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Geology of volcanogenic uranium deposits within the Tallahassee Creek Conglomerate, Tallahassee Creek uranium district, Colorado

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature

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Abstract

Uranium ore deposits of the Tallahassee Creek uranium district are hosted by both the Eocene Echo Park Alluvium and the Oligocene Tallahassee Creek Conglomerate. The most significant deposit, the Hansen ore body, occurs within fluvial arkosic sands of the Echo Park Alluvium and is similar to basal-type sedimentary uranium deposits. In contrast, most uranium mineralization within the Tallahassee Creek Conglomerate appears stratigraphically related to altered volcanic ash near the top of this unit. These bentonitic strata display characteristic clay alteration, limonitic-alteration patterns suggestive of solution-front movement, and evidence of physical injection into surrounding units.

The widespread deformation features, in the upper Tallahassee Creek Conglomerate, are thought to be related to loading of water saturated, unconsolidated stream sediments by overlying andesitic lahars and possibly volume increases due to the alteration of volcanic glass to clay minerals. The alteration permitted contemporaneous release of substantial amounts of uranium and other lithophile elements. Analyses of relatively unaltered glassy air-fall ash and clay-altered ash-rich lenses within the Tallahassee Creek Conglomerate suggest that the alteration processes did produce significant uranium losses. Liberated uranium was locally reprecipitated as lenticular ore bodies in reducing environments near large accumulations of organic debris. Some uranium was not immediately deposited or was remobilized down the paleo-stream channel where it precipitated contemporaneously with silica, as replacements of wood. The occurrence of uranium mineralization within the Tallahassee Creek Conglomerate appears to be at least partly a result of the restricted distribution and alteration of uranium enriched volcanic ash in this unit.

INTRODUCTION

The Tallahasee Creek uranium district is located near the southern margin of the Thirtynine Mile volcanic field, approximately 35 km northwest of Canon City, Colorado (fig. 1). The original discovery of uranium in the Tallahassee Creek district was made during 1954 at the Sunshine mine site (MacPherson, 1959) (fig. 2) and subsequent exploration led to the discovery and development of 11 small open-pit and underground mines. A total of nearly 225,000 kg of U_3O_8, at grades between .20 and .30 percent, was produced from these mines between 1954 and 1972 (table 1). More recently, discoveries of the Hansen (12-14 million kg U_3O_8) and the Picnic Tree (1-2 million kg U_3O_8) ore bodies (table 1; fig. 2 Cyprus Mines, 1980) have made this uranium district one of the most important in Colorado.

The earliest geologic reports of the Tallahassee Creek district were made by Jensen (1956) and MacPherson (1959), although Cross (1895) had briefly described aspects of the Thirtynine Mile volcanic field prior to this. The first comprehensive geologic investigations of the area were made by Chapin (1965) and later expanded upon by Epis and Chapin (1968, 1974), Epis and others (1976), Scott and others (1978), Epis and others (1979a, 1979b), Wobus and others (1979), and Chapin and Cather (1981).

REGIONAL GEOLOGY

Basement rocks in the Tallahassee Creek area include 1.7-b.y.-old schist, gneiss, and granodiorite (Precambrian X); and 1.4-b.y.-old quartz monzonite (Precambrian Y). Exposures of Paleozoic and Mesozoic sediments are nearly absent within the district, although they are present nearby (Scott and others, 1978).

The oldest Tertiary rocks known in the southern part of the Thirtynine Mile volcanic field are widely scattered remnants of the Echo Park Alluvium (fig. 3). This unit is composed primarily of Precambrian detritus that was deposited in depressions and subsiding basins during the development of a widespread Eocene erosion surface of low relief that covered most of south central Colorado (Epis and others, 1976). Within the Tallahassee Creek area, thick sequences (as much as 400 m) of Echo Park Alluvium are present and consist of sheetwash material intertongued with fluvial sediments, which grade upward from conglomerate to sandstone and mudstone (Cyprus Mines, 1980). This material was deposited within the Echo Park graben, a highly complex subsidence structure controlled by major strike-slip faults (Chapin and Cather, 1981; Epis and Chapin, 1974). An approximate age of late early to early middle Eocene (45-50 m.y.) has been assigned to the Echo Park Alluvium on the basis of palynomorph assemblages by R. H. Tschudy and Sharon Van Loenen (App. C).

Volcanism in the Thirtynine Mile volcanic field began with the emplacement of early Oligocene (34.7±0.7 m.y - 36.2±0.8 m.y.) [1/] rhyolitic ash-flows of the Wall Mountain Tuff. The distribution of paleovalleys suggests that the Wall Mountain Tuff had a source to the west, possibly near Mount Aetna in the Sawatch Range (Epis and Chapin, 1974). A period of erosion followed during which major paleochannels were incised into the underlying rocks and filled by sediment of the Tallahassee Creek Conglomerate (fig. 3).

[1/] Ages reported in this paper are those given by Epis and Chapin (1974), except where noted, and have not been corrected for the new IUGS K-Ar constants. Corrections are approximately +.7 m.y. (25 m.y.) to +.9 m.y. (35 m.y.) computed by the method of Dalrymple (1979).

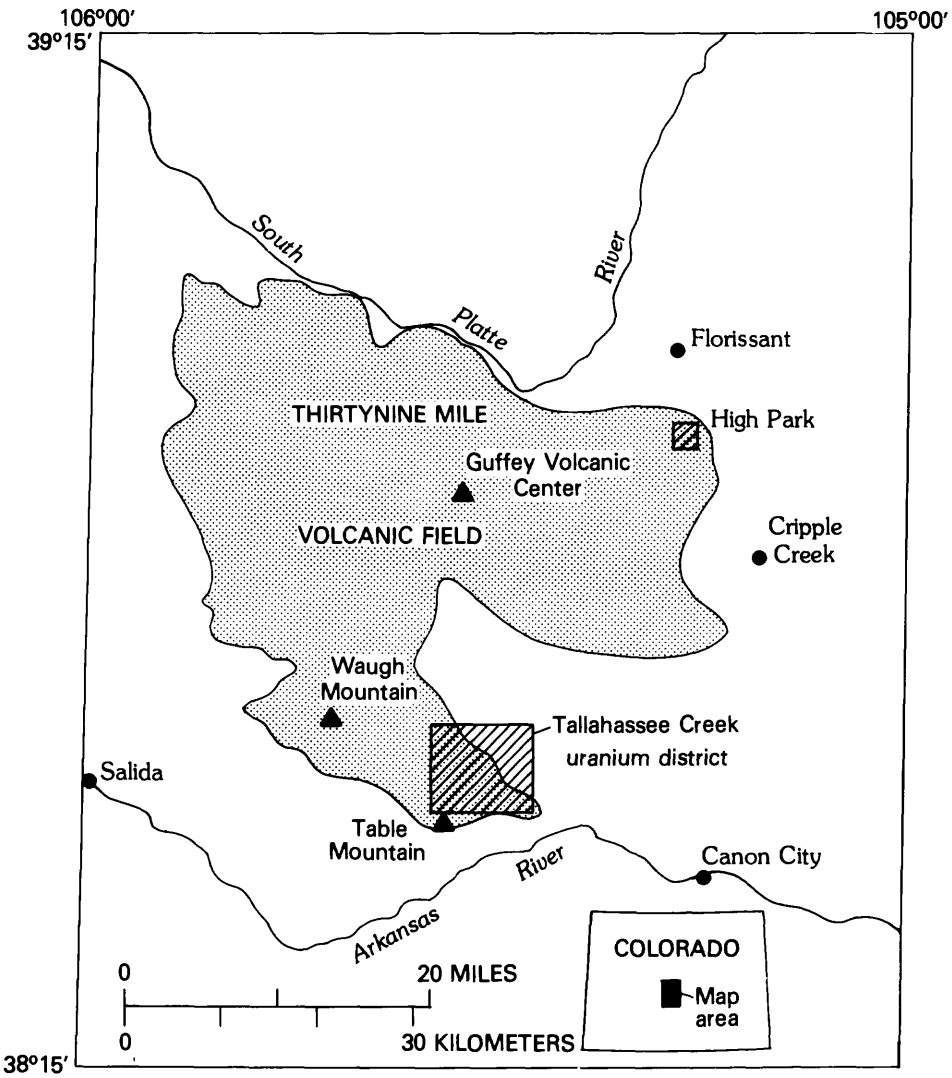

Figure 1.--Map showing the location of the Tallahassee Creek uranium district, the High Park area, and the present extent of the Thirtynine Mile volcanic field, south central Colorado.

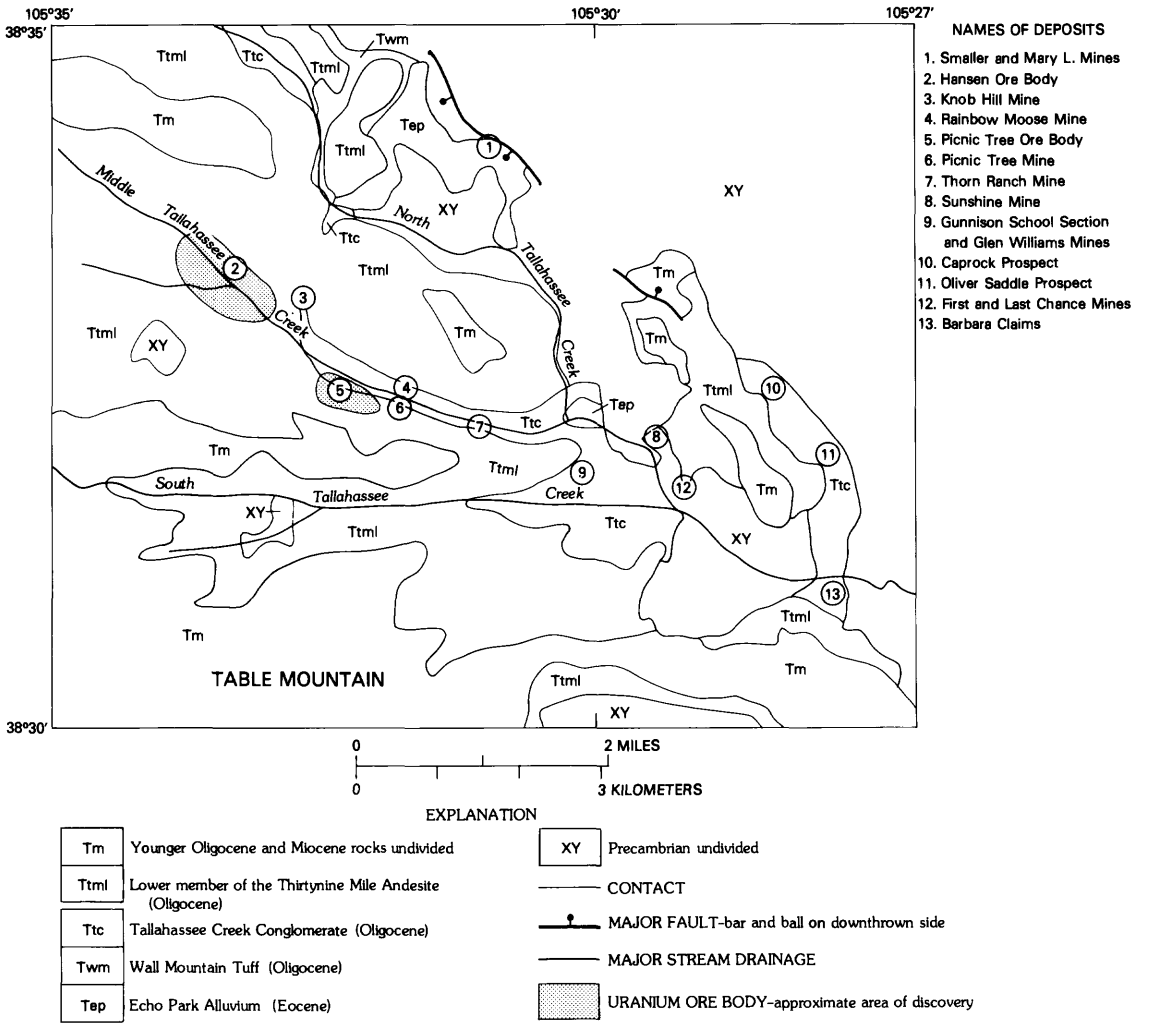

Figure 2.--Simplified geologic map of the Tallahassee Creek uranium district showing the locations of uranium ore bodies, mines, and prospects. (after Chapin, 1965; Epis, Wobus, and Scott, 1979a; 1979b and Wobus, Epis, and Scott, 1979.)

Table 1.--Location and known uranium production or reserves of deposits within the Tallahassee Creek uranium district.

	Name of deposit	Location	Uranium production or reserves (R)	Average grade
1.	Smaller-Mary L. Mines	38°34'15"N, 105°30'55"W	45,630 kg	.30% U_3O_8
2.	Hansen Ore Body	38°33'00"N, 105°33'20"W	12 million kg (R)	.08% U_3O_8
3.	Knob Hill Mine	38°33'00"N, 105°32'40"W	5,460 kg	.20% U_3O_8
4.	Rainbow Moose Mine	38°32'20"N, 105°31'45"W	21,530 kg	.20% U_3O_8
5.	Picnic Tree Ore Body	38°32'15"N, 105°31'50"W	1.1 million kg (R)	.09% U_3O_8
6.	Picnic Tree Mine	38°32'15"N, 105°31'50"W	23,990 kg	.20% U_3O_8
7.	Thorn Ranch Mine	38°32'30"N, 105°31'00"W	6,260 kg	.20% U_3O_8
8.	Sunshine Mine	38°32'00"N, 105°29'45"W	2,830 kg	.27% U_3O_8
9.	Gunnison School Section and Glen Williams Mine	38°31'54"N, 105°30'05"W	39,520 kg	.24% U_3O_8
10.	Caprock Prospect	38°32'25"N, 105°15'00"W	----	----
11.	Oliver Saddle Prospect	38°32'00"N, 105°38'00"W	----	----
12.	First and Last Chance Mines	38°31'54"N, 105°29'00"W	53,181kg	.30% U_3O_8
13.	Barbara Claims Prospect	38°31'00"N, 105°27'45"W	Unknown	Unknown

(compiled from Nelson-Moore and others, 1978; Hon and Dickinson, 1982)

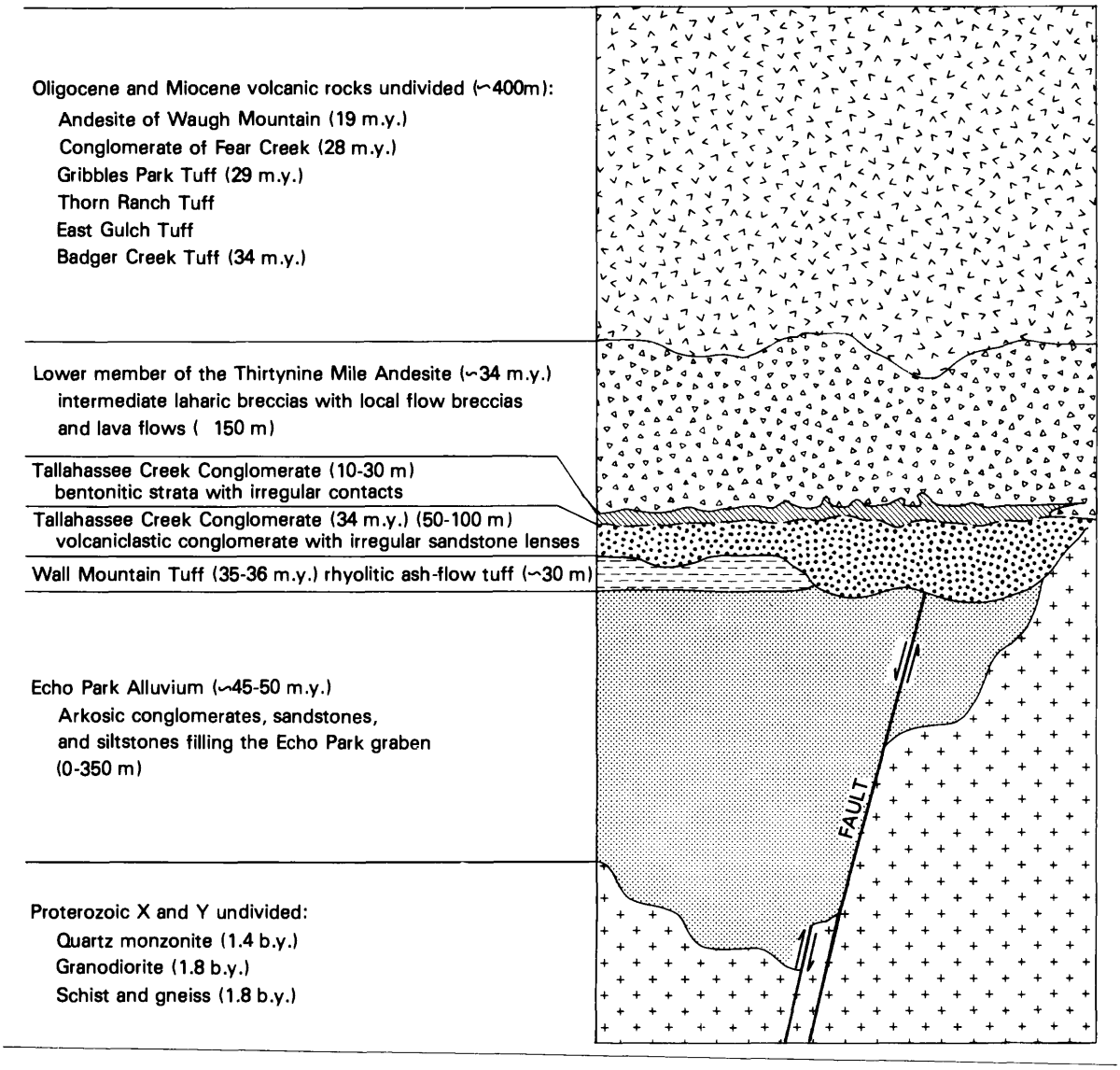

Figure 3.--Schematic stratigraphic section through the Tallahassee Creek uranium district (prior to erosion). (Compiled from Chapin and Cather, 1981; Cyprus Mines, 1980; Epis and Chapin, 1974.)

