40-8783

RUTH AND NORTH BUTTE PROPERTIES

SIMILARITY REPORT

for

Wyoming Department of Environmental Quality

(Land Quality Division)

and

U.S. Nuclear Regulatory Commission

by

URANERZ U.S.A., INC.

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88-0559

List of Figures

List of Tables

1.0 INTRODUCTION

Uranerz U.S.A., Inc. (UUS), a Colorado corporation with offices in Denver and Casper, is the owner of the Ruth and North Butte uranium properties located in T. 42 N., R. 77 W. (Johnson County) and T. 44 N., R. 76 W. (Campbell County), respectively. In 1983-84 UUS conducted a successful in situ solution mining R&D (pilot test) operation at the Ruth site demonstrating both the amenability of the ore body to solution mining, and the expertise of the company in the fields of in situ mining and aquifer restoration. Documenation of state and federal approval of the aquifer restoration is contained in a DEQ letter dated March 21, 1986 and in an NRC letter dated February 4, 1986. Due to the success of the R&D operation at the Ruth site, and the acquisition of the North Butte property, UUS now intends to develop commercial in situ uranium mining operations at both properties.

On June 29, 1987, representatives of UUS met with key staff members of the Department of Environmental Quality (DEQ) and the Nuclear Regulatory Commission (NRC) to inform the regulatory agencies of company plans for the commercial development of the Ruth and North Butte ore bodies. During the meeting, UUS stated that they intend to mine both properties concurrently, with the Ruth operation being a satellite of the North Butte operation. Each of the two properties will, however, have its own mine permit and NRC source material license. As a part of the licensing plan, UUS asked that the DEQ and NRC not require an R&D (pilot test) operation at the North Butte site due to the physical and chemical similarities of the Ruth and North Butte sites.

In order to demonstrate the similarity of the two sites, UUS presented various geologic cross sections and other technical data during the meeting. UUS stated that as a follow up to the meeting, the company would prepare for the agencies a similarity report that provides detailed technical data comparing the physical and chemical properties of the two sites. This document is the aforementioned similarity report which compares the Ruth and North Butte properties.

At the end of the meeting the DEQ and the NRC both stated that the general operating plan for the Ruth and the North Butte operations was acceptable. The two agencies agreed that an R&D test at North Butte would not be required unless the commercial permit application indicates significant differences in the geology, mineralogy, or hydrogeology at the two locations. Based on the information and data contained in this report, UUS feels that the two properties are sufficiently similar to allow the regulatory agencies to commercially permit and license North Butte without requiring an R & D pilot test. Accordingly, UUS respectfully requests that the LQD/DEQ and the NRC issue a formal opinion stating that an R&D pilot test will not be required at North Butte.

2.0 GEOGRAPHIC SETTING

The North Butte and Ruth properties are both located in the central portion of the Powder River Basin in northeast Wyoming. A regional map showing the location of the two sites is presented in Fig. 2-1. The projects are some twelve air miles apart and are situated at approximately the same elevation. The average elevation at North Butte is 5000 feet and the average elevation at Ruth is 4800 feet. The Ruth property is located in Sections 13, 14, 23, 24, 25, and 26 of Township 42 North, Range 77 West, Johnson County, Wyoming. The North Butte property is located in Sections 18 and 19 of Township 44 North, Range 75 West and sections 13, 24, and 25 of Township 44 North, Range 76 West, Campbell County, Wyoming.

The surface at both locations is privately owned, while UUS owns the uranium mineral rights. The property at Ruth consists of about 1961 acres, and the property at North Butte consists of about 952 acres. The topography in this region of the Powder River Basin is rolling prairie, moderately to deeply incised by ephemeral and intermittent stream channels. The land is used mainly for grazing of livestock, and oil and gas production. The nearest community to Ruth is Edgerton, some 20 road miles to the southwest, and the nearest community to North Butte is Savageton, some 15 road miles to the northeast.

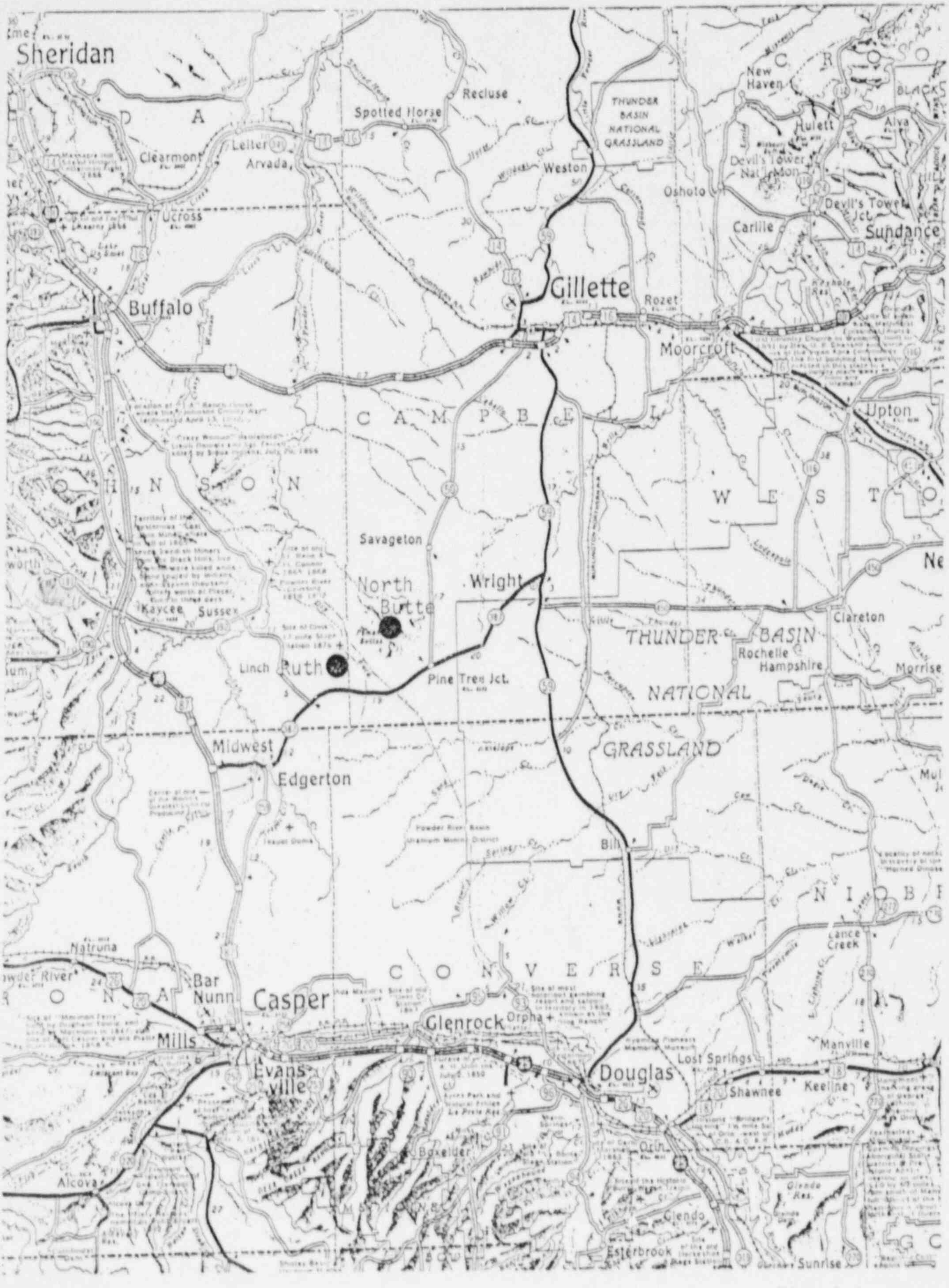

Fig. 2-1
Regional Map

3.0 GEOLOGIC COMPARISON

3.1 Regional Geology

The Powder River Basin is a large structural and topographic depression parallel to the Rocky Mountain trend. The basin is bounded on the south by the Hartville Uplift and the Laramie Range. On the east by the Black Hills, and the Big Horn Mountains and the Casper Arch on the west. The Sheep Mountain Anticline in southeastern Montana forms the northern boundary of the Basin

The Basin is an asymmetrical syncline. The Basin's axis closely parallels the western margin. During sediment deposition, the structural axis (the line of greatest material accumulation) shifted westward resulting in the asymmetry present in the Basin. On the eastern flank of the Basin, sedimentary rock strata dip gently to the west at approximately 0.5 to 3 degrees. On the western flank, the strata dip more steeply (0.5 to 15 degrees) to the east, toward the axis of the Basin, with the dip increasing as distance from the axis increases.

The Basin incorporates a sedimentary rock sequence that approaches 15,000 ft. thick along the synclinal axis. These sedimentary rocks range in age from Tertiary (3 million to 70 million years B.P.) to Cambrian (500 million to 570 million years. B.P.). The Tertiary rock units were deposited in fluviatile to lacustrine environments in a cyclic fashion. The Tertiary fluvial system had a general drainage direction from south to north. Source areas of the sediments were primarily located to the south and southwest. Today the drainage systems, both surface and subsurface, still generally follow the Tertiary paleodrainage trends. Rock types generally consist of sandstones, siltstones, shales, and numerous coal seams. The Tertiary rock units outcropping within the Basin are the Fort Union Formation (Paleocene), the Wasatch Formation (Eocene), and the White River Formation (Oligocene). The North Butte and Ruth solution mining sites are located within the Wasatch Formation as seen in Fig. 3-1.

The basement rocks of the basin are sediments of Paleozoic and Mesozoic age. Today, these igneous and metamorphic rocks form the outcrop rim around the Basin.

The Wasatch Formation consists of brown to gray claystone, siltstone, and carbonaceous shales interbedded with buff sandstone lenses and coal beds. In the vicinity of the Pumpkin Buttes, the Wasatch Formation is predominantly a pink, to red and gray, variegated sequence. The formation has a maximum thickness of about 3,500 ft. within the Powder River Basin. In the Pumpkin Buttes area, it is about 1,500 ft.

thick (Troyer et al, 1954). The base of the Wasatch Formation in both the Ruth and the North Butte areas is about 1,350 ft. below the surface.

In the Central Powder River Basin, the Wasatch can be divided (Troyer et al, 1954) into a lower siltstone unit, about 500 ft. thick, a middle unit, 200-300 ft. thick, containing numerous sandstone beds, and an upper siltstone unit. The sandstone beds in the middle unit are commonly more than 100 ft. thick, and can be several miles long and wide in the vicinity of Pumpkin Buttes. These units are composed of fine to coarse-grained, cross-bedded, arksoic sandstones locally containing stringers and lenses of conglomerate. The sandstone is usually poorly to moderately indurated and often calcareous. The sandstone beds are typically separated by siltstones and claystones, ranging from 10 to 25 ft. thick.

Wasatch Formation sandstones in the Powder River Basin are often good aquifers with groundwater movement generally trending to the north. Groundwater movements followed, more or less, the same general direction during the geologic history of the basin. Oxidation fronts in the sandstone units moved predominantly from the south and southwest towards the north on the west side of the basin axis and from the south and southeast on the east side of the axis, once again toward the north, forming uranium enrichment zones.

The North Butte and Ruth solution mining sites are both situated in the Eocene Wasatch Formation. The target sand units are in the lower part of the formation, at an approximate average depth of 525 ft. for the Ruth and 625 ft. for North Butte. The host sands for both ore bodies are primarily arkosic in composition, very friable, and contain substantial organic debris and carbonaceous stringers. There are some small, localized, sandy shale lenses within the sands, but the main sand units are relatively free of shale except for some clay in the matracies.

The structural attitude of the beds is nearly horizontal with only a slight dip of 0.5 to 1 degrees to the northwest for both the Ruth and North Butte sites. Evidence of faulting has not been observed at either site, neither directly by field observations, nor indirectly through drill hole correlations. The closest known faulting and folding is present approximately 3 mi. to the west of the Ruth site along Pine Ridge.

At the Ruth site the mineralized sandstones are bounded above and below by essentially impermeable shale layers. The lower barrier shale is approximately 35 ft. thick with a coal seam near the top of the bed. The upper shale barrier is approximately 40 ft. thick with the coal seam near the top of the bed. It consists of thin, alternating shales and silty shales. At the North Butte site the upper and lower aquitards (shale barriers) are composed of shales, silty shales and shaley lignite interbeds.

Both ore bodies are typical roll front deposits. In the Ruth area the oxidation front extends from the northwest to southeast with locally very complex features. Several individual fronts superimposing each other are present in the Ruth ore body. In the North Butte area the oxidation front extends from the northeast to the southwest. It also has several vertically superimposed individual roll fronts. In the North Butte area, due to the occasional vertical contact between the mineralized sands there are often several smaller fronts in more than one sand unit, which overlay each other.

The host sandstones are composed of quartz, feldspars, and rock fragments with locally occurring carbon fragments. Grain size ranges from very fine-grained sand to small granules. The sandstone is weakly to moderately cemented and friable. Occasional occurrences of pyrite and calcite as cementing materials can be observed. The uranium is deposited upon individual detrital sand grains or upon and within authigenic clays in the interstices. The interstitial clays present are primarily montmorillonite with lesser amounts of kaolinite. Hematite is a common oxidation product of pyrite within the host rock, along with minor limonite. Accessory biotite and muscovite are also present.

3.2 Correlation

Attached are two cross sections and their location map (Fig. 3-1A) relating the Uranerz Ruth ISL test site with the North Butte property. One cross section was made using the T-R-4 coal (Uranerz labeling) as a marker bed (Fig. 3-2), and the other cross section was made using a constant elevation (4600 ft. above sea level) as a datum line (Fig. 3-3). The coal marker bed correlation will be the most useful and easy to read. The second, (elevation) correlation, is provided for information purposes.

As can be seen from the cross sections, the sands in the Ruth and the North Butte properties can be aligned. The sands and coal marker beds are consistent throughout the area and can be traced from one property to the other. The sands are identified in Table 3-1.

In the past, as various mineral exploration companies gained experience in a particular region, systems of nomenclature were devised to identify different geological horizons. Due to the confidential nature of the information obtained from

Table 3-1

SAND IDENTIFICATION

Ruth				North Butte
Barren Sand	51 Sand	Equates to	F Sand	Proposed Upper Monitored Aquifer
Barren Sand	50 Sand	Equates to	C Sand	Ore Sand
Proposed Upper Monitored Aquifer	30 Sand	Equates to	B Sand	Ore Sand
Ore Sand	20 Sand	Equates to	A Sand	Ore Sand
Proposed Lower Monitored Aquifer	10 Sand	Equates to	1 Sand	Proposed Lower Monitored Aquifer

the drilling programs of the various companies there was very little communication between them. Uranerz U.S.A., Inc. and Cleveland Cliffs Iron Company were working in neighboring areas, but each established their own nomenclature for identifying the sand units. Although the sands involved at the Ruth and North Butte properties are the same they have different labeling.

The "10" sand at Ruth, as can be seen in Table 3-1, is labeled the "1" sand at North Butte and is the Planned Lower Monitored Aquifer for both sites. The "20" sand is the ore bearing aquifer at the Ruth ISL site and becomes the "A" sand at the North Butte property where it is also an ore bearing aquifer. The "30" sand at the Ruth, distinguished as the "B" sand at North Butte, is the primary ore bearing aquifer at North Butte. This sand is the proposed Upper Monitored Aquifer for the Ruth site. The "50" sand is very poorly developed at the Ruth site although in other areas of Uranerz holdings it is better developed. The "50" sand becomes better developed in the North Butte area and is the upper ore bearing aquifer or the "C" sand. The "51" sand at the Ruth site is the aquifer which provided plant and wash water during Uranerz' R & D project. It equates to the "F" sand at the North Butte site and is not an ore bearing aquifer at either site. The "F" sand is the proposed Upper Monitored Aquifer sand for North Butte.

3.3 Conclusion

In conclusion, as stated in the above text, the two ore bodies are contained in the same geological system. Both ore bodies are found in the lower-middle sequence of the Wasatch Formation. The host sands at both locations are arkosic with occasional minor argillaceous intervals. They are mostly poorly cemented and friable. The sands are composed of quartz, feldspars and rock fragments with varying amounts of disseminated carbon fragments. Hematite and, to a lesser extent, pyrite and calcite are found as cementing agents. Locally occurring muscovite, biotite and limonite are also present at the two sites.

Neither ore body shows any evidence of structural instability such as faulting. Both uranium deposits are the typical roll front type deposits, with superimposing ancillary fronts present.

Although there is considerable thickening and thinning of the sands and their separating aquicludes, it can be seen that they are continuous throughout this region of the Powder River Basin.

The sand units involved in both the Ruth and North Butte deposits, as stated, can be traced from one ore body to the other. The aquifers in the Ruth area are more distinct from each other with better developed aquicludes or shale barriers between the middle sand units than are those of the North Butte site. As the sands move to the northeast from the Ruth site, the aquicludes between the "A/20" and "B/30" sands and between the "B/30" and "C/50" sands thin, and by the time the North Butte deposit is reached they are entirely missing in some areas, allowing vertical contact between the sands. The aquicludes above the "C/50" sand and below the "A/20" sand seem to be laterally extensive borders between prior and later episodes of fluctuating sand deposition.

The grain size, distribution, and lithologic composition of the sands in the mineralized aquifers are very similar. The conditions of the parameters of the various sand constituents at both the Ruth and North Butte sites are shown on Table 3-2.

As seen from visible samples in the borehole cuttings and in examination of the cores from both sites the sands are quite similar with all variables falling into categories which could be expected at either site. Anything encountered in the cuttings or core of an individual well at either property could be expected to be present in at least some wells at the other property.

Table 3-2

SAND COMPARISON

Parameter	Ruth	North Butte
Grain Size	Very fine to coarse	Very fine to coarse
Grain Shape	Predominantely subrounded to subangular	Predominantely subrounded to subangular
Sorting	Moderate to well sorted	Moderately sorted
Consolidation	Poor	Poor
Sand	80 - 90% Quartz	80 - 90% Quartz
Rock Fragments	About 10%	About 10%
Color	Medium gray to pink	Medium gray to pink
Accessory Minerals		
Pyrite	Trace to moderate	Trace to minor
Carbon	Trace to minor	Trace to minor
Muscovite	None to trace	None to trace
Biotite	Trace	Trace
Chirt	Trace to minor	Trace

4.0 HYDROGEOLOGIC COMPARISON

4.1 Description of Local and Regional Hydrogeology

Each of the aquifers of interest to Uranerz' ISL sites exist in the Wasatch formation of Eocene age. This formation as described in Section 3 of this report, contains alternating layers of sands and shales. The major sands can be correlated for numerous miles and are the basis for regional aquifers in the Powder River Basin. The geologic setting and aquifer properties of the major Wasatch sands have been defined at numerous sites in the Powder River Basin due to interest in mineral development in these aquifers. Conditions at these other sites are similar to those defined at the Uranerz two sites.

