APPENDIX 5

PETROLOGICAL ANALYSIS

A PETROLOGICAL EXAMINATION OF CUTTINGS FROM THE PACOOTA P3 INTERVAL IN EAST MEREENIE NO. 13 AMADEUS BASIN, NORTHERN TERRITORY

by

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1. INTRODUCTION

The purpose of this study was to examine cuttings from the Pacoota Sandstone P3 interval in an attempt to identify its porosity distribution and characteristics and to provide an explanation for the poor flow performance encountered in East Mereenie #13. One particular aspect which was to be investigated was whether the widespread iron staining in the P3 interval was in any way related to variations in porosity or permeability in the sandstones.

Log interpretation indicates intermittent porosity from 5074' down to near the top of the P4 interval (5244'), with the main porous zone (5074'-5106') being the P3-120/130 sand.

2. SAMPLING AND ANALYTICAL PROGRAM

A continuous suite of cuttings samples from 5040' to 5250' was provided. All the samples were first examined with a stereomicroscope to see if any porous zones were recognizable. Each sample was then qualitatively assessed on an arbitrary porosity scale as follows:

- Tight - no porosity visible in any cuttings
- Trace - a small percentage of chips show occasional pores
- Minor - a small percentage of cuttings show obvious porosity
- Moderate - a significant proportion of cuttings show obvious porosity
- Major - a majority of cuttings show porosity

The samples were also graded dependent on the degree of iron staining as:- nil, slight, moderate, strong.

The results of this examination were then compared with the CDL/CNS log and a series of samples, both porous and tight, were selected for thin-section preparation and examination under the polarising microscope.

Under the polarising microscope the cuttings in each thin-section were counted into 7 categories as follows:-

1. Tight, highly cemented by quartz overgrowths and lacking iron coating or staining.
2. Tight, cemented by quartz overgrowths but with obvious iron coating and staining also present.
3. Tight, cemented by quartz overgrowths but also with significant amounts of clay coating grains and filling pores.
4. Tight, cemented by quartz overgrowths and also by carbonate and/or anhydrite.
5. Porous, with incomplete quartz overgrowth cement and no iron staining or coating.
6. Porous, with incomplete quartz overgrowth cement but with significant iron staining or coating.
7. Tight, non-reservoir lithologies including siltstone, shale and possibly some halite? and gypsum?

3. RESULTS

Table 1 lists the results of the preliminary examination of all cuttings samples together with the porous intervals as indicated on the logs.

Table 2 lists the analysis of the 7 thin-sections with the percentage of cuttings recorded in each of the 7 categories.

From Table 1 it can be seen that the main P3-120/130 porous interval is recognisable in the cuttings with a fairly close correspondence to the interval as evident on the logs. However, the other intervals which appear porous on the logs are much more difficult to recognise in the cuttings. In particular, the porous zone at the top of the P3-230 interval (5184'-5192') is scarcely recognisable and the 5212'-5219' (P3-240) interval was not detected at all.

The data for the 7 selected thin-sections (Table 2) generally agrees with the preliminary assessments listed in Table 1.

SAMPLE DEPTH (ft)	UNIT	POROUS INTERVALS FROM LOGS	QUALITATIVE ASSESSMENT CUTTINGS POR.	IRON STAINING
5040-5050			tight	slight
5050-5060			tight	slight
5060-5070	5068		tight	moderate
5070-5080		5074	minor	moderate
5080-5090		5082 5085	minor-moderate	slight-mod.
5090-5100	P3-120/130		minor-moderate	slight
5100-5110	5107	5107	moderate	slight
5110-5120	5116		minor	slight
5120-5130	P3-150		trace	moderate
5130-5140	5133	5130-33	minor	moderate
5140-5150			trace	moderate
5150-5160			tight	moderate
5160-5170	5160		tight	moderate
5170-5180	P3-190 5179	5174-75	tight	moderate
5180-5190	5184	5184	trace	moderate
5190-5200	P3-230	5192	trace	mod.-strong
5200-5210	5207 5209		minor	mod.-strong
5210-5220	P3-240 5219	5212-19	tight	strong
5220-5230	5223	5227-30	minor	strong
5230-5240	P3-250 5231	5232-34	tight	strong
5240-5250	top P4 5244		tight	strong

TABLE 1 LOG INTERPRETATION AND CUTTINGS ASSESSMENT

SAMPLE DEPTH (ft)	LITHOLOGIC CATEGORIES 1	2	3	4	5	6	7
5040-5050	43	18	32	7	-	-	-
5080-5090	46	37	6	1	1	-	9
5090-5100	27	22	2	2	20	18	9
5100-5110	18	25	7	-	22	15	13
5160-5170	46	32	12	2	1	1	6
5180-5190	52	19	12	7	-	1	9
5210-5220	44	25	5	5	9	3	9
	TIGHT				POROUS		TIGHT NON-RESERVOIR

TABLE 2. THIN-SECTION ANALYSIS OF SELECTED CUTTINGS SAMPLES

Only the P3-120/130 sand shows any significant porosity and this occurs towards the lower half of the interval. The preliminary examination of cuttings did not rate any of the samples as showing major porosity and this is supported by the two thin-sections of the porous cuttings samples (5090'-5110') in which only 38% and 37% respectively of the total cuttings were rated as porous.

