Uranium Roll Front Zonation in the Southern Powder River Basin, Wyoming

By Bruce Rubin[1]

INTRODUCTION

Techniques in the exploration for uranium in Tertiary Basins of Wyoming have taken a giant step forward over the last decade. No longer is the random drilling, or "hit-or-miss" method utilized by most companies or independents. Instead, the Geochemical Cell, or "roll-front" concept has been used extensively, and its use has been a major factor in recent discoveries, especially in the southern Powder River Basin.

Briefly, the "roll-front" is a "C"-shaped interface between the altered and unaltered portions of a sandstone along which uranium has been deposited. (see fig. 1) The interface probably is caused by oxidizing agents moving down dip through a carbonaceous and pyritic water saturated sandstone (reducing environment). (Rackley, et al. 1968) As the oxidizing agents move through the reducing environment they alter the sandstone and precipitate uranium on the interface ahead of the altered portion of the sandstone.

Alteration consists mainly of sandstone color change, removal of pyrite and carbon, and kaolinization of feldspars. Although interfaces extend thousands of feet laterally, the upper and lower surfaces are only a few tens of feet apart.

Previously, only two general criteria were used to locate "roll-fronts" in sedimentary host rocks. They were, through surface profile drilling:

1) to locate altered sandstone,

2) to locate unaltered sandstone.

Subsequent splitting of the distances between altered and unaltered sandstone until the so-called high grade "nose" or frontal portion of the "roll-front" was intercepted was a reliable but costly eventuality. (see fig. 2) Geological investigations made during Teton Exploration Drilling Company's recent discovery in the southern Powder River Basin, Wyoming, may have yielded a new technique in the exploration for uranium; a technique based on the altered-unaltered sandstone relationship, but 20-40% more efficient.

Investigation has shown a definite zonation across the "roll-front"; a zoning that, when effectively interpreted and utilized, gives the geologist a better insight into the configuration of the deposit as well as saving time, effort, and money, since fewer holes will be needed for the successful completion of each profile.

ACKNOWLEDGEMENTS

Special thanks to Bob Johnson, an early collaborator, whose advice and ideas helped to develop the "zonal" concept. The specific contributions of the many who aided in the collection and interpretation of data upon which this report is based, and the cooperation of the management of Teton Exploration Drilling Company and Duval Corporation, are hereby acknowledged.

STRATIGRAPHY AND ALTERATION ZONING

The ore-bearing formation in Teton's investigation is the Wasatch formation of Eocene Age, overlying the Paleocene Fort Union formation. The Wasatch is continental in nature, consisting of interbedded sand, silt, and shale. Due to deposition in a fluvial environment there are, locally, abrupt changes in rock type such as pinch-outs and scour zones. But, analysis of the area on a gross scale indicates the overall continuity of the sand units to be fairly consistent. (see fig. 3)

It was this continuity of geology, along with readily discernable alteration products and a large amount of usable data that enabled the writer to recognize the discreet zones across the "roll-fronts." The following describes, in sequence, from unaltered to most altered, the nature of the sandstone and the radiometric characteristics of each zone of the "roll-front." Zones illustrated in Figure 4 have been numbered to facilitate computerization.

