U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

To accompany the

Preliminary Geologic Map of the Galena Canyon Quadrangle, Lander County, Nevada

by

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DESCRIPTION OF MAP UNITS

Qd **Mine dump (Holocene)**--Present around active and abandoned mining operations in the Copper Canyon, Iron Canyon, an Copper Basin areas

Qfp **Flood plain deposits (Quaternary)**--Includes sand, silt, and clay deposits in the flood plain of the Reese River in the southeast corner of the quadrangle. Contacts approximately located using large-scale color aerial photographs

Qaf **Younger alluvium and fanglomerate deposits (Quaternary)**--Clay, silt, sand, and gravel primarily in active stream channels but also covering outwash fans at the mouth of major drainages emanating from the range. Contacts of outwash fans approximately located using large-scale color aerial photographs

Qc **Colluvium (Quaternary)**--Includes talus, slope wash, and other colluvial deposits

Qls **Landslide deposits (Quaternary)**

Qoa **Older alluvium (Quaternary)**--Poorly sorted gravel deposits with a silty to sandy matrix. Includes terrace and valley-fill deposits at higher elevations; dissected by stream channels containing younger alluvium (Qaf). Probably equivalent in age to older fanglomerate (Qof)

Qof **Older fanglomerate deposits (Quaternary)**--Unsorted gravel deposits with a silty to sandy matrix in fan deposits covering large areas of the southern and eastern part of the quadrangle. Dissected by stream channels and outwash fans containing younger alluvium (Qaf). Probably equivalent in age to older alluvium (Qoa)

Tb **Olivine basalt (Pliocene)**-- Constitutes southernmost exposures in the southwest part of quadrangle. Rock is black dense olivine-bearing basalt with hematitic scoriaceous flow tops and agglomeratic units locally. Sample of basalt collected from immediately south of the quadrangle yielded a whole-rock potassium-argon age of 3.3 ± 0.17 Ma (McKee, 1992). Probably correlative with 2.8 ± 0.1 Ma basalt exposed in the southern part of the Antler Peak quadrangle to the west (E.H. McKee, oral commun., 1993; Doebrich, 1995).

Tc **Caetano Tuff (Oligocene)**-- Exposed as cliff-forming unit in the northeast corner of the quadrangle where it is in depositional contact with Harmony Formation and Antler Peak Limestone. Rock is light pinkish-gray crystal-lithic welded ash-flow tuff with glassy quartz phenocrysts. Lower units tend to be more lithic rich and less welded. Biotite from exposures near Elephant Head (SE ¼ sec. 28, T. 32 N., R. 44 E.) yielded a 34.5 Ma Potassium-argon age (recalculated from McKee and Silberman, 1970).

Tgp **Granodiorite porphyry (Oligocene)**-- This is the most widely exposed of the intrusive rock units in the quadrangle. Rock consists of orange-brown (weathered surface) to grayish-green (fresh surface), porphyritic aphanitic to seriate dikes and small stocks. Phenocrysts include plagioclase (andesine) and bipyramidal quartz, generally 3 mm to 1 cm across, and locally large megacrysts of potassium-feldspar as much as 4 cm across. Many dikes are emplaced into north-trending faults, particularly in a 1-km wide north-south zone extending from Philadelphia Canyon (sec. 26, T. 31 N., R. 43 E.) to Long Peak (sec. 26, T. 32 N., R. 43 E.).

Another north-south zone containing large north-trending dike-like bodies and small plugs extends from the mouth of Little Cottonwood Canyon (N ¼ sec. 7, T. 31 N., R. 44 E.) north to the upper part of Long Canyon (NE ¼ sec. 30 and W ¼ sec. 29, T. 32 N., R. 44 E.). Several radiometric age determinations indicate granodiorite porphyry (also referred to as latite porphyry by Loucks and Johnson, 1992) in the Battle Mountain area is largely Oligocene. Primary hornblende in granodiorite porphyry from immediately north of the quadrangle yielded a 35.4±1.1 Ma-age by potassium argon method (McKee, 1992). Primary biotite from a granodiorite porphyry dike exposed in the Iron Canyon pit (SW ¼, sec. 23, T. 31 N., R., 43 E.) yielded a potassium-argon age of 38.6±1.1 Ma (E.H. McKee, oral commun., 1994). Primary biotite and hornblende from similar appearing dikes at the Buffalo Valley mine, 10 km west of the quadrangle, yielded ages of 36.9±1.1 Ma and 33.7±1.1 Ma, respectively, (E. H. McKee, oral commun., 1994; Doebrich, 1995). At the south end of Lone Tree Hill, about 25 km northwest of the quadrangle, a granodiorite porphyry dike yielded potassium-argon ages of 39.4±1.2 Ma and 36.3±1.3 Ma on biotite and hornblende, respectively (E.H. McKee, written commun., 1993).

