Charles Darwin Cruise 128

Kairei and Edmond Hydrothermal Plumes

Rodriguez Triple Junction, Indian Ocean

26th May to 26th June 2001

Charles Darwin Cruise 128 Ship's complement

Ship's Officers:

Geoff Long	Master
Peter Newton	First Mate
Andy Cope	Second Mate
Mike Hood	Third Mate
Sam Moss	Chief Engineer
Martin Holt	Second Engineer
Gary Slater	Third Engineer
John Harnet	Third Engineer
Jeff Baker	ELO

Ship's Crew:

Tiny Pook	Bosun
Martin Harrison	Bosun's mate
Phil Allison	AB
Gary Crabb	AB
John Dale	AB
Joe Perkins	AB
Andy Ottesen	Cook
Clive Perry	Senior Catering Manager
Peter Lynch	Head Cook
Duncan	
Sheila Link	Steward
Wally Link	Steward

Scientific Complement:

Paul Tyler	SOC Joint PSO
Chris German	SOC Joint PSO
Peter Statham	SOC
Peter Herring	SOC
Mark Rudnicki	Duke University, North Carolina, USA
Mark Varney	SOC
Hedy Edmonds	University of Texas at Austin, USA
Kate Black	SOC
Valerie Chavagnac	SOC
Doug Connelly	SOC
Fumi Kouzuma	Hokkaido University, Japan
Kuichi Koike	Research Institute of Innovative Technology for the Earth, Japan
Ben Boorman	SOC
Gareth Knight	UKORS SOC
Dave White	UKORS SOC
Kevin Smith	UKORS SOC
Steve Whittle	UKORS SOC

Charles Darwin Cruise 128

Summary and Comment

1. It was not possible to achieve all the objectives of CD128 as well as NERC Grant No GR3/13065 as in our opinion, *Charles Darwin* was not fit for purpose as specified in the cruise application and the Principal Scientists' meeting. The main problem was the efficacy of the Deep Tow cable. This was unable to transmit signals from BRIDGET, which made the use of BRIDGET, a central part of our programme, impossible. In addition, the fibre optic capability of the Deep Tow did not function and thus the use of SHRIMP was limited to flying it on instrumentation rather then having real time video.
2. Despite this lack of fitness for purpose we have nothing but praise for the entire ship's crew and the unstinting efforts of the UKORS technical support in trying to remedy the situation and lead to a well structured scientific programme.
3. Lost time occurred as the UKORS technicians tried to repair the deep tow cable and as a result ended up out of rest time. We had to stand down for 8 h because of this as they drive the winches.
4. As a result of the failure of the deep tow cable the cruise plan, particularly for chemistry, was modified and we believe achieved acceptable success.
5. One week before the cruise we found out by chance that there was a spare berth as UKORS did not require it. It would have helped scientific organisation if this had been communicated to the PSO
6. Once on board we were informed that the cruise end (boat transfer to Port Louis) would be at 09.00 on 26th June not the 27th as advised to PSO in Southampton.
7. The use of the USBL greatly enhanced our position monitoring. However, there was only one monitor, in the plot, and we recommend that there should be a USBL repeater on the bridge
8. Modification to the hull mounting of the USBL should be investigated as the raising and lowering of this was a time-consuming and very energetic job

Charles Darwin Cruise 128 Cruise Narrative

All times are local (GMT-5h)

Monday 28th May. Left Port Louis, Mauritius at 18.00h. Start of cruise was delayed by the delayed arrival of required materials for the cruise

Tuesday 29th May Passage: Safety meeting. Cruise participants meeting. Lab preparation

Wednesday 30th May Passage: Lab preparation

Thursday 31st May Passage in deteriorating weather

Friday 1st June Arrived on station at the 'Edmond' site (23°52.69'S; 69°35.83'E) at 02.00h. Deployed the CTD(S)(#01) at 03.45 and recovered at 09.30. Good CTD data although there were some problems with the recording and two of the three SAPS filters had split. BRIDGET was prepared for deployment and launched at 14.00h. At 14.30h the data up the wire were intermittent at best and the instrument was recovered. Examination of the connectors suggested poor connections and the deep-tow cable was reterminated. The opinion of the technicians was that the cable was beyond use. The RMT1+8 was prepared for use and launched at 15.55h but after paying out 2000m of cable there was no acoustic response from the nets and the tow was aborted and the nets brought back on board. At 21.00h we set sail for the Kairei site.

Saturday 2nd June Arrived at the Kairei site at 25°19.17'S; 70° 02.40'E at 09.00 and deployed the CTD(S)(#02) at 09.52h. The depth of this site was 2350m and the plume depth 2150 to 2350m. The CTD was recovered successfully at 15.22h with excellent water samples and good CTD data. One of the SAPS filters was damaged. The new Titanium CTD was prepared for its first deployment to treat the bottles. The CTD(T)(#03) was deployed at 19.45h and recovered at 21.10h. *Charles Darwin* steamed to the start of the net transect and the RMT 1+8 was deployed at 23.15h . At depth the first net was opened but the onboard tracking lost contact with the net. The single net opening became an oblique haul to the surface.

Sunday 3rd June However, on retrieval at 08.00h the RMT1+8 sample revealed a rich haul of plankton including two bresiliid shrimp larvae that were separated and preserved. The rest of the haul was preserved whole. BRIDGET was then prepared for deployment and deployed at 11.40h. 2000m of cable were paid out but the electrical contact with BRIDGET was terrible and the deployment terminated and BRIDGET brought on deck by 14.25h. The problem. again, was the quality of the deep tow cable, even after retermination. After discussion with the TLO it was decided to try and find the fault. 1000m were cropped in 100m increments but the cable still had poor resistance. As there was a known fault in the cable 500m from the drum the decision was taken to spool off all the cable and examine the inner 500m. During the evening the whole scientific party and the technicians and deck crew hand spooled off the deep tow cable but to no avail. Work was suspended at midnight as technician rest time was mandatory.

Monday 4th June. RRS *Charles Darwin* was hove to until 08.00 as the technicians had to have mandatory rest time. This had not been possible the day before owing to the demands on working on the deep tow cable. At 08.32 the CTD(S)(#04) as deployed at 25° 18.8'S; 70°02.5E to a plume depth of 2350m. This deployment was successful with both data and samples being collected. On completion of the station the deep tow cable was streamed and rewound onto the drum. At 20.03h a second successful CTD(S)(#05) was deployed at the plume site. The station was completed at 23.10h and *Charles Darwin* steamed to the start of the plankton net track at 25°11'S; 68°54.50E.

