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Some Seismic Results of the RIO BLANCO Explosion in the Colorado River Region, USA

(Shot Report No. 5)

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C Blamey

SBN 85518076 5

FOREWORD

During the course of a speech to the United Nations on 5th December 1968, Ambassador William C Foster, United States representative on Committee I on disarmament, made the following statement:-

"As demonstrated by activities such as these, the United States is continuing to devote considerable resources to seismic research so as to improve the capability to detect and identify underground seismic events. However, it is a fact that, with the existing technology, we are unable to gather all available seismic data at long distances. We are unable at such distances to detect or locate accurately all seismic events or to identify positively whether certain seismic signals come from earthquakes or man-made explosions.

Fortunately, there is clearly a widespread desire - fully shared by the United States - for further advancement in seismic technology and for increased international exchange of information in this field.

It is in keeping with this desire that I should like to present today a proposal which the United States considers could do much to advance objectives in these areas. The United States proposes that some underground nuclear explosions be conducted with the collateral objective that these serve as explosions for world-wide seismic investigation. This investigation is one in which all States with the appropriate seismic instrumentation could participate. Indeed, the success of this proposal would depend in large measure on the extent of world-wide participation in the collection and evaluation of the seismic data."

One contribution by the United Kingdom to the proposal is the publication of the principal data recorded by four seismometer array stations which supply data regularly to the AWRE Blacknest Seismological Centre. Three array stations are controlled respectively by the Department of Energy, Mines and Resources, Canada, the Bhabha Atomic Research Centre, Trombay, India and the Australian National University, Canberra, Australia. The fourth station, Eskdalemuir array in Scotland, is controlled by Blacknest.

The publications will be used to summarise data recorded from explosions of interest for which full details of location, depth and yield are available. If the opportunity occurs data from other seismological stations will also be included.

S D Abercrombie
Senior Superintendent
Detection Systems

Shot Report No. 1: P D Marshall, E W Carpenter, A Douglas and J B Young: "Some Seismic Results of the LONGSHOT Explosion". AWRE Report No. 067/66, HMSO

Shot Report No. 2: P D Marshall: "Some Seismic Results of the MEDEO Explosion in the Alma Ata Region of the USSR". AWRE Report No. 033/70, HMSO

Shot Report No. 3: D J Corbishley: "Some Seismic Results of the US GASBUGGY and RULISON Underground Nuclear Explosions". AWRE Report No. 046/70, HMSO

Shot Report No. 4: P G Gibbs and C Blamey: "Some Seismic Results of 12 Underground Nuclear Explosions at the Nevada Test Site, USA". AWRE Report No. 032/72, HMSO

SUMMARY

This report provides seismological data from the underground triple nuclear explosion known as RIO BLANCO recorded by arrays in Australia, Brazil, Canada and Scotland, and single seismometers in England and South Africa. The shot was detonated in Colorado, USA and the location, depth, source medium and yield have been published by the United States Atomic Energy Commission.

1. INTRODUCTION

RIO BLANCO is the third in a series of explosions detonated in the Colorado Plateaux by the United States Atomic Energy Commission as follows:-

GASBUGGY	10 December 1967	26 kton)	Shot
			) Report
RULISON	10 September 1969	40 kton)	No. 3
RIO BLANCO	17 May 1973	90 kton [1] (3 of 30 kton each - in a vertical line).	

These enterprises were carried out jointly with commercial oil companies to investigate the feasibility of releasing natural gas from comparatively impervious ("tight") strata. Figure 4 shows the relative positions of these explosions as well as a number of other explosions in and around Colorado, which include the CLIMAX experimental explosion [2], the ROCKVILLE DAM explosion [3] and several mining shots.

Figure 5 is an equidistant azimuthal great circle projection of the world, centred on RIO BLANCO, showing the relative positions of the various recording stations used in this report and the explosion. Four of the recording stations, EKA, YKA, WRA and BDF, are linear arrays [4] and are illustrated in figure 6. The other two stations, WOL and SWD, have recording vaults at a single location.

Table 1 lists the intersection points of the two arms of the linear arrays, and the other recording site positions.

TABLE 1

Yellowknife, Canada	(YKA)	62° 29' 35.62" N	114° 36' 19.08" W
Eskdalemuir, Scotland	(EKA)	55° 19' 59.48" N	3° 9' 31.52" W
Tennant Creek, Australia	(WRA)	19° 56' 52.08" S	134° 21' 02.88" E
Brazilia, Brazil	(BDF)	15° 39' 49.8" S	47° 54' 12.0" W
Wolverton, England	(WOL)	51° 18' 45.77" N	1° 13' 22.10" W
Swaziland, South Africa	(SWD)	26° 24' 00" S	31° 46' 00" E

The distance, azimuth and back bearing between RIO BLANCO and each of these recording stations, as computed with the GEDESS computer program [5], are given in table 2.

TABLE 2

Details of Recording Sites

Station	Distance, Degrees	Back Bearing, Degrees	Azimuth, Degrees
YKA	23.04	167.6	352.6
EKA	65.94	305.5	37.1
WRA	123.26	55.0	270.9
BDF	78.76	316.9	121.3
WOL	69.28	308.1	39.9
SWD	144.32	302.1	80.3

TABLE 3

Shot Details

Code name	RIO BLANCO [6]
Date	17 May 1973
Origin time	16 00 00.0 GMT
Site Latitude Longitude	37° 47' 34.8" N 108° 21' 59.6" W
Depth, Relative to Ground Zero	5840 ft (1780 m) 6230 ft (1899 m) 6690 ft (2039 m)
Geological Medium	Shale and Sandstone
Yield	3 each 30 kton (= 90 kton)

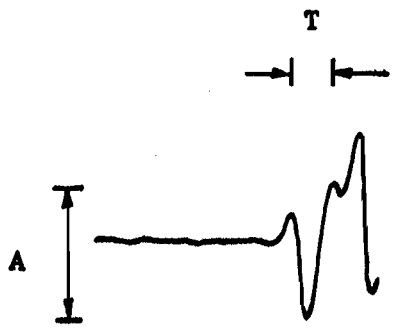
2. RESULTS

The arrays are sited principally to record signals from Europe and Central Asia, within distances of 90°. The Australian array (WRA) and the Swaziland Station (SWD) are more than 117° from RIO BLANCO, so the first arrivals at these stations are branches of the P signal [7] which have traversed the earth's core (PKP). In computing magnitude m_b for the recordings at these two stations, the distance corrections for magnitude $B(\Delta)$ published by Sweeter and Blandford [8] were used. The time differences observed minus computed (O-C) (see table 4(a)) given for these signals refer to the main (D) branch of PKP. Jeffreys and Bullen travel times were used [7].