A substantial amount of volcanic ash and andesitic debris was deposited near the top of the conglomerate from early local vent eruptions of the lower member of the Thirtynine Mile Andesite. Because of the characteristic clay alteration of tuff deposited within the stream channel, this upper portion of the Tallahassee Creek Conglomerate has been referred to as the bentonitic strata by Epis and Chapin (1974). Near Salida (fig.1), a basaltic andesite flow interonguing with the Tallahassee Creek Conglomerate has been dated at 34.3 ± 1.5 m.y. [2/] by C.E. Chapin (Marvin and Cole, 1978, p.8). The Tallahassee Creek Conglomerate directly overlies the Wall Mountain Tuff in this area and occupies a paleovalley that trends eastward toward the Tallahassee Creek uranium district. Continued eruptions of andesite, from scattered vents and breccia cones, formed the lower member of the Thirtynine Mile Andesite a thick (100-250 m) coalescing sheet of laharic and flow brecciated material (fig. 3). To the north, this activity was preceded by the emplacement of intermediate composition domes, flows, and pyroclastics related to the Antelope and Thirtyone Mile Mountain volcanic centers (Epis and Chapin, 1968). In this region, the lower member of the Thirtynine Mile Andesite is partly contemporaneous with and older than hypabyssal rhyolitic to andesitic domes and andesitic to basaltic dikes related to the Guffey volcano (fig.1). The upper member of the Thirtynine Mile Andesite (34.1±1.1 m.y.) consists mainly of andesite flows that appear to represent the remnants of this composite stratovolcano (Epis and Chapin, 1968). This volcanic activity apparently disrupted the northern end of the Echo Park graben complex, as is suggested by the distribution of Echo Park Alluvium near these volcanic centers.

Within and to the west of the Tallahassee Creek district, a sequence of major ash-flow tuffs (the Badger Creek, East Gulch, Thorn Ranch, and Gribbles Park Tuffs) were deposited over the lower member of the Thirtynine Mile Andesite from 34 m.y. to 29 m.y. ago (fig. 2) (Epis and Chapin, 1974). These ash-flow tuffs also appear to have had a source to the west of the Thirtynine Mile volcanic field and their deposition to the northeast and beyond appears to have been blocked by the Guffey volcano (Epis and Chapin, 1974).

Remnants of the conglomerate of Fear Creek (27.8±.6 m.y.) on Table Mountain (fig.1) and Miocene (18.9±1.2 m.y) bimodal volcanics centered near Waugh Mountain (fig. 1) represent the most recent activity within the region (Epis and Chapin, 1974).

URANIUM DEPOSITS

Uranium deposits of the Tallahassee Creek district can be generally classified into two principal types, based on whether they are hosted by the Echo Park Alluvium or the Tallahassee Creek Conglomerate. Mineralization within the Echo Park Alluvium bears gross similarities to other basal-type (Katayama, 1960) uranium deposits reported from Washington (Becraft and Weis, 1963), California (Rapp, 1978; Montgomery, 1978), Nevada (Birkholz, 1978),

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[2/] Age recalculated using old Western constants (Dalrymple, 1979) to conform with other K-Ar ages presented in this paper.

British Columbia (Boyle, 1979, 1982), and Japan (Doi and others, 1975; Kamiyama and others, 1976). Parameters common to all of these deposits are tabular geometry, Tertiary age, the presence of locally carbonaceous fluvial sediments resting unconformably on much older igneous and metamorphic rocks, and a capping of generally thick sequences of volcanic and/or volcaniclastic rocks. The Hansen ore body (fig.2), within the Eocene Echo Park Alluvium, is one of the largest known deposits of this basal-type, although stratigraphic and structural controls (Cyprus Mines, 1980; Chapin and Cather, 1981) suggest that it may differ in some respects. However, the additional local presence of significant uranium deposits within the younger and stratigraphically "higher" (fig. 3) volcaniclastic rocks of the Tallahassee Creek Conglomerate is apparently unique.

The Echo Park Alluvium contains 80 percent to 90 percent of the known uranium reserves in the district, although most of the deposits and prospects occur in the Tallahassee Creek Conglomerate. Indicated and inferred reserves of the Picnic Tree ore body (1-2 million kg) (fig. 2) account for most of the uranium in the Tallahassee Creek Conglomerate. In comparison, past production from the Last Chance, First Chance, Glen Williams, Gunnison School Section, Picnic Tree, Rainbow-Moose, Thorn Ranch, Sunshine, and Knob Hill mines (fig. 2; fig. D2-D10) amounted to slightly less than 200,000 kg of U_3O_8 (Nelson-Moore and others, 1978). Three additional prospects are known within the Tallahassee Creek Conglomerate, slightly to the southeast of the main district and "downstream" along the major paleochannel (figs. 2, 4). Outside of the district, only one significant uranium deposit has been discovered in the Tallahassee Creek conglomerate at High Park (fig. 1). However, the deposit at this locality is probably of the basal-type as the Tallahassee Creek Conglomerate lacks the volcanic ash bed present at Tallahassee Creek and rests directly on Precambrian granite or a thin veneer of Echo Park Alluvium (sheetwash facies <10 m thick).

Geology of the Tallahassee Creek Conglomerate

In the vicinity of the Tallahassee Creek uranium district, the Tallahassee Creek Conglomerate is largely confined to a northwest-southeast trending paleochannel that is exposed for approximately 20 km (fig. 4). Subsurface information (Cyprus Mines, 1980) indicates that a branch of this channel also continues under Middle Tallahassee Creek (fig.2) in the general direction of Waugh Mountain (fig. 1). This channel system apparently drained to the south, as indicated by the increase in thickness and width of fluvial sediments in this direction (Epis and Chapin, 1974). A reconstruction of the top of the stream profile also shows a gentle gradient of 0^{o}-3^{o} to the southeast (fig. 4), although slight post-depositional movement along fault blocks of the Echo Park graben system may have modified the original gradient (C.E. Chapin, written commun., 1982).

At its type section near the confluence of Middle and South Tallahassee Creeks, the Tallahassee Creek Conglomerate is about 100 m thick. Most of the unit is composed of volcaniclastic boulder conglomerate that is tan to gray in color, weakly indurated, and shows poor to moderate sorting and stratification. Clasts are commonly subrounded to rounded pebbles, cobbles

and boulders of various lithologies including early Tertiary volcanic rocks of unknown source, locally derived Precambrian rocks, well-rounded quartzite, and smaller amounts of Wall Mountain Tuff and Paleozoic rocks in a matrix of arkosic sand. Locally, discontinuous lenses of medium- to coarse-grained sandstone are present and, like the conglomerate matrix, the lenses are primarily composed of quartz and feldspar grains. The quartzite clasts are apparently derived from a distant source outside the Thirtynine Mile volcanic field and their presence probably indicates deposition within a major channel system. (Ken Bondurant, oral commun., 1979).

This lower volcaniclastic unit of the Tallahassee Creek Conglomerate was deposited in a high-energy fluvial environment as bed load material. Although the stream gradient was probably greater than the profile from the top of the unit indicates (fig. 4), the abundant coarse debris also suggests a source for the stream in a nearby uplifted region.

In the Tallahassee Creek uranium district, the volcaniclastic conglomerate is overlain by varying thicknesses (5 m to 30 m) of bentonitic strata with a matrix of clay and sand (Epis and Chapin, 1974). These bentonitic strata are gray to purplish-gray in color, weakly indurated, poorly stratified and show a low degree of sorting, characterized by a high matrix-to-clast ratio. Subangular to angular pebbles and cobbles of andesite, lithologically similar to and probably derived from volcanics within the lower member of the Thirtynine Mile Andesite, are dominant in this unit. In addition, angular boulders of Wall Mountain Tuff (as much as 5 m in diameter) are present along with varying amounts of rounded clasts, similar in lithology to those found within the volcaniclastic conglomerate. The matrix is primarily poorly sorted tuffaceous sandstone composed of angular rock fragments, quartz and feldspar grains scattered through altered fine-grained tuffaceous material. Locally, thin discontinuous lenses (10 to 30 cm thick) of nearly pure tuff grade upwards into tuffaceous sandstone and conglomerate. Examination of X-ray diffraction data from whole-rock powders indicate the presence of poorly crystallized smectite group clays. These were present in 10 of 11 samples of sandstone and conglomerate matrix; 3 of 5 samples from tuff lenses showed similar alteration. This suggests that the use of the term bentonitic to describe these sediments is acceptable, although more detailed studies are needed to adequately describe the clay mineralogy.

The lower volcaniclastic conglomerate generally grades into the overlying bentonitic strata of the Tallahassee Creek Conglomerate over a short distance (1-4m). The poorly sorted, angular, and matrix supported nature of the volcanic clasts in the bentonitic strata, along with the presence of large blocks of Wall Mountain Tuff, suggests that much of this material was introduced rapidly into the stream channel. This may have occurred as a result of reworking of unconsolidated laharic material and introduction of debris as slope wash or, alternatively, C.E. Chapin (written commmun., 1982) has suggested that the uppermost portion of the bentonitic strata was a large epiclastic mudflow deposited upon tuffaceous conglomerate and occupying much of the paleochannel in the Tallahassee Creek district. The abundant volcanic ash found within the bentonitic strata appears to have been ponded in quiet areas of the stream drainage where it was interbedded with organic debris. Much of the ash was later reworked by stronger currents into tuffaceous

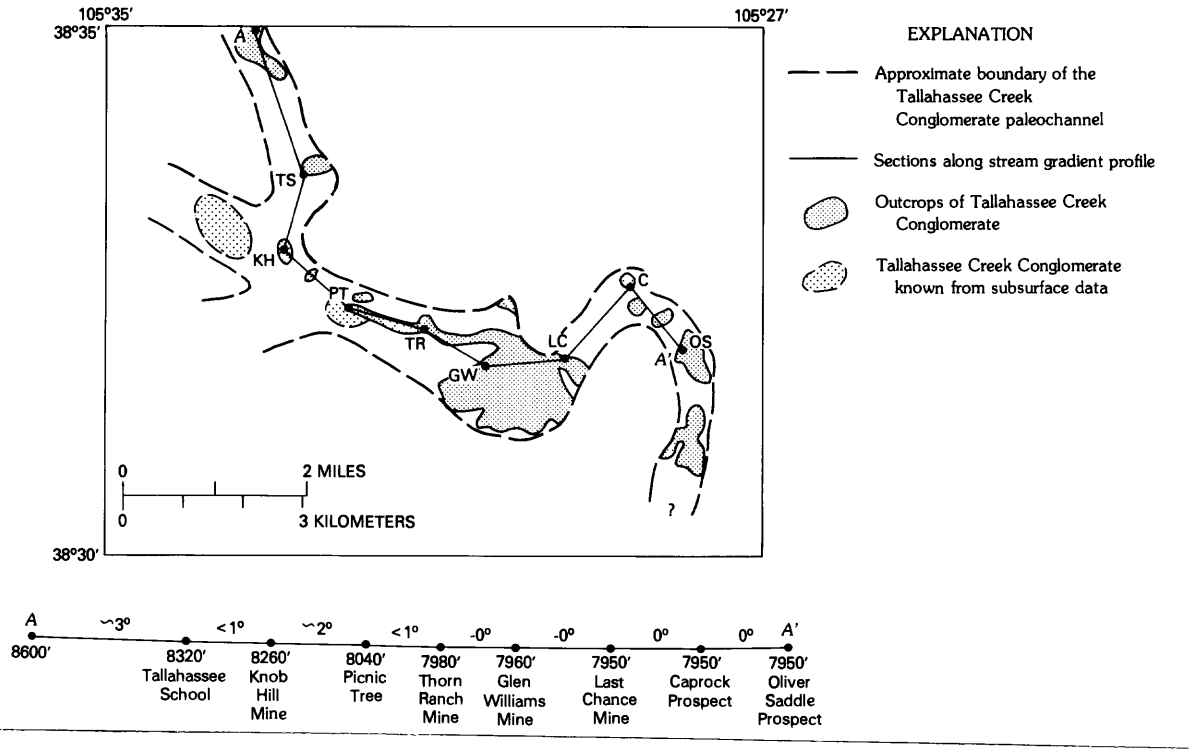

Figure 4.--Map of the Tallahassee Creek uranium district showing the approximate boundaries of the southeast trending Tallahassee Creek Conglomerate paleochannel and the line A-A' of the present stream-gradient profile (elevations are taken from the top of the Tallahassee Creek Conglomerate).

conglomerates and sandstone that are commonly overlain by the poorly stratified material mentioned previously. The introduction of this material into the bentonitic strata was evidently contemporaneous with local pyroclastic eruptions, lahars, and lava flows that caused a widespread choking of stream drainages within the Tallahassee Creek area. However, local channels (5 to 15 m wide) containing sediment similar to the volcaniclastic boulder conglomerates are present within the bentontic strata, indicating that through-going drainages persisted for some time. Similar small channels are also incised into andesitic volcanic flows at the Rainbow Moose and Knob Hill mines (fig. 2; figs. D2,D3). Deposition of the Tallahassee Creek Conglomerate appears to have continued until the accumulation of the lower member of the Thirtynine Mile Andesite eventually blocked all drainages into the area.

Contacts of the bentonitic strata with the overlying laharic and flow breccias of the lower member of the Thirtynine Mile Andesite are highly irregular. At the Glen Williams and Gunnison School Section mines (figs.D7,D8), large "injections" of bentonitic strata extend more than 10 m into the overlying andesitic lahars. More commonly, large blocks of andesitic breccia appear to have been incorporated within the bentonitic strata near deformed contacts. In addition, at the Last Chance mine (fig. D10), beds of lower volcaniclastic sandstone and conglomerate are laterally truncated at a highly deformed contact with an irregular mass of bentonitic strata. Elsewhere, small discontinuous lenses and blocks of volcaniclastic mudstone, sandstone, and conglomerate are commonly included within the bentonitic strata and appear to have been contorted, or irregularly folded, and display "pull-apart" structures. Other evidence of disruption was observed in a few bleached and altered boulders of Wall Mountain Tuff that were intruded along fractures by thin dikelets of altered matrix from tuffaceous conglomerate host. The bentonitic strata are also characterized by pervasive limonite staining, commonly with the appearance of large-scale liesegang banding; and thin, well-cemented parallel laminae of Fe-Mn oxides which suggest that oxidizing conditions may have accompanied deformation. These features are highly variable and locally appear to mimic solution fronts, flowage, folding, and original bedding within the bentonitic strata, but are generally sharply truncated at the boundaries of this unit.

Uranium in the Tallahassee Creek Conglomerate

All of the significant uranium deposits in the Tallahassee Creek Conglomerate, with the exception of the First and Last Chance mines (fig.2), occur in tuffaceous sediments within the bentonitic strata. Ore bodies are crudely tabular or lenticular in configuration (MacPherson, 1959), and uranium appears to have been localized by accumulations of fragmental carbonaceous material associated with diagenetic pyrite. Occasionally, mineralized and carbonized wood showed signs of partial silicification, but this is generally uncommon. In other portions of the tuffaceous conglomerate, wood fragments that appeared bleached, crumbly and occasionally partially silicified, but still retaining fibrous cellular textures are present. This material is uncarbonized, contains little uranium (49 ppm U, sample LC-1, table 3), and may represent partially carbonized, partially silicified wood later modified by oxidation of the remaining carbon.

