TIPLT

1991-92 TIBETAN PLATEAU PASSIVE-SOURCE SEISMIC EXPERIMENT

Submitted by
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PASSCAL Data Report 93-005

Revised Report as of 10/06/94

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Data Report

for the

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ABSTRACT

This report describes the distribution to the IRIS Data Management Center of data collected by 11 broadband PASSCAL stations operated in the Tibetan Plateau between July of 1991 and June of 1992. Data formats, auxiliary information files, calibration information and the organization of the distribution data tapes are discussed.

1. Introduction

The 1991-92 Tibetan Plateau Passive-Source Seismic Experiment was a collaborative effort between the University of South Carolina, SUNY-Binghamton, and the Institute of Geophysics, State Seismological Bureau, China. US and Chinese seismologists deployed 11 broadband seismic stations within the Tibetan Plateau between July 1991 and June 1992 (Figure 1). This experiment was jointly funded by the US and Chinese National Science Foundations to collect data that will better constrain the seismic 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 any publications resulting from the use of this data properly acknowledge the source of the data and the extensive efforts of the US and Chinese scientists who collected it. A suggested acknowledgement:

> *Data from the Tibetan Plateau were collected in a joint project between the University of South Carolina (T. Owens and G. Randall), SUNY-Binghamton (F. Wu), and the research group of R. Zeng, Institute of Geophysics, State Seismological Bureau, China. US funding for the field experiment was provided by NSF awards EAR-9004428, EAR-9005594, EAR-9004221.*

The primary purpose of this report is to describe the organization and format of the data distribution to the IRIS DMC. The data is being delivered to the DMC as 13 tapes. Twelve of these tapes are seismic trace data in SEG-Y format. One tape is the Auxiliary Information Tape (AIT) that contains various other information needed to make use of these data. All tapes are low-density Exabyte tapes written as UNIX tar tapes with a blocksize of 124 on a Sun workstation running SunOS4.1.3.

2. Auxiliary Information Tape

The AIT is a tar tape of a directory of various supporting information about the experiment. The upper-level directory name is *Tibet_Data_Report* and is 89.9 Mb in size. We will describe the contents of the sub-directories within this report. The directory names and their sizes are:

Auxilliary Information Tape

Subdirectory Name	Contents	Size (Mb)
BSSA_Paper	PostScript files of BSSA paper describing the experiment	7.9
Info_Files	Supporting Information such as event and station locations	0.1
SOH_Files	Complete Reftek State of Health Files	54.8
Text	This Report in PostScript	0.4
CAL_Traces	End-of-Project Sensor Calibration Traces	5.1
Clock_Info	Summaries of clock performance entries in State of Health files	0.8
Lhasa_Events	SEG-Y data for events extracted from Lhasa continuous data stream	21.1

3. General Experiment Information

We used Reftek 72A-02 DAS units with 360Mb hard disks for this experiment. Sites were located in vaults we constructed for this experiment or at existing vaults (see Figure 1). The file *Info_Files/Station_Locations* gives the 4-character station name, the latitude, longitude and elevation (in meters) of each site. The file *Info_Files/Box2Site* correlates the DAS serial numbers with their appropriate site names. We used 10 Streckeisen STS2 sensors and 1 Guralp CMG-3ESP sensor. The Guralp was located at site LHSA prior to 08:00 on day 91.201 and at TUNL after 05:52 on day 91.210. Our operating parameters and triggering experience is described in a recent BSSA article included in the *BSSA_Paper* subdirectory. This subdirectory includes PostScript files. These can be printed on any PostScript printer. A suggested command on SunOS4.1.3:

```
cat BSSA_Paper/*.ps | lpr
```

4. Recording Parameters

We operated three Data Streams during this deployment. *Data Stream 1* was a 5 sample/sec (sps) triggered data stream that operated between days 91.184 and 91.249. It was intended to trigger only on teleseismic surface waves, but we found that it did not collect data different from Data Stream 2, so it was disabled to conserve disk space. *Data Stream 2* was a 40sps triggered data stream that operated at all sites except LHSA for the whole experiment. Excessive triggering required that this stream be disabled at LHSA after day 91.235. More information about our triggering experience can be found in the BSSA article. *Data Stream 3* was a 1 sps continuous data stream that recorded in 1 hour blocks except in two cases. At LHSA, after 13:31 on day 91.235, Data Stream 3 was recorded at 5 sps continuous. At TUNL, Data Stream 3 was recorded in 2 minute records at 20 sps between 09:00 on 91.184 and 08:00 on 91.191. The sampling rate was decreased to 1 sps at this time, but the record length was not increased to 1 hour until 04:00 on day 91.210.

