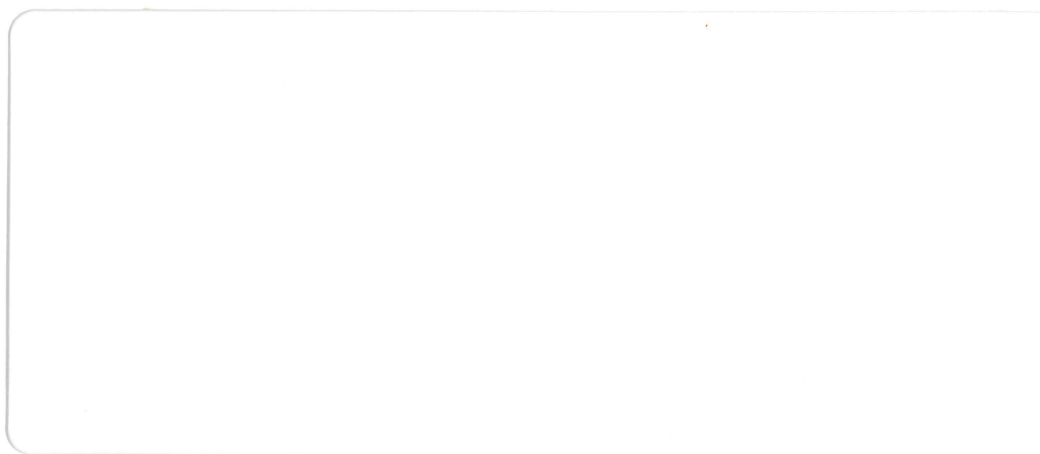


56296
P. 13

The Snellius-II Expedition

Progress Report



7-1000

Theme I
Geology and Geophysics of the
Banda Arc and adjacent areas

Campaign GF 2
Buru, Seram and Kai-islands
August - October 1985

Table of contents

	Page	
1	INTRODUCTION	4
2	RESEARCH PROGRAMME	
2.1	General	5
2.2	Objectives, Methods	6
2.2.1	Party A	6
2.2.2	Party B	6 - 7
2.3	Locations and travel scheme	7 - 8
2.4	Preparatory phase in Indonesia	8 - 9
3	CAMPAIGN GF2	
3.1	BURU	10
3.1.1	Introduction	10
3.1.2	Sections studied and conditions in the field	10
3.1.2.1	Party A	10
3.1.2.2	Party B	11
3.1.3	Progress of fieldwork	
3.1.3.1	Party A	11 - 12
3.1.3.2	Party B	12 - 13
3.1.4	Geological observations	
3.1.4.1	Party A	14 - 15
3.1.4.2	Party B	15
3.1.5	Preliminary results	
3.1.5.1	Party A	15 - 16
3.1.5.2	Party B	16
3.2	SERAM	
3.2.1	Introduction	17
3.2.2	Sections studied and conditions in the field	
3.2.2.1	Party A	17 - 18
3.2.2.2	Party B	18
3.2.3	Progress of fieldwork	
3.2.3.1	Party A	18 - 19
3.2.3.2	Party B	19 - 20
3.2.4	Geological observations	
3.2.4.1	Party A	21 - 22
3.2.4.2	Party B	22 - 23
3.2.5	Preliminary results	
3.2.5.1	Party A	23
3.2.5.2	Party B	23 - 25
3.3	KAI	
3.3.1	Introduction	26
3.3.2	Sections studied and conditions in the field	26
3.3.3	Progress of fieldwork	26 - 27
3.3.4	Geological observations	27 - 28
3.3.5	Preliminary results	28 - 29

	Page
4	TRAINING AND EDUCATION 30
5	REFERENCES 31 - 32
6	ENCLOSURES
	1. List of participants 33
	2. GF2 campaign map 34
	3. Locations studied in Buru 35
	4. Legend for use of lithological columns party GF2 A 36
	5. Exposure map of Hotong and Rumbia rivers 37
	6A-H. Lithological columns of Hotong section 38 - 45
	7. Lithological column of Rumbia section 46
	8. Exposure map of Duna River 47
	9. Lithological column of Duna section 48
	10. Exposure map of Lumara river (GF2 B) 49
	11. GF2A locations studied in Seram 50
	12. Exposure map of Masa river 51
	13A-F. Lithological columns of Masa section 52 - 57
	14. Exposure map of Kwa and Rioapa rivers 58
	15A-C. Lithological columns of Kwa section 59 - 61
	16A-K. Lithological columns of Rioapa section 62 - 71
	17. Exposure map of GF2 B campaign in W Seram 72
	18. Exposure map of GF2 B campaign in Central Seram 73
	19. Exposure map of GF2 A campaign in Kai islands 74

1. Introduction

Field campaign GF2 was the last of all Snellius II expeditions. For logistic reasons it had to be organised between mid August - mid October 1985, i.e. took place after the official end of the Snellius II programme. The progress of the expedition didn't suffer from this negative aspect, thanks to the many prearrangements in Indonesia by NRZ and Indonesian officials, which we gratefully acknowledge. As campaign GF2 is the continuation of campaign GF1, there is no need to repeat the general goals of our research etc., as formulated in chapters 2 and 3 of the GF1 Progress Report.

This report compiles data provided by the various team members. M.E.M. de Smet completed the lithological columns and maps of party A.

2. Research programme

2.1 General

Campaign GF2 is the direct continuation of the field programme of GF1. Both programs are concerned with onshore research to elucidate aspects of the geology and geophysics of the Banda Arc (Theme I). During this campaign the islands of Buru, Seram and Kai were visited, with Ambon as base station for the various journeys. To cover the objectives of our research programme campaign GF2 consisted of two different field parties. Unlike the situation during GF1 campaign the third, paleomagnetism party made an independent second expedition (reported as GF3). Party A studied selected stratigraphic sequences exposed on the islands whereas Party B studied metamorphic rock complexes. Because of the widely different rock types these "sediments" and "metamorphics" groups, as they are called, had to visit different parts of the islands (see map, encl. 2).

2.2 Objectives and methods

2.2.1 Party A

The main objective is to determine the nature and calculate the timing and magnitude of vertical movements by analysing selected Neogene - Quaternary sections in Buru, Seram and Kai islands. Secondly sampling on a reconnaissance basis is required of older Tertiary sediments on Kai.

The methods consist of:

a. in the field : Stratigraphical logging and sampling of key sections for paleoenvironmental interpretation, event detection and age dating. Structural reconnaissance mapping (if possible) of the selected areas to sustain the detailed stratigraphical analysis and determination of structural style. Additional measuring and sampling of elevated beaches and reef terraces to determine young sealevel changes and/or vertical movements. Sampling of reef limestones for radiometric age determinations (^{14}C analysis chiefly).

b. in the laboratory : study of the preserved microfossil assemblages for age and paleoenvironmental data. Additional study of geochemical parameters if requested (e.g. of intercalated tuffs). Intergration of all stratigraphic data for correlation across the Banda Arc, with geohistory analysis giving rates and magnitudes of vertical movements.

2.2.2 Party B

The objective of the research on metamorphism is to establish the P(ressure) - T(emperature) conditions during the successive metamorphic stages. Geothermobarometry will be based on the study of minerals as well as fluid inclusions. The absolute age of the metamorphism is also an important objective. Reconstruction of the original depositional environment and origin of magma is an additional goal.

The methods followed are:

a. in the field : Analysis of the deformational history of the rocks using visible tectonic features. Samples are taken (a number of them oriented) from outcrops with recognizable metamorphic minerals. For radiometric age determinations on minerals and/or whole rock and for geochemical work large samples had to be collected. Further the cobble float of the rivers selected is searched for indications of changing metamorphic conditions upstream.

b. in the laboratory : Study of thin sections to establish the stable metamorphic parageneses and the deformational scheme in combination with the typology and development of folding. In polished thin sections relevant minerals are analysed with the electron microprobe. Rocks with promising fluid inclusions are selected for further investigations. A number of rocks are crushed for chemical analysis of both mayor and trace elements with aid of the X-ray fluorescence spectrometer and neutron activation analysis. Table I gives an overview of the analyses already

carried out (July 1986).

TABLE I - Overview of petrological investigations of collected samples GF1-2B

	thin sections studied	polished thin sections analysed	chemical analysis
Central Timor	90	--	10
Atapupu (N Timor)	40	4	2
SE Sulawesi	85	5 a)	2
Buru	30	1	--
Lintas Seram	25	--	--
Kaibobo (W Seram)	35	2	--

a) B_0 values of phengite in mica schist samples from a section E and W of Kolaka were measured with aid of X-ray diffraction. They appear all to be fairly high-P micas, which is in disagreement with the hypothesis of Hamilton (1979) suggesting presence of olistostromes containing large blocks with high-P minerals in that area.

2.3 Locations and travel scheme

Both parties operated in Buru and Seram. In addition, party A visited Kai islands. The Dutch members of the GF2 team left Holland on August 17th and arrived in Ambon on August 27th. Ambon served as the base. Here, by courtesy of Drs. P. Buurman and Drs. A. Leget of the Regional Development and Planning Project CTA 72 (Bappeda I Ambon Maluku) we could make additional studies of aerial photographs. The last team member (MdS) returned on October 18. Expedition leader A.R. Fortuin had to return to Holland after the Buru campaign because of a thumb fracture. His duties were taken over by M.E.M. de Smet, who also arranged the export of the Dutch share of the samples. About half of the total period of roughly 2 months could be spent in the field.

TABLE II - Travel scheme onshore research campaign GF1

1985

17/8	28/8	14/9	29/9	18/10
preparatory stage (Java)	GF2 Buru	GF2 Seram	GF2 Kai and return	
	team A 13d. sediments	team A 9d. sediments	team A 8d. sediments	
	team B 13d. metamorphics	team B 13d. metamorphics	team B returns (4/10 dep. Ambon)	

2.4 Preparatory phase in Indonesia

The following daily account describes the progress of the preparations in Jakarta and Bandung.

Saturday, August 17

Departure from Schiphol airport.

Sunday, August 18

Arrival in Jakarta. To Sabang Hotel.

Monday, August 19

To LIPI headquarters to find out that our research papers are not yet completed. Provide the additional information desired. In afternoon by train to Bandung.

Tuesday, August 20

Meet H.M.S. Hartono, Soebardjio Tjokrosapoetro and other colleagues of the Marine Geological Institute. Discuss the field programme and results of the previous campaign (GF1). As the completion of the research permit paperwork still needs some days, we gratefully accept the possibility of visiting the Volcanological Observatory of Gunung Galunggung volcano. In the evening enjoy a social meeting with all GF2 participants in the house of Soebardjio Tjokrosapoetro, the Indonesian coordinator of the onshore campaigns.

Wednesday, August 21

Together with Ir. Dadang Kadarisman of MGI to Gunung Galunggung area.

Thursday, August 22

Visit area destroyed by Gunung Galunggung eruption. At Volcanological Observatory meet volcanologist Hilman, who guides us on a walk to the crater rim of G. Galunggung. Return late at night in Bandung.

Friday, August 23

Visit Marine Geological Institute for last arrangements. We are informed that our research papers are ready now at LIPI. Therefore leave for Jakarta in afternoon. Agree to meet our Indonesian counterparts in Ambon on 27/8 at Rezfanny Hotel.

Saturday, August 24

Visit Mrs. Moertini at LIPI office. Receive all papers necessary. Book afternoon flights to Ambon (some of us with stop-over in Denpasar). After booking hear that our counterparts probably cannot arrive in Ambon before 29/8. We are invited by S. Tjokrosoerto to return to Bandung again, which invitation however cannot be accepted as the flights are booked already. Urge for speed in order not to get behind the planned travel scheme. Two of us fly straight to Ambon, whereas the others will spend the weekend in Bali.

Sunday, August 25

Bali.

Monday, August 26

(National holiday) Bali.

Tuesday, August 27

Arrive in Ambon, together with counterparts Agus and Siregar from LGPN-LIPI (Bandung).

Wednesday, August 28

Report to police officials and Governors' administration. In afternoon meet Drs. Peter Bennema of the Regional Development and Planning Project and get valuable information concerning transport facilities etc.

Thursday, August 29

No details; waiting for the MGI group.

Friday, August 30

Study aerial photographs, kindly provided by the Planning & Development team. In the afternoon our MGI counterparts arrive.

Saturday, August 31

Shopping for the Buru expedition (food and camping equipment). Departure to Namlea (Buru) late at night.

3. Campaign GF 2

3.1 BURU

3.1.1 Introduction

To study the sedimentary history and history of vertical movements in the northern part of the Banda Arc the island of Buru had to be involved. Despite relatively scarce information concerning the Neogene geology, S. Tjokrosapoetro et al. (1981) unambiguously showed that the northwestern sector of this densely forested island gives best opportunities to reach the goals of Party A. The type section of the so-called Hotong Formation in the Bara Bay area (encl. 3) was selected for recording and sampling of the Mio-Pliocene. As metamorphic rocks are extensively exposed in the southeastern sector of the island team B selected the area N of Waiteba (encl. 3) for their investigations.

Prior to the field campaign aerial photographs were studied in Ambon. As topographic base maps we used copies of the 1:250.000 US Army topographic command SA 52-13.

3.1.2 Sections studied and conditions in the field

Enclosures 4 - 10 give the details of the surveyed river transects and the recorded lithology and collected samples. Because of the absence of roads the study areas had to be reached by using boats chartered in the capital Namlea.

3.1.2.1 Party A

The Neogene rocks selected for study are situated south of Bara Bay, in the foothills of Kaku Palatmada mountain (2050 m.). The principal section is formed by outcrops along Wai Hotong (Wai or Wa means river). According to existing information (S. Tjokrosapoetro et al., 1985), the succession is of Early - Middle Miocene age. Because of observed gaps in the record also a branch river (Wa Rumbia) was prospected. In addition, overlying coarse clastic sediments of Plio-Pleistocene (?) age were studied, mainly along Wai Duna.

During our visit the rivers were fairly to difficultly accessible, depending on local relief factors. As the rainy season had not yet finished the rivers discharged considerable amounts of water. This, together with heavy rains during part of the campaign hampered easy progress. The upstream work at Hotong river had to be stopped because of the presence of steep waterfalls. The exposures recorded and sampled are of fair to excellent quality, but the nature of the sediment appeared rather unfavourable for micropaleontological studies..

Transport of food, equipment and samples was possible by the employment of up to twenty men from Kampong Bara.

3.1.2.2 Party B

For the study of metamorphic rocks in Buru a section along the Lumara River (SE Buru) was selected. Progress of fieldwork was severely hampered by heavy rainfall. The first three days no fieldwork was possible at all, the river being too high and carrying too much suspended matter. After the continuous rains stopped fieldwork was still difficult because the level of the water was still high, with strong currents, so that in many places the river could only be crossed by using rotan safety-lines. In a number of cases exposures could be reached only by swimming, because most of the exposures occur in the outward curves of the river where the water is deepest. Moreover, the hills between the curves of the river are steep, very slippery and densely grown by bushes (most of the big trees having been removed some five years ago).

Fieldwork was regularly interrupted by rain showers, keeping the exposures wet and difficult to study properly.

3.1.3 Progress of fieldwork

3.1.3.1 Party A

Sunday, September 1

Arrive in Namlea at 05.00 in the morning. Report to Camat at 07.30. As no local boat is at its immediate disposal the group has to stay in Namlea.

Monday, September 2

Departure for Bara Bay with rented boat. Stop in Airbuaya to spend the night.

Tuesday, September 3

Arrive early in the afternoon at the work site, the mouth of the Hotong River. Contract twenty local laborers (at Bara village) to join the party. Make campsite in this uninhabited area.

Wednesday, September 4

Proceed through Hotong River upstream. Set-up campsite at farthest place where this can be done according to our guide. This place is about 5 km upstream. Plenty of rain.

Thursday, September 5

Just before the team reaches the farthest possible place that can be reached in one day march, A.R. Fortuin slides from a huge boulder. In a frantic jump to escape falling on his back, he smashes his left thumb against the rocks. It swells immediately and is bandaged. Later, when back in Ambon it will turn out to be broken. Further progress of the group is impossible as its way is blocked by a waterfall and steep valley slopes. The altitude reached is about 150 m. This means that the basal part of the Hotong sections has to remain unstudied (we estimate some 200 m of sediment). Start sampling and recording the succession in the

downstream direction. Heavy rains almost prevent working; hardly no photographs can be made. Though Fortuin is handicapped he is able to make notes and photos.

Friday, September 6

Move campsite and continue working downstream until proximity of base camp near river mouth. Downstream part of Hotong River is poorly exposed. Rain again.

Saturday, September 7

De Smet, Van Marle and Siregar prospect branch river, whereas the others take rest. Use this first sunny day to dry all equipment and clothes. Arrange transport for reconnaissance trip by prahu for the next day.

Sunday, September 8

Break-up campsite and make reconnaissance trip with the chartered boat of the village chief of Bara kampong along the NW coast of Buru, in order to find exposed Pliocene rocks. Walk into Flia river, but fail to find reasonable outcrops. Decide to return to Bara, where along Duna river better outcrops can be expected. Spend night in schoolbuilding of Bara kampong.

Monday, September 9

Set-up campsite along Wa Duna and investigate the river section. Good exposures of coarse clastics.

Tuesday, September 10

Continue working along Wa Duna.

Wednesday, September 11

Take rest and make final preparations to return to Ambon.

Thursday, September 12

Return to Bara kampong and wait for rented ship to arrive from Namlea. Departure in afternoon. Continue our journey back during the night.

Friday, September 13

Arrive in Namlea early in the morning. Go to the local guesthouse for food and rest and wait till the departure of the night ferry to Ambon. The metamorphics team returns in the afternoon.

Saturday, September 14

Arrive in Amboina early in the morning. Take Rest. Fortuin visits hospital to have an X-ray photo made. When a fractured thumb is very evident it is decided he better should return to Amsterdam.

Sunday, September 15

Fortuin returns to Holland (by KLM), while the others start to prepare for the Seram trip.

3.1.3.2 Party B

Sunday, September 1

The GF2 metamorphic fieldwork group departs from Namlea in a small boat with a 40 HP outboard engine, but is forced to stop four hours on the coast of Cape Kayuputih and to spend the night in Liat (E coast) due to high seas.

Monday, September 2

Arrival at Waiteba, just E of the mouth of Lumara river. The kepala dessa is visited and porters are hired. On foot to a hamlet some 3 km NW of Waiteba, where the night is spent, because three porters do not want to go any further.

Tuesday, September 3

From the Buru-language-speaking kampong new porters are acquired and the party goes on to roughly the place that was planned as a base camp at + 7 km NW of Waiteba. Rain is starting at 8 a.m. and will continue to pour down for three days.

Wednesday, September 4 and Thursday, September 5

The group waits for the uninterrupted rains to end in a very wet and uncomfortable camp.

Friday, September 6

In the morning the heavy rains stop. As planned, Enom Surya Nila and Supriadi make a detailed map of some kilometers of the upstream river pattern - with the aid of compass and a 25 m rope - so as to be able to reconstruct the exact location of the base camp on the aerial photo map made at Ambon. Helmers and Linthout do some geological reconnaissance along the river N of the camp.

Saturday, September 7 and Sunday, September 8

The complete party performs geological investigations upstream from the camp.

Monday, September 9

Another rainy interval, samples are registered and packed.

Tuesday, September 10 and Wednesday, September 11

Geological investigations by three members of the group. Supriadi arranges matters concerning the transport of rock samples and materials to Waiteba.

Thursday, September 12

Registration of samples and discussion of fieldwork results.

Friday, September 13

Transport Waiteba - Namlea in the same 40 HP boat as was used before. The group experiences this trip as a very hazardous one, especially because of the crossing of Namlea-bay, where the small boat met very high waves. Arrive in Namlea at late afternoon and joins Party A.

Saturday, September 14

At 8 a.m. arrival at Ambon from Namlea.

3.1.4 Geological observations

3.1.4.1 Party A

Hotong river section (Miocene)

Altogether about 500 m of sediments have been studied and sampled. A total of 47 samples for biostratigraphic-paleoecological investigations was taken. Unfortunately the base of the Hotong Formation could not be reached.

The exposed succession is characterized by the presence of interbedded coarser and finer grained clastics of generally dark colour. Both conglomeratic and clayey intervals occur. Calcareous deposits are subordinate. The sediments probably were deposited in open marine, moderately deep environments (upper slope), as facial aspects of both deltaic and submarine fan deposits can be recognized. Distinct turbidites showing Bouma sequences have been observed, but their proportion is limited. In general, the succession recorded might indicate a gradual upward deepening. Much of the sediment shows fracture cleavage.

Wa Duna section (? Pliocene)

This section was not reported by Tjokrosapoetro et al. (1985), but has been mentioned by Verbeek (1908), one of the early Dutch investigators of the Moluccan realm. The Duna river forms a gorge like, steep valley with up to 100 m High walls. The valley is cut into coarse conglomerates belonging to the Leko Formation. The tectonic dip of the strata is under 10° . The conglomerates, however, are arranged in bundles of coarser and finer strata, dipping up to 25° . This dip therefore is of sedimentary origin. The progradational character of these coarse clastics (boulders up to 2 m diameter), forming sets of at least 50 m high suggests deposition within a fan delta system. Observed reverse grading within these mega sets points to deposition of the coarse clastics from mass flows in a standing body of water. Therefore a submarine origin is likely for the conglomerates. Fossils have not been observed. The stratigraphical thickness of this prograding and laterally variable unit is hard to establish at Wa Duna. Channel-fill units are intercalated. Unfortunately, the contact with the underlying Hotong Formation could not be reached

Prograding fan delta systems are less common features in the sedimentary record and as such worthwhile to be mentioned. The lack, however, of fossils will make an age assignment difficult. It is therefore strongly recommended that a reexamination takes place of the fossiliferous strata recorded from the type section of this formation at Labuan Leko (Siregar, 1977) (material stored at G.R.D.C. Bandung?). A visit to this more remote section was not planned for this campaign and could not be arranged.

The tilt of the youngest Plio-Quaternary (?) is constant towards the sea. Also the morphology of the elevated fault blocks in the hinterland reflects this dip, thus witnessing recent uplift.

Boulders of bituminous shales

In addition to the previous observations we want to report the presence

of boulders of bituminous shales in the actual river bed of Wa Duna. The black boulders have a very prominent bituminous smell. The source rock should be exposed somewhere upstream. As these bituminous sediments have only been mentioned by early workers, (Verbeek, 1908, p. 574-577; the river is called "la riviere Sifou", but it is very evident from Verbeek's descriptions that kampong Wai Sifou is the Present Kampong Bara and that Wai Duna and Wai Sifou are synonyms). Verbeek reports that the bituminous boulders deserve serious attention for possible future economic geological prospects (the production of ichthyol) and quotes an interesting geochemical analysis by von John (1906). Because this analysis points to close similarities with the Austrian "Seefelder Schichten", presently known to be source rock of major hydrocarbon accumulations, detection of the source area of these boulders is strongly recommended.

3.1.4.2 Party B

Field observations :The exposures reveal mostly quartzitic phyllites/schists and occasionally marbles. Original bedding (S_0) is seen in alternation of micaceous and quartzitic layers. Synsedimentary deformation is recognized in metamorphosed slumpbreccias, Metamorphosed pebbly mudstones and intraformational conglomerates.

Schistosity (S_1) is well developed in the pelitic layers; folding gives rise to a prominent transposition cleavage (S_2). Folded folds can be observed in quartzitic layers. Kinking is seen in mica-rich phyllites. At the northernmost exposure (GF2BB7) an andalusite-bearing quartzvein is found in situ.

Due to lack of time and difficult conditions the studied profile is relatively short. Much attention is therefore given to the study of boulders and pebbles, to provide extra information.

In addition to the exposed rock-types boulders and pebbles of kyanite-bearing andalusite-quartzveins and amphibolites are found. Not once, however, gneisses, migmatites or granites.

Minerals recognizable with the hand-lens: andalusite, albite, amphiboles (actinolite, hornblende and Al-rich types), biotite, calcite, chlorite, colourless mica (i.a. probably pyrophyllite, as plumose aggregates), garnet, graphite, ilmenite/titano-hematite (metallic luster in schists), kyanite, staurolite. Moreover, the possibility of the presence of cordierite in the spots, seen in phyllitic schists, cannot be excluded. Sillimanite is not observed.

3.1.5 Preliminary results

3.1.5.1 Party A

All samples collected have been prepared for study of the microfossil assemblages. According to a first survey of the benthonic foraminifera (H. van Marle, internal report VU), the preservation of most of the microfossil material is very disappointing. Crushed foraminifera are

common, due to the observed cleavage. A quantitative study of the benthonic foraminifera, as planned, is therefore impossible. The washed residues are rich in clastic debris, chiefly grains of quartz and metamorphics. Concerning the inferred sedimentary environment: an offshore area where muddy sediment was constantly supplied from nearby debris sources, meagre biotopes must already have existed during deposition, resulting in a low number of foraminifera per unit of volume. Time and again low oxygen environments must have existed. Altogether ca. 40 species can be recognized. There are no evident faunal differences between the basal and upper parts of the Hotong Formation and a depositional depth of 500-1500 m seems likely because of the presence of forms like Planulina wuellerstorfi, Laticarinina pauperata, Siphonina bradyana, Pullenia bulloides and Oridorsalis sp. This environment is therefore deeper than interpreted by Tjokrosapoetro et al. (1985)

The planktonic foraminifera (data kindly provided by S.R. Troelstra) indicate that the entire interval has been deposited within the early Miocene. Large globular individuals of Globigerina venezuelana, Globigerina dissimilis and Globoquadrina spp., present in the lower part of the section indicate deposition within Biozones N4 - N6. Towards the top of the section members of the Praeorbulina group, e.g. Globigerinoides sicanus, Praeorbulina glomerosa and Praeorbulina transitoria are common, which together - in the absence of typical Orbulina - point to an age within Zone N8.

