CENOZOIC ROCKS OF NEVADA – FOUR MAPS AND BRIEF DESCRIPTION OF DISTRIBUTION, LITHOLOGY, AGE, AND CENTERS OF VOLCANISM

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MAPS

Sheet 1. Distribution and lithologic character of 43- to 34-million-year-old sedimentary and igneous rocks of Nevada, showing centers of volcanism.

2. Distribution and lithologic character of 34- to 17-million-year-old sedimentary and igneous rocks of Nevada, showing centers of volcanism.

3. Distribution and lithologic character of 17- to 6-million-year-old sedimentary and igneous rocks of Nevada, showing centers of volcanism.

4. Distribution and lithologic character of sedimentary and igneous rocks and unconsolidated deposits of Nevada less than 6 million years old, showing centers of volcanism.

ABSTRACT

Cenozoic igneous and sedimentary rocks are widespread in Nevada. The patterns of their distribution change markedly with time. Four age categories of Cenozoic rocks are considered here: 43 to 34 m.y., 34 to 17 m.y., 17 to 6 m.y., and less than 6 m.y. The 43-m.y. age represents the approximate start of widespread volcanic activity in Nevada. Volcanic rocks ranging in age from 43 to 34 m.y. occur in a broad, poorly defined, east-west-trending belt across eastern and central Nevada between lat. 38°30′ and 40°30′ N. These rocks, mostly andesitic and rhyolitic lava flows and sparse ash-flow tuffs, are apparently a westward continuation of rocks of similar age in Utah. Rocks in the 43- to 34-m.y. age interval also are abundant in northeastern Nevada (northern Elko County), where ash-flow tuffs are as common as lava flows. Most volcanic rocks that range in age from 34 to 17 m.y. are silicic ash-flow tuffs that occur in an irregular west-northwest-trending belt lying between 37° and 39° N. at the eastern border of the State and between 38° and 40° N. at the western border. This belt extends into Utah on the east and the Sierra Nevada region of California on the west. Volcanic rocks that range in age from 17 to 6 m.y. are widespread; they are mostly rhyolitic and basaltic rocks in northern and southern Nevada and andesitic and basaltic rocks in western Nevada. Volcanic rocks less than 6 m.y. old occur largely as scattered basaltic cinder cones and lava flows.

Sedimentary rocks in Nevada are mostly tuffaceous units less than 17 m.y. old and unconsolidated valley alluvial and playa deposits generally less than 6 m.y. old. Sedimentary rocks older than 17 m.y. are relatively sparse.

INTRODUCTION

A synthesis of data on the distribution of Cenozoic rocks in Nevada has recently been completed as a part of the preparation of the Preliminary geologic map of Nevada (Stewart and Carlson, 1974). On the State map, Cenozoic rocks are divided into four broad categories on the basis of age—43 to 34 m.y., 34 to 17 m.y., 17 to 6 m.y., and less than 6 m.y.—and within each of these age categories the distribution of specific rock types are shown. To focus clearly on this information, four maps have been prepared showing outcrop patterns, lithologic character of the rocks, and centers of volcanism within each age group (sheets 1, 2, 3, and 4).

Cenozoic rocks older than 43 m.y. are not considered here, as they consist of poorly dated continental sedimentary rocks and a few widely scattered intrusive rocks.

The sources of data used in preparing the outcrop maps presented here are the same as those given on sheet 4 of the Preliminary geologic map of Nevada (Stewart and Carlson, 1974). Sources of data used in locating the centers of volcanism are shown in table 1.

This brief test focuses mainly on the general character and distribution of Cenozoic rocks in Nevada. No detailed description of the petrology, chemistry, or origin of the rocks is attempted. General discussions of these aspects are given by Armstrong and others (1969), McKee and others

TABLE 1. Sources of data for volcanic centers

Churchill County
- H. F. Bonham, oral communication, 1975
- J. H. Stewart, this report
- Burke and McKee, 1973
- Riehle and others, 1972

Clark County
- Anderson, 1974

Douglas, Lyon, and Ormsby Counties
- M. W. Reynolds, oral communication, 1974

Elko County
- R. R. Coats, written communication, 1974

Esmeralda County
- Robinson and others, 1968
- Ashely, 1974
- Robinson and Crowder, 1973
- Albers and Kleinhampl, 1970
- J. H. Stewart, this report

