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The Conterminous United States Mineral Appraisal Program: Background Information to Accompany Folio of Geologic, Geochemical, Geophysical, and Mineral Resources Maps of the Tonopah 1° by 2° Quadrangle, Nevada

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The Conterminous United States Mineral Appraisal Program: Background Information to Accompany Folio of Geologic, Geochemical, Geophysical, and Mineral Resources Maps of the Tonopah 1° by 2° Quadrangle, Nevada

By DAVID A. JOHN, J. THOMAS NASH, DONALD PLOUFF, and DONALD H. WHITEBREAD

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The Conterminous United States Mineral Appraisal Program: Background Information to Accompany Folio of Geologic, Geochemical, Geophysical, and Mineral Resources Maps of the Tonopah 1° by 2° Quadrangle, Nevada

By David A. John, J. Thomas Nash, Donald Plouff, *and* Donald H. Whitebread

ABSTRACT

The Tonopah 1° by 2° quadrangle in south-central Nevada was studied by an interdisciplinary research team to appraise its mineral resources. The appraisal is based on geological, geochemical, and geophysical field and laboratory investigations, the results of which are published as a folio of maps, figures, and tables, with accompanying discussions. This circular provides background information on the investigations and integrates the information presented in the folio. The selected bibliography lists references to the geology, geochemistry, geophysics, and mineral deposits of the Tonopah 1° by 2° quadrangle.

INTRODUCTION

This circular, as well as separately published maps and Open-File Reports, is part of a series of U.S. Geological Survey reports that present information about the mineral resource potential of the conterminous United States. These reports were compiled under the Conterminous United States Mineral Appraisal Program (CUSMAP). CUSMAP is intended to provide mineral resource appraisal information to assist in the formulation of a long-range national minerals policy and to assist Federal, state, and local governments in their land-use planning. The products of CUSMAP also are intended to increase geological, geochemical, and geophysical knowledge of the conterminous United States. Consequently, CUSMAP provides a regional geologic, geochemical, geophysical, and mineral resource framework for mineral exploration and for more specific studies such as resource appraisals of U.S. Forest Service and U.S. Bureau of Land Management Wilderness Study Areas.

Manuscript approved for publication, July 25, 1991.

Location and Geography

The Tonopah 1° by 2° quadrangle covers about 19,300 km^2 in south-central Nevada between latitudes 38° and 39° N. and longitudes 116° and 118° W. (fig. 1). The quadrangle is located in the Basin and Range physiographic province, an area of alternating north-northeast-trending mountain ranges and valleys formed by late Cenozoic faulting. The mountain ranges constitute about 50 percent of the quadrangle. Elevations range from the 11,949 ft summit of Mt. Jefferson in the Toquima Range to about 4,500 ft on the floor of Columbus Salt Marsh near Coaldale. Internal drainage characterizes the Tonopah quadrangle; no perennial rivers flow through the quadrangle. Most drainage is parallel to length of the valleys and commonly ephemeral and partially subsurface.

About 80 percent of the Tonopah quadrangle lies in Nye County; the southwest corner and the west-central edge of the quadrangle lie in Esmeralda and Mineral Counties, respectively (fig. 1). Tonopah, the county seat of Nye County, is the only sizeable city in the quadrangle with a 1990 population of about 4,300. Other small towns include mining centers at Gabbs and Round Mountain and much smaller populations at Manhattan, Ione, Coaldale, and Belmont.

The Tonopah quadrangle is crossed by relatively few paved roads. Two major highways cross the quadrangle: U.S. Highway 6 runs east-west near the southern edge of the quadrangle, and Nevada Highway 376 runs north-south through the center of the quadrangle (fig. 1). Nevada Highway 361 crosses the northwestern corner of the quadrangle. Gravel roads traverse most valleys, and most ranges are crossed by dirt roads or jeep trails.