At the Picnic Tree ore body (fig.2), the bentonitic strata are approximately 8 m thick and commonly contain one or two mineralized zones. Where this unit was encountered in the subsurface at least one radiometric anomaly was present, usually near its top (Gene Ealy and Ken Bondurant, Cyprus Mines, oral commun., 1979).

At the Rainbow Moose mine, and probably the Knob Hill mine (fig.2), uranium mineralization also occurs within carbonaceous paleosols developed on and between vesicular andesitic breccias (fig. 2; figs. D2,D3). Uranium solutions appear to have migrated laterally into these buried soils from the adjacent paleochannels that contain mineralized tuffaceous conglomerate.

Pitchblende with minor coffinite are the primary ore minerals reported from the deposits, whereas coatings and fracture fillings of autunite associated with hematite, limonite, and gypsum occur as oxidation products. (MacPherson, 1959; Nelson-Moore and others, 1978). Two assays of thin laminae of secondary Fe-Mn oxides gave values of .01 percent and .03 percent U_3O_8, suggesting that some uranium may have also been adsorbed by these compounds. Examination of chemical data (table 2) indicates that mineralized bentonitic strata may also contain anomalous amounts of the elements Fe, P, Co, and Mo.

At the First and Last Chance mines (fig. 2, fig. D10), uranium ore bodies occur within the lower volcaniclastic conglomerate as small pods of ore in lenses of carbonaceous sandstone and near pockets of carbonaceous trash in the conglomerate. Uraniferous solutions migrating through permeable channel sandstone and conglomerate appear to have deposited uranium in reducing environments as irregular roll fronts, due to the non-uniform and discontinuous nature of the host rocks. Autunite is the only uranium mineral reported from this locality (Nelson-Moore and others, 1978), although uranium is also associated with carbonaceous material in gray reduced sandstone, possibly as pitchblende. Ore samples from these mines appeared to be enriched in the elements Fe, P, Be, Co, Cu, Ni, Pb, Sc, Y, and Zr (table 2). Some fragments of uranium-bearing silicified wood were also found within the lower volcaniclastic conglomerate at the Last Chance Mine.

Uranium mineralization at the Oliver Saddle and Barbara Claims prospects (fig. 2; fig. D9) also occurs within the lower volcaniclastic conglomerate, but is associated with silicified and opalized wood containing abnormal amounts of Fe, P, As, Be, Co, Mn, Ni, V, Y, Zn, and possibly rare-earth elements (table 3) in comparison to other uraniferous silica precipitates (Zielinski, 1980; Zielinski and others, 1980). The prominent lenses of tuff characteristic of the bentonitic strata further upstream along the paleochannel (fig. 4) appear to be absent at these localities, although this may be partially a function of poor exposure. Autoradiographs of fluorescent (>.05 percent U) silicified wood samples suggest that uranium, at least partially in a hexavalent state, was deposited contemporaneously with colloidal silica as replacements of the wood fragments. Mineralized silicified logs as much as 1 meter in diameter and several meters in length have been found at both prospects. Sandstone and fine conglomerate around the wood commonly contain hexavalent uranium minerals, and regularly appear partially silicified in outcrop. Unlike the uranium deposits within the main part of the Tallahassee Creek district, unaltered carbonaceous material is conspicuously absent at these occurrences.

Table 2.--Analyses of uranium mineralized samples from ore zones within the upper bentonitic strata and the lower volcaniclastic conglomerate of the Tallahassee Creek Conglomerate. [Uranium and thorium were determined by delayed neutron activation, H.T. Millard, Jr., chief analyst; all other elements done by semi-quantitative emission spectrometry, J.L. Seeley, chief analyst. All values in ppm except Fe and P in wt.%]

	Mineralized samples from the bentonitic stata												Mineralized samples from the lower volcaniclastic conglomerate				
MDE	305	444	366	478	364	363	495	493	401	486	400	485	438	436	358	355	359
U	43	53	130	203	226	335	460	706	2040	2110	2780	5420	94	105	1220	5310	12300
Fe%	4.2	2.5	1.6	1.9	2.3	12.0	10.0	3.4	5.7	2.3	4.7	4.6	1.3	1.8	>20	11	2.9
P%	.24	.40	.45	.16	.44	>.45	.29	.15	.30	.17	>.45	>.45	.28	.17	.29	>.45	>.45
Ba	960	1500	1700	920	1200	1500	1100	1200	1400	870	1500	1000	1200	1100	630	640	920
Be	3	3	6	3	3	9	6	3	5	4	6	6	2	3	14	30	12
Ce	180	<100	<100	120	<100	130	<100	<100	120	150	150	320	<100	110	<100	180	250
Co	50	54	170	48	4	86	56	43	78	30	130	37	31	55	820	160	500
Cr	19	<10	17	25	17	18	22	19	15	28	18	28	15	24	28	32	23
Cu	27	15	63	29	18	39	41	22	25	100	37	87	8	16	320	180	170
La	71	44	47	40	34	60	63	44	70	63	76	140	66	62	38	130	130
Mn	840	390	>5000	200	210	>5000	3000	1400	800	<200	1300	280	200	270	920	630	350
Mo	17	<10	<10	64	12	98	13	<10	22	36	24	620	<10	<10	<10	<10	<10
Ni	21	33	71	61	9.0	130	50	37	79	25	110	46	22	63	450	170	700
Pb	29	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	12	210	90
Sc	13	15	21	11	22	22	17	14	15	24	15	46	16	<10	60	530	90
Sr	690	740	630	800	780	690	980	2500	100	780	910	1100	540	610	430	810	820
V	140	130	210	110	200	210	150	110	180	240	220	240	82	110	130	320	150
Y	34	24	37	33	26	50	32	34	36	37	40	160	260	31	84	>2000	300
Zn	120	77	190	<50	<50	280	<50	<50	67	91	81	130	<50	59	<50	240	130
Zr	320	480	310	430	320	340	470	410	420	420	450	1000	380	390	520	>1000	790

Table 3.--Analyses of silicified wood from the Tallahassee Creek uranium district

[Uranium was determined by delayed neutron activation, D.M. McKown, chief analyst; all other elements were determined by semi quantitative (±20-50%) inductively coupled plasma spectroscopy (ICP), J.L. Seeley, chief analyst. All values given in ppm, except Fe and P in percent].

	LC-1	MDE-396	MDE-497A	MDE-497B	BC-2	MDE-439	HT-2
U	49	200	1500	16000	843	<100	182
Fe	.20	.16	4.6	.28	2.1	4.0	5.3
P	<.01	<.01	.09	.01	.1	.01	.02
As	<20	<20	50	80	20	160	50
Ba	33	130	91	190	170	42	43
Be	<2	2	8	6	4	5	5
Ce	16	56	30	11	88	14	<8
Co	<2	17	57	45	20	17	25
Cr	<2	2	10	20	3	2	<2
Cu	4	11	11	19	4	15	14
La	<4	20	20	5	42	10	<4
Mn	32	110	320	100	940	240	160
Mo	<4	9	4	9	<4	8	9
Nd	<8	30	27	<4	80	13	<8
Ni	<4	29	93	73	25	30	52
Pb	<8	<8	19	29	<8	<8	<8
Sc	<4	<4	7	<4	6	5	8
Sr	9	62	22	17	20	6	6
V	58	66	380	330	200	28	49
Y	<4	16	130	25	180	19	34
Yb	<2	2	9	3	11	2	3
Zn	<4	60	110	70	21	40	89

Potential uranium source rocks

Uraniferous solutions in the Tallahassee Creek Conglomerate were probably derived from the sequence of volcanic rocks present in this region. The most probable sources are the Wall Mountain Tuff, which was partially eroded during deposition of the Tallahassee Creek Conglomerate, as well as the abundant tuff found as lenses within the bentonitic strata in the district. The overlying lower member of the Thirtynine Mile Andesite is dominantly composed of intermediate laharic breccias, which contain 2-4 ppm uranium (4 samples) and are considered less favorable as source rocks. These andesites are relatively impermeable volcanic units that probably blocked any contribution of uraniferous solutions from the younger ash-flow tuffs overlying them in the Tallahassee Creek uranium district.

Due east of the district, within the Salida-Waugh Mountain paleovalley (fig. 1.), the Tallahassee Creek Conglomerate is directly overlain by one of these younger ash-flow tuffs, the compositionally zoned quartz latitic-dacitic Badger Creek Tuff. The uranium content of this unit averages 6.4 ppm whereas the thorium content is 19.2 ppm (10 samples) (L.B. Smith written commun. 1980; Hon, unpub. data). Much of the Badger Creek Tuff is poorly welded and composed of vitric pumice (8 ppm U, 1 sample), however, it is difficult to evaluate uranium losses in this unit because of to the presence of primary chemical variations inherent to zoned ash-flow sheets (Hildreth, 1979). Uranium losses from this unit are probably significantly less than those observed from the Wall Mountain Tuff described in the next section. On the basis of this information and the absence of any significant uranium anomalies within the Tallahassee Creek Conglomerate in this area, it is not considered likely that significant amounts of uranium were transported in solution along the Salida-Waugh Mountain paleovalley to the Tallahassee Creek district, where it could then form as ore bodies.

Analyses of the Wall Mountain Tuff suggest that devitrification of this unit may have released significant amounts of uranium within the region. Uranium data (App. B) show average contents of 11 ppm for glassy basal vitrophyres (3 samples), 8.2 ppm for fresh samples of devitrified tuff (10 samples), and 6.6 ppm for devitrified tuff noticeably affected by surface weathering (9 samples). The average thorium content of all 23 samples is 44 ± 6 ppm (App. B). Using 11 ppm uranium as an estimate of the original uranium content for the Wall Mountain Tuff, based on the glassy samples, and a Th/U ratio of 4:1, it appears that losses of 3 to 5 ppm uranium during devitrification and subsequent alteration, are probable. This is consistent with the magnitude of uranium losses reported for suites of devitrified rhyolites (Lipman, 1965; Rosholt and others, 1971; Zielinski and others, 1977; Zielinski, 1978). In contrast, samples from altered boulders of Wall Mountain Tuff within the Tallahassee Creek Conglomerate averaged 14 ppm uranium (19 samples, App. A.2) compared to uranium contents of 6-11 ppm (22 samples, App.B) of similar samples from the outcrops, suggesting uranium enrichment of the boulders. Devitrification and subsequent uranium losses from the volume of Wall Mountain Tuff overlying the Echo Park graben alone could have supplied far more than the required amount of uranium for all of the deposits in the Tallahassee Creek uranium district.

Structural information indicates that the Tallahassee Creek Conglomerate near the Picnic Tree ore body (table 1, fig. 2) rests directly upon an uplifted block of Precambrian basement within the Echo Park graben complex (MacPherson, 1959; Cyprus Mines, 1980). This block may have deflected uranium-bearing groundwaters, flowing through permeable units within the Echo Park Alluvium upwards into the Tallahassee Creek Conglomerate thereby contributing to the mineralization within this unit (C.E. Chapin, written commun. 1982). Although this process is a distinct possibility, groundwaters generally contain low concentrations of dissolved uranium, and therefore formation of an ore body would require the movement of large volumes of water over long periods of time. The movement of such large volumes of water through the upper Tallahassee Creek Conglomerate would have to have occurred prior to the alteration and concommitant loss of permeability within the bentonitic strata. The apparently "rapid" alteration of the bentonitic strata, soon after deposition, suggests that it is unlikely that the Wall Mountain Tuff was a major source of uranium for deposits in the Tallahassee Creek Conglomerate. Uranium loss from this unit may, however, have made a significant contribution to the formation of deposits within the Echo Park Alluvium.

A more probable source of uranium for deposits in the Tallahassee Creek Conglomerate may be the intercalated tuff within the bentonitic strata. This tuff was originally an air-fall ash that is presumably related, based on its restricted distribution, to a local center within or near the Tallahassee Creek district. After initial eruption, the ash was subsequently reworked and deposited, commonly with fine organic material, in quiet stream margins, and probably also in shallow depressions throughout the region. Lenses of tuff are distributed within the Tallahassee Creek Conglomerate from the Last Chance mine upstream along the paleochannel to the Knob Hill mine (Figs. 2, 4) and have also been encountered in drilling over the Hansen ore body (Cyprus Mines, 1980).

Air-fall tuff lithologically similar to that within the bentonitic strata was found interbedded with overlying andesitic lahars near the Glen Williams mine. This tuff appeared to be at least 1.5 m thick, flat lying, fine grained, unstratified, and tan to light purplish gray in color at the outcrop. In thin section, the tuff contains unoriented microlitic to lath-like sodic plagioclase, lithic fragments, and glassy pumice in a matrix of glass shards and very fine volcanic dust. Compositionally, the tuff is a quartz latite containing 68 percent SiO_2 recalculated on an anhydrous basis (table 4). Samples of this tuff (table 5) also yielded values of 15.7 ppm U and 7.1 ppm U, respectively (after leaching in cold, dilute HNO_3 to remove any soluble uranium). The presence of undevitrified glass in shards and pumice, and the relative impermeability of the surrounding andesite breccias to groundwater suggests that these figures approximate the original uranium content of the tuff. In comparison, two samples from tuff lenses that were altered to clay minerals (X-ray diffraction data) averaged only 4.1 ppm U, whereas unmineralized tuffaceous sandstone averaged approximately 4.3 ppm U (table 5). The thorium content of altered and relatively unaltered ash samples shows little fluctuation (between 14 and 16 ppm Th, table 5) in contrast to the uranium values, and suggests that thorium content was not significantly affected during alteration of the tuffaceous sediments.

Using values of 3-6 ppm U from the above data to approximate uranium losses during the alteration of ash to clay minerals, estimated total loss of uranium from the bentonitic strata within the Tallahassee Creek uranium district ranges from approximately 1 million to 2 million kg of uranium.[1/] These estimates suggest that the uranium found in known deposits within the Tallahassee Creek Conglomerate (table 1) could have been supplied by alteration of ash at the top of this unit. However, this process could not have provided an adequate source of uranium for the Hansen ore body (table 1) in the underlying Echo Park Alluvium.

Genesis of uranium deposits

The geochemical evidence suggests that substantial amounts of uranium (as much as 75 percent of the original glass content) were released during the alteration of volcanic ash within the upper Tallahassee Creek Conglomerate. The percentage uranium losses are similar to those reported by Zielinski (1982), who also documented significant depletions in the amounts of SiO_2, Na_2O, and K_2O as well as other alkali elements during the alteration of rhyolitic air-fall ash to montmorillonite. Although both Na_2O and K_2O were depleted in altered samples of tuff from the Tallahassee Creek Conglomerate, SiO_2 contents remained about the same (table 4). Zielinski (1982) observed that SiO_2 contents in his samples were also in excess of the compositional range normally reported for smectite group clays. He suggested that the presence of quartz phenocrysts or secondary silica precipitates might account for anomalous SiO_2 content. Similarly, the high SiO_2 content of altered tuffs from within the Tallahassee Creek Conglomerate may be explained by the addition of quartz grains during fluvial reworking. Higher MgO content was observed in both studies and is a result of structural incorporation into bentonitic clays.

The alteration of ash to clay is postulated to occur under alkaline, oxidizing conditions that allow for the transportation of uranium and silica. In addition, glass dissolution and clay alteration proceed much more quickly at elevated temperatures (Hawkins, 1961; Zielinski, 1977). Heating of water-saturated tuffaceous sediments within the Tallahassee Creek Conglomerate may have occurred during the emplacement of overlying andesitic breccias, and could have been instrumental in accelerating alteration. Accompanying the change from hydrated volcanic glass to bentonitic clays are some increases in volume, although as much as 50 percent of any expansion may have been taken up by the original porosity of the tuff. The loading and possible swelling of tuffaceous sediments provides a reasonable explanation for the widespread injection and deformational features observed within the upper Tallahassee Creek Conglomerate in this area. In the Rainbow Moose mine (fig. D8), water-

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[1/] Other figures used in calculations were: bulk density of the air-fall ash (1.5 gm/cm^3), thickness of the ash (10m), and the area covered by the ash within the Tallahassee Creek Conglomerate paleovalley (20 km^2). The total uranium loss is given by the equation: volume (cm^3) x bulk density (g/cm^3) x uranium loss ($^{ug}/g$) x (kg/ug)

saturated tuffaceous conglomerate was squeezed upwards into steam spiracles and fractures within an overlying andesitic lava flow (Chapin, 1965). At this locality, it is clear that rapid heating of water, contained in sediments of the Tallahassee Creek Conglomerate, was an important factor in the formation of injection features.

