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Norske Murphy Oil Co.
Attn: Mr. Peter Taylor

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Wintershall Norge A/S
Attn: Dr. W. Stemmler

K/S A/S Polaris Oil Consortium
Attn: Mr. E. Flinder

Statoil
Attn: Mr. K. Helle

Forus, 8 June 1979
Ref: 12/00/01

BA 79-0130-1

Dear Sirs,

Subject: Comparison of geochemical reports from 3/5-1 and 3/5-2

Enclosed is one copy of a report from our research laboratories (GR&DC) at Harmarville, dated 11th May 1979. You will remember that when the work on the samples from the Rotliegendes in 3/5-1 was first done by Geochem Laboratories in England and GR&DC at Harmarville, there was a difference of opinion as to the presence or otherwise of migrated hydrocarbons. We think the present report goes as far as is possible towards resolving these differences.

The variations in some of the data generated by the two laboratories is due partly to different techniques but mainly to the difference in sample size; GR&DC composited the samples every sixty feet but Geochem analysed each ten foot sample separately. In retrospect we do not think that such a delicate analysis as was required can be reliably performed on such small, un-preserved (canned) samples as were available.

The relatively new technique of examining fluid inclusions under very high magnification is perhaps the most reliable indicator of the presence of some hydrocarbons within the Rotliegendes reservoir in well 3/5-1 but we do not think that it is possible to assess the significance of these minute quantities in resolving whether or not the Rotliegendes has acted as either a trap or migration pathway.

Yours very truly,

P.E.C. Reed

Encl.

cc: NPD
Attn: Mr. I. Aarseth

NHD/as

Rec'd 12/00/07
3/5-1
Evaluation of Geochem report by GR&DC.

FROM R. C. Burruss AT Harmarville DATE May 11, 1979

TO Dr. D. A. Jeffrey AT Harmarville REFERENCE 4224DC43

SUBJECT Evaluation of Geochem Labs (U.K.), Inc. Report, "Migrated Crude Oil Detection in Norske Gulf's 3/5-1 Well," and Comparison with GR&DC Analyses of Cuttings from the 3/5-1 and 3/5-2 Wells

As per the letter from P. E. C. Reed to R. V. Brodine (Attn: D. A. Jeffrey) dated January 17, 1979, the final report by Geochem Labs (U.K.), Inc. entitled "Migrated Crude Oil Detection in Norske Gulf's 3/5-1 Well" has been evaluated. The results of Geochem's study were examined for consistency and compared with the GR&DC cuttings extract data discussed in GR&DC Technical Memorandum No. 4225TJ094-R, "North Sea Source and Migration Study" by D. M. Demshur. In addition, thin sections of cuttings from the 3/5-1 and 3/5-2 wells were examined with fluorescence microscopy for hydrocarbon fluid inclusions and for free oil as streaming or bleeding cuts. Based on both GR&DC extract analyses and fluorescence observations, residues of migrated liquid hydrocarbons with an apparent Jurassic source are believed to be present in the Permian Rotliegendes section of the 3/5-1 well.

Evaluation of Geochem Labs (U.K.) Data

My confidence in the Geochem Labs interpretation is strongly limited by large internal inconsistencies in their C_{15}+ extract data and the apparent inappropriateness of their use of gasoline range hydrocarbon analysis for examination of migration "residues." In the first case, the apparent discrepancy between Geochem's reported total extract data and the % total organic carbon, in which samples at 10,170 ft, 10,290 ft, 10,320 ft, and 10,890 ft have between 4 and 8 times more extract than total organic carbon, is an artifact of the analysis. Geochem extracted the samples before performing the total organic carbon analysis (as per telecon between D. A. Jeffrey and N. Bailey, May 10, 1979). Although they justified this on the basis of small sample size (less than 1 gram for samples at 10,170 ft and 10,290 ft), it is completely unreasonable to use such small samples, especially in the presence of the pervasive sample contamination by drilling additives reported by Geochem Labs. Such small samples yield extremely small amounts of extract fractions (note some fraction weights reported in Geochem's Table 5A are less than 0.001 gm) which lead to large analytical weighing errors. In GR&DC procedures, we attempt to always use 50 gm samples and composite cuttings as necessary to do this. In this case, the GR&DC data are based on up to 60 ft interval composites as opposed to Geochem's 10 ft sample interval.

These contamination and weighing errors are emphasized by two aspects of the Geochem data. In their Tables 5A and 5B, the amount of extractable material (in ppm, Table 5B) inversely correlates with the weight of the sample, whereas no correlation should occur.

This strongly suggests gross contamination combined with weighing errors. The contamination is admitted by Geochem and is the only explanation for the rather unusual C_{15}^{+} saturate fraction GC patterns reported in their Figure 4.