One sample (4-51) from the conglomerates exposed along the Duna river could demonstrate their marine character (paleodepth between 0-200 m max.), which confirms the inferred fan delta environment.

3.1.5.2 Party B

So far, the investigation of thin sections confirms the field observations. In Buru, we reached the sillimanite zone. The presence of relictic kyanite was confirmed. Kyanite crystals rimmed or cut by andalusite blasts indicate an early metamorphism at relatively high pressure followed by a stage under lower pressure. The presence of staurolite indicates that during a certain period the temperatures of metamorphism were over $\pm 510^{\circ}\text{C}$. Assuming contemporaneous growth of kyanite and staurolite, pressure during their formation must have exceeded 4 kilobar. The absence of sillimanite and anatexitic rock-types suggest that the maximum temperature of metamorphism was well below $\pm 640^{\circ}\text{C}$.

We tentatively conclude for the area of the lower Lumara-river an early metamorphism under so-called Barrovian-type conditions (intermediate pressure facies series of Miyashiro), culminating at P 4 kb and 510°C T (?) 600°C , followed by a phase of so-called Buchan-type metamorphism (= low-pressure regional metamorphism). Further retrogressive metamorphism has caused the growth of i.a. chlorite.

The occurrence of (ortho?)-gneissic pebbles at the beach of Waiteba suggests the presence of (granite) gneiss areas elsewhere in Southern Buru.

3.2 SERAM

3.2.1 Introduction

The inland of Seram enjoys the doubtful fame of being extremely hard to penetrate into. The topography is very rugged and dense rain forests cover most of the island. Despite these limiting factors some localities in southern and western Seram could be selected that appeared within relatively easy reach from the coast. The description of most of these localities are outdated (e.g. Rutten & Hotz, 1920), but additional study of aerial pictures in Ambon showed sufficient locality details.

The photogrammetric map of the East Indies, scale 1:250.000, sheet Ambon SA 52-14 (revised edition, 1965) served as a topographic base. Furthermore team B used a trajectory map of the trans Seram road (courtesy of Mr. Pitoyo, trans Seram project). Geological base maps used are:

- a) Geological map of West Seram (Valk, 1945).
- b) Preliminary geological map of the Ambon Quadrangle, Maluku (Tjokrosapoetro et al., 1983).
- c) Preliminary geological map of the Masohi quadrangle, Maluku (Tjokrosapoetro et al., 1983).

3.2.2 Sections studied and conditions in the field

3.2.2.1 Party A

The sections studied are located in the Kairatoe district (encl 11 - 16). The sediments are of Plio-Pleistocene age. The first section is located along Wai Masa, a tributary of the Tala River, which flows into Elpaputih Bay, S. Seram. It extends over about 2.5 km from the confluence with Wai Tala till a 20 m high waterfall further upstream. The covered stratigraphic interval is estimated 510 m.

Secondly, exposures along Rioeapa river were studied. The section starts at the contact between the metamorphic basement rocks and the overlying Neogene, exposed some hundreds of metres NNE of the confluence of the rivers Kwa and Rioeapa, extending downstream in the direction of kampong Sukaioati. It ends about 1 km N of the dam in Rioeapa river NE of that village.

The third section is formed by the exposures along Wai Kwa. It starts about 2.5 km NNW from the confluence with Wai Rioeapa, also at the contact between Neogene and metamorphic rocks and finishes near the confluence. This section covers an older part of the Neogene succession and is complementary to the Rioeapa section.

The Masa river is reasonably well accessible, although the forest is very dense. Access to the Kwa-Rioeapa appeared more difficult. The rivers discharge lots of water, especially after rainy days, such as endured when working there. Working under these conditions was extremely heavy. Transport from Ambon to Seram and along the coast of Seram has been without problems. A good road exists from Kairatoe to the dam in Rioeapa river, near the village of Sukaioati. Eight local inhabitants were

employed for assistance in the field.

3.2.2.2 Party B

The investigations took place in W Seram in the Kaibobo-Piru area (encl. 17). Coastal outcrops were studied as well as some inland localities. One of the team members did some additional work near Kawa River in NW Seram. In Central Seram (encl. 18), the party studied a section along the trans-Seram road under construction. This is a roughly 15 km long transect, located NE of Elpaputih Bay.

In general, weather conditions were good, but one afternoon was lost due to heavy rainfall. In W. Seram a boat was used to visit the coastal exposures. Most of these outcrops had to be visited at low tide; they are restricted to the tips of capes, while beaches along the bays give no exposures at all. Many exposures, especially of schists, turned out to be badly altered.

For the work along the trans-Seram road two motorcycles from local owners were used. The road is in a very bad condition. Intensive tropical weathering prevented easy sampling.

3.2.3 Progress in the field

3.2.3.1 Party A

Monday, September 16

From Ambon to Seram. First Ambon - Telehu by bemo; Telehu - Almahai by ferryboat. Visit to police station. Masa River, however, appears to belong to the Kecamatan of Kairatoe. Almahai - Wasia by motorboat; Wasia - Tala by tractor. Stay for the next days at balai dessa of Tala.

Tuesday, September 17

Reconnaissance of Masa River. Study of first part of Masa River section. Very long working day.

Wednesday, September 18

Study of second part of Masa River section.

Thursday, September 19

Tala - Kairatoe partly by motorboat and, because of engine trouble, partly by a passing ferry. Visit to Camat of Kairatoe. Stay at mess of Kairatoe.

Friday, September 20

Kairatoe - Soekaioti by bemo. Visit to Kepala Kampong. Campsite near the dam in Rioeapa River. The group is brought there by armed official.

Saturday, September 21

Reconnaissance of Rioeapa River till confluence with Kwa River. Study of first part of Rioeapa River section. Campsite near confluence of the two rivers.

Sunday, September 22

Reconnaissance and study of Kwa River section.

Monday, September 23

Study of second part of Rioeapa River section. Very hard and long working day. Campsite near the dam in Rioeapa River.

Tuesday, September 24

Sukaioati - Kairatoe by truck; Kairatoe - Waai by ferryboat; Waai - Ambon by bemo.

3.2.3.2 Party B

Monday, September 16

Departure from Ambon and arrival at Kairatu at 6 p.m.; visit to Camat. Here it appears that Kaibobo is resorting under the Kecamatan of Piru.

Tuesday, September 17

By longboat to Kaibobo. Kepala desa offers hospitality in his house and also puts a local perahu with 8 HP engine at our disposal. Incidental visit to the exposures of Triassic limestone around the village. Afternoon lost due to heavy rainfall.

Wednesday, September 18

Reconnaissance of coast north of Kaibobo and visit to the exposures of mica schists and greenschist at cape Tutunaten. A walk southward through the mangrove, to find additional exposures turns out to be unfruitful and depressing. Supriadi visits the Kecamatan office in Piru.

Thursday, September 19

Visit to the capes of Murua, Tapan and Sisi to study exposures of ultramafics.

Friday, September 20

March from Kaibobo inlandward through terrane with cordierite granites (which are not exposed along the coast). Descend to the coast alongside Wai Latira where weathered micaschist and micaquartzite are exposed on the riverbanks. After making preparations for spending the night provisionally in a cabin, the group is finally picked-up at 8 a.m. by delayed longboat.

Saturday, September 21

Visit to capes of Terua and Pamali for a study of micaschist and greenschist and their deformation.

Sunday, September 22

By 8 HP longboat to wood factory at Waisarisa and from there with 150 HP speedboat to Ambon.

Monday, September 23 and Tuesday, September 24

Ambon, preparations for trip to Central Seram. Supriadi returns to Bandung.

Wednesday, September 25

Transport Ambon-Central Seram. 11.30 a.m. arrival at Amahai, visit to the police for registration. Register in hotel in Masohi. In the evening visit Mr. Pitoyo of the Proyek Pembangunan Jalan Amahai-Soleman (trans Seram road project). Mr. Pitoyo gives us invaluable information about the condition of the Trans Seram road, he suggests us to use light-weight motor bikes; he offers us lodging in his basecamp I at 17 km of the road and also arranges our transport to that site. We are greatly indebted to Mr. Pitoyo for his help and hospitality. Arrange motorbikes.

Thursday, September 26

Transport by car to the collapsed bridge over the Wai Ruatan, which river was crossed on foot as well as the Wai Nua and the 1 km track in between. Further transport to the Teon-Nila-Serua transmigration project by truck. Visits to the military and police posts and to the camat. 4 p.m. arrival at basecamp, km 17 of Trans Seram.

Friday, September 27, Saturday, September 28 and Sunday, September 29

Fieldwork along Trans Seram using motor bikes as far as km 37.5, from there on foot to the end of the track at ca. km 40. Here, the fault is reached that borders the metamorphic rocks to the north (just N of "point a" indicated on the map by Germeraad, 1946).

Monday, September 30

Visit to camat of TNS and transport back to Masohi in the already described complicated way. In the evening courtesy visit to Mr. Pitoyo.

Tuesday, October 1

Journey from Seram to Ambon, arrival at noon.

Wednesday, October 2

Packing of rock samples and arrangement of transport to Jakarta. Courtesy visits. Excursion to serpentinite-granite contacts in SW Ambon under heavy rains.

Thursday, October 3

Take rest.

Friday, October 4 - Monday, October 7

Journey back to Bandung, with stop over in Jogjakarta, to spend the weekend.

Tuesday, October 8

Visit Soebardjio Tjokrosapoetro and deliver the field report of team B. Give all information necessary for clearance letter regarding export of the samples. E. Surya Nila, who is carrying out additional fieldwork N of Piru, will arrange shipment of the samples to Jakarta. Courtesy visits. Enjoy the pleasant evening visit to the Sopaheluwakan family.

Wednesday, October 9

By train to Jakarta.

Thursday, October 10

Flight GA 834 to Amsterdam.

3.2.4 Geological observations

3.2.4.1 Party A

Masa River section (encl. 13)

The Neogene deposits are unconformably situated on a basement of metamorphic rocks and are unconformably covered, near the coast, by Quaternary alluvial sediments. The river outcrops are mainly of reasonable - good quality, but sometimes are covered by travertine, which obscures rock texture and small-scale sedimentary structures.

The exposed succession is hardly disturbed. Beds show some large open folds along the section, but are mainly dipping E-SE at an angle of 10-40 degrees. At two places along the section, the metamorphic basement crops out in a stratigraphic position below the Neogene. This situation is interpreted as caused by the presence of a paleorelief of the basement, since there are no indications for larger faults.

The lithology is rather monotonous. The sediments consist of laminated and cm-thick, parallel bedded siltstones, clayey siltstones and marls. The basal contact with the metamorphic basement is marked by a sedimentary breccia. The middle part of the succession contains a few intercalations of medium - coarse, poorly sorted sandstones with bioclastics, lacking obvious sedimentary structures. The top part contains a 10 m thick, laterally thinning unit of poorly sorted sandstones and conglomerates, showing channel structures and cross-bedding on various scales.

A low energy, upper bathyal environment is concluded, with a limited influx of gravitational deposits. We didn't observe important changes of environment during deposition of these strata. The remarkably well preserved lamination, almost throughout the whole section, indicates restricted bioactivity at the seafloor. The sedimentary basin probably had a rather isolated position, outside the main routes of sediment transportation and with restricted environmental conditions.

N.B.: In the Masa River area, geometric relations of the Neogene deposits with underlying and surrounding metamorphic rocks support the idea that the Neogene was deposited here in a submarine basin of small size, over a paleorelief of metamorphics.

Rioeapa- and Kwa River sections (encl. 15,16)

Plio-Pleistocene deposits are unconformably overlying a basement of metamorphic rocks and unconformably underly Quaternary alluvial sediments. The sediments are not continuously exposed along the rivers, but since the dip of the strata is moderate and the exposures often form high walls, a rather complete stratigraphic column could be composed. A crust of travertine locally prevented detailed lithological observations. The stratigraphical interval covered measures about 700 m.

The Neogene is hardly disturbed. Beds almost continuously dip to the S at an angle of 5 to 15 degrees. Relatively small, open folds occur at a few places. Like at the Masa River, the contact with underlying metamorphics

suggests that the Neogene covers a paleorelief.

The bulk of the sediments consists of parallel bedded marls with varying amounts of silts and sands. Shell fragments and plant remains occur throughout the deposits, although hardly ever in large amounts. In between the marls, 3 larger (up to 70 m thick) and several smaller units of poorly sorted sandstones and conglomerates are present, showing channel structures and many bundles of laterally thinning beds. Scouring occurs frequent. Distinct turbidites are rare. Transport occurred probably as massflows. Rapid lateral facies changes and geometric features of the coarse clastic units suggest that they have limited lateral extension.

We conclude an outer neritic to upper bathyal, low energy environment, with presence of local feeding channels of a submarine fan system. This sedimentary fan must have existed outside the studied area. In comparison with the Masa River section, the environment has been more open here.

3.2.4.2 Party B

West Seram

In the so-called Kaibobo complex as exposed in the Peninsula of that name at least five units are recognized.

- A. Complex of deformed and severely serpentized plagioclase-bearing peridotite with bodies of leucogabbro. Veins of very coarse-grained hornblende-diorite and of even grained biotite-granite are seen to cut the deformed and serpentized ultramafics.
- B. Intrusive dike-like body of fine-to medium grained cordierite granite with a roof of biotite-bearing aplitic to granophyric granite. Numerous inclusions in the cm-scale of quartzite and schist are found. The elongated fragments tend to stretch sub-parallel to the gneissic structure of the cordierite granite. We note this as a typical feature of the rock-unit. Its outcropping area (N-S) is discordant to the observed layering (NE-SW) in the ultramafics.
- C. (Garnet-) micaschist and green(ish) schist with augen of albite and epidote feasibly represent low to medium grade metamorphic products of partly volcanoclastic sediments. Three phases of deformation are recognized. Regular changes in the vergence of minor folds indicate the presence of large scale folds as well. High metamorphic minerals as described by Valk (1945) sillimanite, staurolite and cordierite are not observed. Chlorite, biotite, garnet and gray-green amphibole are recognized.
- D. Amphibolites in the strict sense are found only as loose blocks, just W of the mouth of the Wai Latira.
- E. Mainly calcareous sediments of reported Late Triassic age, exposed around and south of the village Kaibobo. These however, are not studied.

Central Seram

Between km 17.5 and km 40 of the Trans Seram road 41 exposures were studied and sampled. The rocks are mostly micaschist alternating with (mica) quartzite. From km 37 to the North, intercalations of amphibolite occur; the thickness of the amphibolite layers varies from cm scale to some 20 meters. As a rule the amphibolite layers, as well as their internal foliation indicated by feldspar streaks, are concordant with the S_0 of the metasediment. Only once a discordant relation is observed.

Coarse grained schist with cm-large garnets is found in the northern part of the section; medium- and fine-grained schist prevails in the South. Phyllonitic rock associated with northerly directed thrust movements are observed near km 39. No indications of a tectonical discordance in the rest of the section are observed. Three phases of deformation are recognized; a northern vergence prevails in the dominating F3 folds. Occasional but regular occurrence of S-vergence indicates the presence of large scale folds. The style of deformation is the same throughout the section. Metamorphic minerals observed are: amphibole (also in some schist), biotite, garnet and probably chloritoid.

From the riverfloat near km 17 a collection of apparently non-weathered pebbles is made for possible age determination on biotite.

3.2.5 Preliminary results

3.2.5.1 Party A

The sections studied together appear to cover most of the Pliocene and part of the Pleistocene. According to H. v. Marle (internal report VU) the benthonic foraminiferal associations indicate deposition in upper-middle bathyal depths. Probably depths did not exceed 600 m. As concluded from the frequent presence of shallow water species together with distinct deeper water forms, a constant reworking of sediment deposited in shallower environments must have taken place. No distinct faunal trends indicating shallowing or deepening have been observed in the sections, which suggests a balance between subsidence of the basin margin and its infilling. This pattern differs from that observed in the central Timor basin. The assemblages more resemble those studied from Buton (GF1) than from Timor (GF1).

3.2.5.2 Party B

West Seram

As the cordierite granite body is discordant with structures recognized in both the schistose metamorphics and the ultramafics, this granite is likely to be the youngest unit. Carbonate-rich inclusions in the plagioclase-bearing peridotite could be used to argue the ultramafics to be younger than the U. Triassic limestone. On the other hand these inclusions can be interpreted as low T rodingites; thus they give no clue to the relative age of the ultramafics.

Tectonic contacts being obliterated - at least not exposed - the following chronological succession of geological events cannot be more than very tentative:

1. deposition of volcanoclastic series;
2. metamorphism and deformations;
3. deposition of Triassic sediments;
4. emplacement of ultramafics;
5. genesis of the hybride cordierite-granite (related to 4?) and its intrusion.

Due to lack of macroscopic critical minerals a metamorphic history for the schists and greenschists cannot yet be evaluated.

A comparison between the Kaibobo complex and the Atapupu complex of northern Timor (also composed of serpentized ultramafics and metamorphic sediments and amphibolites) has been made (Audley-Charles et al., 1979).

In our opinion the following data will have to be given serious consideration in any further discussion of this "mirror-image" hypothesis concerning the geotectonic relation between southern Seram/Ambon and northern Timor.

- a. The Atapupu complex comprises also strongly serpentized peridotites but these do not contain plagioclase; moreover, leucogabbroic rocks are not found there.
- b. Cordierite-granite is not found in Atapupu.
- c. The Atapupu amphibolites (several tens of metres thick) have only scarce equivalents in Kaibobo.
- d. Counterparts of the "eclogites" and high-grade metamorphosed sediments are not found in the Kaibobo peninsula.
- e. The metamorphic (volcanoclastic) sediments are of low grade and have no direct counterpart in the Atapupu complex.
- f. A very characteristic positive correlation can be made by the occurrence in both complexes of the ubiquitous hornblende dioritic dikes and veins cutting the ultramafics. These may at least be used to set minimum ages to the emplacement of both complexes.

N.B. The subsequent investigations proved that field observations a and d are no longer valid.

Central Seram

Staurolite has been observed after study of thin sections from garnet mica schists. Metamorphism of the rocks exposed along the Trans Seram Road seems to be of the Barrovian type grading up to almandine amphibolite facies in northerly direction. The seemingly gradual increase in metamorphic intensity, the uniformity in style of deformation throughout the section as well as the absence of positive indications for tectonic discordancy in the middle parts of the section lead us to

question the presence of a thrustzone in that central part as suggested by Audley-Charles et al. (1979). If there is any discordancy it can only be older than the metamorphism and accompanying deformations.

In the literature the metamorphic rocks of Seram are grouped into three informal rock-units:

- a. the Kobipoto complex (not yet studied by us but reported to comprise high-grade metamorphics and migmatites);
- b. the Kaibobo complex, in which non-metamorphic intrusives are comprised as well.
- c. the Tehoru metamorphics, of "Paleozoic" age (intercalated limestone contains rests of Paleozoic crinoids).

In all three complexes the metamorphites are of rather uniform composition; in vast majority they are of (semi) pelitic to arenitic origin, only locally interrupted by intercalations of metabasic rocks.

The metamorphics of Seram have thus been divided and grouped into three different units on the basis of supposed differences in metamorphic grade (Kobipoto complex, high-grade); on the local association with non-metamorphosed intrusives (Kaibobo complex) and on the presumed existence of a tectonic discordancy (separating the supposed lower-grade Tehoru formation from the Kaibobo complex).

In our opinion the above division (proposed by Audley-Charles et al., 1979) is premature. Only after unraveling the tectonic and metamorphic history and the dating of the major events a serious proposal for a grouping of the metamorphics of Seram can be made. In the present state of knowledge the metamorphic rock-units that can be established are better described into detail and given each their own informal name.

Some remarks concerning general aspects of metamorphism in the Banda arc
The metamorphic rocks of SE Sulawesi cannot be compared with other metamorphic rocks of the arc. Peridotites with accompanying rocks formed at Atapupu, N Timor appear to be very similar to those formed at Kaibobo, W Seram (and Ambon). The metamorphic rocks on central Timor and on Buru and Seram show mutual differences in tectonic position, age of metamorphism and rock-type in general.

3.3 KAI

3.3.1 Introduction

The Kai islands were only visited by Party A. But limited exposures of the Late Neogene have been reported (Heim, 1939). Nevertheless investigations in Kai were considered necessary in order to obtain additional data concerning the study of vertical movements in the eastern segment of the Banda arc. Within the tight time schedule a visit to the larger and more difficultly accessible island of Tanimbar, where larger outcrops exist, was considered too complicated. Moreover, study of the Kai islands very well supports Cruise G3 (Aru trough). In addition to the Neogene studies our associate scientist A.J. Barber (London) independently gathered structural geological data. As a topographic base map sheet Kai SB 53-5 of the photogrammetric map of the East Indies was used. The geological base map is the preliminary geological map of the Kai Quadrangle (Achdan & Turkandi, 1982).

3.3.2 Sections studied and conditions in the field

According to the preliminary geological map of Kai islands (Achdan & Turkandi, 1982) Plio-Pleistocene rocks at Kai Kecil would crop out at two places: In the north of the island near Gelanit and in the south near Ohoinol. Both places were visited but, except for some very small exposures, they were completely covered by vegetation. At Kai Besar Eocene rocks are reasonably well exposed along the coast. Miocene rocks, however, are not competent and poorly exposed. Only some spot samples could be gathered at places S of Elat and along the coast near Larat, SW Kai Besar.

Transportation forms a serious problem at Kai Besar. On land everything has to be done on foot, while reaching the coastline from the seaside is hampered by wide reefs and rough sea. The East coast could not be reached because of rough weather.

3.3.3 Progress of fieldwork

Sunday, September 29

From Ambon to Kai (Langur) by small airplane (Merpati Airways). Stay for the next days at hotel Rozemgen in Tual.

Monday, September 30

Visits to Bupatih office and Police office at Tual and Camat office at Langur. Reconnaissance of northern part of Kai Kecil. Spot sampling of Plio-Pleistocene outcrop just N of Gelanit, about 8 km NW of Langur.

Tuesday, October 1

Reconnaissance of southern part of Kai Kecil. Spot sampling of Plio-Pleistocene outcrops in the neighbourhood of Ohoinol, 25 km S of Langur.

Wednesday, October 2

Tual - Elat by ferryboat. Visit to Camat office and Police office at Elat. Stay for the next days at Camat house. Reconnaissance of exposures around Elat.

Thursday, October 3

Reconnaissance by motorboat of SW coast of Kai Besar. Spot sampling of Oligo-Miocene near Larat. Serious problems in trying to reach the coast.

Friday, October 4

Reconnaissance and spot sampling of Miocene SW of Elat. Study and sampling of Eocene deposits along the coast S of Elat.

Saturday, October 5

Elat - Tual by ferryboat.

Sunday, October 6 till Thursday, October 10

Delayed return journey because of engine problems of the plane, a subsequent waiting list, and money problems of Merpati Airlines personnel. One of the team members returns to Ambon on October 7, the others cannot follow before October 10.

3.3.4 Geological observations (encl.19)

Kai Kecil

General situation: The whole island is formed by 4 to 5 reef terraces which still retain their original horizontal position. Their maximum elevation does not exceed some tens of metres above sealevel. Only at a few places the Plio?-Pleistocene nucleus of the island crops out. The size of the exposures turned out to be only a few square metres. The geological map of Achdan and Turkandi (1982) seems mainly based on air photographic studies. Topographic and vegetational features reveal the pattern shown on this geological map.

Because of the very limited exposure the stratigraphic interval covered does not exceed a few metres. The sediment, consisting of bioclastic calcarenites and marls, is fairly weathered. The quality of the samples (8) is therefore poor. The lithology indicates a marine, low energy environment. According to the geological map the outcrops of the Plio-Pleistocene basement are anticlinal nuclei. Our field observations support this interpretation. No indications for intensive deformation of the Plio-Pleistocene have been observed. The overlying reefs have an undisturbed subhorizontal position.

Kai Besar

The geology of Kai Besar contrasts strongly to that of Kai Kecil. Kai Besar is a narrow mountain range, reaching up to 800 m above sealevel. Although the present coral reefs around the island are very large, the island seems to have no elevated reefs, except for one, which occurs near the village of Larat and emerged some metres above sealevel. Plio-Pleistocene deposits are almost absent and have not been sampled. Instead, outcrops of the Oligo-Miocene and Eocene have been studied and sampled.

The stratigraphic thickness covered is unknown as far as the Oligo-Miocene is concerned. For the Eocene a 40 m thick sequence could be studied. Altogether 20 samples were collected.

Kai Besar forms a sliver of a large, open anticlinorium with Eocene rocks in the centre. The axis of this anticlinorium is oblique to the axis of the island. Many small open folds on a 100 m scale are visible in exposures along the coastline. The overall picture is that the island has a coherent structure and lacks intensive deformation.

The Eocene consists of laminated calcilutites and fine-grained, burrowed calcarenites. The Oligo-Miocene seems to consist of calcarenites and marls, locally containing silica concretions. In both cases an open marine low energy environment (outer neritic - bathyal) can be concluded.

Remark

The contrasting structural characteristics of Kai Kecil and Kai Besar give reason to assume a very different history of vertical movements of the two islands at least from the Pliocene onwards.

3.3.5 Preliminary results

Our collected data are insufficient for a detailed reconstruction of the vertical movements of the Kai islands. The overall geological reconnaissance, however, is valuable to correlate with seismic reflection profiles from the surrounding offshore areas (see also results by Dr. Barber below).

The benthonic foraminiferal associations from the samples of Kai Kecil, as reported by van Marle (internal report VU) are reasonably well preserved and indicate deposition in upper-lower bathyal environments 500-2000 m. Reworking of faunal elements from shallower environments is evident in some of the samples.

