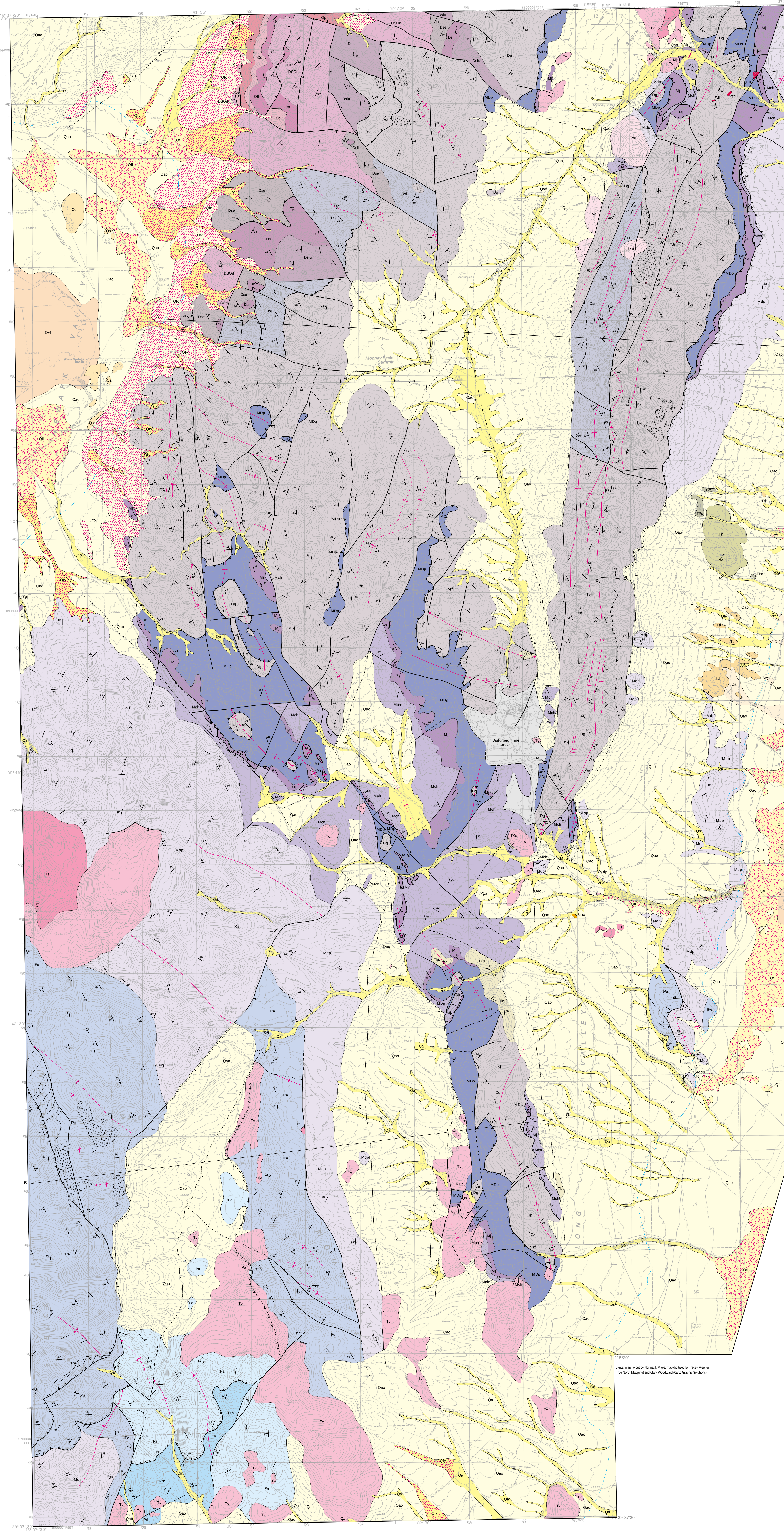
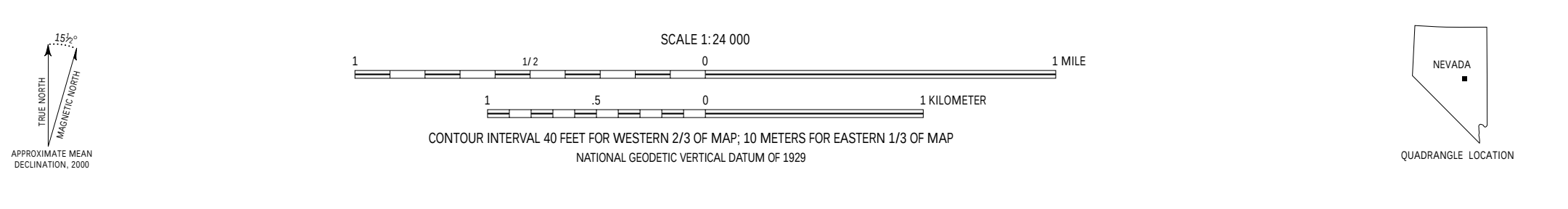
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

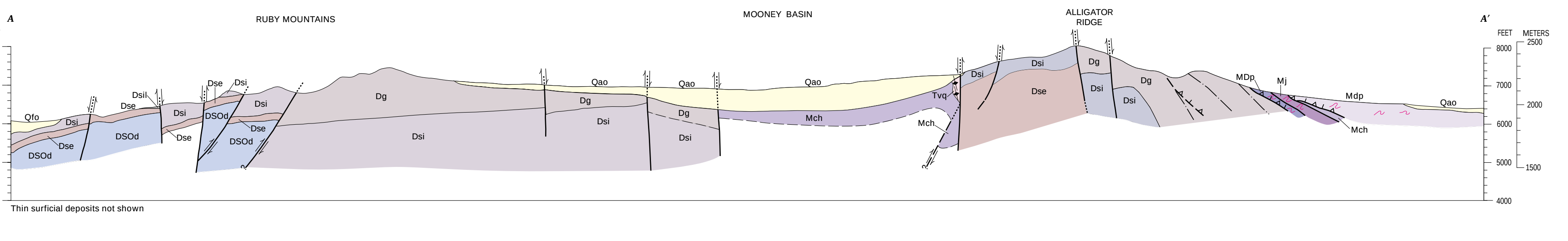


Digital map layout by Norma J. Maes; map digitized by Tracey Mercier (Yust North Mapping) and Clark Woodward (Carto Graphic Solutions).

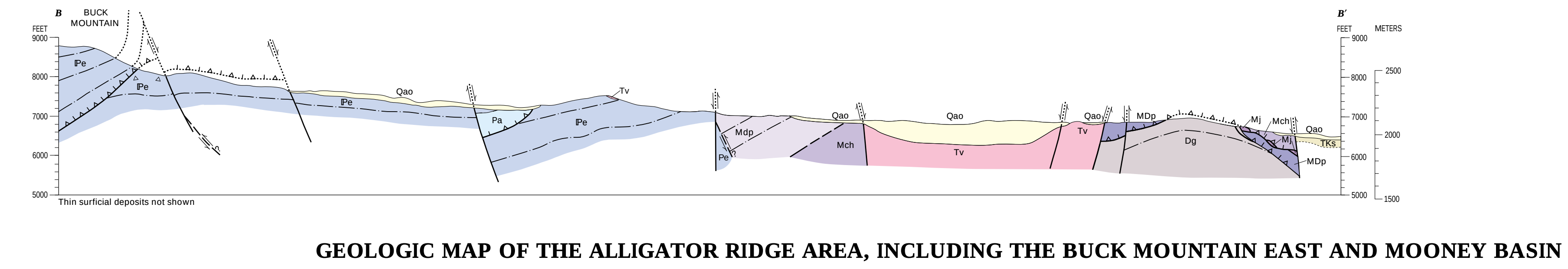
Base from U.S. Geological Survey
Buck Mountain East, Mooney Basin Summit, 1990
(Provisional editions); Long Valley Slough and
and Sunshine Well NW, 1982.



