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Thermal history and organic maturation of Paleozoic rocks,
Pocatello Area, Southeastern Idaho

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THERMAL HISTORY AND ORGANIC MATURATION OF PALEOZOIC ROCKS,
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ABSTRACT

Study of organic maturation of Paleozoic rocks in the vicinity of the Fort Hall Indian Reservation revises prior interpretations of thermal history. Prior studies indicated that the black organic-rich shales of the Meade Peak Member of the Permian Phosphoria Formation at the Gay phosphate mine were heated beyond the oil generation window due to burial prior to unroofing during the Cretaceous Sevier orogeny. Instead, the supermature organic matter resulted from Tertiary hydrothermal and/or igneous activity that had only local heating effects.

Reinterpretation of structural relations along the Putnam thrust in the northeastern part of the Fort Hall Indian Reservation show that allochthonous lower Paleozoic strata overlie parautochthonous Meade Peak Member of the Permian Phosphoria Formation. These relations are contrary to the interpretations of Trimble (1982) who showed Triassic rocks overlying Ordovician rocks due to Sevier thrusting. The supermature lower Paleozoic rocks in the Putnam allochthon may have been heated in a setting to the west prior to eastward thrusting in Cretaceous time. Our interpretation of lower Paleozoic strata thrust over the Permian Meade Peak Member during the Cretaceous Sevier orogeny enhances the possibility of hydrocarbon generation after Sevier folding and thrusting. Extensive Tertiary basin-range block faulting may locally militate against hydrocarbon preservation in reservoirs of Paleozoic and Mesozoic rocks.

INTRODUCTION

Prior maturation studies of black shale samples from the Permian Meade Peak Member at the Gay phosphate mine (Claypool and others, 1978) concluded that these organic-rich rocks were metamorphosed (supermature) beyond the oil generation window due to burial before development of the Sevier thrust system in late Mesozoic time. Harris and others (1980) reported conodont alteration index (CAI) values of 2-2.5 and 2.5-3, respectively, for Permian strata in the Gay mine area; these CAI values indicate heating above the thermal window for oil generation.

Field studies in 1984 indicated that some of the organic-rich beds in the Gay mine area did not appear to be metamorphosed (supermature), so we sampled these strata for further study.

Our reassessment of thermal alteration in the Gay phosphate mine area of the Fort Hall Indian Reservation is based on conodont color alteration and Rock-Eval analysis. In addition to samples from the Gay mine area, conodont color data were obtained on three samples of Oquirrh Formation (Pennsylvanian-Lower Permian) west of Bannock Creek in the Deep Creek Range.

STRUCTURAL RELATIONS ALONG THE PUTNAM THRUST

Recent geologic mapping (Hladky, 1986; F.R. Hladky and K.S. Kellogg, unpublished data) in the Yandell Springs 7 1/2-minute quadrangle and USGS phosphate exploration drilling west of the Gay phosphate mine in 1986 demonstrates that in some places the Pennsylvanian Wells Formation overlies the Triassic Dinwoody Formation or the Permian Phosphoria Formation in thrust

contact. These field relations show that thrusting during the Sevier orogeny resulted in older-rock over younger-rock structural relations, which also has been demonstrated for the Sevier thrust belt in extensive areas of southeastern Idaho by Oriel and Platt (1980).

Structural relations along the Putnam thrust in the northeastern part of the study area (fig. 1) show that allochthonous lower Paleozoic strata overlies parautochthonous Meade Peak Member of the Permian Phosphoria Formation. These relations are contrary to the interpretations of Trimble (1982) who showed Triassic rocks overlying Ordovician rocks due to Sevier-age thrusting. The supermature lower Paleozoic rocks in the Putnam allochthon may have been heated in a setting to the west prior to eastward thrusting in Cretaceous time. Our interpretation of lower Paleozoic strata thrust over the Permian Meade Peak Member during the Cretaceous Sevier orogeny enhances the possibility of hydrocarbon generation after Sevier folding and thrusting. The possibility of hydrocarbon preservation in reservoirs is uncertain.

RESULTS

The locations of our samples are shown on Figure 1. Table 1 gives the location, age, and thermal alteration according to CAI (Conodont Color Alteration Index) values. Table 2 gives the organic geochemical data obtained from Rock-Eval analysis of six samples from three localities in the Gay phosphate mine area. These data show that the Permian Meade Peak Member of the Phosphoria Formation is within the window for oil generation.

Two samples of Lower Pennsylvanian Wells Formation from the southern ridge-crest of Dare Peak, adjacent to and west of the Gay mine, have CAI values of 1.5-2 (loc. 4, table 1); this range of values is in the upper part of the thermal window for oil generation (Harris and others, 1980).

