CTO 41. Karbelkar Ibrahim B. 2/CK
17. Dey/Minal Kanti ERPOI 43. Dias/Reginaldo G.S
18. Ghosh Dastidar/Pumendu ERPOI 44. Soares/Inacio Xavier G.S
20. Mohite/Deepak/Manohar POM 46. Silveira/Tomas G.S
21. Hazarika/Arun POM 47. Fernandes/Geraldo G.S
23. Neduvayil/Anandan/Kutty SHM 49. Perumal/Mani U.S
25. Landge/Shamrao/Mashapa SHM 51. Keekan Muhammed Rasheed SUH
26. Ahmed/Kadir SHM 52. Bamban/Vishvanatha Pattathanam LMN
6. OBJECTIVES

The main objectives of the cruise were to acquire Multibeam swath bathymetry (Hydrosweep), Geophysical data and to carry out CTD observations, collect water, sediment, and rock samples at select locations for geological, biological, physical and chemical oceanographic studies.

These studies are aimed at characterizing the ridge axis terms of the tectonic segmentation and to delineate the hydrothermal mineralization zones based on the geological, chemical and biological signatures.

7. WORK ACCOMPLISHMENT

7.1 Survey plan & equipment used

The survey during SK-195 onboard ORV Sagar Kanya was planned to map the ridge segment between 04°30'S and 07°55'S latitudes and 67°30'and 69°10'E longitudes with 100% coverage using the swath bathymetry and to carry out seabed sampling and CTD observations in the same area. The basic planning of the cruise tracks was done based on the satellite gravity map. The survey lines for mapping and geophysical data were planned in the NE-SW direction over the ridge segment in order to be perpendicular to the ridge-axis. The distance between the lines was kept at 3 miles. This spacing provides 100% coverage over the region. The length of the lines is limited to 60 miles to map the rift valley and the off axis highs and to document magnetic anomalies up to 2. As the survey progressed these track lengths and orientations were altered to achieve proper coverage with respect to the ridge axis. The survey strategy was to map the segments with swath bathymetry and then select the locations for seabed, water column sampling and CTD observations. It was planned to have CTD observation at every 10 miles all along the rift valley. Typical sampling locations were along the rift valley, ridge-transform intersection regions and the off-axis highs. Sampling locations were selected based on the high-resolution seafloor maps.

The following equipment were used:

1. MAGELLAN Global Positioning System receiver
2. KRUPP-ATLAS Hydrosweep swath bathymetric system
3. Honeywell ELAC Deep-Sea Echosounder
4. KSS-30 Seagravimeter
5. G-886 GEOMETRICS Marine magnetometer
6. GeoAcoustics Sub bottom profiler GeoPro4
7. SBE 911 CTD system with 1.8 litre capacity NISKIN bottles on Rosette
8. Onboard Automatic weather station
9. RD Instruments VM-ADCP System
11. Meteorological kit DYNALAB
12. Chain bag dredge
13. Pipe dredge
14. Spade corer
15. Ovens and refrigerators
16. PCs were used for data logging and processing.
7.2 Geology & Geophysics

Swath bathymetry

The Hydrosweep system functioned satisfactorily throughout the cruise. The data were logged on magnetic tapes and also on a PC. Towards the end of the cruise the mag tape drive gave problem, due to this some of the data were not recorded on mag tapes.

Swath bathymetric data were acquired along the 3 mile interval tracks planned based on the satellite gravity map (Fig. 1). The tracks are planned to cover the ridge axis with a 30 mile off axis coverage on either side of the spreading center. The track interval is maintained at 3 nautical miles in order to achieve 100% insonification of the seafloor. A total of about 19757 sq. km area has been covered with 100% coverage over three segments of the ridge axis. These three segments fall in Block-I, Block-II and Block-III areas of survey (Fig. 1). The Hydrosweep data was processed onboard using LINUX PC. The plotting of the seafloor maps and images was accomplished by GMT software.

The spreading center in Block-I is characterized by a well defined rift valley and consists of two small segments of 36 and 26 km in length. These segments are offset to about 10 km by a transform fault. A well-developed corner high is observed at the ridge-transform intersection (RTI), this corner high also forms a part of the Kurchatov seamount. The off-axis traces of this transform fault have not developed into a fracture zone. The southern segment terminates into a transform fault the off axis traces of which define the Vityaz fracture zone. The ridge takes major offset across this first order transform; the offset is about 100 km.

The rift valley character in Block-II is distinctly different than the segment north of Vityaz fracture zone. The ridge axis is linear and shallow in nature, the depth of the rift valley varies from 3000 to 3500 m whereas in Block-I it is about 4000 to 4200 m. The ridge segment is straight with well-defined ridge parallel topographic fabric. The near straight and linear segment terminates in a transform fault at about 6° 30’S latitude. The transform fault has off-axis features that define fracture zone. A well developed inside corner high is mapped at the RTI. The corner high is about 1800 m.

The transform fault between the Block-II and Bock-III offsets the ridge axis by about 75 km. A well-developed corner high rising to a depth of 1600 m is mapped at the RTI. The ridge crest topographic character of the segment in Block-III is similar to Block-I. Here the ridge axis splits into short segments characterizing fourth order segmentation.

The swath bathymetric maps were used to select the seabed sampling locations and the CTD casts. The seafloor image along with the seabed sampling locations is given in (Fig. 2). High-resolution maps are essential to precisely locate the sampling locations. Availability of a large format color plotter onboard would have been very useful in the selection of the right locations.

