



## ***Rio Blanco Oil Shale Company Tract C-a, Rio Blanco County, Colorado: Summary of geology and current development***

E. A. Ziemba

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# RIO BLANCO OIL SHALE COMPANY TRACT C-a, RIO BLANCO COUNTY, COLORADO: SUMMARY OF GEOLOGY AND CURRENT DEVELOPMENT

E. A. ZIEMBA  
Rio Blanco Oil Shale Company  
Aurora, Colorado 80014

### STRATIGRAPHY

A generalized stratigraphic column of Tertiary Eocene rocks in the Piceance Creek basin is shown in Figure 1. The column makes no attempt to maintain vertical scale representative of individual stratigraphic unit thicknesses. Its primary function is to portray the relative stratigraphic positions of the basin's major and minor Eocene units, the position of the basin's main oil-shale interval within the Parachute Creek Member, Green River Formation, and the oil-shale interval as defined at Tract C-a. Also shown are key markers, both lithologic and electric log, which are important in oil-shale stratigraphic correlations.

Figure 2 is a southwest-northeast stratigraphic cross section across Tract C-a utilizing oil-grade logs of three of the 27 coreholes drilled on the tract. It is oriented approximately normal to depositional or isopach strike of the main oil-shale interval of the Parachute Creek Member. The section portrays the tract's principal stratigraphic oil-shale characteristics, including the positions

of four key electric log markers (A- and B- grooves, Blue and Orange markers) and two key lithologic markers (Mahogany marker and Mahogany bed). These six stratigraphic markers are not only areally persistent within Tract C-a but also throughout most of the Piceance Creek basin.

The oil-shale zonation established by Rio Blanco Oil Shale Company within Tract C-a also is shown on the cross section of Figure 2. It is based on a zonation first established by the U.S. Geological Survey within the main oil-shale interval (A-groove to Blue marker) on a regional scale. The Rio Blanco zonation expands that of the U.S. Geological Survey stratigraphically above and below the main oil-shale interval resulting in 19 discrete oil-shale zones; 9 relatively rich and 10 relatively lean. These zones are designated L-00 through L-8 in stratigraphically ascending order with the alternating rich and lean zones identified "R" and "L", respectively. However, the Mahogany and A-groove (AG) zonal nomenclature is retained because of their well-established usage.

### STRUCTURE

The regional setting of Tract C-a within the Piceance Creek basin is shown in Figure 3. The tract (approximately 5,100 acres) is situated on the basin's west flank where regional dip is basinward generally to the east and northeast.

Figure 4 portrays Tract C-a structure based on photogeologic mapping, surface geologic mapping and subsurface corehole and well control. The horizon mapped is the middle of the A-groove, the key electric log marker immediately above the Mahogany zone shown on the cross section of Figure 2 (corehole CE 702 log). In general, beds within the tract strike to the north and northwest and dip gently basinward to the east and northeast at slopes of 2-4° (37-66 m/km) except where locally disturbed by folds and faults.

The structural framework of Tract C-a is dominated by the low-relief southeast-plunging Sulfur Creek anticlinal nose and three en echelon grabens (fault systems) on its northeast flank. The trends of these grabens are all parallel or subparallel to the Sulfur Creek anticlinal axis. The northernmost graben is the most structurally complex of the three with up to 71 m of displacement mapped at the surface where it crosses Corral Gulch. Several minor folds and subsidiary faults complete the structural framework. All faults thus far mapped are high angle to vertical.

### RESOURCES

A total of 27 coreholes have been drilled on Tract C-a to define its resources. Combined, these coreholes have yielded some 9900 m of core.

### Shale Oil

The entire oil-shale interval underlying Tract C-a (L-8 zone through L-00 zone of Figure 2) increases in both thickness and grade across the tract basinward to the northeast. It averages 370