Finally, the use of gasoline range analyses to look for "residues" of migrated liquid hydrocarbons in a water-wet reservoir rock (Rotliegendes sand) seems to be a poor choice. The small (C_4-C_7) hydrocarbon molecules to which this technique is sensitive have the highest aqueous solubilities (relative to C_{15}^{+} hydrocarbons). Thus, if aqueous pore fluid migration is still active in the Rotliegendes section, any C_4-C_7 residues of an earlier migrated oil (hopefully reservoired elsewhere) would be washed out. Indeed, the fact that Geochem Labs reported no results for gasoline range analyses of the deeper Rotliegendes samples is entirely consistent with this possibility.

GR&DC Total Extract Data, 3/5-1 and 3/5-2 Wells

In an attempt to determine the source of the hydrocarbon extracts from the Rotliegendes section of the 3/5-1, the total extract compositions (as weight % saturates, aromatics, asphaltenes, and resins or NSO's) of these samples were compared with those of the Zechstein section of 3/5-1 and the Jurassic section of 3/5-2. They were further compared with the Geochem Labs total extract data (their Table 5B). These comparisons appear in Figure 1, a triangular diagram of weight % saturates vs. aromatics vs. the sum of resins plus asphaltenes.

On examination of Figure 1, several points are obvious. First, the Upper and Mid-Jurassic extracts of the 3/5-2 well (possible source rocks) cluster in discrete fields. Second, the Rotliegendes extracts of 3/5-1 scatter widely across these Jurassic "fields" randomly, as we might expect for a migration "residue." Third, comparison with the Zechstein extracts of GR&DC and Geochem Labs in Figure 1 shows that the GR&DC Zechstein extracts are somewhat offset from the general scatter of the GR&DC Rotliegendes extracts. This suggests the Zechstein may not be the source of the Rotliegendes residues. Although the Geochem Labs extracts are somewhat similar to the GR&DC Zechstein extracts, they are strongly depleted in aromatics. The similarity may be fortuitous and strongly influenced by both sample contamination (reported by Geochem) and internal inconsistency in their data (see above).

Finally, the gas chromatographic patterns for the C_{15}^{+} saturate hydrocarbons at 10,340 ft (Rotliegendes) in the 3/5-1 well and 10,450'-10,480' and 10,660'-10,720' in the 3/5-2 well reported in the GR&DC report by D. M. Demshur are quite similar to each other. More important, they are similar to extracts of a typical mature, liquid hydrocarbon source rock. This further strengthens the argument that the Jurassic section penetrated in the 3/5-2 well is the source of hydrocarbons present in the Permian Rotliegendes section of the 3/5-1 well.

Comparison with Fluid Inclusion Observations and Fluorescence Microscopy

Fluid inclusions in sedimentary rocks form from very small amounts of subsurface fluids trapped within mineral grains either in overgrowths of clastic grains and cements or along healed microfractures.

hydrocarbon fluid inclusions can be detected by high magnification (500X) fluorescence microscopy. Furthermore, fluorescence microscopy also reveals small amounts of free hydrocarbons adsorbed on grain boundaries, oxide coatings, or open microfractures by the presence of "bleeding cuts" into the microscope immersion oil.

I examined samples from the Zechstein and Rotliegendes sections of the 3/5-1 well and part of the Jurassic section of 3/5-2 (spanning a mud-logged oil show) to establish if hydrocarbon inclusions were present and if so, if they displayed features allowing either the Zechstein and Rotliegendes to be correlated or the Rotliegendes of 3/5-1 to be correlated with the Jurassic of 3/5-2. Yellow fluorescent fluid inclusions occur in Zechstein carbonate grains in 3/5-1. Inclusions also occur in Rotliegendes samples at 10,390'-10,450' along a healed microfracture in a quartz grain and in a carbonate chip at 11,200 ft. Furthermore, oxide coated quartz grains at 11,200 ft gave a bleeding, yellow cut into the microscope immersion oil. These observations of inclusions and bleeding cuts in quartz grains in the mid and basal Rotliegendes strongly limit the probability that these hydrocarbons have a local Zechstein source.

Observations on the Jurassic of the 3/5-2 well revealed no fluid inclusions. However, several grains in each thin section prepared for the intervals 11,000'-11,060', 11,120'-11,180', and 11,360'-11,420' gave yellow fluorescent bleeding cuts similar to those observed in the 3/5-1 well cuttings at 11,200 ft. It is quite important to note here that the observations in the two wells are approximately depth equivalent and further that the mud logger reported a yellow fluorescent oil show at 11,060'-11,130' in the 3/5-2 well.

The similarities of the fluorescence microscopy results on laterally (depth) equivalent samples from the 3/5-1 and 3/5-2 wells and the concidence of this interval with an oil show in the 3/5-2 well strongly suggests the Jurassic section penetrated by 3/5-2 is the source of the traces of hydrocarbon liquid found in the Rotliegendes section of 3/5-1.

