Ritzma – Igneous Dikes of the Eastern Uinta Mountains, Utah and Colorado

Special Studies 56

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By Howard R. Ritzma

UTAH GEOLOGICAL AND MINERAL SURVEY
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Sentinel Rock, large dike outcrop, seen from above with view to east into Gilbert Creek Basin. Fault zone into which dike is intruded is marked by line of vegetation to left (north) of lake (proposed name, Steppingstone Lake).

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By HOWARD R. RITZMA[1]

ABSTRACT

Gabbro and diorite dikes of early Paleozoic age intrude the Precambrian sediments of the eastern Uinta Mountains from Kings and Gilbert Peaks, Utah, eastward for 76 miles to Lodore Canyon, Colorado. Five outcrop areas are in Utah and one in Colorado. All are small in areal and linear extent and generally inconspicuous.

The dikes are intruded into a WNW to ESE-trending fault and fracture zone which appears to have been broken into segments by post-intrusion strike-slip faulting with left-lateral displacement.

Field examination and assays of samples show scant mineralization associated with the intrusive episode. Assays of dike rock show anomalous amounts of TiO_2, an average of 3.7 percent for 26 samples. Quartzite and shales in contact with the dikes and associated fault gouge are only slightly mineralized but do show some consistent titanium enrichment.

Known outcrops of the dikes in Utah occur within the easternmost part of the High Uintas Primitive Area and extend for 25 miles across an area proposed for classification as wilderness. The dikes do not appear to have potential economic value that would affect classification of the lands in question as primitive or wilderness in character.

INTRODUCTION

In the early 1950s the writer found a small water-rounded cobble of fine-crystalline, dark, igneous rock in the bed of the Whiterocks River on the south flank of the Uinta Mountains. Since it was then thought that there were no igneous rocks in the Uintas, it was assumed that the rock had been artificially introduced into the river gravels. The site of the find was a popular camp ground, a circumstance that reinforced the assumption.

Some years later this find was mentioned to Ernest and Billie Untermann, curators of the Utah Field House of Natural History museum in Vernal, and the writer was pleased to learn that the Untermanns had encountered a previously unmapped igneous dike in the eastern Uintas, first from reports and samples brought in by prospectors and later from personal reconnaissance in the field.

The location of this dike was shown in general fashion on the northeast quarter of the state geologic map (Stokes and Madsen, 1961) from information furnished by the Untermanns. Mention of the dike as "gabbroid" was also made in Utah Geological and Mineralogical Survey Bulletin 72 (Untermann and Untermann, 1964, p. 21, 71) and its extent projected westward based on the find in the Whiterocks River by the writer. The Untermanns also made brief mention of the dike in a later publication (1972, p. 137) and exhibited samples of it in the museum at Vernal. A sample of dike rock furnished to the Utah Geological and Mineral Survey by the Untermanns in 1972 was subsequently dated as 453 ± 17 m.y. (Ritzma, 1974, p. 95).

Studies undertaken to evaluate the mineral potential of the High Uintas Primitive Area resulted in U.S. Geological Survey Bulletin 1230-1 (Crittenden, Wallace and Sheridan, 1967). Field work for this study, which figured in classification of the area as "primitive," was conducted during 1965 and 1966. In the bulletin, Plate 1, a reconnaissance geologic map of the primitive area, lists mafic dikes in the explanation and shows two such dikes outcropping on the eastern edge of the area. The text of the bulletin does not describe the dikes and contains several statements that "bedrock within the primitive area consists entirely of sedimentary rocks" (p. 1) and "complete absence of igneous rocks in the area" (p. 20). One assay, however, is described as having come from "hornfels adjoining dike" (p. 19).

Based on the mapping of Crittenden, Wallace and Sheridan (1967, Plate 1) and unpublished mapping of the Utah Geological and Mineral Survey, the then-known dike outcrops in the Uinta Mountains were shown on Hintze's Geologic Map of Utah (1980).

MAPPING, SAMPLING AND ANALYTICAL WORK

Since 1976 the Utah Geological and Mineral Survey has investigated occurrences of igneous rocks and associated mineralization in the eastern

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Uinta Mountains. The work was undertaken for four reasons: to determine the extent of igneous rocks in the eastern Uintas, to provide information in response to proposals that large additional areas in the Uinta Mountains be designated as wilderness, to resolve the differences in information previously cited in U.S. Geological Survey Bulletin 1230-1, and to provide accurate location of the dikes for the planned revision of the state geologic map. In the course of the investigation, radiometric dating indicated that the dikes are about the same age as early Paleozoic, diamond-bearing, kimberlite diatremes discovered in recent years in southeast Wyoming. Aside from the contemporaneous intrusive age, relationship of the two appears to be remote.

In 1976 and 1977, several localities were visited along the faults flanking the range on the south and in the area east and west of State Highway 44 along the Daggett-Uintah county boundary. No igneous rocks or associated mineralization were found.

In 1977, the Lakeshore Basin and Deadman Lake Basin exposures were examined, mapped, and sampled. These areas were revisited in 1978 and additional outcrop areas were found and sampled. In 1979 and 1980, the area from Deadman Lake Basin west for ten miles through the headwaters of the Whiterocks River was examined. Numerous areas of altered sediments were found but only one small outcrop of igneous rock. Much float was observed in moraines around Chepeta Lake. In 1981, the outcrop areas at Gunsight Pass and in and around Gilbert Creek Basin and Gilbert Peak were visited, mapped, and sampled.

The Uinta Mountain dike project has occupied less than six field days in any single year of its duration and a total of 26 days in six years. The writer participated in nine of the ten field investigations conducted from 1976-81. Andrew E. Godfrey, geologist, U.S. Forest Service, participated in the 1977 and 1978 field trips and twice arranged for helicopter support. Hellmut H. Doelling, senior geologist, UGMS, accompanied the writer on a one-day examination of outcrops in the Gilbert Peak Basin and Gilbert Peak areas in September 1981. Helicopter transport for this trip was provided by the U.S. Air Force/Air National Guard. Others who have assisted in field work on the project are: Craig Dixon (1978; 1979), David Taff (1980), Paul R. Ritzma (1979; 1980; 1981), and Steven Prodnuk (1981).

Field work in the Gunsight Pass and Gilbert Creek Basin and Gilbert Peak outcrop areas was greatly facilitated by unusually warm and dry summer weather in 1981 and light snow cover in the previous winter. Areas above 11,000 feet were almost devoid of snow, possibly to a degree not known in half a century or more.

A sample of the Lodore Canyon, Colorado dike was obtained by Michael L. Perry, formerly director, Dinosaur Natural History Museum, Utah Division of Parks and Recreation, Vernal, and assays are included in this report. Petrographic work was performed by Lewis M. Downey, Salt Lake City. Assays were performed by Rocky Mountain Geochemical Laboratories, West Jordan, Utah.

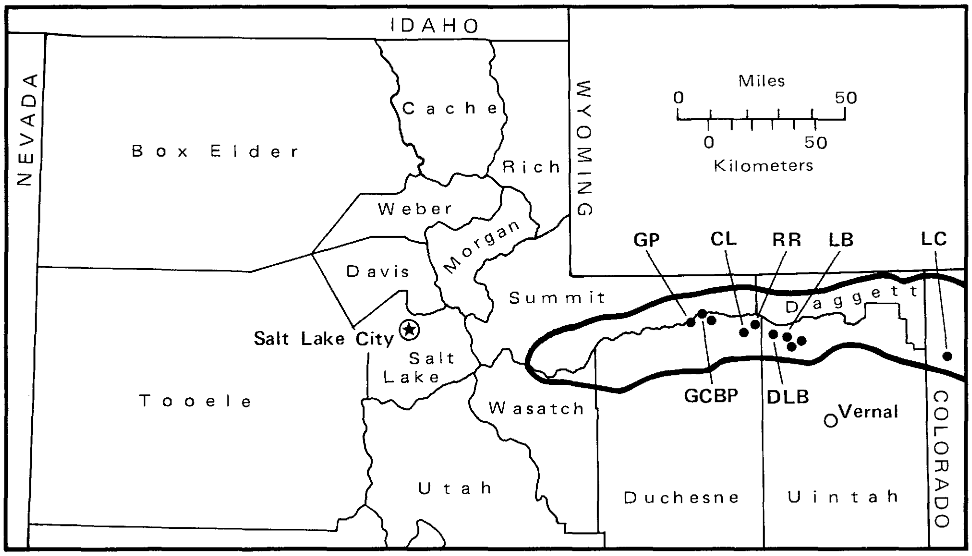
DESCRIPTION OF OCCURRENCES

General

Igneous rocks are found in six localities in the Uinta Mountains in northeast Utah and northwest Colorado (Figure 1). These localities span a distance of 76 miles from Gunsight Pass, 1.5 miles north-northeast of Kings Peak, on the west to Pot Creek in Lodore Canyon on the east. The five western localities are in Utah; the Lodore Canyon dike is the only occurrence known in Colorado.

These igneous rocks occur as discontinuous exposures of dark, basic dikes intruded into fracture zones and faults located generally a short distance south of the axis of the Uinta Mountain Arch (or anticline). They are everywhere intruded into the very ancient but only slightly metamorphosed sediments of the Precambrian Uinta Mountain Group. The dike rock has consistently yielded radiometric age dates of about 500 million years, close to the boundary between the Cambrian and Ordovician periods, early in the Paleozoic era. Since the Uinta Mountain Arch (or anticline) did not take shape until late Paleocene through medial Eocene time (about 65 to 50 million year ago), the position of the dike complex relative to the axis of the arch appears to be coincidental. However, exposure of the stratigraphically oldest rocks in the Uinta Mountains along the broad axis of the arch coupled with the deepest erosion by Quaternary glaciation in the topographically highest parts of the range undoubtedly are key reasons for the exposure of the dike outcrops close to the structural axis.

The strike of the dikes is everywhere northwest, usually about N 65° to 70° W. This west-northwest trend coincides with similar pervasive trends of faulting, fracturing, and jointing throughout the range. These have exerted strong control on orientation of drainages, alignment of cirque basins, and shaping of general topography of the range, even to



LEGEND

UTAH LOCALITIES
GP = Gunsight Pass*
GCBP = Gilbert Creek Basin and Gilbert Peak*
CL = Chepeta Lake (abundant float - no outcrops)
RR = Rose Ridge (northwest part of Whiterocks Lake Basin)
DLB = Deadman Lake Basin
LB = Lakeshore Basin

COLORADO LOCALITY
LC = Lodore Canyon

*Localities **GP** (Gunsight Pass) and **GCBP** (Gilbert Creek Basin and Gilbert Peak) are on the east edge and extend a short distance into the High Uintas Primitive Area. Other localities in Utah are all within proposed eastward extension of the primitive area.

Figure 1. Index map showing locations of dike outcrops.

the location of passes and trails. Local variations from the N 65° to 70° strike trend may amount to 40° to 45°, invariably to a more northerly strike.

