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7.2 The Lop Nor nuclear explosion of 5 October 1993

Introduction

As described in Section 7.1, we conducted a threshold monitoring experiment for the Lop Nor test site in Southern Sinkiang, China, for several days prior to the 5 October nuclear explosion. A large earthquake and aftershock sequence occurred in the Southern Sinkiang province only three days before the explosion, and this gave an opportunity to make some interesting comparisons, elaborated upon in this study.

The Lop Nor nuclear explosion of 5 October 1993

The explosion took place on 5 October 1993, with origin time 02.00 GMT. Table 7.2.1 lists the basic parameters of the event as provided by various sources. The m_b magnitudes range from 5.65 to 5.90. The most accurate location is provided by the PDE bulletin, which uses a world-wide network for location purposes. The solutions by the Intelligent Monitoring System (IMS) (Bache et al, 1993), both automatic (IMS) and after analyst processing (ARS), are also listed. The NORSAR automatic and reprocessed solutions (based on the new SUN-based processing system) are included in the table. The SUN-based NORSAR trace plot is shown in Fig. 7.2.1.

Figs. 7.2.2 and 7.2.3 show plots of the interactive IMS processing results. The trace plots of Fig. 7.2.3 are based on array beams for the four arrays Apatity, ARCESS, NORESS, GERESS and a single channel (A0) for Spitsbergen. The FINESS array was not yet operational at the time of the explosion.

Table 7.2.2 summarizes the automatic processing results for the six arrays. The NORESS array has the best signal-to-noise ratio (1376.2) for this event, and by extrapolation this array would be expected to have a detectable signal for an event about 2.5 magnitude units lower. ARCESS and NORSAR also show outstanding SNR. The velocity/azimuth estimates are within the expected uncertainty for all arrays. Note that the Spitsbergen array is only partially installed, and this is reflected in its processing results.

Comparison with previous events

We now proceed to make a brief comparison between the 5 October 1993 explosion, the large 21 May 1992 explosion at the same site and the two largests events in the 2 October S. Sinkiang earthquake sequence.

Table 7.2.3 summarizes the PDE parameters for these four events. The 21 May 1992 explosion is comparable in m_b to the main shock of 2 October 1993, and the 5 October 1993 explosion is comparable to the 2 October 1993 aftershock. This similarity is illustrated by Fig. 7.2.3, which shows the NORESS P-wave recordings (A0Z seismometer) for the four events, all plotted to the same scale.

Fig. 7.2.4 show long-period recordings, from the NORESS broad-band seismometers for the four events. Again, the same scale is used in all four cases. The surface waves of the main earthquake have been "clipped" (for display purposes). This figure is very illustrative, and the following observations may be made.

- As expected, the main earthquake and the large May 1992 explosion have vastly different size of surface waves, in spite of their similar m_b value. Thus, discrimination based on M_s:m_b is simple in these cases.
- The October 1993 Lop Nor explosion can likewise be readily identified as an explosion on the basis of M_s:m_b at NORESS, either by measuring M_s on the "marginal" surface wave shown on Fig. 7.2.4, or by using "negative evidence" in the case of NORESS. In fact, the long-period "noise magnitude" is well below the expected M_s value for any earthquake of corresponding m_b value.
- The surface waves of the 2 October aftershock cannot be measured on NORESS recordings, and this event cannot be identified as an earthquake from NORESS data using M_s:m_b. The reason is the large coda level even one full hour after the main shock.

It has previously been found, on the basis of the GSETT-2 experiment (see section 7.6) that a modern network dominated by high-frequency arrays is very efficient in detecting aftershocks closely following large earthquakes (see also Ringdal, 1992). The reason is that the high-frequency coda drops very rapidly after the initial P onset, and the high-frequency arrays are able to exploit this drop-off in the detection processing. On the other hand, the long-period coda stays at a high level for many hours following large earthquakes, and no efficient methods have been found so far to suppress this coda sufficiently to extract very small surface waves. This is only one of many examples illustrating that the progress in recent years in seismic event detection has not been matched by a similar progress in event identification.