Most of the mountain ranges in the western two-thirds of the quadrangle (Paradise, Toiyabe, Toquima, and Monitor Ranges, and Shoshone Mountains) are part of Toiyabe National Forest, and the 1989 Nevada Wilderness Act established three wilderness areas in the quadrangle—

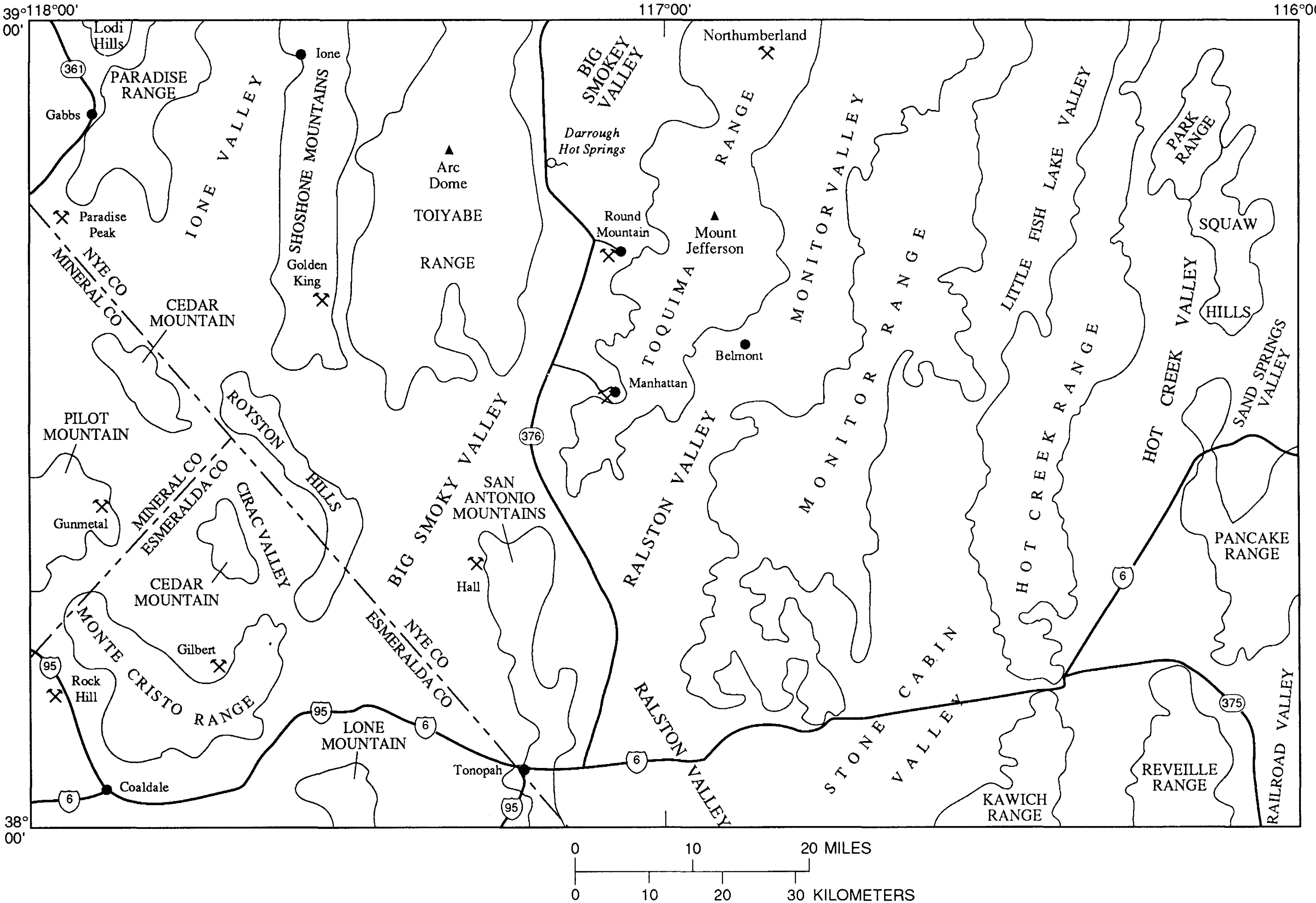

Figure 1. Index map showing major geographic and physiographic features in the Tonopah 1° by 2° quadrangle and locations of roads and major mines.

