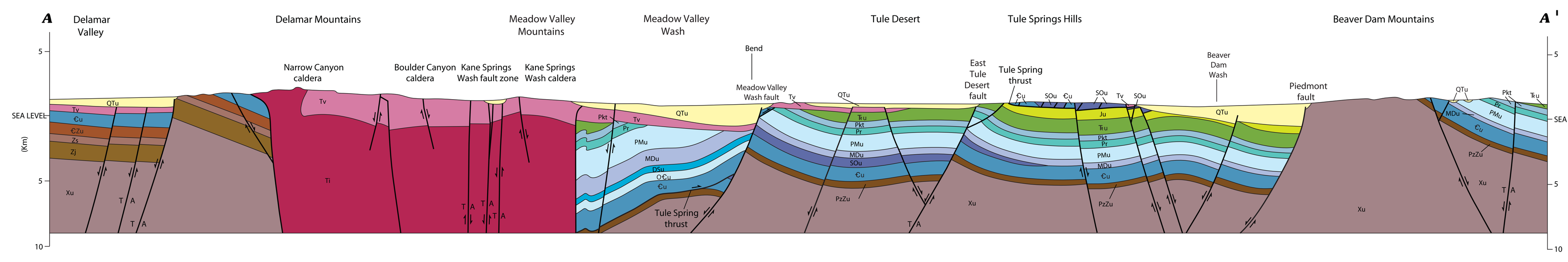
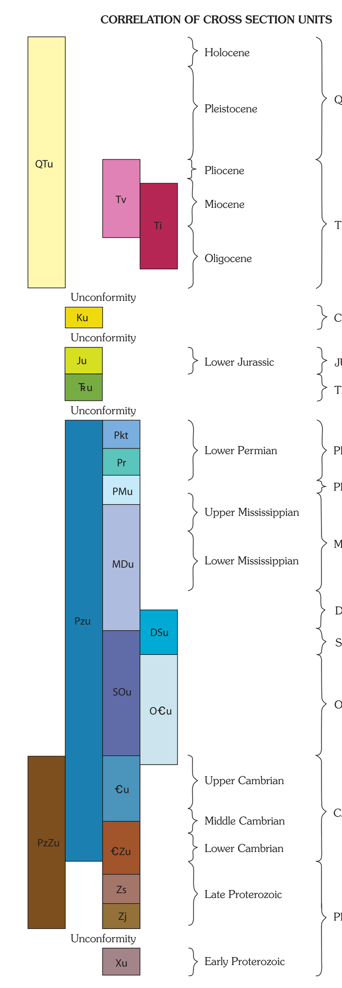
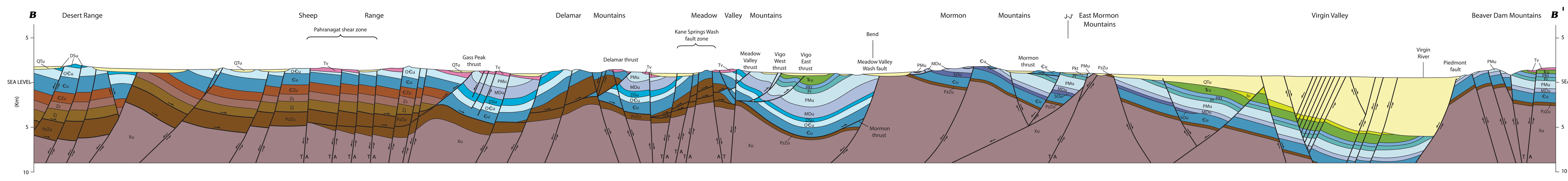