Tuesday 5th June The RMT1+8 was deployed at 02.15 and recovered at 12.20 after successfully collecting plankton samples including larvae of vent shrimp. *Charles Darwin* returned to the vent site and completed another successful CTD(S)(#06) deployment between 16.30 and 18.57h. The ship steamed towards the net deployment site for the night tow and on the way conducted another test of BRIDGET. As before no signal was received on the deck units and the trial was terminated.

Wednesday 6th June The RMT1+8 was deployed at midnight of 5th and recovered at 10.30 having successfully collected a suite of plankton samples. The *Charles Darwin* then steamed towards the vent site and en route a final test of BRIDGET was made after the swivel had been repotted and checked. As before no signal was received and all BRIDGET operations were reluctantly terminated for the duration of CD128. The *Charles Darwin* returned to the vent station and at 16.52 deployed the CTD(S)(#07) with three SAPS attached. This was recovered successfully at 22.54h with good water and filter samples. The ship then returned to the beginning of the plankton net track.

Thursday 7th June The RMT1+8 was deployed at 04.48h and recovered successfully with good plankton samples at 11.50. The CTD(S) (#08)was deployed at 14.45 for a 12 h station to examine the effects of tidal flow on the plume. The CTD was recovered at 04.30 the following morning and the data were excellent.

Friday 8th June The RMT1+8 was deployed at 04.50h and recovered at 13.00h with a successful set of plankton samples. A second 12h CTD (#09 and 10) was deployed at 17.00h and was completed at 03.00 on June 9th.

Saturday 9th June RMT/19-21 was deployed at 08.36 and recovered at 14.26 with a successful sample. CTD(S) (#11) was deployed loaded with SAPS at 18.15 and recovered at 23.00 having obtained good samples of particulate material in the SAPs and water samples for the chemists. At this point the weather had deteriorated and all overside operations were postponed until early morning.

Sunday 10th June. The Jt-PSOs met with the TLO and the Master at 07.30 and it was agreed that it was too rough for overside operations. Because the weather forecast for the area was poor it was decided to proceed to the NE where there was a better chance of clement weather and the proposed off-axis station could be completed. *Charles Darwin* steamed through the day and night and arrived on station at 09.00 on June 11th.

Monday 11th June. The new CTD(T) (#12) was deployed at 12.32 and a series of water samples taken throughout the water column from the bottom to the surface. However, on recovery at 16.40 it was obvious there had been a major failure of the water bottle retainers as most had slipped out of their retaining slots and were only held in the frame by blue rope the TLO had tied as an additional precaution (see photo). No samples from this deployment were useable. The CTD(S)(#13) was prepared for deployment and deployed at 17.42 and recovered at 21.15 with an excellent series of samples. By this point the problem with the CTD(T) had been identified as the bottles slipping out of their slots. This was remedied by using cable ties to retain the water bottles in their slots. To test the efficacy of this repair the CTD(T) was deployed to 500m depth and hauled to the surface with the bottles open (#14). The bottles were still in position so the CTD(T) was immediately lowered to 500m again (#15) and the bottles closed remotely. On recovery at 23.50 all bottles bar one had closed and all were still in their frame. The ship now had to hove to for the night as we were out of technician time.

Tuesday 12th. June The CTD(T) (#15) was deployed at 07.15 in ~4000m of water and recovered successfully at 11.23h with a full set of samples bar one bottle that failed to close. On completion of this station *Charles Darwin* sailed to the ridge flank station at 24°41.15'S; 71°07.69'E arriving at 04.45 the following morning.

Wednesday 13th June. The CTD(S) (#16) was deployed at 05.00h and recovered at 08.10 with a successful set of samples. On completion of this station *Charles Darwin* returned to the Kairei site to complete sampling there. *Charles Darwin* arrived on station near the Kairei site at 17.00h and the RMT1+8 was deployed at 17.15 and recovered at 02.30 the following morning.

Thursday 14th June. *Charles Darwin* steamed to the position of the Kairei site arriving at 05.00h. The CTD(S)+SAPS (#17) was deployed at 05.30 and recovered with samples at 10.33. The SAPS pumps were replaced and the CTD(S)+SAPS (#18) was redeployed at 12.22 and recovered at 17.32 with the required samples. The CTD frame was stowed and SHRIMP was prepared for launch. SHRIMP (#01) was deployed at 19.00h and recovered at 01.30h on the morning of the 15th. Examination of the video tapes showed one had recorded successfully whilst the other had not switched on. Good video of the anemone field near Kairei was recorded.

Friday 15th June. *Charles Darwin* steamed to the beginning of the track for the RMT tow. A single RMT1+8 was launched at 02.55 and recovered at 10.05. The nets has not closed properly at depth (ie ~100m above the seabed) but had closed in midwater prior to recovery. A small plankton sample was recovered in both nets. The *Charles Darwin* repositioned itself at the Kairei site and two CTD(S)+SAPS were conducted consecutively (#19 and 20). Both deployments brought back filters covered with dark particulates. The CTDs were completed by 01.10 on June 16th.

Saturday 16th June. At 02.05h SHRIMP (#02) was deployed at the Kairei site and logged in position over the site whilst the video was running. Recovery was at 08.10. The CTD(S) + SAPS (#21) was deployed at 10.08 and recovered at 15.38. The filters of the SAPS were the blackest found on the cruise so far. *Charles Darwin* then steamed to off-station to conduct a 'blank' station for the SAPS. The CTD(S)+SAPS(#22) was deployed and recovered between 17.30 and 20.27h. This station completed the programme at Kairei site and the *Charles Darwin* steamed to the Edmond site at 23° 52.69'S; 69°35.83'E arriving at 07.30 on the morning of the 17th June.

Sunday 17th June Sea conditions at Edmond were greatly improved over those at Kairei with a very low gentle swell and wind <5 ms^{-1}. SHRIMP was deployed at 08.15h. During deployment we realised that the wire left on the deep tow cable was insufficient for the depth of the water and the deployment was abandoned. At 13.45 CTD(S)+SAPS (#23) was deployed and recovered at 19.44 with good samples. The RMT1+8 (#26-28) was deployed at 21.30 and recovered at 09.10 on June 18th.