Arc Dome, Alta Toquima, and Table Mountain. Much of the rest of the quadrangle is administered by the U.S. Bureau of Land Management, and parts of nine BLM wilderness study areas are located in its eastern part.

Previous Work

Prior to the early 1900's only brief references were made to the geology of the Tonopah quadrangle. Most early geologic studies focussed on the major mining districts, especially the Tonopah, Manhattan, and Round Mountain districts, which were discovered in the early 1900's. Important early studies of these districts include: Tonopah district—Spurr (1902, 1905, 1915), Locke (1912), Bastin and Laney (1918), and Nolan (1930, 1935); Manhattan district—Ferguson (1924); and Round Mountain district—Ferguson (1921) and Ferguson and Cathcart (1954). Other early summaries of mining districts in the Tonopah quadrangle include Knopf (1921a, b), Ferguson (1917, 1933), and Lincoln (1923). Production data for the late 1800's and first part of this century are summarized by Couch and Carpenter (1943). Kral (1951) summarized the mineral deposits in Nye County.

The first detailed geologic studies of large parts of the quadrangle were made by H.G. Ferguson, S.W. Muller, and S.H. Cathcart in the 1920's to 1940's and led to publication of a series of maps and reports that described the geology of much of the west half of the quadrangle and the adjacent east half of the Walker Lake 1° by 2° quadrangle (Muller and Ferguson, 1936, 1939; Ferguson and Muller, 1949; Ferguson and others, 1953, 1954; Ferguson and Cathcart, 1954).

County reports published by the Nevada Bureau of Mines and Geology for Mineral County (Ross, 1961), Esmeralda County (Albers and Stewart, 1972), and northern Nye County (Kleinhampl and Ziony, 1984, 1985) provide much of the geologic and mineral-deposit framework for the present study. Geologic maps in these reports were used to compile a preliminary geologic map of the quadrangle and to evaluate the need for new geologic mapping.

During the 1960's and early 1970's much of the eastern part of the Tonopah quadrangle was mapped at a scale of 1:48,000 by the U.S. Geological Survey as part of a project supported by the U.S. Atomic Energy Commission to find a nuclear test site as an alternative to the Nevada Test Site. Geologic maps produced during this project include Dixon and others (1972), Ekren and others (1972, 1973a, b), Quinlivan and Rogers (1974), and Snyder and others (1972), and topical studies included Ekren and others (1974a, c, 1976).

Results of many topical studies in the Tonopah quadrangle have been published during the past 35 years, and maps and reports from many of these studies are listed in the selected bibliography. Some of the more notable topical studies include studies by D.R. Shawe of the Round Mountain, Manhattan, and Belmont areas (Shawe, 1977a, b, 1981a, b, 1988; Shawe and others, 1986), stratigraphic and structural studies of Mesozoic rocks in the Pilot Mountains (Oldow, 1981; Oldow and Bartel, 1987), stratigraphic studies in the Union district (Silberling, 1959), Paleozoic stratigraphy in the Toquima Range (Kay and Crawford, 1964), studies of bedded barite in the Toquima Range (Shawe and others, 1967, 1969), studies of the Northumberland caldera (McKee, 1974), the Toquima caldera complex (Boden, 1986, 1989), and the Lunar Lake caldera (Ekren and others, 1974b), studies of the late Tertiary structure of Little Fish Lake Valley (Ekren and others, 1974a), structural studies of pre-Tertiary rocks in the Toiyabe Range (Babaie, 1984, 1987), and regional structural studies (Oldow, 1984).

Recent detailed studies of mineral deposits, prospects, and mining districts in the Tonopah quadrangle include the Round Mountain district (Fifarek and Gerike, 1991; Mills and others, 1988; Sander, 1988; Sander and Einaudi, 1990; Shawe, 1988; Shawe and others, 1986; Tingley and Berger, 1985), Tonopah and Divide districts (Bonham and Garside, 1974, 1979, 1982; Bonham and others, 1972; Silberman and others, 1979), Hall (Nevada Moly) deposit (Shaver, 1984, 1986, 1991; Shaver and McWilliams, 1987), Hasbrouck Mountain prospect (Graney, 1987), Royston prospect (Seedorff, 1981, 1991), Northumberland mine (Ott, 1983), Gunmetal mine (Grabher, 1984), and the Paradise Peak deposit (Thomason, 1986; Dobak, 1988; John and others, 1989, 1991).

