BOROVOYE DIGITAL SEISMOGRAM ARCHIVE FOR UNDERGROUND NUCLEAR TESTS DURING 1966–1996

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Summary

Seismic waveform data digitally recorded at the Borovoye Geophysical Observatory (BRV), in northern Kazakstan since 1966 are available for analysis. The BRV archive for 711 Underground Nuclear Tests[1] (UNT) carried out by five nuclear powers since 1966 are reformatted into CSS 3.0[2] data format. The list of event numbers in the BRV archive for UNTs from various test sites is given in Table 1.

A major digital seismogram archive at Borovoye is being reformatted into a modern format suitable for analysis and preservation. Since 1991, the authors at the Lamont-Doherty Earth Observatory (LDEO) and at the Institute for Dynamics of Geosphere (IDG), Moscow have worked hard under the auspices of the IRIS Consortium, the Air Force Office of Scientific Research and Defense Threat Reduction Agency, U.S. Department of Defense, International Science and Technology Center (ISTC), Moscow, and other organizations to preserve the 30 years of digital seismogram archive at BRV (see a feature article in *EOS* by Richards, Kim and Ekström, 1992).

This release of the BRV digital seismogram data archive results from nearly 10 years of hard work by many engineers and analysts at IDG, Moscow. Drs. Nadezhda Belyashova and Natalia Mikhailova at the Institute of Geophysical Research, National Nuclear Center (NNC), Republic of Kazakstan helped to complete the BRV archive tape presevation project. Drs. Gregory van der Vink and David Simpson at the IRIS Consortium provided important help during the early years of the BRV archive preservation project. This note describes certain information regarding these waveform data archive and provides basic parameters needed to analyze them.

[1]We shall use the distinction between a nuclear test and a nuclear explosion that was adopted in the revised protocol of 1990 for the Threshold Test Ban Treaty. Thus, a single underground nuclear test (UNT) can consist of a number of different underground nuclear explosions (UNEs) provided these are carried out within a time interval not exceeding 0.1 s and within an area delineated by a circle whose diameter is less than 2 km. Explosions with a time interval longer than 0.1 s, or a distance greater than 2 km, are counted as separate tests. We note that this distinction between UNTs and UNEs has been followed in official Russian documentation of the Soviet test program at STS, but with one exception, namely the nuclear test which was conducted at Degelen in a tunnel on January 30, 1974. (see Khalturin et al., 2001).

[2]Center for Seismic Studies version 3.0 relational database format.

Table 1: Borovoye Digital Archive for World-wide Underground Nuclear Tests, 1966–1996

Country	Test site	Time period	BRV data
USSR	Semipalatinsk Test Site	1966 Dec 18 – 1989 Oct 19	228
	Novaya Zemlya	1967 Oct 21 – 1990 Oct 24	31
	Peaceful Nuclear Explosions	1967 Oct 06 – 1988 Sep 06	80
China	Lop Nor Test Site	1970 Sep 22 – 1995 May 15	11
France	Tuamotu Archipelago	1977 Mar 19 – 1996 Jan 27	68
United Kingdom	Nevada Test Site	1978 Apr 11 – 1989 Dec 08	15
United States	Nevada Test Site	1967 May 23 – 1992 Mar 26	278
	Total number of UNTs in the BRV archive		711

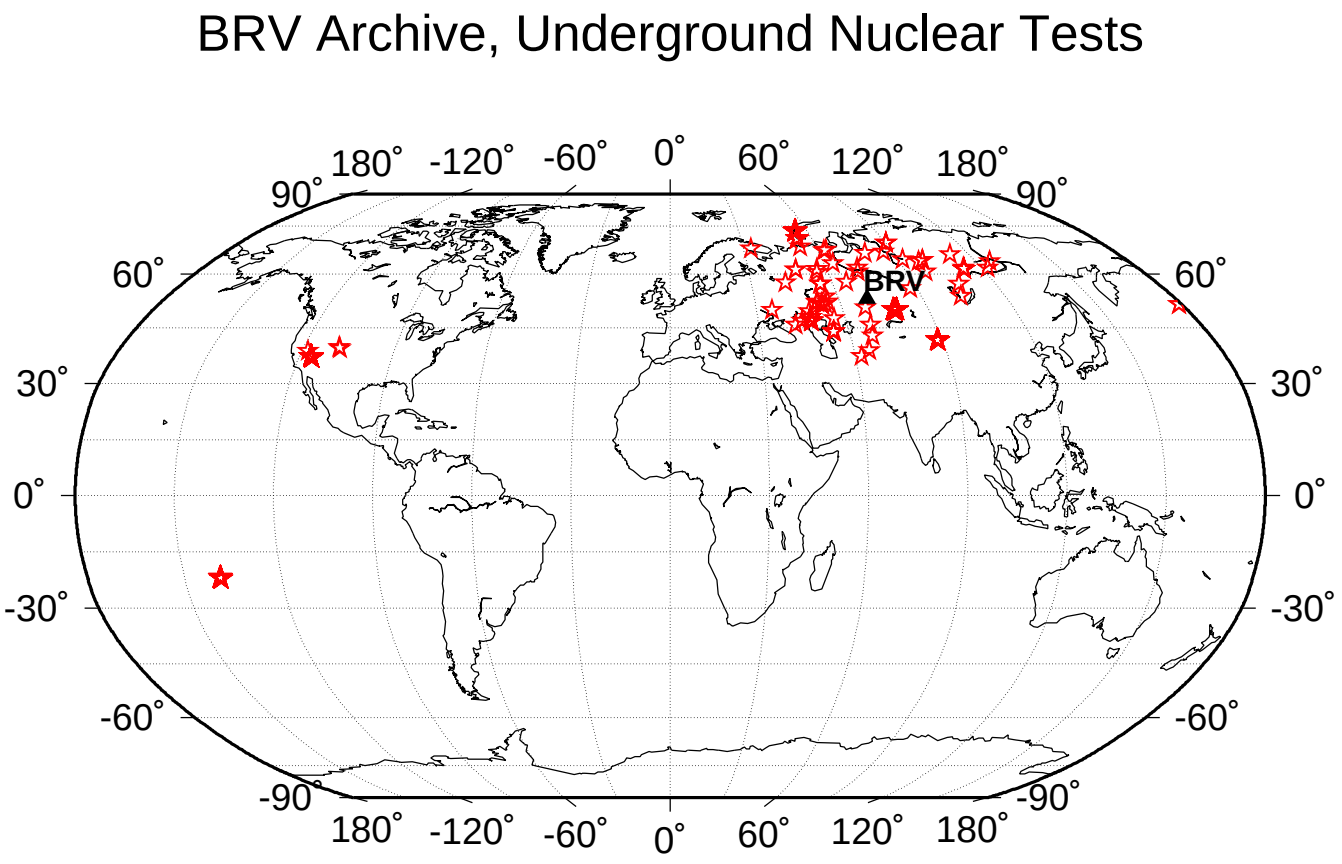

Figure 1: The Borovoye archive for world-wide underground nuclear tests (*stars*) during 1966-1996.

1. Borovoye Archive for UNTs carried out by Former Soviet Union

Former Soviet Union (FSU or USSR) conducted its first nuclear test on August 29, 1949 and the last – 715th, nuclear test on October 24, 1990. The official publication from the Ministry of Atomic Energy & Ministry of Defense, Russian Federation (Mikhailov et al., 1996) lists a total of 715 nuclear tests and peaceful nuclear explosions. Among the 715 tests, 219 tests were atmospheric, underwater and space explosions, and remaining 496 tests were underground tests (see Table 2).

Table 2: Borovoye Archive for USSR Underground Nuclear Tests

Location/Type	UNT	Air/Surface	Underwater	total	BRV archive
Semipalatinsk Test Site	340	116		456	228
Novaya Zemlya Test Site	39	86	5	130	31
Peaceful Nuclear Explosions	117			117	80
Missile Test Range		10		10	
Weapons test		2		2	
Total	496	214	5	715	339 (68%)

Thus, the BRV archive provide data for about 2/3 of the announced UNTs at various test sites of the FSU.

2. BRV Archive Data from UNTs at Semipalatinsk Test Site, FSU

Official Russian publications (Mikhailov et al., 1996; USSR Nuclear Tests, 1997) have listed 340 underground nuclear tests that were conducted during 1961-1989 at the Semipalatinsk Test Site (STS) in Eastern Kazakstan. Only 271 of these nuclear tests appear to have been described with well-determined origin time, coordinates and magnitudes in the openly available technical literature (Khalturin et al., 2001). Thus, if we count only these 271 UNTs, then the BRV archive provide data for nearly 85% of these UNTs at Semipalatinsk Test Site.

In Figure 2, we show a map of the Semipalatinsk Test Site boundaries (as reported by the Soviet Union at the time of TTBT entry-into-force in 1990), together with the locations of 228 UNTs with BRV archive data. There are three source regions of the seismic data from UNTs at Semipalatinsk Test Site as shown in Figure 2. These are known as Balapan, Degelen and Murzhik subareas.

2.1 BRV Archive Data for Balapan Subarea of the Semipalatinsk Test Site

105 UNTs were conducted at Balapan subarea of the STS during 1965-1989. Among these, one UNT had yield of less than 1 ton and could not be identified by seismic method (see Mikhailov et al., 1996). BRV archive contains seismic data from 93 UNTs. These are listed in Table A1 and are plotted in Figure 2. Borovoye archive covers seismic data from over 90% of all

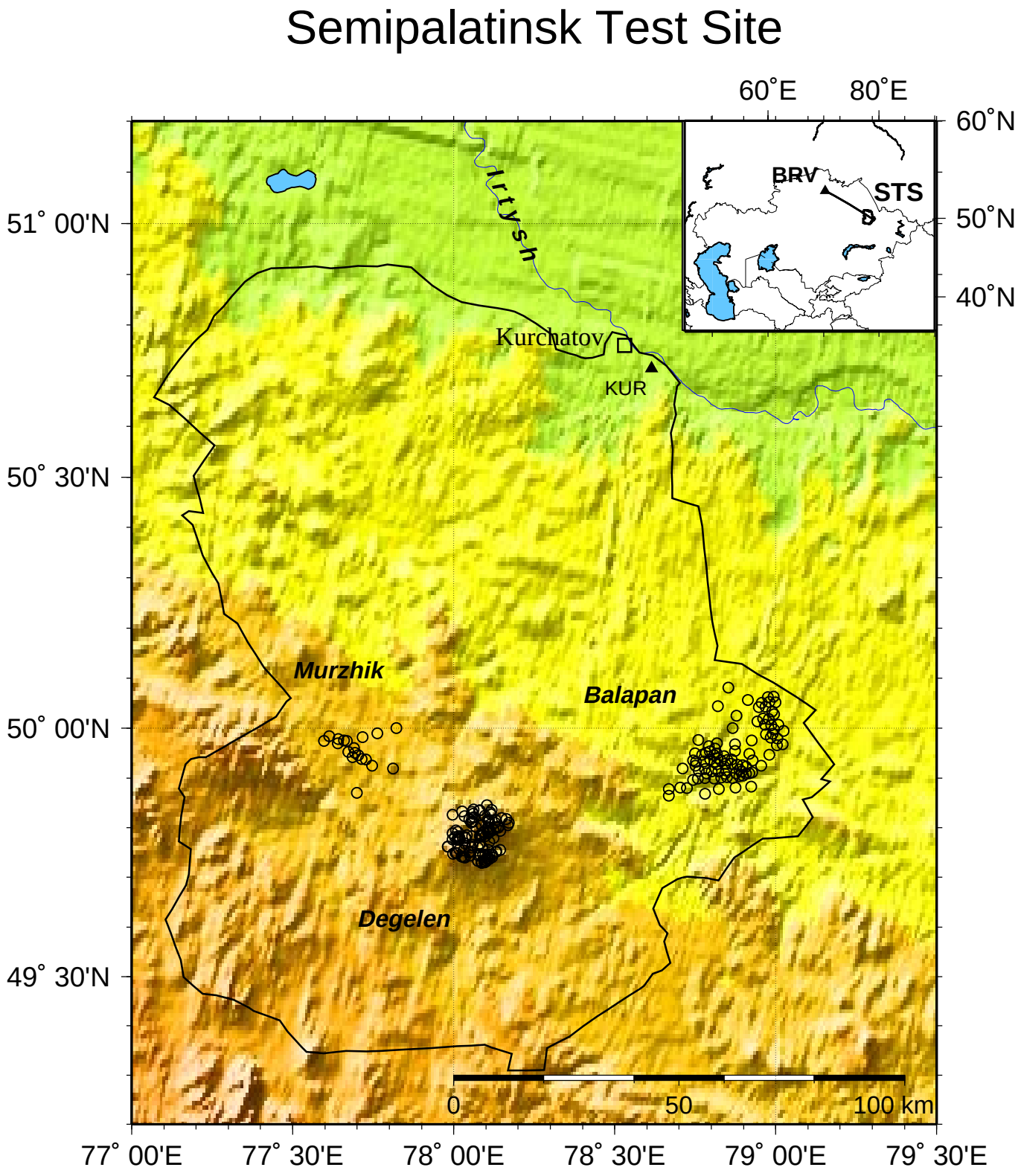

Figure 2: UNTs at Semipalatinsk Test Site (*circles*) recorded at Borovoye (BRV) during 1966-1989. Kurchatov was a restricted town supporting USSR nuclear testing in the region.

Table 3: Underground Nuclear Tests at the Semipalatinsk Test Site

Location/subarea	UNT	<1 ton	Double	small	Detectable	BRV archive
Balapan	105	1	1	3	100	93
Degelen	209	14	12	26	155	116
Murzhik	26		1	2	23	19
Semipalatinsk Test Site	340	15	14	31	278	228

UNTs conducted at Balapan subarea. For UNTs at Balapan subarea until Dec. 1972, ground truth information on location and origin times are taken from Bocharov (1989; see also Vergino, 1989). For UNTs since 1973, the location are from the ground truth information available from National Nuclear Center, Republic of Kazakstan (NNCRK; 1999), while the origin times are taken from the Lilwall and Farthing (1990) of the British Atomic Weapons Establishment (AWE). We take the body-wave magnitude given in Ringdal et al. (1992), which are the maximum likelihood mb's detemined by AWE. All UNTs at the Balapan subarea were carried out in vertical shafts drilled down to about 500 m from the ground level. The Balapan subarea is nearly flat with an average elevation of about 300 m. Accurate origin times for 10 UNTs during 1985–1989 are given in Adushkin et al. (1997). These origin times are used to evaluate origin times of other UNTs since 1973 given in various catalogs. Our evaluation indicates that the origin times and location biases in the AWE catalog[3] are smallest among the available catalogs. Our analysis indicates that the AWE origin times should be accurate within ± 0.15 sec.

2.2 BRV Archive Data for UNTs at Degelen Subarea of the Semipalatinsk Test Site

There are waveform data from 116 UNT at Degelen Mt. region of the STS in the BRV archive. Table A2 lists date, time, location and magnitude of these UNTs. Almost all UNTs in the Degelen subarea have been carried out in horizontal tunnels dug into granitic rocks of the Degelen Mt. For most UNTs till 1972, ground truth data are given in Bocharov (1989). For UNTs between 1973-1989, location is given for the portal of the tunnel (Leith, 1998), while the origin times are taken from Lilwall and Farthing (1990) of the British Atomic Weapons Establishment. Although, the locations are given up to five decimal digits, the accuracy of the actual shot points can be away from the given locations by as much as few hundred meters, thus these locations could be considered GT2 quality[4]

Notice that BRV waveform data archive contains four pairs of UNTs at STS which were exploded almost simultaneously, or within a short time interval, less than 10 sec (see Table 4).

The BRV archive also contains waveform data from three small UNTs at Degelen subarea which were not well documented in the open literature (see Khalturin et al., 2001). These UNTs are; Sep. 02, 1967 (#271), Jan. 29, 1971 (#332) and Dec. 28, 1988 (#707)(see Table A2).

[3]joint epicenter determination (JED) method described by Douglas (1967) to ISC data are use to obtian origin times and locations, using several UNTs at STS as master events for which ground truth information was given by Bocharov et al. (1989; also Vergino, 1989).

[4]GT2 is used here to indicate ground truth data with location accuracy of about $\pm$ 2 km.

Table 4: BRV archive for UNTs at STS which were detonated almost simultaneously

Date	Time (hh:mm:sec)	$m_b(P)$	Test id	Test site
Dec. 10, 1972	04:27:00.0	5.72	376	Degelen
	04:27:10.0	5.96	377	Balapan
Oct. 29, 1977	03:06:59.97	5.60	473	Degelen
	03:07:04.92	5.56	474	Balapan
Aug. 29, 1978	02:36:59.95	5.20	493	Degelen
	02:37:08.75	5.90	494	Balapan
Nov. 29, 1978	04:33:00.17	5.21	507	Degelen
	04:33:04.99	5.96	506	Balapan

2.3 BRV Archive Data for UNTs at Murzhik Subarea of the Semipalatinsk Test Site

Waveform data from 19 UNTs from the Murzhik subarea in the STS are included in the BRV archive database (see Table A3). Locations and origin times for 13 UNTs from 1966 through 1972, are taken from Bocharov (1989). For UNTs since 1973 at Murzhik subarea, so far no ground truth data are available and the locations and origin times of six UNTs since 1973 through 1980, are take from Lilwall and Farthing (1990). Note that for the UNT on Aug. 4, 1976, location and origin time are taken from Khalturin et al. (2001).

3. Borovoye Archive Data for UNTs at Novaya Zemlya Test Site

There are 39 UNTs at Novaya Zemlya Test Site (see Mikhailov et al., 1996) and the BRV archive provide seismic records from 31 UNTs. Table A4 lists paramters for BRV archive data from UNTs at Novaya Zemlya Test Site. Location, origin time and maximum likelihood body-wave magnitude are taken from Marshall et al. (1994). Note that longitude given in Marshall et al. (1994) is moved to the West by 0.009° as indicated by Richards (2000). Most of the UNTs conducted at the NZ Test Site are multiple explosions (see Table A4). In Figure 3, we show a map of the Northern and Southern Test Site boundaries of the Novaya Zemlya test sites (as reported by the Soviet Union at the time of TTBT entry-into-force in 1990), together with the locations of 31 UNTs with BRV archive data. Most of the UNTs are conducted in tunnels dug in the mountains south of the Matochkin Shar Strait as shown in Figure 3. Three UNTs with BRV archive data are conducted in vertical shafts at the southern Novaya Zemlya Test Site (Test No. 388, 392, 430 and 431 in Table A4).