Gravity and Magnetics

Gravity and total intensity magnetic data were acquired concurrent with swath bathymetry and single beam echo sounding data. The objective of collecting this data was to study tectonic evolution of the ridge and its segmentation.
Gravity: The gravity data were acquired along the cruise tracks planned at about 3.0 nautical mile spacing (Fig. 1). Free-air gravity mimicked the seafloor topography with prominent variations over the rift valley and the off-axis topographic highs. The free-air gravity anomalies varied from -58 to 199 mGals. Integrated analysis of the gravity along with magnetic and swath bathymetric data is envisaged to provide insights about the deep crustal structure.

Magnetics: The total magnetic intensity data were acquired with G-886 marine Proton precession magnetometer. The sensor was towed at a distance of about 250 m astern of the ship to minimize the effects of the ship on the total intensity measurements.

The magnetic data along with position information from the GPS system is logged on a PC and the analog data was recorded using a printer.

The total magnetic intensity anomaly field in the three Ridge segments of the study area varies from -200 to +200 nT. This variation on segment scale is very distinct suggesting not only inter-segmental variation but also the intra-segmental variation. The segment in block II clearly depicts the intra-segmental variation both in morphology and spreading rate.

Sub Bottom Profiling (SBP)
The sub-bottom profiler data were acquired using GeoAcoustics make GeoPro4 system. The system was operated at 3.5 KHz and the data are recorded on the hard disk of in Muse SEGY format. These data are copied on to CDs for further analysis.

The area is devoid of sediment cover. Sediment pockets are observed within the deeps of the fracture zone areas. These appear to consist of compact sediments based on the character of the reflection. Strong hyperbolic reflectors are noticed in the rift valley shoulders and on the off-axis highs. SBP data was used to select the seabed sampling locations.

Block I:
The axial depth is more than 4000 m in the southern end which shallows towards north (ref. line 8 to line 11). Along the line 13 the axial valley is very shallow <3600 m and is not well developed. In the northern part of the block, the southwestern flank of the rift valley in the northern part is gently shallows from 3800 to a water depth of 3100 m, whereas the northeaster flank has a steep slope and shallows towards 2800 m. The flanks of the axial valley in the southern part of the segment after its oblique nature, has the opposite character, i.e., the northeastern flank has gentle slope whereas the southwestern flank has a steep slope.

Block II:
The northern part of the segment in block II south of the Vityaz Transform is characterized by shallow and very wide axial valley (2800 to 3000 m water depth), which suggests the fast spreading character of this part of the segment. The ridge axis deepens (>4200 m) towards south. There is a bend in the axial valley in the central part of the segment, which may probably refer as the fourth order discontinuity.

Block III:
The area is characterized by deep at centre of the segment (water depth > 4000 m) with narrow valley and shallower (~ 3800 – 4000 m) at the end of the segment. The
hump noticed in profiles of central part of the rift valley may probably indicative of neo-volcanic zone.

**Seabed Sampling**

During the course of the cruise, geological sampling using pipe dredge, chain bag dredge and spade core operations were carried out.

**Dredge operations**

Altogether 14 dredging operations were made (Table I, Fig. 1). The first chain bag dredge (DR # 01) was lost. During the 2\textsuperscript{nd}, 3\textsuperscript{rd} and 4\textsuperscript{th} operations, a pipe dredge was used but without any successful recovery. From 5\textsuperscript{th} to 14\textsuperscript{th} dredging operations, chain bag dredge was used. Many successful recoveries were made during the operations of DR#06, DR#09 to DR#14. DR#5 and DR#7 collected few biological samples like shrimp and brittle star while DR#8 did not collect any samples.

Rocks were recovered from various topographic locations such as rift valley, rift flanks and Kurchatov seamount. The samples collected were columnar and pillow basalts (fresh and weathered), serpentinites, serpentinised basalts, gabbros, pumice and the surrounding calcareous sediment. On a few samples, a thin veneer of ferromanganese coating was observed.

**Individual Dredge Samples Descriptions:**

**DR # 06**

Twelve pieces of pillow fragments/basaltic chips of different sizes varying between 0.5 cm to 4.5 cm and of about 100 g were recovered. Most of the pieces are encrusted with Fe-Mn oxides.

**DR # 09**

The dredge recovered about 1200 kg of assorted rocks that represent serpentinites, gabbros, pumice and conglomerate/breccia(?). Sediment that came with the rocks are found to be calcareous as confirmed by reaction with dilute HCl. The rocks are of varying sizes between 2.5 cm to 50 cm. The rocks have various hues of green that could be olivine/serpentine/chlorite and with white/pink streaks of feldspar (?) mineral. Several samples have a thin coating of brownish-black Fe-Mn oxides. Some samples show clear striations indicating slickenside structure and also sheared features. Many samples have a flaky, rectangular micaceous mineral suggesting metamorphic processes. Interestingly the recovery seems to be devoid of any fresh basalt.

In addition to the rock and sediment samples, biological organisms like shell fragments and tubes of benthic foraminifera were also collected.

**DR # 10**

The dredge recovered about 400 kg of rocks that appear to be similar and uniformly coated with Fe-Mn oxides. The size of the samples ranges between 12 and 33 cm. Most of the recovered samples are broken fragments of columnar basalts with reddish brown tinge indicative of slight alteration. A couple of pillow basalts too were recovered of sizes 13 to 33 cm. The rocks are aphyric and with signs of low temperature alteration. A few samples have a thin glassy crust, which is partly altered.