Monday 18th June. The RMT was recovered at 09.10 with a small sample. At 10.45 five SAPS were deployed on a wire over the stern of *Charles Darwin* and lowered to depth to filter seawater before being recovered at 18.55 with good samples. At 20.52 the RMT1+8 was deployed and recovered next morning.

Tuesday 19th June Recovery of the RMT was complete by 08.05. Only nets 1 and 2 had operated as acoustic contact with the nets was lost through the extreme length of wire out. However, the four samples contained a variety of organisms including a very large *Gnathophausia*. *Charles Darwin* steamed back to the Edmond site and deployed a string of SAPS on wire into the plume. The SAPS were recovered at 18.40 with good residues on the filters. After steaming to the start of the net transect the RMT1+8 (#32-34) was deployed at 20.10. During the late evening and night the weather deteriorated rapidly to give 30knot winds and strong seas. After opening and closing 2 of the net pairs the decision was taken to recover the nets. They were brought to 500m wire at by 05.00 (June 20th) but it was considered too dangerous (heavy seas and darkness) to recover them. The nets were finally recovered at 08.45 but the sampled was badly damaged and the nets torn with one loosing its entire cod end.

Wednesday 20th June. All overside work was halted owing to the heavy seas and strong winds. Stock was taken of the conditions every 3h but after discussion with the Master all work was suspended until 08.00h on the 21st.

Thursday 21st June Seas were still heavy and the wind speed varied between 20 and 30 knots. Later that morning the seas appeared to moderate and after consultation with the Master a CTD(S)(#24) was attempted. At 500m the wire angle had become so acute the deployment was aborted on instructions from the Master. *Charles Darwin* hove to in heavy seas and 30 knot winds.

Friday 22nd June. Seas were still heavy with 30knot winds. *Charles Darwin* remained at or near station until 18.00h. At this point there was discussion about the possibility of using nets as the seas appeared to have moderated but within a short period they were very rough and any attempt was abandoned. At this point, in discussion with the Master, the science programme was terminated and *Charles Darwin* steamed for Mauritius.

Saturday 23rd June, Sunday 24th June, Monday 25th June Charles Darwin steaming to Mauritius. Packing boxes, processing data, preparation for departure.

Tuesday 26th June Boat transfer from Charles Darwin to Port Louis.

SCIENTIFIC REPORTS

A. Geochemistry

1. Overview

Chris German, Peter Statham, Hedy Edmonds & Mark Rudnicki

The geochemistry programme for CD128 was severely compromised by the inability to operate our BRIDGET deep-tow vehicle from the faulty deep-tow fibre-optic cable provided aboard RRS *Charles Darwin*. BRIDGET operations were designed as a leading component of our proposed research and were to have dominated the first 11 days of our 31-day research cruise. This proposed activity represented not only 40% of the total geochemistry programme but was also designed to inform the entire multi-disciplinary operations of CD128.

Because of our inability to map the detailed dispersion of the plume overlying the Kairei vent-field our scientific objectives and mode of operation had to be re-thought completely. Instead of a detailed process-oriented study of the dispersing hydrothermal field it was decided, instead, to carry out a more limited evaluation of the processes active in the young hydrothermal plume, overlying and immediately adjacent to the Kairei vent-field at ca. 25°S and then to conduct a modest level of inter-comparison with the young hydrothermal plume immediately overlying the just-discovered Edmond vent-site, near 24°S.

In the absence of BRIDGET, operations for geochemistry were restricted to conventional CTD-rosette operations +/- large volume Stand Alone Pump deployments. A total of 24 CTD operations were conducted. Three of these were completed at the Edmond site (CTDs 01, 23 & 24 – the latter aborted due to bad weather). A first test-deployment of the new JIF-funded Ti system was completed (CTD 03) in which all bottles were fired at the maximum (mid-water) castdepth of 1500m . Further operations using this new system, together with a 30L background profile and a conventional deep-ocean profile were conducted off-axis, East of the Ridge-Crest, as stations CTD 12- CTD 16. All other CTDs were carried out at the Kairei vent-site (CTDs 02, 04-11, 17-22).

Large-volume stand-alone-pump deployments were also incorporated into 11 of the CTD stations conducted, CTDs 01 & 23 at the Edmond site and, at Kairei, CTDs 02, 07, 11 & 17-22 (the latter being a dip-blank at a background station within the rift valley). In addition, two further sets of dedicated SAPs deployments were conducted using the SAPs wire deployed astern of the ship (5 SAPs per deployment) at the Edmond vent-site.

At the conclusion of the cruise, plans for two further sets of SAPs deployments were abandoned, together with one final CTD cast (CTD 25), at the Edmond vent-site due to 72 hours of continuous bad weather.

2. BRIDGET Operations.

Mark Rudnicki & Dave White.

At the start of the cruise, BRIDGET was reconfigured to allow 2 *in-situ* analysers (Mn and Fe) to be added to the system. Two pie-conn segments are now available to provide power (24 V d.c.) and RS-232 serial communications. These modifications should now be considered part of the BRIDGET core system in anticipated future use of these sensors. The BRIDGET software has also been modified to parse data from these instruments and merge the data in with the main BRIDGET data stream. The power for the in-situ analysers can be switched via a relay controlled by a digital output line from the ADC card. This was provided to allow the sensors to be activated at depth, although this could also be achieved by modifying the software within the analysers.

In addition, an analog channel and switched power supply line have also been provided for a Seabird dissolved oxygen sensor and pump.

Although BRIDGET appeared to be communicating well over the deep-tow cable whilst on deck, communications failed when the system was deployed. Insulation testing of the swivel and cable revealed a low resistance between the coax shield and the cable armour, which should have been open circuit. Once the termination had been removed, this short was found to be a problem with the deep-tow cable itself. The likely result of this short circuit would be a decrease in cable bandwidth, which proved fatal for BRIDGET modem communications. An attempt was made to optimise modem signals on the deep-tow cable by optimising the matching between the modems (600 Ω) and the cable (approx. 8 Ω /km) by winding new signal transformers for the top and bottom interfaces. This proved insufficient to restore communications.

In an attempt to locate and eliminate a discrete fault on the deep-tow cable, 1000 m was removed from the bottom end in 100 m sections, and 600 m from the top end. The deep-tow cable was tested as each section was removed, but the problem persisted.

