PRELIMINARY GEOLOGIC MAP
OF THE LAKETOWN QUADRANGLE,
RICH COUNTY, UTAH

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UTAH GEOLOGICAL AND MINERAL SURVEY
a division of
Utah Department of Natural Resources and Energy

TO ACCOMPANY MAP 58    JUNE 1982
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INTRODUCTION

The south end of Bear Lake, Utah, had not been previously studied in sufficient detail to provide a geologic map at a scale of 1:24,000. The structural geology and regional structural relationships were not adequately known, and recent stratigraphic work in the region required recognition of new formations not previously mapped. The area is of interest because it lies in the Thrust Belt region, which has been the scene of several new discoveries of petroleum in Wyoming and Utah, and because it is part of a rapidly developing recreational area.

The Laketown quadrangle is located near the western boundary of the Wyoming ranges within the Middle Rocky Mountain geographic province. The area lies at the south end of Bear Lake Valley, is bounded on the west by the Bear River Range, and is bordered on the east and south by the Bear Lake Plateau.

Maximum relief in the area is 1,617 feet, with elevations ranging from 5,923 feet at Bear Lake (water level) to 7,540 feet near the south end of Laketown Canyon. Much of the area consists of a moderately dissected, plateau-like surface formed on the flat-lying Wasatch Formation of Tertiary age, which unconformably overlies older, dipping strata. Where streams have incised narrow canyons into the underlying Paleozoic and Mesozoic rocks, topography is rugged. Good bedrock outcrops are limited to ledge or cliff exposures within these canyons. An exception to this occurs in the northeast corner of the area where the hogback ridges along the lakeshore are composed of well exposed, overturned Mesozoic rocks.

The first geological investigations of the Laketown quadrangle were carried out by early government-sponsored surveys of the western territories. Reports of the King Survey (King, 1878) make no specific mention of the Laketown area, but the northern part of Map II (Utah Basin) extends into the southern portion of the Laketown quadrangle. The Hayden Survey (Hayden, 1872) passed through Bear Lake Valley in 1871 en route from Soda Springs, Idaho, to Evanston, Wyoming. Gale and Richards (1910) produced a map at a scale of 1:62,500 that included portions of T. 12 and 13N., R. 6 E. and mapped rocks of Ordovician age and younger. Richardson (1913) described the post-Cambrian Paleozoic rocks in the Bear Lake area and, based on field work done in 1912 and 1935, authored a U.S. Geological Survey Bulletin on the Randolph, Utah-Wyoming 30-minute quadrangle (Richardson, 1941), the only comprehensive study of the geology of the area including a geologic map at a scale of 1:125,000. The present study originated from a recently completed M.A. thesis by this writer (Valenti, 1980).

STRATIGRAPHY

General

Rocks exposed in the Laketown quadrangle have a total thickness of approximately 15,000 feet; rocks not exposed may increase the thickness of the sedimentary section by at least 6,000 feet. Listed units extend in age from the Precambrian to the Early Tertiary, all systems being represented except the Cretaceous. All of the exposed rock units of the Laketown quadrangle are sedimentary in nature. In addition there are unconsolidated units of Quaternary age of alluvial, colluvial, or lacustrine origins.

Precambrian-Cambrian Rocks

Brigham Quartzite – The oldest rocks exposed in the Laketown quadrangle are defined as the Brigham Quartzite, which crops out in isolated exposures along the western border of the area. The quartzite is fine to coarse sand size, locally pebbly to cobbly; is composed primarily of quartz, which appears to be recrystallized to a great degree and is quite dense; and is gray, light brown, to red-pink in color. Bedding is not everywhere discernable, but in places traces of crossbedding are observable. No fossils, but some possible borings, were found.

Exposures of the Brigham Quartzite are so incomplete and isolated from other units that no stratigraphic studies are possible. However, the lithology is different from any other in the area, making the unit easily distinguishable. Outcrops of the Brigham Quartzite are herein considered to be blocks involved in splay at the front of the Paris thrust fault.

Cambrian Rocks

Langston Formation – Only a partial section of the Langston Formation occurs in the Laketown area. In the west half, sec. 13, T. 12 N., R. 5 E., 594 feet of dusky blue to medium gray limestone and dolomite, weathering yellowish brown to light gray, crop out in ledges and small broken cliffs and are herein assigned to the Langston Formation. At this location in Laketown Canyon the Langston Formation is faulted against the younger St. Charles Formation, but the base of neither formation is exposed. The contact between the Langston Formation and the overlying Ute Formation is placed in a small gulley to the south (stratigraphically upwards) of...
which tan to green shale occurs interbedded with bluish gray limestone.

