Results of Tests of Oil and Water Saturation, Pilot Bore, Lakes Entrance, Vic.

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- Preliminary Report -

RESULTS OF TESTS OF OIL AND WATER SATURATION, PILOT BORE, LAKES ENTRANCE, VICTORIA.

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This report deals with saturation and porosity tests carried out on 28 core samples from the pilot bore at Lakes Entrance.

The cores were obtained with a Baker core barrel operated by a percussion drilling rig. This type of coring tool is generally regarded as a satisfactory means, from a lithological point of view, of obtaining samples of the formations drilled, but as far as saturation tests are concerned, the core samples obtained are so broken and subject to contamination and flushing by the drilling water that saturation results obtained from them must be regarded with considerable suspicion. The position was aggravated in the tests under discussion by the fact that the more competent sandstones, which yielded the largest fragments (the so-called biscuits) and hence those least likely to be flushed or contaminated by drilling water, were found to be singularly free of oil. It seemed likely that the less competent layers of sandstone, which had been reduced by the action of drilling to either small sized pieces or sand, were the ones carrying oil and the material derived from such sandstones was most susceptible to flushing and contamination by drilling water.

The experimental work in connection with saturation determination is necessarily slow as each sample is under test for a period of from 5 to 15 hours. In order to limit the time required for the presentation of results and because of the uncertainty in the interpretation of results it has been considered advisable to confine the tests to those core samples which correspond to oil horizons as indicated by an increase in oil yield when the particular section was drilled.

Sections which yielded oil are represented by cores 5, 6, 7, 11, 12, 13, and 14, They amount to 93 inches out of a total of 274 inches drilled and it is considered unlikely that any of the remaining 181 inches would be oil-bearing as bailing tests showed that it did not contribute any oil to total oil yield for the bore.

Tests were made of selected portions of the abovementioned cores and one test was made of sand from an unproductive section, namely Core 23. Of the 93 inches which corresponds to sections yielding oil, it was obvious from visual inspection of the cores that not all of it was oil-bearing. Saturation tests were made on samples representing 51 inches. Of the remaining 42 inches approximately 10 inches was lost in coring and 32 inches rejected when visual observation clearly indicated that it had no oil in it. Some tests were carried out on samples rejected in this manner as a check on the observation and no oil was detected by test.

A visual inspection of the cores indicated that oil was confined to the 'sand' and fine, angular fragments. The more solid portions, i.e. the so-called biscuits and larger angular fragments were oily in appearance when first seen but upon breaking them in halves it was obvious that the oil was purely superficial in occurrence - the oil appearing as a thin coating on the fragment. The thickness of this coating varied from a maximum of approximately 1/8 inch to a mere film.

In most cases where oil saturation was determined for the larger fragments, this oily film or coating was carefully removed with a wire brush before the test was commenced. In one case, however, namely Core 12 - (3.1" - 6.2"), a comparison was made between the apparent oil saturation of the oil-coated fragment and the saturation of adjacent fragments from which the oil coating had been scraped. It was found that the failure to remove the oil coating resulted in an apparent oil saturation (expressed as if the oil was evenly distributed throughout the sample) of approximately 8 per cent. whereas the removal of the coating reduced this figure to approximately 1 per cent.

As the oily coating was of the order of 1/16 inch thick and its volume small in comparison to the volume of the sample as a whole it is evident that its saturation must have been high.

The nature of the oily coating is not self-evident. It may be oil which has been yielded by adjacent formations, and which has adhered to the fragments, or it may have been derived from highly saturated beds of glauconitic sandstone of low competency which have been squeezed out of the formation during drilling and been distributed throughout the cored section.

A test is in hand at the present time to determine what apparent oil saturation can be attained by water saturated sandstone fragments which have been standing in oil, but whatever such a test might reveal, the initial undertainty arises through the method employed for coring. It is understood that a second 'pilot bore' is contemplated from which it is hoped to obtain rotary or diamond drill core samples taken with due regard to precautionary measures which can be adopted to reduce contamination of the core to a minimum or at least permit of an estimation of the degree of contamination to be made.

