Throughflow Initial Training Network

Cenozoic evolution of the Indonesian Throughflow (ITF) and the origins of Indo-Pacific marine biodiversity: Mapping the biotic response to environmental change

A Marie Curie Initial Training Network

SEVENTH FRAMEWORK PROGRAMME

THROUGHFLOW

MARIE CURIE ACTIONS

Network Training Activity 2

'High-resolution chronostratigraphy in clastic and carbonate settings'

Early Stage Researcher Preliminary Reports

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1. Shallow marine palaeoenvironments and the ITF – Preliminary report

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The aim of this project is the study of the evolution of shallow-water marine carbonate palaeoenvironments during the Oligocene-Miocene transition and their response to variations in the ITF.

The study area is located in East Kalimantan and Java (Indonesia).

The ITF flows through the Makassar Strait (between the islands of Borneo and Sulawesi), allowing heat transfer between the Pacific Ocean and the Indian Ocean and thus controlling the entire oceanic circulation and the climate on a global scale.

The morphology of the Makassar Strait is deeply controlled by the complex tectonic history of the region, related to the convergence between the Indo-Australian and the Pacific plates; during the Oligocene-Miocene transition (about 25 Ma) the collision between these plates determined the narrowing of the Strait and the constriction of the ITF, producing important changes on the global water circulation and probably influencing the global climatic system.

At a local scale, these events are predicted to have led to changes in the palaeoenvironments, affecting the sedimentation patterns, organism distribution and sea-water geochemistry, thus influencing reef growth and carbonate production in the area.

These events are likely to be recorded in shallow-marine carbonate deposits, sensitive to hydrodynamic and ecological variations.

To achieve the project objectives, fieldwork was performed during the Network Training Activity 2 (NTA2, 15 November – 18 December 2010) in selected localities (cliffs, quarries and mines) from East Kalimantan (Indonesia).

This work included a detailed study of the selected sections through:

- detailed recognition of sedimentary features (lithology, facies, sedimentary structures, bedding geometry, geometry of stratigraphic surfaces) and fossil assemblages;
- sampling of the different recognized facies for thin sections;
- drawing of detailed sedimentary logs;
- detailed recording of sedimentary features by high resolution photography of the outcrops.

The five week activity was divided into two main parts:

- Introduction, short courses and presentations from the ESRs (15 – 25 November), held in Jakarta and Bandung (Pusat Survei Geologi, partner institution in this project).
- Fieldwork in Samarinda and Bontang (East Kalimantan) (26 November – 18 December).

During the first part, the group discussed the necessary equipment and the methodology to follow for the field work, establishing some basic rules and standards aimed at improving the communication and data exchange between the different participants (e.g.: GPS system, useful software, terminology).

Some professors from different institutions gave introductory classes of subjects specifically related to the project.

Dr. Willem Renema from NCB Naturalis, Leiden (the Netherlands) presented the fieldwork plans and specific objectives. He also introduced some concepts of stratigraphy and the

"South East Asia Letter Stages", the biostratigraphic scale currently applied to the Tertiary sedimentary succession of South East Asia. He also showed the main features of modern and fossil coral reefs through the presentation of photographs.

Dr. Jeremy Young (NHM London) gave a short course about "Timescales and biostratigraphy", presenting different stratigraphic techniques commonly used in Geology including chronostratigraphy, biostratigraphy, magnetostratigraphy, and cyclostratigraphy.

The presentation was completed by a practical activity, the construction of an "age-depth plot" for a real case from a spreading oceanic ridge, which gave the ESRs the possibility to apply some of the previous concepts.

Prof. Juan Carlos Braga, from Granada University (Spain), presented a brief introduction to "Carbonate sequence stratigraphy", illustrating the basic concepts of sequence stratigraphy (sequence, systems-tract, sequence boundary) applied to carbonate sedimentology. The presentation included a review of the main features of the carbonate depositional systems and was accompanied by practical examples, taken from existing platforms like the Great Bahama Bank. The last part introduced the problems and the differences existing in applying sequence stratigraphy to terrigenous and carbonate settings.

During the last day in Bandung, each ESR introduced his project, giving a short (15-20 minutes) oral presentation regarding the general objectives, the methods for the field and laboratory work and the expected results from his own work

The second part of the project took place in East Kalimantan, in the Mahakam Delta area.

In particular:

- from 26 November to 03 December - Samarinda and surroundings
- from 04 December to 11 December - Bontang and surroundings
- from 12 December to 18 December - Samarinda and surroundings

On 30 November, the geologist Irfan Cibaj (consultant for TotalFinaElf, Balikpapan) showed to the group the geology of the Samarinda zone, through the presentation of a long (about 3 km) composite sedimentary succession, cropping out in numerous quarries of the area.

In the field trip, we visited the subsequently studied localities TF52, TF76, TF101, TF78 (see appendix), looking at the sedimentary evolution of the Miocene deltaic system from the outcropping base (Air Putih area) toward the top (new Stadium of Samarinda).

The complete log produced by this geologist constitutes a general, robust stratigraphic framework for the detailed study aimed by the Throughflow group.

The detailed work performed in Kalimantan included the study of 17 TF localities (TF51, 52, 56, 57, 59, 60, 76, 78, 79, 101, 126, 127, 128, 129, 130, 131, 153) with the production of 20 sedimentary logs of the carbonate bodies (see appendix), for a total of about 345 m logged sedimentary succession.

In total, 193 samples for thin sections were collected from the different localities, together with thousands photographs. In one case (locality TF79), the bedding allowed to take pictures of some stratal surfaces for photomosaic composition and quantitative analysis of the relative percentage of the main fossil components.

In each locality, every single level of the log is associated with detailed pictures.

The subdivision of the fieldwork was as follows:

- 26 November – Introduction to the fieldwork, Samarinda stadium area

- 27 November – Exploration of the Senoni-Tenggarong area
- 28 November – TF76
- 29 November – TF76, TF52
- 30 November – Fieldtrip with Irfan Cibaj
- 01 December – TF52, TF101
- 02 December – TF56
- 03 December – Organization of the collected data, redrawing of the logs
- 04 December – Travel to Bontang and exploration of new localities
- 05 December – TF153
- 06 December – TF126
- 07 December – TF126, TF127
- 08 December – TF153
- 09 December – TF59, TF60
- 10 December – TF129, TF128
- 11 December – TF131, TF60, return to Samarinda
- 12 December – TF57, TF51
- 13 December – TF130, TF78
- 14 December – TF79, brief presentation of the performed fieldwork
- 15 December – TF79
- 16 December – Organization of the collected data, redrawing of the logs
- 17 December – Package of the collected samples
- 18 December – Return to Europe\

From a brief, initial analysis of the collected data, it is possible to obtain some preliminary results, regarding the sedimentary features of the studied carbonate bodies:

- The studied rocks probably are Early-Middle Miocene in age, but further study is required.

- The carbonate sediments represent a very small part of the entire succession, probably less than 1%, but they are very important because of their abundant fossil content and palaeoenvironmental significance.

- Carbonate bodies have limited thicknesses (few meters to tens of meters) but can extend laterally up to a few kilometers (e.g.: Batu Putih Limestone close to Samarinda).

- Carbonate bodies correspond to small patch reefs and/or foraminiferal shoals, developed in a big deltaic complex; further study is required to understand whether their development is linked to local factors (e.g.: water circulation patterns, presence of restricted areas with scarce terrigenous sedimentation) or more general controls, such climate, eustatism or tectonics.

- The corals in the fossil reefs present an incredible diversity, developed mainly in the core of the reefal body.

- The patch reefs show a common development pattern, starting from a terrigenous substrate (usually siltstone or sandstone). In detail, the base is usually constituted by very thin platy corals (few millimeters thickness) in a terrigenous matrix, passing upward to bigger and thicker corals in a more carbonate matrix, eventually forming a real framestone with a bioclastic packstone matrix containing algae, large benthic foraminifera, bivalves, gastropods, echinoids. The upper part is characterized by an overall decrease in carbonate content, corals diversity and dimensions and reduced variability in their growth-morphologies; the top shows facies very similar to the basal ones (very thin platy corals in a terrigenous matrix) and true siliciclastic sediments (siltstone and sandstone) without corals.

- The aforementioned features, together with the characteristics of the deltaic succession, suggest the existence of one or more orders of cyclicity controlling the sedimentation; this will be the object of further studies.

In conclusion, the NTA2 in Indonesia was a great opportunity to learn new concepts and improve some geological techniques, useful for the study on the field and in the laboratory of carbonate rocks specifically related to tropical shallow marine environments.

In particular, the short courses improved my knowledge of basic stratigraphic techniques (e.g.: biostratigraphy, sequence stratigraphy) applied to carbonate sedimentology, while the fieldwork was aimed at learning the way of studying reefal carbonate bodies, including sedimentary logging, sampling and taking pictures for further reconstructions.

An important training aspect of this fieldwork is the participation in an international team, which helped to develop communicative skills and improve my knowledge of English.

In the following months, I will perform analyses on the collected samples, aimed at verifying the preliminary ideas and producing a coherent sedimentary model for the development of small patch reefs in a terrigenous context in low latitudes.

In order to understand the influence exerted by the ITF and its variations through the geological time, it will be useful to study older limestones (Oligocene), representative of bigger carbonate systems (e.g.: carbonate platforms), in which the influence of the deltaic sediments is less important. Similar rocks are cropping out in the Mangkalihat Peninsula, at the northern margin of Kutai Basin (East Kalimantan), and Java.

2. Bryozoa taxonomy and palaeoecology in the Neogene of SE Asia: exploring the origin of high Recent diversity and applying bryozoans in palaeoenvironmental analysis.

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Introduction

Under the umbrella of the Throughflow Project I participated in the first fieldtrip to Indonesia from 15th November to 11th December 2010 in order to pioneer the study of Cenozoic bryozoans and add these colonial animals to the range of organisms from which biotic responses to changing environments through time can be assessed.

In fact, almost nothing is still known about the fossil bryozoans from the Cenozoic of the entire Indonesian Archipelago. Braga (2001) reviewed all previous bibliographical references and ascribed the lack of bryozoans to the difficulty in locating good outcrops and stratigraphical sections due to the structural and tectonic complexity of the entire area, as well as the intense weathering of the rocks in the humid and rainy climate.

Before the fieldwork I completed a literature review ascertaining that the number of papers to cite Cenozoic bryozoans are few and occurrences are rare. I also listed the recorded taxa, finding a total of 11 species and 21 genera. Some authors only identified specimens to family level. The specimens were collected from East Java, Lombok, Madura, Sulawesi, Tanimbar, East Borneo and Malaysian Borneo, ranging from Eocene to Miocene in age.

My first aim for this project will be to identify the bryozoan taxa present in the Cenozoic sections I sampled in the field, integrating this data with that from fossil and recent material already present in the collections of the Natural History Museum in London and in the Nationaal Natuurhistorisch Museum Naturalis in Leiden, to track changes in bryozoan diversity and taxonomic composition during the Cenozoic.