Ute Formation — In the southern portion of Lake-town Canyon, along the border between sec. 13 and 14, T. 12 N., R. 5 E., there is an exposure of thin-bedded limestone with interbedded shale banded above and below by thick-bedded, cliff-forming dolomite and limestone. The limestone within this interval is gray to blue, locally colored red, pink, or green; is laminated to thin-bedded; has a platy to slabby parting character; is locally oolitic; and contains some intraformational conglomerate. A fossiliferous specimen analyzed by Richard Robison (1979, written communication) of the University of Kansas yielded Ehmaniella, which is typically found in northeastern Utah within the Ute Formation (Robison, 1976, p. 100). The rocks in this interval are herein assigned to the Ute Formation. A measured section of the above exposures yielded a thickness for the Ute Formation of about 1,100 feet. This value seems abnormally high compared to thicknesses of the Ute Formation in the Bear River Range, where the thickness ranges between 685 and 790 feet (Maxey, 1958, p. 672). It is possible that the Ute Formation is actually thicker in the Laketown area than in the Bear River Range exposures. However, the abnormal thickness is more likely due to repetition of part of the unit by unidentified reverse faulting or error in my measurement. Repetition by reverse faulting is typical in this region.

Blacksmith Dolomite — A cliff-forming, gray to bluish, sugary-weathering dolomite occurs in the southern part (sec. 14, 23, and 26, T. 12 N., R. 5 E.) of Lake-town Canyon and is herein assigned to the Blacksmith Dolomite. Some intervals of the unit are silty and cross laminated, and others are oolitic. The base of the Blacksmith Dolomite marked by the transition from drab, shaly slopes of the Ute Formation to thick-bedded, ledge- and cliff-forming dolomite. Creek bed exposures in the southern half of sec. 26, T. 12 N., R. 5 E., just south of the map area, show this thick-bedded carbonate unit to be overlain by green shales and nodular limestone of what appears to be the Bloomington Formation. A 329 foot partial exposure of the Blacksmith Dolomite was measured in the SE¼, sec. 14, T. 12 N., R. 5 E. Estimates of total thickness of the unit in the region range from 235 feet (Williams, 1948, p. 1133) near the type locality to 725 feet (Richardson, 1941, p. 21) west of Garden City, Utah.

St. Charles Formation — Exposures of the Bloomington and Nounan formations, normally found between the Blacksmith Dolomite and St. Charles Formation, are not found in the quadrangle. Partial exposures of the St. Charles Formation occur in the mapped area, and 647 feet of gray limestone and dolomite, which weather tan with sugary surfaces, were measured near the center of sec. 13, T. 12 N., R. 5 E. Strata of the Middle Cambrian Langston are faulted against the St. Charles Formation, and the base of neither formation is exposed. Upwards, the contact between the St. Charles Formation and the overlying Garden City Limestone is marked by a change from thicker bedded, gray to tan ledges and small cliffs to thin-bedded, platy limestone.

Ordovician Rocks

Garden City Limestone — The Garden City Limestone consists of light gray to bluish gray, laminated to thin-bedded limestone with abundant intraformational conglomerate and layers of fossil hash. The unit outcrops as a distinctively ledgy interval of platy looking limestone. An exposure in NW¼, sec. 13, T. 12 N., R. 5 E. was found to be 947 feet thick. The Garden City Limestone is also exposed at the mouth of Laketown Canyon and at the base of the low hills, covered with the Tertiary Wasatch Formation, one to two miles west of Laketown.

Fish Haven Dolomite — This unit was not positively identified in the quadrangle, but may locally be present at the top of the Garden City Formation in Lake-town Canyon. At that location 170 feet of dark weathering, thick-bedded, cherty dolomite is present at the top of the Garden City Formation.

