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BUREAU OF MINERAL RESOURCES

(PETROLEUM TECHNOLOGY SECTION)

REPORT No. 1953/52

TESTING OF CORES

from

AUSTRALIAN ASSOCIATED OILFIELDS (N.L.) WELL No. 2

ROMA, QUEENSLAND.

by

M.C. KONECKI.

INTRODUCTION

Six wax-sealed samples of cores were received with a request that they be tested for porosity, permeability and oil and water content. Testing was carried out by Messrs. N.V.H. Hoyling and H.S. Taylor-Rogers at the Newcastle Technical College - to the Principal and Staff of which institution grateful acknowledgment of their co-operation and utilization of their apparatus and laboratory space is made.

CONCLUSIONS

1. The interval represented (3549'8" - 3556') has the physical characteristics of an oil sand, which could give satisfactory production.

2. The oil contents of the samples submitted are low. This may be due to the conditions of drilling and the lapse of time between cutting the core and coating with wax.

3. The water content of the samples is low.

4. Salinity of the cores is not inconsistent with that of a sand originally impregnated with moderately saline water.

5. The sand, as received, appears to contain mostly gas.

RESULTS

The table set out on the next sheet contains the results of test and of working up the experimental figures obtained.

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Sample (Depth)	(A) (3549'8")	(B) (3550')	(C) (3552'8")	(D) (3553'2")	(E) (3554'10")	(F) (3556')	
Porosity	17%	18.7%	16.4%	17.7%	18.6%	21.8%	
Vertical Permeability	735 md.	607 md.	449 md.	1197 md.	1132 md.	2120 md.	
Horizontal Permeability	646 md.	1096 md.	425 md.	Not tested	1208 md.	996 md.	
Residual Water Content (by wt.)	3.1%	0.27%	2.4%	0.36%	0.66%	0.36%	
Residual oil content (by wt.)	1.7%	1.24%	Nil.	0.85%	1.02%	0.04%	
Cl content	Neg'ble	Neg'ble	Neg'ble	Neg'ble	Neg'ble	Neg'ble	
Residual water Saturation (% of porosity)	18.25	1.45	14.65	2.3	3.55	1.65	
Residual oil Saturation (S.g.0.917) (% of porosity)	10.90	7.23	0	5.23	5.98	0.200	
Gas Saturation (% of porosity) (by difference)	70.85	91.32	85.35	92.47	90.47	98.15	

EXPERIMENTAL PROCEDURE.

1.) Effective Porosity. The volume of a cubical fragment of core was determined by displacement of mercury from a Hubbard gravity bottle. Acetone-extracted, dried and weighted fragment was immersed in Bromoform of known specific gravity, and a vacuum of about 27.5 inches of mercury applied till no more bubbles were observed issuing from the fragment. The vacuum was released and bromoform allowed to impregnate the fragment for ten minutes. The vacuum was re-applied and, when bubbles ceased to issue, again released and allowed to stand for ten minutes. The procedure was repeated till no more bubbles issued on applying the vacuum. The sample was then extracted from the bromoform, quickly dried between blotting paper and weighed. By difference the weight of bromoform was determined and hence its volume, which was taken as equivalent to the accessible pore-space in the sample.
This volume was expressed as a percentage of the volume of the whole fragment.

2.) Permeability. A piece of core was shaped into a cube, which was measured by a micrometer screw gauge. This was mounted in Wood's metal in a special bomb so that a gas could be passed through the sample, either perpendicular or parallel to the bedding.

Dried air was passed through the mounted acetone-extracted and dried sample. The differential pressure (p) was measured in centimetres of mercury by a U-tube gauge, one arm of which was connected to the high-pressure side of the sample and the other to the low-pressure side. The differential pressure expelled water from a large reservoir, and the time was taken for a standard volume (v) to be collected.

Permeability perpendicular to the bedding is called "vertical", and, paralled to the bedding, "horizontal".

The figures were calculated from the formula:

$$k = \frac{h \times V \times v \times 76000}{a \times p \times t} \text{ millidarcys, where}$$

h is the height of the core cube (or cylinder) in cm.,

V " the volume of air (in cc.) passing, which equals volume of water collected,

v " the viscosity of air at temp. of test (in centipoises),

a " the area of cross-section of the core-cube in cm^2,

p " differential pressure in cm. of mercury,

t " time in seconds for "V" to pass over.

3.) Water Content. A weighed collection of fragments from the centre of the core was refluxed with solvent of boiling-range 110 - 120°C. in the normal Dean & Stark apparatus till no more water collected in the trap (about one hour). Water, condensed on the inside of the condenser, was washed into the trap with more solvent, the contents of the trap allowed to cool to room temperature and the volume of water read. This was expressed as a percentage by weight of the unextracted sample.

