United Kingdom Atomic Energy Authority

AWRE, Aldermaston

AWRE REPORT NO. 032/72

Some Seismic Results of 12 Underground Nuclear Explosions at the Nevada Test Site, USA

(Shot Report No. 4)

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FOREWORD

During the course of a speech to the United Nations on 5th December 1968, Ambassador William C Foster, United States representative in 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 worldwide 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 worldwide participation in the collection and evaluation of the seismic data."

One form of the United Kingdom contribution to the investigations will be Shot Reports which present the principal data recorded by the 4 seismological array stations sponsored by the UK Atomic Energy Authority and operated with the co-operation of the Department of Energy, Mines and Resources, Canada, the Bhabha Institute for Atomic Research, Trombay, and the Australian National University, Canberra.

As the opportunity occurs, the Shot Reports will be used to summarise data recorded from any interesting explosions on which full details of location, depth and yield are accessible.

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

SUMMARY

This report provides the seismic data, from 4 UKAEA sponsored arrays, of 12 nuclear explosions, detonated underground at the Nevada Test Site, for which locations, depths, source media and yields have been published by the United States Atomic Energy Commission.

1. INTRODUCTION

The Nevada Test Site consists of a number of firing areas which are shown in figure 13. The 12 shots referred to in this report were all fired in the Northern Areas. Table 13 lists 8 in the Pahute Mesa region, 3 in the Yucca Flat and one, Piledriver, just off the Northern extremity of the Yucca Flat. Figure 14 shows the firing sites and figure 15 is an equidistant azimuthal projection, centred on NTS, showing its relationship to the four array sites. The geometry of the arrays is illustrated by figure 16.

The parameters of distance, azimuth and back bearing between NTS and each of the array stations vary little between each of the 12 firing positions. Table 14 [1] lists these parameters referred to the 4 arrays. Shot details are given in tables 1(a) - 12(a) [2,3] along with the seismic observations (tables 1(b) - 12(b)).

TABLE 13

Chronological List of Shots with Code Names and Locations

13 September 1963	Bilby	Yucca Flat
6 May 1966	Chartreuse	Pahute Mesa
27 May 1966	Discus Thrower	Yucca Flat
2 June 1966	Piledriver	Granite-N of Yucca Flat
30 June 1966	Halfbeak	Pahute Mesa
20 December 1966	Greeley	Pahute Mesa
23 May 1967	Scotch	Pahute Mesa
26 May 1967	Knickerbocker	Pahute Mesa
26 April 1968	Boxcar	Pahute Mesa
8 December 1968	Schooner	Pahute Mesa
19 December 1968	Benham	Pahute Mesa
8 July 1971	Miniata	Yucca Flat

TABLE 14

Distances and Azimuths Relative to NTS

Array Station	Distance, Δ°	Back Bearing	Azimuth
YKA	25.42° ± 0.09°	182.9° ± 0.3°	1.7° ± 0.2°
EKA	71.67° ± 0.08°	309.2° ± 0.2°	33.7° $^{+0.0^\circ}_{-0.1^\circ}$
WRA	117.05° ± 0.10°	57.8° ± 0.1°	264.7° ± 0.1°
GBA	127.96° ± 0.10°	13.8° ± 0.2°	343.1° ± 0.2°

All values lie within the given tolerances which are the overall scatter of the group.

The four linear arrays [4] (figure 16) from which data are included are:-

Eskdalemuir, Scotland (EKA) 55° 19' 59.0" N 3° 9' 33.0" W
Yellowknife, Canada (YKA) 62° 29' 34.3" N 114° 36' 16.5" W
Tennant Creek, Australia (WRA) 19° 56' 52.0" S 134° 21' 03.0" E
Gauribidanur, India (GBA) 13° 36' 15.0" N 77° 26' 10.0" E

2. RESULTS

These arrays are sited principally to record signals from Europe and Asia within distances of 90°. The Indian and Australian arrays are more than 117° distant from NTS so the first arrivals for these arrays are branches of the P signal which have traversed the core (PKP). The time differences O - C (see tables 1(b) to 12(b)) given for these signals refer to the main (D) branch of PKP. J-B travel times were used.

The delayed and summed records for each explosion are shown in figures 1 - 12 and corresponding magnitude assessments in tables 1(b) - 12(b). Some events overloaded all channels at YKA ($\Delta = 25\frac{1}{2}°$). One event (SCHOONER - 8 December 1968) was not detected at EKA, and the recordings for some of the events at GBA and WRA are not available.

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 Atomic Energy Establishment, Trombay, India; and the Australian National University, Canberra, Australia.

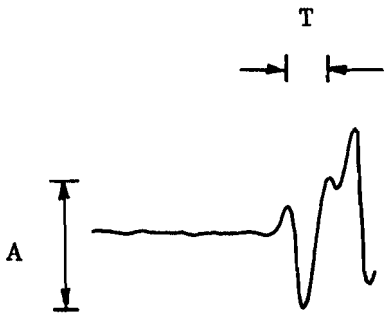
REFERENCES

1. 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 054/68, HMSO

2. D L Springer and R L Kinnerman: "Seismic Source Summary for United States Underground Explosions 1961 - 1970". Bulletin of the Seismological Society of America, 61, 4 (August 1971)

3. Earthquake Data Report. United States Department of Commerce, NOAA, EDR No. 46-71 (28 July 1971)

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)



In the following figures 1 to 12, 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.

TABLE 1(a)

Code Name		BILBY (See reference [2])
Date		13th September 1963
Origin time		17 00 00.13 GMT
Site	Latitude Longitude	37° 03' 37.5" N 116° 01' 18.0" W
Depth, relative to ground zero		2344 ft (714 m)
Geological medium		Tuff
Yield		235 kton

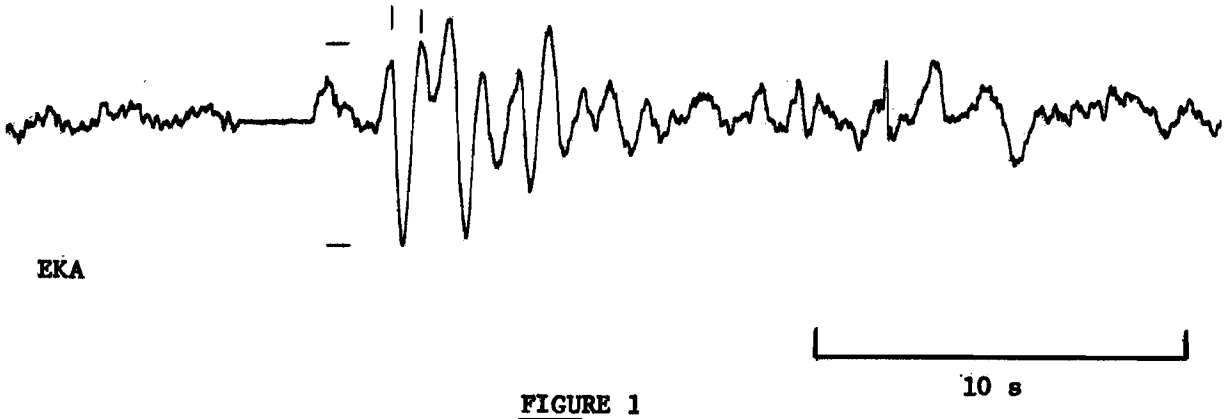


FIGURE 1

TABLE 1(b)

Array Station	Onset, h miμ s	O - C, s	Amplitude, mμ	Period T, s	Magnitude, m_b
EKA	17 11 22.6	- 2.5	28	0.8	5.45

O = observed onset time C = computed onset time

TABLE 2(a)

Code Name		CHARTREUSE (see reference [2])
Date		6th May 1966
Origin time		15 00 00.08 GMT
Site	Latitude Longitude	37° 20' 52.8" N 116° 19' 19.0" W
Depth, relative to ground zero		2183 ft (665 m)
Geological medium		Rhyolite
Yield		70 kton

