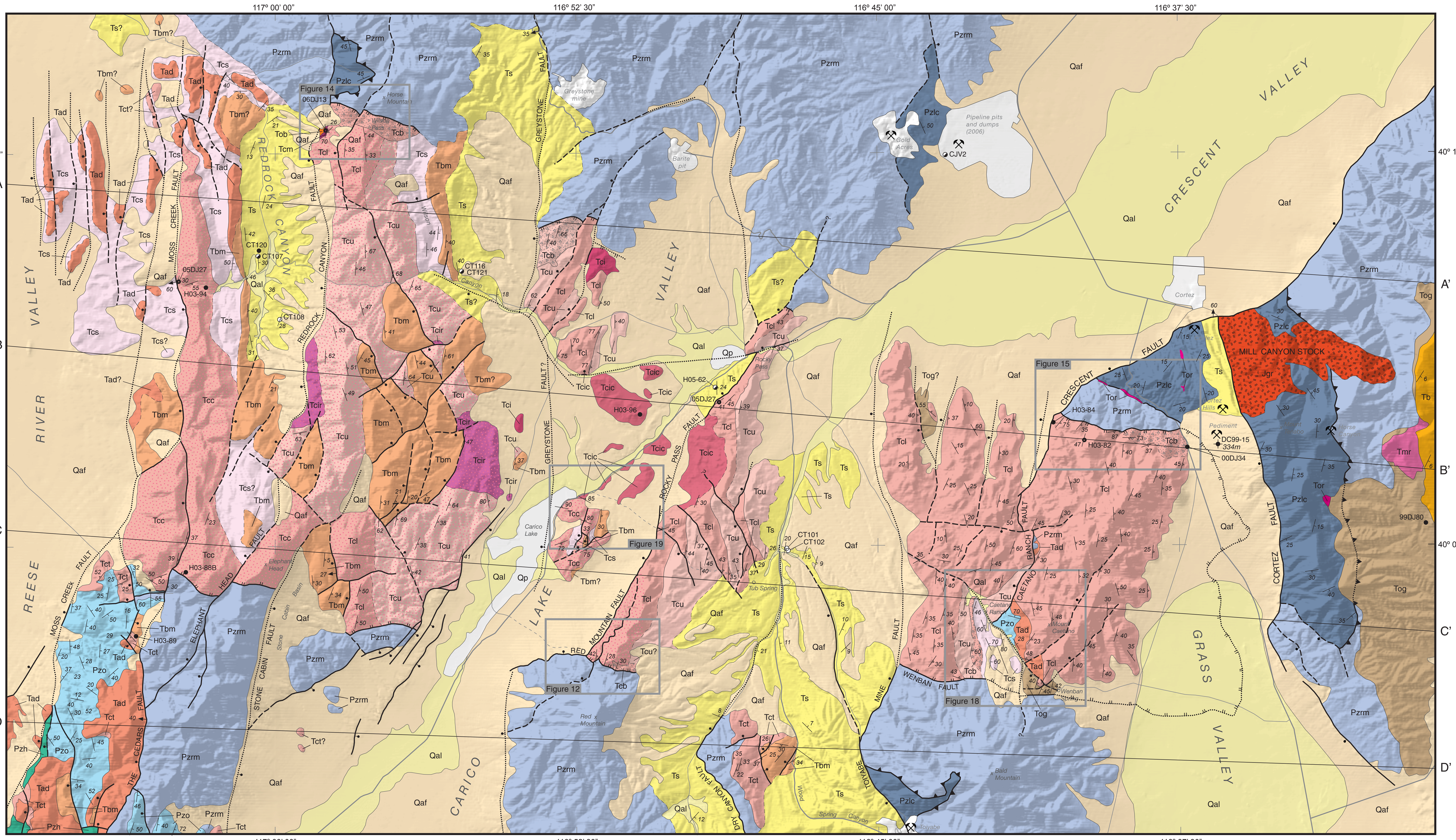
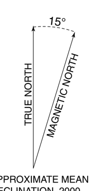
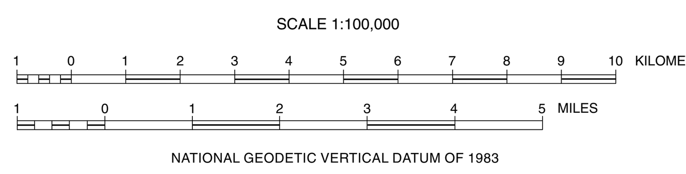
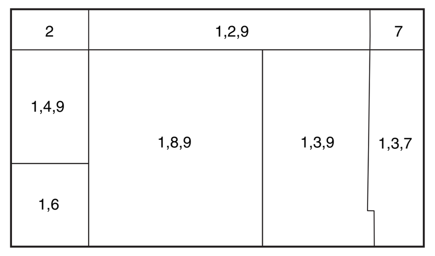