Results obtained by Associate Scientist Dr. Barber

Dr. Barber participated as an associate scientist with cruise G3 and the GF2 campaign in Kai. His participation was supported financially by a Consortium of oil companies. It had been intended that Dr. Barber should visit the Kai islands together with Party A, especially to visit several mud volcanos and to study tectonic features. Owing to delays in obtaining a research permit, security clearance and a flight, he arrived in Ambon when Party B was on its return. Useful geological and logistic information could, however, be exchanged. Here, the conclusions presented in Dr. Barber's report are quoted (A.J. Barber, 1985 - Preliminary report on an expedition to the Kai islands, eastern Indonesia, 8-22 October 1985. Geol. Res. in SE Asia, report no. 39, univ. of London, 12 p.):

1. From regional tectonic considerations the Kai islands lie in a major sinistral transcurrent fault zone at the eastern margin of the NNE-ward moving Australian Continental Plate, and the western margin of the Banda Sea Plate.

2. The Aru Trough, to the east of Kai, is a transtensional, pull-apart basin formed where the eastern margin of the Australian Plate has been extended, thinned and subsided. Seismic reflection profiles show that fault movements related to this process are still in progress at the present time.

3. Kai Besar lies on a ridge forming the western margin of the Aru Trough. This ridge was uplifted during the Plio-Pleistocene, but is currently undergoing subsidence. Faults exposed on Kai Besar show evidence of recent movement and some of them are sinistral wrench faults.

4. Kai Kecil and the region to the west including Tayandu Islands, Kur and Fadol, as far as the eastern slope of the Weber Deep, consists of deformed continental basement with a Mesozoic to Tertiary core, derived from the eastern margin of the Australian continent. This area is currently undergoing compression with overthrusting, as indicated by active mud volcanism, and is being uplifted. Compression and uplift are probably taking place in a transpressional tectonic environment.

5. The boundary between the transtensional regime in the Aru Trough, which is part of the Australian Plate, and the transpressional regime in the Outer Arc Ridge, which is part of the Banda Sea Plate, lies in the strait between Kai Besar and Kai Kecil. Convergence is taking place along this boundary which is probably an overthrust, in which Kai Kecil is being thrust over Kai Besar. This overthrusting is responsible for the current uplift of Kai Kecil and the subsidence of Kai Besar.

6. The Weber Deep is a further zone of transtension, which has resulted in massive recent subsidence due to the thinning of the crust to oceanic thickness.

4. Training and education

Various Indonesian geologists did/do visit the Free University for training and education concerning campaigns GF1/2.

Ir. Enom Surya Nila is visiting VU for training from April 1986 to October 1986. At present he is doing mineralogical analysis with the electron microscope and will soon continue with a study on fluid inclusions.

Ir. Jan Sopaheluwakan will be in Holland for three years to prepare a Ph D thesis focussed on the Timorese rocks. At present he follows the same programme as E.S.N. to establish metamorphic conditions in that area.

Ir. Sapri Hadiwasastra is studying nannofloras from Timor and Buton as part of his training programme (April-September 1986).

Drs. Mimin Karmini studied planktonic foraminifera from Timor as part of her trainingsperiod in Amsterdam.

Priantono Astiario MSc will visit VU in late 1986 to take part in research concerning Seram and uplifted coral reefs.

Soebardjio Tjokrosoetro MSc (coördinator of GF campaigns) will visit the Free University in late 1986 a.o. to take part in GF1-2 research.

5. References

- Achdan, A. and Turkandi, T. (1982): Provisional geological map of Kai Quadrangle, Maluku. Geol. Res. and Dev. Centre, Bandung.
- Audley - Charles, M.G. et al. (1979): Reinterpretation of the geology of Seram: implications for the Banda Arc and northern Australia. J. Geol. Soc. London, 136; 547-568.
- Bemmelen, R.W. van (1949): The geology of Indonesia. Government Printing Office, The Hague.
- Chao-Shing, L. and McCabe, R. (1986): The Banda - Celebes - Sulu basin; a trapped piece of Cretaceous-Eocene oceanic crust? Nature 322; 51-84.
- Germeraad (1946): Geological map; from Ph. D. thesis on the geology of Central Ceram, Univ. of Utrecht.
- Hamilton, W.H. (1979): Tectonics of the Indonesian region. U.S.G.S. Prof. Paper 1078, 345 p.
- Hartono, H.M.S. and Tjokrosoepetro, S. (1984): Preliminary account and reconstruction of Indonesian Terranes. Proc. Indon. Petr. Ass. 13th Annual Convention, May 1984, 185-226.
- Heim, A. (1939): Geological reconnaissance report on the Tanimbar, Kai and Aroe islands. Unpublished report, Library GRDC, Bandung.
- John, C. von, (1906): Ueber die chemische Beschaffenheit der Asphaltschiefer der Bara-Bai (Buru). N. Jahrb.f.Min., Beilageband XXII, 686-691.
- Jong, H. de (1923): Studien über eruptiv und mischgesteine des Kaibobogebietes. In: (Rutten & Holz, ed.) Geological, Petrological and Paleontological results from Ceram.
- Rutten, L. and Hotz, W. (1920): De geologische expeditie naar Ceram, tiende verslag. Tijdschrift van het Koninklijk Nederlands Aardrijkskundig Genootschap; 2e ser. dl XXXVII, 1920.
- Tjokrosoepetro, S., Budhitrisna, T. and Rusmana, E. (1985): Report on the geology of Buru quadrangle, Maluku. Unp. Report. Geol. Res. Dev. Centre, Bandung.
- Tjokrosoepetro, S. and Budhitrisna, T., (1982): Geology and tectonics of the northern Banda arc. Bull. Geol. Res. Dev. Centre, Bandung, 6; 1 - 17.
- Valk, W. (1945): Contributions to the geology of West Seram. Thesis University of Utrecht.

- Verbeek, R.D.M., (1908): Rapport sur les Moluques. Jaarb. Mijnw. in Ned. Oost Indië, T XXXVII, 844 p.
- Zillman, N.J. and Paten, R.J. (1975): Exploration and Petroleum Prospects of Bula Basin, Seram Indonesia; Proc.Indon.Petr.Ass. 4th Annual Convention, June 1975; 129-148.

6. Enclosures

SNELLIUS-II EXPEDITION
CAMPAIGN GF2
List of participants

BURU

Party A

Party B

Free University, Amsterdam:

Dr. A.R. Fortuin
Dr. M.E.M. de Smet
Drs. L.J. van Marle

Free University, Amsterdam:

Drs. H. Helmers
Drs. K. Linthout

Marine Geological Institute Bandung:

Mr. Priantono Astiario MSc.
Ir. Achmad Masduki
Mr. Basuki Sugiharto

Marine Geological Institute Bandung:

Ir. Enom Surya Nila
Mr. Supriadi

LGPN-LIPI, Bandung:

Drs. M. Safei Siregar
Mr. Agus

SERAM

Party A

Party B

Free University, Amsterdam:

Dr. M.E.M. de Smet
Drs. L.J. van Marle

Free University, Amsterdam:

Drs. H. Helmers
Drs. K. Linthout

Marine Geological Institute Bandung:

Mr. Priantono Astiario MSc
Ir. Achmad Masduki
Mr. Basuki Sugiharto

Marine Geological Institute Bandung:

Ir. Enom Surya Nila
Mr. Supriadi

LGPN-LIPI, Bandung
Drs. Jan Sopaheluwakan

KAI

Party A

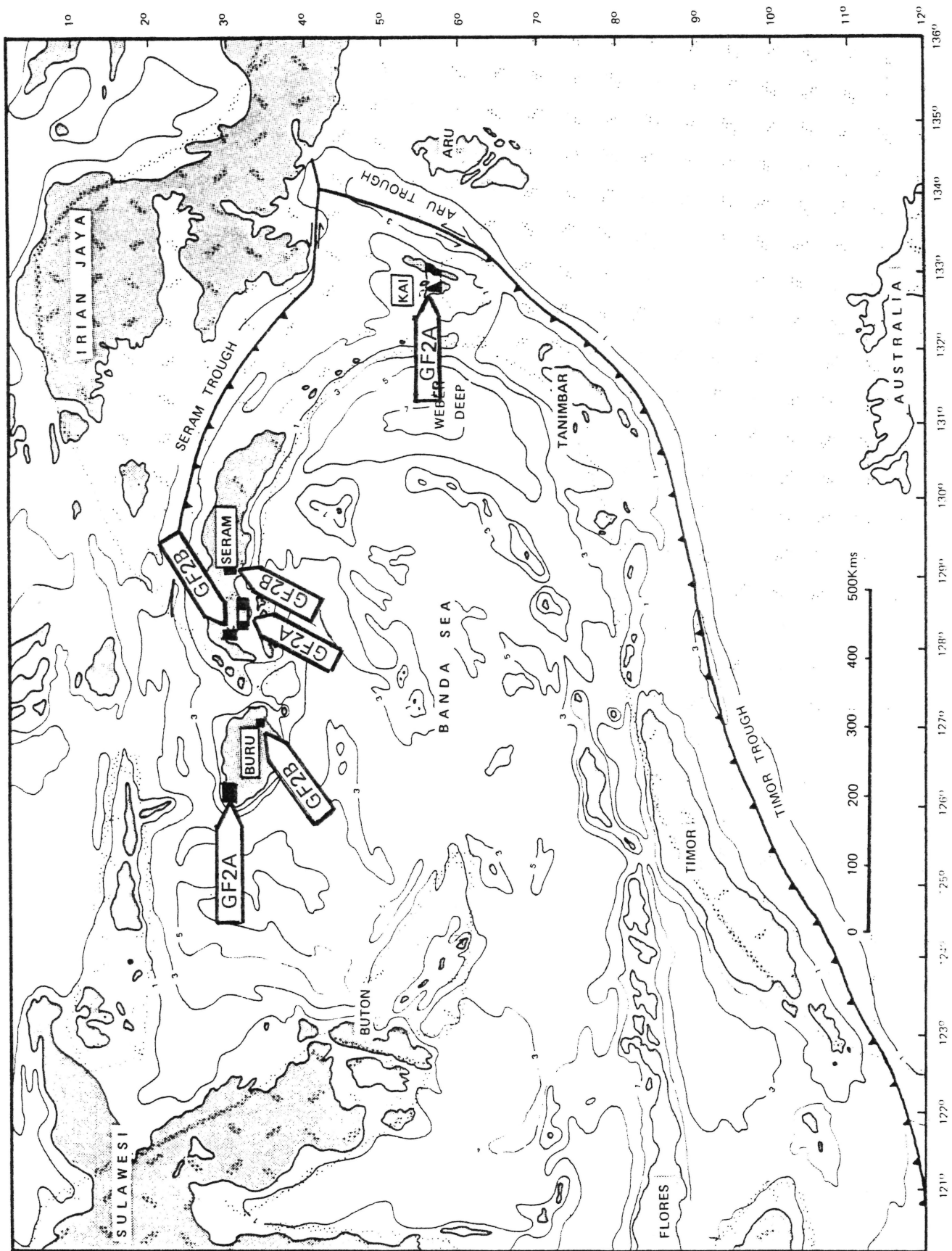
Free University, Amsterdam:

Dr. M.E.M. de Smet
Drs. L.J. van Marle

Marine Geological Institute Bandung:

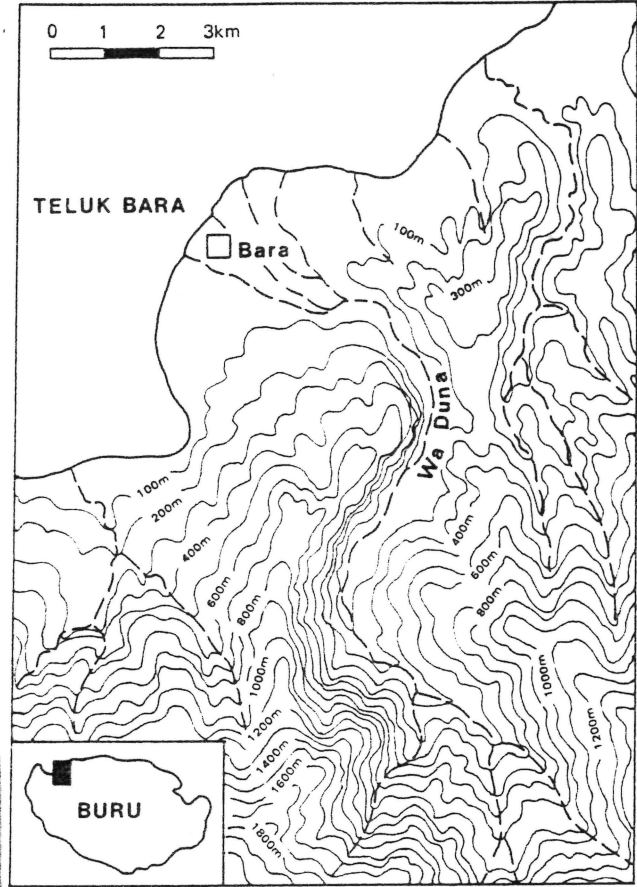
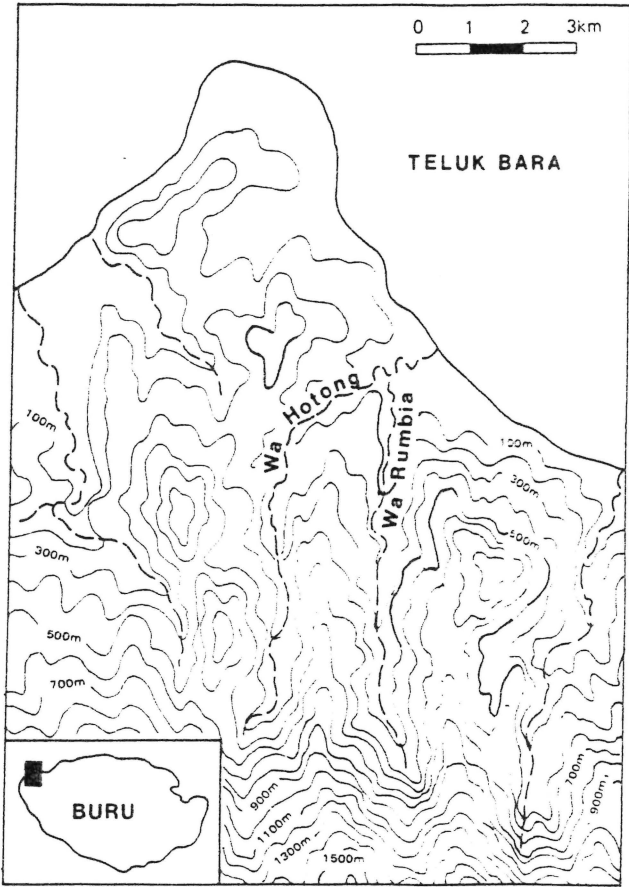
Mr. Priantono Astiario
Mr. Basuki Sugiharto

Enclosure 1

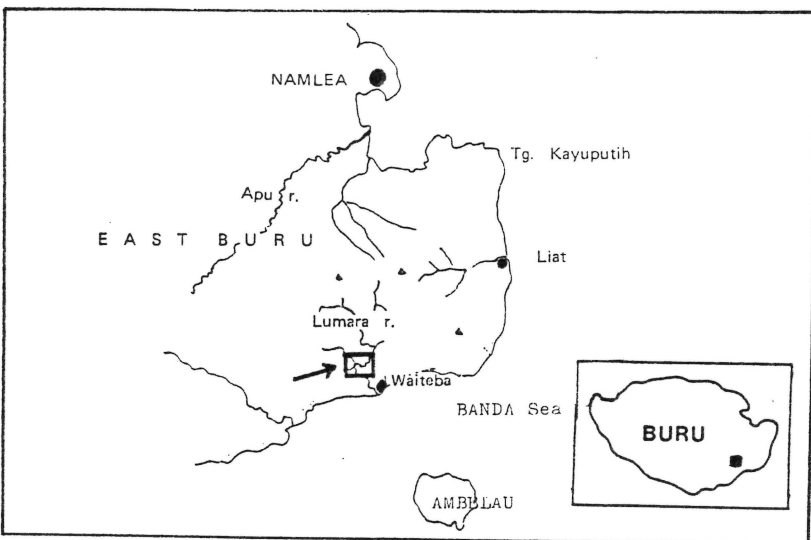


GF2 Campaign Map

Enclosure 2












GF2A locations in NW Buru



GF2B Locations in SE Buru

LEGEND FOR THE STRATIGRAPHIC
COLUMNS OF TEAM GF2A

(compiled by M.E.M. de Smet)

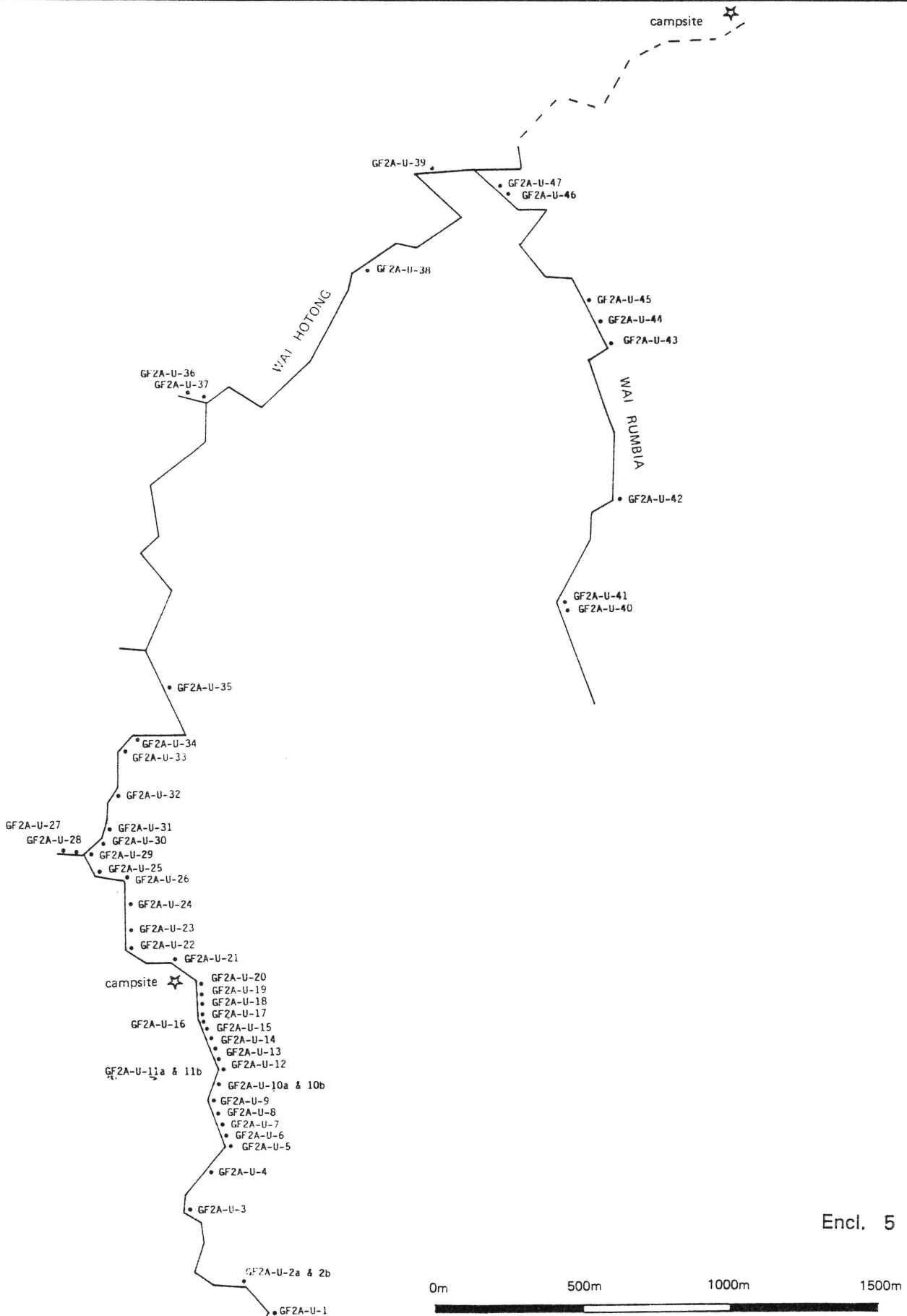
	Clay	⊥	Turbidite
	Marl	≡	Parallel lamination
	Silty/sandy marl	⋈	Cross bedding
	Calcilutites	∞	Convolute lamination
	Marly calcilutites	∩	Slumping
	Calcarenites	∪	Load casting
	Coarse-fine sandstones	∩	Scoar-and-fill structures
	Conglomerates	∪	Channels
	Tuff	∩	Laterally changing thicknesses
		∩	Bivalves (- fragments)
		∩	Gastropods (- fragments)
		∩	Scaphopods (- fragments)
		∩	Plant remains
		∩	Coral (- fragments)
		∩	Bioturbation

Enclosure 4

LIPI
Theme: GF2A Expedition: Buru
Completed by M.E.M.de Smet

INDONESIAN-DUTCH SNELLIUS II EXPEDITION
Area: Bara Bay Sections: Hotong and Rumbia Rivers

NRZ
Date: 03-07 Sept. 1985
Fig: Hotong and Rumbia, general situation and sampling sites