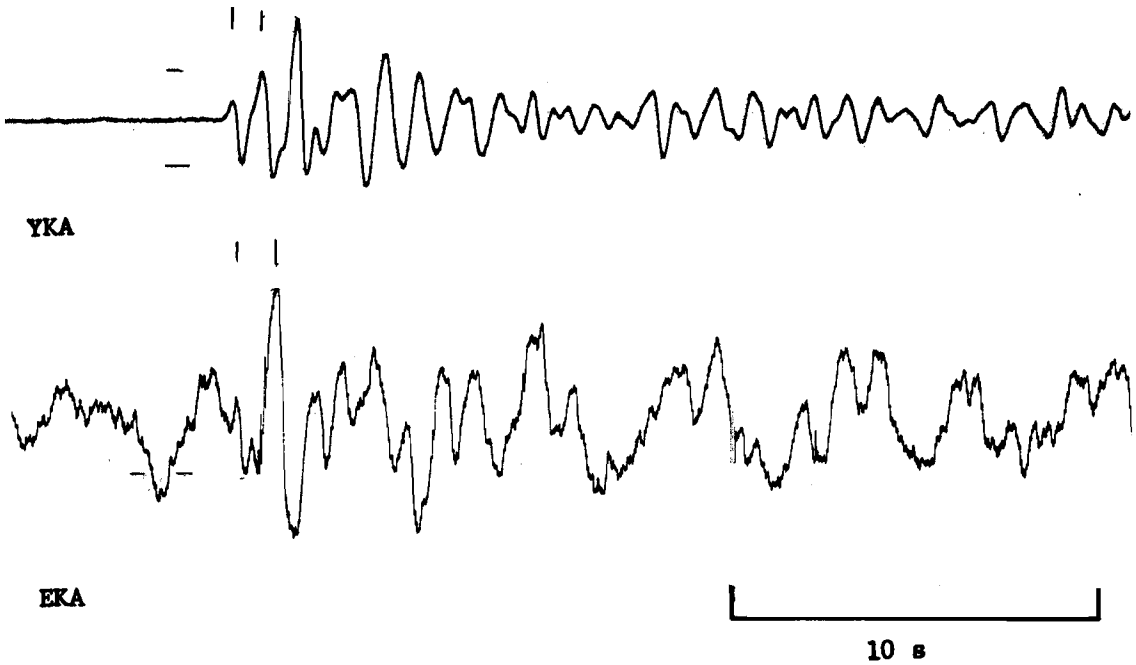


FIGURE 2

TABLE 2(b)

Array Station	Onset, h min s	O - C, s	Amplitude, mμ	Period T, s	Magnitude, m_b
YKA	15 05 26.8	- 2.9	31	0.85	5.03
EKA	15 11 21.8	- 2.9	15	1.0	5.08

O = observed onset time C = computed onset time

TABLE 3(a)

Code Name		DISCUS THROWER (see reference [2])
Date		27th May 1966
Origin time		20 00 00.04 GMT
Site	Latitude Longitude	37° 10' 42.2" N 116° 05' 51.9" W
Depth, relative to ground zero		1106 ft (337 m)
Geological medium		Tuff
Yield		21 kton

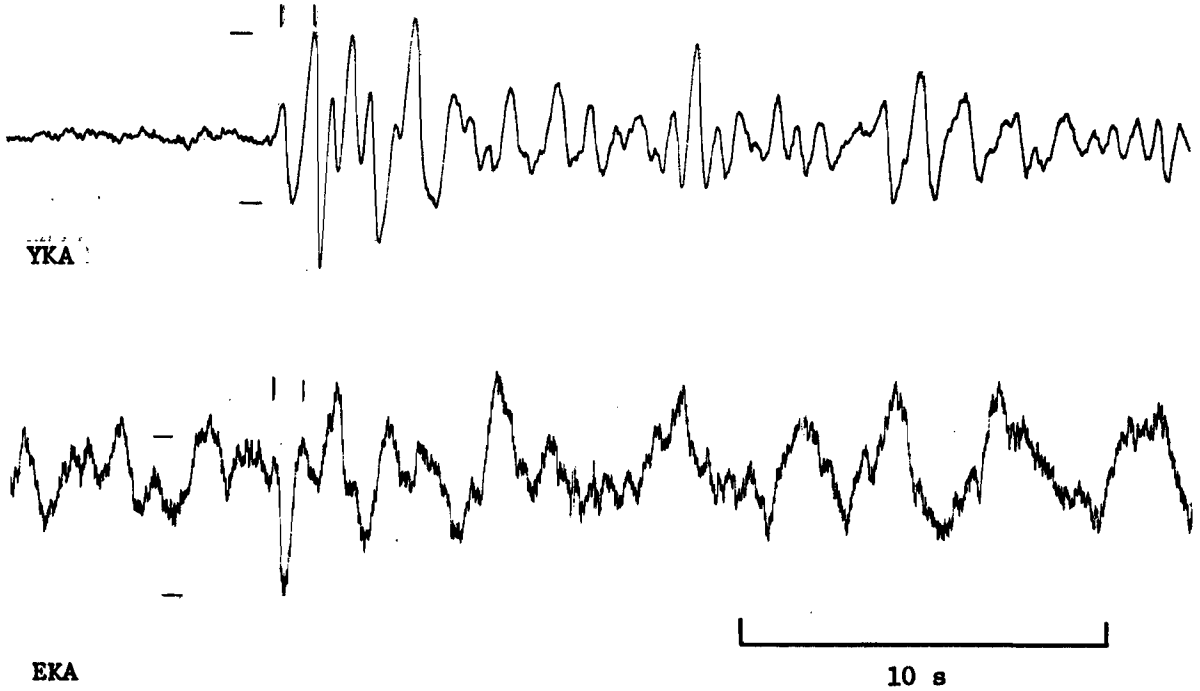


FIGURE 3

TABLE 3(b)

Array Station	Onset, h min s	O - C, s	Amplitude, mμ	Period T, s	Magnitude, m_b
YKA	20 05 28.0	- 2.5	11	0.9	4.54
EKA	20 11 22.2	- 2.6	5	0.8	4.66

O = observed onset time C = computed onset time

TABLE 4(a)

Code Name		PILEDRIVER (see reference [2])
Date		2nd June 1966
Origin time		15 30 00.09 GMT
Site	Latitude Longitude	37° 13' 37.4" N 116° 03' 19.9" W
Depth, relative to ground zero		1518 ft (462 m)
Geological medium		Granite
Yield		56 kton

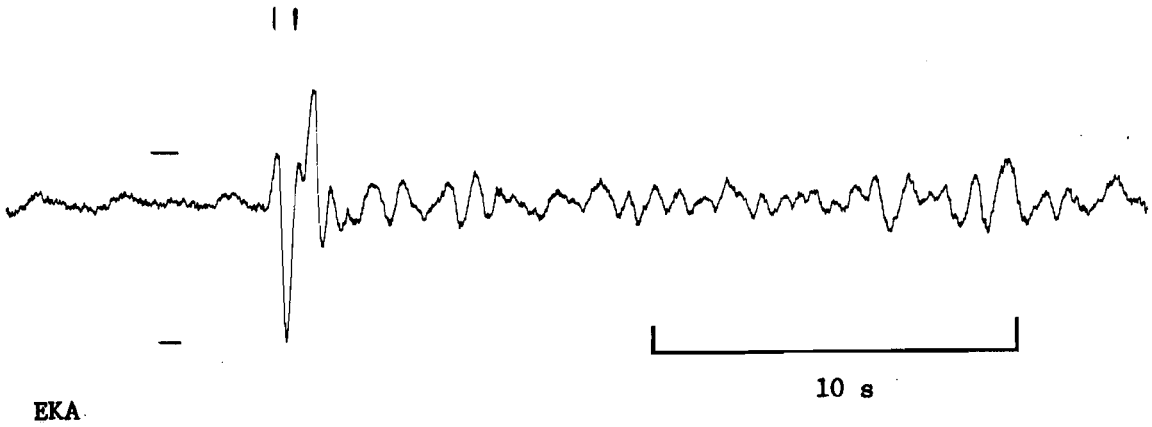


FIGURE 4

TABLE 4(b)