4. Borovoye Archive Data for Peaceful Nuclear Explosions in FSU

The Former Soviet Union carried out 117 Peaceful Nuclear Explosions (PNE)[5] throughout its territory as shown in Figure 4. BRV archive contains 80 PNEs which are listed in Table A5. Ground truth data are available for many of these PNEs (see Sultanov et al., 1999). Epicentral

[5]Here we are taking the definition of a PNE as a nuclear test conducted off recognized test sites.

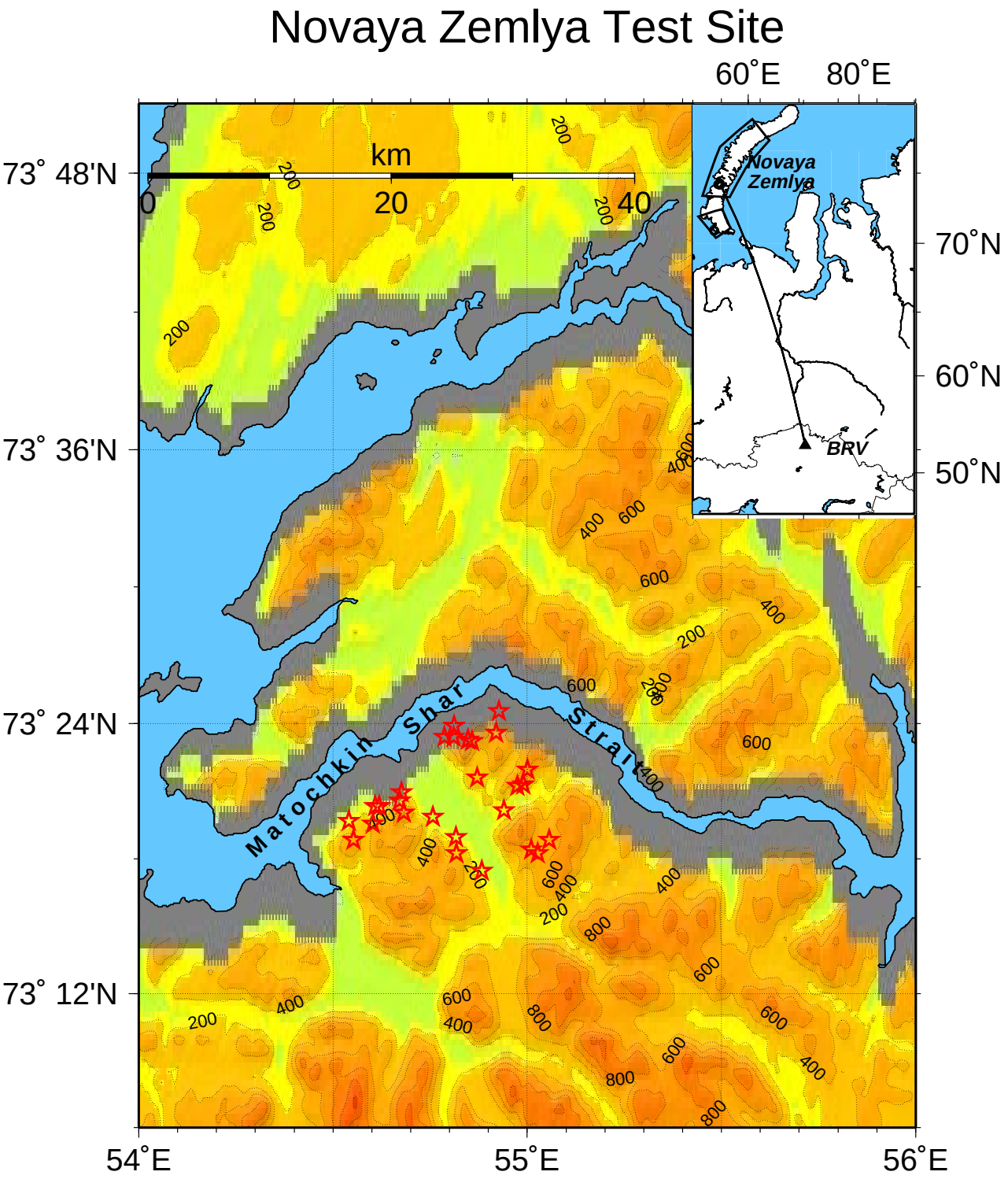

Figure 3: Locations of UNTs (*circles*) at Northern Novaya Zemlya Test Sites recorded at Borovoye during 1967-1990 are shown on topographic relief map. Southern and Northern Test Sites on Novaya Zemlya and great circle path between BRV and NZ test site is indicated (*inset*).

distance ranges from 2.8°to 29.7°from BRV and have a wide azimuthal coverage providing excelent data for studies of regional seismic wave propagation in Central Asia (see Figure 4). We will show an example waveform to illustrate the quality of the BRV archive data.

PNE on Oct. 17, 1978, 14:00:00.16

This PNE is conducted in Tyumen region at a location 63.185°N, 63.432°E and depth of burial of 593 meters (Sultanov et al., 1998). The event id is #503 (see Table A5) which is also called "Kraton" shaft KR-1 and had a yield of 22 kt. It was detonated in sandstone/shale material and had magnitude, $m_b(P)$=5.5. Figure 4 shows the location of the event (#503 in the figure).

The waveform data are recorded by STsR-SS 10-channel system, which has three-component, short-period seismometers (KS channels) and records with sampling rate of 31.25 samples per second (dt=0.032 s, fN=15.6 Hz) – channel names sZ07, sN08, and sE09. SS system also has three-component long-period seismometers (channels lZ02, lN03 and lE04), and a low-gain short-period vertical-component (channel, sZ01). Three channels (5, 6 and 10) are usually unused for recording seismic signals.

The instrument responses of KS channels are nearly flat to ground displacement between 0.6 to 5 Hz with a nominal gain of 1268 counts/micrometer at 1.5 Hz (Figure 11; Kim & Ekström, 1996). The vertical record from this PNE has peak amplitude of 842 counts which yields ground displacement of about 0.68 micrometer. Note that maximum digital counts available for the Borovoye digital archive data is 1024 counts (11 bit A/D with a sign bit).

For comparing the regional records from the Borovoye digital archive data with those recorded by recent broadband instrument from IMS and IRIS/GSN stations, it is useful to differentiate the BRV records, since they are recorded with the instrument response which produces nearly ground displacement records (see, Richards, Kim & Ekström, 1992).

The velocity record from this PNE is plotted in Figure 5. The vertical records in various frequency bands - 0.5–2 Hz through 8–10 Hz, are plotted with time axis in group velocity (km/s). Notice that regional characteristic phases, *Pn*, *Pg*, *Sn* and *Lg* are all well excited by the test. The *P* waves (*Pn* and *Pg*) as well as *Sn* waves are energetic at all frequency bands with strong coda following the onset arrivals, while *Lg* waves are relatively weak and show larger amplitude, but short duration (at around 3.3 km/s). The strong signal arrives at around 3 km/s cannot be easily identified. In general, the quality of the record is satisfactory. Notice that one of the short-period horizontal component record (sE09) is clipped.

To examine the periodicity of the signal, we calculate the spectrogram (Figure 6). The spectrogram shows time invariant spectral bands at 3.5, 6, 9.5 and 11.5 Hz which are usually associated with source multiplicity (see e.g., Kim et al, 1994). The average frequency difference (df) between these spectral banding is about 2.7 Hz which suggests a multiple source with time difference of about 0.4 sec (Figure 7).

In case of ripple fired quarry blasts or underwater explosions, complex interference pattern as well as spectral bandings due to source multiplicity and reverberations in the water column lowers the Pn/Sn ratios as noted by Kim et al. (1993, 1994 and 1996). Hence, relatively low Pn/Sn ratios of this PNE are not unusual. In such case, spectral bandings and cepstral peaks should be used as additional event screening criteria (see Annex 2 to the CTBT Protocol, September 1996).

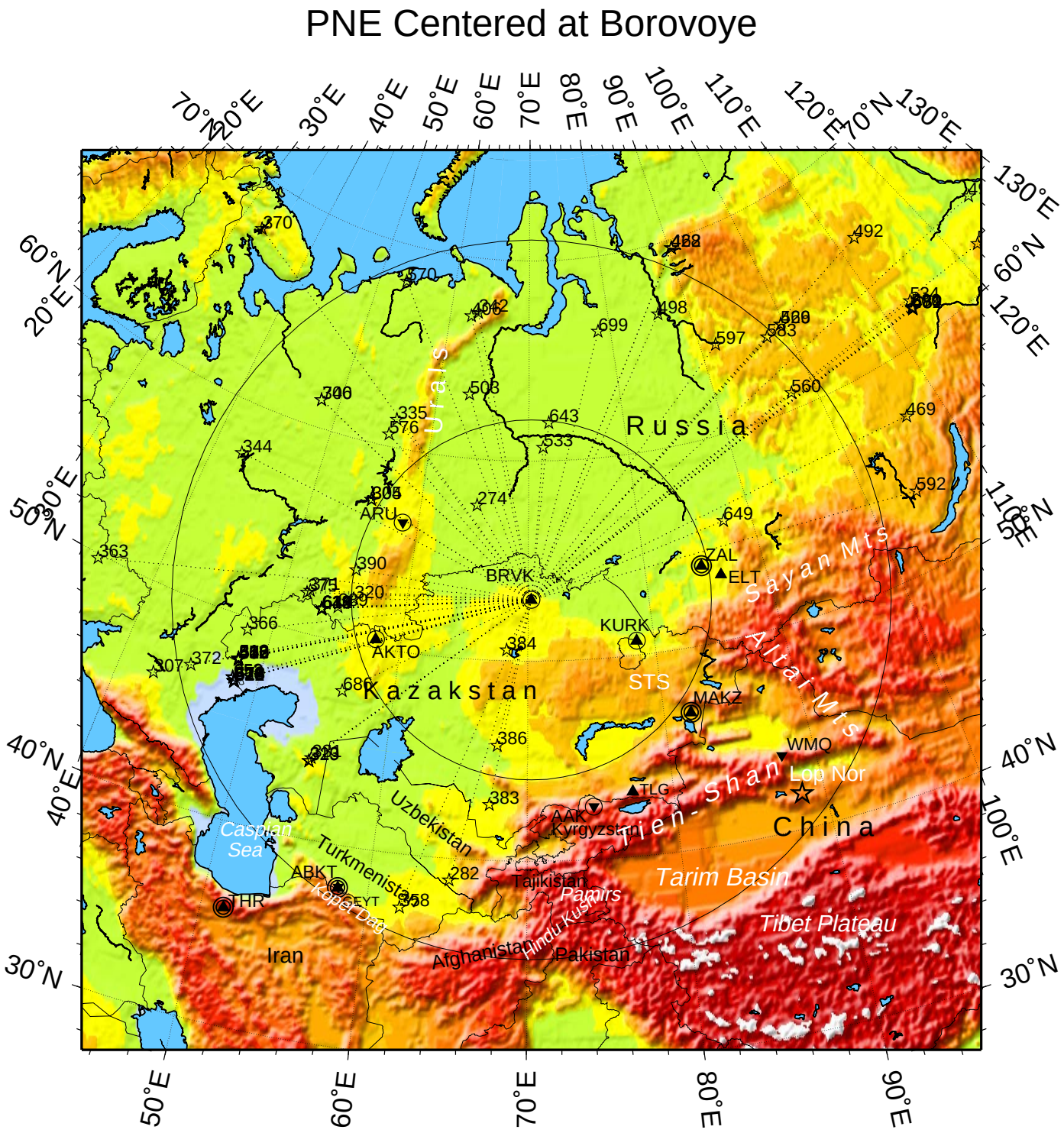

Figure 4: Soviet PNEs (*stars*) recorded at Borovoye during 1967-1988. Event id in Table 5A is indicated for each PNE. IMS primary (*double circle*), auxiliary (*single circle*), IRIS/GSN (*inverted triangle*) and Kazakstan Broadband Seismographic Network stations are indicated (*solid triangle*). Large circles around BRV indicate 1000 and 2000 km distance ranges from the staton.

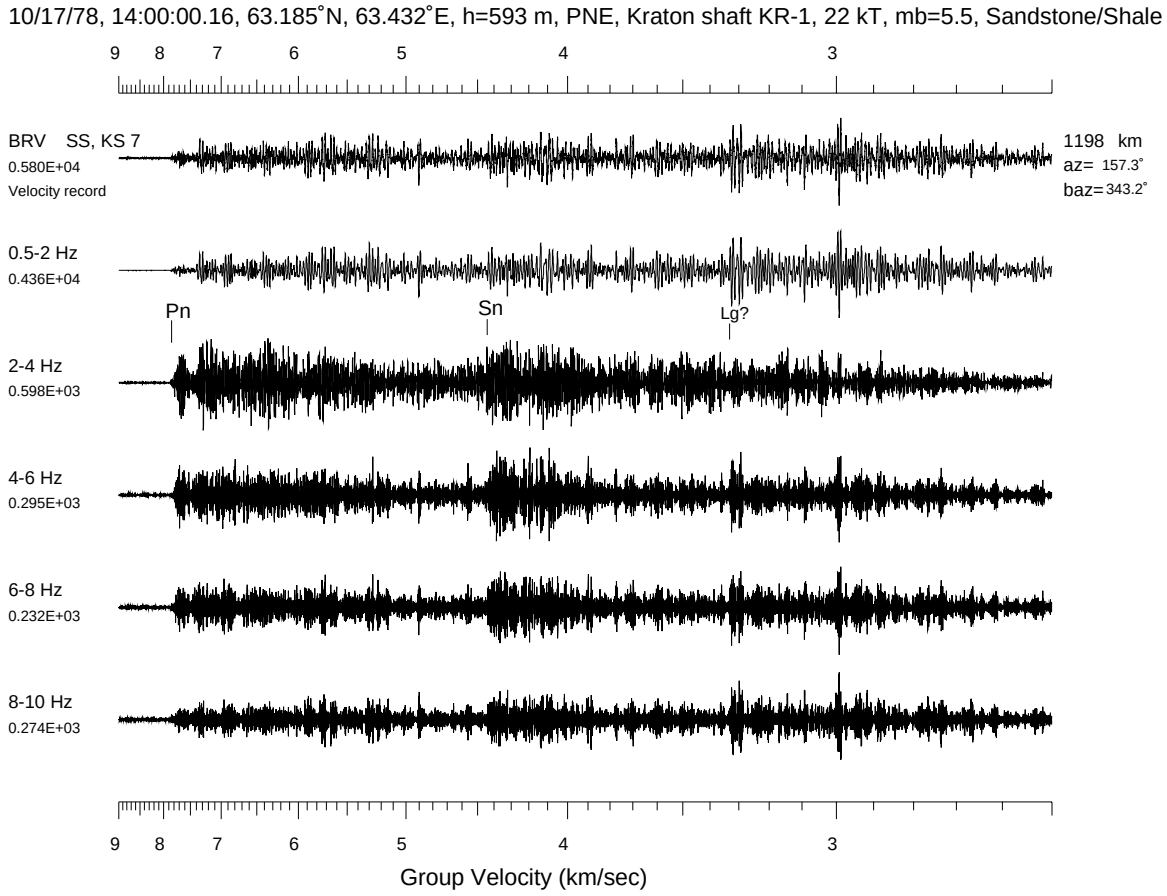

Figure 5: Vertical, velocity record filtered in various frequency bands – 0.5–2 Hz through 8–10 Hz, are plotted with time axis in group velocity (km/s). The *P* waves (*Pn* and *Pg*) as well as *Sn* waves are energetic at all frequency bands with strong coda following the onset arrivals, while *Lg* waves are relatively weak.

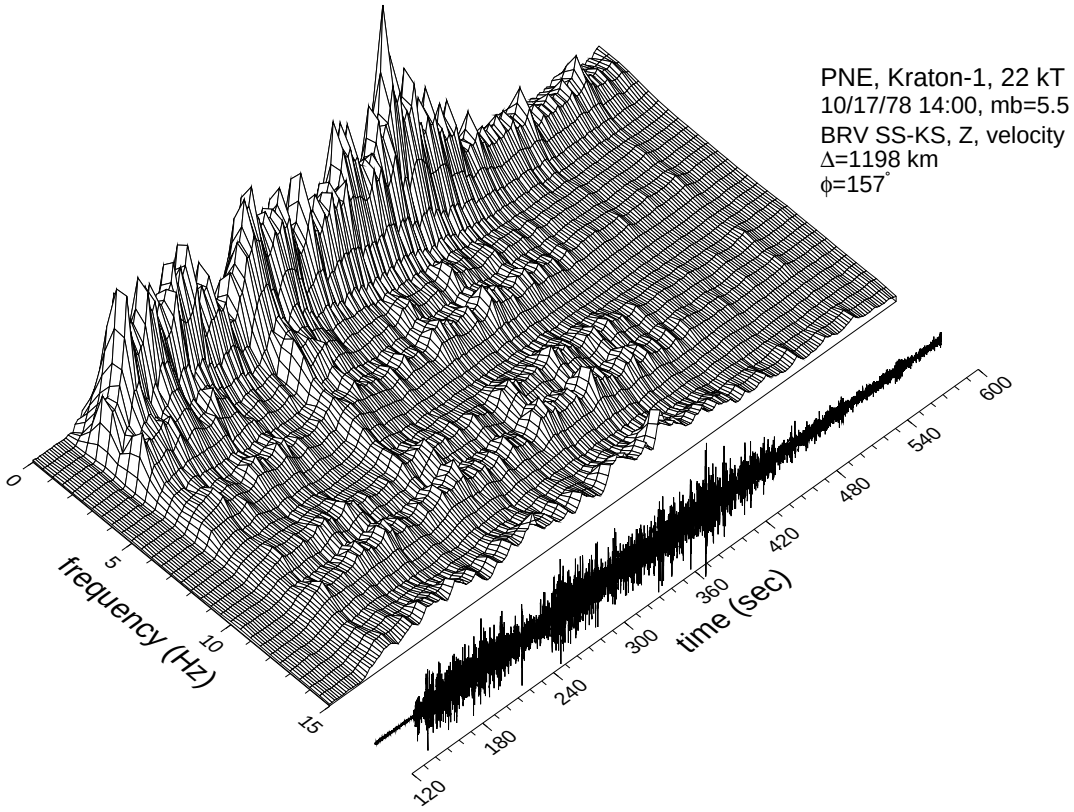

Figure 6: Spectrogram of the velocity record from PNE on 10/17/78. The spectrogram shows time invariant spectral bands at 3.5, 6, 9.5, 11.5 Hz which are usually associated with source multiplicity.