Unaltered Host Rock

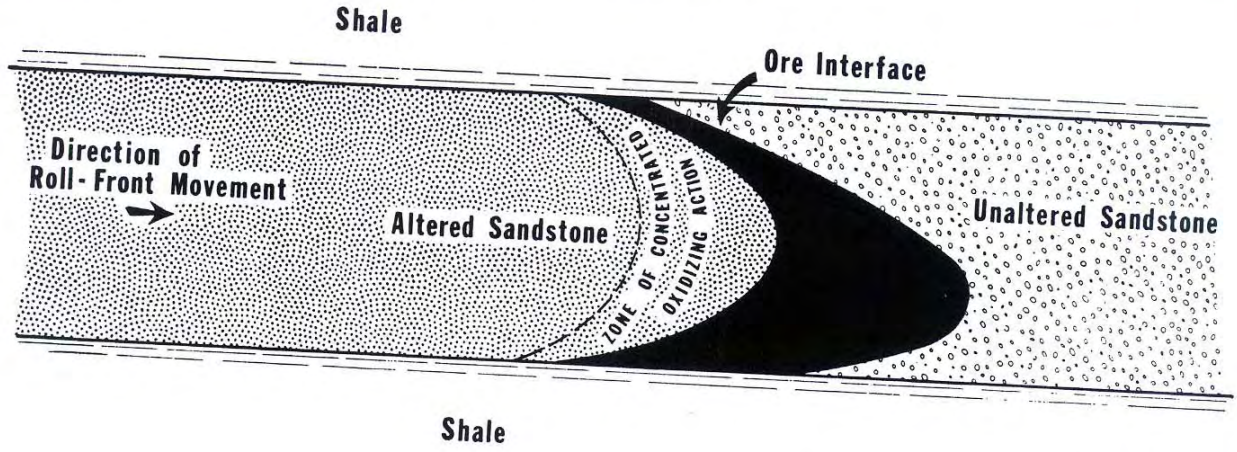
The unaltered host rock is a light to medium gray, (Geological Society of America Rock Color Chart, 1963), sub-arkosic sandstone. Grain size varies from medium-fine to medium coarse, and sorting commonly is fair. The sand grains are mostly sub-angular; grain size, sorting, and angularity are unaffected by subsequent alteration. Main constituents include clear to medium gray quartz (80%), and light gray to medium red feldspars (15%). Carbon fragments are shiny and firm (<5%); pyrite aggregates are glossy and smooth (<1%). There are no anomalous "kicks" on the gamma log in the unaltered sandstone.

Remote Seepage Zone

The Remote Seepage Zone is very similar to the Unaltered Zone and is recognized only by a weak anomalous "kick" on the gamma log at the base of the sand host. Cores of the Remote Seepage Zone

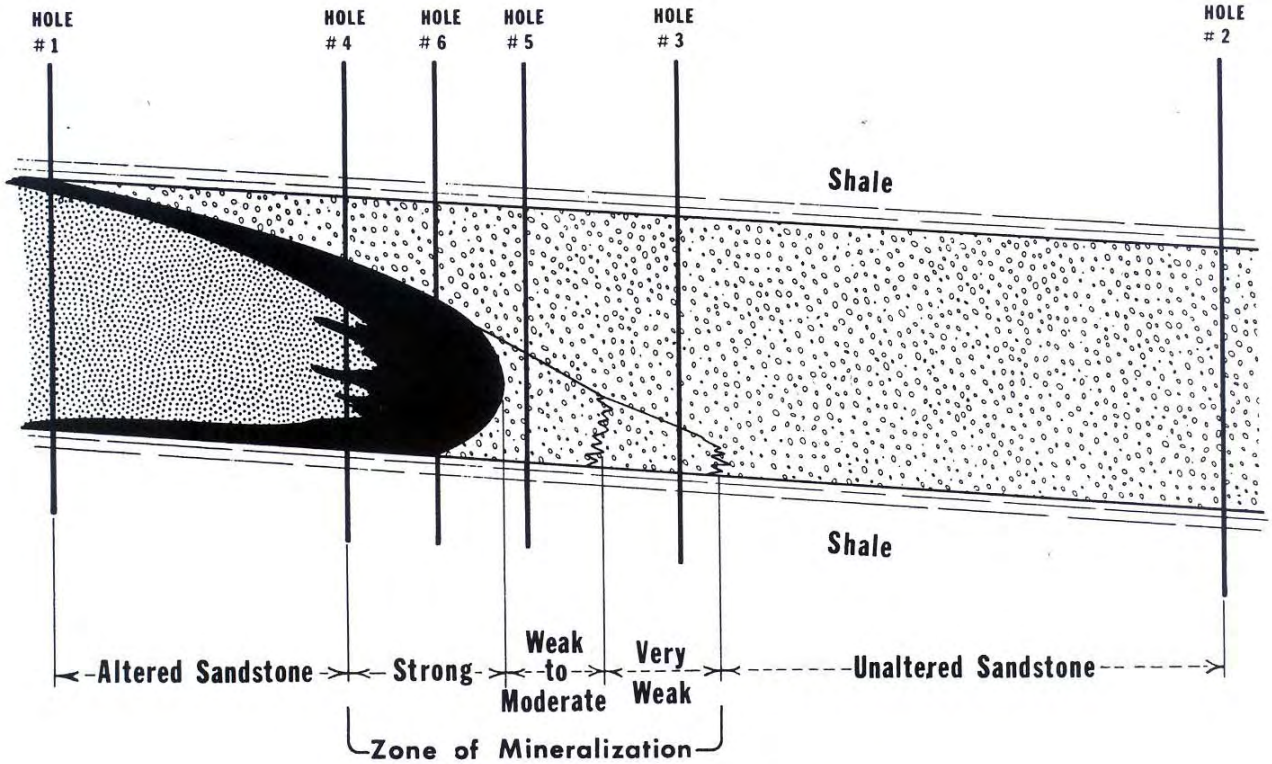
Uranium deposits in the Powder River Basin have been found during the past decade through the extensive use of the "roll-front" concept. Until now far too many holes were drilled to successfully complete each profile across the various "roll-fronts" discovered. The recognition of six zones across the "roll-front" has enabled the geologist to effectively utilize his drilling so as to intersect the high grade ORE ZONE with fewer holes per profile. Consequently, time, effort, and money have been saved allowing the geologist more time to do more meaningful geology and imaginative thinking.

