U-16

I.S. 1670.

2/8-2 : Miocene - Lwr. Cret.

PAN AMERICAN PETROLEUM CORPORATION
RESEARCH CENTER

SOURCE ROCK EVALUATION

- Amoco Norway 2/8-2 -

Geochemistry Group

R. L. Ames
J. A. Williams
R. E. LaPlante

Distribution: K. D. Soule, Amoco Europe
E. K. Waering, Amoco Norway
Attn A. J. Snyder
S. A. Antoniuk, AIOC
W. R. Walton
J. A. Momper

Technical Service 7890CC
Amoco Norway Oil Company
December 2, 1970

James A. Wrayton
12-8-70

DISCUSSION

Source rock and elemental analyses have been completed on 12 sidewall cores of Tertiary shales and 2 core chips of Lower Cretaceous shales from the Amoco Norway 2/8-2 well. The sidewall cores were moist and well preserved on receipt due to the wrappings of aluminum foil and plastic bags. The sidewall cores were composited into sets of two in order to obtain enough extractable organic matter for chromatography and carbon isotope analysis.

Organic carbon values (Table 1) indicate that the Tertiary shales generally have average to above average petroleum-generating potential, particularly in the Oligocene. Whether this potential has been realized depends on the thermal history of the sediment and its exposure time and temperature requirements for hydrocarbon generation. In the Amoco Norway 2/8-2 well, the zone of peak generation evidently is confined to the Lower Eocene and older deposits. The indicated thickness of this zone, as determined from geochemical measurements, agrees fairly well with the interval predicted early in 1970 from exposure time-temperature considerations, using data available from the Amoco 22/18-1 well in U.K. waters.

From elemental analysis data (Table 2), the zone of significant hydrocarbon generation is indicated by a change from hydrogen enrichment to hydrogen depletion in the residual organic matter. Relative hydrogen enrichment in residual organic matter results from evolution of considerable CO_2 during early, low-temperature diagenesis. Hydrogen depletion results primarily from generation of hydrogen-rich hydrocarbons at a later, higher temperature stage of diagenesis. The evolution of CO_2 also continues during this stage. Figure 1 shows that hydrogen depletion begins at about 8000 feet in the Amoco Norway 2/8-2 well, indicating this to be the top of the zone of significant petroleum generation. Peak petroleum generation is indicated by elemental analysis to be occurring below about 9000 feet. Prior to geochemical analysis of any sediment or rock samples from the North Sea Tertiary Basin, it was predicted from available subsurface temperatures and time-stratigraphic data in the Amoco 22/18-1 well that peak generation should be taking place in the lower 500 to 1000 meters of the Tertiary sequence in the deepest parts of the Tertiary Basin. However, there was no information at the time when that conceptual interpretation was made which permitted a conclusion about the products generated. We did not know if the organic matter was sufficient or suitable for oil generation and expulsion.

Elemental analyses and extractable organic matter data have now provided important evidence as to the hydrocarbon types produced during organic diagenesis in the Paleocene and Lower Eocene. Previous studies have indicated that gas or gas condensate is the primary product from source bed sequences containing hydrogen-deficient organic material. In general, source beds undergoing hydrocarbon generation will provide principally oil from organic matter containing more than about 7 percent hydrogen, principally condensate and gas from material containing approximately 6 to 7 percent hydrogen, and mostly gas from organic material which contains less than about 6 percent hydrogen. Thus, the Amoco Norway 2/8-2 Tertiary samples contain organic matter that should produce mostly gas condensate and gas.

The relatively low extractable organic/total organic ratios in the samples from 9000 to 9600 feet confirm the conclusion that gas or gas condensate should be the dominant petroleum type formed during diagenesis. If liquid petroleum was the primary product of generation, the amount of extractable material should increase greatly in the zone of significant generation (below 8000 feet), with the extractable organic/total organic ratios attaining values of 0.08 to 0.12 in the peak generation zone (below 9000 feet). Small amounts of extract in potentially good source beds located within the peak generation zone suggest that gas or gas condensate rather than oil was the primary product of generation. The lighter hydrocarbons comprising natural gas and condensate are not recovered in normal extraction procedures.