Eureka County
- Albers and Kleinhampl, 1970

Humboldt County
- Korringa, 1973
- F. J. Kleinhampl and J. H. Stewart, unpublished data, 1974

Humboldt County—*continued*
- Albers and Kleinhampl, 1970
- McKee and others, 1976

Lander County
- McKee, 1970
- Stewart and McKee, 1975
- Wrucke and Silberman, 1975
- J. H. Stewart, this report
- Burke and McKee, 1973

Lincoln County
- E. B. Ekren, E. F. Cook, G. L. Dixon, E. N. Hinricks, D. C. Noble, P. P. Orkild, and K. A. Sargent, unpublished data, 1972
- Noble, 1968

Mineral County
- Albers and Kleinhampl, 1970
- Kleinhampl and others, 1975
- Gilbert and others, 1968
- F. J. Kleinhampl, oral communication, 1974
- W. J. Carr, oral communication, 1975
- E. B. Ekren, F. M. Byers, R. C. Bucknam, P. P. Orkild, oral communication, 1975
- Ekren and Byars, 1976

Nye County, north part
- Ekren and others, 1974
- Scott and Trask, 1971

Nye County, north part—*continued*
- McKee, 1974
- Bonham and Garside, 1974
- Sargent and Houser, 1970
- F. J. Kleinhampl, oral communication, 1974
- J. H. Stewart, this report
- H. F. Bonham, written communication, 1973
- Speed and McKee, 1976

Nye County, southern part
- Christiansen and others, 1976
- Ekren and others, 1971
- Orkild and others, 1968
- Ekren, 1968
- W. J. Carr, unpublished data, 1973
- Noble and Christiansen, 1974
- J. H. Stewart, this report

Pershing County
- Albers and Kleinhampl, 1970
- Willden and Speed, 1974, p. 37

Washoe and Storey Counties
- Bonham, 1969
- H. F. Bonham, written communication, 1975
- J. H. Stewart, this report

White Pine County
- M. C. Blake, oral communication, 1975

(1970), McKee (1971), Lipman and others (1971, 1972), Christiansen and Lipman (1972), and Noble (1972).

AGE CLASSIFICATION

Rocks are categorized here and on the State map by age in millions of years, rather than by formal series names. Such a practice is possible where, as in Nevada, radiometric dating of volcanic rocks, mainly by the K-Ar method, is extensive and is desirable because the limiting ages appear to mark times of significant change in the type and location of volcanism that may reflect fundamental changes in tectonic setting.

An age of 34 m.y. was selected as a boundary between the two oldest groups of volcanic rocks, which differ significantly in lithologic character and distribution pattern. Rocks older than this age are predominantly silicic and intermediate calc-alkaline lava flows that occur in the northeastern part of the State; younger rocks are mainly silicic ash-flow tuffs spread across the central part of the State. The boundary between the next two younger units, 17 m.y., falls within a period of relatively low volcanic activity in Nevada (McKee and others, 1970). Prior to 17 m.y., calc-alkaline intermediate volcanism was dominant, but after 17 m.y. large volumes of basaltic lava were extruded. The 17-m.y. age appears to mark a time of significant tectonic change in the State that eventually led to the development of extensional basin-and-range structure (McKee, 1971; Christiansen and Lipman, 1972; Stewart, 1971). The 6-m.y. boundary between the two youngest categories marks the approximate end of widespread ash-flow tuff activity in Nevada. Subsequent volcanic activity was confined largely to isolated basaltic cinder cones and lava flows. Volcanic rocks less than 6 m.y. old occur mostly along the borders of the Great Basin outside of Nevada.

RELIABILITY OF DATA

In parts of Nevada, excellent data on the age, distribution, and lithology of Cenozoic rocks are available from detailed mapping and numerous radiometric age determinations. In other parts of the State, only poor data are available from reconnaissance mapping and a few scattered dates. In general, the reliability of the data is reflected in the distribution and number of radiometric age determinations; such data have been summarized for much of the State by McKee and others (1971), Silberman and McKee (1972), Marvin and others (1973), McKee and Marvin (1974), and McKee and others (1976).

