Estimation of oil discovery and production in Australia from undiscovered accumulations (onshore)

SEAPUP (Simulated Exploration And Production of Undiscovered Petroleum) is a computer program designed and employed at BMR to assess Australia’s undiscovered petroleum resources and to estimate discovery and production of crude oil from 1987 to 2000. During each iteration, the program simulates drilling a range of petroleum traps and estimates the size of discoveries, the year of their discovery, their economic viability, lead times from discovery to production, and annual production.

The program has been run for all of Australia and for the onshore and offshore regions separately.

The first step in the estimation for onshore Australia was to categorise the petroleum traps that could occur in each prospective sedimentary basin into a number of super-plays, each of which consists of a single trap type within an independent petroleum system. The next step was to compile all relevant historical data, particularly for the new-field wildcat wells drilled and the oil and gas accumulations identified in each play, for input to the computer. Preliminary processing, sorting, plotting, and statistical analysis of these data were then carried out in preparation for examination by groups of colleagues.

Output from the SEAPUP program

Simulated drilling of all traps in the onshore petroleum traps model represents the discovery of all undiscovered crude oil accumulations and provides a probabilistic assessment of undiscovered onshore oil resources (Fig. 8) and an estimate of the risked average undiscovered crude oil resources in each basin (Fig. 9).

Figure 10 shows how drilling, hypothetically, a range of 50 to 150 petroleum traps each year from 1987 to 2000, under a range of assumptions regarding efficiency of exploration, economic accumulation sizes, lead times, and production rates, provides estimates (at the 10, 50, and 90% probability levels) of the number of wells drilled, number of discoveries made, success and discovery rates, number of accumulations brought into production, and crude oil production rates for each year. Corresponding estimates can also be obtained for the whole period from 1987 to 2000. In addition, the program estimates how much of the oil will be economic and how much will occur in fields that may be brought into production during 1987 to 2000.

The identical range of information may be obtained for any play or for any sedimentary basin.

Limitations

The main deficiency in the estimates is that for many basins we do not have enough information on which to base a reliable assessment. We cannot assess oil that we cannot conceive. For instance, it is possible that oil occurs in well-known play types in as yet unknown sedimentary sequences or in unknown play types in known sequences. Even in well-known plays in well-known sedimentary sequences, our perception of the number and size of the undiscovered fields will improve with the quality and density of the seismic surveys undertaken and as a result of revisions to the reserves of the identified fields. Thus, the range of values given in the estimates may be conservative.
Checking the estimates and the model

A seemingly obvious way of checking the model is to run the program using data appropriate to some time in the past, such as, e.g., 1976, to see if it predicts subsequent events reasonably precisely. However, SEAPUP contains both the experience of the events that occurred from 1976 to 1986 and subjective expert opinion, and it cannot be reliably converted into a model applicable to 1976. The only diagnostic testing that can be carried out is best performed by comparing these estimates with the actual future outcome. Each estimate is given as a cumulative probability distribution against which the outcome can be easily compared. However, there are no commonly accepted standards by which differences between individual estimates given as ranges of values and their outcomes may be judged, especially when dealing with highly skewed distributions. It seems better that the acceptability of an estimate be left to the judgement of the scientists familiar with the region and with the underlying reasons for the trends.

For more information contact Dr David Forman at BMR (Resource Assessment Division).

New potential reservoir identified in Clarence-Moreton Basin

An article in the previous issue of the BMR Research Newsletter (8, 7) drew attention to the enhanced petroleum source-rock potential of the Clarence-Moreton Basin in northeastern New South Wales, as a result of a recent 4-year BMR-State Geological Survey study. The study has developed a revised stratigraphic framework for the basin and has now identified a widespread unit that has considerable potential as a petroleum reservoir.

The Clarence-Moreton Basin contains Mesozoic sediments in part equivalent to oil-producing sequences in the Surat and Eromanga Basins. A major problem confronting the search for hydrocarbons in the basin has been the difficulty of predicting the distribution of potential reservoir sandstones. The Ripley Road Sandstone and its equivalent, the Helidon Sandstone (Fig. 11), consist of quartzose sandstone and have long been regarded as the most promising potential reservoirs. The Gatton Sandstone and Koukandowie Formation generally consist of lithic sandstone and have been considered to have less potential. Although some porous intervals were encountered by drilling in the Koukandowie Formation, the intervals were thought to be discontinuous. Sandstones in the Walloon Coal Measures are very rich in volcanic rock fragments and thus have little reservoir potential, though coal and shale make this formation an excellent potential petroleum source. Sediments above the Walloon Coal Measures crop out too extensively to be good targets.

Field work has now traced the relatively quartz-rich Heifer Creek Sandstone Member of the Koukandowie Formation from the area where it was originally identified in the northern part of the basin in Queensland, to the western and southern basin margins in New South Wales. Once the unit’s stratigraphic position was established in outcrop it was recognised in petroleum wells across most of the southern part of the basin. Modal analyses of sandstone from the Heifer Creek Sandstone Member average 50% quartz compared to 33% quartz in other sandstones of the Koukandowie Formation. The member can thus be readily identified in outcrop, and in well sections it shows lower gamma log readings than other sandstones in the formation.

Is CO₂ involved in the migration of hydrocarbons from type-III kerogen?

Oxygen-rich, type-III kerogen, such as that associated with coal and dispersed coal particle releases CO₂ and water during decomposition, as crude oil is soluble in supercritical CO₂. Some Australian crude oils that coexist, in reservoirs, with high concentrations of CO₂, and the work suggests that supercritical fluid CO₂ may be involved in migration.

The amount of CO₂ generated is a function of the total-organic-carbon (TOC) content of the rock, coals generally yielding up to 130 kg/t; thus, after allowing for the relatively small amount of CO₂ dissolved in pore waters, there is still a large excess of CO₂ available to facilitate the migration of crude oil. Indeed, in some rocks with TOC values of only 5%, the CO₂ generated in situ can still dissolve and transport over 110 ppm of hydrocarbons.

Laboratory comparison of a Bowen Basin crude oil with a source-rock extract from the same location showed that the crude oil is enriched in biphenyl, methylbiphenyls, dimethylbiphenyls, and fluorene. This enrichment can be replicated in the laboratory by extracting crude oil with supercritical CO₂. As the temperature and density conditions for the extraction are similar to those in the reservoir, the enrichment of biphenyls and fluorene in the crude oil, relative to the sediment, is attributed to a migration effect caused by selective solvation and extraction of these compounds from the source rock by supercritical CO₂. Similar examples of crude oils showing fractionation effects consistent with migration in supercritical fluid CO₂ are known from the Gippsland, Carnarvon, and Cooper-Eromanga basins.

For further information contact Dr Phil O’Brien or Mr Allan Wells at BMR (Division of Continental Geology).