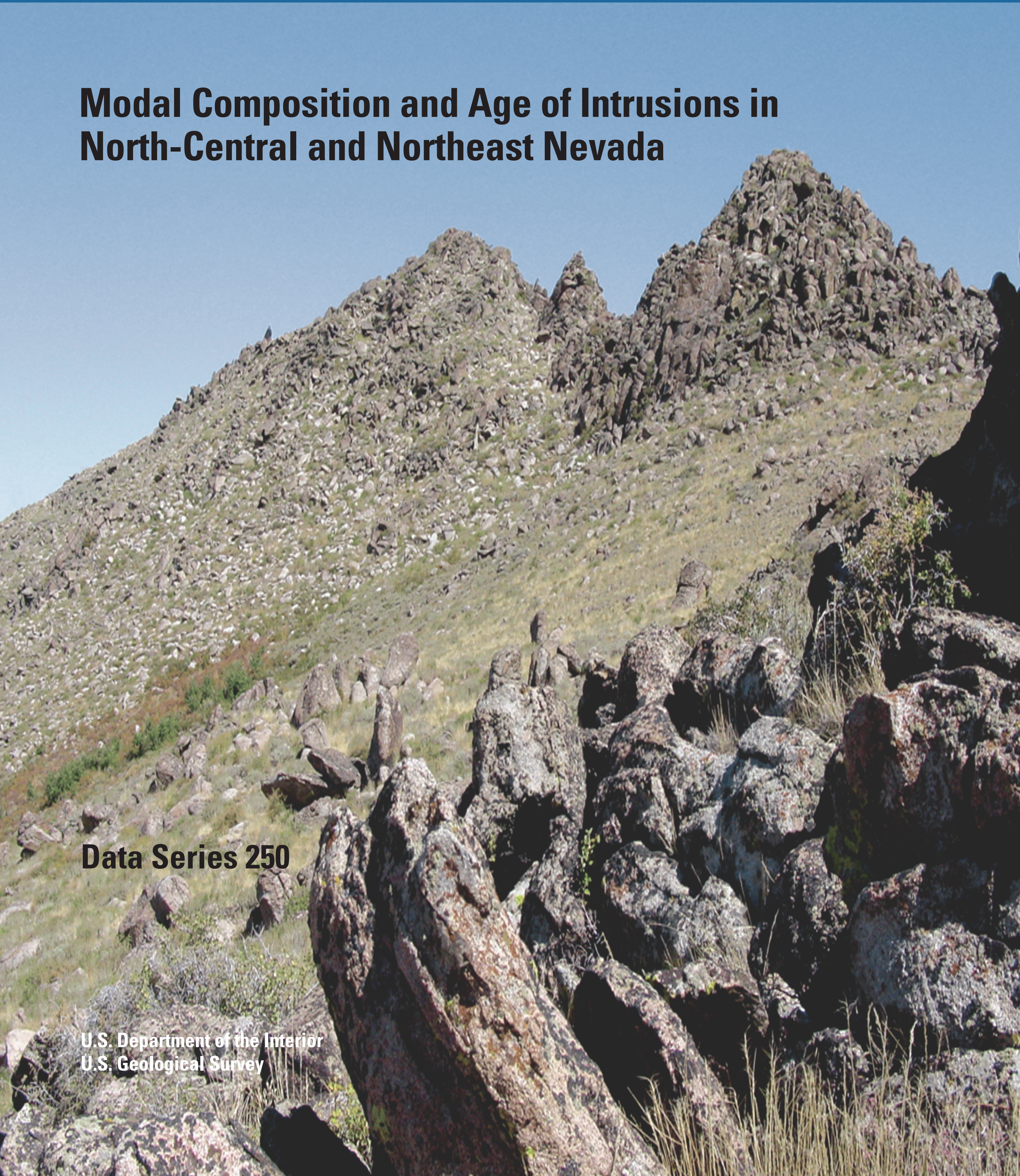
USGS
science for a changing world

Modal Composition and Age of Intrusions in North-Central and Northeast Nevada



Data Series 250

U.S. Department of the Interior
U.S. Geological Survey

Cover: Prominent granite outcrops at Lone Mountain, north-northwest of Elko, Nevada, are part of the Nannies Peak intrusion.

Modal Composition and Age of Intrusions in North-Central and Northeast Nevada

By Edward A. du Bray and A. Elizabeth Jones Crafford

Data Series 250

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia: 2007

Version 1.0

For sale by U.S. Geological Survey, Information Services
Box 25286, Denver Federal Center
Denver, CO 80225

For more information about the USGS and its products:
Telephone: 1-888-ASK-USGS
World Wide Web: http://www.usgs.gov/

This publication is available online at:
http://pubs.usgs.gov/ds/2007/250

Suggested citation:
du Bray, E.A., and Crafford, A.E.J., 2007, Modal composition and age of intrusions in north-central and northeast Nevada: U.S. Geological Survey Data Series 250, 1 CD-ROM.

ISBN 1411317998

Contents

Figures

Plate

Modal Composition and Age of Intrusions in North-Central and Northeast Nevada

By Edward A. du Bray and A. Elizabeth Jones Crafford[1]

Introduction

Data presented in this report characterize igneous intrusions of north-central and northeast Nevada and were compiled as part of the Metallogeny of the Great Basin project conducted by the U.S. Geological Survey (USGS) between 2001 and 2007. The compilation pertains to the area bounded by lats 38.5° and 42° N., long 118.5° W., and the Nevada-Utah border (fig. 1). The area contains numerous large plutons and smaller stocks but also contains equally numerous smaller, shallowly emplaced intrusions, including dikes, sills, and endogenous dome complexes. Igneous intrusions (hereafter, intrusions) of multiple ages are major constituents of the geologic framework of north-central and northeast Nevada (Stewart and Carlson, 1978). Mesozoic and Cenozoic intrusions are particularly numerous and considered to be related to subduction along the west edge of the North American plate during this time.

Henry and Ressel (2000) and Ressel and others (2000) have highlighted the association between magmatism and ore deposits along the Carlin trend. Similarly, Theodore (2000) has demonstrated the association between intrusions and ore deposits in the Battle Mountain area. Decades of geologic investigations in north-central and northeast Nevada (hereafter, the study area) demonstrate that most hydrothermal ore deposits are spatially, and probably temporally and genetically, associated with intrusions. Because of these associations, studies of many individual intrusions have been conducted, including those by a large number of Master's and Doctoral thesis students (particularly University of Nevada at Reno students and associated faculty), economic geologists working on behalf of exploration and mining companies, and USGS earth scientists. Although the volume of study area intrusions is large and many are associated with ore deposits, no synthesis of available data that characterize these rocks has been assembled.

Compilations that have been produced for intrusions in Nevada pertain to relatively restricted geographic areas and (or) do not include the broad array of data that would best aid interpretation of these rocks. For example, Smith and others (1971) presented potassium-argon geochronologic and basic petrographic data for a limited number of intrusions in north-central Nevada. Similarly, Silberman and McKee (1971) presented potassium-argon geochronologic data for a significant number of central Nevada intrusions. More recently, Mortensen and others (2000) presented uranium-lead geochronology for a small number of central Nevada intrusions. Sloan and others (2003) released a national geochronologic database that contains age determinations made prior to 1991 for rocks of Nevada. Finally, C.D. Henry (Nevada Bureau of Mines and Geology, written commun., 2006) has assembled geochronologic data for igneous rocks of Nevada produced subsequent to completion of the Sloan and others (2003) compilation. Consequently, although age data for igneous rocks of Nevada have been compiled, data pertaining to other features of these rocks have not been systematically synthesized. Maldonado and others (1988) compiled the distribution and some basic characteristics of intrusions throughout Nevada. Lee (1984), John (1983, 1987, and 1992), John and others (1994), and Ressel (2005) have compiled data that partially characterize intrusions in some parts of the study area. This report documents the first phase of an effort to compile a robust database for study area intrusions; in this initial phase, modal composition and age data are synthesized. In the next phase, geochemical data available for these rocks will be compiled. The ultimate goal is to compile data as a basis for an evaluation of the time-space-compositional evolution of Mesozoic and Cenozoic magmatism in the study area and identification of genetic associations between magmatism and mineralizing processes in this region.