The delayed and summed records of the explosion signal from each array are shown in figure 1. Figure 2 shows the signals from single seismometers at Wolverton and Swaziland and response curves for these systems are given in figures 7 and 8. (The signal was not detected by the Indian array (GBA) which is in the core shadow, $\Delta = 128°$.)

The WOL LPSP and SWD records illustrated in traces (a) and (c) of figure 2 are tightly filtered versions of the direct output of a long period vertical component seismometer at each station, while figure 2(b) shows the output from a single vertical short period seismometer at WOL having a natural period of 1.67 Hz.

Figure 3 shows the long period surface waves recorded at Yellowknife long period array. The surface wave magnitude M_s (see table 4(b)) has been calculated using the method recommended by Marshall and Basham [9]. Figure 9 shows the response curve for this system.



In figures 1 to 3 guide lines (as shown above) have been added to indicate the $\frac{1}{2}$ cycle measured for amplitude determination.

T = Period of $\frac{1}{2}$ cycle used.

A = Deflection from which amplitude was calculated.

3. ACKNOWLEDGMENTS

The recordings at the overseas stations were made possible by the co-operation of the Earth Physics Branch, Department of Energy, Mines and Resources, Ottawa, Canada; the Australian National University, Canberra, Australia; and the Department of Geosciences, University of Brasilia, Brazil (via the good offices of the Institute of Geological Sciences, Edinburgh).

TABLE 4

(a) Short Period Results (Body Waves)

Station	Onset, h min s	O-C, s	Period, s	Amplitude, mμ	Magnitude, m_b
YKA	16 05 05.4	- 2.1	0.65	99	5.48
EKA	16 10 45.8	- 3.7	0.75	17	5.36
WRA	16 18 58.7	- 0.3	0.60	10	5.58
BDF	16 12 03.4	- 2.9	0.80	39	5.50
WOL (LPSP))	16 11 07.7	- 2.9	(0.70	97	6.06
) WOL (1.7 Hz))			(0.60	25	5.8
SWD	16 19 36.0	- 2.0	0.75	13	4.88

O = observed, C = computed.

(b) Long Period Results (Surface Waves) Yellowknife (YKA)

Recording Site	Period, s	Amplitude, mμ	Magnitude, M_s
Local	17.5	1393	4.25
Mile 12	17.5	1598	4.31
N of Blue 10	15.5	1384	4.25

Note: The value of magnitude m_b = 5.48 given for YKA is derived from a single seismometer signal, as the summed signal illustrated in figure 1 includes some slightly overloaded channels.

REFERENCES

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3. UED Seismic Data Laboratory Report No. 158, "ROCKVILLE DAM". 3 April 1966: Long Range Seismic Measurements (19 August 1966)

4. C G Keen, J Montgomery, W H H Mowat, J E Mullard and D Platt: "British Seismometer Array Recording Systems". C Radio and Electronic Engineer, 30, 5 (November 1965)

5. J B Young and P G Gibbs: "GEDESS: A Series of Computer Programs for Deriving Information at Selected Recording Sites for Signals from Known Hypocentres". AWRE Report No. 054/68, HMSO

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7. H Jeffreys and K E Bullen: "Seismological Tables 1970". British Association for the Advancement of Science, Gray Milne Trust, London Office of the British Association, Burlington House, London W.1

8. E J Sweeter and R R Blandford: "Seismic Distance - Amplitude Relations for Short Period P, P_{diff}, PP and Compressional Core Phases for $\Delta > 99°$". SDAC-TR-73-9 (November 1973)

9. P D Marshall and P W Basham: "Discrimination between Earthquakes and Underground Explosions Employing an Improved M_S Scale". Geophys J Roy Astr Soc, 28, 431-458 (1972)

