GEOLOGIC MAP OF THE LEMAY ISLAND QUADRANGLE, BOX ELDER COUNTY, UTAH

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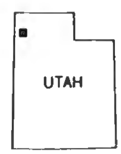

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GEOLOGIC MAP OF THE LEMAY ISLAND QUADRANGLE, BOX ELDER COUNTY, UTAH

By David M. Miller [1] and Linda L. Glick [2]

INTRODUCTION

The Lemay Island quadrangle in northwest Utah (fig. 1) comprises lowland of the Great Salt Lake Desert, the northern end of the Silver Island Mountains (known as Crater Island), and part of the Little Pigeon Mountains and Lemay Island. In this part of Utah, "island" is commonly applied to a mountainous feature that rises from mud flats or other flatland of the desert. Lemay Island, at an elevation of 4,906 feet (1,495 m), is the highest point in the quadrangle; the lowest point is slightly under 4,240 feet (1,292 m) near Crater Island. The flatland in the quadrangle is divided into two realms—(1) anastomosing stream deposits, eolian sands, and alluvial fan deposits that slope gently southward to the Grouse Creek sinks, where ephemeral streams derived from Grouse Creek stop (fig. 1); and (2) white mud flats or playa deposits along the south margin of the quadrangle, most of which are part of the Pilot Valley playa described by Lines (1979).

Mountainous parts of the Lemay Island quadrangle are underlain by Devonian to Permian sedimentary rocks of the Cordilleran miogeocline, by Jurassic granitoid rocks, and by Tertiary lava. The Paleozoic strata, which accumulated under shallow-marine conditions on the ancient continental shelf, are generally similar to those in the northern Pilot Range about 3.7 miles (6 km) to the west (Miller, 1984) but differ in important respects with those exposed to the north at Bovine Mountain (Jordan, 1979), to the south in the Silver Island Mountains (Miller, 1984), and to the east in the Newfoundland Mountains (Allmendinger and Jordan, 1984). The remainder of the quadrangle is covered by surficial deposits of Quaternary age, including alluvium, lake sediments, and eolian sand. Much of the Quaternary surficial sediment was deposited in Pleistocene Lake Bonneville, which covered the entire quadrangle at its high stand. The major structural features and physiography of the quadrangle—mountain ranges composed of pre-Cenozoic rocks and broad valleys filled with thick sequences of Cenozoic strata—resulted from one or more episodes of upper crustal extension in Neogene time.

Previous geologic studies in the quadrangle include Doelling's (1980) small-scale geologic map and Anderson's (1960) detailed study of Crater Island. Companion reports to this one include the Pigeon Mountain, Jackson, and Lucin 4 NW quadrangles (fig. 1; Glick and Miller; 1986; in press; Miller and Glick, in press).

STRATIGRAPHY

Devonian Rocks

The Guilmette Formation (Dg) occurs in an isolated hill at the south end of the Little Pigeon Mountains. The hill contains highly faulted and fractured light-gray limestone and dolomite, and subordinate dark-gray to black dolomite. Abundant *Amphipora* and algal heads occur in some beds, and one section about 66 feet (20 m) thick contains quartz sand disseminated in a limestone matrix as is typical of the upper part of the Guilmette in the Pilot Range (Miller and Schneyer, 1985).

Mississippian Rocks

The Tripon Pass Limestone (Mtp) in the Little Pigeon Mountains lies disconformably beneath the Strathearn(?) Formation. It is poorly exposed, and consists mostly of thin-bedded, black, silty limestone. Rare thick beds of limestone contain abundant crinoidal debris. *Phycosiphon* trace fossils occur in the silty limestone. Conodonts recovered from silty limestone 7 feet (2 m) below the top of the unit (Table 2, location 2) and from fossiliferous limestone more than 50 feet (15 m) below the top of the unit (Table 2, location 3) are late Kinderhookian (late Early Mississippian). The unit is correlated on the basis of age and lithology with the Tripon Pass Limestone in the Pilot Range (Miller and Schneyer, 1985). Thick limestone beds of crinoidal debris in the Tripon Pass in the Little Pigeon Mountains are absent in exposures of the unit in the Pilot Range. These

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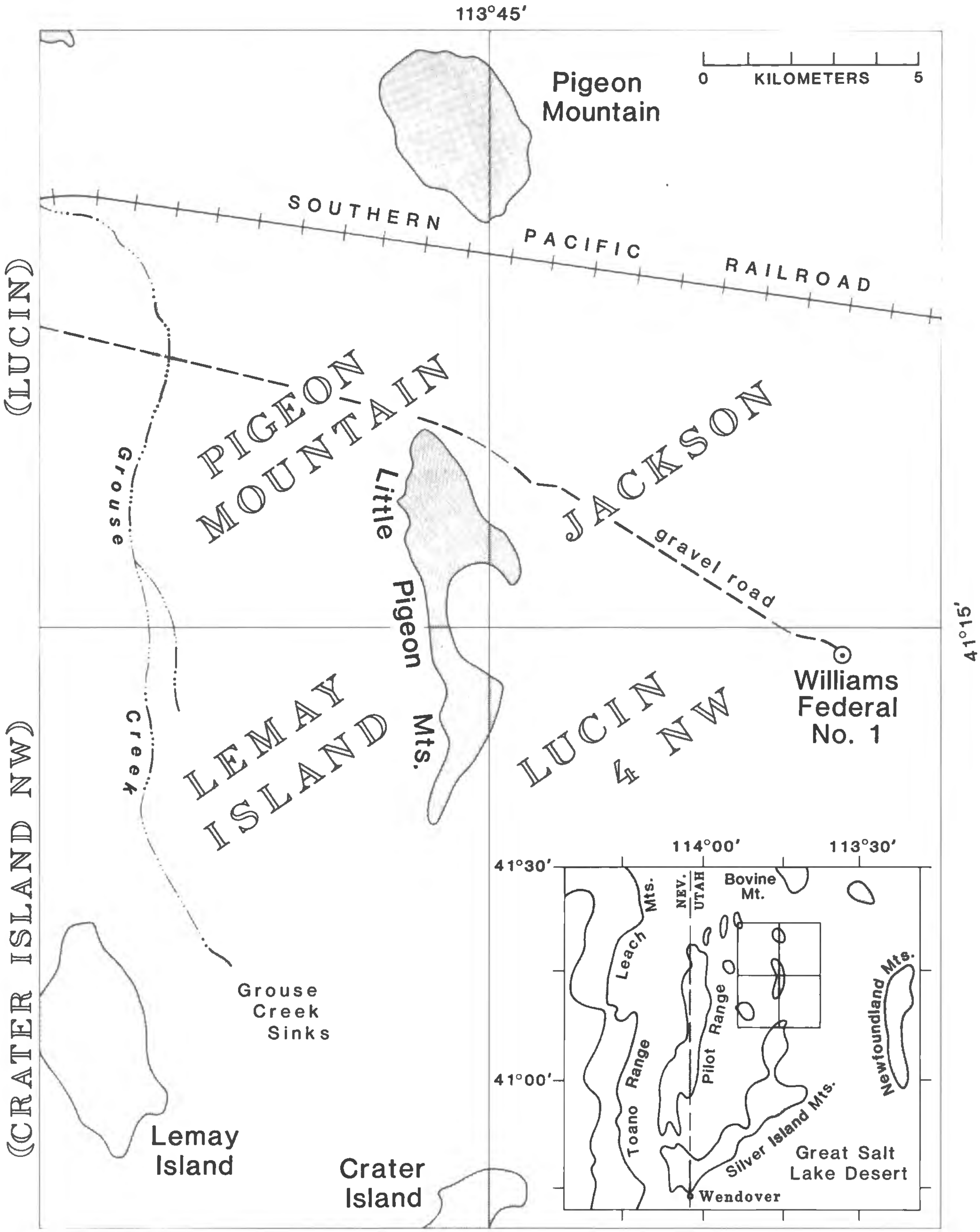