Thickness of the dikes varies considerably reaching a maximum of 100 feet and averaging about 15 to 20 feet. They also pinch out upward in at least three exposures in the walls of cirque basins or canyons. Most exposures are in the floors or along the walls of cirque basins. The small areal extent of the dikes and the very limited amount of float observed in glacial and stream deposits downstream from outcrops suggest that the dikes have been exposed by the erosion of only the most recent stages of glacial activity in the Uintas (last 100,000 years?). More dike rock can be assumed to be present beneath glacial deposits and talus and felsenmeer, notably in the Chepeta Lake area where much broken dike rock is found in moraines. The granular texture and deeply weathered nature of much of the dike rock appears to contribute to its rapid disintegration, particularly as fragments in the fast-moving mountain streams and especially in abrasive contact with pebbles and cobbles of the highly resistant quartzites and quartzitic sandstone of the Uinta Mountain Group.

Dike rock color ranges from gray through shades of greenish gray and greenish black to black. Texture ranges from dense, very fine crystalline to coarse crystalline. Rock type is mostly diorite ranging to gabbro. Some of the dense, fine crystalline dike rock can be distinguished in the field from quartzite of similar color only with considerable difficulty.

The dikes are in contact with quartzites and shales of the Uinta Mountain Group and are emplaced in fault and fracture zones. Only minor mineralization of the fault gouge and adjacent wall rock has been observed. Alteration of the Uinta Mountain Group metasediments which imparts a bleached, baked, or fused appearance is frequently present adjacent to the dikes, along joints and fracture zones in areas between dike outcrops, and in areas along strike (usually west-northwest to east-southeast) from areas of outcrop. Presumably this alteration in the latter instances indicates close proximity of intrusive rock.

Barite is abundant in some contact areas. The dike rock is anomalously rich in titanium and, to some degree, in iron. Since the dikes intrude iron-rich metasediments, enrichment of this element is considered not unusual. Minerals identified which contain titanium are rutile, ilmenite, and titaniferous magnetite.

Some samples of dike rock are slightly to moderately magnetic. Many fragments found in moraines in the Chepeta Lake area are moderately magnetic and contain concentrations of titaniferous magnetite. This rock has not been found in place.

Description of Outcrop Areas (West to East)

Gunsight Pass - A single dike crops out in Gunsight Pass, 1.6 miles north- northeast of Kings Peak and 2.1 miles south-southwest of Gilbert Peak (Figure 2.) The igneous rock intrudes a northwest-southeast striking fault and fracture zone which parallels a major fault zone of similar trend exposed 1000 to 1200 feet northeast of the dike and north of the pass. The area between the dike and the major fault displays closely spaced joints and fractures along which breccias have developed. The fault in which the dike is emplaced appears to have less than 50 feet of throw, down to the north. The larger fault has about 250 to 300 feet of throw down to the south. Gunsight Pass (elevation 11,888 feet) has developed in the strongly fractured and jointed graben between the two faults. The strike of the fault zone is about N 50° W. The dike at its east end has a N 52° W strike which changes to N 30° to 35° W near the top of the pass.

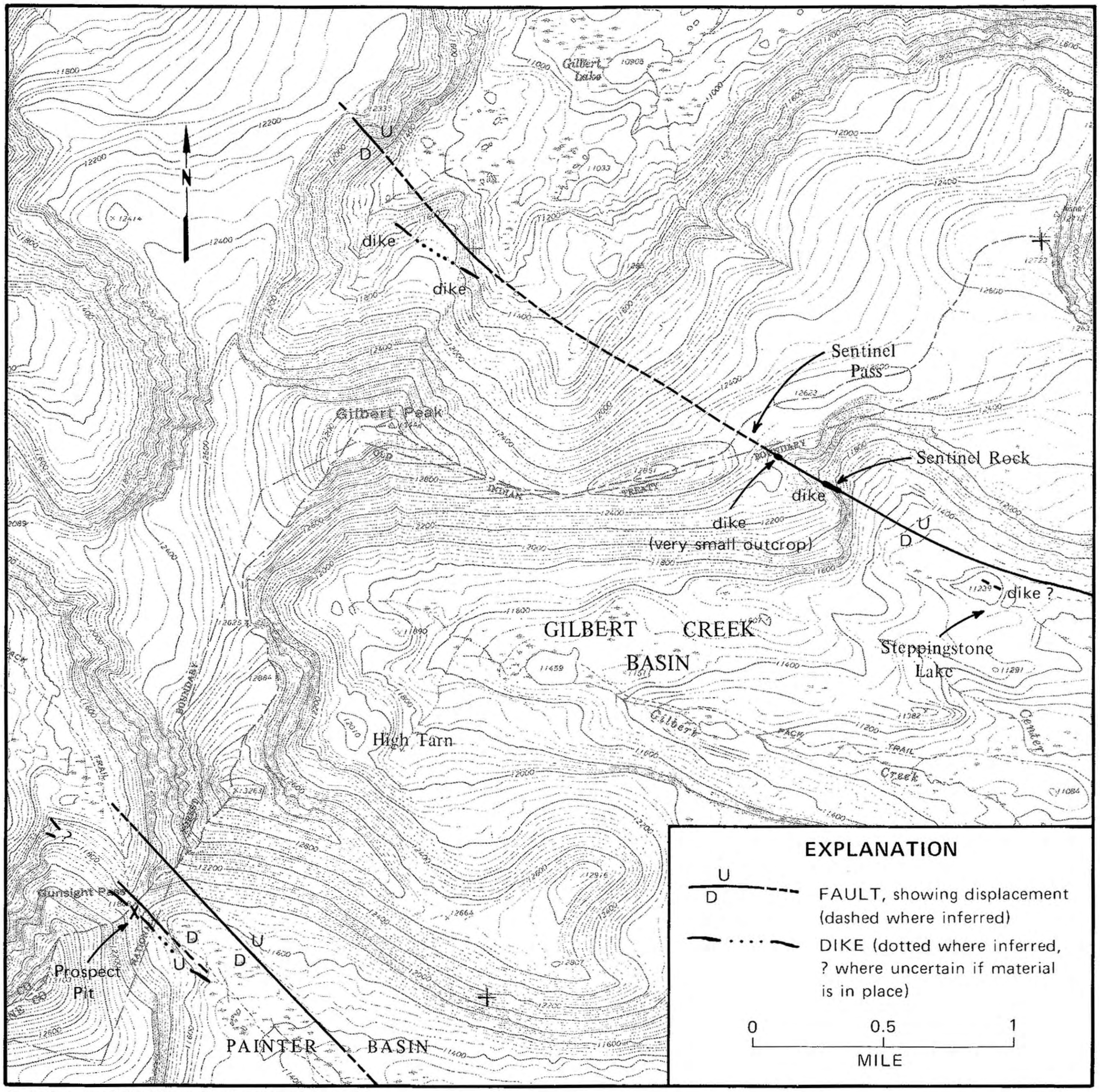
The dike crops out for about 0.5 miles from southeast to northwest across the crest of the pass. There are three principal areas of outcrop. About 0.4 miles northwest more dike rock appears in the extensive talus, but it was not possible to determine if this material is in place or has moved down from the top of the pass.

The dike is mainly light to very dark gray (nearly black), dense diorite with little variation along the outcrop. To the east it is more coarsely crystalline and contains considerable porphyritic-appearing material in which the larger crystals are barite in a dense, dark gray to black groundmass. The dike is discontinuous and quite variable in thickness, ranging from zero to 28 feet in thickness and averaging about 8 feet. The greatest thickness observed is near the top of Gunsight Pass where the maximum thickness may include one or more inclusions of altered metasediments. Extensive cover of talus and felsenmeer made precise observation difficult. A small prospect pit has been excavated (unknown date) in the dike a short distance south of the crest of the pass. A brecciated zone (fault gouge?) near the crest of the pass and about 100 feet to the northwest is slightly mineralized with small amounts of specular hematite and chalcopyrite in clusters of coarse quartz crystals. Samples of the dike are very slightly magnetic or non-magnetic.

The ruins of a cabin were noted a short distance north of the main trail leading to the pass, about 1.5 miles east of the easternmost outcrops. No outcrops were found at this locale, but abundant dike rock litter was found around the cabin.

Gilbert Peak and Gilbert Creek Basin - East and north of Gilbert Peak a dike which strikes N 60° W is exposed discontinuously for a distance of 2.0 miles (Figure 2). The easternmost outcrop forms a prominent wall about 100 feet high that juts upward from the southwest floor of a cirque basin tributary to Gilbert Creek basin. Sentinel Rock has been proposed as a name for this outcrop by the Utah State Committee on Geographic Names (Figure 8b). The dike intrudes a prominent fault and fracture zone except at its northwest end where the fault diverges from the dike to the north (Figure 8a). The fault has less than 100 feet of displacement down to the southwest in the vicinity of the dike outcrops and dies out to the northwest. Crittenden, Wallace and Sheridan (1967, Plate 1) extend the fault and dike for more than 4 miles to the east-southeast of Sentinel Rock, but brief reconnaissance of this area could not confirm the presence of dike outcrops. However, altered metasediments were noted along the fault-fracture zone, and erosion along the zone controls the configuration (N 75° W strike) of the north wall of Gilbert Creek basin and the drainage courses in the northern part of the basin. A small linear outcrop striking about N 65° W was noted about 10 feet from the shore of Steppingstone Lake (proposed name), elevation 11,239 feet, under about one foot of water. The high level of the lake from recent snow melt (September 1981) made it impossible to examine the outcrop carefully, but it was noted to have the appearance of a dike.

The exposure at Sentinel Rock is one of the largest single dike outcrops found in the Uinta Mountains. Its extent, horizontal and vertical, affords a unique three-dimensional view of the dike including a number of xenoliths of variably altered and unassimilated country rock (Figure 8c). The contact with the Uinta Mountain Group metasediments is well exposed on the north side of the dike where, at the time of observation (September, 1981), a stream of water from melting snow cascading down the headwall of the cirque basin provided



Base from USGS Kings Peak 7½' quadrangle.

Figure 2. Map of Gunsight Pass, Gilbert Creek Basin, and Gilbert Peak localities.

clean, washed exposures for about 0.1 mile along the contact zone. About 0.2 mile northwest of Sentinel Rock along strike and about 350 feet higher on the cirque wall, a very inconspicuous outcrop of weathered dike rock protrudes through extensive talus. The dike here is coarsely crystalline, exhibits spheroidal weathering, and forms small patches of greenish brown, granular soil.

Two small areas of dike rock crop out on a spur of Gilbert Peak (elevation 13,422 feet) leading down into the cirque basin containing Gilbert Lake and drained by the West Fork of Beaver Creek. The dike crops out on the east and west sides of the spur and is apparently concealed by talus and felsenmeer coating the top of the spur. These dike occurrences were not visited. One was observed from the north side of Sentinel Pass (proposed name) and both were mapped from aerial photographs confirmed by a close fly-over by helicopter. The dike strikes N 55° W but the fault zone diverges to a more northwesterly strike (N 42° W).

