TANZ

THE 1994-95 TANZANIA PASSIVE-SOURCE SEISMIC EXPERIMENT

Submitted By

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PASSCAL Data Report 97-005

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ABSTRACT

This report describes the distribution to the IRIS Data Management Center of data collected by 21 broadband PASSCAL stations operated in Tanzania between May of 1994 and June of 1995. All recorded data are provided in SEED format. This report describes additional information about the data that was discovered after the SEED volumes were sent to the DMC or are difficult to provide within the SEED format. Reported information primarily involves timing and gain problems discovered during our own data analysis.

1. Introduction

The 1994-95 Tanzania Passive-Source Seismic Experiment (Figure 1) was a collaborative effort between Penn State University, the University of South Carolina and the Geological Survey of Tanzania (MADINI). This experiment was jointly funded by the US National Science Foundation and MADINI to collect data that will improve our knowledge of the crustal and upper mantle structure of this region. Instrumentation for this deployment was provided by the PASSCAL program of IRIS. In accordance with PASSCAL guidelines, all of the data collected during this deployment is being released with this data report. We ask that publications resulting from the use of these data properly acknowledge the source of the data and the extensive efforts of the scientists who collected it.

Instrumentation for this project consisted of 24-bit PASSCAL/Reftek data loggers, Streckeisen STS-2 sensors, and Guralp CMG-3ESP sensors. Data were recorded on two data streams continuously at 20 samples/sec and 1 sample/sec. The original station field tapes were duplicated at our field base in Tanzania, then organized into network-day volumes in SEGY format using PASSCAL software and the YODA facility at the IRIS DMC. A Datascope CSS database for the experiment was then created using software written at UC-San Diego and the University of Colorado. Time-corrected CSS "wfdisc" files were generated from the Reftek State of Health log files using the "soh2db" utility written at the University of South Carolina. Finally, SEED volumes were written from the completed Datascope database using the "db2sd" utility in the Datascope distribution. The resulting SEED volumes contain the nominal instrument response information for each site. Each network-day may have two SEED volumes. One SEED volume is tagged as a "NO_TIME" volume. These volumes contain stations for which we cannot confirm accurate timing. These data may still be useful for studies that require only relative phase time. The overall "uptime" for our experiment was 83.6%. We define "uptime" as recovery of data that we believe has accurate timing. A summary of network uptime (Figure 2) illustrates our difficulty in keeping sites functional during the rainy season, particularly during the months of January and February of 1995. Problems were related to power loss (due to cable-chewing insects), occasional problems due to limited solar power, and minor vandalism.

Since the SEED volumes were written and distributed to the DMC, we have discovered other timing and data problems. These problems are documented in this report. We are providing an Auxilliary Information Directory (AID) containing various files that may be useful to users of this data set.

2. Auxilliary Information Directory

The AID contains various supporting information about the experiment. The upperlevel directory name is *Tanzania_Data_Report* and is 8.3 Mb in size. We will describe the contents of the subdirectories within this report. The directory names and their sizes are:

Auxilliary Information Directory

Subdirectory Name	Contents	Size (Mb)
Figures	PDF files of figures for this report	0.8
Text	This Report in PDF Format	0.2
Clock_Info	Files related to timing problems	2.7
Gain_Info	Files documenting gain problems	4.6
Other_Info	Miscellaneous other useful files	0.2

3. Timing Problems

The majority of our sites were equipped with OMEGA clock systems. A few had GPS clocks. Timing was generally stable and clock corrections were generated and applied with software provided by PASSCAL. Since the SEED volumes were generated, we have picked phases for thousands of local and teleseismic earthquakes as part of our ongoing research efforts. In the process, we have discovered some apparent timing problems in the data. Some of these were introduced by erroneous time corrections. Appropriate equations to fix these problems are provided here. Other timing problems appear to be related to internal instabilities in the Reftek clocks that occur when the instruments lose power for extended time periods. We cannot determine with confidence the appropriate time corrections for these cases, so we can only provide warnings in this report. To aid users in evaluating site timing, we provide files in the *Clock_Info* directory called *STA_Residuals_Local* and *STA_residuals.PDF*, where STA is a 4-character station name. The format of the *STA_Residual_Local* files is:

Epochtime Residual

where *Epochtime* is the number of seconds since 00:00:00 on 1/1/1970, *Residual* is the time residual for that pick determined from our location process. We also provide plots of Epochtime-vs-Residual in the *STA_residuals.PDF* files for quick-look checking for problem areas. Both the residual files and their associated PDF files have only local earthquake residuals through 1995:070.

