Text and references for Nevada Bureau of Mines and Geology Map 145

GEOLOGIC MAP OF THE BIG BALD MOUNTAIN QUADRANGLE AND PART OF THE TOGNINI SPRING QUADRANGLE

WHITE PINE COUNTY, NEVADA

by

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INTRODUCTION

The map area includes the Big Bald Mountain Quadrangle and the western part of Tognini Spring Quadrangle. It is located south of Overland Pass in the southern Ruby Mountains and the southern Maverick Springs Range, about 60 miles (100 km) south-southeast of Elko, Nevada, and about 50 miles (80 km) northwest of Ely, Nevada (figs. 1A, B). The map area, herein referred to as the Bald Mountain area, includes Big and Little Bald Mountains, Mooney Basin, and the southwest edge of the Maverick Springs Range (fig. 2). Mooney Basin extends about 20 miles (32 km) north from the southern part of Alligator Ridge into the map area, where, at the north end, it merges into Ruby Valley (fig. 2). The map area is on the southern extension of the Carlin gold trend and contains disseminated gold deposits of the Bald Mountain mining district. South of the map area and at the southern end of Mooney Basin, the Alligator Ridge and Yankee disseminated gold deposits were mined. For information on ore deposits, see Hitchborn and others (1996) and Nutt and others (2000). Previous geologic maps of the area include a reconnaissance map by Rigby (1960) and the White Pine County geologic map by Hose and Blake (1976). The map area is contiguous with the Alligator Ridge area to the south mapped by Nutt (2000). Isotopic ages of igneous samples located on this map are shown in table 1.

Table 1. Isotopic age determinations. Numbers refer to sample locations shown on the map.

1.	**aplite dike**: 185.9±3.8 Ma; U-Pb from zircon. 185.9 is $^{207}Pb/^{206}Pb$ age; considered minimum age (Mortensen and others, 2000) **porphyry dike**: 155.5 +7.7/-8.8 Ma, U-Pb on zircon (Mortensen and others, 2000)
2.	**RBM pit** **late crosscutting dike**: 169.4±5 Ma, K-Ar from sericite, Queensland University (personal. commun., Placer Dome, NA, Inc., 2003) **quartz-feldspar porphyry**: 158.1±5.2 Ma, K-Ar from biotite; location about 900 m northeast of RBM pit (Hitchborn and others, 1996)
3.	**crystal tuff**: 35.4±0.9 Ma from biotite, Geochron Laboratories, Cambridge MA (written commun., Placer Dome, NA, Inc., 2003)
4.	**crystal tuff**: 34.7±0.9 Ma from sanidine, Geochron Laboratories, Cambridge MA (written commun., Placer Dome NA, Inc., 2003)
5.	**Rat pit** **porphyry dike**: 152.6-153.4 Ma; U-Pb from zircon; minimum age; $^{207}Pb/^{206}Pb$ age of 162.7±4.9 Ma (Mortensen and others, 2000)
6.	**Bald Mountain stock** **quartz monzonite**: 159.0±0.5 Ma, U-Pb from zircon (Mortensen and others, 2000). In addition, Hitchborn and others (1996) reported K Ar ages from biotite in the Bald Mountain stock as 153.5±5.0 and 157.1±5.1 Ma; exact locations unknown
7.	**porphyry**: 158.9±0.4 Ma, U-Pb from zircon (Mortensen and others, 2000)
8.	**Top pit** **altered quartz monzonite**: sericite: 157.1±0.9 Ma, $^{39}Ar/^{40}Ar$ from sericite; (Alex Iriondo, U.S. Geological Survey, personal commun., 2003); 139.3±5.1 Ma, K-Ar from biotite (Hitchborn and others, 1996)
9.	**Horseshoe** **porphyry dike**: 159.0±0.7 Ma, U-Pb from zircon (Mortensen and others, 2000)
10.	**rhyolite dike**: 35.9±0.1 Ma, U-Pb from zircon (Mortensen and others, 2000)