Present Study

The maps and interpretations included in the CUSMAP folio of the Tonopah 1° by 2° quadrangle are the product of numerous multidisciplinary studies, mostly conducted during 1982–1986. The Tonopah project commenced in October 1981 as a cooperative project of the U.S. Geological Survey CUSMAP program and the Nevada Bureau of Mines and Geology. Initial work consisted of an office compilation of 1:250,000-scale geologic and geophysical maps of the Tonopah quadrangle. Fieldwork commenced during the spring of 1982 and continued through 1985. In addition to geologic mapping, field studies included geophysical, geochemical, and remote-sensing studies and investigations of mines and prospects. Associated topical studies included investigations of plutonic rocks, isotopic dating of igneous and hydrothermal rocks and minerals, regional structural analysis, and detailed study of several mining districts.

The Tonopah CUSMAP project was integrated with studies of proposed wilderness areas in the Toiyabe, Hot

Creek, Antelope, Park, Pancake, and Reveille Ranges (Brem and others, 1991; John and others, 1987; Hardyman and others, 1987; Brooks and others, 1987; Diggles and others, 1986a, b). The project was also integrated with studies by D.R. Shawe in the Round Mountain-Manhattan-Belmont area.

The results of the Tonopah 1° by 2° quadrangle CUSMAP project are presented in a series of U.S. Geological Survey Miscellaneous Field Studies Maps and Open-File Reports listed in table 1. Other maps and reports related to the project are indicated by asterisks in the selected bibliography at the end of this report. A symposium presenting results of the Tonopah CUSMAP program was held on September 26, 1986, in Reno, and abstracts of talks from this meeting are given in Whitebread (1986b).

GEOLOGIC MAP (MF–1877–A)

The geologic map of the Tonopah quadrangle is based on new mapping of about 30 percent of the quadrangle at scales of 1:62,500 or larger and compilation of existing maps for the rest of the quadrangle. Areas selected for geologic mapping were chosen after an assessment of existing geologic maps and consideration of mineral resource potential. Most of the new geologic mapping was performed in the western two-thirds of the quadrangle and included parts of the Paradise, Monte Cristo, Toiyabe, Toquima, and Monitor Ranges, the Cedar and Shoshone Mountains, and the Royston Hills.

The geology of the Tonopah quadrangle is complex and varied. Although pre-Tertiary rocks are present in nearly every range and range in age from latest Precambrian to Late Cretaceous, about 85 percent of the exposed rocks are composed of Tertiary and Quaternary volcanic and sedimentary rocks. About 50 percent of the quadrangle is covered by late Cenozoic surficial deposits.

Pre-Tertiary stratified rocks represent a variety of continental-margin, ocean-floor, and island-arc depositional environments that record a complex history of tectonostratigraphic terrane accretion onto the North American craton during Paleozoic and Mesozoic time (Silberling, 1984, 1986). Latest Precambrian and early Paleozoic rocks are primarily distributed in the eastern two-thirds and the southwestern corner of the quadrangle. These rocks consist of autochthonous uppermost Precambrian and lower Paleozoic shelfal carbonate rocks and orthoquartzites and upper Paleozoic clastic-wedge deposits and shallow marine carbonate rocks formed in the margin of North America; deformed, allochthonous(?), lower Paleozoic continental-slope deposits of the Roberts terrane; and deformed, allochthonous, upper Paleozoic deep-marine pelagic and turbiditic sedimentary rocks of the Golconda terrane. These packages of rocks were juxtaposed during the Antler and Sonoma orogenies in Late Devonian to Early Mississippian and Late Permian to Early Triassic time, respectively. Most of these rocks crop out east or south of the initial $^{87}Sr/^{86}Sr$ isopleth =0.706 (Kistler, 1991) and are inferred to overlie the North American craton.