Based on our analysis, we have identified 4 sites that appear to have suspect timing during periods that we previously believed to have correct timing. This means that data from the time periods described below occur in the properly-timed SEED volumes sent to the IRIS DMC. Therefore, users must consider or correct for these problems when using this data.

TARA, 8/25/1994 (237:21:31:40.000) through 10/12/1994 (285:10:02:01.007). TARA's OMEGA preamp was squashed by an unknown, large animal on Day 1994:237. It was replaced on a standard service run on 1994:285. Subsequent processing applied a drift correction with the wrong sign to the data during this time period. SEED volumes distributed to the DMC contain the improperly time-corrected data. This can result in a timing error of over 6 seconds in the later days of this time period. An example TCL script that can correct this problem is provided in *Clock_Info/tara_fix*. This script will fix a Datascope/CSS database that contains the timing problem. Other users will have to apply the same equations with a script modified according to their application and data format.

KOMO 1/04/95 through 3/08/95. Station clock locked irregularly during this period. Station was up and down due to power problems. We do not trust the timing at this site from 1/04/95 until after 3/08/95 (1995:067:10:17:000), when a pulse time set was performed during a regular service visit.

KOND 2/02/95 through 3/24/95. The DAS lost power 19 times between 1995:031:07:00 and 1995:075:10:00. Excessive residuals begin to appear around 02/05/95. The station clock locked reliably when power was up, but apparently the internal clock did not keep proper time when power was down. Since the OMEGA clock requires the internal clock to be within ±5 seconds of true time, numerous jumps in the station time probably occured. By the 3/24 service run, clock was 50 seconds off. Due to power failures, we do not trust timing at this site from 1995:031:07:00 until 1995:083:14:00.

PAND 8/01/94 through 10/29/94. The OMEGA clock at PAND did not lock from 8/1/94 (1994:213:18:16:30) until 9/26/94 (1994:269:17:37:50). In our time-correction procedures an erroneous drift correction was applied during this period. From 9/26/94 (1994:269:17:37:50) until 10/29/94 (1994:302:12:21:04), a static 30 second time offset existed in the un-time-corrected data. In our time-correction procedures, this offset was erroneously applied with the wrong sign. Therefore, the SEED volumes at the DMC have a 60 second static offset during this time period. A TCL script to correct both these problems is included in *Clock_Info/pand_fix*.

This script will fix a Datascope/CSS database that contains the timing problem. Other users will have to apply the same equations with a script modified according to their application and data format.

4. Gain and Sensor Offset Problems

We experienced two types of problems related to instrument gain and sensor offsets. First, several Reftek DAS units appeared to spontaneously increase their gain from 1 to 32. The instruments also often spontaneously returned their gain to the proper value. All SEED volumes sent to the IRIS DMC assume an instrument gain of 1. The file *Gain_Info/Gain_*32*_Bugs* contains a list of time periods when we believe the gain was 32 at certain sites.

Second, we programmed our DAS units to perform an autorecentering sequence on their sensors every 5 days. Occasionally, this caused an STS-2 sensor to go completely off-center (pegged). This was usually corrected after a subsequent recentering sequence. The file *Gain_Info/Pegged_Sensors* contains a list of time periods when we believe a sensor was pegged.

To aid in indentifying a gain or sensor problem, we generated 1 hour RMS amplitude traces for all station-channels in our network for the entire experiment. These files are included in the AID under *Gain_Info/*199[45]*/STA.rms* where STA is a 4-character station code for our experiment. These files contain 4 columns:

Time (Decimal Julian Day) Z-Channel RMS N-Channel RMS E-Channel RMS

They were generated by modifying program segypeak from the PASSCAL distribution and were run on the original SEGY files. In each year directory, there is a SAC macro rmsplot9[45].m that will produce a plot of these RMS files for a user-chosen range in Julian Days. An example plot is shown in Figure 3.

Our identification of Gain and Pegged Sensor problems in the two summary files may not document all possible problems. Users are urged to use the RMS files provided to check their traces when questions arise.

5. Miscellaneous Other Information.

Several files are provided in the *Other_Info* subdirectory of the AID.

Uptime_Summary_Table contains performance information on our sites, a summary of the information shown in Figure 2. This information is for properly timed sites.

