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and D.M. Finlayson

AGSO Record 2000/40

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The Rabaul Earthquake Location and Caldera Structure (RELACS) Program: Post-Survey Data Processing

A component of the PNG-Australia Volcanological Services Support (VSS) Project funded by AusAID

AGSO Record 2000/40

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EXECUTIVE SUMMARY

The Rabaul Earthquake Location and Caldera Structure (RELACS) program is part of a project undertaken by the Australian Geological Survey Organisation (AGSO) for the Australian Agency for International Development (AusAID). The project, known as the PNG-Australia Volcanological Service Support (VSS) Project Phase 2, is designed to provide material assistance and training to the Rabaul Volcanological Observatory (RVO) following the disastrous 1994 eruption of the Rabaul Volcano. The background and objectives of the VSS project are set out in the Project Design Document submitted to AusAID in November 1996.

The RELACS component of the VSS Project aims to improve the capabilities of RVO to locate and interpret volcano-related earthquake activity near Rabaul. In particular the RELACS program aims are:

- to provide an improved 3-dimensional model of the seismic-wave velocity structure in the Rabaul volcano area to depths of at least 15 km in order to improve the precision with which the locations of volcano-related earthquakes can be determined.
- to improve knowledge and imaging of magma storage and possible magma generation regions at depths down to 50 km.
- to provide an improved capacity to analyse, interpret and display data from the Rabaul earthquake database using the planned Volcano-hazard Mapping and Information System (VMIS) for public planning and decision making.

To achieve these aims, a program of seismic field observation was undertaken in the Rabaul area by a consortium of institutions with significant experience in seismic work, namely the Australian Geological Survey Organisation (AGSO), the Australian National University (ANU), the University of Hokkaido, and the University of Wisconsin.

This Record describes post survey data processing of RELACS field data undertaken at the ANU, the University of Hokkaido and AGSO during 1998-1999. The Record also includes compact discs (CDs) of data files containing information on seismic recording stations, seismic shots, earthquake locations, the arrival times (picks) of seismic waves (phases) at the various seismic sites, and seismic record files from stations in the international SUDS format.

CONTENTS

INTRODUCTION

The seismic data acquisition phase of the RELACS Project was carried out in the Rabaul area, New Britain, during 1997-1998. A detailed description of the field operations in the Rabaul region and how the seismic data were acquired is given in the operations report compiled by Finlayson et al. (2000, in prep). This document describes the processing of these seismic data from their procurement on 'JAZ' cartridges and CDs to final archiving of SUDS format data and picked event files on tape and CD.

Fig. 1 is a map of the Rabaul area showing the locations of seismic recording stations (onshore and offshore) and marine seismic shots fired in the sea areas around Rabaul. The coordinates and other details of recording stations and seismic shots are contained in Appendix 1 and Appendix 2 (from Finlayson et al., 2000 in prep).

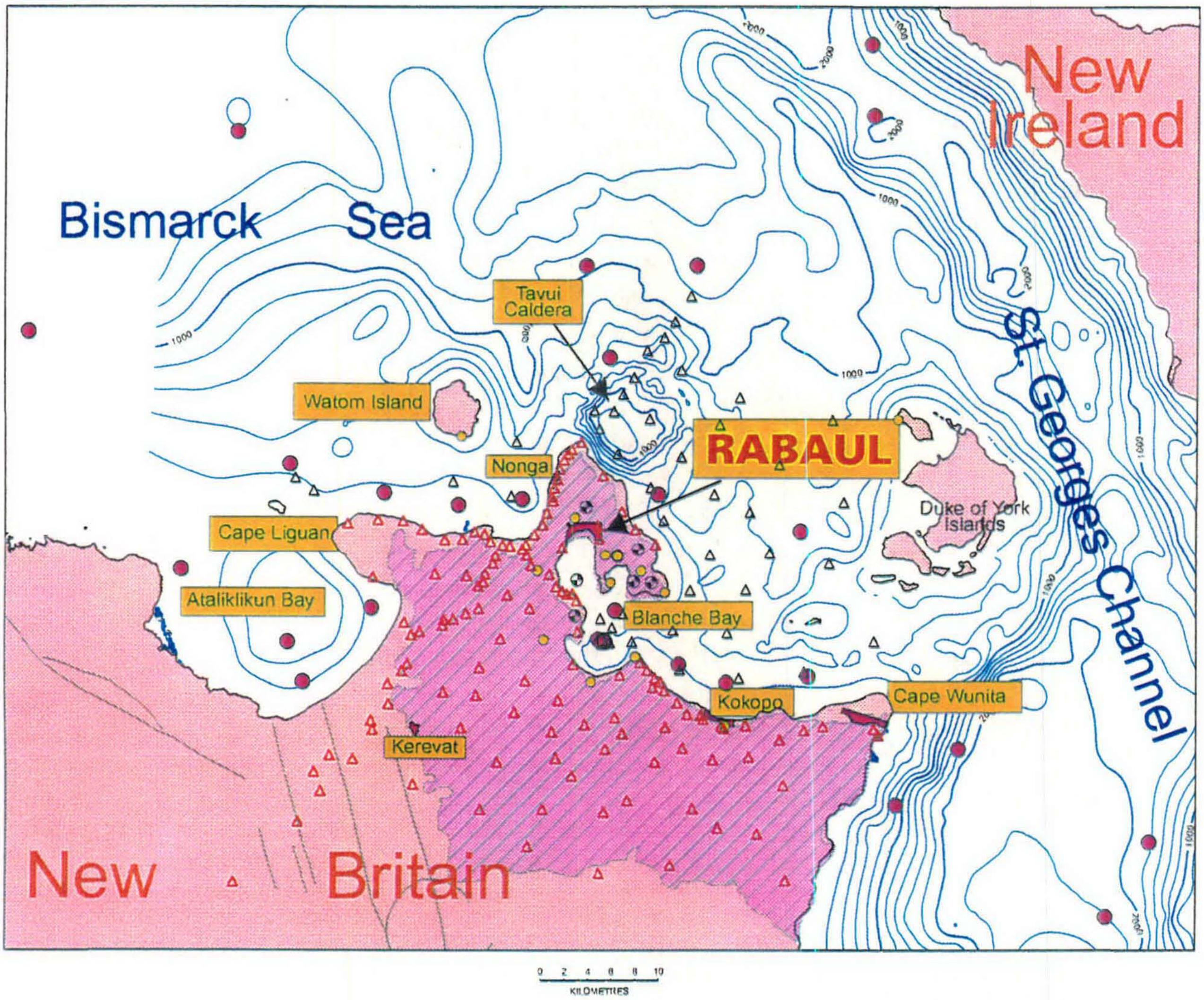

Fig. 1 Location of recording stations, ocean bottom seismographs and marine seismic shots during the 1997-98 RELACS investigations in the Rabaul region, eastern New Britain, Papua New Guinea. Δ – onshore recording stations and ocean bottom seismograph stations; • – marine seismic shot locations; O - RVO seismic stations; ⊕ - active volcanic centres.

OUTLINE OF DATA ACQUISITION IN THE RABAUL REGION

The equipment used to acquire seismic data in the Rabaul area and survey logistics are discussed in detail by Finlayson et. al, (2000 in prep.). The data described in this Record were mostly acquired using ANU Flashcard Recorders. These recorders used solid-state PC cards (flashcards) as the data mass storage devices in each recorder (two per recorder). During service visits to the seismic sites these flashcards were exchanged to maintain continuous recording. Data were then downloaded to larger storage devices at a central processing office based at the Rabaul Volcanological Observatory (RVO).

Field procedures

A brief summary of the procedures adopted during the data acquisition phase is outlined below:

- During each visit to a flash-card recorder the used flash cards were extracted and fresh (erased) cards put in their place. The data recording format used by the ANU-built flash-card recorders is designated as ANUF.
- At the end of the day the field party brought back to the office the 10-20 cards from 5-10 instruments they had serviced during that day.
- The contents of each flash card were then dumped on to a PC hard disk and the files examined and checked for errors. The integrity of the file format was routinely examined. Also routinely examined were the GPS time corrections applied to the internal clock. (An improved computer utility subsequently developed for examining files in ANUF format is PCPLOT03.C which can plot the raw data, display header information and output GPS clock times.)
- Trace noise levels and waveform snapshots were studied, and frequent cross-checks of the analog seismic records at RVO were made to find true events.
- The file name convention used was STN_XYZT.DAT where STN = station code, XYZ = 'Julian' day number of recovery of data from the recorder, and T = flash card number (e.g. R11_3081.DAT).
- After each file had been examined and there were sufficient files to fill a CD and a JAZ data storage cartridge, the data were archived and the files erased from the PC hard disk.
- The archives on CDs and JAZ cartridges were stored in the office at RVO until the end of the survey and then airfreighted to the ANU in Canberra.