A last attempt was made to deploy BRIDGET with 3100 m sea cable remaining. High frequency noise on the line was found to be due to a reversal of wiring in the TOBI swivel provided. This fault was remedied, although it was noted that the TOBI swivel contacts were in poor condition. Bridget again failed to communicate once the wiring in the swivel had been corrected. This may, in part, have been to the extra load required to drive the much shorter deep-tow cable.

It should be noted that during 4 previous cruises on the RRS *Discovery* and RRS *Charles Darwin*, Bridget modem communications worked well. Nevertheless, a more robust system of communications should be developed and trialed for situations where a well-maintained deep-tow cable is not available.

Many thanks to the RSU mechanical technicians Steve Whittle and Kevin Smith for their hard work and expertise in trying to solve the problems with the deep-tow cable.

3. Hydrographic sampling

Peter Statham

There were a total of 24 CTD casts (see daily record of events). Three of these used the new titanium rosette-CTD system, and clean trace element sampling bottles (see separate section).

All remaining samples were collected using a stainless steel CTD-rosette system and 10 L externally sprung Niskin bottles. The samples collected at the CTD stations are listed in Table X. Details on He, methane and pH measurements made, or to be made, on these samples are covered elsewhere in this cruise report.

Table 1. Samples collected from all CTD stations (including trace metal samples via Titanium system)

Sample:	Number of samples:	Samples for:
Dissolved oxygen	132	Analysed on ship; geochemistry
Salinity	44	Analysed on board; calibrations and validation of bottle firing depths
Nutrients (inorganic N,P,Si)	132	To be analysed at SOC; used to study geochemical reactivity in the plume
Trace metals	155	Geochemistry (SOC). Samples were filtered through either 0.4 or 0.1 µm polycarbonate filters
Alkalinity, DIC	136	Dr Nick Bates, Bermuda; plume pH
Methane	119	Prof.T.Gamo, Hokkaido Univ, Japan.
Nitrogen oxides	96	Nitrogen isotope ratios (University of Texas at Austin)
Rare Earth Elements	31	Duke University/SOC
Platinum group elements	24	Dr Greg Ravizza, WHOI

Most trace element samples will be used to study plume geochemistry in combination with particle samples collected using stand alone in situ pumps (SAPS) deployed at the same time; see separate section.

4. Use of new JIF-award trace metal clean sampling system

Peter Statham

As part of the recent Joint Infrastructure Fund allocation for marine equipment, a new trace element clean water-column sampling system was purchased. The current cruise provided an excellent chance to test this new system in a clean open-ocean environment. A site was occupied in deep water to the northwest of the Kairei hydrothermal vent field. On the first deployment, several bottles became detached from the rosette plates (none was lost due to the security strop used). It was thought this problem occurred because of the poor location of the rods on the back of the bottles into the rosette plates, and all rods were extended to give a more secure location in the top plate. On the next deployment several bottles again came loose. On re-evaluating the situation it was felt the whole bottle was moving up and down too easily in the rosette plates, thus allowing the bottles to become dislodged. The bottom of each bottle was thus secured to the bottom plate of the rosette with a substantial cable tie to prevent movement. This strategy proved successful, and full water column sampling was carried out (except for bottle 14 where the release pin on the rosette stuck). After the cast all bottles were carefully rinsed in de-ionised water prior to packing in plastic tubing ready for return to the SOC. Samples will be analysed at SOC for a range of trace elements including those (Zn, Fe) for which conventional CTD systems have proven inappropriate because of contamination.

5. Dissolved tracer investigations

Sampling for Helium (Mark Varney)

All individual CTD stations have been sampled for helium gas. Helium was the first sample to be taken from each Niskin bottle on recovery of the CTD, followed by methane, nitrous oxide, oxygen, alkalinity and salinity. Out of the 23 CTD stations visited, a total of 144 helium samples have been taken. One of the CTD stations visited includes a full "open ocean" 24-bottle profile (CTDS/15; 23°12.52'S 73°22.52'E) that has not been previously sampled for helium.

Samples were taken in duplicate in copper tubes that are pneumatically crimped and sealed. The tubes were QC checked for leaks, cleaned, and carefully stored prior to transport back to the UK for subsequent analysis on the Noble Gas Mass Spectrometer system recently developed at Southampton Oceanography Centre.

The data will be available in approximately 6 months, as the mass spectrometric system is presently being used for tritium analyses. It is intended to measure the two helium isotopes, He-3 and He-4, to determine the "age" of the various water masses in the water column and within the hydrothermal plumes.

Sampling for oxygen (Mark Varney)

In parallel with the helium samples, oxygen samples were taken at the same time, but analysed on board. A standard "Winkler titration" technique involving the precipitation of manganous chloride and back titration with thiosulphate was used to analyse each sample as soon as possible after recovery. A total of 144 samples were analysed, some in duplicate.

Individual measurements of dissolved oxygen concentration have been used to calibrate the SBE oxygen sensor on the CTD. The measurements obtained from the titrations are in excellent agreement with the continuous oxygen sensor profiles obtained from the CTD hydrographic casts. There was also excellent agreement with historic WOCE data sets obtained in similar geographic regions to where these samples were taken. Oxygen measurements also provide information on the amount of oxygen used up by respiratory processes in deep water masses during the "grand conveyor belt". This data are already placed in the CD128 CTD log.

Sampling for methane (Fumi Kouzuma)

Approxmately 119 samples wer etaken by standard methods for dissolved methane analysis. These samples are to be returned to Japan for analysis in the laboratory of Prof. Toshi Gamo at Dept.Earth Science, Graduate School for Science, Hokkaido University.

6. Dissolved-particulate interactions in hydrothermal plumes

Chris German, Peter Statham et al

The processes active in hydrothermal plumes determine the net flux of heat and matter from high-temperature venting to the oceans. In particular plume particle formation and hydrothermal scavenging are key processes which modify the dissolved chemical flux from vent-fluids. Critical among these hydrothermal plume processes, is the fate of the dissolved Fe(II) discharged from high-temperature vents. Along the Mid-Atlantic Ridge, rapid precipitation of fine-grained sulphide and oxyhydroxide phases occurs leading to the formation of a particle-laden plume in which Fe-rich particles both: i) co-precipitate other dissolved metals supplied from hydrothermal vent-fluids and ii) scavenge other dissolved species (e.g. REE, Th) from the ambient water-column. At 9°N on the East Pacific Rise, however, high dissolved Fe concentrations have been reported suggesting that quite distinct dissolved-particulate interactions occur. One hypothesis is that these differences arise from a systematic decrease in Fe-oxidation rate along the mixing path of the oceans. If that were the case, hydrothermal plumes rising above the Kairei and Wedmond vent-sites should exhibit intermediate rates of dissolved Fe oxidation and precipitation over periods of ~1-4 hours (Field & Sherrell, 1999). For typical deep-ocean currents of ca.2cm s-1 this would imply processes active from directly above a vent-site up to a range of ~1-2km.