GEOLOGIC SETTING

The Bald Mountain area is underlain by Paleozoic miogeoclinal carbonate and clastic rocks, a Jurassic stock, Tertiary sedimentary and volcanic rocks, and Quaternary deposits. It lies within an area where the crust was thinned along the eastern side of a Late Proterozoic rift in the North American craton (Wooden and others, 1998). The region has undergone numerous tectonic events since Late Proterozoic rifting. The Bald Mountain area is (1) in the foreland of the Roberts Mountains allochthon emplaced in the Devonian and Mississippian time, (2) on the east edge of deformation related to the late Paleozoic Humboldt orogeny (Ketner, 1977), (3) in the hinterland of the Cretaceous to early Tertiary Sevier thrust belt (Armstrong, 1968), (4) in an area of Jurassic deformation, metamorphism, and plutonism (Miller and Hoisch, 1995), and (5) in an area of large-magnitude Tertiary extension and at the southern end of the Ruby Mountains-East Humboldt Range metamorphic core complex (Snoke and Howard, 1984; Snoke and Lush, 1984). Jurassic and Cretaceous deformation and plutonism, and Late Cretaceous to Oligocene and Miocene extension are documented in the Ruby Mountains-East Humboldt Range complex (Hudec, 1992; McGrew and Snee, 1994; McGrew and others, 2000). The Northern Snake Range core complex is to the southeast (fig. 1A).

Cambrian to Tertiary rocks are exposed in the map area. The rocks dip mostly east and are progressively younger from west to east. The easterly dip of the rocks is such that from the western base of Big Bald Mountain to the eastern edge of the map area, a disrupted section of Middle Cambrian through Lower Pennsylvanian rocks is exposed. A Jurassic stock crops out near Big Bald Mountain and Tertiary sedimentary and volcanic rocks are present on the west edge of the map area and, to the east, along Mooney Basin. Jurassic to Tertiary dikes are along faults east of Mooney Basin. The stock is northwest trending along what mineral explorationists term the Bida trend (fig. 2). A fault along the western side of the map area caused mile-scale, down-to-the-west displacement.

