POTENTIAL BY-PRODUCTS FROM OIL SHALE PICEANCE BASIN, COLORADO

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INTRODUCTION

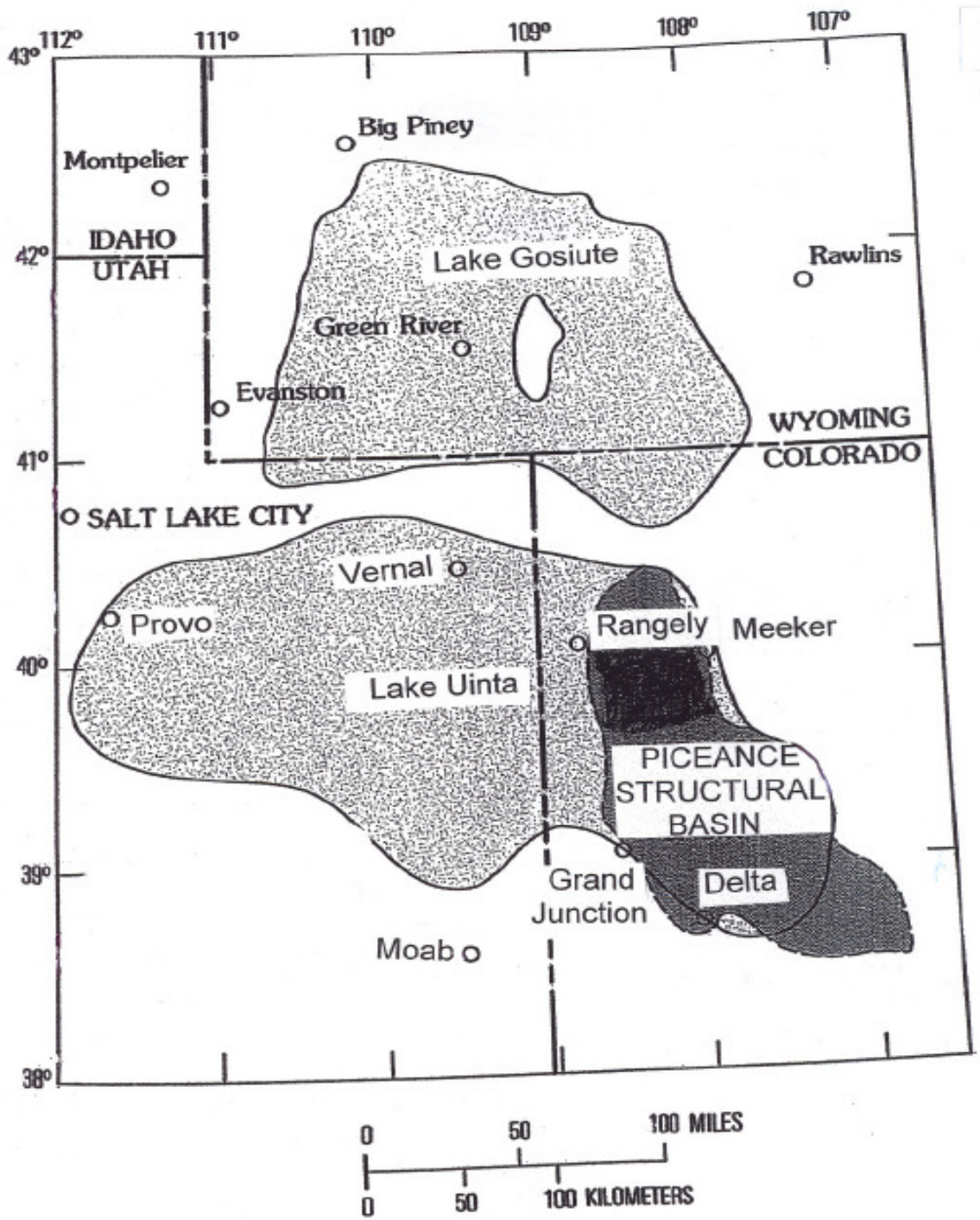
The purpose of this discussion is to draw attention to several potentially valuable mineral resources that occur in the oil shale beds, and the need for R&D to explore the feasibility of their co-recovery with shale oil.

The potential "rock value" of these mineral products could about equal or exceed that of the shale oil from the same "ore". If their production is feasible, (1) an overall "oil shale" operation should be significantly more profitable, and (2) oil shale of lower grades could be produced, thus adding perhaps a 100 billion bbl to our total shale "reserves".