Ordovician samples from the upper plate of the Putnam thrust west of the Gay phosphate mine (loc. 5, 6, fig. 1, table 1) have CAI values of 3.5; these values are consistent with burial depths of allochthonous strata estimated to be about 5-6 km (16,000-20,000 ft) as a result of pre-Sevier thrust stacking. These burial depths are compatible with the Ordovician CAI data of Harris (1979). The higher thermal history of the lower Paleozoic rocks in the Putnam allochthon suggests that they were transported eastward from an area to the west that had elevated rock temperatures prior to Cretaceous Sevier folding and thrusting.

CAI data for the Pennsylvanian part of the Oquirrh Formation west of Bannock Peak (loc. 7, 8, 9, fig. 1, table 1 and fig. 2) show a wide range of thermal alteration. The wide range of CAI values in a single sample of unit A of the Oquirrh Formation indicates hydrothermal activity and/or contact metamorphism (Anita G. Harris, 1985, written commun.). CAI values for the unit B sample (loc. 8, table 1, fig. 1) of the Oquirrh Formation are also the result of thermal alteration other than burial because the CAI value of 1.5 for the sample from unit C (loc. 9) of the Oquirrh would be consistent with a burial depth of about 1.2-1.4 km (4,000-8,000 ft), according to Harris (1979).

Data obtained from Rock-Eval analysis and conodont alteration colors indicate that post Late Pennsylvanian strata in the Pocatello area were not altered beyond the thermal window of oil generation (CAI = 1-2, Harris and others, 1980) due to burial before the Sevier orogen. We suspect that the sample studied by Claypool and others (1978) from the Meade Peak shale at the Gay mine was either oxidized or altered by weathering and/or biological degradation.