Calcareous sediment and biological organisms such as broken shell, fragments, and brittle star were also collected along with the dredged rocks.
DR # 11
Two samples of fresh pillow basalts weighing about 8 kg and of 12 and 17.5 cm in length were collected. The samples have glassy veneer and are either aphyric or have sparse phenocrysts. Alteration strains are conspicuous.

DR # 12
Four pieces of rock samples totaling about 25 kg were collected. A large fragment of columnar basalt of 19 cm long and the interior is fresh. The basalt is covered with glassy veneer that in turn is coated by Fe-Mn oxides. The Fe-Mn oxides show botryoidal morphology. The other three rock pieces are variously altered pillow fragments (up to 22 cm long) that are partly covered with a thin layer of Fe-Mn encrustation.

DR # 13
Dredging of the Kurchatov Seamount revealed a suite of rocks comprising of basalts with a thin cover of Fe-Mn oxides, serpentinised basalts, serpentinites and pumice. Calcereous sediment was also recovered along with the rock samples.

DR # 14
Mostly columnar and a few pillow basalts were collected. Some of the samples have a thin glassy crust coated with Fe-Mn oxides. Serpentinisation of columnar basalts is not uncommon. Several of the samples and a large boulder (~53 cm) show distinct and extensive jointing patterns.

Most of the samples were photographed and representative samples were selected for further processing in the laboratory. The remaining samples were numbered and packed.

Sediment Sampling
Two spade core operations (SC # 01 and 02) were carried out in sedimented areas based on the SBP data, but with no recovery.

7.3 Physical oceanographic observations

CTD observations
SBE 9/11 plus CTD system with pressure, temperature, conductivity, turbidity, Light Scattering Sensor (LSS) and Transmissometer sensors were operated. The CTD observations were made at 23 stations (Cruise track, Table-II). Water samples were collected using the NISKIN bottles on Rosette sampler. Near seabed depths were reached with the help of altimeter sensor and water samples were collected within 5 m above the seabed.

In the study area of the Indian Ocean, the sea surface temperature (SST) was, in general, above 27.9°C and relatively higher than the air temperatures.

Preliminary analysis from the vertical temperature and salinity sections reveals the salient features of surface mixed layer and the thermocline/ halocline layers below. Mixed layer depth in general varied between 40 and 60 metres with deep thermoclines extending upto 1200 m. Chlorophyll maxima was usually observed a few metres above the mixed layer depth.

Additional sensors were installed to the CTD system for measuring Light Scattering (LSS), and light transmission (transmissometer) for collecting information pertaining
to the particle concentration at the CTD stations. These measurements were aimed to monitor the hydrothermal plume signatures. LSS measures the scattering strength and is a good indicator of the particle concentrations, particularly in the vicinity of hydrothermal plumes. Transmissometer has a path length of 25 cm and is also a very sensitive unit. This sensor, showed some variations in signal strength of the order of few micrograms per liter at the above stations. Due to the large wire angle at stations 04, 05, 12, and 20 CTD operations could not be carried close to the sea bottom.

During this cruise as a part of NIO's drift buoy program, two drift buoys were deployed in the Indian ocean at locations: 06°32' S, 67°46'E; 05°56'S, 68°40'E.

**VM-ADCP**

Vessel Mounted Acoustic Doppler Current Profiler (VM-ADCP) recorded information on subsurface currents in the depth range 15 - 250 m and was operated in the navigation mode. Post processing and analysis of these data would be carried at NIO.

**Met observations, AWS and TSG**

Surface meteorological observations were made at the CTD stations, various parameters covered included the air temperature, sea surface temperature, wind speed and direction, relative humidity radiation and sea surface pressure (Table-III).

Automatic Weather Station (AWS) recorded the surface meteorological observations throughout the cruise. Besides this, IISC also installed one more AWS which carried measurements of surface meteorological parameters. Stormy weather conditions (sea state upto 6) prevailed at the beginning of the voyage with occasional strong winds upto 15 m/s. However, the weather improved during the remaining part of the cruise when the actual survey of the study area was done.

Thermo-salinograph (TSG) was operated to record surface temperature and salinity right from Male to the survey area and continued till the end of the cruise. Though the temperatures closely matched with CTD and bucket thermometer values, salinities from TSG were very lower by about 3 PSU.

### 7.4 Chemical oceanographic observations

Water column chemical parameters like Total Dissolved Manganese (TDM), Total Dissolved Iron (TDI), silicate, sulphide, Dissolved Oxygen (DO), Methane content, Redox potential (Eh), pH etc are important traces to locate the active hydrothermal vent field. The enrichment (or depletion) of those traces in deep-sea water in comparison to ambient waters indicates the presence of nearby hydrothermal plumes.

In order to look at the chemical signatures from the hydrothermal vent fields sampling was done at all CTD stations. The bottom most sample in almost all the cases was around 8 meters above sea bottom. Out of 23 stations (Fig. 1, Table-II), 7 were in the rift valley where the depth was greater than 3500 m and the remaining on the flanks where the depth ranged from around 1800 m till around 3000 m. Water sampling was done based on temperature, salinity, transmissometer and light scattering sensor (LSS) profiles of the CTD. Sub-sampling was done for dissolved oxygen (DO), methane, pH, redox potential (Eh), total dissolved manganese (TDM), total dissolved iron (TDI), dissolved silicate and sulphate. Except for methane all analysis were completed on board.
The water samples were analysed for the above-mentioned parameters within four hours after sampling. For on-board analysis the following methods and materials were used.