To test our hypotheses a series of parallel sets of investigations were conducted. First a suite of dedicated Fe(II) oxidation experiments/incubations were achieved by tripping bottles known to be rich in hydrothermal plume material (together with above-plume background samples) at the very end of CTD-rosette casts such that they could be recovered inboard promptly and transferred immediately to a constant-temperature (ca 2°C) laboratory. A second approach was to deploy novel in situ dissolved Mn and Fe sensors whenever possible on all CTD-rosette deployments for intercomparison with Niskin-bottle derived dissolved and particulate data (see later). A third approach was to routinely filter all water samples collected from CTD-rosette casts. Sequential filtration was conducted, such that - from each Niskin bottle - filtered seawater samples (500-1000mL) were obtained which had been passed through 0.4µm and, in some cases, 0.1µm pore-size 47mm diameter filters. Filtered particulate material was retained for all pore-size filters. Total numbers of samples were: filtered seawater 156, filtered particulates: 156. Finally, to complement the small volumes of particulate material obtained from clean-lab filtration, a further suite of particulate samples were collected by in situ large-volume filtration using Stand Alone Pumps equipped with 293mm diameter Nuclepore filters of pore-size 1.0µm, 0.4µm and - rarely - 0.1µm. Individual reports of different aspects of the at-sea sampling and analytical programme follow, below.

<u>Iron (II) oxidation rates in hydrothermal plumes (Peter Statham)</u>

Superheated water emanating from hydrothermal vents contains high (circa 5 mM) concentrations of dissolved reduced Fe II. The rate at which this dissolved Fe II is oxidised to particulate Fe III on mixing with cold deep ocean waters may be an important control on some dissolved trace elements in the ocean. This is because the iron (III) oxides formed are an efficient scavenging agent for many trace elements present in seawater. In order to study the Fe II oxidation rate, samples of plume water were collected by Niskin sampling bottle, and either spiked with Fe II or left with naturally occurring concentrations of Fe(II) in the sampling bottles at circa 2°C. Sub-samples of seawater were taken at intervals, and Fe II determined using the species specific reagent Ferrozine and spectrophotometric measurement of resulting red coloured compound. The data were analysed to give estimates of first order removal rates of the Fe(II). Vertical profiles of Fe (II) in the plume were also measured; Figure 1 shows the vertical profile at the Edmond site.

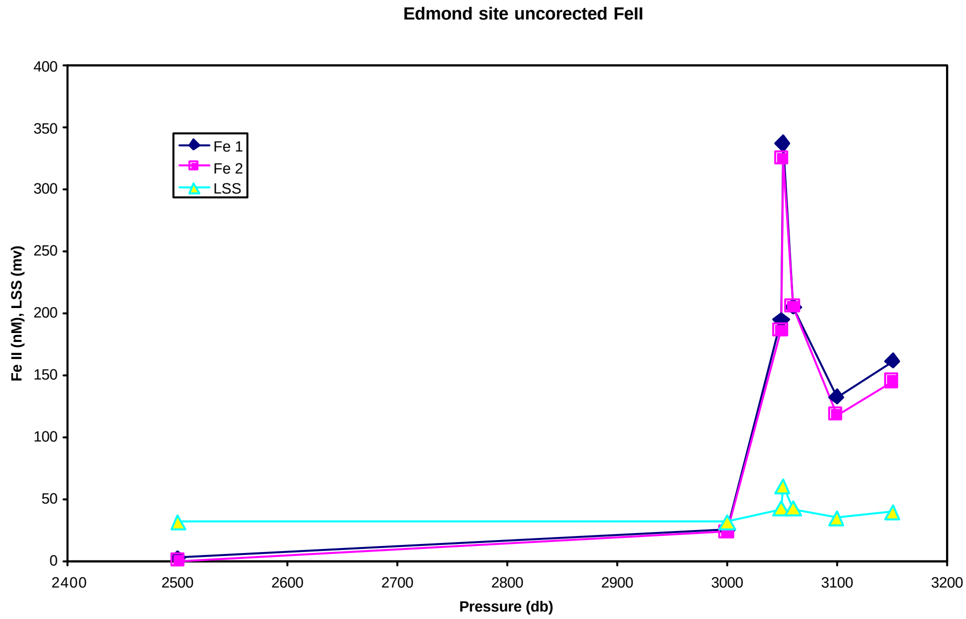


Figure 1. Vertical profile of dissolved Fe (II) at the Edmond vent site. Fe1and Fe2 are replicate analyses. LSS is the output from the light scattering sensor; the correspondence between high particle concentration and Fe II is clear. Dissolved Fe data have not been corrected for losses between analysis on board ship and the original closing of the Niskin sampling bottle.

<u>*In Situ* analyser systems for dissolved Fe and Mn (Doug Connelly)</u>

New *in situ* analyser systems for dissolved trace metals in seawater are being developed at SOC, which will operate at typical ocean depth, and give quasi-continuous records of the measured dissolved Fe and Mn. These data are particularly relevant to studies in hydrothermal plumes where Mn acts as an excellent tracer of the hydrothermal plume, and the geochemically important Fe (II) introduced into the plume has a very short lifetime (see earlier section). The systems use spectrophotometric detection of coloured complexes formed with the Fe and Mn. Sensitivity is enhanced by over an order of magnitude relative to conventional detectors by the use of long light guide tubes as a cell. Solutions are propelled along tubes by solenoid pumps, rather than the more conventional peristaltic pumps used in other systems.