Acknowledgments

We would like to thank the staff of the USGS Denver library, who were critical to the success of this compilation. In particular, the library staff used the interlibrary loan process to obtain many of the geologic reports on which this compilation

[1]GeoLogic, 9501 Nettleton Drive, Anchorage, AK 99507

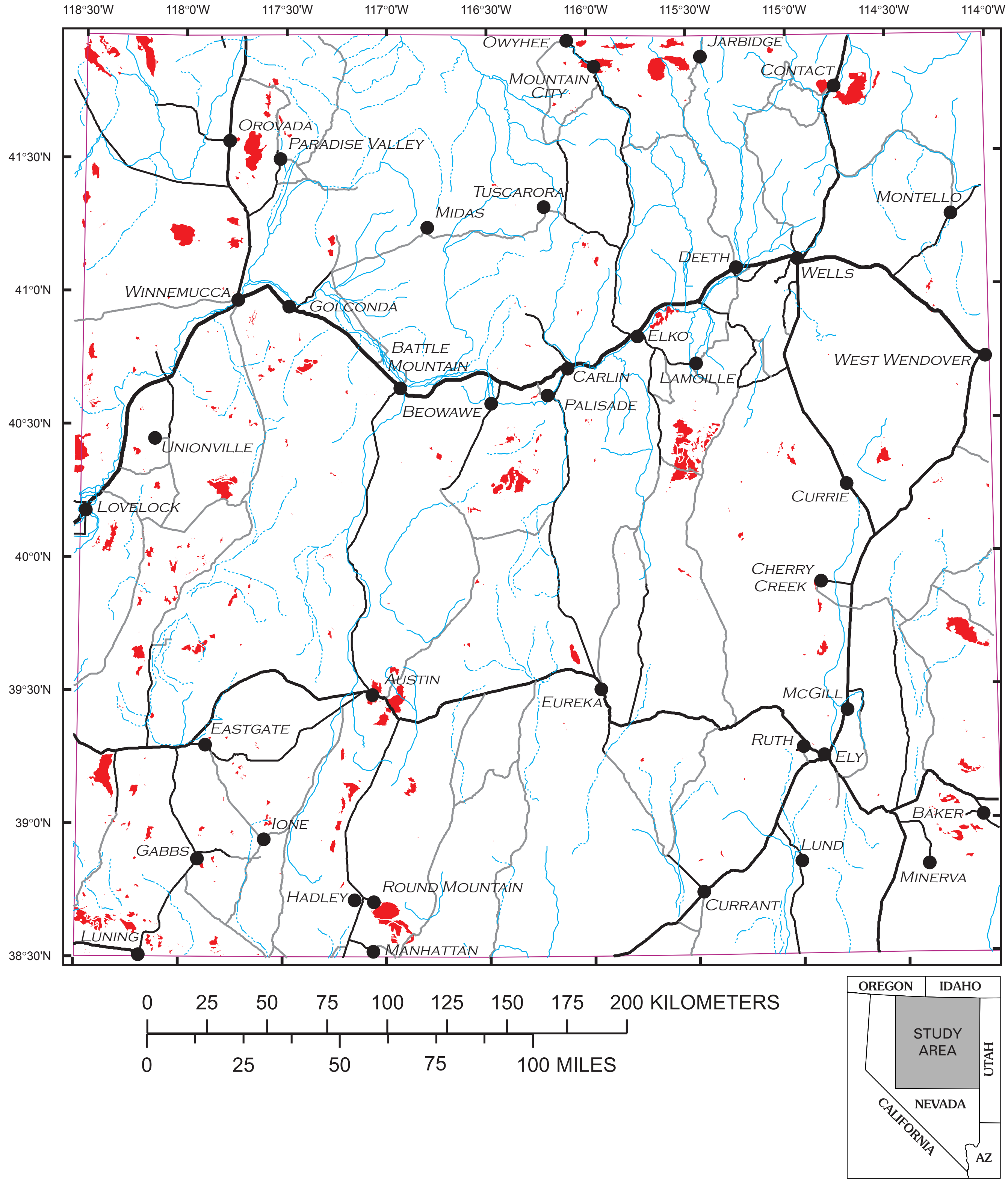


Figure 1. Index map showing approximate distributions of intrusive rocks in north-central and northeast Nevada. Thin purple line outlines the study area. Intrusions indicated by red polygons.

is based. Financial support provided by the USGS to Crafford enabled compilation of the digital geologic map. We would like to gratefully acknowledge technical reviews by S.D. Ludington and J.L. Doebrich that helped improve this report.

Data Sources and Compilation Methods

Many geologic investigations have demonstrated that study area intrusions are principally of three ages, Jurassic, Cretaceous, and Eocene. In the western part of the study area, a number of intrusions are thought to be of Triassic age (Johnson, 1977). Christiansen and Yeats (1992) documented southward-sweeping Eocene magmatism that began in British Columbia at about 54 Ma and extended into Nevada by 43 Ma. Eocene intrusions are voluminous in the study area and may be related to foundering of the Farallon slab beneath western North America (Humphreys, 1995). Several small, shallowly emplaced Miocene intrusions have been delineated in various parts of the study area (plate 1). This report does not contain data for Paleozoic intrusions, which are principally of very mafic composition and are likely parts of detached, allochthonous thrust sheets.

The geologic base for this database is derived from Crafford's (in press) new 1:250,000-scale compilation of Nevada geology, which uses a projected North America UTM coordinate system (zone 11N) and the North American Datum of 1927 (NAD27). The new map was created using the Nevada Bureau of Mines and Geology county reports and accompanying 1:250,000-scale geologic maps and the 1:500,000-scale geologic map of Nevada (Stewart and Carlson, 1978) as primary sources. County map polygon attributes were updated to reflect new regional geologic interpretations, to reconcile county boundary issues, and to reflect new information. Only about 10 percent of the actual polygon shapes were revised. Geologic mapping, usually at larger scale, conducted subsequent to completion of the county maps has shown that some intrusions portrayed on the county maps are composite. Using more recent mapping, internal contacts were added within composite plutons in order to delineate separate intrusions. The resulting compilation served as the starting point for the work described here. Geochronologic and modal composition (hereafter, composition) information was compiled for each intrusion depicted on the new map. Map unit labels used to categorize intrusions of the study area have been further refined and updated from those used on the new statewide map (Crafford, in press) in order to reflect geochronologic and composition information compiled as part of this study.

We inferred that the best geochronologic and composition data for study area intrusions could be gleaned from detailed (1:62,500 and larger scale) geologic maps (in preference to publications that lack associated geologic maps) and accompanying descriptions of map units. The new digital geologic map (Crafford, in press) was used to identify the spatial limits of study area intrusions. This location information was used as input to the search engine for the USGS National Cooperative Geologic Mapping Program catalog of geologic mapping (http://ngmdb.usgs.gov/). Results of these searches identified the geologic maps that portray each study area intrusion. Copies of original data source materials (subsequently referred to as sources), including published maps and maps contained in Master's and Doctoral theses, were obtained and used to compile geochronologic and composition data for each study area intrusion. In rare cases, quite generalized data included on the county maps and in their associated reports were compiled because these are the only data available for particular intrusions. Data for about 300 intrusions from about 200 sources were identified and are incorporated in the accompanying database. We believe that this process has resulted in compilation of the best available geochronologic and composition data for study area intrusions.

The list of citations below identifies the sources that were used to compile age and composition data for study area intrusions. Full citations for each of these publications are provided in the "References Cited" section of this report. Numbers beside each citation below correspond to entries in the "source" columns included on the spreadsheet and (or) in the shapefile (in_nam_src, age_src, comp_src, geol_refs).

1. Maher (1989)
2. Minor and others (1989)
3. Vikre (1985a)
4. Hotz and Willden (1964)
5. Erickson and Marsh (1974a)
6. Erickson and Marsh (1974b)
7. Gilluly (1967)
8. Theodore (2000)
9. Willden (1964)
10. Henry and Boden (1998)
11. Coats (1971)
12. Decker (1962)
13. Coats and Greene (1984a)
14. Coats and Greene (1984b)
15. Coats and Greene (1984c)
16. Bushnell (1967)
17. Coats and others (1977)
18. Coash (1967)
19. Higgs (1960)
20. Coats (1987)
21. Slack (1974)
22. Gibbons (1973)
23. Lee and Van Loenen (1971)
24. Starkey (1987)
25. Evans and Ketner (1971)
26. Ketner (1973)
27. Ketner and Smith (1963)
28. Smith and Ketner (1978)
29. Glick (1987)
30. Day and others (1987)
31. Silberling and Nichols (2002)
32. Hope (1972)

33. Messin (1973)
34. Miller and others (1987)
35. Sayyah (1965)
36. O'Neill (1968)
37. Snow (1964)
38. Willden and Kistler (1969)
39. Barnes and others (2001)
40. Evans (1974a)
41. Evans (1974b)
42. Peters (2003)
43. Shawe and others (1962)
44. Muffler (1964)
45. Gilluly and others (1965)
46. Roberts and others (1967)
47. Haworth (1979)
48. Stewart and McKee (1969)
49. McKee (1968a)
50. Nolan (1962)
51. Hose and others (1976)
52. Moores and others (1968)
53. McGrew and Miller (1995)
54. Whitebread (1969)
55. McDonald (1989)
56. Humphrey (1960)
57. Morabbi (1980)
58. Fritz (1968)
59. Boyden (1972)
60. Sayeed (1973)
61. Brokaw and others (1973)
62. Heidrick (1965)
63. Drewes (1967)
64. Lee and others (1999a)
65. Lee and others (1999b)
66. Miller and others (1999)
67. Miller and others (1994)
68. Miller and others (1995)
69. McKee (1976a)
70. Kleinhampl and Ziony (1984)
71. Lumsden (1964)
72. Coles (1989)
73. Shawe (1995)
74. Shawe (1999)
75. Silberling and John (1989)
76. Bonham (1970)
77. Silberling (1959)
78. Shawe (2002)
79. Cohen (1980)
80. Means (1962)
81. McKee (1968b)
82. Speed and McKee (1976)
83. Pullman (1983)
84. John (1988)
85. Tingley (1986)
86. Ekren and Byers (1986a)
87. Taylor (1982)
88. Satterfield (2002)
89. Ekren and Byers (1986b)
90. Hudson and others (2000)
91. Ekren and Byers (1985a)
92. Willden and Speed (1974)
93. John (1995)
94. John and Silberling (1994)
95. Bryan (1972)
96. Henry (1996)
97. Barrows (1971)
98. Wallace and others (1969a)
99. John (1993)
100. Nevada Bureau of Mines and Desert Research Institute (1963)
101. John (1983)
102. Doebrich (1994)
103. Clement (1961)
104. Doebrich (1995)
105. Gilluly and Masursky (1965)
106. Emmons and Eng (1995)
107. McKee and Stewart (1969)
108. Stewart and McKee (1968)
109. Stewart and McKee (1977)
110. McKee (1976b)
111. Welch and others (1981)
112. Whitebread (1994)
113. Perry (1985)
114. Whitebread and Sorensen (1980)
115. Johnson (1977)
116. MacKenzie and Bookstrom (1976)
117. Silberling and Wallace (1967)
118. Decker (1972)
119. Wallace and others (1969b)
120. Lovejoy (1959)
121. Neff (1969)
122. Armstrong and Suppe (1973)
123. Armstrong and others (1976)
124. Best and others (1974)
125. Carlson and others (1975)
126. Coats and McKee (1972)
127. Coats and others (1965)
128. Damon (1965)
129. Edwards and McLaughlin (1972)
130. Elison and others (1990)
131. Erickson and others (1978)
132. Thole and Prihar (1998)
133. Evernden and Kistler (1970)
134. Garside and others (1981)
135. Gilluly (1965)
136. Groff and others (1997)
137. Armstrong (1964)
138. Armstrong (1966)
139. Armstrong (1970a)
140. Armstrong (1970b)
141. John and Robinson (1989)
142. Henry and Ressel (2000)
143. Hitchborn and others (1996)