CONTOUR INTERVAL 40 FEET FOR WESTERN 2/3 OF MAP; 10 METERS FOR EASTERN 1/3 OF MAP
NATIONAL GEODETIC VERTICAL DATUM OF 1929



Thin surficial deposits not shown



Thin surficial deposits not shown

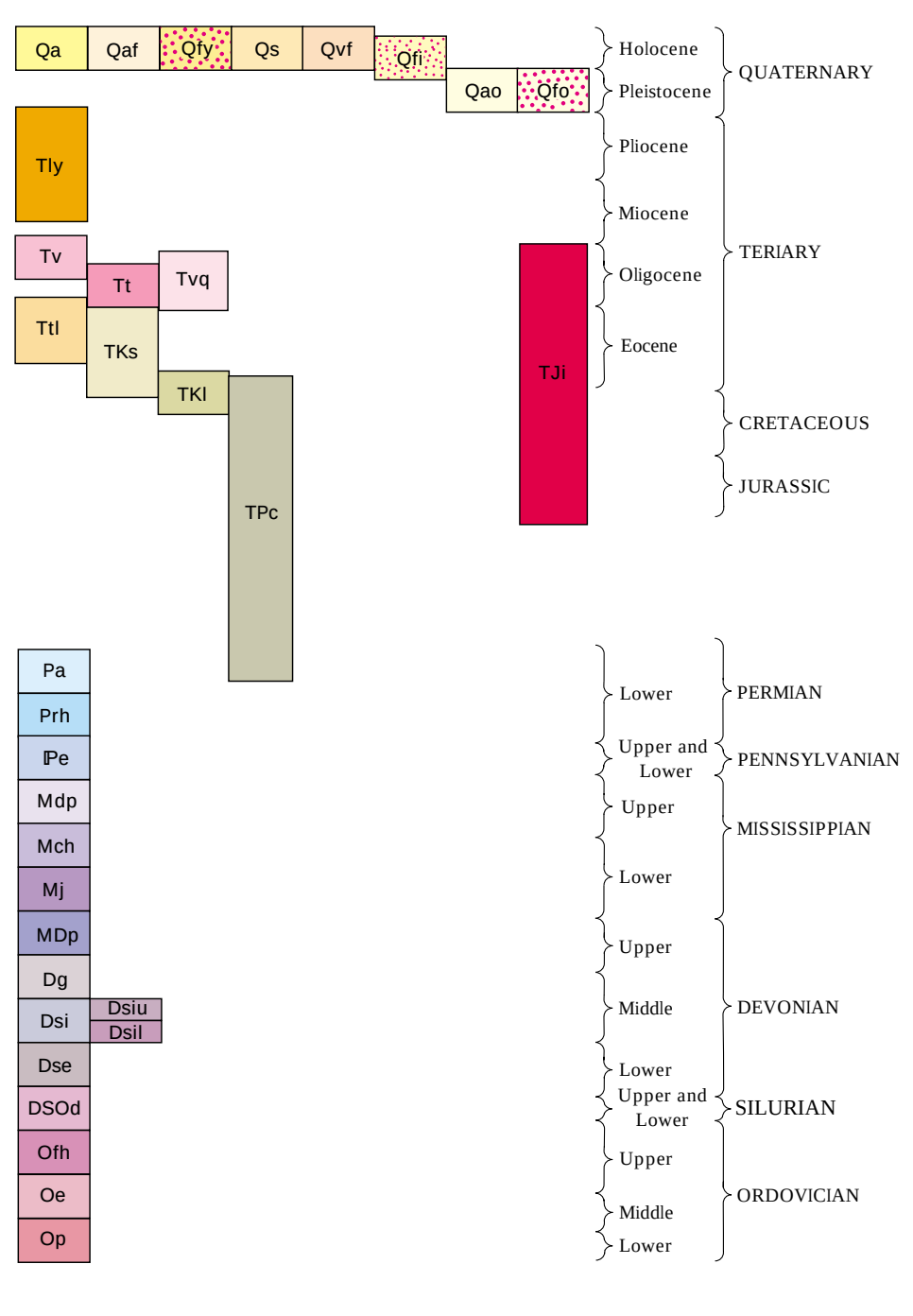
CONVERSION FACTORS

Multiply	By	To obtain
inches (in.)	2.54	centimeters (cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)

GEOLOGIC MAP OF THE ALLIGATOR RIDGE AREA, INCLUDING THE BUCK MOUNTAIN EAST AND MOONEY BASIN SUMMIT QUADRANGLES AND PARTS OF THE SUNSHINE WELL NE AND LONG VALLEY SLOUGH QUADRANGLES, WHITE PINE COUNTY, NEVADA

By
Constance J. Nutt
2000

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Qa **Stream alluvium (Holocene)**—Sand, silt, clay, and gravel deposited in confined ephemeral stream channels. Cuts late Pleistocene lake shoreline

Qaf **Alluvial and slopewash deposits (Holocene)**—Sand, silt, clay, and gravel deposited at the mouth of ephemeral streams on the gentle slope on the east side of the range. Deposits only a few ft thick. Cuts late Pleistocene lake shoreline

Qfy **Young alluvial fan deposits (Holocene)**—Poorly sorted sand, silt, clay, pebble, gravel, and cobbles deposited in alluvial fans along valley margins. Almost all are in the western part of the map area. Cuts late Pleistocene lake shoreline

Qs **Sand dunes and sand sheets (Holocene)**—Very fine grained, well-sorted, pinkish-gray to white calcium carbonate sand and moderate-reddish-orange, fine- to coarse-grained, moderately sorted quartz and carbonate sand in dunes and sheets in Newark and Long Valleys. Moderate-reddish-orange sand present near outcrop of quartzite and conglomerate of Diamond Peak Formation along the southeastern side of the range. Dunes 5-15 ft (1.5-4.5 m) high

Qvf **Recent valley fill (Holocene)**—Sand, silt, clay, and calcium carbonate and alkali precipitate that cover Late Pleistocene pluvial sediments in Long and Newark Valleys. Includes marsh deposits in Newark Valley

Qfi **Intermediate-age alluvial fan (Holocene and Pleistocene)**—Silt and clay deposited in widely spread fans in the eastern and western parts of the map area. Originally widely distributed; now dissected and partly covered by units Qa, Qaf, Qfy, and Qvf. Much larger and extended farther out into the valley than Qaf and Qfy deposits forming today. Thickness less than 10 ft (3 m) in most areas. Cuts late Pleistocene lake shoreline

Qao **Older alluvium (Pleistocene)**—Clay, silt, sand, and gravel deposited along the flanks of ridges in Long and Newark Valleys as well as in basins within the range. Unconsolidated to poorly bedded and cemented by calcium carbonate. In Mooney Basin, has slight (4 degree) dip to the southwest. May include alluvial deposits. Late Pleistocene lake shorelines in Long and Newark Valleys are preserved on the alluvium. Thickness unknown, but probably 100's of ft (tens of m)

Qfo **Older alluvial fans (Pleistocene)**—Poorly sorted sand, silt, clay, and gravel deposited in well-developed fans. Mostly in the western part of the map area. Late Pleistocene lake shorelines preserved on the fans. Thickness unknown, but probably 100's of ft (tens of m)

TERTIARY ROCKS

Tly **Young Tertiary limestone (Pleistocene to Miocene)**—Thick-bedded, white to pinkish-gray, fine-grained limestone with 10-15% sand and pebble-size angular fragments of Paleozoic carbonate and clastic rock and Tertiary volcanic rock. About 10 ft (3 m) thick in one outcrop in eastern part of map area; upper and lower contacts are not exposed

Tv **Tertiary volcanic rocks, undifferentiated (Miocene(?) and Oligocene)**—Intermediate-composition volcanic flows, tuffs, and flow breccias that in most places overlie biotite lithic tuff. Includes some biotite tuff at base where tuff is too thin to be mapped as a separate unit. Typical outcrop weathers to pale reddish brown and forms platy or blocky talus slopes. Consists of a fine-grained matrix with numerous fine- to medium-grained feldspar phenocrysts and, less commonly, quartz and hornblende phenocrysts. Total thickness unknown, but about 300 ft (92 m) exposed near Moore Springs