Data processing stages

For the purposes of this Record the processing of these field data is subdivided into three stages:

- Stage 1: data conversion from ANUF field data to SUDS format on PC
- Stage 2: manual picking of seismic events
- Stage 3: automatic picking of events and final archiving of data on tape and CD.

In addition to the ANUF recorders mentioned above, other instrument types used in the RELACS survey included ocean-bottom seismographs (OBS) from the University of Hokkaido, two broad-band seismographs (RefTek) from the ANU, and the instruments of the RVO harbour network.

Data retrieval from OBS instruments in the field was handled by the University of Hokkaido staff. Each instrument recorded internally on digital or analog tape. Tapes from each instrument were checked for format integrity and time calibration and then archived in the office at RVO until the end of the RELACS survey when they were airfreighted to the University of Hokkaido for analysis.

Data retrieval from RefTek broad-band instruments was handled by RELACS staff. The data were recorded on hard disk in the recorder. When full (after three weeks recording) the disk was replaced and the used disk taken to the office at RVO where it was copied to tape and stored until the completion of the survey. The tapes were then transported to the ANU in Canberra for analysis.

DATA PROCESSING STAGE 1: CONVERSION OF FIELD DATA TO SUDS FORMAT AND PRELIMINARY ARCHIVING

The data archiving format used by RVO is an international standard format developed by staff at the United States Geological Survey; the acronym for this format is SUDS (Seismic Unified Data System). This is the sensible choice of format for the RELACS data and the RELACS project was obliged to produce a seismic data archive in SUDS format.

The field recording during the RELACS survey was continuous at each site. Most of the time the recording is of seismic noise and other events of no interest to the project. Events of interest included the marine seismic explosions detonated as part of the RELACS programme, and natural earthquakes, both local and distant, that may occur at any time.

Automatic event detection

The first data processing step undertaken by RELACS staff consisted of developing an automated event detection routine that was then used to construct lists of seismic events for all land recorders in operation at any given time throughout the RELACS survey. Cross comparison of the timing of these events at all the recording stations then served the purpose of eliminating various noise events at individual sites caused by vehicles and people.

The RELACS event list

Approximately 2300 events were detected automatically. Of those, about 850 events were recorded by more than 50% of all recording stations in operation. These 850 events form the basis of a seismic event list for which data were archived.

The National Earthquake Information Center (NEIC) of the US Geological Survey collects earthquake recordings from all over the Earth and locates the earthquakes on a routine basis. Bulletins of preliminary determinations of epicentres (PDE) are reported a few months after the event. Information from these bulletins was used to augment the event list for the RELACS archive and to identify a number of the detected events, especially teleseismic events (i.e. earthquakes at a large distance from Rabaul). The additional events were chosen at strategic locations and azimuths where the earthquake magnitude indicated that the event might be detected at Rabaul.

The event list ultimately used for the construction of the RELACS data archive was named EVLIST.ALL (see Appendix 3). This list contains 977 events of which 30 were the RELACS project marine seismic shots.

Seismic waveform extraction from field CDs

Program CODFATSG.C was developed at the Research School of Earth Sciences (RSES) at ANU by Armando Arcidiaco to extract data from the CD archive, in the original ANUF format, and convert this into SUDS format data on a PC. Batch file processing was used, in conjunction with a number of Fortran programs, to facilitate this process. This program incorporated a number of error checking routines that automatically checked the validity of header information supplied by the original ANUF files and corrected this information in the output SUDS files. This process was carried out for all events on the event lists for all ANUF files returned from Rabaul on approximately eighty CDs.

Usually two minutes of data were extracted for each station/event combination. This normally meant 6000 data samples per channel at the usual sample frequency of 50 samples per second. This was increased to three minutes and more for distant events (the greater the distance to the event, the greater the time separation of P waves and S waves, thus the need for a longer record).

Data from OBS instruments were extracted and digitised at the University of Hokkaido, then sent via the internet to ANU where they were converted to SUDS format using software developed by Olafur Gudmundsson and incorporated into the RELACS archive. Data from broad-band instruments were extracted and converted to SUDS format at the ANU. Data from RVO stations in SUDS format were transported to the ANU on a ZIP cartridge and incorporated there into the RELACS archive.

File labelling and preliminary archiving

With a view to archiving data the following strategy was adopted for labelling seismic waveform files:

- Seismic stations were categorised according to type, and the data files extracted from a particular station assigned a prefixed letter, S, B, R or O, according to this type (refer to file SITES.DAT for location of stations and recorder type). Letter 'S' designates ANU Flashcard recorders at RELACS land stations, 'B' designates broad-band RefTek stations, 'R' designates Rabaul Vulcanological Observatory (RVO) permanent sites, and O designates the Hokkaido University ocean bottom seismograph (OBS) stations.
- Files also contained a five digit numeric part following this letter which represented 'Julian' day, hour and minute of start time of trace. File suffixes were given the three-character station code. Thus B3310152.V19 represents event data for broad-band station V19 which occurred at 'Julian' day 331, hour 01, and minute 52. Although the RELACS experiment ran into a second year there was no ambiguity with 'Julian' days because there was no overlap in day numbers, the experiment running from day 237 of 1997 to day 022 of 1998.
- Using a similar scheme, all files for the same event were placed in a subdirectory prefixed 'E' followed by the same seven-digit event name as used for its contained files. For example, the file S3141133.K03 would occur in subdirectory E3141133 - all these subdirectories being contained in directory EVENTS. Thus the first three event directories of the archive have the following structure:

EVENTS

E2371151

(All SUDS files for event time 2371151)

S2371151.I10
S2371151.K03
S2371151.R29
S2371151.V28
etc...........

E2371527

(All SUDS files for event time 2371527)

S2371527.I10
S2371527.K03
S2371527.K61
S2371527.K67
etc...........

E2371805

(All SUDS files for event time 2371805)

S2371805.I10
S2371805.S66
S2371805.T09
S2371805.V01
etc...........

In addition, each event was assigned an event ***number***, an integer 1 to 977 based on each event's chronological position in the 'Julian' day/hour/minute sequence (see file EVLIST.ALL and Appendix).

DATA PROCESSING STAGE 2: MANUAL SEISMIC PHASE (EVENT) TIME PICKING

A subset of the original event list, EVLIST.ALL, was made covering all RELACS marine seismic shots and some natural earthquake events for which there was a high detection response of the RVO stations, along with a handful that were to provide additional coverage at particular distances and azimuths. This file was called EVLIST.PIC (the list of events that were to be subsequently picked).

Viewing waveform data on screen

Manual picking of events in the EVLIST.PIC file was first conducted for the RELACS marine seismic shots. Initially the International Association of Seismology and Physics of the Earths Interior (IASPEI) program PITSA was used for event picking, however it was found to be time consuming due to the fact that the frequent mouse and keyboard operations had to be used alternately. It was also found to be unstable, especially when filtering had to be applied. Moreover, output was not 'user friendly' and did not contain much information that was of interest, such as a quantified measure of signal to noise (S/N) ratio and distance to the event.

Hence an in-house ANU program, 7VIEWSUD.C, was developed that improved and extended these elements which were deficient in PITSA. 7VIEWSUD was developed as an event picking program that operated entirely from the keyboard and which produces a separate output file for each event - VPICK.XXX where XXX is Event Number (refer to Appendix for format of VPICK files). Full operating instructions for the running of 7VIEWSUD can be found in file 7VIEWSUD.DOC in the STAGE2 archive directory.

Event time picking procedures

To assist in the picking of events for which the S/N ratio was relatively low, two procedures were adopted, the procedure used depending on the nature of the signal and whether or not a provisional location was given in the event list. Events for which traces had a weak signal, but still recognisable on many stations, *and* for which a location was given, would be scanned with 7VIEWSUD to determine a station that possessed a high quality signal. The arrival time at this station would then be used, together with the location of the event, to predict an arrival time for every other station. This narrowed the search band considerably. However, traces would only be picked for which there was an unambiguous onset. The program developed for the prediction of the arrival times was DISTANCE.FOR (see Appendix 3).