Data are generally adequate to assign rocks to one or another of the lithologic categories used in compiling the State map. Data on the ages of the rocks are not nearly so complete, despite hundreds of age determinations already in hand. In some parts of the State, rocks are categorized merely on the basis of the general age of rocks in the surrounding region. Such a practice tends to oversimplify the pattern of distribution of any one age grouping. Data are particularly sparse in western Pershing County and parts of Churchill, Douglas, Lyon, Ormsby, and Mineral Counties. In particular, age assignments of andesitic rocks in central and western Nevada are uncertain in many areas. The age of the andesite and basalt flows (sheet 3) is uncertain locally. Most rocks in this unit are within the 17- to 6-m.y.-age range, but some rocks in northernmost Nevada are as old as 21 m.y. (E. H. McKee, oral communication, 1974), and some rocks younger than 6 m.y. are probably present in this unit in western Nevada.

Three main types of Cenozoic intrusive rocks–granitic, mafic, and rhyolitic–are distinguished on the State map, but no age subdivision was attempted. In this report, however, the intrusive rocks are assigned to one or another of the four age categories used for the other types of Cenozoic rocks. Where radiometric dating is available, these data were used to assign intrusive rocks to one category or another. Where such data are not available, the age of the intrusive rock was considered to be that of nearby extrusive rocks.

Rocks Ranging in Age from 43 to 34 m.y. (sheet 1)

Major Cenozoic volcanic activity in Nevada began approximately 43 m.y. ago (R. R. Coats and E. H. McKee, oral communication, 1975; McKee and others, 1976). For about the next 9 m.y. (43-34 m.y.), eruptive rocks were primarily andesitic to rhyolitic lava flows, except in northern Elko County, where voluminous silicic ash-flow tuffs occur. Intrusive rocks of this age, particularly granitic rocks in central and eastern Nevada, are fairly abundant.

The lava flows in the 43- to 34-m.y. group in Nevada consist of moderately to highly potassic andesite, latite, quartz latite, and rhyolite (Blake and others, 1969; Noble, 1972; McKee, 1971). The flows are locally several thousands of feet thick and must have been derived from many local sources. These sources are not sufficiently well defined to be shown on sheet 1, except for the Mount Lewis caldera in Lander County (Wrucke and Silberman, 1975) and small volcanic centers in Eureka and White Pine Counties.

The lava flows occur in a broad, poorly defined east-west-trending belt in Nevada that appears to be a continuation of rocks of similar composition and age in Utah.

Rocks Ranging in Age from 34 to 17 m.y. (sheet 2)

A significant change in the character of volcanic activity in Nevada approximately 34 m.y. ago (McKee, 1971; Noble, 1972), is marked by the beginning of voluminous eruptions of quartz latitic and rhyolitic ash-flow tuffs that continued until about 17 m.y. ago. Basaltic lavas are relatively sparse in the 34- to 17-m.y. interval.

A number of source areas have been identified for these 34- to 17-m.y.-old volcanic rocks, and include calderas, large andesitic volcanos, and two major east- to southeast-trending volcano-tectonic troughs (Burke and McKee, 1973).

The major area of ash-flow activity during the interval from 34 to 17 m.y. extends east and west in a broad belt from southwestern Utah into eastern California. In Utah, this belt includes many units described by Mackin (1960), and in California, such units as the Valley Springs Formation (Slemmons, 1966) and the Delleker Formation (Durrell, 1966).

Rocks Ranging in Age from 17 to 6 m.y. (sheet 3)

Another marked change in the character of volcanic activity in Nevada, perhaps the most significant during the Cenozoic, occurred approximately 17 m.y. ago with the beginning of widespread eruptions of mafic lava, mostly basalt, and bimodal assemblages of rhyolite and basalt, including alkali-olivine and tholeiitic basalts and high silica subalkaline rocks, as well as peralkaline rhyolites (Christiansen and Lipman, 1972; McKee, 1971). Calc-alkaline volcanic activity was sparse during this time interval except in westernmost Nevada and northern California, where widespread and voluminous andesitic volcanism represents a southward continuation of the extensive andesitic volcanism then occurring along the western continental margin in the Cascade Range of Washington, Oregon, and northern California (Christiansen and Lipman, 1972).

Sedimentary rocks in the 17- to 6-m.y. age group are widespread in Nevada and consist mainly of tuffaceous sandstone, conglomerate, and siltstone. Sedimentary rocks older than 17 m.y. are relatively sparse in Nevada.