Shaded-relief topography from USGS National Elevation Dataset (30m grid; *http://ned.usgs.gov*).
Base map from USGS *Crescent Valley* and *Fish Creek Mountains* quadrangles (1:100,000 scale).
UTM Projection, Zone 11

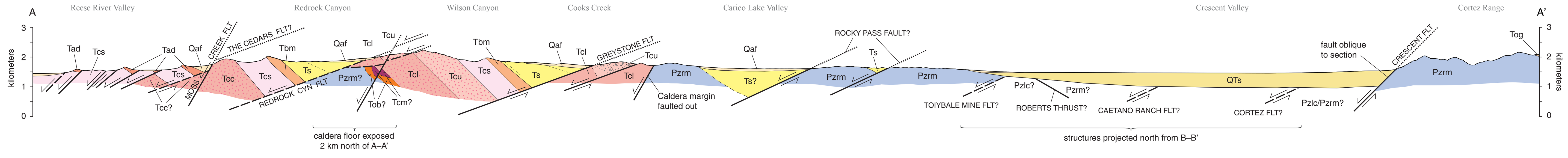


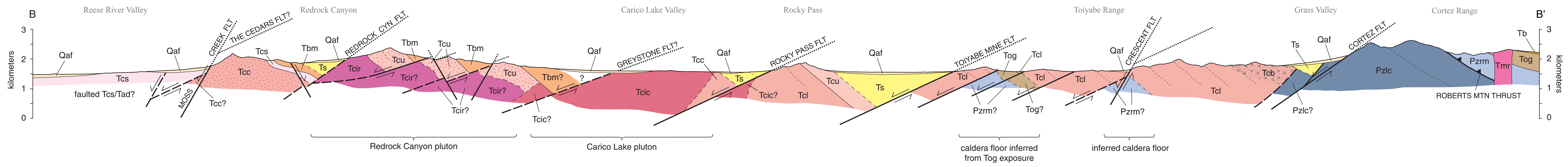


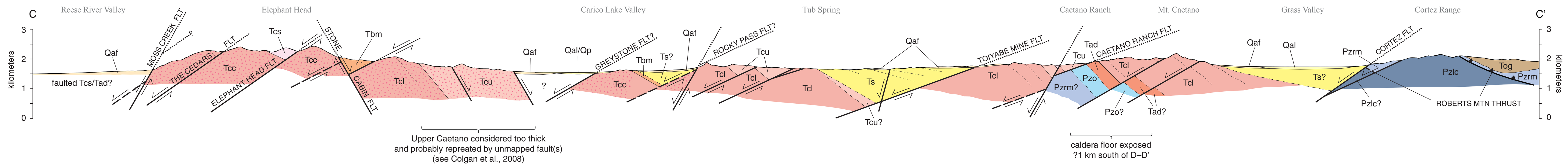


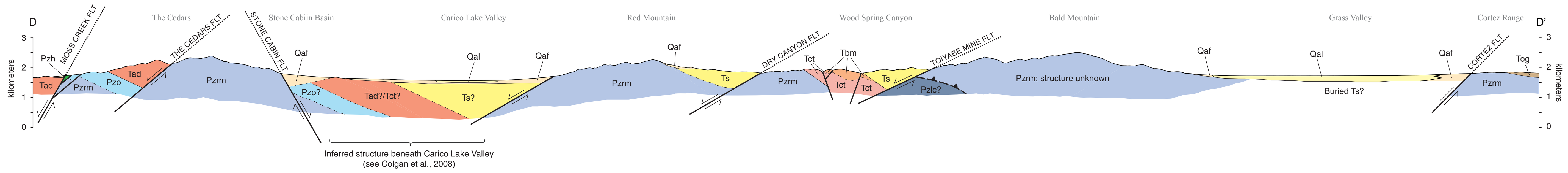
Sources of map data

1. New mapping by the authors.
2. Gilluly and Gates (1965)
3. Gilluly and Masursky (1965)
4. McKee and Stewart (1969)
5. Stewart and McKee (1969)
6. Moore et al. (2007)
7. Roberts et al. (1967)
8. Stewart and McKee (1969)
9. Stewart and McKee (1977)