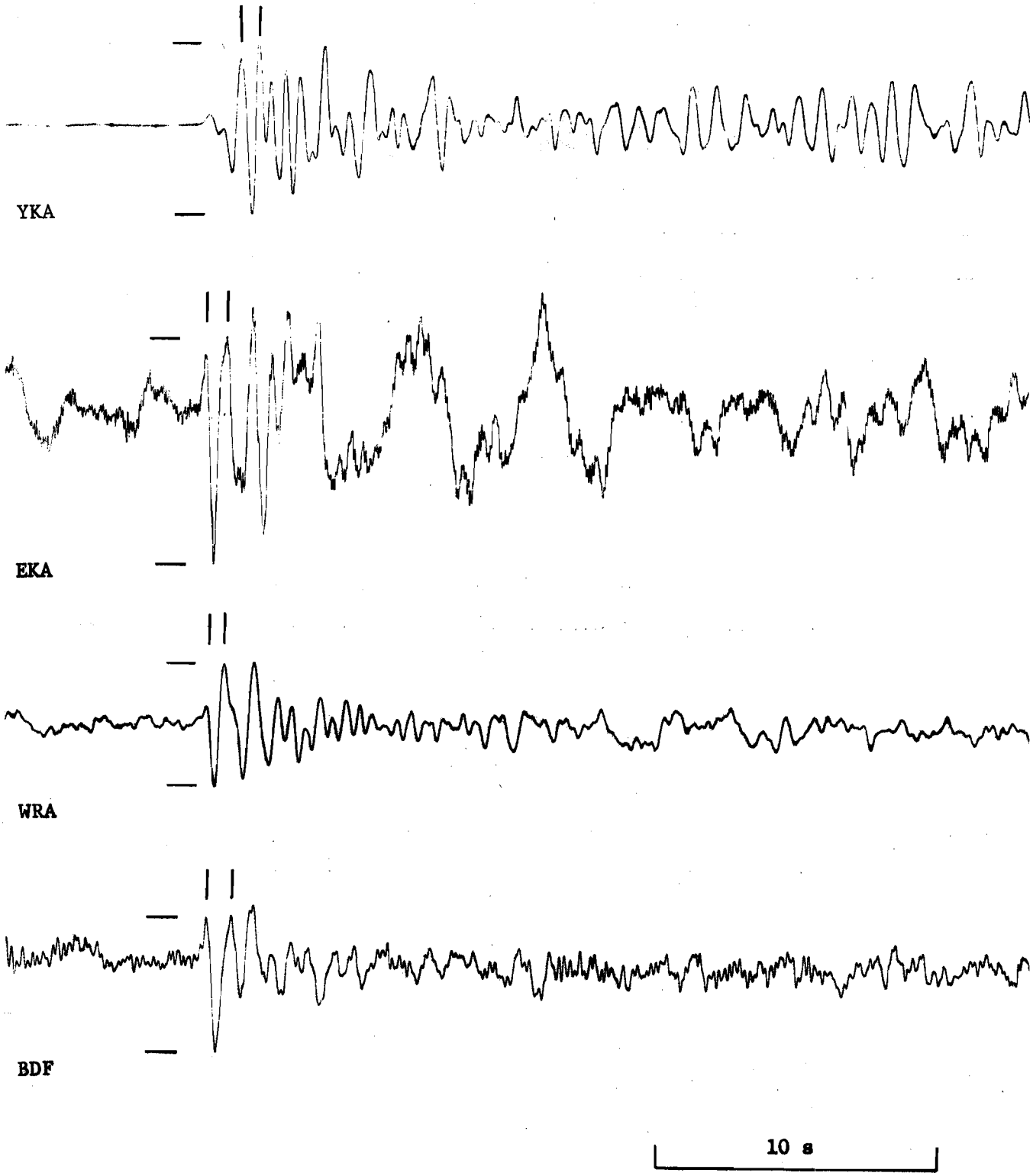

FIGURE 1. SUMMED SIGNALS (UNFILTERED) OF R10 BLANCO AT THE ARRAY STATIONS

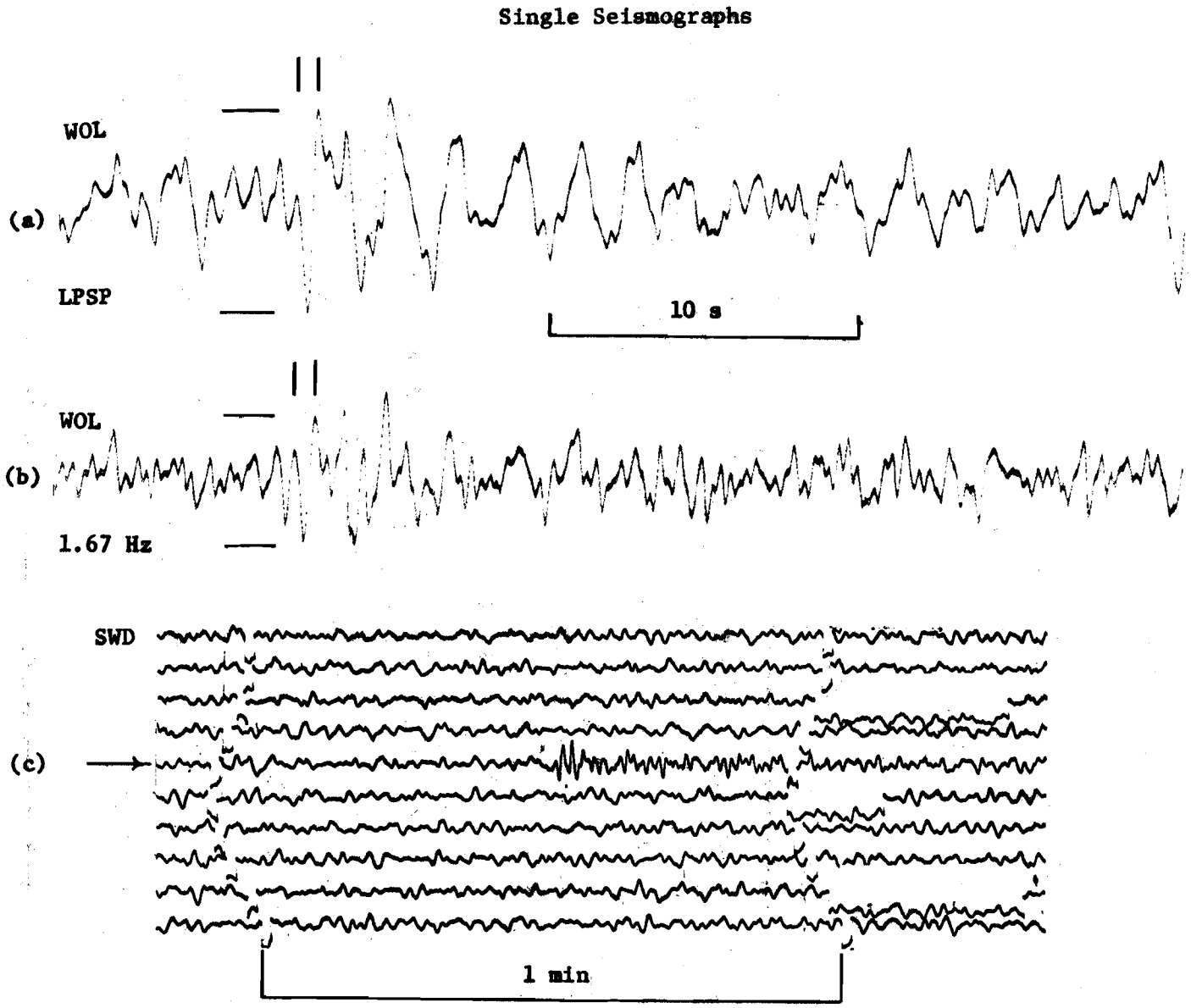