5. Trace Data Archives

The contents of the 12 SEG-Y Data Archives are summarized in the file *Info_Files/Tape.Summary*. Triggered data streams that have not been event associated are included in tapes 1, 2, 4, 7, 8, 10, and 11. These volumes total 5716 Mb. The 40 sample/sec (sps) triggered Data Stream #2 was event associated using PASSCAL software and rearchived on tapes 6, 9, and 12. These volumes total 2570 Mb. Continuous data streams are distributed on tapes 13 and 14. These volumes total 2402 Mb. Tapes 3 and 5 were superceeded by Tape 13 and were not distributed to the DMC.

The directory structures on the tapes 1, 2, 4, 7, 8, 10, 11, 13 and 14 are exactly has generated by the PASSCAL code "ref2segy", with exceptions noted here. Ref2segy was used to extract the data from field tapes and disks. This generates directory and file names of the form:

RDDD.SS/HR.MN.SC.SNUM.C

where DDD = Julian Day of Year, SS = Data Stream Number, HR = Hour of first data point, MN = Minute of first data point, SC = second of first data point, SNUM = DAS serial number, C = component number (1,4 = vertical; 2,5 = Positive North; 3,6 = Positive East). All times are GMT.

Exception #1: The LHSA continuous data after 13:31 on day 91.235 are included in the form described above, but in a subdirectory DS3L.91 (on tape 13) or DS3L.92 (on tape 14). This was necessary because, as described above, the sampling rate changed from 1 to 5 samples/sec at this time.

Exception #2: At TUNL, between 09:00 on 91.184 and 04:00 on day 91.210, continuous data was recorded in two minute records instead of 1 hour records. This data was read to disk with the -h option of ref2segy. This creates an additional subdirectory for every hour. Thus, between the dates listed, TUNL data is of the form

RDDD.SS/HR/MN.SC.SNUM.C

This data can be merged into longer files using PASSCAL's segymerge code.

We renamed the State of Health files generated by ref2segy to be of the form:

NAME.rDDD.SNUM.[log or err]

DDD and SNUM are as defined above. NAME is the 4-character station name of the site. The State of Health files are included in the *SOH_Files* subdirectory of the AIT tape.

The data on tapes 6, 9, and 12 is exactly as generated by PASSCAL codes "reap" that receives ordered output from PASSCAL code "creat_table". An association was declared when any two stations triggered within 90 seconds of each other. By using our SOH file naming convention, "reap" generated the following directory/file structure:

YR.DDD/YR.DDD.HR.MN.SC/SS/NAME.HR.MN.SC.SNUM.C

Early in the experiment, we attempted to separate unassociated "seismic" triggers from other unassociated triggers. This proved to be too time consuming, but on tape 6 there is a directory called "orphans" that contains these events for days 91.186 until 91.259. This directory has the same structure as generated by "reap", but without the specific event directories.

6. Association of Triggers with PDEs

We correlated the "Associated Events" found with program reap with the USGS Monthly Preliminary Determination of Epicenters (PDE) locations as obtained from the IRIS DMC. We found 614 PDE events correlated with our data set. These correlations are given in files *Info_Files/Final_Locs*.91 for 1991 events and *Info_Files/Final_Locs*.92 for 1992 events. Each line of these files is of the form:

DIRNAME:ORIGINTIME:LAT:LONG:DEPTH:MB

where DIRNAME is the directory name from reap, ORIGINTIME is the PDE origin time for the event. The format of the origin time is "YrDayHrMinSec.T". Latitude and longitude follow the standard convention of N latitude and E longitude are positive, S latitude and W longitude are negative. DEPTH is in kilometers. MB is the PDE body wave magnitude of the event.

All of the event directories in the *Final_Locs* files should be on tapes 6, 9, or 12 except as noted in the *Info_Files/Association_Problems* file. These were events associated after the tape volumes were written and therefore must be added by the users.