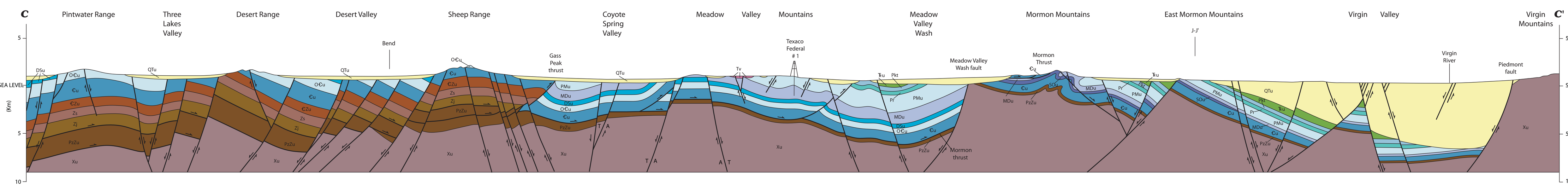
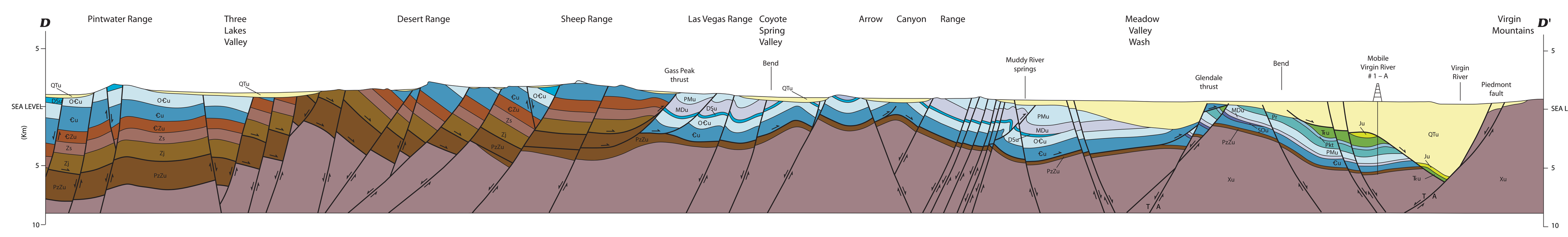
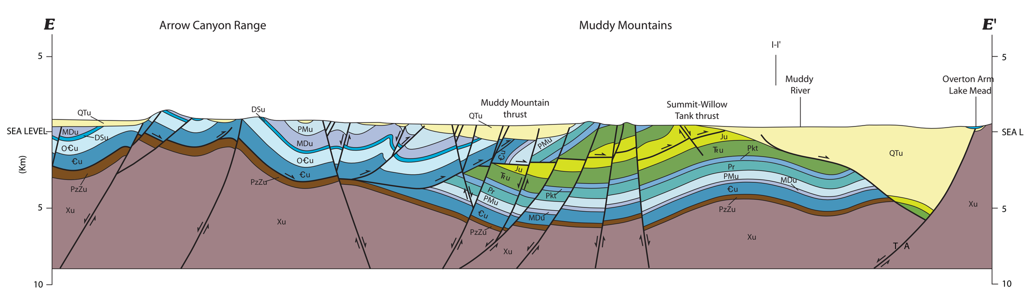