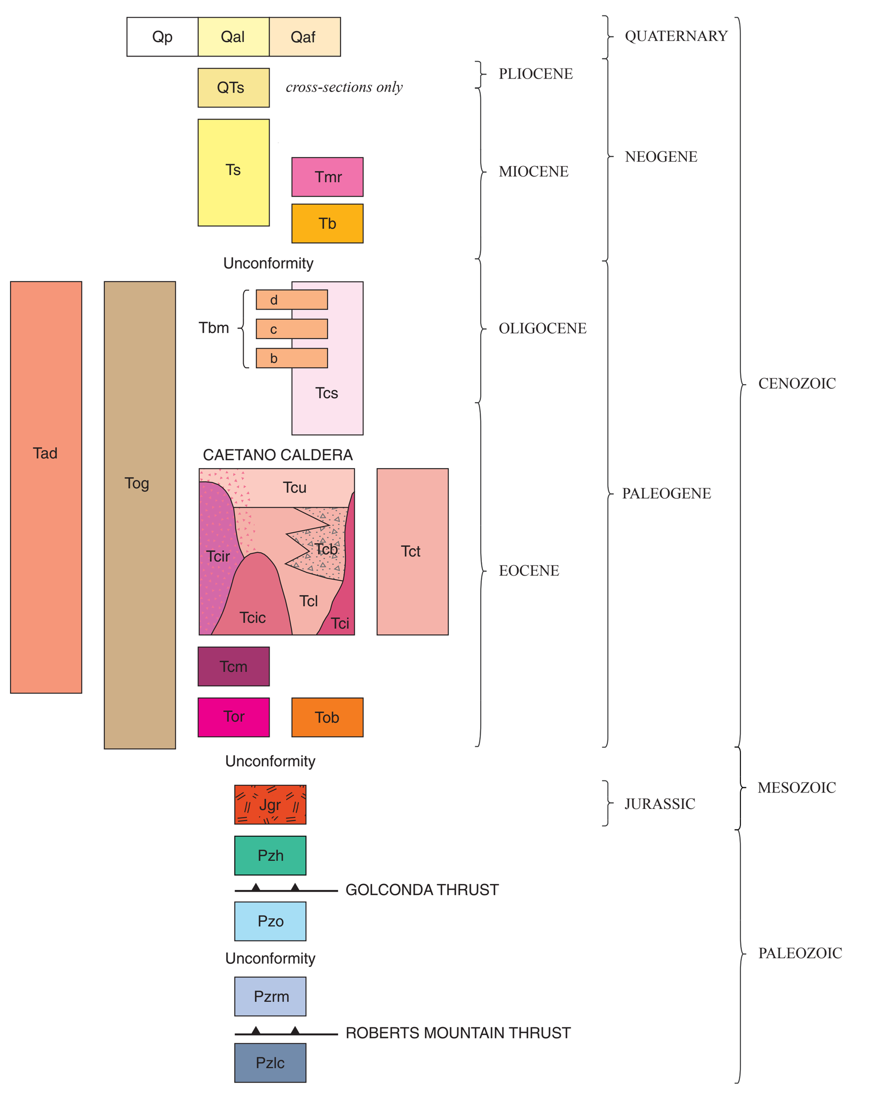
GEOLOGIC MAP AND CROSS-SECTIONS OF THE CAETANO CALDERA, LANDER COUNTY, NEVADA

By
Joseph P. Colgan, Christopher D. Henry, and David A. John

2008

Geologic Map and Cross Sections of the Caetano Caldera, Lander County, Nevada
Colgan et al.
Plate 1
Supplement to *Geosphere*, v. 4, no. 1 (February 2008)

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qal — **Alluvium (Holocene)**—Unconsolidated alluvial sand and gravel and lacustrine deposits in modern stream beds and valleys.