Silurian Rocks

Laketown Dolomite — The Laketown Dolomite was named by Richardson (1913, p. 410) from exposures of “massive light gray to whitish dolomite, containing lenses of calcareous sandstone” located in the southeast fork of Lake-town Canyon along what was at that time the Laketown—Randolph road. He noted that the Laketown Dolomite was actually a magnesian limestone, estimated the formation to be about 1,000 feet thick, and assigned the unit to the Middle Silurian. Budge (1966) obtained a total thickness of 952 feet at the type locality and recognized two members. Although the formation appears monotonous and indistinct upon cursory examination, the rocks are fairly readily distinguished from adjacent units by their overall whitish weathering character and thick bedding. The lower contact is poorly exposed, may be gradational, and is marked by the change from dark gray, cherty dolomite of the upper Garden City Formation (possibly the Fish Haven Dolomite) to light gray dolomite of the Lake-town Dolomite. The upper contact is marked by the change from dark gray, very thick-bedded dolomite of the upper Laketown Dolomite to light gray, laminated dolomite of the basal Water Canyon Formation. The Laketown Dolomite is a strong cliff-former.
Devonian Rocks

Water Canyon Formation — This unit is a slope former and is typically exposed as scattered dolomite ledges cropping out on grass covered slopes. Brown sandstone float and fish scales preserved on shaley partings occur on the grassy slopes. A thickness of 238.5 feet was obtained in sec. 17, T. 12 N., R. 6 E.; Williams and Taylor (1964, p. 51-52) listed a thickness of 253 feet for exposures in sec. 7, T. 12 N., R. 6 E. The thinness and nonresistant character of the formation made mapping it difficult. Contacts could be confidently located only at a few exposures; thus, most contacts of the formation on the accompanying map are approximately located or inferred. Williams and Taylor (1964, p. 38-53) recognized two members. In sec. 8, T. 12 N., R. 6 E., the unit could not be identified by the present writer between cliff exposures of the overlying Hyrum Dolomite and the underlying Laketown Dolomite.

Hyrum Dolomite — In the Laketown area the Hyrum Dolomite is a distinctive cliff-forming unit composed primarily of laminated to thick-bedded, dark brown weathering, cliff-forming dolomite. The middle and upper portions contain poorly exposed beds of calcareous, yellowish, cross-bedded quartz sandstone. The lower contact is well defined in the southeast fork of Laketown Canyon. There a ledge of light gray, sugary weathering dolomite of the Water Canyon Formation is overlain by a dark brown dolomite which forms cliffs at the base of the Hyrum Dolomite. The upper contact is poorly defined and appears to be gradational. Where exposed (sec. 17 and 18, T. 12 N., R. 6 E.), the contact is arbitrarily placed at the base of the lowermost yellowish to orangish gray limestone above the brown dolomites and interbedded calcareous sandstones of the upper Hyrum Dolomite.

Benson (1966, Figure 10) showed approximately 670 feet of what he called Jefferson Formation located between the Water Canyon and Beirdeanu formations in Laketown Canyon. The present writer measured 702 feet of Hyrum Dolomite at the same exposures.

Three Forks Formation (Beirdeanu) — Rocks in the Laketown area between the Hyrum Dolomite and the Lodgepole Limestone have been called both the Three Forks Limestone and the Beirdeanu Formation. In the mapped area, the Three Forks Formation consist of ledges of yellowish gray, silty and argillaceous limestone, and sandy, shaly, limestone intraformation breccia which Williams (1971, p. 228) suggested might be a solution breccia. Halite casts, mudcracks, and possible solution veining occur within rocks of the unit. The Three Forks Formation is generally a nonresistant unit, forms slopes, and is poorly exposed. However, due to its deep orange-red color and the fact that the formation is bounded above and below by resistant, thick-bedded, well exposed carbonates, the stratigraphic interval occupied by the Three Forks Formation can be easily recognized.

Mississippian Rocks

Lodgepole Limestone — The Lodgepole Limestone is generally thin bedded, cherty, medium gray with thicker interbeds of phaneritic, bioclastic, and crinoidal limestone. The unit is a strong cliff former underlain and overlain by slope forming units. The only complete exposure of the formation is along Utah Highway 30 in Old Laketown Canyon, where the unit crops out on the vertical east limb of an anticline. Partial and less well exposed outcrops occur south along the same anticline, where the Lodgepole Limestone caps the divide between the canyons, and at the mouth of the southeast fork of Laketown Canyon, where the Lodgepole Limestone crops out in the resistant trough of a syncline.

The present writer obtained a thickness of 703 feet for the Lodgepole Limestone in Old Laketown Canyon whereas Sando and others (1959, p. 2762) suggest an approximate thickness of 600 feet. Because of structural complications, especially deformation due to interbed slip, thickness estimates are unreliable in the steep limb of the anticline across which Old Laketown Canyon is incised.

Little Flat Formation — This unit correlates with the lower portion of Richardson's (1913) Brazer Limestone. About 100 feet of brown shale, oolitic phosphorite, and cherty limestone occur at the base of the formation; this nonresistant interval forms a slope in contrast to the ledges and cliffs formed by limestones of the underlying Lodgepole Limestone. The remaining 600 feet of the formation consist of interbedded sandy, cherty dolomite and limestone, and medium to thick-bedded, brown weathering, calcareous quartz sandstone.