Array Station	Onset, h min s	O - C, s	Amplitude, mμ	Period T, s	Magnitude, m_b
YKA	15 35 28.9	- 1.4	Overloaded	0.6	-
EKA	15 41 21.7	- 3.0	14	0.65	5.23

O = observed onset time C = computed onset time

TABLE 5(a)

Code Name		HALFBEAK (See reference [2])
Date		30th June 1966
Origin time		22 15 00.07 GMT
Site	Latitude	37° 18' 56.9" N
	Longitude	116° 17' 56.3" W
Depth, relative to ground zero		2688 ft (819 m)
Geological medium		Rhyolite
Yield		300 kton

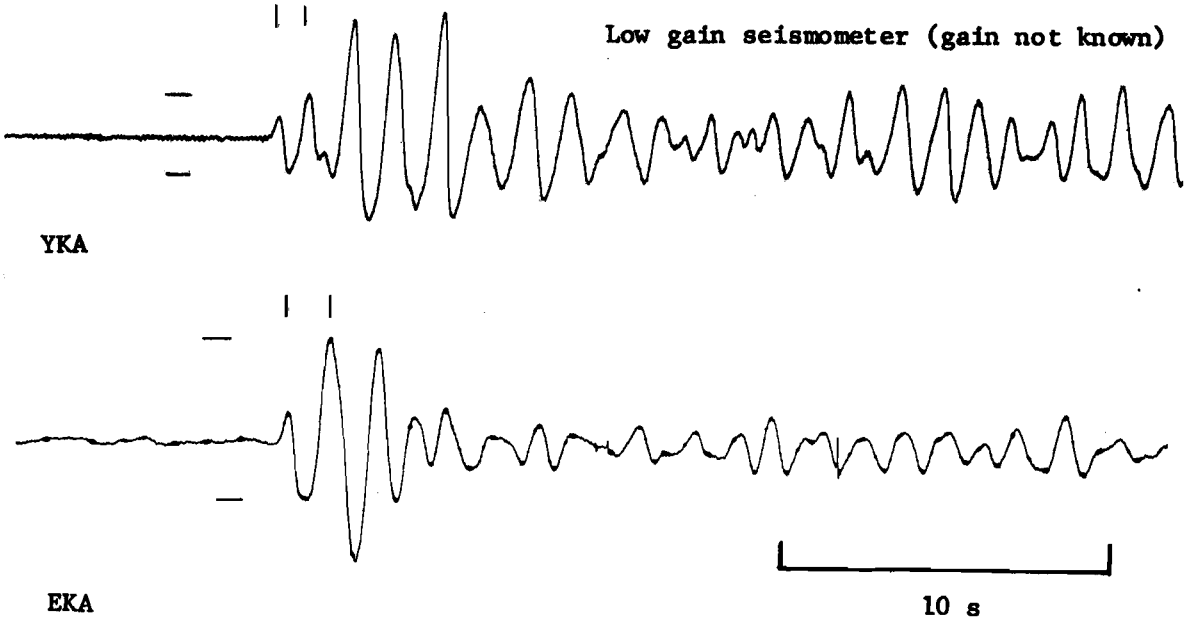


FIGURE 5

TABLE 5(b)

Array Station	Onset, h min s	O - C, s	Amplitude, mμ	Period T, s	Magnitude, m_b
YKA	22 20 27.0	- 2.8	Overloaded	0.85	-
EKA	22 26 21.9	- 2.8	96	1.15	5.82

O = observed onset time C = computed onset time

TABLE 6(a)

Code Name		GREELEY (See reference [2])
Date		20th December 1966
Origin time		15 30 00.08 GMT
Site	Latitude Longitude	37° 18' 07.4" N 116° 24' 29.9" W
Depth, relative to ground zero		3985 ft (1215 m)
Geological medium		Tuff
Yield		825 kton

FIGURE 6

TABLE 6(b)

Array Station	Onset, h min s	O - C, s	Amplitude, mμ	Period T, s	Magnitude, m_b
YKA	15 35 26.7	- 3.1	Overloaded	0.9	-
EKA	15 41 21.8	- 3.0	178	1.3	6.03

O = observed onset time C = computed onset time

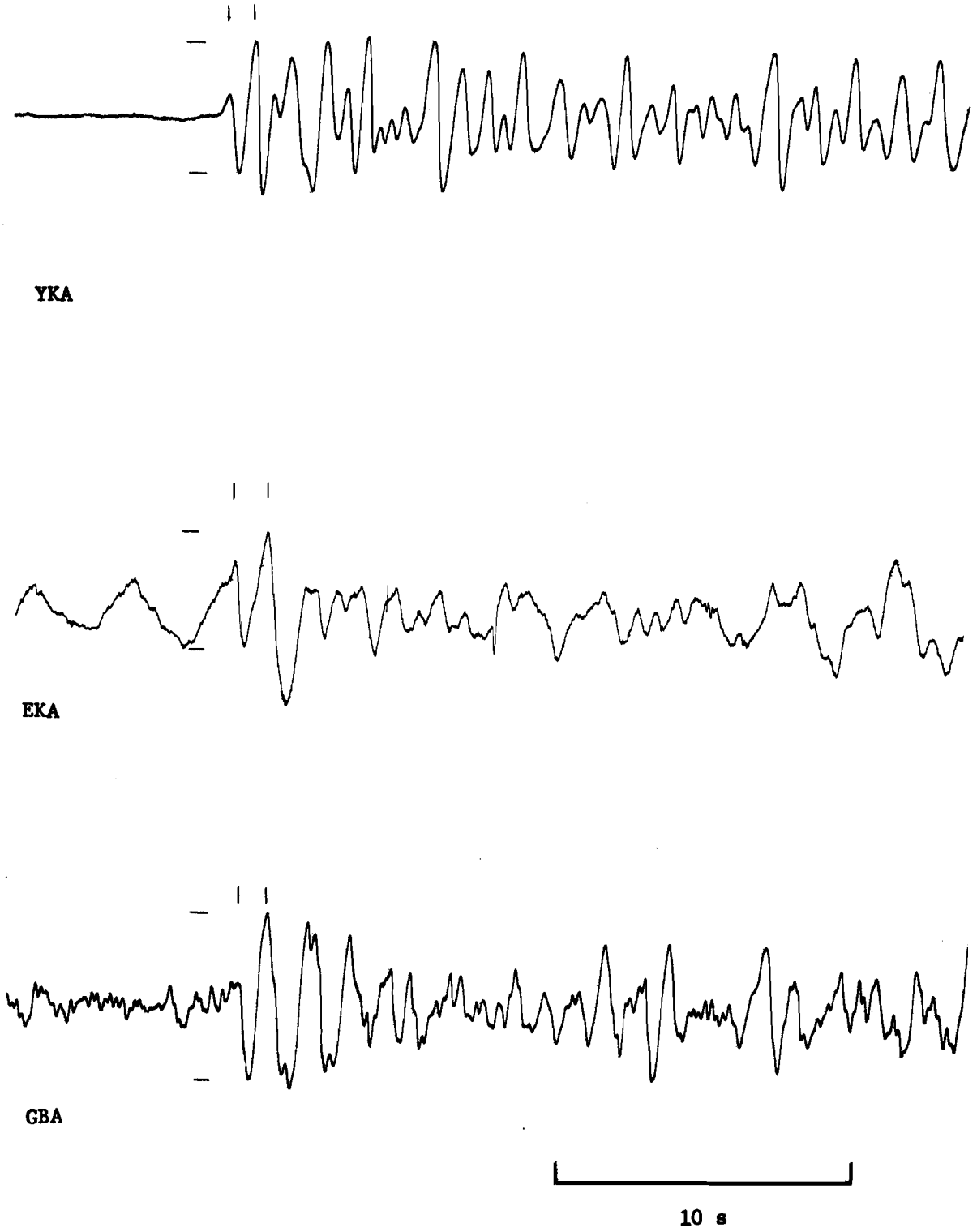


FIGURE 7

TABLE 7(a)

