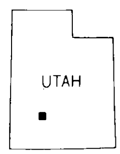
GEOLOGIC MAP OF THE FREMONT PASS QUADRANGLE, IRON AND GARFIELD COUNTIES, UTAH

By John J. Anderson

U.S. Geological Survey



UTAH GEOLOGICAL AND MINERAL SURVEY

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UTAH GEOLOGICAL AND MINERAL SURVEY

606 Black Hawk Way
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GEOLOGIC MAP OF THE FREMONT PASS QUADRANGLE, IRON AND GARFIELD COUNTIES, UTAH

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INTRODUCTION

The southern part of the Fremont Pass quadrangle is in the northeastern Markagunt Plateau, the northern part in the southeastern Tushar Mountains. These areas are in the High Plateaus subprovince which is structurally transitional between the block-faulted Basin and Range Province to the west and the more stable Colorado Plateaus of which it is a part.

The Marysvale volcanic field, one of the largest eruptive piles in the western United States, straddles the High Plateaus and extends into the Basin and Range. The Fremont Pass quadrangle in the southern part of this field contains extensive volcanic accumulations from it. These are underlain and overlain by regional and local sedimentary and volcanic units and include a large Tertiary pluton. All the rocks are cut by numerous high-angle, dip-slip faults. General discussions of the geology in and near the Fremont Pass quadrangle are given in Anderson (1965), Anderson and others (1975), Rowley and Anderson (1975), Rowley and others (1978, 1979), Shawe and Rowley (1978), and Steven and others (1978, 1979). Geologic mapping has been done of areas to the north of the mapped area by Anderson (1986), and Anderson and others (1986), to the west and south by Anderson (1965), and to the east by Anderson (1965) and Rowley (1968).

STRATIGRAPHY

Rocks exposed in the Fremont Pass quadrangle total about 5,000 feet (1525 m) in thickness and range in age from Eocene to Holocene. Most consist of volcanic mudflow breccia of the Mount Dutton Formation, representing the southern apron of a series of clustered stratovolcanos that occur northwest, north, and northeast of the mapped area (Anderson, 1986; Anderson and others, 1986). Locally included within the Mount Dutton Formation is an eolian sandstone blown into the area from the south and west during a temporary lull in the volcanism.

The Mount Dutton Formation is underlain by a series of mostly regional units and a batholith-size plutonic mass. The oldest of the rocks belong to the Claron Formation, the basal Tertiary unit over much of southwestern Utah. This fluvial and lacustrine sedimentary unit is the same as the pink beds that have weathered and eroded to form the spectacular badland topography so prominent at Bryce Canyon National Park, 25 miles (40 km) southeast of the mapped area, and at Cedar Breaks National Monument, 30 miles (48 km) to the southwest. Locally the Claron may be overlain by an ash-flow tuff of the Needles Range Formation, a regional unit erupted from a source in western Utah which is not, however, exposed in the quadrangle. An ash-flow tuff of the Isom Formation swept into the western portion of the quadrangle from a distant source in the eastern Basin and Range Province. It pinched out against local topographic highs created in part by a locally derived ash-flow tuff, the Buckskin Breccia. The Buckskin Breccia represents an early eruptive phase of the igneous activity that later emplaced the Spry intrusion. The Isom Formation tuff and Buckskin Breccia tuff interfinger just to the west of the quadrangle. Deposition of the Bear Valley Formation tuffaceous sandstones followed. The Kingston Canyon Tuff Member is found interbedded with the Bear Valley Formation and indicates the beginnings of Mt. Dutton volcanism. All of these units were then arched and intruded by the Spry intrusion. The thick volcanic mudflow breccias and other lithologies of the Mount Dutton Formation were then deposited.

During late Tertiary and Quaternary block faulting activity, downthrown blocks were locally filled with clastic sediments derived from the erosion of nearby upthrown blocks. Closed basins predominated; a prominent high-level pediment in the southeastern part of the quadrangle may relate to this period. Later development of through-

[1] Current address: Department of Geology, Kent State University, Kent, Ohio 44242

flowing drainage led to downcutting and erosion of the closed-basin sediments, now mapped as the Sevier River Formation. Quaternary sediments in many parts of the quadrangle mostly date to the period of integration of through-flowing drainage as basin-range faulting continued.