Recharge to these sands is mainly on their outcrops with some influx of groundwater from vertical movement through adjacent aquitards. Flow in the aquifers generally move to the north in this area with a small portion of the groundwater discharging to streams.

Table 3-1 presents the correlation between the different sands at the Ruth and North Butte sites. Section 4 uses the North Butte labels for the different aquifers. The "A" sand is the ore bearing aquifer at both the Ruth and North Butte sites, while the "B" and "C" sands are also ore bearing in the North Butte site. Confinement generally exists between the "A" and "B" aquifers at the North Butte site, while the "B" and "C" sands are directly connected over a substantial area. As indicated in the Geologic Section of this Report, the aquitard between the "F" and "C" sands in the North Butte area are separated by a regionally developed bed of shale.

4.2 Comparison of Aquifer Properties

At both the Ruth and North Butte sites, considerable effort has been expended to define aquifer properties. Most work performed at the Ruth site was done in the Research and Development study area. The purposes of some of the tests at the Ruth site were to define individual well efficiencies and optimum injection characteristics. For these tests, determination of aquifer properties was not of primary importance, and the data were not collected to allow accurate definition of the aquifer properties. At the North Butte site, much work was focused on defining aquifer properties and dewatering rates at a proposed underground mine. Because of the emphasis on determining shaft dewatering rates, a large portion of the aquifer tests were performed on wells multiply completed in the aquifers that the proposed shaft was to penetrate. While tests performed in multiply completed wells provide specific information essential to planning an underground mining operation, they do not usually provide properties and characteristics of specific and individual aquifers.

Aquifer properties have been determined by others at numerous locations over an area of approximately 15 miles by 15 miles (see Fig. 4-1). The North Butte site is located in the north central portion of this area, while the Ruth site is in the southwest corner of the area. These data show that permeabilities at the North Butte and Ruth sites generally fit within the range of values determined for the 225 square mile area with the North Butte values generally at the upper end of the range and the Ruth values at the lower end of the range.

A summary of horizontal hydraulic conductivity (permeability) values determined from pumping and recovery tests that are considered representative is presented in Table 4-1. At the Ruth site, several wells were involved in more than one aquifer test. For these wells, the values given in Table 4-1 are averages from tests in which the well was an observation well. Results for pumping wells were not included in the averages, because well inefficiency apparently greatly influenced these results. Available information about these wells and others considered pertinent to the study areas is given in Table 4-2. In Table 4-2, wells with names presented in upper case letters are those for which aquifer properties are presented in this report. Well locations are shown in Fig. 4-1. Figs. 4-2 and 4-3 present the locations of wells in the Ruth and North Butte sites. Fig. 4-1 shows the area covered by these two maps.

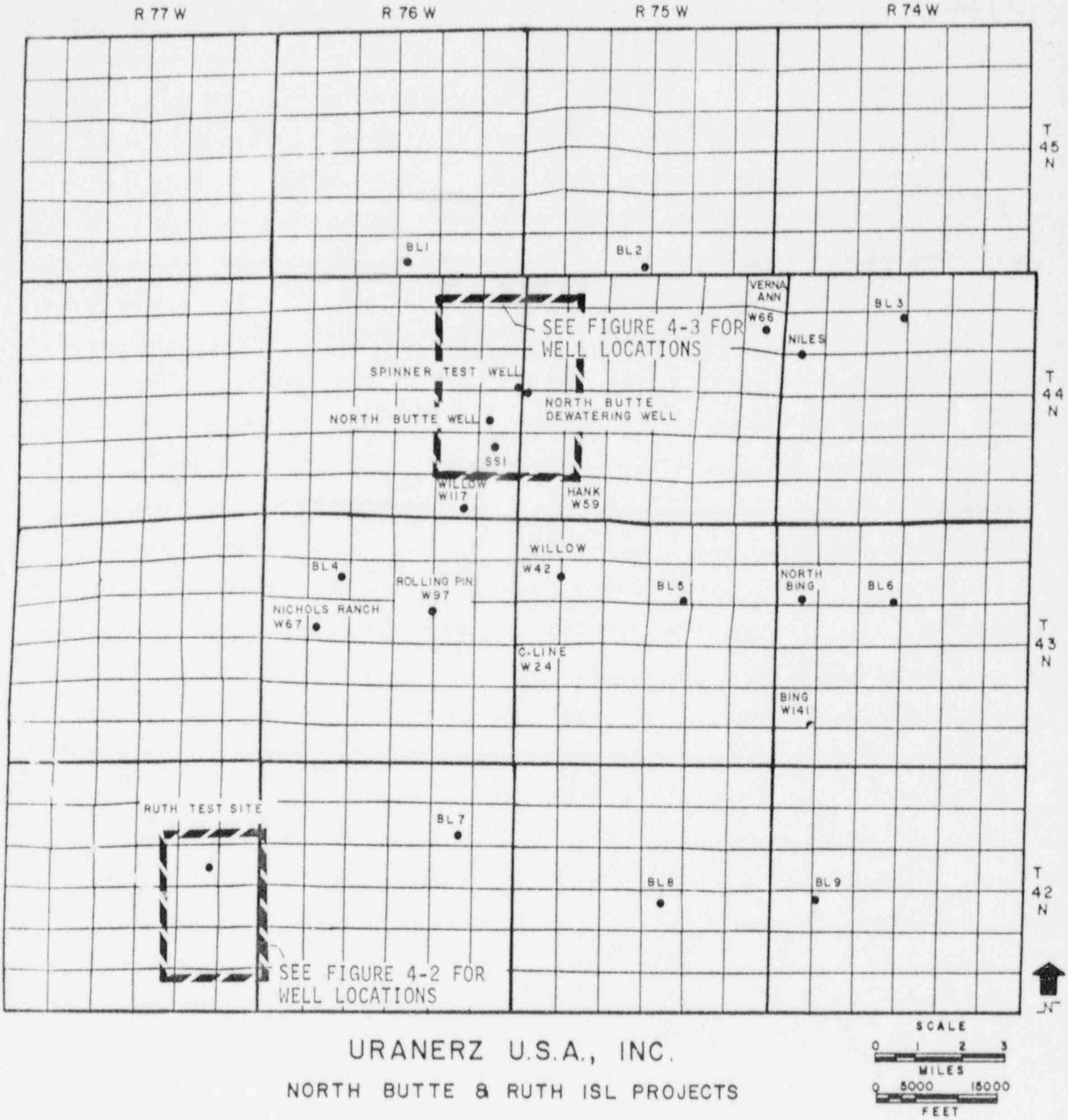

FIGURE 4-1. LOCATION OF WELLS ADJACENT TO URANERZ RUTH AND NORTH BUTTE PROPERTIES.

TABLE 4-1. SUMMARY OF HORIZONTAL HYDRAULIC CONDUCTIVITY VALUES DETERMINED FROM RUTH AND NORTH BUTTE AQUIFER TESTS.

WELL	AQUIFER	HORIZONTAL HYDRAULIC CONDUCTIVITY (cm/sec)	(ft/day)
		RUTH SITE	
3L	A SAND	1.08X10-4	0.31
4L	A SAND	1.26X10-4	0.36
5L	A SAND	0.76X10-4	0.21
6L	A SAND	0.64X10-4	0.18
8L	A SAND	1.24X10-4	0.35
1-M-20	A SAND	1.88X10-4	0.53
4-M-20	A SAND	1.41X10-4	0.40
5-M-20	A SAND	1.42X10-4	0.40
7-M-20	A SAND	1.34X10-4	0.38
		NORTH BUTTE SITE	
SS1 U	C SAND	6.90X10-4	1.95
SS1 M	B SAND	9.40X10-4	2.66
		3.00X10-3	8.50
SS1 L	A SAND	4.10X10-4	1.16
SSE U	F SAND	1.10X10-3	3.11
SSE M	B SAND	4.57X10-4	1.30
SSE L	A SAND	3.05X10-4	0.86
N BUTTE	C SAND	6.00X10-4	1.70
		ADJACENT AREAS	
SSW U	F SAND	2.41X10-3	6.83
SSW M/U	C SAND	2.41X10-4	0.68
SSW M/L	B SAND	1.10X10-4	0.31
SSW L	A/L SAND	3.66X10-6	0.01
BL1 U	C SAND	5.49X10-5	0.16
BL1 M	A/U SAND	6.40X10-5	0.18
BL1 L	A/L SAND	7.93X10-4	2.25
BL2 M	C SAND	4.40X10-4	1.25
BL2 L	A SAND	3.90X10-4	1.11
BL3 U	B SAND	5.22X10-4	1.48
BL3 M	A SAND	3.07X10-4	0.87
BL3 L	2 SAND	1.37X10-4	0.39
BL4 M	F/U SAND	5.49X10-5	0.16
BL4 L	1 SAND	6.10X10-5	0.17
BL5 U	B SAND	1.40X10-3	3.97
BL5 M	A SAND	6.30X10-4	1.78
BL5 L	1 SAND	7.80X10-5	0.22
BL6 U	B SAND	1.90X10-4	0.54
BL6 M	A SAND	3.08X10-4	0.87
BL6 L	1 SAND	3.05X10-5	0.09
BL7 M	A/L SAND	1.74X10-6	0.005
BL7 L	1 SAND	4.27X10-5	0.12
BL8 U	B/L SAND	5.49X10-5	0.16
BL8 M	A SAND	2.80X10-5	0.08

TABLE 4-1. SUMMARY OF HORIZONTAL HYDRAULIC CONDUCTIVITY VALUES DETERMINED FROM RUTH AND NORTH BUTTE AQUIFER TESTS (continued).

WELL	AQUIFER	HORIZONTAL HYDRAULIC CONDUCTIVITY (cm/sec)	(ft/day)
		ADJACENT AREAS (continued)	
BL8 L	1 SAND	6.10X10-5	0.17
BL9 U	A/L SAND	2.35X10-4	0.67
BL9 M	1 SAND	4.50X10-4	1.28
BL9 L	2 SAND	1.62X10-4	0.46
N BING	B SAND	1.50X10-3	4.25
	B SAND	2.50X10-3	7.10
NICHOLS	1 SAND	2.10X10-4	0.60
N ROLLING PIN	F SAND	7.00X10-5	0.20
C LINE	F SAND	1.06X10-5	0.03
DRY WILLOW	F SAND	9.80X10-4	2.77
WILLOW	F SAND	2.20X10-3	6.24
HANK	F SAND	1.76X10-4	0.50
BING	A/U SAND	6.00X10-4	1.70
VERNA ANN	A/U SAND	1.06X10-4	0.30
		7.06X10-5	0.20

TABLE 4-2. BASIC INFORMATION FOR RUTH AND NORTH BUTTE SITES WELLS.

WELL	AQUIFER	TOTAL DEPTH (m)	(ft)	COMPLETED INTERVAL (m)	(ft)	SURFACE ELEVATION (m)	(ft)	M.P. (ft+L.S.)
				RUTH SITE				
3L	A SAND	-	-	153.1-155.2	502-509	1471.98	4829.33	
4L	A SAND	-	-	152.2-154.6	500-507	1471.76	4828.62	
5L	A SAND	-	-	154.0-155.8	505-511	1473.32	4833.73	
6L	A SAND	-	-	153.4-154.6	503-507	1474.24	4836.73	
71	A SAND	-	-	-	-	1472.29	4830.34	
8L	A SAND	-	-	154.9-158.3	508-519	1469.69	4821.83	
9L	A SAND	-	-	155.8-157.4	511-516.5	1472.33	4830.50	
1-m-10	1 SAND	-	-	172.6-203.1	566-666	1472.15	4829.90	
1-M-20	A SAND	168.9	554	150.1-169.0	492-554	1471.85	4828.90	
1-m-30	B SAND	-	-	127.8-138.8	419-455	1474.14	4836.43	
2-m-20	A SAND	160.0	525	-	-	1470.08	4823.1	
4-M-20	A SAND	-	-	157.7-175.4	517-575	1477.50	4847.44	
5-M-20	A SAND	-	-	150.4-171.7	493-563	1473.68	4834.91	
7-M-20	A SAND	169.2	555	153.9-167.9	505-551	1473.66	4834.83	
						1469.78	4822.10	
8-m-20	A SAND	169.5	556	158.6-162.9	525-534	1466.36	4810.89	
1-w-51	F SAND	-	-	25.9- 57.3	85-188	1474.17	4836.50	
1-M-51	F SAND	49.4	162	28.0-49.4	92-162	1472.26	4830.24	
				NORTH BUTTE SITE				
SS1 U	C SAND	113.1	371	99.4-113.1	326-371	1516.0	4974.01	1.1
SS1 M	B SAND	138.4	454	124.4-138.4	408-454	1515.7	4973.17	0.9
SS1 L	A/L SAND	198.4	651	164.6-198.4	540-651	1515.9	4973.83	0.6
sslp u	C SAND	107.3	352	100.6-107.3	330-352	1516.7	4975.89	0.5
sslp m	B SAND	135.0	443	125.0-135.0	410-443	1515.2	4971.24	1.5
sslp l	A/L SAND	179.8	590	171.0-179.8	561-590	1516.7	4975.93	1.3
SSE U	F SAND	88.7	291	78.0-88.7	256-291	1552.1	5092.10	1.4
SSE M	B SAND	169.2	555	136.6-169.2	448-555	1552.1	5092.34	1.5
SSE L	A SAND	204.8	672	-	-	1554.1	5098.8	-
spinner	F/U SAND	243.8	800	83.8-105.1	275-345	--	--	
	C/B SANDS	243.8	800	138.7-201.2	455-660	--	--	
	A/L SAND	243.8	800	219.4-237.7	720-780	--	--	
SS2 U	F SAND	114.6	376	-	-	1558.7	5113.7	
SS2 M	C/B SANDS	195.4	641	-	-	1559.4	5116.2	
SS2 L	A SAND	235.3	772	-	-	1560.8	5120.6	
SS2P U	F SAND	115.2	378	-	-	1556.4	5106.3	
SS2P M	C/B SANDS	195.0	639.7	-	-	1559.0	5114.8	
SS2P L	A SAND	243.7	799.6	-	-	1563.8	5130.5	
N BUTTE well 1	C SAND ALL	243.8	800			1566.5	5139.8	4.0
				ADJACENT AREAS				
SSW U	F SAND	65.8	216	52.1-65.8	171-216	1502.0	4927.93	1.0
SSW M/U	C SAND	105.5	346	93.0-105.5	305-346	1501.7	4926.98	2.1
SSW M/L	B SAND	147.2	483	108.8-147.2	357-483	1502.5	4929.58	1.9
SSW L	A/L SANDS	184.4	605	172.5-184.4	566-605	1502.3	4928.80	-

TABLE 4-2. BASIC INFORMATION FOR RUTH AND NORTH BUTTE SITES WELLS (cont).

WELL	AQUIFER	TOTAL DEPTH (m)	(ft)	COMPLETED INTERVAL (m)	(ft)	SURFACE ELEVATION (m)	(ft)	M.P. (ft+L.S.)
				ADJACENT AREAS (continued)				
BL1 U	C SAND	137.2	450	120.1-136.8	394-449	1505.0	4938	
BL1 M	A/U SAND	178.3	585	163.7-178.0	537-584	1505.0	4938	
BL1 L	A/L SAND	208.8	685	191.1-208.5	627-684	1505.0	4938	
bl2 u	F SAND	117.0	384	108.9-117.0	357-384	1580.3	5185	
BL2 M	C SAND	151.2	496	136.8-151.2	449-496	1580.3	5185	
BL2 L	A SAND	225.5	740	207.9-225.5	682-740	1580.3	5185	
BL3 U	B SAND	100.9	331	86.5-100.3	284-329	1521.5	4992	
BL3 M	A SAND	132.6	435	123.4-132.3	405-434	1521.5	4992	
BL3 L	2 SAND	206.6	678	191.1-206.6	627-678	1521.5	4992	
bl4 u	F/U SAND	94.5	310	77.7- 94.2	255-309	1513.6	4966	
BL4 M	C SAND	134.4	441	118.3-132.3	388-440	1513.6	4966	
BL4 L	1 SAND	242.0	794	221.0-240.5	725-789	1513.6	4966	
BL5 U	B SAND	197.8	649	175.3-197.8	575-649	1648.9	5410	
BL5 M	A SAND	243.5	799	229.8-243.5	754-799	1648.9	5410	
BL5 L	1 SAND	265.5	871	251.8-265.5	826-871	1648.9	5410	
BL6 U	B SAND	129.2	424	118.6-128.9	389-423	1610.8	5285	
BL6 M	A SAND	179.8	590	152.4-179.8	500-590	1610.8	5285	
BL6 L	1 SAND	230.7	757	204.8-230.7	672-757	1610.8	5285	
bl7 u	A/U SAND	108.8	357	87.8-108.8	288-357	1522.7	4996	
BL7 M	A/L SAND	126.2	414	116.4-125.0	382-410	1522.7	4996	
BL7 L	1 SAND	160.6	527	136.2-160.3	447-526	1522.7	4996	
BL8 U	B/L SAND	128.3	421	107.9-128.0	354-420	1629.7	5347	
BL8 M	A SAND	162.8	534	135.0-161.2	443-529	1629.7	5347	
BL8 L	1 SAND	219.8	721	195.1-219.8	640-721	1629.7	5347	
BL9 U	A/L SAND	112.2	368	104.2-112.2	342-368	1611.1	5286	
BL9 M	1(?)SAND	161.5	530	126.5-161.5	415-530	1611.1	5286	
BL9 L	2(?)SAND	195.4	641	170.1-195.4	558-641	1611.1	5286	
NICHOLS	1 SAND							
N BING	B SAND							
N ROL PIN	F SAND							
C LINE	F SAND							
DRY WIL	F SAND							
WILLOW	F SAND							
HANK	F SAND							
BING	A/U SAND							
VER ANN	A/U SAND							
h1a-p3	C SAND	142.6	468	141.1-142.6	463-468	1567.7	5143.7	1.7
h1b-p3	above F	79.2	260	--	--	1567.4	5142.8	1.7
h1c-p1	below AL	240.2	788	235.6-237.1	773-778	1567.9	5144.4	1.8
h1c-p2	BC (?)	224.9	738	220.4-221.9	723-728	1567.9	5144.4	1.8
h1c-p3	above C	134.1	440	129.5-131.1	425-430	1567.9	5144.4	1.8
h2a-p1	AL	227.6	747	226.2-227.6	742-747	1562.8	5127.4	1.7
h2a-p2	B SAND	169.8	557	168.2-169.8	552-557	1562.8	5127.4	1.7
h2b-p1	below AL	290.4	953	285.9-287.4	938-943	1562.8	5127.6	1.7
h2b-p2	below AL	256.9	843	252.4-253.9	828-833	1562.8	5127.6	1.7
h2c-p1	below AL	237.7	780	233.2-234.7	765-770	1562.6	5127.0	0.7
h2c-p2	A/L	221.3	726	216.7-218.2	711-716	1562.6	5127.0	1.7
h2c-p3	F SAND	125.0	410	120.4-121.9	395-400	1562.6	5127.0	1.7

TABLE 4-2. BASIC INFORMATION FOR RUTH AND NORTH BUTTE SITES WELLS (cont).