In the northwestern part of the quadrangle, island-arc-related Triassic and Lower Jurassic strata and related upper Paleozoic andesitic volcanic and volcaniclastic rocks of the Walker Lake terrane are exposed. Rocks of the Walker Lake terrane show no clear sediment-provenance relation to the North American craton until latest Triassic time. These rocks lie north and west of the initial $^{87}Sr/^{86}Sr$ isopleth =0.706 and are inferred to lie west of the edge of the North American craton. Rocks of the Walker Lake terrane show evidence for two prominent deformations during Jurassic to mid-Cretaceous time (Oldow, 1981, 1984; Silberling, 1984, 1986; Silberling and John, 1989).

Plutonic rocks, ranging in age from Late Triassic to middle Tertiary, only cover about 2 percent of the quadrangle but are widely distributed across its western two-thirds. Small bodies of mafic granodiorite and quartz monzodiorite of Late Triassic to Early Jurassic age (approximately 221 to 198 Ma) are the oldest plutons exposed and crop out in the southwestern part of the quadrangle near the inferred edge of the North American craton. Late Cretaceous age, weakly peraluminous, coarsely porphyritic biotite granites form the largest plutons and are exposed extensively in the central part of the quadrangle. Small stocks of granite porphyry of Late Cretaceous age formed several low-fluorine porphyry molybdenum systems including the Hall (Nevada Moly) deposit in the San Antonio Mountains. Numerous tungsten skarn deposits are associated with small Late Cretaceous metaluminous granite or granodiorite plutons, mostly located in the western half of the quadrangle.

Middle to late Tertiary volcanic and sedimentary rocks form about 85 percent of the exposed rocks in the quadrangle. Tertiary rocks are divided into four age groups, 40 to 33 Ma, 33 to 24 Ma, 24 to 21 Ma, and 21 to 1.65 Ma, and the geologic map is divided into four areas that have different volcanic stratigraphies. The map shows the distributions of 21 regionally widespread, discrete, ash-flow tuff units in addition to undivided ash-flow tuffs of the four age groups.

The oldest Tertiary rocks, which primarily consist of continental sedimentary rocks and intermediate lava flows, are mostly limited to the eastern part of the quadrangle. Beginning about 33 Ma and continuing to about 21 Ma, eruptions of Tertiary rocks were dominantly composed of silicic ash-flow tuffs erupted from numerous sources both within and outside of the Tonopah quadrangle. About 17 calderas that formed during eruptions of these units have been identified in the eastern two-thirds of the quadrangle. Beginning about 21 Ma and continuing through the end of Tertiary time, volcanism changed and became dominantly represented by intermediate to mafic lava flows and volumetrically minor silicic intrusive rocks and lava flows. These rocks are extensively exposed in the western part of the quadrangle but are virtually absent east of the Toiyabe Range and San Antonio Mountains. Also, beginning about 15 Ma, thick sections of continental sedimentary rocks were deposited in shallow basins formed by crustal extension across large parts of the western half of the quadrangle.

Late Tertiary to Quaternary basalts are the youngest rocks and are exposed in the southeastern part of the quadrangle. Latest Tertiary and Quaternary surficial deposits fill late Cenozoic basins and cover about 50 percent of the quadrangle.

GEOCHEMICAL MAPS (MF–1877–B)

Regional geochemistry of the Tonopah quadrangle is described in 21 maps based on analyses of stream sediments (Nash and Siems, 1988). Geochemical results are plotted on a simplified geologic map base at a scale of 1:500,000. Two sample media were used to characterize regional geochemical trends: the –60 mesh (<0.25 mm) fraction of 1,217 stream-sediment samples and the nonmagnetic heavy-mineral-concentrate fraction produced by panning and further laboratory separations of 1,181 stream-sediment samples. All samples were analyzed for 31 elements (Ag, As, Au, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, La, Mg, Mn, Mo, Nb, Ni, Pb, Sb, Sc, Sn, Sr, Th, Ti, V, W, Y, Zn, and Zr) by a six-step semiquantitative emission-spectrographic method (Grimes and Marranzino, 1968). The stream sediments were also analyzed using a wet chemical procedure (Viets, 1978) for As, Bi, Cd, Sb, and Zn, which have high limits of determination by the emission spectrographic method. Details of the analytical methods and analytical results for the stream-sediment and heavy-mineral-concentrate samples can be found in reports by Fairfield and others (1985), Hill and others (1986), and Siems and others (1986).