Tt **Tuff (Oligocene)**—White biotite lithic tuff with numerous pumice fragments and medium-grained quartz, feldspar, and biotite phenocrysts set in fine-grained clayey altered matrix. Commonly fluvially reworked to immature biotite-quartz-feldspar sandstone that, in places, contains boulders of reworked vitrophyre. Erosional and angular unconformable surface between the tuff and underlying Tertiary sedimentary rocks and Paleozoic rocks. $^{40}Ar/^{39}Ar$ age of sanidine from reworked tuff is 34.99+0.08 Ma (Nutt, 1996; L.W. Snee, U.S. Geological Survey, written commun., 1996). Thickness variable from a few feet to tens of feet (meters to tens of meters) in most areas, but is 200-300 feet (60-90 meters) near Moore Springs at the western edge of the map area

Tvq **Rhyolite (Oligocene)**—Foliated, porphyritic, pinkish-gray to light-brownish-gray rhyolite consisting of medium-grained quartz, feldspar, and biotite phenocrysts in fine-grained matrix. Locally, feldspars are altered to clay or the rock is silicified and brecciated and is pinkish gray or greenish gray. Foliation is contorted, but is mostly vertical, and outcrop is interpreted as rhyolite domes. Only crops out in the northeastern part of the map area. Thickness unknown

Ttl **Undifferentiated tuff (unit Tt) and limestone (Oligocene and Eocene)**—Thin-bedded pinkish-gray lacustrine limestone that contains fossil snails about 0.08 in (2 mm) in length. Characterized by puffy, white, clay-rich soil partially covered with tuff and limestone float, and interpreted as the contact or near the contact of unit Tt and Eocene sedimentary rocks. Only exposed on the east side of Alligator Ridge. Thickness is about 10 ft (3 m)

TKs **Sedimentary rocks (Eocene and Cretaceous?)**—Pale-red-purple to grayish-pink and grayish-orange volcaniclastic and siliceous sandstone, siltstone, and shale, moderate-reddish-brown conglomerate, and minor lacustrine limestone with Eocene-age snails to about 0.08 inch (2 mm) in length. Sandstone is fine to medium grained and commonly contains angular pebbles of Paleozoic rocks and clay-altered volcanic fragments. Pebbles predominantly derived from the Diamond Peak Formation and include quartzite and chert, but also include clay-altered shale and volcanic rock; lower part of conglomerate contains angular clasts of clay that are interpreted as tear-up shale. Lower conglomerate may include rocks of Cretaceous Nework Canyon Formation. Unit is silicified and clay-altered. Depositionally, but discordantly, overlies Chainman Shale, Joanna Limestone, Pilot Shale, and Guilmette Formation and is discordantly overlain by biotite tuff. Outcrops at and near Alligator Ridge mine and to the south; in no area are both upper and lower contacts exposed. Best exposure at the Alligator Ridge mine. Maximum exposed thickness is about 150 ft (46 m)

TKl **Limestone (Eocene(?) and Cretaceous(?))**—Pinkish-gray, poorly bedded, aphanitic to fine-grained, thick-bedded to massive limestone. Tectonically fractured. No fossils observed. Conformable contact with underlying conglomerate; upper contact not exposed. About 250 ft (68 m) thick in eastern part of the map area

TPc **Conglomerate (Eocene(?) to Permian(?))**—Moderate-reddish-orange to moderate-reddish-brown, friable, calcite-cemented conglomerate, with rounded, but poorly sorted, pebbles and cobbles of Diamond Peak Formation. Found as small, scattered outcrops along east side of range and overlying Diamond Peak Formation. Overlain conformably by unit TKl. About 15 ft or less (4.5 m or less) in thickness

TERTIARY TO JURASSIC ROCKS

TJi **(Tertiary to Jurassic)**—Porphyritic dikes consisting of quartz, clay-altered feldspar, and, rarely, biotite, set in fine-grained clay-altered matrix. Only crops out in northeastern part of the map area

PALEOZOIC

Pa **Arcturus Formation (Lower Permian)**—Slope-forming and poorly outcropping, thin-bedded, platy, fine-grained, grayish-orange limestone and siltstone and minor light-gray to medium-gray limestone. Abundant fusulinids as much as 1 inch (2.5 cm) in length. The uppermost part of the unit exposed in the map area is a ridge-forming, thick-bedded, gray, fossiliferous limestone with conglomeratic lenses containing chert pebbles. Arcturus outcrop is restricted to southern part of map area; probably underlies some of the alluvial cover in low area east of Buck Mountain. Upper contact not exposed. Lower contact with Rib Hill Sandstone is not conformable; much, if not all, of the discordance is tectonic and due to low-angle faulting and disharmonic folding. In places, Rib Hill is not present and Arcturus rests on Ely Limestone. Because of cover by Quaternary sediments and low-angle fault between Rib Hill Sandstone and Arcturus, thickness of Arcturus in map area is unknown; Rigby (1960), who combined the Rib Hill and Arcturus, estimated 1,500-2,000 ft (458-610 m) thickness

Prh **Rib Hill Sandstone (Lower Permian)**—Ledge- and slope-forming, pale-yellowish-orange to grayish-orange, thin- to thick-bedded, platy calcareous siltstone to fine sandstone. Contains fine-grained grayish-orange limestone nodules as much as 4 inches (10 cm) in diameter. Upper contact at change of slope corresponding to change in lithology from predominantly sandstone to platy limestone. Lower contact not exposed in map area; about 235 ft (72 m) of Rib Hill Sandstone crops out in map area

IPe **Ely Limestone (Middle to Lower Pennsylvanian)**—Ledge- to cliff-forming, very light gray to yellowish-gray, thin-bedded to massive, regularly bedded, fine-grained bioclastic limestone that is characterized by grayish-orange to moderate-yellowish-brown chert lenses. Interbedded, slope-forming and poorly outcropping, moderate-reddish-orange to grayish-orange siltstone mostly found as float. May include Permian Strathearn Formation that overlies Ely Limestone just west of the map area on top of Buck Mountain (W. S. Snyder, Boise State University, oral commun., 1999). Ely makes up the high and poorly vegetated cliffs of Buck Mountain at the western edge of the map area. Top of unit not exposed. Lower contact gradational from limestone and conglomeratic limestone of the underlying Diamond Peak Formation to the regularly bedded and cliff-forming limestone of the Ely Limestone. Lower contact is placed at base of cliff that corresponds to predominance of limestone. Entire unit not exposed in map area, but is greater than 1,500 ft (458 m) thick.

Mdp **Diamond Peak Formation (Upper Mississippian)**—Distinctive clastic unit of sandstone, quartzite, siltstone, shale, conglomerate, and limestone that is characterized by cliffs of chert-bearing conglomerate. Sandstone and quartzite, the most abundant rock types, are medium grained, well sorted, grayish orange, pale orange, pale yellowish orange, grayish orange to moderate yellowish brown, grayish red to moderate red, and white. Shale and siltstone rarely crop out, but form ledges between sandstone beds. Conglomerate is moderate reddish orange, dark yellowish orange, grayish orange and pale yellowish orange, matrix and clast supported, moderately sorted, and contains rounded to subangular pebbles and cobbles in a quartz sand matrix. The clasts are predominantly quartzite and green and red chert pebbles derived from the Ordovician Vinini Formation that crops out west of the map area. Limestone is thin to thick bedded, very light gray to light gray or light brownish gray where silty, and contains abundant bioclastic material, particularly crinoids and horn corals. In the upper part of the unit, thick-bedded fossiliferous limestone is interbedded with conglomeratic limestone, conglomerate, quartzite, and sandstone. Contact with the underlying Chainman Shale is gradational and placed at the base of persistent thick sandstone beds, typically at a change in slope. About 2,200 ft (671m) thick in western part of map area