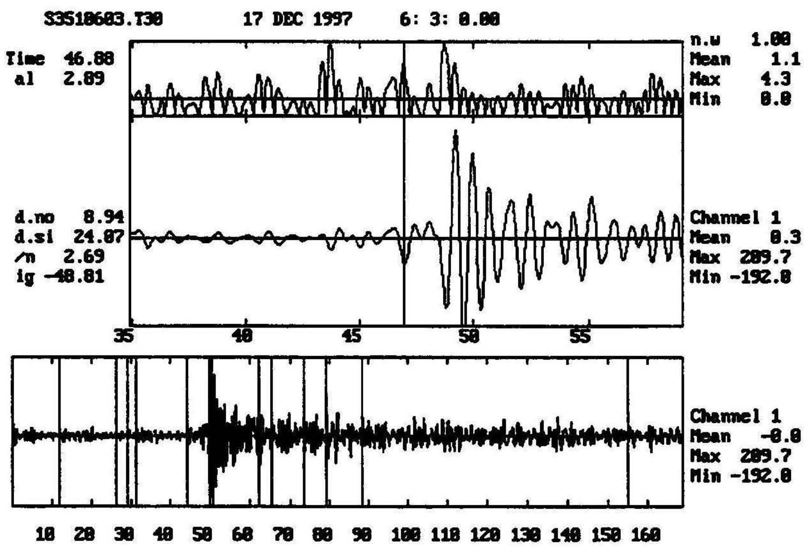

Fig. 2 Window of 7VIEWSUD program showing features evident on the trace for Station T30, Event 809 (3510603) after medium band (1.0 - 3.0 Hz) filtering,.

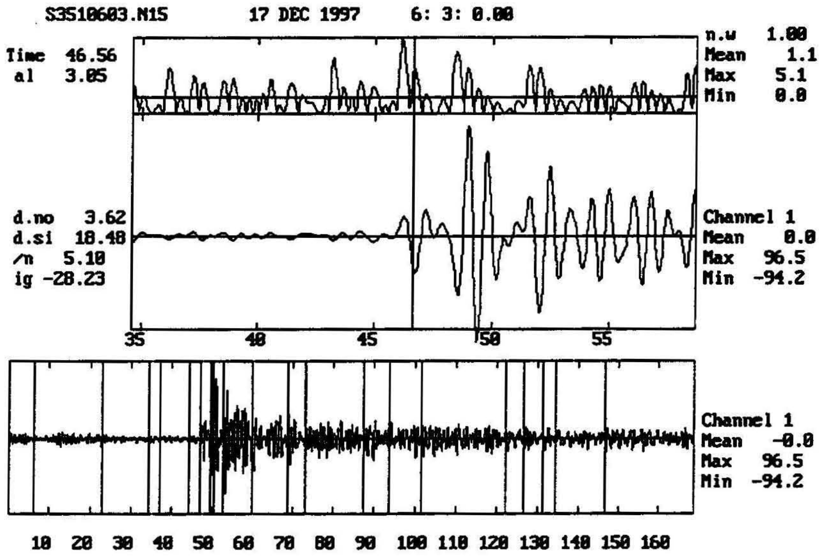

Fig. 3 Window of 7VIEWSUD program for Station N15, Event 809 (3510603) after medium band (1.0 - 3.0 Hz) filtering in which the same features as seen in Figure 2 can be identified.

The second procedure was applied to events for which the seismic event could only be recognised after the traces had been subjected to filtering - invariably teleseismic events with filtering window chosen as 0.1-1.0 Hz. This procedure involved the picking of 'features', usually two or three on each trace, recognisable for most stations, and taking mean $[M_l]$ times of arrival of these features and subtracting a Δt value, Δt being defined as [time of first arrival] - $[M_i]$ for the clearest trace (i.e. the trace with the highest S/N ratio). This method produced arrival times that were relatively consistent (see Fig. 2 and Fig. 3) for many events which responded well to filtering. The degree to which these arrival times corresponded with true onset times was dependent on the quality of just one trace - the clearest - and to some extent on the magnitude of the Δt value. However, by testing this method on some teleseismic events for which all arrivals were clear, it was considered that the difference between true arrival times and those calculated on the basis of this procedure were generally less than 0.1 second.

Event time archive

Upon analysis of events from EVLIST.PIC it was found that for twenty-seven of them no recognisable signal was apparent in the trace, even after filtering. These event files and their associated directories were subsequently deleted leaving a total of 948 events remaining in the archive.

Some 145 events were manually picked representing a total of 11,860 phases. About 90% of these were first arrival P-wave phases, the remainder being S-wave phases. A Microsoft Excel 'radar' plot of azimuth/distance of these events is shown in Figure 4. It can be seen from this plot that all azimuths are represented by at least one event. This distribution is sufficient for the purpose of seismic undershooting the Rabaul volcano to illuminate the deep crustal structure beneath it. The excess of data from southerly azimuths is a consequence of the uneven distribution of seismicity around Rabaul. The limited rate of seismicity to the north dictated the length of the RELACS observational period.

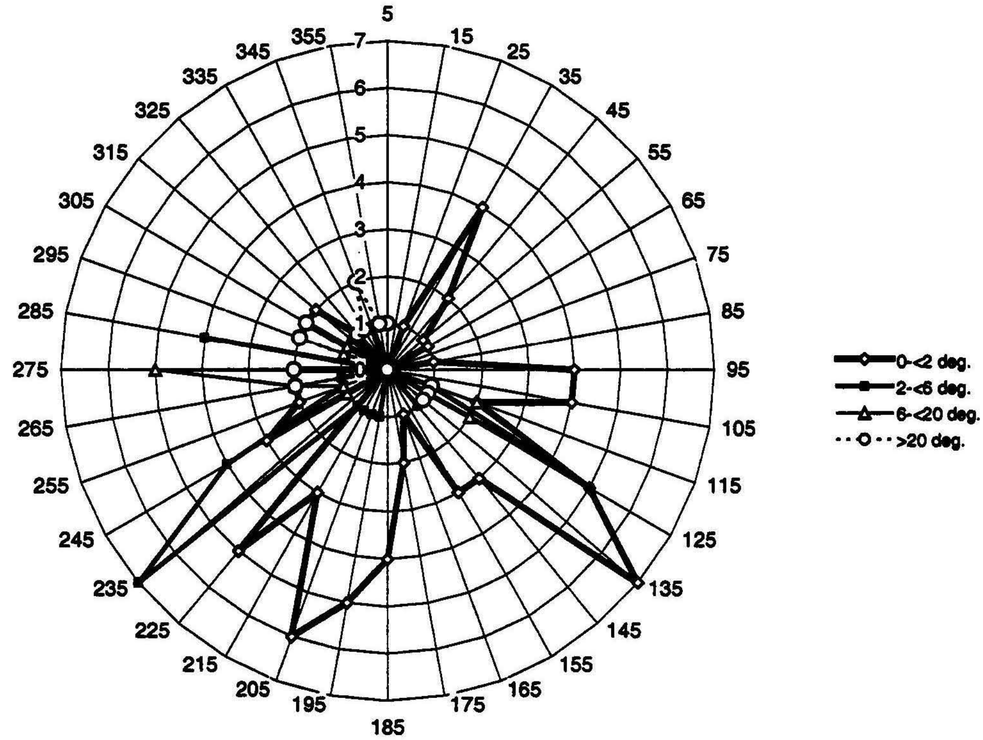

Fig. 4 Azimuth and distance of manually picked RELACS seismic events.

DATA PROCESSING STAGE 3: AUTOMATIC SEISMIC PHASE (EVENT) TIME PICKING

The remainder of the archive is not of direct use for the purposes of the RELACS project. The 803 events that were not manually picked consist primarily of tectonic events related to the subduction processes at the New Britain Trench and crustal deformation in the area around the triple junction between the Solomon, Bismarck and Pacific plates. These events are clearly detected only by the RELACS array, but not by other seismic networks, and thus have not been located. They are potentially a valuable source of information about the deeper structure and tectonics of the area. In order to make these data more accessible an automated picking procedure was developed at RSES by Armando Arcidiaco to quickly construct a database of onset times for these events.

The resulting automatic picking program, AUTOPICK.C, performed well with respect to the picking of P-wave phases. It was set up to run under batch file processing and the arrival times for the remaining 803 events picked and archived. The resulting pick files were named APICK.XXX (where XXX is the event number) to distinguish them from the manually picked VPICK.XXX files. Program HISTOGM.FOR was written to give a quick overview of the reliability of APICK (and VPICK) files by plotting a histogram of arrival times with station code as ordinate (see Appendix

3). Stations with large deviations from a modal distribution (or bimodal distribution in the case of VPICK files with S-wave phases) were deleted using program DELSTN.C (see Appendix 3).