Code Name		SCOTCH (See reference [2])
Date		23rd May 1967
Origin time		14 00 00.04 GMT
Site	Latitude	37° 16' 30.3" N
	Longitude	116° 22' 11.9" W
Depth, relative to ground zero		3207 ft (977 m)
Geological medium		Tuff
Yield		150 kton

TABLE 7(b)

Array Station	Onset, h min s	O - C, s	Amplitude, mμ	Period T, s	Magnitude, m_b
YKA	14 05 27.1	- 2.9	60	0.90	5.28
EKA	14 11 22.3	- 2.6	31	1.10	5.35
GBA	14 19 07.3	- 0.7	10	1.00	-

O = observed onset time C = computed onset time

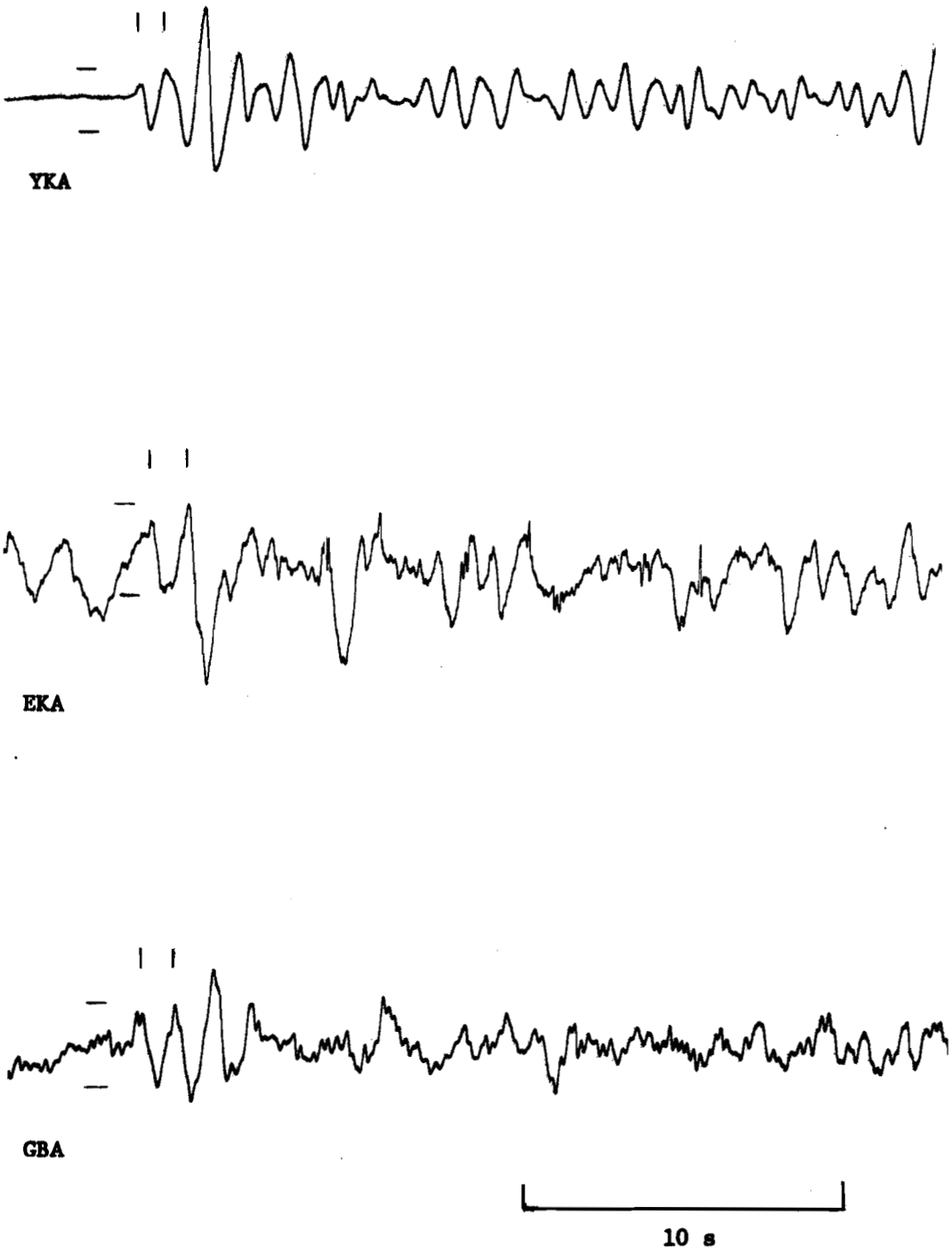


FIGURE 8

TABLE 8(a)

Code Name		KNICKERBOCKER (See reference [2])
Date		26th May 1967
Origin time		15 00 01.50 GMT
Site	Latitude Longitude	37° 14' 52.6" N 116° 28' 48.6" W
Depth, relative to ground zero		2069 ft (631 m)
Geological medium		Rhyolite
Yield		71 kton

TABLE 8(b)

Array Station	Onset, h min s	O - C, s	Amplitude, mμ	Period T, s	Magnitude, m_b
YKA	15 05 28.9	- 1.8	15	0.8	4.74
EKA	15 11 24.0	- 2.7	10	1.1	4.84
GBA	15 19 08.4	- 1.1	6	1.1	-