Theme: GF2A Expedition: Buru
 Completed by H.E.M.de Smet

INDONESIAN-DUTCH SNELLIUS II EXPEDITION

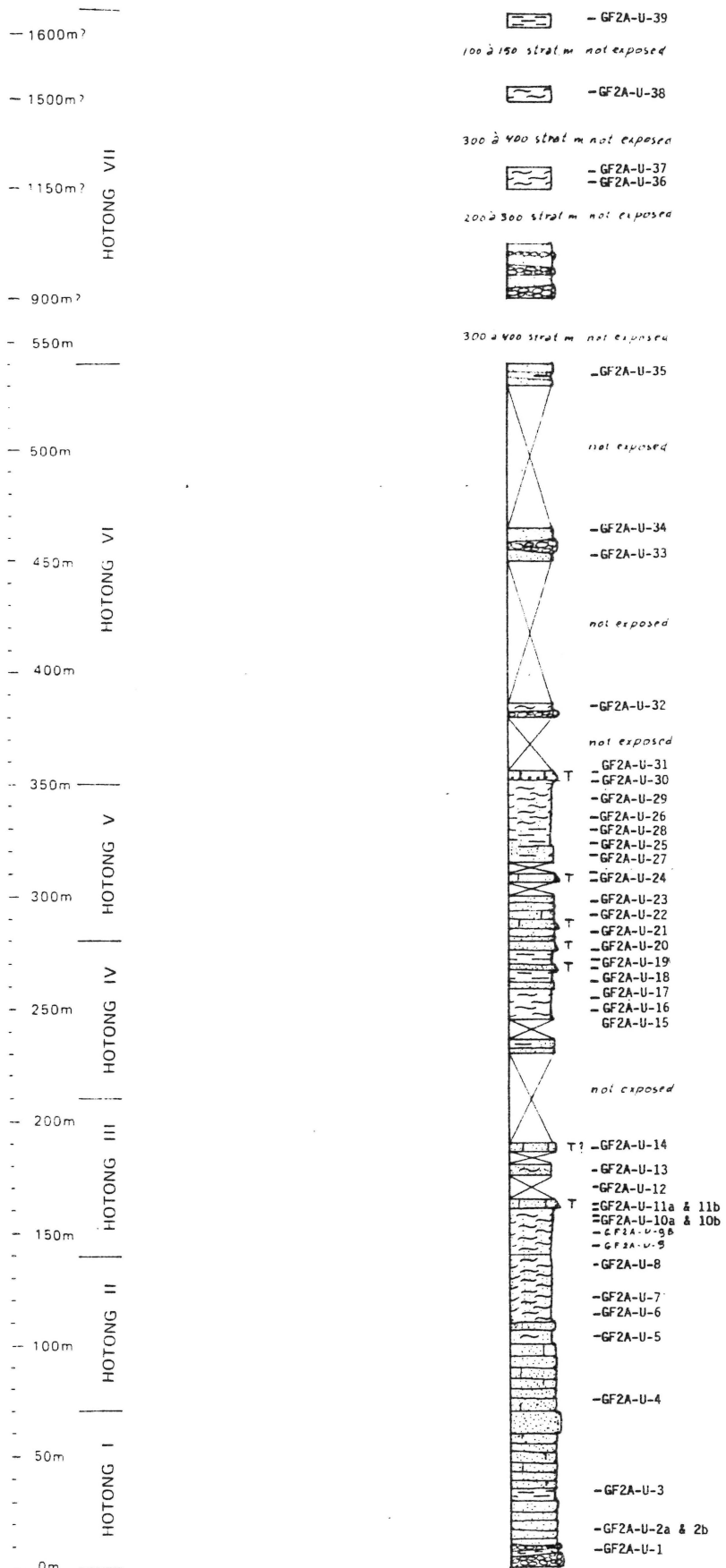
Area: Bara Bay

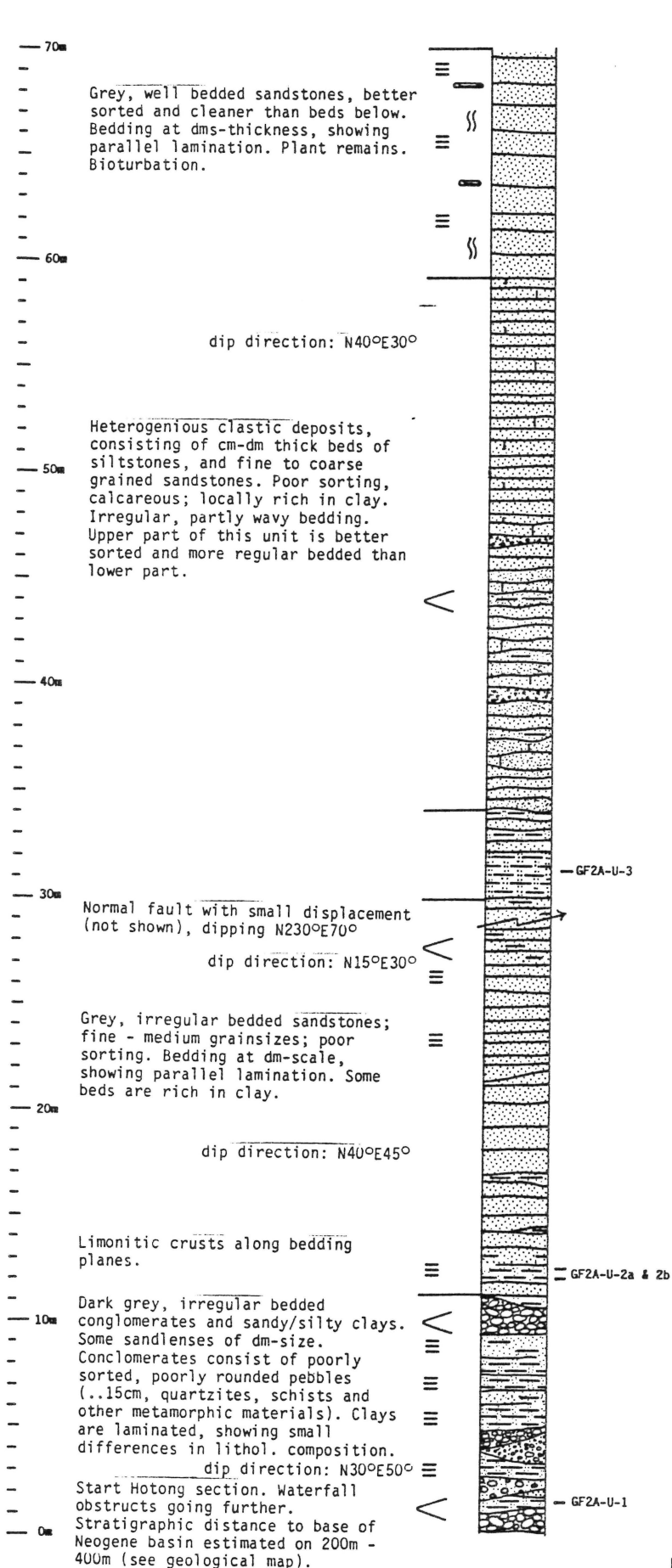
Section: Hotong River

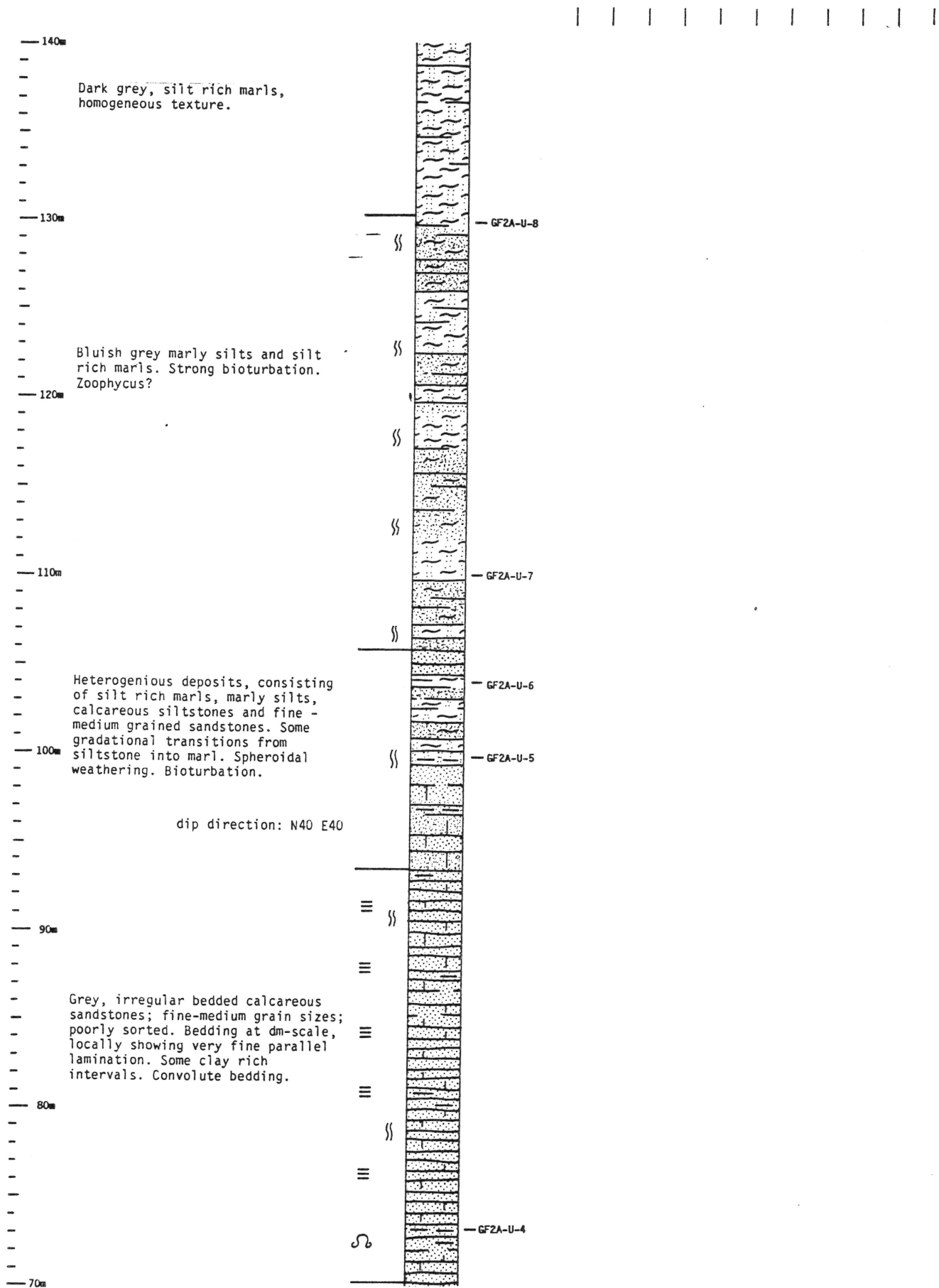
NRZ

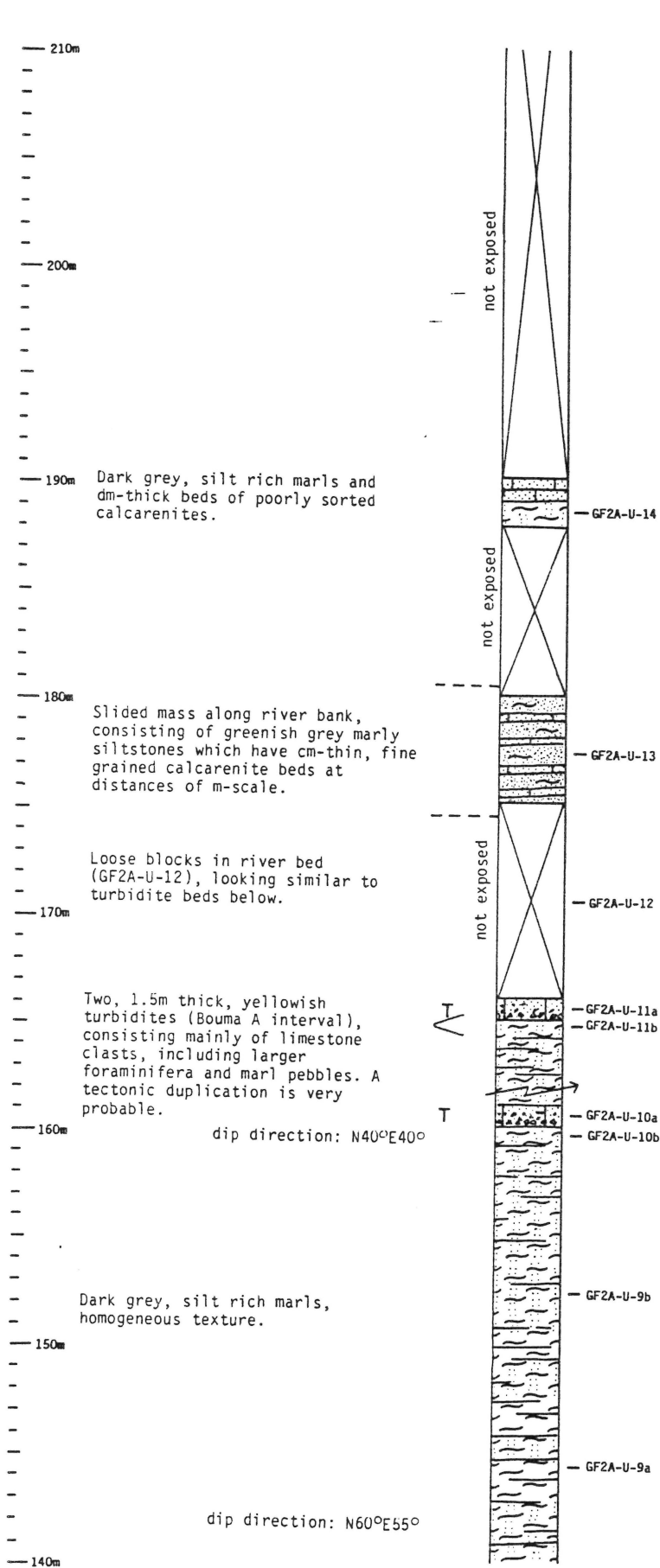
Date: 03-06 Sept. 1985

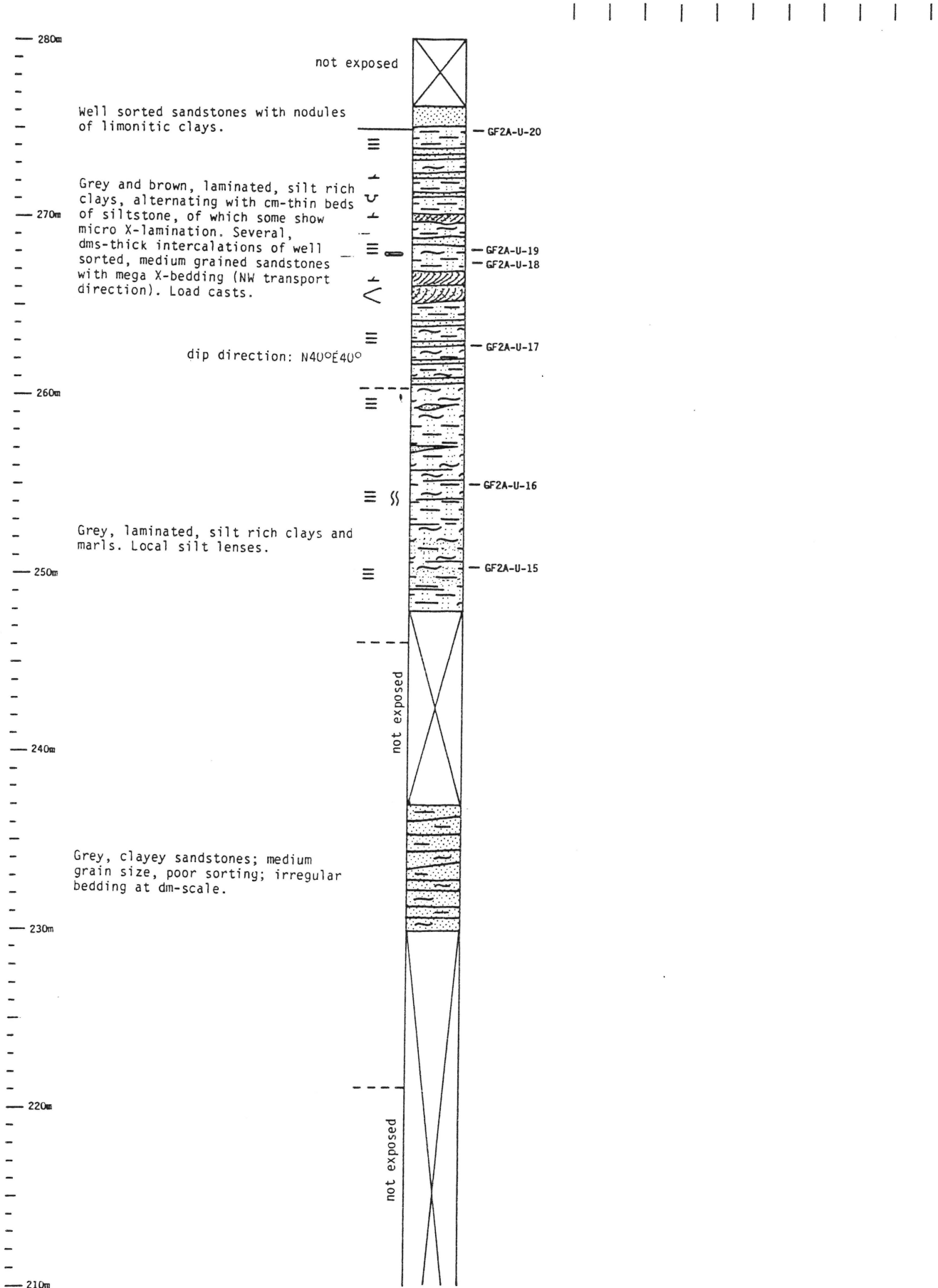
Fig: Hotong, schematic stratigraphic column
 (composite section)

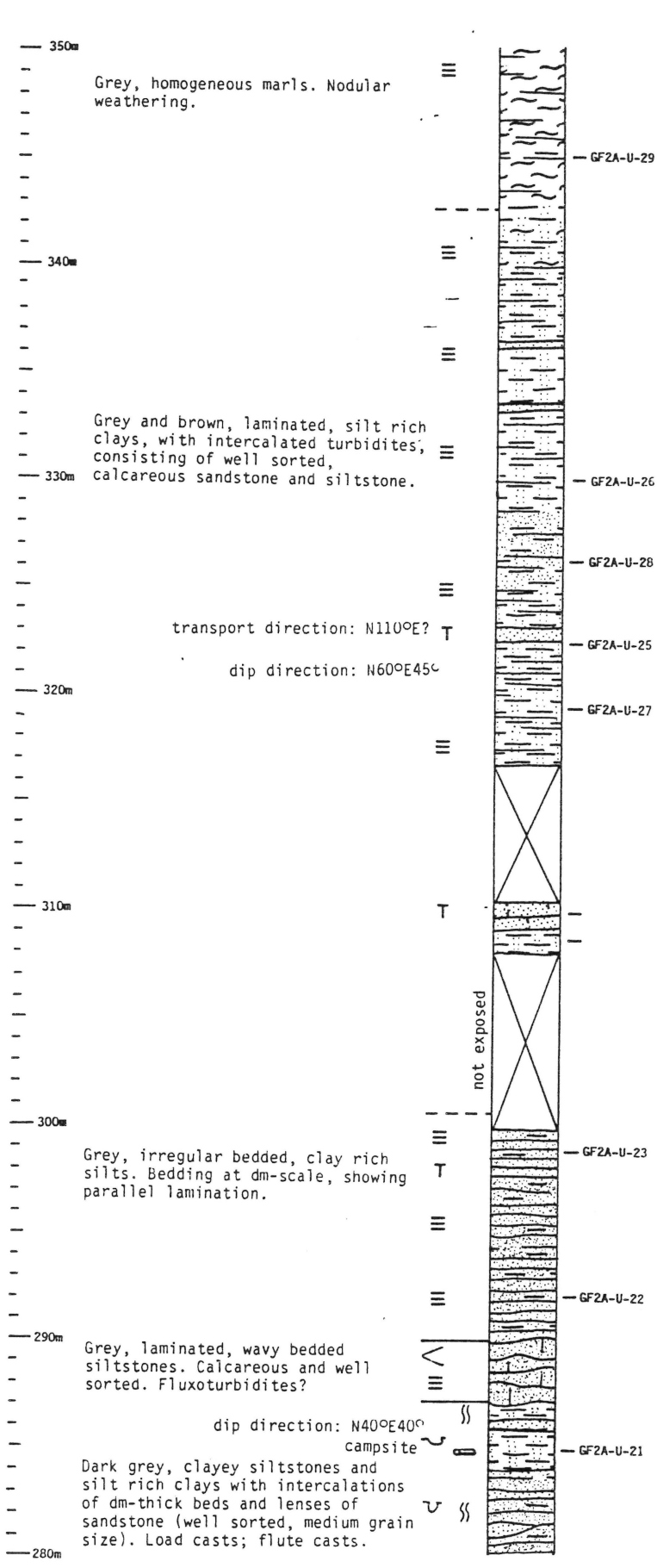


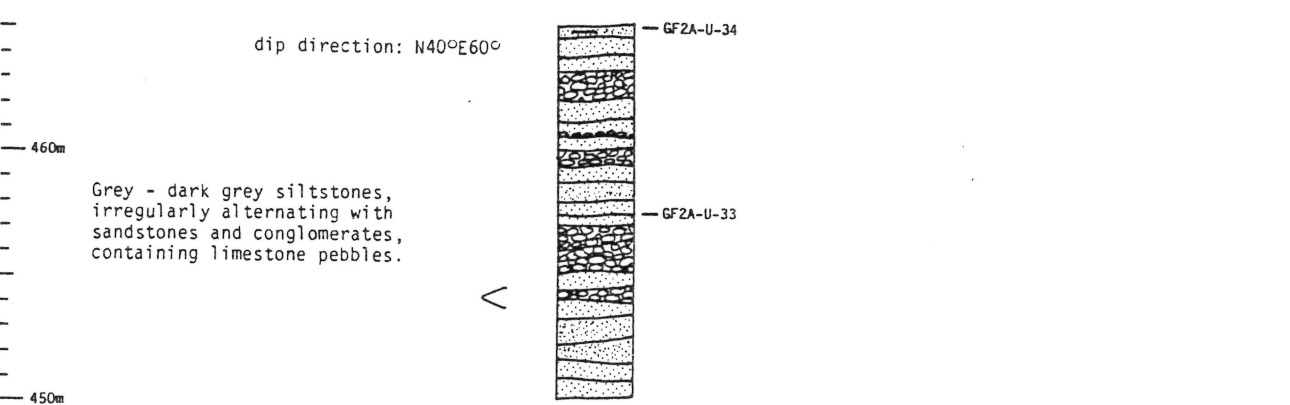
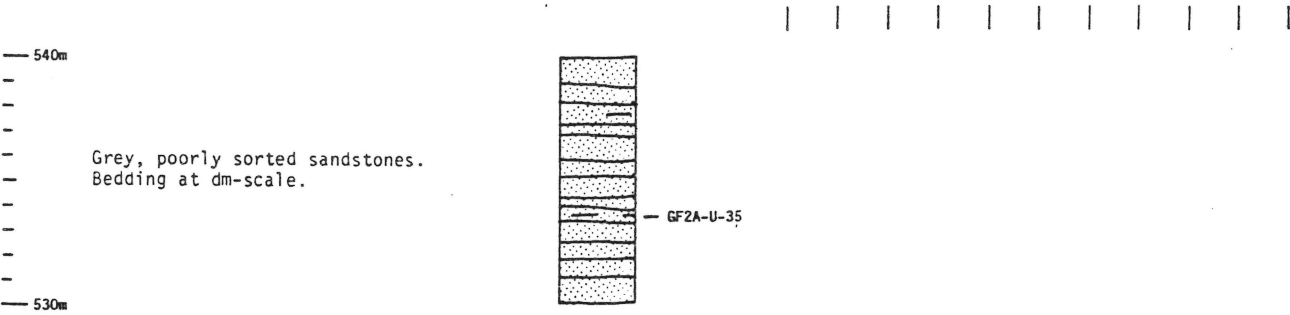




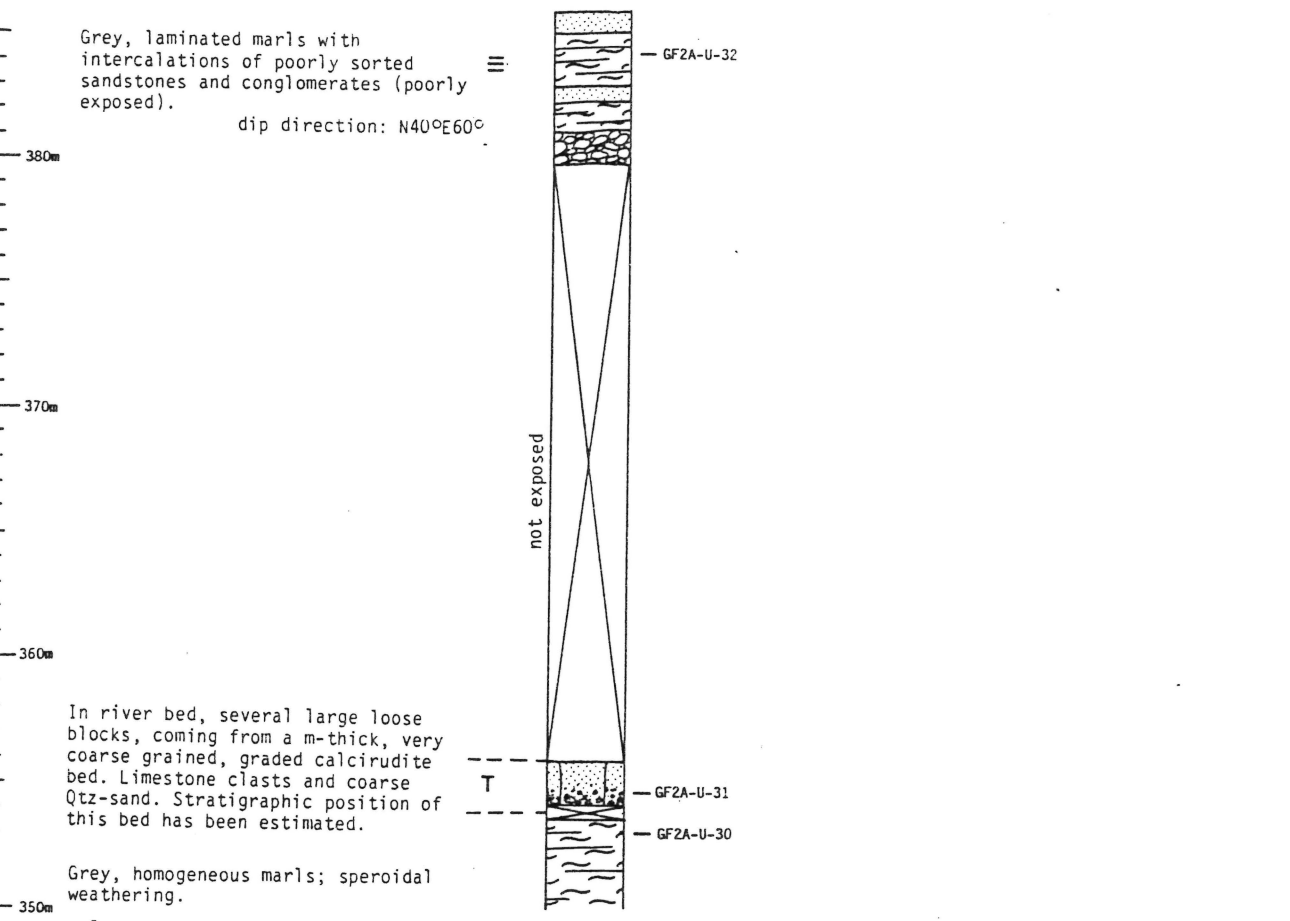






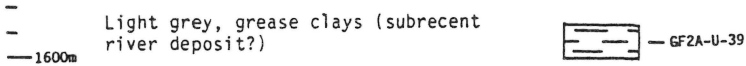


70?m. strat. not exposed

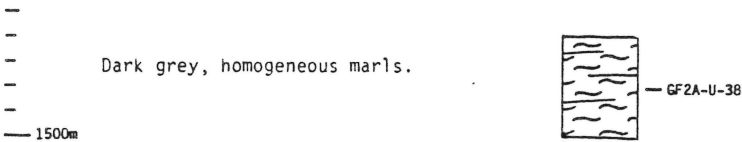


Upper part of Hotong section forms stratigraphical equivalent of Rumbia section

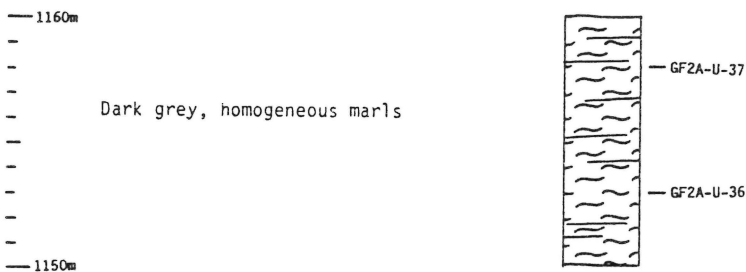
End Hotong section.