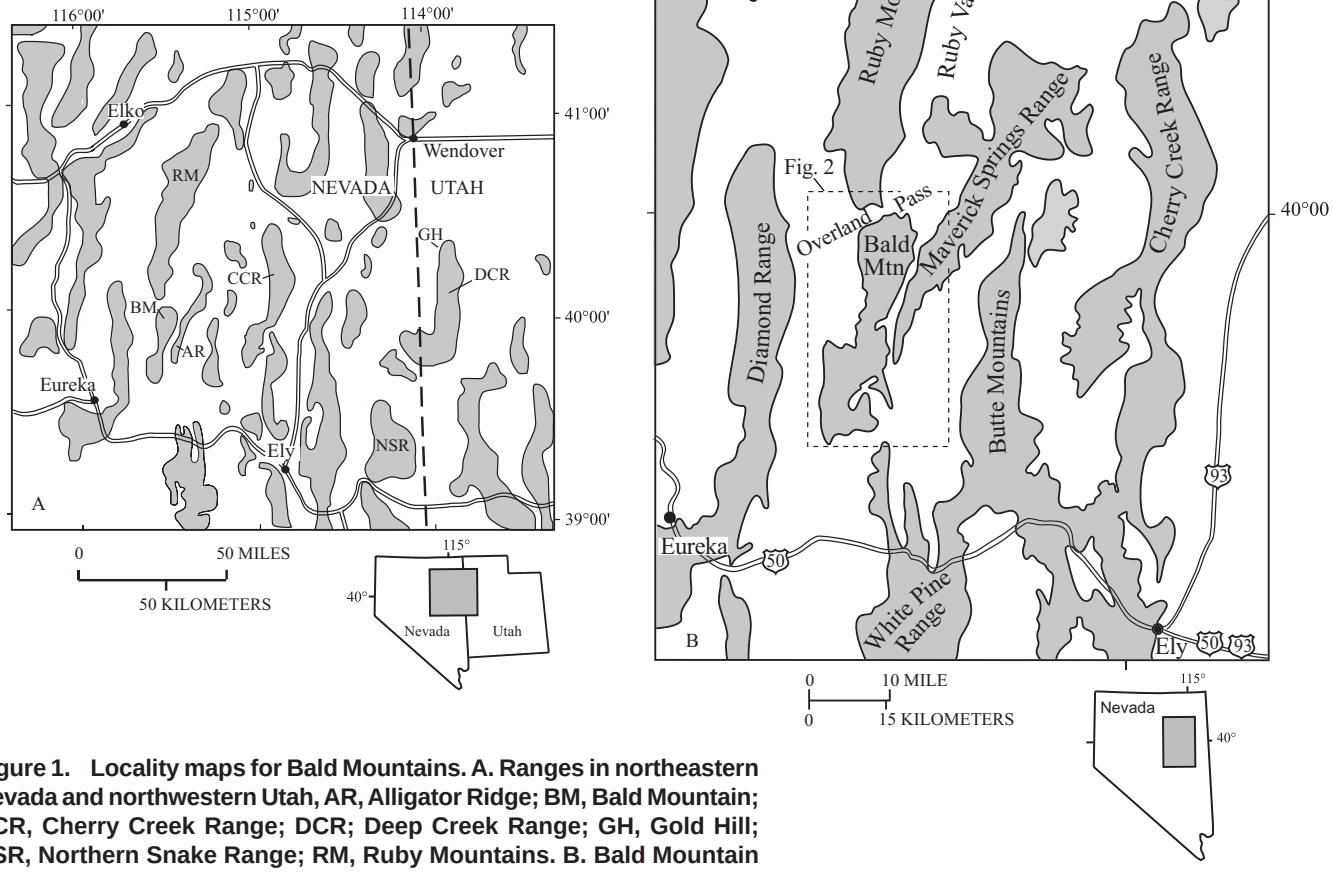

Figure 1. Locality maps for Bald Mountains. A. Ranges in northeastern Nevada and northwestern Utah, AR, Alligator Ridge; BM, Bald Mountain; CCR, Cherry Creek Range; DCR; Deep Creek Range; GH, Gold Hill; NSR, Northern Snake Range; RM, Ruby Mountains. B. Bald Mountain and nearby ranges, and location of figure 2.

PALEOZOIC ROCKS

Paleozoic rocks in the map area include the uppermost part of the Middle Cambrian Eldorado Formation through the lower part of the Mississippian to Lower Pennsylvanian Diamond Peak Formation. The Cambrian and Lower Ordovician section is dominated by thin- and thick-bedded limestone, silty limestone, siltstone, and shale and is capped by the Middle Ordovician Eureka Quartzite. Overlying the Eureka Quartzite is about 3,000 feet (915 m) of massive to thin-bedded Upper Ordovician through Middle Devonian dolomites, overlain by about 1,500 feet (460 m) of massive to thin-bedded limestone and minor dolomite of the Middle and Upper Devonian Guilmette Formation. The cliff-forming Guilmette Formation is overlain by Upper Devonian to Upper Mississippian clastic rocks and limestone deposited in the foreland of the Antler highland to the west.

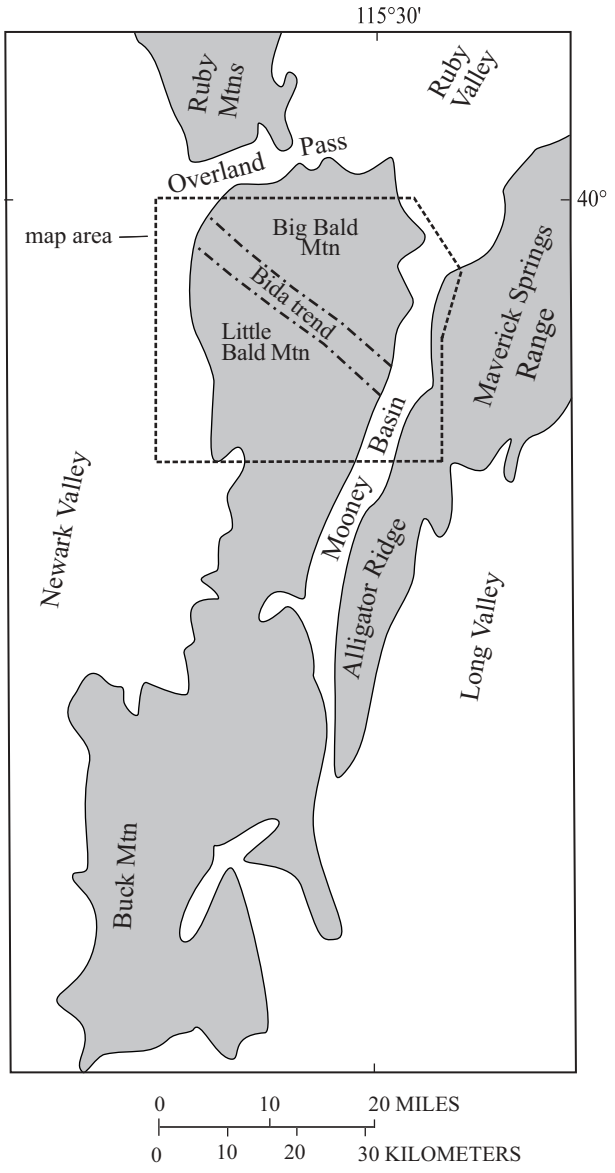

Figure 2. Bald Mountain and Alligator Ridge area. Map area and approximate area of figure 4 shown by dotted lines.

