COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1969 / 113

Echo-Sounding and Facies Delineation

by

H.A. Jones

ECHO-SOUNDING AND FACIES DELINEATION

by

H.A. Jones

Record 1969/113

CONTENTS

ECHO-SOUNDING AND FACIES DELINEATION

by

H.A. Jones

SUMMARY

A close study of 1500 miles of fathometer records obtained with a standard Marconi "Fishgraph" 24 Kc/sec echo-sounder from the north-west Australian continental shelf and upper continental slope has shown that the density of the botton-echo trace can to a limited extent be used to interpret the nature of the material forming the sea floor. However, variations in density of the trace closely related to small (11-metre) changes in water depths is a dominant feature of these records and usually obscures the variations caused by differences in bottom sediment lithology. The regular, depth-controlled variations in density of the trace must be caused by interference and this implies that the effective angle of the sound beam producing bottom echos must closely and accurately approximate to 8.5^{o} or to a whole number multiple of 8.5^{o}. This feature of a standard wide-beam echo-sounder is unexpected, may be of wide application, and should be borne in mind by those attempting to delineate facies from fathometer records.

INTRODUCTION

Marine geologists have long recognized that some information on the nature of the material forming the sea floor can be deduced from the records of standard high-frequency navigational or fish-finding echo-sounders. However it has also been appreciated that factors other than the lithology of the bottom sediments or the presence of rock outcrops affect the quality of the bottom-echo trace on the record. The problem has been reviewed, for example, by Taylor Smith & Li (1966) who stress the importance of sediment porosity and other properties which, together with echo-sounder frequency, determine the density of the trace on the record. There are, of course, other variables introduced by the echo-sounding equipment itself, such as stylus wear and power supply fluctuations, which require consideration.

ECHO-SOUNDER RECORDS

During a survey by the Bureau of Mineral Resources in 1968 of the sediments, morphology, and structure of an area of continental shelf off north-western Australia, about 1500 miles of echo-sounding records were obtained with a standard Marconi "Fishgraph" echo-sounder operating at 24 Kc/sec. Examination of the traces and comparison with bottom samples recovered confirmed that the quality of the bottom-echo trace on the records was, to a linited extent, influenced by the nature of the bottom. Rock outcrops, which consisted of coral reef structures or cemented carbonate detritus in this area, tended to produce a thin but sharp trace, as did also clean-washed sands. Muddy sediments, however, produced a thicker, somewhat fuzzy trace. This correlation between the type of trace and the nature of the bottom was not sufficiently clear cut to be of significant value in facies delineation, and to a large extent was obscured by another factor which is the primary subject of this communication.

Detailed study of the echo-sounder records has revealed that many of them show a consistent and close relationship between the thickness and density of the bottom-echo trace and the depth of water under the transducer. The West Australian continental shelf in the region of 19°S, where this work was carried out, is almost flat over wide areas with a slope seawards of well under 10 feet to the mile. Beyond the shelf edge break in slope, at about 100 metres depth, the gradient steepens but rarely exceeds 100 feet to the mile down to 400 metres depth. Minor irregularities, such as ripple marks, are generally absent. The fathometer records made during traverses across this flat and featureless shelf and slope often show bottom-echo traces which increase and decrease in thickness and density as the water depth changes. The cycle is repeated once for every 10 to 12 metres difference in depth, and no clear relation between the type of surface sediment and the difference in trace density is apparent. It would be tempting to postulate that some penetration of the bottom was achieved and that the difference in amplitude of the reflected signal is due to differences in the lithology of the sub-bottom sediments undetected by surface sampling. Such rythmic alternation of sub-bottom lithology might represent minor still-stands during the post-Pleistocene transgression, or zones of sandy and muddy sediment related to post-submergence deposition, now covered by a thin skin of Recent sediment. However, the existence of these features on the fathometer records down to at least 350 metres water depth, the very regular 11-metre interval between cycles, and their persistence across varying bottom lithologies and across irregular terrain in submerged reef areas, all argue against this hypothesis and together must preclude its possibility.

The close correlation between water depth and the variations in trace density rules out the influence of variables introduced by the performance of the echo-sounding equipment itself as a possible cause. Since the character of the reflecting surface has also been excluded, it follows that interference phenomena must be responsible, and this requires a transmitted sound energy configuration unexpected in a wide-beam transducer.

Sound at the low ultrasonic frequency of 24 Kc/sec has a wavelength of about 6 cm in sea water. The vertical-path echo from a near-horizontal reflector will differ in phase from echos travelling at an angle to the vertical which have travelled a longer distance. At a certain angle in a given depth of water, and at whole number multiples of that angle, the phase difference must approximate to the wavelength and the amplitude of the signal received will be increased. At intermediate angles, of course, destructive interference correspondingly reduces the amplitude of the signal; the net result, where the sonic energy is transmitted evenly through a wide-angle cone, is a signal of constant amplitude. In the present instance constructive interference appears on the echo-sounder records at vertical intervals of 11 metres and grades into a much weaker signal at the intermediate depths. Calculation shows that a phase difference of 6 cm in a vertical distance of 11 metres (22 metres two-way distance) occurs between vertical-path sound and sound travelling at an angle of 4.25° from the vertical. Theoretically therefore, at a constant energy output, a narrow-beam sound pulse of cone angle 8.5° should give a stronger echo of a flat bottom in water depths of 11 metres and multiples of 11 metres than in water of intermediate depths. Cone angles of 17°, 25.5° etc. would produce a similar, but less strongly marked interference pattern.

It is concluded that with the echo-sounder configuration used the bottom-echo trace effectively records signals reflected from sound transmitted in a cone of 8.5° angle (or 17° etc.); furthermore that this cone angle defines to a remarkably accurate degree the area of the sea bed contributing effective echos. The writer can give no explanation as to why this sharp cut-off in reflected sound occurs, and appreciates that the explanation of the observed features offered in terms of acoustics is superficial and ignores many complexities. However there seems to be no way to account for the regular variations in bottom-echo trace density except by interference phenomena, and it is difficult to construct a theory to explain these phenomena in terms other than those suggested above.

ACKNOWLEDGEMENT

Mr. A.J. Barlow of the Bureau of Mineral Resources examined the fathometer records and suggested interference mechanism as a possible cause of trace density variation.

REFERENCE

TAYLOR SMITH, D., & LI, W.N., 1966 - Echo-sounding and sea-floor sediments *Marine Geol*. 4, 353-364.