Td **Diabase (Oligocene)**--Dark gray-green, fine- to medium-grained equigranular rock found as a north-northwest-trending dike in the Butte Canyon area (NE ¼ sec. 22, T. 31 N., R. 43 E. and SE ¼ sec. 15, T. 31 N., R. 43 E.)

Thp **Hornblende porphyry (Oligocene)**--Grayish-green, porphyritic aphanitic rock with phenocrysts of hornblende and plagioclase. Crops out as small dikes in the SE ¼ of section 25, T. 32 N., R. 43 E.

Tgdc **Granodiorite of Copper Canyon (Oligocene or Eocene)**--Same as altered granodiorite of Copper Canyon of Theodore and others (1973). Exposed over small area west of the East Copper Pit (boundary of secs. 22 and 27, T. 31 N., R. 43 E.). Emplacement was temporally and genetically related to copper-gold replacement mineralization at the East ore body (East Copper Pit) (Theodore and Blake, 1975) and gold-silver skarn mineralization at the Tomboy and Minnie deposits (secs. 27 and 34, T. 31 N. R. 43 E.) (Theodore and others, 1990). Rock is potassically altered medium- to coarse-grained porphyritic biotite granodiorite with smoky-gray quartz phenocrysts, sericitized feldspar phenocrysts, secondary biotite, stockwork quartz veining, and secondary copper oxides. Primary biotite yielded potassium-argon ages of 38.5±0.8 Ma, 38.2±0.8 Ma, and 38.0±0.8 Ma (Theodore and others, 1973)

Tr **Rhyolite (Oligocene or Eocene)**--Exposed as two intrusive bodies in the vicinity of the Little Giant Mine (NE ¼ sec. 36, T. 32 N., R. 43 E.). Rock is pinkish white (weathered surface) to gray (fresh surface), fine - to medium-grained and weakly porphyritic, with phenocrysts of biotite, bipyramidal smoky quartz, sanidine, and hornblende (Theodore and others, 1992). Flow banding best developed near contacts with surrounding Harmony Formation. Potassium-argon determinations on primary biotite yielded 39.1±1.0-Ma and 37.3±1.1-Ma ages (McKee, 1992). See Theodore and others (1992) for a more detailed description

Tmb **Biotite-hornblende monzogranite of Bluff area (Oligocene or Eocene)**--Exposed in small area along northern margin of quadrangle northwest of Labrador pit (NE ¼ sec. 29, T. 32 N., R. 44 E.). Rock is hypidiomorphic-granular to porphyritic with phenocrysts of plagioclase, quartz, hornblende, and biotite in a microaplitic groundmass (Theodore and others, 1992). Age determinations, by the potassium-argon method, on primary hornblende and biotite yielded 39.0±1.1-Ma and 39.3±1.0-Ma ages, respectively (McKee, 1992). See Theodore and others (1992) for a more detailed description

Kmp **Megacryst porphyry (Late Cretaceous)**--Exposed as east-west trending dikes and plugs between Long Canyon and the Contention Pit (secs. 29 and 32, T. 32 N., R. 44 E.) and as stocks and plugs north of Licking Creek (sec. 30, T. 32 N. R. 44 E.). This unit is part of the Buckingham stockwork molybdenum deposit (Theodore and others, 1992). Rock is highly altered and consists of phenocrysts of pink and white potassium feldspar and bipyramidal quartz, 5 mm to 2 cm across, and microphenocrysts of plagioclase (altered to clay and white mica)and biotite, 5 mm to 10 mm across, in a medium-grained to microaplitic groundmass. Contains quartz stockwork veins but in less abundance than monzogranite porphyry (Km). Crosscutting sets of pyrite veins (altered to iron oxide) are common. Secondary copper (chrysocolla and (or) malachite) and molybdenite is present locally along faults in the megacryst porphyry (Theodore and others, 1992). Secondary white mica (sericite ?) from the megacryst porphyry has yielded potassium-argon ages of 88.0±2.0 Ma, 86.1±2.0 Ma, 85.5±1.9 Ma, 77.4±1.6 Ma, 61.7±1.5 Ma, 75.7±1.6 Ma (McKee, 1992). See Theodore and others (1992) for a more detailed description