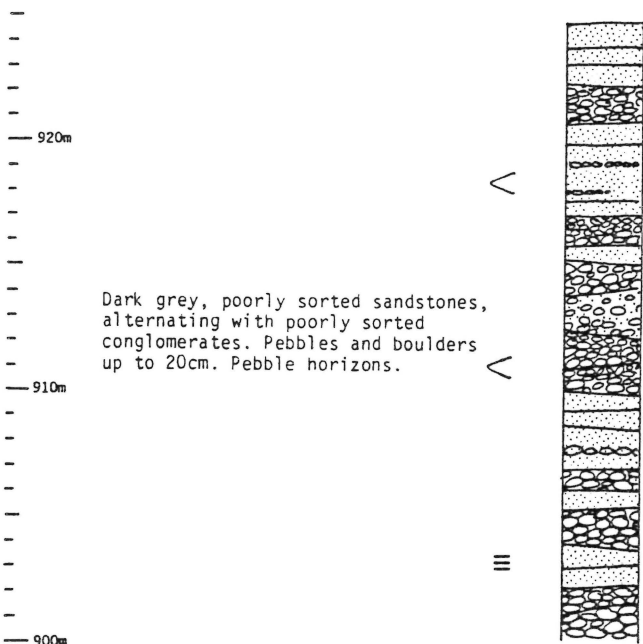
100? strat.m. not exposed

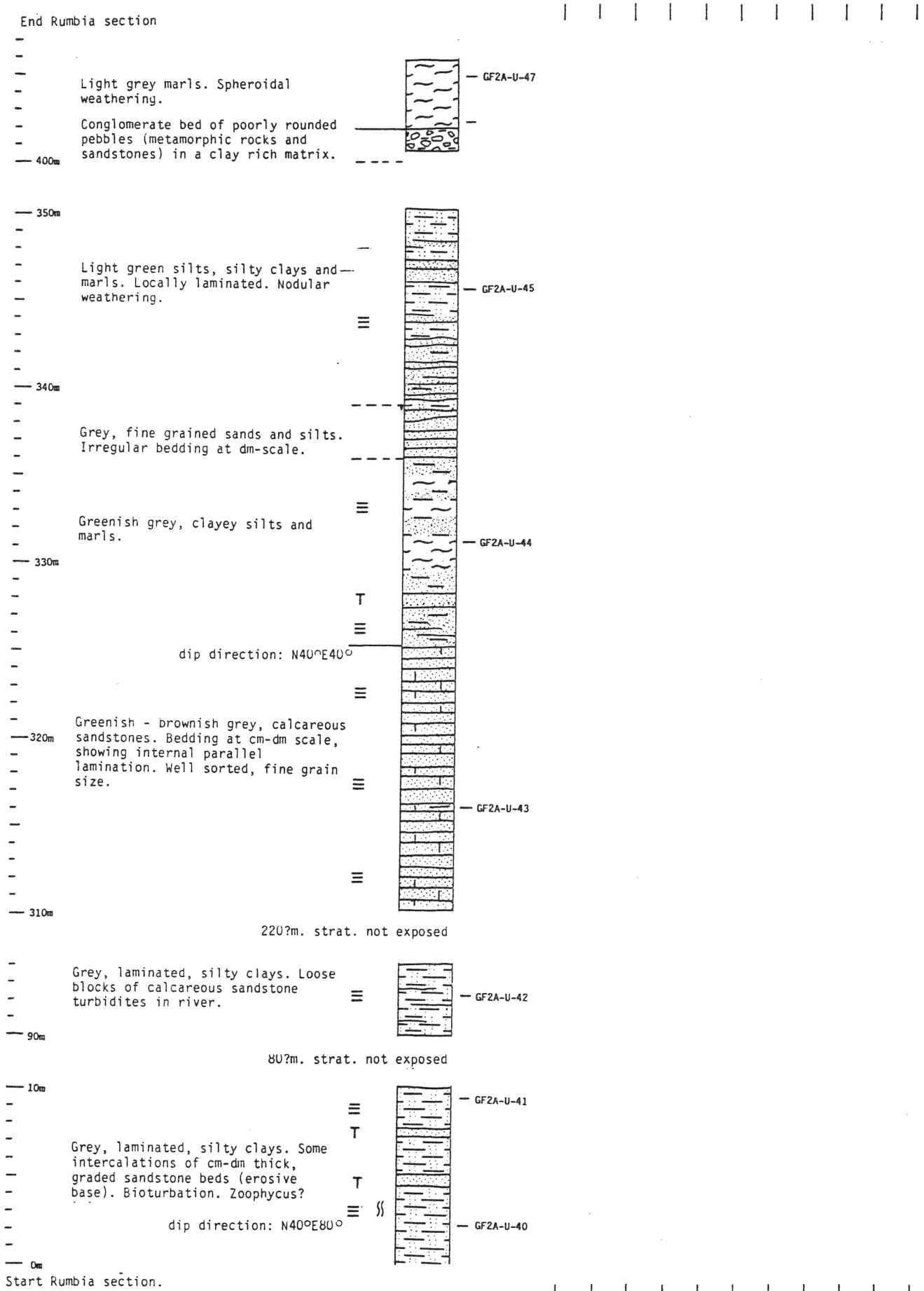


340?m. strat. not exposed



225?m. strat. not exposed





LIPI
Theme: GF2A Expedition: Buru
Completed by H.E.M.de Smet

INDONESIAN-DUTCH SNELLIUS II EXPEDITION

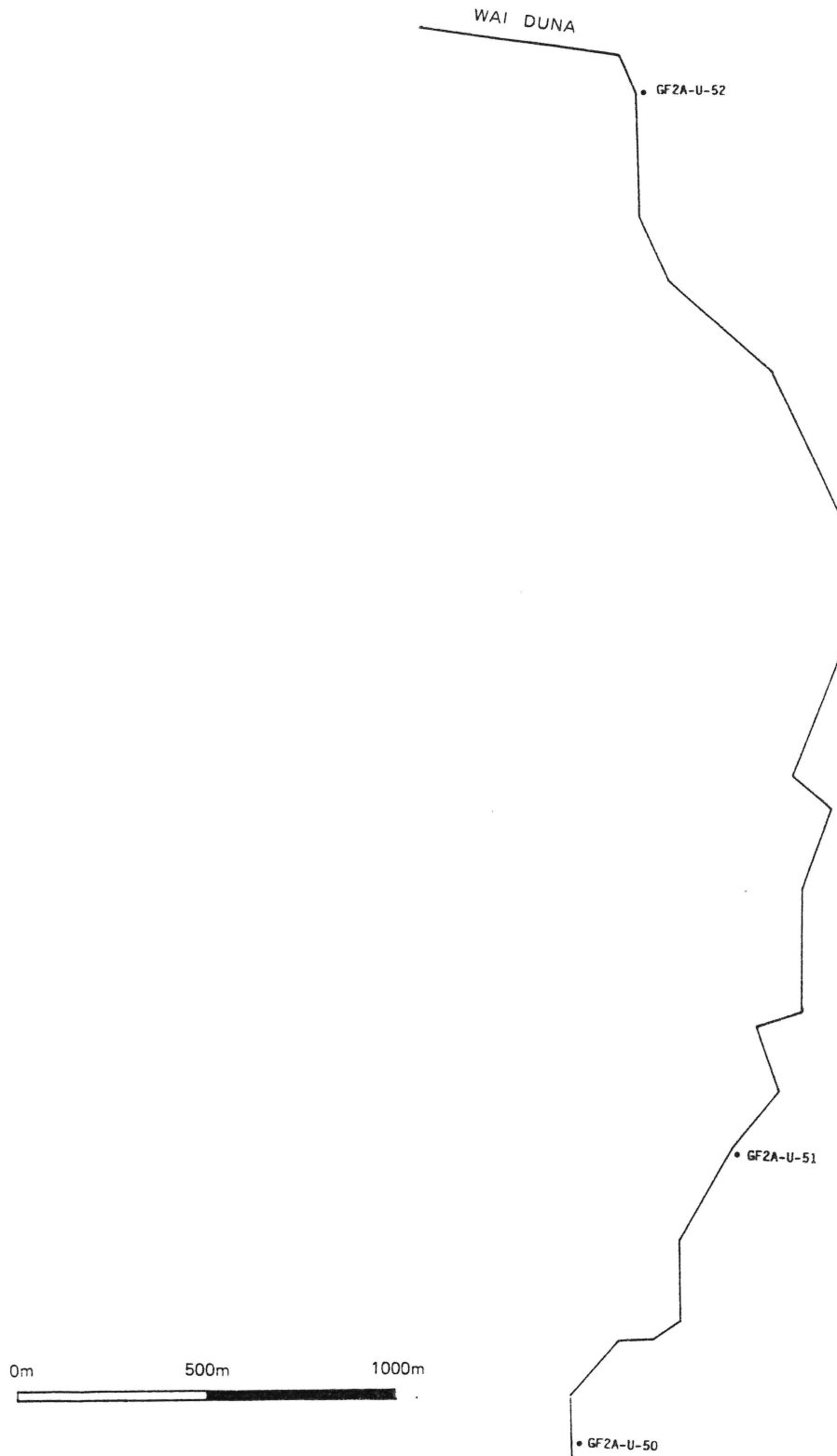
Area: Bara Bay

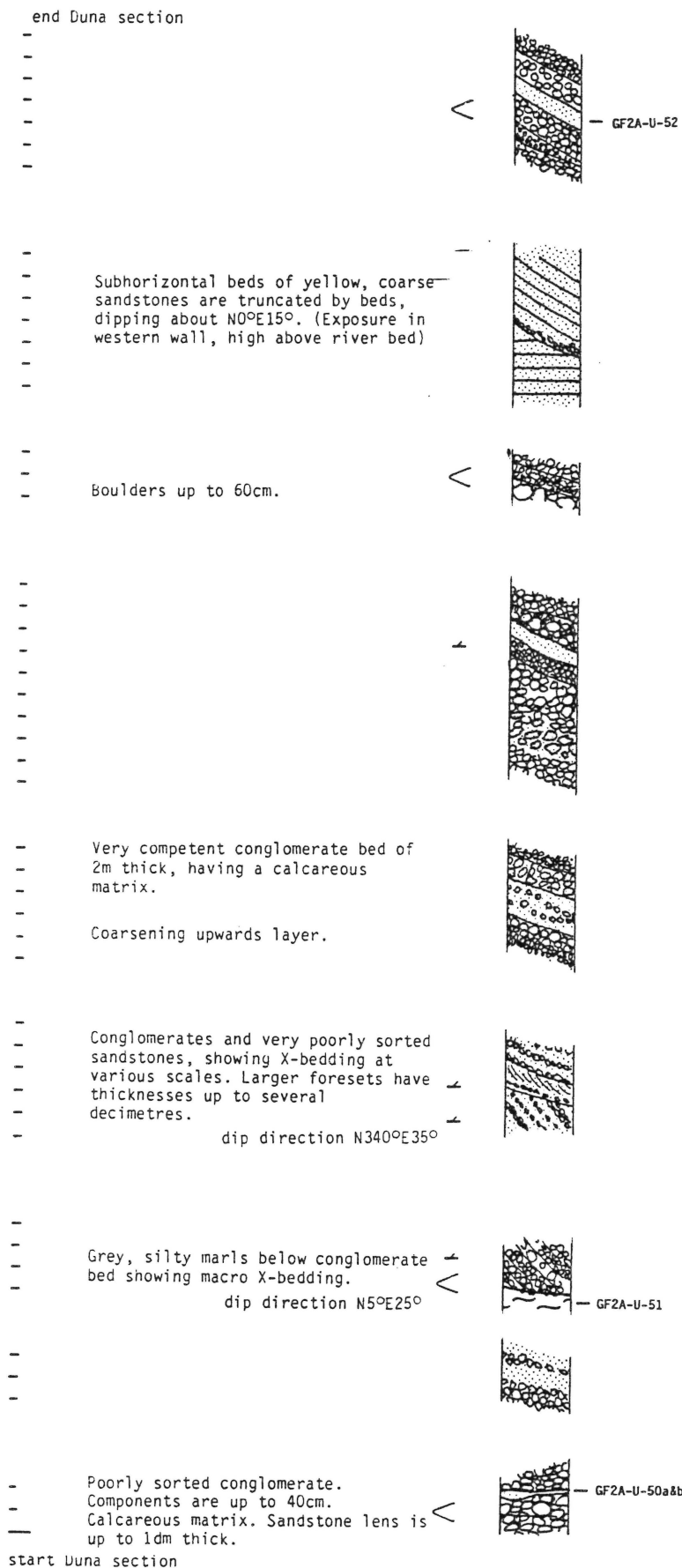
NRZ

Section: Duna River

Date: 07 Sept. 1985

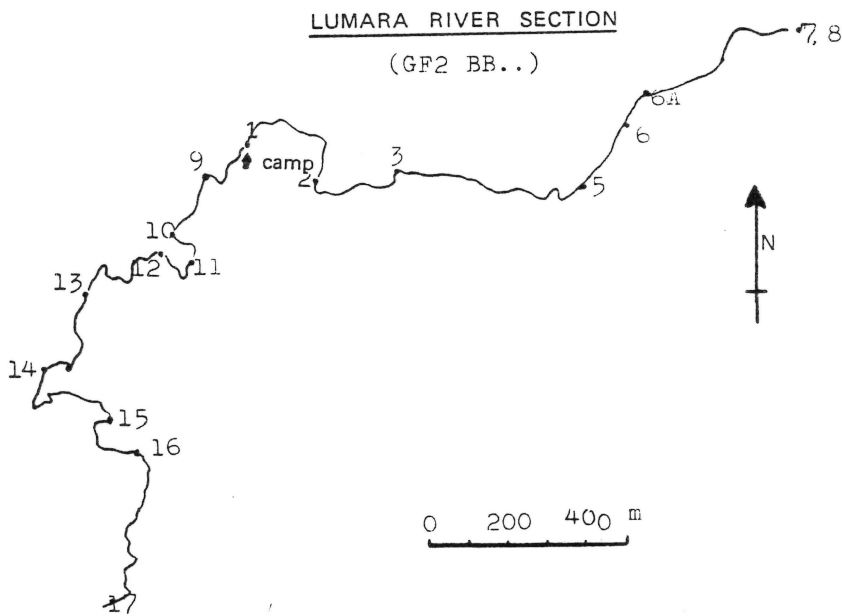
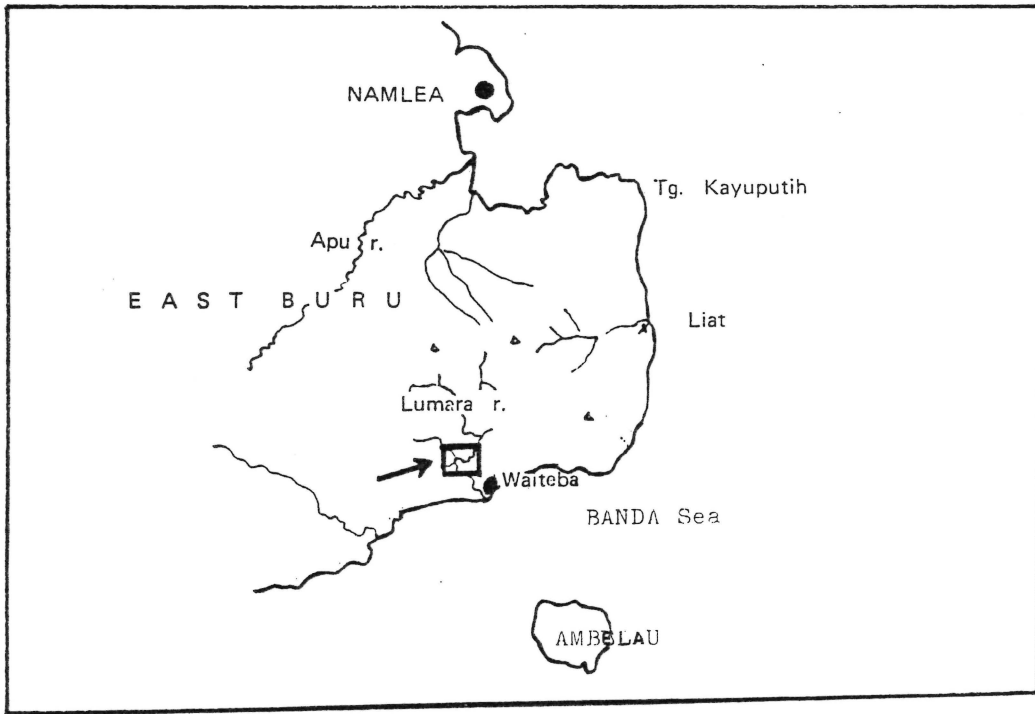
Fig: Duna, general situation and sample sites





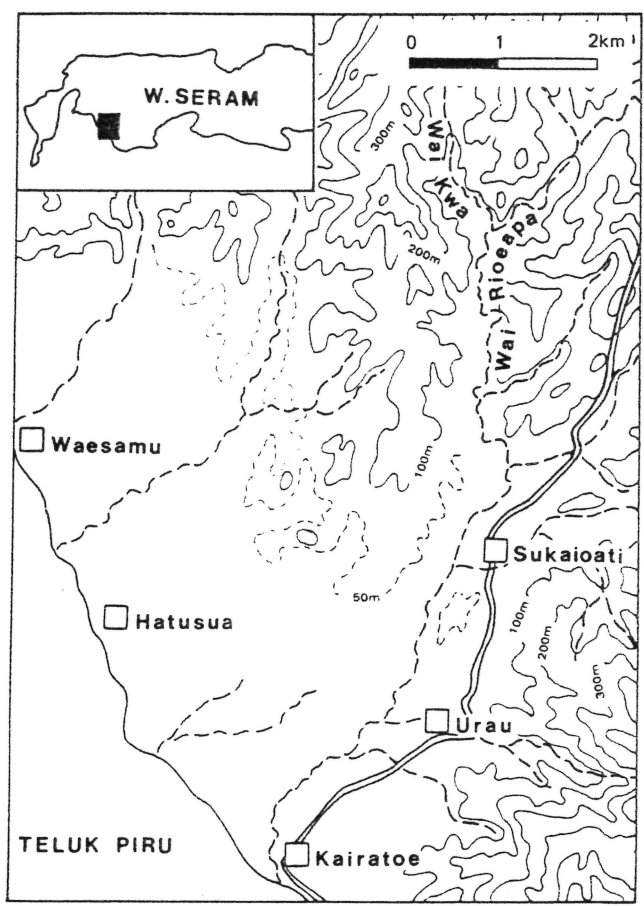
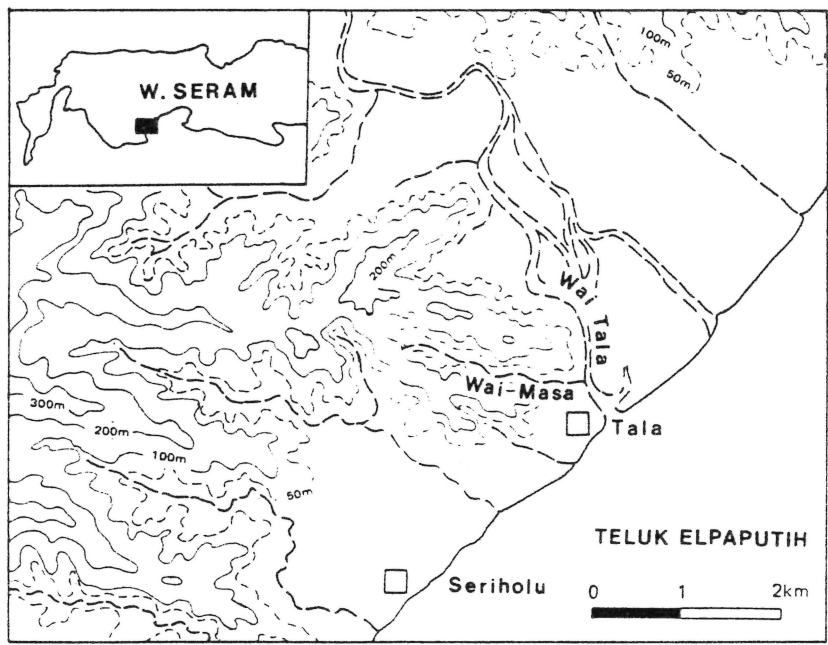
Along Duna River, rocks are almost continuously exposed, in part along the river bed and in part high in the river walls. They consist of irregular bedded, very well cemented conglomerates and some sandstones, dipping about north at an angle of about 5 - 35 degrees. Conglomerates are polymict, consisting of limestones, sandstones and metamorphic materials. There are units, which are more than ten metres thick and consist of a monotonous, very poorly sorted conglomerate, while at other places, beds have thicknesses of decimetres to metres and show mutual differences in size of components and/or rate of sorting, etc. The deposits seem to be sterile. No bioturbation or bioclasts of any kind have been observed. Except for a few, very small occurrences, no soft sediments have been found along the section.

In this figure, some of the observed situations are sketched.



LOCATION MAP OF GF2BB SAMPLES (team B), SE BURU

Encl. 10

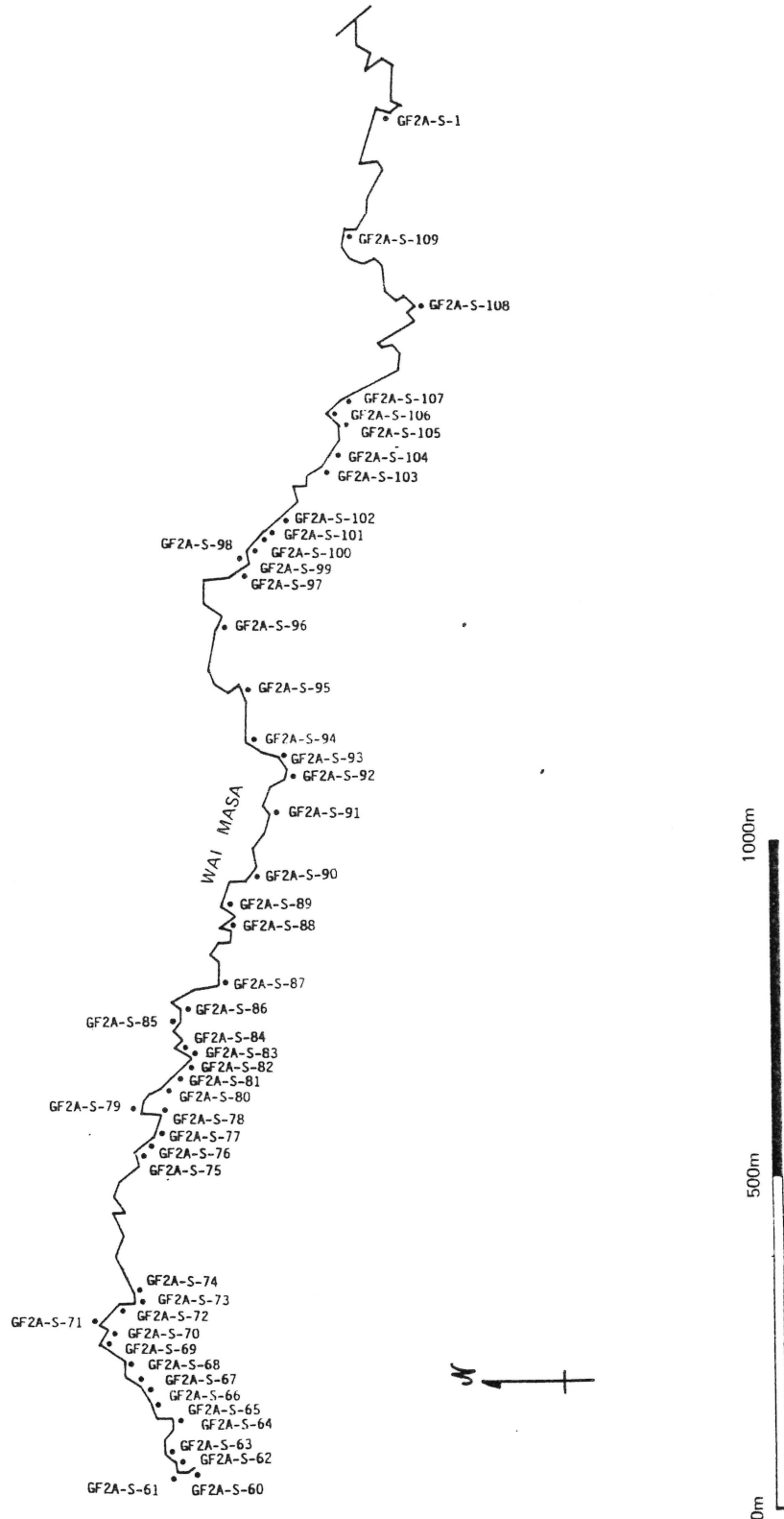


LOCATION MAP OF GF2A SECTIONS IN WEST SERAM

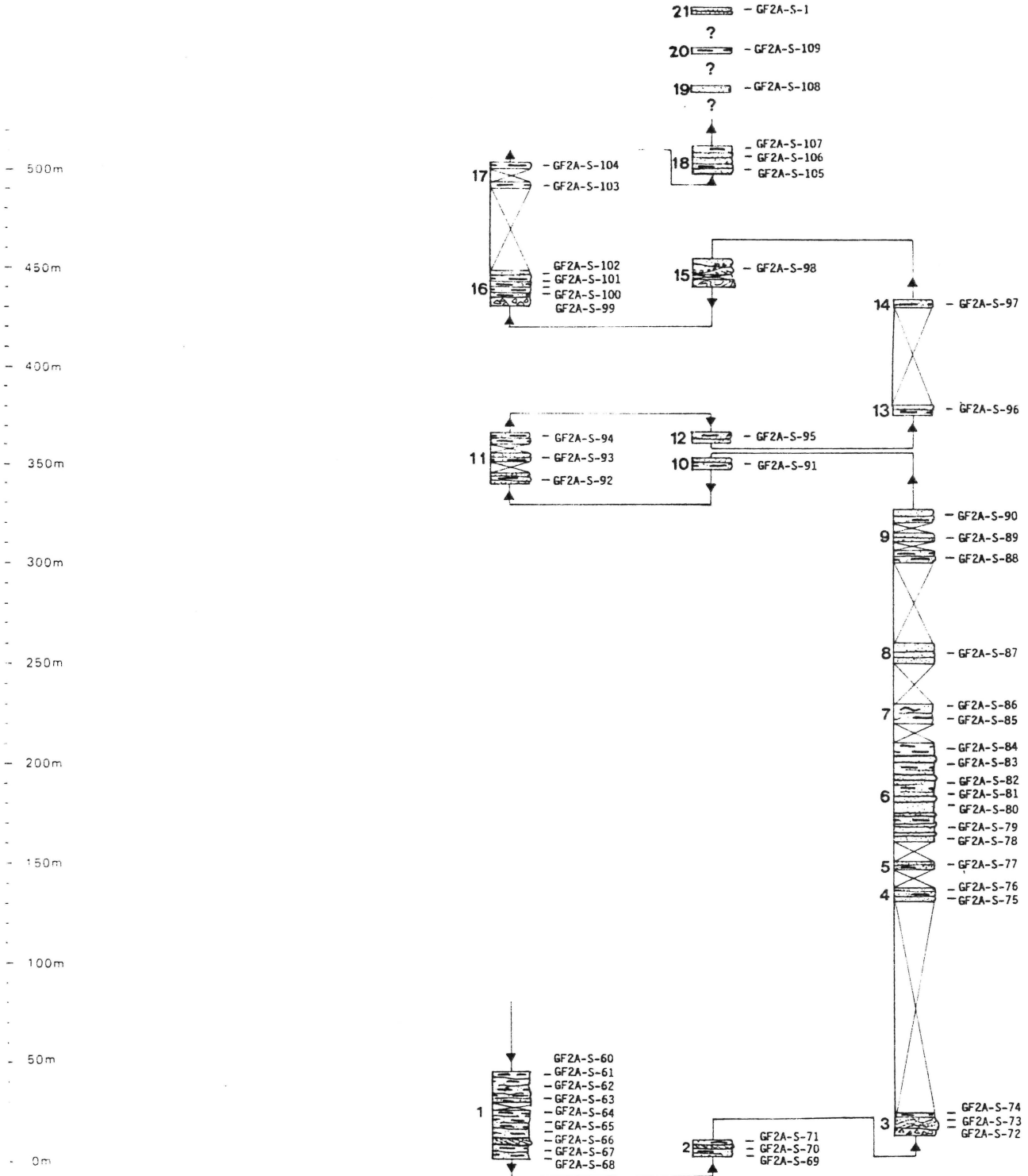
LIPI
Theme: GF2A Expedition: Seram
Completed by M.E.M.de Smet