Nine geochemical maps were prepared from the results for stream-sediment samples for use in mineral exploration and resource assessment. Six of the maps are for single elements (Ag, As, Cu, Mo, Pb, and Sb), and three are multielement maps based on scores in factor analysis of the stream-sediment data. One of the multi-element maps shows the distribution of samples having high scores for an ore suite (Ag-Pb-Zn-Cu-Sb) that resembles the assemblage in silver-rich polymetallic base-metal ores such as found at Belmont. The other two multi-element maps show the distribution of samples having high scores in groups of elements that may be related to hydrothermal alteration rather than ore as such.

Information from geochemical analyses of heavy-mineral-concentrate samples is presented in 12 maps, nine of which are for single elements (Ag, Ba, Bi, Cu, Mo, Pb, Sb, Sn, and W). Experience with geochemical analyses of heavy-mineral concentrates in the Tonopah quadrangle and elsewhere in the western United States indicates that this medium emphasizes contributions from ore-associated minerals and alteration. A multi-element map based on factor analysis sample scores for the suite W-Bi-Mo-Pb-Cu-Ag was useful for outlining the locations of samples characteristic of skarn-type mineralized rocks. Another plot shows the distribution of factor scores for the suite Sb-Zn-Ag-Pb-Mo, which appears to be characteristic of epithermal ores and altered rocks. A third multi-element map shows the distribution of sample scores for the suite Ni-Co-Fe-Cu (and, to a lesser extent, Mo-Pb-Zn), which appears to reflect the abundance of sulfidic alteration assemblages.

The geochemistry of gold is not described in these maps because experience by U.S. Geological Survey geochemists over the past 20 years has shown that sampling problems in the field and laboratory, due largely to the well known "nugget effect," produce many false, nonreproducible anomalies unless special methods are used. For this regional study, these methods were deemed too costly, and instead we recommend an indirect approach utilizing pathfinder elements for gold deposits such as As and Sb.

The geochemical maps are intended to be mostly descriptive to avoid possible bias introduced during interpretation. Interpretative maps and discussion are available in a companion report (Nash, 1988) which utilizes the same regional stream-sediment database but relates it more specifically to geochemistry of altered and mineralized rock samples, local geology, and known mines and prospects.

AEROMAGNETIC MAP (MF–1887–C)

The aeromagnetic map was compiled as a mosaic of aeromagnetic maps from 11 aeromagnetic surveys that were corrected for the effect of the Earth's normal regional magnetic field and approximately adjusted to the magnetic datum of the adjacent Walker Lake quadrangle (Plouff, 1987). One survey was part of a regional study (U.S. Geological Survey, 1971); six surveys were associated with activities of the U.S. Atomic Energy and Nuclear Regulatory Commissions (U.S. Geological Survey, 1968, 1979a, b, c, d, and unpublished data, 1974); one survey was associated with a wilderness area study (U.S. Geological Survey, 1985b); and three surveys were contracted for the Tonopah CUSMAP (U.S. Geological Survey, 1984a, 1984b, 1985a). Locations of the three CUSMAP surveys were selected for the following purposes: (1) to map the northern part of the

Mt. Jefferson caldera, which was included in parts of three disparate surveys, and to map the Darrough Hot Springs geothermal area at 1,600 m closer to the ground than the existing survey, (2) to map an area that straddles three surveys and includes areas of low background magnetization and reversed magnetization near Thunder Mountain, and (3) to map a broad area of low magnetization near the southern edge of Cedar Mountain, where the effects of rock alteration might be discerned, and to obtain coverage with greater resolution near the Monte Cristo Range.