WELL	AQUIFER	TOTAL DEPTH (m)	(ft)	COMPLETED INTERVAL (m)	(ft)	SURFACE ELEVATION (m)	(ft)	M.P. (ft+L.S.)
				ADJACENT AREAS (continued)				
h3-p1	AL SAND	230.1	755	221.0-222.8	725-730	1567.0	5141.2	1.8
h3-p2	C SAND	152.7	501	148.1-149.6	486-491	1567.0	5141.2	1.8
h3-p3	F SAND	121.1	398	117.0-118.6	384-389	1567.0	5141.2	1.8
h4-p1	B SAND	183.0	600	178.3-179.8	585-590	1565.2	5135.4	0.7
h4-p2	C SAND	152.5	500	147.8-149.4	485-490	1565.2	5135.4	0.7
h4-p3	shallow	38.6	126	34.1- 35.7	112-117	1565.5	5135.4	0.7
h5-p1	above A/L	219.5	720	214.9-216.4	705-710	1568.3	5145.5	1.7
h5-p2	B SAND	173.7	570	172.2-173.7	565-570	1568.3	5145.5	1.7
h5-p3	F SAND	96.9	331	96.3-97.8	316-321	1568.3	5145.5	1.7
h6-p1	B SAND	188.4	618	183.8-185.3	603-608	1564.6	5133.3	1.5
h6-p2	C SAND	152.1	499	147.5-149.0	484-489	1564.6	5133.3	1.5
h6-p3	F SAND	102.9	338	98.3- 99.8	322-328	1564.6	5133.3	1.5
h7-p1	B SAND	180.4	592	175.9-177.4	577-582	1565.7	5137.2	1.7
h7-p2	C SAND	150.0	492	145.4-146.9	477-482	1565.7	5137.2	1.7
h7-p3	btw C&F	125.0	410	121.9-123.4	400-405	1565.7	5137.2	1.7
h8-p1	AL SAND	223.4	733	218.8-220.4	718-723	1563.2	5129.0	1.2
h8-p2	B SAND	180.4	592	175.9-177.4	577-582	1563.2	5129.0	1.2
h8-p3	above F	77.3	254	72.5- 74.1	238-243	1563.2	5129.0	1.2
h9-p1	B SAND	162.8	534	158.2-159.7	519-524	1549.1	5082.6	1.7
h9-p2	C SAND	126.3	414	121.8-123.3	400-404	1549.1	5082.6	1.7
h9-p3	above F	46.6	153	42.1- 43.6	138-143	1549.1	5082.6	1.7
h10-p1	B SAND	201.2	660	196.6-198.1	645-650	1576.0	5170.8	1.8
h10-p2	C SAND	170.6	560	166.1-167.6	545-550	1576.0	5170.8	1.8
h10-p3	above F	57.9	190	53.3- 54.9	175-180	1576.0	5170.8	1.8
h11-p1	AL SAND	235.6	773	231.0-232.6	758-763	1565.0	5134.8	1.2
h11-p2	B SAND	192.9	633	188.4-189.9	618-623	1565.0	5134.8	1.2
h11-p3	above F	83.2	273	78.6- 80.2	258-263	1565.0	5134.8	1.2
h12-p1	B SAND	190.2	624	189.6-191.1	622-627	1568.3	5145.6	1.8
h12-p2	C SAND	155.1	509	154.5-156.1	507-512	1568.3	5145.6	1.8
h12-p3	F SAND	98.8	324	98.1-99.7	322-327	1568.3	5145.6	1.8

NOTE: Wells in this table with names containing capital letters also have aquifer properties presented elsewhere in this report.

M.P. = Measuring Point on top of casing.
L.S. = Land Surface

4-1. Figs. 4-2 and 4-3 present the locations of wells in the Ruth and North Butte sites. Fig. 4-1 shows the area covered by these two maps.

At the Ruth site, horizontal hydraulic conductivity of the "A" sand ranges from 0.18 to 0.53 ft/day (0.64 x 10-4 to 1.88 x 10-4 cm/sec). At the North Butte site and adjacent areas, the range of horizontal hydraulic conductivities in the "A" sand (including,the "A" Upper sand), is from 0.005 to 2.25 ft/day (1.74 x 10-6 to 7.93 x 10-4 cm/sec). The typical "A" sand permeability is 1.1 ft/day (3.9 x 10-4 cm/sec). Comparison of the Ruth site "A" sand permeability to that in the North Butte area shows that the "A" sand is generally more permeable at the North Butte site. Typically the "A" sand at the North Butte site is three times more permeable than at the Ruth site. However, the permeability values encountered at the Ruth site fall within the lower portion of the range of permeability values observed at the North Butte site and adjacent areas.

The permeabilities of the "B" and "C" sands at the North Butte site and adjacent areas range from 0.16 to 8.5 ft/day (5.49 x 10-5 to 4.50 x 10-4 cm/sec), with a representative value for these aquifers being 2.0 ft/day ([illegible]) x 10-4 cm/sec).

Several tests have been conducted on wells completed in the "1" sand, which is stratigraphically under the "A" sand, and range of permeabilities observed in the "F" sand is a little wider, from 0.03 to 6.83 ft/day (1.06 x 10-5 to 2.41 x 10-3 cm/sec). Average values for these two sands are 0.64 ft/day (2.24 x 10-4 cm/sec) for the "1" sand and 1.95 ft/day (6.87 x 10-4 cm/sec) for the "F" sand.

In the area adjacent to the North Butte, vertical hydraulic conductivity has been calculated for the aquitard between the "F" and "B" sands at the North Bing well site. Values were determined to be 0.002 ft/day (7 x 10-7 cm/sec) for this aquitard. Subsequently, during model simulation of the groundwater systems in the area, it was found that a value of 0.003 ft/day (1 x 10-6 cm/sec) was too large. In order to simulate observed head differences, a value 40 times less was required. In addition, a vertical hydraulic conductivity test was performed on the "B" sand at the North Bing well site. Vertical permeability of that sand was determined to be 6.24 ft/day (0.0022 cm/sec).

Tests of vertical permeability were not performed on aquitard materials at the Ruth site. Because of the tight, shaley nature of the aquitard samples collected, laboratory analysis was judged to be impractical. A literature value of 2.43 x 10-5 ft/day (8.58 x 10-9 cm/sec) has been selected as representative of the Ruth site aquitard vertical permeability. Hydro test No. 9 results tend to confirm the small vertical permeability of Ruth site aquitards in a qualitative sense.

sentative of the Ruth site aquitard vertical permeability. Hydro test No. 9 results tend to confirm the small vertical permeability of Ruth site aquitards in a qualitative sense. No drawdown was observed in adjacent aquifer wells after pumping well 4L for greater than 38 hours.

Based on data and observations made at the two sites, aquitards separating the proposed upper and lower monitored aquifers are continuous throughout the proposed wellfield areas, and hydraulic connection between aquifers through the aquitards is very small. However, in order to measure aquitard vertical permeability accurately, field tests utilizing piezometers completed in the individual aquitards will be necessary. These tests, using the Neuman-Witherspoon method of analyses, will be performed as part of the commercial permitting process for the two properties.

5.0 WATER QUALITY COMPARISON

The quality of the groundwater at the Ruth and North Butte sites is not the same in terms of the absolute values for the various chemical species; however, the waters are similar in that the Total Dissolved Solids concentrations are of the same order of magnitude. A tabulation of water quality data for several wells at both sites is presented in Table 5-1.

The major difference in the water quality at the two locations is the level of Sulfate which is four to five times higher at the North Butte site in comparison to the Ruth site. The fact that UUS was able to successfully restore the production zone aquifer water quality at the Ruth R&D operation lends further support for not requiring an R&D test at North Butte since based on water quality this site should be easier to restore than Ruth.

The values for the concentration of radium 226 at North Butte are considerably lower than the values at Ruth. This can be explained by the fact that the wells at North Butte with the low radium 226 concentration are either located outside of the ore body or have multiple sand completions which include units that are not mineralized. It is anticipated that the radium values at North Butte for wells completed in the ore body will be similar to the Ruth radium values.

NORTH BUTTE-RUTH PROJECTS

Table 5-1

REPRESENTATIVE BASELINE WATER QUALITY DATA

Location	Ruth	Ruth	Ruth	Ruth	Ruth	N. Butte	N. Butte	N. Butte	N. Butte	N. Butte	N. Butte	N. Butte	N. Butte	N. Butte	N. Butte
Well Name	4L	4L	8L	8L	1-M-51	North Butte Well		Dewatering Well		SS1 - Upper		SS1 - Middle		SS1 - Lower	
Sand Unit Sampled	A	A	A	A	F	ABC&F	ABC&F	ABC	ABC	C	C	B	B	A	A
Date Sampled	6/12/80	7/18/80	10/08/80	12/16/80	5/06/81	11/2978	8/06/79	9/11/78	2/14/79	10/13/78	4/17/79	11/08/78	4/17/79	10/12/78	3/06/79
Parameters															
pH (pH Units)	7.81	8.43	7.82	8.25	8.25										
Conductivity (umhos/cm)	453	524	468	523	472	209	1,240	1,734	2,110	1,635	1,415	1,500	1,380	1,680	1,459
TDS	332	308	332	299	394	860	717	1,060	816	920	820	902	862	512	847
Sodium	112	102	109	99	139	158	190	176	200	221	209	182	208	158	240
Potassium	5	6	5	5	4	4.9	4.9	5.4	6.1	5.8	36	41	5.7	4.6	4.4
Calcium	8	7	6	6	7	70	58	63	56	41	29	38	41	41	42
Magnesium	2	3	2	4	2	17	12	16	7.9	10	7.8	12	8.5	8.8	10
Sulfate	110	0	98	75	56	428	418	612	586	506	505	511	522	496	501
Chloride	8	10	6	9	9	4.9	3.2	5.1	6.7	4.6	4.6	9	4.5	4.3	3.6
Carbonate	0	22	0	17	14	0	11	0	17	0	0	0	0	7	7
Bicarbonate	193	142	193	163	290	154	139	90	5	111	85	120	111	115	120
Ammonia (as N)	<0.05	.18	<0.05	.28	<0.05										
Nitrate (as N)	<0.05	<0.05	<0.05	<0.05	<0.05										
Fluoride	.51	.51	.43	.38	.65	.14	.1	.12	.24	.09	.07	.11	.2	.1	.12
Boron	.08	.1	.08	<0.01	<0.01	<.1	<.1	.6	<0.01	.6	<0.01	<.1	<0.01	.3	.1
Aluminum	.2	<0.05	.38	<0.05	<0.05	<.1	<.3	<.1	<0.05	<.1	<0.05	<.1	<0.05	<0.1	<.3
Arsenic	.014 0		.094	.022	<0.005	<.003	<.002	<.005	<0.005	<.003	<0.005	<.003	<0.005	<.003	<.002
Barium	<0.03	<0.03	<0.03	<0.03	<0.03	<.1	<.3	<.1	<0.03	<.1	<0.03	<.1	<0.03	<.1	<.02
Cadmium	<0.002	<0.002	<0.002	.004	<0.002	<.01	<.01	<.01	<0.002	<.01	<0.002	<.01	<0.002	<.01	<.01
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	<.01	<.02	<.01	<0.01	<.01	<0.01	<.01	<0.01	<.01	<.02
Copper	<0.01	<0.01	.02	<0.01	<0.01	<.01	<.01	<.01	.03	<.01	<0.01	.04	<0.01	.02	<.01
Iron	.02	.05	<0.01	.01	.05	.15	<.01	.03	.06	<.01	.03	.23	.08	<.01	<.01
Lead	.15	<0.01	<0.01	<0.01	<0.01	<.01	.03	.03	.03	<.01	<0.01	<.01	.04	<.01	.04
Manganese	.01	.01	.02	.03	.02	.08	.07	.03	<0.01	<.01	.01	<.01	.01	<.01	<.01
Mercury	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	.009	<.001	<.0005	<0.0005	<.0005	<0.0005	<.0005	<0.0005	<.0005	<.001
Nickel	<0.02	<0.02	<0.02	<0.02	<0.02	<.01	.02	.04	.03	<.02	<0.02	<.01	<0.02	.02	.02
Selenium	<0.005	.003	<0.005	<0.005	<0.005	<.003	<.001	<.002	.06	.008	<0.005	<.003	<0.005	<.003	<.001
Zinc	.89	<0.005	.08	.04	.01	<.02	.59	.31	.13	<.01	<0.005	.03	<0.005	<.01	.02
Molybdenum	<0.05	<0.05	<0.05	<0.05	<0.05	.4	<.2	<.2	<0.05	<.1	<0.05	.4	<0.05	<.1	<.2
Uranium (as U3O8)	.006	.01	.071	.026	.001	.003	<.001	.002	<.001	.005	.01	.023	.014	.014	.006
Vanadium	<0.05	<0.05	<0.05	<0.05	<0.05	<.1	<.4	<.3	<0.05	<.1	<0.05	<.1	<0.05	<.1	<.7
Radium 226 (PiC/L)	175	161	120	136	3.8	2.1	<0.5	2.8	9	54	15.6	3.3	.2	53	1.0

(1) Analysis reported in mg/l unless otherwise noted.

(2) "<" means not detected at level indicated.

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6.0 MINERALOGY AND LEACHABILITY COMPARISON

In order to compare the mineralogy and leachability of the North Butte site with the Ruth site, a total of 10 core samples from North Butte were sent to the Uranerz Exploration Department in Bonn, Germany, for detailed analyses. The results from the analyses were compared with earlier studies of cores from the Ruth property. A detailed report of the analyses and comparisons is included with this document as Appendix A. The following is a summary of the detailed mineralogical report.

The host rocks of both occurrences, North Butte and Ruth, are about identical. The Ruth host rocks were determined to be medium grained, moderately sorted arkosic arenites with varying feldspar content. The North Butte host rock is also determined to be a generally medium grained, moderately sorted arkosic arenite.

The matrix of both occurrences is predominantly montmorillonite/smectite and subordinately kaolinite (and also some sericite). It seems that the North Butte rocks contain lower amounts of clay minerals than the Ruth rocks. An important matrix difference between North Butte and Ruth matrices is the locally strong appearance of calcite at North Butte, whereas carbonate is reported from Ruth as a subordinate matrix constituent. In both occurrences, the rock matrix was deposited after the settling of the clastic grains, and in places corrosion of the clastic grains by the matrix clay minerals is visible. In both occurrences, the smectites/montmorillonites have partly high swelling capacities, but it seems that the North Butte smectites may be swelling even more than those of Ruth.

The distribution of the uranium and vanadium ore minerals is mostly the same at both locations. The most important difference in the ore distribution of the two occurrences is that the North Butte ore is lacking the uranium minerals grown between clastic silicate minerals and their secondary quartz overgrowths. Another less important difference is that the uranium at North Butte was nowhere determined to occur in organic material but only to be attached to fragments of such organic matter. The uranium and vanadium ore minerals of North Butte were much more easily determinable than those of Ruth. The only uranium mineral determined from North Butte is coffinite. The uranium minerals from Ruth were determined as pitchblende with traces of Fe, Mn, Ti and V and minor carnotite; however, it cannot be discarded that coffinite is also present at Ruth (formerly identified as pitchblende).

The ion exchange capacities of the whole rocks from North Butte are similar to those from Ruth:

0.6 - 2.4 meq/100 g rock (North Butte)

vs. 2.1 - 3.6 meq/100 g rock (Ruth)

In both occurrences the ion exchange capacities of the whole rocks were well correlable with the extrapolated amounts of clay minerals in the rocks.

Leachability of North Butte Ore

Based on the presented results it is predicted that the in situ leachability of the North Butte ore should be similar but generally slightly better than that of the Ruth ore. Negative parameters for the in situ leachability of the North Butte ore could be the locally strong occurrence of calcite plugging the rock porosity. Other negative factors might possibly be the strong swelling (coagulation) capacity of the smectites in the rock matrix, the presence of gypsum in the matrix, and the locally intimate intergrowth patterns of coffinite in the clay minerals.

7.0 SUMMARY

Uranerz USA, Inc. intends to commercially permit and mine two uranium properties in the Powder River Basin using in situ leach (ISL) technology. In support of these planned commercial activities, Uranerz conducted a successful R & D mining and aquifer restoration operation at one of the two properties- the Ruth site. The other site, the North Butte property, is only about 12 air miles from the Ruth property, and the two uranium deposits are very similar. The alkaline leach technology successfully tested during the R & D operation at Ruth will be utilized in the commercial operations at the two sites.

Geologically, the Ruth and North Butte properties are very similar. The uranium mineralization at both sites is contained in the same sandstone units of the lower portion of the Wasatch Formation at a depth below land surface of 525 to 625 feet. These sandstone units are directly correlatable from one property to the other. The structural attitude of the Wasatch Formation at both sites is nearly flat and there is no evidence of faulting at either location. The two properties also have continuous confining shale layers above and below the mineralized sandstone units. The ore bodies at Ruth and North Butte are both typical Powder River Basin roll front deposits and are part of the same roll front system. Other successful ISL R & D projects using the same type lixiviant in addition to Ruth are RME Reno Ranch and Malapai Willow Creek. These two projects both leached and restored in the same roll front system.

The available hydrogeologic information for the Ruth and North Butte properties indicates that there are no significant differences in the aquifer properties. The permeabilities at the two locations are not identical but both have values that are typical of Wasatch sands in the Powder River Basin and will respond well during exploitation. Likewise, the water quality is somewhat different as is typical for the area, but the comparison of individual parameters reveals values that are the same order of magnitude with North Butte having the poorer water quality. Based on the existing water quality and clay content, the North Butte production zones are expected to be easier to restore than the Ruth production zone.

The mineralogical and leachability portion of this report indicates that there are no significant differences in the mineralization based on existing data from the two sites. The variability that does exist in the mineralogy is not unusual for the Powder River Basin and can be found in deposits adjacent to each other. It is expected that the ore bodies at the two properties will have similar leach characteristics while using the lixiviant technology which was tested at the Ruth and Willow Creek ISL pilot operations.

Uranerz USA, Inc. in the preparation of its commercial ISL permits and licenses for the North Butte property is not planning to conduct an R & D pilot test operation. The reasons for not performing a pilot test are as follows:

1) Successful R & D ISL mining and restoration of the Ruth project only 12 miles from the North Butte site as well as the Willow Creek R & D project five miles to the West of North Butte.
2) Geologic, hydrologic and mineralogic similarity of the Ruth property and the North Butte property as documented in this report;
3) History of other successful R & D operations in the Powder River Basin situated in the same geologic environment (same roll front system);
4) Recent successful aquifer restoration of a commercial uranium ISL facility in Fremont County that used the same lixiviant and oxidant that Uranerz plans to use at North Butte.
5) Demonstrated experience and expertise of the Uranerz ISL staff that will manage both the Ruth and North Butte commercial operations.