GMT_Figure_1 is a script of GMT (Generic Mapping Tool) commands used to generate Figure 1. *Site_Locations.xy* is a file with station latitude and longitude information suitable for use in the GMT script. *tzcraton.xy* is a file with latitude and longitude information for the Tanzania Craton boundary shown in Figure 1. Full station information (latitude, longitude, elevation, instrument response, etc) are included in the SEED volumes sent to the IRIS DMC.

The file *Trace_Length_Problem* summarizes an observation that is worth documenting but does not appear to have caused any problems. We have found several cases where the number of samples in a trace reported in the Reftek State of Health log is greater than the actual number of samples contained in the trace. Most of these problems occurred when a station was going down due to power problems. We have corrected most of these errors, however SEED volumes for 49 cases were written before the problem was discovered. The SEED volumes passed all verify tests, but could presumably have slightly less data than expected. We have had no reported trouble related to this problem. We are just reporting it for completeness.

6. Calibration Issues

The STS2 sensors are feedback stabilized seismometers with a effective natural period of 120 seconds and a effective damping of 0.7 critical. The published sensitivity is 1500 volts per meter/second in differential mode. The Guralp CMG3-ESP are also feedback stabilized seismometers with a effective natural period of 30 seconds and a effective damping of 0.7 critical. The published sensitivity is 2000 volts per meter/second in differential mode. Theoretically feedback stabilized seismometers should be extremely stable, and the frequency response should depend only on the feedback parameters and not exhibit the significant variations over time.

Our calibration procedure used the Reftek DAS calibration mode with the step calibration. We implemented a procedure where we performed a calibration while the upload of the DAS disk to tape was underway. This provided about an hour or more of calibration data during most service visits. After the disk upload was complete, we uploaded the calibration data to a separate tape. We have examined most of these calibration data to look for gross problems. However, we have not attempted to invert the resulting calibration data for instrument parameters and the calibration data was not processed with the normal field tapes, so it is not included in the SEED volumes.

7. Ongoing Research

We have published, submitted for publication, or expect to submit for publication in 1997, the following research results. Users of this data interested in these or other studies are encouraged to contact the Project PIs at any time for an update on our continuing efforts.

Published and Submitted Papers

Langston, C.A., R.A. Brazier, A.A. Nyblade, and T.J. Owens (1997). Local magnitude scale and seismicity rate for Tanzania, East Africa, *submitted to Bull. Seis. Soc. Am.*, August 1997.

Last, R.J., A.A. Nyblade, C.A. Langston, and T.J. Owens (1997). Crustal structure of the East African Plateau from receiver functions and Rayleigh wave phase velocities, *J. Geophys. Res*, in press.

Zhao, M., C.A. Langston, A.A. Nyblade, and T.J. Owens (1997). Lower crustal rifting in the Rukwa Graben, East Africa, *Geophys. J. International*, 129, 412-420.

Nyblade, A.A., C. Birt, C.A. Langston, T.J. Owens, and R.J. Last (1996), Seismic experiment reveals rifting of craton in Tanzania, *EOS. Trans. Am. Geophys. Un.*, 77, 517+521.

Owens, T.J., A.A. Nyblade, and C.A. Langston (1995). The Tanzania Broadband Experiment, IRIS Newsletter, 14, 5-7.

Papers in Preparation

Brazier, R.A., A.A. Nyblade, C.A. Langston, and T.J. Owens (1997), Upper mantle structure beneath Tanzania, East Africa from inversion of Pn traveltimes.

Langston, C.A., A.A. Nyblade, and T.J. Owens (1997), Regional wave propagation and lithospheric structure of Tanzania, East Africa.

Owens, T.J., A.A. Nyblade, and C.A. Langston (1997), Shear wave anisotropy observations beneath Tanzania, East Africa.

Ritsema, J., T.J. Owens, A.A. Nyblade, and C.A. Langston (1997), Investigation of the seismic structure benath the Tanzania Craton and East Africa Rift by teleseismic travel-time inversion.

Zhao, M., C.A. Langston, A.A. Nyblade, and T.J. Owens (1997), Upper mantle structure beneath southern Africa.