DATA ARCHIVING

A final archive of data was made at RSES on tape ('exabyte' tapes in both PC and Unix format) and at AGSO on CD ROM. The SUDS data have been archived in directory EVENTS with the structure detailed under Stage 1 above; the 'VPICK' and 'APICK' files have been placed in directories of the same name; processing utilities, data files and 'readme' files that correspond to the various stages discussed in this document have been archived under STAGE1, STAGE2 and STAGE3 directories. A complete listing of source codes of C programs, Fortran programs, include files and batch files that were used in the data processing (excluding IASPEI routines) occurs in directory MISCELLANEOUS.

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APPENDIX 1

SEISMIC STATION INFORMATION

Notes: ANUSS = ANU solid-state (flashcard) recorder; UW = University of Wisconsin recorder; RefTek = ANU Broadband Refraction Technology recorder; RVO = RVO permanent harbour network station; UH = University of Hokkaido ocean bottom seismograph; GPS = Garmin 12XL positioning; DGPS = Ashtech Z12 differential GPS positioning.

Stage 1 = 21 Aug. – 3 Nov. 1997; Stage 2 = 4-17 Nov. 1997; Stage 3 = 18 Nov. 1997 – 12 Jan 1998.

Site No.	Site code	Site name	Latitude Degrees S	Longitude Degrees E	Elevation (m)	Positioning method	Recorder type	Recording stage
1	V01	Vuvu	-4.211803	152.126376	14.9	DGPS	ANUSS	1, 2, 3
2	R02	Ramalmal	-4.225831	152.101142	81.4	DGPS	ANUSS	1, 2, 3
3	K03	Kabakada	-4.204375	152.094998	54.7	DGPS	ANUSS	1, 2, 3
4	R04	Raluana 3	-4.233704	152.057366	152.3	DGPS	ANUSS	1, 3
5	T05	Tovakudum	-4.193792	152.033316	6.4	DGPS	ANUSS	1, 2, 3
7	K07	Kabaira	-4.236335	152.010381	13.7	DGPS	ANUSS	1, 3
8	G08	Geo. Brown HS	-4.269849	152.034136	24.4	DGPS	ANUSS	1, 2, 3
9	T09	Tokelikel	-4.271879	152.063075	94.8	DGPS	ANUSS	1, 2, 3
10	I10	Iatapal	-4.259583	152.090534	215.9	DGPS	ANUSS	1, 2, 3
11	R11	Raluan 2	-4.259636	152.129089	282.1	DGPS	ANUSS	1, 3
12	R12	Rapopo	-4.281969	152.106941	259.7	DGPS	ANUSS	1, 3
13	V13	Vunagogo	-4.313389	152.125663	366.1	DGPS	ANUSS	1, 3
14	T14	Tingnagalip	-4.303531	152.091007	217.9	DGPS	ANUSS	1, 3
15	N15	Napapar	-4.336967	152.117424	290.9	DGPS	ANUSS	1, 2, 3
17	T17	Tavilo	-4.306021	152.032243	29.4	DGPS	ANUSS	1, 2, 3
18	N18	Napapar 4	-4.348788	152.076955	161.4	DGPS	ANUSS	1, 3
19	V19	Vudal	-4.350050	152.009933	20.0	GPS	RefTek	1, 2, 3
20	L20	Lianga 1	-4.391284	152.040558	38.1	DGPS	ANUSS	1
21	V21	Vunagomore	-4.324385	152.088218	193.8	DGPS	ANUSS	3
22	T22	Tolam	-4.410011	152.091499	159.1	DGPS	ANUSS	1, 3
23	R23	Rapitok	-4.374487	152.104245	194.5	DGPS	ANUSS	1, 3
24	V24	Vunakabi	-4.351816	152.145798	413.7	DGPS	ANUSS	1, 2, 3
25	P25	Palabarip	-4.346400	152.170666	380.0	GPS	AUNSS	3
26	G26	Gunanur	-4.327976	152.150407	329.6	DGPS	ANUSS	1, 3
27	R27	Rabagi 1	-4.371688	152.148568	352.9	DGPS	ANUSS	3
28	V28	Vunamurmur	-4.309052	152.197712	202.2	DGPS	ANUSS	1, 2, 3
29	R29	Ranguna	-4.318601	152.222604	55.4	DGPS	ANUSS	1, 2, 3
30	T30	Tagarima	-4.348333	152.232166	120.0	GPS	AUNSS	3
31	T31	Tinganalom	-4.341212	152.193949	290.3	DGPS	ANUSS	1, 3
32	G32	Gunanba Vil.	-4.365004	152.186802	292.7	DGPS	ANUSS	1, 2, 3
33	M33	Mamata	-4.385022	152.160928	331.1	DGPS	ANUSS	1
34	T34	Takubar	-4.409972	152.138803	129.4	DGPS	ANUSS	1, 3
35	R35	Rabata	-4.437778	152.127582	116.0	DGPS	ANUSS	1
36	N36	Nukumal	-4.458709	152.181997	129.1	DGPS	ANUSS	1
37	W37	Wairiki	-4.412266	152.185650	200.0	GPS	ANUSS	3
38	M38	Malakuna 4	-4.403460	152.203529	197.1	DGPS	ANUSS	1, 2, 3
39	L39	Lianga 2	-4.391205	152.040599	42.5	DGPS	ANUSS	1
40	H40	Gunanba Sch.	-4.353414	152.199480	264.6	DGPS	ANUSS	1, 3
41	V41	Vunamami	-4.338702	152.248666	65.5	DGPS	ANUSS	1, 2, 3
42	V42	Vunapope	-4.349415	152.276403	60.0	DGPS	ANUSS	1, 2
43	T43	Tinganavudu	-4.374616	152.224283	200.0	GPS	ANUSS	3
44	G44	Gunanur 2	-4.372884	152.268084	107.5	DGPS	ANUSS	1, 3
45	T45	Tobera 1	-4.409566	152.252800	165.0	GPS	ANUSS	3
46	C46	Clifton	-4.452470	152.236163	100.2	DGPS	ANUSS	1
47	T47	Tobera 2	-4.424000	152.271800	155.0	GPS	ANUSS	3
48	B48	Bitagalip	-4.370905	152.295357	77.7	DGPS	ANUSS	1, 3
49	R49	Ralubang	-4.428533	152.301800	200.0	GPS	ANUSS	3
50	U50	Ulaveo	-4.347699	152.351299	39.5	DGPS	ANUSS	1, 2
52	T52	Tapo	-4.392288	152.321538	123.9	DGPS	ANUSS	1
54	W54	Watwat	-4.464019	152.323470	168.7	DGPS	ANUSS	1, 2, 3