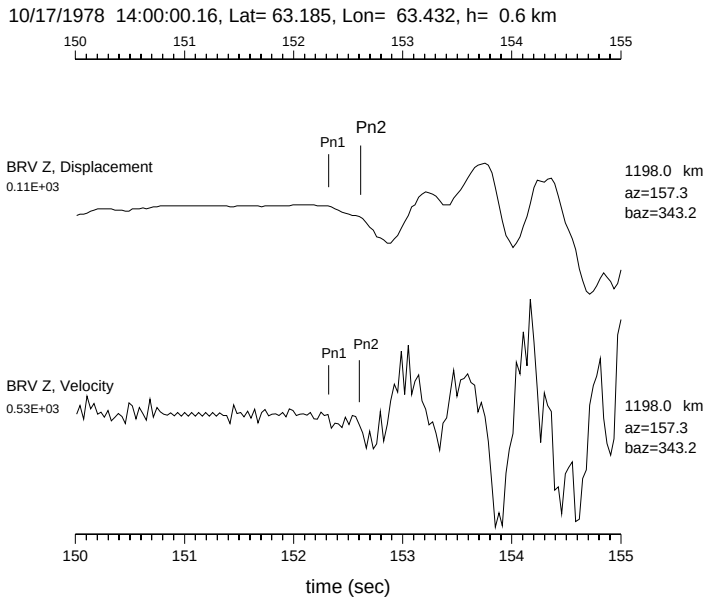

Figure 7: First few seconds of the records from the PNE on 10/17/78 are plotted to show possible multiple *Pn* arrivals marked as *Pn1* & *Pn2*.

5. Borovoye Archive Data for Chinese Nuclear Tests

Since 1964, China carried out nuclear tests in Xinjiang-Uygru Autonomous Province in western China. During 1969 through 1996, 22 UNT are known to have been conducted at the Lop Nor Chinese Test Site. Borovoye archive has waveform data from 11 UNTs as listed in Table A6. The epicentral distance from the Chinese Test Site to BRV is about 1800 km. The locations and origin times of the UNTs at Lop Nor during 1969-1992 are determined by Douglas et al. (1993) and Gupta (1995) by using JED method. Engdahl (2001) also re-located most of the Chinese UNTs by cluster analysis. The locations given by Engdahl are plotted in Figure 8 and are given in Table A6. As noted by Douglas et al. (1993), epicenters of the UNTs at Lop Nor are clustered into three groups; A, B and C (see Figure 8). According to the topography and geology, it was argued that UNTs in subregion A are in vertical shafts, while UNTs in subregions B and C are detonated in horizontal tunnels.

6. Borovoye Archive Data for French Nuclear Test

France carried out over 190 nuclear tests at the Pacific Test Center – Tuamotu Archipelago, French Polynesia, during July 2, 1966 through July, 15, 1996. 137 UNTs were carried out in the region around Mururoa Atoll, Tuamotu Archipelago, while 10 UNTs were carried out in the region around Fangataufa Lagoon. The Borovoye archive provides waveform data from 68 tests at the French Polynesia test sites as listed in Table A7.

For seven UNTs at Tuamotu Archipelago, no seismologically determined locations are available in open literature. These are listed on official French list with nominal time and location (22°S, 139°W). These UNTs are listed in Table A7 with their "Site" column denoted as "-" (null) entries. Locations of the 61 UNTs of which we have BRV archive data, carried out by France at Tuamotu Archipelago, French Polynesia Test Site are plotted in Figure 9.

The distance range from the UNTs at the French Polynesia test sites to Borovoye is about 141.7°with station to event azimuth of about 47°. At this distance, *PKIKP* phase, which traveled through the inner core of the Earth is the first arrival *P* wave.

Note that France carried out four atmospheric nuclear tests at the Reggane, Algeria (26.17°N, 0.08°E) during 1960-1961. 13 UNTs were carried out at Hoggar, Algeria (24.05°N, 5.05°E; Sahara Desert) test site during 1961 through 1966. Unfortunately, none of these tests in the Sahara Desert are available in the Borovoye archive.

7. Borovoye Archive Data for U.S. Nuclear Tests

The United States conducted 1,054 nuclear tests of which 815 (plus 24 jointly with U.K.) were UNT (DOE/NV209 REV-15, Dec. 2000) from July 1945 through September 1992 (see Table 5). The BRV archive has waveform data from a total of 278 nuclear tests conducted by the US from May 1967 through March 1992. These UNTs are plotted in Figure 10 and are listed in Table A8.

Ground truth information on the nuclear tests in the US were published in 1971 and 1973 for years 1961–1970 and 1971–1973, respectively by Springer & Kinnaman (1971 & 1973). In the latest publication by DoE (see DoE/NV209 Rev 15, Dec. 2000), detonation times and locations

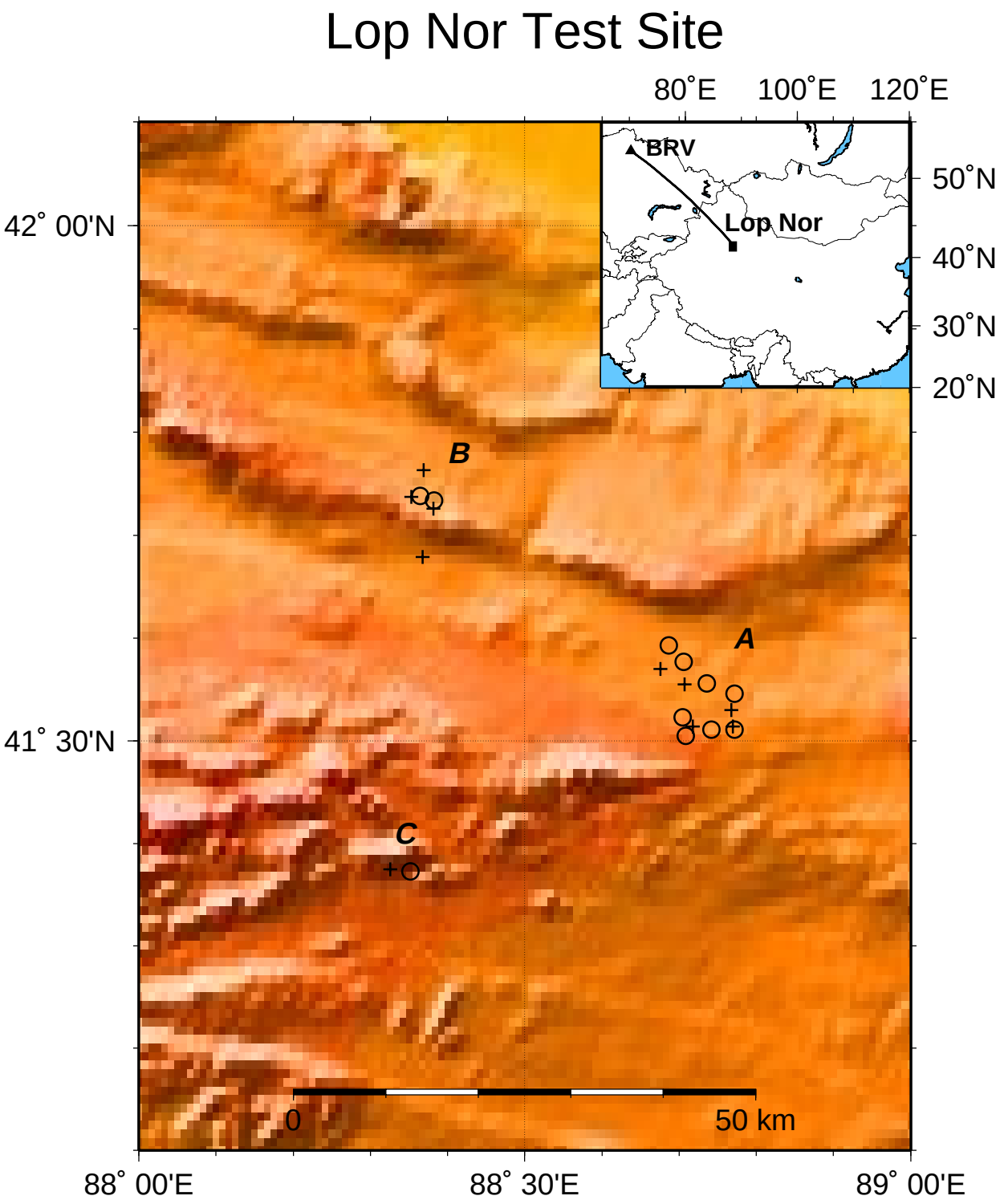

Figure 8: Locations of the UNTs at Lop Nor Chinese Test Site . Notice that UNTs are clustered into three groups: A, B and C. UNTs not contained in the BRV archive are plotted with crosses.

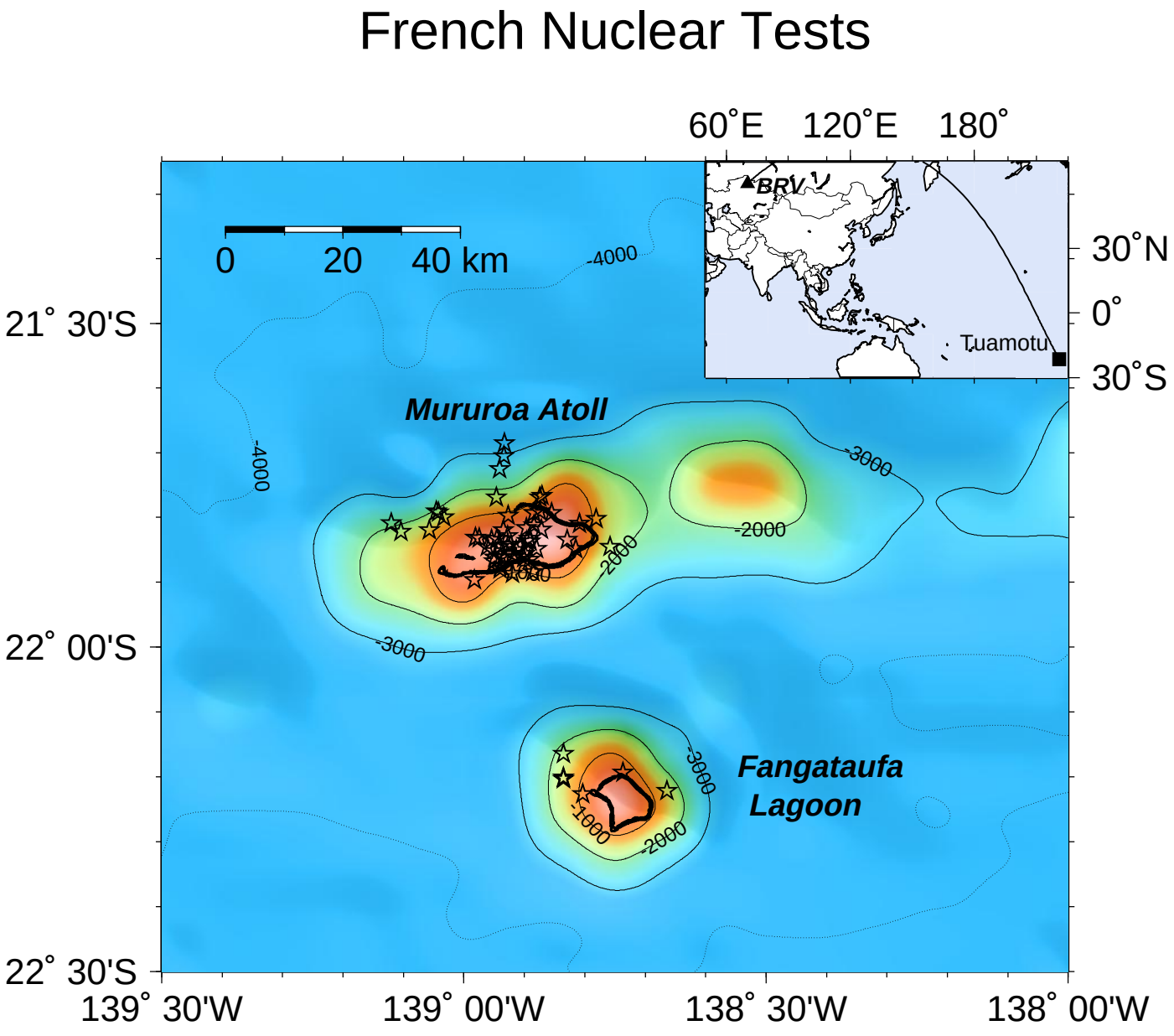

Figure 9: Locations of the French UNTs at Tuamotu Archipelago, French Polynesia. Notice that UNTs are clustered into two areas: Mururoa Atoll and Fangataufa Lagoon.

(latitude, longitude, and surface elevation) are included and are intended for use in the calibration of seismic stations that are part of the International Monitoring System (IMS) called for in the Comprehensive Nuclear Test Ban Treaty (CTBT).

Table 5: United States Nuclear Tests - Total - By Location

Location	US	US-UK
Total South Atlantic	**3**	-
Bikini	23	-
Christmas Island	24	-
Enewetak	43	-
Johnston Island	12	-
Pacific	4	-
Total Pacific	**106**	-
Alamogordo, New Mexico	1	-
Amchitka, Alaska	3	-
Carlsbad, New Mexico	1	-
Central Nevada	1	-
Fallon, Nevada	1	-
Farmington, New Mexico	1	-
Grand Valley, Colorado	1	-
Hattiesburg, Mississippi	2	-
Nellis Air Force Range	5	-
Rifle, Colorado	1	-
Total Other	**17**	-
Atmospheric, NTS	100	-
Underground, NTS	804	24
Total NTS	**904**	24
TOTAL TESTS	**1,030**	**24**

Time calibrations are obtained from the National Institute of Standards and Technology WWV radio stations. Tests were typically planned to be detonated on the exact hour, minute, or second. However, the firing systems always introduce some delay so that the actual detonation time could be as much as 150 milliseconds later than intended. When this delay is available, detonation times are given to the nearest 0.01 second, uncorrected for WWV propagation, otherwise a default value of 0.00 is given.

Latitude and **longitude** locations are the surface-ground-zero location of the drill hole or other emplacement location. Locations and surface elevations were originally surveyed in the respective State Plane Coordinates, North American Datum of 1927. These were then converted to latitude and longitude using the 1984 reference spheroid and surface elevation corrections. These corrections apply to all U.S. tests except for those in Alaska. These coordinates are presented to an accuracy of 0.001 degree or approximately 100 meters.

8. Borovoye Archive Data for British Nuclear Tests

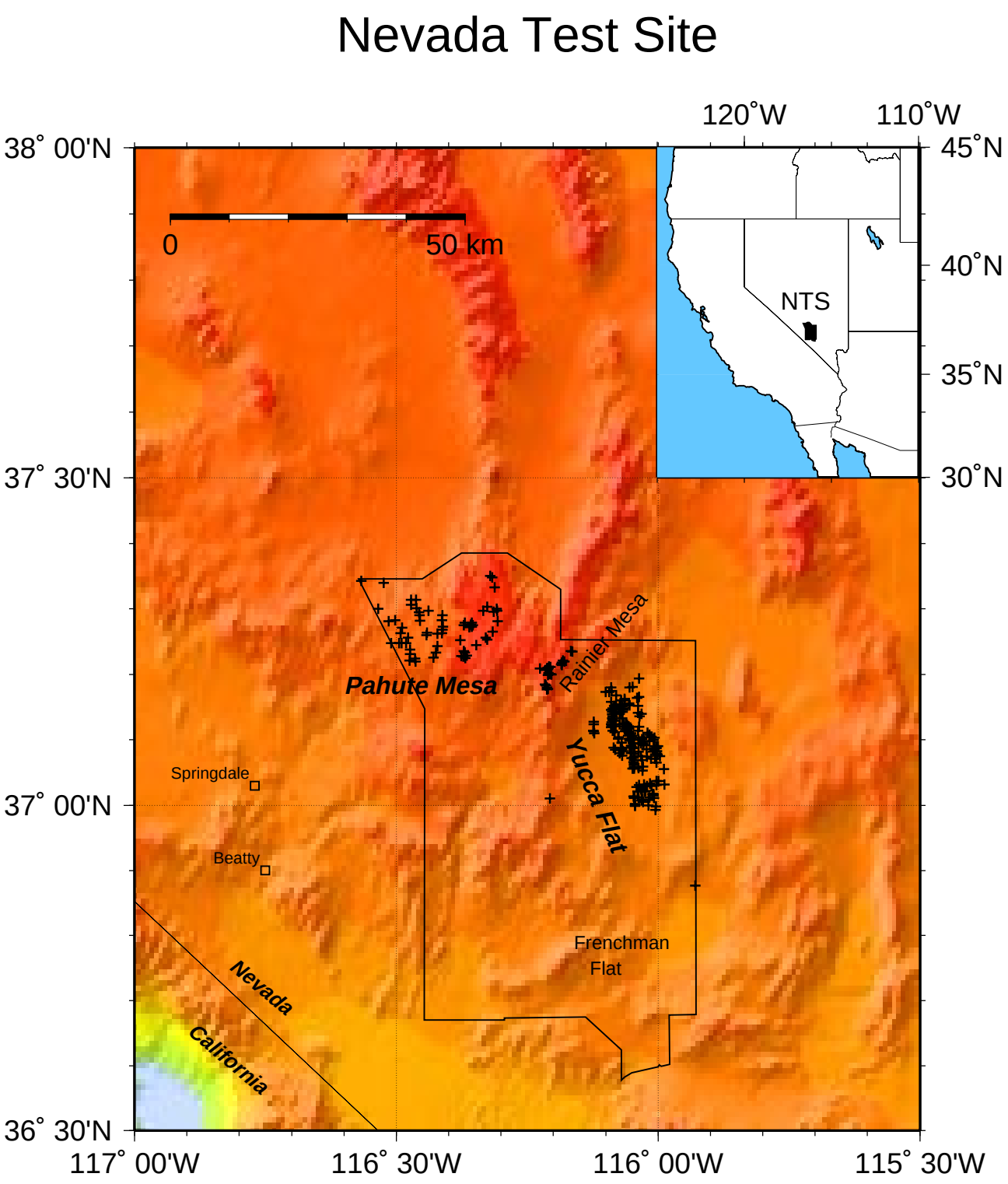

Figure 10: Locations of the UNTs carried out by the United States and jointly with United Kingdom at the Nevada Test Site (*crosses*). Most of the UNTs were clustered at Pahute Mesa, Yucca Flat and Rainier Mesa.