[1]Geologist, Teton Exploration Drilling Co., Casper, Wyoming.



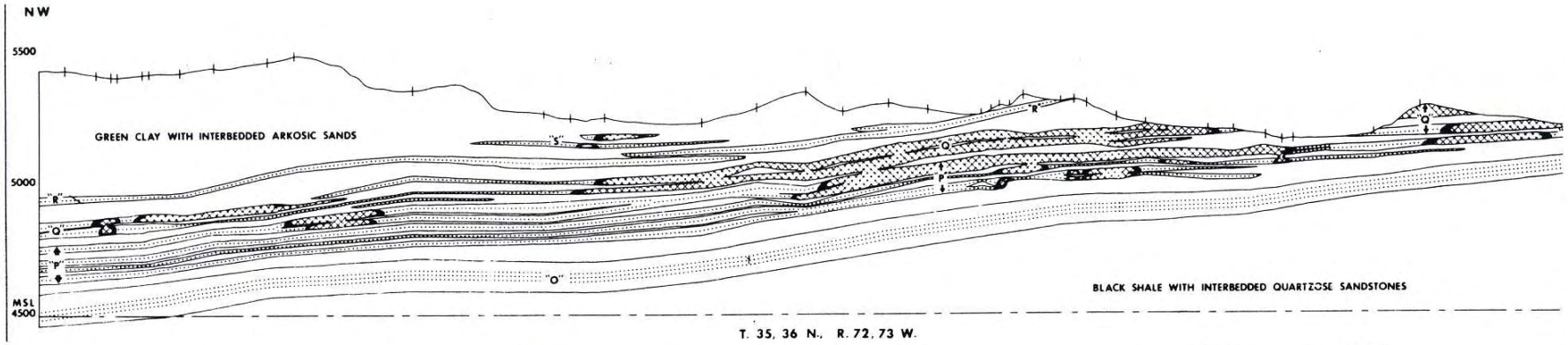
CROSS-SECTION ILLUSTRATING THE "CLASSIC-TYPE" URANIUM "ROLL-FRONT"

FIG. 1

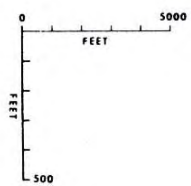


CROSS-SECTION ILLUSTRATING A TYPICAL SOUTH POWDER RIVER BASIN TYPE "ROLL-FRONT" AND HOLES DRILLED USING THE "SPLITTING THE DISTANCE" TECHNIQUE.

FIG. 2



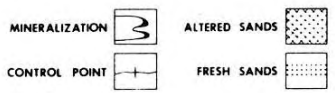
T. 35, 36 N., R. 72, 73 W.



LONGITUDINAL CROSS-SECTION
POWDER RIVER BASIN
WYOMING

RUBIN 1971

FIG. 3



host rock exhibit no visible alteration.