144. Lee and others (1981b)
145. Ketner (1998)
146. Ross (1961)
147. Vikre (1985b)
148. Kistler and others (1981)
149. Krueger and Schilling (1971)
150. Lee and Marvin (1981)
151. Lee and others (1980)
152. Lee and others (1970)
153. Lee and others (1981a)
154. Lee and others (1968)
155. Lee and others (1986b)
156. Marvin and Cole (1978)
157. Marvin (1968)
158. Marvin and Dobson (1979)
159. Marvin and others (1989)
160. McDowell (1971)
161. McDowell and Kulp (1967)
162. McKee and John (1987)
163. McKee (1992)
164. McKee and Silberman (1970)
165. McKee and others (1976)
166. Miller and others (1990)
167. Morton and others (1977)
168. Nolan and others (1974)
169. Nutt and Hart (2003)
170. Page (1965)
171. Pullman (1984)
172. Rahl and others (2002)
173. Ressel, M.W., Newmont Mining Corporation and Henry, C.D., Nevada Bureau of Mines and Geology (unpublished data, 2005)
174. Ressel and others (2000)
175. Mortensen and others (2000)
176. Schilling (1965a)
177. Schilling (1965b)
178. Neff (1983)
179. Silberling (1975)
180. M.L. Silberman (unpublished data, 1975)
181. Silberman and McKee (1971)
182. Silberman and others (1974)
183. John (1992)
184. Smith and others (1971)
185. Speed and Armstrong (1971)
186. Stablein (1969)
187. Theodore and others (1973)
188. Tingley (1975)
189. Tower (1982)
190. Lee and others (1986a)
191. Shawe and others (1986)
192. Ekren and Byers (1985b)
193. Marsh and Erickson (1977)
194. Compton (1960)
195. Radtke (1985)
196. Hardyman and others (1988)
197. Kistler and Lee (1989)
198. AngloGold Ashanti (unpublished data, 2006)
199. Nolan and others (1971)
200. Thurber (1982)

Information for some intrusions was incomplete or may have been misleading or incorrect, and (or) we may have incorrectly interpreted and compiled data presented in the sources, any of which could cause inaccuracies in the database. An effort has been made to minimize such inaccuracies.

Data Structure

Data are compiled in spreadsheet form using Microsoft Excel and can be accessed using software compatible with .xls files. The database release (file, IntrusionsNENV.xls) includes two worksheets that are accessed using tabs arrayed along the base of the spreadsheet display. The tab labeled "IntrNENVpolys" is the primary data compilation. A copy of the compilation was sorted alphabetically, based on intrusion name, and then filtered to yield a unique, single-row listing for each intrusion. The resulting derivative database, accessed using the tab labeled "IntrSorted," succinctly presents the composition and age of each intrusion. The database release also includes tab-delimited, text file versions of the primary data compilation (file, IntrNENVpolys.txt) and the sorted, derivative version (file, IntrSorted.txt). Data contained in the primary compilation are joined with an ArcGIS shapefile of the study area intrusions to create an attributed shapefile (Intrusions_polyNENV.shp). The attributed shapefile documents the distribution of study area intrusions and can be used in conjunction with ArcGIS to display their associated composition and age information. Subsequent references to spreadsheet and shapefile refer to these two files. Metadata for the ArcGIS files are embedded in the geospatial database and are also contained in a freestanding text file (file, Metadata.txt).

Data Fields

Data fields presented and described below represent those considered most important to establishing a foundation for compilation of geochemical data for study area intrusions. Data for each of these fields constitute a column, or set of related columns, in the spreadsheet (IntrusionsNENV.xls) and shapefile (Intrusions_polyNENV.shp). Data in these columns can be sorted, queried, and interpreted to address questions concerning basic characteristics of study area intrusions. Specifics of these data fields are also described in the metadata that accompanies the shapefile.

intrusion_name

A unique geographic name was defined for each intrusion; these names are compiled in the "intrusion_name" column. Sources that were used to define intrusion ages and compositions were also used to help define geographic names. Intrusion names identified in the sources were adopted for the compilation. For some study area intrusions, no geographic names had been previously defined. In these cases, a nearby named geographic feature was adopted and assigned as the intrusion name. Many intrusions are depicted as a single polygon in the shapefile to which a unique geographic intrusion name is assigned. In many cases, intrusions consist of multiple polygons that, based on plausible geologic reasoning, are probably parts of a single intrusion that is differentially exposed as isolated masses. In these cases, the same geographic intrusion name was assigned to a group of spatially related intrusion polygons. Assigned geographic intrusion names do not constitute formal stratigraphic nomenclature. However, for intrusions with either formal or informal stratigraphic nomenclature, and to the extent that the sources identified these names, geographic names included in this compilation are in accord with established stratigraphic nomenclature.

in_nam_src

Sources that explicitly identified geographic names for intrusions are identified in the "in_nam_src" column on the spreadsheet. Blank cells in this column indicate intrusions for which sources did not identify a geographic name for the associated intrusion; in these instances, we assigned the name of a nearby named geographic feature as the intrusion name.

age

The ages of study area intrusions have been of keen interest and a large number of age determinations have been made. The database column titled "age" contains ages of study area intrusions compiled from sources cited in "age_src." Numeric entries are geochronologic data, in millions of years. In cases for which numeric data are lacking or inconclusive, the best available chronostratigraphic age data are compiled. Multiple geochronologic age determinations have been obtained for some intrusions. In these cases, an age range, based on all identified age determinations, is presented. Presenting ages rounded to the nearest million years is suitable for our compilation; however, full analytical precision and accuracy data can be obtained by consulting the source of compiled age data.

age_src

Radiometric age data for samples of study area intrusions were compiled from primary data sources. Principal sources of geochronologic data for these intrusions include Smith and others (1971), Silberman and McKee (1971), and Mortensen and others (2000). These and sources compiled by Sloan and others (2003) and C.D. Henry (Nevada Bureau of Mines and Geology, unpublished data, 2006) are tabulated in the "age_src" database column.

best_age

As described above, multiple age determinations are available for some intrusions. In the column titled "best_age" we compile, based on geologic reasoning and the reliability of the isotopic systems used in various age determinations, what we consider to be the best approximate age of each intrusion. Ages of intrusions with single age determinations are simply replicated in this column. Entries in the "best_age" column, in millions of years, depict the time-space evolution of magmatism in the study area. In most cases, the age value in the "best_age" column is derived from the range of values in the "age" column. However, when other geologic reasoning suggests a different or more specific "best_age" (for example, Cove, Hoodoo, Stony Basin central), the user should consider the "best_age" data, not the "age" data, as the interpreted age of the intrusion. Blank entries in the "best_age" column indicate that the "age" column contains no numeric age data and so no "best_age" estimate can be made.

modal_composition

Intrusive rock modal compositions are classified using their relative proportions of quartz, alkali feldspar, and plagioclase and nomenclature defined by Streckeisen (1973). The most informative sources presented relative proportions of the feldspars and quartz in text accompanying geologic maps; this information was used to establish composition (or composition range) names, compiled in the "modal_composition" column, for study area intrusions. Intrusions for which no modal composition information is available are simply classified as "Intrusive rock." Many of the sources for our compilation predate the classification recommendations of Streckeisen (1973); most of these used the classification of Johannsen (1939) to define intrusion compositions. To the extent possible, and using whatever ancillary data were available, intrusion compositions were converted from the nomenclature of Johannsen (1939) to that of Streckeisen (1973). Most of these transformations were simple and obvious. However, the two systems use the term quartz monzonite to define significantly different rocks. Most of the composition field called quartz monzonite by Johannsen (1939) is referred to as monzogranite in the Streckeisen (1973) system. Not all sources defined which of the two classification schemes was used to categorize intrusion compositions, so some ambiguity persists. Compositions were recast to Streckeisen (1973) nomenclature in cases for which sufficient data were available to achieve this with some confidence.