Furthermore, it should be possible from the fossil bryozoans to estimate MART (mean annual range in temperature) values using within-colony variance in zooid size, and also to apply variations in branch diameter of erect bryozoans to estimate relative bathymetry. However, these analyses depend on the abundance and preservational quality of the specimens obtained.

Materials and Methods

The sampling operation took place in eastern Kalimantan. The investigated sections are localized in the Samarinda area where I worked from the 27th November until the 3rd December, and in the Bontang area where I worked from the 4th until the 8th December.

In the Samarinda area I studied a total of six sections: two sections (TF52 and TF76) in the locality called Airputih, two others (TF53 and TF56) exposed in the Badak locality, and the last two (TF51 and TF57) in the Stadion. The first four outcrops are all located in some active hand-hammer quarries, while the Stadion sections are located in an active coal mine. In Bontang I explored several different outcrops but I mainly worked in TF151 and TF154.

During the teamwork in the field we tried to standardize operating procedures first marking the sections with their own abbreviation and GPS coordinates, then making a large-scale log and description of the sedimentary outcrops, taking some pictures and collecting different types of samples where this was considered appropriate and useful to attain our different aims.

I collected a total of 22 samples (16 bulk samples and 6 float samples): 5 samples in TF51 (2 float and 3 bulk), 1 bulk sample in TF53, 5 samples in TF56 (2 float and 3 bulk), 3 samples in TF57 (2 float and 1 bulk), 2 bulk samples in TF76 and 6 bulk samples in TF154. Float samples consist of platy or branching corals sometimes encrusted by bryozoan colonies clearly visible to the naked eye; sometimes the presence of bryozoans is not so obvious and it will be necessary later to examine the corals more thoroughly under the microscope in laboratory. Bulk samples consist of muddy and silty sediments, mixed with abundant corals fragments.

Some samples were treated during the field trip to check for bryozoans. Corals were washed and brushed in order to remove mud that largely covered them and they were dried under natural condition. Sediments samples were washed through two sieves (1 mm and ½ mm mesh), obtaining separate sediment fractions, dried at room temperature, and briefly observed under a stereomicroscope in order to pick out bryozoan fragments.

Work accomplished and preliminary results

For each investigated section, below is summarized the work accomplished and some preliminary results for bryozoans.

TF52 – My group was the first one that visited this section. We logged it, finding two carbonate levels with laminated platy corals, very much recrystallized, forams and echinoids. As I was unable to see any bryozoans in the field, no samples were collected specifically for bryozoans.

TF76 – In this section I collected two bulk samples from two different beds reported in the first rough log as “Bed 3”, consisting of fragment of branching and thin platy corals, and “Bed 5”, consisting of dark grey siltstones with a rich bioclastic content including corals, molluscs, echinoid spines and bryozoans. At first sight there are no bryozoans in the material coming from Bed 3. The material collected from Bed 5 contains some traces of encrusting bryozoans on the bases of platy corals but they seem too poorly preserved for determination, and also some very small fragments of erect species and Phidoloporidae probably belonging to the genus *Reteporella*. I collected only one bulk sample from this layer because colleagues had previously collected a large number of samples.

TF53 – In this section, discovered by my group during an exploration day in Badak, we found in a hand-hammer quarry a very small carbonate outcrop where the float material contained some fragments of erect bryozoans, probably belonging to the genus *Nellia,* attached to the tops of platy corals. The quarry was in a very confused condition so it was difficult for the group to reconstruct the original reef development and to log properly the section without the help of more expert stratigraphers. I collected only one small bulk sample in order to better determine whether it would be interesting to consider this locality in the future, even though many of the sections are rapidly removed and no longer exist. In some limestone blocks, unfortunately not in situ, I could also observe some encrusting specimens seemingly belonging to the genus *Steginoporella*.

TF56 – I collected in this site two float samples consisting on some fragments of branching corals and three bulk samples coming from two different levels reported in the log as “Bed 11” and “Bed 12”, located on the top of the reef, consisting of foliaceous corals. There was no obvious evidence of bryozoans.

TF57 – This section is located inside an active coal-mine. I collected two float samples consisting of platy corals encrusted by anascan and cribrimorph bryozoan colonies, probably only two different species and not very abundant. Some of these colonies are very huge and, for the first time, the specimens appear very well preserved. I also collected one bulk samples from "Bed 7", and other bulk samples were collected by colleagues from the same level specifically for bryozoans. I have already washed and checked one of these bulk samples but I did not find any bryozoans (forams were very abundant).

TF51 – This section is located near TF57 inside the coal-mine and it represents the top of the reef. Two float samples were collected. They consist of platy and branching corals encrusted by anascan and cribrimorph bryozoan colonies. The richest layer for bryozoans is, at first sight, the base of level 4 that consists of very thin platy corals. Three bulk samples were collected from this layer.

In Bontang, after a general overview of all the sections we had at our disposal and after exploring a large number of new sections as well, I was able to judge that this kind of environment is not good for bryozoans, less than the Samarinda area. Facies contain a higher muddy siliciclastic component and bryozoans seem to be intolerant of the siliciclastic input characteristic of these Miocene patch reefs. I collected only 6 bulk samples in TF154 from a rich branching corals layer but there were no evidence of bryozoans. During the work in Bontang area I also helped my colleagues to collect samples for mollusc and coral biodiversity. In TF126, a section located inside the coal-mine, during sampling for corals, we had found platy corals encrusted by rare bryozoans, so it will be useful to observe under the microscope all coral samples.

Gained skills

This was the first geological field trip in my career so it was a very interesting and useful experience. I could appreciate for the first time how researchers can work all together to reach different aims. I learned how to approach properly sections for study, section logging, and how to collect different types of samples in order to obtain different kinds of results and also how to treat samples before observing them in the laboratory.

Furthermore the workshops hosted by the Pusat Survei Geologi (Geological Survey of Indonesia) in Bandung, helped me to gain a basic understanding of the regional sequence stratigraphy of the Kutai Basin and Mahakam Delta, including sedimentary facies and biotic associations. It was also interesting to learn about palaeoenvironmental and palaeoecological analysis in carbonate and clastic facies. Finally, I found the training on communicating science very useful to attain some skills on written communication to general audiences.

3. Neogene Circulation Patterns and Biogeography of foraminifera in the Indo-Pacific Connection

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Project Objectives

The Miocene history of biodiversity in the Indonesian Throughflow (ITF) is complex, with extensive reef development and increased speciation linked closely with the Oligocene-Miocene constriction of deep water flow through the ITF. Distinct changes in circulation and environmental conditions at this time period are also intricately linked with biological development, and as such this is an important area of study for the THROUGHFLOW project.

My part of the project focuses on the use of foraminifera, marine protists which build their shells from calcite, and their use in palaeoenvironmental reconstruction. Both geochemical and biostraphic data will be generated from foraminifera in stratigraphic units sampled in Kalimantan. In geochemistry terms, we aim to produce isotope records for the Miocene period being studied, in particular stable carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) isotopes, and also analyse for magnesium/calcium (Mg/Ca) ratios, though these depend strongly upon the abundance and preservation of foraminifera within our samples. Oxygen isotopes are correlated with global ice volume, and therefore global temperatures and salinity, whilst carbon isotopes represent a record of oceanic ventilation, affected strongly by circulation and water mass changes. Magnesium/calcium ratios (Mg/Ca) act as a proxy for sea surface temperatures, thus a multi-proxy approach provides a strong record of past ocean conditions in terms of temperature, salinity and pH. Biostratigraphy studies will be used to map the distribution, both spatially and temporally, of distinct species of foraminifera within our samples. Using modern analysis of foraminifera species and their environmental niches, it is possible to discern the environmental conditions present at the time of foraminifera growth, providing even further information on palaeoceanographic conditions.

Field Methods

The fieldwork was carried out in two separate sections. First, a 6-day workshop was undertaken in Bandung, Java, in collaboration with the Pusat Survei Geologi (Indonesian Geological Survey, PSG). This involved a series of lectures on stratigraphy, biostratigraphy and field methods, led by senior members of the THROUGHFLOW team, as well as a day spent with the Early Stage Researchers (ESRs) presenting their own projects. This time was important to allow all ESRs to understand one anothers proposed research, and to determine areas where collaboration will become more important. It also gave us the opportunity to learn the field objectives of other members and discuss in detail our proposed methods for the next stage of the fieldwork- this became important in ensuring maximum time efficiency whilst out in the field. Whilst in Bandung, we also had the opportunity to gain field experience of the geology we would expect in Indonesia, with some day trips out to local outcrops led by Fauzie Hasibuan of the PSG.

The second part of the fieldwork, lasting approximately three weeks took place in Kalimantan (Fig. 3.1), split predominantly between the cities of Samarinda and Bontang. The objective for all ESRs during this part of the fieldwork was to learn further stratigraphy and field techniques, and apply these to take samples for later analysis at each ESRs respective institution. To sample for foraminifera, it was necessary to locate clay rich sediments, which are the likeliest location for well preserved microfossils. We therefore looked to sample sections of shales and marls found within the overall succession being studied. At each site,

Figure 3.1 Overall map of the region with sample localities and GPS tracks marked. Note the presence of the Mahakam River and Mahakam Delta flowing into the Makassar straight, forming the large deltaic sequences we observe in many localities.

the first task was to create a stratigraphic log of the site, together with a record of GPS location, noting position of any clay-rich units. From the base of each of these units, samples were taken at regular intervals (or, as regular as possible depending on difficulty of sampling, vegetation cover, etc). This involved digging with a pick-axe into the section to remove weathered material. A large number of our localities were recently opened quarries and mines (for example, TF78 and TF101), thus the material had not yet been badly weathered and satisfactory material could be found relatively close to the surface. In other localities the rock face had been exposed for long periods of time and it was necessary to dig up to 50cm into the bed to locate well-preserved material. Once a hole was dug, samples were removed using a clean geological hammer and transferred into plastic sample bags, trying to minimize contamination from surface material as much as possible. Ideally, about 500g or more of material needed to be taken to ensure foraminiferal abundance was great enough for chemical analysis. Sample spacing was variable, usually in the region of 50cm to 1m.

During this period we worked closely with all members of the team, gaining skills in wider areas such as coral and mollusc taxonomy, magnetostratigraphy sampling and carbonate facies sampling and analysis. We also had a series of workshops from industrial experts, which proved invaluable in understanding the geology of the area. Irfan Cibaj, working with Total Oil in Indonesia, spent two field days working with our team. During this time, he gave a complete overview of the geology of the area, taking us to a number of outcrops which proved important in linked up stratigraphic units in the Samarinda area. We also had seminars from Bob Morley of Palynova in the UK, who gave talks on coal formation, an important element found in many of the deltaic deposits of the area, and palynology, the study of fossil pollen.