TERTIARY SYSTEM

Claron Formation

Throughout much of the southern High Plateaus, the Claron Formation can be subdivided into two informal members; the contact between the two is at the base of a conspicuous, massive, resistant limestone bed below which the rocks are mostly red and above which they are mostly white. No such stratigraphic marker is present within the area of this map. The absence of this, or any other, established means of defining the two members has precluded mapping them here, but the exposed strata appear to belong to the lower member. Thus they are mostly some shade of red, although in some places this coloration is a wash derived from fine-grained, hematite-impregnated sediments staining the exposed surfaces of more drab-colored rocks. The rocks themselves are largely argillaceous freshwater limestone, calcareous siltstone, sandstone, and subordinate conglomerate. The irregularly but well-bedded strata range from 6 inches (0.2 m) to 3 feet (0.9 m) thick. Intertonguing and lateral gradation of rock types along the same stratigraphic interval is the rule rather than the exception.

The strata here mapped as Claron Formation are considered correlative with those in the southern Markagunt Plateau that Gregory (1949, 1950, 1951) assigned to the Wasatch Formation. Spieker (1946), however, demonstrated that the type Wasatch of northern Utah and adjacent parts of Wyoming does not extend even as far south as central Utah, let alone to the southern part of the state. Thus Anderson and Rowley (1975), following the suggestion of Mackin (1960), abandoned the term "Wasatch" in the southern High Plateaus and resurrected the name "Claron" that first was applied by Leith and Harder (1908) to strata equivalent to the Wasatch in the Iron Springs district of southwestern Utah.

The age of the Claron Formation has not been established with certainty. Gregory (1950) reported "late Eocene" freshwater fossils from the uppermost "Wasatch" strata at Cedar Breaks National Monument, but the possibility exists that lowermost Claron strata may be as old as Paleocene(?) or even Late Cretaceous(?). The thickness of the Claron strata exposed in this quadrangle is perhaps as much as 1,000 feet (305 m), but poorly exposed outcrops make this figure an estimate. Included with the Claron as mapped northwest of Granite Knolls are a few tens of feet of clean, white quartzite considered by Doelling (1975) perhaps to be pre-Claron in age.

Buckskin Breccia

Overlying the Claron Formation in the Fremont Pass quadrangle is the Buckskin Breccia. Locally the Needles Range Formation (dated at about 29.5 m.y.) may underlie the Buckskin Breccia, but there are no surface exposures. The Buckskin Breccia consists of moderately resistant, light- to medium-gray and grayish-pink, lithic-crystal ash-flow tuff, and possibly autoclastic flow-breccia and(or) mudflow breccia. This unit contains abundant lithic clasts that make up as much as 50 percent of the rock. Most of the clasts are identical with rock of the Spry intrusion and are set in a dusty, devitrified glass matrix commonly, but not always, including vaguely defined glass shards as well as fragmented grains of plagioclase, amphibole, biotite, pyroxene, and Fe-Ti oxides. In places, the Buckskin Breccia consists of at least four separate well-bedded cooling units lying one atop the other or else separated by several feet of tuffaceous sandstone. The unit was defined by Anderson and Rowley (1975) who considered it to be Miocene based on the local interfingering relationship with the Isom Formation. The 26 m.y. K-Ar age of the Isom now is considered Oligocene, so the Buckskin Breccia is also Oligocene. Its thickness within this quadrangle reaches a maximum of nearly 300 feet (91 m), but elsewhere it is as much as 725 feet (220 m).

Isom Formation

A key stratigraphic and structural reference plane over much of southwestern Utah, the Isom Formation typically is made up of ledge-forming, pale-red, pale-reddish-purple, and grayish-reddish-purple, densely welded vitric-crystal ash-flow tuff and(or) tuff lava. Usually the rock contains 10 to 20 percent phenocrysts, 1 to 3 mm in size, of plagioclase and subordinate augite set in a groundmass with the texture and appearance of unglazed porcelain. The basal portion of the tuff, however, generally is a dark-gray to brownish-black, obsidian-like vitrophyre. Locally it exhibits secondary flowage structures, including autobrecciation and flow foliation; it also commonly contains numerous horizontal, pancake-shaped, light- to medium-gray ash-flow tuff lenticules that either are collapsed pumice or else are the products of devitrification by trapped gas pockets that formed during the vapor phase of cooling. The Isom Formation was defined by Mackin (1960) and has a source area believed to be in the Great Basin west of the Iron Springs district of southwestern Utah. A K-Ar age of 26 m.y. was determined on a sample of the unit (Fleck and others, 1975). Widespread in the quadrangles immediately to the south and southeast, it crops out in only one place at the west-central edge of this quadrangle; there it is about 30 feet (9 m) thick.

