NORSAR

ROYAL NORWEGIAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

Scientific Report No. 5-74/75

FINAL TECHNICAL REPORT
NORSAR PHASE 3

1 July 1974 – 30 June 1975

Prepared by
K. A. Berteussen

Kjeller, 8. August 1975

Sponsored by
Advanced Research Projects Agency
ARPA Order No. 2551

R. IN SITU STRESS MONITORING

It has been known for some time now that several narrow spectral peaks in the NORSAR short period recordings have their origin in hydroelectric power plants in the vicinity of the array. The exact nature of the generating mechanism is not known, but it is characteristic that the seismic spectral component is found at the very frequency of the revolving mass, which is typically a few hundred tons. A slight eccentricity in that mass could therefore account for the leaked energy.

The most prominent contribution in this respect is obtained near subarray 14C from the Hunderfossen power plant, which has been found to generate a strong spectral component at 2.78 Hz, corresponding to 166 2/3 rpm. The location of this steady-state energy source together with the closest seismometers is shown in Fig. R.1, where it is seen that the distances range from 4 to 14 km. In the initial analysis of the data it was discovered that the frequency of the desired spectral component was not stable; there were in fact relatively rapid variations within the frequency range 2.774 to 2.781 Hz, so that an extensive Fourier analysis was required just in order to locate the spectral peak. In order to circumvent this problem, and to get a noise-free source channel, a unit was built (at the University of Copenhagen) which uses as input the 50 Hz, 220 v power, and outputs a signal which is divided 18 times in frequency, to 2.78 Hz, and scaled down to a voltage of $\pm$ 4.6 v. This unit has now been hooked on to channel 14C05, thereby replacing the seismic data with a 2.78 Hz sine wave representing the source of the narrow spectral component.

The analysis of the data has so far only been preliminary, involving spectral analysis of consecutive 3- minute intervals over a time span of a few hours. It is noteworthy that the introduction of the source channel reduced the required computer time by almost a factor of 10, since a running estimate of the frequency is now easily available; previously it had to be estimated from the seismic data. Even with very little blocking of data, we have obtained phase estimates for the closest channels (1 and 2) with a stability of about $\pm 1^0$, which corresponds to a precision of about $\pm 10^{-3}$ for the distances involved in this experiment. In order to monitor phase velocities, we have to study phase angle differences, and Fig. R.1 shows that there are a number of

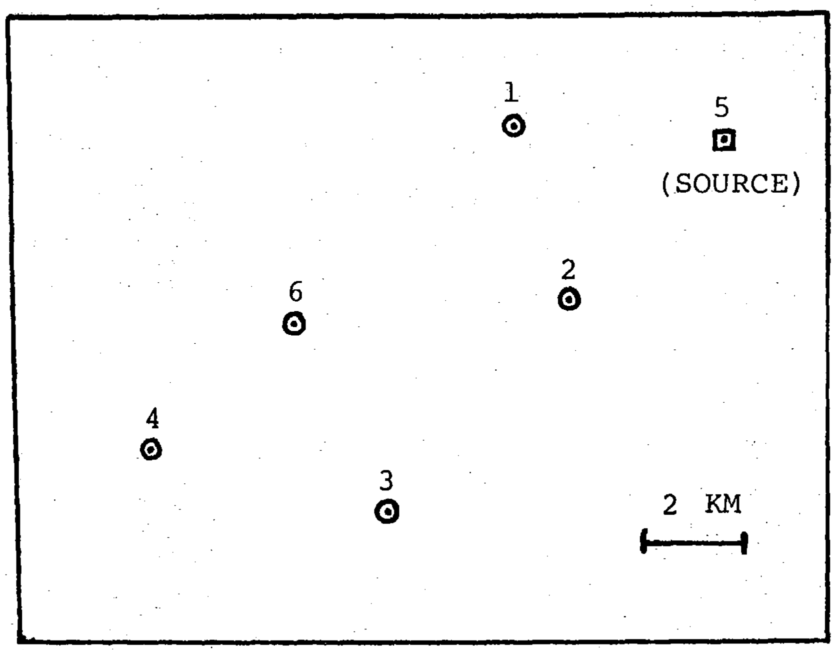

Fig. R.1 The relative locations of the Hunderfossen power plant (source) and the 5 channels currently giving short period seismic data from subarray 14C (circles). Seismometer no. 5, which used to be located in the NW part of the subarray, has been replaced by a sine wave representing the source (see main text).

possible combinations. The most stable results have been obtained using channels 1 and 2 in combination with the source channel (5), even though there is an unknown phase difference between the revolving mass and the generated current, which we use as reference. For the other channels (3 and 6) the loss in signal-to-noise ratio seems to be about compensated for by the increased distance, yielding the same relative stability.

By studying the distribution of the phase velocity differences versus travel distance, it is not possible to find any particular phase velocity which fits all the data well. However, a velocity of about 5 km/s appears to give the best overall fit. Because of the frequency variation of the source we also get an independent estimate of phase differences versus frequency, yielding group velocity, and the few data obtained so far have given estimates around 3 km/s both for combinations 1-5 and 2-5 (see Fig. R.1).

A computer program has now been developed which computes the horizontal tidal strain in any particular direction for the area around subarray 14C. We plan to continue this experiment by looking for possible phase velocity differences for different strain situations. The results obtained so far indicate that by adding much larger amounts of data, it could be possible to obtain phase difference estimates with a precision closer to 10^{-4}.

H. Bungum,
K. Aki (Cambridge, U.S.A.)
T. Risbo (Copenhagen, Denmark)