Locality No.	Date	GPS		No. of samples	Locality Description
		Lat.	Long.		
TF76	27/11/10	00.46635 S	117.12193 E	6	Quarry with coral-rich carbonate overlain by mudstone rich in organic matter (OM), grading upwards to siltstone lower in OM. Capped by thick cross bedded sandstone (likely turbidite) and a further carbonate.
TF52	28/11/10	00.46894 S	117.12094 E	9	Sequence of fine grained, laminated sands, above which lies a thin (approx. 5m) marl with thin interbedded sands. Sand content increases upwards, then overlain by a carbonate rich in large benthic forams.
TF101	2/12/10	00.50775 S	117.10052 E	52	A thick (approx 70m) shale sequence, with some thin interbedded sandstones, and sandy nodules. Sand content increases until a large sandstone bed, which is overlain by a carbonate sequence.
TF79	4/12/10	00.43234 S	117.13783 E	8	Carbonate equivalent to highest carbonate in TF76, laid over by parasequences of shales, sands and carbonates. Large carbonate at bed is site of Giant Tridacna fossils. Vegetation impeded sampling.
TF80	5/12/10	00.46279 S	117.11054 E	22	A newly-cut drainage ditch 2km west of TF76, a very thick (approx 100m) section of shales and clays with some thin interbedded sandstones, and one thick turbidite (approx 10m).
TF78	6/12/10	00.51847 S	117.10265 E	39	New quarry, composed of 5 visible (possibly more) parasequences of shales, sands and carbonates. Shales approximately 5 to 10m thick.
TF153	8/12/10	00.09618 N	117.38062 E	10	A thin clay bed (2m), heavily weathered, overlain by 2-3m of laminated clays and sands, light brown in colour. Sand content increases upwards-
TF151	8/12/10	00.16723 N	117.43736 E	7	Heavily weather roadcut, with sandy clay (2m) grading into clay (light grey/brown, 2m) then to shales (3-4m). Overlain by a silty coral rich layer, capped by a carbonate.
TF154	8/12/10	00.16729 N	117.4397 3E	5	Light brown/grey clays (3m) interbedded with branching coral rich layers of approximately 0.5m. Above is a section of thicker sands and silts interbedded with 3 thin clay beds (approx 0.5m each)
TF129	10/12/10	00.12610 N	117.38558 E	9	Mine near Bontang, composed of a large shale unit overlain by a thick carbonate. Gradient of slope and vegetation made regular sampling difficult. Shale becomes siltier towards top of section.

Table 3.1: List of locality number, date sampled, GPS location, number of samples and brief descriptions of localities, focused on clay rich sections.

Localities and Sampling

Localities sampled for microfossils are summarized in table 3.1 and figure 3.1. Stratigraphic logs can be found in the appendix, together with complete sample lists. The best preserved, and most sampled localities were TF101 and TF78. These provided large, continuous sections of shale for sampling at regular intervals. TF80 was also a well preserved site with a long (100m) continuous shale section, but due to its location inside an in-use drainage ditch with vegetation cover on each side, sampling resolution was significantly lower.

Preliminary Results and Future Work

Approximately 200 samples were taken in total, the majority coming from the Samarinda area, and some from the Bontang area to the North. The abundance and preservation of foraminifera in the samples are key to their later analysis, but this could not be determined in the field. However, nannofossil analysis performed by Dr. Jeremy Young of the Natural History Museum (NHM), London showed a high abundance of nannofossils in the same samples.

With adequate abundance and preservation on return of the samples, we aim to perform a variety of geochemical analyses. It is essential to collaborate with other ESRs, for example Nathan Marshall at the University of Utrecht, who will be providing age constraints from magnetostratigraphy. Using these age constraints together with other sources of information will allow us to stratigraphically link all of the localities across the Samarinda and Bontang areas. This will provide us with a continuous sequence of units and their relevant ages, allowing us to link isotope curves we generate across the sequences.

Summary of Training Acquired

The overall objective of the fieldwork is to not only gather samples for research purposes, but also provide transferrable skills to each ESR. I have gained a vast array of skills throughout this fieldwork, summarized below:

- Sequence stratigraphy: The workshop in Bandung, consisted of a series of seminars on the fundamentals of sequence stratigraphy, and its application to fieldwork, gave a solid foundation on recognizing sedimentological sequences (for example, the common deltaic sequences we observe throughout the Samarinda region) and interpreting the environment they formed in. Working together with stratigraphy experts in the field allowed wider application of this knowledge. By the end of the fieldwork I was able to stratigraphically log all outcrops found in the region, and provide an interpretation of its likely environment. These field skills are important to a micropalaeontologist, where rapid identification and logging of microfossil-rich units in the field allows efficient use of time.

- Paleontology: Working closely with palaeontologists from the NHM and the Naturalis, Netherlands, gave an insight into the taxonomy and development of biology in this region. For example, Ken Johnson provided information on coral taxonomy and succession through a carbonate sequence. Frank Wesselingh and Jon Todd provided information on mollusc taxonomy, whilst Willem Renema also gave discussions on large benthic foraminifera, and their associated use in dating carbonate sequences. The general aim of the THROUGHFLOW project is to identify reasons for the growth of biodiversity in the ITF region, so understanding all aspects of biodiversity and their relative importance is a necessary skill.

- Field sampling techniques: In particular, techniques for sampling of material for micropalaeontology analysis was an important skill developed, with some expert help from Dr. Jeremy Young of the NHM, London. Recognition of well preserved material, as well as reduction of contamination through sampling, are important issues in this environment.

- Communication and collaboration: Giving a seminar in Bandung to members of THROUGHFLOW, and the PSG, gave an opportunity to practice and gain feedback on vital communication skills. Presenting research at conferences forms an integral part of this position, so developing communication skills in this way was very beneficial. Regular collaboration with other team members throughout the trip, as well as short daily updates presented to the group, also enhanced my ability to communicate in a concise, scientific manner.

- Public engagement: One of the outcomes of the training activity is to provide ESRs with public engagement skills. This was coordinated by Lil Stevens of the NHM, and involved each ESR contributing to a regularly updated blog aimed at members of the public with an interest in palaeontology. This provides skills in writing to a wider audience than the usual scientific audience a researcher may expect.

4. Impact of changes in the Indonesian Throughflow for global climate evolution - a modeling approach.

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Research Questions

South East Asia currently accommodates the most diverse shallow marine ecosystems on Earth but there is evidence that this diversity has not been present in that region during the early Cenozoic. In fact, one hypothesis is that this biota development is related to past tectonic changes in the region. Movement of the Indian-Australian, Sundaland-Eurasian and Pacific plates led to the closure of a deep water passage between the Pacific and the Indian Ocean around 25 Ma ago. The overall aim of this network project is the analysis of local and global environmental changes caused by this partial closure of the oceanic gateway and its link to local marine biodiversity increase in South East Asia. My project will focus on changes in the Indonesian Throughflow (ITF), the global ocean circulation and the climate during the Cenozoic. Specifically, it has three main objectives:

Objective 1: To assess the impact of tectonic changes that occurred during the Oligocene/ Miocene on the ITF and global climate. As an aside, the experiments performed will also be used to trace potential dispersal patterns of marine organisms in the Throughflow region by means of trajectory calculations. This information is crucial for other projects in the consortium that aim at reconstructing dispersal patterns.

Objective 2: To test the influence of changes in atmospheric pCO2 on the Indonesian Throughflow during the Oligocene and to understand why Oligocene climate is apparently rather insensitive to changes in atmospheric pCO2 content.

Objective 3: To test if increasing glaciation in Antarctica during the middle Miocene leads to a northward shift of the tropical rain belt in the Indonesian Throughflow region (Holbourn et al., 2009, Geology).

Overview of field methods

During the work field we followed a pre-established protocol in order to collect our data. These are the steps that describe in order our procedure:

1. Examine the locality to determine whether it could provide us with significant data for our studies and to identify which ESR's could be interested in it.

2. Assign it an owner, who is going to be the coordinator of the work at that outcrop.

3. Assign an ID to the outcrop, a unique identifier.

4. Write down the GPS coordinates at the base of each section.

5. Measure the strike and dip using a geological compass. Strike and dip are parameters that define the orientation of a stratum. The strike line of a bed is the intersection between the plane of the bed and any horizontal plane. The dip is the steepest angle of descent of a bed.

6. Produce a log of the locality with a suitable resolution. A log is a detailed description of a section. It may include the thickness of each strata, its lithological characteristics, a description of its fossils, etc...

7. Take photographs of the whole bed, from the base to the top.

8. Collect the samples. It is very important to perform this part of the work after the stratigraphic log has been done and the pictures have been taken, as an out-of-context sample is useless. Every ESR is collecting his own samples, specifying the locality ID and the exact point in the section where they have been collected. The samples may be rocks or fossils: corals, coralline algae, bryozoans, foraminifera or molluscs.

Summary of work accomplished

From my point of view, one of the major achievements of the NTA-2 was providing the ESR's with a global overview of the project. Since I am carrying out the modelling work, I did not take part actively in the data collecting process in Borneo, I rather assisted the other ESR's if required. However it was really interesting to learn the field techniques used and to understand which paleo-climate data could be obtained from the samples. Apart from the work in the field, currently I am in charge of assessing the impact on climate of the tectonic changes that occurred during the Oligocene/Miocene. I am setting up two experiments for 30 and 20 Ma with realistic tectonic boundary conditions and fixed atmospheric CO2 concentration (600 ppm), using the comprehensive Community Climate System Model version 3 (CCSM3). More specifically, at the moment I am studying how to generate the input files for CCSM3 from paleo-topography and paleo-bathymetry data.

Preliminary results

So far I have run a simulation with CCSM3 using boundary conditions appropriate for the state of the climate system before industrialization. The results will be used in the future to identify the differences between the pre-industrial climate and the climate resulting from the Oligocene/Miocene boundary conditions.

Training Summary

During this field work I learned how my work and the rest of the network members' work are related. Carrying out a geochemical analysis of the samples of fossils collected, values of different paleo-climatological variables, such as ocean temperature or salinity, may be reconstructed. During the field work (thanks to the interdisciplinary exchange within the research group) I learned in detail what these methods consist of. Here I will provide a brief summary of two techniques applied to the paleo-temperatures reconstruction. The Mg/Ca method is relatively recent but very effective. During the formation of the calcite, magnesium may sometimes replace calcium. The higher the temperature surrounding water, the more frequent this replacement occurs. Thus Mg/Ca ratios increase with increasing temperature. Other kinds of geochemical methods are based on the analysis of the isotopic composition of the carbonates in the different fossilized structures. The $^{18}O/^{16}O$ ratio present in the calcium carbonate depends again on seawater temperature at the time of formation. However this ratio is also strongly influenced by the $^{18}O/^{16}O$ of the surrounding seawater. In this case separating the effect of temperature is more difficult and additional data related to global ice volume and local salinity are required.

5. Geochemical proxy calibration along the Indonesian Throughflow (ITF) pathway

Elena Lo Giudice Cappelli

Christian-Albrecht-University of Kiel. Institute of Geosciences

Summary of Network Training Activity 2

Network Training Activity 2: Field training in high-resolution chronostratigraphy in clastic and carbonate settings.

The event lasted five weeks from 15th November to 18th December 2010 and was held in Bandung (Java), Samarinda and Bontang (East Kalimantan) Indonesia. It was divided in two parts: from 18th to 25th of November lectures, workshops, field excursions were carried out in Bandung; from 26th of November to 16th of December the field training took place in East Kalimantan and lectures were given by guest scientists.