A notable feature resulting from volcanism during the 17- to 6-m.y. time interval is a slightly arcuate belt of siliceous ash-flow tuffs and lava flows that contains most of the recognizable calderas, extending in a general east-west direction across Nevada and the central Sierra Nevada of California. In addition to the volcanic centers shown on sheet 3, the Little Walker caldera (Noble and others, 1974) occurs along this trend in California.

Siliceous ash-flow tuffs and lava flows are also voluminous in northernmost Nevada, and are part of a broad region of volcanism that includes southeastern Oregon and the Snake River Plain of Idaho. Extending southward into central Nevada from this northern region is a well-defined belt of siliceous and mafic lava flows that follow the southeastern half of a 465-mile-long belt of closely spaced, partly en echelon faults extending from central Oregon to central Nevada (the Oregon-Nevada lineament; Stewart and others, 1975). In Nevada, the lineament is marked by a conspicuous coextensive aeromagnetic anomaly.

Rocks less than 6 m.y. old (sheet 4)

Only scattered volcanic activity has occurred in Nevada during the past 6 m.y. Alluvial and playa deposits of this age, on the other hand, are widespread, covering over half the State. Landslide and morainal deposits are relatively sparse and occur primarily in mountainous areas of northern and western Nevada.

The volcanic rocks consist mostly of scattered basaltic cinder cones and lava flows with many local sources. Two maars occur in the Lunar Crater area in central Nye County (Scott and Trask, 1971), and one near Fallon in Churchill County. Some andesitic and rhyolitic volcanism occurred in Storey County, southern Washoe County, and western Mineral County. A large composite andesitic volcano is recognized in southern Lyon County.

Late Cenozoic volcanism was concentrated primarily near the margins of the Great Basin and adjacent to the Colorado Plateaus (Best and Brimhall, 1974, fig. 1).

SUMMARY AND CONCLUSIONS

Cenozoic rocks of Nevada reveal a complex evolutionary pattern: mainly andesitic to rhyolitic flow rocks with minor ash-flow tuffs (43 to 34 m.y.) in northeastern, central, and east-central Nevada, through largely silicic ash-flow tuffs (34 to 17 m.y.) across south-central Nevada, to basaltic and bimodal basaltic-rhyolitic volcanic rocks in northern and southern Nevada, and andesitic rocks in western Nevada (17-6 m.y.), to, finally, scattered basaltic volcanism (less than 6 m.y.). A notable feature of this evolution is a southward migration of broad, poorly defined, east-west- or west-northwest-trending volcanic belts in central Nevada in the 43- to 34-m.y. interval, to south-central Nevada in the 34- to 17-m.y. interval, to southern Nevada in the 17- to 6-m.y. interval (Stewart and others, 1976). Although volcanic activity was widespread in Nevada during the 17- to 6-m.y. time interval, the east-west volcanic belt in southern Nevada is distinguished by the abundance of siliceous ash-flow tuffs and related major volcanic centers.

Another feature of the complex volcanic pattern in Nevada is the south- to south-southeast-trending Cenozoic Cascade belt of andesitic volcanism, parallel to and inland from the Pacific margin of North America. This belt is not clearly recognized in California or Nevada prior to 17 m.y. ago, although it was well defined in Oregon and Washington before that time (Peck and others, 1964; Lipman and others, 1972, fig. 2). Evidence of andesitic volcanism prior to 17 m.y. ago in northern California, however, may be obscured by younger volcanic activity. During the 17- to 6-m.y. interval, the Cascade andesitic belt clearly reached as far south as southern Mineral County, Nevada. Some andesitic rocks younger than 6 m.y. in western Nevada may be related to the Cascade trend, but the southern limit of most andesitic volcanism during this time interval was in northern California.

The scarcity of basaltic rocks older than 17 m.y. and the abundance of such rocks younger than 17 m.y., as shown by the maps, is a significant relation that has been discussed by McKee and others (1970), McKee (1971), and Christiansen and Lipman (1972). In addition, sedimentary rocks older than 17 m.y. are relatively scarce, but such rocks younger than 17 m.y. are abundant, indicating the development of sediment-filled basins as the result of the onset of basin-and-range structure (McKee and others, 1970).