The dike at Sentinel Rock is a dark gray to greenish black diorite, more coarsely crystalline in the middle of the dike and very dense and fine crystalline along the border. This dense rock is extensively jointed and weathers to prominent sheets and slabs. The maximum thickness of the dike at Sentinel Rock is 38 feet on the east end. There is about the same thickness on the west end but this is interrupted by several xenoliths of much altered quartzite. The dike rock around the xenoliths is more deeply weathered and has a porphyritic texture.

The contact of the dike with the Uinta Mountain Group metasediments is well exposed on the north side of Sentinel Rock and is sharp with a zone of alteration of less than 1.5 feet and mostly less than 0.5 foot. Alteration observed is mostly bleaching, baking, and fusing of the wall rock with very sparse mineralization, mostly specular hematite and pyrite (or chalcopyrite?). Alteration has affected siltstone units more than quartzite, and a few very thin apophyses of coarse dike rock were noted injected for 0.1 to 0.3 foot along the bedding planes of a prominent gray-green siltstone. Samples from this locality are non-magnetic or only slightly magnetic.

Chepeta Lake - Chepeta Lake is the largest of four lakes located in the cirque basin which is the headwaters of the Whiterocks River (Figure 3). Abundant float of dike rock was found scattered throughout the medial moraine separating Mocassin and Wigwam Lakes from Papoose and Chepeta Lakes and in the morainal material used to construct the dams that raise the levels of Wigwam, Mocassin, and Chepeta Lakes. No dike outcrops were found. Alteration areas, mostly bleached and baked-appearing quartzite, were found along fracture zones east of Wigwam Lake and north of Papoose Lake, and it is inferred that glaciers scoured off the top of several dike outcrops which are now concealed beneath moraines and talus in the cirque basin. Two small flexures with associated jointing and alteration areas are located directly on strike with the dike outcrops found to the east on Rose Ridge.

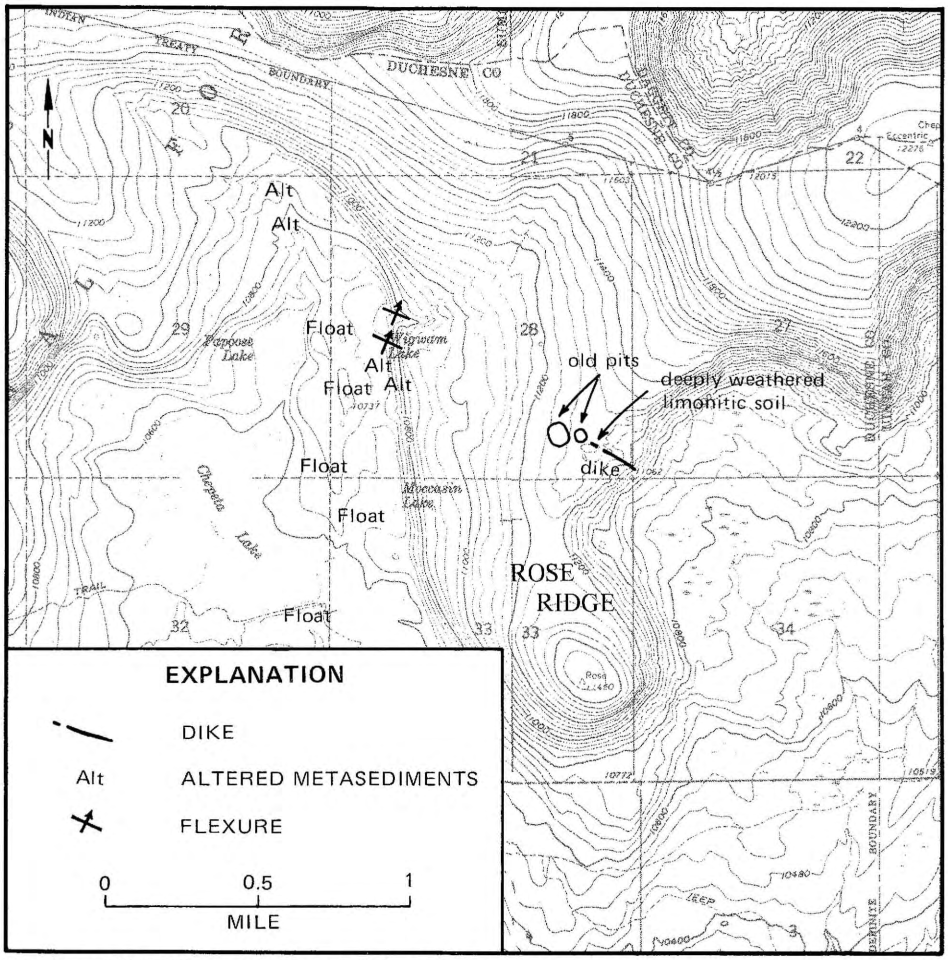
Dike rock of varying texture was noted in the moraines, but a dense, fine crystalline diorite is most common. Some of this rock contains titaniferous magnetite and is moderately magnetic.

Rose Ridge - Small outcrops of dike rock occur at the north end of Rose Ridge (unofficial name) in SW SW SW section 27 and SE SE SE section 28, T. 5 N., R. 1 W., Duchesne County, about 1.1 miles east-northeast of the southwest corner of Chepeta Lake (Figure 3). (Rose Ridge takes its name from triangulation station Rose, elevation 11,450 feet, about 0.8 mile south of the outcrops.) The area is in the extreme northwest corner of the large, compound cirque basin containing Whiterocks and about seven other large lakes and drained by East Fork Whiterocks River. No float or other outcrops of dike rock were found in the 7.0 to 7.5 square miles of the cirque basin. An area of alteration on the southeast edge of the basin is discussed under Deadman Lake below.

The dike is exposed for about 600 feet from an elevation of 11,100 to 11,270 feet on a southeast-facing cirque wall. It makes a narrow ridge of gray to greenish black color that contrasts with the dark red color of the talus-coated cirque walls. The dike strikes N 68° W and appears to be nearly vertical. Maximum thickness is 65 feet, averaging about 38 feet.

The middle part of the dike is a dense, medium to coarse crystalline diorite of mottled appearance with characteristic blocky weathering. One area of fine crystalline, dark green "gabbroic" dike rock displays conspicuous spheroidal weathering. The entire dike outcrop is deeply weathered. Extensive veining of white and pink barite and specular hematite occurs throughout the dike. Some of the "gabbroic" rock is slightly magnetic.

Contact of the dike with the Uinta Mountain Group metasediments is sharp with only a narrow zone of altered quartzite about 0.2 to 1.5 feet thick noted. Principal alteration of country rock is baking and fusing of quartzite, usually to a gray-purple or tan color. There is sparse veining and clustering of specular hematite. The contact is poorly exposed on the north, but a zone of soft, limonitic soil appears to mark weathered gouge along a fault and the north border of the intrusion. A similar area of deeply weathered limonitic soil northwest of the end of the dike on the crest of Rose Ridge also appears to mark a fault zone and the border of the dike. About 500 feet farther northwest along strike (N 65° W) several small prospect pits were noted with blocky dike material in the dumps. Since lichens were noted to be well established on some of the broken and disturbed material on the dumps, the pits appear to have been dug 50 to 70 years ago and possibly 150 or more years ago. About 0.6 mile farther along strike on the east shore of Wigwam Lake, fracturing and two small flexures with associated zones of alteration, mostly bleaching and sparse hematitic



Base from USGS Chepeta Lake and Whiterocks Lake 7½′ quadrangles.

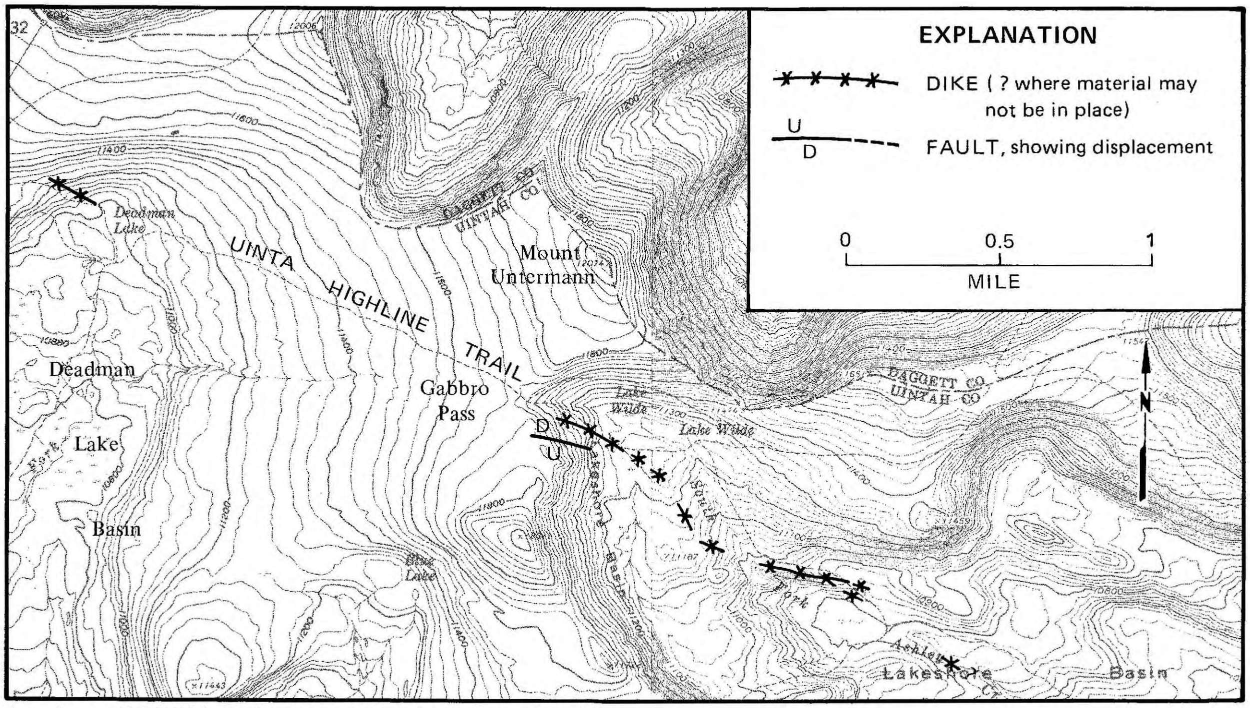
Figure 3. Map of Chepeta Lake and Rose Ridge localities.

veining, were noted.

Deadman Lake - A single outcrop of dike rock occurs in Deadman Lake Basin 300 feet north of the lake and about 75 to 275 feet above the level of the lake (Figure 4). The dike crops out in the north wall of this broad, southfacing cirque basin at elevations from 11,050 to 11,250 feet. No other outcrops of dike rock were found in the basin or on strike to the northwest into the cirque basin drained by the East Fork of Whiterocks River.