FIGURE 2. SINGLE SEISMOMETER RECORDINGS FROM STATIONS WOL AND SWD

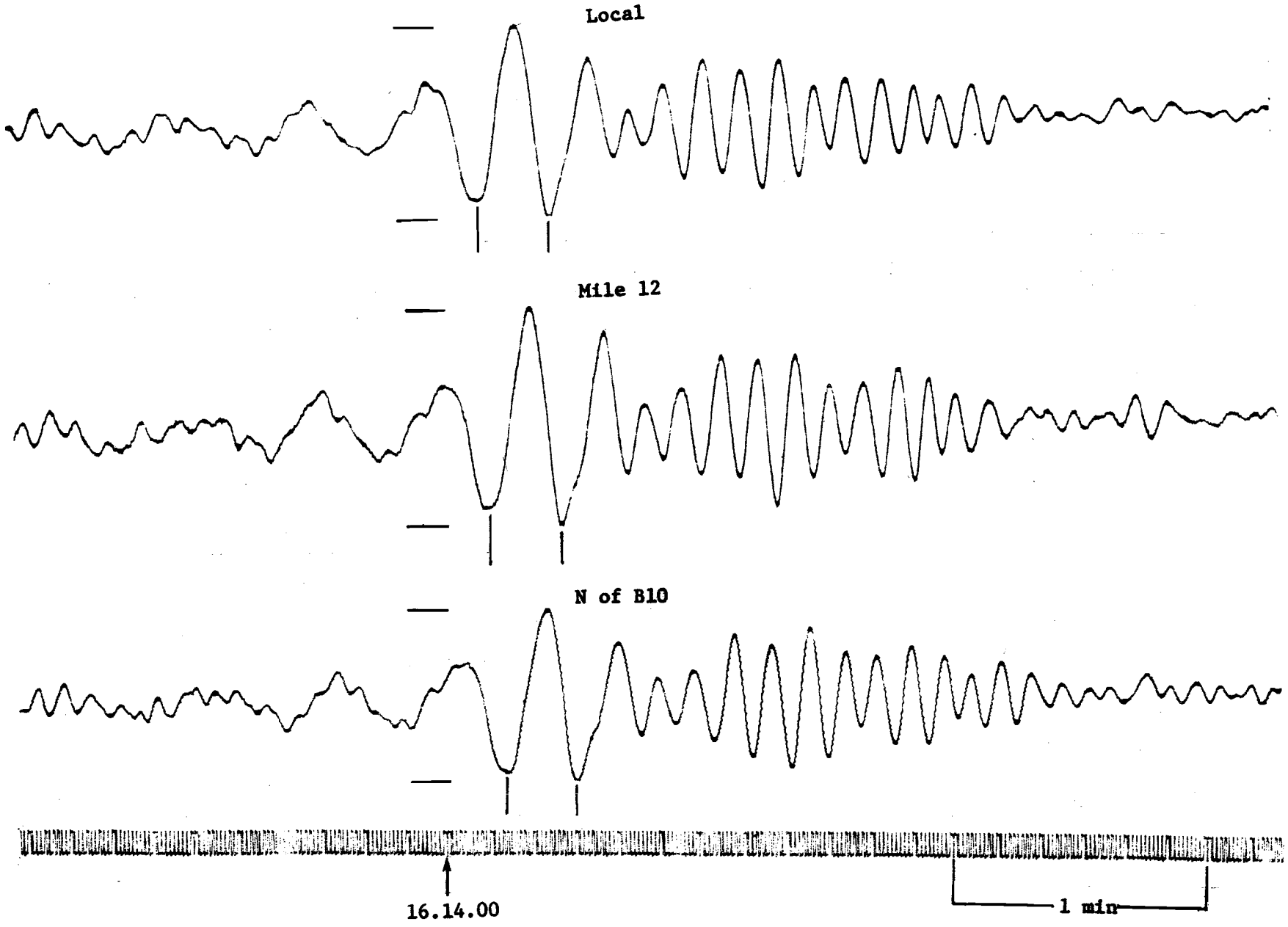

FIGURE 3. SURFACE WAVES FROM YKA - LONG PERIOD ARRAY