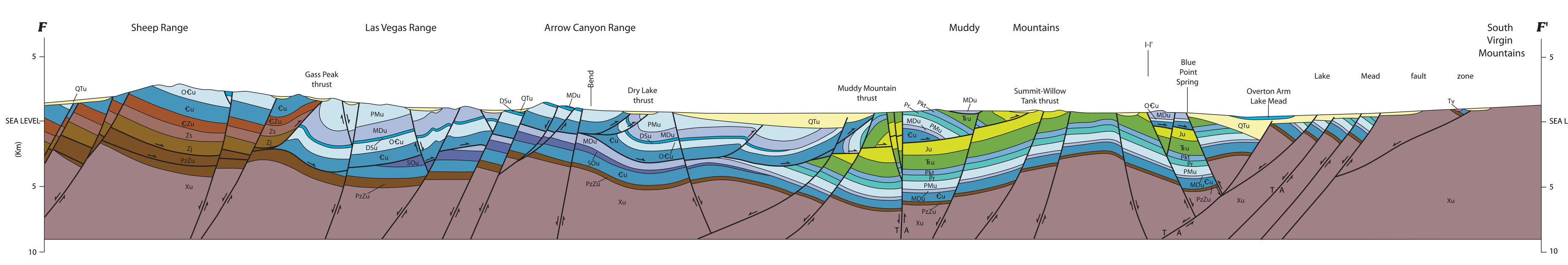


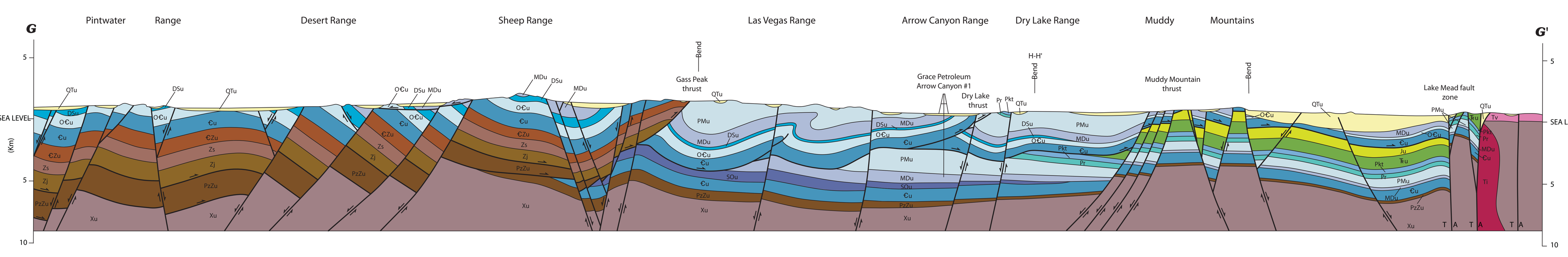


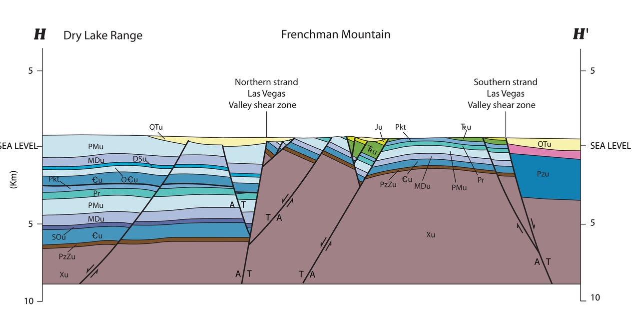


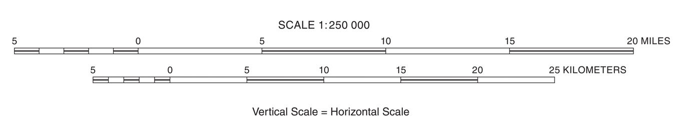


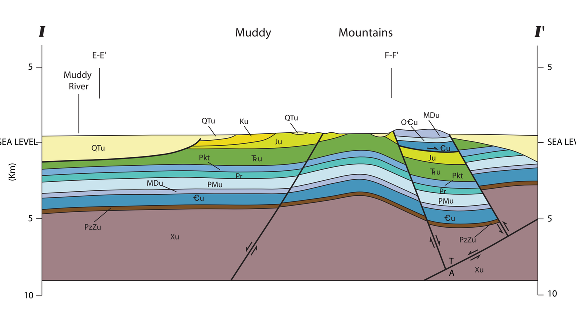


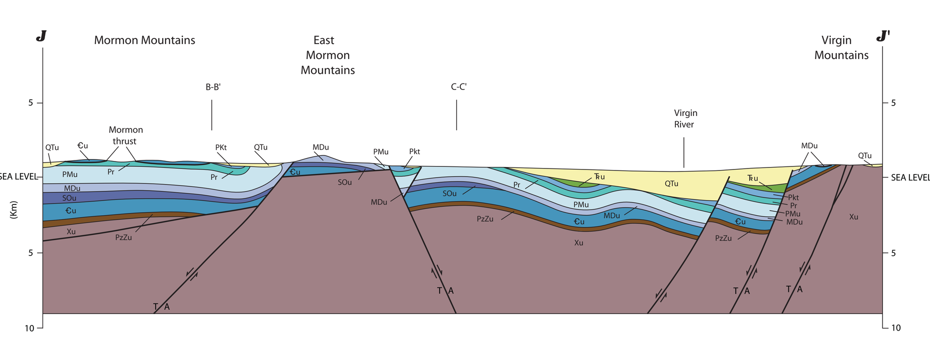












DESCRIPTION OF CROSS SECTION UNITS

QTu — **Quaternary and Tertiary rocks, undivided (Holocene to Oligocene)**—Alluvium (Holocene to Pliocene), playa deposits (Holocene to Pleistocene), eolian deposits (Holocene), spring discharge deposits (Holocene to Pleistocene), calcrete (Pleistocene to Pliocene), and landslide megabreccia deposits (Pleistocene to Miocene). Includes sedimentary rocks equivalent to the Muddy Creek Formation (Pliocene-Miocene), and the Horse Spring Formation (Miocene and Oligocene). Unit from 0 to greater than 8,000 m thick