From October 3, 1952 through November 26, 1991, the United Kingdom conducted 45 nuclear tests of which 24 were UNTs carried out jointly with the United States at the Nevada Test Site (Table 6; Bolt, 1976). The BRV archive has waveform data from a total of 15 underground nuclear tests conducted by the U.K. from 1978 through 1989 at NTS (DOE/NV209 REV-15, Dec. 2000). These UNTs are plotted in Figure 10 and are listed in Table A9.

Table 6: United Kingdom Nuclear Tests - Total - By Location

Location	Time period	Lat.	Long.	Atmospheric	UNT
Monte Bello Island, W. Australia	1952-1956	20.3°S	115.5°E	3	-
Emu Field, S. Australia	1953	28.7°S	132.4°E	2	-
Maralinga, S. Australia	1956-1957	30.2°S	131.2°E	7	-
Malden Island, Line Islands	1957	4.3°S	154.3°W	3	-
Christmas Island, Line Islands	1957-1958	1.7°N	157.3°W	6	-
Nevada Test Site	1962-1991	37.0°N	116.0°W	-	24
TOTAL TESTS				**21**	**24**

9. Brief Description on Instrument Responses of the Borovoye STsR-TSG System

Three main seismograph systems have been used at Borovoye since 1965. They are; KOD system operated from 1966–Nov 1973 and had polarity reversal on all channels; STsR-SS system was operating from Feb 1973 to July 1994 and STsR-TSG system operating from Feb 1973 to July 1994. An additional system, called ASSTs, has been operated from Apr 1990 to July 1994. Instruments used at BRV during 1966–1996 are given in Table 7.

Instrument responses are included in the CSS 3.0 database. Most of the responses are given in discrete form as fap (frequency-amplitude-phase) files for particular channels and time period. Channel names, sample rates and nominal gains are also given in Table 7. Figure 11 shows the nominal amplitude response of the 24-channel STsR-TSG system (see Kim & Ekström, 1996).

BRV Archive Seismogram Data Format & Dropoffs

The original archive tapes at BRV were recorded by LMR-3 (June 1966 - Nov. 1973) and LMR-6 (Feb 1973 - July 1994) digital recorders (Adushkin & An, 1990), and these data loggers wrote up to 24 channels of digital data in 17 track, wide tape (35 mm). Each data sample is 16 bit (two-byte unsigned integer) and the data values are encoded in the lowest 11 bits (bits 0-11; bit 0 being the least significant bit). Therefore, data values range from 0 to 2047 unsigned integers. Four bits (bits 12 through 15) of the two-byte samples are not used, except the first 64 bytes of the first blocks, where the *time stamp* is encoded in bits 12 through 15. The time stamp provides information on channel number, digitizing interval, date, record start time (to nearest msec) and time correction.

Note that there are several drop offs of data points which were represented as “null” value in the original data. These drop offs were known to be due to the “time stamping” process in the original recording stage at BRV (Shishkevish, 1975). There are also “null” data values toward the end of the trace, and these are believed to be due to filling “null” values to fill the requested

Table 7: **Instrument Characteristics at Borovoye (BRV)**$^{(*)}$

System name	Seismometer	Channel type	Ts$^{(1)}$ (sec)	Ds$^{(2)}$	Sm$^{(3)}$ (counts/μm)	fn$^{(4)}$ (Hz)	dt$^{(5)}$ (msec)	Channel number
KOD	SKM-3	HG$^{(6)}$	3.5	1.0	3000	2.0	30	1,3,4
		LG(Z)			300	2.0	30	-
	SKD		30.0	0.71				-
STsR-SS	SKM-3	HG	2.0	0.5	2000	1.8	24	7,8,9
		(76-80)			1000	1.8	32	7,8,9
		LG(Z)			200	1.8	32	1
					20	1.8	96	6
	SKD	HG	25.0	0.71	5	0.14	192	2,3,4
					0.5	0.14	192	1,5,10
STsR-TSG	KS	HG	1.5	0.71	4500	2.37	26	7,8,9
		(1977)			2000	2.37	26	7,8,9
					1000	2.37	26	4,5
	KSM	HG	1.5	0.5	100000	1.43	26	10,11,12
		LG(Z)			1000	1.43	26	3
	KSVM	HG(Z)	1.5	0.5	4600	1.43	26	2
		LG(Z)			50	1.43	26	1
	DS	HG	20.0	0.71	50	0.1	312	19,20,21
	DSM	HG	28.0	0.71	1000	0.07	312	22,23,24
		LG			10	0.07	312	15,16,17
ASSTs	SSM-S		2.0	-	250	-	-	-

$^{(*)}$ KOD system operated from 1966–Nov 1973 and had polarity reversal on all channels, STsR system is operating from Feb 1973 to present, and ASSTs is operating from Apr 1990 to present.
$^{(1)}$ Ts = Seismometer natural period in second.
$^{(2)}$ Ds = Seismometer damping constant, critical damping = 0.71.
$^{(3)}$ Sm = Nominal sensitivity (gain) in count/micron for ground displacement.
$^{(4)}$ fn = Normalization frequency where nominal sensitivity is measured.
$^{(5)}$ dt = Sampling interval in millisecond.
$^{(6)}$ HG is actually the base channel and not necessarily a high-gain; LG = low-gain channels and (Z) indicates that it is only vertical component.
N.B., Nominal gains have changed from time to time, for example, during 1976-1980 data on SS-SKM channels and on 1977 data for TSG-KS channels.

time window when data were played back from the original 17-track tape in order to write the ADM format files.

It should be noted for these archive data that the data are of variable quality. Some signals are badly clipped. However, for some examples the data are of excellent quality.

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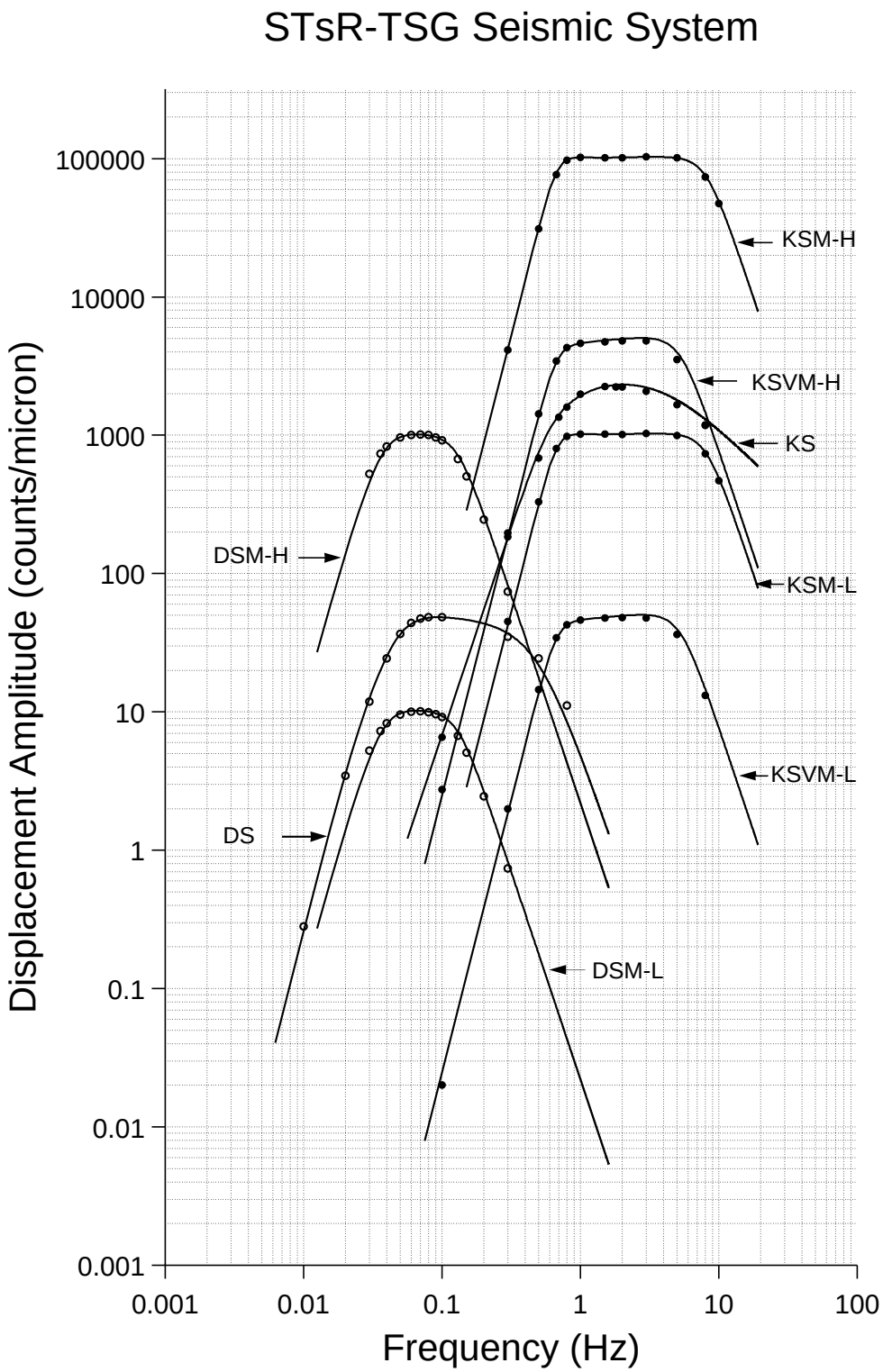

Figure 11: Summary of spectral amplitude responses for all vertical-component seismographs of the TSG system. For each seismograph, frequency-amplitude responses given in the log book at BRV (*closed circles*) and the amplitude responses obtained after the calibration pulse inversion (*solid lines*) are plotted together for comparison.

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Table A1: Borovoye archive data for underground nuclear test at Balapan subarea of STS, 1968–1988[1]

Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Latitude (°N)	Longitude (°E)	m_b (P)	Instrument type[2]	Comments
285	1968-06-19	05:05:59.8	49.98025	78.98550	5.28	KODB/M	Bocharov
312	1969-11-30	03:32:59.7	49.92428	78.95575	6.02	KODB/M	Bocharov
341	1971-06-30	03:56:59.8	49.94600	78.98047	4.94	KODB/M	Bocharov
355	1972-02-10	05:03:00.0	50.02428	78.87808	5.27	KODB/M	Bocharov
373	1972-11-02	01:27:00.2	49.92697	78.81725	6.16	KODB	Bocharov
377	1972-12-10	04:27:10.0	50.02700	78.99556	5.96	KODB/M	Bocharov/Double
382	1973-07-23	01:23:00.11	49.96889	78.81750	6.17	KODB/M	AWE/NNC
416	1974-12-27	05:46:59.35	49.96583	79.00333	5.50	TSG	AWE/NNC
433	1975-10-29	04:46:59.82	49.95389	78.87389	5.61	SS/TSG	AWE/NNC
435	1975-12-25	05:16:59.65	50.04389	78.82000	5.69	TSG	AWE/NNC
440	1976-04-21	05:02:59.70	49.90056	78.83083	5.12	SS/TSG	AWE/NNC
443	1976-06-09	03:02:59.75	49.99361	79.02444	5.07	TSG	AWE/NNC
444	1976-07-04	02:56:59.94	49.90417	78.89944	5.85	SS/TSG	AWE/NNC
448	1976-08-28	02:56:59.99	49.97500	78.92639	5.74	SS/TSG	AWE/NNC
453	1976-11-23	05:02:59.75	50.01306	78.94333	5.79	SS	AWE/NNC
454	1976-12-07	04:56:59.85	49.94389	78.83917	5.80	SS/TSG	AWE/NNC
460	1977-05-29	02:57:00.01	49.94639	78.77167	5.75	SS/TSG	AWE/NNC
461	1977-06-29	03:07:00.35	49.99944	78.86667	5.20	SS/TSG	AWE/NNC
468	1977-09-05	03:02:59.86	50.05556	78.91417	5.73	SS/TSG	AWE/NNC
474	1977-10-29	03:07:04.92	50.05222	78.98028	5.56	SS/TSG	AWE/NNC/Double
478	1977-11-30	04:06:59.85	49.96722	78.87444	5.89	SS/TSG	AWE/NNC
487	1978-06-11	02:57:00.08	49.91333	78.80194	5.83	SS/TSG	AWE/NNC
488	1978-07-05	02:46:59.97	49.90000	78.86667	5.77	SS/TSG	AWE/NNC
494	1978-08-29	02:37:08.75	50.00611	78.96722	5.90	SS	AWE/NNC/Double
496	1978-09-15	02:36:59.90	49.92833	78.86167	5.89	SS/TSG	AWE/NNC
505	1978-11-04	05:05:59.81	50.04167	78.94722	5.56	SS/TSG	AWE/NNC
506	1978-11-29	04:33:04.99	49.95333	78.79528	5.96	SS/TSG	AWE/NNC/Double
514	1979-02-01	04:13:00.17	50.08083	78.85333	5.29	SS/TSG	AWE/NNC
521	1979-06-23	02:57:00.02	49.91472	78.84583	6.16	TSG	AWE/NNC
522	1979-07-07	03:46:59.81	50.03306	78.98917	5.84	SS	AWE/NNC
526	1979-08-04	03:56:59.97	49.90306	78.88778	6.13	SS/TSG	AWE/NNC
528	1979-08-18	02:51:59.61	49.94806	78.91889	6.13	SS/TSG	AWE/NNC
538	1979-10-28	03:16:59.45	49.99667	78.99500	5.98	SS/TSG	AWE/NNC
540	1979-12-02	04:36:59.95	49.90944	78.78444	5.99	SS/TSG	AWE/NNC
542	1979-12-23	04:56:59.93	49.93222	78.75278	6.13	SS/TSG	AWE/NNC
546	1980-04-25	03:57:00.03	49.97639	78.75944	5.45	SS	AWE/NNC
548	1980-06-12	03:27:00.11	49.98872	78.99108	5.52	SS/TSG	AWE/NNC
552	1980-06-29	02:33:00.19	49.94861	78.81806	5.69	SS/TSG	AWE/NNC
554	1980-09-14	02:42:41.63	49.93667	78.79750	6.21	SS	AWE/NNC
558	1980-10-12	03:34:16.58	49.96750	79.02250	5.88	SS/TSG	AWE/NNC
564	1980-12-14	03:47:08.91	49.90889	78.91861	5.93	SS/TSG	AWE/NNC
566	1980-12-27	04:09:10.56	50.06194	78.97528	5.87	SS/TSG	AWE/NNC
568	1981-03-29	04:03:52.51	50.01806	78.97881	5.49	SS/TSG	AWE/NNC

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Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Latitude (°N)	Longitude (°E)	m_b (P)	Instrument type[(2)]	Comments
569	1981-04-22	01:17:13.82	49.89889	78.80861	5.94	SS/TSG	AWE/NNC
571	1981-05-27	03:58:14.82	49.98694	78.97056	5.30	SS/TSG	AWE/NNC
577	1981-09-13	02:17:20.76	49.91333	78.89444	6.06	SS/TSG	AWE/NNC
582	1981-10-18	03:57:05.14	49.92806	78.84472	6.00	SS/TSG	AWE/NNC
585	1981-11-29	03:35:11.11	49.90194	78.84889	5.62	SS/TSG	AWE/NNC
587	1981-12-27	03:43:16.62	49.93306	78.77833	6.16	SS/TSG	AWE/NNC
589	1982-04-25	03:23:07.88	49.91694	78.88778	6.03	SS/TSG	AWE/NNC
591	1982-07-04	01:17:16.65	49.95861	78.81167	6.08	SS/TSG	AWE/NNC
594	1982-08-31	01:31:03.17	49.91417	78.76139	5.20	SS/TSG	AWE/NNC
604	1982-12-05	03:37:15.04	49.93083	78.80972	6.08	SS/TSG	AWE/NNC
606	1982-12-26	03:35:16.68	50.06306	78.99389	5.58	SS/TSG	AWE/NNC
611	1983-06-12	02:36:46.01	49.92500	78.89806	6.02	SS/TSG	AWE/NNC
625	1983-10-06	01:47:09.08	49.92458	78.75069	5.95	SS	AWE/NNC
626	1983-10-26	01:55:07.33	49.91250	78.82167	6.04	SS/TSG	AWE/NNC
628	1983-11-20	03:27:06.86	50.05083	78.99917	5.33	SS/TSG	AWE/NNC
632	1984-02-19	03:57:05.85	49.89611	78.74306	5.77	SS	AWE/NNC
633	1984-03-07	02:39:08.80	50.05000	78.95611	5.56	SS	AWE/NNC
634	1984-03-29	05:19:10.66	49.91111	78.92694	5.86	SS/TSG	AWE/NNC
636	1984-04-25	01:09:05.99	49.93583	78.85056	5.90	SS/TSG	AWE/NNC
637	1984-05-26	03:13:14.85	49.97889	79.00556	6.01	SS/TSG	AWE/NNC
638	1984-07-14	01:09:12.99	49.90944	78.87722	6.10	SS/TSG	AWE/NNC
654	1984-10-27	01:50:12.93	49.93472	78.92806	6.19	SS/TSG	AWE/NNC
656	1984-12-02	03:19:08.85	50.00611	79.00889	5.77	SS/TSG	AWE/NNC
657	1984-12-16	03:55:05.07	49.94583	78.80861	6.12	SS/TSG	AWE/NNC
658	1984-12-28	03:50:13.09	49.88028	78.70389	6.00	SS/TSG	AWE/NNC
659	1985-02-10	03:27:09.98	49.89917	78.78056	5.83	SS	AWE/NNC
660	1985-04-25	00:57:08.97	49.92667	78.88083	5.84	SS	AWE/NNC
661	1985-06-15	00:57:03.25	49.90861	78.84278	6.05	SS/TSG	IDG/NNC
663	1985-06-30	02:39:05.26	49.86444	78.66861	5.92	SS/TSG	IDG/NNC
667	1985-07-20	00:53:16.91	49.94972	78.78389	5.89	SS/TSG	AWE/NNC
670	1987-03-12	01:57:19.57	49.93528	78.82889	5.31	SS/TSG	AWE/NNC
671	1987-04-03	01:17:10.28	49.91806	78.78028	6.12	SS/TSG	AWE/NNC
673	1987-04-17	01:03:07.09	49.87778	78.66889	5.92	SS/TSG	AWE/NNC
678	1987-06-20	00:53:07.09	49.93528	78.74417	6.03	SS/TSG	AWE/NNC
683	1987-08-02	00:58:09.27	49.88056	78.87472	5.83	SS/TSG	IDG/NNC
688	1987-11-15	03:31:09.08	49.89861	78.75806	5.98	SS	AWE/NNC
689	1987-12-13	03:21:07.31	49.96306	78.79306	6.06	SS	IDG/NNC
691	1987-12-27	03:05:07.00	49.87944	78.72500	6.00	SS	IDG/NNC
693	1988-02-13	03:05:08.327	49.93667	78.86389	5.97	SS/TSG	IDG/NNC
694	1988-04-03	01:33:08.294	49.90833	78.90833	5.99	SS/TSG	IDG/NNC
696	1988-05-04	00:57:09.261	49.94944	78.75028	6.09	SS/TSG	IDG/NNC
698	1988-06-14	02:27:08.98	50.01889	78.96056	4.80	SS/TSG	AWE/NNC
701	1988-09-14	03:59:59.69	49.87778	78.82306	6.03	SS/TSG	AWE/NNC
703	1988-11-12	03:30:06.26	50.04306	78.96889	5.24	SS/TSG	AWE/NNC
706	1988-12-17	04:18:09.291	49.88194	78.92472	5.83	SS/TSG	IDG/NNC
708	1989-01-22	03:57:09.02	49.93944	78.81944	6.10	SS/TSG	AWE/NNC
709	1989-02-12	04:15:09.342	49.91861	78.71111	5.86	SS/TSG	IDG/NNC
711	1989-07-08	03:47:00.03	49.86778	78.78028	5.55	SS/TSG	AWE/NNC