The Cambrian rocks are similar to those at Eureka, Nevada, as described by Nolan and others (1956), and this map generally uses that nomenclature: Eldorado Formation, Geddes Limestone, Secret Canyon Shale, Hamburg Formation, Dunderberg Shale, and Windfall Formation (fig. 3). A difference is the Eldorado and Hamburg Formations at Bald Mountain are both limestones in contrast to their dolomite composition at Eureka. The Lower Ordovician Pogonip Group is informally separated into lower, middle, and upper parts that probably correspond respectively to the Goodwin Limestone, Ninemile, and Antelope Valley Members of Nolan and others (1956) at Eureka. Limey sandstone similar to that of the Ninemile Member at Eureka crops out only on Big Bald Mountain in the map area. The Middle Ordovician Eureka quartzite is easily identified by its white color and the lower part of the Upper Ordovician Fish Haven Dolomite by its brown color and black chert; both have similar lithologic types in nearby ranges (Hose and Blake, 1976).

Silurian and Devonian 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) (fig. 1A). For this report, as for the Alligator Ridge area to the south (Nutt, 2000), the nomenclature used is from the Deep Creek Range (Nolan, 1935; Nutt and Thorman, 1994), the Cherry Creek Range near Ely, Nevada (Poole and others, 1988), the regional stratigraphic studies of Osmond (1954, 1962), the county map (Hose and Blake, 1976) 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 and Simonson Dolomite are used instead of the lower part of the Nevada Formation. The Sevy Dolomite is restricted to very fine grained, very light gray laminated dolomite with floating sand grains; the lower part of the Sevy as used by Rigby (1960) is included in undivided Ordovician, Silurian, and Devonian dolomites. Guilmette is used instead of Devils Gate because of the recognition of lateral change from limestone to dolomite to the south in the Alligator Ridge area (Nutt, 2000). The Sevy and Simonson are used instead of Nevada Formation because of their lithologic similarity to Simonson and Sevy and the paucity of sandstone that is characteristic of the Nevada Formation.

The Devonian and Mississippian clastic and subordinate carbonate rocks include the Upper Devonian and Lower Mississippian Pilot Shale, Lower Mississippian Joana Limestone, Lower and Upper Mississippian Chainman Shale, and Upper Mississippian and Lower Pennsylvanian Diamond Peak Formation. These units are lithologically similar to those described from nearby ranges (Hose and Blake, 1976) and at Alligator Ridge (Nutt, 2000).

JURASSIC ROCKS

The Late Jurassic Bald Mountain stock is coarse-grained biotite quartz monzonite. U-Pb geochronology on zircon reveals an age of 159±0.5 Ma for the stock (Mortensen and others, 2000), which confirms the Jurassic age determined by K-Ar on biotite (153.5±5.0 Ma and 157.1±5.1 Ma) reported in Hitchborn and others (1996) The stock intruded Cambrian and Ordovician rocks and has a contact aureole up to 5,000 feet (1.5 km) wide, The coarse-grained character of the stock, the extensive contact metamorphism, and its emplacement in the lower part of the Paleozoic stratigraphic section suggest that the stock intruded at intermediate depth.

Mafic, intermediate-composition, and aplitic dikes and sills are present near the stock. U-Pb ages of zircon from a variety of intrusive rocks indicate that most dikes and sills in the Bald Mountain area are coeval with the stock (Mortensen and others, 2000). The exception is an aplite sill on the west side of Big Bald Mountain that crops out at or near the contact between Middle Cambrian Geddes Limestone and Secret Canyon Shale and in the lower part of the Secret Canyon Shale. A U-Pb age of zircon indicates emplacement of the sill at a minimum age of 185.9±3.8 Ma (Mortensen and others, 2000; Mortensen, personal commun., 2002); the sill is the oldest intrusive rock recognized in the Bald Mountain area.