About 1 mile west of Deadman Lake in a broad saddle between two unnamed peaks (elevation north peak, 11,535 feet; elevation south peak 11,811 feet) an area of altered Uinta Mountain Group metasediments was found in which the usually dark red quartzite is extensively brecciated and bleached to tan and yellow. There is also abundant clustering and veining of specular hematite. The alteration and mineralization is similar in appearance to that noted elsewhere in areas close to or adjacent to dikes. It appears almost certain that this saddle between Whiterocks Lake and Deadman Lake basins is underlain by dike rock at very shallow depth. Several areas of brecciated quartzite and minor alteration, mainly bleaching, were also noted along the northwest cirque wall of Deadman Lake Basin on the southwest flank of peak 11,534.

The single exposure at Deadman Lake is less than 100 feet long but has been considerably augmented by excavation for prospecting. The dike is at least 35 feet thick with an added transitional zone on the south 3 to 5 feet thick, of brecciated and altered Uinta Mountain Group quartzite admixed with blebs of barite flecked with specular hematite. The south contact is sharp and marked by a vertical vein of barite 0.5 to 2.0 inches wide (Figure 9a). The nearly horizontal quartzite adjacent to the barite vein shows almost no contact metamorphic



Base from USGS Whiterocks Lake and Leidy Peak quadrangles.

Figure 4. Map of Deadman Lake and Lakeshore Basin localities.

effects. There are no exposures of the north contact, but the width of the dike probably does not exceed 50 feet. The north contact of the dike appears to be irregular and occurs within a zone of apparently disturbed metasediments, probably fault gouge.

The middle portion of the dike is a dark gray to gray-green, medium, crystalline, diorite with abundant barite in veins and clusters throughout. Detailed descriptions are provided in the petrography section (page 10).

The area east and southeast of Deadman Lake was examined principally because of an alignment noted on aerial photographs that appeared to connect the dike outcrop in Deadman Lake Basin with those in Lakeshore Basin two miles east. Since the Uinta Highline pack trail coincides exactly with this alignment (N 65° W strike), the photo alignment may actually be an expression of the trail. The area is a plateau entirely and uniformly covered by felsenmeer which supports sparse vegetation. Elevation is 11,000 to 11,500 feet. The trail, well travelled by pack trains for decades, is a barren strip incised in the rocky surface paralleled by two narrow strips of slightly more luxuriant vegetation supported by horse manure.

Two broad, shallow cuts, possibly 10 to 15 years old, were found along the N 65° W strike and close to the trail east of Deadman Lake. These cuts exposed bed rock (quartzite) and ashy clays (possibly Miocene Browns Park Formation) beneath the coating of felsenmeer. No dike rock was noted. Farther east, toward Gabbro Pass, a vertical shaft, about 6 feet square, timbered, and filled almost to the top with water was noted (Figure 9b). No float of dike rock was found in the debris around the shaft. The shaft appeared to be considerably older than the cuts noted farther west.

Lakeshore Basin - Outcrops of dike rock occur for 1.2 and possibly 1.5 miles from northwest to southeast across Lakeshore Basin, an east-facing set of stepped cirque basins between Leidy and Marsh Peaks which are drained by the South Fork Ashley Creek (Figure 4). The dike is exposed in the lower part of the basin at 10,720 feet and extends west-northeast to the headwall at 11,500 feet elevation west of Lake Wilde. Exposures are intermittent but there is no difficulty in following the dike from one outcrop to the next. The easternmost outcrop occurs in a forested area and is possibly a large mass of dike material incorporated into a lateral moraine. The basin has a scattered thin veneer of glacial and glacial lake deposits on its floor and extensive talus and scree fields along the cirque walls.

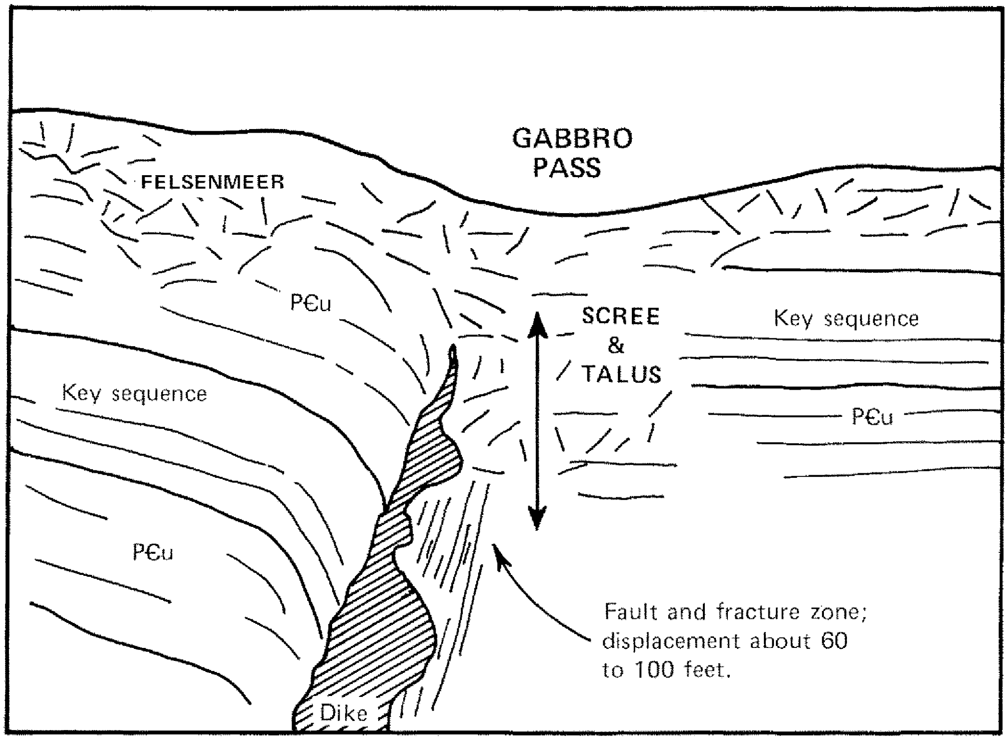


Figure 5. Diagrammatic section of outcrops in headwall of Lakeshore Basin.

Strike of the dike averages N 65° W except for one sharp change in the west part of the basin which coincides with a similar change in topographic orientation and the course of South Fork Ashley Creek. The dike pinches and swells from a few to an average of 15 feet in thickness across the basin, and pod-like masses are 50 feet thick in the west headwall of the cirque. Maximum thickness is at least 100 feet on the north shore of an unnamed lake (elevation 10,792 feet) where the dike appears to bifurcate and plunge rapidly to the east. This is the last definite outcrop on the east. Attitude of the dike is nearly vertical; however, dip of a few degrees to the south is discernible in the headwall of Lakeshore Basin. The dike pinches out upward in these exposures and does not penetrate the entire Precambrian metasedimentary section.

The dike intrudes a zone of faulting, intense fracturing, and steep dips (drag) associated with the faulting. In the headwall of Lakeshore Basin relationships can be seen in cross section (Figures 5 and 10a). Elsewhere in Lakeshore Basin to the east, outcrops of vertical quartzite beds are interspersed with outcrops of the dike itself.

The dike rock in Lakeshore Basin is light gray to greenish black, fine to medium crystalline diorite. In the headwall of Lakeshore Basin, there are conspicuous areas of spheroidal weathering (Figure 10b). In a small prospect pit on the point of a hill west of and overlooking unnamed lake (elevation 10,792 feet), the dike is finely granular and weathers to small blocks (Figure 11a). The thick dike exposures north and northwest of this lake intrude shattered, baked, and bleached quartzite. Here the dike has crudely developed columnar jointing and weathers to large blocks (Figure 11b). Detailed descriptions are provided in the section on petrography (page 10).

Lodore Canyon - A single dike occurrence has been reported from Lodore Canyon, Moffat County, Colorado (W.R. Hansen, USGS, letter, November 8, 1977). The dike is mentioned in U.S. Geological Survey GQ 1403 (Hansen, 1977), and more detailed information has appeared in informal USGS publications.

The dike is emplaced in a west-northwest trending fracture zone which is traceable for 30 miles (strike N 65° to 68° W). This zone controls the drainage of Pot Creek in Utah and Colorado as well as Zenobia Creek in Colorado. The dike occurs a short distance west of the right-angle junction of the fracture zone with Lodore Canyon (and the Green River) on the west side of the river in the narrow side canyon of Pot Creek. The locality is a popular overnight camp site for river-runners.

The dike is everywhere in contact with the Precambrian Uinta Mountain Group and is reported to be truncated at one point by a north-northeast trending fault which, along strike, passes beneath the Lodore Formation (late Cambrian) without offset. The dike dies out upward in about 350 feet of vertical distance above the river level.

The rock is described as dark gray and vesicular, resembling basalt, but close to trachyte in composition. Age determined by Rb-Sr analysis is 491 m.y. (early Ordovician) (W.R. Hansen, USGS, July 1980). Among unusual features of the rock is a TiO_2 content of 4.35 percent. Utah Geological and Mineral Survey analyses of the rock measure a TiO_2 content of 3.95 and 4.46 percent, closely comparable. Assays of samples obtained by Michael L. Perry, Utah Division of Parks and Recreation, while on a river trip are included in this report.

PETROGRAPHY

Petrographic work was performed by Lewis M. Downey, a student, University of Utah, on four samples:

78-123-UMD Deadman Lake. Center of dike.
78-124-UMD Deadman Lake. Contact zone near south border of dike.
78-125-UMD Lakeshore Basin. Headwall of cirque at foot of Gabbro Pass. Center of dike.
78-126-UMD Lakeshore Basin. Prospect pit on top of ridge west of "lake 10,792". Center of dike.

General and specific descriptions (directly quoting Downey) follow.

General Descriptions

These rocks were examined in polished, potassium stained thin section with the petrographic microscope and the electron microprobe. A Tracor-Northern energy dispersive spectrum analyzer (EDS) was used to determine elements composing particular mineral phases. The instrument used is the ARL-EMX electron microprobe and attached EDS belonging to the Department of Geology and Geophysics at the University of Utah. Operating conditions were 15 KV accelerating potential and 0.03 microampere sample current. The detection limit of elements with the probe-EDS is approximately 0.1 percent (by weight).