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Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Latitude (°N)	Longitude (°E)	m_b (P)	Instrument type[(2)]	Comments
712	1989-09-02	04:16:59.85	50.00583	78.98556	4.94	SS/TSG	AWE/NNC
714	1989-10-19	09:49:59.81	49.92222	78.90833	5.86	SS/TSG	AWE/NNC

[(1)] Test No.=unique test number given in Mikhailov et al. (1996) for 715 nuclear tests in USSR; body-wave magnitude, $m_b(P)$, from Marshall et al. (1985); Bocharov=ground truth data from Bocharov (1989); NNC=ground truth location by the National Nuclear Center, RK (1999); AWE=origin time from Lilwall & Farthing (1990); Double=double tests either proceeded or followed by another test at Degelen by few seconds; [(2)] Instrument type=instrument used, KODB= KOD low-gain system; KODM= KOD high-gain system; SS=STsR-SS system; TSG=STsR-TSG system (see Kim & Ekström, 1996); Precision of the seismically determined origin times are indicated by their decimal points and the accuracy of the groundtruth information is also indicated by the decimal point.

Table A2: Borovoye archive data for underground nuclear test at Degelen subarea of STS, 1967–1989[1]

Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Latitude (°N)	Longitude (°E)	m_b (P)	Instrument type[2]	Comments
264	1967-02-26	03:57:59.8	49.74569	78.08231	6.03	KODB	Bocharov
266	1967-04-20	04:08:01.0	49.74161	78.10542	5.56	KODB	Bocharov
267	1967-05-28	04:07:59.6	49.75642	78.01689	5.46	KODB	Bocharov
268	1967-06-29	02:56:59.9	49.81669	78.04903	5.34	KODB/M	Bocharov
269	1967-07-15	03:26:59.9	49.83592	78.11817	5.39	KODB	Bocharov
270	1967-08-04	06:58:00.3	49.76028	78.05550	5.32	KODB/M	Bocharov
271	1967-09-02	04:04:00.0	49.74194	78.02556	4.10	KODB	Khalturin
275	1967-10-17	05:04:00.2	49.78089	78.00383	5.63	KODB/M	Bocharov
277	1967-10-30	06:04:00.0	49.79436	78.00786	5.41	KODB/M	Bocharov
279	1967-12-08	06:03:59.8	49.81714	78.16378	5.31	KODB	Bocharov
280	1968-01-07	03:46:59.9	49.75442	78.03094	4.98	KODB	Bocharov
281	1968-04-24	10:35:59.7	49.84519	78.10322	4.91	KODB	Bocharov
284	1968-06-11	03:05:59.7	49.79300	78.14508	5.24	KODB/M	Bocharov
294	1968-11-09	02:54:00.1	49.80053	78.13911	4.75	KODB	Bocharov
296	1968-12-18	05:01:59.7	49.74594	78.09203	5.04	KODB/M	Bocharov
297	1969-03-07	08:26:59.8	49.82147	78.06267	5.66	KODB/M	Bocharov
300	1969-05-16	04:02:59.7	49.75942	78.07578	5.26	KODB/M	Bocharov
302	1969-07-04	02:46:59.6	49.74603	78.11133	5.24	KODB/M	Bocharov
303	1969-07-23	02:47:00.2	49.81564	78.12961	5.50	KODB/M	Bocharov
306	1969-09-11	04:02:00.0	49.77631	77.99669	4.91	KODB/M	Bocharov
308	1969-10-01	04:02:59.9	49.78250	78.09831	5.26	KODB/M	Bocharov
315	1969-12-29	04:02:00.0	49.73367	78.10225	4.22	KODB	Bocharov
316	1970-01-29	07:03:00.0	49.79558	78.12389	5.60	KODB/M	Bocharov
318	1970-03-27	05:02:59.6	49.74781	77.99897	4.93	KODB/M	Bocharov
319	1970-05-27	04:03:00.0	49.73131	78.09861	4.20	KODB	Bocharov
321	1970-06-28	01:58:00.0	49.80150	78.10681	5.87	KODB/M	Bocharov
324	1970-07-24	03:57:00.0	49.80972	78.12839	5.34	KODB/M	Bocharov
326	1970-09-06	04:02:59.9	49.78889	77.99750	5.53	KODB/M	Bocharov
330	1970-12-17	07:01:00.0	49.74564	78.09917	5.43	KODB/M	Bocharov
332	1971-01-29	05:03:00.0	49.80528	78.16861	4.47	KODB	Khalturin
333	1971-03-22	04:33:00.3	49.79847	78.10897	5.77	KODB/M	Bocharov
337	1971-04-25	03:32:59.9	49.76853	78.03392	6.08	KODB/M	Bocharov
338	1971-05-25	04:03:00.4	49.80164	78.13883	5.05	KODB/M	Bocharov
350	1971-11-29	06:02:59.9	49.74342	78.07850	5.46	KODB/M	Bocharov
351	1971-12-15	07:52:59.8	49.82639	77.99731	4.90	KODB	Bocharov
353	1971-12-30	06:21:00.2	49.74917	78.00611	5.84	KODB/M	Bocharov
356	1972-03-10	04:56:59.8	49.74531	78.11969	5.45	KODM	Bocharov
357	1972-03-28	04:22:00.1	49.73306	78.07569	5.18	KODB/M	Bocharov
360	1972-06-07	01:28:00.0	49.82675	78.11547	5.42	KODB/M	Bocharov
365	1972-08-16	03:16:59.8	49.76547	78.05883	5.11	KODB/M	Bocharov
376	1972-12-10	04:27:00.0	49.81939	78.05822	5.72	KODB/M	Bocharov/Double
378	1972-12-28	04:27:00.0	49.73919	78.10625	4.60	KODB	Bocharov
379	1973-02-16	05:03:00.0	49.81583	78.10667	5.48	KODB/M	AWE/Leith

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Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Latitude (°N)	Longitude (°E)	m_b (P)	Instrument type[(2)]	Comments
381	1973-07-10	01:27:00.15	49.79111	78.01278	5.34	KODB	AWE/Leith
391	1973-10-26	04:27:00.14	49.75222	78.13250	5.23	KODB/M	AWE/Leith
414	1974-12-16	06:23:00.14	49.76778	78.08167	4.94	TSG	AWE/Leith
415	1974-12-16	06:41:00.34	49.83306	78.02667	4.89	TSG	AWE/Leith
434	1975-12-13	04:56:59.99	49.81333	78.10861	5.00	SS/TSG	AWE/Leith
436	1976-01-15	04:46:59.97	49.81000	78.17139	5.18	SS/TSG	AWE/Leith
441	1976-04-21	04:58:00.16	49.75472	78.10750	4.94	SS/TSG	AWE/Leith
442	1976-05-19	02:57:00.2	49.77750	78.01556	4.72	SS	AWE/Leith
445	1976-07-23	02:33:00.19	49.74333	78.05167	4.96	SS	AWE/Leith
451	1976-10-30	04:57:00.21	49.83139	78.05722	4.62	SS/TSG	AWE/Leith
456	1976-12-30	03:57:00.31	49.78028	78.03667	5.09	TSG	AWE/Leith
457	1977-03-29	03:56:59.95	49.77639	78.01750	5.41	SS/TSG	AWE/Leith
459	1977-04-25	04:07:00.16	49.81333	78.10861	5.07	SS/TSG	AWE/Leith
463	1977-07-30	01:57:00.11	49.75056	78.04917	5.13	SS/TSG	AWE/Leith
465	1977-08-17	04:26:59.97	49.83083	78.11389	5.01	SS/TSG	AWE/Leith
473	1977-10-29	03:06:59.97	49.83417	78.08028	5.60	SS/TSG	AWE/Leith/Double
479	1977-12-26	04:03:00.24	49.81083	78.05417	4.91	SS/TSG	AWE/Leith
482	1978-03-26	03:56:59.96	49.76194	77.98250	5.69	SS/TSG	AWE/Leith
483	1978-04-22	03:07:00.01	49.75167	78.13167	5.35	TSG	AWE/Leith
485	1978-05-29	04:56:59.85	49.79139	78.09444	4.68	SS/TSG	AWE/Leith
489	1978-07-28	02:46:59.89	49.75500	78.14500	5.75	TSG	AWE/Leith
493	1978-08-29	02:36:59.95	49.81333	78.10861	5.20	SS	AWE/Leith/Double
501	1978-10-15	05:37:00.14	49.73667	78.11111	5.15	SS/TSG	AWE/Leith
504	1978-10-31	04:17:00.19	49.78861	78.10750	5.25	SS/TSG	AWE/Leith
507	1978-11-29	04:33:00.17	49.78333	78.01556	5.21	SS/TSG	AWE/Leith/Double
509	1978-12-14	04:43:00.03	49.81583	78.10667	4.74	SS/TSG	AWE/Leith
511	1978-12-20	04:33:00.04	49.81083	78.05417	4.71	SS/TSG	AWE/Leith
518	1979-05-06	03:17:00.07	49.76194	77.98250	5.22	SS/TSG	AWE/Leith
519	1979-05-31	05:55:00.05	49.81278	78.05944	5.27	SS/TSG	AWE/Leith
532	1979-09-27	04:13:00.00	49.75056	78.04917	4.42	SS/TSG	AWE/Leith
535	1979-10-18	04:17:00.11	49.82417	78.09750	5.23	SS/TSG	AWE/Leith
539	1979-11-30	04:53:00.58	49.78306	78.08667	4.42	SS/TSG	AWE/Leith
541	1979-12-21	04:42:00.09	49.79222	78.11300	4.71	SS/TSG	AWE/Leith
545	1980-04-10	04:07:00.19	49.78250	78.05722	4.98	SS/TSG	AWE/Leith
547	1980-05-22	03:57:00.14	49.77972	78.03639	5.53	SS/TSG	AWE/Leith
553	1980-07-31	03:33:00.07	49.79056	78.09083	5.33	SS/TSG	AWE/Leith
555	1980-09-25	06:21:13.06	49.78333	78.08056	4.83	SS/TSG	AWE/Leith
573	1981-06-30	01:57:15.34	49.76750	78.08083	5.16	SS/TSG	AWE/Leith
574	1981-07-17	02:37:18.12	49.80139	78.13139	5.07	TSG	AWE/Leith
575	1981-08-14	02:27:15.24	49.75222	78.05306	4.88	SS/TSG	AWE/Leith
584	1981-11-20	04:57:05.07	49.73667	78.10417	5.00	SS	AWE/Leith
586	1981-12-22	04:31:05.27	49.83417	78.08028	4.96	SS/TSG	AWE/Leith
588	1982-02-19	03:56:13.42	49.82333	78.03333	5.40	SS/TSG	AWE/Leith
590	1982-06-25	02:03:07.16	49.77139	78.11083	4.57	SS/TSG	AWE/Leith
593	1982-08-23	02:43:06.70	49.74028	78.03083	4.44	SS	AWE/Leith
596	1982-09-21	02:57:03.17	49.77917	78.12472	5.15	SS/TSG	AWE/Leith
605	1982-12-25	04:23:08.38	49.78111	78.03500	4.47	SS/TSG	AWE/Leith
608	1983-03-30	04:17:10.22	49.78500	78.04056	4.61	SS/TSG	AWE/Leith

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Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Latitude (°N)	Longitude (°E)	m_b (P)	Instrument type[(2)]	Comments
609	1983-04-12	03:41:08.26	49.78556	78.08472	4.65	SS/TSG	AWE/Leith
610	1983-05-30	03:33:47.04	49.74111	78.12028	5.43	SS	AWE/Leith
612	1983-06-24	02:56:13.85	49.73972	78.03583	4.46	SS/TSG	AWE/Leith
617	1983-09-11	06:33:13.10	49.78472	78.08417	4.48	SS/TSG	AWE/Leith
629	1983-11-29	02:19:08.80	49.73028	78.09583	5.31	SS	AWE/Leith
631	1983-12-26	04:29:09.25	49.79000	78.10917	5.48	SS/TSG	AWE/Leith
635	1984-04-15	03:17:11.46	49.76056	78.08917	5.72	SS/TSG	AWE/Leith
648	1984-09-09	02:59:08.85	49.80444	78.08750	4.89	SS/TSG	AWE/Leith
650	1984-10-18	04:57:08.32	49.72944	78.08639	4.25	SS/TSG	AWE/Leith
655	1984-11-23	03:55:07.48	49.81250	78.05944	4.38	SS/TSG	AWE/Leith
668	1985-07-25	03:11:09.23	49.81917	78.14944	4.82	SS/TSG	AWE/Leith
669	1987-02-26	04:58:24.32	49.83417	78.08111	5.40	SS/TSG	AWE/Leith
676	1987-05-06	04:02:08.11	49.77583	78.01222	5.60	SS/TSG	AWE/Leith
677	1987-06-06	02:37:09.25	49.83667	78.06167	5.40	SS/TSG	AWE/Leith
680	1987-07-17	01:17:09.18	49.77583	78.01972	5.80	SS	AWE/Leith
685	1987-09-18	02:32:10.01	49.80444	78.08750	4.30	SS	AWE/Leith
687	1987-10-16	06:06:06.99	49.72972	78.08667	4.60	SS/TSG	AWE/Leith
690	1987-12-20	02:55:09.14	49.77583	78.01222	4.80	SS/TSG	AWE/Leith
692	1988-02-06	04:19:09.13	49.77583	78.01972	4.70	SS/TSG	AWE/Leith
695	1988-04-22	09:30:09.44	49.79028	78.10694	4.90	SS/TSG	AWE/Leith
702	1988-10-18	03:40:09.16	49.78000	78.01722	4.90	SS/TSG	AWE/Leith
704	1988-11-23	03:57:08.99	49.77944	78.03722	5.40	SS/TSG	AWE/Leith
707	1988-12-28	05:28:10	49.80111	78.06861	3.74	SS/TSG	Khalturin/Leith
710	1989-02-17	04:01:09.22	49.82778	78.05972	5.00	SS/TSG	AWE/Leith
713	1989-10-04	11:30:00.16	49.74833	78.00944	4.60	SS/TSG	AWE/Leith

[(1)] Test No.=unique test id number given in Mikhailov et al. (1996) for nuclear tests in USSR; Body-wave magnitude, $m_b(P)$, from Marshall et al. (1985) and Ringdal et al. (1992). Bocharov=ground truth data from Bocharov (1989); Leith=ground truth location by Leith (1998) for entrance to the tunnels; AWE=origin time from Lilwall & Farthing (1990); Khalturin=location and origin time from Khalturin et al. (2000); Double=double tests either proceeded or followed by another test at Balapan by few seconds; [(2)] Instrument type=instrument used, KODB= KOD low-gain system; KODM= KOD high-gain system; SS=STsR-SS system; TSG=STsR-TSG system (see Kim & Ekström, 1996); Precision of the seismically determined origin times are indicated by their decimal points and the accuracy of the groundtruth information is also indicated by the decimal point.