J. Fyen
F. Ringdal

References

Bache, T.C., S.R. Bratt, H.J. Swanger, G.W. Beall and F.K. Dashiell (1993): Knowledge-based interpretation of seismic data in the Intelligent Monitoring System, *Bull. Seism. Soc. Am.*, 83, 1507-1526.

Ringdal, F. (1992): GSETT-2 evaluation: Detection of aftershocks from the W. Caucasus earthquake of 29 April 1991, *Semiann. Tech. Summary, 1 Oct 91 - 31 Mar 92*, NORSAR Sci. Rep. 2-91/92, Kjeller, Norway.

Ref.	Origin time	Lat	Lon	mb
IMS (automatic)	01.59.59.7	41.386	89.619	5.65
ARS	01.59.54.8	41.110	89.371	5.65
NORSAR SUN (automatic)	02.00.01.0	42.449	89.195	5.88
NORSAR Rerun SUN	02.00.01.3	41.365	87.339	5.83
PDE	01.59.56.5	41.647	88.681	5.90

Table 7.2.1. Location estimates by various systems of the 5 October 1993 Lop Nor nuclear explosion. Two of the estimates were made automatically (indicated in the table).

Array	Onset time	Res	STA/LTA	Vel	Res	Azi	Res
NORESS	278:02.08.44.398	1.71	1376.2	16.8	2.36	77.5	1.4
ARCESS	278:02.07.54.320	2.66	566.7	14.3	0.66	82.2	-14.9
GERESS	278:02.09.04.350	2.62	121.9	17.5	2.71	65.8	-2.2
Apatity	278:02.07.28.750	2.16	177.8	14.8	1.50	103.3	0.9
Spitsbergen	278:02.08.23.900	3.35	37.2	7.9	-6.17	94.0	-2.9
NORSAR	278:02.08.44.800	1.48	408.9	14.5	0.05	77.4	1.3

Table 7.2.2. Automatic detection list for the Lop Nor nuclear explosion 05 October 1993. The columns show array name, automatic SigPro onset time, onset residual relative to PDE origin time, maximum signal-to-noise ratio (STA/LTA), apparent velocity (km/sec), residual in km/sec, back-azimuth in degrees, back-azimuth residual. All residuals are relative to predictions using IASPEI91 tables and PDE origin time and location.

Event	Ref.	Origin time	Lat	Lon	mb	Ms
Lop Nor 92	PDE	21 May 92 04.59.57.5	41.604	88.813	6.5	5.0
Lop Nor 93	PDE	05 Oct 93 01.59.56.5	41.647	88.681	5.9	4.8
Main shock	PDE	02 Oct 93 08.42.32.8	38.141	88.638	6.2	6.3
Aftershock	PDE	02 Oct 93 09.43.19.5	38.127	88.502	5.7	5.3

Table 7.2.3. PDE parameters for four events discussed in the text.