Near Seepage Zone

The first signs of alteration can be detected in the Near Seepage Zone, and are seen as weak, spotty limonite stains on the quartz grains with traces of kaolinite from feldspar. The anomalous "kick" on the gamma log is stronger than that of the Remote Seepage Zone but rarely exceeds an ore grade and thickness of 5'@.12% U308. Both radiometric anomaly and alteration usually are confined to the lower 1/2 to 1/3 of the sand host.

Ore Zone

Increased mineralization changes the overall color of the host rock to medium gray/medium dark gray in the Ore Zone. Limonite stain increases to about 5%, and the first signs of hematite staining occur. Kaolinite from feldspar increases to about 15%, and initial pyrite breakdown can be seen as slight pitting and tarnishing. The gamma log anomaly is fairly strong and unbroken; grades and thicknesses of the ore are rarely less than 6'@.15% U308. Both alteration and radiometric anomaly usually are confined to the lower 2/3 to 1/2 of the sand host.

Interface Zone

The Interface Zone includes more intense oxidizing action than any other zone. This oxidizing alteration changes the color of the host rock in the Interface Zone to medium gray/yellowish gray. This is caused by a moderate amount of limonite stain; hematite is scarce, but increasing. Kaolinite from feldspar increases to 25%. Pyrite is more pitted and tarnished, but still readily discernable. Carbon, beginning to show the effects of alteration, is slightly dull and slightly flaky. The gamma log anomaly is broken into a series of at least two, usually three "kicks." The ore grades tend to be greater than .15% U308, while the ore thicknesses tend to be less than 6'. Cores of the Interface Zone host rock show dark gray sand in the position of the "kicks," and yellowish gray sand between the "kicks." Both alteration and radiometric anomaly usually are confined to the lower 2/3 of the sand host.

Near Barren Interior Zone

The alteration of the Near Barren Interior Zone is recognized easily because of its grayish orange/grayish yellow color. Limonite stain is dominant; hematite stain is increasing. Kaolinite from feldspar is greater than 50%; pyrite is pitted and dull and on the verge of being totally destroyed. Carbon is dull and flaky. The gamma log anomaly is usually two strong "kicks"; the upper "kick" is usually about 1/4 the way down from the top of the sand host, and the lower "kick" is at the base of the sand host. Cores of the Near Barren Interior Zone host rock show dark gray sand in the position of the "kicks" and yellowish/orange sand between the "kicks." Grades and thicknesses of the ore commonly are about 6'@.15% U308.