These turned out to be fairly unusual rocks in two respects: 1) the presence of abundant and relatively large rutile grains, and 2) the dominance of albite as the feldspar in sample 126. Samples 78-123, 125, and 126 exhibit fairly ordinary igneous rock textures. The essential minerals in those specimens are plagioclase and biotite. Based upon the average plagioclase composition (andesine-An_{37}), the presence of quartz and biotite, and the absence of hornblende, pyroxene, and olivine, this rock is best described as a biotite diorite. Plagioclase compositions were determined by optical methods on sample 78-125 and the presence of Ca and Na in the feldspars was confirmed with the probe-EDS. Partial alteration of the feldspars may make the optically determined composition more sodic than the true average since the Ca rich portions are selectively altered rendering them useless for analysis. An unusual feature of these rocks is the abundance of relatively large crystals of rutile (TiO_2), $\sim$3 percent as 0.5 mm aggregates intergrown with quartz in sample 125 and $\sim$3 percent as acicular crystals up to 2 mm in sample 126. The rutile crystals in sample 125 are intergrown or held together by quartz exhibiting a shadowy extinction, indicating strained quartz. Because strained quartz is characteristic of metamorphic rocks it is suggested that the rutile-quartz clots are xenoliths incorporated into the dike rocks from the quartzites in the underlying section. The same association of rutile and strained quartz is observed in sample 126 in addition to the larger (2 mm) solitary needles of rutile.

Sample 126 is compositionally distinct from 123 and 125. It is composed primarily of albite (Na plagioclase) and biotite. The absence of Ca in the plagioclase was confirmed with the probe-EDS and is unusual for such a dark rock exhibiting otherwise ordinary igneous characteristics. The optical properties of the feldspar are consistent with the absence of Ca, that is, that the feldspar is practically pure albite. Sample 126 is perhaps best described as a soda biotite diorite.

Sample 124 represents the mechanical and hydrothermal action at the dike contact. The polished thin section exposed the feldspar (albite) - specularite veining and a microbreccia which composes the greenish 2.5 and 5.0 cm fragments which are "glued together" by the albite and specularite in the hand specimen.

As indicated by the probe-EDS the only element residing in the magnetite besides Fe is Ti. This is expected since the magnetite contains ilmenite ($FeTiO_3$) exsolution lamellae.

Sample Number 78-123-UMD-Deadman Lake
Petrographic description: Biotite diorite

Texture: Medium grained hypidiomorphic granular

Primary igneous mineralogy

50-60% Plagioclase feldspar almost entirely altered to sericite and lesser amounts of calcite and chlorite. Subhedral laths up to 3 mm long. Composition unknown due to alteration but zoned extinction suggests a Ca-Na type (as opposed to albite)

10% Biotite as aggregates of anhedral flakes up to 3 mm across occurring interstitial to plagioclase. Partly altered to chlorite, calcite, and rutile

5% Apatite as acicular hexagonal crystals

5% Quartz as subhedral grains and aggregates up to 3 mm in diameter

5% Magnetite with ilmenite solution lamellae

$\lesssim$ 1% Rutile crystals, 0.2 mm diameter, associated with magnetite

Secondary minerals (hydrothermal or deuteric)

5-10% Calcite occupying altered plagioclase

Sericite as fine grained aggregates pseudomorph after plagioclase feldspar. The sericite did not stain so is probably paragonite (Na-mica)

Chlorite, as:

1) Pseudomorph after biotite. Optically negative therefore Mg/Mg+Fe+Mn. 0.48 (Albee, 1962)

2) With sericite and calcite occupying altered plagioclase grains

$\lesssim$ 1% Pyrite

$\lesssim$ 1% Rutile as 0.01 mm grains and/or aggregates in altered biotite

Sample Number 78-124-UMD Deadman Lake

Petrographic description:

1) Albite-chlorite rock

2) Microbreccia

Mineralogy

1) 70% Albite as untwinned euhedral laths up to 6 mm in length

30% Biotite almost completely altered to chlorite and rutile. As anhedral grains up to 5 mm in diameter

< 1% Epidote, one grain 0.3 mm in diameter

$\lesssim$ 1% Specularite (hematite) as hexagonal flakes up to 0.2 mm in diameter

2) A microbreccia consisting of chlorite, clays (probably montmorillonite), sericite, quartz, and a trace of biotite. Remnants of clay altered feldspars (formerly plagioclase) are recognizable. The breccia is cut by veinlets of albite.

Sample Number 78-125-UMD Lakeshore Basin

Petrographic description: Biotite diorite

Texture: Medium grained hypidiomorphic granular

Primary igneous mineralogy

40% Plagioclase feldspar as subhedral grains up to 2 mm in length. Compositions of smaller crystals are An_{28} (oligoclase) and of larger zoned crystals, An_{52} (labradorite) in the cores to An_{24} (oligoclase) in the rims. Average feldspar composition (19 grains) is An_{37} (andesine)

40% Biotite as interlocking networks up to 6 mm across, interstitial to the plagioclase laths. Partially altered to chlorite.

5% Apatite as euhedral hexagonal prisms up to 0.2 mm in diameter and 3 mm in length

5% Quartz as subhedral grains up to 1 mm in diameter

5% Magnetite with ilmenite exsolution lamellae

Secondary mineralogy (deuteric or hydrothermal)

Chlorite:

1) As a minor alteration product of plagioclase along twin planes and fractures

2) As alteration product of biotite. The chlorite is optically negative therefore Mg/Mg+Fe Mn... 0.48 mole fraction (Albee, 1962)

Sericite as a minor alteration product of plagioclase

Geothite, a weathering product of magnetite

Rutile as 0.01 mm grains in chloritized biotite

Xenolith mineralogy

2-4% Rutile as euhedral crystals up to 0.1 mm in aggregates up to 0.5 mm intergrown with strained quartz

Sample Number 78-126-UMD Lakeshore Basin

Petrographic description: Soda biotite diorite

Texture: Fine grained hypidiomorphic granular

Primary igneous mineralogy

40-50% Biotite as anhedral grains up to 1 mm across, interstitial to plagioclase. Almost entirely altered to chlorite

30-40% Plagioclase as subhedral laths up to 3 mm long, partially altered to sericite and

Table 1. Assays of Samples.

Element	% or ppm	Samples: Gunsight Pass 81-30-UMD (UGMS)	Gunsight Pass 81-31-UMD (UGMS)	Gunsight Pass 81-33-UMD (UGMS)	Gilbert Creek Basin 81-41-UMD (UGMS)	Gilbert Creek Basin 81-42-UMD (UGMS)
Aluminum (Al_2O_3)	%	9.5%	12.8%	13.2%	12.4%	12.8%
Barium (Ba)	ppm	140	280	280	650	360
Beryllium (Be)	ppm	2	2	2	2	2
Calcium (CaO)	%	0.21%	1.94%	1.02%	3.93%	5.48%
Chromium (Cr)	ppm	-5	50	40	20	10
Cobalt (Co)	ppm	15	60	55	45	35
Copper (Cu)	ppm	10	25	10	55	40
Iron (F_2O_3)	%	5.40%	14.7%	13.8%	13.3%	12.2%
Lead (Pb)	ppm	65	55	70	35	35
Magnesium (MgO)	%	0.87%	3.12%	3.05%	3.78%	3.13%
Manganese (MnO)	ppm	167	2900	2400	2100	1900
Molybdenum (Mo)	ppm	2	2	2	2	2
Nickel (Ni)	ppm	30	60	55	40	30
Silicon (SiO_2)	%	74.7%	46.9%	48.9%	48.4%	47.6%
Titanium (TiO_2)	%	0.48%	3.73%	3.50%	3.46%	3.72%
Tungsten (W)	ppm	-5	10	10	15	5
Vanadium (V_2O_5)	ppm	100	700	615	635	575
Zinc (Zn)	ppm	110	180	175	150	160
Sample description		Mineralized fault gouge and hornfels, northwest side of Gunsight Pass	Prospect pit south of top of Gunsight Pass	Easternmost exposure of dike at foot of Gunsight Pass	Middle of dike, Gilbert Creek cirque basin "Sentinel Rock"	Border of dike (sheeted area), Gilbert Creek cirque basin "Sentinel Rock"
(Person sampling)		(HRR)	(HRR)	(HRR)	(HRR)	(HRR)

chlorite. Corroded biotite-chlorite. Average composition (10 grains) is albite (An_6). One grain of oligoclase (An_{16}) was found

5-10% Quartz as anhedral grains up to 3 mm across. Corroded by biotite-chlorite

5% Magnetite with ilmenite exsolution lamellae

3- 5% Rutile as acicular crystals up to 2 mm in length and also as smaller anhedral grains associated with strained quartz

3% Apatite as acicular, hexagonal crystals up to 1 mm long

Secondary mineralogy

1% Calcite occurring as cores of quartz aggregates

Chlorite as alteration product of biotite

Rutile as alteration product of biotite

Chlorite as alteration product of plagioclase

Sericite as alteration product of plagioclase

Geothite as weathering product of magnetite

ASSAYS

Thirteen samples of dike rock selected from all areas of outcrop and one sample of float have been assayed for the abundance of 18 elements. These are tabulated in Table 1, arranged from west to east, along the entire length of the dike complex from Gunsight Pass to Lodore Canyon.

All assays were performed by Rocky Mountain Geochemical Corporation, West Jordan, Utah.

Dike samples, presumably from the Gunsight Pass and Sentinel Rock localities, were analyzed by the U.S. Geological Survey in 1982 and yielded 3.86 to 3.89 percent and 4.50-4.55 percent TiO_2. These samples were obtained during the 1965-66 field investigations and were retrieved from USGS files for more recent studies (Max Crittenden, telephone conversation, February 17, 1982).

Dike rock from Lodore Canyon analyzed by x-ray fluorescence by the U.S. Geological Survey (W.R. Hansen, letter, January 12, 1982) yielded 4.36 percent TiO_2. This result is closely comparable to UGMS sample 80-11-UMD which assayed 4.31 and 4.49 percent.

A sample of dike rock close to the contact at

Table 1. Assays of Samples — continued.

Element	% or ppm	Samples: Chepeta Lake 80-01-UMD (UGMS)	Rose Ridge 80-02-UMD (UGMS)	Rose Ridge 80-03-UMD (UGMS)	Rose Ridge 80-04-UMD (UGMS)	Rose Ridge 80-08-UMD (UGMS)
Aluminum (Al_2O_3)	%	12.8%	nd	nd	13.3	7.25%
Barium (Ba)	ppm	140/210	59,100	320	525/600	125
Beryllium (Be)	ppm	2	nd	nd	2	2
Calcium (CaO)	%	1.62%	nd	nd	3.32%	0.17%
Chromium (Cr)	ppm	15/25	25	25	20/35	10
Cobalt (Co)	ppm	40/70	75	55	55	85
Copper (Cu)	ppm	20/125	15	15	80	30
Iron (F_2O_3)	%	11.1%	nd	nd	10.8%	13.0%
Lead (Pb)	ppm	10/25	15	15	15/20	15
Magnesium (MgO)	%	5.60%	nd	nd	3.89%	4.47%
Manganese (MnO)	ppm	1300	nd	nd	2400	196
Molybdenum (Mo)	ppm	2	2	2	2	4
Nickel (Ni)	ppm	25/45	65	30	35/40	45
Silicon (SiO_2)	%	47.6%	41.8%	59.5%	36.9/48.4%	59.2%
Titanium (TiO_2)	%	3.26/3.39%	1.47%	2.41%	3.12/3.70%	1.21%
Tungsten (W)	ppm	5	nd	nd	15	nd
Vanadium (V_2O_5)	ppm	670	nd	nd	660	410
Zinc (Zn)	ppm	65/135	20	15	115/120	50
Sample description		Gabbroic (mafic) phase of dike, float from Chepeta Lake Dam	Dioritic dike with barite and specular hematite veins, Rose Ridge outcrop	Dioritic phase of dike, center of exposure, Rose Ridge outcrop	Gabbroic (mafic) phase of dike Rose Ridge outcrop	Gabbroic (mafic) phase of dike with thin barite and abundant hematite veins, Rose Ridge outcrop
Person sampling		(HRR, PRR)	(DT)	(DT)	(DT)	(DT, HRR)

Deadman Lake was assayed for gold and silver and yielded .05 oz/ton silver and less than .001 oz/ton gold. A number of assays of material from Deadman Lake and Rose Ridge made available to the writer on a confidential basis by a prospector from a nearby Uinta Basin town also showed very low values for gold and silver and no detectable platinum.