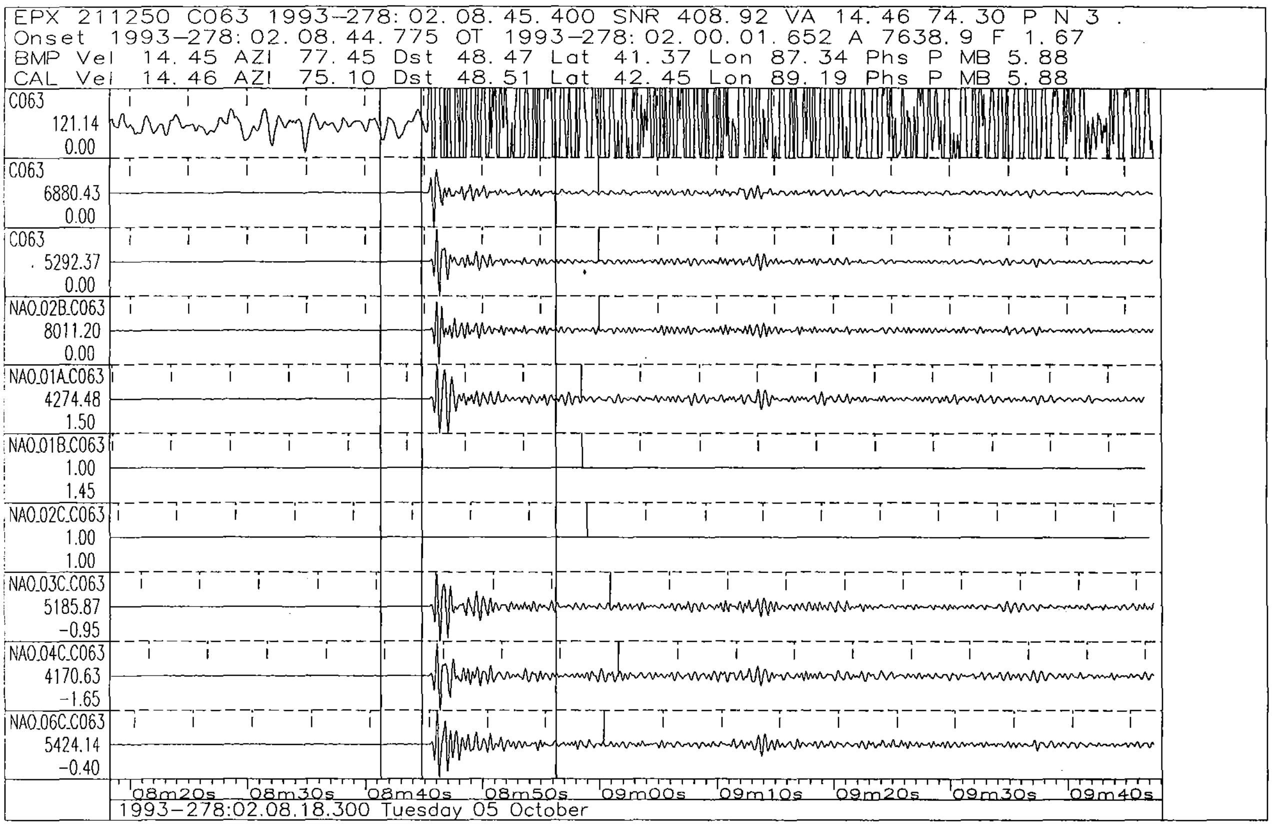

Fig. 7.2.1. Plot of the automatic NORSAR detection/event processor output for the nuclear explosion of 5 Oct 93.