Mch **Chainman Shale (Upper and Lower Mississippian)**—Poorly outcropping shale, siltstone, and limestone that typically underlie grass-covered valleys or rolling hills. Limestone is micritic and characterized by its dark-gray color on fresh surface. Upper part is predominantly poorly exposed grayish-green to black carbonaceous shale with sandstone beds and lenses increasing upward. Best exposures of this part of the unit are in the Buck Pass area. The lower part comprises more resistant siltstone and limestone. Basal calcareous siltstone is overlain by grayish-orange to dark-yellowish-orange, thinly bedded and platy micritic limestone. Best exposure is in low hills east of Buck Pass. Thickness is about 1,000 ft (305 m)

Mj **Joana Limestone (Lower Mississippian)**—Cliff-forming, medium- to coarse-grained, thin- to thick-bedded limestone characterized by abundant crinoids and black chert. Regular bedding with resistant 1-2 inch (2-5 cm) chert layers. Commonly replaced by moderate-red to very light gray jasperoid; where replaced by jasperoid, relict bedding is tightly folded and unit is typically thinned. Contact with underlying Pilot Shale is sharp, and the Joana cliffs are in bold contrast to the underlying Pilot Shale. Thickness about 120 ft (37 m)

MDp **Pilot Shale (Lower Mississippian and Upper Devonian)**—Slope-forming, poorly outcropping, platy, dark-yellowish-orange calcareous siltstone with interbedded thin-bedded micritic limestone. Upper 10 ft (3 m) is quartzose sandstone. Host for disseminated gold deposits at Alligator Ridge and Yankee mines. Contact with underlying Guilmette Formation is jasperoid, in places discordant to bedding; interpreted as silicified fault breccia between the competent limestone of the Guilmette and the incompetent siltstone of the Pilot Shale. Thickness is 300-400 ft (90-120 m)

Dg **Guilmette Formation (Upper and Middle Devonian)**—Cliff- and ledge-forming limestone and dolomite that make up many of the ridges in the map area. Includes the Devils Gate Limestone and part of the Nevada Formation described near Eureka, Nevada (Nolan and others, 1956). Upper part is massive, cliff-forming, medium-gray to medium-dark-gray, fine-grained limestone that is laminated and contains abundant algal structures. On the east side of Alligator Ridge, laminated limestone changes laterally into laminated dolomite. Middle part is a slope of laminated dolomite similar in lithology to Simonson and Sevy Dolomites. Limestone is medium gray to medium dark gray, less commonly brownish gray and light brownish gray, in many places cut by calcite veins, and typically forms rounded outcrop. Lower part is interbedded thick- to thin-bedded dolomite of Sevy and Simonson lithology and medium-gray to medium-dark-gray limestone. Lower contact with Simonson Dolomite is transitional; contact is at base of thick limestone beds. Because of widespread faults and folds, thickness unknown but estimated as at least 1,500 ft (460 m)

Dsi **Simonson Dolomite, undifferentiated (Middle Devonian)**

Dsiu **Upper member**—Slope-forming, thin- to thick-bedded dolomite of varying lithology. The most prominent lithology is laminated light-gray, light-brownish-gray, and brownish-gray dolomite, but also includes very light gray to light-gray, very fine to fine-grained dolomite similar to that of the Sevy Dolomite and fine- to medium-grained sugary dolomite. Estimated to be 450-500 ft (137-153 m) thick

Dsil **Lower member**—Cliff-forming, uniform light-gray-brown, medium- to coarse-grained, obscurely bedded to thick-bedded and laminated dolomite. Laminations are best observed on weathered surfaces. Weathered outcrop is blocky and contains voids along bedding. Sand lenses in lower 30 ft (9 m). Lower contact is transitional over about 20 ft (6 m), and sand lenses are in both the upper Sevy Dolomite and lower Simonson Dolomite. Contact placed where uniform light-gray dolomite dominates, which corresponds to base of cliff. Estimated to be 300-350 ft (92-107 m) thick

Dse **Sevy Dolomite (Lower Devonian)**—Uniform, ledge-forming, thin- to thick-bedded, laminated, very fine grained, dense dolomite that is very light gray to light gray on surface, light gray to light brownish gray on fresh fractures. Very light gray color shows well on slopes. Floating sand grains, particularly in the upper part. Transitional lower contact corresponds to change in slope. Rigby (1960) included much of the underlying unit DSOd dolomite in the Sevy; the description herein assigns Sevy as used by Nolan in the Deep Creek Range. Contact put at change in slope. Thickness is about 150 ft (46 m)

DSOd **Devonian, Silurian, and Ordovician dolomites, undifferentiated (Lower Devonian to Upper Ordovician)**—A variety of interbedded dolomites. The upper part is ridge- to cliff-forming, obscurely bedded, very light gray to pinkish gray on weathered surface, white to light gray on fresh surface, thick bedded, in places laminated, sugary, medium to coarse grained, and contains rare chert. Forms rounded outcrop. In the uppermost part, contains beds with lithology similar to units Dse and Dsi; also contains minor sand lenses. The middle part is ridge- to cliff-forming, medium-bedded, commonly laminated, fine- to medium-grained, brownish-gray dolomite. The lower part is ledge-forming gray dolomite that is thin to thick bedded, fine to medium grained, and in places sugary. This sequence of dolomites is transitional between the Devonian Nevada Formation of the Eureka area (Nolan, 1956) to the west and Devonian, Silurian, and Ordovician rocks in the Deep Creek Range (Nolan and others, 1935; Nutt and Thorman, 1994). In the Alligator Ridge area, the unit has much less sand than occurs in the Nevada Formation. Unit includes rocks that Rigby (1960) included in the Sevy Dolomite. Total thickness unknown because rocks are cut by faults and covered by alluvium, but is estimated at about 1,000 ft (1,600 m).

Ofh **Fish Haven Dolomite, lower part (Upper Ordovician)**—Ledge-forming, thick-bedded, fine- to medium-grained, fetid, pale-brown dolomite with abundant chert and fossil fragments. Chert is moderate-red on the surface and gray to black on fresh surface; occurs along laminations. Abrupt, easily mapped upper contact. About 125 ft (38 m) thick

Oe **Eureka Quartzite (Upper and Middle Ordovician)**—Cliff-forming, thick-bedded to massive, cross-bedded, fine-grained, distinctive vitreous quartzite. White, weathers grayish pink. Upper and lower contacts sharp. Crops out only in northwestern part of the quadrangle, in and south of Martin Canyon. About 230 ft (70 m) thick

Op **Pogonip Group (Middle and Lower Ordovician)**—Only in northwestern part of the map area, in Martin Canyon. Also, makes up cliff on north side of Martin Canyon, just to the north of the map area. In the map area, only upper tens of ft (m) of the unit crop out in the slope beneath a Eureka Quartzite cliff. Where exposed in the map area, unit underlies pale-orange to grayish-orange slope consisting of thin- to medium-bedded, medium-light-gray silty limestone and grayish-orange siltstone. Limestone with grayish-orange silt layers forms a chickenwire texture. Sharp upper contact

Contact—Dashed where approximately located, dotted where concealed

Strike and dip of bedding
40 **Inclined**
Vertical
65 **Overturned**

Fault—Bar and ball on downthrown side, arrow showing relative movement, dashed where approximately located, dotted where concealed

Reverse fault—Solid teeth on upper plate, dashed where approximately located, dotted where concealed

Low-angle, younger-over-older, Eocene or older attenuation fault—Open teeth and bar on upper plate, dashed where approximately located, dotted where concealed

Anticline—Arrow showing direction of plunge, dashed where approximately located, dotted where concealed

Syncline—Arrow showing direction of plunge, dashed where approximately located, dotted where concealed

Shoreline of late Pleistocene lakes in Newark and Long Valleys

Disturbed mine area—Includes pits, buildings, and dumps

Marker bed

Major breccia zone

Bed in cross section

Foliation, near vertical—In cross section *A–A′* only

Small scale folds—In cross section *A–A′* only

INTRODUCTION

The Alligator Ridge area is in east-central Nevada, about 50 mi (80 km) northwest of Ely, Nevada (fig. 1). Alligator Ridge is part of the Big Bald Mountain-Buck Mountain region that is the southern extension of the Ruby Mountains south of Overland Pass (figs. 1, 2). Long Valley and Newark Valley bound the range to the east and west, respectively, and were the sites of late Pleistocene lakes (Mufflin and Wheat, 1979). The Alligator Ridge area hosts disseminated gold deposits at Alligator Ridge and Yankee mines, and it is on the southeastern edge of the Bald Mountain mining district, which also hosts disseminated gold deposits. This geologic map of the Alligator Ridge area is a mosaic of Mooney Basin Summit, Buck Mountain East, and parts of Long Valley Slough and Sunshine Well NW 1:24,000-scale U.S. Geological Survey quadrangle maps. Previous geologic maps of the Alligator Ridge area are by Rigby (1960) and by Hose and Blake (1976).