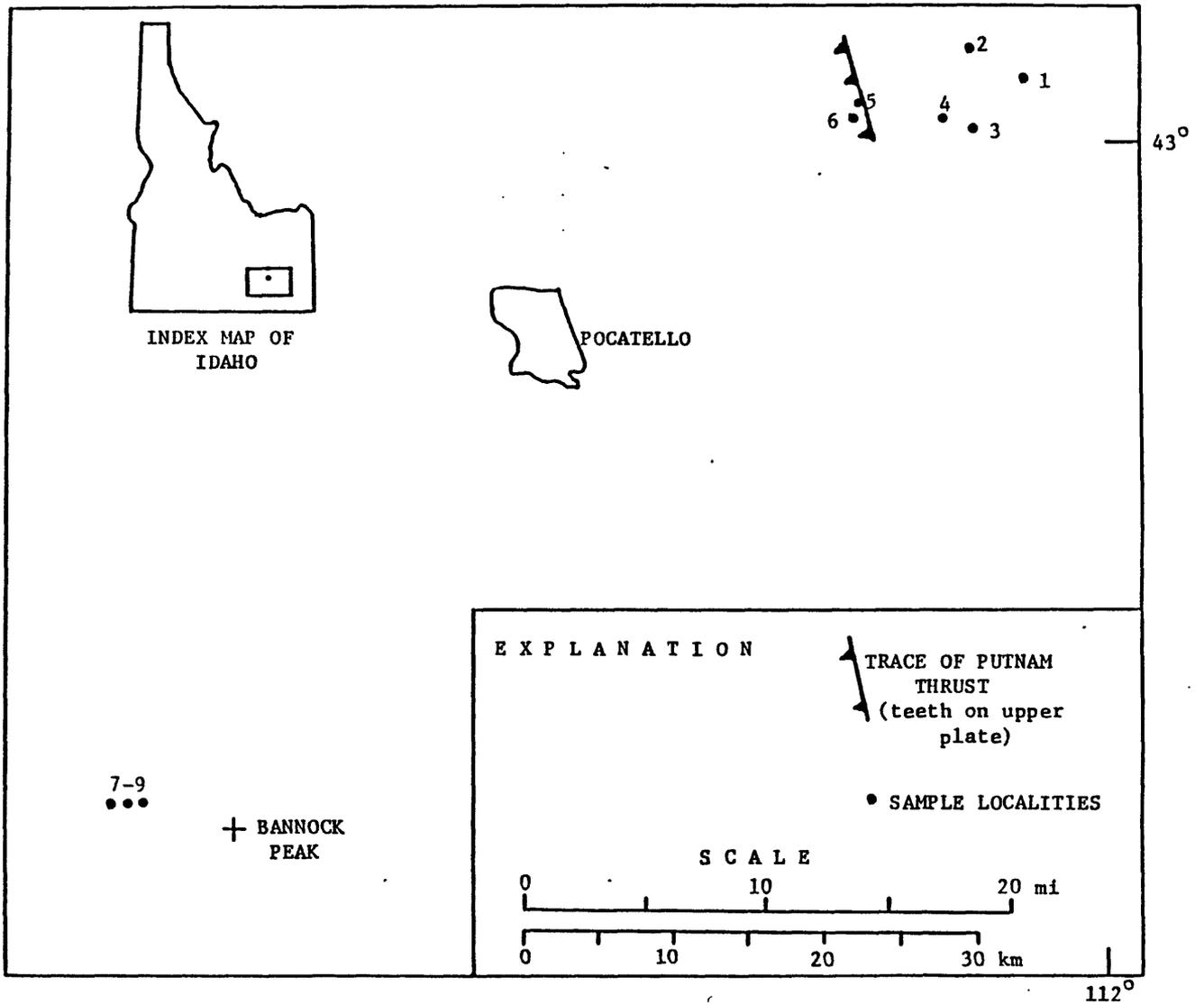


Figure 1.--Location of samples for thermal alteration studies in the Pocatello, Idaho area.

Table 1.--Location, age, thermal alteration and comments on Paleozoic rock samples on and near the Fort Hall Indian Reservation in Idaho

[Sample localities numbered on Figure 1]

Locality	Formation, age	Location	Thermal history information	Comments
1	Meade Peak Member, Phosphoria Formation Permian	SE, 32, T4S., R38E Bingham County	Rock-Eval analysis indicates samples are not beyond the oil generation window (Table 2)	Autochthonous
2	Meade Peak Member, Phosphoria Formation Permian	SE, SE, 15, T4S., R37E Bingham County	--do--	--do--
3	Meade Peak Member, Phosphoria Formation Permian	S 1/2, 3, T5S, R37E Bannock County	--do--	--do--
4	Wells Formation, Lower Pennsylvanian	Sen, SW, 4, T5S, R37E Bannock County	CAI values ¹ of 1.5-2 for two samples; at least 60-90°C	Parautochthonous
5	Lower Member, Fish Haven Dolostone, Upper Ordovician	NE, SE, 35, T4S, R36E Bingham County	CAI value of 3.5 for one sample; at least 180°C	Upper plate of Putnam Thrust; allochthonous from west
6	Garden City Limestone Lower Ordovician	Sen, NW, 2, T5S, R36E Bannock County	CAI value of 3.5 for one sample; at least 180°C	--do--
7	Unit A, Oquirrh Formation Lower Pennsylvanian	NW, NW, 1, T10S, R31E Power County	CAI values of 4, 5.5 & 6 for one sample; at least 200°C	Allochthonous; alteration indicates hydrothermal effect
8	Unit B, Oquirrh Formation Pennsylvanian	SE, SW, 36, T9S, R31E Power County	CAI value of 2.5-3 for one sample; at least 110-150°C	Allochthonous
9	Unit C, Oquirrh Formation Middle to Upper Pennsylvanian	Sen, SE, 36, T9S, R31E Power County	CAI value of 1.5 for one sample; at least 60°C	Allochthonous

¹All CAI determinations by Anita G. Harris; Rock-Eval by Ted Daws

Table 2.--Organic geochemical data for the Meade Peak Member of Phosphoria Formation, Gay phosphate mining area, Fort Hall Indian Reservation, Bingham and Bannock Counties, Idaho.

[TOC = total organic carbon, S₁ = volatile hydrocarbon fraction, S₂ = pyrolyzable hydrocarbons, T_{max} = maximum temperature of S₂ peak, ppm = parts per million, H index - milligrams of hydrocarbon per gram of total organic carbon, O index - milligrams of carbon dioxide per gram of total organic carbon]

Sample No., Location and (Sample type)	TOC (wt.%)	S ₁ (mg/gram)	S ₂ (mg/gram)	Production index		H index (mgHc/ gramTOC)	O index (mg CO ₂ / gram TOC)	T _{max} (°C)
				$\frac{S_1}{S_1 + S_2}$	$\frac{S_2}{S_1 + S_2}$			
83FP-211, SE, 32, T4S R38E (grab sample from face, X-2 pit)	10.6	.33	9.2	0.03		86	27	442
83FP-213, loc. as 211 (grab sample from face, X-2 pit)	22.6	.63	22	.03		99	17	451
83FP-215, SE, SE, 15, T4S, R37E (0.5 m thick channel sample from mine face)	22.6	1.9	26	.07		110	5	454
83FP-216, loc. as 215 (0.5 m thick channel sample from mine face)	21.3	2.1	25	.08		120	6	455
S40-67088-91, S1/2, 3, T5S, R37E (drill cuttings from 88-91 ft depth)	8.8	.48	7.3	.06		82	3	457
S40-67092-97, loc. as above (drill cuttings from 92-97 ft depth)	8.1	.42	9.5	.04		120	6	451