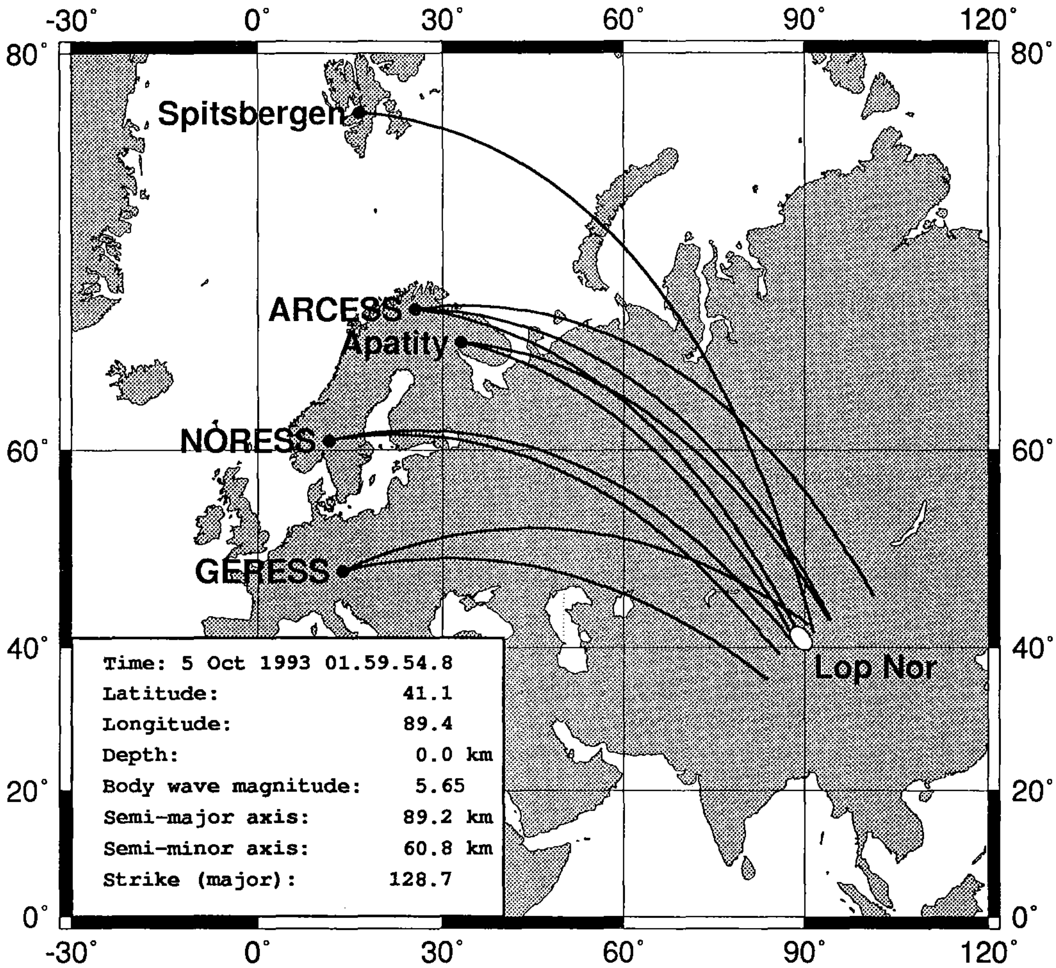

Fig. 7.2.2. Map showing the IMS solution (after analyst review) of 5 Oct 93 explosion. The great circle path for the detecting arrays (based on P and PcP estimated azimuths) are also shown.