The Little Flat Formation is moderately to poorly exposed. Above the stream gully exposures of the basal phosphatic interval the formation is typically exposed as vertical ledges scattered amid talus piles and grassy slopes. The upper contact, which crops out only on the north side of the highway in Old Laketown Canyon, is here considered to occur at the base of the lowermost ledge of thick-bedded, bioclastic limestone of the Monroe Canyon Limestone. Total thickness of the Little Flat Formation is approximately 700 feet.

Monroe Canyon Limestone — The only outcrop of the Monroe Canyon Limestone within the map area occurs in sec. 32, T. 13 N., R. 6 E., where a thickness of 287 feet was obtained by the present writer. Thick
bedded, light gray weathering bioclastic limestone 127 feet thick occurs at the base of the formation. This is overlain by 51 feet of cherty limestone, which are in turn overlain by 109 feet of bluish gray, phaneritic dolomite. The Monroe Canyon Limestone is a resistant unit and forms steeply dipping, overturned ledges.

**Pennsylvaniaian Rocks**

**Wells (?) Formation** — A 579-foot thick interval of interbedded calcareous quartz sandstone and chert, sandy limestone is poorly exposed in a ¼ mile north-south trending strip at the junction of Old Laketown and Six Mile canyons, sec. 32, T. 13 N., R. 6 E. This stratigraphic interval was referred to as the Weber Quartzite by Gale and Richards (1910, Plate XII) and by Williams (1953, 1955, 1962); it was called the Wells Formation by Richardson (1913, p. 414-15). The interval consists of “fine- to medium-grained quartzite sandstone and sandy dolomite with minor interbeds of coarse-grained limestone breccia and fine-grained dolomite (Sando and others, 1959, p. 2766).” The distinct lower contact of the Wells (?) occurs at the change from resistant, thick-bedded, clean dolomite of the uppermost Monroe Canyon Limestone into poorly exposed sandy limestone and calcareous sandstone. The upper contact is not exposed but is assumed to occur at the base of the phosphatic interval of the overlying Phosphoria Formation.

**Permian Rocks**

**Phosphoria Formation** — Poor exposures of the Phosphoria Formation occur along a north-south strip in sec. 32, T. 13 N., R. 6 E. in Six Mile Canyon. A 40 foot phosphatic brown shale occurs at the base of the formation and is overlain by 160 feet of olive gray to yellowish orange, resistant chert and cherty debris covered intervals. These units probably represent the Meade Peak Phosphatic Shale and the Rex Chert Members respectively. The upper Cherty Shale Member may or may not be present.

The lower contact of the formation is poorly exposed and is assumed to occur at the base of the dark phosphatic shale. The upper contact is arbitrarily drawn at the top of the uppermost chert exposure, but strata above the chert may be transitional into the overlying Dinwoody-Woodside Formation.

**Triassic Rocks**

**Dinwoody-Woodside Formation** — The Dinwoody-Woodside Formation is exposed in the east central portion of the quadrangle on the overturned, west dipping, anticlinal flank. In the northern part of this exposure resistant limestones hold up small dipslope forming ridges along the north face of Six Mile Canyon. Scarp faces of the ridges are littered with drab to maroon siltstone and limestone debris. Pelecypods, linguloid brachiopods, and coiled cephalopods are the most conspicuous fossils found within the unit.

The contact between the underlying Phosphoria and the Dinwoody-Woodside formations could not be positively identified by the present writer. It is inferred to occur at the top of the uppermost chert of the Phosphoria Formation. The upper contact occurs at the base of the prominent, massive limestone considered regionally to represent the base of the Thaynes Formation. Estimated thickness of the Dinwoody-Woodside Formation is 1,175 feet.

**Thaynes Formation** — The Thaynes Formation in the Laketown area consists of brown weathering limestone and olive gray, calcareous siltstone and shale bounded above and below by prominent, massive limestones. The lower massive limestone appears to be the Meekoceras bearing limestone recognized regionally as the base of the Thaynes Formation.

The formation is fossiliferous throughout and locally contains abundant ammonoid cephalopods and gastropods. Petroliferous (“bleeding”) concretions occur locally. The Thaynes Formation crops out in a north-south band across which Old Laketown and Six Mile canyons are cut. In this outcrop band the beds are overturned and dip westward, and the formation is 1,060 feet thick. A few small outcrops of the Thaynes Formation occur at the base of the overturned Mesozoic sequence north of the Six Mile Canyon exposures.

