Wave equation processing is an obvious area in which rapid and beneficial advances in our industry have been made. While migration is usually the first application associated with wave equation methods, it is by no means the only use. Improved velocity estimates, coherency studies, near surface resolution, modelling, attenuation measurements etc. are but a few of the myriad applications. Use of wave equation processes is an important contributor to the success of the 3-D methods mentioned above. Migration of events on a conventional seismic section deals with the events on that section as coming from the plane of that section. This is, of course, patently absurd, but generally, as true optimists, we have acknowledged the problem, and then promptly done nothing about it. Alas, no longer may we plead such a defence.

Given all the improvements in instrumentation, field techniques and processing, there remains the proof of the pudding — Interpretation. It is a trite but mostly true expression that nearly all the big structures have been drilled onshore Australia — and found wanting.

The nature of the traps that we are exploring requires more than a gross structural interpretation. We are therefore required to use a host of methods even now that were impossible a few years ago. The most obvious interpretative aid for the geophysicist will be the interactive computer terminal. Granted the complexities of programming, it would seem that in the next decade, the masses of data to be handled for interpretation will demand a computer data base even for the housekeeping. The joys of reiterative modelling of an interpretation will become commonplace as we seek finer and more subtle information. The man-machine combination will form a vital synergistic relationship in applications from velocity analysis to contouring. The most elegant algorithms for mathematical optimisation are only an aid to the trained, experienced, human brain in reasoned judgement.

More statistical analysis methods will be used in the future as an inerpretation tool An example is the use of cluster analysis for indentification of genuine gas induced bright spots. The combinations of high amplitude, negative polarities, lower-relative velocities, flat spots, edge diffractions etc. can be studied to separate the real from the maybe.

The relationship of shear and P-wave velocities and amplitudes will yield quantitative estimates of certain elastic constants related to rock type and fluid content.

An extremely important aspect of the interpretative process is the display. The development from the pasted together mōnitor records through to the variable area section display has often been cited as the greatest single improvement in data processing in the 1950's and early 1960's. A similar improvement is likely in the use of colour displays overlaid on the conventional monochromatic structural section. These colour displays of seismic attributes such as reflection strength, polarity, frequency, phase, velocity and the like increase the visual dynamic range of the interpreter and allow him to more precisely define anomalous zones. In the display of 3-D data, the movie-like succession of horizontal sections known as Seiscrop are valuable tools to the interpreter.

It is apparent that the improvements of the past in our industry and the predicted trends for the future rely heavily on the skills of the people involved. In the ultimate judgement, the interpreter, well trained in geology and geophysics, will provide the resources of the future. This is the key to success in the 1980's.

QUANTIFIED STRATIGRAPHY — AN EXPLORATION APPROACH FOR THE EIGHTIES

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Quantified stratigraphic parameters from seismic and well data provide the paleogeographic and facies information necessary for the development of an accurate geologic framework for hydrocarbon exploration. The key parameters are (1) geologic age, (2) sea-level changes, (3) paleobathymetry and paleotopography, (4) subsidence and uplift, and (5) sedimentation rate. This paper discusses how these parameters are quantified from and applied to seismic and well data using seismic stratigraphy and geohistory analysis.

Seismic stratigraphic analysis permits interpretation of the geologic age, paleobathymetry, paleotopography, and gross facies directly from seismic data. Well control provides verification or modification of these interpretations by carefully tying the well control to the seismic data using synthetic seismograms. The well information in turn provides the data for geohistory analysis. This approach quantitatively illustrates the interrelation of the stratigraphic parameters and allows the interpreter to evaluate the effects of each.

This procedure is applied to offshore Western Africa. It demonstrates how quantified stratigraphic parameters affect the interpretation of basin evolution and sedimentary filling and how a quantified stratigraphic framework is developed for hydrocarbon exploration.

THE DEFINITION AND DEVELOPMENT OF THE MACKEREL FIELD

GIPPSLAND BASIN

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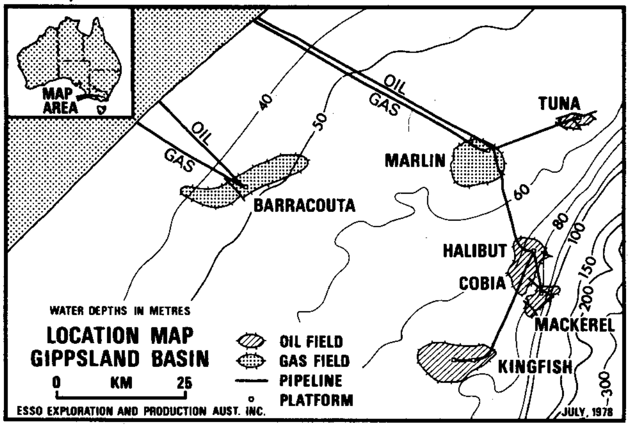
The Mackerel Oil Field located offshore in the Gippsland Basin was discovered in April 1969, with the Mackerel-1 well. The field contains oil in Eocene/Paleocene reservoir sands which lie beneath an unconformity at the top of Latrobe Group. Calcareous shales and mudstones of the Oligocene Lake's Entrance Formation seal the field which is a topographic-erosional feature. By the end of 1973, 235 kms of seismic had been shot in an irregular grid involving



