BMR has just completed a 3½ year NERDDC-sponsored study of the petroleum potential of the southern McArthur Basin. This study has considerably enhanced our view of the basin’s petroleum potential, through the discovery of petroleum source rocks, potential reservoir rocks, and the world’s oldest oil. The final report to NERDDC is available as BMR Record 1987/48.

The report includes a discussion of the geology, sedimentology, reservoir potential, source-rock potential, maturation, hydrocarbon composition, and potential plays. It incorporates the results of geochemical and organic petrographic analyses of 1100 samples from 55 locations and discusses an approach to source-rock assessment in the Proterozoic.

Good to excellent source rocks indicated

Five potential source rocks have been discovered (Fig. 16). They occur at various stages of thermal maturity in different parts of the basin. Two of these source rocks, the lacustrine Barney Creek Formation in the McArthur Group and the marine Velkerri Formation in the Roper Group, compare favourably in thickness and potential with rich, demonstrated source rocks in major petroleum-bearing provinces in the Phanerozoic. Organic carbon contents in the Barney Creek Formation range up to 7%, with organic-rich intervals up to 200 m thick; the organic matter is Type I to Type II and in marginally mature samples consists of fluorescent lamalginite. Organic carbon contents in the Velkerri Formation range up to 6.5%, with organic-rich intervals up to 80 m thick; the organic matter is Type II. Extractable hydrocarbon yields from mature samples indicate that good to excellent source rocks are present. The potential of these Proterozoic source rocks was confirmed in no uncertain fashion by the discovery of ‘live’ oil in an interbedded mudstone and siltstone sequence in the Velkerri Formation in the BMR Urapunga No. 4 stratigraphic hole drilled during the study. The composition of the oil and of extractable hydrocarbons suggests that most of the organic matter was derived from prokaryotic organisms. The major classes of hydrocarbons identified were n-alkanes, mononuclear branched alkanes, cyclohexylalkanes, and acyclic isoprenoid alkanes. There were also low abundances of pentacyclic triterpanes, comprising hopanes and methylhopanes. The presence of low amounts of stearanes in some samples indicates that eukaryotic organisms existed as far back as 1690 Ma.

Maturation level

A variety of techniques have been used to assess the maturation level of these Proterozoic sediments. Tmax measurements from Rock Eval analyses show the same relationship to hydrocarbon generation as found in Phanerozoic sediments. Methyl Phenanthrene Indices and reflectance measurements on lamalginite and bitumen have also been used to determine maturation levels. The Methyl Phenanthrene Index has been recalibrated against vitrinite reflectance for the purposes of this study. As might be expected from reflectance measurements of hydrogen-rich organic matter in Phanerozoic samples, reflectance values of Proterozoic lamalginite and bitumen are lower than the vitrinite reflectance levels calculated from the Methyl Phenanthrene Indices for the same samples. Nevertheless, systematic depth changes in reflectance do occur and with adequate calibration can be used to assess maturity of Proterozoic sediments.

McArthur Group and Nathan Group potential

The sediments of the McArthur and Nathan Groups consist mainly of evaporitic and stromatolitic cherty dolostones interbedded with dolomitic siltstone and shale with some thin sandstones. They were deposited in a complex interfingering set of environments including marginal-marine, lacustrine, and fluvial. Source beds are located in the Barney Creek, Yalco, and Liddim formations. Potential reservoir beds are vuggy carbonates or breccias associated with penecontemporaneous faulting. Both source and reservoir distributions are likely to be complex and difficult to locate and predict. The maturation levels of McArthur Group sediments are also very variable, ranging from marginally mature to mature in the Glyde Sub-basin and on the eastern margin of the Batten Trough, to late mature to overmature in the central and northern parts of the Batten Trough. Maturation levels can also vary rapidly on a local scale; this may be associated with movement of hydrothermal fluids along faults. Considerations of burial history suggest that hydrocarbon generation occurred during deposition of the McArthur and Nathan Groups, and was followed by erosion prior to the deposition of the Roper Group. Thus, preservation of hydrocarbons in these older sediments represents a significant risk for petroleum exploration.

Roper Group potential

In contrast, the sediments of the younger Roper Group consist of quartz arenite, siltstone, and shale, which are characterised by more uniform facies deposited in a stable marine setting. Source beds are located in the Velkerri and laterally equivalent ‘Lansen Creek Shale’ and McMin Formations. Potential reservoirs consist of thin shelf sandstones. Both source and reservoir facies are laterally extensive (over 200 km). Maturation levels in the Velkerri Formation and ‘Lansen Creek Shale’ fall within the oil window through-out the study area, but the McMin Formation is marginally mature where sampled. Porosity and permeability measurements of potential sandstone reservoirs are generally low because of extensive quartz cementation. The burial history suggests that hydrocarbons were generated during deposition of the Roper Group. There is a real possibility that hydrocarbon accumulation may have largely pre-dated the cementation and inhibited it in the accumulation zone. The critical question is whether any hydrocarbon accumulations have been preserved until the present day. However, discovery of ‘live’ oil at relatively shallow depth in the Velkerri Formation in the BMR Urapunga No. 4 stratigraphic hole and the possibility of accumulation occurring prior to reservoir cementation provide encouragement that commercial hydrocarbons may be preserved in protected Roper Group reservoirs.

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McArthur Basin Bulletin released


This long-awaited Bulletin was released in July 1987. It presents the results of detailed stratigraphic and sedimentological studies of this mid-Proterozoic basin carried out between 1977 and 1982, dealing with that part of the basin lying between the Roper River and the Queensland-Northern Territory border.

Mineral and petroleum potential

The Bulletin includes descriptions of the region occupied by the very large HYC (McArthur) lead-