It appears that uranium deposits within the Tallahassee Creek Conglomerate formed syngenetically with the alteration of volcanic tuff to bentonitic clays. The low permeability of the bentonitic strata suggests that any significant uranium loss must have occurred prior to or along with the alteration of this unit. This alteration occurred under oxidizing conditions and released uranium into solution, while locally sufficient amounts of carbonaceous material were present within the bentonitic strata to provide persistant reducing environments, possibly due to biogenic production of H_2S. In these areas, pod-like uranium deposits were formed in contrast to areas of more scattered organic fragments that became totally oxidized and lack any significant mineralization.

The Tallahassee Creek Conglomerate paleochannel (fig. 4) apparently provided a confined conduit for the migration of these uraniferous solutions downstream to the southeast. The Last Chance Mine (figs. 2,5) represents the maximum known extent of tuff lenses within the conglomerate in this direction. At this locality, uranium was precipitated at favorable reducing sites within the lower volcaniclastic conglomerate and apparently to some extent within the bentonitic strata. In addition, some mineralized silicified wood is present within this deposit and the nearby Sunshine Mine. Silica along with some uranium (probably as U^{+6}) continued in solution until changes in chemical conditions allowed their precipitation as cherty and opaline replacements of wood in the vicinity of the Oliver Saddle and Barbara claims (fig. 5). These systematically varying types of uranium ore bodies suggest that local differences in the occurrence and preservation of reducing environments influenced the formation of uranium deposits within the Tallahassee Creek Conglomerate.

CONCLUSIONS

On the basis of the geologic and geochemical data of this study, the formation of uranium deposits in the Tallahassee Creek Conglomerate was controlled not only by the presence of permeable sediments and favorable reducing environments, but also by the restricted local distribution of uraniferous volcanic ash. The alteration of this ash to bentonitic clays, and the associated release of uranium may have been catalyzed by heating during the emplacement of the lower member of the Thirtynine Mile Andesite. However, these deposits appear to provide a direct link between the alteration of volcanic ash and the formation of sedimentary uranium deposits, a connection that has been hypothesized frequently in the past.

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Table 4.--Major-element analyses of relatively unaltered air-fall tuff from near the Glen Williams and Gunnison School Section mines and clay-altered ash-rich lenses from the bentonitic strata of the Tallahassee Creek Conglomerate. [All elements were determined by X-ray flouresence (XRF) and values are reported in weight percent, J.E. Taggart, chief analyst.]

Sample	unaltered air-fall ash		altered air-fall ash	
	TC-3	TC-4	TC-1	TC-8
SiO_2	62.2	62.4	62.9	65.0
Al_2O_3	16.9	16.4	15.4	14.0
Fe_2O_3*	2.46	2.57	1.80	2.18
MgO	1.21	1.0	3.18	2.58
CaO	3.39	3.38	1.06	1.67
Na_2O	2.23	2.40	<.15	.83
K_2O	2.61	2.86	.14	.83
TiO_2	.85	.80	.10	.54
P_2O_5	.26	.28	<.05	.15
MnO	.03	<.02	<.02	<.02
LOI	6.99	6.49	14.5	10.9
Total	99.13	98.58	99.08	98.68

* Total iron given as Fe_2O_3

** Loss on ignition (LOI) at 900°C consists primarily of H_2O with minor CO_2.

Table 5.--Trace element analyses of relatively unaltered air-fall tuff from near the Glen Williams and Gunnison School Section mines and clay-altered ash-rich lenses from the bentonitic strata of the Tallahassee Creek Conglomerate, [Uranium and thorium were determined by delayed neutron activaton, on samples leached with dilute HNO_3, D. M. McKown, chief analyst. All other elements were determined by quanatitive (±5-10%) energy dispersive XRF. All values given in ppm.]

	unaltered air-fall ash		altered air-fall ash		ash-rich sandstone matrix		
	TC-3	TC-4	TC-1	TC-8	TC-2	TC-5	TC-7
U	15.7	7.1	1.4	6.9	4.1	2.4	6.3
Th	16.0	13.9	15.6	13.9	19.7	15.6	16.6
Rb	195	231	<6	37	53	53	82
Sr	770	824	122	445	853	791	662
Y	19	20	<4	13	25	15	30
Zr	240	240	83	131	199	229	287
Nb	16	12	<3	20	24	18	24
Mo	<3	<3	<3	6	<3	<3	<3

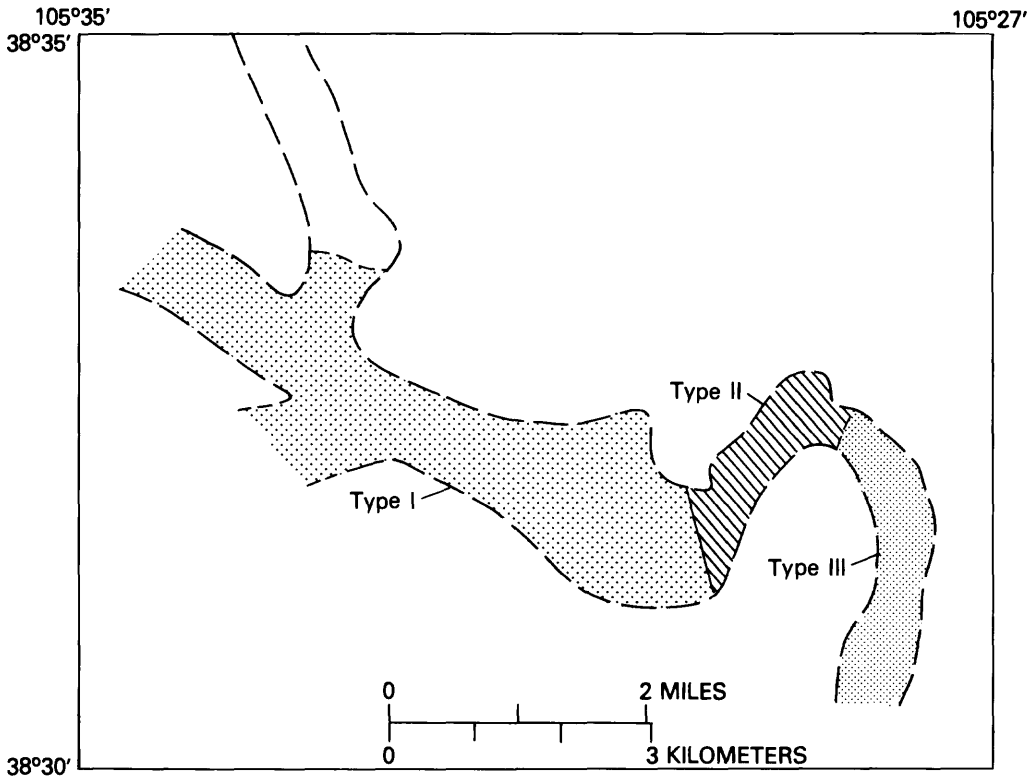

Figure 5.--Map of the Tallahassee Creek paleochannel showing the areal distribution of various types of uranium deposits within the Tallahassee Creek Conglomerate.

Type I: uranium (U^{+4}) deposited in pads and lenses near accumulations of carbonaceous material within the bentonitic strata.

Type II: uranium (U^{+4}) deposited in discontinuous rollfronts within carbonaceous zones of lower volcaniclastic conglomerate and sandstone.

Type III: uranium (U^{+6}) deposited with silica as replacements of wood fragments within the lower volcaniclastic conglomerate.

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Appendix A.1

Description of samples from mines and prospects within the Tallahassee Creek uranium district. (Ttc - Tallahassee Creek Conglomerate)

Smaller-Mary L. Mines

MDE-367	Carbonaceous sandstone*
MDE-368	Calcite replaced wood*
MDE-369	Calcite replaced wood*
MDE-370	Carbonaceous sandstone*
MDE-371	Altered Precambrian gneiss
MDE-372	Carbonaceous fine sandstone*
MDE-373	Fault gouge*
MDE-374	Fault gouge w/secondary U*
MDE-375	Black shale *
MDE-376	Oxidized shale*
MDE-377	Fault breccia

Rainbow Moose Mine

MDE-474	Wall Mountain Tuff boulder, upper Ttc
MDE-475	Wall Mountain Tuff boulder, upper Ttc
MDE-476	Carbonaceous wood, upper Ttc*
MDE-477	Carbonaceous sandstone, upper Ttc
MDE-478	Ash-rich lens, upper Ttc*
MDE-479	Carbonaceous ash, upper Ttc
MDE-480	Matrix from conglomerate, upper Ttc
MDE-481	Wall Mountain Tuff boulder, upper Ttc
MDE-482	Wall Mountain Tuff boulder
MDE-483	Ash-rich lens, upper Ttc
MDE-484	Vesicular andesite
MDE-485	Carbonaceous ash, upper Ttc*
MDE-486	Carbonaceous ash, upper Ttc*
MDE-487	Vesicular andesite
MDE-488	Organic horizon, upper Ttc*
MDE-489	Vesicular andesite
MDE-493	Bentonitic conglomerate, upper Ttc*
MDE-495	Carbonaceous ash, upper Ttc*
MDE-496	Ash-rich lens, upper Ttc
TC-8	Ash-rich lens, upper Ttc

Picnic Tree Mine

MDE-490	Wall Mountain Tuff boulder, upper Ttc
MDE-491	Wall Mountain Tuff boulder, upper Ttc
MDE-492	Oxidized wood fragment, upper Ttc
TC-7	Ash-rich sandstone, upper Ttc

Thorn Ranch Mine

MDE-473	Bentonitic conglomerate, upper Ttc

Sunshine Mine

MDE-444	Ash-lens, upper Ttc
MDE-445	Conglomerate matrix, upper Ttc
MDE-446	Wall Mountain Tuff boulder, upper Ttc
MDE-447	Conglomerate matrix, upper Ttc

Gunnison School Section and Glen Williams Mine

MDE-305	Ash-rich sandstone, upper Ttc
MDE-306	Fe-Mn rich lens, upper Ttc
MDE-307	Ash-rich lens, upper Ttc
MDE-308	Ash-rich sandstone, upper Ttc
MDE-309	Sandstone, upper Ttc
MDE-310	Volcanic boulders, upper Ttc
MDE-312	Sandy mudstone
MDE-313	Wall Mountain Tuff boulder
MDE-314	Wall Mountain Tuff boulder
MDE-315	Wall Mountain Tuff boulder
MDE-316	Ash-rich lens, upper Ttc
MDE-317	Wall Mountain Tuff boulder
MDE-318	Wall Mountain Tuff boulder
MDE-319	Wall Mountain Tuff boulder
MDE-320	Wall Mountain Tuff boulder
MDE-394	Andesitic breccia, Thirtynine Mile Andesite
MDE-395	Andesitic breccia, Thirtynine Mile Andesite
MDE-396	Partially silicified wood fragment
MDE-397	Wall Mountain Tuff boulder
MDE-398	Wall Mountain Tuff boulder
MDE-399	Wall Mountain Tuff boulder
MDE-400	Mineralized sandstone
MDE-401	Mineralized sandstone
MDE-402	Wall Mountain Tuff boulder
TC-1	Ash-rich lens, upper Ttc
TC-2	Ash-rich sandstone, upper Ttc

Near the Glen Williams Mine

MDE-456	Air-fall tuff
MDE-457	Air-fall tuff
TC-3	Air-fall tuff
TC-4	Air-fall tuff

Oliver Saddle Prospect

MDE-436	Altered sandstone*
MDE-437	Altered conglomerate matrix
MDE-438	Silicified conglomerate*
MDE-439	Silicified wood*
MDE-440	Silicified wood*

First and Last Chance Mines

MDE-301	Matrix from conglomerate, lower Ttc
MDE-302	Sandstone lens in lower Ttc
MDE-303	Volcanic boulders, lower Ttc
MDE-304	Volcanic boulders, lower Ttc
MDE-354	Silicified wood, lower Ttc*
MDE-355	Oxidized sandstone around 354*
MDE-356	Oxidized conglomerate lower Ttc*
MDE-357	Oxidized conglomerate, lower Ttc*
MDE-358	Oxidized sandstone, lower Ttc*
MDE-359	Carbonaceous sandstone, lower Ttc*
MDE-362	Ash-rich lens, upper Ttc
MDE-363	Fe-Mn stained conglomerate, upper Ttc
MDE-364	Ash-rich conglomerate, upper Ttc
MDE-365	Andesitic breccia, Thirtynine Mile Andesite
MDE-366	Fe-Mn rich lenses, upper Ttc
TC-5	Ash-rich sandstone, upper Ttc

Barbara Claims Prospect

MDE-497	Silicified wood

* ore-grade samples

Appendix A.2

Analyses of samples from mines and prospects within the Tallahassee Creek uranium district

(Uranium and thorium were determined by delayed neutron activation, H. T. Millard, Jr., chief analyst; all other elements were determined by semi-quantitative emission spectrometry, J. L. Seeley, chief analyst; U.S. Geological Survey, Branch of Analytical Laboratories.)

Elements looked for but not detected (in ppm)
As (<200), Au (<10), Bi (<10), Cd (<2.0), Hg (<500), Re (<50), Sb (<100), Se (<200), Sn (<10), Te (<50), W (<100).

Sample Number	U-ppm	Th-ppm	Al%	Ca%	Fe%	K%	Mg%	Na%
MDE-367	212.000	<89.00	6.90	.89	5.10	2.80	1.50	1.10
MDE-368	6,520.000	<3,000.00	<.25	>20.00	5.20	.19	<.10	<.15
MDE-369	19,500.000	<8,500.00	.31	>20.00	6.20	.37	.15	<.15
MDE-370	2,600.000	<580.00	6.00	6.80	4.90	2.10	.72	.89
MDE-371	49.100	83.50	7.80	.53	2.90	3.70	.45	2.00
MDE-372	2,540.000	<920.00	6.40	.28	3.70	2.20	.46	1.00
MDE-373	711.000	<190.00	9.80	.43	3.50	2.80	1.30	.27
MDE-374	2,390.000	<25,800.00	7.40	1.20	2.60	2.30	1.10	.42
MDE-375	1,300.000	<310.00	9.40	.76	4.10	2.50	1.80	.74
MDE-376	283.000	<91.00	6.60	7.60	11.00	2.60	1.30	1.00
MDE-377	31.200	37.00	5.50	5.70	1.10	3.10	.20	.76
MDE-474	10.300	11.00	4.40	.89	.56	1.40	.35	.90
MDE-475	13.200	49.20	7.60	.86	.94	4.90	.19	2.70
MDE-476	1,950.000	<520.00	2.60	1.20	>20.00	1.70	.86	.70
MDE-477	3.000	5.00	5.40	5.40	4.30	3.30	1.90	1.30
MDE-478	203.000	<40.00	8.20	1.50	1.90	1.20	1.10	1.20
MDE-479	36.100	<12.00	8.10	1.60	1.50	1.10	.99	1.10
MDE-480	5.920	13.00	6.70	1.40	5.40	.93	1.50	.91
MDE-481	9.770	38.00	8.00	.94	.83	>5.00	.21	3.10
MDE-482	9.290	64.50	9.70	.89	1.30	1.80	<.10	1.30
MDE-483	5.380	12.40	6.70	.66	1.20	.45	1.30	.33
MDE-484	87.900	<21.00	10.00	3.30	4.30	2.80	.56	2.00
MDE-485	5,420.000	<2,800.00	6.60	4.40	4.60	.92	.82	.69
MDE-486	2,110.00	<580.00	9.50	1.30	2.30	1.30	1.30	1.10
MDE-487	133.000	<29.00	11.00	4.00	4.50	3.00	.43	2.20
MDE-488	265.000	<53.00	9.50	2.20	2.80	1.40	.99	1.30
MDE-489	30.900	<10.00	9.90	3.80	9.00	3.60	.35	2.60
MDE-493	706.000	<220.00	6.40	11.00	3.40	1.80	.74	1.50
MDE-494	731.000	<220.00	6.60	12.00	3.80	1.80	.82	1.40
MDE-495	460.00	<150.00	7.10	3.20	10.00	1.80	1.30	1.50
MDE-496	1.200	13.80	11.00	3.10	2.00	2.40	.32	2.40
MDE-490	19.700	52.30	9.30	1.10	.98	2.60	.55	1.70
MDE-491	22.500	48.50	8.20	.86	.87	>5.00	.17	3.20
MDE-492	157.000	<38.00	.58	.29	1.70	.14	<.10	<.15
MDE-473	12.700	<6.00	5.80	13.00	3.90	2.00	.52	1.70
MDE-444	53.200	<16.00	8.40	2.30	2.50	1.80	.46	2.10
MDE-445	60.200	<46.00	8.80	2.00	3.90	2.30	.60	2.30
MDE-446	4.280	16.20	11.00	3.80	2.90	2.20	.55	2.40
MDE-447	10.800	<6.40	9.40	3.70	6.00	1.90	.64	2.50
MDE-305	42.800	<14.00	7.80	1.60	4.20	1.10	1.10	1.10
MDE-306	7.760	<17.00	2.40	.96	>20.00	1.20	.56	.52
MDE-307	7.450	<25.00	6.80	.63	1.90	.20	1.50	<.15
MDE-308	10.900	14.00	8.30	1.30	2.20	1.00	1.20	1.00
MDE-309	4.250	11.20	9.20	2.50	2.40	2.00	.55	1.90