The first objective of Network Training Activity 2 was to provide an introduction about stratigraphy and to achieve this objective lectures were given during the first part of the NTA 2 about:

- Introduction to Stratigraphy
- Introduction to Biostratigraphy and Age Model
- Introduction to Sequence Stratigraphy
- Introduction to the field sites

Furthermore, each ESR gave a presentation about his personal project and his fieldwork goals. Lectures about regional stratigraphy of the Kutai Basin were given by guest scientists during the training field in East Kalimantan to allow us to identify the best sampling sites.

The second objective of Network Training Activity 2 was fieldwork training according to the different topics characterizing the project:

- Sedimentary logging in clastic and carbonate facies
- Examination of sequences for palaeoenvironmental and palaeoecological analysis in carbonate facies
- Palaeoecological analysis of clastic sequences
- Field techniques for magnetostratigraphic analysis
- Regional and global nannofossil stratigraphy
- Larger benthic foraminifera stratigraphic frameworks
- Field methods for sampling fossil communities from ancient reef settings

To achieve this objective 42 stratigraphic sections in the middle to late Miocene were measured and described, and more than 1500 samples were collected. These samples include rocks, fossils, bulk sediments and drilled plugs.

Overview of the Kutai Basin

The Kutai Basin is the deepest Tertiary basin in Indonesia, having accumulated over 14 km of sediment. It is bounded by the Paternoster platform, Barito Basin and the Meratus Mountains to the south, by the Schwaner Block to the southwest, the Mangkalihat high to the north-northeast, and the Central Kalimantan Mountains to the west and north (Moss and Chambers, 1999). The Kutai Basin (Fig. 5.1) is subdivided into the Upper Kutai Basin, consisting of Paleogene outcrops with Cenozoic volcanics possessing a strong northwest-southeast structural grain, and the Lower Kutai Basin with Miocene strata cropping out in north-northeast trending structures (McClay *et al*., 2000).

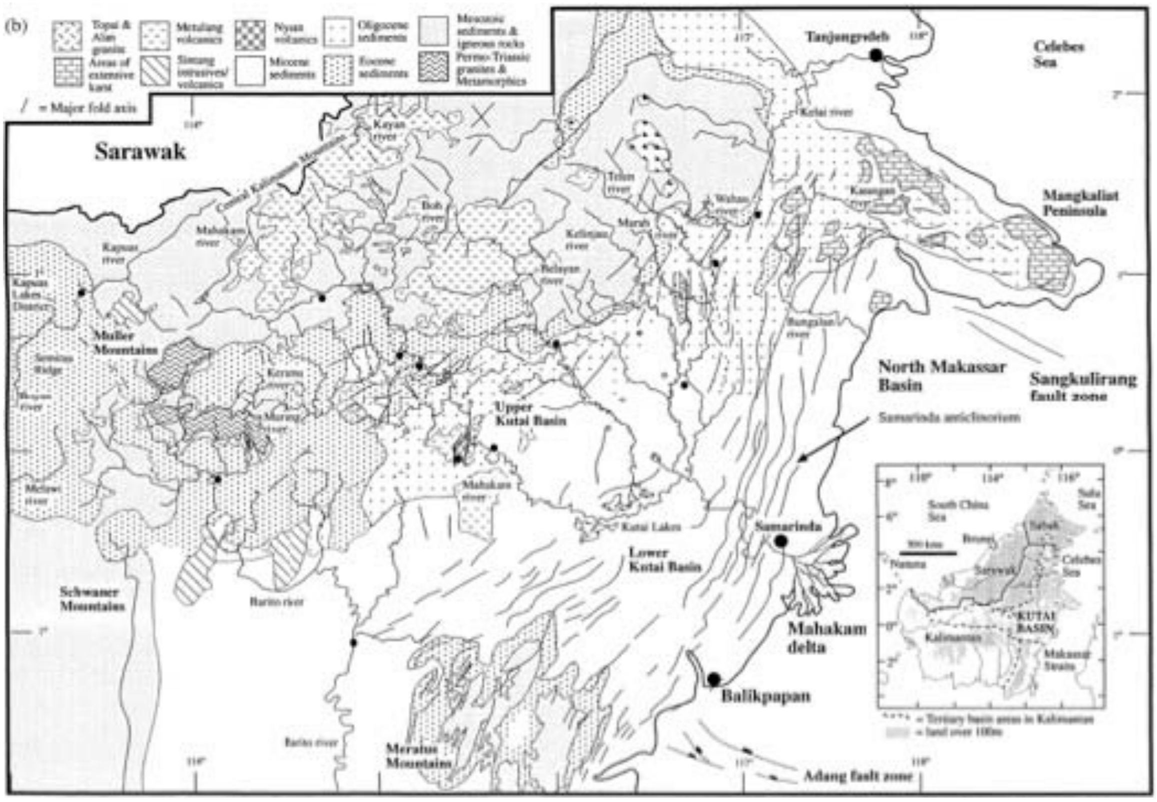

Figure 5.1: Geographical map of the Kutai Basin showing areas mentioned in the text.

The Tertiary history of the Kutai Basin includes a middle to late Eocene syn-rift phase, a late Eocene to Oligocene sag phase and a renewed phase of tectonic activity and subsidence in the late Oligocene to Miocene. Basin inversion, beginning at least as early as the end of the lower Miocene, resulted in reworking of earlier sediments and ongoing deposition of "syn-inversion" deltaic packages. Continuing erosion from the hinterland, and from the Tertiary section, in response to Miocene and Pliocene tectonic activity, resulted in eastward prograding deltaic deposition (Chambers and Daley, 1995, Moss *et al*., 1997).

In the Lower Kutai Basin, clastic deposition occurred almost continuously from the middle Eocene (synrift), through the Oligocene (postrift), to present-day recording eastward progradation of the Mahakam Delta system. As a result, there has been a progressive eastward migration of the basin depocenter. Uplift and removal of the section (particularly focused on the anticlines) occurred progressively from west to east as a result of middle Miocene to present-day contraction that produced the Mahakam fold belt. The Mahakam Delta system deposited up to 3 km of sand, shale and coal-rich sequences in the proximal deltaic *facies* and an underlying thick, shale-dominated sequence in the distal marine prodelta *facies* (McClay *et al*., 2000)2.

Scientific objectives of the fieldwork:

1. To investigate the early/middle Miocene climate.
2. To study the stratigraphy of the Kutai Basin.
3. To reconstruct Miocene palaeobathymetric evolution.

Main steps to achieve these objectives:

1. Investigate the early/middle Miocene climate using planktonic and benthic foraminiferal $\delta^{18}O$, $\delta^{13}C$ and Mg/Ca derived temperatures as proxy data.

Figure 5.2. Section TF 78.

2. Determine the stratigraphy of the investigated area using changes in the distribution of planktonic foraminiferal index species in time as well as $\delta^{18}O$, $\delta^{13}C$ curves (early/middle Miocene).
3. Reconstruct Miocene palaeobathymetric evolution based on the distribution of smaller benthic foraminifera.

Figure 5.3. Section TF 79 with samples.

Field Methods

Samples of about 500 g of clay and shale were collected from bulk sediments in 10 of the 42 measured sections (Figs. 5.2,5.3) (relatively deep sea environments). To get fresh material free from contamination, it was necessary to dig about 1 m deep into the sediment using hammer and pick axe in order to select large pieces of unaltered material (Fig.5.4).

Each sample was put into a plastic bag, clearly labeled with a permanent ink marker (Fig. 5.5) with site name, sampler initials, and ample number. In addition a plastic label with the same information was put inside each plastic bag in case the outer writing should disappear.

Figure 5.4 Hammering.

Figure 5.5. A labeled sample.

Site name	Type of sediment	N° of samples	Resolution
TF 76	shale overlying carbonate	6	1m
TF 52	shale between two carbonate layers	9	1m
TF 79	shale overlying carbonate	8	1m
TF101	large shale bed overlain by carbonate and sandstone with clay laminations	52	1m in the large shale bed (base); in the upper part only the clay layers were sampled
TF 78	5 shale beds between sandy layers	33 +6	1m
TF 80	large bed of shale and clay	22	variable resolution depending on outcrop exposure
TF153	soft light brown/grey clay overlying carbonate	9	50 cm
TF151	shale becoming sandy downwards	7	50cm
TF154	very thin layers of clay within carbonate	5	one sample within each clay-layer
TF129	shale beds overlain by carbonate	9	irregular sampling spacing due to the difficult location of the outcrop

Table 5.1. List of Sites and Samples.

Progress

- Development of stratigraphic and sedimentological skills through lectures and field training, for instance learning how to log a sediment succession and recognize individual layers/beds occurring along the section.
- Application of this new knowledge to sample collection and section description in the field.
- Effective organization and archiving of samples: writing adequate labels, taking notes about the original location of samples and inserting relevant information in a detailed log.
- Work as part of a group, sharing personal experiences and cooperating to achieve pre-defined objectives.
- Share information within the group and develop ideas about optimal use of collected material and about future work.
- Share this experience with a wider community of scientists and non-specialists by posting on the Natural History Museum blog.

6. Inter- and intra specific variation in large benthic foraminifera and biostratigraphy of Cenozoic of SE Asia

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Introduction

In the period from November 16th until December 18th 2010, I participated in a THROUGHFLOW *Network Training Activity 2: High-resolution chronostratigraphy in clastic and carbonate settings*. The activity itself took place at different locations in Indonesia. The fieldwork started in Jakarta where all the participants gathered and waited for project leaders to get all the paperwork. When everything was finalized and collected, we proceeded to Bandung, to our hosts, the Pusat Survei Geologi. There, together with our Indonesian colleagues, we participated in a THROUGHFLOW workshop where we got basic information about different aspects of our research and our future fieldwork (stratigraphy and sequence stratigraphy, biostratigraphy, general geology of our target areas). During the workshop we also formed different sections (stratigraphy, biodiversity, geochemistry) comprised of supervisors and ESR's with similar area of research who discussed the best methodology for doing their part of the research, which was afterwards presented to the entire group. The final part of the workshop were presentations of the ESRs where all of us gave a short summary of our area of research and our goals for the future, and in the discussion part after the presentations we organised possible collaboration between ESRs, which was done very successfully. After the end of the workshop we flew to Samarinda, East Kalimantan, where we started our fieldwork.