Early and middle Cenozoic volcanic activity in Nevada is related by most workers to the generation of magmas along an Andean-type subduction zone dipping eastward under western North America (Lipman and others, 1971, 1972; McKee, 1971; Noble, 1972). The onset of bimodal basaltic and rhyolitic volcanism approximately 17 m.y. ago is generally interpreted as related to extensional events that tapped deep magma sources in the mantle (Christiansen and Lipman, 1972; McKee, 1971). The cause of this extension is not clearly understood but is thought to be either (1) oblique tensional fragmentation within a broad belt of right-lateral movement along the western side of the North American lithospheric plate (see Atwater, 1970), (2) spreading related to subduction of a spreading ridge (the East Pacific Rise) (see McKee, 1971), or (3) spreading caused by mantle upwelling behind a magmatic arc (black-arc spreading) or to slackening compression after destruction of a subduction system (Scholz and others, 1971).

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REFERENCES

Albers, J. P., and Kleinhampl, F. J. (1970) Spatial relation of mineral deposits to Tertiary volcanic centers in Nevada, *in* Geological Survey research 1970, Chap. C.: U.S. Geol. Survey Prof. Paper 700-C, p. C1–C10.

Anderson, R. E. (1974) Large-magnitude late Tertiary strike-slip faulting north of Lake Mead, Nevada: U.S. Geol. Survey Prof. Paper 794, 18 p.

Armstrong, R. L., Ekren, E. B., McKee, E. H., and Noble, D. C. (1969) Space-time relations of Cenozoic silicic volcanism in the Great Basin of the Western United States: Am. Jour. Sci., v. 267, p. 478–490.

Ashley, R. P. (1974) Goldfield mining district, *in* Guidebook to the geology of four Tertiary volcanic centers in central Nevada: Nevada Bur. Mines and Geology Rept. 19, p. 49–66.

Atwater, Tanya (1970) Implications of plate tectonics for the Cenozoic tectonic evolution of western North America: Geol. Soc. America Bull., v. 81, no. 12, p. 3513–3535.

Best, M. G., and Brimhall, W. H. (1974) Late Cenozoic alkalic basaltic magmas in the western Colorado Plateaus and the Basin and Range transition zone, U.S.A., and their bearing on mantle dynamics: Geol. Soc. America Bull., v. 85, no. 11, p. 1677–1690.

Blake, M. C., Jr., Hose, R. K., and McKee, E. H. (1969) Tertiary volcanic stratigraphy of White Pine County, Nevada [abs.]: Geol. Soc. America Abs. with Programs 1969, pt. 5, Rocky Mtn. Sec., p. 8.

Bonham, H. F. (1969) Geology and mineral deposits of Washoe and Storey Counties, Nevada, *with a section on* Industrial rock and mineral deposits *by* Keith G. Papke: Nevada Bur. Mines Bull. 70, 140 p.

Bonham, H. F., Jr., and Garside, L. J. (1974) Tonopah mining district and vicinity, *in* Guidebook to the geology of four Tertiary volcanic centers in central Nevada: Nevada Bur. Mines and Geology Rept. 19, p. 42–48.

Burke, D. B., and McKee, E. H. (1973) Mid-Cenozoic volcano-tectonic features in central Nevada [abs.]: Geol. Soc. America, Abs. with Programs, v. 5, no. 1, p. 18.

Christiansen, R. L., and Lipman, P. W. (1972) Cenozoic volcanism and plate-tectonic evolution of the western United States. II, Late Cenozoic: Royal Soc. London Philos. Trans., v. 271, p. 249–284.

Christiansen, R. L., Lipman, P. W., Carr, W. J., Byers, F. M., Jr., Orkild, P. P., and Sargent, K. A. (1976) The Timber Mountain-Oasis Valley caldera complex of southern Nevada: Geol. Soc. America Bull. (in press).

Durrell, Cordell (1966) Tertiary and Quaternary geology of the northern Sierra Nevada, *in* Bailey E. H., ed., Geology of northern California: California Div. Mines and Geology Bull. 190, p. 185–197.

Ekren, E. B. (1968) Geologic setting of Nevada Test Site and Nellis Air Force Range, *in* Eckel, E. C., ed., Nevada Test Site: Geol. Soc. America Mem. 110, p. 11–19.

Ekren, E. B., Anderson, R. E., Rogers, C. L., and Noble, D. C. (1971) Geology of northern Nellis Air Force Base Bombing and Gunnery Range, Nye County, Nevada: U.S. Geol. Survey Prof. Paper 651, 91 p.