Tv — **Tertiary volcanic rocks, undivided (Pliocene to Oligocene)**—Ash-flow tuff, airfall tuff, lava flows, and basalt flows. Exposed in the Delamar Mountains (A-A') and in the Lake Mead area (G-G'). Several hundred meters to greater than several thousand meters thick

Ti — **Tertiary intrusive rocks, undivided (Miocene and Oligocene)**—Granitic or silicic intrusive rocks in the Delamar Mountains (A-A') and in the Lake Mead area (G-G')

Ku — **Upper and Lower Cretaceous rocks, undivided**—Sevier-age synorogenic deposits, including the Baseline Sandstone (Upper and Lower Cretaceous) and Willow Tank Formation (Lower Cretaceous). The Baseline Sandstone and Willow Tank Formation, which overlie Jurassic sandstone along an angular unconformity, are exposed mostly in the Muddy Mountains and shown in I-I'. Unit has combined thickness of 1,000 to more than 1,600 m

Ju — **Lower Jurassic rocks, undivided**—Includes the Aztec Sandstone in most of southern Nevada (Basin and Range province), and the correlative Navajo Sandstone in southwest Utah and northwest Arizona (Colorado Plateau Province). Unit also includes the Kayenta and Moenave Formations, which underlie both the Aztec Sandstone and Navajo Sandstone. Exposed in Tule Springs Hills, Muddy Mountains, Beaver Dam Mountains, Virgin Mountains, and Lake Mead area. Unit has combined thickness of 1,000 to 2,200 m

Ŧu — **Triassic rocks, undivided**—Chinle (Upper Triassic) and Moenkopi (Middle? and Lower Triassic) Formations exposed in the eastern Meadow Valley Mountains, Tule Springs Hills, Mormon Mountains, Muddy Mountains, Beaver Dam Mountains, Virgin Mountains, and Lake Mead area. Unit has combined thickness of about 1,000 m

Pzu — **Paleozoic rocks undivided (Lower Permian to Cambrian)**—May include parts of all Paleozoic units listed below. Shown in H-H' south of Frenchman Mountain

Pkt — **Kaibab and Toroweap Formations, undivided (Lower Permian)**—Exposed in the eastern Meadow Valley Mountains, Tule Springs Hills, Mormon Mountains, Muddy Mountains, Beaver Dam Mountains, Virgin Mountains, and Lake Mead area. Unit is 300 to 500 m thick

Pr — **Lower Permian redbeds**—Unit defined by Longwell and others (1965) and correlated with parts of the Queantoweap and Esplanade Sandstones and the Hermit Formation. Exposed in the eastern Meadow Valley Mountains, Tule Springs Hills, Mormon Mountains, Muddy Mountains, Beaver Dam Mountains, Virgin Mountains, and Lake Mead area. Unit is 400 to 600 m thick

PMu — **Lower Permian to Upper Mississippian rocks, undivided**—Bird Spring (Lower Permian to Upper Mississippian) and Indian Springs (Upper Mississippian) Formations in west and central parts of the study area as far east as the Muddy Mountains, Tule Springs Hills, and Mormon Mountains, and Callville Limestone (Pennsylvanian) and Pakoon Dolomite in the eastern part of the study area in the Lake Mead area and in the Virgin and Beaver Dam Mountains. Combined thickness of unit from about 460 to 2,500 m thick

MDu — **Upper Mississippian to Lower Devonian rocks, undivided**—In the west and central parts of the study area includes the Joana Limestone (Lower Mississippian) or Monte Cristo Group (Upper and Lower Mississippian), Crystal Pass Limestone or Pilot Shale (Lower Mississippian to Upper Devonian), Guilmette Formation (Upper and Middle Devonian) or Sultan Limestone (Lower Mississippian to Middle Devonian), Simonson Dolomite (Middle Devonian), and Sevy Dolomite (Lower Devonian). Also includes Scotty Wash Quartzite and Chainman Shale (Upper Mississippian) in the northern Meadow Valley Mountains and Delamar Mountains. In the eastern part of the study area, in the Lake Mead area and the Virgin and Beaver Dam Mountains, includes the Redwall Limestone (Upper and Lower Mississippian) and Temple Butte Limestone (Upper and Middle(?) Devonian). Combined thickness of unit is from about 300 to 1,800 m