In nearly every sample tested the liquid content was found to be sufficient to fill the pore space completely. However, it was found as a result of experiments carried out with typical samples of glauconitic sandstone that fragments of size similar to those in the cores, become completely saturated upon immersion in water for periods as short as 30 minutes. As the coring process was carried out under water it is not surprising that the cores were completely saturated, and further, the fact that they were completely saturated cannot be taken as evidence that the glauconitic sandstones are completely saturated in situ.

As mentioned above, some of the core samples had the consistency of sand which it is believed has been derived from the complete crushing of an incompetent sandstone. This belief is based partly on the fact that unconsolidated sand does not occur in the glauconitic sandstone section in any of the neighbouring bores which have been cored with a rotary drill and partly on evidence arrived at by Mr. Noakes (1) by grain size analysis and general considerations of the cementing material present.

As this material seems to be associated with the occurrence of oil, its true nature is of considerable importance in understanding reservoir conditions. The true nature, however, can best be determined from fresh evidence which it is hoped the second 'pilot bore' will give, and until such time as this fresh evidence is available, the true nature must remain in doubt.

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(1) See accompanying report by L. C. Noakes.

The Measurement of Oil and Water Saturation.

The apparatus used in the tests is shown in Figure 1 and it is similar to that described by Yuster (2).

The sample to be tested was reduced to pieces about the size of a pea, weighed and placed in the extraction thimble. The thimbles generally recommended for this work are 'Alundum' or 'Alfrax', of suitable permeability but, as thimbles of this type were unprocurable, a thimble was made from a piece of glass tubing which was drawn down to make a fine hole at one end. This hole was at the bottom of the thimble and it allowed the solvent to drain through the sample during the extraction process. A cotton wool plug in the bottom of the thimble prevented the escape of any of the sample or the blocking of the hole. The thimble holds approximately 15 cc. of sample.

The thimble was next placed in the apparatus and the solvent boiled. The solvent used was Shell cleaner X2 with a boiling point range from 90° - 110°C.

The flow of hot solvent vapour past the thimble vapourized the water which was carried over with the solvent vapour, condensed, and collected in the graduated water receiver. Condensed solvent overflowed from the water receiver and was returned to the extraction thimble - flowing down through the sample and returning by way of the hole in the bottom of the thimble to the boiling flask.

The heat was regulated to permit the thimble to remain full of solvent without overflowing.

After several hours all the water vapour had been driven off and collected in the graduated water receiver while the oil had been removed from the sample by the continuous flow of hot solvent through the sample in the thimble. The time required for a complete extraction depends on the fineness of the sample. Five hours was usually sufficient for the sand samples while angular fragments or biscuits reduced to pea size usually required from 10 to 15 hours.

When the extraction was complete, the thimble was removed, its contents dried and weighed to obtain the total loss of weight.

The weight of the water lost was determined from that collected in the graduated receiver, while the oil removed was taken as the difference between total loss of weight and weight of water collected.

The dried sample was next tested for porosity. In the case of sand samples, the dried sand was packed firmly into a measuring cylinder and tamped until its volume was a minimum. The volume so obtained was taken as the overall volume of the sample. The sand was next added to a measured quantity of petrol in a measuring cylinder, stirred until no air bubbles issued from it, and the volume of the grains found from the change in reading.

The volume of the voids was the difference in these two volumes and was expressed as a percentage of the overall volume.

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(2) S. T. Yuster. Determination of Sautration by Extraction and Distillation. Oil Weekly, March 20th. 1944.

In the case of fragments of sandstone the procedure differed in that the volume of the fragments was found by saturating them in petrol and adding them to a measured quantity of petrol in a graduated cylinder. They were then dried, powdered and the grain and void volumes determined as outlined above.

Saturations were expressed as percentages of the pore volume or voids filled with water and oil respectively.

Results of the Tests.

The results of the tests are shown in the accompanying table. It will be observed that the oil saturation was not determined for six samples. Those were samples which visual inspection showed to be oil free and their water saturations were determined by loss of weight on drying.

It will be seen that the tabulation shows a number of samples for which the total saturation - water plus oil, exceeds 100 per cent. This is no doubt due to errors in the measurement of the pore volume. A slight adjustment to the porosity, which is proportional to the pore volume, is sufficient to reduce all the measured saturations to 100 per cent. total. This adjustment has been made in the tabulation, the figure in parenthesis being the adjusted values.