Other intervals indicated as porous on the logs revealed only a low percentage of porous cuttings in thin-section. The 5180'-5190' sample (top P3-230) was virtually devoid of porous cuttings and the 5210'-5220' sample (P3-240) contained only 12% of porous cuttings.

4. DISCUSSION

Even accepting the likelihood of some bias in the cuttings samples towards a concentration of the more highly cemented cuttings due to some loss of any extremely porous and friable cuttings which degrade to single grains, the proportion of obviously porous cuttings in even the most porous intervals is not high. Such a cuttings bias is also likely to be minimal in a reservoir as indurated as the Pacoota Sandstone.

The low percentage of porous cuttings may indicate that porosity is streaky within the porous zones probably due to variations in the extent of cementation by quartz overgrowths. In all samples the majority of non-porous cuttings consist of sandstone in which porosity has been obliterated almost entirely as a result of quartz overgrowth cementation. In the P3-230 and 240 samples around 70% of the cuttings have been totally cemented by quartz overgrowths and little else.

In the porous cuttings, porosity is mostly intergranular and occurs where quartz overgrowths have partly but not completely filled the intergranular spaces. Because overgrowths have partly occluded the pore space, pore sizes tend to be small. Only a few isolated examples of secondary porosity due to partial dissolution of feldspars were seen.

Assuming the cuttings examined are representative of the lithologies penetrated, then a qualitative assessment of the main porous intervals indicated on the logs suggests that the P3-230 and 240 sands are unlikely to flow and only the P3-120/130 sand seems capable of flowing and then only from its lower half. No thin-sections were made of samples covering some of the smaller porous intervals in the P3-250 and near the base of the P3-150 and 190 sands but the preliminary cuttings examination did not reveal significant porosity in any of these intervals and flow from them is considered unlikely.

The topmost sample examined in detail (5040'-5050') contains a considerable proportion (32%) of cuttings in which grains were clay coated or pores were clay-filled. These relatively clay-rich sands are mostly in the fine-very fine sand range. In all other thin-sections the proportion of clay-rich grains was lower with a maximum of 12% occurring in two samples.

Iron staining is widespread through the Pacoota P3 interval. The staining is due to the presence of haematite which imparts an obvious red-brown coloration to the cuttings. In thin-section however, it is apparent that the actual amount of haematite in the rocks is generally not high. It usually forms no more than a thin coating or film on the grains and it is usually located on the original rounded surface of the detrital sand grain and has then been enclosed within the later quartz overgrowths. In only a few cuttings did the iron appear to be sufficiently abundant to cause any significant porosity reduction. There is some indication both from the preliminary cuttings examination and also from thin-section study that the haematite coatings may be more prevalent in the finer grained sands. Otherwise there does not appear to be a strong relationship between the presence or absence of haematite coatings and porosity development. Data from Table 2 indicate that in the porous P3-120/130 interval, almost half of the porous cuttings are also haematite coated.

5. CONCLUSIONS

1. Preliminary identification of porosity in cuttings is generally in agreement with results of more detailed analysis in thin-section.

2. Even in the most porous zones within the P3 interval, porous cuttings make up less than 40% of the total cuttings and the majority are tightly cemented by quartz overgrowths.

3. Although there is some indication that haematite is more prevalent in the finer grained sandstones, there is no clear evidence that it plays a major role in porosity or permeability reduction. Most haematite staining is only a superficial layer which is often enclosed within later quartz overgrowth cement.

4. On the basis of the porosity indications in the samples, it is concluded that only the lower part of the P3-120/130 interval is likely to flow and even within this interval porosity may be streaky and discontinuous.

6. RECOMMENDATIONS

1. While it is comparatively straightforward to compare samples for differences in porosity, the actual assessment of the permeability and potential flow prospects of an interval on the basis of a cuttings examination is extremely difficult. A more reliable evaluation could be made if a number of samples were available as standards from other intervals whose flow performance and characteristics were better known. Consequently it is recommended that consideration be given to obtaining for comparative purposes cuttings samples from some earlier wells from which flows have been obtained to provide a more reliable standard from which to assess reservoir characteristics.