Sample Number	U-ppm	Th-ppm	Al%	Ca%	Fe%	K%	Mg%	Na%
MDE-310	1.090	4.00	11.00	3.40	4.20	.60	.74	1.70
MDE-312	3.400	<16.00	9.20	1.20	6.00	2.90	1.30	1.70
MDE-313	.970	12.40	11.00	3.80	5.90	3.30	.26	2.70
MDE-314	6.500	51.80	7.40	.60	1.20	4.40	.12	2.70
MDE-315	7.390	47.40	7.90	.61	1.20	4.50	.12	2.70
MDE-316	5.100	14.80	8.30	1.60	2.70	1.40	.93	1.30
MDE-317	5.400	45.30	8.10	.76	1.20	4.30	.11	2.60
MDE-318	25.900	<27.00	6.60	.55	.78	3.80	<.10	2.10
MDE-319	4.940	12.00	9.50	2.70	4.20	.61	1.30	1.50
MDE-320	15.400	53.90	6.90	11.00	2.30	.55	1.30	.51
MDE-394	2.160	7.69	9.50	3.60	6.20	2.10	.79	2.70
MDE-395	1.720	10.30	8.40	2.40	6.50	2.30	.95	2.60
MDE-396	108.00	<27.00	4.70	.87	2.40	1.50	.36	1.50
MDE-397	47.300	<14.00	7.20	.61	.66	3.80	.18	3.00
MDE-398	32.800	<12.00	5.50	.54	.71	3.00	.18	1.90
MDE-399	17.100	38.20	7.70	8.20	1.00	2.80	.41	1.90
MDE-400	2,780.000	<630.00	9.30	2.20	4.70	1.90	.70	1.80
MDE-401	2,040.000	<470.00	8.40	1.90	5.70	2.10	.53	2.00
MDE-402	20.000	66.10	7.90	1.20	2.10	1.10	1.40	.94
MDE-456	29.600	<11.00	9.30	2.60	1.90	2.10	.69	2.20
MDE-457	21.600	<8.70	9.00	2.90	2.40	2.50	.53	2.70
MDE-436	105.000	<25.00	6.10	1.80	1.80	1.60	.36	1.60
MDE-437	21.200	<8.30	6.20	2.10	9.40	1.70	.68	1.60
MDE-438	93.700	<23.00	5.30	1.70	1.30	1.50	.18	1.50
MDE-439	48.600	<13.00	.27	.10	6.70	<.08	<.10	<.15
MDE-440	37,700.000	<10,000.00	.33	.76	3.00	.27	<.10	.16
MDE-301	4.240	13.00	6.70	1.30	3.10	1.60	.51	1.50
MDE-302	4.780	<15.00	6.70	5.20	1.50	2.10	.35	1.70
MDE-303	3.910	8.50	11.00	3.70	6.00	1.60	.80	2.00
MDE-304	3.000	<14.00	11.00	3.40	4.00	.79	.93	1.90
MDE-354	12,500.000	<5,600.00	1.50	16.00	7.30	.51	.24	.76
MDE-355	5,310.000	<2,600.00	5.60	9.70	11.00	1.40	.76	1.30
MDE-356	15.300	20.50	8.70	3.50	10.00	2.40	.84	2.20
MDE-357	74.700	<44.00	7.80	2.90	8.70	2.70	.70	2.20
MDE-358	1,220.000	<370.00	5.90	1.50	>20.00	1.70	.88	1.30
MDE-359	12,300.000	<5,500.00	6.80	2.60	2.90	1.70	.71	1.60
MDE-360	2.730	<12.00	6.10	.42	.59	>5.00	<.10	3.30
MDE-361	2.900	18.00	6.20	.43	.61	>5.00	<.10	4.30
MDE-362	35.800	<36.00	9.00	2.00	3.10	2.20	.67	2.10
MDE-363	335.000	<130.00	7.80	2.00	12.00	2.40	.61	1.70
MDE-364	226.000	<100.00	8.90	2.20	2.30	2.40	.67	1.90
MDE-365	3.980	<14.00	8.00	4.10	15.00	2.00	.63	2.20
MDE-366	130.000	<65.00	6.50	1.80	19.00	2.40	.51	1.60
MDE-497	4,110.000	<9,500.00	.27	2.40	3.20	<.08	<.10	<.15

Sample Number	P%	Si%	Ti%	Ag-ppm	B-ppm	Ba-ppm	Be-ppm	Ce-ppm	Co-ppm
MDE-367	.10	28	.41	<1.0	63	590	4.7	<100	21.0
MDE-368	<.02	<10	<.03	<1.0	<10	<20	1.1	<100	36.0
MDE-369	<.02	<10	.03	<1.0	<10	66	4.5	<100	78.0
MDE-370	.08	25	.25	7.8	27	650	8.9	200	26.0
MDE-371	.07	31	.21	<1.0	<10	570	4.9	200	1.8
MDE-372	.06	28	.32	<1.0	24	760	6.9	150	17.0
MDE-373	.07	29	.62	<1.0	110	560	13.0	220	21.0
MDE-374	.06	33	.38	<1.0	<10	550	15.0	220	39.0
MDE-375	.08	27	.64	<1.0	110	420	6.4	280	32.0
MDE-376	.09	22	.37	<1.0	62	950	5.7	190	25.0
MDE-377	.03	35	.14	<1.0	<10	820	2.2	110	3.9
MDE-474	.06	>40	.18	<1.0	<10	3,200	2.6	<100	6.0
MDE-475	.05	33	.26	<1.0	<10	1,500	3.2	190	1.4
MDE-476	.08	21	.09	<1.0	10	>5,000	7.3	<100	170.0
MDE-477	.04	33	.13	<1.0	<10	710	3.1	<100	11.0
MDE-478	.16	27	.55	1.3	<10	920	3.1	120	48.0
MDE-479	.17	31	.54	1.2	<10	940	2.8	110	31.0
MDE-480	.12	25	.34	<1.0	<10	580	3.3	<100	21.0
MDE-481	.06	36	.27	<1.0	<10	1,600	3.3	180	3.1
MDE-482	.07	28	.38	1.0	46	2,000	2.4	200	7.1
MDE-483	.06	34	.21	<1.0	<10	410	1.9	<100	13.0
MDE-484	>.45	25	.99	1.6	<10	1,800	4.3	180	71.0
MDE-485	>.45	21	.40	1.3	<10	1,000	5.7	320	37.0
MDE-486	.17	28	.65	1.5	<10	870	3.9	150	30.0
MDE-487	>.45	25	1.10	2.0	<10	2,000	3.2	170	44.0
MDE-488	.22	27	.70	1.5	<10	1,100	7.2	180	100.0
MDE-489	>.45	25	.94	<1.0	<10	2,000	4.1	120	21.0
MDE-493	.15	17	.44	<1.0	<10	1,200	3.1	<100	43.0
MDE-494	.14	17	.46	<1.0	<10	1,200	3.4	<100	49.0
MDE-495	.29	22	.56	<1.0	<10	1,100	5.5	<100	56.0
MDE-496	.19	25	.47	<1.0	<10	2,300	1.7	130	4.1
MDE-490	.08	30	.35	<1.0	37	1,600	3.2	200	4.2
MDE-491	.06	32	.25	<1.0	<10	1,600	3.6	220	2.1
MDE-492	.05	>40	.06	<1.0	<10	330	3.8	190	13.0
MDE-473	.17	16	.43	<1.0	<10	1,300	1.7	<100	19.0
MDE-444	.40	25	.54	1.1	<10	1,500	2.8	<100	54.0
MDE-445	.22	27	.55	<1.0	<10	1,500	4.0	130	27.0
MDE-446	>.45	29	.71	1.3	<10	1,600	2.1	130	21.0
MDE-447	>.45	27	.70	<1.0	<10	1,400	3.4	<100	27.0
MDE-305	.24	32	.51	<1.0	13	960	3.2	180	50.0
MDE-306	>.45	20	.13	<1.0	<10	1,700	8.7	<100	26.0
MDE-307	.03	30	.09	<1.0	<10	140	2.1	<100	4.3
MDE-308	.13	28	.50	<1.0	<10	860	3.3	110	24.0
MDE-309	>.45	30	.75	<1.0	<10	1,700	2.5	140	8.3

Sample Number	P%	Si%	Ti%	Ag-ppm	B-ppm	Ba-ppm	Be-ppm	Ce-ppm	Co-ppm
MDE-310	.25	28	.60	<1.0	<10	500	2.0	<100	11.0
MDE-312	.06	37	.39	<1.0	26	730	5.2	170	11.0
MDE-313	>.45	26	.60	<1.0	<10	2,300	2.4	190	10.0
MDE-314	.04	32	.23	<1.0	<10	1,000	2.9	200	<1.0
MDE-315	.04	35	.23	<1.0	<10	1,000	3.2	210	4.4
MDE-316	.40	27	.49	<1.0	<10	1,200	2.3	110	28.0
MDE-317	.05	36	.25	<1.0	<10	1,500	3.4	250	3.4
MDE-318	.04	35	.20	<1.0	<10	1,200	2.8	180	3.9
MDE-319	.17	26	.47	<1.0	<10	810	1.9	120	8.4
MDE-320	.04	18	.16	<1.0	<10	590	1.8	150	5.5
MDE-394	.20	24	.88	<1.0	<10	1,700	2.2	110	19.0
MOE-395	.09	23	.64	<1.0	<10	1,200	3.6	180	38.0
MDE-396	.05	39	.26	<1.0	<10	830	3.9	100	67.0
MDE-397	.06	>40	.21	<1.0	<10	1,200	3.8	200	11.0
MDE-398	.04	>40	.15	<1.0	<10	1,000	3.1	140	7.9
MDE-399	.04	24	.24	<1.0	<10	1,400	2.8	140	4.6
MDE-400	>.45	27	.62	<1.0	<10	1,500	5.8	150	130.0
MDE-401	.30	26	.56	<1.0	<10	1,400	5.1	120	78.0
MDE-402	.08	26	.26	<1.0	<10	1,300	4.9	200	8.4
MDE-456	.15	33	.65	1.7	<10	1,400	4.2	110	48.0
MDE-457	.19	32	.75	1.7	<10	1,800	3.2	160	26.0
MDE-436	.17	36	.38	<1.0	<10	1,100	3.3	110	55.0
MDE-437	.19	33	.41	<1.0	13	1,100	2.9	<100	43.0
MDE-438	.28	34	.39	1.3	<10	1,200	2.1	<100	31.0
MDE-439	.05	>40	<.03	<1.0	53	330	9.4	<100	35.0
MDE-440	>.45	>40	.05	<1.0	13	>5,000	14.0	420	120.0
MDE-301	.11	31	.32	<1.0	<10	810	2.6	130	24.0
MDE-302	.09	32	.27	<1.0	<10	960	2.6	<100	13.0
MDE-303	>.45	27	.81	<1.0	<10	1,100	3.1	<100	35.0
MDE-304	.19	28	.52	<1.0	<10	720	2.6	<100	39.0
MDE-354	>.45	24	.07	<1.0	<10	410	50.0	230	180.0
MDE-355	>.45	22	.22	<1.0	<10	640	30.0	180	160.0
MDE-356	.42	26	.80	<1.0	<10	1,300	5.5	<100	72.0
MDE-357	>.45	27	.59	<1.0	<10	1,300	5.5	110	90.0
MDE-358	.29	28	.27	<1.0	<10	630	14.0	<100	820.0
MDE-359	>.45	27	.41	1.1	<10	920	12.0	250	500.0
MDE-360	.03	>40	.06	<1.0	<10	350	2.7	<100	1.0
MDE-361	.04	>40	.06	<1.0	<10	370	2.6	140	1.3
MDE-362	.11	27	.40	<1.0	<10	1,700	2.7	140	23.0
MDE-363	>.45	27	.66	<1.0	<10	1,500	8.7	130	86.0
MDE-364	.44	27	.96	<1.0	<10	1,200	2.6	<100	4.0
MDE-365	>.45	25	.75	<1.0	<10	1,200	3.1	<100	19.0
MDE-366	.45	26	.56	<1.0	<10	1,700	6.4	<100	170.0
MDE-497	>.45	>40	.06	<1.0	<10	530	15.0	260	64.0

Sample Number	Cr-ppm	Cu-ppm	Ga-ppm	La-ppm	Li-ppm	Mn-ppm	Mo-ppm	Nb-ppm	Ni-ppm
MDE-367	40	45.0	22	54	64	810	16	<25	32.0
MDE-368	14	4.3	14	120	<50	2,400	<10	<25	27.0
MDE-369	19	8.2	27	170	<50	1,800	<10	<25	49.0
MDE-370	26	42.0	23	83	<50	940	12	<25	32.0
MDE-371	<10	3.7	28	120	<50	470	<10	<25	5.9
MDE-372	24	21.0	24	40	71	450	120	<25	26.0
MDE-373	59	85.0	29	98	92	410	<10	<25	28.0
MDE-374	22	43.0	26	94	<50	630	15	<25	36.0
MDE-375	52	57.0	22	120	140	850	20	<25	47.0
MDE-376	36	43.0	21	89	54	860	55	<25	33.0
MDE-377	11	8.5	11	70	<50	5,000	<10	<25	7.2
MDE-474	13	20.0	<10	30	<50	260	<10	<25	8.6
MDE-475	<10	4.9	16	110	<50	330	<10	<25	4.1
MDE-476	14	12.0	15	65	<50	3,000	<10	<25	110.0
MDE-477	16	9.3	11	<20	<50	1,300	<10	<25	12.0
MDE-478	25	29.0	17	40	<50	200	64	<25	61.0
MDE-479	21	32.0	16	47	<50	<200	15	<25	23.0
MDE-480	19	26.0	18	43	<50	920	<10	<25	16.0
MDE-481	<10	7.4	15	96	<50	200	<10	<25	4.8
MDE-482	<10	5.8	22	96	<50	<200	<10	35	10.0
MDE-483	13	16.0	13	<20	<50	<200	<10	<25	11.0
MDE-484	22	61.0	23	110	<50	300	18	47	48.0
MDE-485	28	87.0	21	140	<50	280	620	<25	46.0
MDE-486	28	100.0	25	63	<50	<200	36	<25	25.0
MDE-487	22	46.0	24	110	<50	810	16	42	50.0
MDE-488	26	32.0	23	85	<50	400	14	<25	48.0
MDE-489	21	52.0	25	96	<50	2,500	11	<25	17.0
MDE-493	19	22.0	16	44	<50	1,400	<10	<25	37.0
MDE-494	20	24.0	16	44	<50	1,500	<10	<25	40.0
MDE-495	22	41.0	21	63	<50	3,000	13	<25	50.0
MDE-496	<10	52.0	20	80	<50	<200	<10	<25	5.6
MDE-490	<10	7.3	19	120	<50	<200	<10	<25	8.3
MDE-491	<10	7.0	16	120	<50	310	<10	<25	5.3
MDE-492	<10	9.6	<10	23	<50	<200	<10	<25	21.0
MDE-473	17	23.0	14	41	<50	2,200	<10	<25	13.0
MDE-444	<10	15.0	19	44	<50	390	<10	31	33.0
MDE-445	<10	17.0	20	73	<50	1,100	<10	41	33.0
MDE-446	<10	18.0	25	65	<50	<200	<10	34	18.0
MDE-447	11	39.0	25	56	<50	1,100	<10	<25	18.0
MDE-305	19	27.0	22	71	<50	840	17	<25	21.0
MDE-306	13	29.0	24	56	<50	>5,000	<10	<25	39.0
MDE-307	<10	4.6	16	<20	<50	<200	<10	<25	8.0
MDE-308	19	23.0	22	45	<50	500	12	32	15.0
MDE-309	22	25.0	22	70	<50	220	13	35	8.7