During this cruise, *in situ* systems designed to measure dissolved iron and manganese were tested. Several problems were identified. The large version of the pumps used ceased working after several hours of operation *in situ*. The most probable cause of this was expansion of the rubber membrane in the pump head through contact with the silicone oil in which the analyser components were immersed, and locking of the pump mechanism. On stripping the pumps down and re-adjustment the pumps worked satisfactorily. The other major problem experienced was with the light-guide tubes. The signal decreased during the cruise, and it was noticed that light escaped from the walls of the tubing, thus reducing the light reaching the detector. This behaviour was attributed to increased roughness and scattering of light, either through degradation of the inner wall of the tubing (which seems unlikely as it is made of a Teflon) or build up of material on the inner wall of the tube. Attempts to clean the tubing wall with detergent, ethanol or dilute acid had no effect. Despite these problems, which negated their extensive use, the systems were demonstrated to be capable of working at depths of greater than 3000m, and for the control and data collection systems to work well.

Trace Metal Clean Sampling (Douglas Connelly and Valerie Chavagnac)

After the collection of the gas samples (methane, oxygen and helium) and pH from the niskin bottles the bottles were taken to the trace metal clean van. Samples were filtered through 0.4 µm nuclepore filters, and within plume samples were also filtered through 0.1µm filters. The filters were retained and refrigerated. Filtered seawater was preserved using ultra high purity nitric acid, a second aliquot was taken from each bottle for nutrient analysis, these samples were preserved using mercuric chloride.

The dissolved seawater samples and particulate samples will be analysed for a suite of trace metals back at SOC. The sample data will also be used by a NERC funded PhD student. The nutrient samples will be analysed at SOC.

In situ filtration and particle geochemistry (Hedy Edmonds)

Challenger Oceanic Stand-Alone Pumps (SAPs) were deployed in two ways on CD128: on the CTD rosette (three pumps at a time) and in the more traditional method on a plastic-coated wire from the stern (five pumps). Deployment on the rosette frame allowed us to take advantage of real-time data, particularly from the Seatech Light Scattering Sensor (LSS), to optimize our position within the hydrothermal plume. In addition, water bottles could be tripped on the same cast, and during pumping, to allow direct comparison of the geochemistry of the particulate material (collected on the SAPs) with the dissolved concentrations of the same elements (by filtering the Niskin bottles). At four stations (CTDs 01, 02, 07, and 23), the three SAPs were loaded with filters of different pore sizes (0.1 µm, 0.4 µm, and 1.0 µm) in order to look at whether particle chemistry varies as a function of particle size. Whenever possible, 1.0 µm SAPs were deployed with manganese filter cartridges to sample dissolved thorium isotopes as well. Pumps were deployed with 1.5 to 3.5 hour delay times depending on conditions, and all deployments with the exception of CTD 22 involved a two-hour pumping time. At station CTD 22, the pumps were deployed on the rosette frame but not turned on, in order to serve as complete sample processing blanks.

SAP sampling is detailed in an attached table and summarized here.

At the four stations mentioned above, the configuration consisted of 0.1 µm, 0.4 µm, and 1.0 µm filters, the latter with Mn cartridges. The 0.1 µm samples will be analyzed for a suite of elemental concentrations at SOC. The 0.4 µm and 1.0 µm samples will first be sent to the University of Texas at Austin Marine Science Institute (UTMSI): collaborator H.N. Edmonds will analyse them for thorium isotopes and ^{210}Pb, perform the sample digestions and return an aliquot to SOC for elemental analyses. Manganese cartridges will go to UTMSI for thorium isotope analyses.

At CTDs 11, 17, 18, 19, 20, and 21, all three SAPs were deployed with 1.0 µm filters, and one with Mn cartridges. The sample with Mn cartridges will be analysed for elemental concentrations and thorium isotopes as above. One of the additional filters will go to Dr. V. Chavagnac, SOC Fellow, for analysis of hafnium isotopes and/or cerium isotopes. The third filter was collected for Dr. G. Ravizza of the Woods Hole Oceanographic Insitution for osmium isotope analysis.

SAPs stations 01 and 02 at the Edmond site involved deployment of five SAPs off the stern of the ship, at depths ranging from 2600 to 3150 m. All were loaded with 1.0 µm filter and four out of five pumps on each deployment included Mn cartridges. All samples will be analysed as above for elemental and thorium isotope geochemistry at UTMSI and SOC.

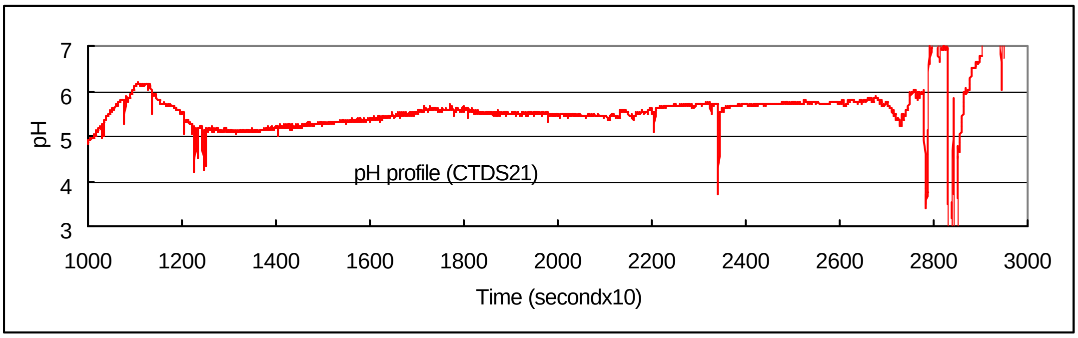
7. The measurement of pH by pH sensor in the Indian Ocean

Yuichi KOIKE

The high accuracy deep-sea pH sensor is composed of a pH sensor probe, pH data logger, endurance pressure case, underwater cable and battery. This system's size is 200mm in height and 85mm in diameter. The pH sensor probe is made from an ISFET (Ion Sensitive Field Effect Transistor) pH electrode and a Cl-ISE (Chloride Ion Sensitive Electrode). The pH data logger can accumulate in memory pH data converted from electrical signal to pH count by pH sensor probe with temperature and time data. The pH electrode can in proportion to H+ ion activity of the solution, interface voltage is caused to determine the current between source and drain.

pH sensors attached the frame of CTD rosette multi sampler and the side of BRIDGET, and measured pH value every 10 seconds during operation. Before and after measurement, the pH probe was calibrated by standard solution (2-aminopyridine; AMP; pH=6.7866, 2-amino-2-hydroxymethil-1,3-propanediol; TRIS; pH=8.0893) for proof of pH data.

