APPENDIX IV: JOIDES CORES–EVIDENCE OF MIGRATION OF HYDROCARBONS IN PLEISTOCENE SEDIMENTS OF THE SHATSKY PLATEAU, WESTERN PACIFIC OCEAN

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ABSTRACT

A survey of organic carbon and hydrocarbon contents in six DSDP cores revealed a Pleistocene abyssal sample so anomalously rich in heavy hydrocarbons that the hydrocarbons must have migrated from surrounding sediments. This sample, from the Shatsky Plateau of the western Pacific Ocean, contains over a hundred parts per million heavy hydrocarbons but less than a tenth of a per cent organic carbon.

Four other abyssal samples and one bathyl sample contain low amounts of both hydrocarbons and organic carbon and are comparable to some DSDP Leg 1 samples analyzed earlier.

INTRODUCTION

As part of the continuing survey of composition and properties of DSDP cores, samples have been taken from the cores at many drilling sites and quickfrozen especially for organic geochemical studies. All such samples from Legs 4, 5 and 6 were analyzed for their organic carbon contents by the Department of Chemistry, Woods Hole Oceanographic Institute. From among these, six were selected for further analyses at Esso Production Research Company because they had relatively high organic carbon contents or were dark in color, two properties that often indicate the presence of significant quantities of hydrocarbons. DSDP identification and descriptions of these samples are given in Table 1. Sample 1 is from beneath the Caribbean near the Lesser Antilles; Samples 2 and 3 are from the eastern Pacific off northern California; Samples 4 through 6 are from the Shatsky Plateau under the western Pacific.

BITUMEN AND HYDROCARBON CONTENTS

Each sample was analyzed for its content of gasoline-range (C_4-C_7) hydrocarbons, total extractable organic matter (bitumens) and C_{15}+ hydrocarbons by procedures published by Dunton and Hunt (1962) and Gehman (1962).

Results are shown in Table 2. Gasoline-range (C_4 to C_7) hydrocarbons are not included because they were found only in trace quantities–right at the limit of detection of our method (0.04 ppm) for all six samples. This lack of light hydrocarbons confirms that the samples, like those abyssal samples from the Gulf of Mexico (Koons, 1970), are juvenile. Maturation, necessary for generation of gasoline-range hydrocarbons in quantities typical of ancient rocks (Dunton and Hunt, 1962), has not occurred.

Organic carbon contents range between 0.08 and 0.45 per cent on a dry weight basis, and are very similar to some of the values (0.11 to 0.84 per cent) reported by Koons for three abyssal samples from Leg 1 in the Gulf of Mexico and another from the Bermuda Rise in the Western Atlantic. These organic carbon contents are also in about the same range (0.04 to 0.31 per cent) as in bathyl samples from core-holes J-3, J-4 and J-6 from the 1965 JOIDES Program (Bray and Evans, 1969). Hence in total organic carbon contents there was nothing unusual about these six samples.

Nor was there anything unusual about the heavy hydrocarbon contents in three of them, Samples 1, 2 and 3. They range from 35 to 42 ppm–in the same range (<4 to 46 ppm) reported by Koons, and somewhat above the range (5 to 23 ppm) reported by Bray and Evans. Hence these new samples do not appear to be petroleum source rocks as defined by Philippi (1957).

The anomalous sample is Sample 5, one of the three samples from the Shatsky Plateau. Although it is the leanest in organic carbon of the three, or of any abyssal JOIDES samples reported to date, and in the same range as a few bathyl samples reported by Bray and Evans, it has much more heavy hydrocarbon. The ratio of C_{15}+ hydrocarbon to organic carbon is 0.13, or larger than ratios reported for either ancient or Recent nonreservoir rocks. It is twice as rich in hydrocarbon relative to organic carbon as the mean (geometric) ancient carbonate rock reported by Hunt (1961) and Gehman (1962), richer than Recent carbonates (Gehman), and similar to only one carbonate sample of undetermined age reported by Neruchev (1962). Moreover the ratio is far above the values (0.01 and lower) found by Kidwell (1958) on the lowest organic-carbon (0.2 to 0.4 per cent) samples from the Gulf of Batabano. It is also far above the values of the hydrocarbon to organic carbon ratio (about 0.01) of low organic carbon (0.09-0.05 per cent) bathyl carbonate samples reported by Bray and Evans.

