IN-SEAM SEISMIC METHODS: A REVIEW

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Seismic reflection methods sample targets *remotely* from the vicinity of the ground surface. This, as much as the dimensions and physical properties of the target itself, imposes limitations on the resolution attainable. The coal mining industry has evinced a need for structural information on a scale smaller than is routinely attainable in reflection profiling, and at a range beyond the penetration of ground probing radar. Seismic waves generated and detected *within* a seam can in principle be used to delineate putative targets (faults, seam-splits, wash-outs, intrusions, and so on) of dimensions less than a seam thickness at a range (from a working face, say) or at least a few tens of metres. Dispersive channel waves of both Rayleigh and Lowe type are potentially most suitable for in-seam mapping (Krey, *Geophysics,* 1963). Notwithstanding the intuitive simplicity of so-called in-seam methods, practical implementations have proved elusive, as evidenced by intensive research projects in Germany, Britain, Czechoslovakia, the U.S.A., and recently Australia. To date, mathematical modelling and two-dimensional analogue scale modelling have both revealed characteristics of the generation and propogation of channel waves which bear importantly on the potential exploitation of these waves. In particular, Dresen and co-workers at the University of Bochum have shown how distinct Rayleigh-type wave groups arise from the interplay between source resonance effects and the propagation path transfer function. These and other important results from model studies underpin both the technical specification of in-seam systems, and the processing and interpretation of in-seam data. The published literature on in-seam methods is sparse, particularly with regard to technical specifications of high frequency sources and detectors suitable for safe operation in mines, or for operation in boreholes. The present paper reports on recent progress in in-seam research overseas.

DEVELOPMENT OF AN ON-LINE PROCESSING SYSTEM FOR SHALLOW MARINE REFLECTION DATA

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Elaborate digital signal processing has been a common component of land and marine seismic surveys for some time. Such processing, however, is not used in all types of exploration. In general, digital processing has been restricted to high cost industries involved in deep surveys such as petroleum exploration. Because of the high cost of computing time and the enormous volume of data collected, it has not been possible until recently to contemplate the application of these digital techniques to data acquired in low cost, shallow marine seismic surveys. Such surveys are widely used for mineral exploration and engineering investigations, either inshore in harbours, lakes or estuaries, or offshore near coastal regions.

Shallow surveys are characterized by low acquisition costs and conventional computer processing costs can rarely be justified even though such surveys are often plagued by well known problems which invariably degrade shallow reflection data. Such problems include siesmic source noise such as bubble oscillation for sparkers, reverberation, pulse distortion surface reflection, water-borne noise and multiple reflections. Source noise, reverberation within the water layer and multiple reflections from the sea floor are particularly serious problems in shallow water reflection surveys.

The recent development of relatively inexpensive microprocessors now makes it possible to implement a low cost, on-line digital signal processing system. Perhaps the most revolutionary development in computer technology in recent years, the microprocessor is a logic device which is able to function, sequentially, as an indefinite variety of logic devices. Coupled to a memory the microporcessor becomes a micro-computer and when used in an on-line configuration the problem of storage of huge data sets is circumvented. An on-line system has the farther advantage in that it allows feed back to the geophysicist so that decisions can be made during the survey and system parameters varied to take account of changing conditions or to emphasise particular features of interest.

Current analog equipment for shallow reflection data comprises an acoustic sparker or boomer source, hydrophone receiver, pre-amplifier, band-pass filters, amplifiers and an electrostatic recorder or profiler producing the seismic reflection section. A digital system replacing or parallelling this rudimentary system must be able to handle a fairly large amount of data in real time intervals and complete processing within a single cycle of operation i.e. between successive source energy emissions. Around 100 db of dynamic range is also required at a sampling rate of about 15 kilo samples/sec. Most microprocessors are not able to meet these requirements unassisted so some form of hardware assistance is necessary. This is actually an advantage, since it allows for other than the usual data representations. The first digital system was realized on the MC6800 microprocessor but this had limitations and a second more sophisticated system based on the LSI 11/23 microporcessor is being developed. Both systems, however, have the same design philosophy.

Hardware assistance to the microprocessor is in four main areas: data conversion, system timing, data input and output and arithmetic manipulation. In the MC 6800 version of the system all input and output is interrupt driven from external devices such as the digital-to-analog converter or the profiler. The overheads associated with interrupting the processor placed severe limitations on the system. To avoid