**Ankareh Formation** — The Ankareh Formation in the Laketown area is herein considered to comprise all strata between the prominent limestone at the top of the Thaynes Formation and the sandstones of the Nugget. The unit consists primarily of reddish shales and siltstones and gray to red limestones; these lithologies appear to grade into one another both laterally and vertically. The middle portion of the formation contains several hundred feet of friable sandstone, the color of which ranges from white, yellow, orange, red, to maroon. These beds are probably equivalent to the Timothy Sandstone (Mansfield, 1927, p. 91-93). A thin lens of gritstone, perhaps equivalent to Mansfield's (1927, p. 95) Higham Grit, was observed just east of the center of sec. 33, T. 13 N., R. 6 E.

The Ankareh Formation is the easternmost exposed unit of the overturned anticline east of Laketown. The unit is also exposed in a two mile long band on the flanks of the ridge at the southeast corner of Bear Lake. At the latter locality, the unit is well exposed in a series of red colored, overturned, west dipping hogbacks. A measured partial exposure of the Ankareh Formation in NW¼ sec. 4, T. 12 N., R. 6 E. was found to be 938 feet thick. At the stratigraphic top of this exposure a small ridge of red siltstone and shale overlying by a ledge of limestone passes beneath Tertiary Wasatch cover.
Jurassic Rocks

Nugget Sandstone — The Nugget Sandstone is exposed only on the flanks of the highland at the southeast corner of Bear Lake. The unit is a medium to very thickly crossbedded, fine-to medium-grained, well rounded quartz sandstone. The rocks are generally red in color but in some places are grayish white. The red color is presumably due to hematite coating of the quartz grains. Although the Nugget Sandstone is well exposed in the map area, the exposures are incomplete and were not measured. Richardson (1941, p. 29) suggested a thickness of at least 1,000 feet. Personnel from Chevron, U.S.A. suggested (P. R. Lamerson, 1979, personal communication) a thickness of 1,300 feet based on recent drilling data.

Tertiary (Eocene) Rocks

Wasatch Formation — Throughout the map area the Wasatch Formation unconformably overlies all older formations and obscures contact relations and structural features. Good exposures of underlying units are limited to canyons that have been eroded through the Wasatch Formation cover. Rocks of the Wasatch Formation were derived from erosion of areas uplifted during the latter stages of Sevier thrusting. Apparently, the Wasatch Formation sediments rapidly buried pre-existing topography and structure. Local depositional dips would therefore be expected, but bedding in the Wasatch Formation is indistinct to absent and attitudes generally cannot be determined. The predominant lithology is gray, buff, and red sandstone, and conglomerate; gray to red siltstone, shale, and limestone also occur. Clasts of the conglomerates appear to be mostly quartzite, limestone and dolomite, and chert; the cement is calcareous. A conspicuous feature within the Wasatch Formation is the presence of gray oncotic or pisolithic limestones. Due to the erosion of the upper portion of the unit, a complete exposure of the Wasatch Formation does not occur in the area. Initially, the formation was probably over 1,000 feet thick.

STRUCTURE

The Laketown quadrangle is located approximately in the center of the Wyoming-Idaho-Utah thrust belt salient of the Cordilleran foldbelt (Blackstone, 1977, 1981). Folds, typically overturned to the east (in the direction of tectonic transport), are associated with and generally parallel to the thrust faults. Younger normal faults, many of which are evidently (Royse and others, 1975) listric in nature, are superimposed on the folds and thrust faults. The exact structural setting of the map area is unclear. Several regional faults appear to converge at the south end of Bear Lake, but critical relationships are concealed by the Wasatch Formation, which unconformably overlies the bedrock geology. Bear Lake and sediments filling Bear Lake Valley are additional obscuring factors.

Faults

Frontal Imbrications of the Paris Thrust Fault – The Paris thrust fault parallels the east side of the Bear River Range. Exposures of the Brigham Quartzite in secs. 10, 15, and 22, T. 12 N., R. 5 E. are herein considered as inliers contained within the toe of an imbrication of the Paris thrust fault. Cross sections A-A’ and B-B’ show that an inferred thrust fault immediately east of the quartzite exposures placed Brigham Quartzite in contact with Garden City Limestone. A minimum stratigraphic separation of about 6,000 feet is necessary to explain stratigraphic relations along the Paris thrust 2½ miles west of the northwest corner of the map area and 1½ miles east of Garden City, Utah (Richards, 1941, map). This inferred fault is not exposed in the Laketown quadrangle.