55	V55	Vunatat	-4.235146	152.081171	158.4	DGPS	ANUSS	3
56	R56	Raburbur	-4.249831	152.112193	228.5	DGPS	ANUSS	3
57	V57	Vunavai	-4.321905	152.063456	141.6	DGPS	ANUSS	3
61	K61	Karavia	-4.301230	152.161916	15.8	DGPS	ANUSS	1, 2, 3
64	V64	Volavolo	-4.179088	152.146747	38.7	DGPS	ANUSS	1, 2, 3
65	T65	Tavui	-4.148214	152.154871	20.2	DGPS	ANUSS	1, 2, 3
66	S66	Subbase	-4.134765	152.167950	11.5	DGPS	ANUSS	1, 2, 3
67	K67	Korere	-4.160208	152.185156	12.2	DGPS	ANUSS	1, 2, 3
68	N68	Nodup	-4.200451	152.209396	32.6	DGPS	ANUSS, UW	1, 2, 3
69	B69	Baai	-4.211747	152.224891	27.1	DGPS	ANUSS, UW	1, 2, 3
70	M70	Malaguna 2	-4.214084	152.153743	32.7	DGPS	ANUSS	3
71	K71	Vulcan Boat	-4.248749	152.161573	6.9	DGPS	ANUSS	3
72	B72	Boisen	-4.187000	152.199150	20.8	DGPS	ANUSS	3
80	U80	Ulagunan	-4.364131	152.245305	135.4	DGPS	ANUSS	1, 3
83	V83	Vulcan	-4.277149	152.165384	17.9	DGPS	ANUSS, UW	1, 2, 3
90	M90	Magazine	-4.197533	152.180700	6.0	DGPS	UW	1, 2, 3
92	K92	Kiavuna	-4.207333	152.181933	3.1	DGPS	RefTek	1, 2, 3
101	X01	X01	-4.354500	152.393133	15.0	GPS	ANUSS	2
102	X02	X02	-4.349766	152.389650	30.0	GPS	ANUSS	2
103	X03	X03	-4.350700	152.337050	25.0	GPS	ANUSS	2
104	X04	X04	-4.357950	152.318600	40.0	GPS	ANUSS	2
105	X05	X05	-4.347235	152.292858	17.0	DGPS	ANUSS	2
106	X06	X06	-4.347764	152.274461	21.9	DGPS	ANUSS	2
107	X07	X07	-4.342149	152.260934	64.8	DGPS	ANUSS	2
108	X08	X08	-4.339335	152.259076	49.3	DGPS	ANUSS	2
109	X09	X09	-4.330316	152.241266	40.0	GPS	ANUSS	2
110	X10	X10	-4.321033	152.231350	30.0	GPS	ANUSS	2
111	X11	X11	-4.314483	152.228716	20.0	GPS	ANUSS	2
112	X12	X12	-4.311583	152.224316	20.0	GPS	ANUSS	2
113	X13	X13	-4.305633	152.218583	20.0	GPS	ANUSS	2
114	X14	X14	-4.300083	152.212800	30.0	GPS	ANUSS	2
115	X15	X15	-4.253856	152.164652	11.3	DGPS	ANUSS	2
116	X16	X16	-4.248749	152.161573	6.9	DGPS	ANUSS	2
117	X17	X17	-4.249081	152.157561	5.9	DGPS	ANUSS	2
118	X18	X18	-4.247025	152.153933	1.6	DGPS	ANUSS	2
119	X19	X19	-4.243500	152.149066	20.0	GPS	ANUSS	2
120	X20	X20	-4.234163	152.143901	27.4	DGPS	ANUSS	2
121	X21	X21	-4.227487	152.130137	63.4	DGPS	ANUSS	2
122	X22	X22	-4.219833	152.126855	47.9	DGPS	ANUSS	2
123	X23	X23	-4.215346	152.123350	30.4	DGPS	ANUSS	2
124	X24	X24	-4.212717	152.114216	23.6	DGPS	ANUSS	2
125	X25	X25	-4.212073	152.108421	25.6	DGPS	ANUSS	2
126	X26	X26	-4.209523	152.099464	32.3	DGPS	ANUSS	2
127	X27	X27	-4.207643	152.078248	16.9	DGPS	ANUSS	2
128	X28	X28	-4.208025	152.064740	22.4	DGPS	ANUSS	2
129	X29	X29	-4.200607	152.047723	15.0	DGPS	ANUSS	2
130	X30	X30	-4.193160	152.014235	9.3	DGPS	ANUSS	2
131	X31	X31	-4.196100	151.991416	5.0	GPS	ANUSS	2
166	X66	X66	-4.202133	152.087451	15.8	DGPS	ANUSS	2
201	Y01	Y01	-4.140316	152.160517	13.9	DGPS	ANUSS	2
202	Y02	Y02	-4.143800	152.158050	14.1	DGPS	ANUSS	2
203	Y03	Y03	-4.154916	152.151750	15.0	GPS	ANUSS	2
204	Y04	Y04	-4.162908	152.150016	13.4	DGPS	ANUSS	2
205	Y05	Y05	-4.169216	152.146750	13.2	DGPS	ANUSS	2
206	Y06	Y06	-4.175933	152.145900	14.4	GPS	ANUSS	2
207	Y07	Y07	-4.188090	152.141934	10.7	DGPS	ANUSS	2
208	Y08	Y08	-4.196967	152.138960	11.5	DGPS	ANUSS	2
209	Y09	Y09	-4.204159	152.132619	6.0	DGPS	ANUSS	2
210	Y10	Y10	-4.215346	152.123350	30.4	DGPS	ANUSS	2
211	Y11	Y11	-4.212717	152.114216	23.6	DGPS	ANUSS	2
212	Y12	Y12	-4.220464	152.102985	53.0	DGPS	ANUSS	2
213	Y13	Y13	-4.233857	152.095315	187.4	DGPS	ANUSS	2
214	Y14	Y14	-4.239806	152.093971	159.1	DGPS	ANUSS	2
215	Y15	Y15	-4.242800	152.089966	160.0	GPS	ANUSS	2
216	Y16	Y16	-4.263466	152.080666	160.0	GPS	ANUSS	2
217	Y17	Y17	-4.267600	152.071266	130.0	GPS	ANUSS	2
218	Y18	Y18	-4.267950	152.063866	90.0	GPS	ANUSS	2
219	Y19	Y19	-4.276850	152.045766	45.0	GPS	ANUSS	2
220	Y20	Y20	-4.279166	152.039366	21.5	GPS	ANUSS	2
221	Y21	Y21	-4.300533	152.036483	40.0	GPS	ANUSS	2

222	Y22	Y22	-4.315600	152.021583	20.0	GPS	ANUSS	2
223	Y23	Y23	-4.330785	152.022015	11.5	DGPS	ANUSS	2
224	Y24	Y24	-4.372087	151.995159	17.5	DGPS	ANUSS	2
225	Y25	Y25	-4.369471	151.977573	75.9	DGPS	ANUSS	2
226	Y26	Y26	-4.381838	151.965820	98.2	DGPS	ANUSS	2
227	Y27	Y27	-4.396169	151.970772	193.0	DGPS	ANUSS	2
228	Y28	Y28	-4.419295	151.953820	389.1	DGPS	ANUSS	2
229	Y29	Y29	-4.464998	151.905304	599.1	DGPS	ANUSS	2
230	Y66	Y233	-4.343200	152.008783	15.0	GPS	ANUSS	2
301	SUL	Sulphur Ck.	-4.219316	152.186700	7.7	DGPS	UW	1, 2, 3
302	TAV	Tavurvur	-4.231416	152.213833	40.0	GPS	UW	1, 2, 3
303	RAL	Rabalanakaia	-4.220166	152.195983	89.4	DGPS	RVO	1, 2, 3
305	DOY	Duke of York	-4.117483	152.407516	27.7	DGPS	RVO	1, 2, 3
306	VPE	Vunapope	-4.347416	152.277283	50.0	GPS	RVO	1, 2, 3
307	MAL	Malaguna	-4.231083	152.134983	180.0	GPS	RVO	1, 2, 3
308	WTM	Watom Is.	-4.129966	152.076916	37.2	DGPS	RVO	1, 2, 3
309	TAL	Talwat	-4.247666	152.232083	50.0	GPS	RVO	1, 2, 3
310	VUL	Vulcan	-4.282633	152.139700	320.0	GPS	RVO	1, 2, 3
311	RPT	Raluana Pt.	-4.295100	152.209316	4.0	GPS	RVO	1, 2, 3
312	TUN	Tunnel Hill	-4.191450	152.163233	140.0	GPS	RVO	1, 2, 3
313	DAV	Davaon	-4.314083	152.175333	100.0	GPS	RVO	1, 2, 3
314	KPT	Kaputin Pt.	-4.240116	152.190733	3.2	DGPS	RVO, UW	1, 2, 3
315	NAM	Namatanai	-3.665300	152.441600	5.0	GPS	PNG	1, 2, 3
401	O01	OBS01	-4.284950	152.189600	-230.0	GPS	UH	
402	O02	OBS02	-4.263480	152.200370	-110.0	GPS	UH	
403	O03	OBS03	-4.219250	152.265530	-463.0	GPS	UH	
404	O04	OBS04	-4.117150	152.220380	-1044.0	GPS	UH	
405	O05	OBS05	-4.143480	152.196030	-915.0	GPS	UH	
406	O06	OBS06	-4.275930	152.237780	-270.0	GPS	UH	
407	O07	OBS07	-4.275930	152.237780	-270.0	GPS	UH	
408	O08	OBS08	-4.305070	152.242580	-240.0	GPS	UH	
409	O09	OBS09	-4.246320	152.250730	-359.0	GPS	UH	
410	O10	OBS10	-4.174420	152.268500	-679.0	GPS	UH	
411	O11	OBS11	-4.169270	152.220520	-166.0	GPS	UH	
412	O12	OBS12	-4.110700	152.178120	-1038.0	GPS	UH	
413	O13	OBS13	-4.164400	152.070930	-233.0	GPS	UH	
414	O14	OBS14	-4.175470	152.115270	-270.0	GPS	UH	
415	O15	OBS15	-4.134280	152.118730	-298.0	GPS	UH	
416	O16	OBS16	-4.080170	152.244030	-752.0	GPS	UH	
417	O17	OBS17	-4.100830	152.287600	-815.0	GPS	UH	
418	O18	OBS18	-4.117900	152.358330	-927.0	GPS	UH	
419	O19	OBS19	-4.151400	152.318380	-770.0	GPS	UH	
420	O20	OBS20	-4.180030	152.366470	-677.0	GPS	UH	
421	O21	OBS21	-4.218430	152.310620	-637.0	GPS	UH	
422	O22	OBS22	-4.225780	152.355980	-315.0	GPS	UH	
423	O23	OBS23	-4.284220	152.390180	-365.0	GPS	UH	
424	O24	OBS24	-4.161530	151.952300	-249.0	GPS	UH	
425	O25	OBS25	-4.171300	151.965800	-208.0	GPS	UH	
426	O26	OBS26	-4.267200	152.182930	-139.0	GPS	UH	
427	O27	OBS27	-4.274270	152.191830	-215.0	GPS	UH	
428	O28	OBS28	-4.284470	152.207230	-198.0	GPS	UH	
429	O29	OBS29	-4.124470	152.182230	-1080.0	GPS	UH	
430	O30	OBS30	-4.111320	152.193020	-1086.0	GPS	UH	
431	O31	OBS31	-4.098480	152.199670	-974.0	GPS	UH	
432	O32	OBS32	-4.085750	152.207980	-694.0	GPS	UH	
433	O33	OBS33	-4.065680	152.218230	-258.0	GPS	UH	
434	O34	OBS34	-4.055850	152.231250	-360.0	GPS	UH	
435	O35	OBS35	-4.044270	152.238920	-806.0	GPS	UH	
436	O36	OBS36	-4.024950	152.251370	-1100.0	GPS	UH	
437	O37	OBS37	-4.311570	152.288020	-343.0	GPS	UH	
438	O38	OBS38	-4.306670	152.336780	-380.0	GPS	UH	
439	O39	OBS39	-4.277850	152.278980	-449.0	GPS	UH	
440	O40	OBS40	-4.245500	152.292480	-546.0	GPS	UH	
441	O41	OBS41	-4.193850	152.230870	-382.0	GPS	UH	
442	O42	OBS42	-4.187780	152.295450	-617.0	GPS	UH	
443	O43	OBS43	-4.145970	152.243830	-406.0	GPS	UH	
444	O44	OBS44	-4.121320	152.273070	-707.0	GPS	UH	