In the case of sand samples, or samples containing a significant proportion of sand, an oil saturation has been calculated on the assumption that the sand has been derived from an incompetent sandstone of porosity 35 per cent. and that the oil extracted from the sand was originally present in the pores of this sandstone. The porosities calculated in this manner are tabulated under the heading, "oil saturations calculated for 35 per cent. porosity."

Some of the saturation figures so calculated are of the order 12 -14 per cent. but as these sand samples were those most susceptible to contamination or flushing by drilling fluid it is doubtful whether this figure has any real significance.

Some of the sand samples were either free of oil or had very low oil contents. For example Cores 5 (6.3" - 11") and 7 (5" - 7") gave zero oil saturation in spite of the fact that they occur in cored sections which as a whole yielded oil although they do not necessarily represent those parts of the sections which yielded oil.

A third sample, namely Core 23 (1" - 3") had zero oil saturation but it comes from a section of glauconitic sandstone which yields no oil.

The fact that these sands have no oil in them suggests that any change in their original fluid content which may have been caused through flushing or contamination did not increase their oil content. However, there is no evidence to suggest that the reverse is true, namely that their oil contents have been reduced to zero by flushing or contamination.

In fact there is no real evidence from any of the tests carried out to suggest whether or not the original fluid content of the core samples has been changed during coring.

One test which was carried out might have some bearing on this question and it will be described in brief.

A sample of clean dry sand, obtained by grinding glauconitic sandstone, was saturated with oil. It was then agitated violently with water for 30 minutes, excess fluid squeezed from it and a saturation test made on it. It was found to have 83 per cent, oil and 17 per cent. water saturation.

Translating this result into terms of drilling and coring it might be claimed that if any portions of the glauconitic sandstone were 100 per cent. oil saturated, the material representing this in the cores would still have a very high oil saturation when removed from the core barrel even if it had been reduced to sand in the process of coring.

As mentioned earlier in this report, there is reason for believing that the oily material which coats some of the biscuits and larger core fragments has a high oil saturation. It is possible that this coating represents the remnants of glauconitic sandstone or similar rock which had a very high oil saturation initially. From the sparsity of such coating material in any of the core sections it could be inferred that if the above explanation is correct then this highly saturated material represents only a minor portion of the glauconitic sandstone section as a whole but not necessarily a minor part so far as oil yield is concerned.

In one important aspect, however, the test described above cannot represent reservoir conditions.

It is an observed fact that, almost without exception, reservior rocks are partially saturated with water, and this water coats the mineral grains in the rock, the oil being nowhere in actual contact with the grains. In the test described above the sand grains were actually wet by the oil.

An entirely different result might have been obtained if the experiment had been performed with a sand in which the grains were water wet. In this case the water covering the grains would probably have been added to at the expense of oil, and water may even have entirely replaced the oil in the sand.

One may speculate almost indefinitely on the relationship which the observed oil content in the sands and smaller core fragments could bear to the original oil contents of the rocks from which they were derived but such speculation cannot lead to any satisfactory conclusions being drawn.

Conclusions.

Perhaps the most important conclusion that can be drawn from the results under discussion is that a very substantial proportion of the glauconitic sandstone is not oil-bearing. Bailing tests* showed that approximately 181 inches out of a total of 274 inches of the glauconitic sandstone drilled is either free of oil or has too low an oil content to contribute to the oil yield for the hole.

Of the remaining 93 inches, material representing approximately 51 inches was subject to saturation tests; the additional 42 inches being made up of core lost in drilling (approximately 10 inches) and cores not tested because they obviously had no oil in them.

Glauconitic sandstone obtained in the form of so-called biscuits proved to have zero oil saturation with the exception of a few samples for which the precaution of scraping the oily layer from the sample before testing, was not observed.

It is believed that all the glauconitic sandstone which cored in the form of biscuits can be eliminated from the 'possibly oil bearing' horizons because it is most unlikely that their oil content could have been entirely removed during coring by the

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* See accompanying report by L.C. Noakes.

flushing action of the drilling fluid.