Many of the study area intrusions are shallowly emplaced and (or) subvolcanic bodies. As such, their grain size precludes petrographic modal analysis and classification using the Streckeisen (1973) system. These rocks are instead treated as volcanic rocks and their nomenclature established using chemical analyses and the classification grid of Le Bas and others (1986).

comp_src

Modal composition names for samples of study area intrusions were compiled, as described above, from primary data sources. Sources used to compile information in the "modal_composition" column are enumerated in the column titled "comp_src."

age_code

To develop the first part (age) of a geologic map unit "geologicfm" for each polygon, a simplified geologic period "age_code" was first derived by comparing information in the "best_age" or "age" columns to age designations on a standard geologic time scale. Pliocene-Miocene, Miocene, Miocene-Oligocene, Oligocene-Eocene, and Tertiary intrusions were assigned a "T" "age_code." Cretaceous intrusions were assigned a "K" "age_code." Jurassic intrusions were assigned a "J" "age_code." Triassic and Triassic-Permian intrusions were assigned a "TR" "age_code". Tertiary-Cretaceous intrusions, Tertiary-Jurassic intrusions, Cretaceous-Jurassic intrusions, and intrusions with an unknown or poorly known age were assigned a "TJ" "age_code". The age associated with each "age_code" is indicated on the explanation of the geologic map and in the shapefile metadata.

comp_code

To develop the second part (composition) of a geologic map unit "geologicfm" for each polygon, a simplified composition code ("comp_code") was derived for each polygon from information in the "modal_composition" column. The broad array of compositions identified in the "modal_composition" column was binned to provide a reduced number of geologic map units. Felsic phaneritic intrusion compositions ("comp_code" = fi) include aplite, granite, granite-granodiorite, granite-quartz monzonite, granodiorite, granodiorite-dacite, granodiorite-monzogranite, granodiorite-quartz diorite, granodiorite-quartz monzodiorite, leucogranite, leucogranodiorite, monzogranite, monzogranite (aplitic), monzogranite-granodiorite, monzogranite-quartz monzonite, monzogranite-syenogranite, pegmatite and aplite, tonalite, and tonalite-monzogranite; phaneritic intermediate intrusion compositions ("comp_code" = ii) include basalt-dacite-diorite, quartz diorite, quartz monzodiorite, quartz monzodiorite-granodiorite, quartz monzodiorite-quartz monzonite, quartz monzonite, and quartz monzonite-monzogranite; phaneritic mafic intrusion compositions ("comp_code" = mi) include diabase, diorite, diorite-quartz monzonite, gabbroic rocks, metadiorite, monzodiorite, monzogabbro, monzonite, monzonite-quartz monzonite, and monzonite-rhyolite. Jurassic intrusive rocks (mostly gabbro) of the Humboldt complex are assigned a "comp_code" = gb. All phaneritic intrusions whose compositions are unknown or poorly known (diorite-granite, granitic rock, or intrusive rock) are assigned a "comp_code" = i. Shallow intrusions that include some aphanitic groundmass were binned as rhyolite (including quartz porphyry, quartz-feldspar porphyry, and rhyolite) ("comp_code" = ri), rhyolite-dacite ("comp_code" = rhdi), dacite (including dacite and quartz latite) ("comp_code" = di), or andesite ("comp_code" = ai). The rock type associated with each code is indicated on the explanation of the geologic map and in the shapefile metadata.

geologicfm

The final step in defining the age and composition of rock associated with each intrusion polygon resulted in definition of a "geologicfm". Each "geologicfm" was derived by combining the "age_code" and "comp_code" values for each polygon to create a geologic map unit "geologicfm" for portrayal on the geologic map. The explanation of each "geologicfm" is indicated on the explanation of the geologic map and in the shapefile metadata.

geol_refs

In accord with improved geologic knowledge, boundaries of some intrusion polygons, as compiled in the database described here, were modified from those depicted on the source county geologic map. Entries in the "geol_refs" column identify the source (keyed to the numbered source list presented in the "Data Sources and Compilation Methods" section of this report) from which improved polygon boundary information was derived.

county

In order to aid location of intrusion polygons and to enable some sorting processes, the name of the Nevada county or counties that contains each intrusion polygon is compiled in the "county" column.

shape_leng

In order to aid an analysis of intrusion size, the perimeter (in meters) of each intrusion polygon is compiled in the "shape_leng" column.

shape_area

As an additional aid to analysis of intrusion size, the area (in square meters) of each intrusion polygon is compiled in the "shape_area" column.

References Cited

Armstrong, R.L., 1964, Geochronology and geology of the eastern Great Basin in Nevada and Utah: New Haven, Conn., Yale University Ph.D. thesis, 290 p.

Armstrong, R.L., 1966, K-Ar dating using neutron activation for Ar analysis—Granitic plutons of the eastern Great Basin, Nevada and Utah: Geochimica et Cosmochimica Acta, v. 30, p. 565–600.

Armstrong, R.L., 1970a, Geochronology of Tertiary igneous rocks, eastern Basin and Range province, western Utah, eastern Nevada, and vicinity, U.S.A.: Geochimica et Cosmochimica Acta, v. 34, p. 203–232.

Armstrong, R.L., 1970b, K-Ar dating using neutron activation for Ar analysis—Comparison with isotope dilution Ar analyses: Geochimica et Cosmochimica Acta, v. 34, p. 233–236.

Armstrong, R.L., Speed, R.C., Graustein, W.C., and Young, A.Y., 1976, K-Ar dates from Arizona, Montana, Nevada, Utah, and Wyoming: Isochron/West, no. 16, p. 1–6.

Armstrong, R.L., and Suppe, J., 1973, Potassium-argon geochronometry of Mesozoic igneous rocks in Nevada, Utah, and southern California: Geological Society of America Bulletin, v. 84, p. 1375–1391.

Barnes, C.G., Burton, B.R., Burling, T.C., Wright, J.E., and Karlsson, H.R., 2001, Petrology and geochemistry of the Harrison Pass pluton, Ruby Mountains core complex, northeastern Nevada: Journal of Petrology, v. 42, p. 901–929.

Barrows, K.J., 1971, Geology of the southern Desatoya Mountains, Churchill and Lander Counties, Nevada: Los Angeles, Calif., University of California Ph.D. dissertation, 349 p.

Best, M.G., Armstrong, R.L., Gravstein, W.C., Embree, G.F., and Ahlborn, R.C., 1974, Mica granites of the Kern Mountains pluton, eastern White Pine County, Nevada—Remobilized basement of the Cordilleran miogeosyncline?: Geological Society of America Bulletin, v. 85, p. 1277–1286.

Bonham, H.F., 1970, Geologic map and sections of a part of the Shoshone Mountains, Lander and Nye Counties, Nevada: Nevada Bureau of Mines and Geology Map 38, scale 1:62,500.

Boyden, E.D., 1972, Geology of the Steptoe Warm Springs pluton, White Pine County, Nevada: Lincoln, Nebr., University of Nebraska Master's thesis, 66 p.

Brokaw, A.L., Bauer, H.L., and Breitrick, R.A., 1973, Geologic map of the Ruth quadrangle, White Pine County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–1085, scale 1:24,000.

Bryan, D.P., 1972, The geology and mineralization of the Chalk Mountain and Westgate mining districts, Churchill County, Nevada: Reno, Nev., University of Nevada Master's thesis, 78 p.

Bushnell, K.O., 1967, Geology of the Rowland quadrangle, Elko County, Nevada: Nevada Bureau of Mines and Geology Bulletin 67, 38 p.

Carlson, J.E., Laird, D.W., Peterson, J.A., Schilling, J.H., Silberman, M.L., and Stewart, J.H., 1975, Preliminary map showing distribution and isotopic ages of Mesozoic and Cenozoic intrusive rocks in Nevada: U.S. Geological Survey Open-File Report 75–499, 12 p., scale 1:100,000.

Christiansen, R.L., and Yeats, R.S., 1992, Post-Laramide geology of the U.S. Cordilleran region, *in* Burchfiel, B.C., Lipman, P.W., and Zoback, M.L., eds., The Cordilleran Orogen—Conterminous U.S.: Geological Society of America, The Geology of North America, v. G-3, p. 261–406.

Clement, S.C., 1961, Mineralogy of the Copper Canyon quartz monzonite porphyry, Lander County, Nevada: Salt Lake City, Utah, University of Utah Master's thesis, 32 p.

Coash, J.R., 1967, Geology of the Mount Velma quadrangle, Elko County, Nevada: Nevada Bureau of Mines and Geology Bulletin 68, 21 p.

Coats, R.R., 1971, Geologic map of the Owyhee quadrangle, Nevada-Idaho: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–665, scale 1:48,000.

Coats, R.R., 1987, Geology of Elko County, Nevada: Nevada Bureau of Mines and Geology Bulletin 101, 112 p.

Coats, R.R., and Greene, R.C., 1984a, Geologic map of the northeast quarter of the Mountain City quadrangle, Elko County, Nevada, and Owyhee County, Idaho: U.S. Geological Survey Open-File Report 84–684, scale 1:24,000.

Coats, R.R., and Greene, R.C., 1984b, Geologic map of the northwest quarter of the Mountain City quadrangle, Elko County, Nevada and Owyhee County, Idaho: U.S. Geological Survey Open-File Report 84–685, scale 1:24,000.

Coats, R.R., and Greene, R.C., 1984c, Geologic map of the southwest quarter of the Mountain City quadrangle, Elko County, Nevada: U.S. Geological Survey Open-File Report 84–686, scale 1:24,000.

Coats, R.R., Greene, R.C., Cress, L.D., Marks, L.Y., and Davis, W.E., 1977, Mineral resources of the Jarbidge Wilderness and adjacent areas, Elko County, Nevada, *with a section on* Interpretation of aeromagnetic data: U.S. Geological Survey Bulletin 1439, 14 p.

Coats, R.R., Marvin, R.F., and Stern, T.W., 1965, Reconnaissance of mineral ages of plutons in Elko County, Nevada, and vicinity: U.S. Geological Survey Professional Paper 525–D, p. D11–D15.

Coats, R.R., and McKee, E.H., 1972, Ages of plutons and types of mineralization, northwestern Elko County, Nevada: U.S. Geological Survey Professional Paper 800–C, p. C165–C168.