Km **Monzogranite porphyry (Late Cretaceous)**--Exposed as large stocks and dikes in a west-northwest trending zone extending from the south end of the Contention Pit (NE ¼ sec. 32, T. 32 N., R. 44 E.) for about 3.5 km to the west-northwest. This rock is the main intrusive unit of the Buckingham stockwork molybdenum deposit and was emplaced as two main stocks (East and West stocks) (Theodore and others, 1992). The Buckingham deposit is estimated to contain more than 1 billion tons of ore averaging 0.10 weight percent molybdenum (as MoS_2) (Theodore and others, 1992). Copper ore deposits in the Contention, Carissa, Sweet Marie, and Widow pits in the Copper Basin area are genetically related to the emplacement of the monzogranite porphyry (Theodore and others, 1992). The rock is generally yellow-brown to creamy white, hydrothermally altered, and consists of phenocrysts of quartz, potassium-feldspar, and plagioclase, 1 to 1.5 cm wide, in a fine-grained hydrothermally altered groundmass. Stubby books of biotite, 1 to 1.5 mm long, are dispersed throughout and altered to white mica and chlorite. Disseminated cubes of pyrite altered to iron oxide are common. Quartz stockwork veins are abundant and contain potassium feldspar and sulfide minerals. Molybdenite is disseminated in groundmass of the monzogranite porphyry as well as concentrated in veins with secondary copper minerals. A calculated age using ^{39}Ar release during a heating experiment on primary biotite from the monzogranite porphyry is 85.7±0.4 Ma (McKee, 1992). However, Theodore and others (1992) propose that initial emplacement was about 90 Ma, based on relations indicating that emplacement of the monzogranite porphyry preceded that of the megacryst porphyry (Kmp) which has been dated at 88-86 Ma. See Theodore and others (1992) for a more detailed description

ALLOCHTHON OF THE GOLCONDA THRUST

Havallah sequence of Silberling and Roberts (1962), Roberts and Thomasson (1964), Stewart and others (1977), Stewart and others (1986), and Murchey (1990) .

LITHOTECTONIC UNIT 1--In this area, consists of:

ha **Argillite (Permian and Pennsylvanian)**--Crops out in a small area near southwest corner of quadrangle (SW ¼ sec. 34, T. 31 N., R. 43 E) where it has been juxtaposed with Battle Formation by a steeply-dipping normal fault. The rock is gray-green, olive-green, maroon, purple, and black argillite, siliceous argillite, cherty shale, and argillaceous cherty siltstones, with lesser amounts of interbedded (< 5 cm) black and gray chert. Contains Middle Pennsylvanian (Desmoinesian) to Late Permian (Guadalupian) radiolarians and conodonts (Murchey 1990). Corresponds to parts of lithotectonic units 1A, 1B, and 1C of Murchey (1990) and parts of subunits 1 and 2 of Miller and others (1982)

Antler sequence of Roberts (1964)--In this area consists of:

PIPap **Antler Peak Limestone (Permian and Pennsylvanian)**--Exposed in the extreme northeastern part of the quadrangle in the vicinity of Elephant Head (secs. 27 and 28, T. 32 N., R. 44 E.) where it is in fault contact with Harmony Formation (€h), in fault and deposition contact with Battle Formation, is overlain by Caetano Tuff (Tc), and is intruded by dikes of granodiorite porphyry (Tgp). Locally altered to jasperoid (j) (Theodore and Jones, 1992). Consists of medium- to thick-bedded, light- to medium-bluish-gray limestone, that is locally shaly, sandy, and pebbly. Locally contains thin discontinuous beds and nodules of chert. In this area, Theodore and Jones (1992) have subdivided the Antler Peak Limestone into three parts, including two major interlayered facies, all of which correspond with the uppermost strata of the Antler Peak Limestone at its type locality (Roberts, 1964). These subdivisions, a micrite dominated facies, a siliclastite dominated facies, and an undivided part, are not shown on this map. Fusulinid and coral fauna indicate a Late Pennsylvanian (late Missourian) to Early Permian (early Wolfcampian) age for the Antler Peak Limestone (Roberts, 1964).