Bear Valley Formation

The Bear Valley Formation, defined by Anderson (1971), is largely a wind-blown sand deposit that blanketed an area of some 1,000 square miles (2,500 sq km) in the northern Markagunt Plateau, Red Hills, and Black Mountains immediately prior to this same area being inundated by volcanics of the Marysvale pile. Its type section is just to the south of this quadrangle, north of Utah Highway 20 about 1.5 miles (2.4 km) west of its junction with U.S.

Highway 89, from SE¼ NW¼ section 5, T. 33 S., R. 5 W., to NE¼ SE¼ section 32, T. 32 S., R. 5 W.

The rock that comprises the bulk of the Bear Valley formation is a generally weak, pale gray, yellow or green (in places quite vivid) tuffaceous sandstone that is strongly cross-bedded throughout much of its section. Two members can be distinguished on the basis of composition. The lower is made up largely of sub-angular to well-rounded volcanic rock fragments and pyrogenic mineral grains (plagioclase, sanidine, pyroxene, amphibole, and biotite with very minor quartz). The upper contains, in addition, a considerable admixture of sub-angular to angular glass shards, apparently contributed to the sediment by active volcanism and scarcely reworked; it also contains interbeds and lenses of welded and unwelded ash-flow tuff and rare ash beds, all probably erupted from local or nearby vents. Both members are cemented, generally poorly to moderately well, by zeolite (clinoptilolite) that locally has altered to chlorite; it is the latter that in places imparts a striking green color to the rock.

Cross-bed attitudes indicate that the sand of the Bear Valley Formation was mostly deposited by winds that blew from the south and west. Potassium-argon ages of about 25 m.y. have been determined from samples of welded and unwelded tuffs found within the Bear Valley Formation (Fleck and others, 1975), indicating a late Oligocene age. The deposition of sandstone may have continued into the Miocene.

Poorly exposed contacts and the local erosion of its top prevent the obtaining of an exact thickness of the Bear Valley Formation in this quadrangle. The incomplete section is about 500 feet (150 m) thick.

Mount Dutton Formation

Volcanic rock of intermediate (dacite to andesite) composition assigned to the Mount Dutton Formation, defined by Anderson and Rowley (1975), dominates the stratigraphic column of this quadrangle and, indeed, that of much of the southern High Plateaus. In accordance with the concepts of Parsons (1965, 1969) and Smedes and Prostka (1973), the Mount Dutton Formation is subdivided into a vent facies and an alluvial facies, both the products of a series of stratovolcanoes trending more-or-less eastward across what today comprises the southernmost Tushar Mountains. Only the alluvial facies can be mapped with certainty within the quadrangle, although vent facies rock may be present in the northeastern corner. The map units assigned to the Mount Dutton Formation in the quadrangle are described separately below.

Alluvial facies: In the quadrangle, as elsewhere in the southern High Plateaus, rocks assigned to the alluvial facies of the Mount Dutton Formation consist of soft to moderately resistant, mostly light- to dark-gray and brown volcanic mudflow breccia and subordinate fluvial conglomerate and tuffaceous sandstone making up more than one-half of the exposed section. The remainder is made up of lava flows and autoclastic flow breccia identical to their counterparts in the vent facies, together with very minor ash-flow, airfall, and water-laid felsic tuff. The predominant mudflow breccia is characterized by sub-rounded to angular clasts of intermediate volcanic rock, most commonly suspended in a muddy to sandy matrix. The volcanic rock of the clasts is identical to that of the vent facies, that is, it consists largely of amphibole and(or) pyroxene andesite and dacite. Textures range from aphanitic to conspicuously porphyritic with phenocrysts of plagioclase, hornblende, and(or) augite set in a microcrystalline and largely devitrified glass groundmass. The size of the clasts, the ratio of clasts to matrix, and the thickness of individual mudflows all are widely variable. Typically the clasts are of cobble size and make up about one-third of the rock, with individual flows of 5 to 20 feet (1.5 - 6 m) thick. The conglomerate interbedded with the mudflows is largely fluvial, and the interbedded tuffaceous sandstone is partly fluvial and partly eolian; the conglomerate and sandstone consist almost exclusively of reworked volcanic detritus doubtlessly derived in large part from the Mount Dutton volcanic units. The conglomerate and sandstone occur as local channel fillings and as lenses ranging from about 1 to 10 feet (0.3 - 3 m) thick. The age of the unit is late Oligocene and Miocene based on its interfingering with dated vent facies strata. A partial section of the unit at least 1,500 feet (457 m) thick is exposed in the northern part of the quadrangle.