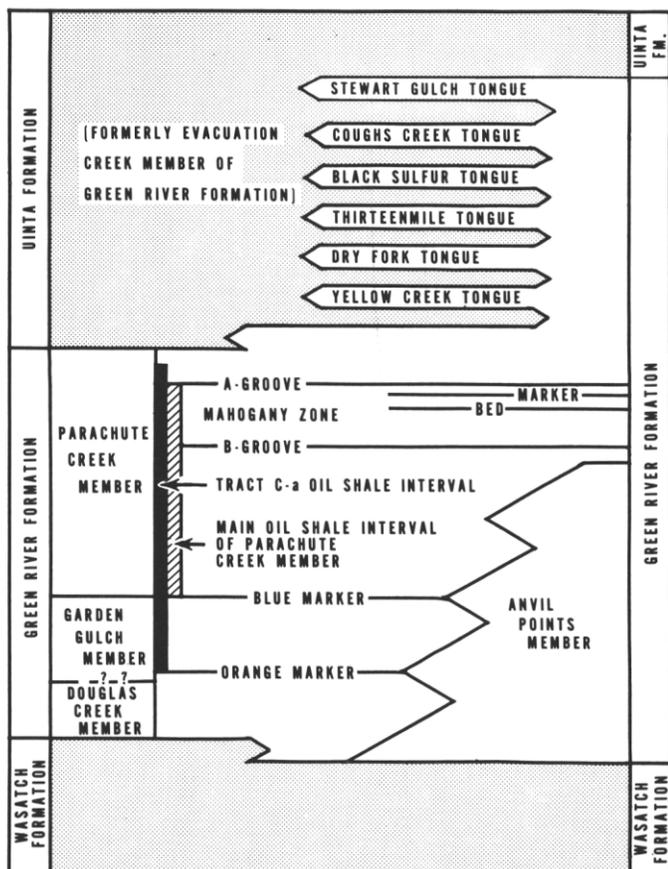


Figure 1. Generalized stratigraphic column of Tertiary Eocene series, Piceance Creek basin.