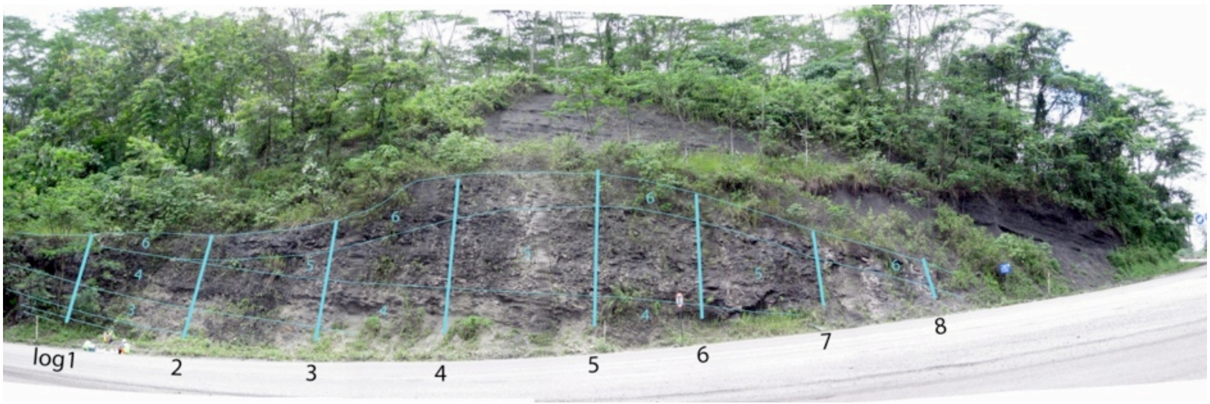

Figure 6.1. Section 126 with possible interpretation of depositional environment. Numbers 1-8 (black) showing locations of logging along the outcrop. Numbers on the section itself (blue) showing number of beds. Scale - people sitting in lower left corner. Original photo by: Nadia Santodomingo.

Aims of the project

Large benthic foraminifera (LBF) are used for biostratigraphy, correlation and zonation. Besides that they are excellent as a paleoenvironmental indicators, and using often very simple statistical methods we can get data such as water depth, temperature, and substrate conditions. After quantifying morphological characters we can determine important genera and species of stratigraphical relevance. Changes in assemblage composition can help in environmental reconstruction thus allowing better understanding of evolution of the Cenozoic foraminifera of SE Asia. Together with the work on samples collected during this field work, I will also make an assessment of the museum collection in NCB Naturalis. This can help in building some standardized overview of SE Asia Cenozoic foraminifera and a general biostratigraphic framework for others to use with their results. Both, the museum collection and material collected during this fieldwork will also be used for numerical community ecological analyses. One of the final goals is the reconstruction of changes that occurred in reef ecology during Late Oligocene-Late Miocene. And finally, the ultimate goal should be an overview of Cenozoic foraminifera of SE Asia. Combining thses results with those of other ITN THROUGHFLOW project members will hopefully result in a stratigraphic framework which will help to finally place Indonesia on deserved place in the geological map of the World. So in conclusion, here are the main aims:

- quantify morphological characters and evaluate their stratigraphical relevance;
- quantify changes in assemblage composition;
- assessments of both museum collections and newly collected material;
- numerical community ecological analyses of both collections.

Field methods

During fieldwork in East Kalimantan the focus of our research was on two areas. The first was in the area around Samarinda and the second one was further north, in the area of Bontang. Our main objectives were locating and logging of suitable sections, and afterwards detailed sampling of the entire sections, or at least the relevant parts of each section. Beside logging my main objective was sampling of carbonate material, especially the material rich in foraminifera, specifically LBF. Field methods involved basic geological work using a notebook, pencil, hammer and a lens. Logging was done (mostly) in pairs, and while one person would examine the outcrop, measure the thickness of beds and determine the composition of rocks, the other would write lithological descriptions and draw schematic logs of the section. After returning to our base camp, logs were digitalized using the free software, SedLog. Sampling was more physical work, and the time used dependent on the rock's hardness. Some outcrops were sampled for a half-day, while the others were visited several times. Each sample was marked with a unique label to avoid confusion. Approximately once a week I organized samples, where all the samples were checked and listed in the TF2010 spreadsheet.

Summary of work

I stayed in the area of Samarinda for 14 days (November 26th until December 3rd; December 12th until December 18th) and during that period I did the work on the following sections:

- Section 52 – logging and sampling (44 samples)
- Section 76 – sampling (19 samples)
- Section 57 – logging and sampling (13 samples)
- Section 51 – logging and sampling (11 samples)
- Section 56 – sampling (21 samples)
- Section 79 – sampling (32 samples)
- Section 130 – sampling (13 samples)

In the area of Bontang I stayed for 8 days (December 4th until December 11th) during which I worked on the following sections:

- Section 153 – sampling (23 samples)
- Section 126 – logging (8 logs) and sampling (32 samples)
- Section 154 – logging
- Section 102 – logging
- Section 128 – logging and sampling (16 samples)
- Section 59 – sampling (14 samples)

In total, we stayed in the field work for 22 days (excluding Jakarta and the Bandung workshop). During that time I participated in logging of 7 sections and collected 238 samples which were shipped to Europe. The logs of the sections were digitally drawn using freeware program of the SEARG, SedLog 2.1.4, and the samples were listed in the TF2010 spreadsheet in Microsoft Excel.

During our stay in Samarinda we also had two visiting lecturers. Irfan Cibaj from *Total E&P*, Indonesia, gave a presentation and a two day excursion regarding the sequence stratigraphy of the East Kalimantan. Robert J. Morley from *Palynova* gave a presentation about the regional evolution of Kutai Basin.

Conclusion

The purpose of this fieldwork and the entire ITN project for the ESRs is organised around learning how to do independent research regarding area of interest for each individual. During this field work we have gone through the process from basic geology lectures, presenting our own projects and goals of this project, to advanced sampling and logging of sections on our own.

I personally gained new knowledge about specific sampling methods regarding my area of research (LBF), from determining suitable outcrops, taking samples (hard rock and bulk samples), making appropriate labelling, storage of samples and keeping sample sheets. Besides that, in discussions with my supervisor (Willem Renema) I got the general overview of the biostatigraphy of the area and also gain some useful on-site suggestions regarding ongoing field work and sampling methods. The logging was also big part of my field work. In cooperation with other supervisors and ESR's we made general logs of the sections, what was prerequisite for the sampling that came afterwards.

When I summarize the benefits of this training activity, I can say that after this fieldwork I am capable of independently doing stratigraphic logs and specific sampling required for reaching the goals that I presented above and in the Bandung workshop. Supervisors and ESRs experienced how to work together, from planning our working days, to helping each other in logging and sampling. I found that to be a very valuable experience from this fieldwork.

7. Research on Cenozoic Molluscs.

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Introduction

The THROUGHFLOW Network Training Activity 2(NTA 2): *High-resolution chronostratigraphy in clastic and carbonate settings* took part between the 16th November and 18th December in Java and East-Kalimantan, Indonesia. The first part of the NTA 2 was a workshop in Bandung (East Java) at the Pusat Survei Geologi (Geological Survey of Indonesia) including presentations of all Early Stage Researchers (ESRs) on their research fields, presentations and training about basics of stratigraphy and sequence-stratigraphy, and discussions on the forthcoming period of fieldwork such as sampling methods. The second part of the NTA was fieldwork carried out in two different areas in East-Kalimantan: the Mahakam Delta area (the surroundings of the city of Samarinda) and the area surrounding the city of Bontang, both located in the Kutai Basin. Main objectives during this period were the investigation of outcrops including geological description and logging of sections and sampling of carbonates and clastic sediments according to the different interests of the participating researchers.

Aims

I aim to assess the development of molluscan diversity in sea grass biotopes in the Miocene of Indonesia in order to understand the timing and depositional context of the origin of the highly diverse faunal associations occurring in the Indo-Pacific. To attain this goal fossil mollusk material from different time intervals of the Miocene is sought after, both from outcrops as well as from museum collections. Therefore my personal aim for the fieldwork carried out during THROUGHFLOW NTA 2 was the collection of comprehensive fossil mollusk associations from shallow marine sediments in Indonesia.

Summary of fieldwork carried out in the Mahakam-Delta area (Samarinda)

Due to a lack of well-preserved, diverse mollusk assemblages in the area of the Mahakam Delta my part during fieldwork in this region was the participation in more general geological research activities such as logging sections and in advance exploration of outcrops in order to explore their suitability for interests of the other ITN participants as well as gaining an understanding of depositional processes relevant also for fossiliferous deposits. Sampling in this area was limited by the low abundance of shell remains. Sampling activities included bulk-sampling of single beds with low abundant mollusk remains or in one case abundant, but non-diverse oysters, collection of specimens from layers or float, and bulk-sampling for fossil groups others than mollusks such as echinoid spines, foraminifers and pollen. All sampling activities included the acquisition of adequate information on the sampled localities such as GPS-coordinates, sedimentological descriptions, photos, and logs.

Apart from the fieldwork activities lectures were given by Irfan Cibaj from *Total E&P*, Indonesia on sequence stratigraphy and the sedimentology of the Mahakam Delta-area including two days of excursion, and Robert J. Morley from *Palynova* on the evolution of the Kutai-Basin. For more detailed information the main fieldwork-activities carried out in the Mahakam delta-area are summarized in Table 7.1.

Date	Locality	Activity
26.11.10	TF 50	geological overview; logging-training

27.11.10	TF 52	participation in detailed logging
28.11.10	TF 53-56	first exploration of the area around Badak
29.11.10	TF76	bulk-sampling of a bed containing mollusk remains
01.12.10	TF 50	bulk-sampling of a bed containing mollusk remains, sampling of oyster-beds
02.12.10	TF 57	first exploration of the outcrop TF 57
13.12.10	TF 78	high-resolution log of one complete sequence
14.12.10	TF 79	float collection (purpose: mollusks, corals)
15.12.10	TF 78	high-resolution sampling of the logged sequence (purpose: foraminifers, pollen)

Table 7.1. Main fieldwork activities carried out in the Mahakam Delta area

3.2 Summary of fieldwork carried out in the area of Bontang

The area of Bontang provided by far the more important localities for my personal field of interest. Localities of increased significance are TF 102, TF 110 and TF 151 and to a minor extent TF 129. Further information on those localities is given separately (see below). Basic geological fieldwork was accomplished on other localities as well. The fieldwork activities carried out in the area of Bontang are summarized in Table 7.2. Additional investigation and collecting on some of the outcrops was further done by my supervisor, Frank Wesselingh.

Date	Locality	Activity
03.12.10	TF 151	arrival in Bontang; first exploration of outcrop TF 151
04.12.10	TF 151-154	exploration of different outcrops
05.12.10	TF 154	participation in logging and sampling
06.12.10	TF102, 108, 151	introduction to the localities in the Indominco-coalmine; first exploration (TF 102, TF 108); float sampling (top of TF 151)
07.12.10	TF 110, 151	logging and sampling (TF 110); logging (TF 151)
08.12.10	TF 102, 151	sampling along transects (TF 102); logging and detailed float sampling (TF 151)
09.12.10	TF 113, 129	exploration (TF 113), logging and sampling (TF 129)
10.12.10	TF 151, 102	completion of work

Table 7.2 Main fieldwork activities carried out in the area of Bontang

Localities of increased interest

TF 102

The locality TF 102 provides patches of coral remains on a bedding plain. The patches are likely in situ and are interpreted as collapsed colonies of branching corals. Some of these patches contain a diverse fauna of coral associated mollusks as well. The patches have been mapped along two transects in cooperation with Nadia Santodomingo. As many as possible of the fossil mollusks have been collected and bulk samples were also taken. The outcropping, mainly clastic, sediments at TF 102 have been logged by Vibor Novak and Aris Kusworo. Two highly fossiliferous beds of coarsening upward clay-silt to sandy silt and the underlying non-fossiliferous clays have been sampled as well.

