OIL SHALE

SOME RESEARCH NEEDS

Emphasis on Piceance Basin
Colorado

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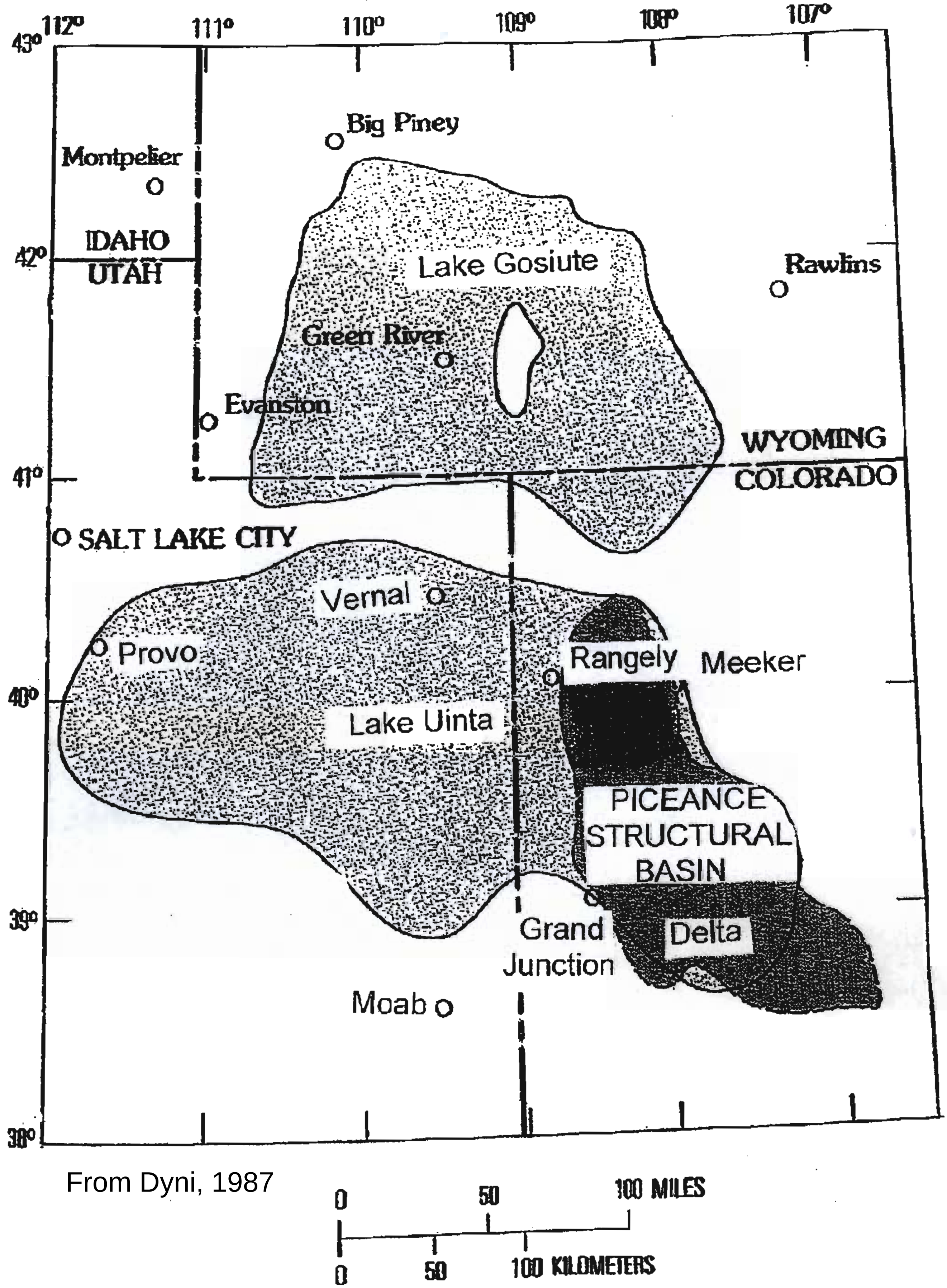
INTRODUCTION