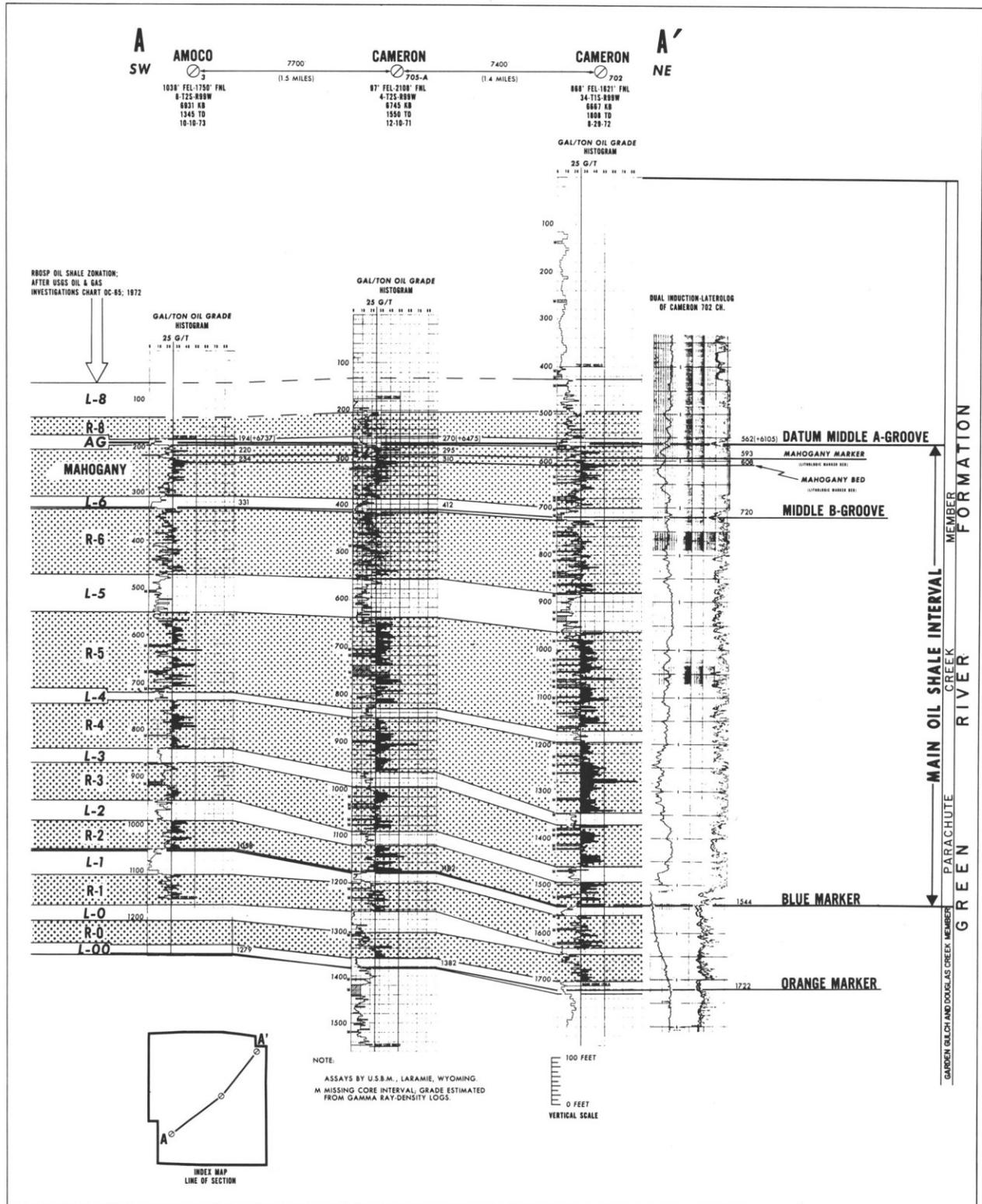
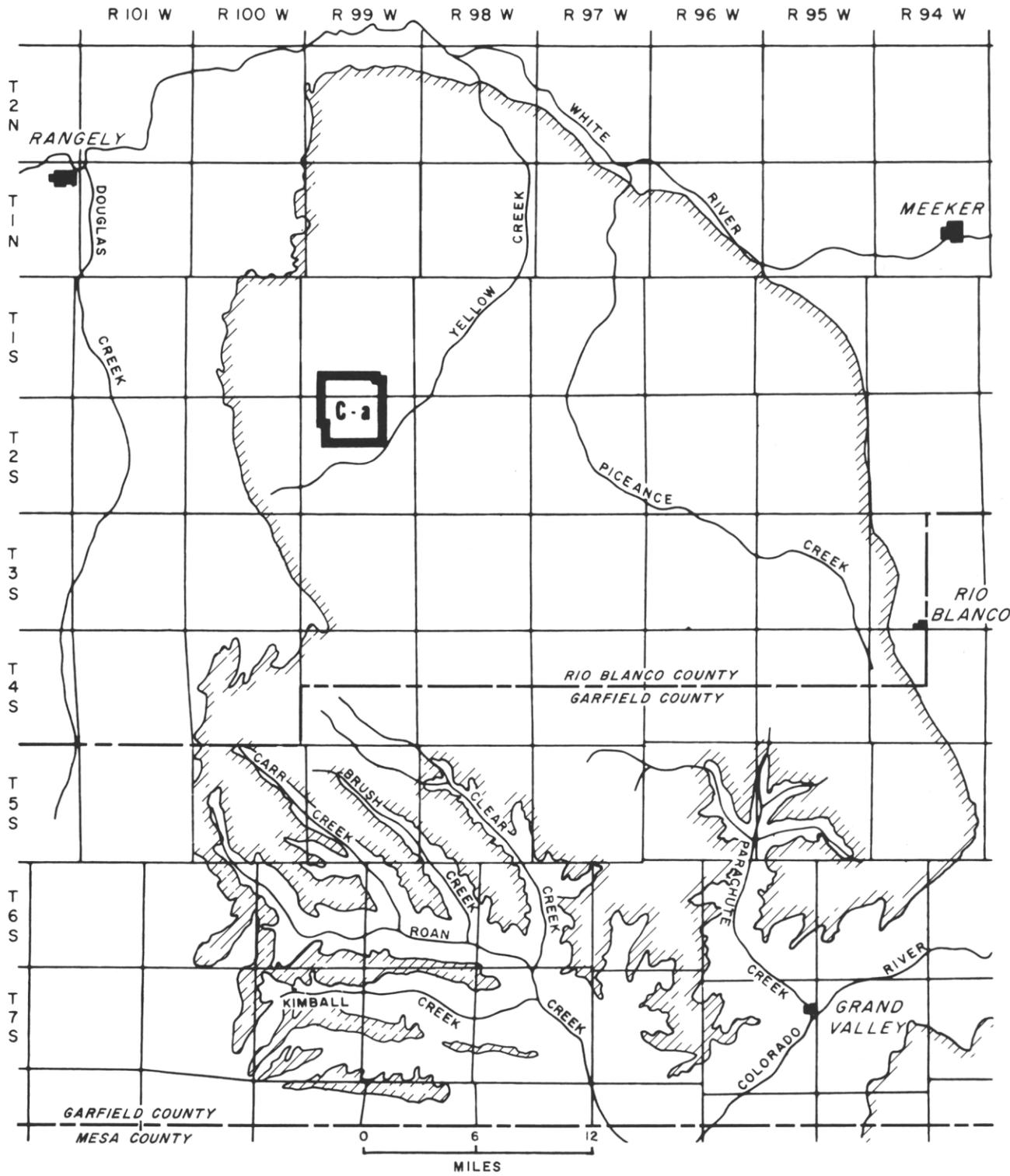


Figure 2. Southwest-northeast stratigraphic cross section, Tract C-a.