Titanium Content

Anomalous high titanium content obtained from samples of fault gouge and breccia, hematite veins, and assorted altered metasediments in the High Uintas Primitive Area was discussed in U.S. Geological Survey Bulletin 1230-1 by Crittenden, Wallace and Sheridan (1967, p. 17-20). It was concluded that the titanium was derived from iron originally of sedimentary origin. Dike material was not analyzed.

Titanium is distributed as follows in Earth's crust and in various rock types (Mason, 1966; Poldervaart, 1955):

Lithosphere (%)	1.60% (Poldervaart); 1.06% (Mason)
Average igneous rock (%)	1.10% (Poldervaart)
Average shale (%)	0.65% (Mason)
Average sandstone (%)	0.25% (Mason)
Average sediment (%)	0.57% (Mason); 0.60% (Poldervaart)

The high titanium values in the samples reported by the U.S. Geological Survey apparently originate from the intrusive igneous rocks which are the subject of this study and not from the metasedimentary country rock. The anomalously high values for titanium (2.41 to 4.49 percent, averaging about 3.7 percent for 26 samples) indicate consistent TiO_2 enrichment of dikes throughout their entire extent from west to east suggesting a parent titanium-rich igneous body for the entire dike complex. Only two samples from the Rose Ridge area (80-02-UMD and 80-08-UMD) yielded significantly lower percentages of TiO_2. However, these two lower values are greater than the titanium value of average igneous rock and for other rock types previously cited (Poldervaart, 1955).

In the petrographic descriptions by Downey included in this report, he suggests that some of the titanium content of the dike rock may have originated from the quartzites of the intruded country rock.

Table 1. Assays of Samples — continued.

		Samples			
Element	**% or ppm**	**Deadman Lake 78-123-UMD (UGMS)**	**Lakeshore Basin 78-125-UMD (UGMS)**	**Lodore Canyon 80-10-UMD (UGMS)**	**Lodore Canyon 80-11-UMD (UGMS)**
Aluminum (Al_2O_3)	%	13.6%	13.2%	11.2%	13.3%
Barium (Ba)	ppm	560	1000	3300/13200	1400/1700
Beryllium (Be)	ppm	2	2	2	3
Calcium (CaO)	%	3.52%	3.31%	1.60%	2.63%
Chromium (Cr)	ppm	5	15	5/30	15/50
Cobalt (Co)	ppm	50	55	50/65	50
Copper (Cu)	ppm	75	35	5/285	25
Iron (F_2O_3)	%	9.50%	10.7%	10.9%	16.8%
Lead (Pb)	ppm	20	20	10/15	-5/10
Magnesium (MgO)	%	3.72%	4.96%	4.98%	5.12%
Manganese (MnO)	ppm	1100	1400	798	930
Molybdenum (Mo)	ppm	3	3	2/3	2
Nickel (Ni)	ppm	30	35	30/40	25/30
Silicon (SiO_2)	%	47.7%	46.3%	44.5/49.1%	44.4/45.4%
Titanium (TiO_2)	%	2.56%	2.99%	3.18/3.95%	4.31/4.49%
Tungsten (W)	ppm	nd	nd	nd	5
Vanadium (V_2O_5)	ppm	480	570	650	575
Zinc (Zn)	ppm	55	170	75/80	50
Potassium (K_2O)					3.22%
Sodium (Na_2O)					0.48%
Phosphorus (P_2O_5)					0.15%
Sample description		Dike, middle portion, dense, unweathered, Deadman Lake	Dike, dioritic phase, coarse granular, headwall, Lakeshore Basin	Hornfels, contact zone, Lodore Canyon, CO.	Dike, Lodore Canyon, CO.
(Person sampling)		(HRR)	(HRR, AEG)	(MLP)	(MLP)

NOTES TO TABLE 1 - Assays

Where two values appear in one column (140/210), two batches from a single sample were analyzed separately and yielded different results. Variation, especially in barium value, results from scattering of barite blebs in samples with resultant enrichment in some batches and not in others.

Minus sign (-5) indicates "less than." nd = not determined Persons sampling: HRR = Howard R. Ritzma; PRR = Paul R. Ritzma; DT = David Taff; AEG = Andrew E. Godfrey; MLP = Michael L. Perry

GEOCHRONOLOGY

Radiometric age dates have been obtained on three samples of dike rock by potassium-argon analysis. These are as follows:

SAMPLE: 81-41-UMD (UGMS sample)

From middle of dike, "Sentinel Rock" exposure, Gilbert Creek Basin, Duchesne County, Utah.

Material analyzed: Whole rock. -60/+200 mesh. Treated with dilute HF and HNO_3 to remove alterations.

Ar^{40*}/K^{40} = .03754 Age = 552 + 21 m.y.

SAMPLE: 78-123-UMD (UGMS sample)

From middle portion of dike, Deadman Lake exposure, Deadman Lake Basin, Uintah County, Utah.

Material analyzed: Ferromagnesian mineral concentrate. Somewhat altered. -60/+200 mesh.

Ar^{40*}/K^{40} = .03322 Age = 496 + 26 m.y.

SAMPLE: GEU-1-74 (sample furnished by G.E. Untermann)

Gabbro, Lakeshore Basin, presumably from outcrops north of unnamed lake "10,792", Uintah County, Utah.

Material analyzed: Plagioclase concentrate. -80/+200 mesh.

Ar^{40*}/K^{40} = .02998 Age = 453 + 17 m.y.

The above K/Ar analyses were performed by Geochron Laboratories Division, Krueger Enterprises, Inc., Cambridge, Massachusetts.

A fourth date obtained from dike rock by rubidium-strontium analyses has been reported by the USGS as 491 m.y. (W.R. Hansen, letter, July 1980).

Figure 6, which depicts the four dates graphically on the geologic time scale (Holmes, 1960), shows a range of dates from middle Cambrian to basal Silurian with significant clustering of dates in Ordovician time. There is some suggestion that intrusive activity was older on the west end of the dike complex becoming younger to the east.

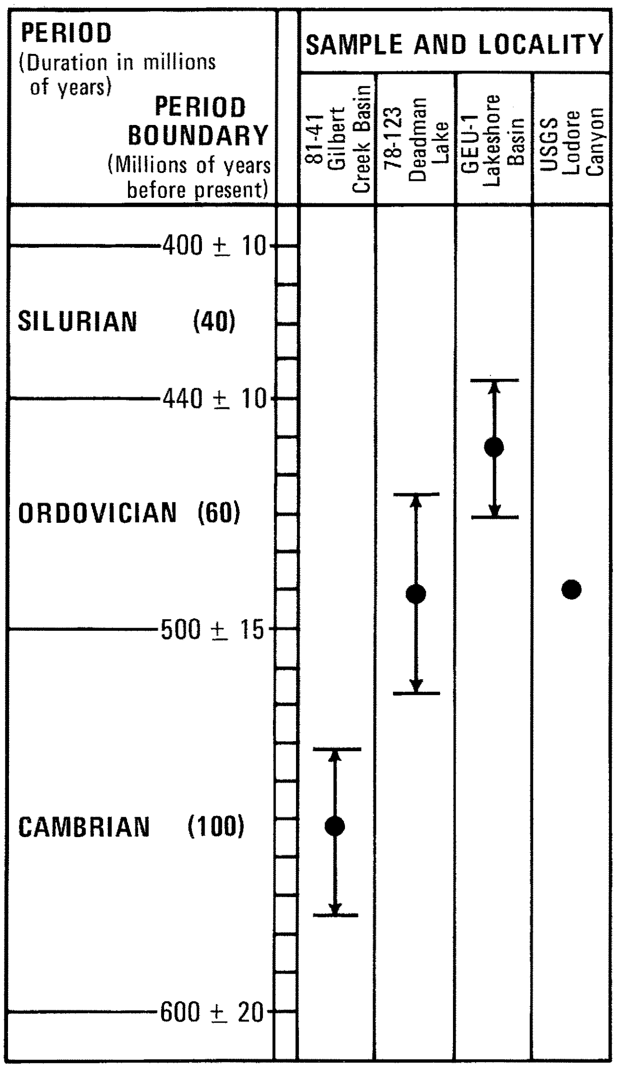


Figure 6. Graph showing range of dates obtained from samples of dike rocks.

REGIONAL STRUCTURAL IMPLICATIONS

Geophysics

Field observations of the dike outcrops indicate that only the uppermost portions of these igneous bodies have been exposed by erosion, the proverbial "tip of the iceberg." The Lodore Canyon outcrop has been exposed for the longest time, possibly ten or more million years. The western outcrops appear to have been exposed only in the most recent stages of Pleistocene glaciation, probably less than 100,000 years. The relatively uniform nature of the rock from west to east suggests that the dikes were fed from a parent igneous body of unknown size which is not exposed anywhere in the region.

The first comprehensive geophysical mapping of the Uintas was conducted in 1955 and included gravity and magnetic surveys. The results, published by Behrendt and Thiel (1963), do not consider the presence of igneous rocks in the area surveyed. Additional work, an aerial magnetic survey, was undertaken by the U.S. Geological Survey in 1965 and this work, combined with other studies, including that of Behrendt and Thiel previously cited, was included in U.S. Geological Survey Bulletin 1230-1. The presence of "mafic dikes" shown on Plate 1 of Bulletin 1230-1, within and around the High Uintas Primitive Area, was not considered in the geophysical interpretation included elsewhere in the bulletin.

In February 1969, an aeromagnetic survey of the Uinta Mountains and adjacent basins was flown by GAI-GMX, Houston, Texas. An interpretation of this survey published that same year (Steenland, 1969) confirmed many of the general conclusions of the older published work but differed in several significant details. Of particular interest is the following observation (Steenland, 1969, p. 49):

> "The shallow magnetic material in T. 3-5 N., R. 2-4 W. may be intrusives or other forms of magnetized rocks occurring in the quartzites along the southern flank of the Uinta Mountains. They might also represent pieces of pre-Uinta Precambrian rock which have been caught up in fault slices. Note that the shallow magnetic material plunging westward in T. 1 N. is on strike with the local positive anomaly mapped by Behrendt and Thiel at approximately 40°41', 110°25' slightly west of the aeromagnetic survey."