Qaf — **Alluvial-fan deposits (Quaternary)**—Unconsolidated to poorly consolidated deposits of boulders, gravel, and sand that form the modern alluvial fans and pediment surfaces mostly developed on Miocene sedimentary rocks.

Qp — **Playa deposits (Quaternary)**—Clay, silt, and sand forming surface deposits in ephemeral lake basins in Carico Lake Valley

QTs — **Basin fill (Quaternary to late Miocene)**—Sediments filling Crescent Valley, shown in cross section only. Inferred to have been deposited during late Miocene to Holocene slip on the Crescent Fault.

Tmr — **Rhyolite dome (Miocene)**—Flow-banded rhyolite dome intruding Paleozoic sedimentary rocks and Tertiary gravel (Tog) along crest of Cortez Range. Sanidine K-Ar age is 15.6 ± 0.4 Ma (Wells et al., 1971, recalculated).

Tb — **Basaltic andesite (Miocene)**—Basaltic andesite lava flows up to 100 m thick on the southeastern crest of the Cortez Range. Whole-rock $^{40}Ar/^{39}Ar$ ages are 16.36 ± 0.05 and 16.67 ± 0.14 Ma (Colgan et al., 2008).

MIDDLE MIOCENE SEDIMENTARY ROCKS

Ts — **Sedimentary rocks (Miocene)**—Poorly exposed sandstone and conglomerate with lesser finer-grained tuffaceous deposits. Mostly light gray-brown, fine- to medium-grained sandstone in beds 10–20 cm thick, containing variable amounts of pyroclastic material including glass shards and crystal and lithic fragments. Sandstones locally contain thin (~10 cm) lenticular beds of conglomerate with 1–5 cm clasts of quartzite, chert, and/or volcanic rocks. More extensive conglomerate deposits consist of poorly consolidated, light-brown, massively bedded, medium- to fine-grained sandstone containing matrix-supported (locally channelized), angular to subrounded cobbles as much as 50 cm across (generally 1–5 cm). Clasts most commonly consist of gray Paleozoic quartzite and chert and locally of Caetano Tuff. Sandstone and conglomerate interbedded with thinly laminated (<1 cm), white tuffaceous shale and 2–5 m thick beds of light gray to white volcanic ash. Age approximately 16–12 Ma, based on sanidine $^{40}Ar/^{39}Ar$ dates and tephra correlations (Colgan et al., 2008).

CENOZOIC ROCKS POSTDATING THE CAETANO CALDERA

Tbm — **Bates Mountain Tuff (Oligocene)**—Composite map unit composed of rhyolite ash-flow tuffs and locally interbedded sedimentary rocks (Tcs). This unit encompasses three genetically unrelated ash-flow tuffs corresponding to units B, C, and D of the Bates Mountain Tuff as defined for exposures at Bates Mountain about 60 km south of the map area (Stewart and McKee, 1968; McKee, 1968; Sargent and McKee, 1969; Gromme et al., 1972). Not all units are present in all sections. $^{40}Ar/^{39}Ar$ ages from John et al. (2007).

Tbm — **D unit of Bates Mountain Tuff**—Mostly densely welded, pumice-rich, and sparsely porphyritic ash-flow tuff containing ~5% phenocrysts of sanidine, anorthoclase, plagioclase, and sparse quartz and biotite. Sanidine $^{40}Ar/^{39}Ar$ age is 25.27 ± 0.07 Ma. Equivalent to Nine Hill Tuff (Bingler, 1978; Deino, 1989).

Tbm — **C unit of Bates Mountain Tuff**—Poorly to densely welded, pumiceous, sparsely porphyritic ash-flow tuff containing phenocrysts of plagioclase, sanidine, prominent embayed quartz, and biotite. Sanidine $^{40}Ar/^{39}Ar$ age is 28.64 ± 0.06 Ma. Equivalent to tuff of Campbell Creek in central and western Nevada (McKee and Conrad, 1987; Henry et al., 2004; Faulds et al., 2005).