Sample Number	Cr-ppm	Cu-ppm	Ga-ppm	La-ppm	Li-ppm	Mn-ppm	Mo-ppm	Nb-ppm	Ni-ppm
MDE-310	48	39.0	26	31	<50	480	<10	<25	15.0
MDE-312	33	23.0	27	66	<50	580	<10	<25	22.0
MDE-313	<10	14.0	27	94	<50	830	<10	<25	11.0
MDE-314	<10	4.0	18	110	<50	260	<10	<25	6.2
MDE-315	<10	1.2	16	110	<50	340	<10	<25	7.3
MDE-316	14	24.0	26	53	<50	210	<10	<25	12.0
MDE-317	<10	1.1	19	120	<50	220	<10	<25	8.2
MDE-318	<10	2.0	14	92	<50	410	<10	<25	7.1
MDE-319	12	12.0	24	49	<50	300	<10	<25	14.0
MDE-320	<10	1.6	15	96	<50	1,100	<10	<25	13.0
MDE-394	13	41.0	26	69	<50	1,100	12	35	15.0
MDE-395	<10	35.0	24	78	<50	2,200	14	31	20.0
MDE-396	11	13.0	11	43	<50	1,200	42	<25	48.0
MDE-397	<10	29.0	17	110	<50	360	<10	29	16.0
MDE-398	<10	8.4	11	84	<50	220	<10	<25	11.0
MDE-399	<10	5.1	15	85	<50	840	<10	30	8.9
MDE-400	18	37.0	30	76	<50	1,300	24	<25	110.0
MDE-401	15	25.0	24	70	<50	800	22	<25	79.0
MDE-402	<10	4.8	22	87	<50	360	<10	<25	10.0
MDE-456	20	28.0	22	57	<50	620	<10	34	29.0
MDE-457	16	29.0	21	71	<50	360	<10	37	20.0
MDE-436	24	16.0	17	62	<50	270	<10	<25	63.0
MDE-437	13	13.0	18	58	<50	380	<10	<25	50.0
MDE-438	15	7.9	12	66	<50	200	<10	<25	22.0
MDE-439	<10	18.0	<10	<20	<50	440	<10	<25	55.0
MDE-440	22	12.0	32	120	<50	430	160	120	49.0
MDE-301	36	45.0	18	56	<50	300	<10	<25	32.0
MDE-302	24	14.0	16	44	<50	250	<10	<25	18.0
MDE-303	57	65.0	27	43	<50	370	14	<25	38.0
MDE-304	110	62.0	25	35	<50	310	<10	<25	42.0
MDE-354	25	440.0	18	140	<50	730	<10	<25	130.0
MDE-355	32	180.0	21	130	<50	630	<10	<25	170.0
MDE-356	27	48.0	27	43	<50	480	<10	<25	63.0
MDE-357	20	48.0	22	47	<50	520	<10	<25	71.0
MDE-358	28	320.0	23	38	<50	920	<10	<25	450.0
MDE-359	23	170.0	25	130	<50	350	<10	<25	700.0
MDE-360	<10	<1.0	17	<20	<50	<200	<10	<25	4.7
MDE-361	<10	<1.0	19	51	<50	<200	<10	<25	4.5
MDE-362	<10	4.5	20	60	<50	2,000	<10	<25	25.0
MDE-363	18	39.0	22	60	<50	>5,000	98	<25	130.0
MDE-364	17	18.0	21	34	<50	210	12	<25	9.0
MDE-365	24	54.0	24	47	<50	1,900	<10	<25	15.0
MDE-366	17	63.0	24	47	<50	>5,000	<10	<25	71.0
MDE-497	25	16.0	10	160	<50	1,400	<10	<25	71.0

Sample Number	Pb-ppm	Sc-ppm	Sr-ppm	Tl-ppm	V-ppm	Y-ppm	Zn-ppm	Zr-ppm
MDE-367	<10	19	100	<10	100	54	<50	340
MDE-368	20	14	330	<10	90	60	<50	900
MDE-369	140	16	290	<10	120	87	<50	>1,000
MDE-370	100	16	180	<10	74	100	<50	450
MDE-371	43	<10	99	<10	<10	66	60	380
MDE-372	<10	<10	110	<10	62	47	<50	780
MDE-373	80	25	140	<10	130	100	120	660
MDE-374	<10	23	160	<10	74	100	190	530
MDE-375	24	28	95	<10	140	110	110	380
MDE-376	13	22	360	<10	100	77	<50	340
MDE-377	<10	<10	130	<10	<10	64	<50	240
MDE-474	<10	<10	360	<10	77	16	<50	300
MDE-475	<10	<10	270	<10	17	35	<50	420
MDE-476	<10	29	440	<10	76	140	<50	940
MDE-477	<10	10	150	<10	45	27	59	180
MDE-478	<10	11	800	<10	110	33	<50	430
MDE-479	<10	<10	890	<10	93	23	<50	290
MDE-480	<10	29	590	<10	140	25	190	340
MDE-481	<10	<10	310	<10	27	28	<50	360
MDE-482	<10	<10	410	<10	30	23	57	490
MDE-483	<10	12	210	<10	64	<10	65	230
MDE-484	<10	19	1,600	<10	180	52	<50	420
MDE-485	<10	46	1,100	<10	240	160	130	>1,000
MDE-486	<10	24	780	<10	240	37	91	420
MDE-487	<10	22	1,700	<10	170	54	53	410
MDE-488	33	24	900	<10	210	60	160	600
MDE-489	<10	20	1,500	<10	200	41	160	460
MDE-493	<10	14	2,500	<10	110	34	<50	410
MDE-494	<10	15	2,800	<10	120	35	<50	420
MDE-495	<10	17	980	<10	150	32	<50	470
MDE-496	<10	<10	1,900	<10	80	18	69	220
MDE-490	<10	<10	360	<10	30	29	<50	430
MDE-491	<10	<10	290	<10	21	38	<50	400
MDE-492	35	<10	88	<10	43	64	<50	>1,000
MDE-473	<10	16	890	<10	130	34	<50	400
MDE-444	<10	15	740	<10	130	24	77	480
MDE-445	12	14	620	<10	150	28	97	630
MDE-446	13	15	1,100	<10	120	32	<50	430
MDE-447	<10	20	1,100	<10	190	37	110	450
MDE-305	29	13	690	<10	140	34	120	320
MDE-306	<10	18	340	<10	270	100	<50	500
MDE-307	<10	<10	120	<10	36	13	80	140
MDE-308	<10	11	690	<10	130	23	71	300
MDE-309	<10	<10	1,200	<10	110	32	<50	320

Sample Number	Pb-ppm	Sc-ppm	Sr-ppm	Tl-ppm	V-ppm	Y-ppm	Zn-ppm	Zr-ppm
MDE-310	<10	30	710	<10	290	23	57	290
MDE-312	<10	18	190	<10	98	52	130	450
MDE-313	12	11	1,600	<10	110	41	110	340
MDE-314	15	<10	140	<10	11	33	<50	360
MDE-315	13	<10	150	<10	21	32	<50	360
MDE-316	<10	<10	730	<10	91	21	64	340
MDE-317	26	<10	220	<10	36	33	<50	380
MDE-318	<10	<10	200	<10	<10	29	<50	340
MDE-319	<10	<10	800	<10	110	16	94	280
MDE-320	<10	<10	280	<10	12	27	98	370
MDE-394	<10	15	1,900	<10	180	34	98	340
MDE-395	<10	20	1,400	<10	190	45	83	230
MDE-396	<10	<10	470	<10	70	29	86	260
MDE-397	<10	<10	290	<10	48	29	<50	280
MDE-398	<10	<10	220	<10	27	25	<50	320
MDE-399	<10	<10	300	<10	17	36	<50	380
MDE-400	<10	15	910	<10	220	40	81	450
MDE-401	<10	15	1,000	<10	180	36	67	420
MDE-402	<10	<10	330	<10	54	23	79	450
MDE-456	21	12	1,000	<10	180	28	69	390
MDE-457	25	11	1,100	<10	170	31	<50	380
MDE-436	<10	<10	610	<10	110	31	59	390
MDE-437	16	16	550	<10	130	81	130	390
MDE-438	<10	16	540	<10	82	260	<50	380
MDE-439	<10	<10	<10	<10	73	32	<50	210
MDE-440	130	60	1,600	<10	260	290	85	620
MDE-301	<10	18	430	<10	150	20	54	290
MDE-302	<10	13	370	<10	100	26	<50	300
MDE-303	16	28	750	<10	220	32	160	340
MDE-304	12	29	680	<10	240	18	77	190
MDE-354	550	720	900	13	300	>2,000	<50	>1,000
MDE-355	210	530	810	<10	320	>2,000	240	>1,000
MDE-356	23	31	840	<10	340	42	<50	310
MDE-357	19	19	800	<10	170	54	54	330
MDE-358	12	60	430	<10	130	84	<50	520
MDE-359	90	90	820	42	150	300	130	790
MDE-360	12	<10	27	<10	24	36	<50	67
MDE-361	<10	<10	38	<10	30	21	<50	<20
MDE-362	<10	<10	590	<10	61	17	77	320
MDE-363	<10	22	690	21	210	50	280	340
MDE-364	<10	22	780	<10	200	26	<50	320
MDE-365	<10	26	1,400	<10	220	35	140	300
MDE-366	<10	21	630	26	210	37	190	310
MDE-497	34	19	190	<10	360	710	65	860

Appendix B

Analyses of Wall Mountain Tuff (TWM) from the Tallahassee Creek uranium district and the surrounding region

(Uranium and thorium were determined by delayed neutron activation, H. T. Millard, Jr., chief analyst; all other elements were determined by semi-quantitative emission spectrometry, J. L. Seeley, Chief Analyst; U.S. Geological Survey, Branch of Analaytical Laboratories.)

Elements looked for but not detected (in ppm): Ag (<1), As (<200), Au (<10), B (<10), Bi (<10), Cd (<2), Cr (<10), Hg (<500), Li (<50), Mo (<10), Nb (<25), Re (<50), Sb (<100), Sc (<10), Se (<200), Sn (<10), Te (<50), Tl (<10), Zn (<50).

Sample Number	Sample Description	U	Th	Al%	Ca%	Fe%	K%	Mg%	Na%	P%	Si%	Ti%	Ba	Be
MDE-350	Vitrophyric TWM	11.10	49	6.80	.70	1.20	>5	.15	2.80	.04	33	.24	1000	3.7
MDE-351	Weathered devitrified TWM	7.18	54	7.80	.57	.52	"	.11	4.10	.04	36	.28	1200	3.7
MDE-352	Altered " "	6.37	51	8.10	.62	2.20	"	.13	4.00	.05	35	.28	1100	4.7
MDE-353	" " "	6.57	41	8.20	.52	4.20	"	.20	3.50	.04	35	.29	1300	5.9
MDE-378	Fresh " "	6.40	47	8.30	.38	1.30	"	.15	3.30	.05	33	.29	1500	3.0
MDE-379	Weathered " "	6.33	51	9.10	.38	1.30	"	.12	3.30	.06	32	.29	1700	3.1
MDE-380	" " "	6.29	48	8.70	.36	1.50	"	.13	3.00	.05	33	.30	1500	3.0
MDE-404	" " "	4.96	45	7.90	.36	1.40	4.90	.12	2.20	.06	29	.26	1700	3.2
MDE-405	" " "	5.70	43	8.60	.39	1.50	>5	<.10	2.70	.07	29	.27	1800	2.6
MDE-406	Altered " "	7.31	40	8.50	.41	1.60	4.90	<.10	2.30	.07	30	.26	1700	3.0
MDE-407	Fresh " "	10.30	27	7.90	1.60	1.40	>5	.16	2.10	.06	29	.25	1700	2.8
MDE-422	" " "	5.80	45	7.40	.41	1.50	3.70	.19	1.80	.06	30	.23	1500	2.7
MDE-423	Weathered " "	6.57	44	7.40	1.30	1.30	3.80	.13	1.80	.07	28	.23	1200	3.0
MDE-428	Fresh " "	11.3	41	6.60	.25	1.10	3.2	<.10	1.50	.07	28	.19	1200	2.2
MDE-429	Altered " "	8.67	44	7.20	.35	1.20	3.5	.14	1.70	.08	29	.23	1500	3.1
MDE-500	Vitrophyric TWM	10.9	44	9.40	1.10	1.60	"	.22	3.40	.07	38	.28	1900	3.8
MDE-501	Fresh devitrified TWM	7.61	34	8.80	1.10	1.60	"	.19	3.70	.07	35	.30	2300	3.3
MDE-509	Vitrophyric TWM	10.8	45	9.00	1.20	1.80	"	.27	5.30	.06	38	.35	1500	4.3
MDE-510	Fresh devitrified TWM	10.5	45	8.70	.82	.94	"	.28	4.90	.06	37	.29	1400	3.6
MDE-511	" " "	9.53	46	8.40	.95	1.40	"	.40	3.40	.06	35	.32	1500	3.3
MDE-512	" " "	7.9	42	8.40	1.10	1.60	"	.36	3.00	.06	34	.34	1800	3.7
MDE-531	" " "	6.26	44	8.20	.60	.37	"	.22	2.80	.05	34	.25	1600	2.5
MDE-532	" " "	6.50	44	7.90	.50	.60	"	.17	2.70	.04	34	.27	1500	2.5

Sample Number	Sample Description	Ce	Co	Cu	Ga	La	Mn	Ni	Pb	Sr	V	Y	Zr
MDE-350	Vitrophyric TWM	190	<1.0	1.7	16	100	370	6.0	42	200	32	35	400
MDE-351	Weathered devitrified TWM	170	<1.0	1.1	17	110	<200	5.8	27	180	20	34	500
MDE-352	Altered " "	180	<1.0	3.1	18	100	250	6.6	21	160	36	32	400
MDE-353	" " "	190	1.0	6.2	19	110	290	7.2	18	170	38	35	390
MDE-378	Fresh " "	240	<1.0	2.6	17	130	260	6.0	33	180	23	40	410
MDE-379	Weathered " "	170	<1.0	3.5	17	110	250	4.7	29	190	<10	36	380
MDE-380	" " "	170	<1.0	3.4	17	110	240	4.4	27	170	<10	37	330
MDE-404	" " "	180	1.8	2.6	17	100	480	6.9	<10	170	30	30	410
MDE-405	" " "	170	<1.0	2.6	18	110	420	6.8	17	180	22	36	410
MDE-406	Altered " "	140	<1.0	2.0	18	100	320	4.9	19	180	16	31	410
MDE-407	Fresh " "	170	1.3	3.3	16	110	500	5.6	15	200	25	35	410
MDE-422	" " "	140	<1.0	4.1	17	110	<200	9.7	19	140	26	37	540
MDE-423	Weathered " "	210	2.3	4.5	19	120	<200	8.8	21	160	41	35	480
MDE-428	Fresh " "	180	<1.0	2.8	20	100	<200	5.1	<10	110	16	27	430
MDE-429	Altered " "	180	<1.0	2.0	21	120	<200	6.0	<10	130	33	33	530
MDE-500	Vitrophyric TWM	230	2.4	5.2	21	130	510	4.5	<10	310	25	40	340
MDE-501	Fresh devitrified TWM	150	2.0	7.6	18	74	370	4.8	<10	350	22	23	380
MDE-509	Vitrophyric TWM	260	3.5	8.7	20	170	680	5.7	17	300	29	47	360
MDE-510	Fresh devitrified TWM	220	2.4	6.7	19	140	350	4.7	12	240	22	37	390
MDE-511	" " "	200	2.3	8.9	16	130	510	4.9	12	280	24	39	410
MDE-512	" " "	190	2.9	8.6	17	110	530	5.0	15	350	31	37	330
MDE-531	" " "	200	1.3	7.9	17	110	530	13.0	<10	190	15	46	450
MDE-532	" " "	130	<1.0	9.4	17	53	530	9.9	<10	190	17	27	390

Appendix C

Palynomorph assemblages from the Echo Park Alluvium. [R. H. Tschudy and Sharon Van Loenen, U.S. Geological Survey, Denver, Colorado]

Sample D6224, brown claystone (base of Echo Park Alluvium), yielded an excellent assemblage including the following:

PISTILLIPOLLENITES
MOMIPITES
INTRATRIPOROPOLLENITES
CARYA 2 species
TAXODIACEAEPOLLENITES
MONOSULCITES
MOMIPITES TENUIPOLUS
ULMIPOLLENITES
cf. CARPINUS
ALNUS 5 pored
PARALNIPOLLENITES
PLICATOPOLLIS
PLATYCARYA
Bisaccate conifer pollen
cf. C3-rt 19
P4-sm 6
P-peri sm
CP3-rt high muri
BCP3-rt new!

This assemblage was accompanied by an abundance of light yellow epidermal and cuticular material and few wood fragments. The assemblage indicates a late early to early middle Eocene age.

Sample D6223-A, gray clayey sandstone, yielded a poor, corroded assemblage consisting of the following:

DELTOIDOSPORA
COROLLINA? corroded
Large trilete spores
Fungus spores
monolete fern spore
CARYA?

These few specimens were accompanied by black woody tissue, a slight amount of dark-brown epidermal tissue and some fungus spores. This sample was too poor to provide any age estimation.