APPENDIX 2

Seismic Marine Shot Information

Notes:
Shot depth = depth of explosive charge below water surface.
A = Position from Ashtech DGPS.
G = Position from Garmin 12XL GPS.
Position is mean of position at deployment and recovery of shot buoy.
Water depth is scaled from best available bathymetric information.
Shot No. 0 – A preliminary test shot included in events list; position is best estimate only.

Shot No.	Shot size kg.	Shot Depth m.	Water depth m.	Date UT 1997	Julian day UT	Shot hour, UT	Shot min.	Shot sec.	Ashtec or Garmin	Latitude Deg. S	Longitude Deg. E
0	25	30	222	05-Nov	309	23	19	30.040	XXX	-4.282017	152.185028
1	25	60	225	05-Nov	309	23	57	30.050	G	-4.283108	152.185717
2	25	90	228	06-Nov	310	00	42	30.068	G	-4.284400	152.186533
3	100	90	290	07-Nov	311	02	53	30.068	A	-4.309997	152.339913
4	150	90	280	07-Nov	311	04	14	30.072	A	-4.314852	152.278210
5	100	90	190	07-Nov	311	05	14	30.071	A	-4.301292	152.242350
6	175	90	90	08-Nov	312	01	40	30.064	A	-4.181953	152.074918
7	200	90	140	08-Nov	312	02	46	30.067	A	-4.172727	152.018888
8	225	90	280	08-Nov	312	04	14	30.066	A	-4.151060	151.947953
9	300	90	1850	10-Nov	314	05	39	30.069	G	-4.435108	152.598367
10	225	90	1700	10-Nov	314	07	49	30.071	G	-4.364733	152.453550
11	100	90	231	11-Nov	315	06	21	30.065	A	-4.284462	152.183152
12	300	90	1450	12-Nov	316	04	07	30.069	G	-4.051358	151.750908
13	325	90	1620	14-Nov	318	03	03	30.067	A	-3.836665	152.386405
14	225	90	1260	14-Nov	318	05	52	30.065	G	-4.002000	152.255300
15	200	90	350	14-Nov	318	07	38	30.066	G	-4.070842	152.189633
16	100	90	300	15-Nov	319	03	03	30.068	G	-4.177542	152.123142
17	125	90	140	15-Nov	319	05	50	30.063	G	-4.259117	152.009342
18	175	90	240	15-Nov	319	23	44	30.063	G	-4.314075	151.957600
19	100	90	218	24-Nov	328	01	41	30.065	A	-4.282452	152.180908
20	100	90	120	24-Nov	328	02	34	30.065	A	-4.261208	152.194188
21	200	90	700	24-Nov	328	05	35	30.065	A	-4.201922	152.334335
22	125	90	300	24-Nov	328	07	04	30.065	A	-4.174265	152.226743
23	350	90	1940	25-Nov	329	02	43	30.064	A	-3.890108	152.388577
24	250	90	1050	25-Nov	329	05	26	30.067	A	-4.002230	152.171322
25	250	90	480	26-Nov	330	03	19	30.067	A	-4.284440	151.946188
26	300	90	90	26-Nov	330	05	10	30.070	A	-4.230355	151.866248
27	350	90	1600	27-Nov	331	01	52	30.065	A	-3.902047	151.907732
28	300	90	800	28-Nov	332	02	17	30.070	A	-4.406902	152.406253
29	350	90	2200	28-Nov	332	05	02	30.072	A	-4.491527	152.565510

APPENDIX 3

PROGRAM AND DATA FILES USED IN PROCESSING RELACS SEISMIC DATA

Below is a brief summary of the most important programs used in the processing of the RELACS seismic data. For further information consult the README files in the STAGE1, STAGE2 and STAGE3 directories on archive CD.

PROGRAM FILES

PCPLOT03 Program for displaying ANUF data. Various options are available, such as plotting the raw data, displaying headers information and GPS clock times. A comprehensive on-screen menu gives all information necessary to run the program.

CODFATSG Program for the conversion of ANUF files to SUDS files. Syntax: codfatsg [file1] [file2] [file3] [path] - file1 is name of output log file (e.g. INFO.TXT); file2 is file containing paths to ANUF data files (e.g. JAZ13.ASC); file3 is event list (EVLIST.ALL); path is path to where output SUDS data is sent. Incorporated in this program are various error-checking facilities to correct for various incorrectly entered header parameters.

7VIEWSUD Program for picking and filtering SUDS files; output file VPICK.XXX where XXX is event number. Syntax: 7viewsud [filename] - filename can be either a specific SUDS file or, by using wildcards, a group of files (e.g. ?3110514.*). A comprehensive manual for using this program is located in file 7VIEWSUD.TXT in the archive directory STAGE2.

Segment of 'VPICK' file - VPICK.545
NOTE: The output 'APICK' files of the automatic picking program have the same format.

```
STN  ID   TYPE           TIME              QUAL  E/I       UNCRTY          TCAPP  Chan    Dist km

X01  545  P   1997 11  7  4 14 33.60  45.80  I     0.00     0.00      0.00    1      13.48
X03  545  P   1997 11  7  4 14 32.66  60.12  I     0.00     0.00      0.00    1       7.65
X30  545  P   1997 11  7  4 14 37.08  20.15  E    -0.05     0.05      0.00    1      32.25
G08  545  P   1997 11  7  4 14 36.86   4.99  E    -0.10     0.10      0.00    1      27.52
K03  545  P   1997 11  7  4 14 36.04   9.33  E    -0.05     0.05      0.00    1      23.74
N68  545  P   1997 11  7  4 14 34.32 121.51  I     0.00     0.00      0.00    1      14.83
V83  545  P   1997 11  7  4 14 34.08  13.36  E    -0.05     0.05      0.00    1      13.19
M38  545  P   1997 11  7  4 14 33.86  63.76  I     0.00     0.00      0.00    1      12.87
R02  545  P   1997 11  7  4 14 35.76   6.15  E    -0.10     0.10      0.00    1      21.99
```

Explanation:
The fields are station code (STN), event number (ID), phase (TYPE - 'P' or 'S'), time (TIME - six fields: year/month/day/hour/min/sec), signal quality (QUAL), phase onset (E/I - emergent/impulsive), pick uncertainty in seconds (UNCRTY - two fields), time correction applied (TCAPP), channel (Chan), distance of event (Dist km).