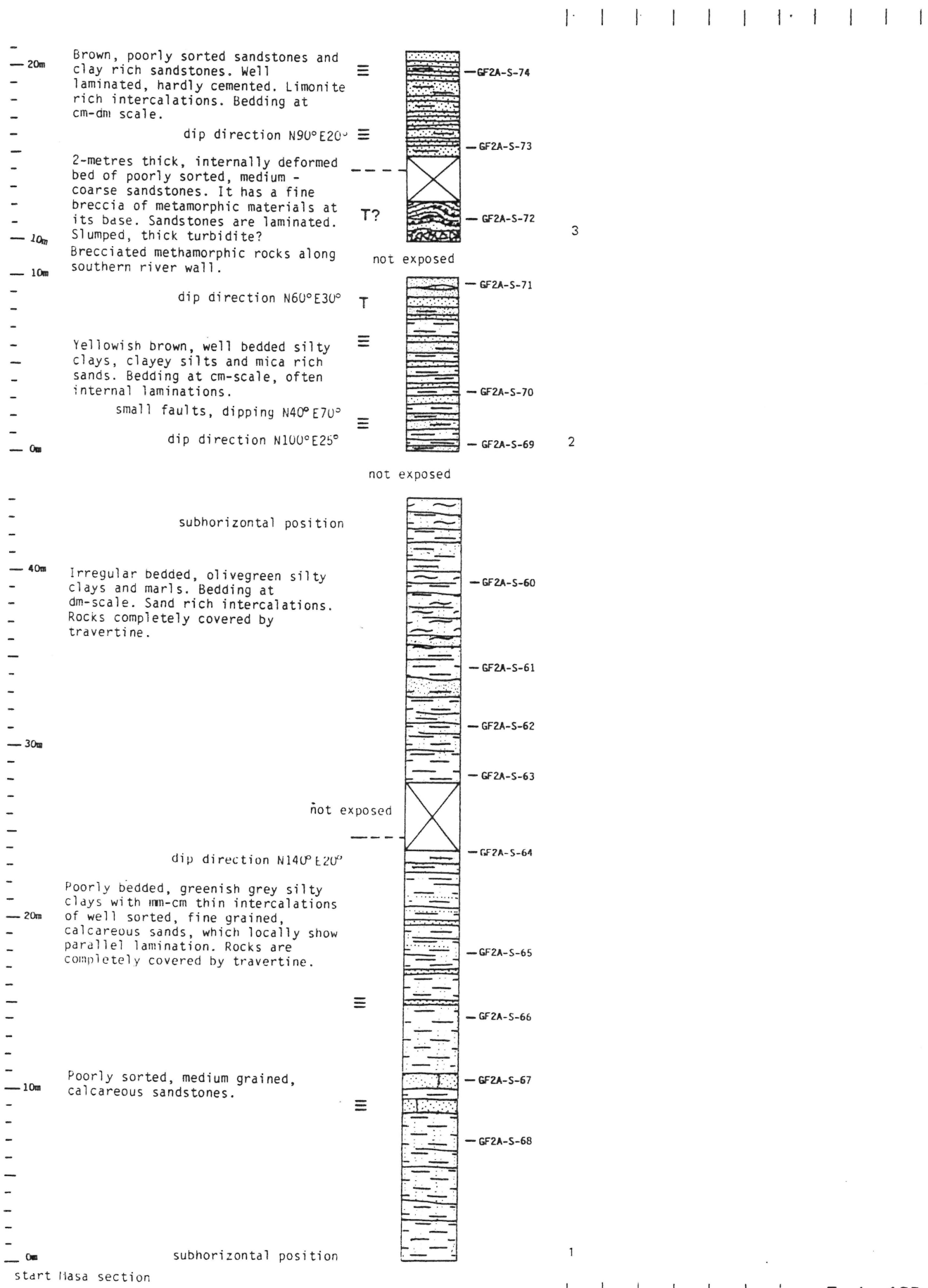
INDONESIAN-DUTCH SNELLIUS II EXPEDITION
Area: Elpaputih Bay

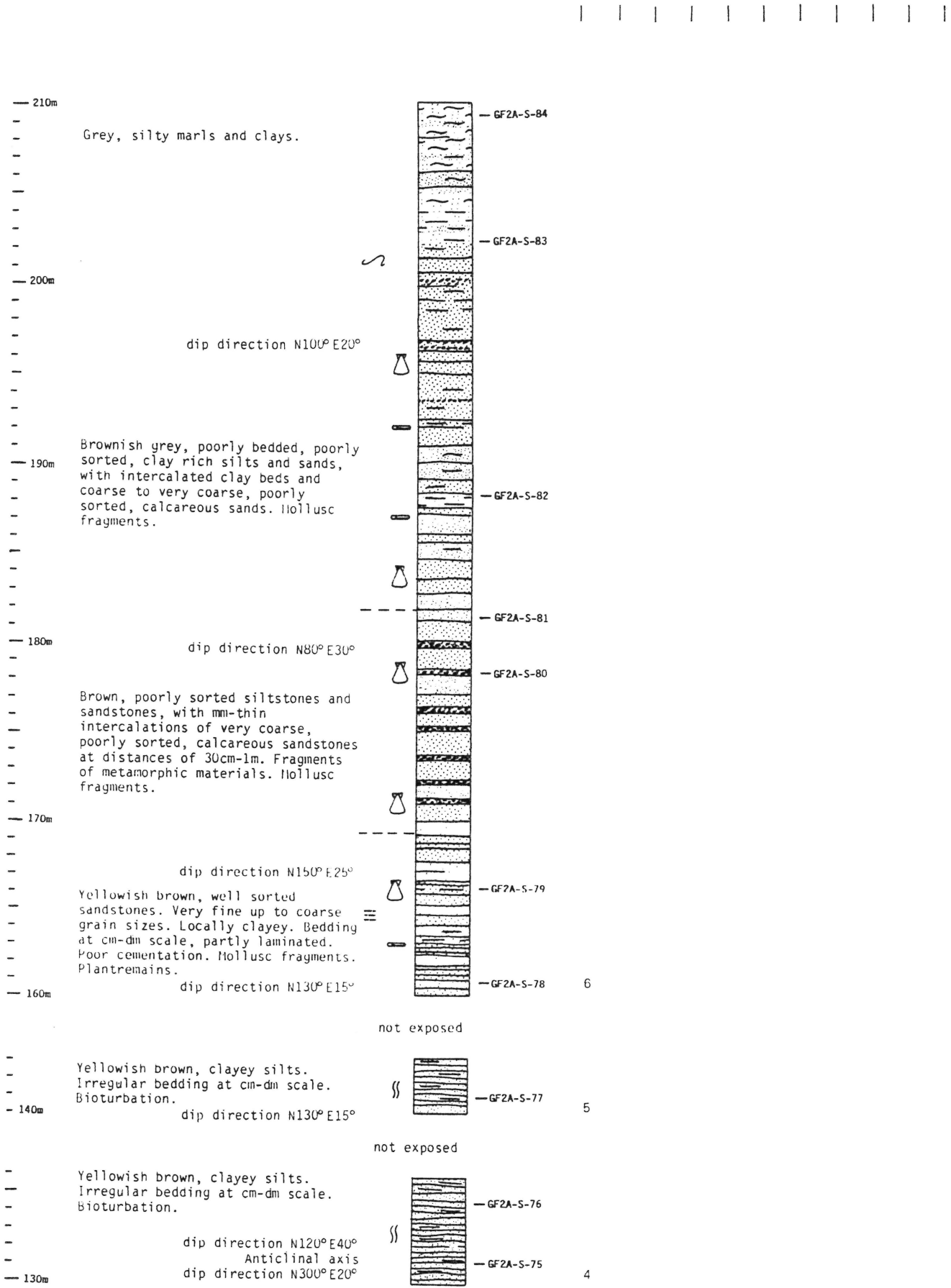
MRZ
Section: Masa River Date: 17-18 Sept. 1985
Fig: Masa, general situation and sample sites

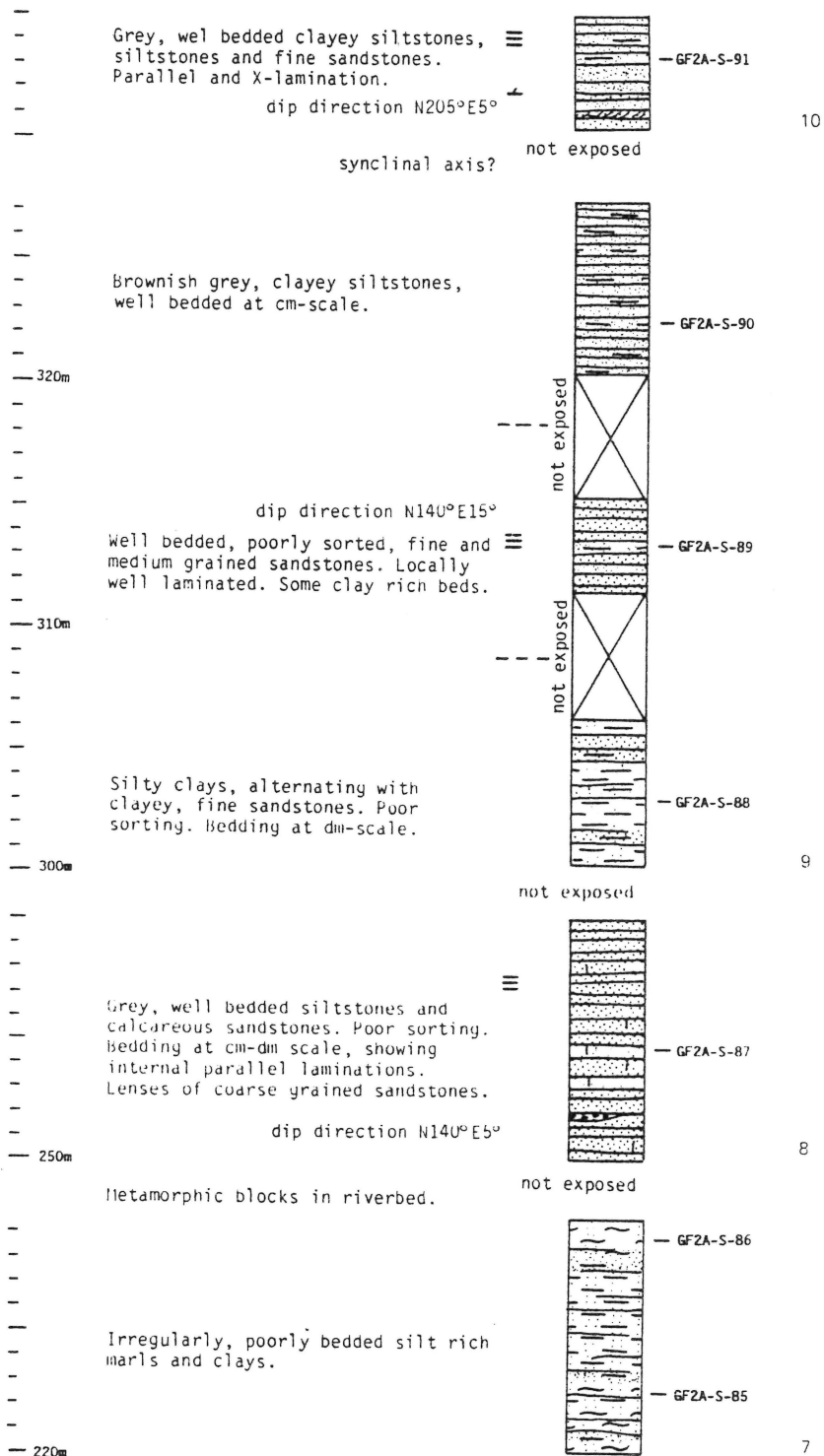


Encl. 12







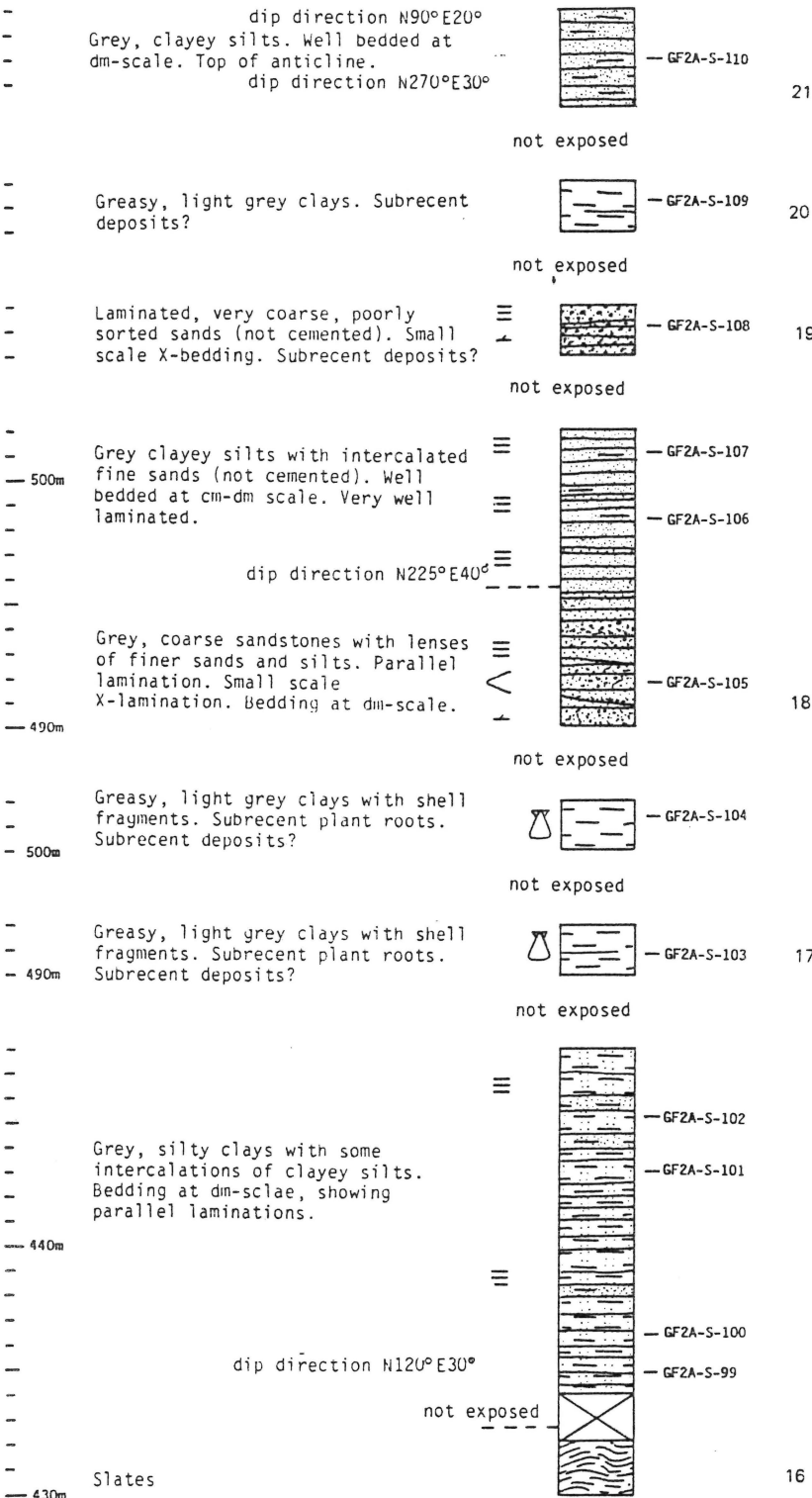


Theme: GF2A Expedition: Seram
 Completed by M.E.M.de Smet

INDONESIAN-DUTCH SNELLIUS II EXPEDITION
 Area: Elpaputih Bay Section: Masa River

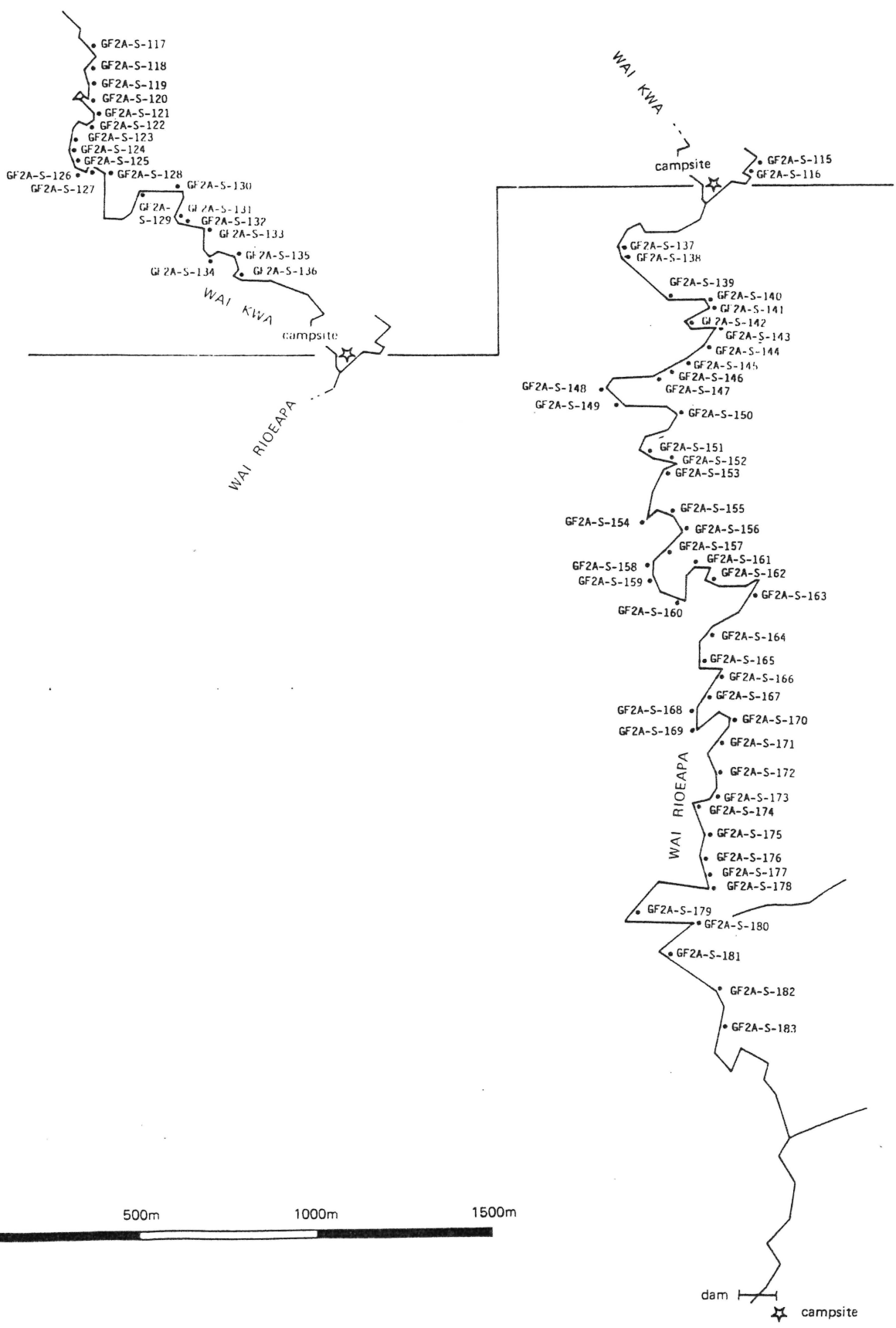
NRZ Date: 17-18 Sept. 1985
 Fig: Masa, exposures 16 - 21

