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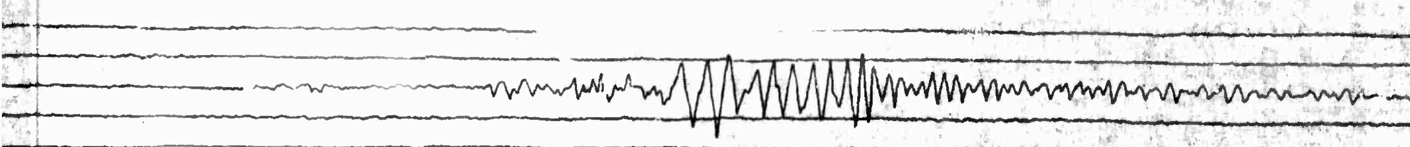

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FINAL SCIENTIFIC REPORT

DETECTION SEISMOLOGY
- A SUMMARY -

by

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UNIVERSITY OF BERGEN

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13. ABSTRACT

This report gives a review of the work conducted and the scientific reports submitted under the EOAR Contract No. F61052-68-C-0019, "Detection Seismology."

The research group at the Seismological Observatory, University of Bergen, concentrated on: Noise and signal coherence study, the study of the crustal effect on the subarray signal, and the study of long period data.

Within this wide frame, this group looked into problems relevant to detection seismology and related topics and made extended use of digital data from the NORSAR array. While for the first two fields the data actually recorded by the NORSAR installation was used, the NORSAR long period data was not available before the expiring date of this contract. Consequently the long period data base has consisted partly of seismograms from the Norwegian Standard Stations and partly of LASA data.

INTRODUCTION

This Report gives a review of the work conducted and the scientific reports submitted under the EOAR Contract No. F61052-68-C-0019, "Detection Seismology".

The research group at the Seismological Observatory, University of Bergen, was established according to the first research proposal, dated August 16, 1967. As stated there, the work was intended to be concentrated on the following problems:

1. Noise and signal coherence study.
2. Study of the crustal effect on the subarray signal.
3. Study of long period data.

Within this wide frame, one wanted to look into problems relevant to detection seismology and related topics. It was intended to make extended use of digital data from the NORSAR array.

While for the first two fields we have made use of data actually recorded by the NORSAR installation, it soon became clear that very few NORSAR long period data would be available until after the expiring date of this contract. Consequently the long period data base has consisted partly of seismograms from the Norwegian Standard Stations and partly of LASA data.

SCIENTIFIC REPORTS

With the starting intention as quoted and the data situation as described in the preceding section, the research conducted under this Contract has led to papers in three specific fields of seismology:

1. Mapping of the noise field in the NORSAR area.
2. Study of the crustal structure in and around the NORSAR area.
3. Long period discriminants and enhancement of surface waves.

Abstracts of the 7 Scientific Reports and the one Journal article submitted under this Contract are given below in chronological order:

1. RYGG, E., H. BUNGUM and L. BRULAND.
Spectral Analysis and Statistical Properties of Microseisms at NORSAR.
Seismological Observatory, Univ. of Bergen, 1969.

ABSTRACT.

Below 0.7 cps the seismic noise recorded by the short period seismometers at NORSAR (Norwegian Seismic Array) is generally dominated by sources in the Atlantic and on the Norwegian coast.

When strong low pressure areas are observed outside the coast, the noise has a dominating direction of propagation from the low, and a velocity generally in the range 3-4 km/sec.

A low in the Baltic Sea has been found to contribute more to the noise at higher frequencies than the Atlantic sources, its influence extending to lower frequencies as the low moves towards the array.

Strong local winds have been found to have little influence in the microseismic range.

The noise coherence between sensors is sometimes much higher in the direction of dominating noise propagation than in other directions. This seems to happen when the noise level is high and when the lows are close to the coast.

From the distribution of the sample variances it is assumed that the noise is stationary within half-hour intervals used in the noise analysis.

The noise predictability has a maximum during periods with high microseismic activity.

2. SELLEVOLL, M. A. and E. SUNDVOR.
A P_n time-term survey in southeastern Norway.
Seismological Observatory, Univ. of Bergen, 1969.

ABSTRACT.

Chemical explosions with charges ranging from 510 kg to 2200 kg were used in this P_n time-term survey in the South-eastern Norway.

The calculated P_n time-terms are indicating a Moho-depth of about 33-35 km in the northern part of the Oslo Graben system. The Moho-discontinuity beneath the Oslo Graben is elevated compared with the regions on its east and west sides.

3. KANESTRØM, R.
The Dip of Moho under the NORSAR.
Seismological Observatory, Univ. of Bergen, 1969.

ABSTRACT.