IPb **Battle Formation (Pennsylvanian)**--Exposed along the west-central and southwestern margin of the quadrangle and in the Elephant Head area in the northeastern part of the quadrangle. Except where faulted, Battle Formation lies in angular unconformity on rocks of Harmony Formation, as in the upper part of Cow Canyon (W ¼ sec.3, T. 31 N., R. 43 E.). In this quadrangle, Battle Formation was host to ore in the upper Fortitude deposit (Wotruba and others, 1988), the East ore body (Theodore and Blake, 1975), the Tomboy and Minnie deposits (Theodore and others, 1990), and partial host in the Labrador deposit (Schmidt and others, 1988). The formation consists of thick-bedded immature conglomerate, sandstone, shale, and limestone. Conglomerate, sandstone, and shale are commonly reddish brown and may be variably calcareous and hematitic. Units are usually bleached where altered. Brachiopod and fusulinid faunas indicate an Early to Middle Pennsylvanian (Morrowan to Atokan) age for the Battle Formation (Roberts, 1964; A.K. Armstrong, written commun., 1992)

ALLOCHTHON OF THE ROBERTS MOUNTAINS THRUST

Scott Canyon Formation

Dso **Olistostrome (Devonian)**--Consistently found immediately below the Dewitt thrust and the overlying Harmony Formation, except where bounded by steeply dipping normal faults. Best examples of this unit are exposed on northeast side and near mouth of Galena Canyon (SW½, sec. 13, T. 31 N., R. 43 E.) and in the S½ of section 2, T. 31 N., R. 43 E. This unit consists of olistoliths of Early Cambrian archaeocyathid- and trilobite-bearing limestone (**ol**) (McCollum and others, 1987; Debrenne and others, 1990), Late Cambrian Harmony Formation sandstone, Ordovician limestone (**ol**) (L.B. McCollum, written commun., 1993), and Ordovician(?) chert (**ch**) in a tuffaceous greenstone matrix. Limestone olistoliths were first described by Roberts (1964) as carbonate lenses or bioherms, and thus the Scott Canyon Formation was assigned an Early Cambrian age based on the contained archaeocyathids and trilobites. However, recent examinations of radiolaria in chert of the Scott Canyon Formation show the formation to be Devonian (Jones and others, 1978; Theodore and others, 1992; Murchey, written commun, 1994). This unit most likely represents volcanogenic debris flows which derived material from a highland and (or) advancing front of an allochthon containing early Paleozoic rocks, and were deposited in a Devonian basin

Dsg **Greenstone (Devonian)**--Dark gray-green to pale green, fine- to medium-grained, and generally massive mafic metavolcaniclastic and metavolcanic rock and hyaloclastite. Considerable carbonate minerals are present locally as interclast material in hyaloclastites and other brecciated metavolcanic and volcaniclastic rocks. Individual flows, as much as 1.5 m thick, are discernable locally, for example on east wall of canyon east of Scott Canyon (SE cor., sec. 11, T. 31 N., R. 43 E.). This unit is believed to be stratigraphically below though gradational with the olistostrome unit and intercalated with the chert and argillite unit. However, the greenstone unit is largely fault bounded with other units of the Scott Canyon Formation

Dsc **Chert and argillite (Devonian)**--Most widely exposed unit of the Scott Canyon Formation. Consists of black, gray, and milky gray-brown radiolarian chert, argillite, and carbonaceous shale. Commonly displays high degrees of folding, brecciation, and recrystallization. The high degree of recrystallization has made it difficult to recover usable radiolaria for dating. Useable radiolarian samples that have been recovered have indicated both Devonian and Ordovician ages for chert (Jones and others, 1978; Theodore and others, 1992; Murchey, written commun., 1994). Chert samples that yielded Ordovician radiolarians were collected immediately adjacent to olistostrome in Galena Canyon (SW cor. sec.13, T. 31 N., R. 43 E) and may in fact be from a large olistolith within the olistostrome unit. It is also possible that tectonically imbricated and downfaulted blocks of Ordovician Valmy Formation are now structurally intercalated with Devonian Scott Canyon Formation (McCollum and others, 1987). Where this might be the case, the unit label **Dsc?** is used