Sample D6223-B, black sandstone (high-grade ore), yielded a fair assemblage including the following:

CARYA
JUGLANS
ALNUS 4 pored
ULMIPOLLENITES
SPARGANIUM
INTRATRIPOROLLENITES? corroded
EQUISETOSPORITES
Bisaccate conifer pollen - all badly corroded.
P-peri sm
CP3-sm
S1-sm
S1-rt large

Palynomorphs were accompanied by an abundance of light yellow epidermal and cuticular tissue with only occasional dark brown to black wood fragments. This sample can be no older than late Paleocene due to the presence of CARYA and JUGLANS pollen. The corroded questionable INRATRIPOROLLENITES grains found suggest an early Eocene age.

Samples of the Echo Park Alluvium were provided by Howard Harlan of Cyprus Mines from drill holes, in and near the Hansen ore body, located in sections 21 and 27, T. 17 S., R. 73 W. Nine additional samples submitted from these localities were barren of palynomorphs.

Appendix D

Geologic sketch maps of mines and prospects within the Tallahassee Creek uranium district.

Figure D1 Geologic Sketch Map of the Smaller and Mary L. Open-Pit Mines, Fremont County, Colorado. (elevation 8200 ft)

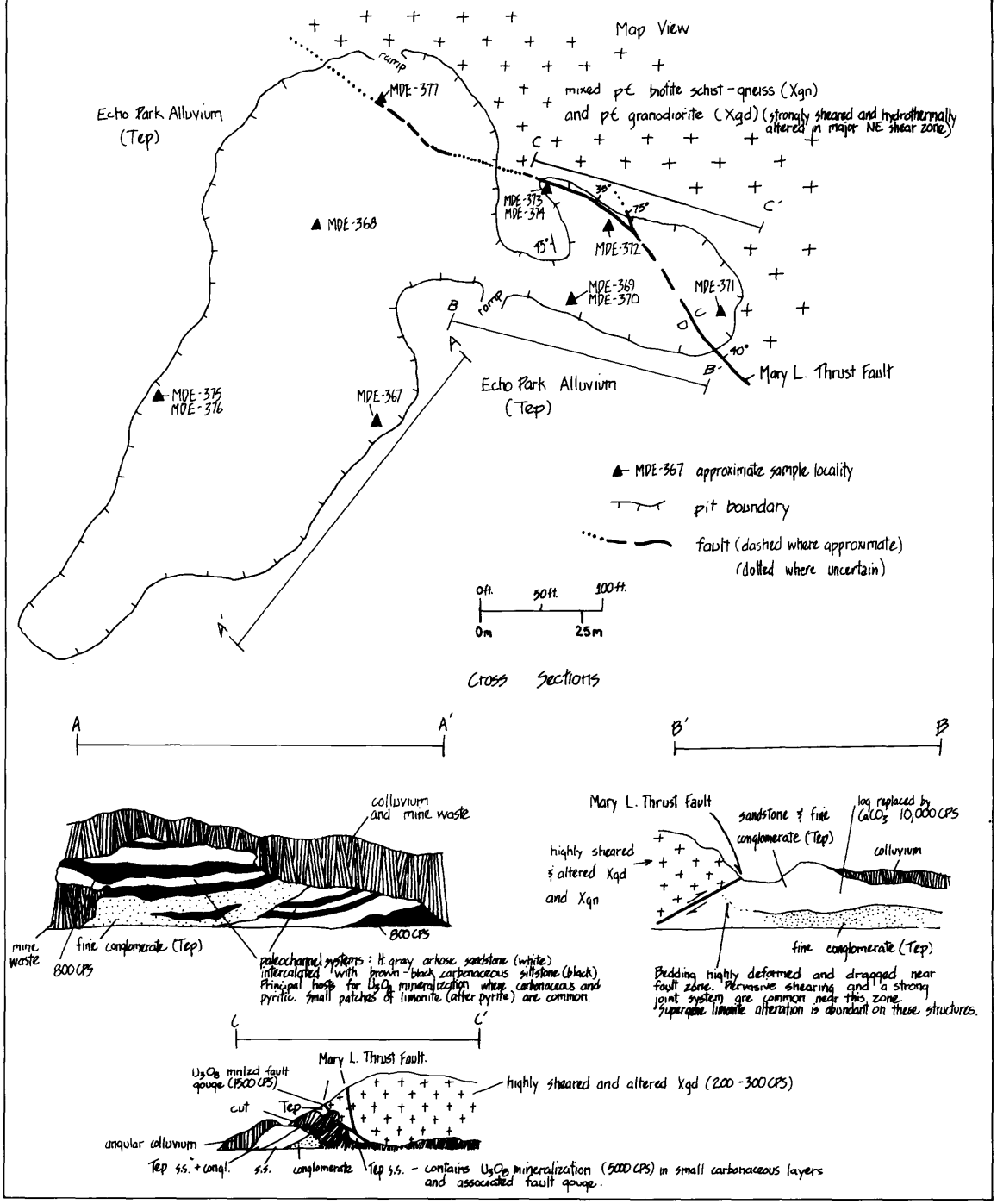


Figure D2 Geologic Sketch Map of the Knob Hill Mine, Fremont County, Colorado. (elevation 8200 ft)

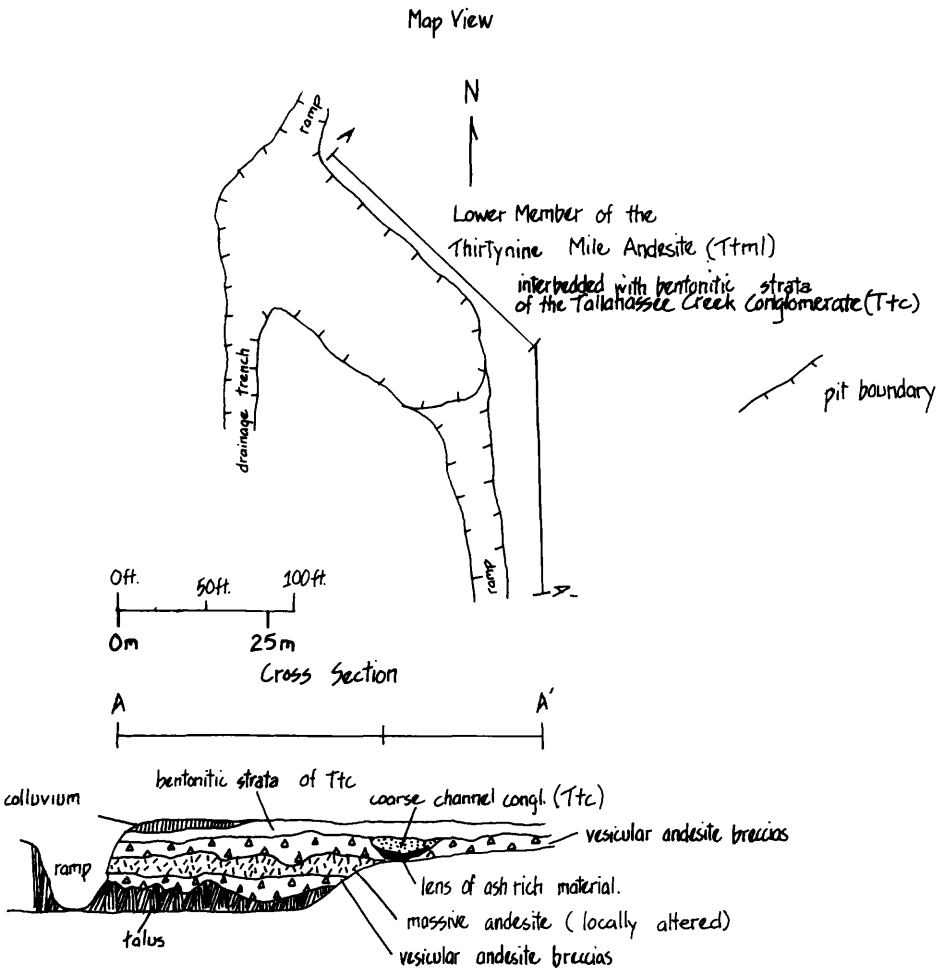


Figure D3 Geologic Sketch Map of the Rainbow Moose Open-Pit Mine, Fremont County, Colorado. (Surface elevation 8020 ft)

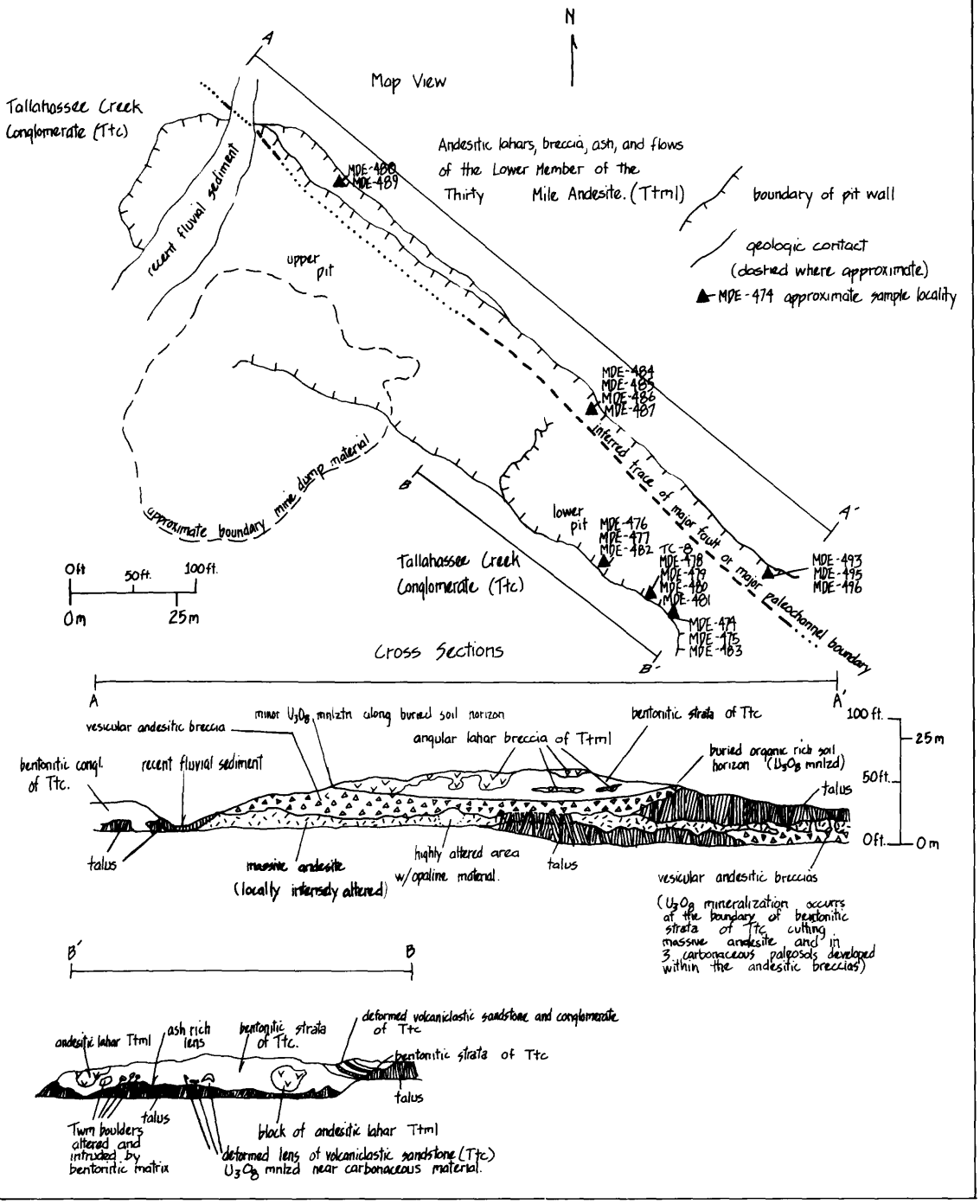


Figure D4 Geologic Sketch Map of the Picnic Tree Open-Pit Mines
Fremont County, Colorado
(elevation 8040 ft)

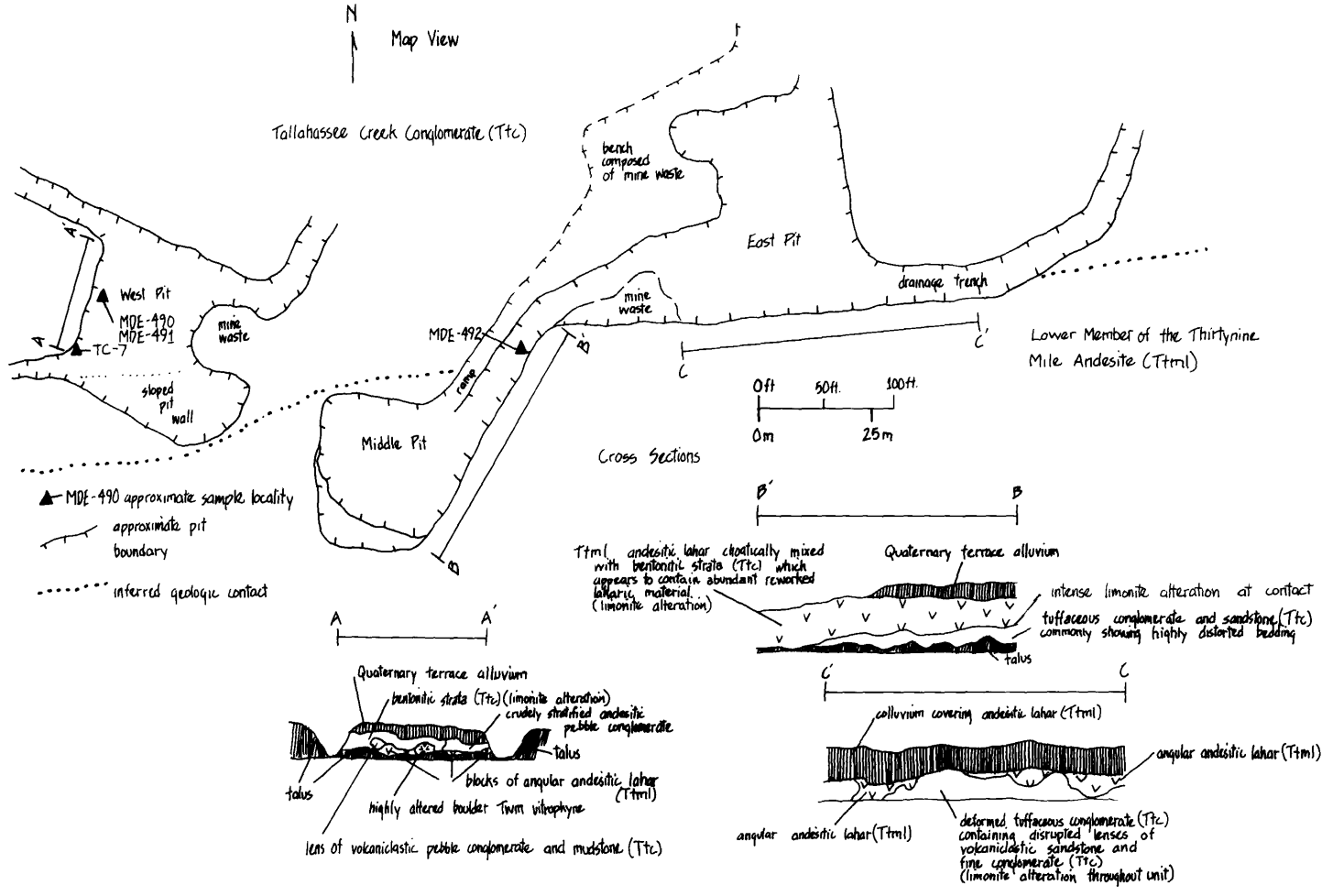


Figure D5 Geologic Sketch Map of the Thorne Ranch Mine
Fremont County, Colorado.
(elevation 7900 ft)