DSu — **Middle Devonian to Silurian rocks, undivided**—Rocks equivalent to parts ofthe Simonson Dolomite (Middle Devonian), Sevy Dolomite (Lower Devonian), and Laketown Dolomite (Silurian). Combined thickness from 200 to 780 m

SOu — **Lower Silurian and Ordovician rocks, undivided**—Rocks equivalent to the Laketown Dolomite (Lower Silurian), the Ely Springs Dolomite (Upper Ordovician), Eureka Quartzite (Middle Ordovician), and the Pogonip Group (mostly Upper and Middle Ordovician, but includes Cambrian rocks in the Sheep Range area). These rocks extend as far east as the Muddy Mountains, Mormon Mountains, and Tule Springs Hills. Unit only includes Ordovician rocks in the Muddy Mountains; Silurian and Ordovician rocks are absent in the Beaver Dam Mountains, Virgin Mountains, and Lake Mead area. Combined thickness of unit from 0 to 1,500 m

O€u — **Upper Ordovician to Upper Cambrian rocks, undivided**—Rocks equivalent to the Ely Springs Dolomite (Upper Ordovician), Eureka Quartzite (Middle Ordovician), and Pogonip Group (Middle Ordovician to Upper Cambrian). Combined thickness from about 550 to 1,200 m

€u — **Upper and Middle Cambrian rocks, undivided**—Includes Nopah (Upper Cambrian) and Bonanza King (Upper and Middle Cambrian) Formations in most parts of the study area. Equivalent rocks along the west end of A-A' in the northern Delamar Mountains include the Nopah Formation and Highland Peak Formation (Middle Cambrian). In the eastern part of the study area in the Beaver Dam and Virgin Mountains, and in the Lake Mead area, includes the Nopah and Muav (Middle Cambrian) Formations. Combined thickness of unit from about 500 to 2,200 m

PzZu — **Paleozoic and Late Proterozoic rocks, undivided**—In western part of study area unit may consist of Cambrian and Late Proterozoic units including the Nopah Formation (Upper Cambrian), Bonanza King Formation (Upper and Middle Cambrian), Carrara Formation (Middle and Lower Cambrian), Wood Canyon Formation (Lower Cambrian and Late Proterozoic), Stirling Quartzite (Late Proterozoic), and Johnnie Formation (Late Proterozoic). Late Proterozoic rocks pinch out in the eastern part of the study area where unit includes onlythe Bright Angel Shale (Middle and Lower Cambrian) and Tapeats Sandstone (Lower Cambrian) in the Mormon Mountains, Tule Springs Hills, Beaver Dam and Virgin Mountains, and Lake Mead area. Combined thickness of unit from 125 to greater than 2,000 m

€Zu — **Middle Cambrian and Late Proterozoic rocks, undivided**—In Pintwater, Desert, and Sheep Ranges includes the Carrara (Middle and Lower Cambrian) and Wood Canyon (Lower Cambrian and Late Proterozoic) Formations. In northern Delamar Mountains (west side of A-A') includes the Chisholm Shale (Middle Cambrian), Lyndon Limestone (Middle Cambrian), and Pioche Shale (Middle and Lower Cambrian). Combined thickness of unit from 360 to 1,000 m

Zs — **Late Proterozoic rocks, undivided**—Includes the Stirling Quartzite in the Pintwater, Desert, and Sheep Ranges, and the partially equivalent Prospect Mountain Quartzite in the northern Delamar Mountains (western part of A-A'). Unit is 600 to 800 m thick

Zj — **Johnnie Formation (Late Proterozoic)**—In the Pintwater, Desert, and Sheep Ranges includes Johnnie Formation; in northern Delamar Mountains includes rocks partly equivalent to the Johnnie Formation. About 1,000 m thick but greater than 1,000 m in northern part of study area

Xu — **Early Proterozoic crystalline rocks**—Gneiss, schist, and granite exposed at Frenchman Mountain, Lake Mead area, Virgin Mountains, Beaver Dam Mountains, and Mormon Mountains

