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DISCUSSIONS ON 10-TON EXPLOSIONS FOR TELESEISMIC OBSERVATIONS

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BACKGROUND

It has long been known (e.g., Bancroft 1966, O'Brien 1967, Jacob 1970) that optimum coupling between an underwater explosion and seismic waves in the ground occurs when the depth of the charge is one quarter of the wavelength of pressure waves in water at the frequency of bubble-pulse oscillation. For a charge of 10 tons of TNT (and for somewhat different masses of other explosives) the resonant depth is about 200 metres, and the resonant period is 0.53 seconds. The fact that this period is close to the optimum for the teleseismic observation of P waves, and that many short-period seismographs have maximum sensitivity for such periods raised the interesting possibility that waves from such comparatively small explosions might be observed at great distances.

A preliminary experiment was carried out in July 1971 by arrangement between the Naval Construction Research Establishment (NCRE) of Rosyth and the Global Seismology Unit of the Institute of Geological Sciences, whereby a 10-ton shot was fired under optimum coupling conditions in the "Devil's Hole" in the North Sea (Jacob and Willmore, 1972). A further refinement was to fire the shot at a total depth of 210 metres of water, the 10-metre stand-off being introduced to reduce energy loss through shattering of the bottom, and to produce more stable resonant conditions.

The degree of success of the experiment (which yielded data from at least 7 stations between 50 and 90°, and a probable observation from Brisbane at 144.7°) was sufficient to lead

to the establishment of a Working Group of the IASPEI in August 1971. Following its first meeting at the General Assembly in Moscow, it was agreed to hold a second meeting on the occasion of the NORSAR Symposium. The working session on this occasion was attended by 7 of the official members of the Working Group or their nominated alternates, and by a number of other interested participants.

DISCUSSIONS IN OSLO

The Working Group drew the following conclusions from the results of the pilot experiment:

a) 10-ton shots, fired under the prescribed conditions, could yield clear P wave onsets on closely-filtered, high-performance seismographs at distances at least as great as 90°. Long-range records were obtainable in favourable locations by conventional equipment (e.g., Brisbane, $\Delta = 144.7^{\circ}$) but onsets were generally close to the noise threshold. The result was to be expected from the apparent body wave magnitude ($m_b = 4.38 \pm 0.40$).

b) The firing conditions appropriate to the 10-ton shot (200 metres below the surface in 210 metres of water) were evidently very close to optimum, and should be adhered to in any future experiments. Charges large enough to produce significantly higher signal levels would be highly unwieldy in open-sea conditions. Charges in the range of 2-5 tons would be useful for regional pilot studies, but could not be expected to yield world-wide observations.

c) The logistics of a world-wide operation would depend largely on the length of time for which temporary field stations could be maintained in uninterrupted operation. Equipment operating continuously would minimise the problems. Equipment with an uninterrupted running time of as little as 1 hour could be used, but this would require shots to be fired within prearranged periods of the order of half an hour.

As the British pilot operation had required about 6 hours of shot preparation and recovery, and as ships might be reluctant to stand by for long periods when the charges had been positioned, it would seem that unrehearsed crews might have considerable difficulties in holding to the schedules imposed by short-run recording equipment.

d) In spite of the inherent difficulties of the project, the Working Group recognised the great potential value of observations from a set of standardised and controlled seismic sources distributed around the seismically active regions of the world. Considerable further benefit would be derived from the fact that, if temporary installations could be sustained in operation for a few months, covering a series of explosions, an unprecedented opportunity would arise for studying the detectability, source mechanism and travel-time patterns of natural events, using the explosions as calibrating points.

e) The members of the Working Group were aware of several field operations during the period June - September 1972, in which suitable recording stations were being deployed. It was thought that two or three potential shooting organisations might provide explosions during this period, but others would require longer notice to set up funds, or to organise pilot studies, which might lead to further experiments in 1973 or 1974.

f) The International Seismological Centre should be approached with a view to applying its normal group and location programmes to the preliminary readings obtained from the proposed operations. The entire suite of records (many of them probably on non-interchangeable magnetic tapes could provide material for numerous parallel research studies, and it was hoped that recording organisations would accept the responsibility of generating appropriate playouts on request.

In view of the above conclusions, the Convenor was authorised to approach organisations with possible shot-firing and recording

capabilities within the above-mentioned time intervals, and agreed to circulate a report on the results of this correspondence by the end of February 1972.

FURTHER PROGRESS

By March 1972, the Working Group was able to report the following progress:

a) An investigation commissioned by the Institute of Geological Science had confirmed that redesign of the explosive container could substantially reduce weight and cost, and the details were being made available to prospective shooting agencies.

b) Discussion of potential hazards had covered the possibilities of damage to fisheries, the generation of tsunamis or turbidity currents, and the triggering of earthquakes. The conclusion was that the risks would be fairly low in any case, and could be reduced to negligible levels by proper attention to shot location and details of firing procedures.

c) Operations in 1972 were likely to include at least two shots, one of which is anticipated about the middle of June in the Western Isles of Scotland, and the other in July off Kangaroo Island in Southern Australia.

d) An attempt would be made to fire towards the beginning of a specified 40-minute period, with a preannounced schedule of alternative times to cover the possibility of failure or postponement of a first attempt. By these means short-run portable equipment could be used. Registration forms, which would enable prospective field parties to be kept informed of the progress of shooting, were available from IGS Edinburgh.

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