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JURASSIC SUPRASTRUCTURE IN THE DELANO MOUNTAINS, NORTHEASTERN ELKO COUNTY, NEVADA

by

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ABSTRACT

K/Ar dating of a granitic stock in the Delano Mountains, northeastern Elko County, Nevada, documents probable Jurassic tectonism. Permian (?) sedimentary rocks have been cut by low-angle bedding-plane faults, and synchronously and/or later folded into one major, and several other minor broad, symmetrical open folds. Emplacement of a granitic stock at 135 m.y. through the previously deformed strata, and subsequent Tertiary normal faulting added to the structural complexity of the area. It is suggested that the relatively moderate pre-Tertiary deformation in the Delano Mountains represents the upper tectonic level of a pre-Cretaceous (Jurassic) suprastructure in Elko County and vicinity.

INTRODUCTION

The Delano Mountains are located in the northeastern corner of Elko County, Nevada (Fig. 1). The area is situated in the northern part of the Basin and Range province, just a few miles south of the overlapping Tertiary volcanics of the Snake River Plain. The Antler Orogenic Belt (Roberts and others, 1958) lies nearby to the west, and the Sevier Orogenic Belt (Armstrong, 1968) to the east (Fig. 2). The Delano Mountains are accessable by gravelled county roads from the town of Montello, about 30 miles to the south.

Early geologic studies in northeastern Nevada were made primarily on a broad, regional basis (Lee and others, 1915; Granger and others, 1957; Steele, 1960). More recent work in Elko County (Gardner, 1968; Riva, 1970; Thorman, 1970; Hope, 1970; Oversby, 1972) has better defined stratigraphic and structural relations in the region. Previous studies in the Delano Mountains have been mainly in connection with the lead-silver ores of the Delano (Delno) mining district (Granger and others, 1957; Olsen, 1960, 1965).

STRATIGRAPHY

General

Owing to the lack of good marker beds, scarcity of recoverable fossils, poor exposures, and locally intense Tertiary normal faulting, stratigraphic and structural relations are still not precisely defined in the Delano Mountains region. Nomenclature is here based principally on physical stratigraphy[1], and agrees in part with formational assignments of Hope (1970). It should be emphasized that the data and interpretations presented here are preliminary. It is hoped that this paper will stimulate more detailed stratigraphic and structural work in an area as potentially critical to an understanding of hinterland evolution as the Delano Mountains and vicinity.

Three Permian (?) formations have been tentatively recognized in the Delano Mountains. These are the Pequop Formation,

the Grandeur Formation of the Park City Group, and the Phosphoria Formation. No lower Paleozoic western facies siliceous-volcanic rocks (Riva, 1962) or Triassic rocks (Clark, 1957) are known to occur in the immediate area.

Pequop Formation

The Pequop Formation (Steele, 1960) in the Delano Mountains is here divided into three distinct units: (1) a lower calcareous sandstone member, (2) middle carbonaceous limestone member, and (3) upper calcarenite member. This subdivision, however, cannot be adequately correlated with the three members of the Pequop (i.e., Lower Moorman Ranch, Summit Springs, and Upper Moorman Ranch) as originally defined by Steele (1960).

The lowermost sandstone member crops out mainly around the igneous stock (Fig. 3). It is an unfossiliferous, fine to coarse-grained calcareous and in places feldspathic (?) sandstone. Fresh surfaces are a pale bluish-green, whereas weathered surfaces are typically buff. Extensive contact metasomatism, however, has commonly altered this unit to a substantial extent. The exposed thickness of this sandstone, the lower contact of which has been truncated by the granitic pluton at Indian Springs, is estimated at 250-300 feet. The upper contact is gradational into the middle member of the Pequop.

The middle member of the Pequop is a highly carbonaceous, dark blue-black, fine to medium-grained limestone. Petrographic analysis shows the presence of about 5 to as much as 15 percent carbonaceous material in the rock. This bituminous character agrees with Bissell's (1970, Fig. 7) Upper Leonardian lithofacies map for northeastern Nevada. The carbonaceous limestone unit is commonly very thin-bedded, and is characterized by crenulated and distorted bedding. The thickness of this carbonaceous limestone member is estimated at 1500 feet, the upper contact of which is gradational into the overlying member.