Table A3: Borovoye archive data for underground nuclear test at Murzhik subarea of STS, 1967–1980[(1)]

Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Latitude (°N)	Longitude (°E)	m_b (P)	Instrument type[(2)]	Comments
262	1966-12-18	04:58:00.0	49.92458	77.74722	5.92	KODB	Bocharov
272	1967-09-16	04:04:00.3	49.93719	77.72811	5.25	KODB/M	Bocharov
273	1967-09-22	05:04:00.0	49.95964	77.69106	5.16	KODB	Bocharov
278	1967-11-22	04:03:59.9	49.94194	77.68683	4.41	KODB	Bocharov
301	1969-05-31	05:01:59.4	49.95031	77.69422	5.29	KODB/M	Bocharov
314	1969-12-28	03:47:00.2	49.93733	77.71422	5.79	KODB/M	Bocharov
323	1970-07-21	03:02:59.7	49.95242	77.67289	5.38	KODB/M	Bocharov
328	1970-11-04	06:02:59.8	49.98922	77.76244	5.44	KODB/M	Bocharov
339	1971-06-06	04:02:59.7	49.97542	77.66028	5.53	KODB/M	Bocharov
340	1971-06-19	04:04:00.1	49.96903	77.64081	5.54	KODB/M	Bocharov
347	1971-10-09	06:02:59.7	49.97789	77.64144	5.37	KODB/M	Bocharov
348	1971-10-21	06:02:59.7	49.97381	77.59733	5.58	KODB/M	Bocharov
367	1972-08-26	03:46:59.7	49.98197	77.71661	5.36	KODB/M	Bocharov
380	1973-04-19	04:32:59.92	49.984	77.614	5.36	KODB/M	AWE
447	1976-08-04	02:57:00	49.87	77.70	4.20	SS	Khalturin
481	1978-03-19	03:46:59.82	49.945	77.704	5.19	SS/TSG	AWE
515	1979-02-16	04:04:00.50	49.974	77.668	5.39	SS/TSG	AWE
524	1979-07-18	03:17:04.92	49.919	77.812	5.16	SS/TSG	AWE
544	1980-04-04	05:32:59.83	50.000	77.823	4.90	SS/TSG	AWE

[(1)] Test No.=nuclear test number given in Mikhailov et al. (1996), which lists 715 nuclear tests conducted by USSR; Bocharov=ground truth data from Bocharov (1989); AWE=origin time and location from Lilwall & Farthing (1990); Khalturin=location and origin time from Khalturin et al. (2000); Body-wave magnitude, $m_b(P)$, from Marshall et al. (1985) and Ringdal et al. (1992). [(2)] Instrument type=instrument used, KODB= KOD low-gain system; KODM= KOD high-gain system; SS=STsR-SS system; TSG=STsR-TSG system.

Table A4: Borovoye archive data for underground nuclear test at Novaya Zemlya Test Sites, 1967–1990[(1)]

Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Lat. (°N)	Long. (°E)	m_b (P)	Inst. type[(2)]	Comments
276	1967-10-21	04:59:58.49	73.390	54.810	5.98	KODB/M	salvo exp. in two tunnels
293	1968-11-07	10:02:05.49	73.387	54.858	6.13	KODB/M	salvo exp. in single tunnel
309	1969-10-14	07:00:06.61	73.390	54.787	6.18	KODB/M	3 explosions
327	1970-10-14	05:59:57.57	73.304	55.027	6.79	KODB/M	3 explosions 150-1500 kt
345	1971-09-27	05:59:55.75	73.393	54.920	6.67	KODB/M	4 explosions 150-1500 kt
368	1972-08-28	05:59:56.87	73.388	54.847	6.49	KODB/M	4 explosions
385	1973-09-12	06:59:54.81	73.314	55.056	6.97	KODB/M	hightest yield Soviet UNT
388	1973-09-27	07:00:01.12	70.731	53.827	5.89	KODB/SS	Southern Test Site
392	1973-10-27	07:00:00.61	70.780	54.026	6.98	KODB/M/SS	Southern Test Site
427	1975-08-23	08:59:58.25	73.334	54.682	6.55	TSG	salvo exp. with 8 explosions
430	1975-10-18	08:59:59.40	70.816	53.744	6.75	TSG	2 expls. shaft Yu-6N
431	1975-10-18	Single explosion in shaft Yu-7 simultaneously with test #430 both Sothern Test Site					
432	1975-10-21	11:59:58.03	73.307	55.010	6.60	SS/TSG	5 explosions
449	1976-09-29	02:59:57.70	73.360	54.871	5.83	SS/TSG	2 expls. reference for JED
450	1976-10-20	07:59:58.07	73.398	54.812	4.98	SS/TSG	4 explosions
467	1977-09-01	02:59:57.97	73.339	54.619	5.66	TSG	4 explosions
471	1977-10-09	10:59:58.12	73.409	54.927	4.36	SS/TSG	single explosion 0.001-20 kt
491	1978-08-10	07:59:57.93	73.291	54.883	6.00	SS/TSG	6 explosions
499	1978-09-27	02:04:58.60	73.349	54.676	5.63	SS/TSG	7 explosions
531	1979-09-24	03:29:59.75	73.343	54.672	5.77	TSG	3 explosions
536	1979-10-18	07:09:58.75	73.316	54.816	5.79	SS/TSG	4 explosions
557	1980-10-11	07:09:57.47	73.336	54.940	5.76	SS	7 explosions
580	1981-10-01	12:14:57.23	73.304	54.818	5.97	TSG	4 explosions
599	1982-10-11	07:14:58.63	73.339	54.608	5.58	TSG	4 explosions
616	1983-08-18	16:09:58.90	73.354	54.974	5.91	SS	5 explosions
624	1983-09-25	13:09:58.22	73.328	54.541	5.77	SS/TSG	4 explosions
651	1984-10-25	06:29:58.12	73.355	54.990	5.82	SS/TSG	4 explosions
682	1987-08-02	02:00:00.20	73.326	54.602	5.82	SS/TSG	5 explosions
697	1988-05-07	22:49:58.34	73.314	54.553	5.58	SS/TSG	3 explosions
705	1988-12-04	05:19:53.30	73.366	55.001	5.89	SS/TSG	5 explosions
715	1990-10-24	14:57:58.45	73.331	54.757	5.70	SS/TSG	8 expls. last Sovie test

[(1)] Test No.=unique test id number given in Mikhailov et al. (1996) for nuclear tests in USSR; Body-wave magnitude, $m_b(P)$, from Marshall et al. (1994); location and origin time from Marshall et al. (1994) and Richards (2000). [(2)] Inst. type= instrument used; KODB= KOD low-gain system; KODM= KOD high-gain system; SS=STsR-SS system; TSG=STsR-TSG system. [(3)] salvo exp.= salvo explosion means two or more separate explosions where a period of time between successive individual explosions does not exceed 5 seconds and where the burial points of all explosive devices can be connected by segments of straight lines, each of them connecting two burial points and does not exceed 40 kilometers in length.

Table A5: Borovoye archive data for Peaceful Nuclear Explosions in the Former Soviet Union, 1967–1988[(1)]

Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Latitude (°N)	Longitude (°E)	Depth (m)	m_b (*P*)	Distance (°)	Az (°)	Instrument type
274	1967-10-06	06:59:57.5	57.70	65.20	172	4.7	5.46	330.2	KODB
282	1968-05-21	03:59:11.98	38.918	65.032	2440	5.4	14.59	196.4	KODB
304	1969-09-02	04:59:58.61	57.220	55.393	1212	4.8	9.45	302.1	KODB
305	1969-09-08	04:59:58.70	57.220	55.417	1208	4.8	9.44	302.1	KOD
307	1969-09-26	06:59:58.14	45.848	42.600	712	5.6	19.23	259.2	KOD
313	1969-12-06	07:02:59.85	43.867	54.800	407	5.8	13.73	234.2	KOD
320	1970-06-25	04:59:55.5	52.20	55.70	702	4.9	8.88	270.3	KODB
329	1970-12-12	07:00:59.83	43.85	54.80	497	6.0	13.74	234.2	KOD
331	1970-12-23	07:00:59.76	44.025	54.933	470	6.0	13.55	234.3	KOD
335	1971-03-23	06:59:58.38	61.40	56.20	127	5.5	11.25	323.4	KOD
342	1971-07-02	17:00:01.13	67.283	63.467	542	4.7	14.60	349.5	KODB
344	1971-09-19	11:00:01.08	57.508	42.643	610	4.5	16.23	296.9	KODB
346	1971-10-04	10:00:00.14	61.358	48.092	595	4.6	14.49	313.6	KODB
352	1971-12-22	06:59:59.0	47.897	48.133	986	6.0	14.94	258.7	KOD
358	1972-04-11	06:00:01.92	37.35	62.05	1720	4.9	16.72	203.3	KODB
363	1972-07-09	07:00:01.25	49.80	35.40	2483	4.8	21.77	275.6	KODB
366	1972-08-20	03:00:00.01	49.400	48.142	489	5.7	14.28	264.1	KOD
370	1972-09-04	07:00:00	67.75	33.10	131	4.6	22.92	324.0	KODB
371	1972-09-21	09:00:00.31	52.118	52.068	485	5.0	11.08	272.4	KODB
372	1972-10-03	09:00:00.18	46.853	44.938	485	5.6	17.34	259.3	KODB
375	1972-11-24	09:00:00.04	51.990	51.867	675	4.5	11.22	271.9	KODB
383	1973-08-15	02:00:00.02	42.775	67.408	600	5.3	10.46	191.7	KOD/SS
384	1973-08-28	03:00:00.04	50.527	68.323	395	5.2	2.81	206.4	KOD/SS
386	1973-09-19	03:00:00.18	45.758	67.825	615	5.1	7.47	193.3	KOD/SS
389	1973-09-30	05:00:00.35	51.65	54.55	1145	5.2	9.69	268.0	KODB
390	1973-10-26	05:59:59.5	53.65	55.40	2026	4.8	8.89	279.8	KODB
406	1974-08-29	15:00:00.39	67.085	62.625	583	5.0	14.51	348.1	SS
428	1975-09-29	11:00:00.43	69.578	90.337	834	4.8	18.91	21.7	SS
438	1976-03-29	07:00:00.23	47.897	48.133	986	4.3	14.94	258.7	SS/TSG
446	1976-07-29	05:00:00.5	47.870	48.150	1000	5.9	14.94	258.6	SS/TSG
452	1976-11-05	03:59:59.98	61.458	112.860	1522	5.3	24.00	52.6	SS
462	1977-07-26	17:00:00.22	69.575	90.375	850	5.0	18.92	21.7	SS/TSG
466	1977-08-20	22:00:00.78	64.108	99.558	600	5.0	18.57	42.1	TSG
469	1977-09-10	16:00:00.18	57.251	106.551	550	4.8	20.88	63.9	SS/TSG
470	1977-09-30	06:59:58.43	47.897	48.161	1500	5.0	14.92	258.7	SS
490	1978-08-09	18:00:00.79	63.678	125.522	567	5.6	29.74	47.3	SS
492	1978-08-24	18:00:00.35	65.925	112.338	577	5.1	24.25	41.7	SS/TSG
498	1978-09-21	15:00:00.19	66.598	86.210	886	5.2	15.62	23.9	SS/TSG
500	1978-10-08	00:00:00.0	61.55	112.85	1545	5.2	23.99	52.4	SS
502	1978-10-17	04:59:59.06	47.850	48.120	1040	5.8	14.97	258.6	SS
503	1978-10-17	14:00:00.16	63.185	63.432	593	5.5	10.74	343.2	SS
510	1978-12-18	07:59:58.5	47.860	48.160	630	5.9	14.94	258.6	SS/TSG
513	1979-01-17	07:59:58.5	47.920	48.120	995	6.0	14.93	258.8	SS/TSG

continue on next page

Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Latitude (°N)	Longitude (°E)	Depth (m)	m_b (P)	Distance (°)	Az (°)	Instrument type
523	1979-07-14	04:59:58.0	47.880	48.120	849	5.6	14.95	258.7	SS/TSG
527	1979-08-12	18:00:00.21	61.803	122.430	982	4.9	28.52	51.4	SS/TSG
529	1979-09-06	18:00:00.31	64.110	99.562	599	4.9	18.57	42.1	SS/TSG
533	1979-10-04	16:00:00.03	60.675	71.455	837	5.4	7.64	4.3	SS/TSG
534	1979-10-07	21:00:00.22	61.85	113.10	1545	5.0	24.12	51.7	SS/TSG
537	1979-10-24	05:59:59.0	47.850	48.140	915	5.8	14.96	258.6	SS/TSG
556	1980-10-08	06:00:00.29	46.757	48.275	1050	5.2	15.43	254.8	SS
560	1980-11-01	13:00:00.42	60.80	97.55	720	5.2	16.60	51.5	TSG
570	1981-05-25	05:00:00.32	68.20	53.50	1511	5.5	17.10	338.6	SS
576	1981-09-02	03:59:59.99	60.60	55.70	2088	4.4	10.94	319.3	TSG
578	1981-09-26	05:00:00.28	46.790	48.313	1050	5.2	15.39	254.8	TSG
579	1981-09-26	05:03:59.94	46.771	48.304	1050	5.3	15.41	254.8	TSG
583	1981-10-22	14:00:00.36	63.80	97.55	581	5.1	17.64	41.9	TSG
592	1982-07-30	21:00:00.00	53.80	104.15	554	5.0	20.00	74.2	TSG
597	1982-09-25	18:00:00.18	64.35	91.80	554	5.2	15.74	35.8	TSG
613	1983-07-10	04:00:00.00	51.363	53.306	907	5.3	10.51	267.5	SS
614	1983-07-10	04:04:59.94	51.367	53.327	917	5.3	10.50	267.5	SS
615	1983-07-10	04:09:59.85	51.380	53.340	841	5.3	10.49	267.6	SS
618	1983-09-24	05:00:00.03	46.783	48.315	1050	5.2	15.39	254.8	SS
619	1983-09-24	05:05:00.03	46.788	48.297	1050	5.1	15.40	254.8	SS
620	1983-09-24	05:10:00.08	46.767	48.310	920	5.0	15.40	254.8	SS
621	1983-09-24	05:15:00.14	46.749	48.303	1100	5.2	15.42	254.7	SS
622	1983-09-24	05:19:59.93	46.754	48.288	950	5.4	15.42	254.8	SS
623	1983-09-24	05:25:00.00	46.766	48.274	1100	5.3	15.43	254.8	SS
639	1984-07-21	02:59:59.81	51.358	53.319	846	5.4	10.51	267.5	SS
640	1984-07-21	03:04:59.71	51.371	53.337	955	5.3	10.49	267.6	SS
641	1984-07-21	03:09:59.85	51.391	53.351	844	5.4	10.48	267.6	SS
643	1984-08-25	19:00:00.33	61.90	72.10	726	5.3	8.89	5.5	SS
649	1984-09-17	21:00:00.03	55.834	87.526	557	5.0	10.37	67.6	TSG
652	1984-10-27	06:00:00.10	46.90	48.15	1000	5.0	15.43	255.4	SS/TSG
653	1984-10-27	06:05:00.00	46.95	48.10	1000	5.0	15.43	255.6	SS/TSG
679	1987-07-07	00:00:00.0	61.50	112.85	1502	5.1	23.99	52.5	SS
681	1987-07-24	02:00:00.0	61.45	112.80	1515	5.1	23.97	52.7	SS
684	1987-08-12	01:30:00.5	61.45	112.80	815	5.0	23.97	52.7	SS
686	1987-10-03	15:15:00.03	47.60	56.20	1002	5.3	10.49	244.3	SS/TSG
699	1988-08-22	16:20:00.07	66.280	78.491	829	5.3	13.83	13.9	SS/TSG
700	1988-09-06	16:19:59.94	61.361	48.092	820	4.8	14.49	313.7	SS/TSG

(1) Test No.=nuclear test number given in Mikhailov et al. (1996); Date and Time=origin time of the tests given in Sultanov et al. (1999); Latitude and Lognitude=location the tests given in Sultanov et al. (1999); m_b(P)=body-wave magnitude of the tests given in Sultanov et al. (1999); Distance=epicentral distance in degrees from the PNE to Borovoye; Az=azimuth in degrees from the station to PNE; Precision of the origin time[6] is indicated by their decimal point. Location accuracies are also indicated by the decimal point.

[6] whole second or one hundredth of a second

Table A6: Borovoye archive data for Chinese Underground Nuclear Tests at Lop Nor, 1969–1995[(1)]

N	Date Year-Mo-Da	Time (hr:mn:sec)	Latitude (°N)	Longitude (°E)	m_b (P)	Event id	Instrument type[(2)]	Comments
01	1969-09-22	16:15:01.57	41.373	88.352	5.2	CH01	KODB	C, tunnel
02	1976-10-17	05:00:01.37	41.734	88.383	4.9	CH04	SS	B, tunnel
03	1978-10-14	01:00:00.25	41.511	88.772	4.9	CH05	SS/TSG	A, shaft
04	1983-10-06	10:00:00.52	41.523	88.705	5.5	CH07	SS/TSG	A, shaft
05	1984-10-03	06:00:00.58	41.577	88.706	5.4	CH08	SS	A, shaft
06	1984-12-19	06:00:00.86	41.738	88.365	4.7	CH09	SS/TSG	B, tunnel
07	1987-06-05	05:00:00.73	41.505	88.709	6.2	CH10	SS/TSG	A, shaft
08	1990-08-16	05:00:00.16	41.511	88.742	6.2	CH13	SS/TSG	A, shaft
09	1993-10-05	01:59:58.99	41.593	88.687	5.9	CH16	TSG	A, shaft
10	1994-10-07	03:26:00.37	41.556	88.736	5.9	CH18	TSG	A, shaft
11	1995-05-15	04:06:00.31	41.546	88.772	6.1	CH19	TSG	A, shaft

[(1)] location and origin time from Engdahl (2001), teleseismic body-wave magnitude from PDE. [(2)] Instrument type= instrument used, KODB= KOD low-gain system; KODM= KOD high-gain system; SS=STsR-SS system; TSG=STsR-TSG system.