The slightly higher extractable organic value for sample ANO-12 may be an indication of an increased capability for liquid hydrocarbon generation at depths below about 9500 feet. The top of the Danian limestone is reported

at 9680 feet, so if an oil-generating zone does exist in the 2/8-2 well, it would be relatively thin, assuming that the available samples are truly representative. It is not likely that such a small interval could have expelled enough oil to form multibillion barrel oil accumulations. However, it is possible that Paleocene source beds may locally be contributing enough oil to modify the correlation characteristics of oil accumulations which were derived from pre-Tertiary sources but which are located in Tertiary reservoirs.

Elemental analysis further shows that the organic matter in the Lower Cretaceous shales has attained a much higher degree of carbonization than the organic matter in the basal Tertiary shales. Figure 1 demonstrates that the increase is more than can be expected by projecting the carbonization trend established in the Tertiary. This suggests that the composition of the organic matter in this interval of the Lower Cretaceous shale reflects a previous burial history that has been obscured by uplift and erosion. In fact, the anomalously low hydrogen and high oxygen percentages in the organic matter in ANO-13 possibly evince the oxidized weathering zone at an unconformity surface. The elemental composition of ANO-14 is consistent with this interpretation in that the hydrogen is slightly low and the oxygen high for such a high degree of carbonization. Organic matter with a similar composition recently has been obtained from partially oxidized outcrop samples.

Samples of unweathered Lower Cretaceous and Jurassic shales will be needed to localize the primary source beds for the oil in the Danian and Cretaceous reservoirs. There is also a possibility that the oil-generating capability of Tertiary source beds is much greater in other parts of the Tertiary Basin. If so, it is expected that samples from Torfelt Field (Amoco Norway 2/5-1) now in process and samples from Amoco Norway 2/11-1 will provide an indication that greater oil-forming capability occurs elsewhere in this province. Cuttings from Amoco 2/8-1 are also in process at this time.

CE Amoco Europe Inc. AREA North Sea

IORIZED BY E. K. Waering DATE 8-5-70

INICAL SERVICE NUMBER 7890CC

E (PROVINCE) Norwegian Sector COUNTY WELL LOCATION Amoco Norway 2/8-2

PAN AMERICAN PETROLEUM CORPORATION
RESEARCH CENTER
SOURCE ROCK EVALUATIONS

SAMPLE			FORMATION	LITHOLOGY	DEPTH	INSOLUBLE RESIDUE %	ORGANIC CARBON WT. %	EXTRACTABLE ORGANIC Bbl/ACRE FT.	EXTRACT. HYDROCARBON Bbl/ACRE FT.	EXTRACT. ORG./TOTAL ORG.	RATING	REMARKS
IER	TYPE	QUALITY										
1	SWC	Good	Miocene	shaly ls	5090 + 5210	39.6	0.7	5.7*	2.5*	0.03	Fair, potential	See Table 2
2	"	"	"	shale	5400 + 5600	91.8	1.5	1.1	0.4	< 0.01	Very good, potential	"
3	"	"	Miocene and Oligocene	"	5800 + 6000	91.6	1.9	2.0	0.5	< 0.01	"	"
4	"	"	Oligocene	"	6200 + 6410	92.5	2.6	1.9	0.5	< 0.01	"	"
5	"	"	"	"	6600 + 6790	89.7	2.0	4.2	1.6	< 0.01	"	"
6	"	"	"	"	7000 + 7200	89.2	1.2	2.8	1.5	0.01	Good, potential	"
7	"	"	"	"	7400 + 7600	90.4	1.0	3.2	1.5	0.01	"	"
8	"	"	"	"	7800 + 8000	91.4	0.9	3.3	1.7	0.02	Fair***	"
9	"	"	Mid-Upper Eocene	"	8200 + 8410	91.1	0.9	2.5	1.1	0.01	" ***	"
10	"	"	Lower Eocene	"	8590 + 8800	88.5	0.4	2.0	1.0	0.02	Poor***	"
11	"	"	Lower Eocene and Paleocene	"	9000 + 9200	91.8	1.0	2.9	1.3	0.01	Good***	Effective Gas-Cond.
12	"	"	Paleocene	"	9400 + 9610	91.2	0.8	6.9	2.4	0.03	Fair***	Source ? "
13	Core	"	Lower Cretaceous	"	10,603	68.0	0.3	0.4	**	< 0.01	Nonsource	Weathered
14	"	"	"	"	10,621	88.4	0.5	0.5	0.3	< 0.01	Poor	

