ENERGY RESOURCES DEMANDS, EXPLORATION AND ENVIRONMENTAL CHALLENGES OF THE 1980'S

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Whether intelligent man likes it or not, the stark facts of history emphasize clearly that most human conflicts arise, develop and escalate out of the competition for natural resources.

At our point in time, competition for the world's dwindling supplies of conventional energy resources, particularly those of oil and gas, squarely head civilization towards intensified intercommunal hostility, with the final probability of global war. Nuclear energy, increasingly via the grossly more energy-efficient "breeder-type" reactors, must offer the more immediate, albeit historically "temporary", solutions. Meanwhile, other more acceptable and basically non-polluting alternatives must be explored and developed. Solar power for lower energy level applications and, eventually, more exotic techniques such as magnetohydrodynamics and nuclear fusion, must provide the hoped-for long-term solutions.

In the interim, and in response particularly to sharply escalated pricing and competition, considerably more oil and gas will ultimately be found and exploited commercially. Similarly, the world's underdeveloped or still unfound, or deeply-buried, coal resource potential remains immense. However, even these are "finite". Against this background, wasteful or unbridled industrial use of fossil fuels must only drain remaining reserves rapidly, and eventually through to exhaustion.

All too soon, coming generations will be deprived completely of Planet Earth's most convenient carbon-based fossil raw materials – ones that should be devoted primarily to petrochemical manufacture and to food production.

Accelerated pollution of the atmosphere via the fossil fuel combustion processes can only lead to greater environmental change, to more human ills and possibly to significant climate change. A threatened warming of the atmosphere via the carbon-dioxide atmospheric "greenhouse" effect, could not only lead to significant biological and ecological upset globally, but also to a dramatic consequential raising of sea level upon excessive melting of polar ice. At worst, coastal cities could be swamped, fisheries modified, subcoastal agriculture wiped out and the world balances of power changed drastically. More hopefully, this greenhouse effect could offset and even reverse the predicted eventual return, in the next few thousand years, of another glacial phase such as has led to the blanketing of Europe and North America with ice sheets repeatedly during the last million or so years.

In the short term, the energy supply situation is grim. Modern technological societies' extraordinary reliance upon petroleum for most of its transport needs, in particular, must be curbed, or diverted into other energy avenues. Short of disaster, then, the world's overall energy needs will continue only to grow. This is where our geophysical industry assumes a rapidly mounting importance.

The application of geophysical technology has, and will continue to have, a major impact on the discovery and development of terrestrial energy resources. Past demands have now developed an industry based on the application of geophysics in the investigation of the shallower earth's crust that currently outlays more than 1.5 billion dollars annually. It is to the "soft-rock" segment of this vital industry that I will now direct my remarks.

Geophysical technology has now developed to a degree only hinted at at the end of Word War II. Immensely improved, and now often highly sophisticated, computerised, applications encompass the whole range of magnetic, gravity, radioactivity, electrical, seismic and kindred techniques. The special needs of the petroleum industry, now expanding also into the coal industry and sedimentary uranium, has demanded new acoustic source and field recording techniques that have greatly improved resolution and accelerated operation. Computer processing has introduced its own revolutions. These have resulted in the removal of much extraneous noise, reverberations, multiples, and so forth, and permitted new estimates of specific accoustic properties of the enclosing sedimentary host rocks..

Advances such as the "bright-spot" techniques in hydrocarbon recognition brings new hope for detailed characterization, recognition, and localization of hydrocarbon deposits more directly. Similarly, high resolution seismic gives promise of precision delineation of underground coal seams sufficient to bring greater confidence in planning of both underground and open cut mining and resulting, in turn, in improved efficiencies and recoveries.

Coupled with new interpretative techniques comes new understanding of sedimentary basin depositional and structural history, also lithology, relative age and hydrocarbon potential, well ahead of the exploration drill.

In gravity techniques, new sensitivites in measurement are promised by experimental gradiometric techniques. Successful development would open the way for rapid detailed aerial and oceanic surveying scarcely before possible.

Remote sensing imagery including thermal techniques adds new dimension to geological mapping and resource exploration generally. In association with extended surface geochemical and other inputs, wide new horizons continue to open.