DOb **Metabasalt and diabase (Devonian and (or) Ordovician)**--Found exclusively as dikes, sills, and possibly flows in the Harmony Formation. Rock is drab gray-green, fine- to medium-grained with felty to diabasic texture. Age is not precisely known though must be pre-Middle Pennsylvanian as some units are folded with Harmony Formation which is overlain by undisturbed Middle Pennsylvanian Battle Formation (NW ¼, sec. 3, T. 31 N., R. 43 E.)

Ov **Valmy Formation (Ordovician)**--Exposed over a small area in the northwest corner of the quadrangle (NE ¼, sec. 27, T. 32 N., R., 43 E.). Consists of blue-gray argillite and thin-bedded black chert. Correlates with unit **Ov4s** of Theodore (1994). May also be structurally intercalated with Scott Canyon Formation (**Dsc?**) in the Galena Canyon area where gray quartzite and chert pebble conglomerates are exposed

Harmony Formation

Chs **Sandstone and shale (Cambrian)**--Most widespread of all rock units in the quadrangle. Consists of greenish-brown medium- to coarse-grained micaceous quartzo-feldspathic sandstone (quartz arenite, arkose, subarkose, and litharenite) pebbly sandstone and lesser shale and calcareous shale. Altered to biotite hornfels in Copper Canyon and Copper Basin areas where proximal to intrusive bodies. Altered to garnet-pyroxene skarn (**sk**) at many deposits in the Copper Basin area and in exposures west of the Labrador pit (NW ¼ sec. 28, NE ¼ sec. 29, T. 32 N., R. 44 E.). In this quadrangle, Harmony Formation was host to supergene copper ore at the Contention, Carissa, Sweet Marie, and Widow deposits and gold-silver skarn and replacement deposits at the Labrador, Surprise, Northern Lights, and Empire deposits (Schmidt and others, 1988). Furthermore, the Harmony Formation is host to half of the 1 billion tons of mineralized rock at the Buckingham stockwork molybdenum deposit (Theodore and others, 1992). The Harmony Formation is considered Late Cambrian in age on the basis of contained trilobites found in the Hot Springs Range, 5 to 10 km west-northwest of the Osgood Mountains (Roberts and others, 1958). Moreover, the regionally distinctive lithology of the Harmony Formation is recognized as olistolithic blocks in the Devonian Scott Canyon Formation (see above) and as clasts in the Upper Devonian Slaven chert in the Shoshone Range, 20 km to the southeast (Madrid, 1987). This suggests that the Harmony Formation is older than Upper Devonian in age

€hl **Limestone and calcareous sandstone (Cambrian)**--Interbedded and gradational with sandstone and shale unit of the Harmony Formation. Commonly found immediately above Dewitt Thrust, such as on the north side of Galena Canyon (sec. 13, T. 31 N., R. 43 E.) though also as isolated exposures surrounded by the sandstone and shale unit.. Consists of gray-brown calcareous sandstone and dark- to buff-gray limestone. Limestone sequences are locally as much as 5 m thick.

SYMBOLS

Contact--Dashed where approximately located; dotted where concealed; queried where location uncertain.

Fault--Dashed where approximately located; dotted where concealed; queried where location uncertain.

Normal fault, ball on downdropped block.

Thrust fault, saw teeth on upper plate.

Fault Breccia

Dike--Granodiorite porphyry (Tgp), hornblende porphyry (Thp), diorite (Td), megacryst porphyry (Kmp).

Diabase/metabasalt dike or sill

Approximate location of outer limit of pyritic alteration zone--Hachured in direction of altered rock

Altered area--Jasperoid in Antler Peak Limestone (j), skarn in Harmony Formation (sk)

Strike and dip of bedding

Inclined, facing not always known with certainty

Vertical

Overturned

Horizontal

Strike and dip of compaction foliation (in Caetano Tuff)

Folds--Showing trace of hinge line and plunge of axis; dashed where approximately located; queried where uncertain; dotted where concealed.