Cohen, D.K., 1980, The geology and petrography of the Millet Ranch plutons—A mixed magma: Reno, Nev., University of Nevada Master's thesis, 62 p.

Coles, K.S., 1989, Geologic map of the Northumberland Pass area, Toquima Range, Nevada: Nevada Bureau of Mines and Geology Open File Report 89–2, scale 1:24,000.

Compton, R.R., 1960, Contact metamorphism in Santa Rosa Range, Nevada: Geological Society of America Bulletin, v. 71, no. 9, p. 1383–1416.

Crafford, A.E.J., in press, Nevada State digital geologic map: U.S. Geological Survey Data Series 249.

Damon, P.E., 1965, Correlation and chronology of ore deposits and volcanic rocks: U.S. Atomic Energy Commission, Geochronology Laboratories, Tucson, Ariz., University of Arizona, Annual Progress Rept. Coo-689-50, Contract At(11-1)-689, p. 43.

Day, W.C., Elrick, Maya, Ketner, K.B., and Vaag, M.K., 1987, Geologic map of the Bluebell and Goshute Peak Wilderness Study Areas, Elko County, Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF–1932, scale 1:50,000.

Decker, D.J., 1972, Geology and ore deposits of the Arabia district, Pershing County, Nevada: Reno, Nev., University of Nevada Master's thesis, 44 p.

Decker, R.W., 1962, Geology of the Bull Run quadrangle, Elko County, Nevada: Nevada Bureau of Mines and Geology Bulletin 60, 65 p.

Doebrich, J.L., 1994, Preliminary geologic map of the Galena Canyon quadrangle, Lander County, Nevada: U.S. Geological Survey Open-File Report 94–664, scale 1:24,000.

Doebrich, J.L., 1995, Geology and mineral deposits of the Antler Peak 7.5-minute quadrangle, Lander County, Nevada: Nevada Bureau of Mines and Geology Bulletin 109, 44 p.

Drewes, Harald, 1967, Geology of the Connors Pass quadrangle, Schell Creek Range, east-central Nevada: U.S. Geological Survey Professional Paper 557, 93 p.

Edwards, George, and McLaughlin, W.A., 1972, Shell list No.1; K-Ar and Rb-Sr age determinations of California, Nevada and Utah rocks and minerals: Isochron/West, no. 3, p. 1–7.

Ekren, E.B., and Byers, F.M., 1985a, Geologic map of the Win Wan Flat, Kinkaid NW, Kinkaid, and Indian Head Peak quadrangles, Mineral County, Nevada: U.S. Geological Survey Miscellaneous Investigations Series Map I–1578, scale 1:48,000.

Ekren, E.B., and Byers, F.M., 1985b, Geologic map of the Gabbs Mountain, Mount Ferguson, Luning, and Sunrise Flat quadrangles, Mineral and Nye Counties, Nevada: U.S. Geological Survey Miscellaneous Investigations Series Map I–1577, scale 1:48,000.

Ekren, E.B., and Byers, F.M., 1986a, Geologic map of the Mount Annie NE, Mount Annie, Ramsey Spring, and Mount Annie SE quadrangles, Mineral and Nye Counties, Nevada: U.S. Geological Survey Miscellaneous Investigations Series Map I–1579, scale 1:48,000.

Ekren, E.B., and Byers, F.M., 1986b, Geologic map of the Murphys Well, Pilot Cone, Copper Mountain, and Poinsettia Spring quadrangles, Mineral County, Nevada: U.S. Geological Survey Miscellaneous Investigations Series Map I–1576, scale 1:48,000.

Elison, M.W., Speed, R.C., and Kistler, R.W., 1990, Geologic and isotopic constraints on the crustal structure of the northern Great Basin: Geological Society of America Bulletin, v. 102, p. 1077–1092.

Emmons, D.L., and Eng, T.L., 1995, Geologic map of the McCoy mining district, Lander County, Nevada: Nevada Bureau of Mines and Geology Map 103, scale 1:12,000.

Erickson, R.L., and Marsh, S.P., 1974a, Geologic map of the Golconda quadrangle, Humboldt County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–1174, scale 1:24,000.

Erickson, R.L., and Marsh, S.P., 1974b, Geologic map of the Iron Point quadrangle, Humboldt County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–1175, scale 1:24,000.

Erickson, R.L., Silberman, M.L., and Marsh, S.P., 1978, Age and composition of igneous rocks, Edna Mountain quadrangle, Humboldt County, Nevada: U.S. Geological Survey Journal of Research, v. 6, p. 727–743.

Evans, J.G., 1974a, Geologic map of the Rodeo Creek NE quadrangle, Eureka County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–1116, scale 1:24,000.

Evans, J.G., 1974b, Geologic map of the Welches Canyon quadrangle, Eureka County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–1117, scale 1:24,000.

Evans, J.G., and Ketner, K.B., 1971, Geologic map of the Swales Mountain quadrangle and part of the Adobe Summit quadrangle, Elko County, Nevada: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–667, scale 1:24,000.

Evernden, J.F., and Kistler, R.W., 1970, Chronology of emplacement of Mesozoic batholithic complexes in California and western Nevada: U.S. Geological Survey Professional Paper 623, 42 p.

Fritz, W.H., 1968, Geologic map and sections of the southern Cherry Creek and northern Egan Ranges, White Pine County, Nevada: Nevada Bureau of Mines and Geology Map 35, scale 1:62,500.

Garside, L.J., Bonham, H.F., Jr., Ashley, R.P., Silberman, M.L., and McKee, E.H., 1981, Radiometric ages of volcanic and plutonic rocks and hydrothermal mineralization in Nevada—Determinations run under the USGS-NBMG Cooperative Program: Isochron/West, no. 30, p. 11–19.

Gibbons, J.A., 1973, The geology of part of the Contact mining district, Elko County, Nevada: Reno, Nev., University of Nevada Master's thesis, 181 p.

Gilluly, J., 1965, Volcanism, tectonism, and plutonism in the western United States: Geological Society of America Special Paper 80, 69 p.

Gilluly, J., 1967, Geologic map of the Winnemucca quadrangle, Pershing and Humboldt Counties, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–656, scale 1:62,500.

Gilluly, J., Gates, O., Plouff, D., and Ketner, K.B., 1965, Tectonic and igneous geology of the northern Shoshone Range, Nevada *with sections on* Gravity in Crescent Valley *and* Economic geology: U.S. Geological Survey Professional Paper 465, 153 p.

Gilluly, J., and Masursky, H., 1965, Geology of the Cortez quadrangle, Nevada, *with a section on* Gravity and aeromagnetic surveys *by* D.R. Mabey: U.S. Geological Survey Bulletin 1175, 117 p.

Glick, L.L., 1987, Structural geology of the northern Toana Range, Elko County, Nevada: San Jose, Calif., California State University Master's thesis, 141 p.

Groff, J.A., Heizler, M.T., McIntosh, W.C., and Norman, D.I., 1997, $^{40}Ar/^{39}Ar$ dating and mineral paragenesis for Carlin-type gold deposits along the Getchell trend, Nevada—Evidence for Cretaceous and Tertiary gold mineralization: Economic Geology, v. 92, p. 601–622.

Hardyman, R.F., Brooks, W.E., Blaskowski, M.J., Barton, H.N., Ponce, D.A., and Olson, J.E., 1988, Mineral resources of the Clan Alpine Mountains Wilderness Study Area, Churchill County, Nevada: U.S. Geological Survey Bulletin 1727–B, 16 p.

Haworth, W.D., 1979, Geology of the northern part of the Diamond Range, Eureka and White Pine Counties, Nevada: Reno, Nev., University of Nevada Master's thesis, 69 p.

Heidrick, T.L., 1965, Geology and ore deposits of the Ward mining district, White Pine County, Nevada: Boulder, Colo., University of Colorado Master's thesis, 154 p.

Henry, C.D., 1996, Geologic map of the Bell Canyon quadrangle, western Nevada: Nevada Bureau of Mines and Geology Field Studies Map 11, scale 1:24,000.

Henry, C.D., and Boden, D.R., 1998, Geologic map of the Mount Blitzen quadrangle, Elko County, northeastern Nevada: Nevada Bureau of Mines and Geology Map 110, scale 1:24,000, 20 p.

Henry, C.D., and Ressel, M.W., 2000, Eocene magmatism and its role in generating sediment-hosted gold deposits of the Carlin trend: Geological Society of Nevada, Symposium 2000, Field Trip Guidebook no. 4, 223 p.

Higgs, N.B., 1960, The geology of the southeastern part of the Jarbidge I quadrangle, Elko County, Nevada: Eugene, Oreg., University of Oregon Master's thesis, 100 p.

Hitchborn, A.D., Arbonies, D.G., Peters, S.G., Connors, 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, April 1995, p. 505–546.

Hope, R.A., 1972, Geologic map of the Spruce Mountain quadrangle, Elko County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–942, scale 1:62,500.

Hose, R.K., Blake, M.C., Jr., and Smith, R.M., 1976, Geology and mineral resources of White Pine County, Nevada: Nevada Bureau of Mines and Geology Bulletin 85, 105 p.

Hotz, P.E., and Willden, Ronald, 1964, Geology and mineral deposits of the Osgood Mountains quadrangle, Humboldt County, Nevada: U.S. Geological Survey Professional Paper 431, 128 p.

Hudson, M.R., John, D.A., Conrad, J.E., and McKee, E.H., 2000, Style and age of late Oligocene–early Miocene deformation in the southern Stillwater Range, west-central Nevada—Paleomagnetism, geochronology, and field relations: Journal of Geophysical Research, v. 105, p. 929–954.