Elastic waves from explosions are recorded at NORSAR and used to determine the dip of Moho under the array. From the azimuthal change of apparent P_n velocities the Moho dis-continuity can be represented by a plane dipping 12.6° in a direction N 66°E.

4. BUNGUM, H., L. BRULAND and E. RYGG.
Seismic Noise Structure at the Norwegian Seismic Array.
Seismological Observatory, Univ. of Bergen, 1969.

ABSTRACT.

Power spectral analysis is frequency-wave-number space and coherence studies in lag space have shown that the noise

recorded by the short period 12 sensor Øyer subarray at NORSAR is critically dependent on the weather situation in the North Atlantic Ocean. In addition to the low frequency noise from the west, there is observed 2-second microseisms from the Baltic Sea. Because of the non-isotropic noise, the coherence is usually strongly azimuthal dependent being represented in lag space by ellipses. Time variations of the coherence by a factor of 5 are easily observed.

5. KANESTRØM, R. and K. HAUGLAND.
   Crustal Structure in Southeastern Norway from Seismic Refraction Measurements.
   Seismological Observatory, Univ. of Bergen, 1971.

ABSTRACT.

A seismic refraction profile was carried out in Southeastern Norway in 1969 as a part of the Trans-Scandinavian Seismic Project. The explosions were also recorded at NORSAR. The data suggest a three layered crust with seismic velocities of 6.2, 6.55 and 7.1-7.3 km/sec. The upper mantle velocity of 8.20 km/sec agrees with values found previously in Scandinavia. The mean depths to the discontinuities within the crust were determined to be 17 and 26 km. The depth to the Moho discontinuity varies from about 32 km in the southern part of the profile to 41 km in the central part. Under NORSAR, the depth to Moho varies from 31.5 in the central part to 38 km under the C-ring. A Q value of 575 was obtained for the mantle from P_n waves.

A linear relationship can be observed between the depth of the mantle and the surface elevation and between the depth of the mantle and the Bouguer anomaly. The density contrast between the crust and mantle was determined to be 0.50 g/cm^3.

6. BRULAND, L. and E. RYGG.

Experiments with Chirp Filtering of Surface Waves.
Seismological Observatory, Univ. of Bergen, 1971.

ABSTRACT.

In connection with the application of linear frequency swept chirp filters to dispersed surface wave trains to LASA, Montana, a number of events from the Sino Soviet region have been examined in order to determine the predictability of the time of the maximum filter output. The group velocities thus reached at are compared with the group velocities obtained by an analyst using ordinary dispersion analysis.

On the basis of the scatter in group velocities found, "arrival time windows" for surface waves from various regions are given.

Dispersion analysis has shown that the assumption of a linear frequency variation in surface waves is not always satisfactory. Therefore, we have also allowed for non-linear frequency variation in the chirp filters, and some applications of such filters are demonstrated.

7. RYGG, E.

Long Period Discriminants and Application of Dispersive Filters for SNR Gain.
Seismological Observatory, Univ. of Bergen, 1971.

ABSTRACT.

The effectiveness of the M_s - m_b discriminant at Kongsberg has been investigated by comparing recordings from a number of explosions and earthquakes. Both US and USSR explosions have been used and differences in surface wave exitation have been demonstrated. Also various kinds of long period spectral ratios have been calculated and compared for three different stations, Kongsberg, Kirkenes and Kings Bay.

The dispersive filter function of the earth between two stations has been developed using the bandlimited spectra of the long period recordings. Different ways of applications are suggested. Experiments made with both Love and Rayleigh waves indicate that long period beamforming can be successfully performed provided the simple sensor outputs are modified by filters correcting for the dispersion suffered within the array. Consequently a need for mapping the interiors of (large) arrays in terms of filters like the one mentioned, results.

We also suggest, without further experiments that the path effects between two epicenters can be studied along the same lines.

8. BUNGUM, H., E. RYGG and L. BRULAND.

Short Period Noise Structure at the Norwegian Seismic Array. Bull. Seism. Soc. Am. Vol. 61, No. 2, April 1971.

ABSTRACT.

Power spectral analysis in frequency wavenumber space and coherence studies in lag space have shown that the noise recorded by the short period Øyer subarray at NORSAR is critically dependent on the weather situation in the north Atlantic Ocean. In addition to the low frequency noise from the west, there is observed 2 sec microseisms from the Baltic Sea. Because of the nonisotropic noise, the coherence is usually strongly azimuthal dependent, being represented in lag space by ellipses. Large time variations of the coherence are demonstrated.