Figure 1. Location map showing mountains (shaded areas) and cultural features in the Lemay Island, Pigeon Mountain, Jackson, and Lucin 4 NW quadrangles, and location of quadrangles in northwest Utah.

beds may represent tongues of the Joana Limestone, the carbonate platform deposit of equivalent age.

Permian(?) and Pennsylvanian(?) Rocks

The Strathearn(?) Formation (PIPs) unconformably(?) underlies the Third Fork Formation and disconformably overlies the Mississippian Tripon Pass Limestone in the Little Pigeon Mountains. The upper contact of the Strathearn(?) is possibly an unconformity because the thickness of the Third Fork Formation decreases southward, but the contact is poorly exposed and has not been verified as an unconformity. The base of the Strathearn(?) is about parallel to bedding in underlying rocks; at this disconformity rocks representing most of Mississippian and Pennsylvanian time are not present.

The Strathearn(?) Formation consists of a lower conglomerate unit and an upper calcareous sandstone unit. The lower unit is crudely bedded, clast-supported, cobble to fine-pebble conglomerate with a matrix of brown calcareous sandstone and sandy limestone. Clasts are of two types: (1) well-rounded, green and black chert, black quartzite, and white quartz up to 2 inches (5 cm) in diameter, and (2) subrounded to subangular, gray limestone and marble up to 4.7 inches (12 cm) in diameter. The well-rounded siliceous clasts are more abundant than the relatively angular limestone clasts, and the black and green color of the chert clasts indicates derivation from the undivided Chainman and Diamond Peak Formations as mapped by Miller and Schneyer (1985) in the Tecoma quadrangle. The limestone clasts are of unknown provenance, but are lithologically similar to the Devonian Guilmette Formation. The matrix consists of poorly size-sorted grains of calcite and quartz that are cemented by calcite. The quartz grains are well rounded, whereas the calcite grains are angular to subrounded.

The upper calcareous sandstone unit is chiefly composed of brown, poorly bedded, moderately size-sorted calcareous sandstone and siltstone. Some beds contain pebbles of chert and quartz. Quartz grains are interlocking in some beds. Calcite occurs both as detrital grains and as cement matrix.

The Strathearn(?) Formation in the Little Pigeon Mountains is probably correlative with conglomerate exposed in the northern Silver Island Mountains about 2 miles (3 km) south of the Lemay Island quadrangle. That conglomerate, which lies between Permian and Mississippian strata, contains clasts derived from Mississippian and Pennsylvanian strata and was assigned by Miller (1984) to the Strathearn(?) Formation on the basis of lithologic similarity with conglomerate in the southern Silver Island Mountains (Schneyer, 1984) and southern Pilot Range (D. M. Miller, 1981, unpubl. mapping). On the basis of stratigraphic position, the conglomerate in the Little Pigeon Mountains probably correlates with the Strathearn(?) Formation, but differences in lithology (Miller, 1984) and in the overlying and underlying strata preclude definite assignment.

Permian Rocks

Third Fork Formation: In the Little Pigeon Mountains, the Third Fork Formation (Ptf) conformably underlies the Badger Gulch Formation and unconformably(?) overlies the Strathearn(?) Formation. It is about 580 feet (175 m) thick in the south and 820 feet (250 m) thick in the north. The basal 32 to 130 feet (10 to 40 m) are poorly exposed yellow to brown calcareous sandstone. Above these nonresistant rocks is moderately resistant, thick-bedded, brown-weathering calcareous sandstone that is dark gray when fresh. Rare beds of sandy limestone also are present. In the upper one-third of the unit, gray and black silty limestone similar to that in the Badger Gulch Formation is interbedded with the calcareous sandstone. The silty limestone contains brachiopods, gastropods, and fusulinids. On the basis of lithology and stratigraphic position, the Third Fork Formation is correlated with calcareous sandstone in the lower part of the Pequop(?) Formation in the northern Pilot Range (Miller, 1985) and the Third Fork Formation in the Leach Mountains (Miller and others, 1984), where it is latest Wolfcampian and early Leonardian in age. Doelling (1980) previously assigned the Third Fork Formation in the Little Pigeon Mountains to Unit 3 of the Oquirrh Formation.

Badger Gulch Formation: The Badger Gulch Formation (Pbg) consists mainly of black to dark-gray, platy, silty limestone, medium- to dark-gray limestone, and rare thick beds of fossiliferous coarse-grained limestone. The unit occurs in the hanging wall of a low-angle fault at Lemay Island and lies conformably above the Third Fork Formation in an incomplete section about 1,075 feet (325 m) thick in the Little Pigeon Mountains. Here, the base of the Badger Gulch is drawn at the base of the lowest coarse bioclastic bed above the calcareous sandstone of the Third Fork Formation. The basal 98 feet (30 m) of the Badger Gulch contains subequal proportions of medium-gray limestone, dark-gray to black silty limestone, and brown calcareous sandstone. The remainder of the formation consists of black, platy, silty limestone and thick-bedded fossiliferous limestone. Recumbent soft-sediment folds and small slumps are common. Large fusulinids similar to those in the Pequop(?) Formation in the Pilot Range are abundant in some beds of bioclastic limestone. On the basis of lithology and stratigraphic position, the Badger Gulch Formation in the Lemay Island quadrangle is correlated with the early Leonardian lower part of the Pequop(?) Formation in the northern Pilot Range (Miller, 1985) and with the Badger Gulch Formation in the Leach Mountains (Miller and others, 1984). The Badger Gulch Formation was previously assigned by Doelling (1980) to the Grandeur Formation (Lemay Island) and Oquirrh Formation Unit 4 (Little Pigeon Mountains).

Trapper Creek Formation: The Trapper Creek Formation (Ptc) is a resistant sequence of thin- to thick-bedded, sandy and cherty limestone and dolomite. The upper part (about 500 feet; 150 m) of the unit conformably underlies the Grandeur Formation at Lemay Island; lower parts of the unit occur to the west in the Crater Island NW quadrangle (Miller and others, 1982). Thick beds of medium- to light-gray bioclastic limestone containing fragments of brachiopods, crinoids, bryozoans, and fusulinids are interbedded with (1) thin-bedded limestone containing quartz silt and fine sand, (2) brown, laminated sandstone and calcareous sandstone, (3) medium- to thick-bedded, gray, silty limestone, and (4) grayish-brown, silty dolomite. The top 66 feet (20 m) of the Trapper Creek is comprised chiefly of bioclastic limestone. Chert nodules and stringers occur throughout the top part of the formation, and soft-sediment folds occur in much of the formation. The top of the Trapper Creek is placed at the top of the highest bioclastic limestone bed.