Humphrey, F.L., 1960, Geology of the White Pine mining district, White Pine County, Nevada: Nevada Bureau of Mines and Geology Bulletin 57, 119 p.

Humphreys, E.D., 1995, Post-Laramide removal of the Farallon slab, western United States: Geology, v. 23, p. 987–990.

Johannsen, A., 1939, A descriptive petrography of igneous rocks: Chicago, Ill., University of Chicago Press, 318 p.

John, D.A., 1983, Map showing distribution, ages, and petrographic characteristics of Mesozoic plutonic rocks in the Walker Lake 1° by 2° quadrangle, California and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF–1382–B, scale 1:250,000.

John, D.A., 1987, Map showing the distribution and characteristics of plutonic rocks in the Tonopah 1° by 2° quadrangle, central Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF–1877–J, scale 1:250,000.

John, D.A., 1988, Geologic map of Oligocene and Miocene volcanic rocks, Paradise Peak and western part of the Ione quadrangle, Nye County, Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF–2025, scale 1:24,000.

John, D.A., 1992, Chemical analyses of granitic rocks in the Reno 1° by 2° quadrangle and in the northern Pine Nut Mountains, west-central Nevada: U.S. Geological Survey Open-File Report 92–246, 35 p.

John, D.A., 1993, Geologic map of the Job Peak quadrangle, Nevada: Nevada Bureau of Mines and Geology Field Studies Map 5, scale 1:24,000.

John, D.A., 1995, Geological map of the Pirouette Mountain quadrangle, Nevada: Nevada Bureau of Mines and Geology Field Studies Map 9, scale 1:24,000.

John, D.A., and Robinson, A.C., 1989, Rb-Sr whole-rock isotopic ages of granitic plutons in the western part of the Tonopah 1° by 2° quadrangle, Nevada: Isochron/West, v. 53, p. 20–27.

John, D.A., Schweickert, R.A., and Robinson, A.C., 1994, Granitic rocks in the Triassic-Jurassic magmatic arc of western Nevada and eastern California: U.S. Geological Survey Open-File Report 94–148, 50 p.

John, D.A., and Silberling, N.J., 1994, Geologic map of the La Plata Canyon quadrangle, Churchill County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–1710, scale 1:24,000.

Johnson, M.G., 1977, Geology and mineral deposits of Pershing County, Nevada: Nevada Bureau of Mines and Geology Bulletin 89, 115 p.

Ketner, K.B., 1973, Preliminary geologic map of the Hunter quadrangle, Elko County, Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF–539, scale 1:24,000.

Ketner, K.B., 1998, Geologic map of the southern Independence Mountains, Elko County, Nevada: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–2629, scale 1:24,000.

Ketner, K.B., and Smith, J.F., 1963, Geology of the Railroad mining district, Elko County, Nevada: U.S. Geological Survey Bulletin 1162–B, scale 1:12,000.

Kistler, R.W., Ghent, E.D., and O'Neil, J.R., 1981, Petrogenesis of garnet two-mica granites in the Ruby Mountains, Nevada: Journal of Geophysical Research, v. 86, no. B11, p. 10,591–10,606.

Kistler, R.W., and Lee, D.E., 1989, Rubidium, strontium, and strontium isotopic data for a suite of granitoid rocks from the Basin and Range province, Arizona, California, Nevada, and Utah: U.S. Geological Survey Open-File Report 89–199, 13 p.

Kleinhampl, F.J., and Ziony, J.I., 1984, Mineral resources of northern Nye County, Nevada: Nevada Bureau of Mines and Geology Bulletin 99–B, 243 p.

Krueger, H.W., and Schilling, J.H., 1971, Geochron/Nevada Bureau of Mines K-Ar age determinations—List 1: Isochron/West, no. 1, p. 9–14.

Le Bas, M.J., Le Maitre, R.W., Streckeisen, A., and Zanettin, B., 1986, A chemical classification of volcanic rocks using the total alkali-silica diagram: Journal of Petrology, v. 27, p. 745–750.

Lee, D.E., 1984, Analytical data for a suite of granitoid rocks from the Basin and Range province: U.S. Geological Survey Bulletin 1602, 54 p.

Lee, D.E., Kistler, R.W., Friedman, I., and Van Loenen, R.E., 1981a, Two-mica granites of northeastern Nevada: Journal of Geophysical Research, v. 86, p. 10,607–10,616.

Lee, D.E., Kistler, R.W., and Robinson, A.C., 1986a, The strontium isotope composition of granitoid rocks of the southern Snake Range, Nevada: U.S. Geological Survey Bulletin 1622, chapter P, p. 171–179.

Lee, D.E., Kwak, L., and Marvin, R.F., 1986b, Uranium-thorium-lead isotopic ages of monazite from the Snake Creek–Williams Canyon intrusion of the southern Snake Range, Nevada: Isochron/West, no. 45, p. 14–16.

Lee, D.E., and Marvin, R.F., 1981, Markedly discordant K-Ar ages for coexisting biotite and muscovite from a two-mica granite in the Toana Range, Elko County, Nevada: Isochron/West, no. 32, p. 19.

Lee, D.E., Marvin, R.F., and Mehnert, H.H., 1980, A radiometric age study of Mesozoic-Cenozoic metamorphism in eastern White Pine County, Nevada, and nearby Utah: U.S. Geological Survey Professional Paper 1158–C, p. 17–28.

Lee, D.E., Marvin, R.F., Stern, T.W., and Peterman, Z.E., 1970, Modification of potassium-argon ages by Tertiary thrusting in the Snake Range, White Pine County, Nevada: U.S. Geological Survey Professional Paper 700–D, p. D92–D102.

Lee, D.E., Stern, T.W., and Marvin, R.F., 1981b, Uranium-thorium-lead isotopic ages of metamorphic monazite from the northern Snake Range, Nevada: Isochron/West, no. 31, p. 23.

Lee, D.E., Stern, T.W., Mays, R.E., and Van Loenen, R.E., 1968, Accessory zircon from granitoid rocks of the Mount Wheeler mine area, Nevada: U.S. Geological Survey Professional Paper 600–D, p. D197–D203.

Lee, D.E., and Van Loenen, R.E., 1971, Generalized geologic map and sections of the area north and northeast of the Mount Wheeler Mine, White Pine County, Nevada: U.S. Geological Survey Professional Paper 668, 48 p.

Lee, J., Gans, P.B., and Miller, E.L., 1999a, Geologic map of the Third Butte East quadrangle, Nevada: Nevada Bureau of Mines and Geology Field Studies Map 16, scale 1:24,000.

Lee, J., Miller, E.L., Gans, P.B., and Huggins, C.C., 1999b, Geologic map of the Mount Moriah quadrangle, Nevada: Nevada Bureau of Mines and Geology Field Studies Map 19, scale 1:24,000.

Lovejoy, D.W., 1959, Overthrust Ordovician and the Nannie's Peak intrusive, Lone Mountain, Elko County, Nevada: Geological Society of America Bulletin, v. 70, p. 539–563.

Lumsden, W.W., Jr., 1964, Geology of the southern White Pine Range and the northern Horse Range, Nye and White Pine Counties, Nevada: Los Angeles, Calif., University of California Ph.D. thesis, 355 p.

MacKenzie, W.B., and Bookstrom, A.A., 1976, Geology of the Majuba Hill area, Pershing County, Nevada: Nevada Bureau of Mines and Geology Bulletin 86, 23 p.

Maher, K.A., 1989, Geology of the Jackson Mountains, northwest Nevada: Pasadena, Calif., California Institute of Technology Ph.D. dissertation, 526 p.

Maldonado, Florian, Spengler, R.W., Hanna, W.F., and Dixon, G.L., 1988, Index of granitic rock masses in the State of Nevada: U.S. Geological Survey Bulletin 1831, 81 p.

Marsh, S.P., and Erickson, R.L., 1977, Geologic map of the Brooks Spring quadrangle, Humboldt County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–1366, scale 1:24,000.

Marvin, R.F., 1968, Transcontinental geophysical survey (35–39 degrees north) radiometric age determinations of rocks: U.S. Geological Survey Miscellaneous Geological Investigations Map I–537, 25 p.

Marvin, R.F., and Cole, J.C., 1978, Radiometric ages; Compilation A, U.S. Geological Survey: Isochron/West, no. 22, p. 3–14.

Marvin, R.F., and Dobson, S.W., 1979, Radiometric ages; Compilation B, U.S. Geological Survey: Isochron/West, no. 26, p. 3–32.

Marvin, R.F., Mehnert, H.H., and Naeser, C.W., 1989, U.S. Geological Survey radiometric ages; Compilation C, Part 3—California and Nevada: Isochron/West, v. 52, p. 3–11.

McDonald, S.F., 1989, Geology, Pogues Station quadrangle, White Pine and Nye Counties, Nevada: San Diego, Calif., California State University Master's thesis, 103 p.

McDowell, F.W., 1971, K-Ar ages of igneous rocks from the western United States: Isochron/West, no. 2, p. 1–16.

McDowell, F.W., and Kulp, J.L., 1967, Age of intrusion and ore deposition in the Robinson mining district of Nevada: Economic Geology, v. 62, p. 905–909.

McGrew, A.J., and Miller, E.L., 1995, Geologic map of Kious Spring and Garrison 7.5′ quadrangles, White Pine County, Nevada, and Millard County, Utah: U.S. Geological Survey Open-File Report 95–10, scale 1:24,000.

McKee, E.H., 1968a, Geologic map of the Ackerman Canyon quadrangle, Lander and Eureka Counties, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–761, scale 1:62,500.