Ekren, E. B. and Byars, F. M., Jr. (1976) Ash-flow fissure vent in west-central Nevada: Geology, v. 4, p. 247–251.

Ekren, E. B., Quinlivan, W. D., Snyder, R. P., and Kleinhampl, F. J. (1974) Stratigraphy, structure, and geologic history of the Lunar Lake caldera of northern Nye County, Nevada: U.S. Geol. Survey Jour. Research, v. 2, no. 5, p. 599–608.

Gilbert, C. M., Christensen, M. N., Al-Rawi, Yehya, and Lajoie, K. R. (1968) Structural and volcanic history of Mono Basin, California-Nevada, *in* Studies in volcanology–A memoir in honor of Howel Williams: Geol. Soc. America Mem. 116, p. 275–329.

Kleinhampl, F. J., Davis, W. E., Silberman, M. L., Chesterman, C. W., and Chapman, R. H. (1975) Aeromagnetic and limited gravity studies and generalized geology of the Bodie Hills and surrounding region, Nevada and California: U.S. Geol. Survey Bull. 1384, 38 p.

Korringa, M. K. (1973) Linear vent area of the Soldier Meadow Tuff, an ash-flow sheet in northwestern Nevada: Geol. Soc. America Bull., v. 84, p. 3849–3866.

Lipman, P. W., Prostka, H. J., and Christiansen, R. L. (1971) Evolving subduction zones in the Western United States, as interpreted from igneous rocks: Science, v. 174, p. 821–825.

_______ (1972) Cenozoic volcanism and plate-tectonic evolution of the Western United States. I, Early and Middle Cenozoic: Royal Soc. London Philos. Trans., v. 271, p. 217–248.

Mackin, J. H. (1960) Structural significance of Tertiary volcanic rocks in southwestern Utah: Am. Jour. Sci., v. 258, no. 2, p. 81–131.

Marvin, R. F., Mehnert, H. H., and McKee, E. H. (1973) A summary of radiometric ages of Tertiary volcanic rocks in Nevada and eastern California, Part III, southeastern Nevada: Isochron/West, no. 6, p. 1–29.

McKee, E. H. (1970) Fish Creek Mountains Tuff and volcanic center, Lander County, Nevada: U.S. Geol. Survey Prof. Paper 681, 17 p.

_______ (1971) Tertiary igneous chronology of the Great Basin of Western United States–Implications for tectonic models: Geol. Soc. America Bull., v. 82, p. 3497–3502.

_______ (1974) Northumberland caldera and Northumberland tuff, *in* Guidebook to the geology of four Tertiary volcanic centers in central Nevada: Nevada Bur. Mines and Geology Rept. 19, p. 35–41.

McKee, E. H., and Marvin, R. F. (1974) Summary of radiometric ages of Tertiary volcanic rocks in Nevada, Part IV, northwestern Nevada: Isochron/West, no. 10, p. 1–6.

McKee, E. H., Noble, D. C., and Silberman, M. L. (1970) Middle Miocene hiatus in volcanic activity in the Great Basin area of the Western United States: Earth and Planetary Sci. Letters, v. 8, no. 2, p. 93–96.

McKee, E. H., Silberman, M. L., Marvin, R. F., and Obradovich, J. D. (1971) A summary of radiometric ages of Tertiary rocks in Nevada and eastern California, Part I, central Nevada: Isochron/West, no. 2, p. 21–42.

McKee, E. H., Tarshis, A. L., and Marvin, R. F. (1976) Summary of radiometric ages of Tertiary igneous rocks in Nevada, Part V: Northeastern Nevada: Isochron/West (in press).

Noble, D. C. (1968) Kane Springs Wash volcanic center, Lincoln County, Nevada, *in* Eckel, E. C., ed., Nevada Test Site: Geol. Soc. America Mem. 110, p. 109–116.

_______ (1972) Some observations on the Cenozoic volcano-tectonic evolution of the Great Basin, Western United States: Earth and Planetary Sci. Letters, v. 17, p. 142–150.

Noble, D. C., and Christiansen, R. L. (1974) Black Mountain volcanic center, *in* Guidebook to the geology of four Tertiary volcanic centers in central Nevada: Nevada Bur. Mines and Geology Rept. 19, p. 27–34.