RELXDIV3 The OBS data were received in large files that contained data for many OBSs. This program split off data from these large files and into individual station data files. Syntax: relxdiv3 [filename] - filename is combined OBS data file, output SUDS files being sent to current working directory.

FILLIB Module containing filter routines.

3SUDLIB Module containing routines for SUDS files - file control, reading, etc.

3SUDPOST Module containing all Postscript routines.

NUMERIC Module containing numeric recipies for filter routines(called by FILLIB.C).

AUTOPICK Autopick program; outputs a file called APICK.XXX where XXX is event number.

1MINUTE This program is used for combining one minute of data from many SUDS files (one per station) for viewing in the IASPEI program PITSA. Syntax: 1minute [event number]. As input it uses file DIST.XXX, the list of stations in this file being used as an input station list for the program, and the 'Velocity' entry in this same file being used as a reduced velocity if required. Output of program is a file called 1MINUTE.SUD. All necessary input files must be present in the current working directory, including all SUDS files for each station occurring in file DIST.XXX, the files DIST.XXX and SITES.DAT. An example of using 1MINUTE.SUD as input for the IASPEI program PITSA for plotting a record section is shown in Fig. 4

3SUDPOST.H Module containing variable definitions for Postscript.

SUDS.H Module containing variable definitions for suds files.

NUMERIC.H Module containing variable definitions for numeric recipies.

3SUDLIB .H Module containing variable difinitions for 3SUDLIB.C.

VIEW.BAT Batch file used to link all modules needed to generate 7VIEWSUD.EXE.

DISTANCE This program is used for the prediction of arrival times of events with low S/N ratio, but the generated output file is also used as input for program 1MINUTE.SUD. A station that possesses the clearest signal is used as a reference to predict the time of arrival on all other stations from a file STATION.XXX (XXX is three-digit event number) which is simply a list of station codes (from SITES.DAT) of stations to be processed. These stations would normally be those aligned along one of the profiles, X, Y or Z of the RELACS survey. Below is a sample segment of output file DIST.537 where the measured arrival time for station K03 was 10.0 seconds, the rest being predicted.

```
EVENT: 573
DELTA T RELATIVE TO STATION: K03
FOR WHICH ARRIVAL TIME IS: 10.00
VELOCITY:  6.0 kM/S
STATION  POLTY  DIST   BACK AZ   DELTA T  ARRIVAL+dT
 K03      -1    13.3    131.9      .0        10.0
 MAL       1     8.0    137.3     -.9         9.1
 R29      -1     5.8    311.9    -1.2         8.8
 RPT      -1     3.1    293.7    -1.7         8.3
```

T05	-1	19.5	121.0	1.0	11.0
V01	-1	10.3	141.5	-.5	9.5
V41	-1	9.4	310.3	-.6	9.4
V42	-1	12.6	305.4	-.1	9.9
V83	1	2.2	110.3	-1.8	8.2
VPE	1	12.5	304.3	-.1	9.9
X01	1	24.5	288.7	1.9	11.9

HISTOGM This program is used as an aid to checking the reliability of picks contained in the 'APICK' and 'VPICK' files ('pick' files) by giving a quick overview of arrival times viewed in the form of a histogram plotted to screen and to a file (named HGA.XXX or HGV.XXX, the 'A' or 'V' indicating a VPICK or APICK input file, and XXX representing event number). The histogram below shows output of HISTOGM when applied to file VPICK.172 and shows clearly the bimodal nature of the arrivals indicating presence of both 'P' and 'S' phases and the probability that the picks are, in general, reliable. Conversely, large scatter in arrival times would indicate the unreliability of picks in the pick file.

```
DATA FOR  VPICK.172
MINIMUM TIME: 55 min 48.32 sec
MAXIMUM TIME: 56 min 13.62 sec

FREQUENCY HISTOGRAM OF ARRIVAL TIMES
ONE-SECOND CLASS WIDTHS (Time rel)
REDUCED BY MINIMUM TIME. FIRST COLUMN
(Time abs) IS LOWER CLASS BOUNDARY IN
SECONDS OF ABSOLUTE TIME.

 Time   Time    No. of STATIONS
 (abs)  (rel)

 48.32   0- 1    2  U50W54
 49.32   1- 2    5  B48G44T52C46V42
 50.32   2- 3    9  H40U80C46G32M38N36R29V41M33
 51.32   3- 4   11  T31K61G26T34V28B69N68R35V24RPTTAL
 52.32   4- 5   17  R02R23T14T22V13R11R12T65K67S66KPTKPTRALRALRPTTUNVUL
 53.32   5- 6    9  V01G08K07K03R04I10T09V64MAL
 54.32   6- 7    4  K07R02R04WTM
 55.32   7- 8    0  |
 56.32   8- 9    0  |
 57.32   9-10    0  |
 58.32  10-11    0  |
 59.32  11-12    0  |
 60.32  12-13    0  |
 61.32  13-14    0  |
 62.32  14-15    0  |
 63.32  15-16    0  |
 64.32  16-17    0  |
 65.32  17-18    0  |
 66.32  18-19    1  V41
 67.32  19-20    2  R29RAL
 68.32  20-21    2  T65RPT
 69.32  21-22    3  R29K67S66
 70.32  22-23    3  G08T09V64
 71.32  23-24    3  K03T05R11
 72.32  24-25    3  V01K07WTM
 73.32  25-26    1  T05
```

DELSTN Program for the automatic deletion of picks from an APICK file. Syntax: delstn [event number] [station code] [phase P/S].

SUDS2ASC One of the programs in the IASPEI (International Association of Seismology and Physics of the Earth's Interior) software library for the reading of SUDS header information and data and conversion to ASCII.

PITSA One of the programs in the IASPEI software library. It's primary function is for the analysis of waveforms and the picking of seismic events, however it can be used to plot record sections with the aid of the programs DISTANCE.FOR and 1MINUTE.C. The procedure for doing this is as follows.

In a file called STATION.XXX (where XXX is three-digit event number) make a list of station codes in a column, these stations being the ones of interest along a particular profile. Next run the program DISTANCE which asks for event number and reads this file as input. The output of program DISTANCE is a file called DIST.XXX. Now run program 1MINUTE with event XXX on the command line. A file 1MINUTE.SUD will now be produced that can be read by PITSA. The following procedure in PITSA is now necessary to plot record sections.

STEP 1: Recalling 1MINUTE.SUD into PITSA
Under toolbar <Files/traces> choose "Retrieve file", then "SUDS", and then enter name of SUDS file (1MINUTE.SUD).

STEP 2: If it is found necessary to delete any traces, perhaps because of problems with trace or origin time, then under toolbar <Files/traces> choose "Delete traces" and enter trace numbers (a group of traces can be entered with a colon between them, e.g. 10:15, meaning all traces between 10 and 15 inclusive.

STEP 3: With reference to the file DIST.XXX it may be found that some of the polarities are -1 and not 1, and therefore the resulting record section will be clearer if all offending polarities are reversed (reverse all 1's or all -1's depending on which occur least in the table). Under toolbar <Utilities> choose "Trace utilities", then "Single channel utilities", then "a*X+b", and then "enter trace index" enter a -1 for 'a' and a 0 for 'b'.

STEP 4: It is necessary for PITSA to calculate epi-/hypo-central distances and to do this, under <Utilities> toolbar choose "Header access", then enter traces (";" is default for "all"). Next choose "Event", "Recalculate parameters". Distances can also be entered manually by choosing "Epi-, hypo- central distances".

STEP 5: To filter traces choose <Advanced tools> on the toolbar, then, say, "Butterworth bandpass", then ";" for all traces. Finally, enter widow range when prompted at "enter filter window".

STEP 6. It will invariably be necessary to zoom traces. On toolbar choose <Routine tools>, "untapered", enter traces ";" for all. Note: sometimes all channels can't be zoomed together because of differences in sample frequency and/or trace begin time. In such cases zoom the recalcitrant traces individually, then zoom the rest using, say 6:21 for all traces between and including 6 and 21.

STEP 7: Screen plot traces. Under <Utilities> toolbar choose "special plots", then "distance lot", then "Hypocentral distance" or "Epicentral distance". Choose ";" for all traces, then "distance vs. zero line", then, say, "keep current scale", then enter % of window to use for trace amplitudes (6 is a reasonable figure for 20 traces).