A NNW trending fault is exposed for about 2,000 feet in sec. 13, T. 12 N., R. 5 E. in Laketown Canyon. There are no exposures of the fault plane on which dip can be determined. The fault places Langston Formation of Middle Cambrian age in contact with St. Charles Formation of Upper Cambrian age, indicating a stratigraphic separation of about 3,600 feet. This fault is herein interpreted to be a frontal splay of the Paris thrust fault (see section D-D’).

Interpretation of the faults along the western border of the Laketown quadrangle as thrust faults rather than as normal faults is more consistent with the geology of adjacent areas (northwest of map area) and with regional structural style. The only evidence of normal faulting along the southwest lakeshore was found in a roadcut along Utah Highway 30 approximately two miles north of the northwest corner of the map area (sec. T. 13 N., R. 5 E.), where strata within the Wasatch Formation are offset a few tens of feet by a NE-SW striking normal fault (see map by Kaliser, 1972).

Meade (?) Thrust Fault — Exposures of the Nugget Sandstone along the eastern lakeshore north of the map area appear to be bordered on the west by a concealed fault that is probably a southward extension of the Meade thrust fault. The Meade (?) thrust fault is considered to underlie the map area (its presence is suggested by seismic profiles), and it apparently is the dominant structural feature in the Laketown quadrangle.

Crawford Thrust Fault — Exposures of the Crawford thrust fault occur 1½-1½ miles southeast of the map area and are located within and east of the Crawford...
Mountains along the Utah-Wyoming border. Seismic data indicate that the Crawford thrust fault joins the regional detachment zone (at approximately −30,000 feet elevation) above the basement at the longitude of Bear Lake. Wells of the Hobgback Ridge field just east of the map area penetrate faults that are probably trailing edge splay of the Crawford thrust fault. These relationships are depicted on cross section D-D'.

Transverse Faults Northeast of Laketown — Two transverse faults were mapped one to two miles northeast of Laketown. In the NE¼ sec. 29, T. 13 N., R. 6 E. a NW-SE striking transverse fault is inferred to offset the Nugget Sandstone with right-lateral motion. Since the fault plane is not exposed dip cannot be determined. No marker bed could be located with which to determine amount of offset, but the offset appears to be slight.

In SW¼ sec. 29, T. 13 N., R. 6 E. a more prominent E-W transverse fault occurs between the N-S striking Hyrum Dolomite (to the south of the fault) and the NW-SE striking Nugget Sandstone (to the north of the fault). The trace of the fault is exposed for a distance of approximately 1,000 feet, but there are no exposures of the fault plane on which dip can be determined. Inferred continuations of the fault are also shown on the map. This transverse fault might be a tear fault offsetting the elsewhere concealed trace of the N-S striking Meade (?) thrust fault in a left lateral manner. Alternatively, the transverse fault might be a part of a re-entrant in the Meade (?) thrust. Lack of adequate exposure of the fault prohibits discrimination between the two alternatives, but the lack of drag effects adjacent to the fault might support the latter interpretation.

Inferred Normal Fault — Most Wasatch Formation beds in the Bear Lake Plateau are nearly flat-lying or dip very gently eastwards. A small exposure of the Wasatch Formation was mapped near the center of sec. 17, T. 13 N., R. 6 E. At this location the strata of the Wasatch Formation strike N-S and dip westward at about 30°. These strata appear to be conformable with adjacent rocks of Triassic and Jurassic age. However, at this location the Wasatch Formation beds lie on top of an overturned sequence of Mesozoic rocks. These anomalous relations can be explained in the following manner. In this vicinity, as elsewhere in the region, strata of the Wasatch Formation were deposited unconformably on the eroded edges of upturned Paleozoic and Mesozoic strata. At this location normal faulting occurred and was perhaps related to larger scale normal faulting along the east side of Bear Lake (see section A-A'). Normal drag of Wasatch Formation strata along a west dipping normal fault (inferred to occur along the eastern boundary of the Wasatch Formation exposure) rotated the Wasatch Formation into its present attitude.

Folds

Laketown Anticline — The homoclinal succession of steeply dipping to overturned beds in Old Laketown Canyon is the eastern limb of what is here informally called the Laketown anticline. This anticline is the most prominent exposed structural feature in the Laketown quadrangle and appears (see sections B-B' and D-D') to be a hanging wall anticline in the toe of the Meade (?) thrust sheet.