Anticline

Syncline

Minor anticline, showing trend and plunge

Horizontal minor anticline, showing trend

Minor syncline, showing trend and plunge

Horizontal minor syncline showing trend

Minor coaxial folds, showing trend and plunge

Minor horizontal coaxial folds, showing trend

Perimeter of open pit mine or open cut--Hachured on excavated side.

Mine dump

Portal

Mineshaft

Prospect

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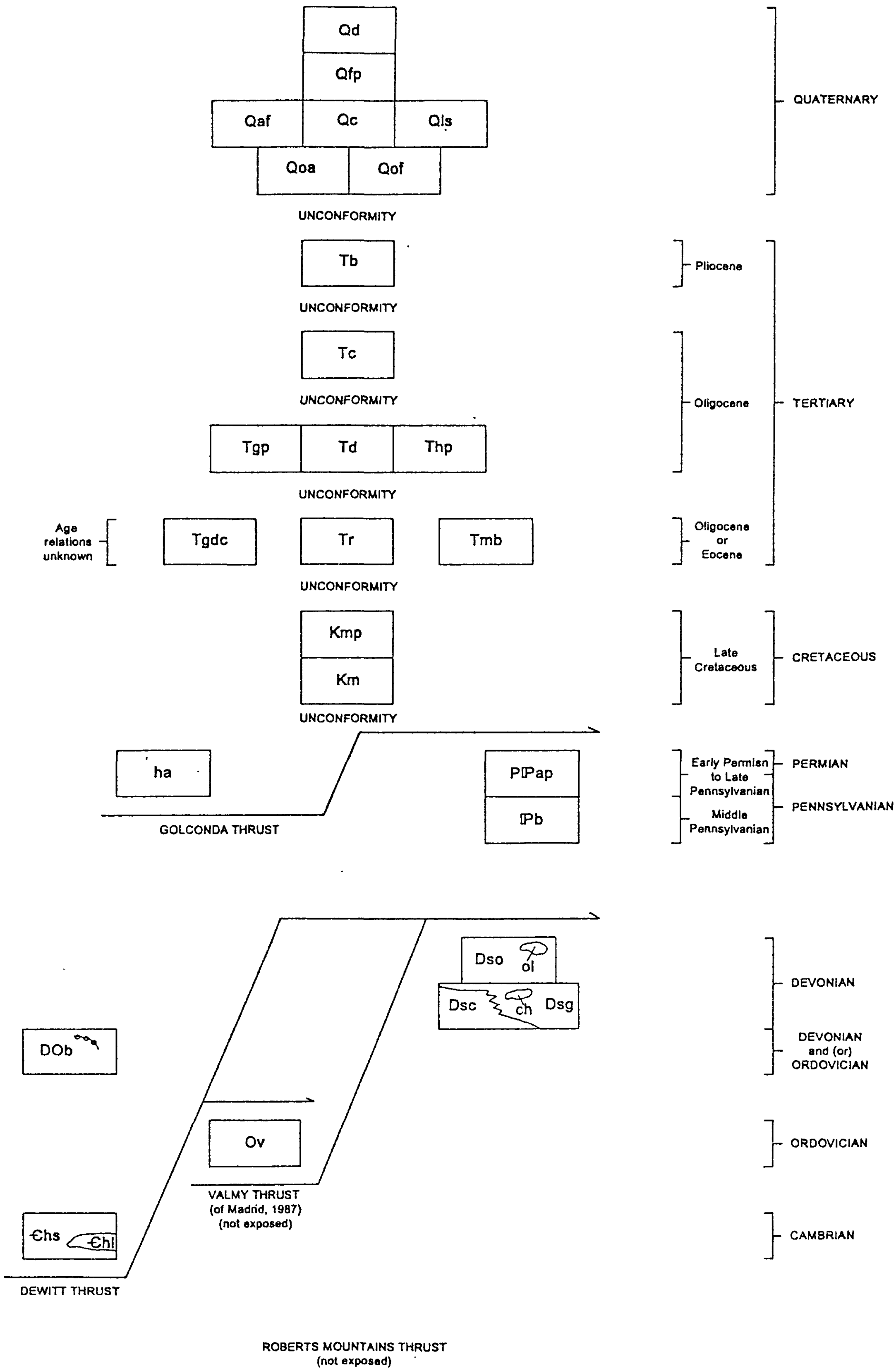