7. Timing Issues

The OMEGA clocks performed well during this experiment. Lengthy clock outages are listed in *Clock_Info/Major_Outages*. In addition, we extracted all clock-related entries in the State of Health files and calculated clock corrections. Some of these corrections are large during periods when antennas were stolen from the sites. In addition, some corrections are large due to erroneous time shifts introduced by "FALSE LOCKS" of the OMEGA clocks. This software bug existed in the units we used in Tibet and did affect our clocks on some occasions. The clock corrections we derived are listed in two files called *Clock_Info/NAME.Large* and *Clock_Info/NAME.NonZero*. The format of these files is: NAME:DDD:HR:MN:SC:CORR:DS where NAME is the station name, DDD:HR:MN:SC define the starting time of the affected SEG-Y trace, CORR is the time correction in milliseconds or the phrase "NO_TIME", and DS is the Reftek Data Stream of the affected trigger. When NO_TIME occurs in field 6, it indicates that no reliable time is available for that particular trace. This situation occurred for triggers prior to the first clock lock after station installation and during problem periods at WNDO and XIGA listed in *Clock_Info/Major_Outages*. When a time correction appears in the CORR field it should be added to the start time of the indicated trigger. No timing corrections have been applied to the SEG-Y traces because the archive tapes were written months before the clock status analysis was completed. The information in the *NAME.Large* and *NAME.NonZero* files correlates with the file names described in Section 5 above, so users can select the size of the correction appropriate for their analysis and easily use these files to generate corrections. For the main triggered data stream (0002), we correlated the time corrections with files on tape archives 6, 9, and 12. The results are summarized in file *Clock_Info/Corrections.DS2*. An excerpt from this file is shown here:

91.236/91.236.17.46.43/02/ganz.17.46.43.0482.4	433	(tape6)
91.236/91.236.17.46.43/02/ganz.17.46.43.0482.5	433	(tape6)
91.236/91.236.17.46.43/02/ganz.17.46.43.0482.6	433	(tape6)
91.237/91.237.04.45.52/02/xiga.04.45.53.0475.4	NO_TIME	(tape6)
91.237/91.237.04.45.52/02/xiga.04.45.53.0475.5	NO_TIME	(tape6)
91.237/91.237.04.45.52/02/xiga.04.45.53.0475.6	NO_TIME	(tape6)
91.237/91.237.05.04.30/02/xiga.04.45.53.0475.4	NO_TIME	(tape6)
91.237/91.237.05.04.30/02/xiga.04.45.53.0475.5	NO_TIME	(tape6)
91.237/91.237.05.04.30/02/xiga.04.45.53.0475.6	NO_TIME	(tape6)
91.238/91.238.15.06.01/02/ganz.15.05.58.0482.4	-29	(tape6)
91.238/91.238.15.06.01/02/ganz.15.05.58.0482.5	-29	(tape6)
91.238/91.238.15.06.01/02/ganz.15.05.58.0482.6	-29	(tape6)

In this example, the files 91.236/91.236.17.46.43/02/ganz.17.46.43.0482.[456] will need 433 msec added to their start time, the data at XIGA has no accurate time (due to a stolen antenna), and the files 91.238/91.238.15.06.01/02/ganz.15.05.58.0482.[456] will need -29 msec added to their start time.

In addition to the variable timing corrections described above, the Reftek DAS software we used has fixed timing shifts associated with the filtering and decimation processes. For our recording parameters, the size of the correction is controlled by the sampling rate:

40 sps	-6 msec correction
20 sps	-31 msec correction
5 sps	-131 msec correction
1 sps	-656 msec correction

Thus, the sum of any variable correction and the appropriate fixed correction should be added to the start time of a trace to obtain absolute time. PASSCAL provides a program, segyshift, that may aid in these adjustments.

8. Calibration Issues

The STS2 sensors are feedback stabilized seismometers with an effective natural period of 120 seconds and an 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 an effective natural period of 30 seconds and an 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. Early in the experiment we attempted calibrations, but found that our calibration parameters were not appropriate, and further calibration was postponed until the last service run.

Our calibration procedure used the Reftek DAS calibration mode with the step calibration and used the continuous data stream 3 to record an hour or more of the long period calibrations. The Reftek calibration parameters used with the STS2 seismometers were: amplitude of 0.5 volts, period of 360 seconds and size of 361 seconds resulting in a square wave of 0.5 volts peak to peak with a period of 720 seconds. The calibration coil for each component of the STS2 was in series with a 5 megohm resistor to accurately fix the calibration current. The three components of the STS2 are electrically merged into a vertical and two perpendicular horizontal components, and the geometry of the internal components will yield no net calibration response on the horizontals in the ideal case. Only the vertical STS2 component was analyzed for calibration.