Kingston Canyon Tuff Member: A small outcrop of the Kingston Canyon Tuff Member of the Mount Dutton Formation is found interbedded high in the section of the Bear Valley Formation in the low hills west of the Spry intrusion. At its type locality in Kingston Canyon, about 15 miles (24 km) northeast of this locality, it is underlain by about 230 feet (70 m) of volcanic mudflow breccia characteristic of the alluvial facies of the Mount Dutton Formation. This indicates that the volcanism that produced the Mount Dutton Formation, which eventually was to inundate this quadrangle, had begun in the north while the sand of the Bear Valley Formation continued to be deposited here.

The Kingston Canyon Tuff Member is a resistant, pale-purple, plagioclase-biotite vitric welded tuff. Typically about 40 feet (12 m) thick, it can be traced over nearly 500 square miles (1300 sq km) in the southern Sevier Plateau. In this quadrangle its outcrop, one of only a very few west of the Sevier River Valley, is only about 15 feet (5 m) thick, but in all other respects it is typical of the unit.

The age of the Kingston Canyon Tuff Member is about 26 m.y. This is based on its stratigraphic position and the fact that is has been arched by the Spry intrusion.

Sandstone Member: A sizeable body of tuffaceous sandstone is mapped as a separate informal unit in the lower part of the Mount Dutton Formation in the southwestern part of the quadrangle. This sandstone, together with strata of volcanic mudflow breccia that separates it from the Buckskin Breccia, originally was considered by Anderson (1965, 1971) to belong to the Bear Valley Formation. More recent work, however, has shown that both the breccia and the sandstone occur higher in the section than does the Bear Valley Formation and that therefore they both should be included within the Mount Dutton Formation. The sandstone now is designated as an informal lower local sandstone unit within the Mount Dutton Formation; this prevents its correlation with the Mount Dutton Formation sandstone member occurring at or near the top of the formation in quadrangles to the north and northeast (Anderson and Rowley, 1975; Anderson, 1985; Anderson and others, 1985).

The local sandstone unit is a soft, light-gray, yellow or tan rock made up largely of sub-angular to well-rounded volcanic rock fragments and pyrogenic mineral grains (plagioclase, sanidine, pyroxene, amphibole, and Fe-Ti oxides, with traces of quartz) that generally are poorly to moderately cemented by zeolite (clinoptilolite). Most of the unit is cross bedded, and an analysis of the cross-bed attitudes indicates that the sediment was deposited by winds blowing from the south and west. Its age is late Oligocene or early Miocene, based on its position within the lower Mount Dutton Formation, with a maximum thickness of about 300 feet (91 m).

Undivided: In some areas of this quadrangle that are underlain by the Mount Dutton Formation, outcrops are not good enough to determine if the rock consists for the most part of the formation's alluvial facies or of the lava flows and autoclastic flow breccia that make up the bulk of its vent facies. In such areas the Mount Dutton Formation is mapped as undivided.

Spry Intrusion

The Spry intrusion was first noted by Callaghan and Parker (1962) and named by Anderson (1971). Detailed descriptions have been published by Grant (1979) and Grant and Anderson (1979). An apparent laccolith of batholithic dimensions, it heretofore has been considered to be the oldest pluton in the southern High Plateaus on the basis of a K-Ar age of 31 m.y. determined by Damon (1968). This age was problematic, leaving unanswered the relationship between the intrusion and the obviously related but seemingly much younger Buckskin Breccia (Anderson and Rowley, 1975). More recently, however, K-Ar ages of 26.1 ± 1.7 and 26.4 ± 3.2 m.y. have been determined on two samples of the Spry intrusion (H. H. Mehnert, personal communication, 1985). These ages are more consistent with field evidence than the earlier and make it clear that the Buckskin Breccia and the Spry intrusion are related to the same episode of igneous activity, the Buckskin Breccia as an early eruptive phase and the Spry intrusion as a later plutonic one.

Typically the Spry intrusion is a light-gray to moderate-reddish-orange quartz latite porphyry that consists of phenocrysts of plagioclase, amphibole, and minor quartz and biotite set in a microcrystalline groundmass of quartz and feldspar. As noted above, this is the dominant lithology of the clasts that characterize the Buckskin Breccia.