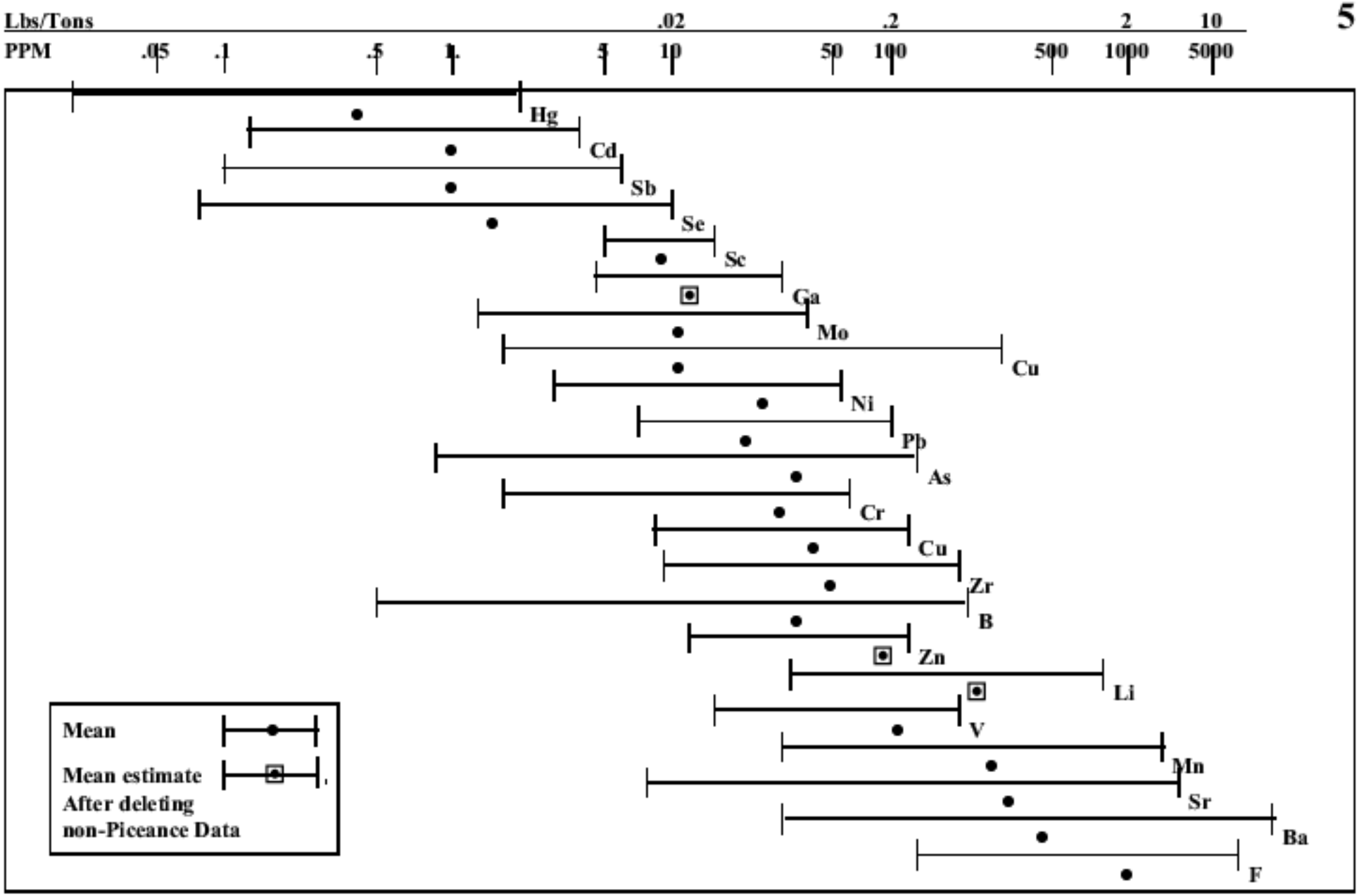
The most important "value" of these materials are as input to our economy.

GEOLOGY

For a general over-view of the geology and mineral resources in Piceance Basin, see Donnell (1987) Dyni (1987). Most of the oil shale resource in Piceance Basin is Federally owned. It underlies more than 1,000 square miles, ranges in thickness from less than 100 feet to more than 2,000 feet, and probably averages 20-30 gallons per ton. The resource is a kerogen-bearing marlstone, deposited in a large interior lake system (Eocene) some 50 million years ago.



MAXIMUM EXTENT OF ANCIENT LAKES UINTA AND GOSIUTE EOCENE TIME



Modified after
Dean, 1976

MINOR ELEMENTS IN OIL SHALE
PICEANCE BASIN, COLORADO

RESOURCES

The resources noted include, Nahcolite, Aluminum, Cobalt, Gallium, Lithium, Manganese, Molybdenum, and Cement. There could well be others, because many "black shale" formations world-wide contain unusual concentrations of metallic minerals.

ALUMINUM: LIGHT METALS, ALLOYS - Dawsonite ($NaAl(OH)_2(CO_3)$ is about 14% Aluminum. Beard, Tait, and Smith (1974) estimated 19 Billion tons of Dawsonite resource. The Dawsonitic shale thus contains about 2.7 Billion tons of Aluminum metal. Grade is in the range of about 1%-10% Dawsonite, and probably averages 5% or more, or about 13 lbs Al/ton. At $1.50/lb, this could add about $21.00/ton ($4.00 to $42.00/ton) to the "rock" value of oil shale.