For the above reasons Uranerz USA Inc. does not feel that a pilot R & D operation at North Butte is necessary on either a technical or environmental basis. Eliminating the R & D phase at North Butte will take at least two years off the time required to begin commercial production at the two properties. Instead of starting commercial production in 1991 as presently planned, it will be 1993 or 1994 before commercial production can commence if an R & D pilot operation is performed at North Butte. Uranerz USA Inc., therefore, requests that the Wyoming DEQ and the NRC specify at this time that a R & D pilot test will not be a prerequisite for commercial licensing of the North Butte property.

APPENDIX A

MINERALOGICAL REPORT 88-3

MINERALOGICAL INVESTIGATION OF TEN (10) SAMPLES FROM NORTH BUTTE

URANERZBERGBAU GMBH

Mineralogical Report 88-3
Project 7347 (3714) North Butte

Mineralogical Investigation
of 10 Samples from
DDH 13-463 C, 19-167 C,
24-646 C, 24-869 C, 25-108, 25-109, 25-223 C
North Butte, Wyoming, U.S.A.

Bonn, January 15, 1988
E-v.Pe/as/abu
Az.: 3811/625

Exploration Department
E. von Pechmann

CONTENTS

1. MAIN RESULTS

The ten investigated rock samples are core halves and consist of moderately to poorly sorted, in parts bedded arkosic sandstones to arkoses ranging in grain size from silt to very small pebble conglomerate (0.03-2.5 mm). The main mineral is detrital quartz; strongly decayed plagioclase and moderately decayed microcline are subordinate clastic components. The host rocks contain rock fragments (quartzitic, gneissic, granitic) and devitrified volcanoclasts besides some fragments of coalified wood. The matrix of the rocks represents up to around 40 vol.-% and consists of smectite (montmorillonite) and of minor kaolinite, gypsum and calcite; in some strongly mineralized samples, calcite is the dominating matrix mineral and almost seals the rock porosity.

The swelling capacity of some clays (irrespective of their occurrence in the A, B, or C sand levels) is, though not exactly measured in the course of the present investigations, very high (up to over 100 %) and typical for smectites. A strong coagulation capacity of the clay minerals observed in some of the investigated samples is perhaps not a negative parameter with respect to the permeability of the host rocks, because the coagulated clay is likely still permeable to moving solutions.

The radioactivity is bound predominantly to the rock matrix and displays a punctiform or, in rich samples, a net-like blackening pattern on the autoradiographs.

Coffinite is the only uranium mineral determined; it occurs mostly as coatings of clay rims around clastic grains (quartz, feldspar), whereby the coatings are up to 3 µm (very seldom 30 µm) thick. In a few parts, coffinite aggregates form up to 0.2 mm large patches. It is generally of a glassy lustre and brownish semi-translucent, i.e. probably in a state of hydration/decomposition (formation of the U^{6+} minerals kasolite-carnotite).

Needles of paramontroseite (VO_2) are associated with many of the coffinite coatings and aggregates. They are locally associated with older, partly framboidal pyrite. The latter mineral is locally weakly bravoite-zoned or marcasitic.

1. MAIN RESULTS

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Ilmenite and sagenitic rutile aggregates are rare detrital components, whereas up to mm large wood fragments are relatively common.

Limonite coats parts of the clastic silicate grains in the radioactive parts as well as in the non-radioactive rock domains.

The host rocks and the ore from North Butte are very similar to those of the Ruth occurrence. The above described characteristics of rock and ore are found in both occurrences. Important differences are:

a) the U ore textures are more simple at North Butte: intimately zoned intergrowths as observed in the Ruth ore (detrital quartz-pitchblende--secondary quartz/clay-pitchblende), were not observed at North Butte;

b) only coffinite appears to occur at North Butte, pitchblende was not observed;

c) the V mineral needles (paramontroseite) are much fresher at North Butte than at Ruth;

d) the North Butte ore is locally much richer in carbonate than the Ruth ore. The North Butte calcite appears to have formed about simultaneously with the paramontroseite;

e) the North Butte clay minerals commonly have an apparently stronger swelling capacity than those of the Ruth occurrence.

f) a coagulation of the clay minerals has not been observed in rocks from Ruth.

The leachability of the ore from North Butte should likely be better than that of Ruth, because of the interlocking patterns of the ore and host minerals which are overall simpler than those of the Ruth ore. Negative parameters for the leachability of the North Butte ore could be the locally intimate intergrowths of clay minerals coating the silicate clasts with the coffinite, possibly the swelling clay minerals in the matrix, the presence of gypsum in the matrix and the locally dense calcite matrix of the mineralized samples, which results in a decreased permeability. However, these parameters can only be quantified by means of systematic mineralogical investigations and laboratory tests.

2. The Samples

Samples taken by:	Dr. Ch. Schmidt / March 1987; K. McFall / Aug. ?, 1987.
Arrival in Bonn:	March 11, 1987; end of Aug. 1987.
Arrival nos.:	775; 804.
UEB sample nos.:	USA 1082, 1084; USA 1175, 1183, 1184, 1186, 1193, 1195, 1196, 1209.
UUS sample nos.:	6799, 6884; 32109, 16201, 16202, 18151, 17120, 17122, 17123, 21355.
Sample locations:	cf. individual sample descriptions.
Investigations required:	comparative petrography / ore mineralogy Ruth - North Butte.
Work performed:	preparation, autoradiography, and microscopy of 10 thin and 9 polished sections; determination of ion exchange capacities of 6 samples; preparation and evaluation of 10 X-ray diffractograms and of 2 X-ray Gandolfi films.

Key words: USA, Wyoming, North Butte, Ruth, mineralogy, uranium, vanadium, sandstones, arkoses, roll-fronts, ore beneficiation, ore processing, in-situ-leaching, leachability, permeability, porosity, carbonates, calcite, coffinite, uraninite, paramontroseite, uranyl vanadates, uranyl silicates, carnotite, kasolite.

3. Individual Descriptions of North Butte Samples

MINERALOGY	Project No.: 3811 (3714)	Area: ddh 25/108
	UUS Sample No.:	Mineralogical Report No.:
	UEB Sample No.: USA 1082	88-3

Sample taken by: Dr. Ch. Schmidt	Mineralogy by/Date E.v.Pechmann/Jan.13,1988
Sampling location: ddh 25/108 (6799); 368.0 ft.	
Arrival No./Date: 775/March, 11, 1987	Sample Type: Core X, Outcrop, Boulder, Other
Investigation: 1 Thin Section, 1 Polished Section, Other: 3 XRD	
Sample stored at: UEB	Radioactivity: 1.734 % U_3O_8

X-ray diffractometry: ore and quartz: quartz, calcite, albite, coffinite, kaolinite/chlorite?

black: calcite, coffinite, paramontroseite (2 determinations)

Microscopy: The heterogranular arkosic sandstone is characterized by the dominant presence of calcite matrix plumbing the rock pores widely (Figs. 1-2). Ore minerals, especially acicular paramontroseite, are growing as coatings of the clastic silicate minerals into the calcite matrix or within the calcite matrix. Brownish semi-transparent coffinite is coating the clastic grains (Figs. 1-2).

The autoradiograph of the polished section shows strong area-wide and punctiform blackening (Fig. 3). The polished section reveals a rich sandstone ore with distances of the clasts of between 0.02 to (rarely) 0.4 mm. The clasts are often overgrown by an around 0.01 mm thick coating of coffinite which in turn is overgrown by 0.025-0.04 mm long needles of paramontroseite (VO_2) (Fig. 4).

Locally the paramontroseite is grown into (around pyrite which also appear in framboids (Fig. 4); partly marcasite contributes to such aggregates.

Coffinite reaches 0.05 mm size in rather coherent aggregates in some grain interstices (Fig. 6); such coffinite aggregates are partly poor in paramontroseite.

Field Name of Rock: Calcite impregnated sandstone

Main Minerals (%):

Subordinate Minerals:

Accessories:

Ore Minerals:

Petrographic Rockname: heterogranular, calcitic arkosic sandstone

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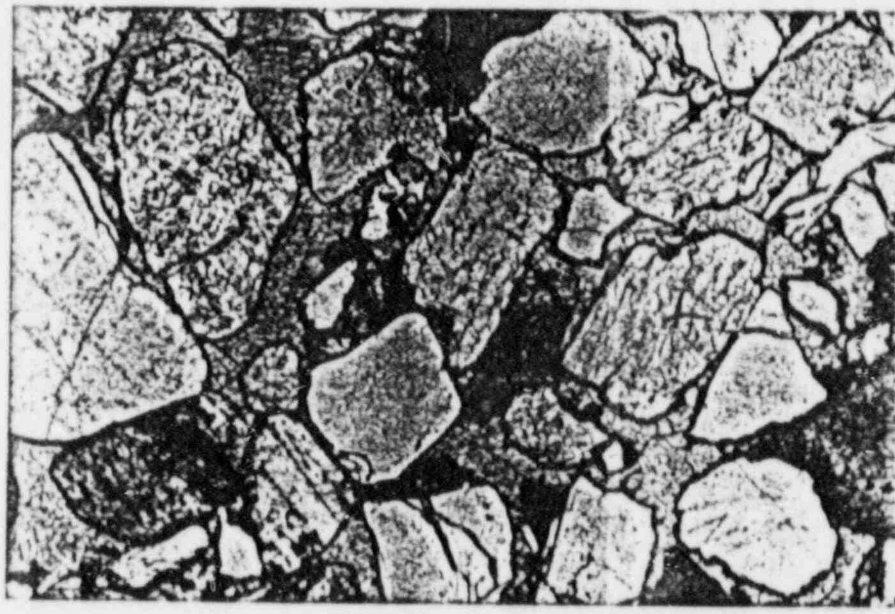
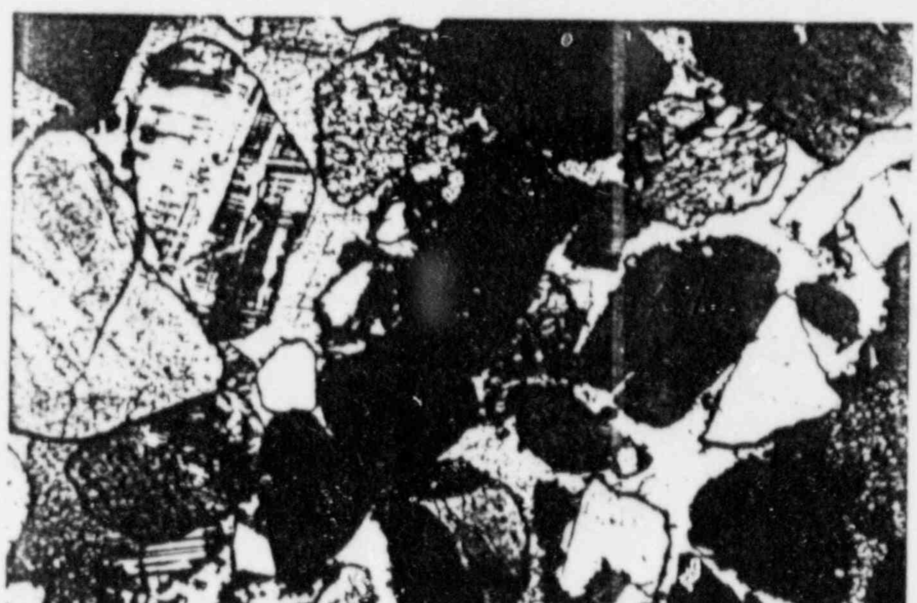
Project: North Butte		
Project No.: 3811 (3714)	Area: ddh 25-108	
UUS Sample No.:	Mineralogical Report No.: 88-3	
UEB Sample No.: USA 1082	Photomicrographs	



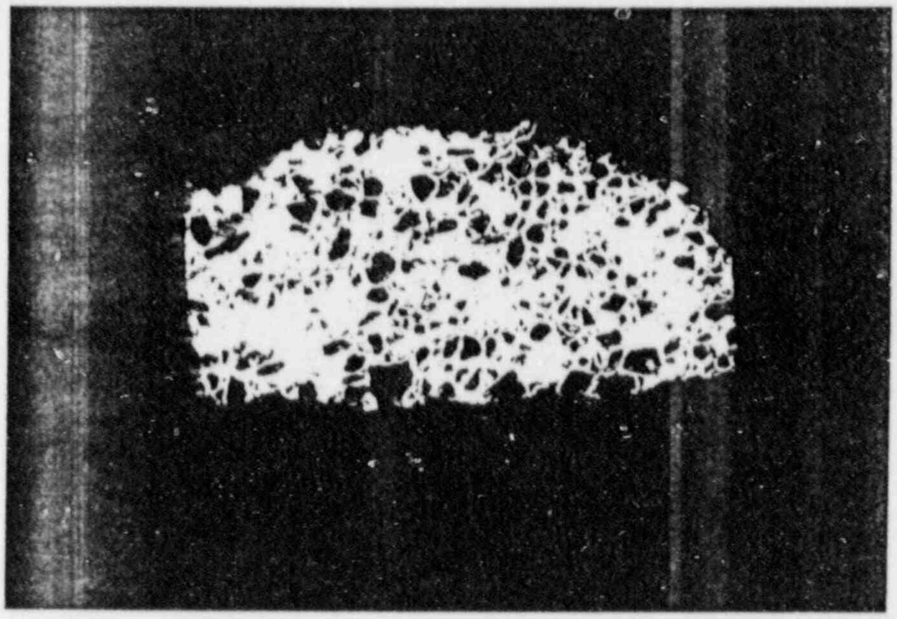


0,5 mm

Figs. 1-2: USA 1082, thin section; obj. 2.5 x air; 1 nic. (top), x nic. (bottom); neg. no. S 324/1-2.

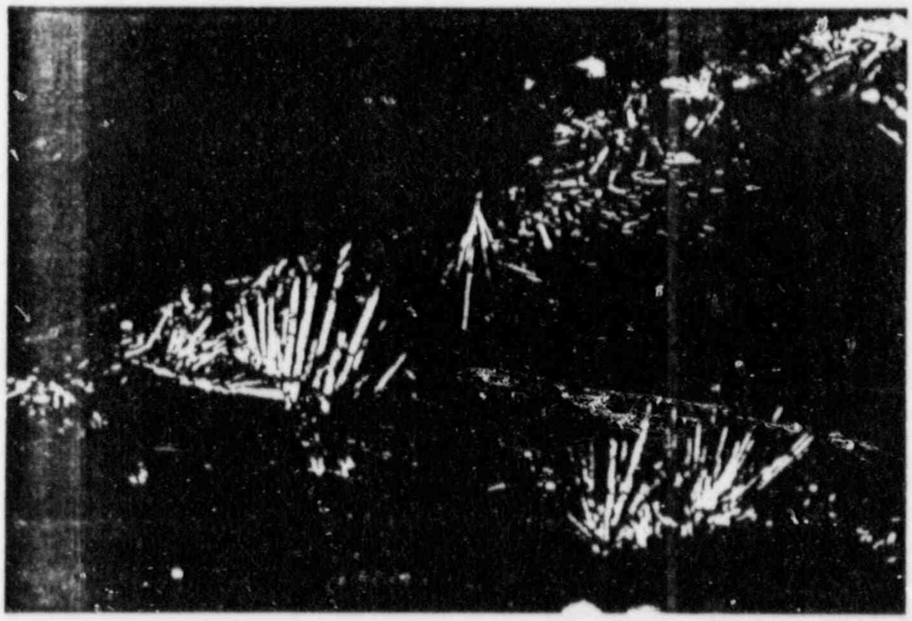
The clastic grains (quartz, microcline, plagioclase, at top left a dull volcanoclast) are coated by coffinite and acicular paramontroseite which grows into the calcite matrix plumbing the rock pores.

URANERZ - MINERALOGY	Project: North Butte		10
	Project No.: 3811 (3714)	Area: ddh 25-108	
	UUS Sample No.:	Mineralogical Report No.: 88-3	
	UEB Sample No.: USA 1082	Photomicrographs	



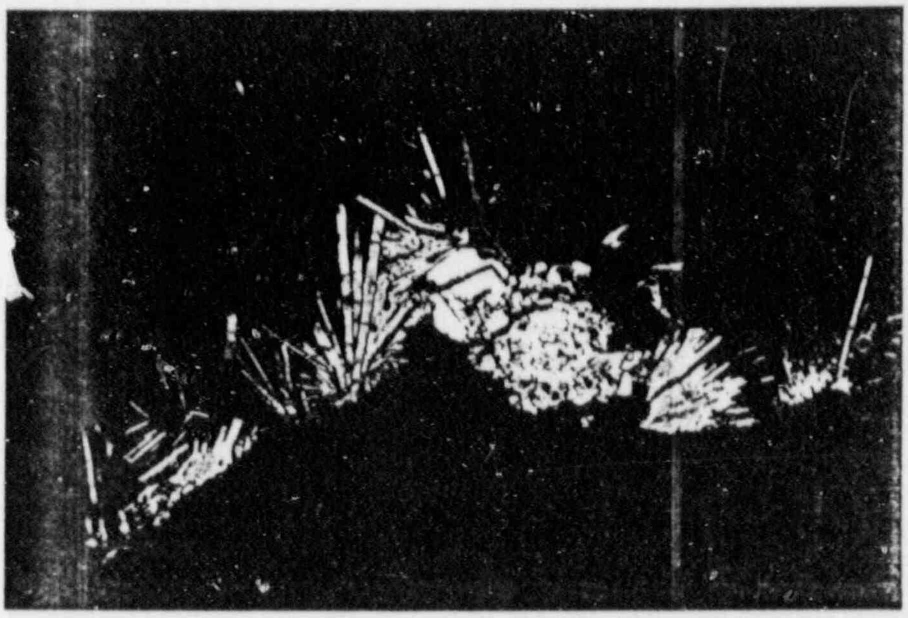
0.3 cm

Fig. 3: USA 1082, polished section; autoradiograph; neg. no. R 1589. Strong punctiform and area-wise blackening reflects the rich uranium mineralization of the calcitic sandstone.