 APPROXIMATE OUTLINE OF GREEN RIVER FORMATION

Figure 3. Regional map, Piceance Creek basin.

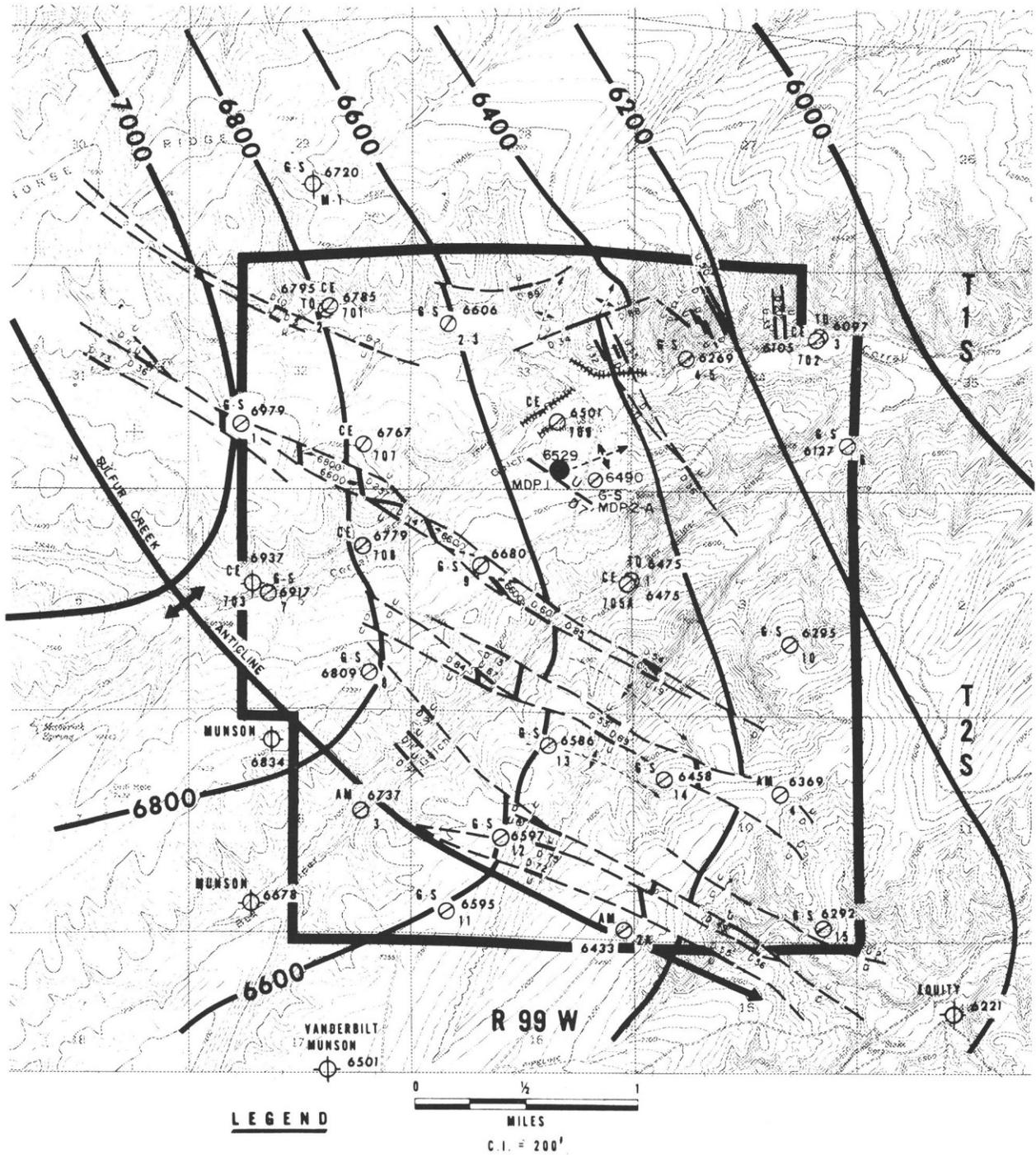


Figure 4. Tract C-a middle A-groove structure map; contours and elevations in feet.

m in thickness and 20.5 G/T oil in grade, and contains 9.1 billion barrels of shale oil in place. Overburden atop this interval averages 102 m in thickness. To put that shale grade into some perspective, a block of 20.5 G/T shale the size of an average office desk weighs 3.2 tons (2900 kg) and contains about 1.6 barrels of shale oil. In more familiar oil-field terminology, 20.5 G/T is equivalent to about 1,500 barrels of oil per acre-foot.