It appears that a nicely representative coral-associated mollusk fauna has been sampled.

TF 110

The clays and silty clays of the locality 110 provide an excellent preserved fauna of largely small mollusks interpreted as a seagrass fauna but also contained clastic seafloor faunas and reef faunas similar to those from locality TF 102. The outcropping sediments are of middle to likely late Miocene age and will be compared to an early Miocene seagrass fauna from Java collected by Frank Wesselingh and Willem Renema in 2006. Since locality TF 110 is an active building site the locality will likely get lost in the close future. It has been logged and sampled (specimens and bulk) extensively, both by me and by Frank Wesselingh.

TF 129

The locality TF 129 is located in the Indominco-mine. It is an outcrop of silty clays interbedded by carbonate layers, overlain by a massive packstone. Fossils occur predominantly in the silty clays at the bottom of the section including shells, crustaceans and echinoids. The section has been logged, float specimens have been collected and bulk samples were taken. The mollusk fauna of TF 110 is a low-diverse marine fauna which will be investigated for palaeoecology (including depth estimates).

TF 151

TF 151 was with more than 20 m the longest section assessed. It contains silty clays at the base which develop into silty sands with different faunas of mollusks and corals. Carbonate beds and silts both rich in turbinid gastropods mark the top of the section. The section has been logged and sampled extensively including bulk sampling and float collection. Work at this locality also included training in facies successions and sequence interpretation by Frank Wesselingh.

Preliminary conclusions

The THROUGHFLOW NTA 2 in Java and East-Kalimantan provided extensive training in field methods such as description and logging of sections and different sampling methods (float collection, collection of individual specimens, bulk sampling of different resolution) including correct labeling of samples. Moreover, skills in treatment of field data has been enhanced by the use of standardized methods and programs such as Garmin-Basecamp for the georeferencing of photos, SedLog 2.1.4 for the production of stratigraphic logs and a master sample sheet (Excel) to collect the complete sample data of all participants. Regarding my personal field of research I gained sufficient well to excellent preserved material to continue my work on Miocene mollusk assemblages of Indonesia with the focus on seagrass communities. Last but not least the NTA 2 provided lessons in organization and teamwork.

8. The origins and evolution of the modern Indo-Pacific reef algal flora

Anja Rösler

University of Granada

Within the general programme of the THROUGHFLOW project, my research project focuses on the origins and evolution of the modern Pacific reef algal flora. My aim is to document the timing and patterns of the diversification of Indo-Pacific reef-building coralline algae, the second most important builders in modern Indo-Pacific reefs. This group appeared in Late Oligocene-Early Miocene times in the Indo-West Pacific area. I will correlate algal origination (and extinction) events to variations in reef fossil assemblages and to regional/global palaeoenvironmental changes. At the same time I will apply molecular phylogenetic analyses and chronology to living coralline algae from modern Indo-Pacific coral reefs, in order to constrain the evolutionary patterns, combining the information provided both by extant and fossil reef floras. First of all I will concentrate on the subfamilies Mastophoroideae and Lithophylloideae, which are the most important ones in reef building. It would be very interesting to see, with the help of the fossils of Indonesia, clues of the influence of representatives of this group on the onset of coral reefs, one of the key systems for the high biodiversity in the region.

In the field trip in the NTA2 my first and main target was to find and collect coralline algae from the Miocene rocks in Kalimantan. My second aim was to learn about geology, especially stratigraphy. Since the training was not only theoretical but also directly working on ancient reefs and carbonate platforms, I was able to learn a lot, with a very qualified team.

Now I will go more into details concerning the activities in NTA2. After some days of administrative paper work in Jakarta, we went to Bandung where our Partner institute, the Pusat Survei Geologi, is based. There we spent a week. In the first day in Bandung we were introduced to the Pusat Geologi Survei and its buildings, which also contain the Bandung Geology museum, the biggest and most complete museum in Indonesia of its kind. Unlike same other museums it is a well kept place that attracts a large number of visitors.

In the teaching room of the Pusat Survei Geologi we took various classes in the following days. The first was an overview, given by Willem Renema from Naturalis in Leiden, over field methods which began with an introduction to stratigraphy, very useful especially for people like me who did not study geology. There we learnt about different fields of stratigraphy, what are the studied units, and important and basic concepts of stratigraphic work. The second class was about peculiarities of the South-East-Asian stratigraphy, and how the findings of our project can contribute to a better understanding of regional geological history. The last part was a field-method overview about really practical questions: "What to do when going to the field?" was discussed in topic-related groups. I learnt the procedure of how and in which order to work in the field, some basic measurement techniques and what has to be absolutely avoided. We also discussed about methods which should be used by the different people, like transects, quantitative methods and how to describe an outcrop.

This freshly acquired knowledge could be tested in the practice already the next day, when we went to two outcrops not far away from Bandung, Rajamandala and Tagog Abu. The former is characterized by an andesitic basement, followed by marly volcanoclastic deposits and shallow marine limestone with many foraminifera which helped to determine the age as late Oligocene-early Miocene. The latter was a muddy sandy limestone outcrop with planktonic foraminifers and cross-bedding.

The workshop in Bandung continued with a lecture given by Jeremy Young about timescales and biostratigraphy with exercises which helped a lot to understand how chronostratigraphic investigation works. We were going on learning many concepts and explanations in the class of Juan Carlos Braga from the University of Granada, who gave an introduction to sequence stratigraphy. This knowledge was also useful later in the field. The last class given by Lil Stevens from the Natural History Museum of London was about communication skills, which will be more and more important in our scientific career. We learnt about writing for the public and giving information about our work to different audience. Then it was the turn for the eleven ESRs, the Early Stage Researchers, to talk to the mixed audience of other ESRs, supervisors and Indonesian collaborators and to introduce their own project and what exactly our contribution to the whole THROUGHFLOW project shall be. It was really interesting to situate myself in the group and to know the other working fields and how everything will flow together. After that Willem Renema gave us a short overview of the sites he and Ken Johnson had already visited half a year ago. He showed us photos and summarized the relative importance of the various outcrops in East Kalimantan and what could be found in each one of them.

After changing our base from Bandung (Java) to Samarinda (East Kalimantan), the real field work started.

The first day in Samarinda was an exclusively training activity in one of the most important outcrops of the area with ancient delta deposits. With the help of the more experienced, sedimentology-trained geologists within the ESRs, we roughly learnt how to measure and log at a detailed scale. Additionally we were shown many interesting features which can be seen at outcrops and help to interpret the paleoenvironment, such as sedimentary cycles, sedimentary structures, and fossils. At the top of the section, there is a small fossil reef, in which I saw fossil coralline algae for the first time in the trip.

The following days we went to visit numerous outcrops and quarries around Samarinda, such as Senoni, Air Puti and Badak, see also Wilson (2005)[1]. In most of them we made a detailed log of the carbonate bodies and where I could find fossils of coralline algae I took various samples. Many of them were associated with fossil corals, encrusting them or at the top or bottom of coral rich beds as nodules or rhodoliths. Those beds where surrounded by other bioclastic carbonates, often with benthic foraminifers, or by silts and clays with microfossils.

In all the evenings after field work we held a meeting, telling where we had been, what we had found, for whom it could be interesting, and how the descriptive process of the sites was going on.

On the 30th of November Irfan Cibaj, a geologist from Total took us to interesting outcrops were he showed us the sequence stratigraphy and Miocene history of the Mahakan delta.

As we are a quite big group, things had to be well organized; so for every concern there was created a committee. Small groups of ESRs were responsible for issues such as planning of cars, gathering data or taking care of first-aid boxes. I was part of the photo committee making sure that everybody's photos were saved in a project hard drive. A selection of these photos will be online before this report is sent.

We spent the days from the 4th to the 11th of December in and near Bontang, a four hour drive north of Samarinda. We logged and sampled various outcrops in this region, including some ancient reefs located in a huge coal mine which yielded many coralline algal samples.

After that we went on exploring and sampling carbonate outcrops around Samarinda, especially of the Batu Putih formation, such as DPR and Permassip, which were already partly described in Wilson (2005). In the last days Bob Morley from Palynova gave us talks about his investigations on the stratigraphic framework of the Kutai Basin. Finally we packed all the samples in wooden boxes to have them shipped to NHM in London and then distributed to the different institutions involved.

Altogether I took almost 400 samples of fossil coralline algae from nine different sections around Samarinda and from eight sections near Bontang. All these samples are precisely located in the section logs with a detailed description of the facies (lithofacies, other fossil components) from which they were taken. Once in Granada, the samples have to be prepared in thin sections, because many taxonomically useful characters can only be seen under a microscope.

As the deposits we have studied and sampled during the field work of NTA2 have an age of roughly early to late Miocene, it would be important for me to have access to rocks of older ages, preferably upper Oligocene sections, in the next trip. This would allow me to scan a wider age range in order to obtain more confident results about the origination dates of the reef building coralline algae of the Indo-Pacific.

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9. Miocene coral reef ecosystems in Southeast Asia

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Scientific questions

Corals build carbonate skeletons that are commonly preserved in the fossil record, so the can be useful sources of information to understand climate dynamics of the oceans, diversification processes, and ultimately their evolutionary history. This project takes place in Indonesia that is one of the countries lying within Southeast (SE) Asia that hosts the 'Centre of Maximum Marine Biodiversity' in the world, also known as the Coral Triangle. The high marine biodiversity in the area is strongly related to the development of modern coral reef ecosystems, which became relatively more common in the region during the Early Miocene (Wilson and Rosen, 1998) Thus, coral reefs have offered the framework where diversification and evolutionary processes of reef corals and other groups have occurred during the last 23 million years(Renema et al., 2008). The Indonesian Throughflow current (ITF) has a major influence on the oceanography, and is the last remaining equatorial oceanic gateway, allowing heat transfer as water flows from the Pacific into the Indian Ocean (Gordon, 2005). The constriction of the deep-water flow through the ITF occurred during the Oligocene/ Miocene transition as a result of the dynamic plate tectonics in SE Asia (Hall, 2002), coinciding with an increase in reef building in the area.

On the other hand, the maintenance of the high biodiversity in the Coral Triangle is currently threatened by factors associated to global climate change such as increasing seawater temperatures and acidification of the oceans (Knowlton and Jackson, 2008). Reconstructions of past climate show that similar global events have also occurred in the past, and particularly during the Cenozoic with alternating periods of global warming and climatic optimums and intervals of rapid injection of CO_2 into the atmosphere (Zachos et al., 2008). Therefore, fossil coral communities living in the region during the Miocene were influenced by climatic changes similar to those predicted for the future and can be used as an excellent model, to understand evolutionary processes (diversification, extinction, migration) of coral reefs, and also to consider some possible trends on biodiversity under the current global climate change scenario.

The main questions addressed in this study are:

1. Which coral species were present during the Miocene in the SE Asia?

Background information and historical collections that provide a first approximation of levels of diversity are mainly kept at the Netherlands Centre of Biodiversity Naturalis in the Netherlands. Dutch researchers carried out the most important monographies during the colonization period, including Martin (1880-1888), Felix (1913-1925), Gerth (1923, 1931-1965) and Umbgrove (1924-1950).