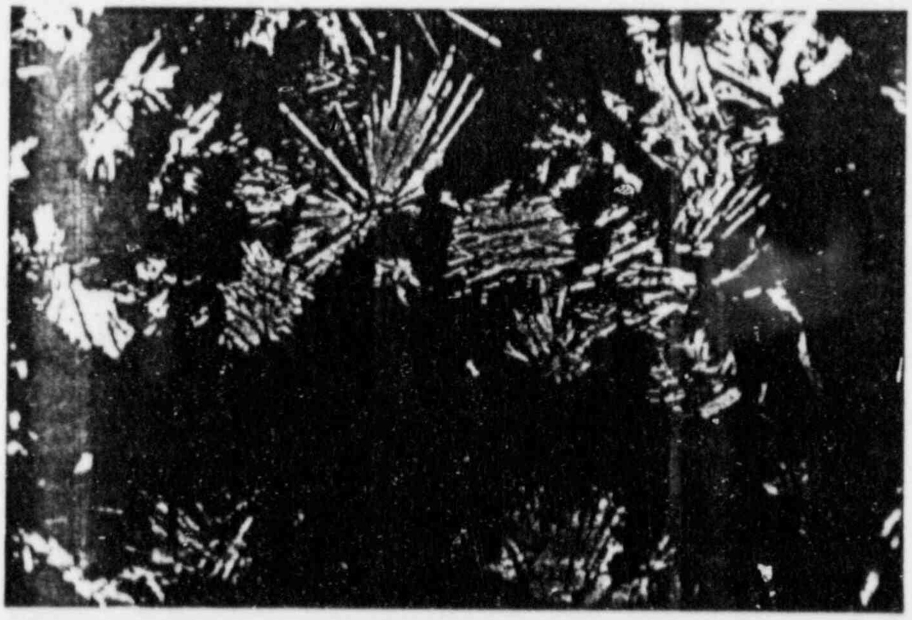
0.02 mm

Fig. 4: USA 1082, polished section; obj. 50 x imm.; 1 nic.; neg. no. S 316-3. Bushes of acicular paramontroseite growing upon a dark grey reflecting layer of coffinite in turn coating clastic silicate grains. The centre of the mineral coated vug is filled by calcite.



0.02 mm

Fig. 5: USA 1082, polished section; obj. 50 x imm.; 1 nic.; neg. no. S 316-2. Paramontroseite needles coating and enclosing partly framboidal pyrite (white) and going upon a (very dark grey) coffinite seam.



0.02 mm

Fig. 6: USA 1082, polished section; obj. 50 x imm.; 1 nic.; neg. no. S 316-4. Aggregates of acicular paramontroseite associated with rather coarse patches of (dark grey) coffinite in a grain interstice.

MINERALOGY	Project No.: 3811 (3714)	Area: ddh 25-109
	UUS Sample No.:	Mineralogical Report No.:
	UEB Sample No.: USA 1084	88-3

Sample taken by: Dr. Ch. Schmidt	Mineralogy by/Date: E.v.Pechmann/Jan. 13, 1988
Sampling location: ddh 25-109 (6884); 564.5 ft.	
Arrival No./Date: 775/March 11, 1987	Sample Type: Core X, Outcrop , Boulder , Other
Investigation: 1 Thin Section , 1 Polished Section , Other:	
Sample stored at: UEB	Radioactivity: 1.379 % U_3O_8

Microscopy: The thin section reveals a medium grained layered arkosic sandstone (grain size up to appr. 0.5 mm) with a strong contribution of matrix (Fig. 7). A great part of the clastic silicate components are coated by a translucent greenish to brownish material which, as is shown by the autoradiographs is radioactive (Fig. 8). The rock contains numerous small fragments or even lines of coalified wood resp. of carbonaceous material which is associated i.e. coated by radioactive matter (Fig. 8).

The polished section shows coffinite to be the uranium mineral mostly occurring again as grain coatings of 0.005-0.03 mm thickness (Fig. 9). Partly the coffinite is associated with paramontroseite as in USA 1082 and locally overgrows pyrite.

Pyrite, framboidal and euhedral, occurs in cracks of coaly material (Fig. 10) or grown into sagenitic rutile (Fig. 11). It is locally bravoite zoned.
Ilmenite is a rare detrital component of the rock.

Field Name of Rock: sanstone; Al-sand

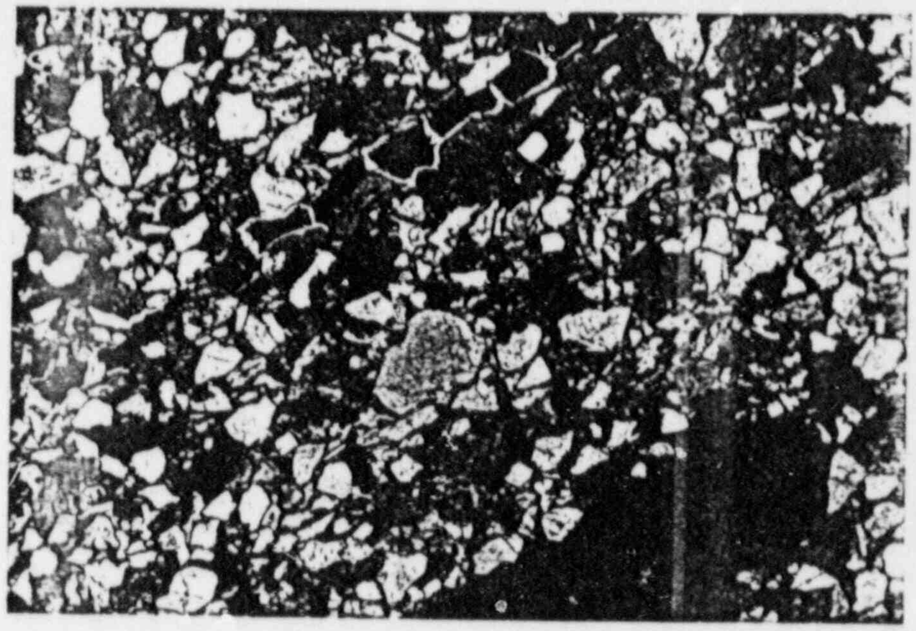
Main Minerals (%):

Subordinate Minerals:

Accessories:

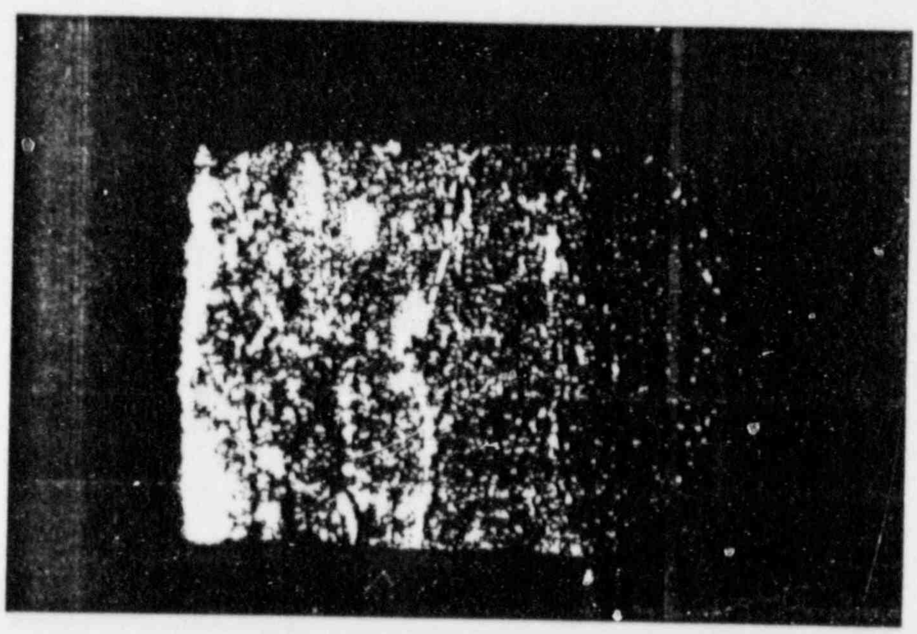
Ore Minerals:

Petrographic Rockname: silty-layered arkosic sandstone



0.5 mm

Fig. 7: USA 1084, thin section; obj. 2.5 x air; 1 nic.; neg. no. S 324-3. Layered, arkosic, matrix-rich sandstone with a line and a large fragment of coalified material (black). The tanning of the matrix derives from the uranium dispersion.



0.3 cm

Fig. 8: USA 1084, thin section; autoradiograph; neg. no. R. 1589. The distribution of the blackening (white) of the autoradiograph shows the layered rock texture; the strongest blackening is associated with C_{org}. material.

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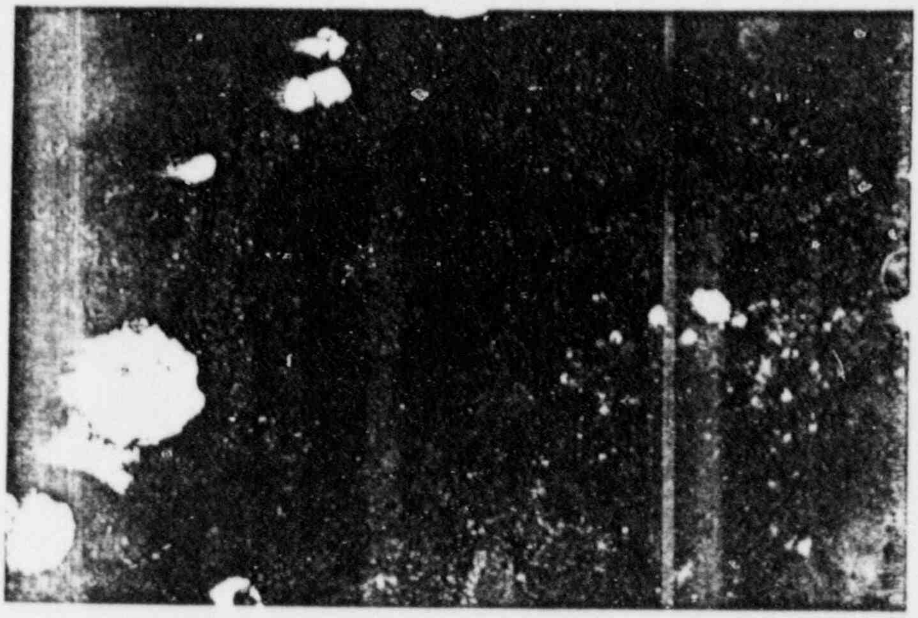
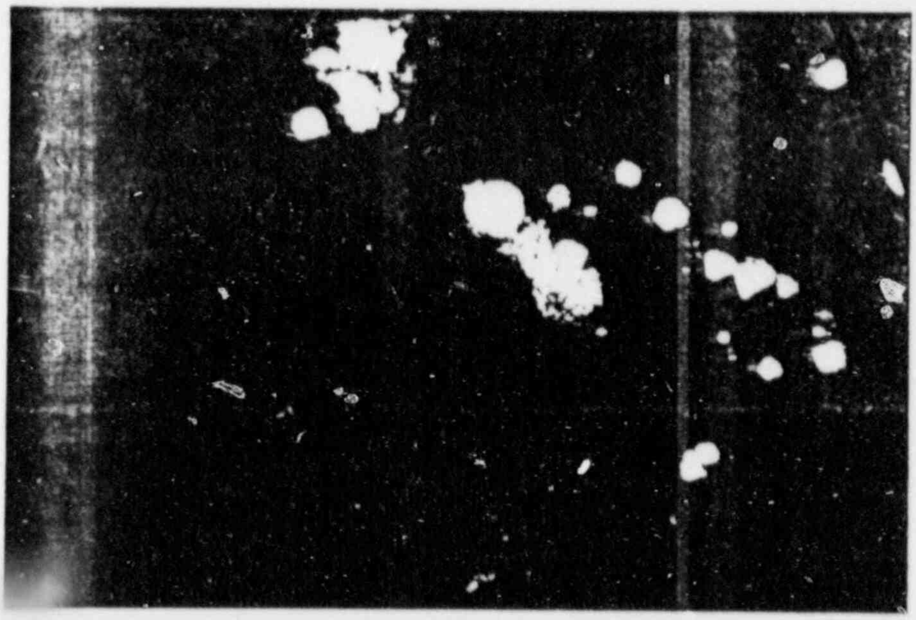
Project: North Butte	
Project No.: 3811(3714)	Area: ddh 25/109
UUS Sample No.:	Mineralogical Report No.: 88-3
UEB Sample No.: USA 1084	Photomicrographs



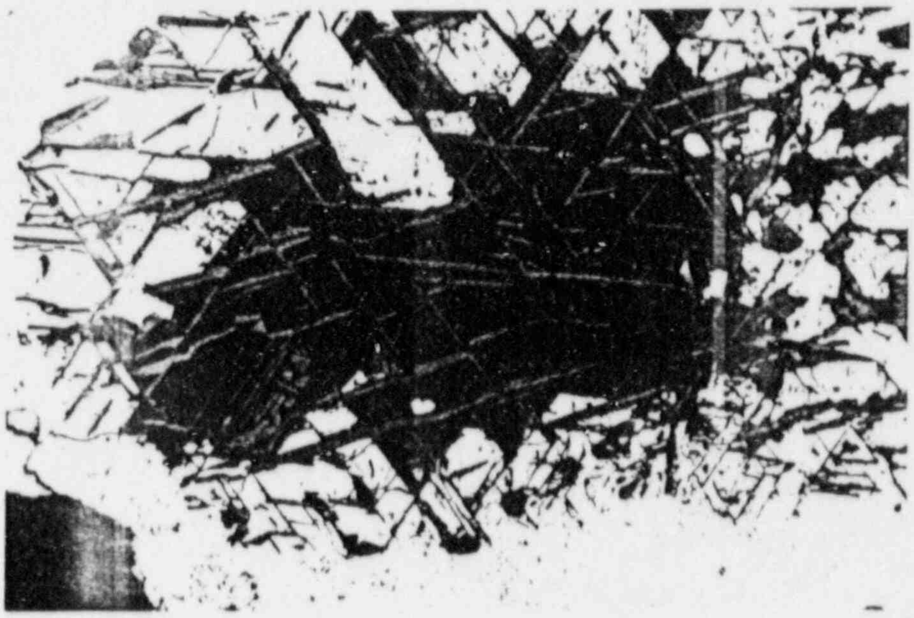
0.02 mm

Fig. 9: USA 1084, polished section; obj. 50 x imm.; 1 nic.; neg. no. S 315-11. Very dark grey reflecting coffinite coating several clastic grains in a grain interstice; partly framboidal pyrite appears white.



0.02 mm

Fig. 10: USA 1084, polished section; obj. 50 x imm.; 1 nic.; neg.no. S 315-16. Framboidal and euhedral pyrite (white) in a fragment of coaly material (very dark grey).



0.02 mm

Fig. 11: USA 1084, polished section; obj. 50 x imm.; 1 nic.; neg. no. S 315-13.
Sagenitic lattice of rutile (grey) filled by pyrite (white).

MINERALOGY	Project No.: 3811(3714)	Area: ddh 13-463 C
	UUS Sample No.: 32109	Mineralogical Report No.:
	UEB Sample No.: USA 1175	88-3

Sample taken by: K.McFall/Aug. 1987	Mineralogy by / Date: E.v. Pechmann/Jan.14,1988
Sampling location: ddh 13-463C; 503.0-503.5 ft	
Arrival No./Date: 804/end of Aug. 1987	Sample Type: Core X, Outcrop , Boulder , Other
Investigation: 1 Thin Section , 1 Polished Section , Other: 2 XRD; clay (ion exchange)	
Sample stored at: UEB	Radioactivity: 210 cps

X-ray diffractometry: clay: smectite; quartz; minor feldspar and kaolinite.

Microscopy: an irregularly sedimented rock with grain sizes of clasts of between 0.02 to 0.3 mm, seldom up to 1.4 mm. The clastic grains have little contact with each other, they are angular, but rounded grains can be observed, too. The grains with lengthy habit are about parallely arranged to each other.

The coarser clasts are commonly of granitic composition.

The matrix consists of pure micaceous (clayey) material which coats almost every clastic grain in form of a thin seam (N.B., obviously the smectitic clay minerals (X-ray determination) are optically quite similar to micas). Part of the clastic grains are likely devitrified volcanoclasts which are strongly altered by clay minerals. But they obviously do not contribute to the low amount of clay minerals (cf. the low ion exchange capacity of the rock). There are also clasts rich in epidote on decayed amphiboles or biotites. Garnets occur very rarely; carbonate represents about 3 % of the rock.

The thin section has about 30 % porosity.

The radioactivity is of regularly punctiform distribution (Fig. 12).

The polished section contains a few very irregular, up to 0.18 mm large aggregates of glassy dark grey-brown reflecting coffinite. Elsewhere the coffinite occurs in form of around 4µm thick coatings on clastic grains or on/in carbonate aggregates (Fig. 13).

The section also shows several up to 20µm large globules of framboidal pyrite.

Up to 0.21 mm large ilmenite grains are partly decomposed into anatase.

Up to 0.07 mm large flakes of graphite are rare.

Field Name of Rock: C-sand

Main Minerals (%):

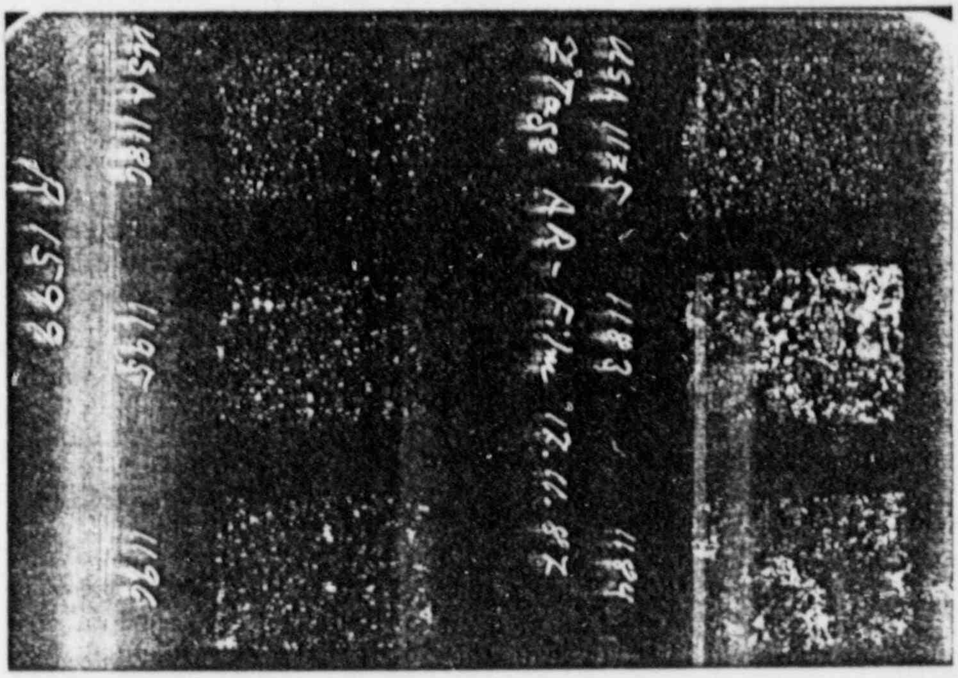
Subordinate Minerals:

Accessories:

Ore Minerals:

Petrographic Rockname: heterogranular arkosic sandstone

URANERZ - MINERALOGY	Project: North Butte		17
	Project No.: 3811 (3714)	Area: ddh 13-463 C	
	UUS Sample No.: 32109	Mineralogical Report No.: 88-3	
	UEB Sample No.: USA 1175	Photomicrographs	



1.0 cm

Fig. 12: Autoradiographs of thin sections; right: USA 1175, USA 1183, USA 1184; left (top to bottom): USA 1186, USA 1195, USA 1196; neg. no. R 1599; natural size.