Research is needed on this 1.5 trillion bbl resource in order to maximize resource recovery in an environmentally acceptable manner. It is equivalent to about 100 "Prudhoe Bays", or, at current use a 200-year supply or a several 1,000 year supply for aviation fuel and petrochemical feedstock. It must be utilized in a well-planned program based on facts and technical expertise. Co-products have the potential to enhance economics, and to supply some probable U.S. shortages. Research needs apply to in-situ, room and pillar, open cast, and any other recovery methods. A basic need is more detailed data on the composition of oil shale. Most of our research knowledge is from studies of richer shale strata, which represent only a part of the total resource. The following is a very brief summation of several research needs. Few of the topics are new, and this summary can at most be considered as a crude "road map," certainly it is not a "blueprint."



From Dyni, 1987

MAXIMUM EXTENT OF ANCIENT LAKES UINTA AND GOSIUTE EOCENE TIME

RESOURCE RECOVERY

Current proposals suggest only about a 10-50 percent resource recovery. Nahcolite is the only co-product noted in the new leases. This implied "high-grading" of the resource is probably not acceptable to the long term National interest. Inevitably it leaves a remaining resource of low grade, in conditions hampering future recovery. All recovery methods need research to maximize recovery. Currently, only surface mining can approach 100% recovery. Note: a 1% loss or recovery, basin-wide, is about a "Prudhoe Bay."

ENVIRONMENTAL ISSUES

Research is needed on:

1. Air emission controls, which may be the limiting factor on production rates.
2. Minimizing water use, and controlling water quality degradation. We need to utilize local water sources, including the 25 million ac-ft of ground water storage in the Uinta-Green River Formations, and possibly deeper sources. Research on mine de-watering is needed to minimize costs and unwanted effects on stream flow and springs.
3. Post-recovery soils; in order to preserve/increase land productivity.
4. Ways to minimize unwanted water quality effects of “spent” shale.
5. Subsidence effects on water, soil, and streams.

CO-PRODUCTS

The potential exists for producing several co-products that could substantially improve profitability (and royalties) and to cushion oil price swings. Some co-products may be critical to the U.S. economy.