Bald Mountain area	Eureka Nolan and others (1956)	Cherry Creek Range Poole and others (1988)	Deep Creek Range Nolan (1935); Nutt and Thorman (1994)
Pennsylvanian and Mississippian			
Diamond Peak Formation	Diamond Peak Formation		
Mississippian			
Chainman Shale	Chainman Shale		
Joana Limestone	Joana Limestone		
Mississippian and Devonian			
Pilot Shale	Pilot Shale		
Devonian			
Guilmette Formation	Devils Gate Formation	Guilmette Limestone	Guilmette Formation
Simonson Dolomite		Simonson Dolomite	Simonson Dolomite
Sevy Dolomite	Nevada Formation	Sevy Dolomite	Sevy Dolomite
Silurian and Ordovician			
Laketown Dolomite	Lone Mountain Dolomite Roberts Mountain Formation	Laketown Dolomite	Laketown Dolomite
Fish Haven Dolomite	Hanson Creek Formation	Ely Springs Dolomite	Fish Haven Dolomite
Ordovician			
Eureka Quartzite	Eureka Quartzite		
Pogonip Group	Pogonip Group		
upper part	Antelope Valley Limestone		
middle part	Ninemile Formation		
lower part	Goodwin Limestone		
Cambrian			
Windfall Formation	Windfall Formation		
Bullwhacker Member	Bullwhacker Member		
Catlin Member	Catlin Member		
Dunderberg Shale	Dunderberg Shale		
Hamburg Formation	Hamburg Dolomite		
Secret Canyon Shale	Secret Canyon Shale		
Geddes Limestone	Geddes Limestone		
Eldorado Formation	Eldorado Dolomite		
not exposed	Prospect Mountain		
	Pioche Shale		

Figure 3. Correlation of Paleozoic rocks. See figure 1A for locations of sections.

TERTIARY ROCKS

Tertiary rocks are exposed on the west side of the map area and along Mooney Basin. In both areas, the rocks mostly lie on Mississippian Chainman Shale or the lower part of the Diamond Peak Formation.

Mooney Basin

Local outcrops of silicified conglomerate along the edge of Mooney Basin are interpreted as likely Eocene, although a Cretaceous age cannot be ruled out. Clasts are predominantly sandstone and conglomerate derived from the Diamond Peak Formation, small black chert fragments, and quartz eyes interpreted as derived from the Jurassic stock or Eocene volcanic rocks. The sandstone and conglomerate clasts are boulder- to pebble-size, angular and poorly sorted, and the overall composition of the unit indicates it was locally derived. Eocene rocks in the Alligator Ridge area are of different composition, including limestone and volcaniclastics, but are similarly found along the edge of Mooney Basin. Silicified conglomerate rests on silicified Paleozoic rocks, indicating a common period of silicification.

Eocene to early Oligocene (using time scale of Berggren and others, 1995) volcanic rocks in the Mooney Basin area are similar to those in the Alligator Ridge area to the south (Nutt, 2000) and overlie the Eocene sedimentary rocks. The basal volcanic rock is a quartz-biotite tuff that crops out near and in the Alligator Ridge Mine. Rhyolite is rare in the map area but caps the ridge just off the east edge of the map area and makes up much of the southern Maverick Range; the same rhyolite forms a small dome in the northern part of the Alligator Ridge area (Nutt, 2000). Rhyolite from the east side of Mooney Basin was dated by U-Pb on zircon as 35.9±0.1 Ma (Mortensen and others, 2000). $^{40}Ar/^{39}Ar$ age determinations of biotites from two samples collected just east of the map area give ages of 36.27±0.11 Ma and 36.56±0.10 Ma (R.J. Fleck, oral commun., 1999).

Miocene to Pliocene(?) volcaniclastic rocks overlie Eocene to Oligocene volcanic rocks along Mooney Basin, and probably fill much of Mooney Basin. Pebbly sandstone and conglomerate contain Paleozoic and Tertiary volcanic rocks. The unit probably is Miocene, but its age is not tightly constrained.

West side of map area

Tertiary rocks are exposed on the west, or downdropped, side of the Ruby fault. Detailed mapping shows that Paleogene rocks similar to those at Alligator Ridge and along Mooney Basin are part of slide blocks that make up the hanging wall of the Ruby fault. One block consists of Mississippian Chainman Shale and lower Diamond Peak Formation overlain by Eocene to Oligocene sedimentary and volcanic rocks. The basal Eocene rocks are angular to subrounded cobble to pebble conglomerate and sandstone composed of reworked quartzite from the Diamond Peak Formation, Conglomerate is overlain by volcaniclastic rocks with rounded quartzite clasts and silicified fine-grained rock that is interpreted as mudstone or sinter. Biotite tuff with an age of 34.7 Ma ± 0.9 (K-Ar, Placer Dome, North American, Inc., personal commun.) overlies these sedimentary rocks, as they do in Mooney Basin and at Alligator Ridge.