0.02 mm

Fig. 13: USA 1175/32109, polished section; obj. 50 x imm.; 1 nic., neg. no. S 321-3.
Seams of coffinite (very dark grey) around euhedral grains of a carbonate aggregate.

MINERALOGY	Project No.: 3811(3714)	Area: ddh 24-646C
	UUS Sample No.: 16201	Mineralogical Report No.:
	UEB Sample No.: USA 1183	88-3

Sample taken by: K. McFall/Aug. 1987	Mineralogy by/Date: E.v.Pechmann/Jan. 14,1988
Sampling location: ddh 24-646C; 526.0-526.5 ft	
Arrival No./Date: 804/end of Aug. 1987	Sample Type: Core X, Outcrop , Boulder , Other
Investigation: 1 Thin Section , 1 Polished Section , Other: 2 XRD; clay-ion exchange	
Sample stored at: UEB	Radioactivity: 500 cps; 0.244 % U_3O_8

X-ray diffractometry: light grey-green clay: quartz, albite, mica, smectite and minor kaolinite.

Microscopy: a coarsely sedimented arkosic sandstone with clasts of up to 2.5 mm size.
The thin section contains plentiful carbonate matrix.
Radioactive ore appears as dots and in clay domains of several mm in diameter (Fig. 12). It occurs between clastic silicate grains and carbonate matrix, in the clayey matrix and associated with/around pyrite grains (Figs. 14-18).
Radioactivity and local limonitic areas exclude each other.

The polished section again shows coffinite as up to 0.005 mm thick coatings on clastic grains; it has a strongly glassy lustre and might be in a hydrated state. Coffinite also occurs in up to 0.08 mm large aggregates forming patches of up to 0.2 mm size. It is often associated with pyrite (Fig. 19) which appears in delicate zonated crystals which are partly framboidal (Fig. 20). The outer rims of such framboidal pyrites are partly marcasitic.

Reddish clayish domains of the rock contain numerous up to 0.01 mm large goethite flakes (possibly also minor hematite) besides up to 0.08 mm large (non framboidal) pyrite and some marcasite.
Marcasite also appears in loose lines around clastic grains.
The rock contains a few needles of paramontroseite.
A mm thick fragment of coalified wood is accompanied by faint radioactivity; this wood also contains framboidal pyrite in cracks.

Field Name of Rock: B-sand

Main Minerals (%):

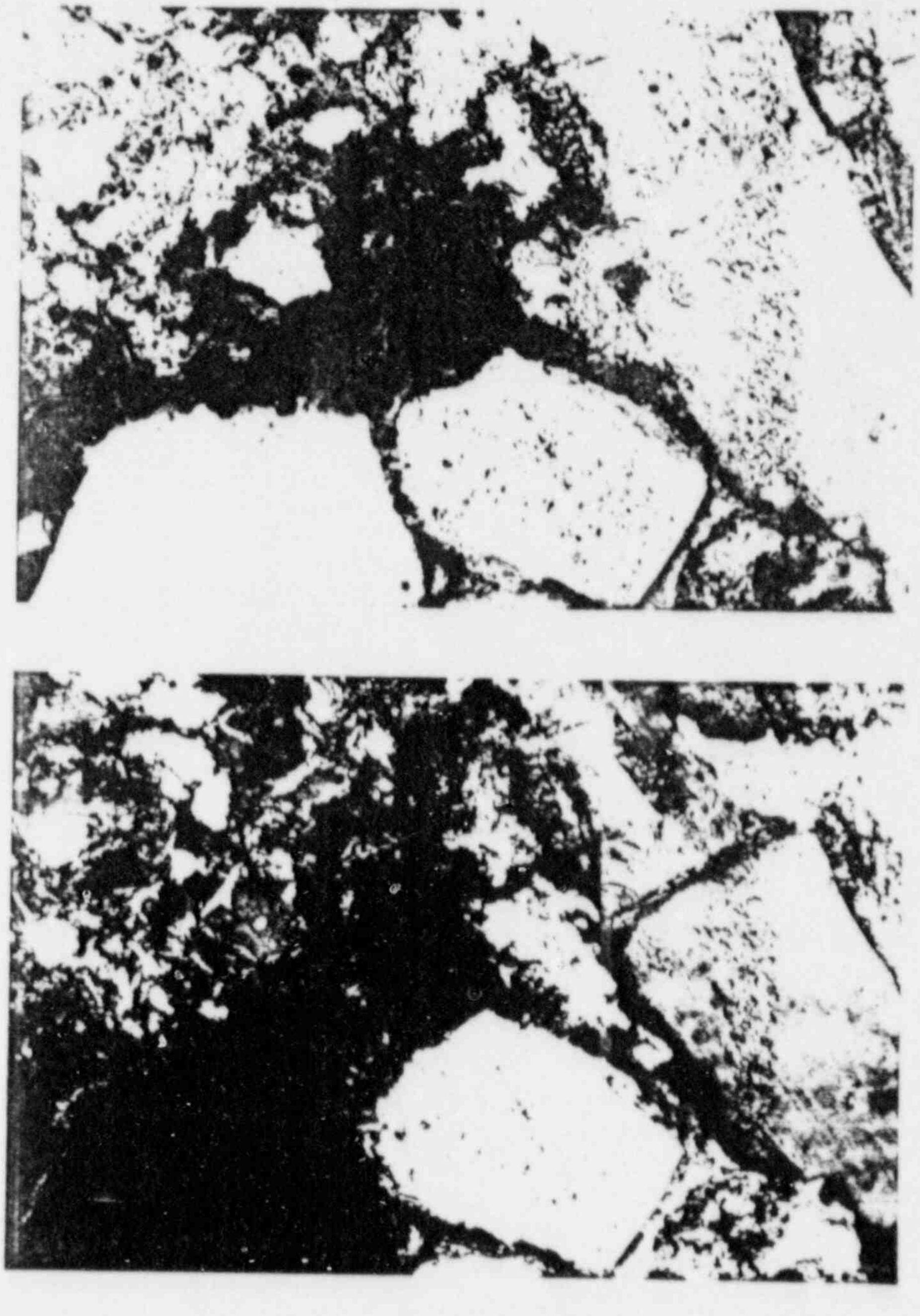
Subordinate Minerals:

Accessories:

Ore Minerals:

Petrographic Rockname:

URANERZ - MINERALOGY	Project: North Butte		19
	Project No.: 3811(3714)	Area: ddh 24-646C	
	UUS Sample No.: 16201	Mineralogical Report No.: 88-3	
	UEB Sample No.: USA 1183	Photomicrographs	



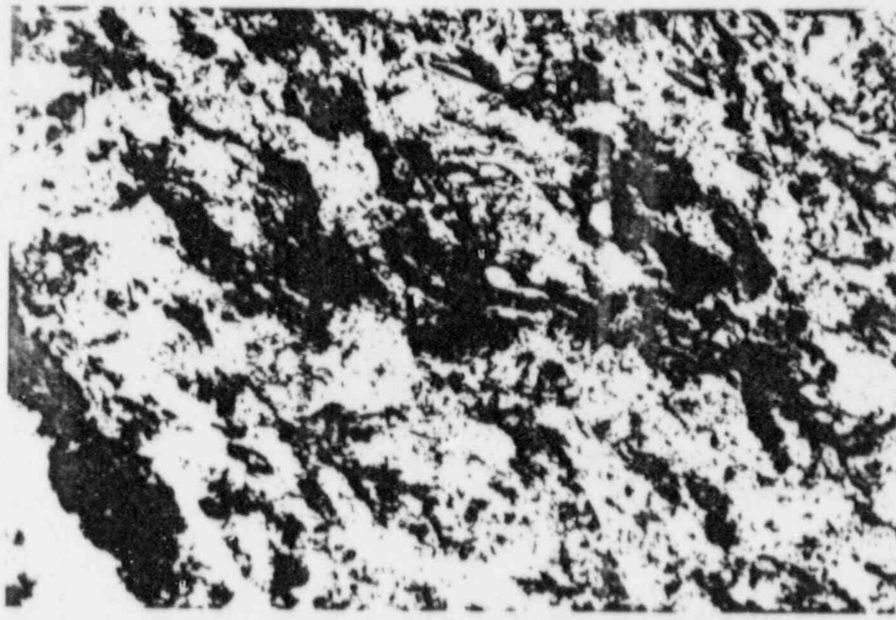
0.1 mm

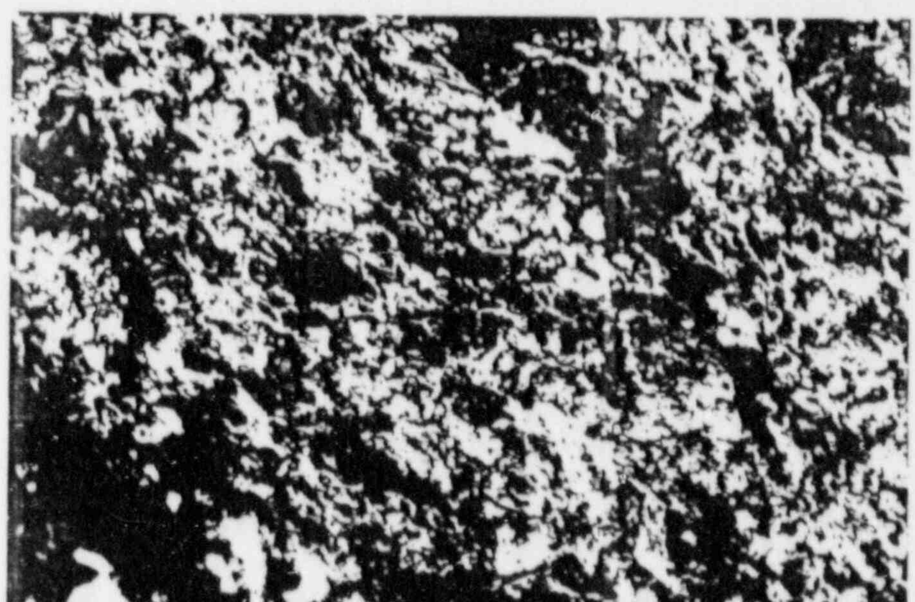
Figs. 14-15: USA 1183 (16201); thin section; obj. 16 x air; top: 1 nic.; bottom: nic. x; with condensor; neg. S 322/10-11. Semiopaque coffinite occurs around pyrite grains (centre, black) within clayish matrix; the coarse grains are quartz clasts.

0.2 mm

Fig. 16: USA 1183 (16201), thin section; obj. 6.3 x air; 1 nic.; with condensor; neg. no. S 322-14.
Black: pyrite; clay matrix; quartz clasts; the coffinite forms the semiopaque material in the matrix and in the clay domains on the right hand side (cf. Figs. 17-18).

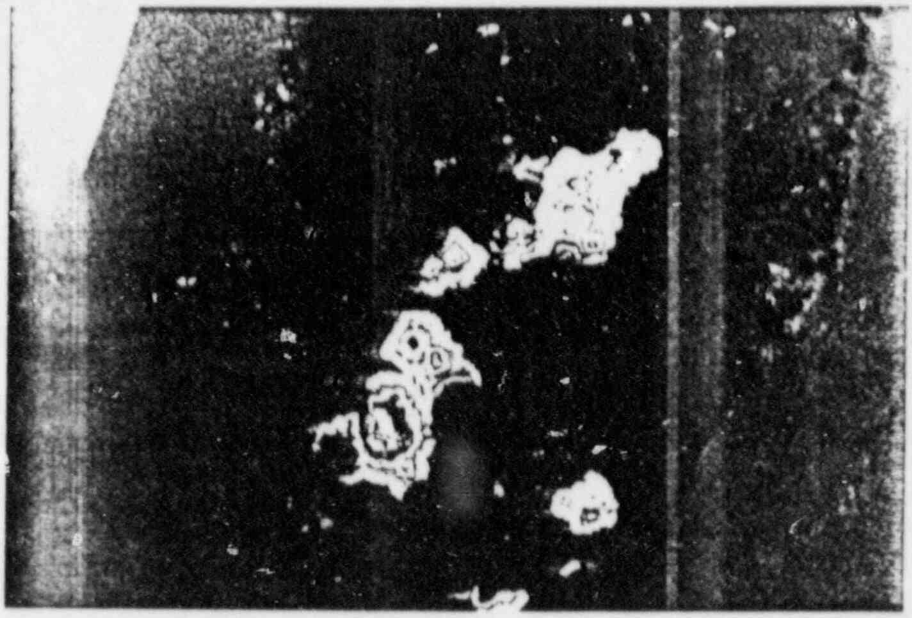
URANERZ - MINERALOGY	Project: North Butte		21
	Project No.: 3811 (3714)	Area: ddh 24-646C	
	UUS Sample No.: 16201	Mineralogical Report No.: 88-3	
	UEB Sample No.: USA 1183	Photomicrographs	





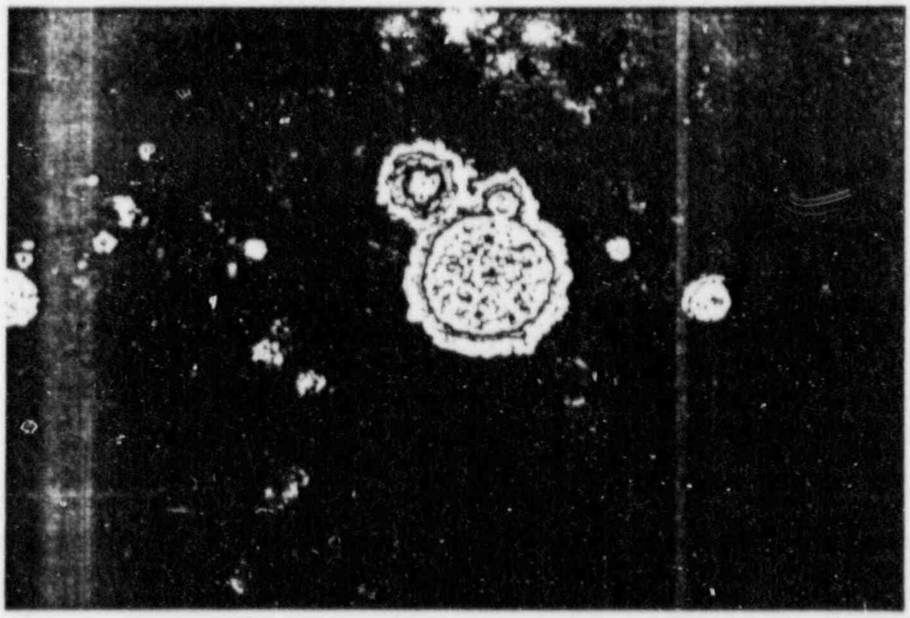
0.1 mm

Figs. 17-18: USA 1183 (16201), thin section; obj. 16 x air; top: 1 nic.; bottom: nic. x; with condensor; neg. no. S 322-12/13. Part of Fig. 16 showing a net of semiopaque coffinite in a clayish rock domain/fragment.



0.02 mm

Fig. 19: USA 1183 (16201), polished section; obj. 50 x imm.; 1 nic.; neg. no. S 322-7.
Coating on clastic grains of very dark grey reflecting coffinite; zoned aggregates of pyrite (white) in a grain interstice.



0.02 mm

Fig. 20: USA 1183 (16201), polished section; obj. 50 x imm.; 1 nic.; neg. no. S 322-3.
Zoned and framboidal pyrite (white).

MINERALOGY	Project No.: 3811 (3714)	Area: ddh 24-646C
	UUS Sample No.: 16202 UEB Sample No.: USA 1184	Mineralogical Report No.: 88-3

Sample taken by: K. McFall / Aug. 1987	Mineralogy by / Date: EvPechmann/Jan. 14.88
Sampling location: ddh 24-646 C; 526.5-527.0 ft.	
Arrival No. / Date: 804 / end of Aug. 1987	Sample Type: Core x, Outcrop , Boulder , Other
Investigation:] Thin Section ,] Polished Section , Other:	
Sample stored at: UEB	Radioactivity: 490 cps; 0.286 % U_3O_8

Microscopy: the thin section of this sample is very similar to that of USA 1183 (16201) (cf. also Fig. 12).
The relatively dense clay matrix encloses about 40 % of clasts which almost do not touch each other.
Uranium occurs in the greenish dense clay matrix and around silicate clasts; again uranium appears in between quartz clasts and carbonate matrix.

The polished section is very similar to that of USA 1183 (16201), too. Coffinite of up to 0.015 x 0.05 mm size forms of to 0.2 mm large patches or occurs as microns thick clast coatings (Fig. 21). Also pyrite occurs in picturesquely zoned aggregates (Fig. 22).

Field Name of Rock: B-sand

Main Minerals (%):

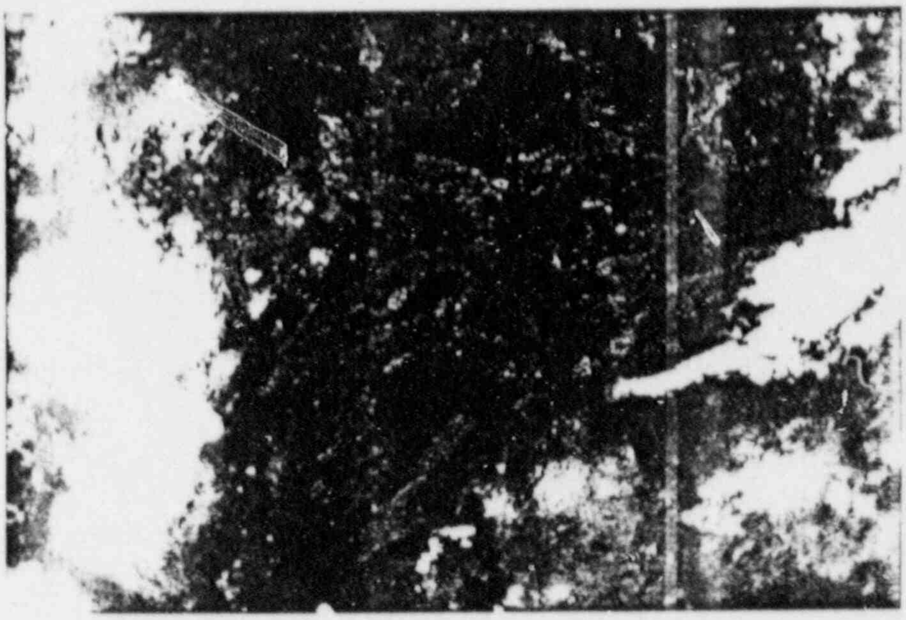
Subordinate Minerals:

Accessories:

Ore Minerals:

Petrographic Rockname:

URANERZ - MINERALOGY	Project: North Butte		24
	Project No.: 3811 (3714)	Area: ddh 24-646C	
	UUS Sample No.: 16202	Mineralogical Report No.: 88-3	
	UEB Sample No.: USA 1184	Photomicrographs	



0.02 mm

Fig. 21: USA 1184 (16202), polished section; obj. 50 x imm.; 1 nic.; neg. no. S 322-9.
Patch of dark grey reflecting coffinite associated with pyrite (white).