Tbm — **B unit of Bates Mountain Tuff**—Moderately to densely welded, sparsely pumiceous, moderately porphyritic ash-flow tuff containing phenocrysts of plagioclase, sanidine, and biotite. Sanidine $^{40}Ar/^{39}Ar$ age is 30.48 ± 0.07 Ma. Equivalent to tuff of Sutcliffe in western Nevada (Henry et al., 2004; Faulds et al., 2005).

Tcs — **Post-caldera sedimentary rocks (Oligocene)**—Platy to poorly bedded, pale gray to greenish weathering, tuffaceous sandstone and siltstone, white finely laminated shale, and boulder to pebble conglomerate containing clasts of porphyritic andesite to 60 cm in diameter and some Paleozoic rocks. Present within the Caetano caldera where they overlie Caetano Tuff. Probably deposited in lacustrine, fluvial and (locally) alluvial fan settings.

EXPLANATION

Contact—Solid where observed in the field by the authors. Dashed where interpreted from air photos or other published maps.

27
Normal Fault—Ball and bar on downthrown side. Arrow indicates dip and dip direction. Solid where observed in the field by the authors. Dashed where interpreted from air photos or other published maps. Dotted where concealed by alluvium.

Caldera Margin—Tick marks toward caldera interior. Solid where observed in the field by the authors. Dashed where interpreted from air photos or other published maps. Dotted where concealed by alluvium.

Thrust Fault—Teeth on upper plate. Solid where observed in the field by the authors. Dashed where interpreted from air photos or other published maps. Dotted where concealed by alluvium.

7 **Strike and dip of inclined bedding**

33 **Strike and dip of compaction foliation in ash-flow tuff**

00DJ34 **$^{40}Ar/^{39}Ar$ sample locality**

DC99 334m **$^{40}Ar/^{39}Ar$ sample locality from drill hole**—Depth in meters.

CT101 **Tephrachronology sample locality**

CT107 **$^{40}Ar/^{39}Ar$ and tephrachronology sample locality**

Mineral deposit

Figure 12 **Extent of detailed geologic map**—Figure numbers correspond to 1:24,000-scale geologic maps in John et al. (2008).

CAETANO CALDERA AND RELATED ROCKS

Tcic — **Carico Lake pluton (Eocene)**—Carico Lake pluton consists of 50–60%, 1–5 mm phenocrysts of smoky quartz, sanidine, plagioclase and 2–3% biotite and hornblende in a microcrystalline quartz-feldspar groundmass. Scattered sanidine phenocrysts are as much as 2 cm long. Small miarolitic cavities are common. Locally flow banded. Intrudes and deforms Caetano Tuff. Sanidine $^{40}Ar/^{39}Ar$ age is 33.78 ± 0.05 Ma (John et al., 2008).

Tcir — **Redrock Canyon pluton (Eocene)**—Strongly altered fine- to medium-grained granite porphyry containing about 30% phenocrysts of rounded smoky quartz and altered sanidine and plagioclase in a felsite groundmass now altered to kaolinite and quartz. Undated but presumed to be late Eocene. Intrudes and hydrothermally alters Caetano Tuff.

Tci — **Caetano intrusive rocks, undivided (Eocene)**—Small ring-fracture intrusion in northwestern Carico Lake Valley is a fine- to medium-grained porphyry with sparse white K-feldspar phenocrysts as much as 1 cm long. It consists of about 45% phenocrysts of plagioclase, K-feldspar, and dark-gray quartz and 3% biotite and sparse hornblende in a microcrystalline groundmass. Small intrusion 2 km northwest of Carico Lake is fine-grained granite porphyry containing about 25–30%, 0.1–3 mm phenocrysts of rounded smoky quartz, sanidine, and plagioclase, and 1-2% biotite and hornblende in an aphanitic groundmass containing abundant miarolitic cavities. Both intrusions are undated but presumed to be late Eocene.

Tct — **Caetano Tuff, outflow sheet (Eocene)**—Densely welded, crystal-rich rhyolite ash-flow tuff identical in composition and age to intracaldera Caetano Tuff (unit Tcc). Forms densely welded, reddish weathering ledges with up to 250 m composite thickness. Black vitrophyric zones locally present. Sanidine $^{40}Ar/^{39}Ar$ ages are 33.83 ± 0.05 and 33.75 ± 0.06 Ma (John et al., 2008).