Remote Barren Interior Zone

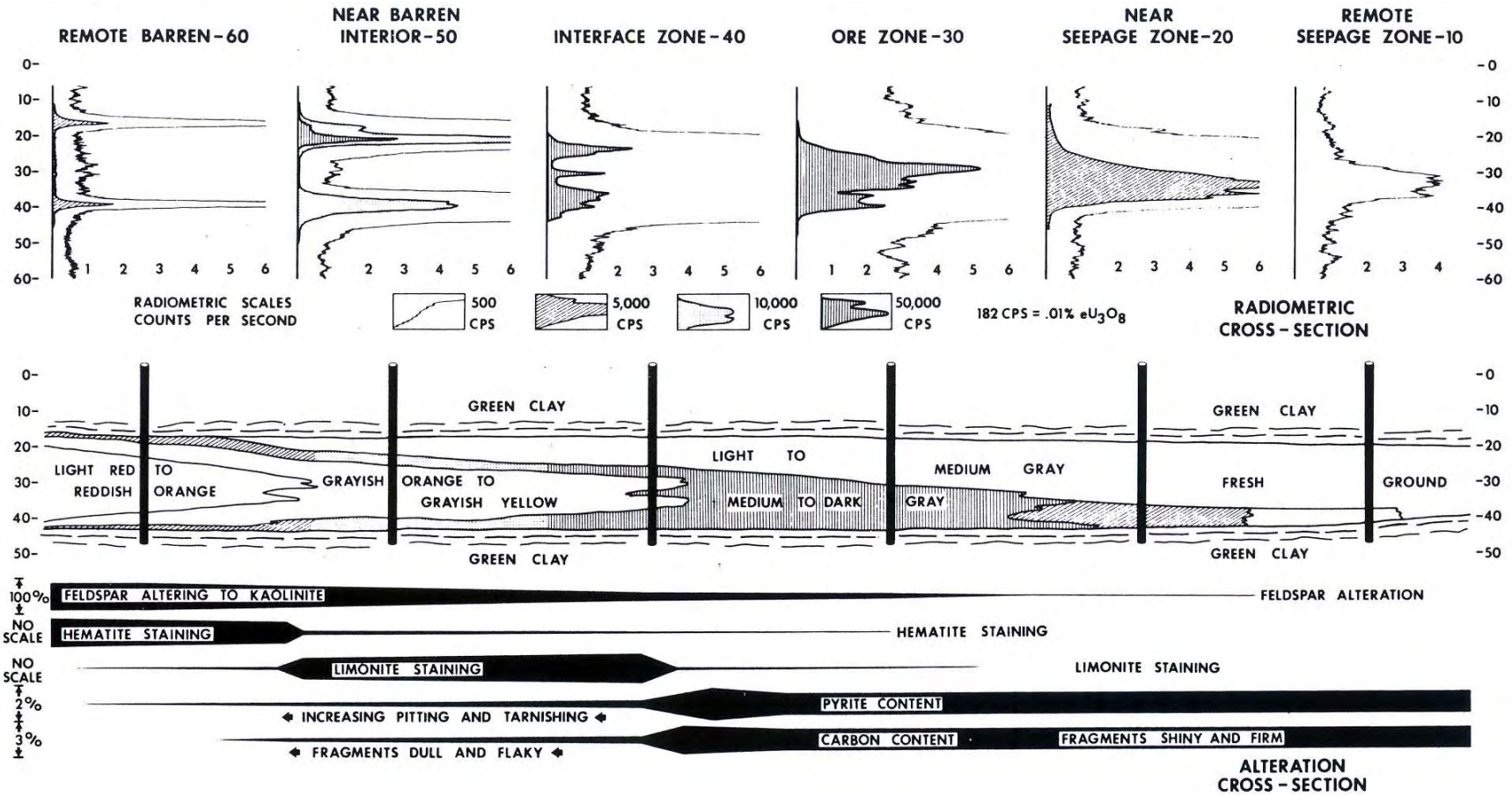
The striking reddish alteration of the Remote Barren Interior Zone is caused by a dominance of hematite stain; limonite stain is weak. Kaolinite from feldspar is greater than 75%, and pyrite and carbon are almost totally destroyed. The gamma log anomaly is usually two "kicks"; one at the top of the sand host, and one at its base. Grades and thicknesses of the ore usually are less than 5'@.12% U308. Cores of the Remote Barren Interior Zone host rock show medium gray sand in the position of the "kicks," and reddish sand between the "kicks." The horizontal distances between zones is proportional to the sand thickness. For instance, in a 30' sand unit the distance from the Remote Barren Interior Zone to the completely unaltered host rock is about 200'. In a 15' sand unit that distance may be 50 feet or less.

The importance of the recognition of these zones and the effective utilization of subsequent drilling cannot be stressed too strongly. To illustrate this point consider, again, figure 2. Here the "splitting the distance" technique was used to intersect the Ore Zone of the "roll-front." If hole #3 had been recognized as a Remote Seepage Zone, hole #4 and hole #5 would not have been needed. An effective off-set hole to position 6 would have been made instead of drilling positions 4 and 5. (Effective off-sets can be made following the recognition of all zones except the Remote Barren Interior and Unaltered host rock.) Figure 2 shows 33% overdrill for that specific profile. If savings of that magnitude in time, drilling, and probing could be duplicated or even approached using the aforementioned zonal criteria, the cost per pound of uranium found would decrease considerably.

PHYSICAL CONTROL OF "ROLL-FRONT" MOVEMENT

Control of the movement of the "roll-front" by the physical nature of the host sandstone was also revealed by the detailed investigation. The speed and direction of the "roll-front" are definitely affected by the thickness and changes in thickness of the host rock. Note how, in figure 5, the zones of the "roll-front" move around thinner sand zones, and toward thicker sand zones.

Commonly, the shale member between host sand horizons will "lens-out" and the "roll-front" of the upper sand will drop through the shale break and occupy portions of the lower sand host. (see fig. 6) The geometry of the "roll-front" in the lower sand host usually is without definite shape and is surrounded completely by unaltered sandstone.