O = observed onset time C = computed onset time

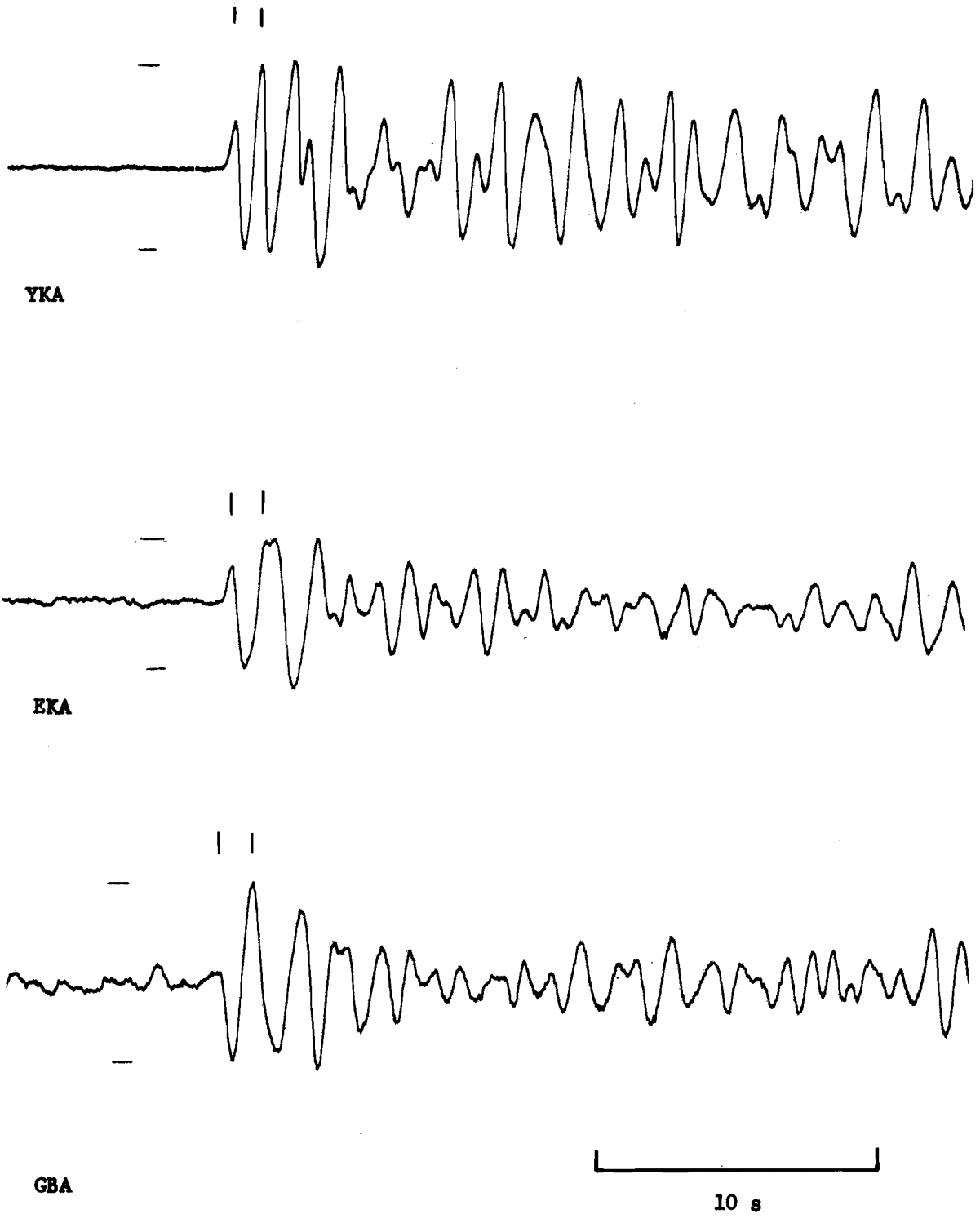


FIGURE 9

TABLE 9(a)

Code Name		BOXCAR (See reference [2])
Date		26th April 1968
Origin time		15 00 00.00 GMT
Site	Latitude Longitude	37° 17' 43.5" N 116° 27' 20.5" W
Depth, relative to ground zero		3800 ft (1158 m)
Geological medium		Rhyolite
Yield		1.2 Mton

TABLE 9(b)

Array Station	Onset, h min s	O - C, s	Amplitude, mμ	Period T, s	Magnitude, m_b
YKA	15 05 27.2	- 2.6	79	0.90	5.40
EKA	15 11 22.1	- 2.7	120	1.15	5.92
GBA	15 19 07.6	- 0.2	57	1.10	-

O = observed onset time C = computed onset time

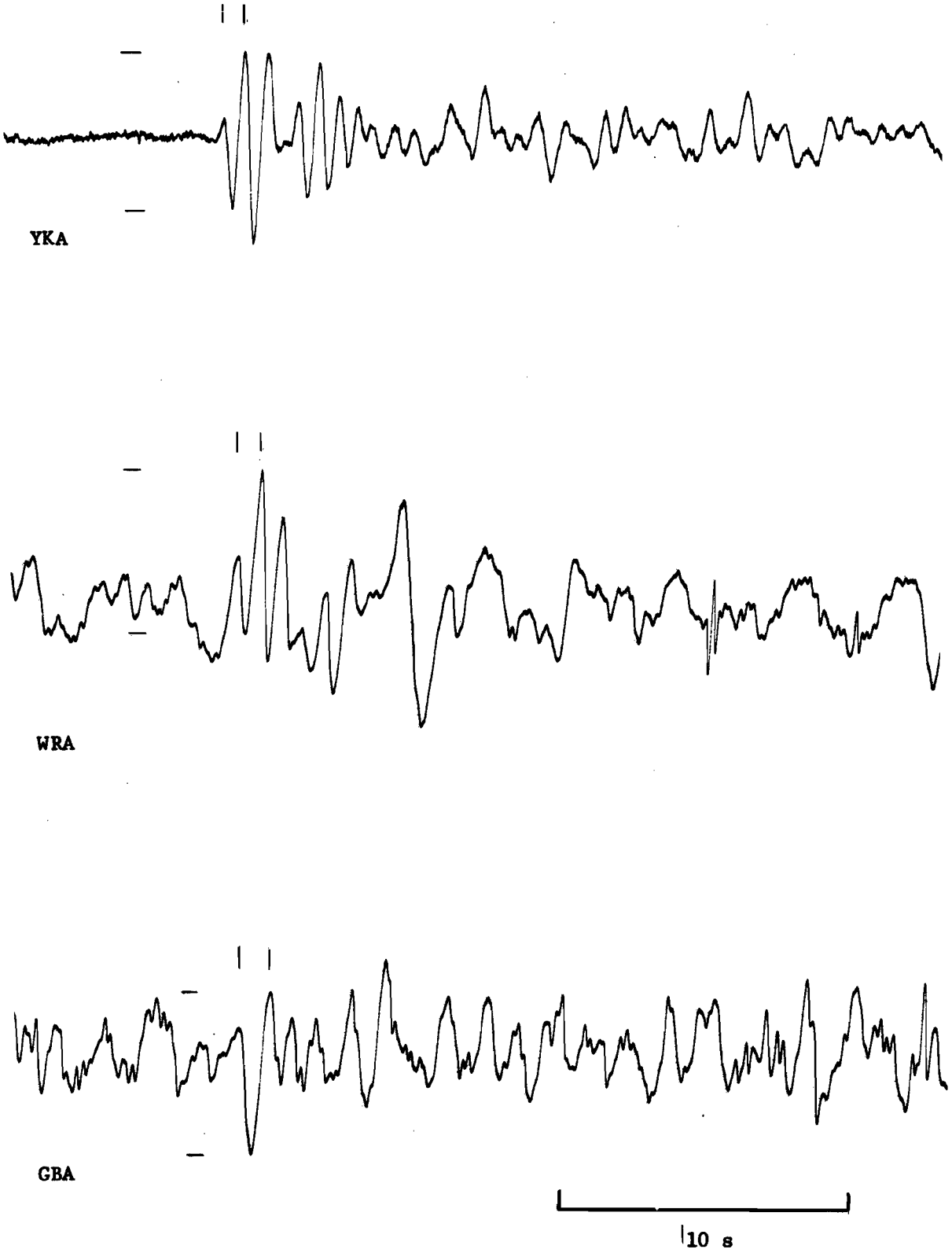


FIGURE 10

TABLE 10(a)

Code Name		SCHOONER (See reference [2])
Date		8th December 1968
Origin time		16 00 00.14 GMT
Site	Latitude Longitude	37° 20' 36.3" N 116° 33' 57.1" W
Depth, relative to ground zero		350 ft (107 m)
Geological medium		Tuff
Yield		35 kton

TABLE 10(b)

Array Station	Onset, h min s	O - C, s	Amplitude, mμ	Period T, s	Magnitude, m_b
YKA	16 05 27.4	- 3.3	13	0.70	4.72
EKA	Not seen	-	-	-	-
WRA	16 18 46.8	- 0.2	3	0.80	-
GBA	16 19 08.1	- 0.5	3	1.00	-