The changes of the pH profiles were minor except CTDS-21.However, pH of CTD-21 that confirmation of big plumes were very acidic (about pH 5)(Figure 2).



But these pH data were not vertical profile. Next turns these data into vertical distribution to connected CTD data.

B. Biological Investigations

1. Composition and Distribution of plankton in deep water adjacent to Karei and Edmond Hydrothermal vents

Peter Herring, Ben Boorman, Kate Black and Paul Tyler

The main cruise objective was to sample the midwater zooplankton and micronekton in the immediate vicinity of the Kairei and Edmonds vent sites, and particularly to establish whether there were any vent shrimp post-larvae present, equivalent to those found previously above MAR vent sites.

The SOC RMT1+8M multiple nets were used for the sampling. This trawl system has 3 pairs of nets operated and monitored acoustically, each pair consisting of an 8m^2 net of mesh 4.5mm and a 1m^2 net of mesh 0.33mm. At the first trial over the Edmonds site the net failed to open until hauled in to 500mwo. At the second tow at the Kairei site (RMT03-06) the first net opened successfully but the monitor trace was lost due to a battery failure and the system was recovered. All the catch was in net 1 that had fished between 2252m and the surface. It contained two vent shrimp post-larvae. Subsequent tows at the Kairei site were successful and comprised three series of tows at plume height, ca 2100-2300m (RMT 07-15), three sampling between plume height and the surface (RMT 16-24) and one net fished close to the bottom (RMT 25). A total of 11 specimens of one type of post-larva (MAR “Type A”) were taken in the tows, 10 at plume height and 1 at 800-1000m depth.

All catches were very small, akin to those at the Broken Spur MAR vent field, and the main contributors to the deep biomass were the fishes *Cyclothone* and *Cyema* and crustaceans *Hymenodora*, *Bentheuphausia* and, less frequently, *Gigantocypris*. Biomass increased towards the surface but at all levels was unusually low, reflecting the oligotrophic nature of the area.

On return to the Edmond site one tow (RMT 26-28) was completed around plume height in a SW direction; the net sank very quickly and the flow rate was very low, indicating a deep water current. A second tow was made in the opposite direction (NE) and required much more wire to reach the same depth. The range problem resulted in the first net failing to close until hauled to 1500m depth; the second net was fished for an hour at that depth and the third was immediately closed before hauling back to the surface. A second SW tow (RMT 32-34) had to be aborted because of bad weather, after fishing nets 1 and 2. The nets had to be held close to the surface for several hours before recovery, with the result that any catch was destroyed and the residue had to be discarded. Continuing bad weather prevented any further sampling at the site.

Despite the very limited sampling that was possible at the Edmond site, 8 post-larvae were taken, 7 in the deep NE tow (RMT 29). The 8 included only one of the Type A larvae present at Kairei; the remaining seven were the type described from the Broken Spur MAR site as “Chorocaris”. Biomass was again very low, with the notable exception of one large *Gnathophausia* from the 1500m haul, a large alepocephalid from plume height and a *Cyema* (?) with greatly enlarged olfactory organs. *Hymenodora* was again the commonest crustacean. Other interesting animals taken during the cruise included several juvenile pelagic holothurians and a number of male anglerfishes. Overall 20 net catches were obtained from the Kairei site and 5 from the Edmond site.

2. Video observations of the seabed

Dave White and Paul Tyler

SHRIMP was deployed on two occasions. Because of the problems with the deep Tow cable no live video was possible but there was some data flow between SHRIMP and the lab. 90 minutes of video was recorded. The second tape on the first deployment did not start. For the first time SHRIMP was used with parallel lasers for scale and these worked magnificantly. A considerable part of the Kairei vent site was covered by the video (see track) but no vents were observed per se. The dominant organisms were anemones and two morphotypes were recognised. The main area of anemones was to the west of the target site. Shrimp were seen swimming within the arc of the video but no swarming shrimp, mussels or alvinoconchids were observed. The main problem was that SHRIMP had to be flown low and as a result there were a number of impacts with the seabed. If live video had been available SHRIMP could have been flown higher and then lowered when close up was required. The may benefit was that the deployments showed SHRIMP could be used to survey a vent area and this will be an important facet when the ROV comes on line.

TECHNICAL REPORTS

1. SHRIMP technical report

David White

SHRIMP was deployed twice at the Kairei site, with Hi-8 video on both deployments and the OI Mk7 35mm camera on the first deployment only.

During the first deployment, the raw ASCII data display stopped working just before the Hi-8 recorders were due to be changed, and it was not noticed that the command to switch on recorder #2 was not received, so only one tape of duration 93 minutes was recorded.

For the second deployment the modem in the sea unit was adjusted, and the system's ground was hard-wired to the cable ground. This is not normally necessary, or desirable, but the low resistance between the armour (sea earth) and the outer conductor may have been causing some problems. On the second deployment the both tapes ran, although the HID lamp went out 25 minutes before the end of the second tape when the vehicle grounded and all communications were temporarily lost. Power cycling restored communications but the HID lamp takes up to 20 minutes to re-start when warm, and only the last 3 minutes of the tapes had lights.

The 35mm camera functioned correctly but the flash did not operate, apparently due to a fault in the FET firing circuit which was not repairable at sea. Two DSPL 100mw red lasers were rigged to give two spots of light approximately 15cm apart. They were permanently powered from the +12V line through the Pie connector, so the vehicle was deployed before switching them on and recovered after switching them off, to avoid any risk of eye damage. A light scattering sensor (LSS) was fitted, but the plumes were not detected, although disturbed sediment from sea-bed contacts and near-misses was easily visible.

The other subsystems, the altimeter and attitude package worked perfectly.

2. BRIDGET (Supplementary to Mark Rudnicki's report)

The low resistance between the sea earth and the outer conductor, measured at approximately 50 kOhms, prevented the modems from maintaining communications. On deck, the vehicle worked perfectly and all the subsystems were checked out.

3. USBL

The Sonardyne Ultra Short Baseline navigation system worked consistently and reliably with two exceptions. The first time the transceiver was deployed, it lost communications with the controller. After about 12 hours of running it acquired the transceiver signal and gave no more trouble for the remainder of the cruise. The other problem is the raising and particularly the lowering of the probe. 1) Some sort of mechanical assistance in lowering would reduce the time taken from the 30 minutes or more that the current operation takes. 2) There are no orientation markings on the shaft itself, nor on the "top hat" the cable passes through. Any small change in orientation, such as would happen if the top hat was removed and replace in a different position should be followed by a “Casius” calibration as set out in the manual. This involves deploying a transponder and steaming around it for about half a day in shallow water.