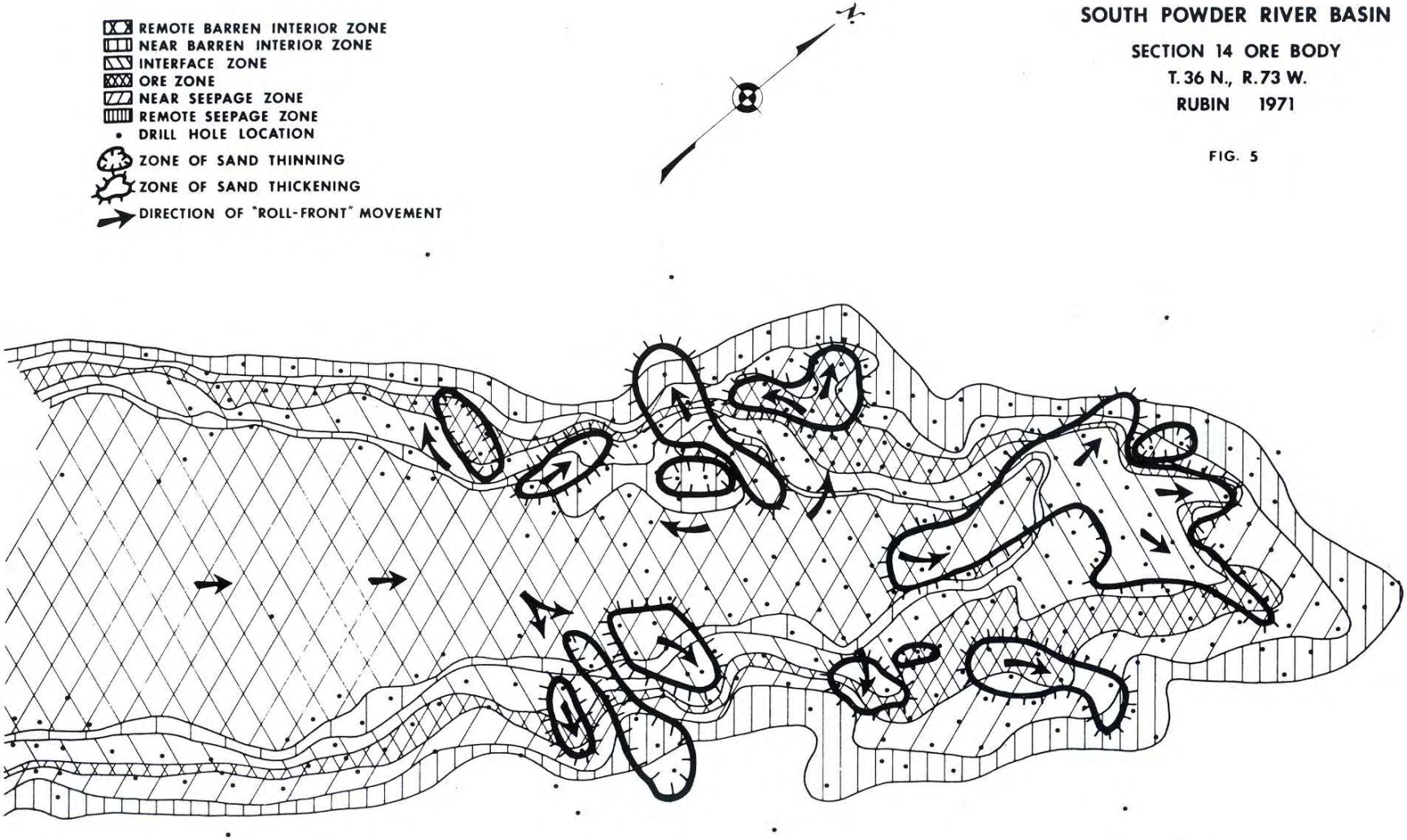
GENERAL ROCK DESCRIPTION

ARKOSIC SAND - COMPACTED BUT NOT CEMENTED
MEDIUM TO COARSE GRAIN
FAIR SORTING
SUB-ANGULAR TO SUB-ROUNDED SHAPES
QUARTZ >80% FELDSPAR <15%
CARBON FRAGMENTS <5% PYRITE ±1%
BLACK AND GREEN ACCESSORY MINERALS <1%