On the basis of lithology and stratigraphic position, the Trapper Creek Formation in Lemay Island is correlated with the upper part of the Pequop(?) Formation in the Pilot Range (Miller, 1985) and the Trapper Creek Formation in the Leach Mountains (Miller and others, 1984) and Cassia Mountains (Mytton and others, 1983). The Trapper Creek Formation at Lemay Island was previously assigned to Permian undifferentiated rocks (Doelling, 1980).

Grandeur Formation of the Park City Group: The Grandeur Formation (Ppg) is a resistant, cherty unit of sandy dolomite and sandstone about 2,445 feet (745 m) thick that conformably overlies the Trapper Creek Formation and underlies the Meade Peak Phosphatic Shale Tongue. The lower one-third of the Grandeur is resistant cherty dolomitic sandstone, and the upper two-thirds is predominantly sandy dolomite. The lower part of the formation is interbedded with underlying Trapper Creek rocks and is characterized by abundant chert in beds, nodules, and stringers. Fine-grained brown sandstone and gray sandy dolomite occur with the chert. In thin section, the sandy dolomite consists of well-sorted angular quartz and subordinate dolomite intraclasts in a dolomite matrix. Bedding is generally of medium thickness, and parallel laminations and planar to trough cross-laminations are common. At the base of the upper, carbonate-dominated part of the formation is a calcareous dolomite bed containing abundant bryozoan fragments and silicified crinoidal debris. Conodonts recovered from this bed (Table 2, location 1) are late Leonardian (late Early Permian). Higher in the upper two-thirds of the Grandeur is a thick sequence of gray medium- to thick-bedded sandy dolomite, fine-grained sandstone, and brown chert. Chert nodules and stringers are common in the dolomite. Chert constitutes up to 60% of the rock in the upper 164 feet (50 m) of the formation. The uppermost 33 to 98 feet (10 to 30 m) of the formation are characterized by thick beds of crinoidal debris in dolomite, interbedded in the top 16 feet (5 m) with black chert.

On the basis of lithology, stratigraphic position, and faunal data, the Grandeur Formation at Lemay Island is correlated with the late Leonardian Grandeur Formation in the Leach Mountains (Miller and others, 1984) and in the Cassia Mountains, Idaho (Mytton and others, 1983). It also correlates with most or all of the chert and dolomite unit of Miller (1985) in the Pilot Range.

Meade Peak Phosphatic Shale Tongue of the Phosphoria Formation: A poorly exposed stratigraphic interval between the Murdock Mountain Formation and the Grandeur Formation contains fragmentary exposures of the Meade Peak Phosphatic Shale Tongue (Ppm). The Meade Peak crops out at the same poorly exposed interval in the Little Pigeon Mountains one km north of the Lemay Island quadrangle. In the southern exposures at Lemay Island, black siliceous siltstone and shale and black chert beds are exposed above the Grandeur. Festoon cross-laminations occur in a thin sandstone bed at the contact. Similar rocks, but in a highly broken and contorted state, are exposed in the basal part of the Meade Peak in the northern part of the island. At that section, thin-bedded, laminated, medium-brownish gray limestone and thick-bedded dark chert occur concordantly beneath the Murdock Mountain Formation. The Meade Peak at Lemay Island is approximately 180 feet (55 m) thick; it is correlated with the Meade Peak Phosphatic Shale Tongue in the Leach Mountains (Miller and others, 1984) on the basis of stratigraphic position and lithologic similarity.

Murdock Mountain Formation: The Murdock Mountain Formation (Pm) at Lemay Island is a thick (2,340 feet; 715 m), resistant unit of chert and sandstone that conformably underlies the Gerster Limestone and overlies poorly exposed nonresistant strata of the Meade Peak Phosphatic Shale Tongue of the Phosphoria Formation. The lower one-third of the Murdock Mountain Formation is poorly exposed and consists of black to charcoal-gray, thin-bedded chert, black sandstone and siltstone, and medium-gray dolomite and dolomitic sandstone. White blebs of chalcedony are common in some beds. The upper two-thirds of the formation is resistant chert and sandstone, with dolomitic sandstone locally abundant. Much of the chert is white to pale-gray and thin-bedded. Darker gray and brown chert and sandstone contain as much as 40% dolomite as irregular blebs and thin beds. Locally, a thick bed of shelly limestone lies about 65 feet (20 m) below the Gerster tongue. The Murdock Mountain Formation in Lemay Island is lithologically similar to the formation in the nearby Leach Mountains, where Miller and others (1984) showed it to be latest Leonardian and early Guadalupian in age. Doelling (1980) referred the cherty sequence of rocks in Lemay Island to the Rex Chert, but this sequence is assigned to the Murdock Mountain Formation herein because lithologies and stratigraphic sequence at Lemay Island closely match the type Murdock Mountain (Wardlaw and others, 1979; Miller and others, 1984) and not the type Rex Chert (McKelvey and others, 1959).

Tongue of the Gerster Limestone: Within the upper part of the Murdock Mountain Formation and about 260 feet (80 m) beneath the base of the Gerster is a section of limestone (10 to 33 feet; 3 to 10 m thick) assigned to the upper tongue of the Gerster Limestone (Pgt) as defined in the Leach Mountains, Nevada (Miller and others, 1984). This limestone tongue is similar to limestone of the main part of the Gerster Limestone, and one bed within the tongue contains abundant productid brachiopods. In southern exposures a tongue of brown calcareous sandstone occurs within the Gerster tongue. Beds in the Gerster tongue are locally dolomitized, and brachiopods altered to dark-gray siliceous "chert" balls. Based on lithologic correlation with the

Leach Mountains and stratigraphic position, the tongue of the Gerster Limestone is early Guadalupian (Miller and others, 1984) in age.

Gerster Limestone: A unit assigned to the Gerster Limestone (Pg) occurs at the top of the Paleozoic section exposed in Lemay Island. This unit consists of light-gray, thick-bedded, coarse-grained, shelly limestone and brown, thin-bedded chert and sandstone. The unit, the top of which is marked by an unconformity, is at greatest about 790 feet (240 m) thick. Limestone in the unit contains conspicuous fragments of bryozoans, crinoids, bivalves, and brachiopods, some of which are silicified and dark colored. Approximately the lower 33 feet (10 m) is gradational with massive, white to dark chert of the upper part of the Murdock Mountain Formation; much of the limestone in this interval is silicified to chert-like rock. Brachiopods 33 feet (10 m) above the base of the unit are altered to balls of dark chert, in some of which relic structures of the fossils are retained. Chert intervals in the Gerster are 13 to 26 feet (4 to 8 m) thick. Based on lithologic correlation with the Leach Mountains and stratigraphic position, the Gerster Limestone is early Guadalupian (Miller and others, 1984).