GEOLOGIC SETTING

East-central Nevada, which includes the Alligator Ridge area, is in the eastern Great Basin and is characterized by north- to northeasterly trending ranges bounded by faults and separated by broad basins (fig. 1). The region is underlain primarily by Proterozoic metamorphic rocks, Paleozoic miogeoclinal carbonate and clastic rocks, Jurassic, Cretaceous, and Tertiary plutons, and Tertiary volcanic rocks. Poorly understood Jurassic deformation, Cretaceous to early Tertiary (Sevier-age) compression, and Tertiary extension affected this area (Thorman and others, 1990). The eastern Great Basin is in the hinterland of the Sevier thrust belt and it is characterized by reverse faults and broad folds and, less commonly, thrust faults. The Roberts Mountains thrust, which was active during the Devonian and Mississippian Antler orogeny and which placed Paleozoic eugeoclinal rocks over Paleozoic miogeoclinal rocks, is west of the study area, near Eureka, Nevada (fig. 1).

Tertiary volcanism and extension followed Mesozoic orogeny in east-central Nevada. Volcanic rocks are broadly divided into an older group of late Eocene to Oligocene tuffs and flows (Brooks and others, 1995) and a younger, mostly Miocene, suite of bimodal rocks. Extension preceded, accompanied, and followed volcanism. One of the major extensional regions in the eastern Great Basin is in the Ruby Mountains (fig. 1), just north of the Alligator Ridge area, where a metamorphic core complex is exposed and records Paleocene and Eocene uplift and rapid Miocene extension along listric faults (Dallmeyer and others, 1986; McGrew and Snee, 1994). Basin-and-range normal faults, typically oriented north-south and post-dating major uplift of the Ruby Mountains, exist throughout the area.

Ordovician through Permian carbonate and clastic rocks, Eocene sedimentary rocks, and Tertiary volcanic rocks underlie the Alligator Ridge area. Outcropping units are predominately Devonian and Mississippian units (Guilmette Formation, Pilot Shale, Joana Limestone, Chainman Shale, and Diamond Peak Formation) and Tertiary volcanic rocks. In contrast, Cambrian and Ordovician rocks and a Jurassic pluton (Hitchborn and others, 1996) crop out near Big Bald Mountain. The Big Bald Mountain-Buck Mountain area, as a whole, is tilted such that increasingly younger rocks are exposed to the south.

Paleozoic rocks

Paleozoic rocks in the map area include the uppermost part of the Lower and Middle Ordovician Pogonip Group through the Permian Arcturus Formation. The Paleozoic rocks are transitional between the rocks to the east, described at Gold Hill, Utah, by Nolan (1935), and to the west, described at Eureka, Nevada, by Nolan and others (1956). For this report the nomenclature I used is from the Deep Creek Range (Nolan, 1935), the Cherry Range near Ely, Nevada (Poole and others, 1988), the studies of Osmond (1954, 1962), and the previous map of the area (Rigby, 1960). In particular, the Guilmette Formation is used in place of the upper part of the Lower to Middle Devonian Nevada Formation and the Middle to Upper Devonian Devils Gate Limestone as used near Eureka. The Sevy Dolomite, Simonson Dolomite, and undifferentiated Ordovician, Silurian, and Devonian dolomites are used instead of the lower part of the Nevada Formation. I chose Guilmette instead of Devils Gate because of the recognition of lateral change from limestone to dolomite, and the Sevy, Simonson, and undifferentiated dolomites are used instead of Nevada Formation because of their similarity to Simonson and Sevy lithology and the paucity of sandstone that is characteristic of the Nevada Formation.

Eocene sedimentary rocks

Eocene sedimentary rocks crop out in the eastern part of the Alligator Ridge area, including at the Alligator Ridge mine. The sequence consists of fluvial and lacustrine sandstone, siltstone, and conglomerate, in part volcaniclastic or igneous-derived, and limestone. The clastic rocks contain chert and quartz clasts derived from the Diamond Peak Formation, and white, clay-altered fragments from an unknown igneous source. The Eocene rocks depositionally, and in places unconformably, overlie Middle and Upper Devonian Guilmette Formation, Upper Devonian and Lower Mississippian Pilot Shale, Lower Mississippian Joana Limestone, and Lower and Upper Mississippian Chainman Shale. They are also unconformably overlain by biotite-quartz lithic tuff, in places reworked to quartz-biotite sandstone, of about 35 Ma (Nutt, 1996).

Cretaceous, Paleocene, and Eocene sedimentary rocks are scattered throughout the eastern Great Basin (Fouch and others, 1979). Fouch and others (1979) and Soloman and others (1979) show that a volcanogenic component is in some places present in Eocene rocks, and it is as old as about 45 Ma.

An Eocene age for lacustrine limestone of the Alligator Ridge area was determined by identification of gastropods from two localities: the Vantage pit at the Alligator Ridge mine and an outcrop on the eastern side of Alligator Ridge (Nutt and Good, 1998). The gastropods are recrystallized; however, excellent morphological details are available from external and internal molds. The sample from the Vantage pit at the Alligator Ridge mine is from limestone interbedded with volcaniclastic sandstone, siltstone, and mudstone. The gastropod fauna is *Pleurolimnnaea tenuicosta* (Meek and Hayden, 1856) and *Lymnaea*, sp. indeterminate, but resembles *L. similis* Meek (1860). The sample from the east side of Alligator Ridge contains gastropods preserved in random orientations on bedding planes. The gastropod fauna consists of *Lymnaea similis* Meek (1860) and *Lymnaea* sp. Good (1983, 1987).

Age of the limestone can be inferred from the stratigraphic distribution of these gastropod species in the Rocky Mountain region where they are associated with ostracodes, charophytes, and fossil mammals (Henderson, 1935; Hanley, 1974, 1976; Good, 1983, 1987). Gastropods at both localities are interpreted as Bridgerian (latest Early to early Middle Eocene). These molluscs indicate the limestone at Alligator Ridge is age correlative to the White Sage Formation in the Deep Creek Mountains, Nevada and Utah, (Potter and others, 1995) and the upper part of the Sheep Pass Formation (Good, 1987).

The depositional environment of the mollusc-bearing limestones is inferred from the paleoecological tolerances of modern molluscs (Dodd and Stanton, 1981). Paleoecological interpretations are drawn at the level of the Family Lymnaeidae. Lymnaeids are basommatophoran pulmonate gastropods (air-respiring gastropods that have returned to aquatic habitats). They can exchange gases through subcutaneous exchange or by bringing their pneumostomes to the air-water interface to intake air into their mantle cavity. Lymnaeids prefer quiet-water habitats, live on aquatic-rooted, emergent vegetation, and are herbivorous (Good, 1987; Hanley, 1976). Lymnaeids are abundant in very small bodies of water with mud bottom and little aeration (Larocque, 1968). The mollusc assemblage indicates the depositional environment was a small, eutrophic, perhaps even ephemeral pond.