Tcb — **Caetano Tuff, breccia (Eocene)**—Mesobreccia and megabreccia dominated by coarse clasts of quartzite and chert. Mesobreccia is massive to thick bedded, quartzite-dominated breccia containing clasts up to 2 m in diameter, mostly matrix supported. Matrix varies from tuffaceous to finely ground quartzite. Also includes matrix-supported, quartzite-argillite pebble layers and sparse interbeds of volcanic sandstone and tuff. Probably deposited by rock falls and debris flows, and possibly by fluvial processes. Megabreccia is composed of individual blocks up to 50 m in diameter, mostly of chert or quartzite, but also Eocene (35 Ma) rhyolite in the northeastern part of the caldera (probably equivalent to Tor), and composite areas of blocks up to ~1 km across, locally with a tuffaceous matrix.

Tcu — **Caetano Tuff, upper intracaldera unit (Eocene)**—Multiple, thin, cooling units of poorly welded to moderately or (rarely) densely welded ash-flow tuffs locally interbedded with coarse conglomerate, sandstone, and fine, platy tuffaceous siltstone. Generally forms pale or banded slopes punctuated by thin ledges of more resistant welded tuff. Tuffs commonly contain angular fragments of densely welded lower Caetano Tuff up to 1.4 m in diameter and locally contain hornblende-pyroxene andesite and Paleozoic fragments to 15 cm. Poorly to moderately welded tuffs are characterized by distinctive orange pumice fragments. Up to 1000 m thick; base of unit defined as a prominent welding break at the top of the lower unit (Tcc), which generally forms a conspicuous slope break marked by a vitrophyre or several meters of conglomerate or sandstone.

Tcl — **Caetano Tuff, lower intracaldera unit (Eocene)**—Compound cooling unit of densely welded, crystal-rich, rhyolite ash-flow tuff, containing about 35–50 volume % phenocrysts as much as 5 mm in maximum dimension. Quartz, sanidine, and plagioclase form >90% total phenocrysts. Distinctive quartz phenocrysts are dark gray to black (smoky) and partly resorbed. Total mafic mineral content generally <4 volume %, consisting mainly of biotite with minor opaque minerals and locally trace hornblende. Euhedral allanite crystals as much as 1 mm long, apatite, and zircon are common accessory phenocryst phases. Strongly flattened pumice fragments generally are crystal rich and contain phenocryst assemblages similar to the matrix. Exposed thickness ranges from 1800 to >3400 m. Weighted mean of nine sanidine $^{40}Ar/^{39}Ar$ ages from both upper and lower units is 33.80 ± 0.05 Ma (John et al., 2008).

Tcc — **Caetano Tuff, upper and lower units (Tcu and Tcl) undivided.**

Hydrothermal alteration—Hydrothermally altered Caetano Tuff and intrusive rocks. White, dark-gray, and dark yellow-gray, commonly red weathering hydrothermally altered rocks. Variable intermediate and advanced argillic alteration assemblages in which plagioclase phenocrysts replaced by kaolinite, sanidine is unaltered, perthitic, or replaced by kaolinite, biotite replaced by kaolinite, white mica, and/or opaque oxides, and groundmass replaced by fine-grained silica and/or kaolinite and fine-grained pyrite. Locally, plagioclase and sanidine are completely leached leaving prominent voids in a siliceous matrix. Most pyrite is oxidized. Locally contains abundant hematite.

CENOZOIC ROCKS PREDATING THE CAETANO CALDERA

Tcm — **Tuff of Cove Mine (Eocene)**—Crystal-rich, rhyolite ash-flow tuff with 30–50% phenocrysts of quartz, sanidine, plagioclase, biotite, and hornblende. Distinguished from the petrographically similar Caetano Tuff by greater total mafic mineral (6–10 volume %) and plagioclase content. Typically contains 5–8 volume % biotite and 1–2% hornblende. Weighted mean of four sanidine $^{40}Ar/^{39}Ar$ ages is 34.22 ± 0.01 Ma (John et al., 2008).