The upper member of the Pequop is a pale gray to dark gray, fine to medium-grained, thin-bedded calcarenite. Broken fossil fragments and local dolomitic and sandy beds characterize this unit. One prominent feature of this upper Pequop member is the

existence of natural caves and arches, and, to a lesser extent, distorted bedding as in the underlying carbonaceous member. The thickness of the upper member of the Pequop is estimated to be about 2000-2500 feet. This unit is overlain by 200-250 feet of dark blue-gray bioclastic limestone. Bedded brown and gray cherts characterize the middle part of this section, which may represent a thin tongue of the Loray Formation (Steele, 1960; Bissel, 1964) in the area. The chert interbeds were chosen as a convenient stratigraphic break between the upper member of the Pequop and the overlying Grandeur Formation.

Grandeur Formation

The Grandeur Formation of the Park City Group (McKelvey and others, 1959; Bissell, 1970) comprises a fairly thick sequence of varying rock types in the Delano Mountains. The dominant lithology is a gray to buff, silty to sandy dolomite. Minor amounts of buff orthoquartzite and blue-gray crinoidal limestone are also present within the unit. The dolomite is typically medium bedded, and in places contains chert lenses and nodules. The thickness of the Grandeur is roughly 2500 feet in the Delano Mountains.

Phosphoria Formation

The Phosphoria Formation (Richards and Mansfield, 1912) in the Delano Mountains is represented by two of its most widely recognized units in the western phosphate field, the Meade Peak and Rex Chert members. A thin sequence of interbedded sandy dolomite and gray to black chert in the lower part of the unit is here included within the Phosphoria, and may represent a northern facies of the Plympton Formation (Hose and Repenning, 1959). The Meade Peak phosphatic shale member (McKelvey and others, 1959) in the Delano Mountains is made up of a thin-bedded, poorly exposed sequence of orange to gray phosphatic siltstone, cherty shale, and brownish-black dense phosphorite (?). The unit is of variable thickness due to the structural elimination of parts of the member by low-angle bedding-plane thrusts.

The Rex Chert member of the Phosphoria Formation is well-exposed on the southwestern side of the Delano range, and is characterized by a 2500-3000 foot section of massively bedded black, gray, and brown chert. The upper contact of the Rex is erosional, being unconformably overlain by late Tertiary sediments and volcanics of the Salt Lake Formation (see Mapel and Hail, 1959).

STRUCTURE

Faults

Two types of faulting have been recognized in the Delano Mountains. Thrusts are known only in the southwestern part of the range, whereas Tertiary normal faults are widespread (Fig. 3). The thrusts are low-angle bedding-plane faults interpreted as occurring between the dolomites and orthoquartzites of the Grandeur Formation, and the overlying bedded cherts of the Rex Chert member of the Phosphoria Formation. Similar "younger over older" bedding-plane faults have been described by Misch (1957, 1960) and others (Hose and Danés, 1968; Hose and Blake, 1969) from many areas of the eastern Great Basin. Plate morphology and regional considerations suggest that thrusting in the Delano Mountains was directed approximately eastward, and was localized mainly within the incompetent Meade Peak member at the base of the Phosphoria Formation. This has resulted in the local preservation of thin wedges of Meade Peak along the southwestern margin of the Delano Mountains. It is estimated that in places as much as several hundred feet of Meade Peak has been faulted out of the section. Because of the poorly defined nature of the stratigraphy of the region, it is possible that other less-marked thrusts and/or klippen may be present in the area. Synchronous and/or later folding of the Delano Mountains has subsequently deformed the thrust sheets; they are therefore not Tertiary "denudation" faults as described by Armstrong (1972).

Moderate to steeply dipping Tertiary normal faults, some of which have significant displacements, have greatly modified

the structure of the Delano Mountains and in places made understanding of pre-Tertiary structures difficult. In addition, westward Pliocene-Pleistocene (?) tilting of the range has also complicated the structure.