Table A7: Borovoye archive data for French Underground Nuclear Tests, 1977–1996[1)]

N	Date Year-Mo-Da	Time (hr:mn:sec)	Latitude (°N)	Longitude (°E)	m_b (*P*)	Instrument type[2)]	Site
01	1977-03-19	23:00:59.89	-21.887	-138.920	5.92	SS	Mururoa
02	1977-11-24	16:59:59.92	-21.884	-138.886	5.86	SS/TSG	Mururoa
03	1978-03-22	17:30:00.45	-21.705	-138.934	4.73	SS/TSG	Mururoa
04	1978-11-30	17:31:59.98	-21.868	-138.950	5.86	TSG	Mururoa
05	1979-06-18	23:27:00.66	-21.810	-138.809	4.71	SS	Mururoa
06	1979-07-25	17:57:00.00	-21.880	-138.940	6.11	SS	Mururoa
07	1980-03-23	19:37:00.00	-21.861	-138.939	5.63	SS	Mururoa
08	1980-04-01	19:31:00.22	-21.845	-138.758	5.05	SS	Mururoa
09	1980-07-19	23:47:00.00	-21.861	-138.934	5.73	SS/TSG	Mururoa
10	1980-12-03	17:33:00.00	-21.875	-138.939	5.58	TSG	Mururoa
11	1981-07-08	22:23:00.30	-21.791	-139.046	5.14	TSG	Mururoa
12	1981-12-05	16:58:01.08	-21.685	-138.933	4.68	SS	Mururoa
13	1981-12-08	16:47:00.23	-21.797	-138.927	5.14	SS	Mururoa
14	1982-07-01	17:02:00.20	-21.769	-138.946	5.08	SS	Mururoa
15	1982-07-25	18:02:00.00	-21.836	-138.896	5.60	TSG	Mururoa
16	1983-04-19	18:53:00.17	-21.819	-138.872	5.70	SS/TSG	Mururoa
17	1983-05-25	17:31:00.12	-21.861	-138.917	5.87	SS/TSG	Mururoa
18	1983-06-28	17:46:00.24	-21.767	-138.871	5.32	TSG	Mururoa
19	1983-07-20	20:30:00	-21.85	-138.90	5.0	SS/TSG	-
20	1983-08-04	17:14:00.20	-21.835	-138.829	5.13	SS/TSG	Mururoa
21	1983-12-07	17:28:00.28	-21.829	-138.928	4.89	SS	-
22	1984-05-08	17:26:00	-21.85	-138.90	5.3	SS	-
23	1984-05-12	17:31:00.04	-21.863	-138.901	5.57	SS/TSG	Mururoa
24	1984-06-12	17:17:00	-21.85	-138.90	4.5	TSG	-
25	1984-06-16	17:43:59.98	-21.849	-138.880	5.28	SS/TSG	Mururoa
26	1984-11-02	20:45:00.13	-21.857	-138.920	5.64	SS/TSG	Mururoa
27	1984-12-06	17:29:00.16	-21.837	-138.890	5.56	SS	Mururoa
28	1985-05-08	20:28:00.24	-21.831	-138.981	5.64	SS/TSG	Mururoa
29	1985-06-03	17:30:00.61	-21.816	-138.897	4.83	SS/TSG	Mururoa
30	1985-10-24	17:50:00	-21.85	-138.90	4.5	TSG	-
31	1985-10-26	16:35:00.24	-21.849	-138.815	5.30	TSG	Mururoa
32	1985-11-24	16:01:00.66	-21.802	-138.781	4.55	SS/TSG	Mururoa
33	1985-11-26	17:42:00.06	-21.856	-138.899	5.76	SS/TSG	Mururoa
34	1986-04-26	17:02:00.67	-21.725	-138.941	4.45	SS/TSG	Mururoa
35	1986-05-27	17:15:00	-21.85	-138.90	4.7	SS/TSG	-
36	1986-05-30	17:25:00.11	-21.862	-138.949	5.58	SS/TSG	Mururoa
37	1986-11-10	16:58:00	-21.85	-138.90	4.9	TSG	-
38	1986-11-12	17:02:00.32	-21.843	-138.927	5.28	TSG	Mururoa
39	1986-12-10	17:15:00.18	-21.833	-138.892	5.23	SS/TSG	Mururoa
40	1987-05-20	17:05:00.12	-21.850	-138.913	5.51	SS	Mururoa
41	1987-06-06	18:00:00.71	-21.769	-138.874	4.40	SS	Mururoa
42	1987-06-21	17:55:00.12	-21.865	-138.891	5.10	SS/TSG	Mururoa
43	1987-10-23	16:50:00.31	-21.845	-138.907	5.54	SS	Mururoa
44	1987-11-05	17:30:00.36	-21.791	-138.874	5.36	SS	Mururoa

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N	Date Year-Mo-Da	Time (hr:mn:sec)	Latitude (°N)	Longitude (°E)	m_b (P)	Instrument type[(2)]	Site
45	1987-11-19	16:31:00.16	-21.845	-138.941	5.74	SS/TSG	Mururoa
46	1987-11-29	17:59:00	-21.85	-138.90	4.6	TSG	Mururoa
47	1988-05-11	17:00:00.27	-21.833	-138.945	5.27	SS/TSG	Mururoa
48	1988-05-25	17:01:00.14	-21.845	-138.961	5.50	SS/TSG	Mururoa
49	1988-11-23	17:01:00.33	-21.835	-138.954	5.29	TSG	Mururoa
50	1988-11-30	17:54:59.98	-22.194	-138.737	5.58	TSG	Fangataufa
51	1989-05-11	16:45:00.52	-21.812	-138.884	5.16	SS/TSG	Mururoa
52	1989-06-03	17:30:00.20	-21.842	-138.922	5.16	SS/TSG	Mururoa
53	1989-06-10	17:29:59.86	-22.222	-138.664	5.52	SS/TSG	Fangataufa
54	1989-10-31	16:57:00.26	-21.793	-138.855	5.30	TSG	Mururoa
55	1989-11-20	17:29:00.27	-21.793	-138.884	5.19	SS/TSG	Mururoa
56	1990-06-02	17:29:58.95	-21.820	-138.935	5.30	SS/TSG	Mururoa
57	1990-06-26	17:59:58.40	-22.204	-138.835	5.50	TSG	Fangataufa
58	1990-07-04	17:59:58.80	-21.809	-139.120	4.90	TSG	Mururoa
59	1990-11-14	18:11:58.41	-22.201	-138.835	5.60	TSG	Fangataufa
60	1990-11-21	16:59:58.42	-21.897	-138.983	5.40	SS	Mururoa
61	1991-05-18	17:14:58.67	-21.800	-139.033	5.00	SS/TSG	Mururoa
62	1991-05-29	18:59:58.40	-22.227	-138.803	5.50	SS/TSG	Fangataufa
63	1991-06-14	17:59:58.47	-21.822	-139.104	5.10	SS/TSG	Mururoa
64	1991-07-15	18:09:58.69	-21.832	-138.975	5.30	SS/TSG	Mururoa
65	1995-10-27	21:59:58.43	-21.852	-138.952	5.40	TSG	Mururoa
66	1995-11-21	21:29:58.62	-21.820	-139.057	4.80	TSG	Mururoa
67	1995-12-27	21:29:58.46	-21.792	-139.042	5.10	TSG	Mururoa
68	1996-01-27	21:29:58.16	-22.165	-138.835	5.20	TSG	Fangataufa

[(1)] Time, location and teleseismic body-wave magnitude from Marshall et al. (1993), for tests till 1989. For tests since 1990, hypocenter parameters are taken from ISC Bulletin. The Site column indicate tests conducted at Mururoa Atoll or Fangataufa Lagoon regions in the Tuamotu Archipelago. Seven tests with no known seismologically determined locations are indicated by ”-” in the Site column and a nominal locations are given [center of the Mururoa site]. [(2)] Instrument type= instrument used, KODB= KOD low-gain system; KODM= KOD high-gain system; SS=STsR-SS system; TSG=STsR-TSG system.

Table A8: Borovoye archive data for US Underground Nuclear Tests, 1967–1992[1)]

Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Lat. (°N)	Long. (°E)	m_b (*P*)	Inst. type[2)]	Location/Yield
501	1967-05-23	14:00:00.04	37.275	-116.371	5.7	KODB	Scotch/155 kt
502	1967-05-26	15:00:01.50	37.248	-116.481	5.5	KODB	NTS/76 kt
505	1967-06-26	16:00:00.08	37.202	-116.209	5.1	KODB	NTS
511	1967-08-18	20:12:30.04	37.012	-116.037	4.6	KODB	NTS
513	1967-08-31	16:30:00.04	37.178	-116.210	5.0	KODB	NTS
514	1967-09-07	13:45:00.00	37.153	-116.054	0.0	KODB	NTS
517	1967-09-27	17:00:00.04	37.099	-116.054	5.7	KODB/M	NTS
518	1967-10-18	14:30:00.08	37.116	-116.059	5.7	KODB	NTS
519	1967-10-25	14:30:00.06	37.032	-116.027	0.0	KODB	NTS
525	1967-12-15	15:00:00.04	37.037	-116.003	0.0	KODB	NTS
526	1968-01-18	16:30:00.13	37.146	-116.067	0.0	KODB	NTS/7.4 kt
527	1968-01-19	15:00:00.00	37.156	-116.055	0.0	KODB	NTS
528	1968-01-19	18:15:00.08	38.634	-118.133	6.3	KODB	Central Nevada
530	1968-01-26	16:00:00.11	37.281	-116.515	0.0	KODB	Cabriolet/2.3 kt
532	1968-02-21	15:30:00.00	37.117	-116.055	5.8	KODB	NTS
538	1968-03-22	15:00:00.04	37.333	-116.312	5.6	KODB	NTS
541	1968-04-10	14:00:00.00	37.154	-116.080	4.6	KODB	NTS
542	1968-04-18	14:05:00.00	37.152	-116.038	4.9	KODB	NTS
544	1968-04-26	15:00:00.07	37.295	-116.457	6.3	KODB	Boxcar/1.3 Mt
545	1968-05-03	16:00:00.04	37.029	-116.021	4.1	KODB	NTS
547	1968-05-17	13:00:00.00	37.120	-116.060	4.7	KODB	NTS
551	1968-06-15	13:59:59.97	37.265	-116.316	5.9	KODB	NTS
571	1968-11-04	15:15:00.09	37.130	-116.087	5.0	KODB	NTS
575	1968-11-20	18:00:00.03	37.010	-116.207	4.9	KODB	NTS
577	1968-12-08	16:00:00.14	37.343	-116.567	4.8	KODB	NTS/30 kt
578	1968-12-12	15:10:00.08	37.121	-116.081	0.0	KODB	6 detonations
581	1968-12-19	16:30:00.04	37.231	-116.474	6.3	KODB/M	Benham/1.15 Mt
582	1969-01-15	19:00:00.07	37.148	-116.067	0.0	KODB	NTS/10 kt
583	1969-01-15	19:30:00.04	37.209	-116.226	5.3	KODB	NTS
585	1969-01-30	15:00:00.04	37.053	-116.030	4.8	KODB	NTS
592	1969-03-20	18:12:00.04	37.022	-116.031	4.6	KODB	NTS
593	1969-03-21	14:30:00.41	37.133	-116.088	4.9	KODB	NTS
595	1969-04-30	17:00:00.04	37.090	-116.007	5.3	KODB	NTS
597	1969-05-07	13:45:00.04	37.283	-116.502	5.8	KODB	NTS
599	1969-05-27	14:15:00.04	37.075	-115.996	5.0	KODB	NTS
601	1969-06-12	14:00:00.04	37.009	-116.031	4.4	KODB	NTS
603	1969-07-16	13:02:30.04	37.119	-116.056	4.7	KODB	NTS
604	1969-07-16	14:55:00.04	37.139	-116.088	5.6	KODB	NTS
605	1969-08-14	14:30:00.04	37.160	-116.064	0.0	KODB	NTS
606	1969-08-27	13:45:00.04	37.021	-116.039	4.7	KODB	NTS
608	1969-09-10	21:00:00.01	39.356	-107.949	5.0	KODB	Grand Valley, CO/Rulison/40 kt
609	1969-09-12	18:02:20.42	36.877	-115.929	4.5	KODB	NTS
610	1969-09-16	14:30:00.04	37.314	-116.462	6.2	KODB/M	NTS
613	1969-10-02	22:06:00.04	51.403	+179.179	6.5	KODB/M	Amchitka, AK/Milow/≈ 1 Mt

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Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Lat. (°N)	Long. (°E)	m_b (*P*)	Inst. type[(2)]	Location/Yield
620	1969-11-21	14:52:00.04	37.031	-116.003	5.0	KODB	NTS
622	1969-12-05	17:00:00.04	37.180	-116.212	5.0	KODB	NTS
624	1969-12-10	15:30:00.07	37.168	-116.080	0.0	KODB	NTS
625	1969-12-17	15:00:00.04	37.083	-116.002	5.5	KODB	NTS
627	1969-12-18	19:00:00.04	37.120	-116.036	5.2	KODB	NTS
628	1970-01-23	16:30:00.21	37.141	-116.038	4.6	KODB	NTS
629	1970-01-30	17:00:00.04	37.031	-116.036	4.6	KODB	NTS
630	1970-02-04	17:00:00.04	37.098	-116.027	5.6	KODB	NTS
632	1970-02-05	15:00:00.04	37.164	-116.040	4.6	KODB	NTS/25 kt
633	1970-02-11	19:15:00.04	37.201	-116.206	4.7	KODB	NTS
634	1970-02-25	14:28:38.04	37.037	-115.999	5.2	KODB	NTS
635	1970-02-26	15:30:00.04	37.116	-116.062	5.3	KODB	NTS
636	1970-03-06	14:24:00.94	37.173	-116.093	4.3	KODB	NTS/8.7 kt
637	1970-03-06	15:00:00.21	37.140	-116.032	4.3	KODB	NTS
639	1970-03-23	23:05:00.04	37.086	-116.022	5.5	KODB	NTS
640	1970-03-26	19:00:00.20	37.300	-116.535	6.5	KODB/M	NTS
641	1970-04-21	14:30:00.04	37.055	-115.989	4.4	KODB	NTS/12.7 kt
642	1970-04-21	15:00:00.04	37.112	-116.083	4.6	KODB	NTS
643	1970-05-01	14:13:00.04	37.059	-116.029	4.2	KODB	NTS
644	1970-05-01	14:40:00.17	37.136	-116.035	4.3	KODB	NTS
646	1970-05-05	15:30:00.17	37.216	-116.185	5.0	KODB	NTS
648	1970-05-15	13:30:00.17	37.166	-116.036	5.1	KODB	NTS
650	1970-05-21	14:15:00.03	37.071	-116.014	5.1	KODB	NTS
651	1970-05-26	14:16:00.17	37.183	-116.214	5.0	KODB	NTS
652	1970-05-26	15:00:00.05	37.113	-116.063	5.5	KODB	NTS/105 kt/90/35ton
655	1970-06-26	13:00:00.04	37.114	-116.087	4.3	KODB	NTS
657	1970-10-14	14:30:00.04	37.071	-116.006	5.5	KODB	NTS
659	1970-11-05	15:00:00.04	37.029	-116.013	4.9	KODB	NTS
662	1970-12-16	16:00:00.09	37.100	-116.009	5.1	KODB	NTS
665	1970-12-17	16:05:00.16	37.129	-116.084	5.8	KODB	NTS/220 kt
666	1970-12-18	15:30:00.20	37.173	-116.100	5.1	KODB	NTS/10 kt
667	1971-06-16	14:50:00.04	37.033	-116.015	4.9	KODB	NTS
668	1971-06-23	15:30:00.04	37.022	-116.024	4.8	KODB	NTS
670	1971-06-24	14:00:00.16	37.147	-116.068	4.9	KODB	NTS
671	1971-06-29	18:30:00.16	37.177	-116.212	4.9	KODB	NTS
673	1971-07-08	14:00:00.08	37.110	-116.052	5.5	KODB	NTS/83 kt
679	1971-08-18	14:00:00.03	37.057	-116.037	5.4	KODB	NTS
681	1971-09-29	14:00:00.04	37.011	-116.008	4.4	KODB	NTS
683	1971-10-08	14:30:00.15	37.114	-116.038	4.7	KODB	NTS
684	1971-10-14	14:30:00.16	37.180	-116.054	4.4	KODB	NTS
685	1971-11-06	22:00:00.06	51.456	+179.102	6.8	KODB/M	Amchitka, AK/Cannikin/$<$ 5 Mt
687	1971-11-30	15:45:00.15	37.160	-116.071	4.7	KODB	NTS
688	1971-12-14	21:09:59.16	37.124	-116.090	4.7	KODB	NTS
698	1972-05-02	19:15:00.04	37.208	-116.210	5.0	KODB	NTS
700	1972-05-17	14:10:00.16	37.121	-116.089	4.4	KODB	NTS
701	1972-05-19	17:00:00.05	37.065	-116.003	4.9	KODB	NTS
706	1972-07-20	17:16:00.16	37.214	-116.184	4.9	KODB	NTS
707	1972-07-25	13:30:00.06	37.012	-116.016	3.8	KODB	NTS

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Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Lat. (°N)	Long. (°E)	m_b (*P*)	Inst. type[(2)]	Location/Yield
709	1972-09-21	15:30:00.19	37.082	-116.037	5.7	KODB	NTS
710	1972-09-26	14:30:00.16	37.121	-116.087	4.4	KODB	NTS
716	1972-12-21	20:15:00.24	37.140	-116.084	4.8	KODB	NTS
719	1973-03-08	16:10:00.19	37.104	-116.028	5.4	KODB	NTS
722	1973-04-25	22:25:00.03	37.005	-116.029	4.7	KODB	NTS
723	1973-04-26	17:15:00.17	37.123	-116.059	5.6	KODB	NTS
726	1973-05-17	16:00:00.12	39.793	-108.368	5.1	KODB	Rifle, CO/Rio Blanco/3x33 kt
729	1973-06-05	17:00:00.17	37.185	-116.216	5.1	KODB	NTS
730	1973-06-06	13:00:00.08	37.245	-116.347	6.1	KODB/M/SS	NTS
731	1973-06-21	14:45:00.08	37.092	-116.028	5.1	KODB	NTS
732	1973-06-28	19:15:12.40	37.148	-116.087	4.9	KODB/SS	NTS
736	1973-10-12	17:00:00.08	37.200	-116.204	4.8	KODB	NTS
753	1974-07-10	16:00:00.09	37.075	-116.033	5.7	SS	NTS
756	1974-08-30	15:00:00.16	37.152	-116.084	5.8	SS	NTS
758	1974-09-26	15:05:00.17	37.133	-116.069	5.6	SS	NTS
768	1975-02-28	16:15:00.09	37.106	-116.057	5.7	SS	NTS
773	1975-05-14	14:00:00.16	37.221	-116.475	6.0	SS/TSG	NTS
774	1975-06-03	14:20:00.17	37.340	-116.524	5.9	TSG	NTS
775	1975-06-03	14:40:00.11	37.095	-116.037	5.7	TSG	NTS
778	1975-06-19	13:00:00.09	37.350	-116.321	6.1	TSG	NTS
779	1975-06-26	12:30:00.16	37.279	-116.369	6.2	SS	NTS
782	1975-10-28	14:30:00.16	37.290	-116.412	6.4	SS/TSG	NTS
784	1975-11-20	15:00:00.09	37.225	-116.368	6.0	SS	NTS
787	1976-01-03	19:15:00.16	37.297	-116.334	6.2	TSG	NTS
788	1976-02-04	14:20:00.11	37.069	-116.031	5.8	SS	NTS
790	1976-02-12	14:45:00.16	37.271	-116.489	6.3	TSG	NTS
791	1976-02-14	11:30:00.16	37.243	-116.421	6.0	SS/TSG	NTS
794	1976-03-14	12:30:00.16	37.306	-116.472	6.3	SS	NTS
795	1976-03-17	14:15:00.09	37.256	-116.329	6.1	SS	NTS
796	1976-03-17	14:45:00.09	37.107	-116.053	5.8	TSG	NTS
799	1976-07-27	20:30:00.08	37.075	-116.045	5.3	SS	NTS
804	1976-12-08	14:49:30.08	37.079	-116.002	4.9	SS/TSG	NTS
805	1976-12-21	15:09:00.17	37.124	-116.068	4.2	SS	NTS
807	1976-12-28	18:00:00.08	37.100	-116.037	5.5	SS/TSG	NTS
808	1977-02-16	17:53:00.16	37.007	-116.032	4.8	SS	NTS
810	1977-04-05	15:00:00.17	37.120	-116.063	5.6	SS/TSG	NTS
811	1977-04-27	15:00:00.08	37.095	-116.029	5.4	SS/TSG	NTS
812	1977-05-25	17:00:00.08	37.094	-116.046	5.3	SS	NTS
815	1977-08-04	16:40:00.07	37.087	-116.008	5.0	SS/TSG	NTS
818	1977-08-19	17:55:00.10	37.110	-116.055	5.6	SS/TSG	NTS
821	1977-09-27	14:00:00.16	37.151	-116.068	4.8	SS	NTS
822	1977-10-26	14:15:00.08	37.008	-116.018	4.4	SS/TSG	NTS
824	1977-11-09	22:00:00.08	37.072	-116.051	5.7	SS/TSG	NTS
825	1977-11-17	19:30:00.08	37.021	-116.026	4.7	SS/TSG	NTS
826	1977-12-14	15:30:00.07	37.136	-116.087	5.7	SS/TSG	NTS
829	1978-02-23	17:00:00.16	37.124	-116.065	5.6	SS/TSG	NTS
830	1978-03-16	15:00:00.07	37.085	-116.082	4.1	SS	NTS
831	1978-03-23	16:30:00.20	37.102	-116.052	5.6	SS/TSG	NTS