Conclusions

The GR&DC results from organic extract analysis and fluid inclusion observations both point to a possible Jurassic source for the traces of hydrocarbons found in the Permian Rotliegendes section penetrated by the 3/5-1 well. Although Geochem Labs (U.K.) disagrees with this conclusion, I am not confident in their interpretation for three reasons:

1. Large inconsistencies between organic carbon and C_{15}^+ extract data due to small sample size and subsequent analytical weighing errors.
2. Gross contamination of the C_{15}^+ saturate hydrocarbon fraction indicated by GC patterns.
3. Inappropriateness of gasoline range hydrocarbon analysis to the study of residues of previously migrated hydrocarbons.

R. C. Burruss

RCB:jmd
DAJ
TJW
Attachment

cc. w/att.: RVB, ESD, TJW, RCB, JGS-WHR

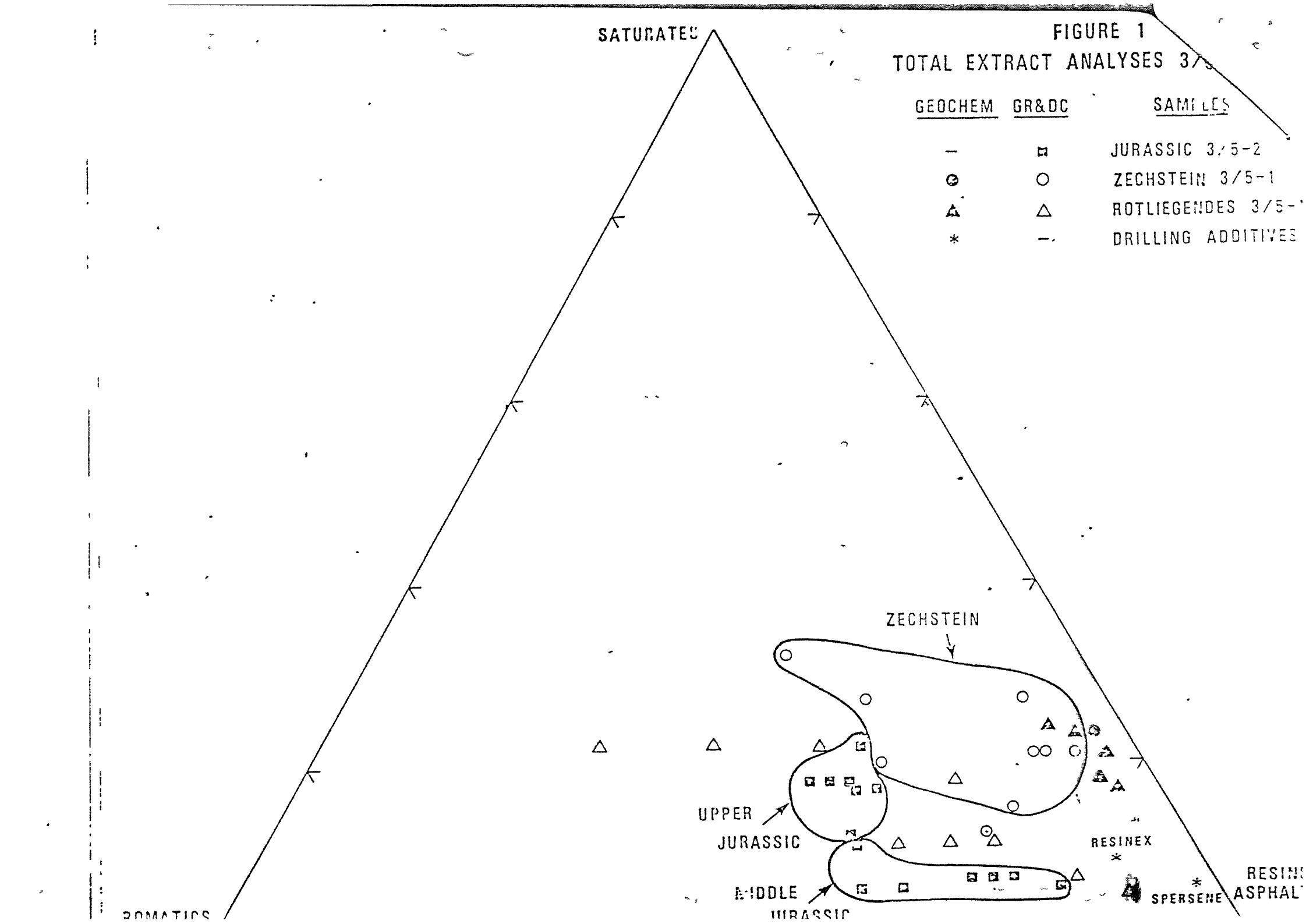

FIGURE 1

TOTAL EXTRACT ANALYSES 3/5

GEOCHEM	GR&DC	SAMPLES
—	▫	JURASSIC 3/5-2
⊖	○	ZECHSTEIN 3/5-1
⧋	△	ROTLIEGENDES 3/5-1
*	—	DRILLING ADDITIVES