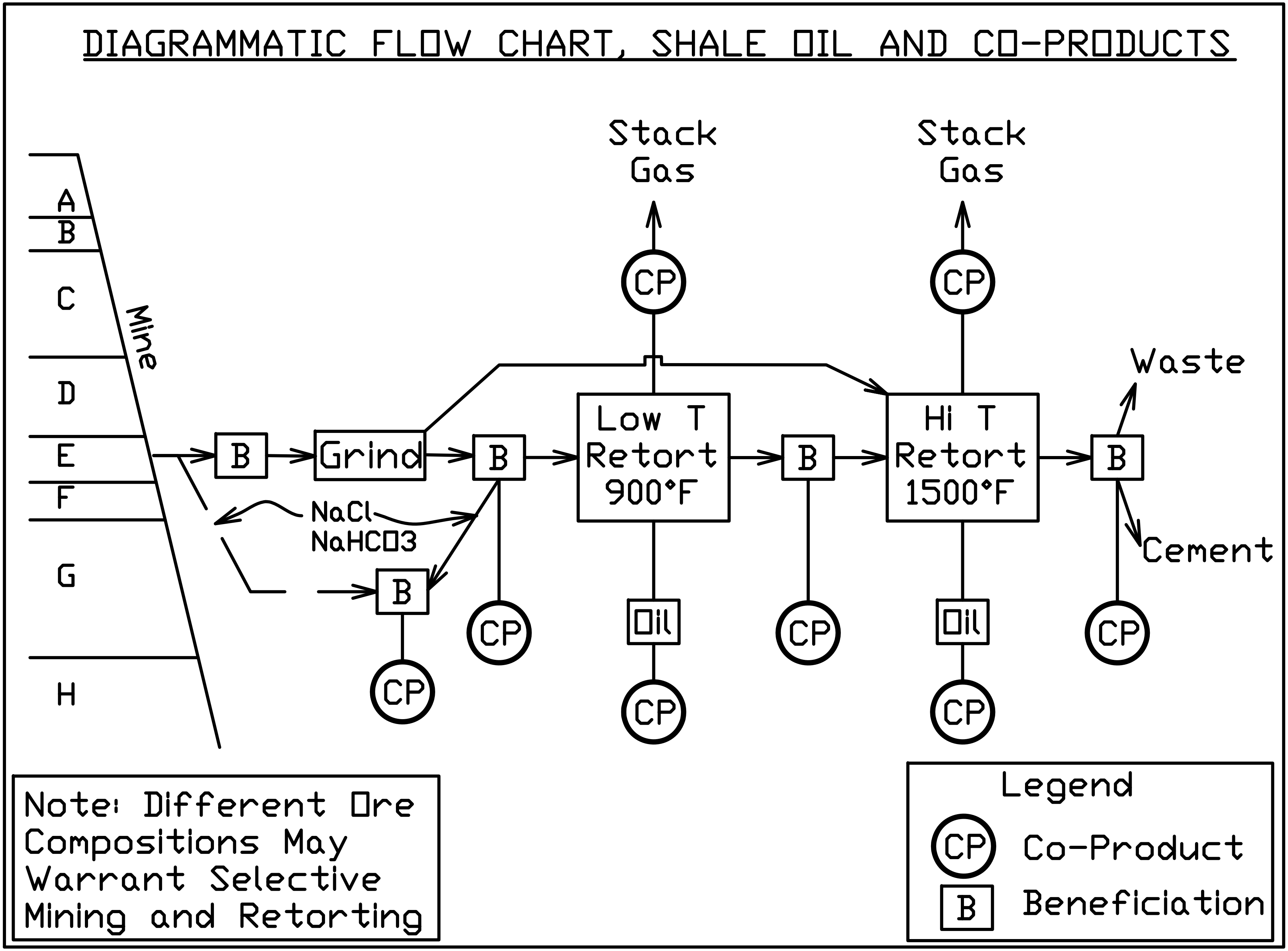
1. Recovery of several minor-trace elements can potentially reduce unwanted effects on air and water.

2. Research is needed on the mineral (or Kerogen) residence, and the stratigraphic occurrences of many minor-trace elements.

3. Co-product recovery can affect mining and retorting methods. Research is needed on types of beneficiation methods (pre and post retorting) and on recovery from raw shale, spent shale, "off gas" and product oil. A 1992 patent describes a method to separate carbonate minerals from kerogen.

CO-PRODUCTS

Nahcolite apparently is the only co-product addressed in the current BLM leasing program. Aluminum (a 3 billion ton resource) in the mineral Dawsonite has been recovered by limited past research. Cement can be produced from spent shale, potentially in very large quantities. Cement production can reduce spent shale management problems, enhance land and water reclamation, and significantly improve economics. Lithium, gallium, sulfur, magnesium, ammonia fertilizer, and several other elements are potential co-products. There has been limited research on their recovery. Total potential "raw rock" values of co-products could exceed that of shale oil.


DIAGRAMMATIC FLOW CHART, SHALE OIL AND CO-PRODUCTS
A
B
C
D
E
F
G
H
Mine
B
Grind
B
NaCl
NaHCO3
B
CP
CP
Low T
Retort
900°F
Oil
CP
CP
Stack
Gas
B
CP
Hi T
Retort
1500°F
Oil
CP
CP
Stack
Gas
B
Waste
Cement
CP
Note: Different Ore
Compositions May
Warrant Selective
Mining and Retorting
Legend
CP
Co-Product
B
Beneficiation

Oil Shale, Piceance Basin

Potential Co Products

(All Numbers are Estimates)