Folds

Folds in the Delano Mountains are broad, open, and relatively simple. The major structure is a roughly symmetrical north-trending, southward plunging anticline, the axis of which parallels the range crest. Several smaller folds (not all shown on Fig. 3) have also been inferred for the northern and eastern margins of the Delano Mountains, some of which are buried under a cover of Tertiary and Quaternary sediments. Permian (?) country rocks are locally domed in the vicinity of the granitic stock at Indian Springs, where the lower Pequop sandstone member commonly dips radially away from the pluton (Fig. 3). In addition, minor drag folds have been recognized on the flanks of the main anticline, and also along some Tertiary normal fault zones.

IGNEOUS ACTIVITY AND GEOCHRONOLOGY

Two periods of igneous activity have been documented for the Delano Mountains and vicinity. The older phase is a pulse of complex granitic plutonism which formed the Indian Springs stock. The younger is represented by late Miocene-Pliocene (?) silicic volcanism several miles to the east of the Delano Mountains and is genetically related to the ore deposits of the Delno mining district, located about three miles north-northwest of Indian Springs (Fig. 3).

The igneous stock is an irregularly shaped, elongate mass with a highly variable composition and texture. Its rocks range from trondhjemite and granodiorite to albite granite, and its textures typically vary from coarsely porphyritic to finely-grained equigranular. Most of the stock is heterogeneously textured quartz monzonite porphyry. Complex arrays of granitic dike swarms, tactite pods and lenses, and associated hydrothermal quartz vein stockworks are common, especially near the eastern

margin of the stock. ~~Minor~~ moderate amounts of silver, tungsten, and molybdenum mineralization are also related to the plutonic igneous activity at Indian Springs.

The emplacement of the granitic pluton has been studied in some detail. Extensive field and petrographic ~~study~~ examination shows no deformational characteristics or other evidence suggestive of a pre-folding age for the stock. West of the stock, strata of the Pequop Formation dip eastward off the north-striking anticlinal axis (Fig. 3). Beds of the lower calcareous sandstone member are locally crumpled and brecciated at the igneous contact; the stock clearly cross-cuts the Permian (?) country rocks, and thus post-dates both the thrusting and folding in the area. In addition, there is no regional metamorphic fabric imprinted either on the igneous pluton or on any of the Paleozoic rocks of the Delano Mountains.

omit?

The age of the stock has been determined by the K/Ar method on a composite sample of pure biotite separated from fresh, unweathered surface and diamond drill-core rock. The biotite for the K/Ar age determination was separated from previously crushed and sieved (-40, +100 mesh) rock by means of heavy liquids (bromoform), a Franz magnetic separator, and hand-picking. The amount of impurities in the analyzed aliquants was substantially less than one percent (by volume).

Table 1. K/Ar age data*

Mineral	%K.	Moles radiogenic ^{40}Ar per gram ($\times 10^{-9}$)	% Radiogenic argon	Age ($\times 10^6$ yrs)**
Biotite 7.214	$\left\{\begin{matrix}7.280\\7.148\end{matrix}\right\}$	1.787	92.2	134.2 ± 1.5
Biotite 7.214		1.812	84.9	136.0 ± 2.0

Constants used were: $1/\lambda = 1.885 \times 10^9$ yr; $^{40}K/K = 0.0119$ atom %
$(^{40}Ar/^{38}Ar)$ Atmos. $= 1.581 \times 10^3$ $(^{36}Ar/^{38}Ar)$ Atmos. $= 5.35$

*Data from Ohio State University K/Ar Laboratory
**Error limits represent an estimate of one standard deviation for each individual analysis calculated in a manner similar to that described by Cox and Dalrymple (1967).

The age was calculated to be 135.1 ± 2.0 m.y. This age probably represents a minimum, however, since radiogenic argon loss might have resulted from heat generated by locally intense hydrothermal alteration and/or by nearby Miocene-Pliocene (?) hypabyssal silicic volcanism. The minimum age of the granitic stock is thus fairly well-established as earliest Cretaceous.

DISCUSSION

The Delano Mountains lie within and along the northwestern margin of the "hinterland" of the Sevier Orogenic Belt of eastern Nevada and western Utah (Armstrong, 1968, 1972). The structures in the hinterland are typified by a wide range of geologic complexity. This heterogeneous structural style includes simple homoclines and broad open folds, deformed imbricate thrust sheets, and tightly folded and highly metamorphosed lower Paleozoic and Eocambrian strata. More specifically, this tectonic pattern is also apparent in northeastern Elko County, east of the Antler Orogenic Belt. Here, extensive eastward and southeastward thrusting has been recognized in part in the Snake Mountains (Gardner, 1968), the Wood Hills and Pequop Mountains (Thorman, 1970), the HD Range (Riva, 1970), and the Windermere Hills (Oversby, 1972).