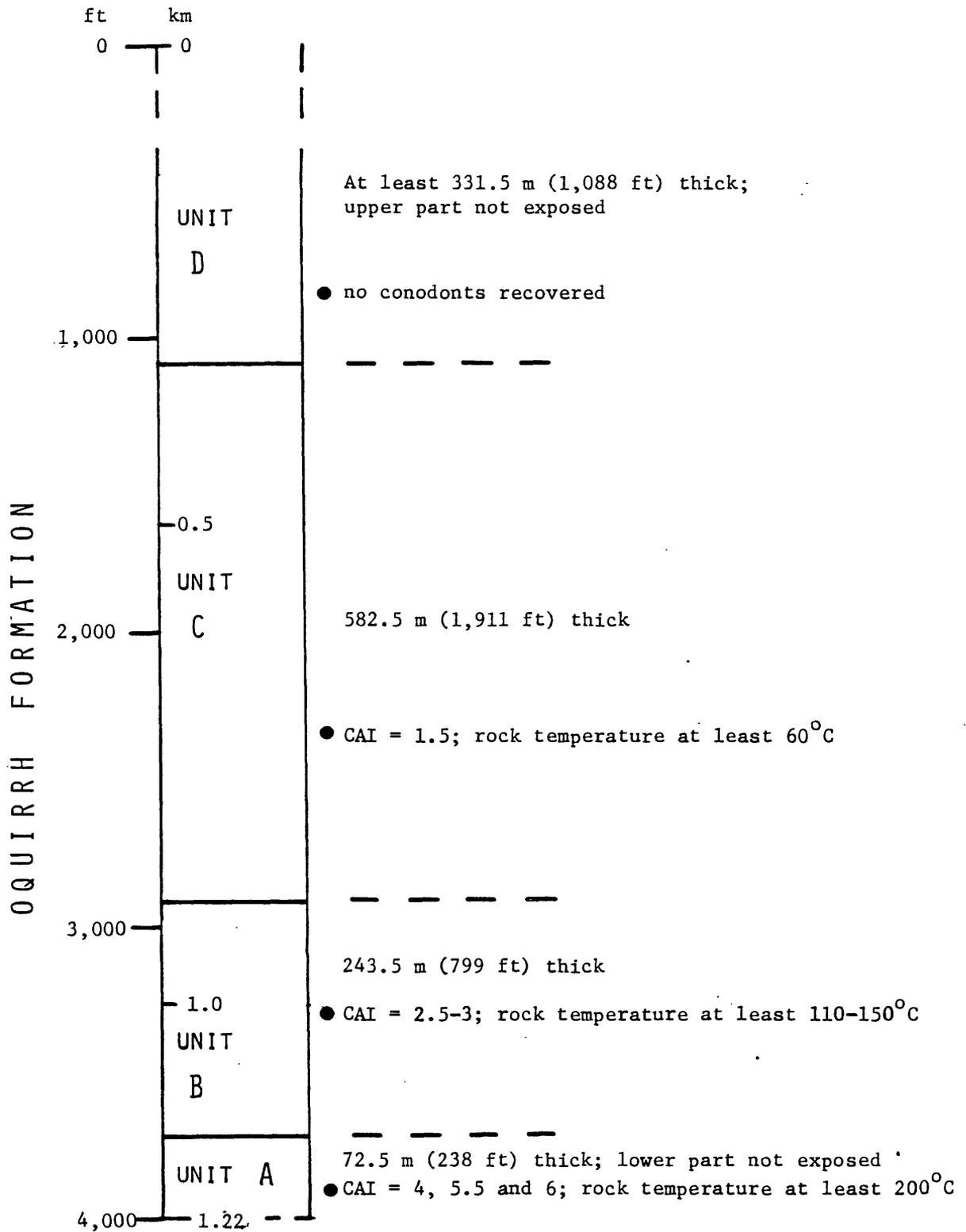


Figure 2.--Conodont alteration index (CAI) data (measured by Anita Harris) for the Oquirrh Formation 3 to 4 miles west of Bannock Peak (fig. 1 and table 1). Measured section number seven of Trimble and Carr (1976, p. 98). Black dots show approximate position of samples.

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