Debris flows overlie the blocks of Paleozoic and Paleogene rocks. The debris flows have inverted clast distribution: the lowest flows have mostly Silurian to Ordovician dolomite whereas higher flows have mostly Jurassic intrusive rock and Ordovician Eureka Quartzite clasts. The debris flow matrix is fine-grained carbonate milled during flow.

STRUCTURE

The Bald Mountain area records repeated episodes of deformation that extend from Jurassic or older to Quaternary. The most prominent structures are northeast-striking faults that extend across the area and the northwest Bida trend (fig. 4). Cambrian and Ordovician rocks and the Jurassic stock are uplifted between the Ruby listric fault on the west and a series of north- northeast-striking normal faults to the east. The Late Jurassic stock and its relationship to faults and folds allow some age constraints on structural events.

The Ruby fault, exposed along the western flank of the Bald Mountain area, has as many as 1.7 miles (2.8 km) of offset. The downdropped side consists of Ordovician to Tertiary rocks in blocks up to 0.5 mile in length and debris flows, One block includes the RBM deposit hosted by Jurassic intrusive rock cutting Mississippian sedimentary rocks. The age of offset on the Ruby fault is constrained to younger than downdropped ~35 Ma volcanic rocks. The most likely age of fault movement is Miocene, when the Ruby Mountain-East Humboldt Range core complex to the north underwent rapid uplift.

The series of north- to northeast-striking faults from the central part of the area to Mooney Basin downdrops rocks to the east. These faults, like the Ruby fault, are interpreted as active during Tertiary extension. However, earlier movement along these faults is suggested by the location of the Top deposit and Jurassic intrusive rock at the intersection of the Dynasty fault and the Bida trend. A landslide deposit east of the Dynasty fault is interpreted as Tertiary in age, and in part controlled by detachment along the lower contact of the Pilot Shale, perhaps during movement on the Dynasty fault. No debris flows exist in this area. North- to northeast-trending Mooney Basin, which extends south to Alligator Ridge, is the longest structure in the area. Based on a regional magnetotelluric survey from west of Eureka, Nevada, to east of Mooney Basin, Rodriguez and Williams (2001) interpreted a north-trending crustal-scale fault zone that is largely coincident with Mooney Basin. Jurassic intrusive rock is cut by north-northeast faults, but also is rarely along the faults, suggesting earlier movement on these features.