8. Acknowledgements

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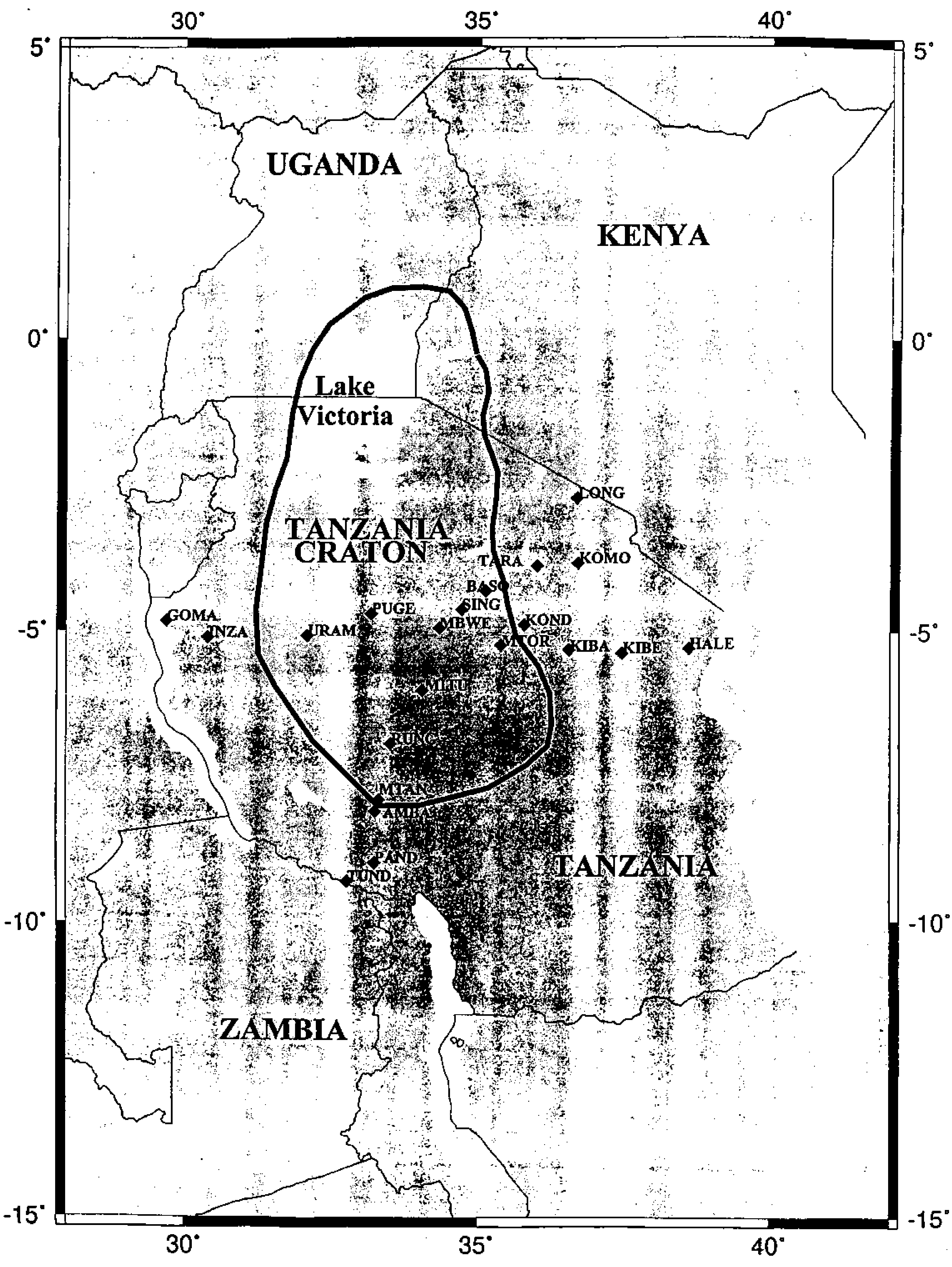
9. Figure Captions

Figure 1. Base map of East Africa showing stations of the Tanzania Passive-source PASSCAL experiment. Black diamonds show individual station locations.

Figure 2. Plot of station uptime (black bars) versus time for the entire Tanzania experiment.