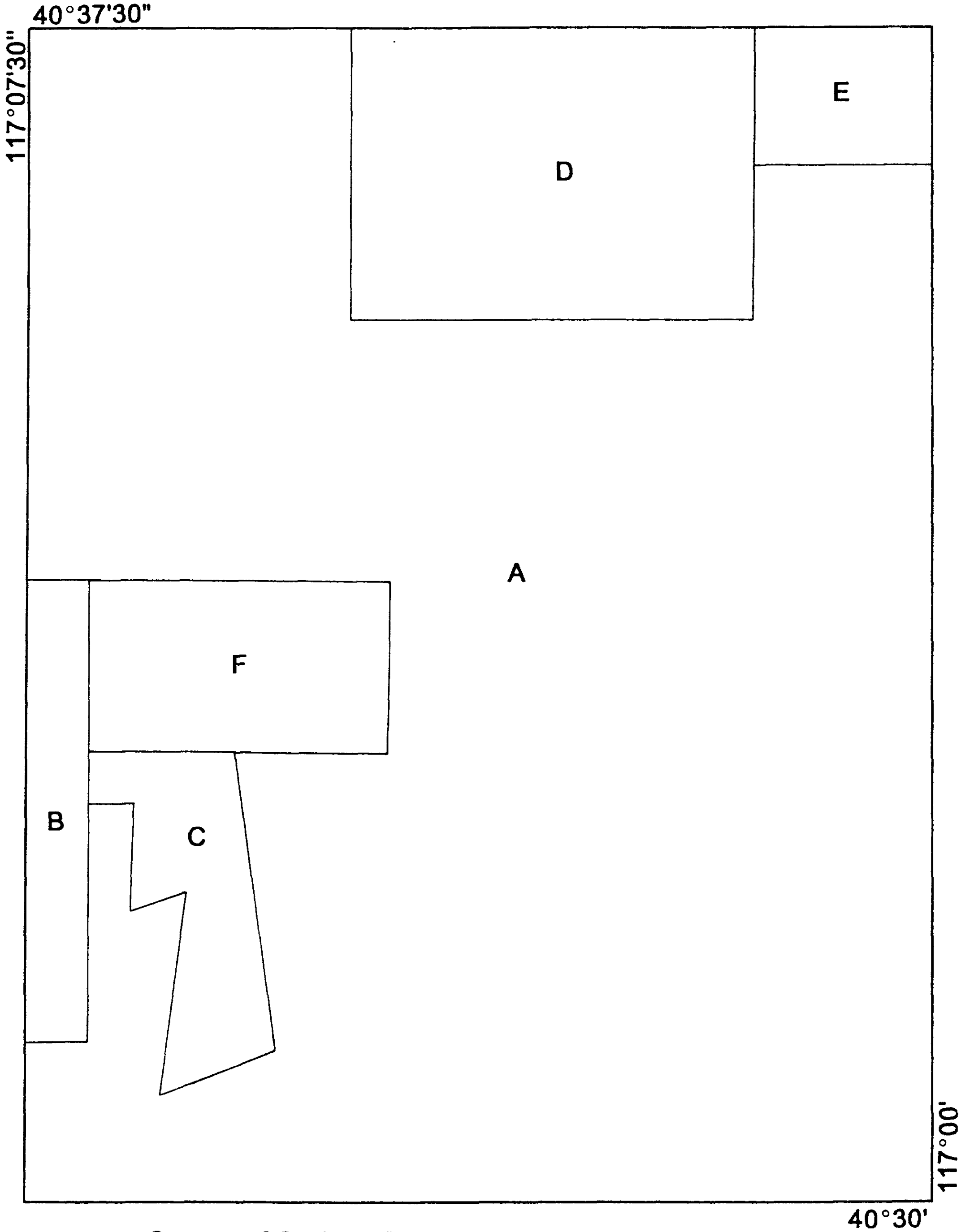
CORRELATION OF MAP UNITS





Sources of Geologic Data

A - J.L. Doebrich, geologic mapping, 1993
B - Modified from Theodore and Blake (1975)
C - Modified from Battle Mountain Gold Co., unpub. data, 1991
D - Modified from Theodore and others (1992)
E - Modified from Theodore and Jones (1992)
F - Modified from L.B. McCollum and M.B. McCollum, unpub. data, 1986