Prominent magnetic anomalies generally are not associated with exposed pre-Cenozoic sedimentary and volcanic rocks in the Tonopah quadrangle primarily because the magnetizations of these rocks are presumed to be low. Secondarily, amplitudes of anomalies are low if the exposures are not topographic highs. Prominent magnetic highs with lateral dimensions as much as 10 km are present over outcrops of Mesozoic plutons and inferred locations of concealed plutons, especially in the western part of the quadrangle (Grauch and others, 1988). Magnetizations of the plutonic rocks probably are moderate but variable. Most Tertiary volcanic rocks have high magnetizations, as indicated by strong correlations of magnetic anomalies with topography and the occurrence of negative anomalies over volcanic rocks that crystallized during a time of reversed magnetic field. Comparison between the original aeromagnetic maps, from which this compilation was derived, and detailed geologic maps is needed to evaluate sources of local magnetic anomalies, especially for subtle sources such as areas of hydrothermal alteration. Previous interpretations of aeromagnetic maps in the Tonopah quadrangle were made by Davis and others (1971, 1979) in the San Antonio Mountains and the Paradise Range, respectively.

K-AR ISOTOPIC DATING MAP (MF-1877-I)

The K-Ar isotopic dating map shows the locations of 65 samples from the Tonopah quadrangle that were dated as part of this project by E.H. McKee using the K-Ar method. An accompanying table provides sample locations and descriptions and analytical data. The samples are scattered throughout the quadrangle, although many samples are concentrated in the Paradise Range, Royston Hills-south Cedar Mountain area, Toiyabe Range, and Toquima Range. Most of the new K-Ar age determinations are for Tertiary volcanic and hypabyssal intrusive rocks; a few samples of hydrothermal-alteration products are also dated.

Newly determined ages of igneous rocks range from about 34 to 7 Ma and are generally compatible with previously published ages (for example, Kleinhampl and Ziony, 1985). Many of these age determinations are used on the geologic map (Whitebread and John, 1991) to help separate the Tertiary volcanic rocks into the four major age groups.

Ages of hydrothermal alteration are reported for the Round Mountain, Paradise Peak, and Golden King mines. Alunite ages from the Round Mountain area (10.2–9.5 Ma) probably represent the age of supergene oxidation, whereas alunite from the Paradise Peak mine (18.0 Ma) and adularia from the Golden King mine (20.9 Ma) probably approximate the ages of precious-metal mineralization in these deposits.

PLUTONIC ROCKS MAP (MF-1877-J)

The map of plutonic rocks shows the distribution of 58 individually mapped granitoid plutons in the Tonopah quadrangle that collectively crop out over about 375 km^2. An accompanying table includes summaries of textural and compositional features, age, and associated hydrothermal alteration and mineralization for each pluton.

Plutonic rocks in the Tonopah quadrangle are divided into seven broad groups on the basis of age, composition, and textural characteristics: (1) Late Triassic to Early Jurassic porphyritic granodiorite and quartz monzodiorite, (2) Late Cretaceous equigranular granodiorite and granite, (3) Late Cretaceous coarse-grained biotite granite, (4) Late Cretaceous granite porphyry, (5) Late Cretaceous granodiorite porphyry, (6) Tertiary granitoids, and (7) mafic plutonic rocks of unknown age. The Tertiary stocks and mafic plutonic rocks only form small exposures relative to the other groups of plutonic rocks.

The oldest plutons are exposed as small, isolated bodies in an east-trending band across the southwestern part of the quadrangle from the Monte Cristo Range east to the vicinity of Tonopah. These rocks are coarsely porphyritic, hornblende-rich granodiorite and quartz monzodiorite that have K-Ar and Rb-Sr isotopic ages ranging from about 221 to 198 Ma. Small base-metal deposits of several types are associated with these plutons.

Four groups of Late Cretaceous or inferred Late Cretaceous granitoids are separated on the basis of differing textures, compositions, and associated mineralization. Coarse-grained, locally coarsely porphyritic, weakly peraluminous biotite granites form the largest plutons and are exposed in the Toquima, Toiyabe and Paradise Ranges, at Lone Mountain, and in the Lodi Hills. Potassium feldspar megacrysts as much as 8 cm long are common in these plutons. The margins of these plutons commonly have northwest-trending cataclastic foliations, possibly indicating a Late Cretaceous deformational event. Although tungsten skarns are locally present around them, these plutons have relatively little associated mineralization. Small stocks of Late Cretaceous granite porphyry crop out in several localities, notably in the northern San Antonio Mountains and at Rock Hill, and commonly are associated with low-fluorine porphyry molybdenum mineralization or alteration. The Hall (Nevada Moly) deposit in the San Antonio Mountains is the largest known metallic mineral deposit genetically related to granitic plutonism in the Tonopah quadrangle. Small bodies of granodiorite porphyry are scattered across the western half of the quadrangle, and tungsten, copper, and iron skarn deposits in adjacent carbonate wall rocks are commonly associated with these intrusions. Equigranular granodiorites also form small scattered plutons across the west half of the quadrangle but have little associated mineralization.