**pH and Redox potential (Eh)**
We measured the pH (-log aH⁺) and Eh of the water samples, immediately after collection with pH meter (PHAN pH analyzer, Lab India, Pvt.Ltd).

**Dissolved Oxygen (DO)**
The dissolved oxygen content was measured by Winkler method (Winkler, 1888). In this method, after collecting the water samples in DO water, the DO was fixed immediately with Winkler A and Winkler B reagents and allowed to settle. After acidification (50% H₂SO₄), the liberated iodine was titrated against the standard Thiosulphate solution using Starch as an indicator. For titration on board dosimat (titration unit) was used.

**Methane**
To estimate the methane content, the water samples were immediately poisoned with saturated HgCl₂ solution and sealed. Then those samples were stored for on shore Gas chromatographic analysis.

**Total Dissolved Iron (TDI)**
The TDI of water samples was measured spectrophotometrically (using UV-1601, UV-Visible spectrophotometer, SHIMADZU, Corp, Japan) following the modified Ferrozine method. With this method the water samples were allowed to react with Ferrozine (monosodium salt hydrate of 3-(2-pyridyl) 5,6-diphenyl-1, 2,4-triazine-p, p disulphonic acid) in presence of ammonium acetate buffer (pH-9.5) and hydroxyl ammine hydrochloride solution. The absorbance of resultant Magenta coloured Fe (II)-Ferrozine complex solution was measured at 562 nm.

**Total dissolved Manganese (TDM)**
To measure TDM in water samples 1-(2-pyridal azo)-2-naphthol (PAN) reagent was added in the presence of borate buffer (pH-10), which develops highly coloured PAN-Mn complex. The absorbance of resultant solution was measured at 569 nm. The interference of dissolved iron was removed by addition of desferroxamine-B solution.

**Dissolved silicate**
Total dissolved silicate in water samples was analysed spectrophotometrically by developing silico-molybdenum blue, with ammonium molybdate and ascorbic acid solutions in the presence of oxalic acid. The absorbance was measured at 810 nm.

**Dissolved Sulphide**
The amount of hydrogen sulphide gas present in water samples were analysed spectrophotometrically by adding 1 ml of p-phenyldiammine hydrochloride and 0.2ml of ferric chloride solution. The absorbance was measured at 600 nm. Due to oxygen content in the samples the sulphide measurement was neglected.

In addition to analysis of metals on board samples have been collected for the same for analysis by GFAAS at the shore based laboratory. Dissolved sulphate, which is an additional parameter in this cruise was measured by addition of barium chloride to a definite quantity of seawater sample in the presence of a stabilizing reagent. The transmittance of the resultant barium sulphate precipitate is measured at 420 nm.

Dissolved oxygen in the rift valley varied between 1.54 ml lit⁻¹ and 4.03 ml lit⁻¹ with an average value of 3.74 ml lit⁻¹, while on the flanks it varied between 1.8 ml lit⁻¹ and 4.1
ml l⁻¹ with an average value of 3.2 ml l⁻¹. pH in the rift valley varied between 7.71 and 7.85 with an average value of 7.79, while on the flanks it varied between 7.66 and 8.17 with an average value of 7.77. Dissolved silicate in the rift valley varied between 63.3 μM and 131.5 μM with an average value of 119.2 μM, while on the flanks it varied between 78.3 μM and 125.4 μM with an average value of 115.5 μM. Other data are still in process.

7.5 Biological oceanographic observations

Water samples
From twenty-three CTD operations (Fig. 1, Table-II), water samples were collected from near bottom and from four other depths for bacteriological studies with emphasis on the microbiology of the plume waters. Bacteriological studies were conducted to isolate and quantify heterotrophic colony forming bacteria using low strength and normal strength nutrient agar media. In addition, aerobic and anaerobic *Thiobacillus denitrificans* like organisms (TDLO) were quantified and isolated, nitrifying bacteria were isolated and quantified. Metal tolerance of heterotrophic bacteria against the metals, Mn, Cd, Co, Zn in various concentrations were quantified and isolated. These water samples were fixed for direct bacterial count using Acridine orange (AODC). Near bottom water samples were estimated for the chlorophyll content to account the phytoplankton sink form the surface.

Benthic samples
Out of fourteen dredge operations, rock samples were collected from three dredge operations, DR-03, DR-10 and DR-14 respectively for the observation of the floral components attached with the rock samples. The biological materials collected during the dredge operations as summarized in the table.

<table>
<thead>
<tr>
<th>Station No.</th>
<th>Fauna</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR-07</td>
<td>1. Serpent star</td>
</tr>
<tr>
<td></td>
<td>2. Unidentified</td>
</tr>
<tr>
<td></td>
<td>3. Shrimp/Lobster</td>
</tr>
<tr>
<td>DR-09</td>
<td>1. Unidentified</td>
</tr>
<tr>
<td>DR-10</td>
<td>1. Brittle star</td>
</tr>
<tr>
<td></td>
<td>2. Unidentified</td>
</tr>
<tr>
<td>DR-13</td>
<td>1. Unidentified</td>
</tr>
<tr>
<td>Dr-14</td>
<td>1. Feather star</td>
</tr>
</tbody>
</table>

These organisms were fixed and preserved for identification and for histological studies. The histological studies will reveal the presence on symbiotic bacteria that is characteristic feature of benthic fauna of a hydrothermal vent.