Explanation of Cross Section Symbols

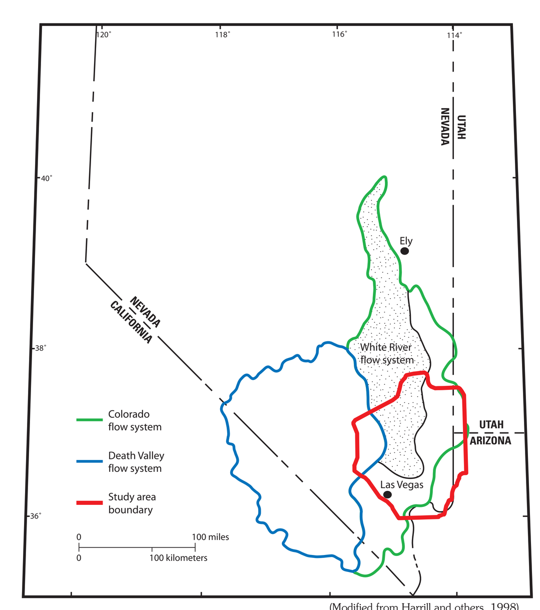
Contact

Normal fault—Arrows indicate direction of fault block movement

Oblique-slip fault—Arrows indicate direction of vertical movement; T indicates fault block movement toward the viewer, A indicates fault block movement away from viewer

Strike-slip fault—T indicates fault block movement toward the viewer, A indicates fault block movement away from viewer

Low-angle fault (low-angle normal or thrust fault)—Arrow indicates relative movement of overriding plate



(Modified from Harrill and others, 1998)

Figure 1. Map showing Death Valley, White River, and Colorado flow systems, and study area boundary.

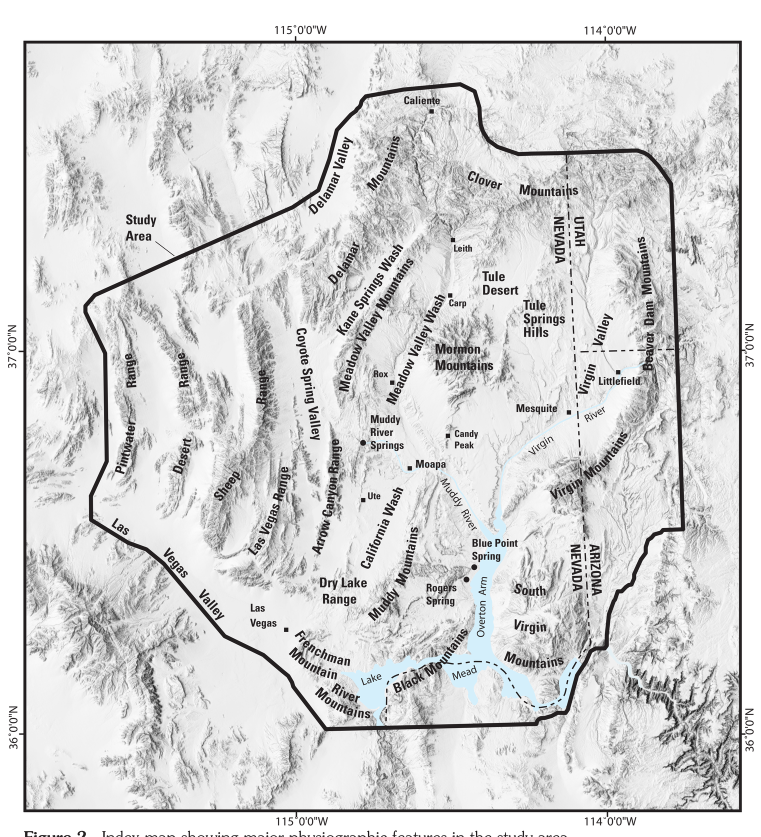


Figure 2. Index map showing major physiographic features in the study area.