Of the total in-place resource of 9.1 billion barrels, about 80 percent, or 7.3 billion barrels, are contained within the main oil-shale interval (Mahogany through R-2 zones of Figure 2). This interval averages 270 m in thickness and 23.2 G/T in grade with an average overburden thickness of 144 m.

Recoverable shale oil at Tract C-a is highly dependent upon the method of development applied. Three methods have been considered by Rio Blanco Oil Shale Co., namely open-pit mining, underground mining (multi-level, room and pillar) and modified in situ. With a total in-place resource of 9.1 billion barrels, estimated recoveries for each of the three methods are as follows:

	Recoverable Recovery	
Method (Bill. Bbls)	Factor (56)	
Open-Pit Mining	5.2	57
Underground Mining	1.1	12
Modified In Situ (MIS)	1.7 - 2.5	19 - 27

Tract development by open-pit mining would exploit the total oil-shale interval present and result in a pit bottoming out at the base of the L-00 zone of Figure 2. Development by underground mining would be selectively confined to several of the richer oil-shale zones shown on Figure 2.

Tract developed by modified in situ methods (MIS) includes surface retorting of oil shale mined out in the preparation of underground retorts. The lower recovery values listed above reflect initial development of about the upper two-thirds of the total oil-shale interval (top R-8 through base R-4 zones of Figure 2). The higher values include potential additional recoveries in a second phase of development in which the lower one-third of the total shale interval might be exploited.

Of the three methods of development considered, open-pit mining clearly would result in the greatest shale-oil recovery at Tract C-a. This was the approach submitted in Rio Blanco's original 1976 detailed development plan. However, the plan called for off-tract lands for both the processing plant and spent-shale disposal. These lands were determined to be unavailable. MIS development of the tract offers the next best recourse recovery and this is the approach now being pursued as outlined in our 1977 revised development plan.

### Dawsonite

The mineral dawsonite [NaAl(OH)<sub>2</sub>CO<sub>3</sub>], a potential source of alumina, is present within the tract's R-2 through R-5 zones (fig. 2). It occurs as microscopic crystals finely disseminated throughout the oil shale and as thin laminations along bedding planes. About 360 million tons of dawsonite are estimated to be present under Tract C-a, containing about 125 million tons of alumina. Recoverable dawsonite has yet to be determined.

### Nahcolite

The mineral nahcolite (NaHCO<sub>3</sub>), a potential source of soda ash, is present within the tract in very minor amounts scattered throughout several of the oil-shale zones. It occurs as thin beds, stringers, nodules and crystal coatings on vug walls and on shale partings. Most of the nahcolite originally deposited within Tract

C-a has been subsequently removed by groundwater leaching (dissolution). Its current very limited presence precludes its designation as a significant tract resource.

## DEVELOPMENT

Rio Blanco Oil Shale Co. is currently in the modular development phase of MIS development of Tract C-a. The objectives of this phase are to gain operating experience, improve process efficiency and define capital and operating costs for a commercial-sized operation, termed the commercial phase. This development program consists of the sequential preparation and burn of three relatively small MIS retorts, the third and largest of which is 18 m x 45 m x about 120 m high as presently designed. The burn of the last retort in this phase is scheduled for completion in early 1982. Total shale oil to be produced from these three retorts is estimated at about 50,000 barrels. In the commercial phase, somewhat larger MIS retorts are envisioned. Coupled with surface retorting of mined-out shale, production of 76,000 barrels of shale oil per day is tentatively scheduled.

In basic terms, shale-oil production by the MIS method utilizes established mining methods to develop underground chambers whose function is essentially identical to conventional surface retorts. A fraction of each chamber's total contained shale volume is first drawn (excavated) to obtain a pre-designed void volume or porosity. The chamber's remaining shale volume is then fragmented by drilling and blasting. The resulting porous rubblized shale mass within the chamber is then retorted in place.