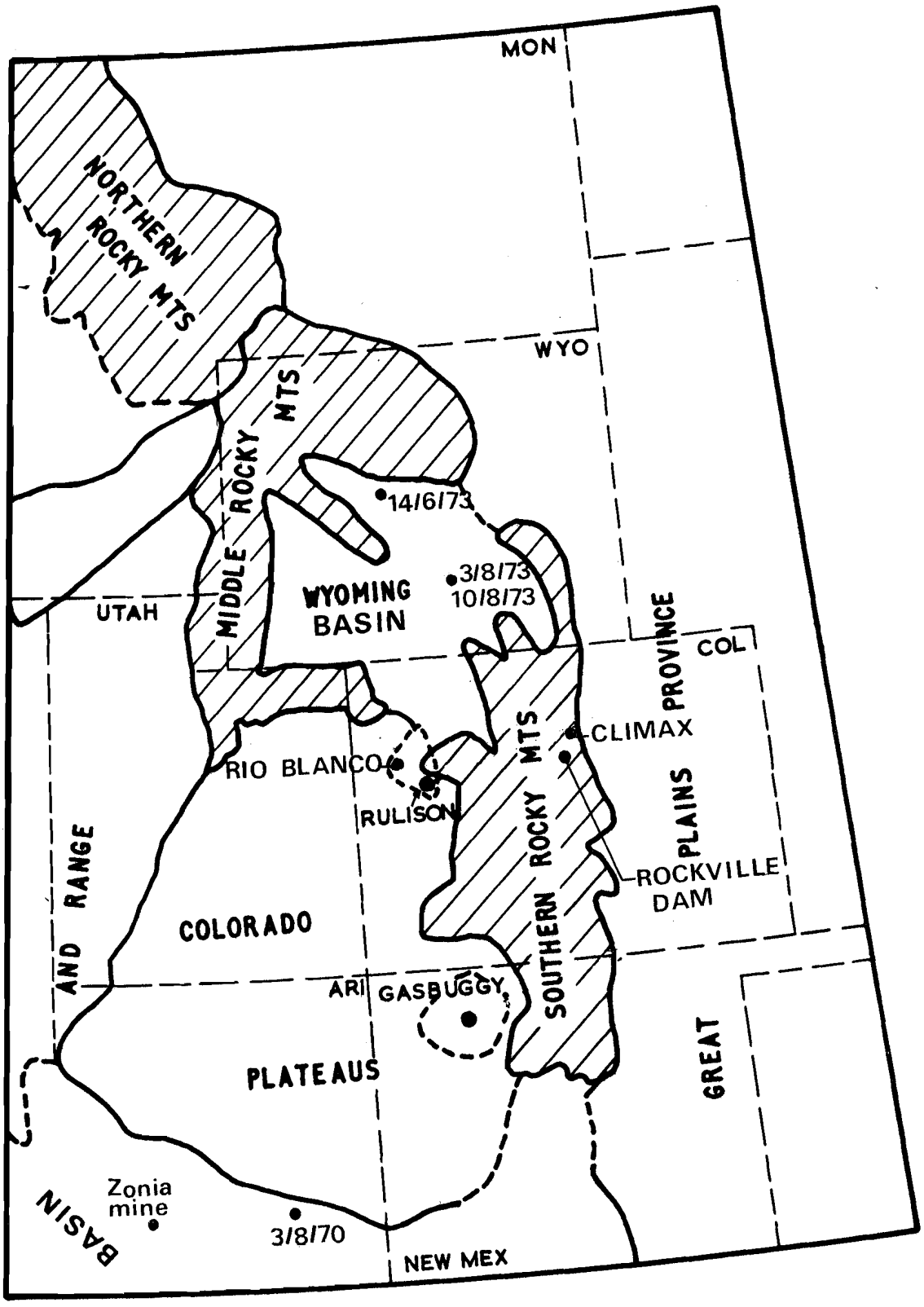

FIGURE 4. LOCATION OF THE RIO BLANCO EXPLOSION

(REFERENCE [6] WAS USED IN THE PREPARATION OF THIS FIGURE)