LOG TEMPERATURE: 137°F @ 5081', 192°F @ 9717', 206°F @ 10,654'. FORMATION TOPS: Danian Ls. 9680'; U. Cret. 10151'; L. Cret. 10,588'

RKS:

eavy hydrocarbon patterns suggest the presence of migrated oil.

ot enough extractable hydrocarbon for measurement.

amples 8 thru 12 are indicated by elemental analysis (Table 2) to be in a tage of significant generation. This interval does not appear to have been an effective source for oil, but may have been an effective source for gas or gas condensate (see attached discussion).

ANALYST

DATE 12-2-70

TABLE 1

Amoco Europe, Inc. AREA North Sea

ZED BY E. K. Waering DATE 8-5-70

AL SERVICE NUMBER 7890CC

PROVINCE) Norwegian Sector COUNTY WELL LOCATION Amoco Norway 2/8-2

PAN AMERICAN PETROLEUM CORPORATION
RESEARCH CENTER
ORGANIC DIAGENESIS DATA

AMPLE TYPE	AMPLE QUALITY	FORMATION	LITHOLOGY	DEPTH	ELEMENTAL ANALYSIS, PERCENT CARBON	HYDROGEN	OXYGEN	NITROGEN	RATIO H/C	STATE OF DIAGENESIS	HYDROCARBON TYPE BY % HYDROGEN	PYROLYSIS
SWC	Good	SAMPLE LOST										
"	"	Miocene		5400-5600	71.63	6.47	18.59	3.31	1.08	Pre-generation	gas-condensate	
"	"	Miocene and Oligocene		5800-6000	74.91	6.33	16.15	2.61	1.01	"	"	
"	"	Oligocene		6200-6410	73.47	5.62	18.56	2.36	0.92	"	gas	
"	"	"		6600-6790	73.68	6.01	18.28	2.03	0.98	"	gas-condensate	
"	"	"		7000-7200	75.87	6.32	15.32	2.49	1.00	"	"	
"	"	"		7400-7600	74.40	6.36	16.84	2.39	1.03	"	"	
"	"	"		7800-8000	76.75	6.65	14.15	2.46	1.04	Early generation	"	
"	"	Mid-Upper Eocene		8200-8410	76.90	6.57	14.12	2.42	1.02	"	"	
"	"	Lower Eocene		8590-8800	73.45	5.90	18.05	2.60	0.96	"	"	
"	"	Lower Eocene and Paleocene		9000-9200	78.11	6.19	12.58	3.12	0.95	Peak generation	"	
"	"	Paleocene		9400-9610	78.65	5.35	13.84	2.16	0.82	"	"	
Core	"	Lower Cretaceous		10,603	82.44	*1.73	*14.38	1.46	0.25	Past peak generation	gas	
"	"	"		10,621	84.22	3.56	10.54	1.69	0.51	"	"	

In the Gulf Coast gas condensate production is associated with beds containing organic matter with approximately 6 percent hydrogen.

y weathered interval indicated.

Log temp. 192°F @ 9,717'
206°F @ 10,654'
137°F @ 5,081'

ANALYST R. E. La Plante C. A. Williams DATE 12-2-70

TABLE 2

Figure 1

ELEMENTAL ANALYSIS of RESIDUAL ORGANIC MATTER

Amoco Norway 2/8-2

Technical Service 7890 CC