The Reftek calibration parameters used with the CMG3-ESP seismometers were amplitude of 0.003 volts, period of 180 seconds and size of 181 seconds resulting in a square wave of 0.003 volts peak to peak with a period of 360 seconds. The CMG3-ESP calibrates only one component at a time and requires that the component be selected manually from the control box. Our procedure was not long enough for all 3 components to be adequately recorded, and only the North component yielded sufficient data to stack and analyze.

Calibration pulses were recorded with a period which was known and permitted repeated calibration results to be cut, time aligned, and stacked to achieve a signal to noise enhancement for a calibration pulse for modeling. An unpublished code of D.B. Harris of LLNL was used to fit synthetic calibration pulses to the observed pulses. The code uses a grid search followed by a conjugate gradient least squares optimization to find a best fit to the observed calibration pulse's free period, fraction of critical damping, amplitude, and bias. Tabulated calibration information consists of free period and fraction of critical damping. We have not completely resolved the amplitude of the calibration signals and feel that the nominal sensitivities are more accurate than our estimated sensitivities. The calibration information for each available calibration is given below.

The calibration data is provided in SEG-Y format in the *CAL_Traces* directory. It is sorted into station subdirectories, e.g. the Amdo calibrations are in *CAL_Traces/AMDO*.

Seismometer Calibration Parameters

Station	Date	Free Period (sec)	Fraction Critical Damping
AMDO	06/07/92	120.2	0.72
BUDO	07/02/92	120.5	0.72
ERDO	06/30/92	121.2	0.72
GANZ	06/02/92	123.6	0.72
LHSA	06/05/92	120.4	0.72
MAQI	06/19/92	121.6	0.72
SANG	06/06/92	120.6	0.72
TUNL	05/17/92	30.3	0.76
USHU	06/17/92	122.6	0.71
WNDO	05/21/92	122.5	0.71

9. Lhasa Event Extractions

To aid in the use of the LHSA data, we used the PASSCAL code segymerge to extract time windows associated with the PDE-correlated events that triggered other sites. We used segymerge to extract windows 100 seconds before through 1500 seconds after the theoretical P-wave arrival time for each of the PDE events we recorded after LHSA began recording 5 sps continuous data. These data are provided in SEG-Y format in the AIT subdirectory *Lhasa_Events*. This directory structure is of the same form as that of the associated events provided on Tapes 6, 9, and 12. Three events had excessive gaps in the LHSA continuous stream:

91.270.11.55.24 841 msec gap
91.347.20.01.02 483829 msec gap
92.137.20.20.20 477403 msec gap

The merged files for these events are in Lhasa_Events, but may be of little use.

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The version of segymerge that we originally used had a bug in it. The SEGY start time of the merged data occasionally included a millisecond value greater than 999. The revised Auxilliary Information Tape has a revised Lhasa_Events directory in which the problem has been fixed by using a new version of segymerge.

In addition, on Tape 13, we have discovered that from Days 94.235 to 94.270, data in the DS3L.91 subdirectory, advertised on page 4 of the data report to be in directories of the form Rxxx.03 are actually in directories of the form Rxxx.05. This is just an informational notice. No action is required by users.