Sevier River Formation

Erosion of the upfaulted High Plateaus led to the deposition of clastic sediments in nearby downfaulted topographic lows. These deposits, largely fluvial, were defined as the Sevier River Formation by Callaghan (1939). In the quadrangle they consist of poorly to moderately consolidated, light-gray, tan, pinkish-gray, and white silty-pebbly sandstone and conglomerate that have a maximum thickness of about 250 feet (76 m). Air-fall tuff beds interbedded with the formation in the Clear Creek area about 30 miles (55 km) to the north have yielded fission-track ages of 14 and 7 m.y. (Steven and others, 1979), indicating a Miocene age. The upper part of the unit, however, locally may be Pliocene or even as young as Pleistocene. The contacts of the formation are poorly exposed and therefore only approximately located in the quadrangle.

QUATERNARY SYSTEM

Older piedmont slope deposits

This unit consists of poorly to moderately indurated, poorly sorted silt, sand, and gravel mantling erosional remnants of widespread pediments. These pediments formerly were graded to the ancestral Sevier River, which was just east and southeast of the area of the present quadrangle, or they were graded to a closed basin, the axis of which was about in the same location. The present Sevier River, to the east and southeast, is from 600 to 1,200 feet (183 - 366 m) below the level of these pediment deposits. Locally the unit includes alluvium of small, ephemeral drainages that today are dissecting the pediment remnants. Considered to be of Pleistocene age, the unit ranges in thickness between 5 and 30 feet (2 - 9 m).

Piedmont slope deposits

This Holocene and Pleistocene age unit is made up of unconsolidated, poorly sorted silt, sand, and gravel occurring as thin mantles on pediments and as thicker accumulations in alluvial fans. Locally occurring within local downfaulted depressions, most of these deposits are dissected by present streams. The unit includes alluvium of small drainages as well as, in places, colluvium, alluvial slope wash, and talus. Its maximum exposed thickness is several tens of feet but may be considerably thicker in large downfaulted depressions such as Dog Valley.

Landslide debris

Landslide debris consists mostly of angular and very poorly sorted material that moved downslope from nearby bedrock to form deposits of lobate form as well as broad aprons mantling steep valley walls and fault scarps. The unit also includes talus and colluvium. It is of Holocene age with a thickness of a few tens of feet.

Playa lake deposits

Playa lake deposits consist of lacustrine clay, silt, and sand deposited in small, undrained depressions in the quadrangle. The age of this unit is Holocene; its thickness is as much as several tens of feet.

Floodplain and channel deposits

This unit consists of channel deposits of silt, sand, and gravel, locally cobbly and bouldery, along the Sevier River; clay and silt overbank deposits on the floodplain also are included. The age of these sediments is Holocene; the maximum thickness is about 25 feet (8 m).

Alluvium

Alluvium consists of silt, sand, and gravel deposited by intermittent and perennial streams in their channels, on bordering floodplains, and as terminal alluvial fans. Locally the unit also includes colluvium, alluvial slope wash, and talus. It is of Holocene age and its maximum thickness is about 15 feet (5 m).

STRUCTURAL GEOLOGY

The structural pattern of the Fremont Pass quadrangle is dominated by normal faults; local arching of strata by the Spry intrusion also has left a significant structural imprint. Several facts are worth noting about the faults because in many ways they are typical of those found throughout the southern High Plateaus. First, no individual fault has a very long trace; the longest is a little more than three miles (4.8 km), and most are half this length or less. Second, almost all fault traces are arcuate or sinuous. Third, many of the faults do not die out along strike to form hinges, but instead their throw remains undiminished until they join another fault. Fourth, all the faults are vertical or subvertical and the sense of movement on them is dip-slip. And fifth, virtually every fault belongs to one of two sets, one striking north-northeastward and the other north-northwest. This results in a very pronounced rhombic fault pattern within the quadrangle. Furthermore, north-northwest-striking faults in the eastern part of the quadrangle pass northward (Anderson, 1986; Anderson and others, 1986) and westward into north-northeast-striking faults to form a zig-zag range front of the Tushar Mountains, a pattern also exhibited throughout the High Plateaus.

Numerous lineaments have been mapped throughout the quadrangle which are not readily seen in the field but are clearly visible on aerial photographs. The parallelism of these lineaments with mapped faults suggests that the lineaments either are faults themselves or are joints formed in response to the same stresses that produced the faults. The great number of the lineaments and the striking rhombic pattern that they form also suggest the possibility that they may be the result of local torsion within an east-trending zone transitional between the eastward-dipping Markagunt Plateau to the south and the westward-dipping Tushar Mountains to the north.