Jurassic Rocks

Part of a pluton greater than 3 miles^2 (7 km^2) in area is exposed in the northern part of Crater Island. The bulk of this pluton is medium- to coarse-grained biotite granodiorite (Jpg) with phenocrysts of pink potassium feldspar up to 1 inch (2.5 cm) in diameter. Hornblende and sphene are common accessory minerals. Pink aplite dikes, pink pegmatite dikes, porphyritic fine-grained dikes, and rare quartz veins cut the coarse-grained phase. The pink aplite dikes most commonly intrude near contacts between the pluton and contact-metamorphosed lower Paleozoic strata. The porphyritic fine-grained dikes are compositionally similar to, and probably represent, the fine-grained phase of the body (Jfg). Two xenolith types are common in the coarse-grained phase: fine-grained, equigranular, hornblende-plagioclase diorite, and medium-grained, porphyritic, biotite quartz monzodiorite with biotite and plagioclase phenocrysts.

Coarse-grained granodiorite grades, over 32 to 65 feet (10 to 20 m), to fine-grained, sparsely porphyritic monzogranite (Jfg). The gradation generally takes place by a gradual decrease in groundmass grain size, but in some areas coarse- and fine-grained lithologies are mixed. The fine-grained phase is typified by a fine-grained matrix of biotite monzogranite and a population of medium- and coarse-grained phenocrysts identical to the grains in the coarse-grained phase, including sparse examples of its phenocrystic potassium feldspar. Phenocrysts in the fine-grained phase typically constitute about 10 percent by volume. The fine-grained phase generally contains no xenoliths or dikes, but one xenolith of the coarse-grained phase was observed, and rare quartz veins occur. Locally, the fine-grained phase is tonalite that is dark gray and rich in biotite. One small area in the fine-grained phase is fractured, altered to limonite, and veined by quartz.

The composite pluton at Crater Island was divided into two stocks, termed the Sheepwagon stock and the North stock, by Anderson (1960); he considered them to be Tertiary. We have obtained a K-Ar age on biotite from the coarse-grained phase, collected south of the Lemay Island quadrangle, of 150.6 ± 3.8 Ma (J. K. Nakata, 1985, written commun.). This Jurassic age is close to those ages determined on other granitoid bodies in the Silver Island Mountains (Miller, 1984).

Tertiary or Jurassic Rocks

Dikes intruding the southern part of the Little Pigeon Mountains strike about north and typically form stripes of orange-weathering float blocks along wave-worn terraces. The dikes are composed of hornblende-biotite granite (TJg) that has medium-grained phenocrysts set in a medium-gray aphanitic groundmass. The dikes are similar in texture and composition to Oligocene dikes in the southern Pilot Range (Miller, 1984) and therefore are probably Tertiary. However, Jurassic granodiorite exposed in Crater Island about 6 miles (10 km) to the south is broadly similar in composition to the dikes so the dikes may, alternatively, be Jurassic.

Tertiary Rocks

Rhyodacite: Rhyodacite lava flows (Tr) unconformably overly the Permian Gerster Limestone at Lemay Island. Although the basal contact of the rhyodacite is not exposed, foliation in the rhyodacite is parallel to the contact and there is no sign of extensive fractures that might indicate a low-angle fault. The rhyodacite contains phenocrysts of quartz, plagioclase, potassium feldspar, hornblende, and biotite in a red-brown, slightly devitrified matrix. Hornblende is reddish-brown, biotite is red and oxidized, and plagioclase shows resorbed, rounded rims and is partly altered to epidote. Zoned potassium feldspar is uncommon. Foliation is imparted by alternating crystal-rich and crystal-poor layers 1.2 to 3 inches (3 to 8 cm) thick and by oriented mafic minerals. Biotite from the rhyodacite gave a K-Ar age of 32.8 ± 1.6 Ma (Table 1).

Sedimentary rocks: Tertiary sedimentary rocks (Ts) occur at the south end of the Little Pigeon Mountains in one small exposure. They consist of poorly sorted heterolithic conglomerate and coarse-grained sandstone. Clasts in the conglomerate are locally derived and represent all of the Paleozoic units in the Little Pigeon Mountains as well as the Jurassic or Tertiary altered granitoid dikes in that range. In thin section the sandstone consists of poorly size-sorted calcite grains, generally angular, less common rounded quartz grains, and rare chert. Crude bedding is variably oriented, but generally strikes northeast and dips moderately southeast; it probably represents local current aberrations from deposition on an irregular surface. Granitoid clasts of

Tertiary(?) age, a sharp angular unconformity at the base, and moderate induration point to a Tertiary age for the deposit.

Quaternary Deposits

Lacustrine deposits resulting from late Pleistocene Lake Bonneville and alluvium consisting in part of reworked lake deposits are widespread in the quadrangle. Old graded roads make much of the western and northern parts of the quadrangle accessible for detailed studies of Quaternary deposits, whereas less accessible areas required study by a combination of field mapping and aerial photograph interpretation.

Although the entire quadrangle was covered by Lake Bonneville, most of the lake deposits subsequently were reworked by alluvial and fluvial processes. Remaining lacustrine deposits were chiefly formed at shorelines prominent in Lemay Island and the Little Pigeon Mountains. Small wave-abrasion platforms define the Provo shoreline in Lemay Island at an elevation about 4,835 feet (1,474 m). The Stansbury shoreline is at an elevation about 4,510 feet (1,375 m) in Lemay Island and the Little Pigeon Mountains. A prominent spit, interpreted as having formed at the Gilbert shoreline of Lake Bonneville, lies at the southeastern base of Lemay Island at an elevation about 4,265 feet (1300 m). The observed elevations for lake levels match closely those described previously by Currey (1982) and Currey and others (1984). Isostatic rebound as described by Crittenden (1963) is pronounced in the Lemay Island quadrangle. Prominent gravel beaches at 4285 ft (1306 m) and 4295 feet (1309 m) occur at the southern tip of Lemay Island.

The northern portion of Pilot Valley playa extends into the Lemay Island quadrangle. Lines (1979) described the morphology, ground water, and brines of the playa. A broad drainage divide between Crater Island and Lemay Island separates ponded water and playa deposits to the southwest from the Grouse Creek sinks to the northeast.

Alluvial mud: The widespread alluvial mud unit (Qam) is composed of fine silt, clay, and salts deposited in very low-gradient, low-velocity drainage systems. Ubiquitous small stream channels indicate that there is little ponding of water despite the extremely gentle gradient. With increasing gradient and better-defined stream channels, alluvial mud grades into coarse-grained alluvium (Qal).

Playa mud: Playa deposits (Qpm) occur in nearly level, undrained basins. The deposits consist of unconsolidated clay, silt, and soluble salts. The salt deposits produce a white, highly reflective surface when dry and a vegetation-free environment. Deposits of the Pilot Valley playa are predominantly carbonate muds with a hard compact surface (Lines, 1979) that overlie lacustrine clay (Nolan, 1927). The Pilot Valley playa contains water only during periods of high precipitation. Other playa deposits exist near Crater Island and in small isolated basins within the Little Pigeon Mountains. The playa deposits in the quadrangle are gradational with alluvial mud deposits, from which they are distinguished by the absence of drainage channels in the playa, slightly flatter topography, and general lack of vegetation.