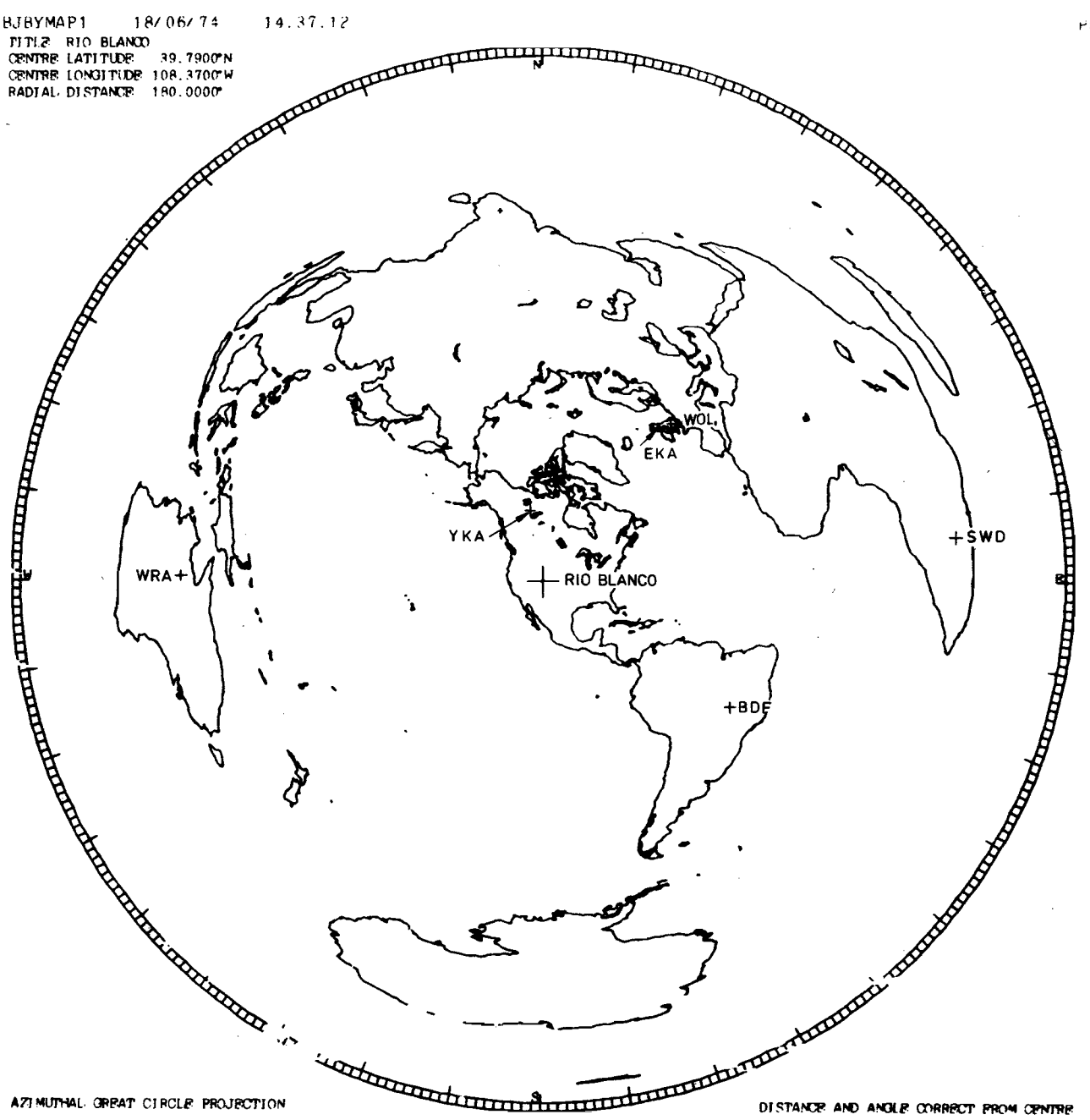

FIGURE 5. EQUIDISTANT AZIMUTHAL PROJECTION CENTRED ON RIO BLANCO SHOWING THE POSITIONS OF THE OTHER RECORDING SITES

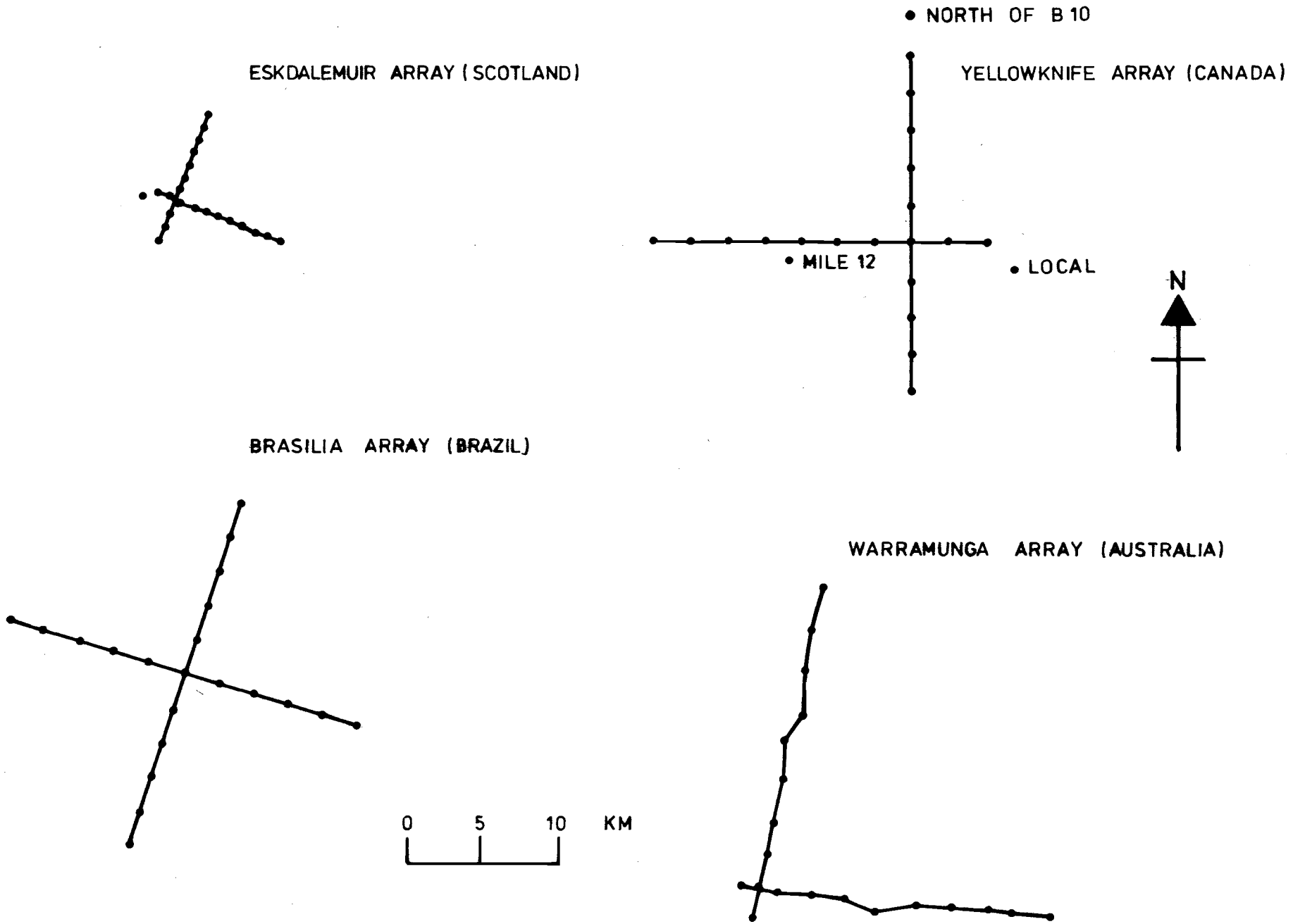

FIGURE 6. THE ARRAYS SHOWING ORIENTATION AND RELATIVE SIZE

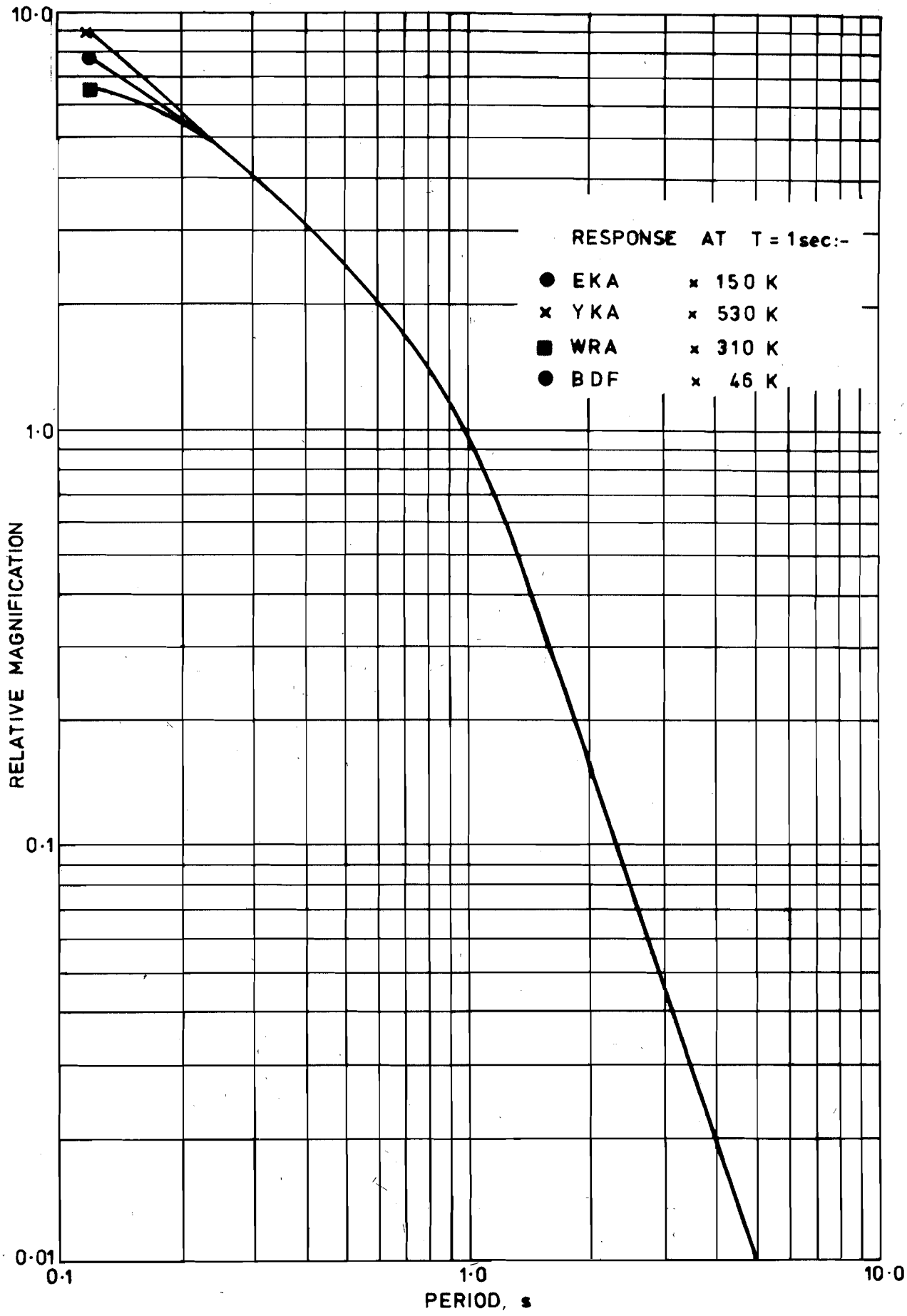

FIGURE 7. MAGNIFICATION SHORT PERIOD ARRAYS