The highest oil saturations were found in sand and finely fragmented samples although the relatively high oil saturations in many of the latter may have been due to oily films covering the fragments as was the case in some of the biscuits tested.

If we now consider all samples which gave 5 per cent. or more oil saturation irrespective of the treatment e.g. scraping of the sample, the total thickness of glauconitic sandstone represented by these samples is approximately 16 inches. If we add to this the 10 inches of glauconitic sandstone for which cores were not obtained (and hence no evidence to say that it wasn't oil-bearing) we arrive at a tentative figure of 26 inches for the maximum thickness of oil-bearing glauconitic sandstone.

In view of the uncertainties which arise in regard to such matters as change in original oil content, contamination of samples by oily layers etc. the figure arrived at above, namely 26 inches, is highly speculative and no good purpose can be served by carrying such speculations any further.

In summing up it might be said that the examination of core samples from the pilot bore has not provided any satisfactory evidence of the degree of oil saturation in the glauconitic sandstones at Lakes Entrance beyond eliminating a considerable portion of those sandstones as being non oil-bearing.

It cannot be too strongly urged that in any subsequent coring operations undertaken with a view to obtaining representative reservoir samples every precaution should be observed which might reduce the chances of flushing or contamination of the cores by drilling fluid and where this cannot be avoided it is recommended that an indicator chemical be added to the drilling water to permit of an estimation being made of the degree of flushing or contamination that has occurred.

CANBERRA, A.C.T.
12th April, 1945.

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PILOT BORE - LAKES ENTRANCE

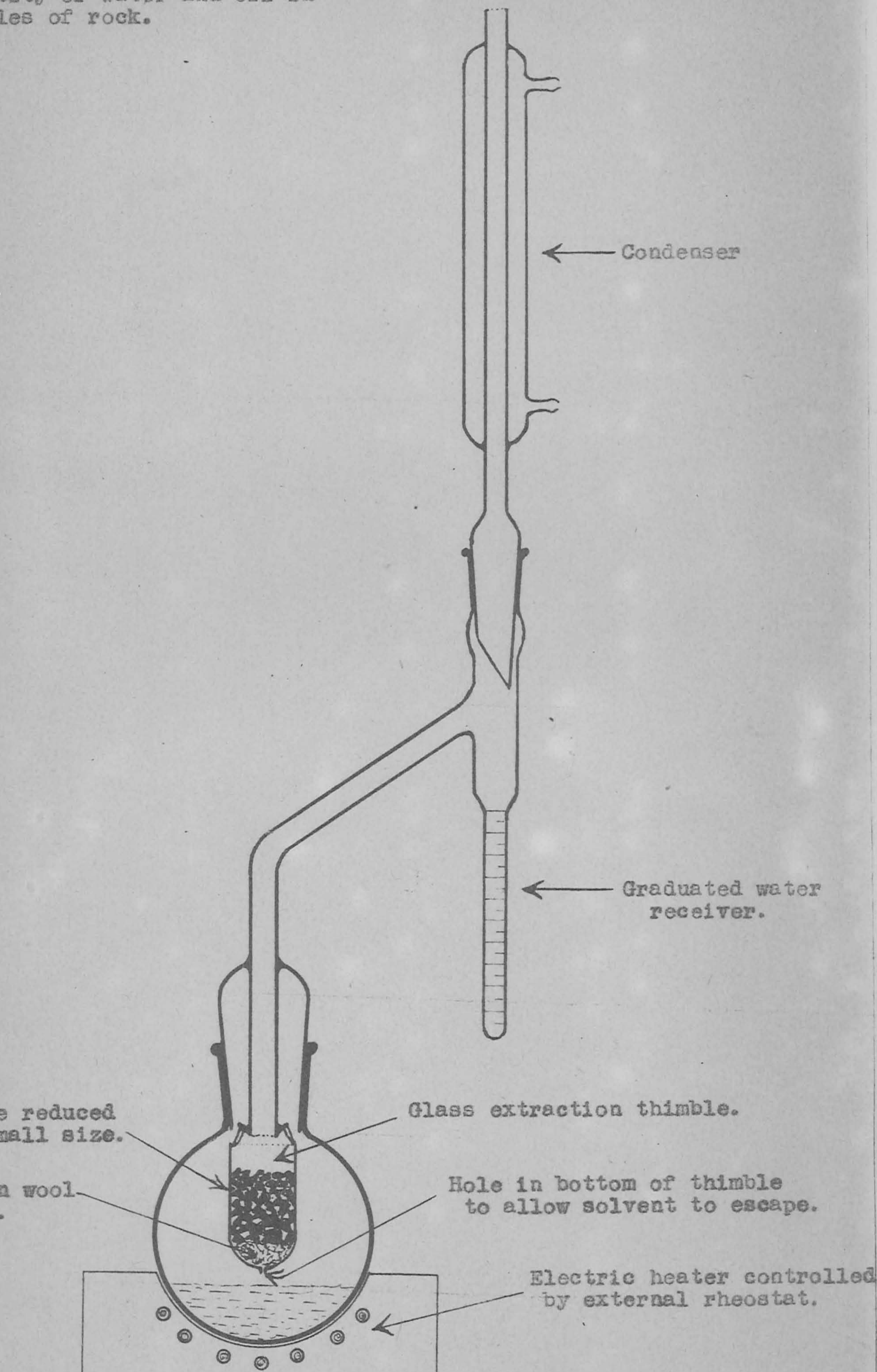
Saturation & Porosity Tests.