Tertiary volcanic rocks

Tertiary volcanic rocks crop out in the northern, southern, and eastern parts of the map area. The basal volcanic rock is a white quartz-biotite tuff that is commonly reworked. An Ar^{40}/Ar^{39} age of 34.99±.08 Ma was obtained from sanidine from reworked tuff (Nutt, 1996; L.W. Snee, U.S. Geological Survey, written commun., 1996). The tuff is overlain by intermediate-composition flow and flow breccia in a sequence similar to elsewhere in the eastern Great Basin (Brooks and others, 1995). The volcanic rock lies unconformably on Paleozoic and Eocene rocks and is less tilted than the underlying rocks. In the west-central part of the map area, reworked tuff dips about 15° east.

STRUCTURE

Rocks in the Alligator Ridge area record multiple folding and faulting events. The present-day topography is dominated by broad, north-trending folds and north-trending basin-and-range normal faults that result in a horst and graben pattern in which the Guilmette Formation is repeatedly exposed on ridges. However, the faults in part overprint and obscure older structures. Low-angle younger-over-older faults, reverse faults, strike-slip faults, and two sets of folds predate the basin-and-range normal faults.

Attenuation faults

The oldest recognized structures are low-angle, younger-over-older faults, herein called attenuation faults, which are shown on the map with open triangles and bars on the upper plate. Attenuation faults exist throughout the eastern Great Basin (Nutt and others, 1996); they are zones of detachment between rocks of contrasting competency, are typically bounded by east-striking faults, are discontinuous over large distances, and cut out tens to thousands of ft of rock. In the map area, attenuation faults are particularly well developed between carbonate and clastic units: the Guilmette Formation and Pilot Shale, the Pilot Shale and Joana Limestone, the Joana Limestone and Chainman Shale, and the Diamond Peak Formation and Ely Limestone.

The origin of the attenuation faults is uncertain. They are interpreted in this region as detachments forming during disharmonic folding. The faults are folded along with their enclosing rocks and the faults are overlain by Eocene sedimentary rocks and Oligocene volcanic rocks. They are therefore Eocene or older structures.

An example of attenuation faults is in the northeastern part of the map area and on the northeastern side of Alligator Ridge, where the Pilot Shale, Joana Limestone, and Chainman Shale are dramatically thinned. Directly to the south, the attenuation faults are steeply dipping and have been reactivated by high-angle normal faults.

Reverse faults

Reverse faults of small to moderate displacement are present. Most are north of Buck Pass and offset Ordovician, Silurian, and Devonian carbonate units along the western side of the range. The north-striking reverse faults that have a few hundred ft or less displacement indicate eastward-directed movement. South of Buck Pass, west-directed movement is interpreted on the western side of Buck Mountain as shown in cross-section B-B'. Both cross sections A-A' and B-B' show normal faults that moved along earlier reverse faults; these interpretations suggest that reverse faults were more widespread than recognized because of later reactivation by normal faults.

West- to northwest-striking faults

West- to northwest-striking faults show only moderate offset, but are interpreted as major crustal features that were repeatedly activated. In the Alligator Ridge and Big Bald Mountain areas, Jurassic or older movement occurred along at least some west- to northwest-striking faults: a west-northwest fault zone about 4 mi north of the map area and in the Big Bald Mountain area shows left-lateral slip and is intruded by, as well as offsets, a Jurassic pluton (Hitchborn and others, 1996; Nutt, unpublished mapping. 1998). In the map area, the fault through Buck Pass shows a similar northwest-strike but the observed offset is in a normal sense; this offset is interpreted as reactivation along an earlier strike slip fault.

The west to northwest faults segment the Big Bald Mountain-Buck Mountain area into distinct structural domains. The fault at Buck Pass separates the northern part of the range, in which east-directed reverse faults exist, from Buck Mountain, at which a west-directed reverse fault is interpreted (cross-section B-B'). Prominent west- to northwest-striking faults north of Buck Pass and in the western part of the map area are at the canyon near Warm Springs Ranch, about 2 mi (3 km) north of the canyon near Warm Springs Ranch, and, at the northern edge of the map, Martin Canyon. Martin Canyon and the fault zone about 2 mi (3 km) north of the canyon near Warm Springs Ranch and about 1 mi (0.6 km) south of Martin Canyon bound a domain that separates the Alligator Ridge area from Big Bald Mountain area. North-trending normal faults that expose Cambrian rocks in the Big Bald Mountain area end at about Martin Canyon. The approximately east-west-trending fault zone about a mile south of Martin Canyon is the boundary along the western part of the range that separates predominantly east-dipping rocks in the Big Bald Mountain area and the northwestern part of the map area from west-dipping rocks to the south. The northwest- to west-striking faults are interpreted as repeatedly being used as accomondation zones during compression and extension.

Normal faults

Mostly north-striking normal faults cut the Alligator Ridge area. Faults include both listric and high-angle. Within the map area, deep basins, such as Mooney Basin, are down-dropped by these faults.

Listric faults that have less than 1,000 ft (305 m) of offset are identified along the eastern margin of Buck Mountain. The map area is just south of the Ruby Mountain-East Humboldt core complex in which a listric fault along the western side of the range dropped rocks down to the west, primarily during Miocene time (Dallmeyer and others, 1986). This fault extends into the Big Bald Mountain area, and it is exposed along the western edge of the range to just north of Martin Canyon (Nutt, unpub. mapping, 1998), which is at the northwestern boundary of the map area. The listric fault along the east side of Buck Mountain, in contrast, drops rocks down to the east. A nearly overturned syncline in the hanging wall suggests that the listric fault followed an earlier reverse or thrust fault with west-directed movement (cross-section B-B').

The high-angle Tertiary normal faults, which in part follow older faults and fold axes, are predominantly north-striking or west- to northwest-striking. Small pods of unit TJi are near or along some of these faults; since unit TJi is older than the normal faults, its presence suggest that the faults were active earlier, in Mesozoic or Paleozoic time. Normal offset is as much as thousands of feet, and, in the east, places Tertiary sedimentary rocks or Tertiary volcanic rocks in contact with Devonian and Mississippian rocks. The west side of Alligator Ridge and adjacent Mooney Basin are bounded by north-striking normal faults. The presence of more than one period of Quaternary alluvial fan development in Long and Newark Valley indicate movement has continued into the Holocene.

Folds

The most prominent set of folds is north-trending and extends nearly the length of the map area. An example of these folds is the anticline along Alligator Ridge; the Yankee and Alligator Ridge mines are on the western flank of this fold. The limbs of north-trending folds have mostly gentle dips, but at Alligator Ridge the east limb of the anticline is steep to overturned. In many places, normal faults follow and offset fold axes. These folds predate Tertiary volcanic rocks, and are presumed to be Jurassic or Cretaceous to early Tertiary (Sevier-age) compressional structures.

A second set of fold axes is northwest-trending (Nutt, 1997). In contrast to the north-trending folds, the northwest-trending folds are localized and of much shorter extent. These shorter folds are associated with northwest- to west-striking faults that typically show normal movement but are interpreted as former strike-slip faults that were active during formation of the northwest folds. A good example of this set of folds is in the northwestern part of the map area in the ridges between Warm Springs Ranch and Mooney Basin and southeast to the Alligator Ridge gold mine. The folds deform the earlier set of folds and deform Eocene sedimentary rocks. These folds are interpreted as being Eocene in age and related to uplift of the Ruby Mountain-East Humboldt Range core complex to the north (Nutt and Good, 1998). Using $^{40}Ar/^{39}Ar$ methods, McGrew and Snee (1994) documented Oligocene and Miocene uplift of the Ruby Mountain-East Humboldt Range core complex, and suggested that poorly constrained hornblende ages from rocks at high structural level indicate initial uplift was in the early Tertiary, estimated between 63 and 49 Ma. Our data constrain deformation to post-early middle Eocene and indicate transpression along the southern edge of the uplifted complex.