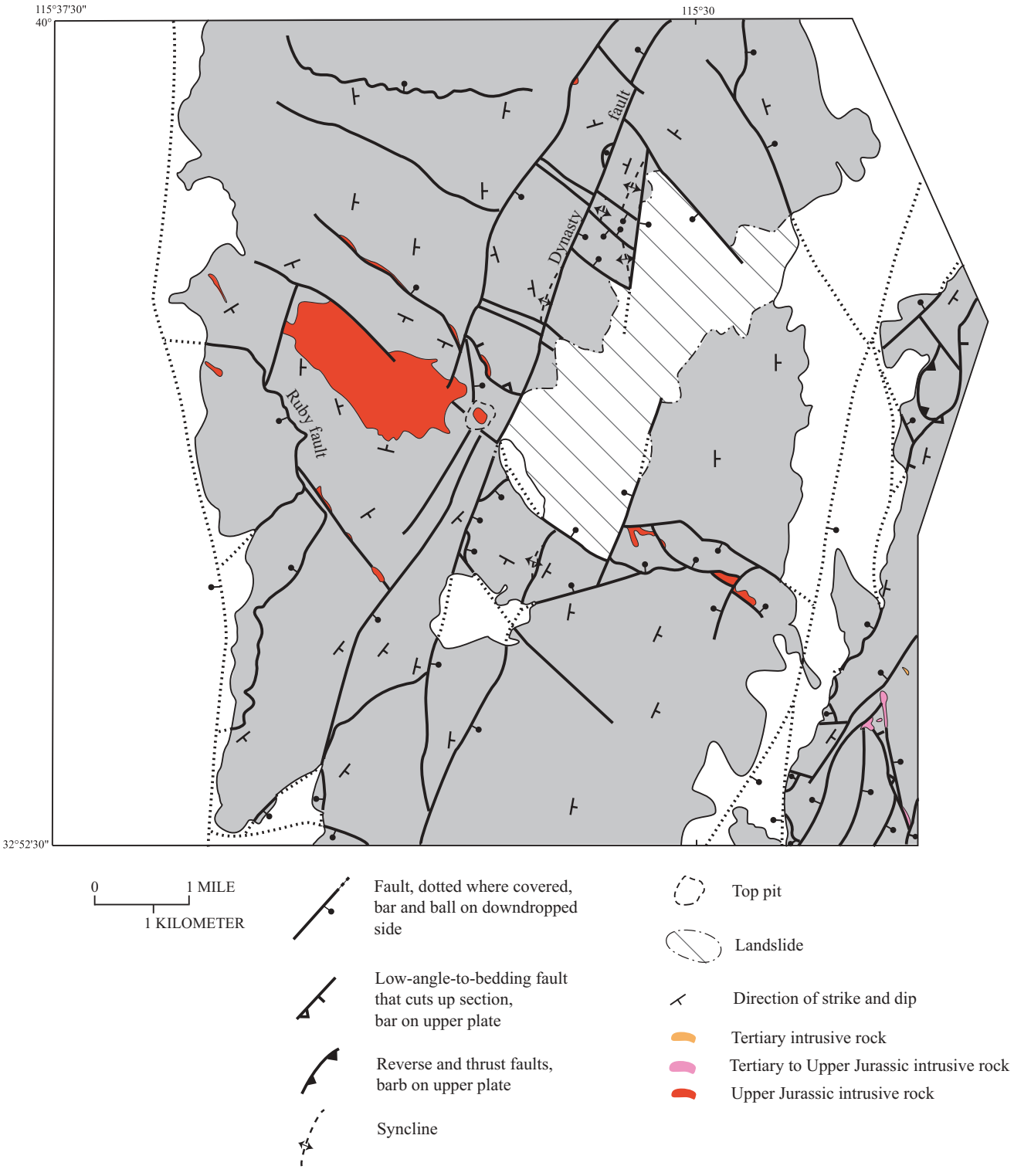

Figure 4. Simplified map showing strikes and dips of bedding, major structures, and most intrusive rock in the Bald Mountain area.

Northwest-striking faults cut the area and controlled ore and emplacement of Jurassic intrusive rock. The northwest Bida trend is a major structure, but most northwest-striking faults have limited strike length. The Bida trend itself does not correspond to any one feature, but rather consists of the Jurassic stock and dikes, and a series of short en echelon faults. The confinement of the stock to a northwest trend as well as presence of lamprophyre dikes suggests that this was a deep structure that was open during the Middle to Late Jurassic. Some of the northwest-striking faults offset intrusive rock, and are interpreted as reactivated structures.

Low-angle faults include those that juxtapose younger over older rocks, and, rarely, thrust faults. The younger-over-older faults are commonly near the contact between beds of contrasting competency such as between the thin-bedded Catlin and the thick-bedded Bullwacker Members of the Cambrian Windfall Formation, along or near the Ordovician Eureka Quartzite, and at the contact of the Mississippian Chainman Shale and Diamond Peak Formation. Similar slippage and brecciation in Devonian and Mississippian rocks took place along the Guilmette Formation-Pilot Shale and Joana Limestone-Chainman Shale contacts, but only limited attenuation of the units was observed. The age of faulting is uncertain; it's possible these faults formed during more than one event.

Normal faults along the east edge of Mooney Basin cut Pliocene to Miocene sedimentary rocks and along the range front cut Pleistocene alluvial fans.

Folds in the Bald Mountain area are limited in length and fragmented, and therefore are not easily recognized. The most prominent fold is a northeast-striking doubly plunging anticline in Devonian and Mississippian rocks in the northern part of the area (fig. 4). This anticline is similar to the miles-long northeast-striking folds that dominate the Alligator Ridge area to the south. The fold cannot be followed through the most disrupted area and is not in the southern part of the map area. The presence of the fold only in Mississippian and Devonian rocks suggests disharmonic folding above the Ordovician Eureka Quartzite. A northwest-trending syncline deforms Cambrian rocks around the stock; surrounding synclines are typical of Jurassic plutons in the eastern Great Basin (Allmendinger and Miller, 1991).

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