As a geologist might I conclude by expressing the exploration industry's greatest remaining need — namely, a technique or techniques that more directly characterise, localise and/or pin-point buried hydrocarbon deposits. The seismic "bright spot" technique is obviously a successful step in this direction. Obviously, electrical and electromagnetic sounding techniques need more research and development with the hope of making still better use of oil's relatively high resistivity and other unique characteristics.

LAND SEISMIC WORK IN AUSTRALIA

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In the evermore urgent search for oil and gas reserves, one scientific aid stands out. The reflection seismograph is the industry's most important tool for resolving complex subsurface geological problems. In Australia the search for oil has been in progress for the past one hundred years. Prior to the 1950's the exploration effort was, at best, spasmodic. It is significant that continuous exploration for oil reserves commenced with the introduction of the seismic tool in Western Australia during the 1950's. In the ensueing thirty years of application, in excess of 215 crew years or some 250,000 line kilometres of seismic coverage have been recorded onshore in Australia. As we move into the 1980's, it is instructive to review our past experiences and consider how we may apply the lessons of the past to the improved tools of the present and the challenge of the future. There have been several reviews of the seismic method since its introduction in the 1930's. During this period predictions were made regarding the future progress of the science. Historically, most of these predictions have come true, at an accelerated rate and with the development of a technology, not known, at that time.

The goal of seismic exploration for the 1980's is quantitative measurement of subsurface lithologic parameters. Given this goal, we need to examine the tools and processes available to achieve it. From the 1950's to the end of the 1960's, almost all land seismic work in Australia was recoded on analog tape (if, in fact, tape was used at all!), with extremely simple field techniques such as split spread continuous or jump profiling. In the 1960's, horizontal stacking field techniques became widely used. Energy sources were predominately dynamite in shot holes, with substantial use of weight dropping and vibratory energy sources. The most profound change in the 1970's was the near universal use of digital recording instrumentation. The key to achievement of the goal suggested above is, of course, resolution. The key to resolution is sample density in three dimensions — two spatial and one time. Hence, actual field configuration of source and receiver arrays will undergo major changes from the styles that we in Australia have been accustomed to. 3-D methods are already in use in other countries. Energy sources will become more efficient. Dynamite will remain, in the foreseeable future, as the prime energy source, rich in high frequency content but with a less than savoury reputation in certain quarters. Methods and techniques, both mechanical and chemical to generate usable envelopes of shear waves will become apparent. Vibratory sources will evolve so that substantially higher input frequencies will be generated and recorded. It seems that although the field recording equipment will become more and more complex and sophisticated, the supplementary (albeit vital) field equipment such as geophones, cables etc. will evolve, just as they have over the past forty years. Geophone sensitivity (in its broadest sense) is governed by physical limitations, and refinements are the likely route of improvement. Digital telementery transmission of geophone signal will be improved, probably to the extent of eliminating cables completely. However, replacement of tne jug hustler seems highly improbable.

The developments of the last decade in the recording instrument technology field suggest that in the 1980's, we will be using equipment capable of recording many thousands of data channels, with the attendant finer sampling rates in time and space. Even now, land seismic crews using in excess of 1000 data channels are operating in various parts of the world. Inherent in the use of these types of hardware are advances such as simultaneous recording and real time processing of data. The complexities of such a venture will lead to almost total onsite computer control of the recording process. The field combination will lead to variable recording parameter control (such as filtering etc.) from point to point.

The major changes expected tin the industry over the next decade will emerge in the data processing field. Processing advances will occur in two basic channels — geoseismic modelling and wave equation processing. Modelling advances foreseen are in the forward and inverse forms. The familiar synthetic seismogram is an example of forward modelling. Refinements in the application of these techniques are expected. Of great importance in our goal ot understanding the subsurface of the earth are the inverse modelling systems. We start with the observed field seismic data, and attempt to work our way backwards along a path strewn with pitfalls, ambiguities, over-simplifications and unknowns to the geologic column. It is in this field that major advances are to be expected. The essential element of the modelling methods is the determination or estimation of the seismic "wavelet" which is embedded in the date. The "wavelet", which is a combination of effects ranging from source to recording instruments, is revealed by both statistical and deterministic methods. The source wavelet may even be measured directly as in the Vibroseis method. With an appropriate wavelet established, it is possible to generate synthetic or simulated sonic logs from the seismic data. Given adequate geological control, such methods appear to be of great promise in our hunt, particularly, for the elusive stratigraphic trap.