To the north in Old Laketown Canyon and at the mouth of Laketown Canyon the axial trace of the fold trends N-S. Southwards the axial trace swings eastward so that at the south end of the anticline the axial trace trends NNW. Throughout its exposed length the fold plunges south to southeast. A northeast plunging southern extension of the fold may be present in sec. 16 and 22, T. 12 N., R. 6 E. The Laketown anticline is a moderately tight fold in its central and northern parts, but a southward decrease in the amount of dip of the limbs indicates that the anticline opens to the south (see sections B-B', C-C', D-D'). The anticline is strongly asymmetrical to the east. Whether the anticline continues northward into Bear Lake Valley or is truncated by the transverse fault described above could not be established on the basis of surface geology.

Unnamed Syncline — A southward plunging syncline occurs at the junctions of Laketown Canyon and its southeast fork and extends northward for 2½-3 miles. The resistant Lodgepole Limestone occupies the trough of the syncline, which is best developed in sec. 17 and 18, T. 12 N., R. 6 E. The contacts are not well expressed at this locality, but no evidence was found for the "obscure faults" of Richardson (1941, p. 40). The sinuous axial trace trends parallel to the axial trace of the Laketown anticline, and the syncline appears to be closely related to the Laketown anticline — the two forming a syncline-anticline couplet at the leading edge of the Meade (?) thrust sheet. In contrast to the anticline, the syncline is more open at its northern end and is tighter to the south.

Small Unnamed Folds — Near the south end of Laketown Canyon the Middle Cambrian section is folded into a gentle syncline. Horizontal beds of the Blacksmith Formation occur in the trough of the fold. The axial trace of the syncline trends NNW across Laketown Canyon and appears to trend N-S farther southward. Total length of the fold appears to be about two miles. The syncline is located between two faults interpreted as frontal splay of the Paris thrust, and the fold probably terminates where the splays merge. Formation of the syncline is presumably related to the faulting.

A small anticline within the Brigham Quartzite occurs in the northwest corner of the map area. Although bedding in the Brigham Quartzite is poorly
expressed, it appears that strata along the lakeshore in sec. 15, T. 13 N., R. 5 E. are overturned. The axial trace of the fold trends approximately N-S, and the fold is about two miles in length. The fold is strongly asymmetrical and locally overturned to the east. This anticline is probably a small hanging wall anticline related to the frontal imbricate fault of the Paris thrust described above.

**ECONOMIC GEOLOGY**

**Oil and Gas** — In recent years the Wyoming-Idaho-Utah Thrust Belt has received renewed attention by industry as a possible major petroleum province. Petroleum potential of the Thrust Belt was analyzed by Monley (1971) and Powers (1977), and recent activity was summarized by Petroleum Information Corporation (1978) and Ver Ploeg (1979). Most of the exploration and drilling activity to date has occurred in Wyoming along the eastern margin of the belt where, typically, Paleozoic and Mesozoic reservoir rocks in a hanging wall anticline are thrust over Cretaceous source rocks in the footwall.

In October 1977, American Quasar 20-1 Hogback Ridge (NE ¼ SE ¼, sec. 20, T. 13 N., R. 7 E.) well discovered natural gas in the Triassic Dinwoody-Woodside and Permian Phosphoria formations less than five miles east of the map area. Although this well indicated tremendous potential gas flow, it was offset in three directions by unsuccessful test wells. Some of the subsequently drilled wells within and east of the map area had gas shows but did not yield commercial production. Hogback Ridge is, at present, a one-well gas field and the northernmost producing field in the Thrust Belt in Utah.

Rocks within the map area contain several elements essential to a petroleum prospect. Nearly every formation from the Devonian Water Canyon to the Jurassic Twin Creek is a potential reservoir and almost half of them are proven reservoirs in the region. The phosphatic shales within the Mississippian Little Flat and Permian Phosphoria formations and intervals within the Triassic Dinwoody-Woodside and Thaynes formations are possible source rocks. Additional drilling will prove whether or not these factors occur in the proper combination of geometry and geologic history.