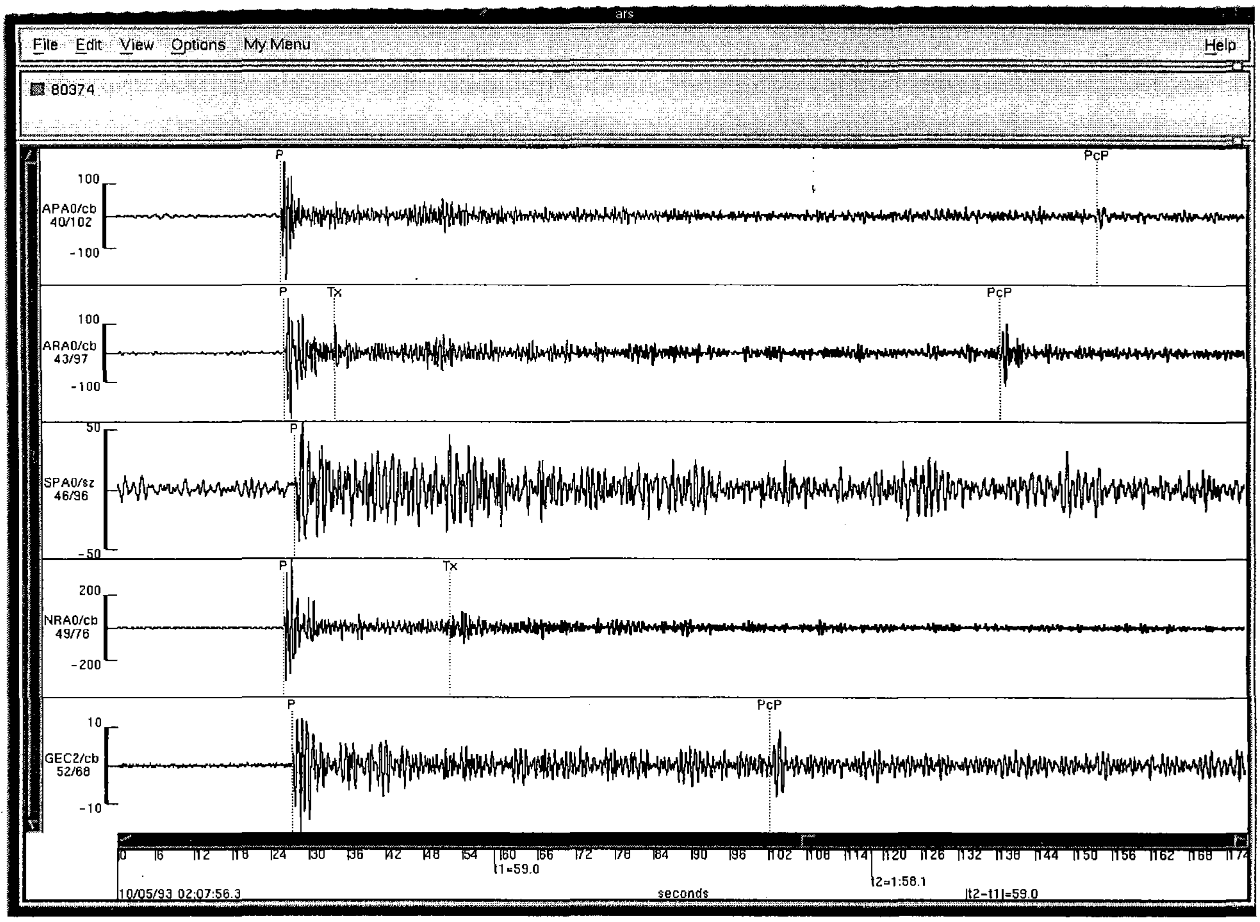

Fig. 7.2.3. P-phase waveforms of the 5 array SP traces (single sensor for Spitsbergen, otherwise array beams) for the 5 Oct 93 explosion.