8. PERFORMANCE OF THE EQUIPMENT

During the cruise following equipments were used:
1. CTD                  23 stations
2. Chain bag dredge    14 stations
3. Spade core           02 stations
4. Hydrosweep swath bathymetry system, magnetometer and gravity meter.
5. ADCP and AWS systems
6. Navigation and computing facilities
MAGELLAN Global Positioning System - The GPS system performed satisfactorily throughout the cruise. The system failed on 28 August 2003 on the return track to Tuticorin. The system was replaced by a spare system available with ELCOME. The original unit needs repairs.

Deep sea echosounder - Deep-sea echosounder has not performed satisfactorily during the cruise. Due to this it was not possible to use pinger for the seabed sampling operations.

Hydrosweep system - The multi-beam swath bathymetry system, Hydrosweep system, was used throughout the cruise. The system has performed satisfactorily. However, the magnetic tape drives started giving problem towards the end of the cruise. Further it is noticed that only one drive was functional at the start of the cruise and then both the tape drives were down during the cruise. These need to be repaired immediately.

Gravimeter - The Bodenseewerk sea gravimeter system KSS 30 worked satisfactorily during the cruise. However, during the calibrations at Karwar port at the start of SK-194 cruise it was observed that the Parabola test was not completed successfully. The reason for this was that the Pitch setting reached saturation and the test could not be conducted at this stage. It appears that this is affecting the quality of the data, during both the cruises SK-194 and SK-195 and it was observed that the free-air gravity values were always positive requiring a base shift to get the actual values.

The Gravimeter needs a through servicing and calibration by qualified service personnel, preferably the service engineers of the manufacturer. Since the system has completed about 20 years of service it may be necessary to plan for the upgradation of the system.

Magnetometer - The magnetometer did not function properly during major part of the cruise. The data was noisy and had abrupt changes. The AMC engineers made several attempts on the sensor and the CPU but could not locate the exact cause. There was no spare CPU onboard for the replacement. It is required to procure spare CPU unit and also send the existing faulty CPUs to the company for test and repair. It is also necessary to have a termination kit.

Deep sea winch - The deep-sea winch gave satisfactory performance under the constant supervision of CEO and his staff.

CTD unit - The CTD system and the winch performed satisfactorily. However, it was observed that the winch was too slow while doing the deep stations. After paying about 3500 to 4000 m, the hauling up speed was very slow. This was stretching the time to about 4.5 to 5 hrs for deep stations. The modern winches are faster and more safe for the cable. Since the CTD system caters to the needs of a large number of scientists it may be worth while to plan for a new winch system.

VM-ADCP - VM-ADCP unit functioned satisfactorily throughout the cruise. Data logging was made along selected lines.

Bucket Thermometer - Bucket thermometer was brought from NIO and it was used to collect the sea surface temperature at the sampling locations. Observations were made at all the CTD stations. The data was logged on the standard data sheet.
Metkit – DYNALAB - The kit was brought from NIO. All the components of the kit performed satisfactorily.

9. PERFORMANCE OF THE SHIP

Ship's staff was cooperative during the survey and at stations while carrying out CTD and seabed sampling. The navigation and engineering departments gave excellent support during the dredging operations resulting in successful dredge hauls. The Catering Officer and his team rendered excellent service.

During the cruise the Boat Drill and Shipboard Oil Pollution Emergency Plan drill were conducted and the Chief Officer explained the duties of each person onboard.

10. CONCLUSIONS

During the cruise as planned the survey was conducted along three segments of the Central Indian Ridge with multi-beam bathymetry, gravity and magnetics. The swath bathymetry maps were used to select the sampling locations for geological sampling in the area.

The dredge operations were successful and a variety of rocks consisting of altered basalts with Fe-Mn oxides, pillow fragments, columnar basalts, and serpentinite from the rift valley, ridge-transform intersection corner highs and off-axis topographic highs were recovered. One chain bag dredge was lost during the first dredging operation. Modifications made onboard to the dredge, of the NIO which was loaded at Karwar, resulted in successful recoveries during subsequent operations.

The sub-bottom profiler worked satisfactorily and the online data was used in conjunction with swath bathymetry to select the locations for geological sampling and CTD casts.

CTD operations were successful. Water samples were collected near to the seabed and at anomalous zones. CTD carousel was fitted with the light scatterometer and trasmissometer and data from these sensors was collected on-line for the detection of the hydrothermal emanations.

Starting the cruise from Male, Maldives, after the completion of SK-194 cruise, was helpful and provided additional days of ship time at the survey area.

11. RECOMMENDATIONS

- At present the gravity, magnetic and Hydrosweep data are being logged separately. **An integrated logging system is essential for the data logging and monitoring of all types of underway data.** Integrated navigation system with logging facility would be an ideal solution.

- The Hydrosweep system performed well during the cruise. It is necessary to plan for the up-gradation of the system and explore the possibility of increasing the swath coverage.

- Gravimeter system urgently requires servicing and calibration by the manufacturers as the Parabola test is not passing through. An urgent action is
requested, as this condition related to the platform would effect the quality of the data. Further, since the system is more than 20 years old it is necessary to make efforts to upgrade/replace the present model with the latest available version.

- A workstation (e.g. SUN Ultra 60 or higher) along with A0 size inkjet (e.g. HP-DesignJet) plotter is required for the onboard post processing of MBS and geophysical data.

- LINUX PCs in the geophysics and physics laboratories are required for post processing and plotting of underway data.