Core Number	Description of Sample	Oil Prod. per day (Pints)	Porosity Per Cent.	Water Sat. Per Cent.	Oil Sat. Per Cent.	Oil Sat.Calc for 35% Por
5 (0 - 3")	sand		51 (53)	98 (93)	7.3 (7)	14
"	Biscuits (a)		40 (44)	114 (100)	-	-
5 (3" -6.3")	Sand plus few fragments.		56 (46)	80(98)	1.8 (2)	4.6
"	Biscuits (a)		44 (44)	101(100)	-	-
5 (6.3"-11")	Fragments (a)	4.3	37 (45)	122(100)	-	-
"	Sand and fragments.		41 (37)	90(100)	0 (0)	0
5 (11"-15")	Fragments (a)		35 (36)	103(100)	-	-
6 (9" -13")	Biscuits (b) (scraped)		35 (x)	100	0	-
"	Sand	2	57 (50)	83 (94)	5 (6)	11
6 (13"-17")	Biscuits (b) (Scraped)		40	100	0	-
7 (5" - 7")	Sand	1.4	54 (53)	98(100)	0 (0)	0
11 (2"- 9")	Small fragments (c)		36 (38)	105(98)	2 (2)	-
"	" " (c)		35 (37)	105 (98)	2 (2)	-
"	Fragments (b) (scraped)		33 (32)	98(100)	0 (0)	-
12 (0-3.1")	Biscuits (a)		19 (23)	122(100)	-	-
"	" (a)		18 (16)	93(100)	--	-
12 (3.1-6.2")	" (a)		30 (35)	110 (93)	8.6 (7)	-
"	" (b) (scraped)	29	32 (32)	100 (99)	1 (1)	-
"	Sand		50 (54)	100 (92)	8.1 (8)	14.5
12 (6.2-8.5")	Fragments & little sand (c)		32 & 50 (42)	91 (93)	5.5 (7)	-
12 (8.5-10")	Biscuits (b) (scraped).		31 (30)	98(100)	0 (0)	-
"	Small (c) fragments.		41 (39)	87 (92)	7.8 (8)	-
"	Biscuits & fragments.		35 (x)	93	7	
13 (1" - 3")	Fragments & sand (c)		38 & 55	98	2	-
14 (1" - 3")	Fragments (scraped) (b)	3	42 (41)	98 (100)	0	-
14 (4"-6")	Fragments & sand (c).		51 (48)	87 (93)	6.7 (7)	12.7
14 (6" - 8")	Sand		52 (50)	94 (98)	2 (2)	4
23 (1" - 3")	Sand	0	54 (47)	88(100)	0 (0)	0

(a) No oil visible in freshly broken sample: Slight oily coating.
(b) Oily coating removed by scraping with wire brush before testing.
(c) Sample passed through 1/4" mesh sieve, oversize being rejected.
(x) Porosity estimated, not measured.

Figure 1.

Apparatus for determining the quantity of water and oil in samples of rock.



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