Actually, the "shallow magnetic materials in T. 3-5 N., R. 2-4 W." described by Steenland are located about 5 to 8 miles south of the intersection of the north-south aeromagnetic flight line with the zone in which the igneous dikes are emplaced in Gilbert Creek Basin. The aeromagnetic survey, indeed, appears to have confirmed the presence of intrusive igneous rocks and strongly suggests that their surface outcrop has been displaced northward by major thrusting at depth.

Probable displacement of the dikes by northward thrusting is in accord with modern concepts of the deep-seated structure of the Uinta Mountains. An extensive literature exists on the structure of the Uintas dating back to the pioneer geologic surveys of the late 1800s. Beginning in the 1950s (Childs, 1950), it has become well established in the geologic literature that the Uintas are a flat-topped anticline

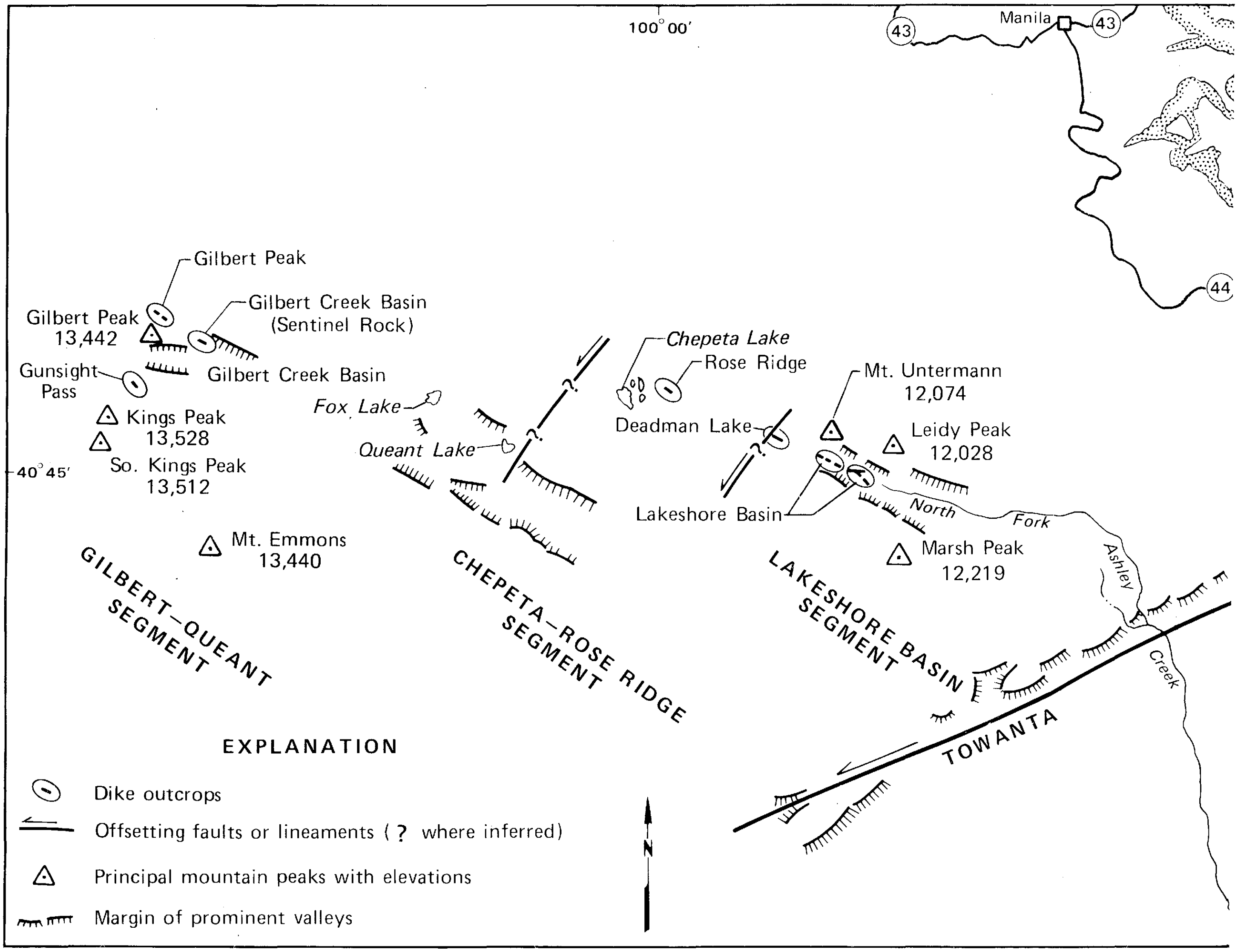


Figure 7. Map showing possible structural offsets along trace of dike.

of regional proportions with oversteepened flanks characterized by thrusting outward to north and south over the adjacent basins, Green River to north and Uinta to south. This structure has been described by Ritzma (1959; 1969; 1971), Eardley (1963), and Sales (1969), and in a number of papers by W.R. Hansen and other modern writers on the subject. The principal thrusting recognized is outward from the core to the north, a concept supported by the geophysical manifestation of the dike complex. More recent concepts of Uinta Mountain structure, as yet unpublished but well-known to petroleum explorationists, visualize the Uintas as mostly allochthonous.

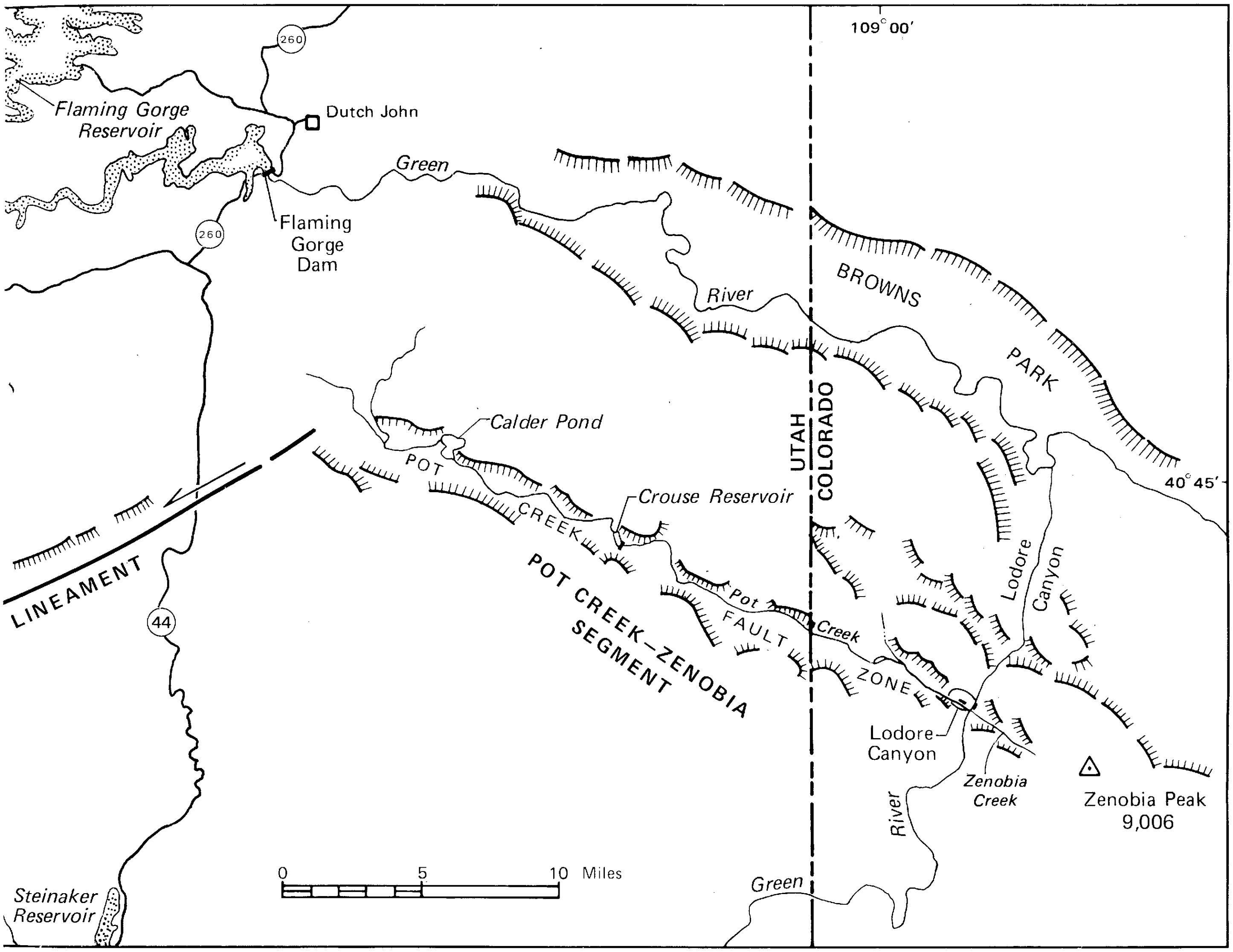
Strike-slip Faulting Within Uinta Mountains

The Uinta Mountains are criss-crossed by three sets of prominent joints and faults with the following average strikes:

WNW-ESE (N 65° to 70° W)
NNE-SSW (N 20° to 25° E)
ENE-WSW (N 65° to 70° E)

The igneous dikes have been intruded in a prominent fault and fracture system of N 65° to 70° W average strike. The dating of the dike rock as approximately late Cambrian or early Ordovician implies that the fault-fracture system into which the igneous rock was intruded is at least that old.

It is likely that the dike was intruded into a zone



of weakness that was, in early Paleozoic time, straight and continuous. When plotted on modern regional maps, the dike outcrops appear to be emplaced in a zone of fracturing and faulting that is now broken into at least four segments by major strike-slip faults of left lateral displacement. These are summarized in Figure 7 as follows:

Pot Creek-Zenobia segment (28 miles long - N 65° W strike).

- Broken by Towanta Lineament (N 65° E strike) (Ritzma, 1976).

Lakeshore Basin segment (17 miles long - N 65° W strike).