4. RMT

The monitor required some retuning of the receiver on two occasions, the first to first to correct for drift in the filters and the second to correct a further drift and to make the receiver more sensitive. The deck unit functioned correctly throughout.

5. CTD data processing

Mark Rudnicki, Phil Taylor

Raw Seabird CTD data files were taken from the logging PC immediately after the completion of a cast for processing outside Seabird's clunky DOS system. As BRIDGET software already exists for adding navigation information into (BRIDGET format) ctd files, pre-processing is required to get the data into a form suitable for this software.

The program sbird_all24 converts a raw Seabird data file into a BRIDGET format ctd file, using callibration information held in a callibration file, and field header information held in a file named sbird.defaults. The defaults file used during cd128 contains the following:

```
18
seconds        0    1
depth          0    500
potemp         10   20
salinity       30   35
temp           10   20
cond           0    40
press          0    500
status         0    10
Oxygen(ml/l)   0    7
oxyc           0    1
oxyt           0    1
Altimeter      0    1
voltage_4      0    1
voltage_5      0    1
voltage_6      0    1
Seatech        0    1
Transmission   0    1
sigma-2        0    1
```

The first line specifies 18 fields to be created, whilst the subsequent lines specify the field name and defulat plotting ranges (used during BRIDGET data acquisition but ignored here). The command line is:

```
sbird_all24 -C/home/snakepit/fishcomm_ansi/cd128.callibration
 -I./ctd/C128_023.dat -O./rvsformat/cd128_023.ctd -L-23.1 -S0.010
```

The -L command line argument selects the latitude for the pressure to depth conversion, whilst the -S command line argument specifies an offe`set to be added to the primary calculated salinity. sbird_all24 does not process the secondary temperature and salinity channels at the moments, but does calculate the derived parameters depth, salinity, oxygen (from oxyt, oxyc or oxygen current), and potential density sigma-2.

The Seabird CTD produces data frames at 24 Hz, which is generally too detailed for our purposes. The next stage of the processing averages this data down to 1 second frames. The command line is:

```
one_second -C ./rvsformat/cd128_023.ctd
 -O ./onesecond/cd128_023_1.ctd
```

Other averaging intervals can be specified by setting -Dn, where n = number of seconds to average over.

The result of these procedures is a BRIDGET format ctd file with 1 Hz data frames.

Acquiring ship's navigation.

The ship's navigation is obtained from raw Level C data files held on the RVS system. GPS information is obtained from gps_4000 and saved as a BRIDGET ctd file at one minute intervals, using the command one_second:

```
one_second -C/rvs/raw_data/gps_4000
 -O/home/brdata/CD128_2001/navigation/GPS_4000_60.ctd -N60 -S$1 -E$2
```

The -S and -E command line arguments specifiy the start and end of the required time interval. USBL data is obtained from the usbl Level C file and converted to ascii, using:

```
rvstoascii -I/rvs/raw_data/usbl
 -O/home/brdata/CD128_2001/navigation/usbl.dat -S$1 -E$2 -T1
 -F3:0,1,2 -N2 -D1 -V
```

Merging navigation with BRIDGET ctd files.

The gps and USBL data are splined and merged into the BRIDGET format ctd files using the following commands:

```
mergenav -N/home/brdata/CD128_2001/navigation/GPS_4000_60.ctd
 -C/home/brdata/CD128_2001/to_be_processed -V
mergeusbl -C/home/brdata/CD128_2001/to_be_processed
 -W/home/brdata/CD128_2001/navigation/usbl.dat -L -F4 -V
```

The end result is a BRIDGET format ctd file with added fields for the ship's position, and the location of the package.

The following scipt (process_ctd2) was used to process the CTD data. The script requires two command line arguments- the start and end time of the interval to be processed. *e.g.*

process_ctd2 2001-151-00:00:00 2001-168-00:00:00

```
#!/bin/csh
#
#                   process_ctd2- Script to process CTD data.
#
#                   RRS Charles Darwin cruise 128, 2001
#
#
#         Stage 1: Convert Seabird raw data file to BRIDGET ctd format
#
sbird_all24 -C/home/snakepit/fishcomm_ansi/cd128.callibration -I./ctd/C128_023.dat -
O./rvsformat/cd128_023.ctd -L-23.1 -S0.010
#
#
#         Stage 2: Average BRIDGET ctd files (24 Hz) to 1 Hz records
#
one_second -C ./rvsformat/cd128_023.ctd -O ./onesecond/cd128_023_1.ctd
#
mv ./onesecond/*.ctd ./to_be_processed
#
#         Stage 3: Get and prepare the ship's navigation and USBL files
#
one_second -C/rvs/raw_data/gps_4000 -
O/home/brdata/CD128_2001/navigation/GPS_4000_60.ctd -N60 -S$1 -E$2
#
rvstoascii -I/rvs/raw_data/usbl -O/home/brdata/CD128_2001/navigation/usbl.dat -S$1 -E$2 -T1
-F3:0,1,2 -N2 -D1 -V
#
#
#         Stage 4: Merge RVS ship's navigation into the 1 second averaged CTD files
#
mergenav -N/home/brdata/CD128_2001/navigation/GPS_4000_60.ctd -
C/home/brdata/CD128_2001/to_be_processed -V
#
#
#         Stage 5: Now compute the BRIDGET position by adding the
#                   usbl offset to the ship's position
#
mergeusbl -C/home/brdata/CD128_2001/to_be_processed -
W/home/brdata/CD128_2001/navigation/usbl.dat -L -F4 -V
#
#
#         Stage 6: Final clearup
#
mv /home/brdata/CD128_2001/to_be_processed/*.ctd /home/brdata/CD128_2001/processed
```

```
#
#
#	Stage 7: Convert the processed, navigated CTD files to ascii
#
rvstoascii -I ./processed/cd128_023_1.ctd -O ./ascii/cd128_023_1.dat -T5 -H -V -
F17:0,2,3,4,5,6,7,8,9,12,16,17,18,19,20,21,22
```

Conclusions

Acknowledgements

Appendices

1. Day plans and modifications for CD128
2. All station data for CD128