McKee, E.H., 1968b, Geologic map of southwestern part of Lander County, Nevada: U.S. Geological Survey Open-File Report 68–173, scale 1:63,360.

McKee, E.H., 1976a, Geology of the northern part of the Toquima Range, Lander, Eureka, and Nye Counties, Nevada: U.S. Geological Survey Professional Paper 931, 49 p.

McKee, E.H., 1976b, Geologic map of the Austin quadrangle, Lander County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–1307, scale 1:62,500.

McKee, E.H., 1992, Potassium argon and $^{40}Ar/^{39}Ar$ geochronology of selected plutons in the Buckingham area, *in* Theodore, T.G., Blake, D.W., Loucks, T.A., and Johnson, C.A., Geology of the Buckingham stockwork molybdenum deposit and surrounding area, Lander County, Nevada: U.S. Geological Survey Professional Paper 798–D, p. 36–40.

McKee, E.H., and John, D.A., 1987, Sample locality map and potassium-argon ages and data for Cenozoic igneous rocks in the Tonopah 1° by 2° quadrangle, central Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF–1877–I, scale 1:250,000.

McKee, E.H., and Silberman, M.L., 1970, Geochronology of Tertiary igneous rocks in central Nevada: Geological Society of America Bulletin, v. 81, p. 2317–2328.

McKee, E.H., and Stewart, J.H., 1969, Geologic map of the Cedars quadrangle, Lander County, Nevada: U.S. Geological Survey Open-File Report 69–158, scale 1:62,500.

McKee, E.H., Tarshis, A.L., and Marvin, R.F., 1976, Summary of radiometric ages of Tertiary volcanic and selected plutonic rocks in Nevada, Part V—Northeastern Nevada: Isochron/West, no. 16, p. 15–27.

Means, W.D., 1962, Structure and stratigraphy in the central Toiyabe Range, Nevada: University of California, University of California Publications in Geological Sciences, 42, p. 71–110.

Messin, G.M.L., 1973, Geology of the White Horse pluton, Elko County, Nevada: Lincoln, Nebr., University of Nebraska Master's thesis, 100 p.

Miller, D.M., Hillhouse, W.C., Zartman, R.E., and Lanphere, M.A., 1987, Geochronology of intrusive and metamorphic rocks in the Pilot Range, Utah and Nevada, and comparison with regional patterns [Bethridge Creek and Pilot Creek areas]: Geological Society of America Bulletin, v. 99, p. 866–879.

Miller, D.M., Nakata, J.K., and Glick, L.L., 1990, K-Ar ages of Jurassic to Tertiary plutonic and metamorphic rocks, northwestern Utah and northeastern Nevada: U.S. Geological Survey Bulletin 1906, 18 p.

Miller, E.L., Gans, P.B., and Grier, S.P., 1994, Geologic map of Windy Peak 7.5′ quadrangle, White Pine County, Nevada: U.S. Geological Survey Open-File Report 94–687, scale 1:24,000.

Miller, E.L., Gans, P.B., Grier, S.P., Huggins, C.C., and Lee, J., 1999, Geologic map of the Old Mans Canyon quadrangle, Nevada: Nevada Bureau of Mines and Geology Field Studies Map 21, scale 1:24,000.

Miller, E.L., Grier, S.P., and Brown, J.L., 1995, Geologic map of the Lehman Caves quadrangle, White Pine County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–1758, scale 1:24,000.

Minor, S.A., Wager, Michael, and Harwood, C.S., 1989, Geologic map of the Trident Peak SW quadrangle, Humboldt County, Nevada: U.S. Geological Survey Open-File Report 89–477, scale 1:24,000.

Moores, E.M., Scott, R.B., and Lumsden, W.W., 1968, Tertiary Tectonics of the White Pine–Grant Range Region, east-central Nevada, and some regional implications: Geological Society of America Bulletin, v. 79, p. 1703–1726.

Morabbi, M., 1980, The geology and ore deposits of Cherry Creek Pluton, White Pine County, Nevada: Boise, Idaho, Idaho State University Master's thesis, 92 p.

Mortensen, J.K., Thompson, J.F.H., and Tosdal, R.M., 2000, U-Pb age constraints on magmatism and mineralization in the northern Great Basin, *in* Cluer, J.K., and others, eds., Geology and ore deposits 2000: Geological Society of Nevada, The Great Basin and Beyond Symposium, May 15–18, 2000, Proceedings p. 419–438.

Morton, J.L., Silberman, M.L., Bonham, H.F., Garside, L.J., and Noble, D.C., 1977, K-Ar ages of volcanic rocks, plutonic rocks, and ore deposits in Nevada and eastern California: Isochron/West, no. 20, p. 19–29.

Muffler, L.J.P., 1964, Geology of the Frenchie Creek quadrangle, north-central Nevada: U.S. Geological Survey Bulletin 1179, 99 p.

Neff, F.T., 1983, The stratigraphy, igneous petrology, and structural geology of the central Antelope Range, northeast White Pine County, Nevada: Arcata, Calif., Humboldt State University Bachelor's thesis, 105 p.

Neff, T.R., 1969, Petrology and structure of the Buffalo mountain pluton (probably Late Permian), Humboldt County, Nevada: Palo Alto, Calif., Stanford University Ph.D. dissertation, 210 p.

Nevada Bureau of Mines and Desert Research Institute, 1963, Geological, geophysical, chemical, and hydrological investigations of the Sand Springs Range, Fairview Valley, and Fourmile Flat, Churchill County, Nevada: U.S. Atomic Energy Commission, Vela Uniform Program, Project Shoal Final Rept. VUF-1001, scale 1:31,680.

Nolan, T.B., 1962, The Eureka mining district, Nevada: U.S. Geological Survey Professional Paper 406, 78 p.

Nolan, T.B., Merriam, C.W., and Blake, M.C., Jr., 1974, Geologic map of the Pinto Summit quadrangle, Eureka and White Pine Counties, Nevada: U.S. Geological Survey Miscellaneous Investigations Series Map I–793, scale 1:31,680.

Nolan, T.B., Merriam, C.W., and Brew, D.A., 1971, Geologic map of the Eureka quadrangle, Eureka and White Pine Counties, Nevada: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–612, scale: 1:31,680.

Nutt, C.J., and Hart, K.S., 2003, Geologic map of the Big Bald Mountain and part of the Tognini Spring quadrangles, Nevada: Nevada Bureau of Mines and Geology Map 145, scale 1:24,000.

O'Neill, J.M., 1968, Geology of the southern Pilot Range, Elko County, Nevada, and Box Elder and Tooele Counties, Utah: Albuquerque, N. Mex., University of New Mexico Master's thesis, 113 p.

Page, B.M., 1965, Preliminary geologic map of a part of the Stillwater Range, Churchill County, Nevada: Nevada Bureau of Mines and Geology Map 28, scale 1:125,000.

Perry, R.M., 1985, Geology and mineral deposits of the northern half of the Mt. Tobin mining district, Pershing County, Nevada: Reno, Nev., University of Nevada Master's thesis, 130 p.

Peters, S.G., 2003, Geologic map of the Bobs Flat quadrangle, Eureka County, Nevada: Nevada Bureau of Mines and Geology Map 138, scale 1:24,000.

Pullman, S.A., 1983, The petrography and petrology of a portion of the northern Cedar Mountains, Mineral County, Nevada: Reno, Nev., University of Nevada Master's thesis, scale 1:12,000.

Pullman, S.A., 1984, K-Ar age of the Cedar Mountain pluton, Mineral County, Nevada: Isochron/West, no. 39, p. 17.

Radtke, A.S., 1985, Geology of the Carlin gold deposit, Nevada: U.S. Geological Survey Professional Paper 1267, 124 p.

Rahl, J.M., McGrew, A.J., and Foland, K.A., 2002, Transition from contraction to extension in the northeastern Basin and Range—New evidence from the Copper Mountains, Nevada: Journal of Geology, v. 110, p. 179–194.

Ressel, M.W., 2005, Igneous geology of the Carlin trend, Nevada—The importance of Eocene magmatism in mineralization: Reno, Nev., University of Nevada Ph.D. thesis, 266 p.

Ressel, M.W., Noble, D.C., Henry, C.D., and Trudel, W.S., 2000, Dike-hosted ores of the Beast deposit and the importance of Eocene magmatism in gold mineralization of the Carlin trend, Nevada: Economic Geology, v. 95, p. 1417–1444.

Roberts, R.J., Montgomery, K.M., and Lehner, R.E., 1967, Geology and mineral resources of Eureka County, Nevada: Nevada Bureau of Mines and Geology Bulletin 64, 164 p.

Ross, D.C., 1961, Geology and mineral deposits of Mineral County, Nevada: Nevada Bureau of Mines and Geology Bulletin 58, 98 p.

Satterfield, J.I., 2002, Geologic map of the southern Sand Springs Range, Churchill and Mineral Counties, Nevada: Nevada Bureau of Mines and Geology Map 133, scale 1:24,000.

Sayeed, U.A., 1973, Petrology and structure of Kern Mountains plutonic complex, White Pine County, Nevada, and Juab County, Utah: Lincoln, Nebr., University of Nebraska Ph.D. dissertation 134 p.

Sayyah, T.A., 1965, Geochronological studies of the Kinsley stock, Nevada, and the Raft River Range, Utah: Salt Lake City, Utah, University of Utah Ph.D. thesis, 112 p.

Schilling, J.H., 1965a, Isotopic age determinations of Nevada rocks: Nevada Bureau of Mines and Geology Report 10, 79 p.

Schilling, J.H., 1965b, Potassium-argon ages of the granitic intrusive rocks: U.S. Atomic Energy Commission Report VUF-1001, p. 159–164.