Although these and other thrust sequences in Elko County were affected by <u>both</u> late Paleozoic Antler forces and younger Mesozoic through Tertiary stresses (Riva, 1970; Oversby, 1972; Armstrong, 1972), Mesozoic tectonism appears to have been the dominant orogenic activity in northeastern Elko County. Documented evidence to date these Mesozoic structures is rare in the hinterland, and relies primarily on intrusive igneous bodies that cross-cut previously deformed strata. Granitic plutons isotopically dated at 150-160 m.y. (Coats and others, 1965) are known to cut complex unmetamorphosed post-Antler thrust sheets in the northern HD Range (Riva, 1970). Also, a Jurassic (160 ± 22 m.y.) Rb/Sr age of deep-seated regional metamorphism has been established in the Ruby Mountains of southern Elko County (Kistler and Willden, 1969), and regional metamorphism and subsequent large-scale thrusting of possible mid-Mesozoic age has been described by Thorman (1970) in the Wood Hills and Pequop Mountains. In addition, an early Mesozoic age of imbricate

thrusting has been suggested by Coats and Mackenzie (1972) for the Divide Peak area of northern Elko County.

The tectonism and plutonism in the Delano Mountains provides a fairly unique situation in which probable mid-Mesozoic (Jurassic) deformation is documented. Because of the lack of coarse post-tectonic detritus in rocks of late Paleozoic-early Mesozoic age, it is now fairly well-accepted that no widespread orogenic activity or synkinematic regional metamorphism took place in the eastern Great Basin before the end of the Triassic (Stokes, 1960; Armstrong, 1968). Since the deformation in the Delano Mountains pre-dates the 135 m.y. pluton, the thrusting and folding must have taken place sometime during the Jurassic. This is assuming that the K/Ar age dates the time of emplacement of the stock, and that it has not been affected by a younger regional heating event as postulated by Armstrong and Hansen (1966, p. 121) for some parts of the eastern Great Basin. The folding in the Delano Mountains may have been synchronous with the thrusting, as for example in the northern Shoshone Range (Gilluly, 1960), or more probably was somewhat later, since the thrusts in the Delano Mountains are here interpreted as being deformed by the folding of the range. This Jurassic tectonism in the Delano Mountains is thus distinctly older than structures in the Sevier Orogenic Belt (Armstrong, 1968, 1972) to the east. Post-intrusive Cretaceous deformation has not been observed in the Delano Mountains, but it is recognized that thrusts and/or metamorphism may be present at depth. Indeed, it is conceivable that both the intrusive stock and Paleozoic rocks of the range may be entirely allochthonous (M.D. Crittenden, 1973, personal commun.).

A brief mention of possible age of deb will be included

An analysis of time-space relations between deformation and plutonism in the Delano Mountains, and orogenic activity in other parts of Elko County and vicinity provides for a possible regional synthesis of Jurassic tectonism and metamorphism. It is suggested that the exposed deformation in the Delano Mountains represents the upper non-metamorphosed part of the "suprastructure" (Armstrong and Hansen, 1966; Armstrong, 1968) of the eastern Great Basin. The shallow aspect of this upper tectonic level is here manifested as only a moderate degree of deformation, and

total absence of regional metamorphism — presumably above a deeper décollement zone (Misch, 1960, 1971) lower in the miogeosynclinal prism. The documented Jurassic tectonism in the Delano Mountains may be temporally related to post-Triassic orogenic activity which is known to have affected parts of the Windermere Hills (Oversby, 1972) and to pre-mid-Jurassic deformation in the north-central HD Range (Riva, 1970, p. 2703) to the west. This suprastructure deformation may also be synchronous with deeper mid-Mesozoic synkinematic regional metamorphism in other parts of Elko County (e.g., Ruby Mountains) and vicinity, or somewhat later as proposed by Misch (1966) for several areas of eastern Nevada, northwestern Utah, and south-central Idaho.