TABLE 1
DSDP Abyssal Sediment Samples, Legs 4, 5 and 6

Sample	Leg	Site	Core	Section	Location	Water Depth (meters)	Depth below Sea Floor (meters)	Description	Age
1	4	30	7	1	12°52.9′N 63°23.0′W	1218	260	Gray to green calcareous clays	Pliocene
2	5	34	5	4	39°28.2′N 127°16.5′W	4322	122	Clayey silt to silty clay, radiolarian mud, clay mud; patches of chalk ooze; diatoms locally abundant	Lower Pliocene
3	5	35-0	6	3	40°40.4′N 127°28.5′W	3373	166	Zeolitic clays, rhythmically banded, dark and light green-grays, some small calcite plates	Pleistocene
4	6	47-0	1	4	32°26.9′N 157°42.7′E	2689	2	Interlayered light olive, greenish and yellowish-gray foraminiferal-nannoplankton marl and chalk ooze	Pleistocene
5	6	49-0	1	3	32°24.1′N 156°35.0′N	4282	4	Brown sandy volcanic mud with 45% clay minerals, 45% glass fragments; trace feldspars and detritals	Lower Pleistocene
6	6	50-1	1	1	32°24.2′N 156°36.0′E	4487	7	Dark yellowish-brown to brown clay; rich (up to 45%) in siliceous fossils, primarily diatoms, some Radiolaria; 5-15% glass, 30-45% clays	Pleistocene

TABLE 2
Geochemical Data on DSDP Samples from Legs 4, 5 and 6

Sample	Organic[a] Carbon wt. per cent	Heavy (C_{15}+) Hydrocarbons, ppm			Total Extractable Organic Matter ppm
		Total	Saturates	Aromatics	
1	0.45	35	17	18	114
2	0.43	42	22	20	123
3	0.39	42	24	18	109
4	0.30	<4	–	–	<10
5	0.08	102	67	35	174
6	0.13	<4	–	–	<10

[a]Data provided by Woods Hole Oceanographic Institute, Chemistry Department.

Similarly, the ratio (0.22) of extractable organic matter (i.e., bitumen) to organic carbon in the anomalous sample is higher than in other abyssal JOIDES samples (0.01 to 0.02) studied by Koons, and bathyl carbonates (0.04 to 0.06) studied by Bray and Evans.

The saturate to aromatic hydrocarbon ratio (1.9) of Sample 5 is about twice that of Samples 1, 2 and 3, and is also about twice as high as those in clastics from DSDP Leg 1, reported by Koons. However the ratio is in the lower range of values in the carbonate-rich bathyl muds analyzed by Bray and Evans.

CONCLUSIONS

Although DSDP samples analyzed to date do not include any sediments thought to be important as source rocks of petroleum, one from Hole 49-0, on the Shatsky Plateau has such high bitumen and C_{15}+ hydrocarbon contents, it appears to contain hydrocarbons and other bitumens that have moved from other abyssal sediments surrounding or beneath it. If the other two Shatsky Plateau samples (Samples 4 and 6) are representative, relative enrichment in this sample over its neighbors is greater than in an embryonic accumulation in a small lenticular sand at Pedernales (Kidwell and Hunt, 1958), although absolute hydrocarbon contents are about the same. Therefore, while this sample cannot be termed a seep or a saturation, such as the spectacular one found on one of the Sigsbee Knolls (Gealy and Davies, 1969), it does provide additional evidence that petroleum migration has already begun in some relatively juvenile abyssal sediments.

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