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REFERENCES

Brooks, W.E., Thorman, C.H., and Snee, L.W., 1995, The $^{40}Ar/^{39}Ar$ ages and tectonic setting of the middle Eocene northeast Nevada volcanic field: Journal of Geophysical Research, v. 100, no. B7, p. 10,403-10,416.
Dallmeyer, R.D., Snoke, A.W., and McKee, E.H., 1986, The Mesozoic-Cenozoic tectonothermal evolution of the Ruby Mountains, East Humboldt Range, Nevada--A Cordilleran metamorphic core complex: Tectonics, v. 5, no. 6, p. 931-954.
Dodd, J.R., and Stanton, R.J., 1981, Paleoecology, concepts and applications: John Wiley and Sons, New York, 559 p.
Good, S.C., 1983, Molluscan Paleobiology of the Sheep Pass Formation (Latest Cretaceous to Eocene) of East Central Nevada: Boulder, University of Colorado, M.S. Thesis, 142 p.
———1987, Mollusc-based interpretations of lacustrine paleoenvironments of the Sheep Pass Formation (Latest Cretaceous to Eocene) of east-central Nevada: Palaios, v. 2, p. 467-478.
Fouch, T.D., Hanley, J.H., and Forester, R.M., 1979, Preliminary correlation of Cretaceous and Paleogene lacustrine and related nonmarine sedimentary and volcanic rocks in parts of the Great Basin of Nevada and Utah, *in* Newman, G.W., and Goode, H.D., eds., Basin and Range symposium and Great Basin field conference: Rocky Mountain Association of Petroleum Geologists and Utah Geological Association, p. 305-312.
Hanley, J.H., 1974, Systematics, paleoecology, and biostratigraphy of nonmarine mollusca from the Green River and Wasatch Formations (Eocene), southwestern Wyoming and northwestern Colorado: Laramie, University of Wyoming, Ph.D. Dissertation, 273 p.
———1976, Paleosynecology of nonmarine Mollusca from the Green River and Wasatch Formations (Eocene), southwestern Wyoming and northwestern Colorado, *in* Scott, R.W., and West, R.R., eds., Structure and Classification of Paleocommunities: Dowden, Hutchinson and Ross, p. 235-261.
Henderson, J., 1935, Fossil nonmarine mollusca of North America: Geological Society of America, Special Paper 3, 313 p.
Hitchborn, A.D., Arbonies, D.G., Peters, S.G., Conners, K.A., Noble, D.C., Larson, L.T., Beebe, J.S., and McKee, E.H., 1996, Geology and gold deposits of the Bald Mountain mining district, White Pine County, Nevada, *in* Coyner, A.R., and Fahey, P.L., eds., Geology and Ore Deposits of the American Cordillera: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1995, p. 505-546.
Hose, R.K., and Blake, M.C., Jr., 1976, Geologic map of White Pine County, Nevada, scale: 1:250,000, *in* Geology and mineral resources of White Pine County, Nevada, Part I, Geology: Nevada Bureau of Mines and Geology Bulletin 85, p. 1-35.
Ilchik, R.P., 1990, Geology and geochemistry of the Vantage gold deposits, Alligator Ridge-Bald Mountain mining district, Nevada: Economic Geology, v. 85, no. 1, p. 50-75.
Larocque, A., 1968, Pleistocene Mollusca of Ohio: Geological Survey of Ohio, Bulletin 62, Part 1, p. 357-553.
McGrew, A.J., and Snee, L.W., 1994, $^{40}Ar/^{39}Ar$ thermochronologic constraints on the tectonothermal evolution of the northern East Humboldt Range metamorphic core complex, Nevada: Tectonophysics 238, p. 425-450.
Meek, F.B., 1860, Descriptions of new fossil remains collected in Nebraska and Utah, by the exploring expeditions under the command of Capt. J.H. Simpson, of the U.S. Topographical Engineers: Philadelphia Academy of Natural Sciences, Proceedings, v. 12, p. 308-315.
Meek, F.B., and Hayden, F.V., 1856, A report on the invertebrate Cretaceous and Tertiary fossils of the upper Missouri country: U.S. Geologic and Geographic Survey of Territories (Hayden Survey), v. 9, 629 p.
Mufflin, M.D., and Wheat, M.M., 1979, Pluvial lakes and estimated pluvial climates of Nevada: Nevada Bureau of Mines and Geology Bulletin 94, 57 p.
Nolan, T.B., 1935, The geology of the Gold Hill mining district, Utah: U.S. Geological Survey Professional Paper 177, 172 p.
Nolan, T.B, Merriam, C.W., and Williams, J.S., 1956, The stratigraphic section in the vicinity of Eureka, Nevada: U.S. Geological Survey Professional Paper 276, 77 p.
Nutt, C.J., 1996, Cretaceous(?) to early Oligocene sedimentary and volcanic rocks at Alligator Ridge, Buck Mountain-Bald Mountain area, central Nevada, *in* Taylor, W.J., and Langrock, H., eds., Cenozoic structure and stratigraphy in central Nevada: 1996 Field Conference Volume, Nevada Petroleum Society Inc., Reno, p. 13-18.
———1997, Sequence of deformational events and the recognition of Eocene(?) deformation in the Alligator Ridge area, east-central Nevada, *in* Vikre, P., Thompson, T.B., Bettles, K., Christensen, O., and Parratt, R., eds., Carlin-type Gold Deposits Field Conference Guidebook, Elko, October 1997, Society of Economic Geologists Guidebook Series v. 28, p. 203-211.
Nutt, C.J., and Good, S.C., 1998, Recognition and significance of Eocene deformation in the Alligator Ridge area, central Nevada, *in* Tosdal, R.M., ed., Contributions to the gold metallogeny of northern Nevada: U.S. Geological Survey Open-File Report 98-338, p.141-150.
Nutt, C.J., and Thorman, C.H., 1994, Geologic map of the Weaver Canyon, Nevada and Utah, quadrangle, and parts of the Ibapah Peak, Utah, and Tippett Canyon, Nevada, quadrangles: U.S. Geological Survey Open-File Report 94-635, scale 1:24,000.
Nutt, C.J., Thorman, C.H., Snee, L.S., and Hintze, L.S., 1996, Eocene or older attenuation faults in the eastern Great Basin, *in* Coyner A.R., and Fahey, P.L., eds., Geology and Ore Deposits of the American Cordillera: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1995, p. 609-623.
Osmond, J.C., 1954, Dolomites in Silurian and Devonian of east-central Nevada: Bulletin of the American Association of Petroleum Geologists, v. 38, no. 9, p. 1911-1956.
———1962, Stratigraphy of Devonian Sevy Dolomite in Utah and Nevada: Bulletin of the American Association of Petroleum Geologists, v. 46, no. 11, p. 2033-2056.
Poole, F.G., Elrick, Maya, Tucker, R.E., Harris, R.N., Oliver, H.W., and Johnson, F.L., 1988, Mineral Resources of the Goshute Canyon Wilderness Study area, Elko and White Pine Counties, Nevada: U.S. Geological Survey Bulletin 1725-E, 13 p.
Potter, C.J., Dubiel, R.F., Snee, L.W., and Good, S.C., 1995, Eocene extension of early Eocene lacustrine strata in a complexly deformed Sevier-Laramide hinterland, northwest Utah and northeast Nevada: Geology, v. 23, p. 181-184.
Rigby, J.K., 1960, Geology of the Buck Mountain-Bald Mountain area, southern Ruby Mountains, White Pine County, Nevada, *in* Boettcher, J.W., and Sloan, W.W., Jr., eds., Guidebook to the geology of east-central Nevada: Intermountain Association of Petroleum Geologists and Eastern Nevada Geological Society 11th Annual Field Conference, 1960, Salt Lake City, Utah, p. 173-180.
Solomon, B.J., McDee, E.H., and Andersen, D.W., 1979, Stratigraphy and depositional environments of Paleogene rocks near Elko, Nevada, *in* Armentrout, J.M., Cole, M.R., and TerBest, Harry, eds., Cenozoic paleogeography of the western United States, Pacific Coast Paleogeography Symposium 3: Pacific Section, Society of Economic Paleontologists and Mineralogists, p. 75-88.
Thorman, C.H., Ketner, K.B., Brooks, W.E., Snee, L.W., and Zimmermann, R.A., 1990, Late Mesozoic-Cenozoic Tectonics in northeastern Nevada, *in* Raines, G.L., Lisle, R.E., Schafer, R.W., and Wilkinson, W.H., eds., Geology and Ore Deposits of the Great Basin: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1990, p. 25-45.