Noble, D. C., Slemmons, D. B., Korringa, M. K., Dickinson, W. R., Al-Rawi, Yehya, and McKee, E. H. (1974) Eurekà Valley Tuff, east-central California and adjacent Nevada: Geology, v. 2, no. 3, p. 139–142.

Orkild, P. P., Byers, F. M., Jr., Hoover, D. L., and Sargent, K. A. (1968) Subsurface geology of Silent Canyon caldera, Nevada Test Site, Nevada, *in* Eckel, E. C., ed., Nevada Test Site: Geol. Soc. America Mem. 110, p. 77–86.

Peck, D. L., Griggs, A. B., Schlicker, H. G., Wells, F. G., Dole, H. M. (1964) Geology of the central and northern parts of the western Cascade Range in Oregon: U.S. Geol. Survey Prof. Paper 449, 56 p.

Riehle, J. R., McKee, E. H., and Speed, R. C. (1972) Tertiary volcanic center, west-central Nevada: Geol. Soc. America Bull., v. 83, p. 1383–1395.

Robinson, P. T., and Crowder, D. F. (1973) Geologic map of the Davis Mountain quadrangle, Esmeralda and Mineral Counties, Nevada, and Mono County, California: U.S. Geol. Survey Geol. Quad. Map GQ-1078, scale 1:62,500.

Robinson, P. T., McKee, E. H., and Moiola, R. J. (1968) Cenozoic volcanism and sedimentation, Silver Peak region, western Nevada and adjacent California, *in* Coats, R. R., Hay, R. L., and Anderson, C. A., eds., Studies in volcanology–A memoir in honor of Howel Williams: Geol. Soc. America Mem. 116, p. 577–611.

Sargent, K. A., and Houser, F. N. (1970) The Shingle Pass Tuff of central Nevada [abs.]: Geol. Soc. America Abs. with Programs, v. 2, no. 2, p. 140–141.

Scholz, C. H., Barazangi, M., Slar, M. L. (1971) Late Cenozoic evolution of the Great Basin, Western United States, as an ensialic interarc basin: Geol. Soc. America Bull. v. 82, p. 2979–2990.

Scott, D. H., and Trask, N. J. (1971) Geology of the Lunar Crater volcanic field, Nye County, Nevada: U.S. Geol. Survey Prof. Paper 599-I, 22 p.

Silberman, M. L., and McKee, E. H. (1972) A summary of radiometric age determinations on Tertiary volcanic rocks from Nevada and eastern California, Part II, western Nevada: Isochron/West, no. 4, p. 7–28.

Slemmons, D. B. (1966) Cenozoic volcanism of the central Sierra Nevada, California, *in* Bailey, E. H., ed., Geology of northern California: California Div. Mines and Geology Bull. 190, p. 199–208.

Speed, R. C., and McKee, E. H. (1976) Age and origin of the Darrough Felsite: U.S. Geol. Survey Jour. Research (in press).

Stewart, J. H. (1971) Basin and Range structure: A system of horsts and grabens produced by deep-seated extension: Geol. Soc. America Bull., v. 82, p. 1019–1044.

Stewart, J. H. and Carlson, J. E. (1974) Preliminary geologic map of Nevada: U.S. Geol. Survey Misc. Field Studies Map MF-609, scale: 1:500,000.

Stewart, J. H., and McKee, E. H. (1976) Geology of Lander County, Nevada, Pt. I, and Stager, H. K., Mineral deposits, Pt. II: Nevada Bur. Mines and Geology Bull. (in press).

Stewart, J. H., Moore, W. J., and Zeitz, Isidore (1976) East-west patterns of Cenozoic igneous rocks, aeromagnetic anomalies, and mineral deposits, Nevada and Utah: Geol. Soc. America Bull. (in press).

Stewart, J. H., Walker, G. W., and Kleinhampl, F. J. (1975) Oregon-Nevada lineament: Geology, v. 3, p. 265–268.

Willden, Ronald, and Speed, R. C. (1974) Geology and mineral deposits of Churchill County, Nevada: Nevada Bur. Mines and Geology Bull. 83, 95 p.

Wrucke, C. T., and Silberman, M. L. (1975) Cauldron subsidence of Oligocene age at Mount Lewis, northern Lander County, Nevada: U.S. Geol. Survey Prof. Paper 876.