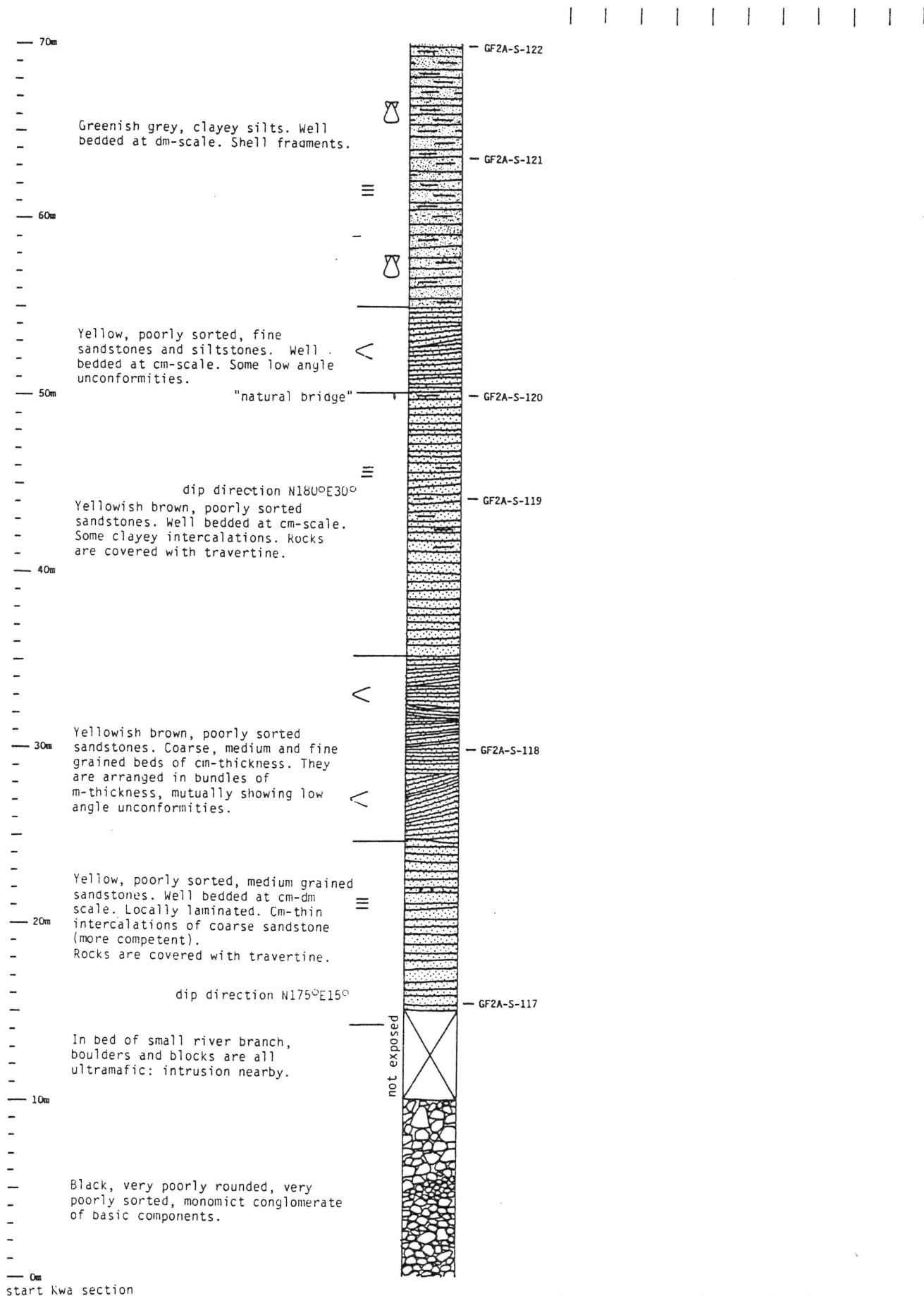
end Masa section

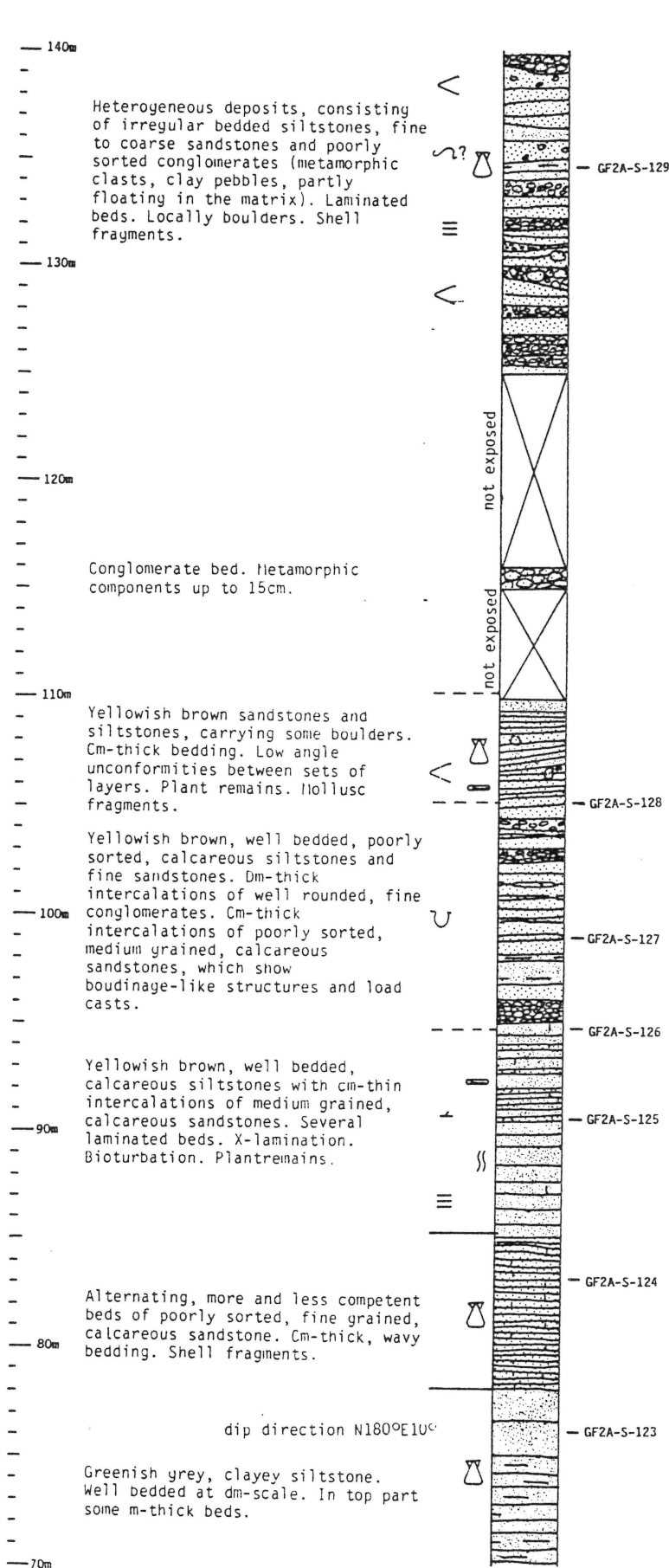


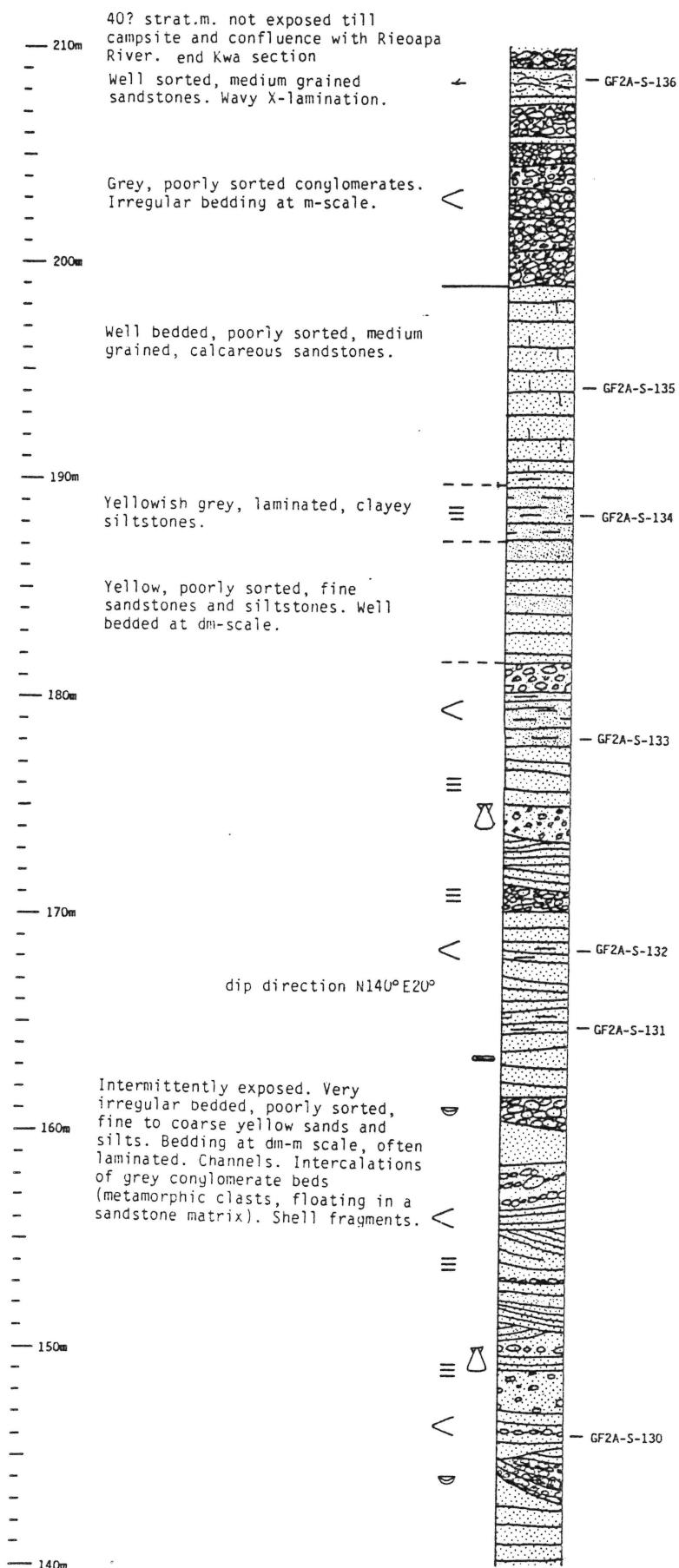
Encl. 13F

LIPI INDONESIA-DUTCH SNELLIUS II EXPEDITION NRZ
 Theme: GF2A Expedition: Seram Area: Piru Bay Section: Kwa and Rioeapa Rivers Date: 20-23 Sept. 1985
 Completed by M.E.M.de Smet Fig: Kwa and Rioeapa, general situation and sampling sites





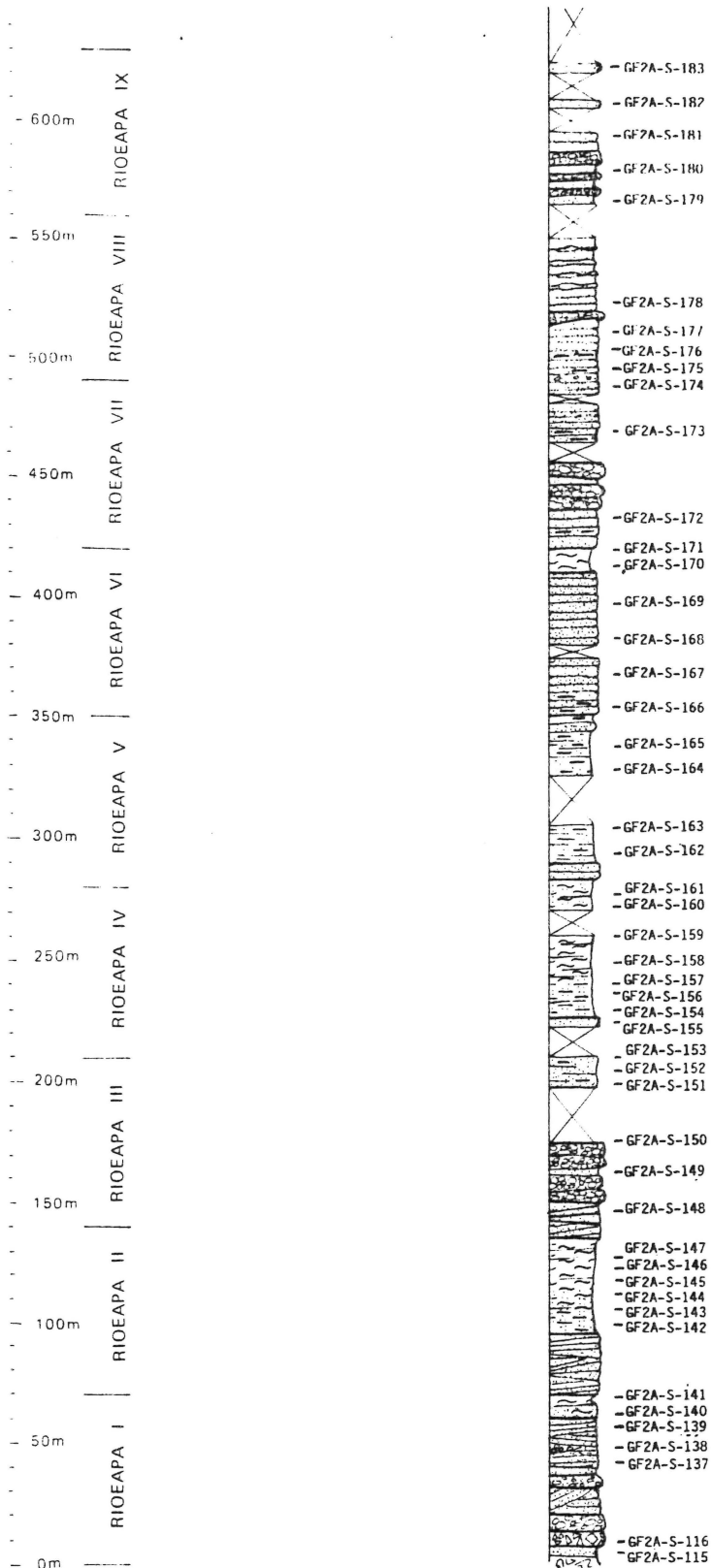




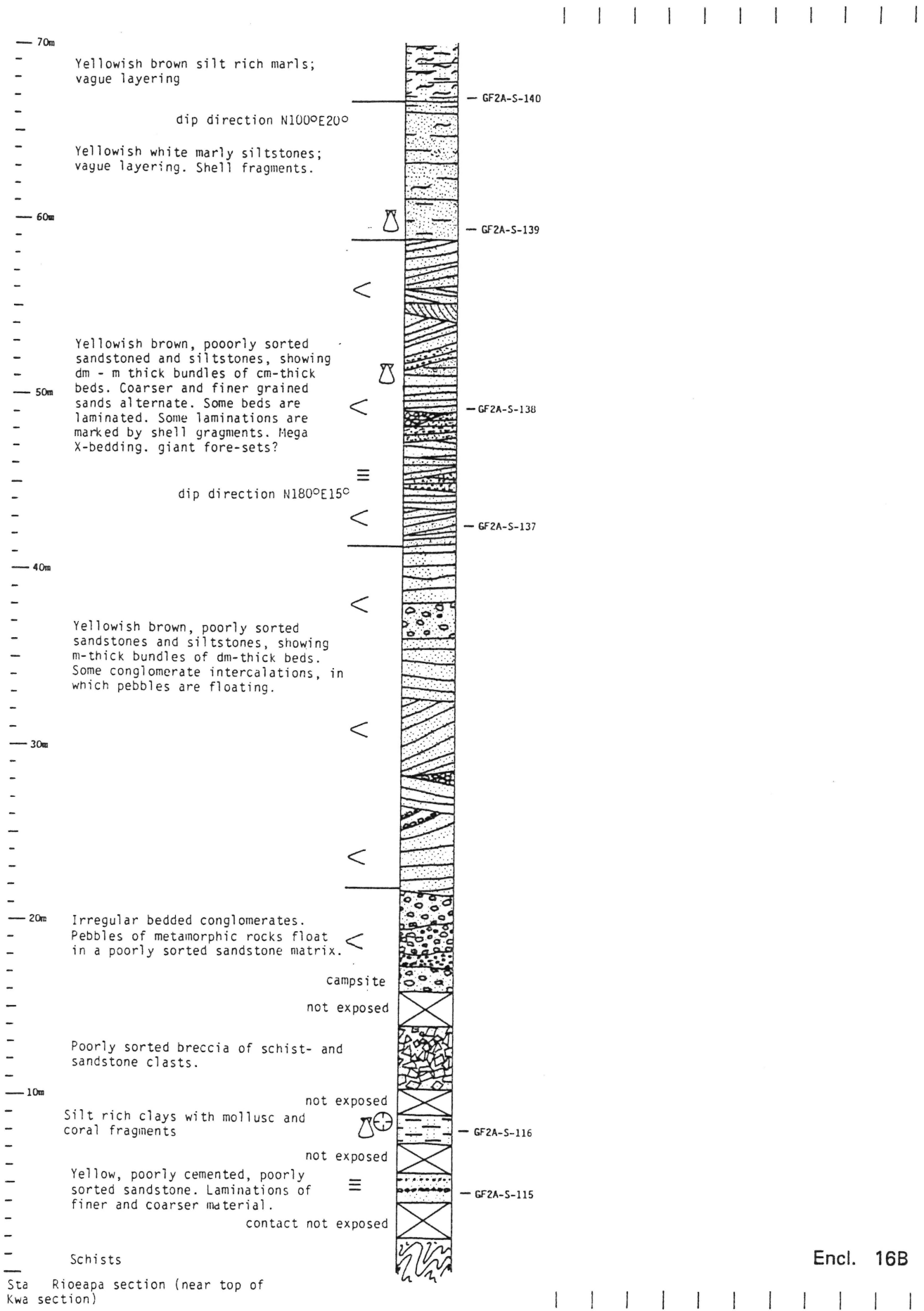
LIPI
 Theme: GF2A Expedition: Seram
 Completed by H.E.M.de Smet

INDONESIAN-DUTCH SNELLIUS II EXPEDITION
 Area: Teluk Bay Section: Rioeapa River

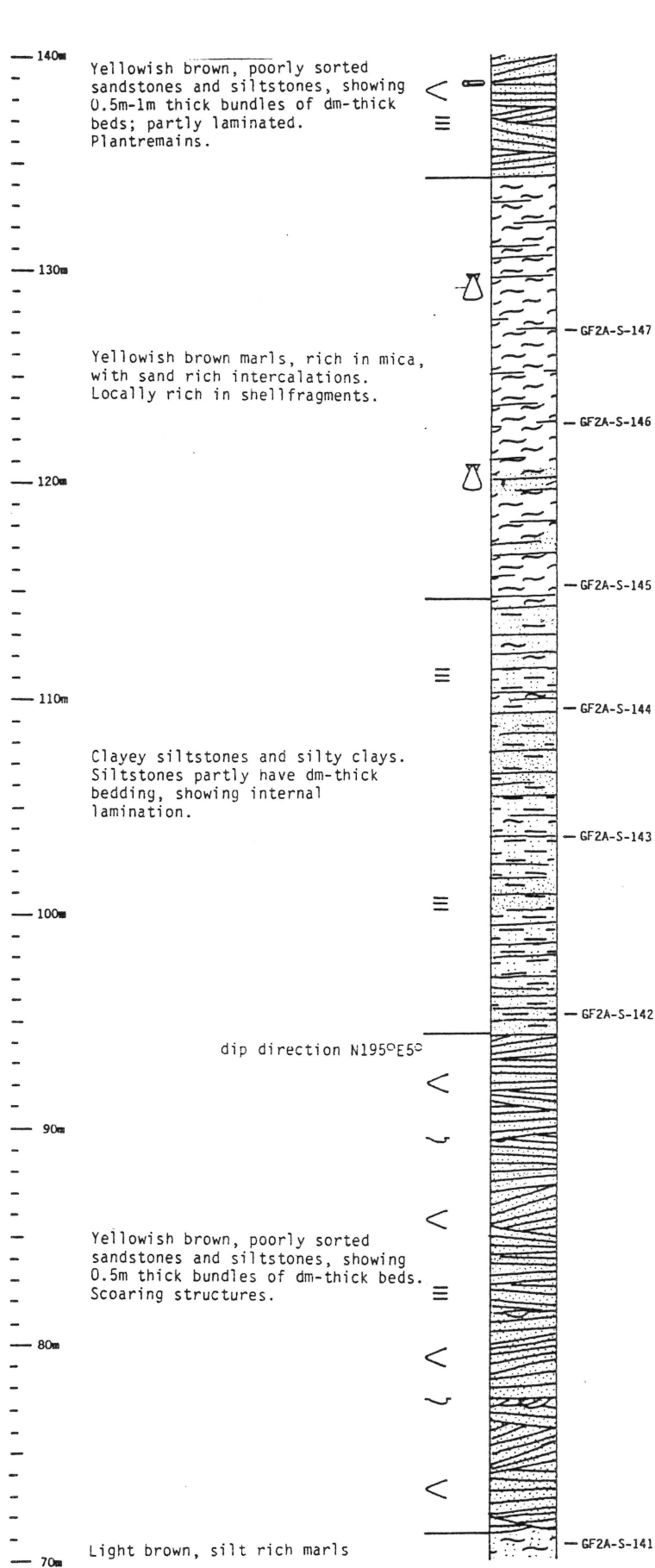
NRZ
 Date: 20-23 Sept. 1985
 Fig: Rioeapa, schematic stratigraphic column