12. LOSSES

During the cruise following losses occurred:

One dredge was lost during dredging operations. Report of the loss was prepared and submitted to NCOAR, NIO and SCI.

13. ACKNOWLEDGEMENT

Master, ORV Sagar Kanya, and his team of Officers and Engineers are thanked for extending their support and co-operation during the cruise. Dr. E. Desa, Director, N.I.O., Goa is thanked for the guidance and encouragement. Dr. P.C. Pandey, Director, NCAOR, Goa, Dr. M. Sudhakar, Program Manager, ORV SK & Group Director, and the team members of the ORV Sagar Kanya management cell of NCAOR are thanked for providing all the support and help. Ship Cell, N.I.O. is thanked for the shore-based support.
Details of operation carried out during the cruise

<table>
<thead>
<tr>
<th>Station No</th>
<th>Latitude (°S)</th>
<th>Longitude (°E)</th>
<th>Depth (m)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR#01</td>
<td>05°08.396</td>
<td>68°07.846</td>
<td>3050</td>
<td>Chain bag Dredge. Dredge lost.</td>
</tr>
<tr>
<td>SC#01</td>
<td>04°57.288</td>
<td>68°25.471</td>
<td>4118</td>
<td>Spade Core. A few tiny pieces of thin Fe-Mn encrustations.</td>
</tr>
<tr>
<td>DR#02</td>
<td>07°36.977</td>
<td>68°03.204</td>
<td>3441</td>
<td>Pipe Dredge. No recovery</td>
</tr>
<tr>
<td>DR#03</td>
<td>07°22.300</td>
<td>68°18.770</td>
<td>3773</td>
<td>Pipe Dredge. No recovery</td>
</tr>
<tr>
<td>DR#04</td>
<td>07°17.191</td>
<td>68°09.334</td>
<td>3650</td>
<td>Pipe Dredge. No recovery</td>
</tr>
<tr>
<td>DR#05</td>
<td>07°04.500</td>
<td>68°15.190</td>
<td>2446</td>
<td>Chain bag Dredge. A shell piece/barnacle.</td>
</tr>
<tr>
<td>DR#06</td>
<td>07°06.531</td>
<td>68°06.406</td>
<td>1560</td>
<td>Chain bag Dredge. 12 small pieces of basalt fragments ~ 100 g were recovered.</td>
</tr>
<tr>
<td>DR#07</td>
<td>07°04.688</td>
<td>68°05.506</td>
<td>1805</td>
<td>Chain bag Dredge. Shrimp and Brittle star</td>
</tr>
<tr>
<td>DR#08</td>
<td>07°25.623</td>
<td>67°50.754</td>
<td>2855</td>
<td>Chain bag Dredge. No recovery</td>
</tr>
<tr>
<td>DR#09</td>
<td>06°38.506</td>
<td>68°19.340</td>
<td>2700</td>
<td>Chain bag Dredge. Total recovery ~1200 kg includes serpentinite, basalt, gabbro and calcareous sediments</td>
</tr>
<tr>
<td>SC#02</td>
<td>06°15.788</td>
<td>68°50.262</td>
<td>4243</td>
<td>Spade Core. No recovery. Box lost.</td>
</tr>
<tr>
<td>DR#10</td>
<td>06°03.047</td>
<td>68°29.865</td>
<td>2362</td>
<td>Chain bag Dredge. Total recovery ~400 kg includes altered basalts with Fe-Mn oxides, calcareous sediments</td>
</tr>
<tr>
<td>DR#11</td>
<td>06°20.077</td>
<td>68°17.509</td>
<td>3573</td>
<td>Chain bag Dredge. Total recovery ~8 kg includes two pillow fragments (slightly altered).</td>
</tr>
<tr>
<td>DR#12</td>
<td>06°32.639</td>
<td>67°59.062</td>
<td>3070</td>