The major displacements along the faults of the southern High Plateaus appear to date to Pliocene and Pleistocene time (Rowley and others, 1981). Faulting may have begun much earlier, however, inasmuch as extensional tectonics generally are associated in Utah with compositionally bimodal (alkali basalt and alkali rhyolite) volcanism which began in neighboring quadrangles about 23 m.y. ago (Anderson and Rowley, 1975; Rowley and others, 1979). Faulting continued into Quaternary time, as evidenced by small fault scarps cutting Quaternary sediments in several places in the quadrangle.

ECONOMIC GEOLOGY

Small amounts of mercury, as cinnabar, occur in hydrothermally altered and opalized rocks of the Claron Formation at various places along the contact with the Spry intrusion in the Granite Knolls area (Doelling, 1975). Bulldozer cuts were made and a small shaft sunk along the contact, but no ore is known to have been shipped. Hematite, limonite, fluorite, and gypsum were reported here, and chemical analyses disclosed anomalous amounts of gold, silver, chromium, strontium, vanadium, and gallium (Doelling, 1975).

GEOLOGIC HAZARDS

Earthquakes have been felt in the Fremont Pass area in the historic past, but there has been no recorded breakage of the surface or any other evidence to indicate that any of these earthquakes resulted from local faulting. Some faults on the map have displaced Quaternary sediments, but none have been proved to be as young as Holocene. Thus, despite the abundant faults in the Fremont Pass quadrangle, any potential hazards posed by earthquakes are difficult to assess. Construction of buildings on any mapped fault, especially those that show evidence of Quaternary movement, should be avoided.

WATER RESOURCES

No perennial streams flow through the Fremont Pass quadrangle; every ephemeral stream, however, can temporarily be a raging torrent during locally heavy summer thunderstorms. Locally ranchers have built small dams to trap such run-off for their cattle. Elsewhere the only available surface water comes from several small springs that probably are controlled by faults. This water is utilized by cattlemen, who pipe it into troughs.

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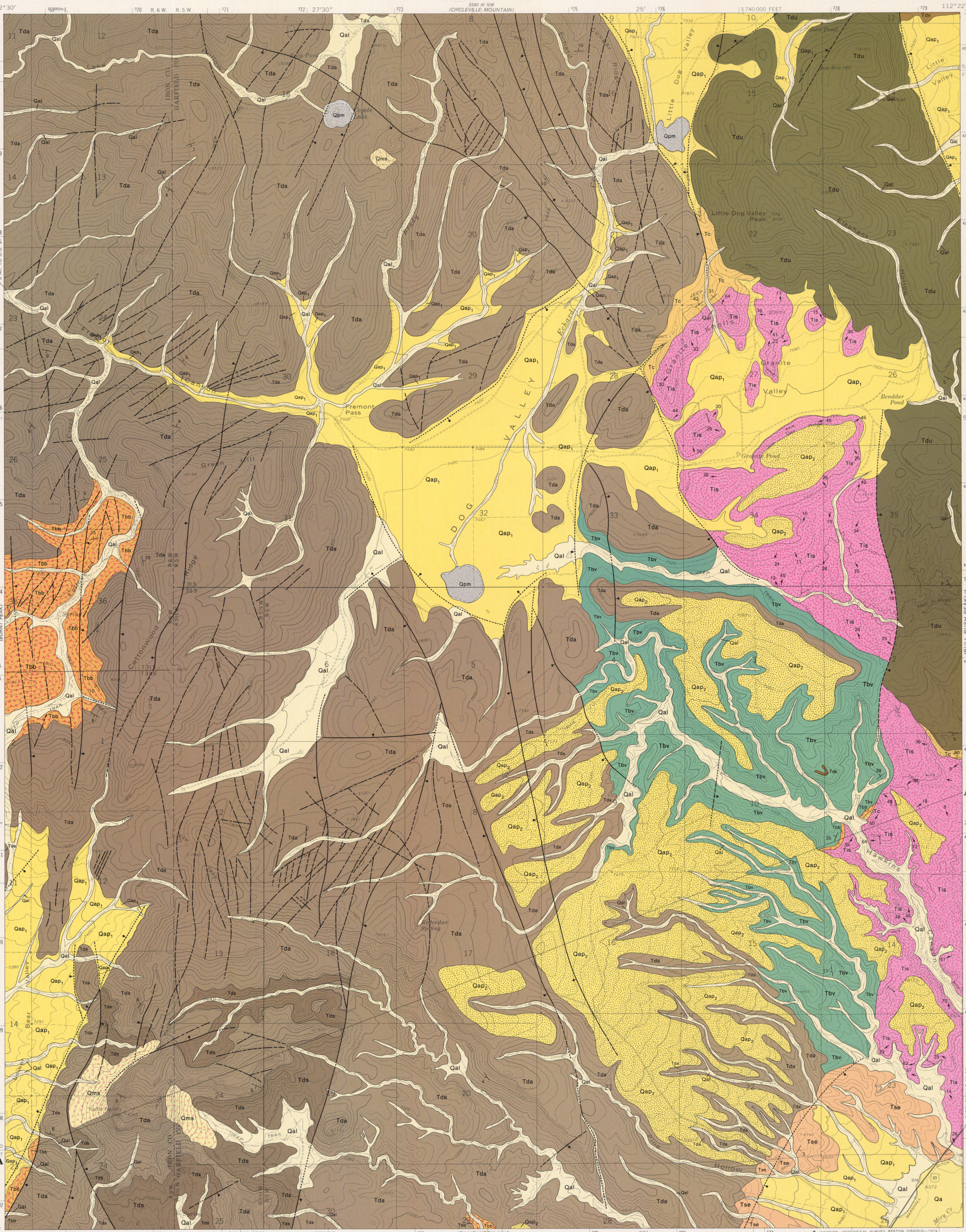