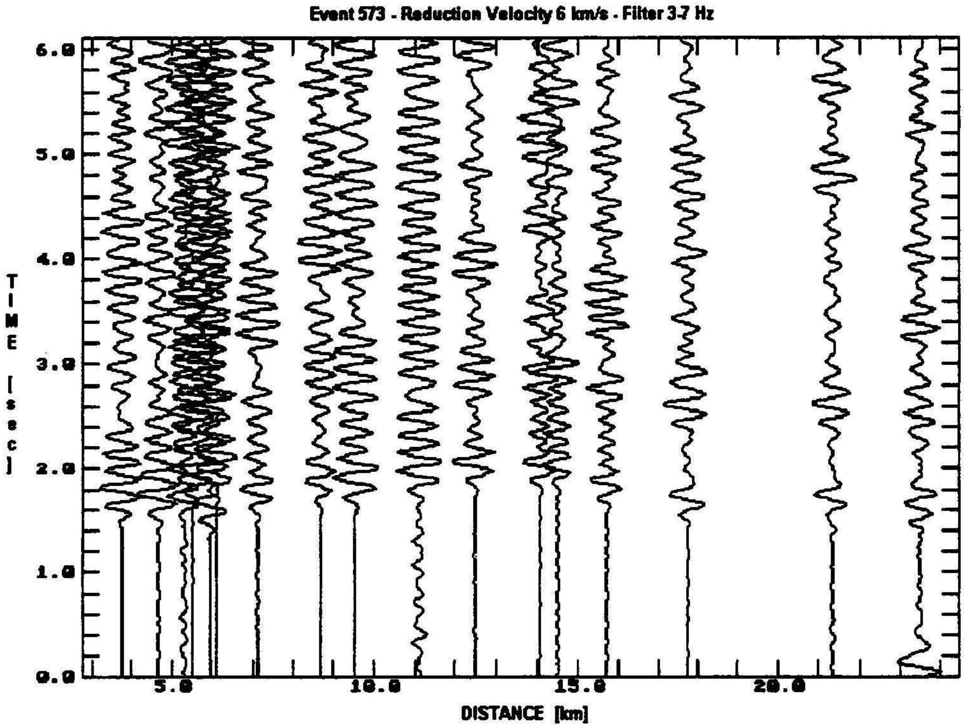

Figure 4 A record section plotted at a reducing velocity of 6 km/s using the IASPEI program PITSA which used as input a file generated by program 1minute.c.

STEP 8: Screen dump. Press [F2] key for screen dump; this gets written to a file SCRDUMP.XYZ where XYZ is 000, 001, etc. PITSA supplies a few printer files (*.PRT) and the appropriate printer file must be copied to the file PITSA.PRT before using the screen dump facility. If the current printer(s) attached to your system are not covered by the *.PRT files it may be necessary to experiment - for example, the file called NEC8SL.PRT, when copied to PITSA.PRT works for the Canon BJC-70 printer. A knowledge of your printer control commands is helpful in modifying the *.PRT commands[2].

DATA FILES

EVLIST.ALL Complete event list - format described below.

Segment of EVLIST.ALL table:

(1)	(2)	(3)	(4)	(5)	(6)	(7) (8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
768	1997	344	18	40	50	10.846	44	99.9990	999.9990	999.9	9.9	-9.9000	-999.9
769	1997	344	18	44	10	1.288	15	-7.1200	148.4900	33.0	3.8	4.7000	231.5
770	1997	344	21	57	30	10.500	26	99.9990	999.9990	999.9	9.9	-9.9000	-999.9
771	1997	345	0	50	40	10.647	33	99.9990	999.9990	999.9	9.9	-9.9000	-999.9
772	1997	345	7	24	40	11.918	45	-5.4050	152.1240	58.0	4.5	1.2000	183.6
773	1997	345	7	44	10	10.918	45	99.9990	999.9990	999.9	9.9	-9.9000	-999.9
774	1997	345	7	49	40	10.776	38	99.9990	999.9990	999.9	9.9	-9.9000	-999.9
776	1997	345	10	52	20	10.429	21	99.9990	999.9990	999.9	9.9	-9.9000	-999.9
777	1997	346	14	3	50	10.820	41	99.9990	999.9990	999.9	9.9	-9.9000	-999.9
779	1997	346	16	43	20	0.780	39	99.9990	999.9990	999.9	9.9	-9.9000	-999.9

780	1997	346	17	24	10	10.360	18	99.9990	999.9990	999.9	9.9	-9.9000	-999.9
781	1997	347	0	48	20	1.000	0	-5.7700	147.6270	33.0	4.4	4.8000	250.7

Explanation:
(1): Event Number **(2):** Year **(3):** 'Julian' day **(4):** Hours **(5):** Minutes **(6):** Seconds **(7):** Two-column field before decimal point. First column: '1' (one) or ' ' (blank); 1 = recorded by an RVO station, blank = not recorded by an RVO station. Second column: event type; 0 = unknown location, 1 = local event, 2 = regional event, 3 = teleseism, 9 = explosion. **(8):** Three digits after decimal point: Percentage of recorders that registered event. **(9):** Number of stations recording event; 0 = all stations recorded event. **(10):** Latitude; 99.9990 corresponds with location unknown. **(11):** Longitude; 999.9990 corresponds with location unknown. **(12):** Depth; 33.0 corresponds with depth unknown. **(13):** Magnitude; 9.9 corresponds with magnitude unknown. **(14):** Epicentral distance (degrees); -9.9000 corresponds with location unknown. **(15):** Back Azimuth; -999.9 corresponds with location unknown.

EVLIST.PIC Event list of manually picked events (format as for EVLIST.ALL). Most of the events in this list have a 'VPICK' file associated with them.

EVLIST.SUB Remaining events that were picked by the autopick program AUTOPICK.C (format as for EVLIST.ALL).

SITES.DAT Seismic station data file, the first twelve entries of which are:

No.	Code	Name	Latitude	Longitude	El. (m)	Pos. Method	Recorder Type	Recording Stage	Polarity
1	V01	Vuvu	-4.211803	152.126376	14.9	DGPS	ANUSS	1, 2, 3	-1
2	R02	Ramalmal	-4.225831	152.101142	81.4	DGPS	ANUSS	1, 2, 3	-1
3	K03	Kabakada	-4.204375	152.094998	54.7	DGPS	ANUSS	1, 2, 3	-1
4	R04	Raluana 3	-4.233704	152.057366	152.3	DGPS	ANUSS	1, 3	-1
5	T05	Tovakudum	-4.193792	152.033316	6.4	DGPS	ANUSS	1, 2, 3	-1
7	K07	Kabaira	-4.236335	152.010381	13.7	DGPS	ANUSS	1, 3	1
8	G08	George Brown HS	-4.269849	152.034136	24.4	DGPS	ANUSS	1, 2, 3	1
9	T09	Tokelikel	-4.271879	152.063075	94.8	DGPS	ANUSS	1, 2, 3	-1
10	I10	Iatapal	-4.259583	152.090534	215.9	DGPS	ANUSS	1, 2, 3	-1
11	R11	Raluan 2	-4.259636	152.129089	282.1	DGPS	ANUSS	1, 3	-1
12	R12	Rapopo	-4.281969	152.106941	259.7	DGPS	ANUSS	1, 3	-1

SHOTS.DAT Shot data file, the first ten entries of which are:

No1	No2	size	sdep	wdep	date	jday	hr	min	sec	loc	latitude	longitude
0	536	25	30	222	5-NOV	309	23	19	30.040	X	-4.282017	152.185028
1	538	25	60	225	5-Nov	309	23	57	30.050	G	-4.283108	152.185717
2	539	25	90	228	6-Nov	310	00	42	30.068	G	-4.284400	152.186533
3	543	100	90	290	7-Nov	311	02	53	30.068	A	-4.309997	152.339913
4	545	150	90	280	7-Nov	311	04	14	30.072	A	-4.314852	152.278210
5	546	100	90	190	7-Nov	311	05	14	30.071	A	-4.301292	152.242350
6	553	175	90	90	8-Nov	312	01	40	30.064	A	-4.181953	152.074918
7	554	200	90	140	8-Nov	312	02	46	30.067	A	-4.172727	152.018888
8	555	225	90	280	8-Nov	312	04	14	30.066	A	-4.151060	151.947953
9	566	300	90	1850	10-Nov	314	05	39	30.069	G	-4.435108	152.598367
10	567	225	90	1700	10-Nov	314	07	49	30.071	G	-4.364733	152.453550

TMxxxyyy.FLT Filter files generated by using filter option '4' in the 7VIEWSUD event picking program - xxx is lower frequency and yyy is upper frequency of window (e.g. 4.1 would be coded as 041).

EVENTTST.DAT File which contains the essential default parameters required for running the 7VIEWSUD event picking program (refer to 7VIEWSUD.TXT in archive directory STAGE2 for format of this file).