O = observed onset time C = computed onset time

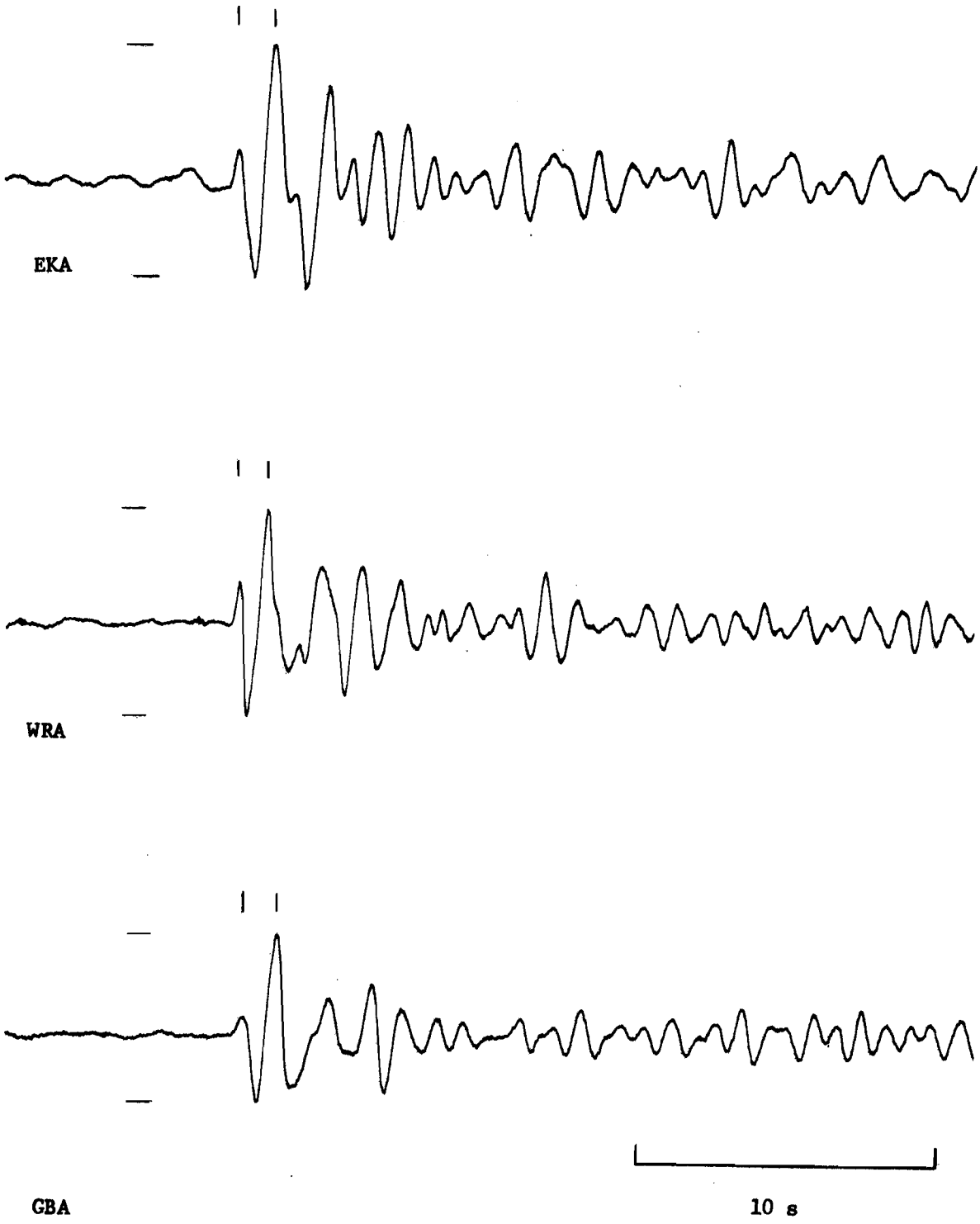


FIGURE 11

TABLE 11(a)

Code Name		BENHAM (See reference [2])
Date		19th December 1968
Origin time		16 30 00.04 GMT
Site	Latitude Longitude	37° 17' 53.3" N 116° 28' 24.9" W
Depth, relative to ground zero		4600 ft (1402 m)
Geological medium		Tuff
Yield		1.1 Mton

TABLE 11(b)

Array Station	Onset, h min s	O - C, s	Amplitude, mμ	Period T, s	Magnitude, m_b
YKA	16 35 28.4	- 1.9	Overloaded	0.95	-
EKA	16 41 22.4	- 2.8	205	1.10	6.17
WRA	16 48 46.0	- 0.8	66	0.90	-
GBA	16 49 06.8	- 1.2	72	0.95	-

O = observed onset time C = computed onset time

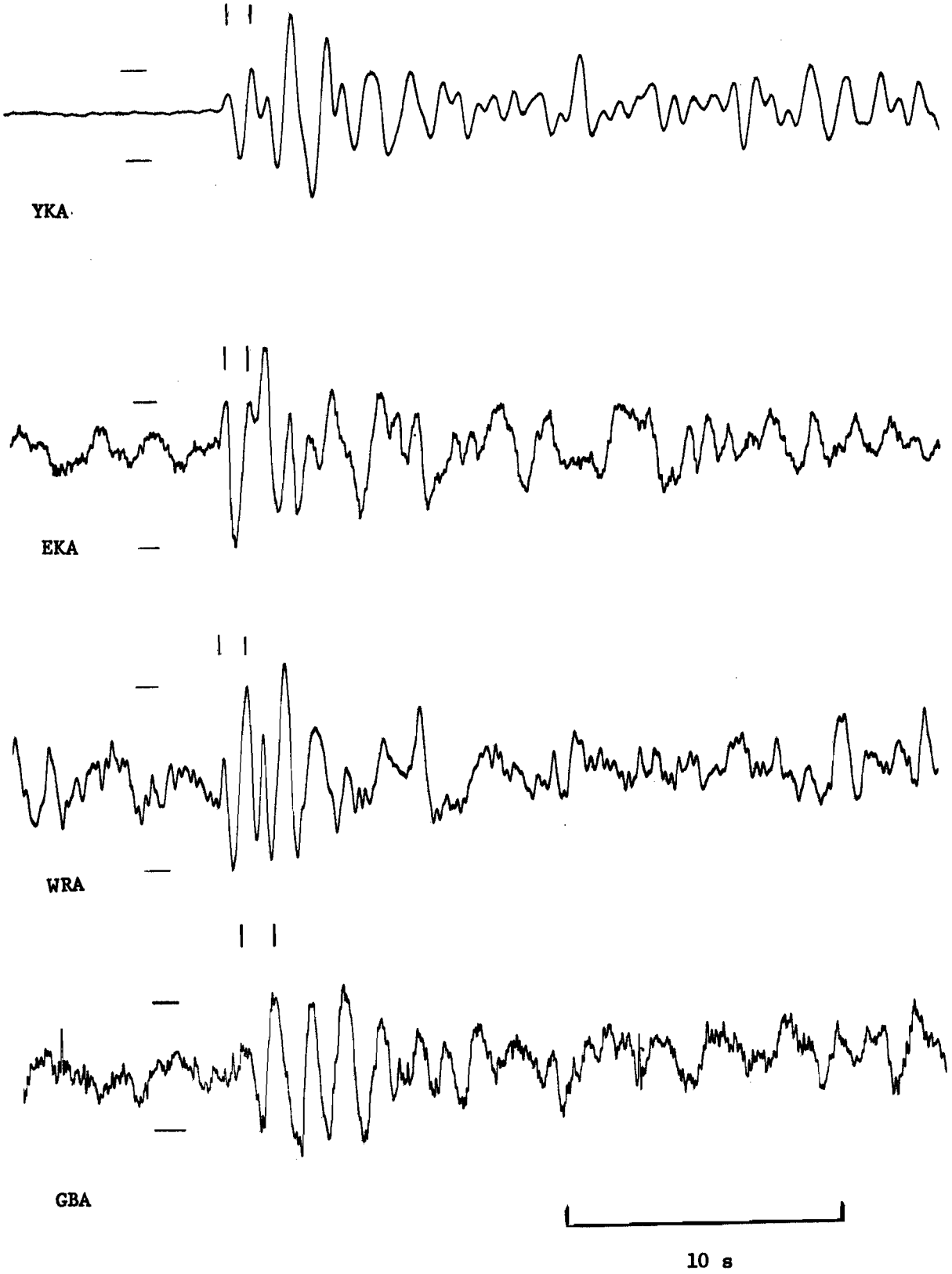


FIGURE 12

TABLE 12(a)

Code Name		MINIATA (See reference [3])
Date		8th July 1971
Origin time		14 00 00.1 GMT
Site	Latitude Longitude	37° 06' 36.4" N 116° 03' 05.1" W
Depth, relative to ground zero		1735 ft (529 m)
Geological medium		
Yield		∿ 80 kton

TABLE 12(b)

Array Station	Onset, h min s	O - C, s	Amplitude, mμ	Period T, s	Magnitude, m_b
YKA	14 05 28.6	- 2.0	37	0.85	5.09
EKA	14 11 22.5	- 2.3	11	0.90	4.97
WRA	14 18 46.7	- 0.5	6	0.80	-
GBA	14 19 07.3	- 1.0	5	1.00	-

O = observed onset time C = computed onset time.

