BIODEGRADATION OF OIL RESERVOIRS

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The origin and history of the Athabasca and associated oil sands formation is concerned with the possibility that the oil sand bitumen is the microbiologically degraded residue of conventional crude oils rather than the alternative an abnormal diagenetic history not involving microbial degradation. Microbial degradation of the oil sand bitumen should be minimal if it is in fact the end product of the degradation of conventional crude oils. For comparative purposes we have studied the effect of microbiological degradation on several conventional pooled oil reservoirs and on oil sand bitumens.

The model systems employed a typical conventional crude oil from Prudhoe Bay, and samples from the Kumak well in the MacKenzie delta. The Kumak samples are of particular interest since production occurs from three zones at A (1353 m., 49°C), B (2148 m., 62°C) and C (2306 m., 67°C), geologically these samples are believed to be of common

origin, but the change in physical properties are believed to be due to biodegradation (1).

The microorganisms were grown using minimal salts media in a gyratory shaker under aerobic conditions at 30°C. 0.2 g to 1 g of oil was incubated. The cultures were obtained from an enrichment of Shell Lake (NWT) soil using either Normal Wells or Kumak (A, B or C) crude oils. From Norman Wells enrichment the mixed culture contained six different species based on the type of colony produced. The mixture consisted of approximately 90% Gram-negative rods and 10% Gram-positive coryneform type rod. The pure culture obtained was the Gram-positive coryneform isolated from the mixed culture. From the different Kumak enrichments the cultures obtained were characterized by an abundance of pseudomonas type rods.

The principal analytical method used was a gas chromatography-mass spectrometry computer system employing multiple ion cross scans (MICS). Visual comparisons between MICS of various samples gives an immediate graphic indication of similarities and differences. The oil was extracted from the culture medium with chloroform, filtered, and separated into three major components by absorption chromatography on Silica Gel (2).

Table 1 reports some of the data on the Kumak samples along with our analysis of the percentage of saturated, aromatic and polar components contained in the bitumens. The

Table 1. The effect of biodegradation upon fractions from three production zones of KUMAK J-06, MacKenzie Delta.

Sample	Culture Method	Fraction Sat.	Arom.	Polar	Recovery	Pour Point °C
KUMAK A	media washed	48%	48%	5%	-	-34
	SLK C*	47	46	7	92%	-
	SLK B	48	44	7	97	-
	SLK A	46	50	4	100	-
KUMAK B	media washed	46	50	4	-	+8
	SLK C	37	57	6	97	+6
	SLK B	39	56	5	75	+4
	SLK A	54	41	5	75	-
KUMAK C	media washed	51	45	4	-	+13
	SLK C	40	55	4	71	-37
	SLK A	51	45	4	-	-
	UREA**	35	61	4	86	-47

*Shell Lake culture grown on KUMAK C then transferred to sample. **Non-adduct of urea clathration of crude oil.

removal of n-alkanes from KUMAK C converts it to a sample much like that of KUMAK A in terms of its physical properties. This supports the hypothesis of Burns et al. (1) that the oil from the shallowest zone has been subjected to biodegradation. The gc-ms patterns for the samples of biodegraded material from the deeper zones (KUMAK B and C) strongly resembled those for A.

We then examined samples of a Prudhoe Bay (PB) crude for comparison with Lower Cretaceous pooled oils such as Bellshill Lake (BH) and Lloydminster (Ll) along with oil sand bitumens from the Cold Lake (CL), Peace River (PR) and Athabasca oil sands. The analytical data from these samples are presented graphically in Figure 1.

The gc-ms reveal close similarities between the biodegradation products of the oil from Prudhoe Bay and the oil sands and heavy oils of Alberta. We are not postulating a common source for all of these oils, although they probably share a similar origin and diagenetic history. These results do not give a direct indication as to the maturity and thermal history of the Alberta oil sands but they do support the hypothesis that the oil sands, and some conventional crude oils found in the reservoirs of the Lower Cretaceous formation of Alberta share a common origin and are related by their degrees of biodegradation.

1. B.J. Burns, J.T.C. Hogarth and C.W.D. Milner, Bull. Can. Pet. Geol., 23, 295 (1975).

2. I. Rubinstein, O.P. Strausz, C. Spyckerelle, R.J. Crawford and D.W.S. Westlake, to be published.

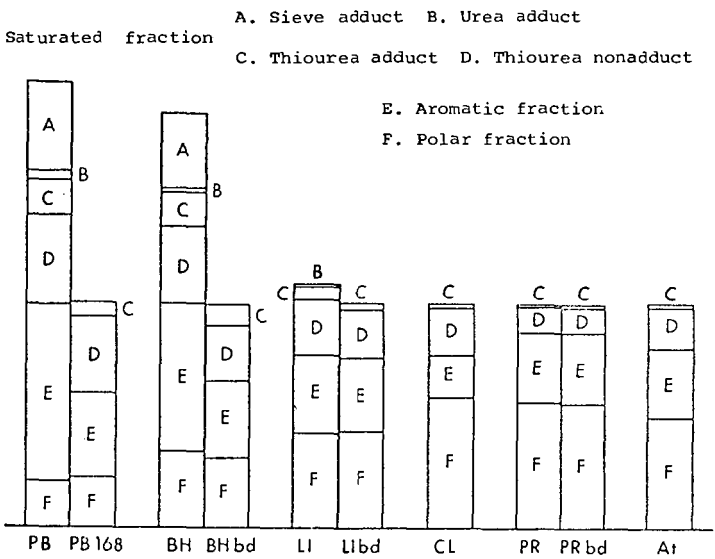

Figure 1. Gravimetric analyses of the Prudhoe Bay oils and the Alberta oils and bitumens.