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FOOTNOTE:

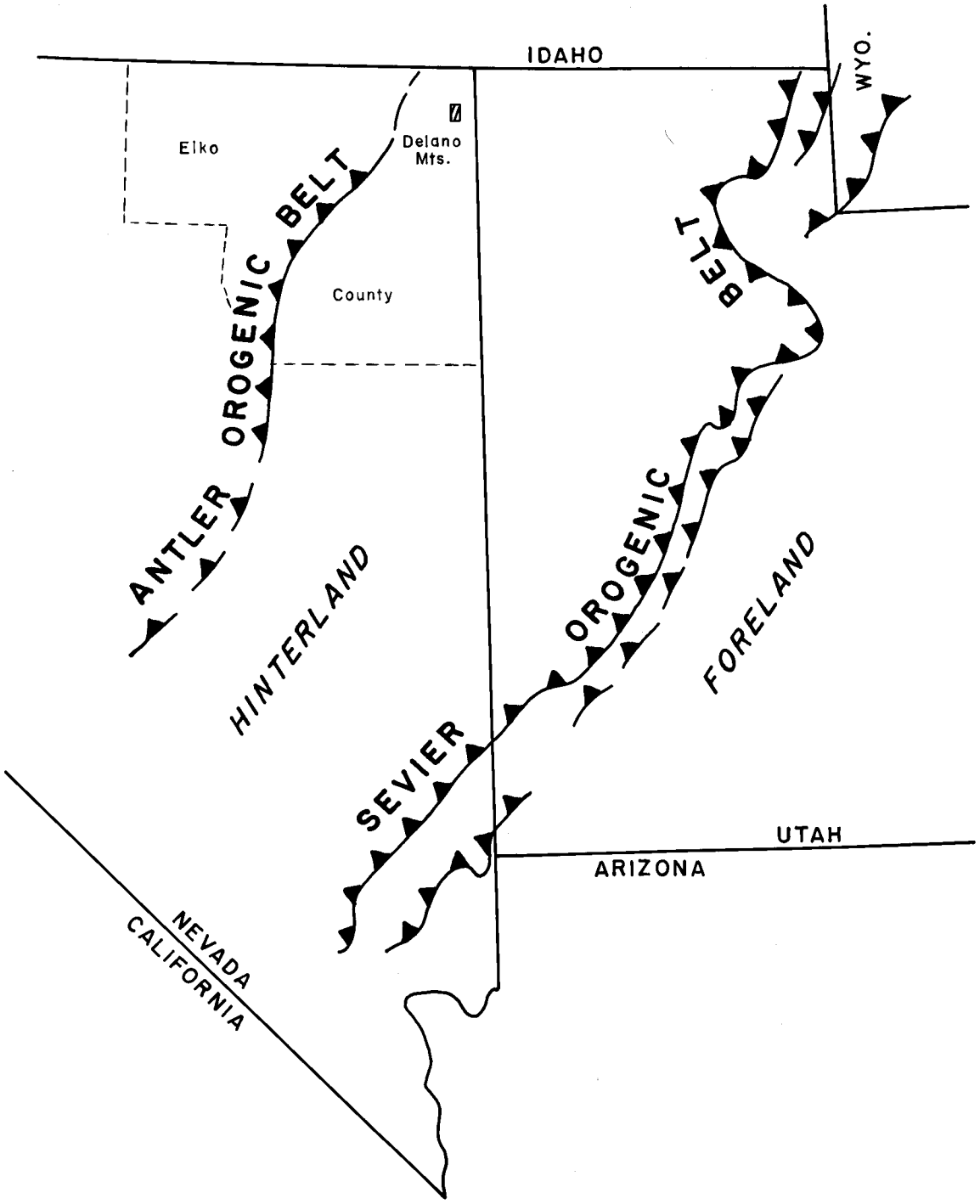
[1] The presence of the fusulinids Schwagerina sp. and Parafusulina sp., identified in 1970 by R.C. Douglass, U.S. Geological Survey, suggests a Permian age for strata in the Leach Range (Fig. 1), which are of similar lithology to rocks in the Delano Mountains to the north.

CAPTIONS FOR FIGURES:

Figure 1. Index map for northeastern Elko County showing location of major topographic and cultural features.