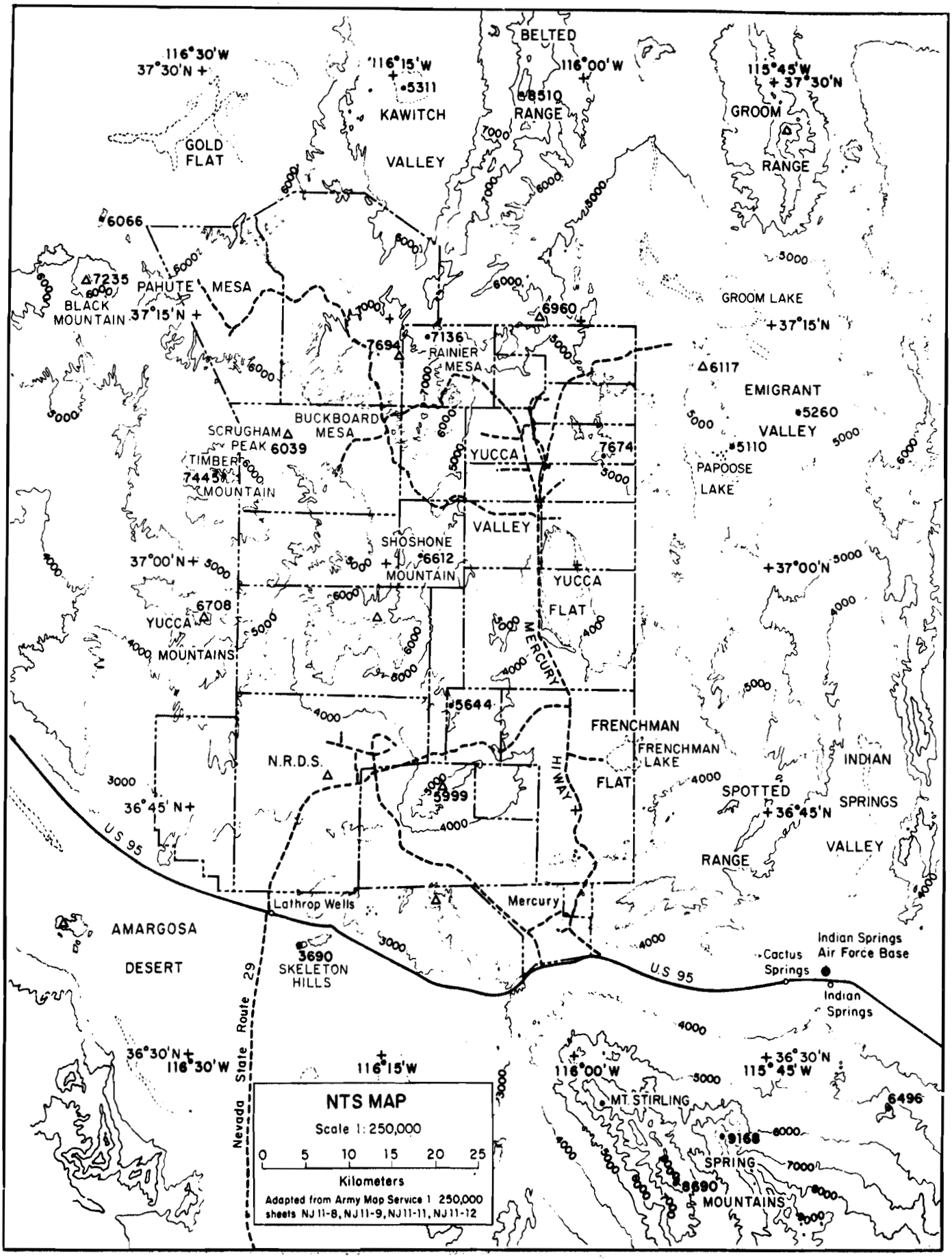


FIGURE 13. MAP OF THE NEVADA TEST SITE SHOWING THE TEST AREAS

(Reproduced from reference [2], figure 1)