Based on a recently completed extensive review of MIS technology, Rio Blanco has made substantial changes in its originally designed modular development program. Figure 5 is an isometric drawing which shows the *previous* program and its mine plan to develop and burn five relatively small MIS retorts. These retorts ranged in size from 9m x 9m x 42 m high to 30 m x 30 m x about 120 m high. An extensive mine network consisting of seven levels (A through G) was required to develop the five retorts.

The *current* modular development program is shown in the isometric drawing of Figure 6. This new program reduces the number of MIS retorts from five to three and the number of mine levels to prepare and burn them from seven to two.

In the current modular development program, the preparation and burn of the three retorts is actually accomplished from both the mine and the surface. The drawn or excavated fraction of each retort is removed via the mine's G Level. The remaining fraction is then rubblized using blastholes drilled from the surface. Retort burn is initiated by a downhole burner lowered to the top of the retort from the surface. Fluids produced from each retort are conveyed via G Level for pumping to the surface. Sub-E Level surrounds the three MIS retorts and serves as a drainage gallery for upper aquifer groundwater. This level is positioned just below the base of the upper aquifer and longholes drilled from it upward into the aquifer are designed to dewater the entire three-retort area. The level's objective is to virtually "dry out" the retort line and prevent any upper aquifer water from flowing into the retorts to preclude their burn.

As previously described, the currently planned commercial phase of Tract C-a development consists of shale-oil production from both MIS retorting (underground) and surface retorting. Even if MIS retorting is successful, an efficient surface retorting method is needed to process the substantial quantities of oil shale mined out during the preparation of large-scale MIS retorts. Should MIS retorting be unsuccessful for any reason, then an efficient surface

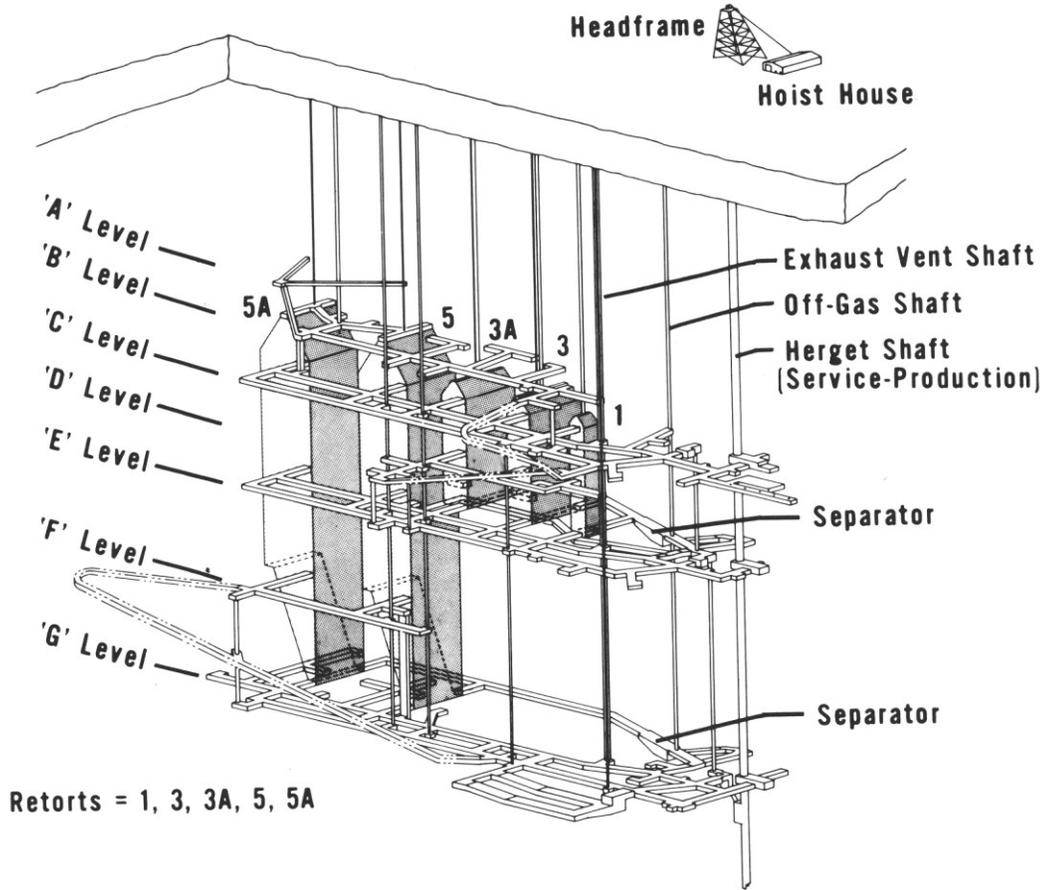


Figure 5. Modular development program, previous plan.