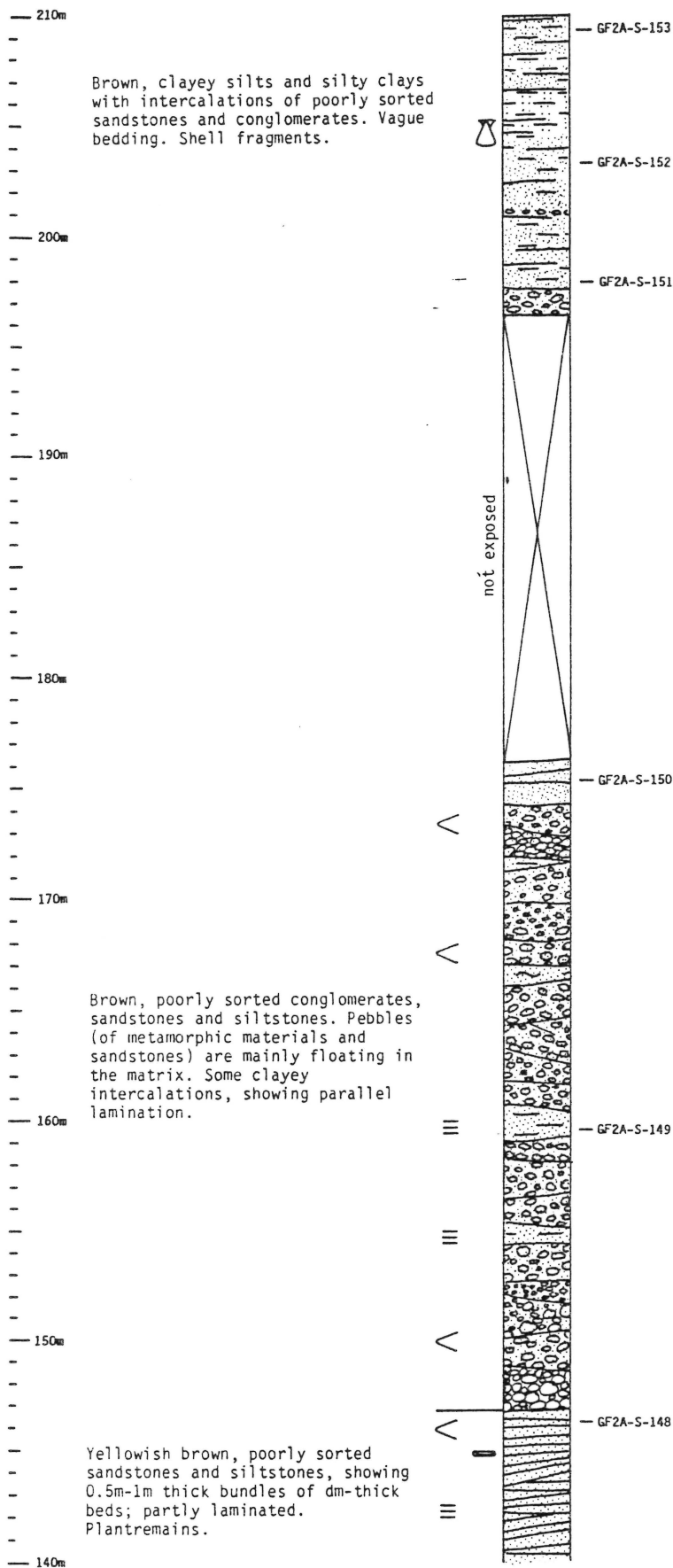


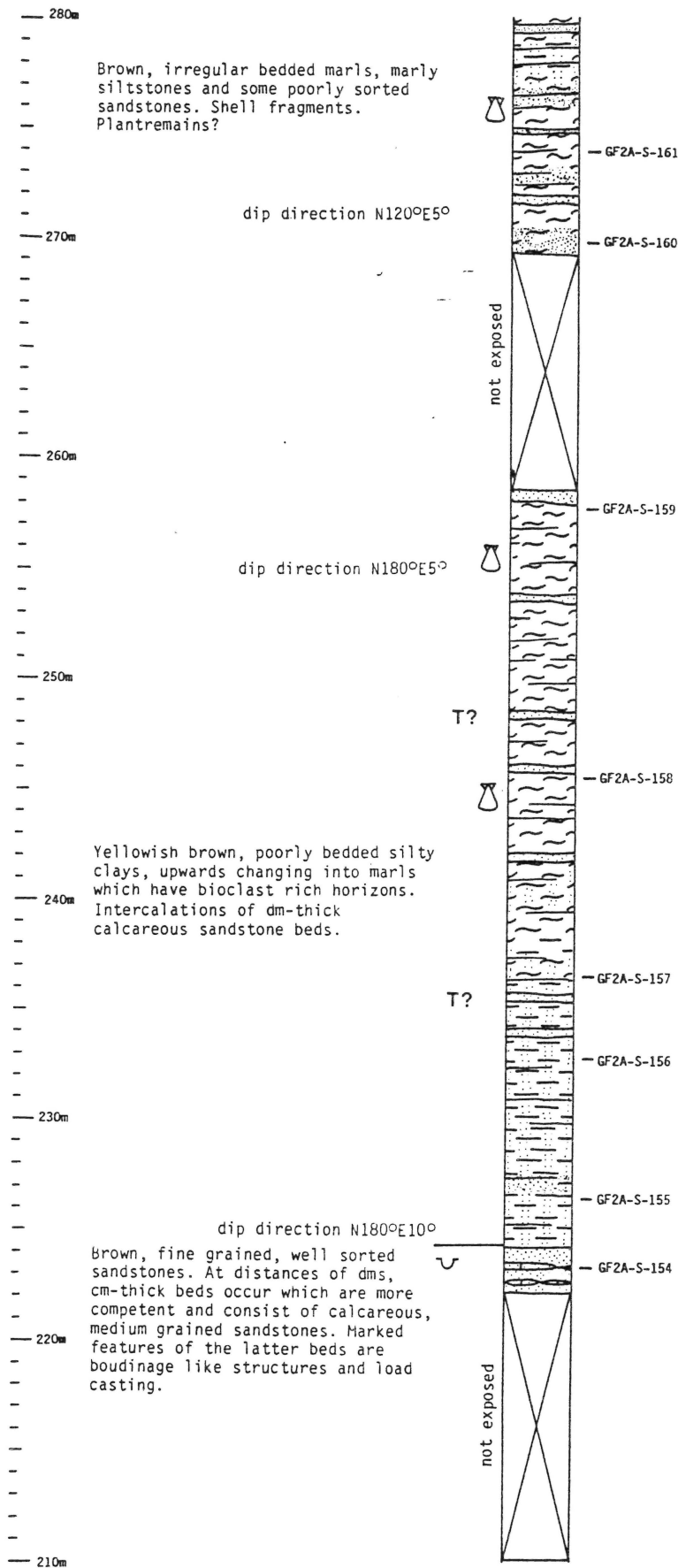
Encl. 16A

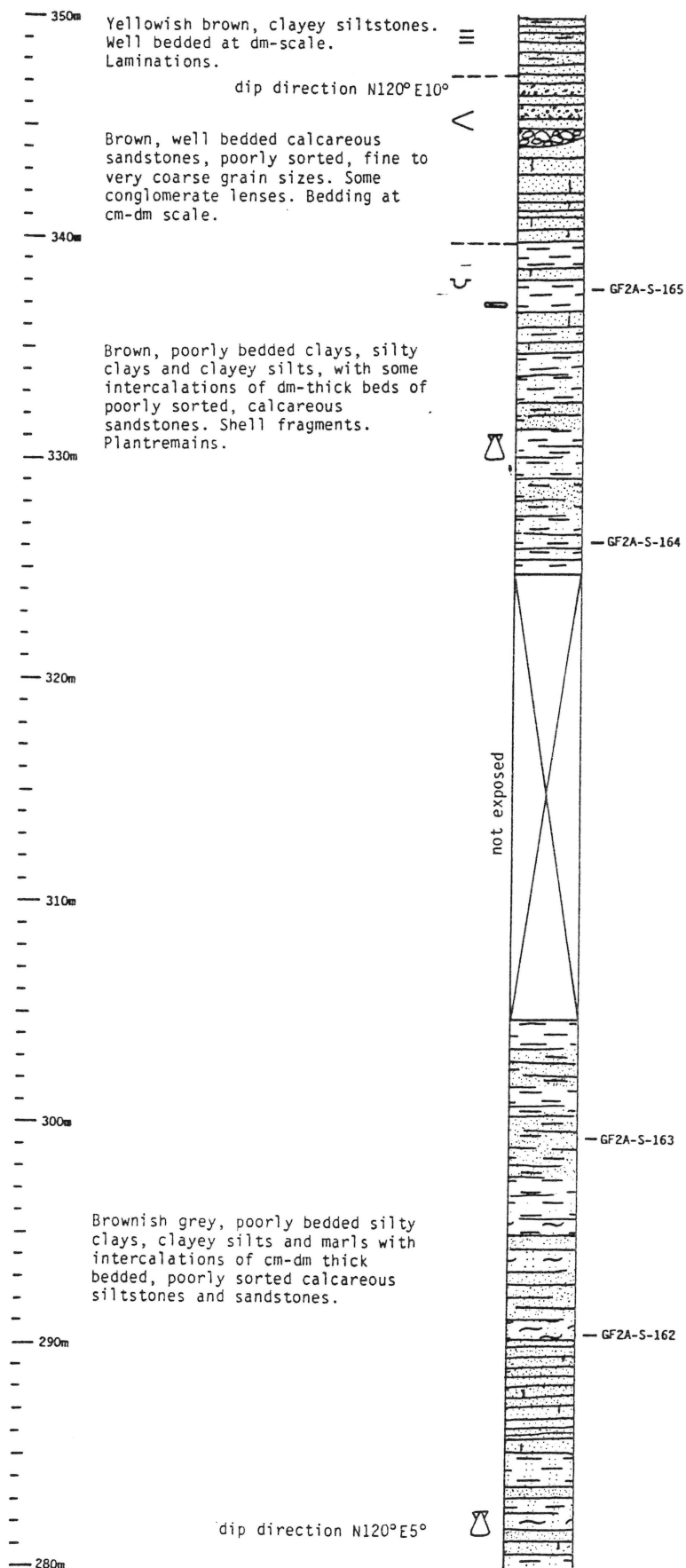


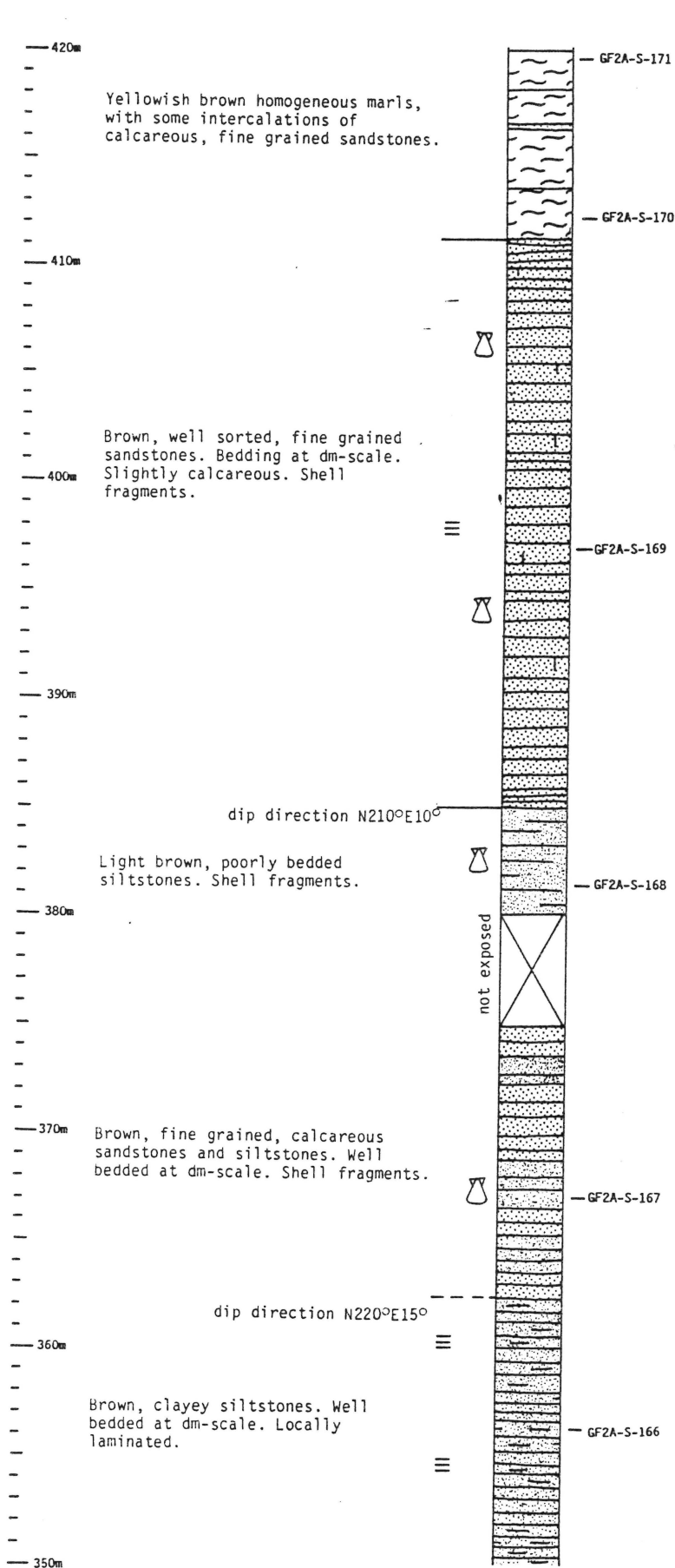
Encl. 16B

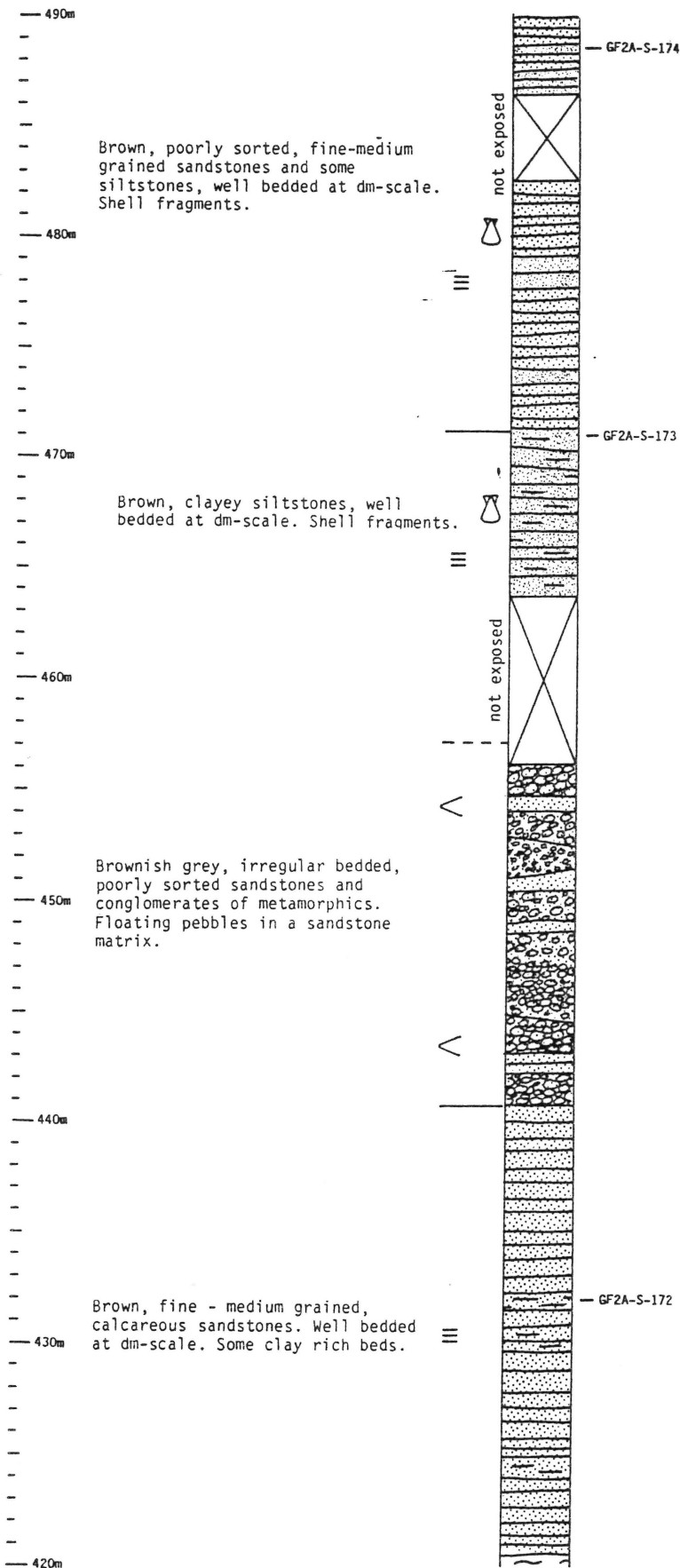


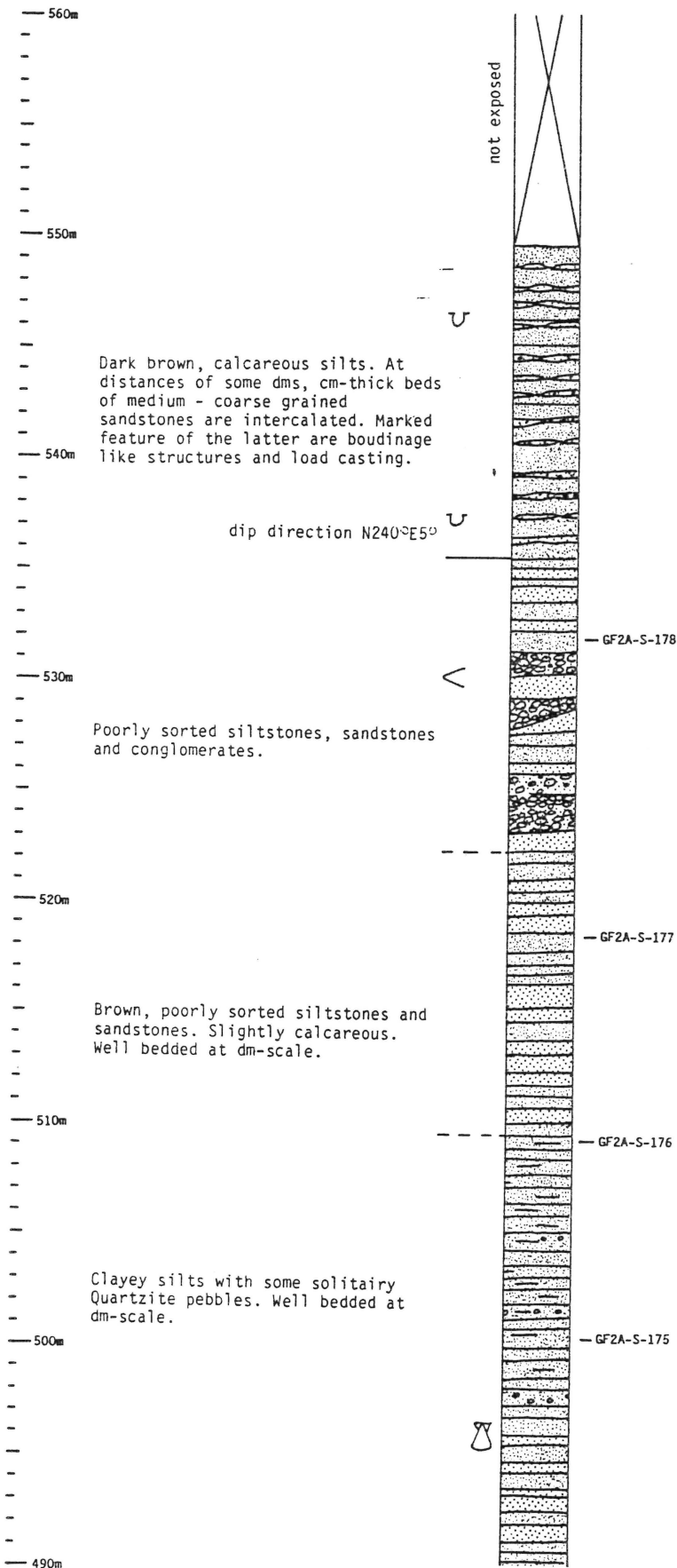


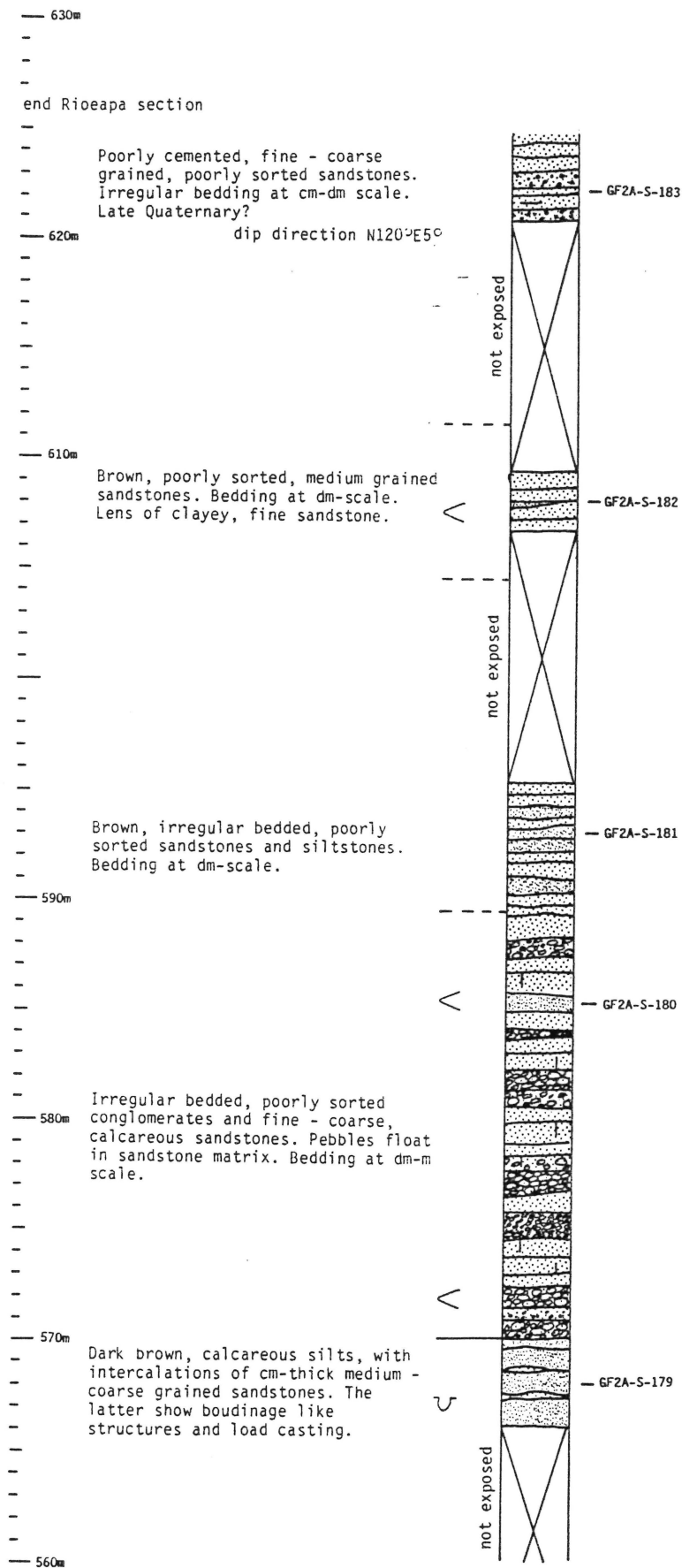


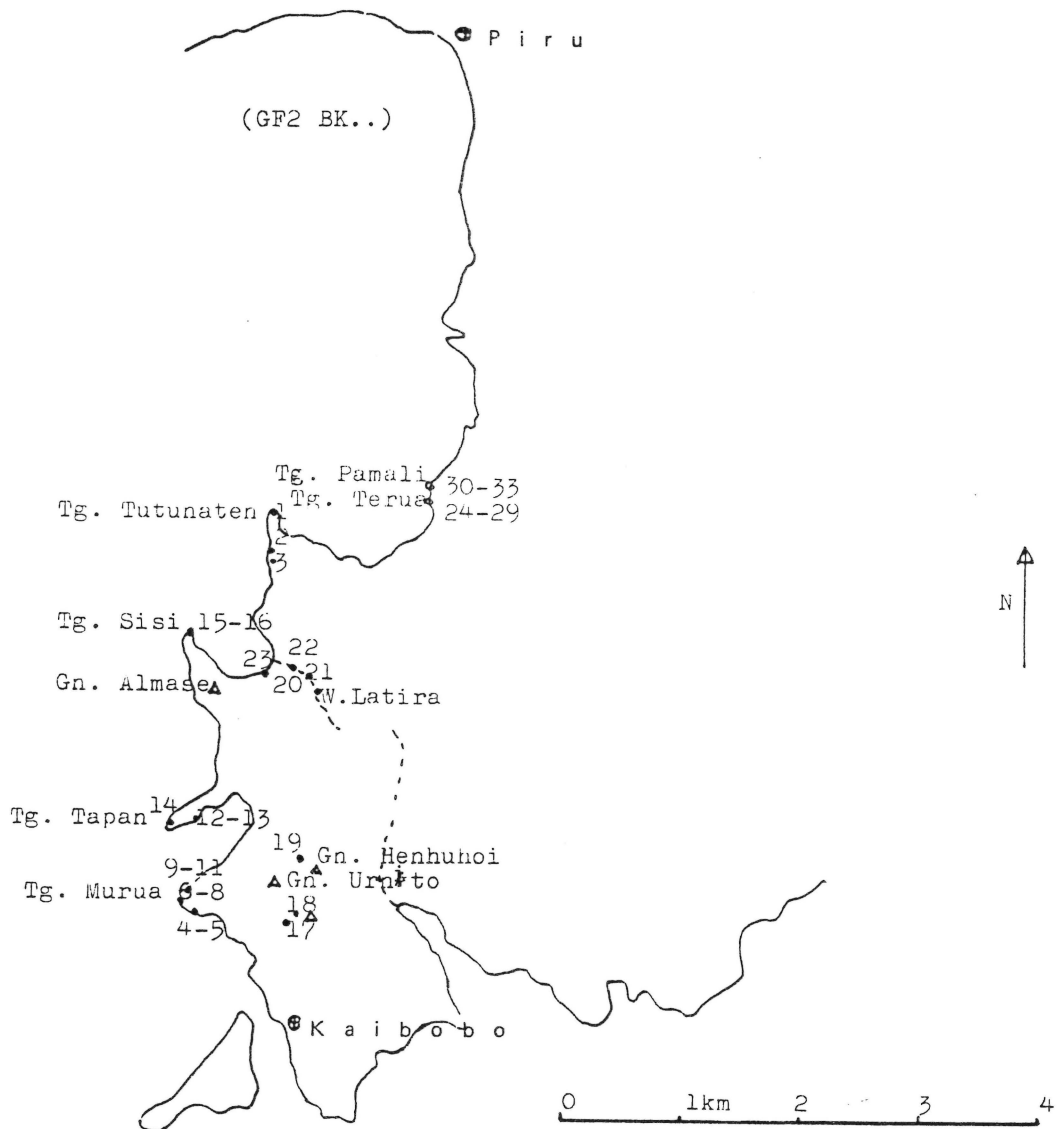
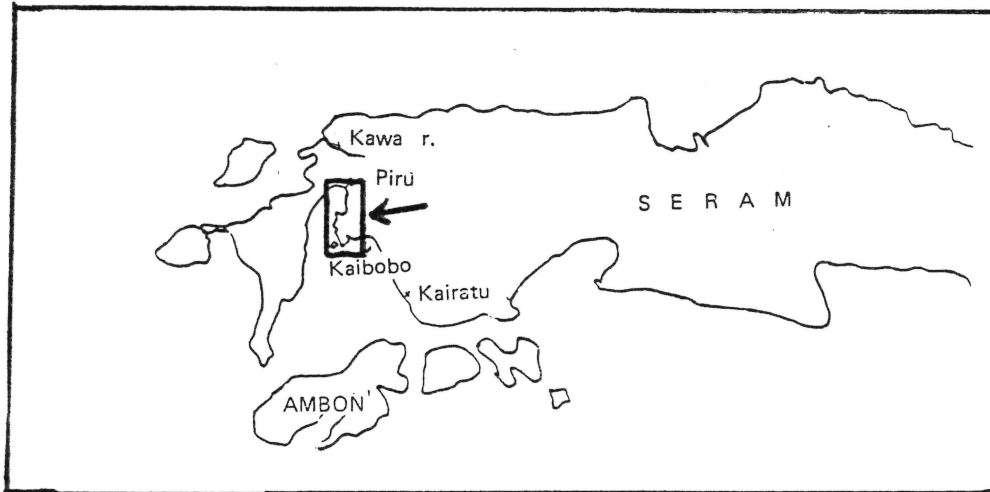






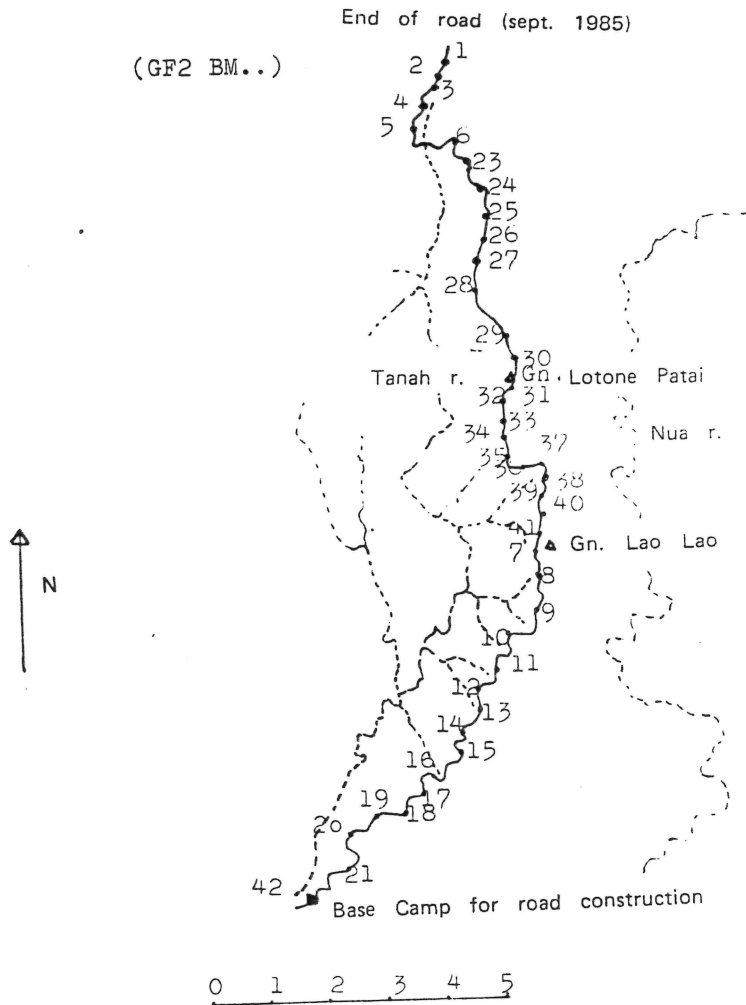
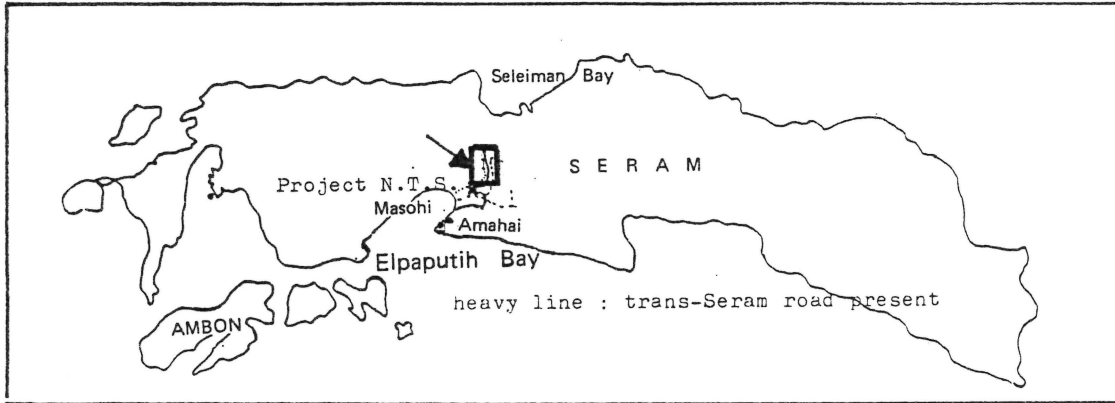






LOCATION MAP OF GF2BK SAMPLES (team B), WEST SERAM

Encl. 17



LOCATION MAP OF GF2BM SAMPLES (team B), CENTRAL SERAM
Encl. 18