Base from U.S. Geological Survey: Fremont Pass Quadrangle, 1966

Field mapping by authors in 1964, 1968-69
Field checked 1983-84

K.D. Brown and D.A. Jenkins, Cartographers

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

UTM GRID AND 1966 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION

GEOLOGIC MAP OF THE FREMONT PASS QUADRANGLE, IRON AND GARFIELD COUNTIES, UTAH

by
John J. Anderson and Timothy C. Grant
U.S. Geological Survey

1986

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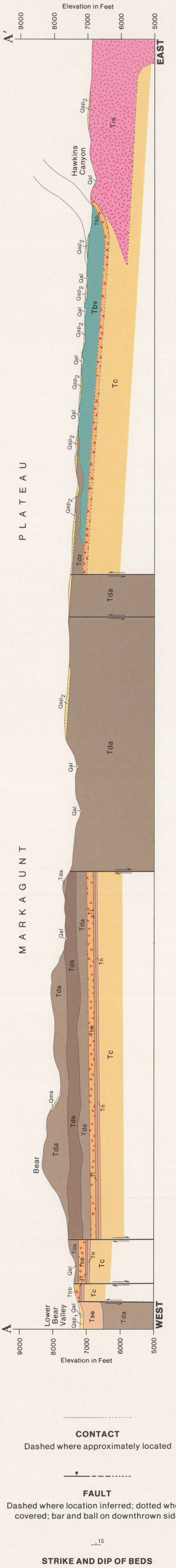
Plate 2
Utah Geological and Mineral Survey Map 81
Geologic Map of the Fremont Pass Quadrangle

FORMATION		SYMBOL	LITHOLOGY	THICKNESS feet (meters)
Surficial deposits		Qal Qan Qpm Qms Qap_1 Qap_2		0-100 (0-31)
Sevier River Formation		Tse		0-250 (0-76)
MOUNT DUTTON FORMATION	Alluvial facies	Tda		
	Undivided	Tdu		
	Vent facies	Tdv		1500+ (458+)
	Local Sandstone unit	Tds		
Bear Valley		Tbv		Tbv 0-500 (0-153)
Kingston Can. Tuff Mbr. of Mt. Dutton Fm.		Tdk		Tdk 0-15 (0-5)
Formation		Tbv		
Buckskin Breccia		Tbb		Tbb 0-300 (0-92)
Isom Formation		Ti		Ti 0-30 (0-9)
Needles Range Fm.		Tn		–
Claron		Tc		
Spry intrusion		Tis		0-650
Formation		Tc		(0-198)