Alluvial gravel: One alluvial gravel deposit (Qag), consisting of tightly packed, rounded gravel and cobbles, was excavated to a depth of 13 feet (4 m) in the southwest quarter of section 18, T. 6 N., R. 17 W. for construction materials. Trough morphology and cross-bedding indicate water flow parallel to the long axis of the sinuous deposit. The gravel appears to interfinger with the adjacent finer-grained alluvium. Other alluvial gravel deposits in the quadrangle have similar surficial characteristics and are inferred to be similar internally.

Many identified alluvial gravel ridges are partly covered by eolian sand deposits, suggesting that more gravel deposits may exist beneath the sand covers. The origin of these deposits as channel fills is described in the Pigeon Mountain quadrangle report (Glick and Miller, in press).

Desert ripples: On aerial photographs, desert ripples (Qar) appear as dark, thin bands representing vegetated berms behind which are light-colored, unvegetated silt and mud. The somewhat arcuate ripples generally trend north to northeast and are convex to the southeast. They occur primarily at the junctions of distal parts of coalesced fans and the relatively flat ancient lake floor.

STRUCTURAL GEOLOGY

Structures in the Lemay Island quadrangle predate Quaternary surficial deposits that comprise 90 percent of the quadrangle. Because of the limited outcrop of pre-Quaternary rocks, structures observed in one area are difficult to relate to those in another and also are difficult to relate to the structural history of the nearby ranges.

Lemay Island

Strata at Lemay Island are generally homoclinal with steep eastward dips; the homocline has been broadly folded so that it forms left-stepping outcrop patterns. Superimposed on the homocline is a nearly flat-lying fault with the Badger Gulch Formation in the hanging wall and the Grandeur Formation in the footwall.

Strata composing the homocline are broadly folded on the map scale, as indicated by strikes of bedding ranging from N. 20° E. through north in the southern part of the island to N. 30° W. in the northeast. Kink folds with folded limbs about 330 feet (100 m) long and with strikes of about N. 60° W. are common. The fold axes trend about N. 30° E. and plunge about 40° northeast. The folds accomplish a sinistral rotation of strata when viewed down the plunge of the fold axis. All cherty rocks are highly fractured but neither breccias nor offset strata suggestive of high-angle faults were found.

Near the low-angle fault, rocks are folded, brecciated, and deformed. Mesoscopic folds near the fault trend N. 30° to 50° E., plunge gently northeast, and have wavelengths of 1.2 to 49 feet (1 to 15 m). The fold geometry above the fault differs from that below the fault; chert and dolomite exhibit kink geometry in the footwall, whereas silty limestone exhibits folds with varying radii of curvature in the hanging wall. Vergence of the folds adjacent to the fault is not systematic. In many places, chert and dolomite are highly fractured and brecciated within a zone some 33 feet (10 m) thick under the fault. Bedding in hanging wall rocks is contorted nearly everywhere. Although the fault is not exposed, tectonite marble in one location may mark the fault. The fault has corrugations or folds in it; these trend about easterly and are shown by the serriate map pattern and in cross section BB′.

Based on offset of hanging wall strata relative to projected exposures of equivalent strata in the footwall, the hanging wall moved 1 mile (1.5 km) eastward. If the orientations of the fault or adjacent strata change in the covered interval to the west, the estimated amount of offset would vary accordingly. Ductile behavior of limestone and intact hanging wall strata indicate that the fault was not caused by surficial gravity sliding. A simple extrapolation of the fault eastward suggests that it cuts the steeply dipping Oligocene rhyodacite, and therefore is probably Neogene in age. Similar low-angle faults 4 miles (6 km) west in the Pilot Range place Permian and Tertiary strata upon Oligocene granite (Miller and others, 1982). The fault in Lemay Island may be related to these low-angle faults in the Pilot Range.

Little Pigeon Mountains

Paleozoic strata in the Little Pigeon Mountains form an east-dipping homocline similar to that at Lemay Island. A major sinistral fault is inferred in the covered interval between Grandeur exposures in the north and Third Fork exposures in the south. The prominent ridge formed by conglomerate in the Strathearn(?) Formation is repeated several times by nearly vertical faults striking N. 75° W. Stratigraphic offset on individual faults is dextral, or south side down, and about 50 to 260 feet (15 to 80 m); total stratigraphic throw on the faults is about 750 feet (230 m). Slickenlines in bedding planes are down the dip suggesting some dip slip for the fault system. However, "drag" folds adjacent to one fault have nearly vertical axes and suggest dextral horizontal movement on the faults. Dolomite and limestone of the Guilmette Formation, exposed at the south end of the range, are highly fractured and cut by numerous small faults on which there is no apparent systematic offset.

Crater Island

Granitoid rocks exposed at the north end of Crater Island are cut by a zone of closely spaced fractures about 330 feet (100 m) wide near the east border of the Lemay Island quadrangle. Quartz veins and altered granitoid rocks are present in the fractured zone. Fractures strike N. 5 to 15° E. and dip 30 to 40° east. There is no evidence for large faults such as those mapped farther south in Crater Island by Anderson (1960).

Structural Configuration of the Basins

Sparse gravity and seismic refraction data (Cook and others, 1964; Berg and others, 1961) suggest that a major fault zone on the west side of the Little Pigeon Mountains displaces Paleozoic strata down to the west about 6,000 feet (1,820 m). Near the west side of the Lemay Island quadrangle, faults evidently step the basement down to the east more gradually. Cook and others (1964) inferred that the graben formed by these fault systems narrows and shoals southward between Lemay Island and Crater Island. Southwest of Lemay Island is another prominent subsurface fault zone that drops bedrock down about 4,000 feet (1,200 m) to the southwest.

ECONOMIC DEPOSITS

No mines, quarries, or prospect pits were observed in the Lemay Island quadrangle during mapping, nor were any described in a recent compilation of the economic geology of Box Elder County by Doelling (1980). Seven possible sources for mineral resources occur in the quadrangle; the potential for each is unknown and has not been evaluated.

(1) Jurassic granodiorite in Crater Island has produced skarn mineralization just south of the Lemay Island quadrangle. Tungsten (Doelling, 1980) and industrial-grade garnet are possible resources. Such a skarn deposit may be buried under Quaternary deposits in the Lemay Island quadrangle. Reddish-brown limonitic alteration of the granodiorite occurs in the highly fractured zone containing quartz veins in the southeast quarter of section 23, T. 5 N., R. 17 W. Casts of pyrite in this zone suggest some metal enrichment.

(2) Jurassic or Tertiary granodiorite dikes in the Little Pigeon Mountains are typically altered orange or brown. Limonitic and argillic alteration may indicate hydrothermal systems related to mineralization.

(3) Tertiary rhyodacite at Lemay Island, although lacking significant alteration, may host disseminated gold analagous to gold-bearing Tertiary volcanic rock in Nevada.