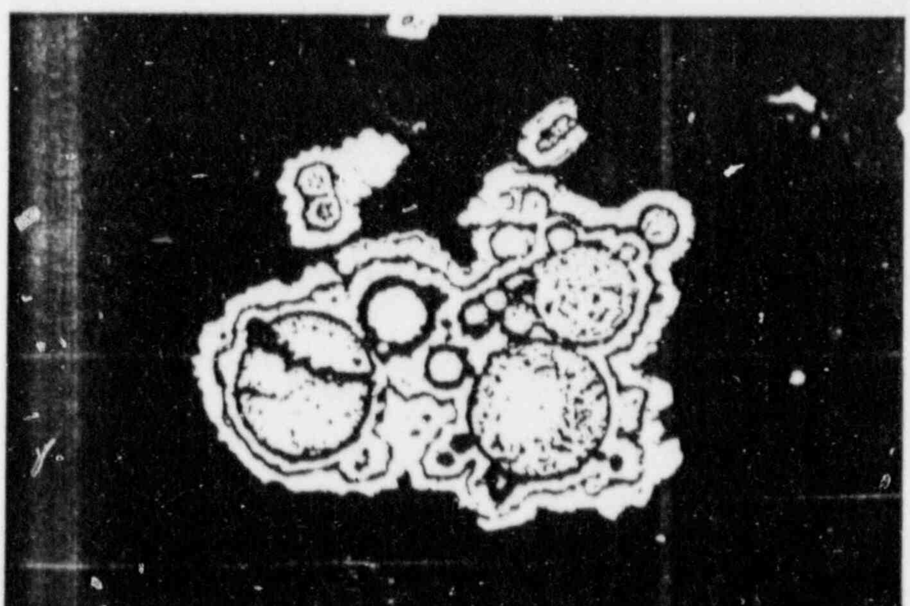


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Fig. 22: USA 1184 (16202), polished section; obj. 50 x imm.; 1 nic.; neg. no. S 322-8.
Aggregate of zoned framboidal pyrite.

MINERALOGY	Project No.: 3811 (3714)	Area: ddh 24-869 C
	UUS Sample No.: 18151 UEB Sample No.: USA 1186	Mineralogical Report No.: 88-3

Sample taken by: K. McFall / Aug. 1987	Mineralogy by/Date: EvPechmann/Jan.15,88
Sampling location: ddh 24-?69 C; 759.0-759.5 ft.	
Arrival No./Date: 804 / end of Aug. 1987	Sample Type: Core x, Outcrop, Boulder, Other
Investigation: 1 Thin Section, 1 Polished Section	Other: 2 XRD, clay - ion exchange
Sample stored at: UEB	Radioactivity: 300 cps 0.440 % U_3O_8

X-ray diffractometry: clay and quartz (heat dried): quartz; bassanite; very minor mica, albite, gypsum, kaolinite; smectite

clay and quartz (air dried): as above, without bassanite (and without gypsum)

Microscopy: the thin section is very similar to that of USA 1175 (32109) except for almost completely missing carbonate in USA 1186.

The polished section shows that radioactivity (cf. Fig. 12) often occurs in the vicinity of fragments of carbonaceous material which contains numerous, 0.007-0.05 mm large aggregates of framboidal pyrite. Radioactivity appears to be bound to very dark grey reflecting coffinite, in ragged aggregates and occurring as grain coatings. But here, as in USA 1175, the lustre is so glassy-transparent that it is almost impossible to determine the (likely hydrated) coffinite as such (Fig. 23) which also coats clastic grains (but in a form almost undiscernable under the ore microscope - uranyl mineral?).
Rather rare pyrite is loosely distributed in the rock. There are a few grains of ilmenite and few needles of paramontroseite.

Field Name of Rock: A-sand
Main Minerals (%):
Subordinate Minerals:
Accessories:
Ore Minerals:
Petrographic Rockname:

0.02 mm

Fig. 23: USA 1186 (18151), polished section; obj. 50 x imm.; 1 nic.; neg. no. S 321-5.
Coating of a clastic grain by coffinite which is likely transferred into a uranyl mineral.

MINERALOGY Project No.: 3811 (3714)	Area: ddh 25-223 C
UUS Sample No.: 17120 UEB Sample No.: USA 1193	Mineralogical Report No.: 88-3.
Sample taken by: K. McFall / Aug. 1987	Mineralogy by/Date: EvPechmann/Jan. 15, 88
Sampling location: ddh 25-223 C; 460.0-460.5 ft.	
Arrival No./Date: 804 / end of Aug. 1987	Sample Type: Core x, Outcrop , Boulder , Other
Investigation:] Thin Section ,] Polished Section , Other: clay - ion exchange	
Sample stored at: UEB	Radioactivity: 380 cps 0.244 % U_3O_8

Microscopy: the thin section resembles the coarse grained parts of USA 1175. The rock is a rather densely packed arkose with grain sizes of the clasts between 0.15 and max. 1.5 mm. The clasts are round to angular, partly consist of devitrified fragments.

The radioactive material, similarly distributed to USA 1195 (cf. Fig. 12), is again partly bound to areas of matrix clay (partly chloritic). It is of course also present as coatings of clastic grains (Fig. 24). The uranium mineral is again in a state of hydration and thus semitranslucent brownish grey.

The polished section displays the besaid thin coatings of glassy coffinite resp. its decaying products (Fig. 24), which are in places overgrown by needles of paramontroseite.

There are also loosely distributed, irregular aggregates of up to 0.01 mm thick and up to 0.1 mm long pyrites, and partly framboidal pyrites along clastic grains.

The pyrite is partly bravoitic, i.e. Ni-bearing.

Field Name of Rock: B-sand

Main Minerals (%):

Subordinate Minerals:

Accessories:

Ore Minerals:

Petrographic Rockname:

URANERZ - MINERALOGY	Project: North Butte		28
	Project No.: 3811 (3714)	Area: ddh 25-223 C	
	UUS Sample No.: 17120	Mineralogical Report No.: 88-3	
	UEB Sample No.: USA 1193	Photomicrographs	

0.02 mm

Fig. 24: USA 1193 (17120), polished section; obj. 50 x imm.; 1 nic.; neg. no. S 321-6.
Very dark grey reflecting coating of glassy coffinite associated with acicular paramontroseite.

MINERALOGY	Project No.: 3811 (3714)	Area: ddh 25-223 C
	UUS Sample No.: 17122 UEB Sample No.: USA 1195	Mineralogical Report No.: 88-3

Sample taken by: K. McFall / Aug. 1987	Mineralogy by / Date: EvPechmann/Jan. 15,88
Sampling location: ddh 25-223 C; 461.0-461.5 ft.	
Arrival No./Date: 804 / end of Aug. 1987	Sample Type: Core x, Outcrop , Boulder , Other
Investigation:] Thin Section ,] Polished Section , Other: clay - ion exchange	
Sample stored at: UEB	Radioactivity: 310 cps; 0.337 % U_3O_8

Microscopy: the thin section resembles that of USA 1193 (17120). The punctiformly distributed radioactivity (Fig. 12) derives from 2-12 µm thick semiopaque coffinite-like coatings on clastic grains (Fig. 25-27) along vugs within clay domains. This uranium should be easily leachable. Locally the coffinite is associated with/surrounding aggregates of pyrite/acicular paramontroseite.

The polished section shows that the coffinite of glassy lustre coats clastic grains (Fig. 28) and partly forms the "matrix" of paramontroseite needles (Fig. 29).

Partly bravoitic pyrite as well as paramontroseite appear randomly distributed in the rock and independent of the presence of coffinite or its derivates (Fig. 30).

Field Name of Rock: B-sand

Main Minerals (%):

Subordinate Minerals:

Accessories:

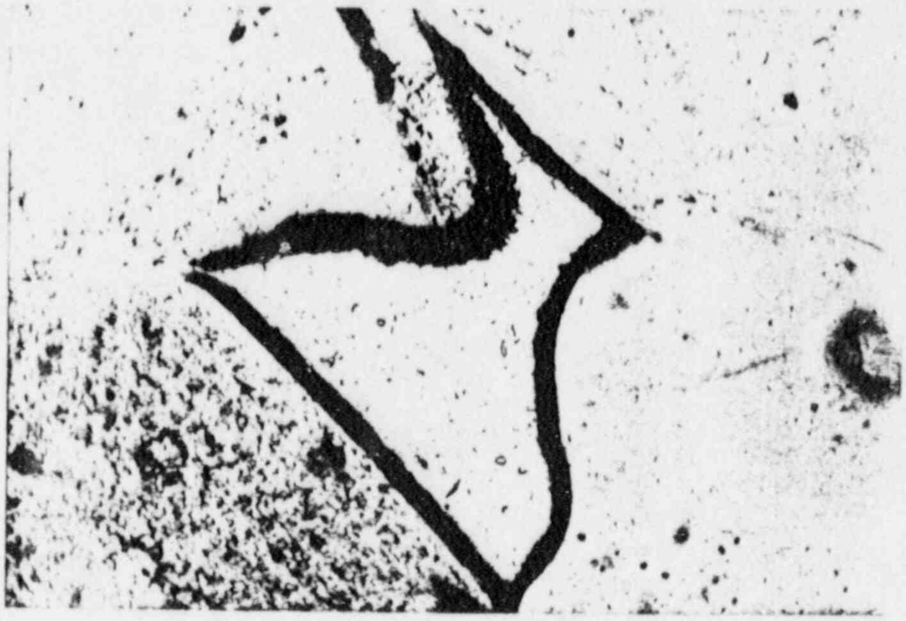
Ore Minerals:

Petrographic Rockname:

URANERZ - MINERALOGY	Project: North Butte	
	Project No.: 3811 (3714)	Area: ddh 25-223 C
	UUS Sample No.: 17122	Mineralogical Report No.: 88-3
	UEB Sample No.: USA 1195	Photomicrographs

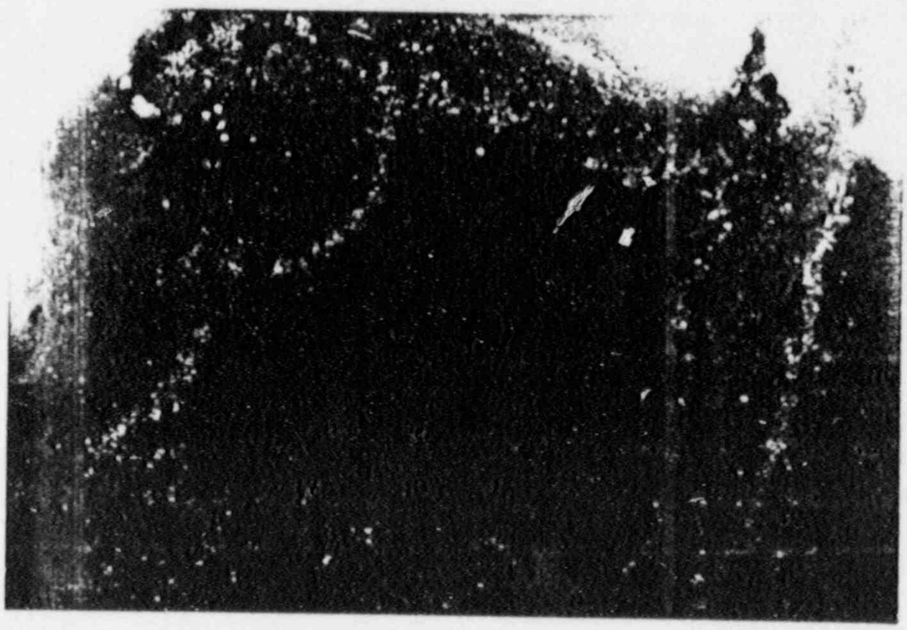
0.1 mm

Figs. 25-26: USA 1195 (17122), thin section; obj. 16 x air; with condensor; top 1 nic.; bottom nic. x; neg. nos. S 323/1-2. Semiopaque coffinite coats a vug in between quartz and striated microcline.



0.1 mm

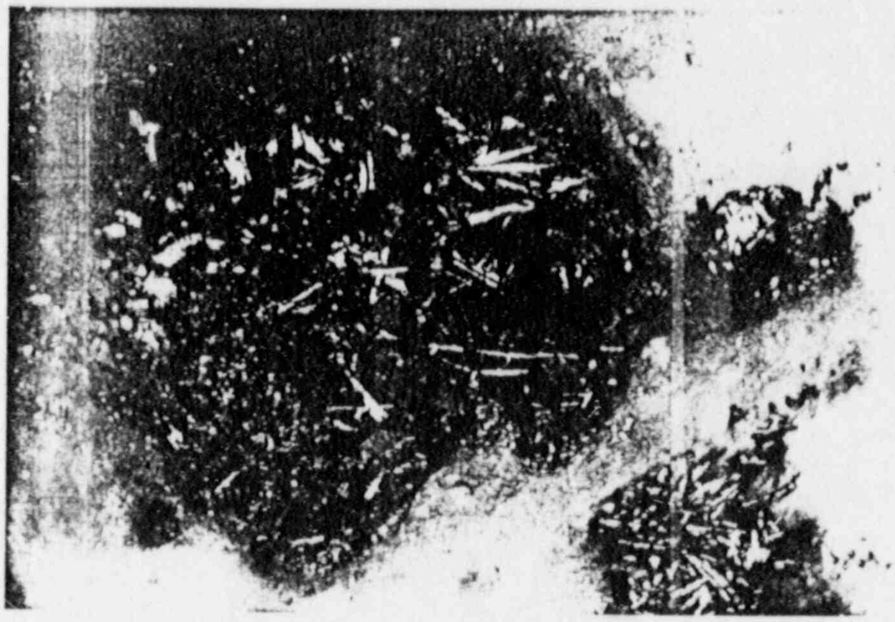
Fig. 27: USA 1195 (17122), thin section; obj. 16 x air; with condensor; 1 nic.; neg. no. S 323-3.
Semiopaque to opaque vug coating of an interstice of clastic grains.



0.02 mm

Fig. 28: USA 1195 (17122), polished section; obj. 50 x imm.; 1 nic.; neg. no. S 321-8.
Coating of coffinite with glassy lustre (very dark grey) on clastic grains partly separated from them by a seam of clayey material.

URANERZ-MINERALOGY	Project: North Butte		32
	Project No.: 3811 (3714)	Area: ddh 25-223 C	
	UUS Sample No.: 17122	Mineralogical Report No.: 88-3	
	UEB Sample No.: USA 1195	Photomicrographs	



0.02 mm

Fig. 29: USA 1195 (17122), polished section; obj. 50 x imm.; 1 nic.; neg. no. S 321-9.
Coffinite (very dark grey) intergrown with acicular paramontroseite.

0.02 mm

Fig. 30: USA 1195 (17122), polished section; obj. 50 x imm.; 1 nic.; neg. no. S 321-11.
Acicular paramontroseite growing on clastic silicate grains.

URANERZ MINERALOGY	Project No.: 3811 (3714)	Area: ddh 25-223 C
	UUS Sample No.: 17123 UEB Sample No.: USA 1196	Mineralogical Report No.: 88-3

Sample taken by: K. McFall / Aug. 1987	Mineralogy by/Date: EvPechmann/Jan.15,88
Sampling location: ddh 25-223 C; 461.5-462.0 ft.	
Arrival No./Date: 804 / end of Aug. 1987	Sample Type: Core x, Outcrop , Boulder , Other
Investigation:] Thin Section ,] Polished Section , Other: 3 XRD; clay - ion exchange	
Sample stored at: UEB	Radioactivity: 300 cps; 0.298 % U_3O_8

X-ray diffractometry: white, soft xx: calcite, mica, kaolinite, swelling clay;

clay, quartz, calcite (heat dried): smectite, bassanite, quartz, microcline/albite, very minor kaolinite;

white, soft (air dried): as above, but without bassanite.

Microscopy: the thin section is very similar to USA 1193; carbonatic matrix is rather common; uranium appears in semiopaque grain coatings; grain interstices are partly open (leachability!) (Figs. 31-32). In parts, the coffinite occurs in the clay matrix (Figs. 33-34). Locally the coffinite is associated with paramontroseite (Fig. 35).

The coffinite in the polished section occurs as grain coatings or in patches (Fig. 36). The grain coatings partly are lines of drops of around 8 μm diameter or are coherent (appr. 10 μm thickness) (Fig. 37).

There are partly rather bravoitic pyrites the centres of which are framboidal in places. Paramontroseite in this sample is rather rare as are a few grains of ilmenite.