However, these relatively small collections and few taxonomic studies are likely inadequate summaries of the ancient coral diversity in SE Asia. For this reason, one aim of the field training (NTA2) was to collect the large amount of material required to develop a consistent taxonomic framework to document diversity during the Miocene. Although coral systematics is currently in a state of rapid advance (Fukami et al., 2008), as new microstructural characters are being explored to attempt species identification (Budd and Stolarski, 2008), in this project we will make the best use of all available information, including revision of museum collections, literature and morphological techniques.

Section name	Latitude	Longitude	Code	No. samples	No. bags	Photo-transect	Colony forms	Sampling type
Top reef Stadion	-0.58573	117.11900	TF51	9	21	no	pl>br	St
Batu Putih 2	-0.46891	117.12127	TF52	8	13	no	pl>br	St
Badak	-0.32203	117.29750	TF56	15	31	unit 7	pl>ms>br	St
Top reef in Mine	-0.58467	117.11983	TF57	13	24	no	pl>br	St
AMP Km27	-0.01819	117.35292	TF59	5	10	unit 4	pl>ms>br	St
Batu Putih 1	-0.46626	117.12183	TF76	10	13	no	pl>br	St
Batu Cermen	-0.43234	117.13783	TF79	8	20	units 2,3,4	pl>ms>br	St
Coral-Mollusc clumps	0.16727	117.44348	TF102	19	19	coral clumps	br	St
NN	0.18897	117.44445	TF107	3	3	no	br>pl	St
NN	0.18528	117.44638	TF108	3	3	no	br>ms	Float
3D-Reef	0.15130	117.30438	TF126	12	23	units 4-5	pl>so	St
Monkey Section	0.20746	117.28673	TF128	1	1	no	pl>so	Float
The rooster's crest	-0.48119	117.11406	TF130	1	1	no	br	St
Molluscs	0.16723	117.43736	TF151	1	1	no	br	St
Rainy Section	0.09644	117.38037	TF153	4	6	unit 12	pl>br	St
Tridacna	0.16729	117.43973	TF154	7	19	units 3-4	br>ms	St
Millipede Hill	0.17145	117.28764	TF106	1	1	no	ms	Float
Badak II	-0.31000	117.39793	TF54	1	1	no	pl	Float
Top hill	- 0.47658	117.11658	TF77	4	6	no	ms	Float
NN	0.18732	117.47622	TF113	2	5	no	br>ms	Float
		Total	20	127	221	12		

Table 9.1. Summary of work accomplished for the Coral Biodiversity component

2. Is the high diversity of the coral triangle the result from low extinction rates or high origination rates (or both) since the Early Miocene?

Related to the first question, this analysis will include a comparison between extant fauna and fossil record of SE Asia. An on-going revision by Johnson et al. (in prep.) shows that the current knowledge on taxonomic inventories for the region include a total of 25 families, 76 genera and 297 species, from which 173 species were extinct, while 124 are still extant and observed in modern reefs. During NTA2 coral specimens were collected from different stages of the Miocene, including Aquitanian, Burdigalian, and possibly the Serravalian and Tortonian. Extant corals will be examined from Museum collections (NHM and NCB) and the possibility of surveys on living coral communities in the surrounding areas will be explored.

3. Which environmental factors control the presence and distribution of coral species in SE Asia during the Miocene?

NTA-2 was focused on fossil coral communities associated with distal deltaic facies in the Mahakan and other rivers in the Kutai Basin. These communities are characterized by diverse assemblages of platy coral species, occurring in different localities and covering different ages (Early to Late Miocene). Development of coral communities under conditions of high turbidity (high siliciclastic sedimentation) and poor light levels were observed. Palaeoecological aspects of Miocene reefs in East Kalimantan, will be analyzed in combination with the results produced by Throughflow researchers working on molluscs, forams, bryozoans, and algae, as well as with data of sedimentology, stratigraphy and high-resolution proxies.

Field Methods

The geology of the Kutai Basin has been studied by Wilson (2005). In the area, carbonates are interbedded with Miocene deposits of the proto–Mahakam delta, and are exposed in a series of folds . The group was divided in five teams (5-7 researchers) to explore and locate the different sections. Sections were located around two main cities in East Kalimantan, Samarinda and Bontang. Sections suitable for stratigraphic assessment were logged. Excellent two- (TF52, TF153) to three-dimensional outcrops (i.e. TF79, TF126) were observed. Outcrops were studied along roads (i.e. TF51, TF57), in active quarries (i.e. TF76, TF52, TF153), disused quarries (i.e. TF59), or construction plots (i.e. TF154, TF108). Despite the artisanal methods of quarrying by locals, it is possible that for the next expedition (June 2011) some of the sections will be drastically removed or no longer exist.

Coral sampling was performed following a stratigraphic outcrop assessment, thus collections were made at the respective units identified in the logs (see Table 9.1). Sampling was focused on platy coral communities embedded in mudstones because they were common assemblages in most of the sections. Feasibility of sample extraction (soft sediments) and good preservation of characters required for taxonomic identification were also criteria that resulted in an emphasis on the collection of platy coral assemblages. However, some colonies were extremely fragile and special care was taken during their collection.

Biodiversity collections

An extensive sampling was carried out in 17 sections, including a total of a 127 samples (221 sampling bags) among specimens and bulk material (Table 9.1). The sampling was based on the stratigraphy, thus each sample was described with the stratigraphic unit/bed where it was collected from, and the respective coordinates of the section (see Appendix). Scaled photographs were taken, especially in those cases when the collection of the specimen would partially damage the sample or was simply not possible to extract from the cemented matrix. Additional samples were collected from the float material at the stations TF54, TF77, TF113, which were visited without a stratigraphic description.

Sampling bags were packed into ten crates and shipped to the NHM (London). Once in the lab, specimens will be sorted, sieved (for bulk samples), cleaned, and identified to the highest taxonomic level, according to their preservation status.

Photo-transects

In order to compare the coral community structure among the different coral assemblages, a methodology of photo-transect was applied. Transects were photographed by using a PVC quadrat (25 x 25 cm) with a perpendicular branch to support the digital camera (Canon PowerShot SD900) and ensure that photos were taken from a fixed distance (Fig. 9.1B). Length of transect varied according to the availability of exposed surface of the coral unit in the outcrop (Fig. 9.1A), for instance in the section TF79 transects were 10m long, while in TF56 they were only 4m long. Since the strike/dip varied

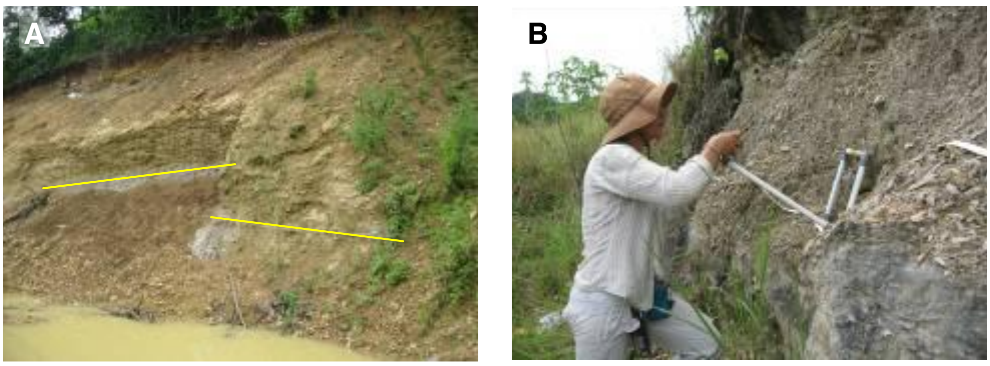

Figure 9.1. Photo-transects methodology to study Miocene coral communities in East Kalimantan. A. Transects at TF153 (Rainy section), 8 m and 4 m along the Unit 12. B. PVC quadrat (25 x 25 cm).

Figure 9.2. Examples of photo-quadrats (25 x 25 cm): (A,B) TF126 3D-Reef, (A) Unit 4 composed by thin platy corals of max. 1 cm, and (B) Unit 5 by thick platy corals, 1.5 – 6cm; (C) TF56 Badak, Unit 7, showing thin platy corals, max. 5 mm; (D) TF79, colony of *Hydnophora* sp., corallite surface exposed. (E) TF79 branching coral; and (F) Branching corals, *Dyctiarea* sp., *Goniopora* sp., and *Seriatopora* sp., conforming clumps at TF102.

among the outcrops, coral colonies were placed either transversally or exhibiting their surfaces with corallites. This factor limit direct comparisons, but some general characteristics can be analyzed from the pictures: colony form (i.e. branching, platy, massive, etc.), size of colonies (i.e. ratio length: width: thickness, area), and when possible, a taxonomic identification will be achieved (Fig. 9.2A-F).

Although photo-transects were mostly performed on platy coral assemblages, other communities composed by branching corals were also photographed according to particular objectives such as the presence of mollusks (Fig. 9.2F). Images include approximately 1250 photo-quadrats for all sections.

Collaborative research

In all sections a collaborative work among the ESRs and supervisors was performed. Integrative biodiversity analysis with other ESRs, including large benthic forams (Vibor Novak), coralline algae (Anja Roesler), mollusks (Sonja Reich), and bryozoans (Emanuela Di Martino), will be possible since all collections were based on the same stratigraphic assessments. The interpretation of palaeoenvironmental conditions is being planned together with ESRs Simone Arragoni (UGR) and Vibor Novak (NCB Naturalis).

Some outcrops offered settings that allow specific studies in the short-term, as follow below:

TF126: This 3D-Reef section shows an excellent setting where development of patch reefs and their controlling factors (sedimentation, water energy, light, etc.) can be modeled. Eight perpendicular sections were described and measured to estimate the shape and geometry of the outcrop; see more details in V. Novak and S. Arragoni reports, also included in this document. Similar analysis on development of patch reefs can be performed in the outcrops TF56 (Badak), TF52/76 (Batu Putih), TF79 (Batu Cermen), TF59 (Southern Hemisphere), and TF153 (Rainy section).

TF102: Mollusks were present in few sections, and this particular assemblage exhibited a diverse fauna composition related to branching coral clumps. Transects were performed to analyze their distribution patterns. Bulk samples were collected from each clump, and they will be sieved and sorted in the lab. The relationship among coral/mollusks associations and environmental characteristics will be explored; whether the presence/absence of mollusks is due to particular environmental factors or preservation conditions (weathering, carbonate dissolution) will be tested. Some additional information is still need to check whether the clumps were found *in-situ* or not, which will be completed during the next field trip (NTA-4).

Summary of work accomplished

Table 9.1 summarizes the number of samples, photo-transects and preliminary observations on the coral composition (growth forms) observed in each section. In addition, 6848 pictures and video files were recorded during the expedition; these images will be sorted by section and theme, such as taxonomic groups, landscapes, photo-quadrats, etc.

Preliminary Results

Corals were a common component of the fossil fauna within the deposits in the basin during the Miocene. They were observed in almost all of the sections studied, and a systematic collection was performed in 17 of the 25 sections. They consisted predominantly of platy forms (Table 1) associated to siliciclastic mudstones characteristic of sedimentary environments adjacent to river deltas.