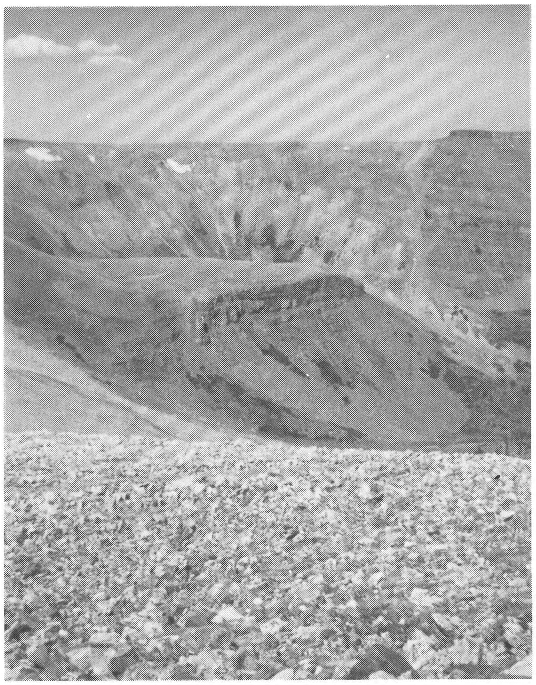
- Broken by unnamed fault? (N 35-40° E strike?).
- Displaced 16 miles to WSW by Towanta Lineament.

Chepeta-Rose segment (7 miles long - N 60° W strike).

- Broken by unnamed fault? (N 35-40° E strike).
- Displaced 1 mile to WSW at east end.

Gilbert-Queant segment (14+ miles long - N 60° W strike).

- Northwest termination not investigated (uncertain).
- Displaced 6 miles to WSW at east end.

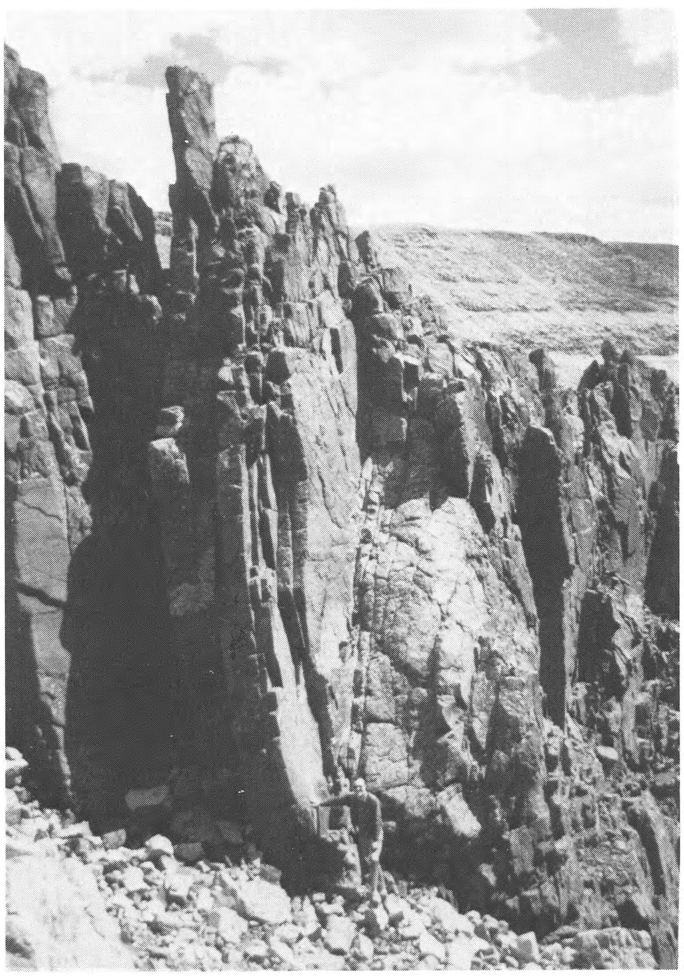


a.

H. R. Ritzma

b.

H. R. Ritzma



c.

H. R. Ritzma

Gilbert Peak and Gilbert Creek Basin.

Figure 8a. View from top of Sentinel Pass (12,580 feet) to east-northeast. Dike emplaced in fault zone (left of center) on spur leading from north flank of Gilbert Peak. Flexure and faulting exposed on cirque wall beyond. Fault (right) diverges from dike. Dike ends on far side of spur (not visible).

Figure 8b. Sentinel Rock, large dike outcrop, at east base of Sentinel Pass and northwest corner of Gilbert Creek Basin.

Figure 8c. West side of Sentinel Rock. Large xenolith of altered metasediments in dike above and to right of geologist.

H. R. Ritzma

a.

Deadman Lake — Gabbro Pass

Figure 9a. Blocky jointing in dike. Barite vein at border of dike. Precambrian Uinta Mountain Group quartzite forming wall rock at far left. Deadman Lake exposures.

b.

H. R. Ritzma

Figure 9b. Water-filled shaft sunk through felsenmeer. On strike of dike between Deadman Lake and Lakeshore Basin west of crest of Gabbro Pass.

Gabbro Pass and Lakeshore Basin

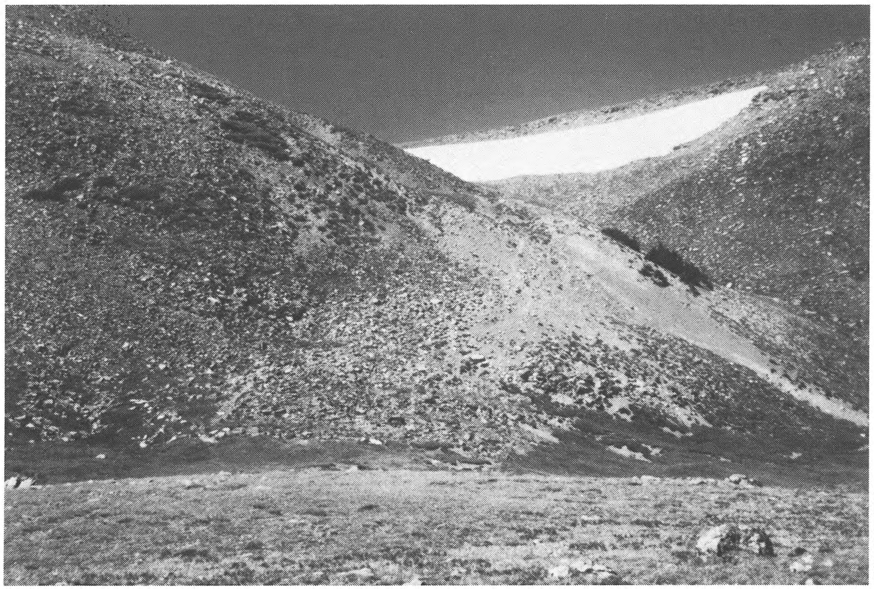


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Figure 10a. View to west at headwall of Lakeshore Basin, Uinta Highline Trail ascending Gabbro Pass. Dike exposed center of photo through cover of talus and scree (*see* diagrammatic section, Figure 5).

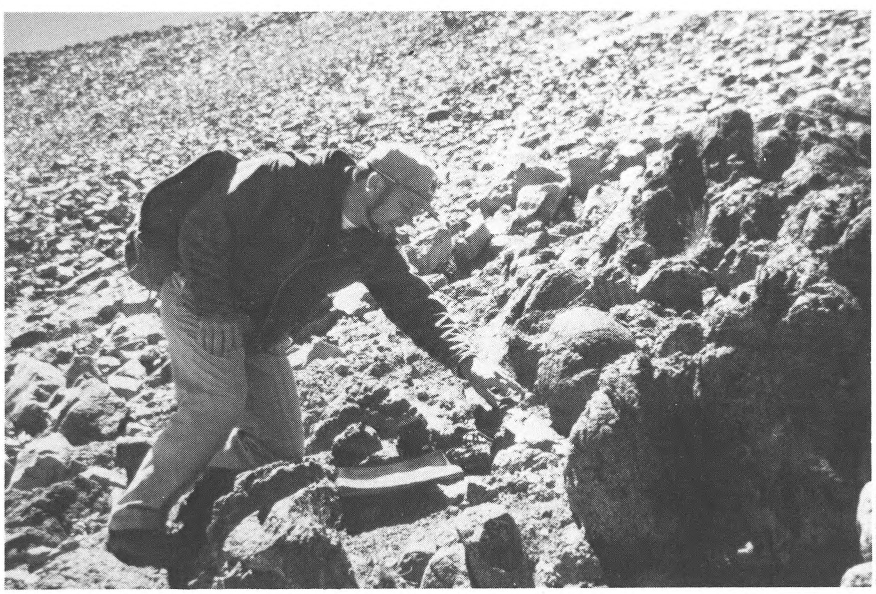

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Figure 10b. Spheroidal weathering of granular dike rock, headwall of Lakeshore Basin.

Lakeshore Basin

H. R. Ritzma

Figure 11a. Small prospect pit in dike on crest of ridge west of unnamed lake (10,792 feet), central Lakeshore Basin. Dike continues ahead and to left (north) of lake (notebook lower left for scale).

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Figure 11b. Massive outcrop of dike seen across unnamed lake (10,792 feet), central Lakeshore Basin.

The Towanta Lineament (Ritzma, 1976) is a deep-seated zone of major crustal disruption, probably originating in Precambrian time and intermittently active since. As recently as 1977 two moderate earthquakes occurred along the lineament near Moon Lake about 45 miles west-southwest of the area of postulated offset of the dike system by the lineament. Sixteen miles of left lateral displacement along the lineament in a span of 500 million years does not exceed a reasonable rate of movement for a structural feature of this magnitude.

The possible fault which offsets the dike system west of Deadman Lake is indicated on aerial photographs and corroborated by reconnaissance in the field. The possible faulting east of Queant Lake is indicated on aerial photographs, but the area has not been examined in the field.

The dike system, based on present knowledge, ends on the west side of Gunsight Pass and northwest of Gilbert Peak. This area has not been investigated in the field, and the presence of additional dike outcrops to the west is considered possible. Oral reports received from prospectors suggest the presence of dikes within the presently defined High Uintas Primitive Area.

CONCLUSIONS

Existence of widely scattered outcrops of igneous dikes that intrude the Precambrian medasediments of the eastern Uinta Mountains indicates that a body of igneous rock of unknown size and shape exists at depth beneath the mountain range. The parent igneous body, source of the dikes, apparently lies to the south of the surface outcrops which have been displaced northward by outward thrusting of the range from the core toward the flanks.

The dike was intruded in late Cambrian or early Ordovician time along a fault/fracture zone of present WNW-ESE trend. Probably continuous, the zone appears to have been broken since the intrusive episode by at least three faults with left lateral displacement.

Scant mineralization accompanied intrusion of the dikes. Composition of the dikes - diorite to gabbro - is notable for anomalous titanium content. However, the small areal extent of the outcrops and their widely scattered occurrence rule out any commercial importance or possible exploitation as a mineral resource.

More detailed examination of areas along the fracture zone into which the dike rock is intruded may lead to discovery of more outcrops overlooked in previous surveys. In particular, the western known end of the dike complex along the east boundary of the High Uintas Primitive Area appears to offer the most fruitful localities for discovery. Assays here (Crittenden, Wallace and Sheridan, 1967, Table 1) of fault breccia yielded consistently high titanium content, possibly indicating proximity of intrusive rock.

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UTAH GEOLOGICAL AND MINERAL SURVEY

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