4.) Oil Content. The extracted water content sample was refluxed in a Soxhlet apparatus with acetone, dried and weighed. The total loss of weight, minus the weight of water collected, was expressed as a percentage of the original sample's weight.

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5.) Chloride Content. The acetone extracted sample was disaggregated to pass a 24 mesh sieve, and a weighed amount leached with distilled water. A large aliquot was taken for a Moht titration using very dilute standard silver nitrate solution.

6.) Water Saturation. This is calculated as the percentage of the water content relative to the effective porosity.

7.) Oil Saturation. This is calculated as the percentage of the oil content relative to the effective porosity. A specific gravity of 0.917 has been established for oil by the Government Analyst of Brisbane Mines Department.

8.) Gas Saturation. This is the difference between 100 and the sum of the water and oil saturations expressed as percentages.

DISCUSSION OF RESULTS.

The oil and water contents as determined are probably in error due principally to flushing of the rather permeable core by the drilling fluid. This would tend to reduce the oil content and increase water content. The latter appears to be very small and may be due to extrusion by release of pressure in the interval between the actual cutting of the core and its sealing in wax. This time, according to field evidence, was about sixteen hours - ample for considerable "weathering" of the core to occur. It follows that the magnitudes of these effects are not determinable. (The high water content of core from 3549'8" is probably due to contamination, with water while cutting the core for tests. The others were cut dry).

Gas saturation, calculated by difference, is similarly probably in indeterminable excess.

Chloride contents, which were expected to indicate the amount of saline water in the formation, were so low as to be very unreliable in making the estimation. This was borne out by analysis of the water used in the drilling fluid and of that resulting from production tests. The chloride contents were respectively 145 and 1610 parts per million. Consideration of the porosity and the small size of the samples available for testing appears to justify the conclusion that the low chloride contents were quantitavely valueless.

The porosity and permeabilities, especially horizontal, are very suitable for a producing oil-sand. Porosity does not vary greatly throughout the sand.

The results of the core-analysis have been plotted against depth in the accompanying graph, which shows that there are two zones where oil-content and permeabilities are most favourable. These are approximately between 3549'8" and 3551'6" and 3553'2" to 3555'. Between 3551'6" and 3553'2" there is a relatively impervious band of apparently low water and oil content. The casing was perforated from 3550'10½" to 3552'2½", in a zone of relatively low vertical permeability and medium oil and water contents, as tested. The graph indicates suitable zones for perforation (and testing) between 3555' & 3553'2", and 3551' and 3549'8".

Due to high permeabilities of the lower zone (below 3553'2") it is more than possible that its actual water content is higher than was measured (loss of water on exposure of core). Consequently the value of this (lower) zone for oil and gas production is rather doubtful. Besides - this (lower) zone is broken up by an "unsaturated" interval 3554'7" - 3554'. No core

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samples were tested from that interval.

Summarising - one may conclude that the oil-sand section penetrated by the well exhibits vertical variations of permeabilities and fluid saturations. There are no impervious bands, which would divide the sand into definitely separate zones. There is also no definite oil-water or oil-gas contact. Fluid saturation is probably controlled by the size and shape of pores (in other words, by permeabilities). There appears to be comparatively high gas content.

Any production (not necessarily commercial) that may be obtained from this sand will invariably consist of gas, water and some oil. By perforating uppermost portion we may reduce amount of water - in the initial stage at least.

Oil (as analysed by the Government Analyst in Brisbane) is heavy. Its specific gravity is 0.917 at 20°C. Initial point of distillation is 150°C. Total distillate is 84%. Residue is 14%. Flash point is 65°C. Sulphur content is less than 0.1%.

In conclusion - few remarks on collecting and handling of cores for core-analysis:

1. In order to avoid loss of reservoir fluids from cores no time should be lost before preserving them in air-tight manner, preferably in special plastic tubes to fit the core diameters very closely in order to reduce the void.

2. The reservoirs cored with water-base mud are subject to flushing of their original fluids. The amount of residual or total water in the core at the time of analysis is the sum of the connate plus any drilling water that might have been forced into the pores.

   To obviate this, oil base mud is desirable when coring oil-sands. Cores cut with the oil-base mud from low-pressure reservoirs will show normally total water saturations that may be assumed to be the connate or the interstitial water saturation of the reservoir.

   Apart from oil-base mud, special muds such as low-water loss, modified-starch drilling fluids may be used in coring sands with low pressures and/or low productive capacity.

The importance of correct depth designation of cored intervals cannot be emphasized too strongly.

Many times core analysis was held responsible for poor completions, while the fault was in the disagreement between driller's and, say, electric log. From my own practice, these depth differences amounted to several feet (in some cases) when depth-checks were made by Schlumberger and Lane Wells people versus driller's log.

M. C. KONECKI.

23 Mar 53.

Core-log.

Australian Associated Oilfields (N.L.)
Bore Nº 2.
Roma
Queensland.