Although preliminary, some general observations can be annotated:

- Platy coral assemblages can be interpreted as an adaptive response to extreme environmental conditions: poor light levels in waters with high sedimentation rates. It can be hypothesized that the coral succession starts with some species able to settle directly on soft sediments, or using fine sand grains, mollusks, or forams, as substrate to initiate growth. These initial stages are characterized by a high diversity, and they are slowly replaced by a community dominated by few coral species that develop thicker and larger colonies (see Figs. 9.2A and 9.2B, illustrating consecutive units 4 and 5 at TF126, respectively). During the specimen examination, special attention will be taken to test whether there is a species turnover phenomenon or colonies simply develop different under different conditions (more light/less sedimentation). Moreover, specimens will be checked to identify which substrates were used by corals to settle on. This development pattern, from thinner to thicker coral communities, was also observed in the sections TF153, TF59, and TF79, as well as others.

- Branching coral assemblages can be explained by variation in the environmental conditions: shallower bottoms with more light and less sediments, higher water currents, changes of the trajectory of the delta river, eustatic sea-level changes, and/or the combination of these characteristics, among others.
- Massive coral colonies were rare and restricted to packstones and rudstones. Preliminary observations during the exploration to Sangkoelirang area show that more complex settings composed by massive and branching corals can be present in the northernmost areas that represent either different habitats - on the margins of the basin or different stratigraphic ages (K. Johnson, pers. comm.).
- Diversity species is high in both platy and branching coral assemblages, and comparable to modern coral settings living under similar environmental conditions. Some genera preliminary identified were *Porites*, *Cyphastrea*, *Echinopora*, *Echinophyllia*, *Leptoseris*, *Stylophora*, *Seriatopora*, *Dictyaraea*, *Goniopora*, among others. A complete inventory of species will be possible after examination of the material.

The analysis of the images and the revision of the collected material will allow a better understanding of these preliminary observations, and will refine the research questions.

New skills

My previous experience on research expeditions was focused on living organisms and the field methods included diving and oceanographic cruises. During the NTA-2 activity I had the opportunity to work for the first time on palaeontological methods under the supervision of experts on this field, and also with an interdisciplinary team composed by specialists on stratigraphy, magnetostratigraphy, and geochemistry. Therefore, I learned methods to collect fossil specimens and some basic knowledge on stratigraphy. I also got my first approach to analyze coral communities under a broader temporal and spatial scale.

This expedition required a initial stage of application for research permits and visas through Indonesian embassies, and upon arrival at the immigration office. After arrival in Jakarta, the process included completion of many different forms and visits to different offices during the first week of the expedition. It was an interesting experience to participate in this process. It is important to recognize that this background work started at the same moment the project was conceived and they were possible by the project coordinators. Research permits are key aspects to take into account for future investigation in Indonesia or other country with these legal requisites.

Multiculturality was another aspect enriched during the NTA-2. The opportunity of living/working during a month with students and supervisors of many other nations with different languages, religions and costumes, allowed the development of many personal aptitudes. The hospitality and kindness of our Indonesian counterparts was crucial to ensure the success of the work. This was also an excellent opportunity to learn more about the Indonesian culture, including some basics words and the diversity of spices and food. On the other hand, difficult weather conditions (high temperatures and humidity) during the working times were overcome with doses of team commitment, tenacity, and a lot of water.

Finally, some important lessons about the planning and design of the field trip will be very useful for the next NTA.

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10. Miocene Palaeoclimates in Kalimantan: Stable Isotope and Trace Element Geochemical proxies and Strontium Isotope Stratigraphy

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Aims and Objectives

The primary goal of this project, within the Throughflow network, is to extract reliable high resolution climate proxy data from well preserved fossil material sourced in a key geological location.

Fieldwork (November and December 2010)

- Mapping and logging of Miocene outcrops and sedimentary sections
- Sampling of discrete horizons for Strontium Isotope Stratigraphy
- Assessment of the nature of well preserved fossil material in the field
- Sampling of well preserved fossils at high resolution wherever possible
- Examination of palaeoenvironmental information available in the field
- Development of methodologies for further fieldwork
- Exploration of potential new areas for future fieldwork

Lab based work

- Strontium Isotope Stratigraphy using selected fossil material to provide temporal framework for this project and other ThroughFlow network member's projects
- Sectioning of suitable fossil material for analysis of growth layers
- X-Ray Diffraction (XRD) analysis to asses mineralogy of authigenic carbonates and suitability for subsequent use in geochemical analysis
- Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICPMS) and Stable Isotope analyses including the assessment, development and implication of various geochemical proxies to reconstruct palaeoclimate parameters such as temperature, pH, salinity and riverine runoff using samples deemed suitable during XRD analysis
- Analysis of data for seasonal cycles
- Examination of potential forcing factors on seasonality and long term climate trends
- Integration of these data with other palaeoclimate data within the ThroughFlow network (Nicholas Fraser and Elena Lo Giudice)
- Input of data into oceanographic models, Amanda Frigola Boix, Bremen

Field Methods

Logging of sections was completed by multiple members of the ThroughFlow team. Where appropriate, collaborative efforts were made to complete work on larger areas or sedimentary sections within a limited time frame. In order to allow for this scenario to operate smoothly each ESR took on a particular task at the field location. Later collection and sharing of all the data, usually during the same day, ensured the continuity of future work on samples and data from each site.

Sampling was carried out after logging of sections was complete. The elevation of each sample was recorded either in meters from the base of the section log or, where appropriate, simply assigned to a certain unit in the sedimentary log (particularly useful for distinct beds with certain characteristics). GPS coordinates were taken for each locality and each sample within the locality (samples acquired as part of this project) to aid high resolution mapping on the return to London.

All samples were wrapped in newspaper and bagged in cloth sample bags. Multiple samples were sometimes bagged together to conserve supplies. This was only carried out for float samples or where more than one specimen was retrieved from a unit.

The samples were finally rechecked and rewrapped where necessary and packed into a single crate with extra newspaper for packing before departure from Samarinda at the end of the trip.

Summary of work accomplished

The initial portion of the field season was spent processing work permit applications in Jakarta, Java so as to allow for the remainder of the fieldwork to be completed within the guidelines of the Indonesian Immigration (Immigrasi). Once the initial stages of application were complete the team moved to Bandung where a total of 7 days were spent with the Indonesian Geological survey. Here Network Board Meetings and other fieldwork planning activities were completed. Standard methodologies for working in the field were also discussed at this stage and later developed or discussed further in the field. A number of sites were visited during this period so as to introduce the team to the type of outcrop likely to be encountered in Kalimantan and a visit to Tangkuban Perahu Volcano was also made.

After the immigration process was complete the team travelled to East Kalimantan. On arrival in Samarinda a small amount of time was spent looking at a large section called ‘Stadion’. This section is a relatively fresh section of deltaic sediments and allowed for the exploration of the teams collective skills within the succession of sediments to be studied in this part of Kalimantan. Subsequent to this teams were divided on the basis of individual project requirements. For the purpose of this project very well preserved material is needed and so routes of enquiry were followed in order to retrieve the best material possible.

A number of days were spent carrying out reconnaissance work for this project and the other ESR’s within the network. These days involved driving to places of potential interest to assess the likelihood of the locality being useful for the project. Advice on where to seek well preserved material was provided by the Indonesian cohort. Selected places were found to be unproductive due to the voracious nature of coal mining in Indonesia. GPS locations marked several years before were found to no longer host sediments. When this occurred much time was spent examining neighbouring sections to be certain that no material was available in the area.

Once a number of suitable localities had been located each individual assessed the suitability of that locality to their project and worked with others accordingly. For the first week or so only a small amount of material suitable for this project was found. The majority of sediments in the Samarinda area were, however, most likely unsuitable for this project.

When the bulk of the work in Samarinda was complete I travelled north to Bontang so as to assess the suitability of material and further work there. It was anticipated by Dr.’s Johnson and Renema that the Bontang area would be quite fruitful. During the first day, whilst organising logistics and accommodation for the remainder of the group, a large volume of suitable material was found in very easy to access outcrops close to Bontang.

Work was carried out here for 6 days and included the bulk of sampling for this project during this first trip. The abundance of samples potentially suitable for geochemical analysis in this area was far greater than further south in Samarinda. A total of 21 samples were acquired during this portion of the fieldtrip, with a much higher proportion being more likely suitable for geochemical analysis as part of this project. During the field training at total of 39 samples were collected. Many of these samples, each labelled within a separate sample bag, contained more than one potential target for analysis as part of this project.

One sample collected by Dr. Jon Todd will possibly provide a great amount of data for multiple members of the project. This large bivalved mollusc (possibly a Tridacnid) may present a long time record that could be utilized for palaeoclimate work in this project. The specimen, when collected, also appeared to have corals both below it (substrate) and covering parts of its shell (encrusting). These corals may further allow assessment of the palaeoenvironments before and during the life period of the mollusc. Furthermore, samples taken from sediments below this horizon, ~15 smaller tridacnid molluscs, may provide the basis for a unique study into a discrete portion of time at this locality (TF108).

Preliminary results

As the samples are still being shipped back from Indonesia no work has, as yet, been completed on them. It is expected that the shipment will arrive in London in late January or early February. Some preliminary results may be available by early March when NTA 3 will take place in the Natural History Museum, London.

IN the latter months of 2010, prior to the fieldwork in Kalimantan, a number of samples were analysed so as to provide training on the LA-ICP-MS system in Royal Holloway. These samples included three corals from Kalimantan, one from the south of the area visited during NTA2 and one from far north in an area to be visited during NTA4.

This data is now being processed and will be incorporated into the project upon the acquisition of sufficient field data (the samples were collected in the mid 20th century and so do not have sufficient field data at present)

Training summary

While in Indonesia the complicated logistical planning required for such fieldwork became apparent. Much of the experience during the first field season will aid the second field season greatly. Extra preparation for the next field trip (currently planned for June 2011) will allow for much more efficient working in the field and improved yield of both samples and complimentary field data. The initial experience of dealing with the terrain likely to be encountered also proved instructive for equipment needed and general field practices.

Much was also learned about the Indonesian people and the best methods of communication and cooperation. The involvement of the Indonesian geological survey, their students and staff, was found to be invaluable. This enabled effective communication both in the field and in logistical matters.

The need for map data, both for navigation and the collection of field mapping data became apparent during the first trip. Though the lack of map-based preparation did not hinder the retrieval of a good collection of potentially suitable material and appropriate accessory data, it is vital that the continued improvement of the geological context of this project is managed efficiently. This will be heavily map-based and is likely to involve the integration of digital satellite imagery so as to enable the best possible maps to be generated using ArcGIS. These maps will be used in the field for navigation, mapping, sample recording and basic geological interpretation. Subsequent to this, similar, improved maps will be used for presentation and publication as necessary. This work is currently underway.

Appendix

Links to data sets and other documents resulting from NTA-2.

1. List of outcrops studied during NTA-2 and NTA-4

2. List of samples collected during NTA-2 and NTA-4

3. Stratigraphic logs of studied sections available on request.