<td>Chain bag Dredge. Total recovery ~25 kg includes four pieces of encrusted basalts.</td>
</tr>
<tr>
<td>DR#13</td>
<td>05°26.918</td>
<td>68°31.755</td>
<td>2258</td>
<td>Chain bag Dredge. Total recovery ~450 kg includes basalts, serpentinite and calcareous sediments</td>
</tr>
<tr>
<td>DR#14</td>
<td>05°11.021</td>
<td>68°28.101</td>
<td>2999</td>
<td>Chain bag Dredge. Total recovery includes columnar basalt, serpentinite and calcareous sediments ~ 1200 kg.</td>
</tr>
<tr>
<td>Stn No</td>
<td>Date</td>
<td>Time(GMT)</td>
<td>Latitude</td>
<td>Longitude</td>
</tr>
<tr>
<td>-------</td>
<td>---------</td>
<td>-----------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Start</td>
<td>End</td>
<td>ddmmss</td>
</tr>
<tr>
<td>01</td>
<td>01/08/03</td>
<td>03:34</td>
<td>07:30</td>
<td>-5 01 57</td>
</tr>
<tr>
<td>02</td>
<td>02/08/03</td>
<td>12:50</td>
<td>16:45</td>
<td>-5 24 00</td>
</tr>
<tr>
<td>03</td>
<td>05/08/03</td>
<td>20:50</td>
<td>00:10</td>
<td>-5 01 41</td>
</tr>
<tr>
<td>04</td>
<td>14/08/03</td>
<td>22:30</td>
<td>00:55</td>
<td>-7 33 42</td>
</tr>
<tr>
<td>05</td>
<td>15/08/03</td>
<td>10:30</td>
<td>14:05</td>
<td>-7 23 03</td>
</tr>
<tr>
<td>06</td>
<td>15/08/03</td>
<td>20:50</td>
<td>00:20</td>
<td>-7 17 06</td>
</tr>
<tr>
<td>07</td>
<td>16/08/03</td>
<td>09:15</td>
<td>11:45</td>
<td>-7 01 31</td>
</tr>
<tr>
<td>08</td>
<td>16/08/03</td>
<td>21:10</td>
<td>22:55</td>
<td>-7 05 10</td>
</tr>
<tr>
<td>09</td>
<td>17/08/03</td>
<td>00:40</td>
<td>05:40</td>
<td>-7 08 01</td>
</tr>
<tr>
<td>10</td>
<td>17/08/03</td>
<td>13:15</td>
<td>15:45</td>
<td>-7 26 43</td>
</tr>
<tr>
<td>11</td>
<td>18/08/03</td>
<td>09:45</td>
<td>11:45</td>
<td>-6 36 24</td>
</tr>
<tr>
<td>12</td>
<td>19/08/03</td>
<td>00:50</td>
<td>06:25</td>
<td>-6 21 19</td>
</tr>
<tr>
<td>13</td>
<td>19/08/03</td>
<td>14:30</td>
<td>18:00</td>
<td>-6 02 22</td>
</tr>
<tr>
<td>14</td>
<td>20/08/03</td>
<td>02:00</td>
<td>06:30</td>
<td>-6 16 56</td>
</tr>
<tr>
<td>15</td>
<td>20/08/03</td>
<td>07:55</td>
<td>10:30</td>
<td>-6 16 31</td>
</tr>
<tr>
<td>16</td>
<td>20/08/03</td>
<td>19:45</td>
<td>22:48</td>
<td>-6 36 58</td>
</tr>
<tr>
<td>17</td>
<td>22/08/03</td>
<td>01:10</td>
<td>03:00</td>
<td>-5 27 04</td>
</tr>
<tr>
<td>18</td>
<td>22/08/03</td>
<td>06:15</td>
<td>10:40</td>
<td>-5 20 04</td>
</tr>
<tr>
<td>19</td>
<td>22/08/03</td>
<td>13:35</td>
<td>16:05</td>
<td>-5 09 03</td>
</tr>
<tr>
<td>20</td>
<td>22/08/03</td>
<td>17:10</td>
<td>21:30</td>
<td>-5 07 21</td>
</tr>
<tr>
<td>21</td>
<td>23/08/03</td>
<td>04:10</td>
<td>06:00</td>
<td>-5 09 14</td>
</tr>
<tr>
<td>22</td>
<td>23/08/03</td>
<td>08:15</td>
<td>13:25</td>
<td>-5 02 04</td>
</tr>
<tr>
<td>23</td>
<td>23/08/03</td>
<td>16:50</td>
<td>18:30</td>
<td>-4 48 02</td>
</tr>
</tbody>
</table>
### Table-III: Meteorological Observations