seven different surveys and a total of four exploration wells had been drilled to provide data for the initial definition of the field.

At the end of 1974, 145 kms of high resolution seismic data were shot on an approximate 1 km x 1 km grid over Mackerel as part of a basin wide survey to define more accurately the top of Latrobe Group sediments. This survey, known as the G74A survey, showed a major improvement in data quality. Frequencies were higher, allowing increased resolution and, significatnly, the post-Latrobe data quality was improved to the extent that the Miocene channeling, which occurs throughout the basin and causes severe velocity distortions, could be mapped with confidence. In 1975, preliminary mapping of the Mackerel area was carried out and in 1976 a detailed pre-development intepretation was undertaken.

The pre-development interpretation highlighted a number of problems. These included a high velocity Miocene channel in the overlying section in the north-east of the field, some possible erosional features of the top of the Latrobe Group reservoir sands, and correlation problems involving the seismic identification of the top of the Latrobe Group.

The northern sector of the field was, in particular, an area where seismic interpretation problems created considerable uncertainty in the pre-development mapping. Migrated seismic sections had indicated the possibility of severe erosional scarps in this area and the more clearly defined of these were included in the structural mapping at this time. In other cases, where high relief escarpments were suspected but could not be unequivocably supported, even on the migrated data, the areas of uncertainty were highlighted on the structure map. In these areas data was required from development wells before the final seismic interpretation could be made.

The pre-development seismic structural and stratigraphic mapping was used to determine the final platform location and to choose the initial development well locations. These well locations were picked to gain early structural control on the top of Latrobe, to test the interpretation in the problem areas, and to investigate the internal geometry of the reservoir units. This latter factor was important because of the possible effects the internal geometry of the reservoir units could have on the field drainage pattern.

The third development well, Mackerel A-5, was drilled on an interpreted high in the northern problem area to test whether these possible erosional scarps were present. The well was dry, confirming that the scarps did exist in this part of the field. Following this, a complete re-interpretation of the field was carried out using migrated sections to locate the scarps. This reinterpretation has provided our current field map. Subsequently, the data from the later development wells have been incorporated as they became available, causing, in general, only minor changes to this mapping.

However, some changes were significant and, again, they related to the problems highlighted in the pre-development mapping. In the same northern sector of the field to the east of Mackerel-3, a Miocene channel, infilled with sediments which have a high velocity, had been mapped in the section overlying the Latrobe Group. The Mackerel A-5 well indicated that the increase in average velocity to the Latrobe might be greater than previously interpreted. This was confirmed by the Mackerel A-10 well, and the increased velocity has the effect of depressing the depth of the north-eastern part of the field. Also in the vicinity of Mackerel-3, there were problems identifying the top of Latrobe seismic event. Two alternatives, a 'high cycle' or a 'low cycle' interpretation were possible. Both of the interpretations were feasible because the highly eroded nature of the Latrobe in this area meant that it was difficult to distinguish between the two cases. Mackerel A-9 was drilled to test this problem and confirmed the 'high cycle' interpretation.

In conclusion, it can be said that the pre-development structural and stratigraphic mapping of the Mackerel Field was successful in delineating the basic size and shape of the field and its internal stratigraphic configuration. This mapping was also successful in identifying all the geophysical and geological problems which were subsequently encountered in the development drilling. Thus a rigorous seismic interpretation provided the geologists and engineers with a sound basis for field development planning.

FIELD DEVELOPMENT WITH THREE DIMENSIONAL SEISMIC METHODS IN THE GULF OF THAILAND – A CASE HISTORY

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The Gulf of Thailand is a Tertiary basin and is of tectonic origin. The section of interest is Miocene and possibly Oligocene in age, and although the principal interest is limited to the upper 12800 meters of section (about 2 seconds in reflection time), there is perhaps as much as 24000 meters (3 seconds) of Tertiary and Mesozoic section overlying a strong reflector which in places tops the basement and in other places may represent the top of the Paleozoic. The Miocene section of interest