(4) Silicified sedimentary rocks in some areas in northern Nevada and Utah host disseminated gold deposits, such as the recently discovered Tecoma deposit (Douglas and Oriel, 1984). Parts of the Trapper Creek, Grandeur, and Murdock Mountain Formations show replacement of sandstone or carbonate rock by silica.

(5) Elsewhere in the region (Maughan, 1979) and nearby in the Leach Mountains (Miller and others, 1984), the Meade Peak Phosphatic Shale Tongue of the Phosphoria Formation bears significant phosphate resources. The Meade Peak is shallowly buried by alluvium and lacustrine deposits at Lemay Island.

(6) Brines at shallow depth in Pilot Valley playa, south of Lemay Island, may contain resources such as potash and lithium (Nolan, 1927; Lines, 1979).

(7) Gravels accumulated in beaches and tombolos abound in Lemay Island, Crater Island, and in the Little Pigeon Mountains. The gravels are sources of construction materials.

GEOLOGIC HAZARDS

Flooding caused by locally heavy precipitation or sustained areal precipitation is a hazard in the Lemay Island quadrangle. The roughly 80 percent of the quadrangle forming poorly drained flatland is subject to short-duration floods during local heavy rainfall. The fine-grained, sparsely vegetated soils in the flatland are generally slippery and soft when wet. Somewhat higher-than-average precipitation in northwest Utah and northeast Nevada, such as occurred during early 1984, can create sufficient runoff in the large watershed of Grouse Creek to cause flooding. The low topographic gradients in the Lemay Island quadrangle promote the distribution of waters along meandering channels and as sheetfloods, making it difficult to predict flood locations. A related flood hazard is present south of Lemay Island and east to Crater Island, at the northern limit of the Pilot Valley playa. Heavy precipitation, particularly if coupled with diminished insolation, creates large areas of ponded water in the Pilot Valley playa. Such playa floods can reach an elevation of about 4,245 feet (1,295 m) before draining around the north end of Crater Island, thus probably checking the further rise of flood waters.

Partly vegetated and unstable eolian sands, which are more than 3.3 feet (1 m) thick in about 15 percent of the quadrangle and are present as thinner deposits in much of the remainder of the quadrangle, may migrate.

Faults bordering the Pilot Range, about 8 miles (14 km) west of Lemay Island, cut Quaternary deposits and may be as young as early Holocene (Miller and others, 1982; Miller and Schneyer, 1985). Although the frequency and magnitude of earthquakes along this fault system are unknown, there is potential for earthquakes affecting the Lemay Island area.

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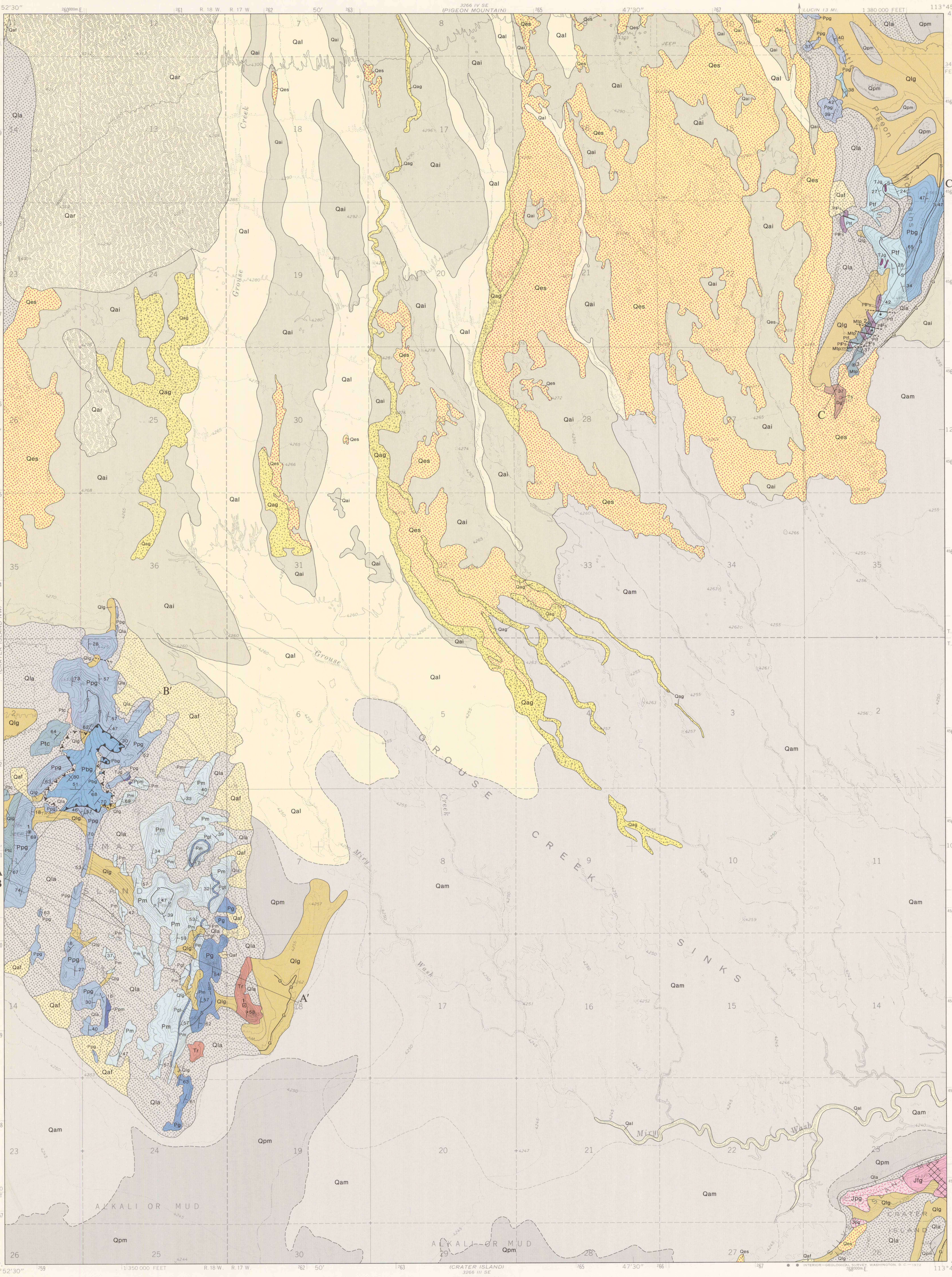


Base from U.S. Geological Survey, Lemay Island Quadrangle 1967

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

Field mapping by authors in 1983-85, assisted by S. Garwin in 1984.
Patricia H. Speranza, Cartographer