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Lat ddmms</th>
<th>Lon ddmms</th>
<th>Sonic Depth</th>
<th>Date</th>
<th>Time GMT</th>
<th>SST BKT °C</th>
<th>WIND Spd m/s</th>
<th>Dir</th>
<th>Bar Pressure °C</th>
<th>Air Temp DB °C</th>
<th>RH %</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>-5 01 57</td>
<td>69 08 15</td>
<td>2879</td>
<td>01/08/03</td>
<td>03:34</td>
<td>28.5</td>
<td>0.5</td>
<td>299</td>
<td>1012.5</td>
<td>31.0</td>
<td>57</td>
</tr>
<tr>
<td>02</td>
<td>-5 24 00</td>
<td>68 35 01</td>
<td>3542</td>
<td>02/08/03</td>
<td>12:50</td>
<td>28.7</td>
<td>2.7</td>
<td>170</td>
<td>1011.3</td>
<td>27.7</td>
<td>72</td>
</tr>
<tr>
<td>03</td>
<td>-5 01 41</td>
<td>68 25 27</td>
<td>3284</td>
<td>05/08/03</td>
<td>20:50</td>
<td>28.4</td>
<td>6.0</td>
<td>138</td>
<td>1007.3</td>
<td>27.6</td>
<td>75</td>
</tr>
<tr>
<td>04</td>
<td>-7 33 42</td>
<td>68 58 16</td>
<td>2228</td>
<td>14/08/03</td>
<td>22:30</td>
<td>27.5</td>
<td>4.6</td>
<td>90</td>
<td>1007.3</td>
<td>26.7</td>
<td>73</td>
</tr>
<tr>
<td>05</td>
<td>-7 23 03</td>
<td>68 14 53</td>
<td>3987</td>
<td>15/08/03</td>
<td>10:30</td>
<td>27.8</td>
<td>6.7</td>
<td>120</td>
<td>1011.3</td>
<td>27.3</td>
<td>71</td>
</tr>
<tr>
<td>06</td>
<td>-7 17 06</td>
<td>68 09 34</td>
<td>3679</td>
<td>15/08/03</td>
<td>20:50</td>
<td>27.8</td>
<td>6.0</td>
<td>104</td>
<td>1011.9</td>
<td>26.6</td>
<td>73</td>
</tr>
<tr>
<td>07</td>
<td>-7 01 31</td>
<td>68 18 02</td>
<td>2219</td>
<td>16/08/03</td>
<td>09:15</td>
<td>28.0</td>
<td>5.6</td>
<td>117</td>
<td>1011.7</td>
<td>27.1</td>
<td>64</td>
</tr>
<tr>
<td>08</td>
<td>-7 05 10</td>
<td>68 04 23</td>
<td>1675</td>
<td>16/08/03</td>
<td>21:10</td>
<td>27.9</td>
<td>6.1</td>
<td>100</td>
<td>1012.3</td>
<td>25.0</td>
<td>78</td>
</tr>
<tr>
<td>09</td>
<td>-7 08 01</td>
<td>67 51 58</td>
<td>4504</td>
<td>17/08/03</td>
<td>00:40</td>
<td>27.7</td>
<td>8.9</td>
<td>102</td>
<td>1002.8</td>
<td>26.2</td>
<td>81</td>
</tr>
<tr>
<td>10</td>
<td>-7 26 43</td>
<td>67 48 11</td>
<td>2716</td>
<td>17/08/03</td>
<td>13:15</td>
<td>27.9</td>
<td>6.3</td>
<td>125</td>
<td>1012.2</td>
<td>26.2</td>
<td>80</td>
</tr>
<tr>
<td>11</td>
<td>-6 36 24</td>
<td>68 19 08</td>
<td>1606</td>
<td>18/08/03</td>
<td>09:45</td>
<td>28.2</td>
<td>9.9</td>
<td>138</td>
<td>1011.4</td>
<td>27.6</td>
<td>69</td>
</tr>
<tr>
<td>12</td>
<td>-6 21 19</td>
<td>68 45 57</td>
<td>3860</td>
<td>19/08/03</td>
<td>00:50</td>
<td>28.0</td>
<td>8.0</td>
<td>122</td>
<td>1012.2</td>
<td>26.3</td>
<td>80</td>
</tr>
<tr>
<td>13</td>
<td>-6 02 22</td>
<td>68 33 48</td>
<td>2272</td>
<td>19/08/03</td>
<td>14:30</td>
<td>28.1</td>
<td>9.6</td>
<td>134</td>
<td>1011.3</td>
<td>27.0</td>
<td>74</td>
</tr>
<tr>
<td>14</td>
<td>-6 16 56</td>
<td>68 12 53</td>
<td>2918</td>
<td>20/08/03</td>
<td>02:00</td>
<td>27.9</td>
<td>7.6</td>
<td>130</td>
<td>1011.3</td>
<td>24.6</td>
<td>85</td>
</tr>
<tr>
<td>15</td>
<td>-6 16 31</td>
<td>68 00 32</td>
<td>2247</td>
<td>20/08/03</td>
<td>07:55</td>
<td>28.2</td>
<td>8.4</td>
<td>132</td>
<td>1000.3</td>
<td>27.2</td>
<td>69</td>
</tr>
<tr>
<td>16</td>
<td>-6 36 58</td>
<td>68 03 07</td>
<td>3495</td>
<td>20/08/03</td>
<td>19:45</td>
<td>28.0</td>
<td>8.7</td>
<td>114</td>
<td>1009.2</td>
<td>26.8</td>
<td>73</td>
</tr>
<tr>
<td>17</td>
<td>-5 27 04</td>
<td>68 31 41</td>
<td>2311</td>
<td>22/08/03</td>
<td>01:10</td>
<td>28.1</td>
<td>5.9</td>
<td>140</td>
<td>1011.8</td>
<td>26.9</td>
<td>74</td>
</tr>
<tr>
<td>18</td>
<td>-5 20 04</td>
<td>60 40 42</td>
<td>4049</td>
<td>22/08/03</td>
<td>06:15</td>
<td>28.2</td>
<td>7.3</td>
<td>123</td>
<td>1002.7</td>
<td>27.5</td>
<td>67</td>
</tr>
<tr>
<td>19</td>
<td>-5 09 03</td>
<td>68 44 07</td>
<td>2319</td>
<td>22/08/03</td>
<td>13:35</td>
<td>28.2</td>
<td>7.0</td>
<td>126</td>
<td>1000.9</td>
<td>27.1</td>
<td>74</td>
</tr>
<tr>
<td>20</td>
<td>-5 07 21</td>
<td>68 37 19</td>
<td>3999</td>
<td>22/08/03</td>
<td>17:10</td>
<td>28.2</td>
<td>6.8</td>
<td>114</td>
<td>1012.9</td>
<td>27.1</td>
<td>74</td>
</tr>
<tr>
<td>21</td>
<td>-5 09 14</td>
<td>68 26 46</td>
<td>1950</td>
<td>23/08/03</td>
<td>04:10</td>
<td>28.0</td>
<td>8.0</td>
<td>112</td>
<td>1003.0</td>
<td>27.4</td>
<td>75</td>
</tr>
<tr>
<td>22</td>
<td>-5 02 04</td>
<td>68 32 47</td>
<td>3742</td>
<td>23/08/03</td>
<td>08:15</td>
<td>28.3</td>
<td>7.0</td>
<td>101</td>
<td>1011.5</td>
<td>25.3</td>
<td>91</td>
</tr>
<tr>
<td>23</td>
<td>-4 48 02</td>
<td>68 41 14</td>
<td>1925</td>
<td>23/08/03</td>
<td>16:50</td>
<td>28.3</td>
<td>7.3</td>
<td>050</td>
<td>1012.7</td>
<td>26.1</td>
<td>79</td>
</tr>
</tbody>
</table>