Shawe, D.R., 1995, Geologic map of the Round Mountain quadrangle, Nye County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–1756, scale 1:24,000.

Shawe, D.R., 1999, Geologic map of the Manhattan quadrangle, Nye County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–1775, scale 1:24,000.

Shawe, D.R., 2002, Geologic map of part of the southern Toquima Range and adjacent areas, Nye County, Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF–2327–A, scale 1:48,000.

Shawe, D.R., Marvin, R.F., Andriessen, P.A.M., Mehnert, H.H., and Merritt, V.M., 1986, Ages of igneous and hydrothermal events in the Round Mountain and Manhattan gold districts, Nye County, Nevada: Economic Geology, v. 81, p. 388–407.

Shawe, F.R., Reeves, R.G., and Kral, V.E., 1962, Iron ore deposits of Nevada—part C; Iron ore deposits of northern Nevada: Nevada Bureau of Mines and Geology Bulletin 53, p. 79–128.

Silberling, N.J., 1959, Pre-Tertiary stratigraphy and Upper Triassic paleontology of the Union district, Shoshone Mountains, Nevada: U.S. Geological Survey Professional Paper 322, scale 1:24,000.

Silberling, N.J., 1975, Age relationships of the Golconda thrust fault, Sonoma Range, north-central Nevada: Geological Society of America Special Paper 163, 20 p.

Silberling, N.J., and John, D.A., 1989, Geologic map of pre-Tertiary rocks of the Paradise Range and southern Lodi Hills, west-central Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF–2062, scale 1:24,000.

Silberling, N.J., and Nichols, K.M., 2002, Geologic map of the White Horse Pass area, Elko County, Nevada: Nevada Bureau of Mines and Geology Map 132, scale 1:24,000.

Silberling, N.J., and Wallace, R.E., 1967, Geologic map of the Imlay quadrangle, Pershing County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–666, scale 1:62,500.

Silberman, M.L., Berger, B.R., and Koski, R.A., 1974, K-Ar age relations of granodiorite emplacement and tungsten and gold mineralization near the Getchell Mine, Humboldt County, Nevada: Economic Geology, v. 69, p. 646–656.

Silberman, M.L., and McKee, E.H., 1971, K-Ar ages of granitic plutons in north-central Nevada: Isochron/West, no. 1, p. 15–32.

Slack, J.F., 1974, Jurassic suprastructure in the Delano Mountains, northeastern Elko County, Nevada: Geological Society of America Bulletin, v. 85, p. 269–272.

Sloan, J., Henry, C.D., Hopkins, M., Ludington, S., Zartman, R.E., Bush, C.A., and Abston, C., 2003, National geochronological database: U.S. Geological Survey Open-File Report 03–236, 6 tables.

Smith, J.F., and Ketner, K.B., 1978, Geologic map of the Carlin–Pinon Range area, Elko and Eureka Counties, Nevada: U.S. Geological Survey Miscellaneous Investigations Series Map I–1028, scale 1:62,500.

Smith, J.G., McKee, E.H., Tatlock, D.B., and Marvin, R.F., 1971, Mesozoic granitic rocks in northwestern Nevada—A link between the Sierra Nevada and Idaho batholiths: Geological Society of America Bulletin, v. 82, p. 2933–2944.

Snow, G.G., 1964, Mineralogy and geology of the Dolly Varden Mountains, Elko County, Nevada: Salt Lake City, Utah, University of Utah Ph.D. thesis, 187 p.

Speed, R.C., and Armstrong, R.L., 1971, Potassium-argon ages of some minerals from igneous rocks of western Nevada: Isochron/West, no. 1, p. 1–8.

Speed, R.C., and McKee, E.H., 1976, Age and origin of the Darrough Felsite, southern Toiyabe Range, Nevada: U.S. Geological Survey Journal of Research, v. 4, p. 75–81.

Stablein, N.K., 1969, Petrogenesis of microcline megacrysts in the New York Canyon pluton, Stillwater Range, Nevada: Evanston, Ill., Northwestern University Master's thesis, 81 p.

Starkey, K.J., 1987, Geology, petrography, chemistry and petrogenesis of the Nannies Peak intrusive complex, Elko County, Nevada: Laramie, Wyo., University of Wyoming Master's thesis, scale 1:24,000.

Stewart, J.H., and Carlson, J.E., 1978, Geologic map of Nevada: Nevada Bureau of Mines and Geology, scale 1:500,000.

Stewart, J.H., and McKee, E.H., 1968, Geologic map of the Mount Callaghan quadrangle, Lander County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–730, scale 1:62,500.

Stewart, J.H., and McKee, E.H., 1969, Geologic map of the Hall Creek and western part of the Walti Hot Springs quadrangles, Lander County, Nevada: U.S. Geological Survey Open-File Report 69–269, scale 1:62,500.

Stewart, J.H., and McKee, E.H., 1977, Geology and mineral deposits of Lander County, Nevada: Nevada Bureau of Mines and Geology Bulletin 88, 106 p.

Streckeisen, A.L., 1973, Plutonic rocks, classification and nomenclature recommended by the IUGS subcommission on the systematics of igneous rocks: Geotimes, v. 18, no. 10, p. 26–30.

Taylor, J.K., 1982, Geology of the Nevada Scheelite mine, Mineral County, Nevada: Reno, Nev., University of Nevada Master's thesis, 94 p.

Theodore, T.G., 2000, Geology of pluton-related gold mineralization at Battle Mountain, Nevada, *with a section on* Potassium-argon chronology of Cretaceous and Cenozoic igneous activity, hydrothermal alteration, and mineralization *by* E.H. McKee, *and a section on* Lone Tree gold deposit *by* E.I. Bloomstein, B.L. Braginton, R.W. Owen, R.L. Parrat, K.C. Raabe, *and* W.F. Thompson, *and a section on* Geology of the Marigold Mine area *by* D.H. McGibbon *and* A.B. Wallace, *and a section on* Geology, mineralization, and exploration history of the Trenton Canyon project *by* R.P. Felder: Tucson, Ariz., University of Arizona and U.S. Geological Survey Center for Mineral Resources, Monograph 2, 271 p.

Theodore, T.G., Silberman, M.L., and Blake, D.W., 1973, Geochemistry and potassium-argon ages of plutonic rocks in the Battle Mountain mining district, Lander County, Nevada: U.S. Geological Survey Professional Paper 798–A, 24 p.

Thole, R.H., and Prihar, D.W., 1998, Geologic map of the Eugene Mountains, northwestern Nevada: Nevada Bureau of Mines and Geology Map 115, scale 1:24,000.

Thurber, J.E., 1982, Petrology and Cu-Mo mineralization of the Kennedy stock, East Range, Pershing County, Nevada: Fort Collins, Colo., Colorado State University Master's thesis, 101 p.

Tingley, I.C., 1986, Geology, petrology, and tungsten mineralization of the southern Lodi Hills, Nye County, Nevada: Reno, Nev., University of Nevada Master's thesis, 327 p.

Tingley, J.V., 1975, K-Ar dates on granodiorite and related scheelite-bearing quartz veins at Tungsten, Pershing County, Nevada: Isochron/West, no. 12, p. 3–4.

Tower, C., 1982, Hydrogeology of a possible geothermal system near Deeth, Nevada: Golden, Colo., Colorado School of Mines Master's thesis, 101 p.

Vikre, P.G., 1985a, Geologic map of the Buckskin Mountain quadrangle, Nevada: Nevada Bureau of Mines and Geology Map 88, scale 1:24,000.

Vikre, P.G., 1985b, Precious metal vein systems in the National district, Humboldt County, Nevada: Economic Geology, v. 80, p. 360–393.

Wallace, R.E., Silberling, N.J., Irwin, W.P., and Tatlock, D.B., 1969a, Geologic map of the Buffalo Mountain quadrangle, Pershing and Churchill Counties, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–821, scale 1:62,500.

Wallace, R.E., Tatlock, D.B., Silberling, N.J., and Irwin, W.P., 1969b, Geologic map of the Unionville quadrangle, Pershing County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–820, scale 1:62,500.

Welch, A.H., Sorey, M.L., and Olmsted, F.H., 1981, The hydrothermal system in southern Grass Valley, Pershing County, Nevada: U.S. Geological Survey Open-File Report 81–915, scale 1:62,500.

Whitebread, D.H., 1969, Geologic map of the Wheeler Peak and Garrison quadrangles, Nevada and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–578, scale 1:48,000.

Whitebread, D.H., 1994, Geologic map of the Dun Glen quadrangle, Pershing County, Nevada: U.S. Geological Survey Miscellaneous Investigations Series Map I–2409, scale 1:48,000.

Whitebread, D.H., and Sorensen, M.L., 1980, Preliminary geologic map of the Granite Mountain quadrangle (SE 1/4 Kyle Hot Springs quadrangle), Pershing County, Nevada: U.S. Geological Survey Open-File Report 80–715, scale 1:24,000.

Willden, R., 1964, Geology and mineral deposits of Humboldt County, Nevada: Nevada Bureau of Mines and Geology Bulletin 59, 154 p.

Willden, R., and Kistler, R.W., 1969, Geologic map of the Jiggs quadrangle, Elko County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ–859, scale 1:62,500.

Willden, R., and Speed, R.C., 1974, Geology and mineral deposits of Churchill County, Nevada: Nevada Bureau of Mines and Geology Bulletin 83, 95 p.

Manuscript approved for publication January 31, 2007
Published in the Central Region, Denver, Colorado
Graphics by authors
Covers by Sharon M. Powers
Photocomposition and editing by Alessandro J. Donatich