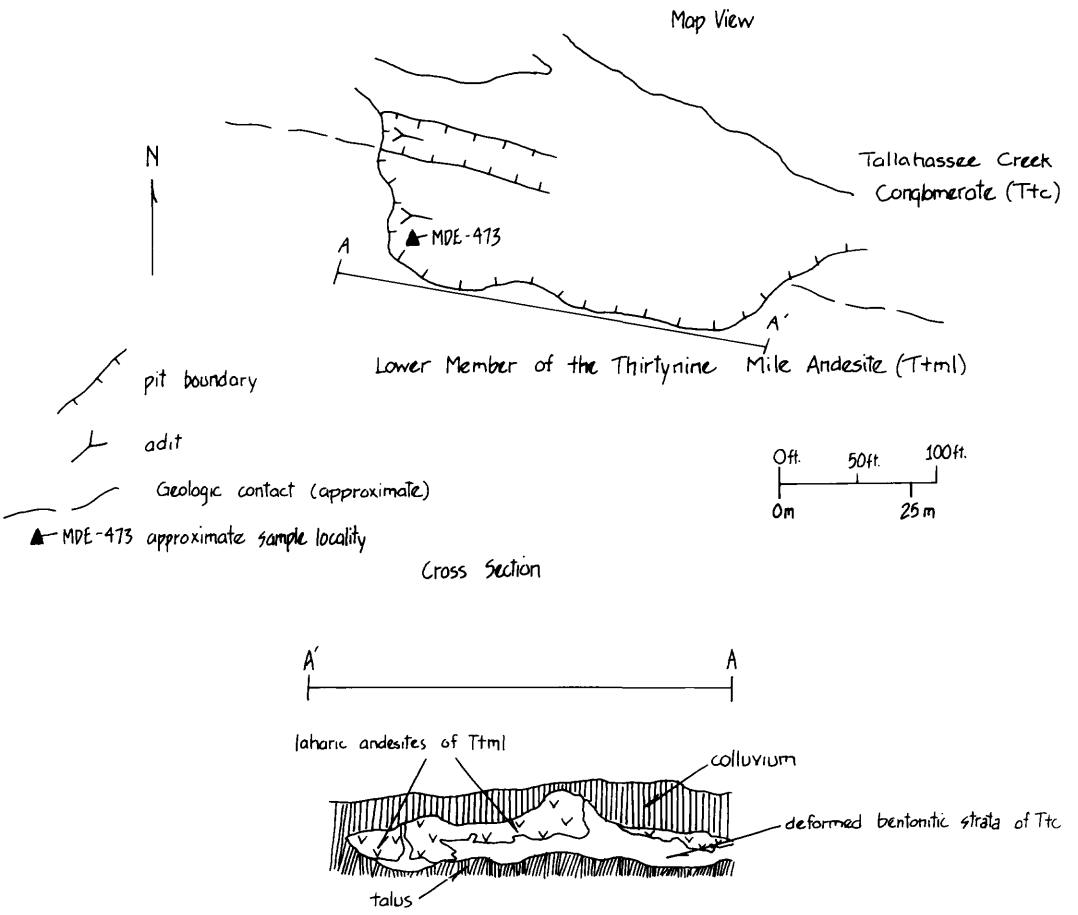
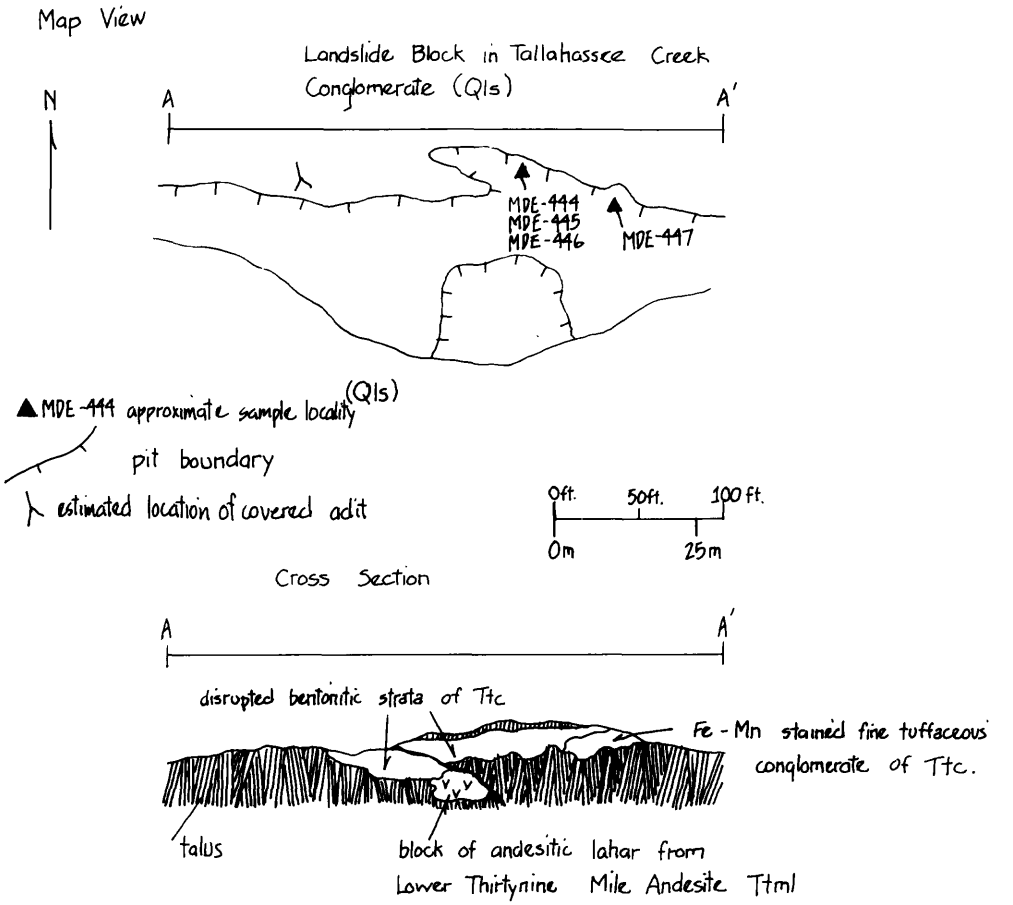


Figure D6 Geologic Sketch Map of the Sunshine Open-Pit Mine, Fremont County, Colorado. (elevation 7850 ft)



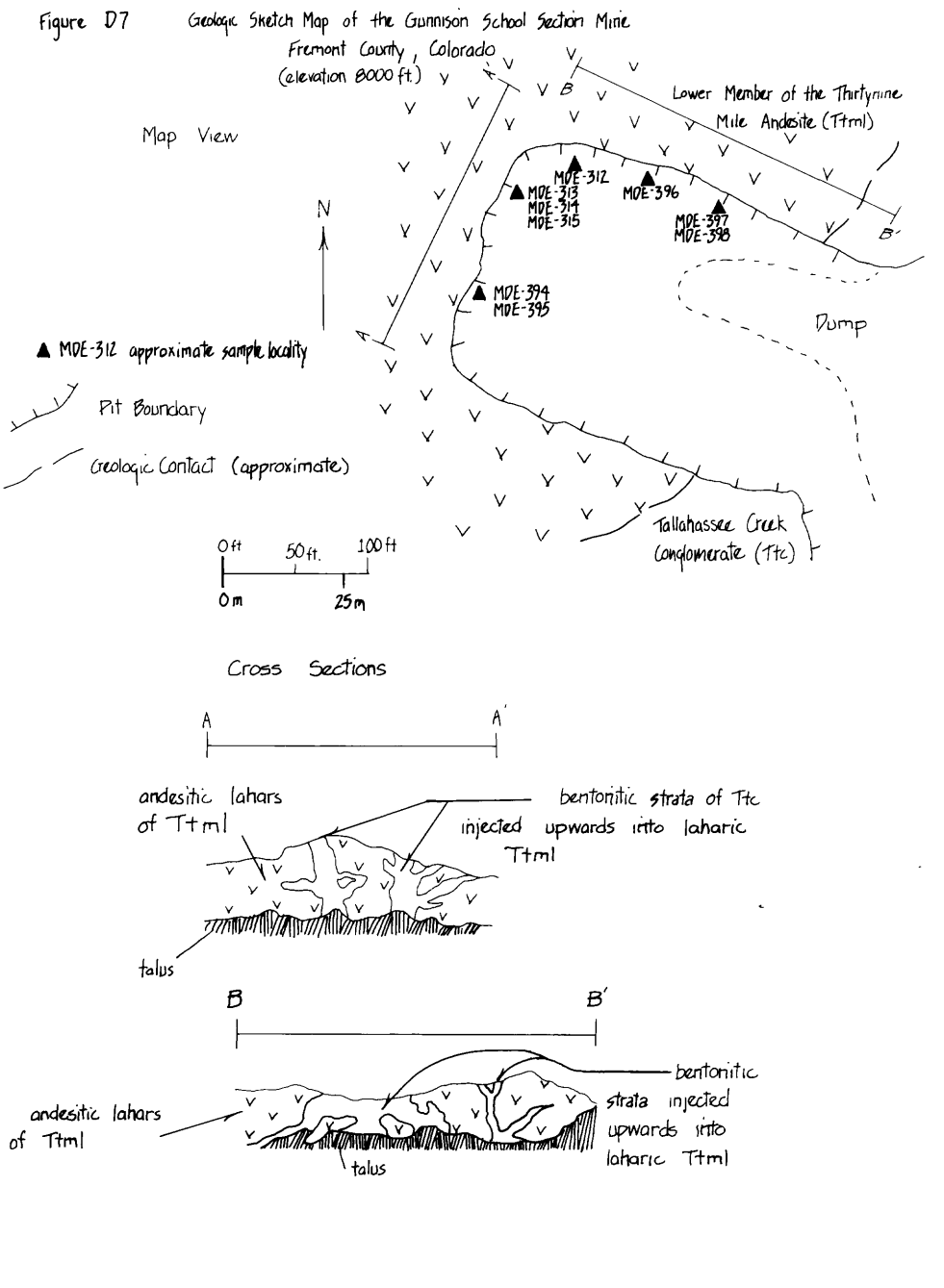


Figure D7 Geologic Sketch Map of the Gunnison School Section Mine
Fremont County, Colorado
(elevation 8000 ft.)
Map View
N
B
B'
Lower Member of the Thirtynine Mile Andesite (Ttml)
MDE-312
MDE-313
MDE-314
MDE-315
MDE-396
MDE-397
MDE-398
MDE-394
MDE-395
Dump
▲ MDE-312 approximate sample locality
Pit Boundary
Geologic Contact (approximate)
Tallahassee Creek Conglomerate (Ttc)
0 ft
50 ft.
100 ft
0 m
25 m
Cross Sections
A
A'
andesitic lahars of Ttml
bentonitic strata of Ttc injected upwards into laharic Ttml
talus
B
B'
andesitic lahars of Ttml
bentonitic strata injected upwards into laharic Ttml
talus

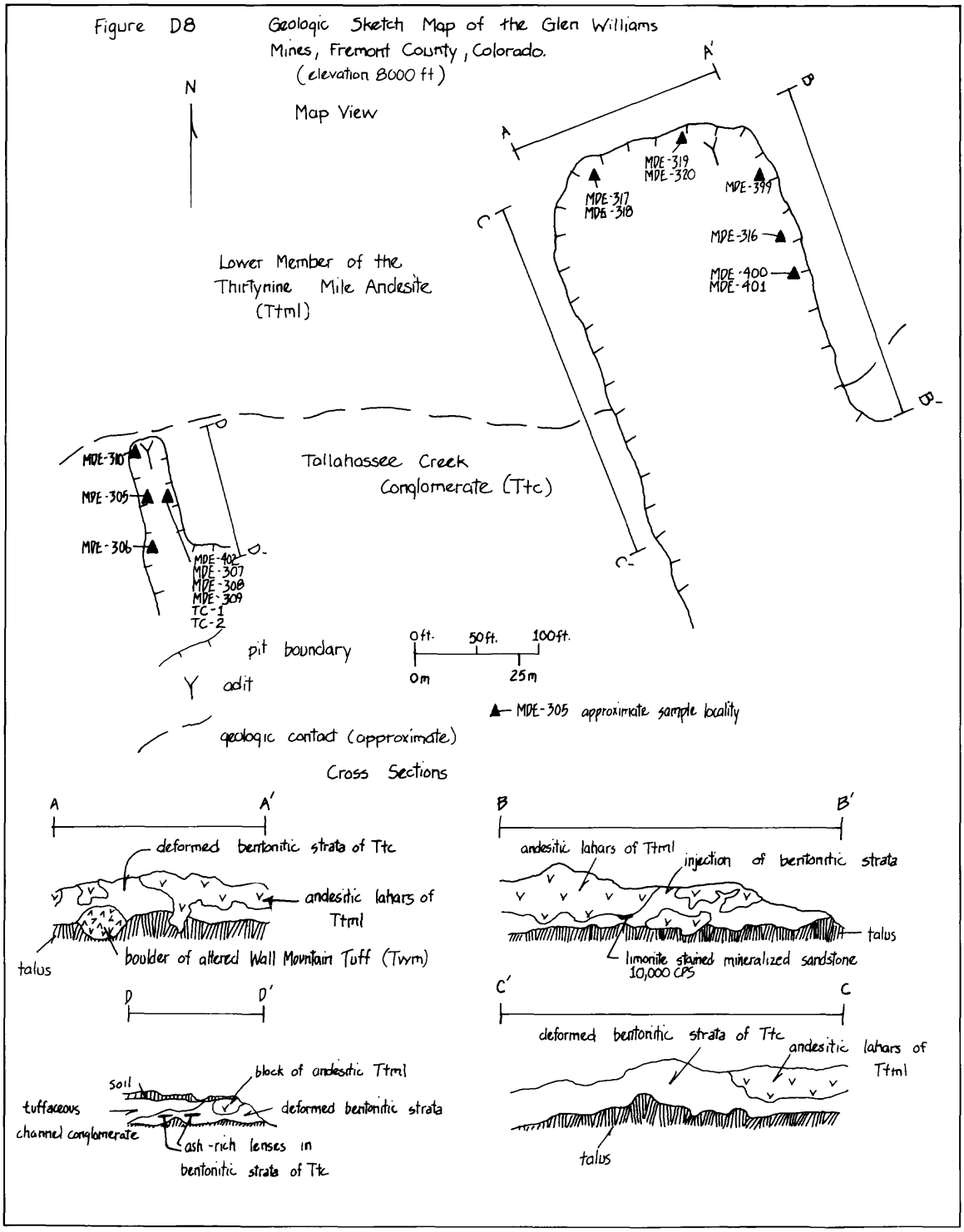


Figure D8 Geologic Sketch Map of the Glen Williams Mines, Fremont County, Colorado. (elevation 8000 ft)
Map View
N
A
A'
B
B'
C
C'
D
D'
MDE-319
MDE-320
MDE-317
MDE-318
MDE-399
MDE-316
MDE-400
MDE-401
Lower Member of the Thirtynine Mile Andesite (Ttml)
Tallahassee Creek Conglomerate (Ttc)
MDE-310
MDE-305
MDE-306
MDE-302
MDE-307
MDE-308
MDE-309
TC-1
TC-2
pit boundary
adit
geologic contact (approximate)
0ft. 50ft. 100ft.
0m 25m
MDE-305 approximate sample locality
Cross Sections
deformed bentonitic strata of Ttc
andesitic lahars of Ttml
talus
boulder of altered Wall Mountain Tuff (Twm)
andesitic lahars of Ttml
injection of bentonitic strata
talus
limonite stained mineralized sandstone 10,000 CPS
soil
block of andesitic Ttml
tuffaceous channel conglomerate
deformed bentonitic strata
ash-rich lenses in bentonitic strata of Ttc
deformed bentonitic strata of Ttc
andesitic lahars of Ttml
talus

Figure D9 Geologic Sketch Map of the Oliver Saddle Prospect
Fremont County, Colorado.
(elevation 7950 ft)

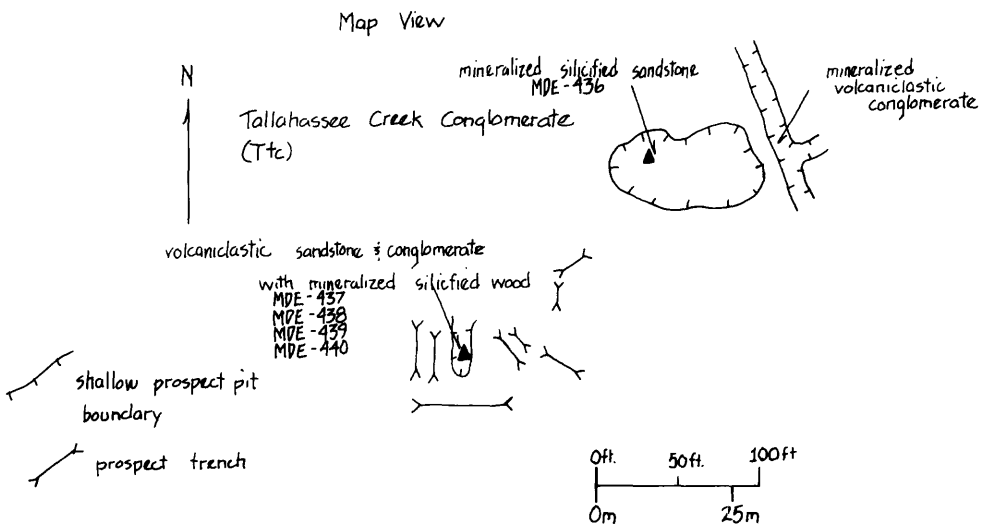


Figure D10 Geologic Sketch Map of the First and Last Chance Open-Pit – Underground Mines, Fremont County, Colorado. (elevation 7900 ft.)