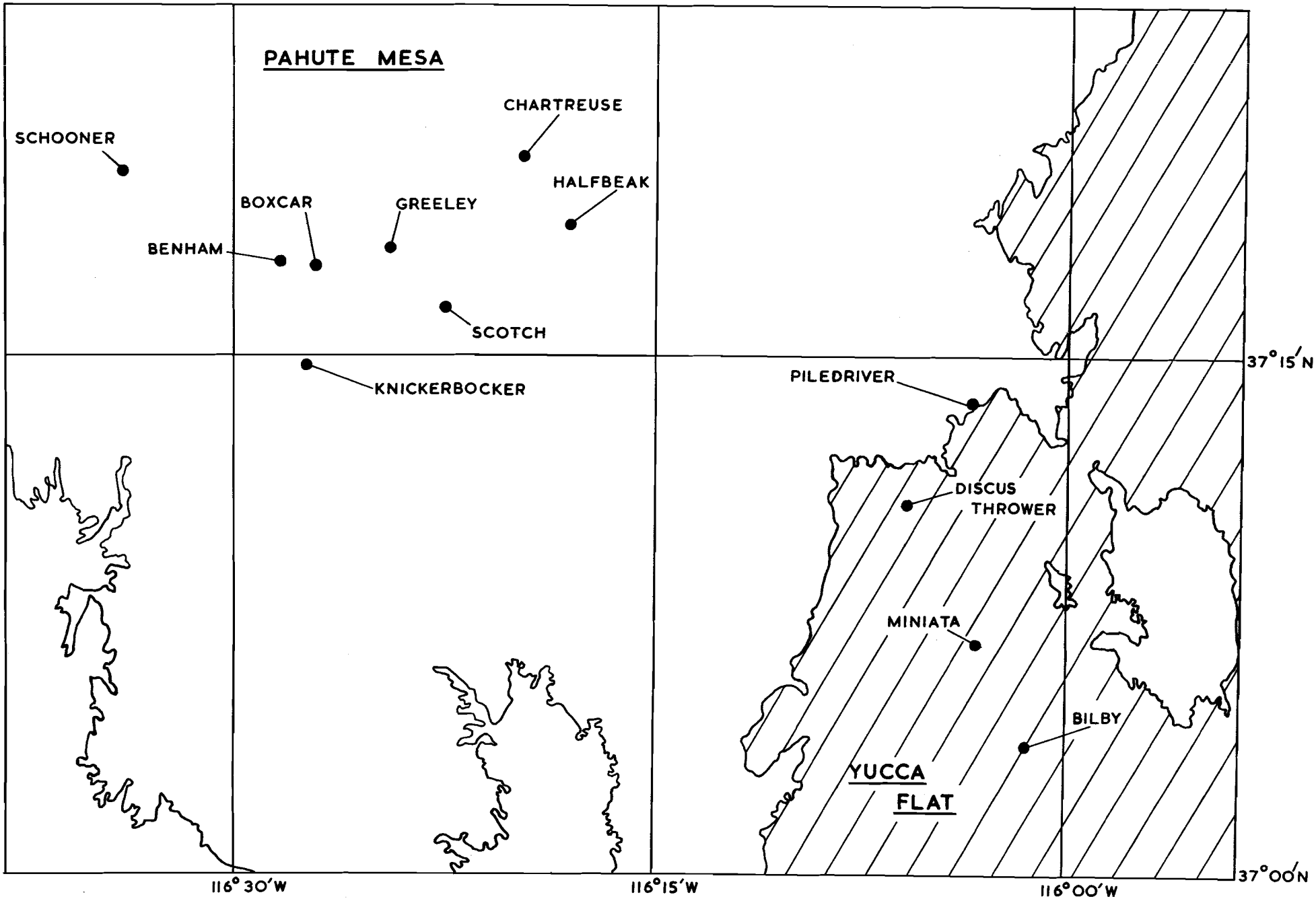


FIGURE 14. LOCATION OF THE 12 EVENTS

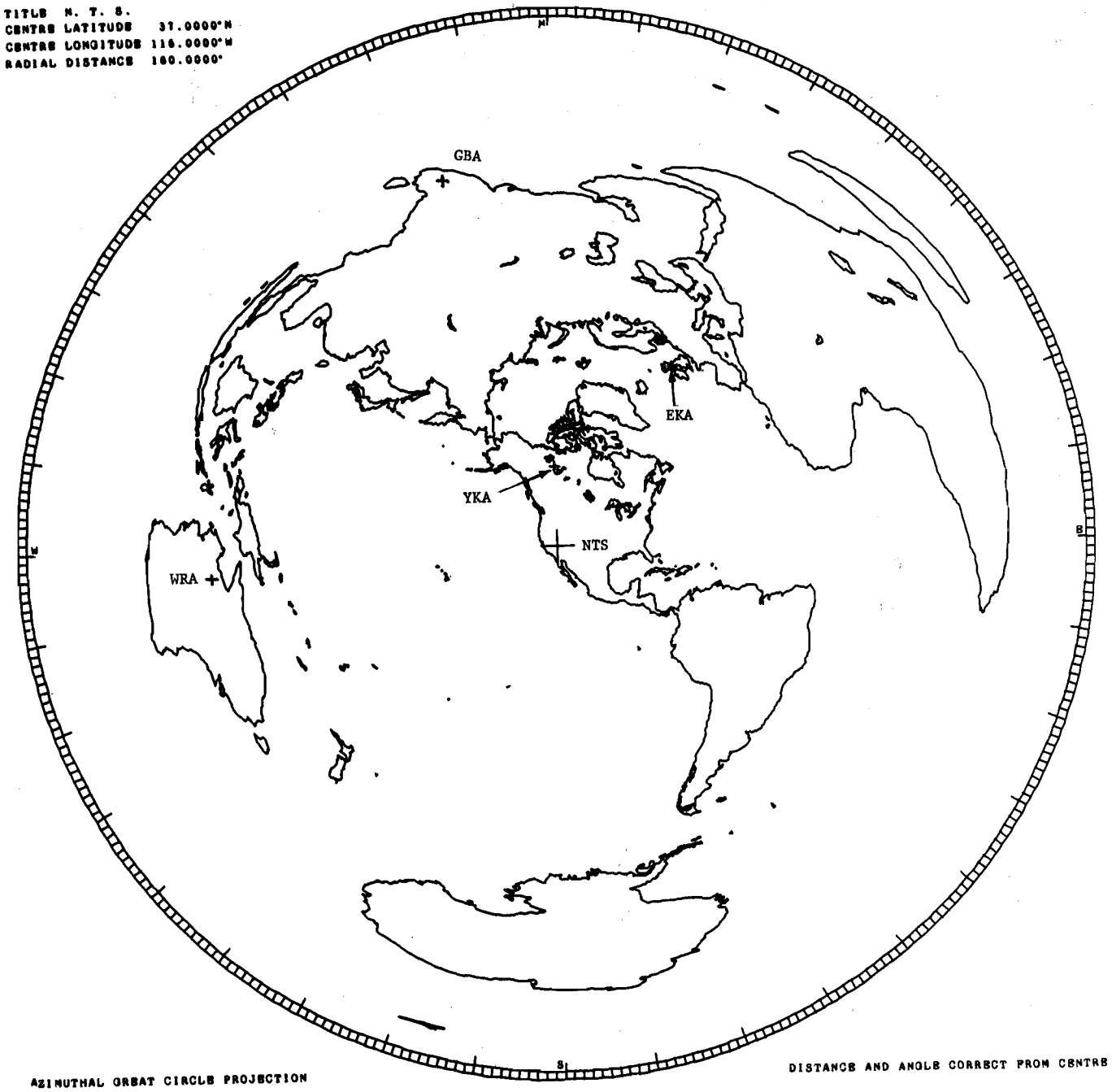


FIGURE 15. EQUIDISTANT AZIMUTHAL PROJECTION CENTRED ON NTS SHOWING THE POSITIONS OF THE 4 ARRAYS

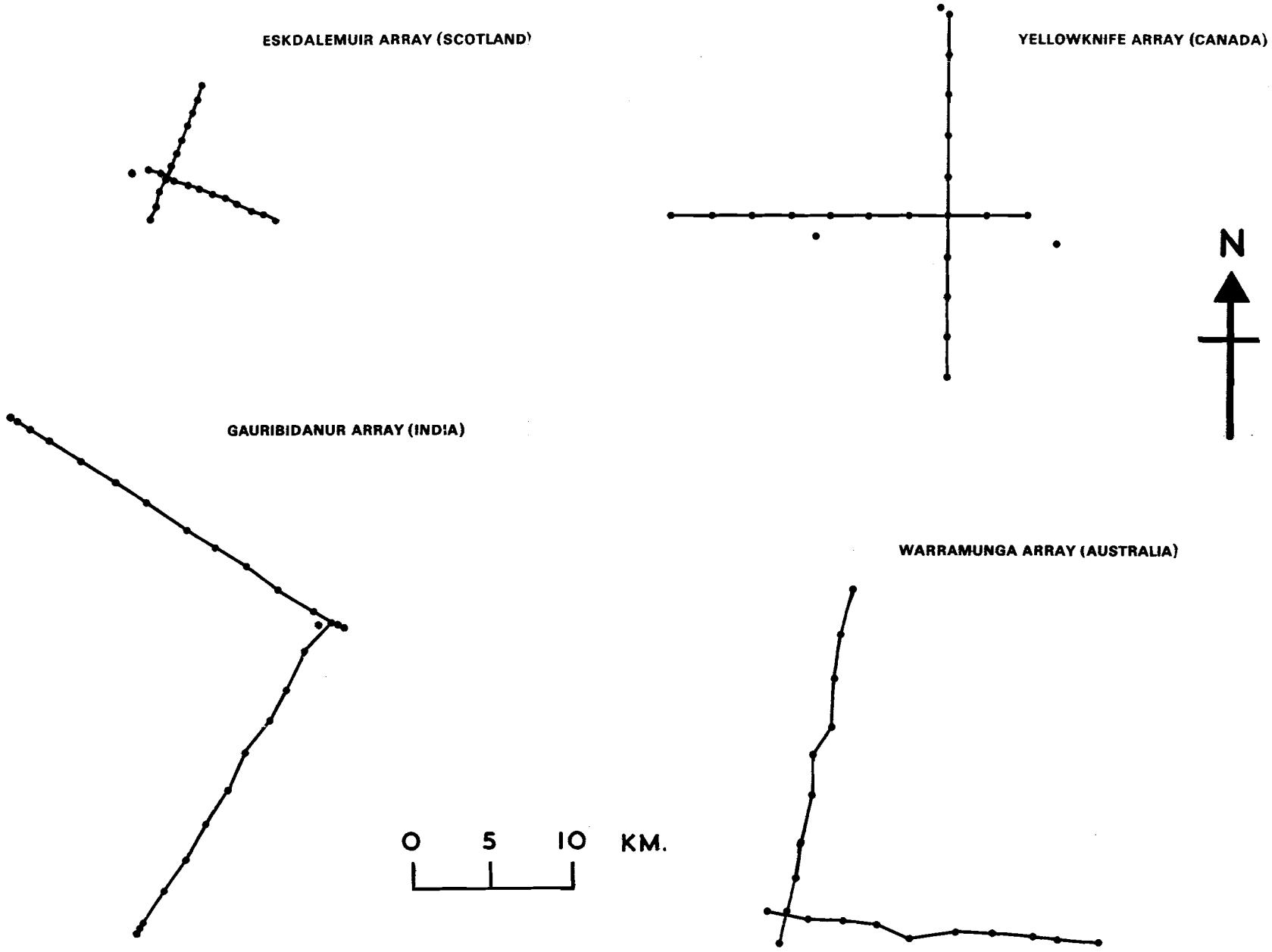


FIGURE 16. THE 4 ARRAYS SHOWING ORIENTATION AND RELATIVE SIZE