**Phosphate**

There are two phosphatic horizons within the sedimentary section exposed near Laketown: the basal part of the Little Flat Formation of Mississippian age, and the Phosphoria Formation of Permian age. Both are exposed on the vertical to overturned limb of the anticline east of Laketown, the former unit in Old Laketown Canyon and the latter in Six Mile Canyon. These deposits were sampled and analyzed (Gale and Richards, 1910, p. 522-26) in early investigations of the western phosphate field, and average values ranging from 13.7 percent to 36.6 percent \( P_2O_5 \) were reported. More recently, Cheney (1957) provided further chemical analysis and information on the genesis of phosphate in the region. He considered the deposit within the Phosphoria Formation near Laketown to be one of the thickest and highest grade deposits of acid- and furnace-grade phosphate rock in Utah. However, Cheney concluded, as did Gale and Richards, that due to economic conditions, the Laketown deposits should be considered a reserve rather than as a primary immediate source of phosphate. Prospect pits occur at outcrops of both units, and an old shaft remains at the exposure of the Phosphoria Formation in Six Mile Canyon. Evidently these deposits never were developed. The phosphate bearing shales within the Phosphoria Formation are documented (Sheldon, 1967) as being source rocks for hydrocarbons.

**Building Materials**

**Sand and Gravel** — Lake sediments, especially beach and bar deposits and including abandoned shoreline features (Williams and others, 1962, p. 24-36) are possible sources of sand and gravel. Additional sources include the Wasatch Formation and, perhaps, some of the reworked gravely materials occurring as slope wash and alluvial fans.

**Riprap** — The Nugget Sandstone and Brigham Quartzite are likely sources for riprap and materials for other civil engineering purposes. A readily available supply is the angular talus material typically found down slope from outcrops of the Nugget Sandstone.

**Building and Paving Stone** — The Brigham Quartzite and Nugget Sandstone are two possible sources of building and paving stone. Both are hard, durable, well exposed, and possibly attractive rock units. As Kaliser (1972, p. 26) states, the Mormon Tabernacle in nearby Paris, Idaho, is built entirely of the Nugget Sandstone. In Laketown the Nugget Sandstone was also used in the construction of a Mormon church. Some of the carbonate rocks abundant in the area may be useful for building purposes.

**Limestone and Dolomite** — The sedimentary section in the Laketown quadrangle is composed primarily of carbonate rock including limestone, magnesian limestone, and dolomite. Such rock materials are useful as refractory material, in the manufacture of lime, carbon dioxide and cement, and might be potential sources of magnesium and magnesium carbonate. Kaliser (1972, Table 6) presented chemical analyses of carbonate rocks exposed in Old Laketown Canyon roadcuts.
Manganese

Manganese occurring in the Lodgepole Limestone is exposed in an abandoned quarry or prospect pit near the center of sec. 9, T. 12 N., R. 6 E. In this isolated exposure structural trends diverge from regional; the rocks have apparently undergone strong local deformation, resulting in the development of fractures, slickensides, rods, and mullions. Although the mineralogy was not studied in detail, the manganese appears to be a wad associated with euhedral calcite and iron oxides including amorphous hematite, limonite, and goethite. The textures exhibited, including colloform, botryoidal, and frambooidal varieties, are typical of colloidal deposition. The deposit appears to be secondary in origin and probably formed by weathering of a limestone that originally contained relatively high concentrations of manganese and iron.

Crittenden (1951, p. 33-34) briefly discussed these exposures, referred to them as the Lakeview claims, and presented results of metallurgical tests performed by the U.S. Bureau of Mines on samples from this locality. The results he presented included a figure of 21.3 percent Mn for one of the samples. He suggested that the dominant manganese mineral is pyrolusite. No economic exploitation of the deposit is known to the present writer.

Water

Bear Lake is utilized as a reservoir to regulate the flow of the lower portion of the Bear River and for power generation. A few farmers in Laketown use lake water for crop irrigation. The lake is currently a popular recreation facility, and the sandy beach at the south end has recently been converted into a state park.

Ground water is readily available in the lowlands around Laketown; shallow wells are sufficient for its retrieval. Springs are fairly abundant in the area, and six are located on the U. S. Geological Survey topographic map of the quadrangle. Some springs seem to be related to faulting (for example, those in sec. 28 and 29, T. 13 N., R. 6 E.). Others may be located at the contact of permeable portions of the Wasatch Formation with impermeable underlying rocks or “issue from solution channels in limestone” (Richardson, 1941, p. 50). The spring water is used for irrigation purposes, in livestock watering tanks, and for human consumption. The Laketown city water supply is taken from a spring located in sec. 7, T. 12 N., R. 6 E. A spring in sec. 26, T. 12 N., R. 5 E. is the main source of water for the creek in Laketown Canyon, which Hayden (1872, p. 157) referred to as Spring Creek.

REFERENCES


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The Survey publishes bulletins, maps, a quarterly newsletter, and other publications that describe the geology of the state. Write for the latest list of publications available.

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