GEOLOGIC MAP OF THE LEMAY ISLAND QUADRANGLE, BOX ELDER COUNTY, UTAH

by
David M. Miller and Linda L. Glick
U.S. Geological Survey

UTM GRID AND 1967 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION

1986

CONTACT

Dashed where gradational; dotted where covered

HIGH-ANGLE FAULT

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

LOW-ANGLE FAULT

Dashed where location inferred; dotted where covered; sawteeth on upper plate

STRIKE AND DIP OF BEDDING

15 Inclined

6 Overturned

Vertical

STRIKE AND DIP OF IGNEOUS FOLIATION

Inclined

TRACE OF LAKE SHORELINE

P Provo

S Stansbury

G Gilbert

ZONE OF ALTERATION

LOCATION OF GEOCHRONOLOGICAL SAMPLE

1

LOCATION OF PALEONTOLOGICAL SAMPLE

2

TABLE 1. POTASSIUM-ARGON GEOCHRONOLOGICAL DATA

Map Number	Sample Number	Material Dated	Mean K_20	^{40}Ar rad (mol/g)	$\frac{100\ ^{40}Ar\ rad}{total\ ^{40}Ar}$	Calculated Age (Ma)	Analyst	Latitude	Longitude
1	M83LI-16	hornblende*	0.7745	3.69375×10^{-11}	18.39	32.8 ± 1.6	W.C. Hillhouse	41°09′08″	113°50′39″

* Hornblende is red-brown, with oxidized rims; hornblende from rhyodacite unit (Tr)

Constants: $\lambda_\epsilon + \lambda'_\epsilon = 0.581 \times 10^{-10}$ year^{-1}; $\lambda_\beta = 4.962 \times 10^{-10}$ year^{-1}; $K^{40}/K_{total} = 1.167 \times 10^{-4}$ mol/mol

TABLE 2. PALEONTOLOGY DATA FOR THE LEMAY ISLAND QUADRANGLE

Map Number	Field Number	USGS Collection	Rock Unit	Fossil Age	Date of Report	Paleontologist	Faunal Description	Location Latitude	Location Longitude
1	M84LI-02	29436-PC	Grandeur Formation	Most likely late Early Permian	12/24/84	John Repetski	*Hindeodus* sp. 1 Pa element 1 Pb element 1 Sa element 1 Sb element *Neostreptognathodus* cf. *N. Sulcoplicatus* (Youngquist, Hawley and Miller) 11 Pa elements The range of *N. Sulcoplicatus* is within the Roadian Stage. This is in approximately the upper third of the Lower Permian of USGS usage. This faunal assemblage represents a shallow-water biofacies.	41°10′13″	113°52′07″
2	M83LP-25	28936-PC	Tripon Pass Limestone	lower part of *Isosticha*-Upper *Crenulata* Zone (=latest Kinderhookian; =middle Early Mississippian)	9/29/83	Anita G. Harris	143 Pa elements of *Siphonodella Isosticha* (Cooper) transitional to *S. Obsoleta* Hass 5 Pa elements of *Polygnathus Communis Communis* Branson & Mehl 2 Pa elements of *Gnathodus Punctatus* (Cooper) 2 Pa elements of *Pseudopolygnathus* spp. 5 long-bladed spathognathodiform elements (cf. "*Spathognathodus*" *Macer* Branson & Mehl) 1 M element 7 Pb elements 2 lonchodiniform elements 1 Sa element 4 Sc elements 580 indet. bar, blade, and platform fragments This collection can be very tightly dated and is diagnostic of the lower part of the *Isosticha*-Upper *Crenulata* Zone (=latest Kinderhookian) and is thus from a correlative of the Joana Limestone.	41°12′54″	113°45′42″
3	M83LP-42	29225-PC	Tripon Pass Limestone	latest Kinderhookian	4/17/84	Anita G. Harris	1 juvenile Pa element of *Gnathodus* cf. *G. Delicatus* Branson & Mehl 1 Pa element fragment of *Gnathodus* sp. indet. 1 Pa element fragment of *Ozarkodina* sp. indet. 1 Pa element of *Polygnathus Communis Communis* Branson & Mehl 5 Pa elements of *Siphonodella Isosticha* (Cooper) 7 indet. bar, blade, and platform fragments The sample is of latest Kinderhookian age and the fauna (there is no mixing of ages) is consistent with the Tripon Pass Limestone.	41°13′07″	113°45′05″

DESCRIPTION OF MAP UNITS

Qaf Alluvial fan deposits—*Unconsolidated fan deposits of gravel, sand, and silt; colluvium included locally.*

Qla Lacustrine and alluvial deposits, undivided—*Alluvium older than Lake Bonneville etched by erosional shorelines, and thin lacustrine gravel and sand deposits.*

Qal Alluvium—*Unconsolidated silt, sand, and fine pebble gravel in ephemeral streams and washes. Includes local floodplain deposits.*

Qes Eolian sand—*Unconsolidated tan to light-brown, fine- to medium-grained sand and tan silt, occurring as complexes of small (2-m-high) dunes or broad sheets covering fine-grained alluvial deposits. Commonly contains detrital evaporite minerals. Most small dune complexes are vegetated.*

Qai Alluvial silt—*Unconsolidated deposits of tan silt, clay, and fine-grained sand. Generally flat-lying, but locally forming eolian mounds less than 1 m high. Dessication features, vegetation, and black algae are common.*

Qam Alluvial mud—*Unconsolidated clay, silt, and soluble salts in low-lying areas characterised by ephemeral, low-gradient drainages. Sparsely vegetated, forming gray to brown plains.*

Qpm Playa mud—*Unconsolidated clay, silt, and white soluble salts in nearly level, undrained, vegetation-free basins.*

Qar Desert ripples—*Light-colored silt ponded behind dark-colored, vegetated sand and silt ridges that form a ripple pattern.*

Qag Alluvial gravel—*Deposits of tightly packed, fine to coarse pebble gravel deposited in narrow, sinuous stream channels discordant with present drainage systems. Maximum clast size is about 5 cm.*

Qlg Lacustrine gravel and sand, undivided—*Unconsolidated gravel and sand that form shoreline deposits of Lake Bonneville. Clasts are well rounded and size-sorted, commonly with little matrix. Locally includes beachrock cemented by calcareous silt*

Ts Sedimentary rocks—*Brown conglomerate and sandstone forming a small outcrop at south end of Little Pigeon Mountain. Conglomerate contains carbonate and granitoid clasts.*

Tr Rhyodacite—*Red-brown, crystal-rich rhyodacite lava flow containing potassium feldspar, plagioclase, quartz, biotite, and hornblende in brown groundmass.*

TJg Granitoid dike—*Orange-weathered, pale-gray, fine-grained biotite granitoid occurring as dikes.*

Jfg Fine-grained granite—*Pale-gray, fine-grained biotite monzogranite with sparse phenocrysts of biotite, quartz, plagioclase, and potassium-feldspar. Intrudes the porphyritic granodiorite unit (Jpg).*

Jpg Porphyritic granodiorite—*Pale-gray, biotite granodiorite containing phenocrysts of pink potassium-feldspar as large as 2.5 cm diameter in a medium- to coarse-grained groundmass of quartz, plagioclase, potassium-feldspar, and biotite with accessory sphene and hornblende. Diorite inclusions and pink aplite dikes common. Includes zone of rocks gradational with the fine-grained granodiorite unit (Jfg).*