DESCRIPTION OF MAP UNITS

QUATERNARY

Qal	Alluvium—*Unconsolidated silt, sand, and gravel along active streams and washes.*
Qan	Floodplain and channel deposits—*silt, sand, and gravel, locally cobbly and bouldery.*
Qpm	Playa lake deposits—*lacustrine clay, silt, and sand.*
Qms	Landslide debris—*disaggregated rock and surficial deposits.*
Qap_1	Piedmont slope deposits—*poorly sorted, unconsolidated silt, sand, and gravel on sloping surfaces from deposition (alluvial fans) and erosion (pediments).*
Qap_2	Older piedmont slope deposits—*poorly to moderately indurated, poorly sorted silt, sand, and gravel mantling pediment remnants.*

UNCONFORMITY

TERTIARY

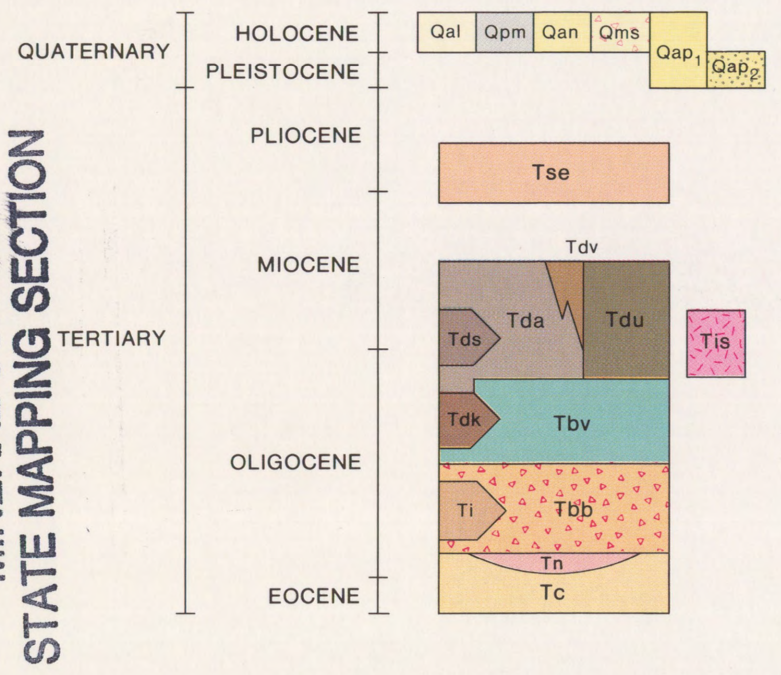
Tse	Sevier River Formation—*poorly to moderately consolidated, light-gray, tan, pinkish-gray, and white silty-pebbly sandstone and conglomerate with local air-fall tuffs.*

UNCONFORMITY

Mount Dutton Formation

Tda	Alluvial facies—*gray and brown, dacitic to andesitic volcanic mudflow-breccia, conglomerate, and tuffaceous sandstone, with subordinate lava flows and autoclastic flow-breccia.*
Tdu	Undivided, mixed vent and alluvial facies.
Tdv	Vent facies, flow breccia.
Tds	Sandstone member—*soft, light-gray, yellow or tan, cross-bedded, zeolite-cemented tuffaceous sandstone.*
Tis	Spry intrusion—*light-gray to reddish-orange quartz latite porphyry, with phenocrysts of plagioclase, amphibole, minor quartz and biotite in a groundmass of microcrystalline feldspar and quartz.*
Tdk	Kingston Canyon Tuff member—*resistant, pale purple, plagioclase-biotite vitric welded tuff.*

Tbv	Bear Valley Formation—*weak, cross-bedded, pale- to dark-gray and greenish-gray, zeolite-cemented, tuffaceous sandstone.*
Tbb	Buckskin Breccia—*moderately resistant, gray to grayish-pink, lithic-crystal ash-flow tuff.*
Ti	Isom Formation—*ledge-forming, pale red, reddish-purple, and reddish-purplish-gray, densely welded vitric-crystal ash-flow tuff.*
Tn	Needles Range Formation—*crystal-rich ash-flow tuff; appears only on cross section.*
Tc	Claron Formation—*well-bedded, argillaceous, freshwater limestone, calcareous siltstone and shale, sandstone, and subordinate conglomerate.*



CONTACT
Dashed where approximately located

FAULT
Dashed where location inferred; dotted where covered; bar and ball on downthrown side

15
STRIKE AND DIP OF BEDS

IDENTIFIABLE STRUCTURAL LINEAMENT

JOINT SET
Orientation of prominent sub-vertical joint set in the Spry intrusion

25
LINEATIONS AND SLICKENSIDES
Bearing and plunge of lineations and slickensides in the Spry intrusion