Resource	Average Concentration (ppm or %)	Lbs/Ton Average	Approximate Price ($/lb)	Approximate Gross Rock Value ($/T)	Potential Gross Revenue ($ Millions/ day)
Dawsonite (AL) (%)	5	14	1.25	18	3
Lithium (ppm)	75	0.15	30	4.5	0.75
Gallium (ppm)	10	0.02	225	4.5	0.75
Subtotal				27	4.5
Cement	10,000 TPD		$120/TON	120	1.2
Nahcolite	10,000 TPD		$120/TON	120	1.2
Shale Oil	25 Gallons per Ton		$80/TON	48	8
Potential Total Oil and Co-Products					15

Note: Cr, Co, Cu, Mg, Mn, Mo, Ni, V, and others occur at generally lower values

Their combined recovery could add from about $100,000 to $5,000,000/day

Nahcolite and Aluminum are concentrated in mid-basin

Assume: 100,000 BPD, 25 GPT

170,000 TPD Mined

RETORT EFFICIENCY

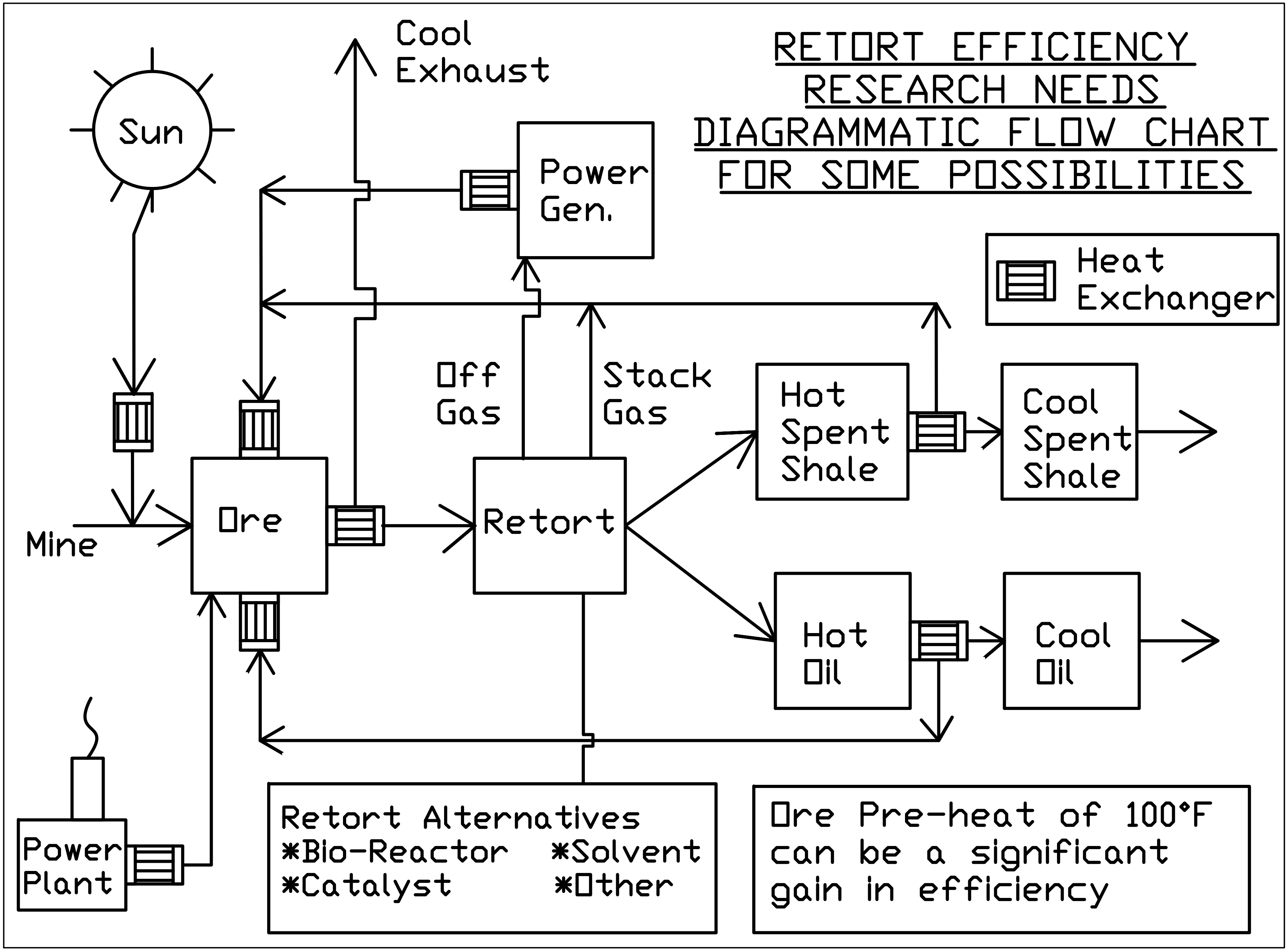
Improvements are needed to enhance oil recovery and to reduce retorting costs. Current retorting needs are about 10% of the product stream, which amounts to 10-20 "Prudhoe Bays," basin-wide. Research needs include:

1. Waste heat recovery (to pre-heat the "ore") from the retorting process is an obvious research project.

2. Non-product heat sources, such as solar pre-heat and waste heat from electrical power generation.

3. The potential use of "catalysts," "bio-enhanced" recovery, and solvents for recovery.

4. Increased efficiency can help dispatch the lingering "Shibboleth" of a negative energy balance for oil shale.


RETORT EFFICIENCY
RESEARCH NEEDS
DIAGRAMMATIC FLOW CHART
FOR SOME POSSIBILITIES
Cool Exhaust
Sun
Power Gen.
Heat Exchanger
Off Gas
Stack Gas
Hot Spent Shale
Cool Spent Shale
Mine
Ore
Retort
Hot Oil
Cool Oil
Power Plant
Retort Alternatives
*Bio-Reactor *Solvent
*Catalyst *Other
Ore Pre-heat of 100°F
can be a significant
gain in efficiency

RETORTING TEMPERATURES

1. "Low" temperature retorting minimizes carbonate decomposition, and the spent shale contains residual hydrocarbons.

2. High temperature retorting requires more energy and may produce more product and more CO_2, but is essential for cement production and for some co-product recovery.

3. Research is needed on "trade-offs" involving energy use, co-products, and environmental effects. Different ore compositions may require different retorting methods, especially for co-product recovery.

CONFLICTS WITH OTHER BASIN RESOURCES

Large resources of groundwater, natural gas, possibly oil, and deep coal underlie the oil shale. There are significant agriculture and wildlife resources in the basin. Research/planning is needed to develop policies and methods that minimize conflicts during oil shale recovery.

“LANDSCAPE,” POST RECOVERY

1. In general, in-situ and room-and-pillar recovery methods tend to cause significant surface subsidence, which can affect secondary recovery of oil shale, and springs and streams.

2. Open-cast methods can result in an elevated reclaimed land surface, and affect the hydrologic system. High permeability mine backfill affects groundwater recharge and storage, and springs and streams.

3. Cement production will reduce the volume of spent shale for disposal thereby reducing open-cast surface “rise.”

SUMMARY

1. Past R & D oil shale operations here produced several 100 thousand bbls of oil, thus production methods that "work" are known. A future petroleum shortage could lead to a "Government Crash Program" in shale oil. Not good, if we lack critical knowledge on how to recover most or all of the resource in an environmentally acceptable manner.

2. Much research could be federally funded (National labs, university grants, U.S.G.S., E.P.A., etc.). Promising results would prompt studies by private industry. The 80% Government-owned oil shale resource could (if appropriately administered) become a positive factor in promoting prudent and effective research and development. An example of economic success of government-private R & D is the Canadian Oil Sands Project.

3. A 1992 act (US Code Title 42 Sec 13142 - not funded) authorized establishment of oil shale research centers.