Figure 2. Tectonic setting of the Delano Mountains in the eastern Great Basin (modified after Armstrong, 1972).

Figure 3. Simplified geologic map of the Delano Mountains, northeastern Elko County, Nevada.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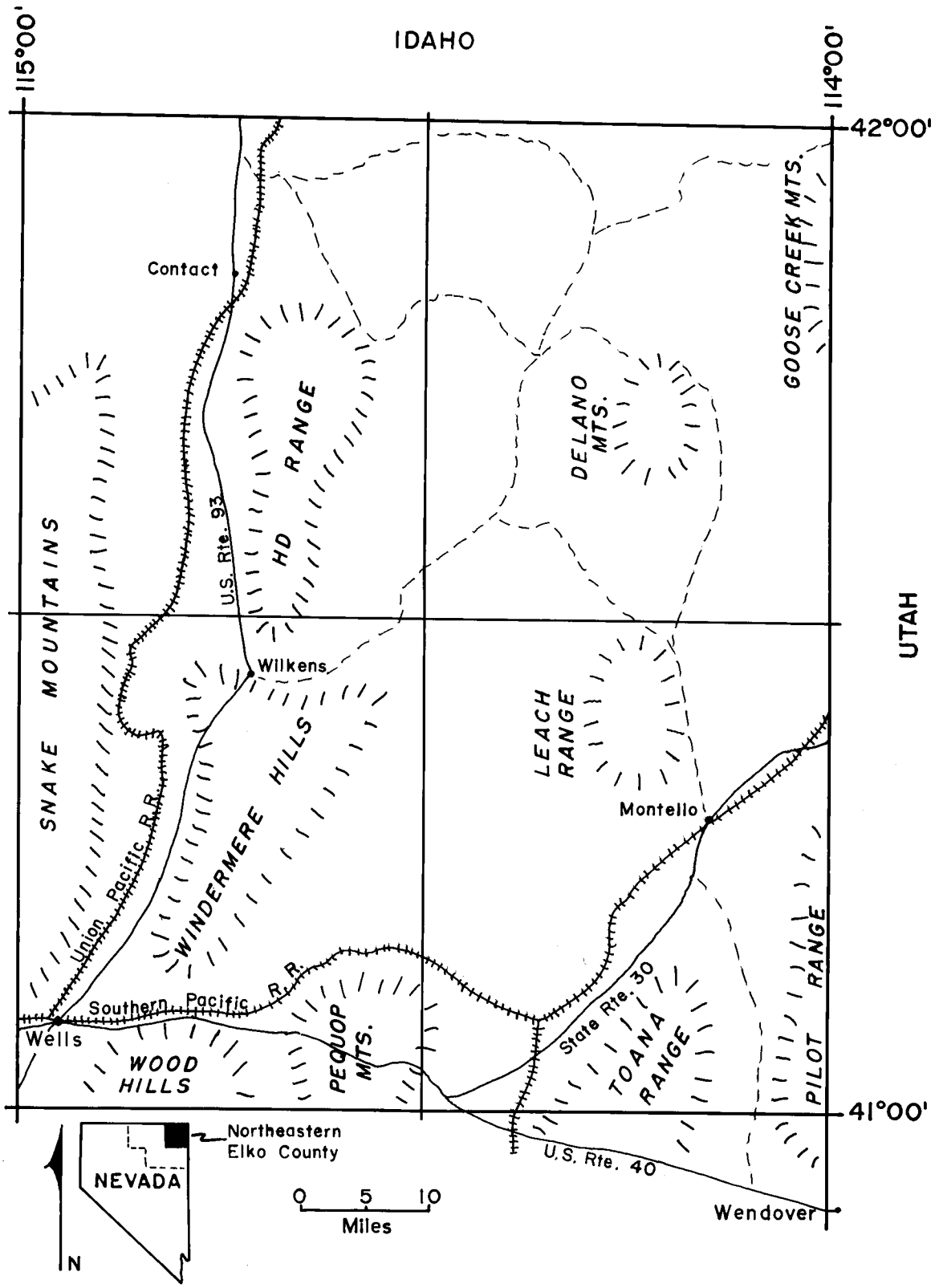
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