Pg Gerster Limestone—*Pale-gray, thick-bedded, shelly limestone. Brachiopods, bryozoans, and crinoid debris abundant; in places fossils are silicified. Brown chert and sandstone beds occur within the limestone.*

Pgt Tongue of Gerster Limestone—*Pale-gray, shelly limestone tongue within Murdock Mountain Formation. Contains one conspicuous bed of brachiopod-rich limestone.*

Pm Murdock Mountain Formation—*Brown, black, and white, thin-bedded chert, brown sandstone, and gray dolomite and dolomitic sandstone.*

Ppm Meade Peak Phosphatic Shale Tongue of the Phosphoria Formation—*Black, platy, siliceous shale; brown, calcareous sandstone and siltstone; gray, thick-bedded dolomite; and minor dark-gray limestone.*

Ppg Grandeur Formation of the Park City Group—*Gray and brownish-gray, medium- to thick-bedded, cherty dolomite with thin interbeds of laminated sandstone and bedded chert, and rare limestone.*

Ptc Trapper Creek Formation—*Thick-bedded gray bioclastic limestone alternating with thin beds of silty limestone, ribbed sandy limestone and dolomite, gray-brown dolomite, and clean gray limestone. Chert sporadically present in silty limestone.*

Pbg Badger Gulch Formation—*Dark-gray to black, platy, silty limestone with bioclastic beds. Lower part of unit, exposed at Little Pigeon Mountain, grades downward into underlying Third Fork Formation with increasing content of brown sandstone.*

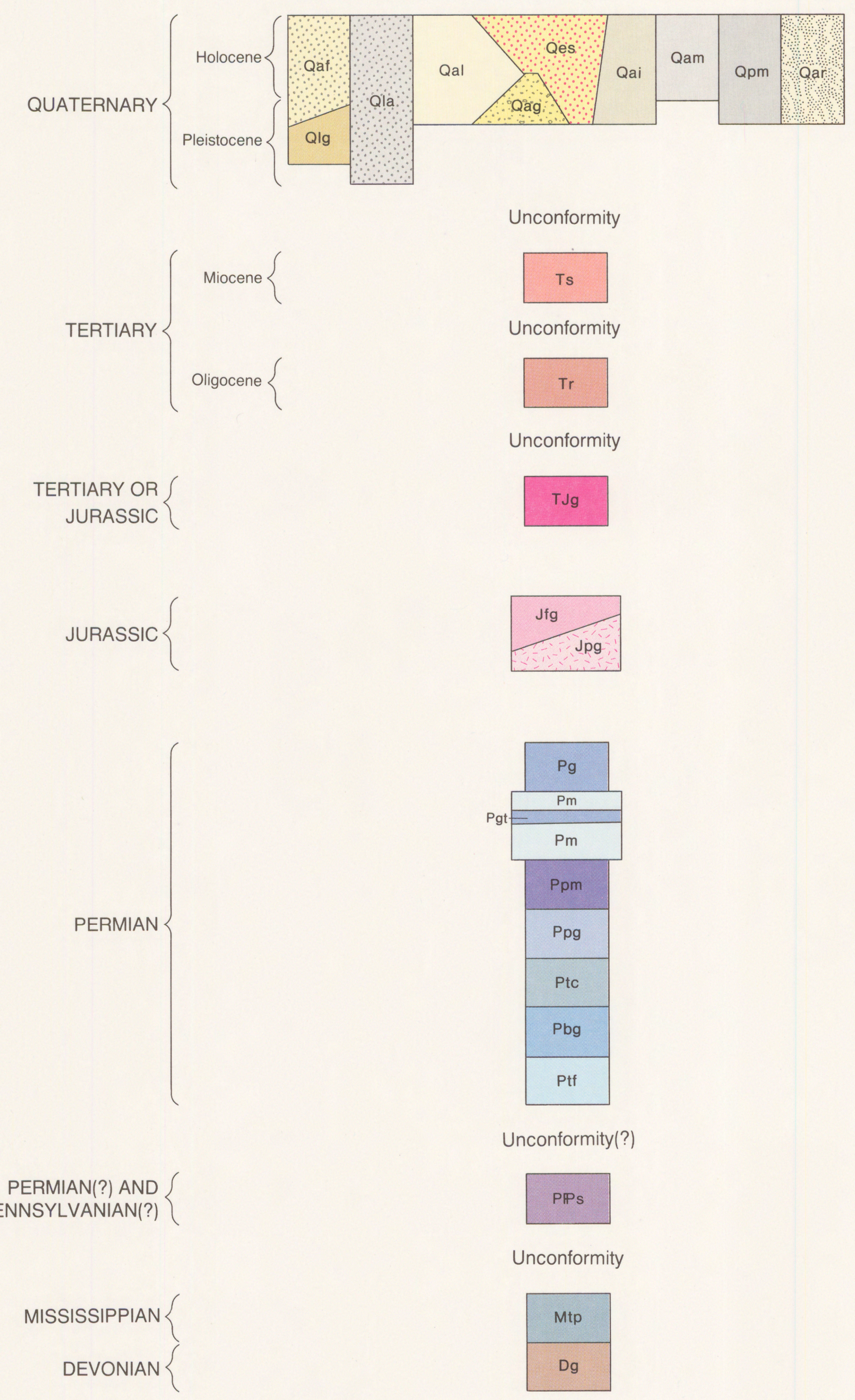
Ptf Third Fork Formation—*Dark-gray, fine-grained, calcareous sandstone; weathers brown. Medium- to thin-bedded; locally interbedded with calcareous siltstone. Upper part contains interbeds of gray to black, fossiliferous, platy limestone.*

PIPs Strathearn(?) Formation—*Conglomerate and sandstone forming prominent ledges. Clasts in conglomerate include green and black chert, dark-colored quartzite, white quartz, and medium-gray limestone. Clasts are supported in a matrix of locally pebbly calcareous sandstone.*

Mtp Tripon Pass Limestone—*Black, platy, shaly to silty limestone; weathers light- to medium-gray. Minor coarse-grained crinoid-rich limestone.*

Dg Guilmette Formation—*Massive to thick-bedded, dark-gray limestone and dolomite; highly fractured. Beds of Amphipora sp. and algal heads. Bedded quartz sand in limestone matrix near top of unit.*

CORRELATION OF MAP UNITS



FORMATION	SYMBOL	THICKNESS feet (meters)	LITHOLOGY
Rhyodacite	Tr	1000-1400 (305-426)	
Gerster Limestone	Pg	790 (240)	
Tongue of Gerster Limestone	Pgt	33 (10)	
Murdock Mountain Formation	Pm	2340 (715)	
Meade Peak Phosphatic Shale Tongue of the Phosphoria Formation	Ppm	180 (55)	
Grandeur Formation	Ppg	2445 (745)	
Trapper Creek Formation	Ptc	500 (150)	
Badger Gulch Formation	Pbg	1075 (325)	
Third Fork Formation	Ptf	820 (250)	
Strathearn(?) Formation	PIPs	120 (35)	
Tripon Pass Limestone	Mtp	650 (200)	
Guilmette Formation	Dg	400 (120)