Tor — **Rhyolite domes and dikes (Eocene)**—Flow-banded, finely, sparsely porphyritic sanidine-quartz-biotite rhyolite lava dome in the southern Cortez Range and numerous dikes in the northern Toiyabe Range. U-Pb zircon age of lava dome is 35.2 ± 0.2 Ma (Mortensen et al., 2000). K-Ar ages from lava dome are 35.2 ± 1.1 Ma (sanidine) and 35.3 ± 1.2 Ma (biotite); K-Ar ages from dikes are 34.7 ± 1.1 to 35.8 ± 1.2 Ma (Wells et al., 1971, recalculated).

Tad — **Andesite and dacite lava (Eocene and Oligocene)**—Finely to coarsely porphyritic andesite and dacite lava flows with phenocrysts comprised mostly of plagioclase and pyroxene with local hornblende. Composite unit includes lavas that predate formation of the Caetano caldera together with flows interbedded in post-caldera sedimentary rocks (unit Tcs). Includes dacite of Wood Canyon mapped by Moore et al. (2007) in the southwestern part of the map area.

Tob — **Basaltic lava flows (Eocene)**—Dark gray, weakly propylitized, fine-grained sparsely porphyritic plagioclase-pyroxene basalt lava flows on the floor of the Caetano caldera west of Wilson Pass. Undated but stratigraphically beneath the tuff of Cove Mine.

Tog — **Boulder to pebble conglomerate and sandstone (Miocene to Eocene)**—Poorly sorted and poorly lithified unit deposited unconformably on Paleozoic basement. More than 400 m thick in the southern Cortez Range, where it contains blocks up to 10 m across of Paleozoic rocks, granitic rocks, porphyritic andesites, flow-banded rhyolites, Caetano Tuff, and several units of Bates Mountain Tuff. Sanidine $^{40}Ar/^{39}Ar$ age from a reworked ash layer in this deposit is 33.97 ± 0.20 Ma (John et al., 2008). Forms part of the caldera floor near Wenban Spring in Toiyabe Range, where it is dark red, moderately well bedded and calcite cemented with angular to subrounded clasts of Paleozoic limestone, chert, and minor quartzite to 90 cm. Also inferred to form part of caldera floor on northwest edge of Toiyabe Range, where lithified conglomerate contains subrounded clasts of quartzite, chert, argillite, granite, diorite, and flow-banded porphyritic rhyolite as much as 1.5 m in diameter in a sandy non-calcareous matrix.

MESOZOIC ROCKS

Jgr — **Mill Canyon Stock (Jurassic)**—Biotite quartz monzonite, locally with plagioclase phenocrysts. Zircon U-Pb age is 158.4 ± 0.6 Ma (Mortensen et al., 2000).

PALEOZOIC ROCKS

Pzh — **Havallah Sequence (Golconda Allochthon) (Permian to Mississippian)**—Argillite, chert, sand, and siltstone mapped by Moore et al. (2005) in the southwestern part of the map area.

Pzo — **Antler Overlap Assemblage (Permian to Pennsylvanian)**—Rocks deposited in angular unconformity on the Roberts Mountains Allochthon. Includes predominantly clastic rocks of the Permian Horseshoe Basin Sequence (Raucheboeuf et al., 2004) and the Pennsylvanian and Permian Cedars Sequence (Moore et al., 2005).

Pzrm — **Roberts Mountains Allochthon (Devonian to Ordovician)**—Argillite, chert, quartzite, sandstone, greenstone, and minor limestone. Includes rocks assigned to the Valmy Formation, Vinini Formation, Elder Sandstone, and Slaven Chert (Gilluly and Gates, 1965; Gilluly and Masursky, 1965).

Pzlc — **Lower plate of Roberts Mountains Allochthon (Devonian to Cambrian)**—Limestone, dolomite, quartzite, and shale. Includes rocks assigned to the Wenban Limestone, Roberts Mountains Formation, Hanson Creek Formation, Eureka Quartzite, and Hamburg Dolomite (Gilluly and Gates, 1965; Gilluly and Masursky, 1965).