MINERAL RESOURCE ASSESSMENT (OPEN-FILE REPORT 86–470)

The mineral resource assessment of the Tonopah quadrangle is presented in preliminary form as two 1:250,000-scale maps and an accompanying report. The assessment consists of descriptive models for 15 metallic mineral-deposit types, grade-tonnage models for 14 deposit types, tabulation by deposit type of known mineral occurrences, locations of tracts permissive for the occurrence of undiscovered metallic mineral deposits, and estimates of the numbers of undiscovered deposits for five of the deposit types. Metallic mineral deposits are divided into two groups on the maps and in the accompanying descriptions of permissive tracts: (1) epithermal, hot-spring, and sediment-hosted gold-silver deposits and simple antimony deposits, and (2) pluton-related deposits. Tracts permissive for undiscovered deposits are delineated for (1) the major deposit types known to be present in the Tonopah quadrangle, including gold-bearing deposits (epithermal gold-silver veins, hot-spring gold, and sediment-hosted disseminated gold-silver); low-fluorine porphyry molybdenum; copper, tungsten, and iron skarns; polymetallic replacement, polymetallic vein; and simple antimony deposits, and (2) two types of deposits not known to be present in the quadrangle (porphyry copper and zinc-lead skarns). The accompanying text describes the methodology used to assess the mineral resource potential of the Tonopah quadrangle, describes known mineral deposits and occurrences in the quadrangle, and summarizes geologic, geochemical, geophysical, and mineral occurrence data for each of the permissive tracts outlined on the maps. Probabilistic, quantitative estimates of the numbers of undiscovered deposits within 1 km of the Earth's surface are given for sediment-hosted gold-silver, polymetallic replacement, polymetallic vein, epithermal gold-silver vein, and hot-spring gold deposits.

The mineral resource assessment of the Tonopah quadrangle generally follows the methodology developed for the Alaska Mineral Resource Assessment Program (AMRAP) (Singer, 1975; Singer and Ovenshine, 1979) and used in several other CUSMAP quadrangle studies (for example, Medford, Oregon, Singer and others, 1983; and Ajo and Lukeville, Arizona, Peterson and others, 1983). Resulting in probabilistic, quantitative estimates of the numbers of undiscovered deposits in the area, the methodology involves three stages: (1) development or adaptation of descriptive and grade-tonnage models of deposit types that are present or are likely to be present in the study area, (2) delineation of areas (tracts) that are permissive for the occurrence of each deposit type, and (3) estimates by a team of experts of the numbers of deposits likely to be present within the permissive tracts. The team of experts for the Tonopah quadrangle estimated that there is a 90 percent probability that one or more undiscovered sediment-hosted gold-silver, polymetallic vein, and epithermal gold-silver vein deposits are in the quadrangle and that there is a 50 percent probability that there are one or more undiscovered polymetallic replacement and hot-spring gold deposits in the quadrangle.

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TABLE 1

Table 1. Contents of the Tonopah 1° by 2° CUSMAP folio

MF–1877–A	Geologic map, by Donald H. Whitebread and David A. John
MF–1877–B	Geochemical maps, by J. Thomas Nash and David F. Siems
MF–1877–C	Aeromagnetic map, by Donald Plouff
MF–1877–I	K-Ar isotopic dating map, by Edwin H. McKee and David A. John
MF–1877–J	Plutonic rocks map, by David A. John
Open-File Report 86–470	Mineral resource assessment, by Greta J. Orris and Frank J. Kleinhampl

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