Field Name of Rock: B-sand

Main Minerals (%):

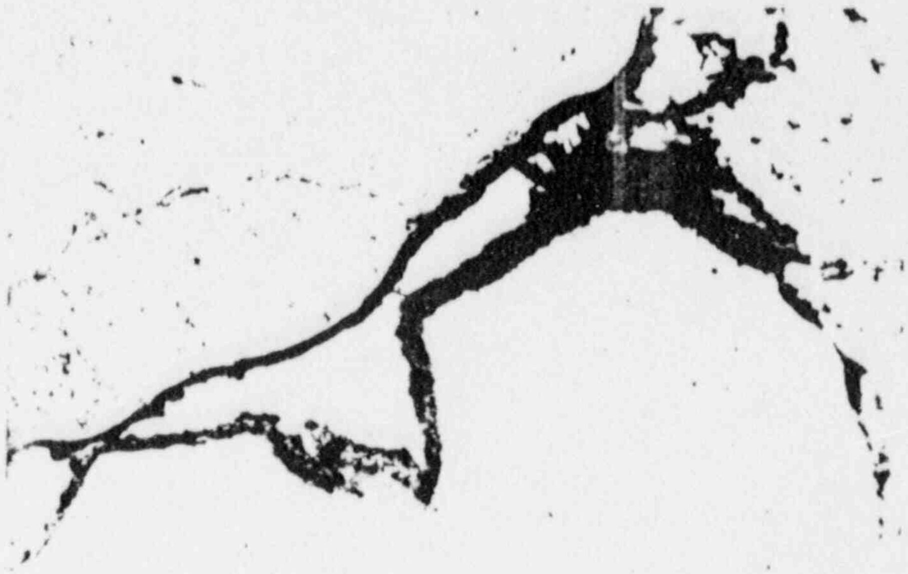
Subordinate Minerals:

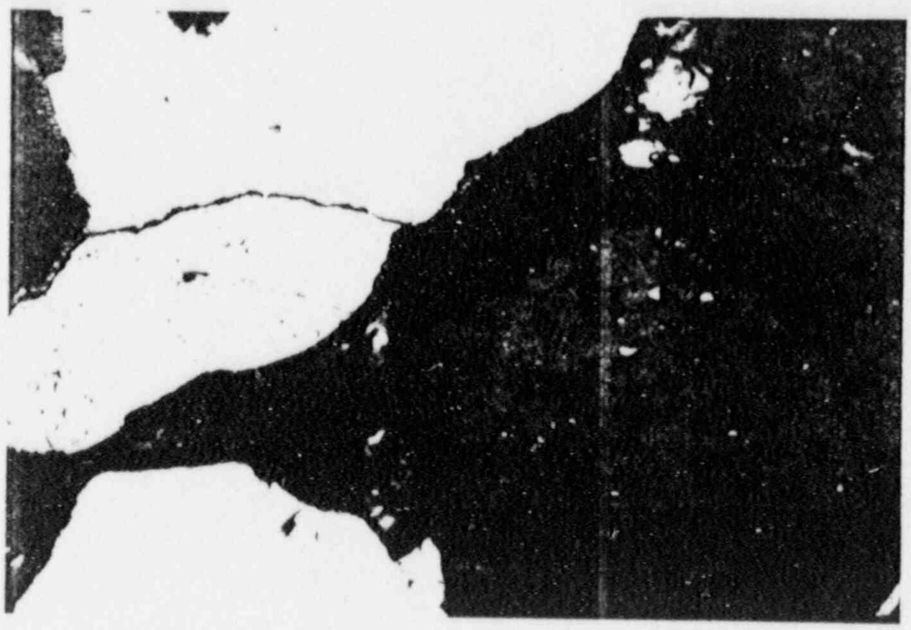
Accessories:

Ore Minerals:

Petrographic Rockname:

URANERZ-MINERALOGY	Project: North Butte	
	Project No.: 3811 (3714)	Area: ddh 25-223 C
	UUS Sample No.: 17123	Mineralogical Report No.: 88-3
	UEB Sample No.: USA 1196	Photomicrographs





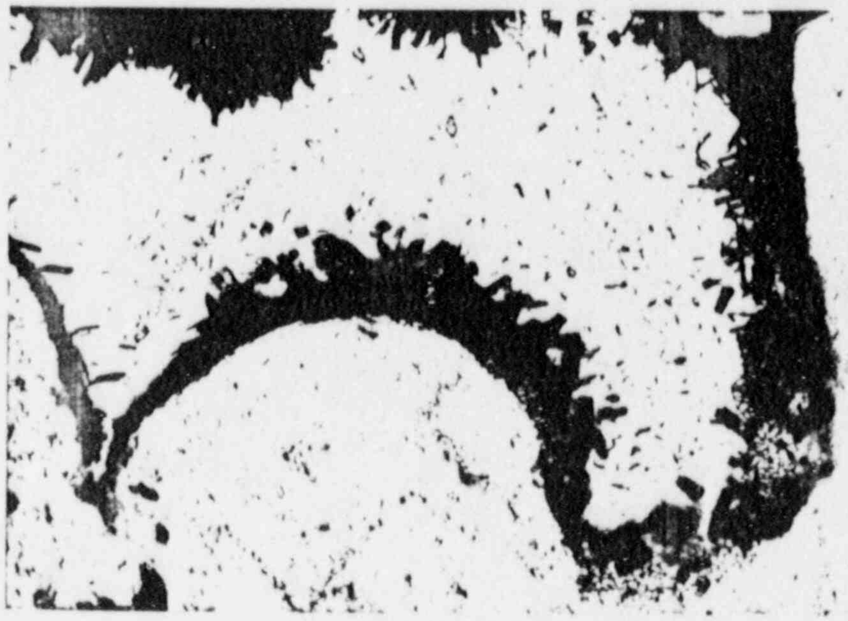
0.1 mm

Figs. 31-32: USA 1196 (17123), thin section; obj. 16 x air; with condensor; top 1 nic.; bottom nic. x; neg. nos. S 323/4-5. Semiopaque coffinite as coating of a hollow vug in between clastic quartz grains.

0.1 mm

Figs. 33-34: USA 1196 (17123), thin section; obj. 16 x air; with condensor; top 1 nic.; bottom nic. x; neg. nos. S 323/6-7. Semiopaque coffinite as coating of a hollow vug in between clastic grains and within clayish matrix (centre).

URANERZ - MINERALOGY	Project: North Butte		36
	Project No.: 3811 (3714)	Area: ddh 25-223 C	
	UUS Sample No.: 17123	Mineralogical Report No.: 88-3	
	UEB Sample No.: USA 1196	Photomicrographs	

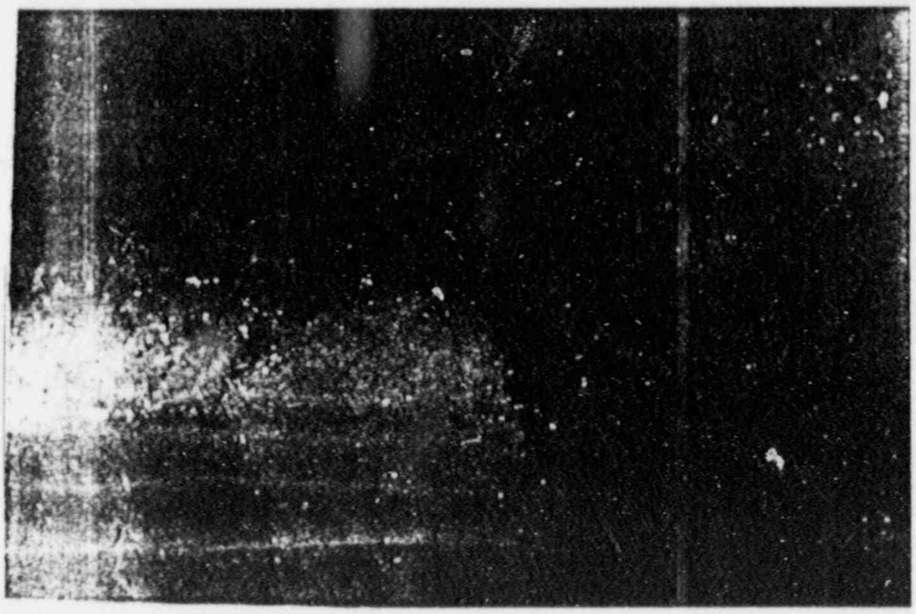


0.1 mm

Fig. 35: USA 1196 (17123), thin section; obj. 16 x air; with condensor; 1 nic.; neg. no. S 323-8.
Coating of a hollow vug by acicular paramontroseite associated with semiopaque coffinite coating perthitic feldspar and quartz grains.

0.02 mm

Fig. 36: USA 1196 (17123), polished section; obj. 50 x imm.; 1 nic.; neg. no. S 321-14.
Irregular aggregate of very dark grey reflecting coffinite.



0.02 mm

Fig. 37: USA 1196 (17123), polished section; obj. 50 x imm.; 1 nic.; neg. no. S 322-1.
Coating of glassy coffinite on clastic silicate grains.

MINERALOGY	Project No.: 3811 (3714)	Area: ddh 19-167 C
	UUS Sample No.: 21355 UEB Sample No.: USA 1209	Mineralogical Report No.: 88-3

Sample taken by: K. McFall / Aug. 1987	Mineralogy by / Date: EvPechmann/Jan. 15,88
Sampling location: ddh 19-167 C ; 548.0-548.5 ft.	
Arrival No./Date: 804 / end of Aug. 1987	Sample Type: Core x, Outcrop , Boulder , Other
Investigation:] Thin Section , Polished Section , Other:	
Sample stored at: UEB	Radioactivity: 50 cps (= bg)

Microscopy: a usual arkosic sandstone without anomalous radioactivity. The size of the clasts is 0.07 - 0.5 mm; the texture is rather dense; the clayey matrix is preserved.
Quartz is commonly corroded by sericite.
Brown semiopaque clast coatings are not radioactive but consist of limonitic material. They strongly resemble those radioactive ones in the other described samples.

Field Name of Rock: B-sand

Main Minerals (%):

Subordinate Minerals:

Accessories:

Ore Minerals:

Petrographic Rockname:

4. Ion Exchange Capacity of North Butte Samples

Procedure: - determination of the ion exchange capacity. Standardized technique after MEHLICH (1953) (1) replacement of the adsorbed cations within the clays by Ba^{2+} ions (= treatment with a 0.2 n $BaCl_2$ solution) until saturation, (2) then replacement of Ba^{2+} by Mg^{2+} (= treatment with a 0.2 n $MgCl_2$ solution). The concentration of Ba^{2+} in the exchange solution (2) corresponds to the ion exchange capacity of the sample, generally expressed in meq./100 g sample.

- chemical analysis of the exchange solution (1).

Ion Exchange Capacity

USA 1175	0.6 meq./100 g rock
" 1183	2.2 meq./ - " -
" 1186	1.7 meq./ - " -
" 1193	1.8 meq./ - " -
" 1195	2.4 meq./ - " -
" 1196	1.6 meq./ - " -

There was not sufficient material to separate the clay fraction (appr. 1-2 wt.% clay).

The ion exchange capacity of smectites ranges between 80 - 150 meq./100 g clay.

Table 1: Assay Results of Exchange Solutions (1)

Sample no.	µg/ml V	µg/ml As	µg/ml Se	µg/ml U
USA 1175	0.30	0.002	0.002	< 0.005
USA 1183	0.10	0.004	0.003	0.025
USA 1186	0.03	< 0.002	< 0.002	0.025
USA 1193	0.04	< 0.002	< 0.002	0.005
USA 1195	0.78	< 0.002	0.003	< 0.005
USA 1196	0.87	< 0.002	0.008	< 0.005

Table 2: Ba Content of Exchange Solutions (2)

Sample no.	Ba µg/ml
USA 1175	30.4
USA 1183	176.0
USA 1186	68.0
USA 1193	104.8
USA 1195	96.8
USA 1196	91.2

5. Comparison between the Ores from North Butte and from Ruth

A mineralogic comparison between the North Butte and the Ruth uranium occurrences can be made only with reservations, for the Ruth ore was investigated much more intensively and above all systematically (cf. Min. Reports 82-48, 83-49), whereas this investigation was carried out on the samples taken from the whole length of the roll-front as systematically as possible.

The host rocks of both occurrences, North Butte and Ruth, are about identical:

The Ruth host rocks were determined as medium grained moderately sorted arkosic arenites with varying feldspar content (cf. Min. Rep. 82-48). The North Butte host rock is determined as a generally medium grained, moderately sorted arkosic arenite, too (cf. Fig. 38).

The matrix of both occurrences is predominantly montmorillonite/smectite and subordinately kaolinite (and also some sericite). It seems as if the matrix content (including pores) of North Butte rocks may be higher (up to over 40 %) than that of Ruth rocks (average up to 17 %).

Though not measured at North Butte, it seems that nevertheless the North Butte rocks contain lower amounts of clay minerals than the Ruth rocks (for it was in places difficult to gain clay material from North Butte).

An important matrix difference between North Butte and Ruth matrices is the locally strong appearance of calcite at North Butte whereas carbonate is reported from Ruth at best as subordinate matrix constituent. Moreover, at North Butte calcite is locally plumbing the rock porosity and destroying the ore in-situ-leachability completely. In both occurrences, the rock matrix was deposited after the settling of the clastic grains, and in places corrosion of the clastic grains by the matrix clay minerals is visible. In both occurrences, the smectites/montmorillonites have partly high swelling capacities, but it seems that the North Butte smectites may be swelling even more than those of Ruth.

The distribution of the uranium and vanadium ore minerals is mostly the same in both occurrences. Thus figs. 1-2 from North Butte ore strongly resemble Fig. 39 showing the typical U-V-ore rims around clastic grains from Ruth. The most important difference in the ore distribution of the two occurrences is that the North Butte ore is lacking the uranium minerals grown between clastic silicate minerals and their secondary quartz overgrowths which are quite typical for Ruth ore (Fig. 40).

Another less important difference is that the uranium at North Butte was nowhere determined to occur in organic material but only to be attached to fragments of such organic matter.

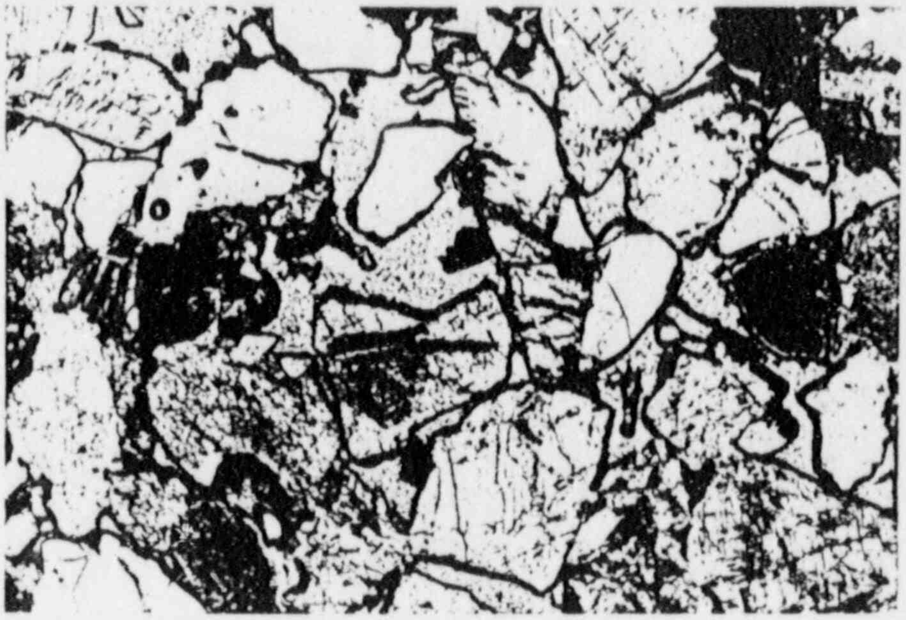
The uranium and vanadium ore minerals of North Butte were much more easily determinable than those of Ruth. The only uranium mineral determined from North Butte is coffinite whereby this coffinite ($USiO_4$) is commonly so translucent and has such glassy a lustre under the microscope that it can be argued that the coffinite is in a state of transformation to a uranyl hydrate, i.e. a gummite mineral, or to e.g. a uranyl vanadate or a silicate (e.g. carnotite, kasolite). But the X-ray diffractograms of yellow minerals did not yet yield clear results so that this question remains open to further mineralogic, electron microprobe work. The only vanadium mineral at North Butte was X-ray determined as paramontroseite (VO_2) whereas at Ruth it was then not possible to define a vanadium mineral; only mixtures of vanadium to uraniferous or iron-bearing compounds were measured from Ruth, and names of such minerals were only tentatively deduced from qualitative electron microprobe work (paramontroseite?, montroseite? - (V,Fe)OOH). The uranium minerals from Ruth were determined as pitchblende with traces of Fe, Mn, Ti and V (Min. Rep. 82-48) and minor carnotite. But it cannot be discarded (any more due to increased experience in microscoping coffinites) that also coffinite is present at Ruth (formerly denominated as pitchblende) (Fig. 41).

The ion exchange capacities of the whole rocks from North Butte are similar to those from Ruth (resp. slightly lower than those from Ruth):

0.6 - 2.4 meq./100 g rock (North Butte)

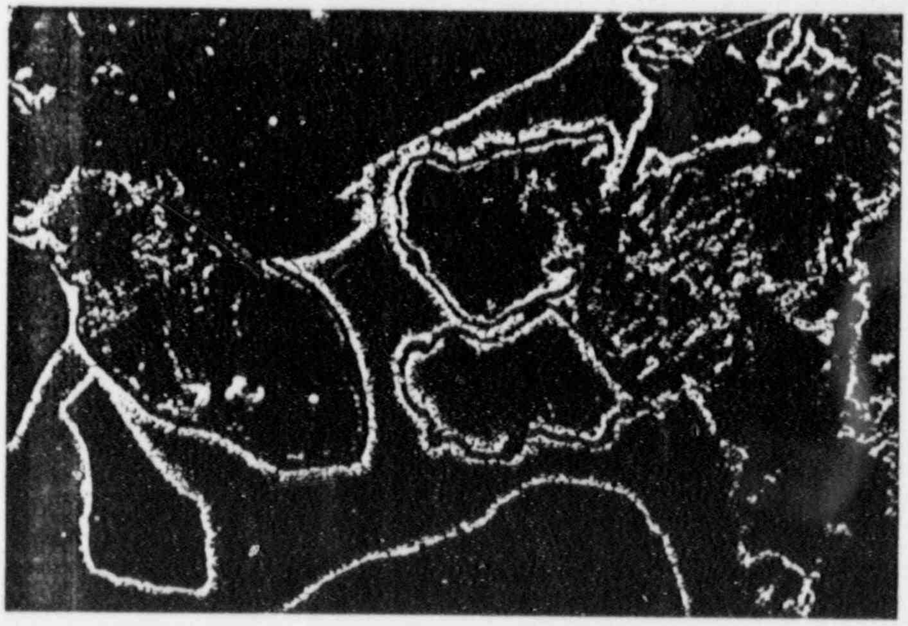
vs. 2.1 - 3.6 meq./100 g rock (Ruth).

In both occurrences the ion exchange capacities of the whole rocks are well correlable with the extrapolated amounts of clay minerals in the rocks.



0.5 mm

Fig. 39: Ruth, Wyo., USA 750; photomicrograph, thin section;
obj. 2.5 x air; 1 nic.; neg. no. S 198-3.
Typical thin section of radioactive ore (black) from Ruth as rims around clastic quartz and feldspar grains (cf. Figs. 1-2).



0.05 mm

Fig. 40: Ruth, Wyo., USA 750-1; photomicrograph, polished section;
obj. 20 x imm.; 1 nic.; neg. no. S 191-5.
Multifold pitchblende layers (grey) which are partly separated from each other by secondary quartz rims around the clastic silicate grains.

0.02 mm

Fig. 41: Ruth, Wyo., USA 750 a; photomicrograph, polished section; obj. 50 x imm.; 1 nic.; neg. no. S 196-3.
Coating of clastic grains by a globular, semitranslucent, very dark grey reflecting mineral (hydrated pitchblende?/coffinite?).

6. Leachability of North Butte Ore

Based on the presented but certainly not yet representative investigation results it is tentatively argued that the in-situ-leachability of the North Butte ore should be generally slightly better than that of the Ruth ore because of the simpler interlocking patterns of the uranium minerals at North Butte compared with the locally complex intergrowths of Ruth pitchblende in between primary silicate clasts and secondary quartz overgrowths.

Negative parameters for the in-situ-leachability of the North Butte ore could be the locally strong occurrence of calcite cement plumbing the rock porosity completely (Figs. 1-2). Other negative factors might possibly be the strong swelling (coagulation) capacity of the smectites in the rock matrix, the presence of gypsum in the matrix, and the locally intimate intergrowth patterns of coffinite in clay minerals.

But it is conceded that more laboratory tests and systematic mineralogic work are necessary in order to be able to make representative and reliable statements on petrography, ore mineralogy, and leaching behaviour of the ore from North Butte.

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