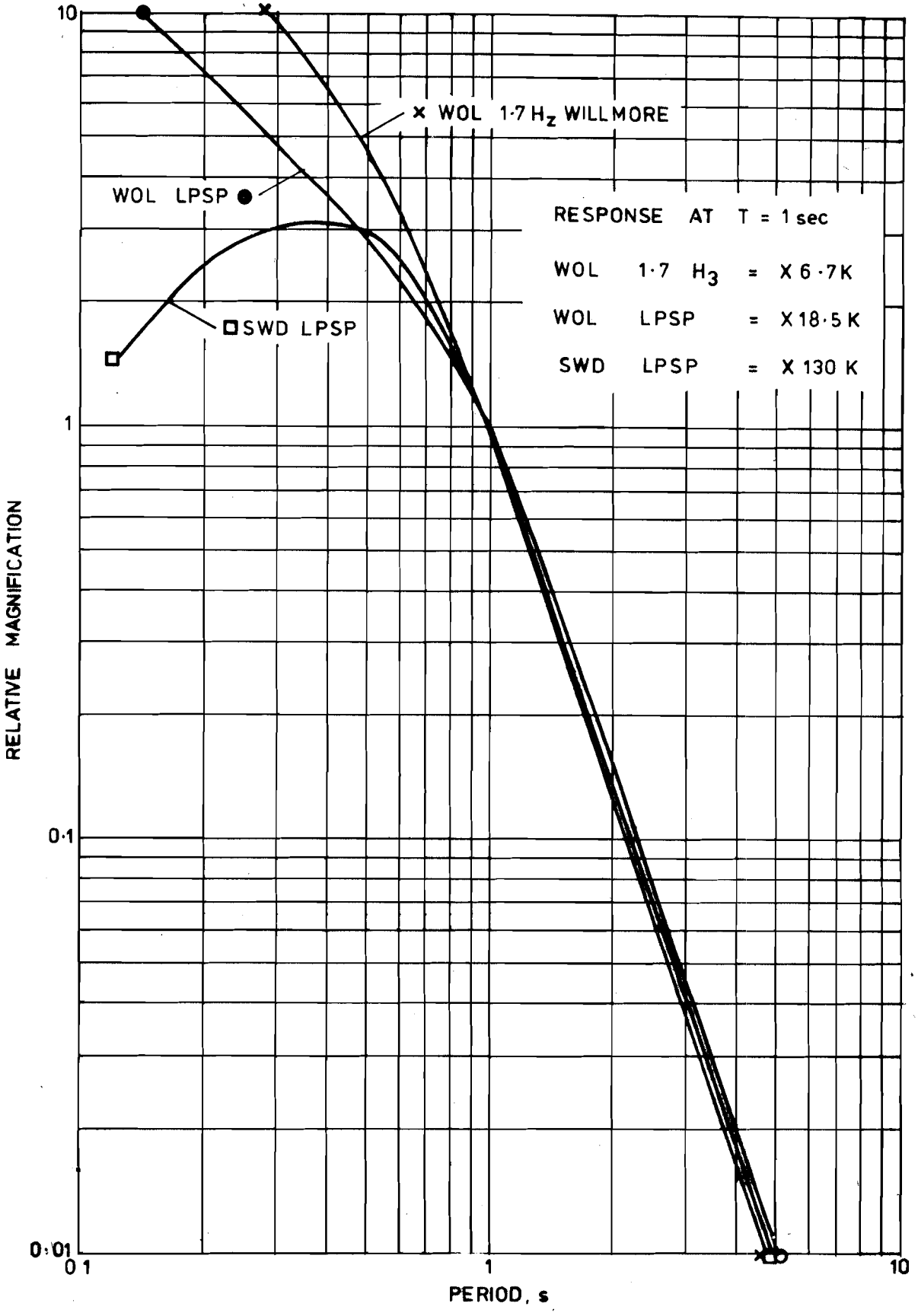

FIGURE 8. MAGNIFICATION OTHER SHORT PERIOD SYSTEMS

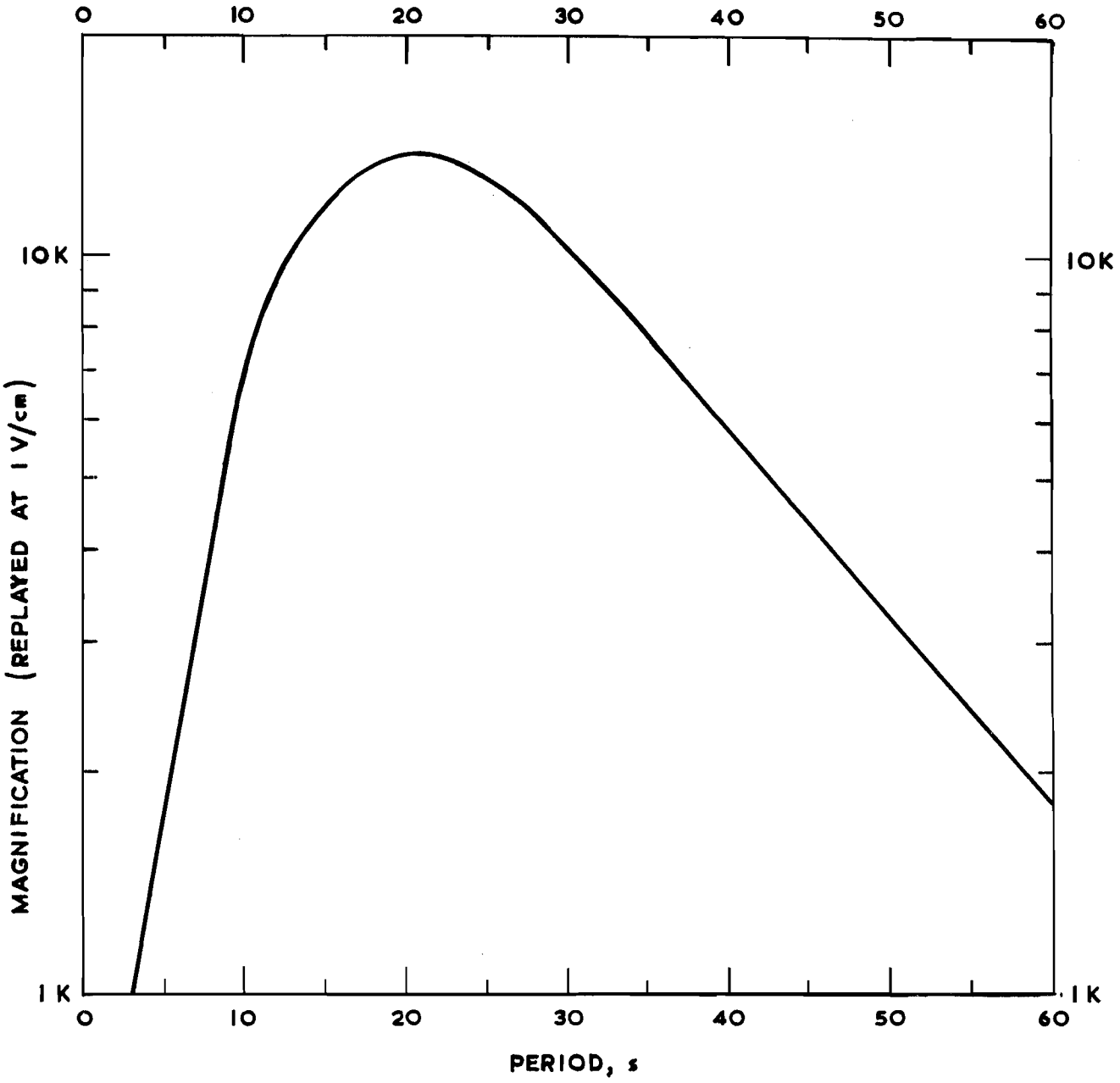

FIGURE 9. THE RESPONSE OF THE YELLOWKNIFE LONG PERIOD ARRAY SEISMOMETERS

DOCUMENT CONTROL SHEET

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Abstract

This report provides seismological data from the underground triple nuclear explosion known as RIO BLANCO recorded by arrays in Australia, Brazil, Canada and Scotland, and single seismometers in England and South Africa. The shot was detonated in Colorado, USA and the location, depth, source medium and yield have been published by the United States Atomic Energy Commission.