REFERENCES

Bingler, E.C., 1978, Abandonment of the name Hartford Hill Rhyolite Tuff and adoption of new formation names for middle Tertiary ash-flow tuffs in the Carson City-Silver City area, Nevada: Nevada Bureau of Mines and Geology Bulletin 1457-D, 19 p.
Colgan, J.P., John, D.A., and Henry, C.D., 2008, Large-magnitude Miocene extension of the Eocene Caetano caldera, Shoshone and Toiyabe Ranges, Nevada: Geosphere, doi: 10.1130/GES00115.1.
Deino, A.L., 1989, Single crystal $^{40}Ar/^{39}Ar$ dating as an aid in correlation of ash flows: Examples from the Chimney Springs/New Pass Tuffs and the Nine Hill/Bates Mountain Tuffs of California and Nevada: New Mexico Bureau of Mines and Mineral Resources, Continental Magmatism Abstracts Bulletin 131, p. 70.
Faulds, J.E., Henry, C.D., and dePolo, C.M., 2003, Preliminary geologic map of the Tule Peak Quadrangle, Washoe County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 03-10, 1:24,000.
Gilluly, J., and Gates, O., 1965, Tectonic and igneous geology of the northern Shoshone Range, Nevada: U.S. Geological Survey Professional Paper 465, 153 p., scale 1:31,680.
Gilluly, J., and Masursky, H., 1965, Geology of the Cortez quadrangle, Nevada: U.S. Geological Survey Bulletin 1175, scale 1:62,500.
Gromme, C.S., McKee, E.H., and Blake, M.C., Jr., 1972, Paleomagnetic correlations and potassium-argon dating of middle Tertiary ash-flow sheets in the eastern Great Basin, Nevada and Utah: Geological Society of America Bulletin, v. 83, p. 1619–1638.
Henry, C.D., Faulds, J.E., dePolo, C.M., and Davis, D.A., 2004, Geology of the Dogskin Mountain Quadrangle, northern Walker Lane, Nevada: Nevada Bureau of Mines and Geology Map 148, scale 1:24,000, 13 p. text.
John, D.A., Henry, C.D., and Colgan, J.P., 2008, Magmatic and tectonic evolution of the Caetano caldera, north-central Nevada: A tilted mid-Tertiary eruptive center and source of the Caetano Tuff: Geosphere, doi: 10.1130/GES00116.1.
McKee, E.H., 1968, Geologic map of the Spencer Hot Springs Quadrangle, Lander and Eureka Counties, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ-770.
McKee, E.H., and Conrad, J.E., 1987, Geologic map of the Desatoya Mountains Wilderness Study Area, Churchill and Lander counties, Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1944, scale 1:62,500.
McKee, E.H., and Stewart, J.H., 1969, Geologic map of The Cedars [15'] quadrangle, Lander County, Nevada: U.S. Geological Survey Open-File Report 69-268, scale 1:62,500.
Moore, T.E., O'Sullivan, P.B., Murchey, B.L., Moring, B.C., Harris, A.G., Blodgett, R.B., and Fleck, R.J., 2005, Geologic map of The Cedars quadrangle, southern Shoshone Range, Nevada: Window to the world: Reno, Nevada, Geological Society of Nevada Symposium Proceedings, May 14-18, p. 67.
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, Nevada, *in* Cluer, J.K., Price, J.G., Struhsacker, E.M., Hardyman, R.F., and Morris, C.L., eds.,
Geology and ore deposits 2000: The Great Basin and beyond: Reno, Nevada, Geological Society of Nevada Symposium Proceedings, May 15-18, p. 419-438.
Racheboeuf, P.R., Moore, T.E., and Boldgett, R.B., 2004, A new species of *Dyoros* (brachiopoda, chonetoidea) from Nevada (United States) and stratigraphic implication for the Pennsylvanian and Permian Antler overlap assemblage: Geobios, v. 37, p. 382-394.
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., scale 1:250,000.
Sargent, K.A., and McKee, E.H., 1969, The Bates Mountan Tuff in northern Nye County, Nevada: U.S. Geological Survey Bulletin, v. 1294-E, 12 p.
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, 1:62,500.
Stewart, J.H., and McKee, E.H., 1969, Geology of the Carico Lake quadrangle, Lander County, Nevada: U.S. Geological Survey Open-File Report 69-268, 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, 114 p., scale 1:250,000.
Wells, J.D., Elliott, J.E., and Obradovich, J.D., 1971, Age of the igneous rocks associated with ore deposits, Cortez-Buckhorn area, Nevada: U.S. Geological Survey Professional Paper 750-C, p. C127-C135.