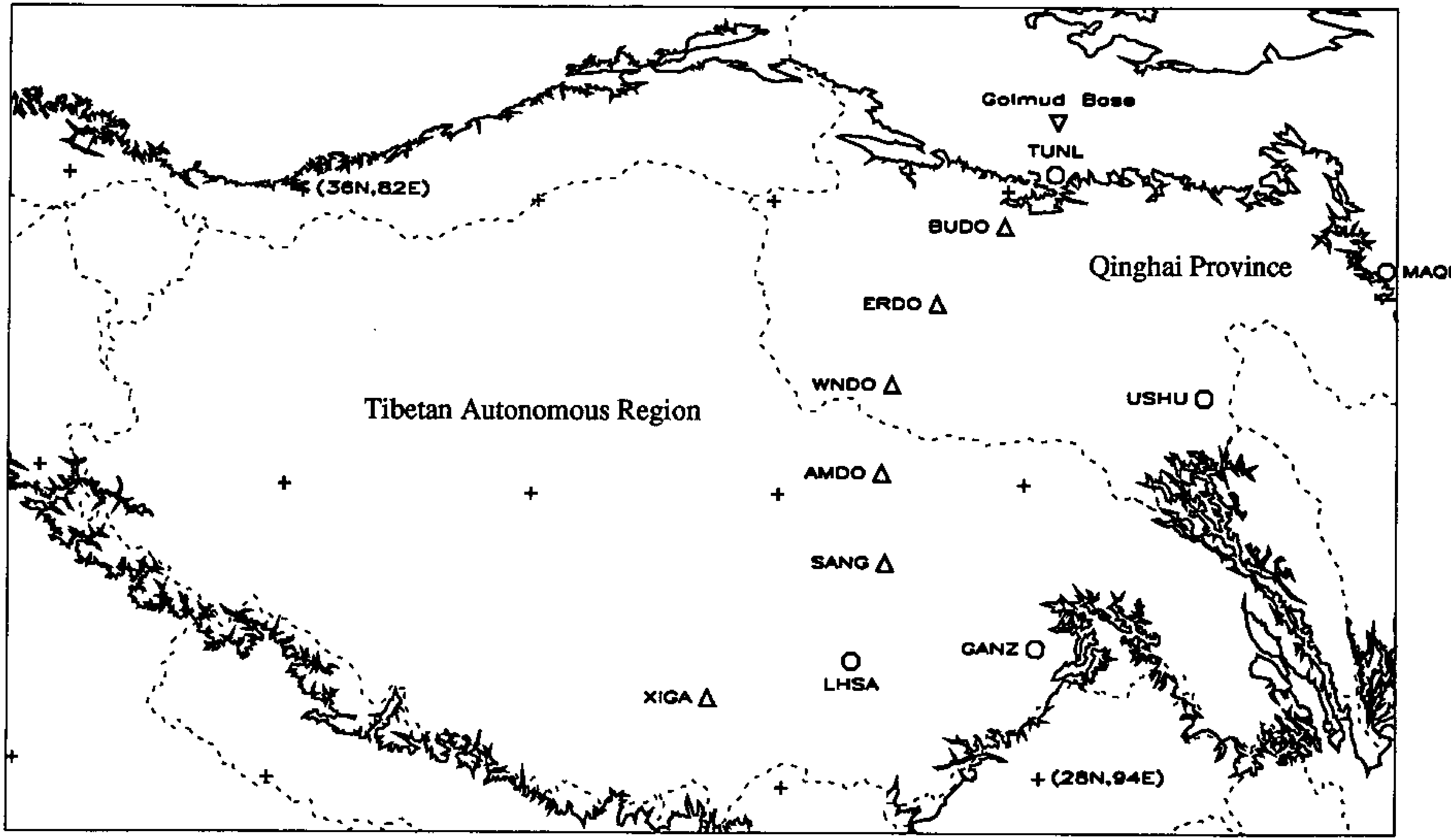
10. Acknowledgements

This experiment was a cooperative project with the Institute of Geophysics, State Seismological Bureau, People's Republic of China through the research group of R.S. Zeng. This project benefited from the hard work and cooperation of the Seismological Bureaus of Qinghai Province and the Tibetan Autonomous Region. Chinese participants included Z. Zeng, Z. Deng, W. Sun, Z. He, and L. Zhu. Additional US participants in the field program included: R.Busby (PIC-LDGO), R. Kuehnel (Carnegie-DTM), S. Owens, M. Salvador, G. Wagner (all at USC). The PASSCAL Instrument Center at Lamont-Doherty Geological Observatory provided considerable support before and during the deployment. S. Owens and K. Perry correlated our events with the PDE locations. This project was supported by NSF Grants EAR-9004428, EAR-9196115 and EAR-9004221.

11. Figure Caption

FIG 1. Location map for the Tibetan Plateau Passive-Seismic Experiment. Heavy contour is the 4000m contour defining the approximate physiographic boundary of the Tibetan Plateau. Open triangles represent stations built by our groups for this experiment. Open circles represent permanent sites of the Chinese regional networks occupied for this project.

1991 Tibetan Plateau Seismic Experiment Station Map



ADDENDUM/ERRATA SHEET

for PASSCAL Data Report 93-005

6/12/95

IRIS DMC distributes the TIPLT set as 7 tapes, containing the 13 volumes mentioned in the documentation *plus* the Revised AIT data supplement.

DMC TAPE #	TIPLT TAPES CONTAINED
1	1,2,4,6 (3 and 5 not distributed)
2	7,8
3	9,10
4	11,12
5	13
6	14, AIT
7	AIT Revised

NOTE: The Revised AIT tape (#7) contains a single tar volume with a block size of 63448. Thus tar extraction must be performed by explicitly indicating the block size.

Example: `tar -xvfb /dev/nrst0 63448`

END ADDENDUM