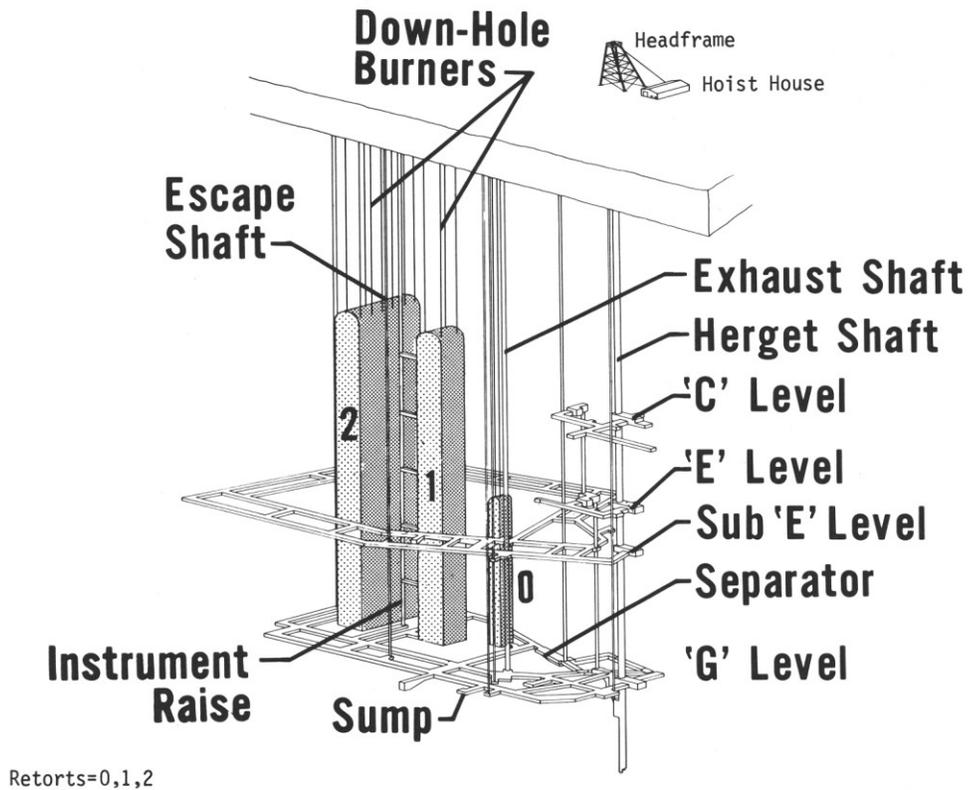


Figure 6. Modular development program, current plan.

RIO BLANCO OIL COMPANY TRACT C-a

retorting process is still critical as an integral part of alternative methods of tract development (open-pit or underground mining). Optimum surface retorting is therefore critical to any commercial development of the tract.

To determine the optimum surface retorting method for use at Tract C-a, Rio Blanco extensively reviewed several technologies and selected the Lurgi-Ruhrgas (L-R) process as the most promising. Planning is now underway for the construction of a 4,400 T/D

L-R modular demonstration retort. Shale feed for the retort will be 217

provided from both the underground MIS mine and a small open pit located near the northwest corner of the tract.

Lastly, the MIS method of shale-oil production on a commercial scale at Tract C-a has great potential but is recognized as risky at this point in time. Many questions related to its technical and economic feasibility require answers based on hard data. Rio Blanco Oil Shale Co. has committed over \$90 million to the current modular development program to provide those answers.





*Lizard Canyon monocline, forming part of northeastern border of Colorado National Monument. Looking southeastward across mouth of Lizard Canyon from southeasternmost loop of Rim Rock Drive just before it ascends Fruita Canyon. Strata range from upper Triassic Chinle Formation at lower right beneath sharp upper bend to upper Jurassic Morrison Formation forming gentle lower bend at left middle. Grand Mesa forms left skyline. From color photograph by S. W. Lohman, U.S. Geological Survey.*