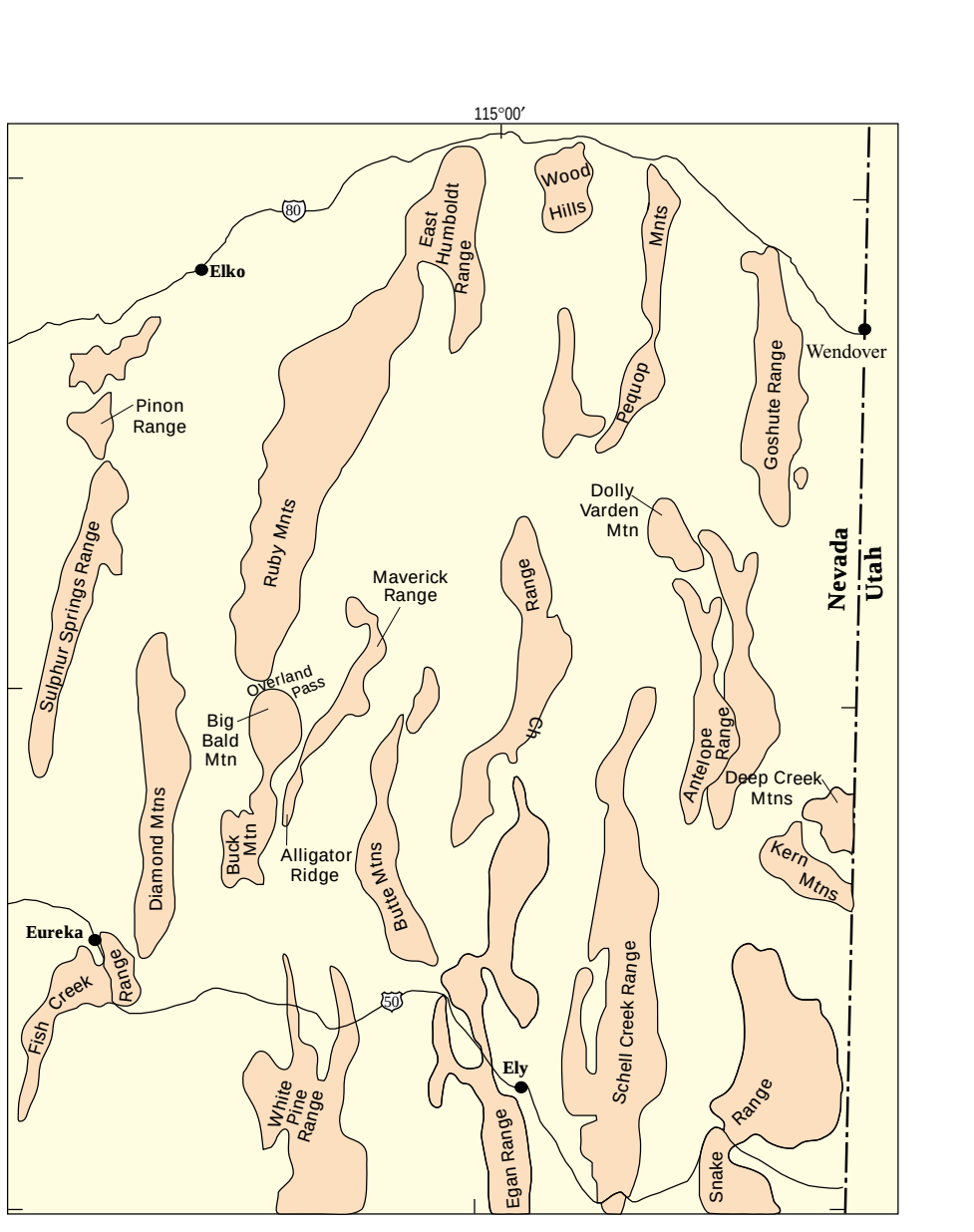

Figure 1. Regional index map of the Alligator Ridge area

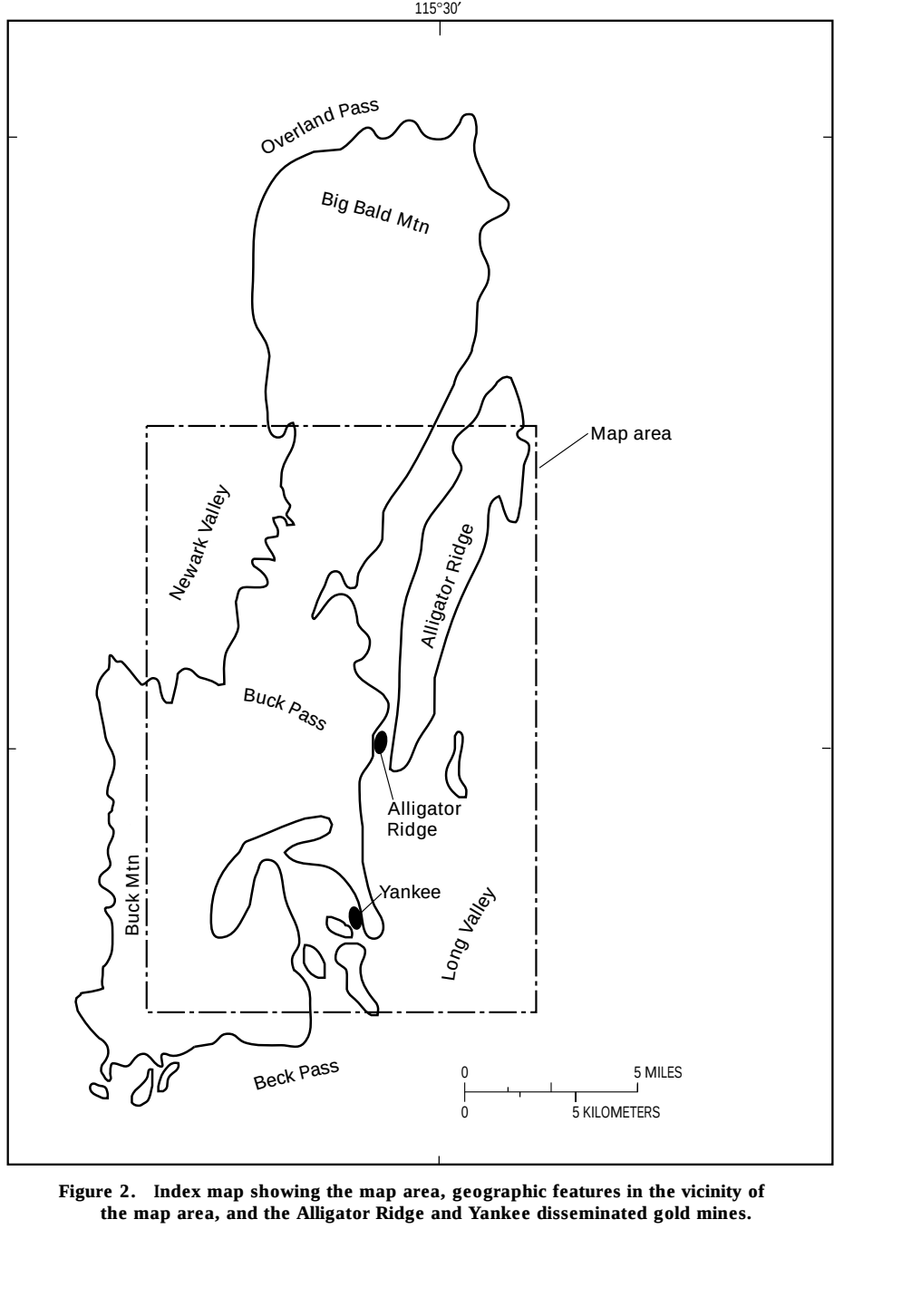

Figure 2. Index map showing the map area, geographic features in the vicinity of the map area, and the Alligator Ridge and Yankee disseminated gold mines

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