Figure 3. Example of RMS Gain Information available through use of the rmsplot94.m SAC macro. Note that Y-axis scale changes at 25000 counts to aid in the identification of problems. Three components of motion are shown. The solid (black) line is the Z component. The dashed (blue) line is the E component. The dotted (red) line is the N component. The sharp vertical lines every 5 days are the autorecentering sequence of the DAS. RMS gain values well above 25000 counts are strongly indicative of sensors that are pegged during the autorecentering sequence. These regions of pegged sensors are generally bounded by the 5-day autorecentering sequences. Not shown on this plot are clear examples of a spontaneous 1 to 32 gain change. These would be most visible on the lower (0 to 25000 count) scale frame and are often not correlated with autorecentering sequences.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HALE
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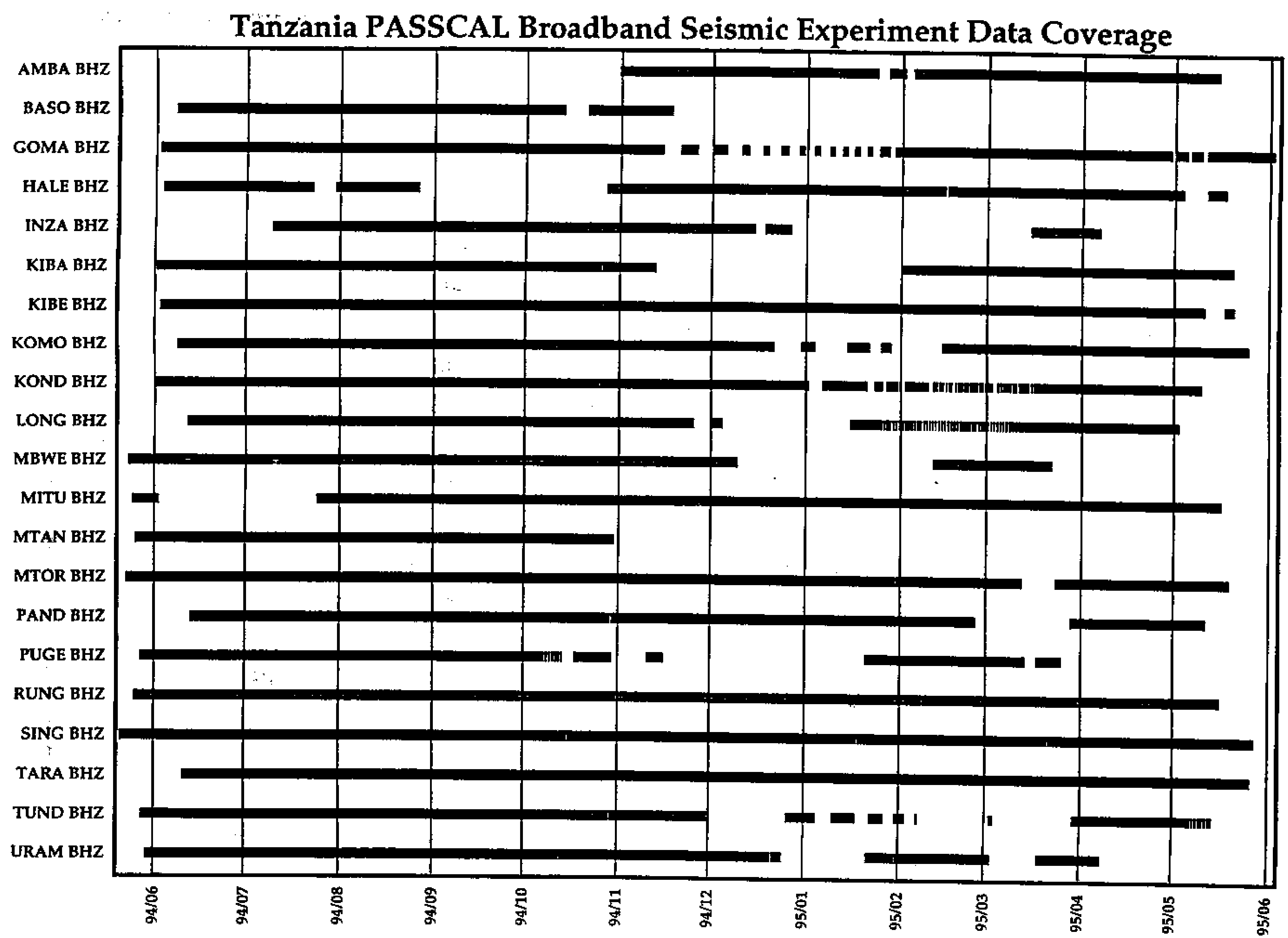
AMBA
PAND
TUND
TANZANIA
ZAMBIA


Tanzania PASSCAL Broadband Seismic Experiment Data Coverage
AMBA BHZ
BASO BHZ
GOMA BHZ
HALE BHZ
INZA BHZ
KIBA BHZ
KIBE BHZ
KOMO BHZ
KOND BHZ
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1 Hour RMS for Station URAM for Days 1994:250 to 1994:300