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Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Lat. (°N)	Long. (°E)	m_b (P)	Inst. type[(2)]	Location/Yield
833	1978-04-11	17:45:00.07	37.233	-116.369	5.5	SS	NTS
839	1978-07-12	17:00:00.08	37.079	-116.045	5.5	SS/TSG	NTS
840	1978-08-31	14:00:00.16	37.276	-116.358	5.6	SS	NTS
841	1978-09-13	15:15:00.16	37.209	-116.212	4.6	SS	NTS
842	1978-09-27	17:00:00.07	37.074	-116.021	5.0	SS	NTS
843	1978-09-27	17:20:00.08	37.080	-116.052	5.7	SS	NTS
848	1978-12-16	15:30:00.16	37.273	-116.411	5.5	TSG	NTS
849	1979-01-24	18:00:00.10	37.105	-116.013	4.5	SS	NTS
850	1979-02-08	20:00:00.09	37.102	-116.056	5.5	SS/TSG	NTS
851	1979-02-15	18:05:00.16	37.152	-116.073	4.8	SS	NTS
852	1979-03-14	18:30:00.10	37.028	-116.041	4.3	SS/TSG	NTS
854	1979-06-11	14:00:00.17	37.290	-116.456	5.5	SS	NTS
855	1979-06-20	15:00:13.54	37.108	-116.016	4.0	SS	NTS
856	1979-06-28	14:44:00.17	37.143	-116.088	5.0	SS	NTS
857	1979-08-03	15:07:30.16	37.084	-116.071	4.5	SS	NTS
858	1979-08-08	15:00:00.11	37.015	-116.009	4.8	SS/TSG	NTS
860	1979-09-06	15:00:00.09	37.088	-116.054	5.8	TSG	Hearts/140 kt
862	1979-09-26	15:00:00.09	37.229	-116.365	5.6	SS/TSG	NTS
865	1980-02-28	15:00:00.09	37.127	-116.089	4.4	SS/TSG	NTS
867	1980-04-03	14:00:00.09	37.150	-116.083	4.7	SS	NTS
868	1980-04-16	20:00:00.09	37.101	-116.031	5.3	SS	NTS
872	1980-06-12	17:15:00.09	37.282	-116.455	5.6	SS/TSG	NTS
874	1980-07-25	19:05:00.08	37.256	-116.478	5.5	SS	NTS
876	1980-09-25	14:45:00.09	37.056	-116.049	4.6	SS	NTS
879	1980-10-31	18:00:00.09	37.211	-116.206	4.7	SS	NTS
880	1980-11-14	16:50:00.08	37.111	-116.020	4.1	SS	NTS
882	1981-01-15	20:25:00.09	37.087	-116.046	5.7	SS	NTS
887	1981-06-06	18:00:00.08	37.303	-116.326	5.6	SS	NTS
894	1981-10-01	19:00:00.10	37.082	-116.010	5.1	SS	NTS
895	1981-11-11	20:00:09.09	37.076	-116.069	4.9	SS	NTS
897	1981-12-03	15:00:00.10	37.148	-116.072	4.8	SS	NTS
898	1981-12-16	21:05:00.09	37.114	-116.124	4.4	SS	NTS
899	1982-01-28	16:00:00.10	37.091	-116.052	5.6	SS	NTS/139 kt
900	1982-02-12	14:55:00.08	37.224	-116.464	5.4	SS/TSG	NTS
901	1982-02-12	15:25:00.09	37.348	-116.317	5.4	SS/TSG	NTS
902	1982-04-17	18:00:00.09	37.017	-116.011	4.5	SS	NTS
905	1982-05-07	18:17:00.11	37.069	-116.046	5.7	SS	NTS
907	1982-06-24	14:15:00.09	37.236	-116.371	5.6	SS	NTS
908	1982-07-29	20:05:00.08	37.102	-116.076	4.4	TSG	NTS
909	1982-08-05	14:00:00.09	37.084	-116.007	5.7	TSG	NTS/138 kt
912	1982-09-23	16:00:00.09	37.212	-116.208	4.9	SS	NTS
914	1982-09-23	17:00:00.09	37.175	-116.089	4.9	SS	NTS
916	1982-11-12	19:17:00.10	37.024	-116.033	4.1	SS/TSG	NTS
917	1982-12-10	15:20:00.09	37.080	-116.073	4.8	SS/TSG	NTS
918	1983-02-11	16:00:00.10	37.056	-116.046	4.1	SS	NTS
919	1983-02-17	17:00:00.09	37.163	-116.064	4.0	SS	NTS
920	1983-03-26	20:20:00.09	37.301	-116.461	5.2	SS/TSG	NTS
921	1983-04-14	19:05:00.12	37.073	-116.047	5.7	SS/TSG	NTS

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Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Lat. (°N)	Long. (°E)	m_b (*P*)	Inst. type[(2)]	Location/Yield
923	1983-05-05	15:20:00.08	37.146	-116.090	4.4	SS	NTS
925	1983-05-26	15:00:00.09	37.103	-116.007	4.5	SS	NTS
926	1983-06-09	17:10:00.09	37.158	-116.090	4.5	SS	NTS
927	1983-08-03	13:33:00.10	37.119	-116.090	4.2	SS	NTS
928	1983-08-11	14:00:00.12	36.998	-116.004	4.4	SS	NTS
930	1983-09-01	14:00:00.08	37.273	-116.356	5.5	SS	NTS/143 kt
931	1983-09-21	15:00:00.09	37.210	-116.210	4.1	SS	NTS
932	1983-09-21	16:25:00.08	37.121	-116.056	4.2	SS	NTS
933	1983-09-22	15:00:00.12	37.106	-116.050	4.1	SS/TSG	NTS
935	1983-12-09	16:00:00.11	37.013	-116.047	4.0	SS/TSG	NTS
936	1983-12-16	18:30:00.09	37.140	-116.073	5.2	SS/TSG	NTS
937	1984-01-31	15:30:00.08	37.113	-116.123	4.3	SS/TSG	NTS
938	1984-02-15	17:00:00.11	37.221	-116.182	5.1	SS/TSG	NTS
939	1984-03-01	17:45:00.09	37.066	-116.047	5.9	SS	NTS
940	1984-03-31	14:30:00.08	37.146	-116.085	4.5	SS	NTS
944	1984-05-31	13:04:00.10	37.103	-116.049	5.8	SS/TSG	NTS
945	1984-06-20	15:15:00.09	37.000	-116.044	4.7	SS	NTS
947	1984-07-25	15:30:00.08	37.268	-116.412	5.4	SS	NTS
948	1984-08-02	15:00:00.09	37.017	-116.009	4.6	SS/TSG	NTS
949	1984-08-30	14:45:00.10	37.090	-116.000	4.5	SS/TSG	NTS
951	1984-09-13	14:00:00.00	37.087	-116.072	5.0	SS	NTS
953	1984-11-10	16:40:00.09	37.000	-116.018	4.4	SS/TSG	NTS
955	1984-12-15	14:45:00.00	37.281	-116.306	5.4	SS/TSG	NTS
957	1985-03-15	16:31:00.10	37.058	-116.046	4.8	SS	NTS
958	1985-03-23	18:30:00.08	37.180	-116.090	5.3	SS/TSG	NTS
959	1985-04-02	20:00:00.09	37.095	-116.033	5.8	SS/TSG	NTS
960	1985-04-06	23:15:00.09	37.201	-116.208	4.8	SS/TSG	NTS
961	1985-05-02	15:20:00.08	37.253	-116.326	5.7	SS	NTS
962	1985-06-12	15:15:00.08	37.248	-116.490	5.5	SS/TSG	NTS
963	1985-06-12	17:30:00.09	37.088	-116.085	4.6	SS/TSG	NTS
964	1985-06-26	18:03:00.08	37.124	-116.123	4.3	SS/TSG	NTS
965	1985-07-25	14:00:00.09	37.297	-116.439	5.2	SS	NTS
967	1985-08-17	16:25:00.09	37.002	-116.044	4.6	SS	NTS
968	1985-09-27	14:15:00.08	37.090	-116.003	4.7	SS	NTS
970	1985-10-09	23:20:00.09	37.210	-116.211	4.2	SS	NTS
971	1985-10-16	21:35:00.09	37.110	-116.122	4.6	SS/TSG	NTS
974	1985-12-28	19:01:00.09	37.238	-116.474	5.3	SS/TSG	NTS
975	1986-03-22	16:15:00.08	37.083	-116.067	5.1	SS/TSG	NTS/29 kt
976	1986-04-10	14:08:30.10	37.218	-116.184	4.9	SS/TSG	NTS
978	1986-04-22	14:30:00.09	37.264	-116.441	5.3	SS/TSG	NTS
979	1986-05-21	13:59:00.08	37.125	-116.061	3.9	SS	NTS
980	1986-06-05	15:04:00.06	37.098	-116.016	5.3	SS	NTS
982	1986-07-17	21:00:00.06	37.279	-116.356	5.7	SS	NTS/119 kt
983	1986-07-24	15:05:00.09	37.143	-116.072	4.4	SS	NTS
986	1986-09-30	22:30:00.10	37.300	-116.308	5.5	SS/TSG	NTS
987	1986-10-16	19:25:00.09	37.220	-116.463	5.6	SS/TSG	NTS
988	1986-11-14	16:00:00.07	37.100	-116.049	5.8	SS/TSG	NTS
989	1986-12-13	17:50:05.09	37.263	-116.413	5.5	SS/TSG	NTS

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Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Lat. (°N)	Long. (°E)	m_b (P)	Inst. type[2]	Location/Yield
990	1987-02-03	15:20:00.08	37.181	-116.049	2.2	SS/TSG	NTS
991	1987-02-11	16:45:00.07	37.011	-116.046	4.5	SS	NTS
992	1987-03-18	18:28:00.09	37.210	-116.209	4.3	SS/TSG	NTS
993	1987-04-18	13:40:00.00	37.248	-116.510	5.5	SS/TSG	NTS
995	1987-04-30	13:30:00.09	37.233	-116.424	5.5	SS/TSG	NTS
996	1987-06-18	15:20:00.08	37.194	-116.036	4.1	SS/TSG	NTS
997	1987-06-20	16:00:00.18	37.220	-116.179	3.5	SS	NTS
998	1987-06-30	16:05:00.10	36.999	-116.044	4.1	SS/TSG	NTS
1000	1987-08-13	14:00:00.09	37.061	-116.046	5.9	SS/TSG	Tahoka
1001	1987-09-24	15:00:00.06	37.228	-116.376	5.7	SS/TSG	NTS
1002	1987-10-23	16:00:00.09	37.142	-116.080	5.2	SS/TSG	Borate
1004	1987-12-02	16:30:00.08	37.235	-116.164	4.1	TSG	NTS
1005	1988-02-15	18:10:00.09	37.314	-116.472	5.3	SS	Kernville
1006	1988-04-07	17:15:00.08	37.013	-116.045	4.0	SS	NTS
1007	1988-05-13	15:35:00.11	37.124	-116.073	4.8	SS/TSG	NTS
1008	1988-05-21	22:30:00.14	37.032	-115.988	4.3	SS	Laredo
1009	1988-06-02	13:00:00.09	37.260	-116.442	5.4	SS/TSG	NTS
1012	1988-07-07	15:05:30.07	37.252	-116.378	5.6	SS	NTS
1013	1988-08-17	17:00:00.09	37.297	-116.307	5.5	SS	Kersage/JVE/100 to 150 kt
1015	1988-08-30	18:00:00.09	37.086	-116.069	5.0	SS/TSG	NTS
1016	1988-10-13	14:00:00.08	37.089	-116.050	5.9	SS	NTS
1019	1988-12-10	20:30:00.06	37.199	-116.210	5.0	SS/TSG	Misty Echo
1020	1989-02-10	20:06:00.06	37.077	-116.001	5.2	SS/TSG	NTS
1021	1989-02-24	16:15:00.08	37.128	-116.123	4.4	SS/TSG	NTS
1022	1989-03-09	14:05:00.09	37.143	-116.068	5.0	SS/TSG	NTS
1025	1989-06-22	21:15:00.08	37.283	-116.413	5.3	SS	NTS
1026	1989-06-27	15:30:00.02	37.275	-116.354	4.9	SS/TSG	NTS
1028	1989-10-31	15:30:00.09	37.263	-116.492	5.7	TSG	NTS
1032	1990-03-10	16:00:00.08	37.112	-116.056	5.0	SS	NTS
1034	1990-06-13	16:00:00.09	37.262	-116.421	5.7	SS/TSG	Bullion
1035	1990-06-21	18:15:00.00	36.993	-116.005	4.0	TSG	NTS
1036	1990-07-25	15:00:00.06	37.207	-116.215	4.7	SS/TSG	NTS
1039	1990-10-12	17:30:00.08	37.248	-116.495	5.6	SS/TSG	Tenabo
1040	1990-11-14	19:17:00.07	37.227	-116.372	5.4	TSG	NTS
1041	1991-03-08	21:02:45.08	37.104	-116.075	4.4	TSG	NTS
1042	1991-04-04	19:00:00.00	37.296	-116.314	5.6	TSG	NTS
1044	1991-08-15	16:00:00.00	37.087	-116.003	4.2	TSG	NTS
1045	1991-09-14	19:00:00.08	37.226	-116.429	5.5	TSG	Hoya/20 to 150 kt
1046	1991-09-19	16:30:00.07	37.236	-116.167	4.0	TSG	Distant Zenith/$<$ 20 kt
1047	1991-10-18	19:12:00.00	37.063	-116.046	5.2	TSG	NTS
1048	1991-11-26	18:35:00.07	37.096	-116.070	4.6	TSG	NTS
1049	1992-03-26	16:30:00.00	37.272	-116.361	5.5	TSG	Junction/20 to 150 kt

[1] time, location, yield and test id from DOE/NV-209-REV 15, December 2000. $m_b(P)$, body-wave magnitude from PDE/ISC. [2] KODB= KOD low-gain system; KODM= KOD high-gain system; SS=STsR-SS system; TSG=STsR-TSG system.

Table A9: Borovoye archive data for Joint US-UK Nuclear Tests, 1978–1989[1)]

Test No.	Date Year-Mo-Da	Time (hr:mn:sec)	Latitude (°N)	Longitude (°E)	m_b (P)	Instrument name[2)]	Test name
834	1978-04-11	15:30:00.16	37.300	-116.328	5.3	SS	Fondutta
846	1978-11-18	19:00:00.17	37.127	-116.085	5.1	SS/TSG	Quargel
859	1979-08-29	15:08:00.17	37.121	-116.067	4.7	SS	Nessel
869	1980-04-26	17:00:00.08	37.248	-116.423	5.4	SS	Colwick
878	1980-10-24	19:15:00.12	37.075	-116.000	4.4	SS	Dutchess
881	1980-12-17	15:10:00.09	37.325	-116.316	5.1	SS	Serpa
896	1981-11-12	15:00:00.10	37.108	-116.050	5.4	SS	Rousanne
903	1982-04-25	18:05:00.09	37.256	-116.423	5.4	SS	Gibne
922	1983-04-22	13:53:00.08	37.111	-116.023	4.0	SS	Armada
941	1984-05-01	19:05:00.09	37.106	-116.023	5.4	SS/TSG	Mundo
954	1984-12-09	19:40:00.09	37.270	-116.498	5.5	SS/TSG	Egmont
973	1985-12-05	15:00:00.07	37.053	-116.046	5.7	SS	Kinibito
981	1986-06-25	20:27:45.09	37.265	-116.500	5.5	SS	Darwin
999	1987-07-16	19:00:00.08	37.104	-116.024	4.8	SS/TSG	Midland
1030	1989-12-08	15:00:00.09	37.231	-116.410	5.5	SS/TSG	Barnwell

[1)] time, location, yield and test ids from DOE/NV-209-REV 15, December 2000. $m_b(P)$, body-wave magnitude from PDE/ISC. From March 01, 1962 through November 26, 1991, a total of 24 unclear tests are conducted at the Nevada Test Site for United Kingdom (UK). [2)] SS=STsR-SS system and TSG=STsR-TSG system.