FIG. 4

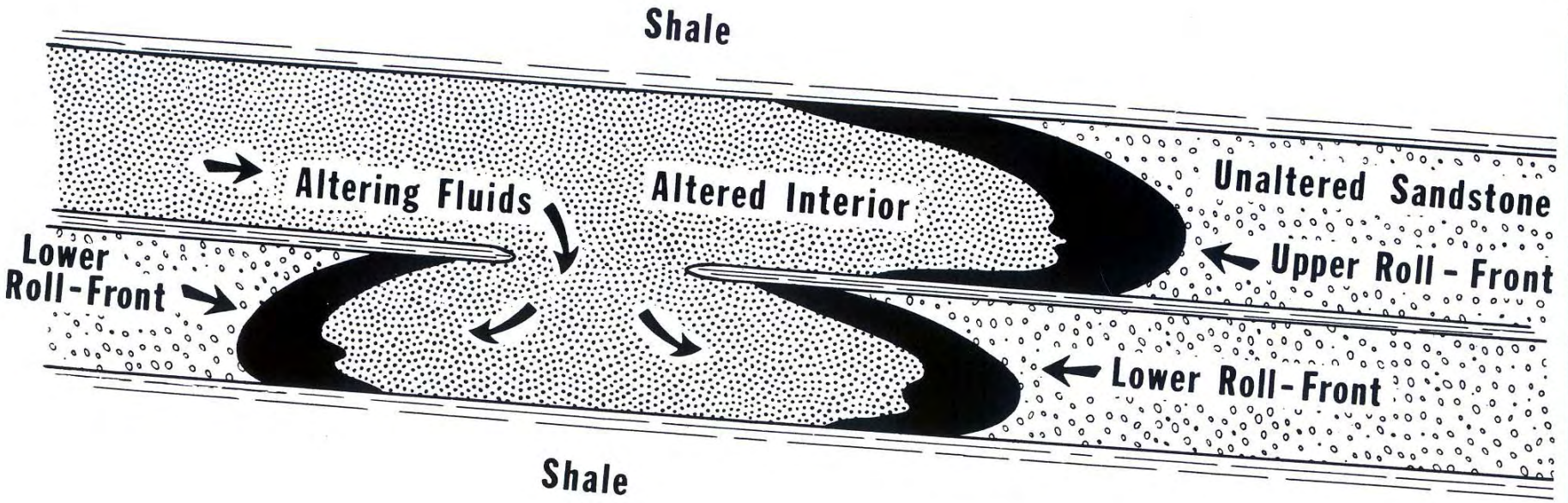
"TYPE" GEOCHEMICAL CELL POWDER RIVER BASIN WYOMING

RUBIN 1971



PLAN VIEW SHOWING MOVEMENT OF "ROLL-FRONT" ZONES WITH RESPECT TO SAND THICKNESS

0 500



CROSS SECTION ILLUSTRATING VERTICAL MOVEMENT OF "ROLL-FRONTS"

FIG. 6

REFERENCES

Adler, H. H., and Sharp, B. J., Uranium Ore Rolls--Occurrence, Genesis, and Physical and Chemical Characteristics, Guidebook to the Geology of Utah, No. 21, Utah Geological Survey, 1967, pp. 53-77.

Bailey, R. V., Applied Geology in the Shirley Basin Uranium District, Wyoming, Contributions to Geology, University of Wyoming, Vol. 4, No.1, 1964.

Johnson, R. L., and Rubin, B. I., Observations on the Relationship of Geologic, Geometric, and Radiometric Characteristics of a Uranium Mineralized Geochemical Cell, 1969. (unpublished company report)

Melin, R. E., Description and Origin of Uranium Deposits in Shirley Basin, Wyoming, Economic Geology, Vol. 59, 1964, pp. 835-49.

Rackley, R. I., Shockey, P. N., and Dahill, M. P., Concepts and Methods of Uranium Exploration, Wyoming Geological Association Earth Science Bulletin, September, 1968, pp. 23-24.