Past R&D

(Haas and Atwood, 1975) suggests that Alumina is readily extractable from some types of retorted shale.

LITHIUM: BATTERIES, PHARMACEUTICALS, LUBRICANTS: Probably occurs as a carbonate (Dean 1976). Concentrations are in the range of 5-700 ppm, average about 70ppm (0.14lbs/ton). Recent Lithium prices are in the $20-40/lb range, or about $3.00- to $6.00/ton of "average" shale.

GALLIUM: ELECTRONICS, LED - Mode of occurrence uncertain. Grade ranges from about 2-40 ppm, and averages about 10 ppm, or 0.02 lbs/ton. At $200-225/lb, this has an added "rock" value of about $1.00 to $ 16.00 per ton of ore.

COBALT: METAL ALLOYS BATTERIES- Mode of occurrence not known. Grade ranges from < 5ppm to about 400 ppm, and averages about 10 ppm, or ≈ 0.02 lbs/ton of shale. Price is in the $100/lb range, adding from about $1.00 to $ 80.00 per ton of shale.

MOLYBDENUM: METAL ALLOYS BATTERIES - Mode of occurrence not known. Grade ranges from 5-40 ppm, and averages 10 ppm, or about 0.02 lb/ton. At $20.00/lb this adds from about a $.80 to $ 6.00 per ton of shale.

MANGANESE: METAL ALLOYS - May occur in dolomite, at concentrations from about 30-2,000 ppm, with an average of about 300 ppm (0.6 lb/ton). At $1.25 lb/lb this could add from about $0.07 to $ 5.00 per ton to the value of oil shale.

CEMENT: CONSTRUCTION MATERIAL - A potential product from retorted oil shale (Limestone/Dolomite). Limited R&D suggest that usable cement is readily obtainable from some types of retorted shale. Assuming that one tenth of the total shale is converted to cement, the resource may be about 300,000,000,000 tons. Current bulk cement is priced in the $100-150 per ton range, for a potential total value in the range of 30-50 trillion dollars.

OIL SHALE, PICEANCE BASIN
POTENTIAL CO-PRODUCTS

100,000 BPD, 25 GPT
170,000 TPD Mined

RESOURCE	Concentration ppm or %			Lbs/Ton			Price	Gross Rock Value, $/T			Potential Gross Revenue Millions Dollars per day		
	Low	Avg	High	Low	Avg	High		Low	Avg	High	Low	Avg	High
NAHCOHLITE	**Assume 10,000 TPD**						**$120/ton**	**120**			**1.2**		
DAWSONITE (AL) %	**1**	**5**	**10**	**3**	**14**	**28**	**1.25/lb**	**3.75**	**18**	**35**	**0.62**	**3**	**5.8**
LITHIUM PPM	**4**	**75**	**800**	**.008**	**.15**	**1.6**	**$30/lb**	**0.24**	**4.5**	**48**	**0**	**0.75**	**3**
GALLIUM PPM	**2**	**10**	**40**	**.004**	**.02**	**0.1**	**$225/lb**	**0.9**	**4.5**	**18**	**0.15**	**0.75**	**3**
SUBTOTAL								**4.89**	**27**	**101**	**0.22**	**4.9**	**18**
CEMENT	**10,000 TPD, Assume 6% of "ore" converted @ $120 ton**										**1.2**		
SHALE OIL							**$80/bbl**	**48**			**8**		
Total Oil and Co-Products, Millions/$/Day											**10**	**15**	**29**

NOTE: Cr, Co, Cu, Mg, Mo, Ni and V occur as generally lower values.
Their combined recovery could add from about $100,000 to $5,000,000/day.

DISCUSSION

The potentially large amounts and values of the "resources" of both oil shale and the above materials clearly justify serious R&D efforts aimed at achieving economic recovery. The potential cash flow from co-produced materials(and appropriate royalty values) could be very large.

Future shale oil production rates are not known, but could be in the range of several 100,000 BPD. Thus, the high stakes are obvious, both in royalties and especially in raw material input to the Nation's economy.

Some of the above estimated "resources" are a significant percentage of U.S. or even world "reserves", and a thus may have a certain geo-political significance.

SOME R&D NEEDS

A basic need is to better define the geologic, stratigraphic, and mineralogical occurrence and concentration of these resources. Some degree of stratigraphic control of concentration is likely, which could facilitate economic recovery. R&D is needed on recovery methods, especially co-recovery with a variety of shale oil recovery methods. In addition, an overall R&D effort is needed to lessen the "retorting" energy required for both shale oil and the above-noted resources. Basin wide, a 1% reduction in such energy is about equal to adding a "Prudhoe Bay" to our resource.

SUMMARY

Because of the enormous size of the resource, and thus the long-term importance to the Nation, development must be aimed at obtaining a high percentage of recovery. The planning stage must not be unreasonably biased toward short-term considerations that would result in either future losses of resources, or in post - recovery conditions that hinder future recovery of resources.