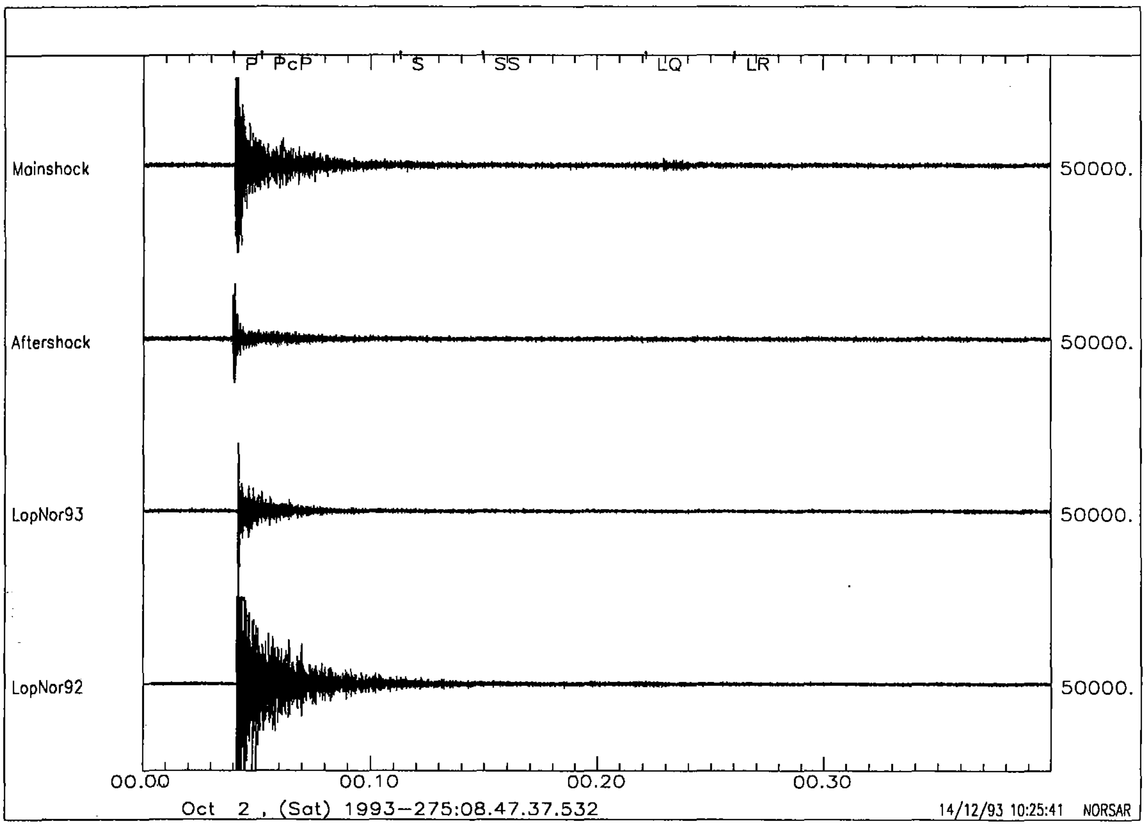

Fig. 7.2.4. NORESS P-waves (A0Z seismometer) for the four events discussed in the text. All traces are in the same scale. Note that, for display purposes, two of the traces have been "clipped".

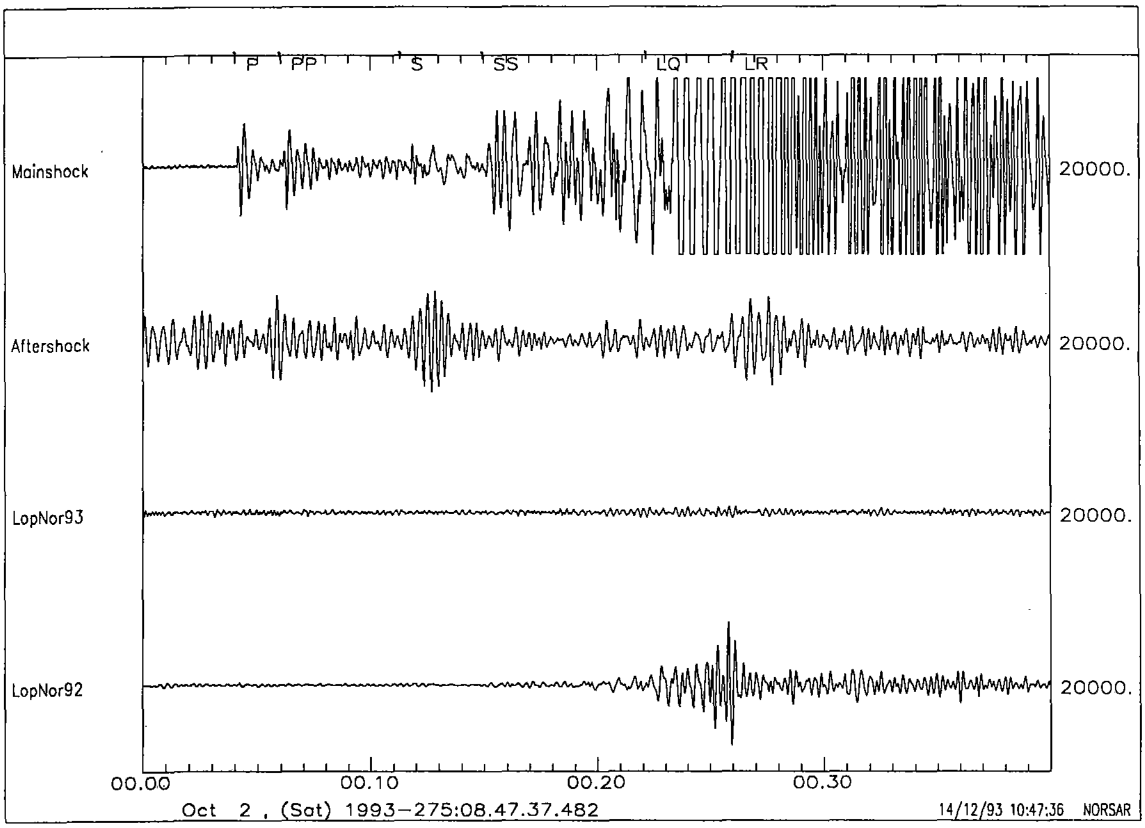

Fig. 7.2.5. NORESS surface waves (Broad-band seismometer) for the four events discussed in the text. All traces are in the same scale. Note that, for display purposes, the top trace has been "clipped".