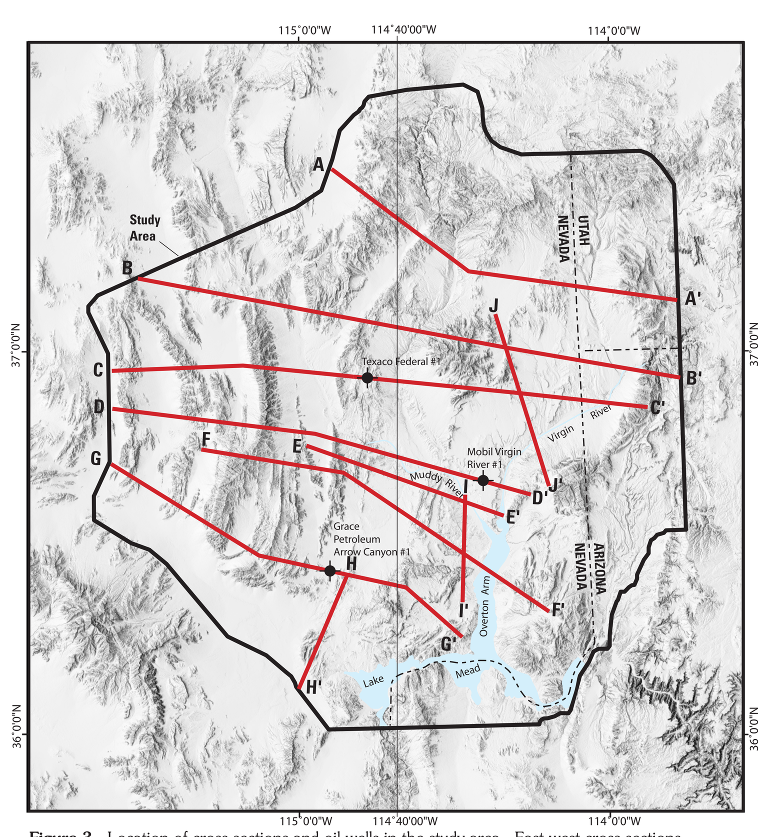


Figure 3. Location of cross sections and oil wells in the study area. East-west cross sections are hung on longitude 114° 40' 00" as a reference line to visually extrapolate the geology between the section lines in a north-south progression.

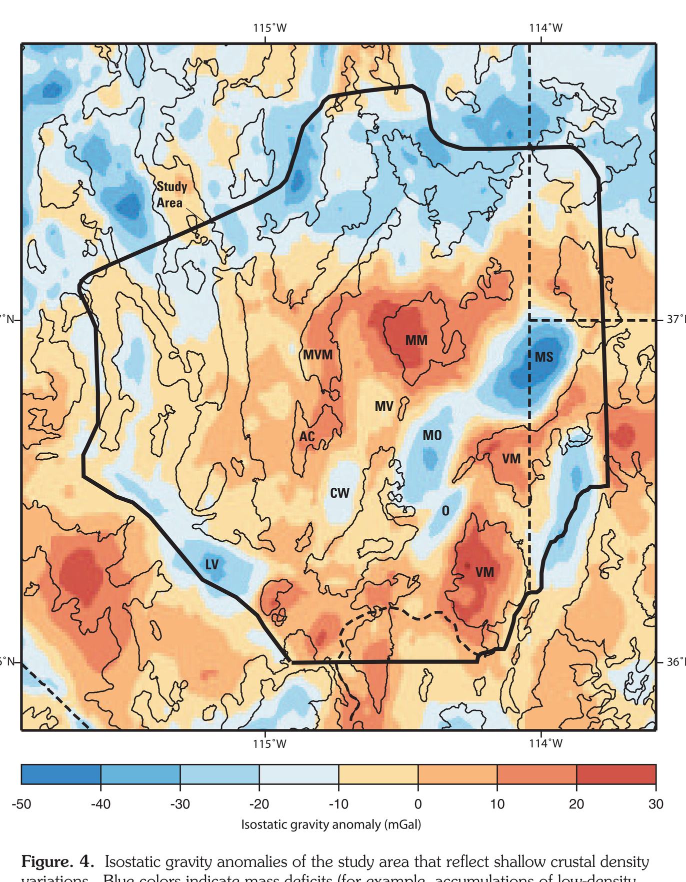


Figure. 4. Isostatic gravity anomalies of the study area that reflect shallow crustal density variations. Blue colors indicate mass deficits (for example, accumulations of low-density material such as Cenozoic basin-fill deposits and/or volcanic rocks) and red colors indicate mass excesses, generally in ranges comprised and underlain by dense units. MS, Mesquite basin; MO, Mormon basin; O, Overton Arm basin; CW, California Wash basin; LV, Las Vegas basin; MV, Lower Meadow Valley Wash basin; MVM, Meadow Valley Mountains; AC, Arrow Canyon Range; MM, Mormon Mountains; and VM, Virgin Mountains. Blue colors in northern part of study area are low-density volcanic rocks. Dark-red colors in Mormon Mountains, Virgin Mountains, and Lake Mead area are Early Proterozoic crystalline rock. Thin black solid lines are range outlines.

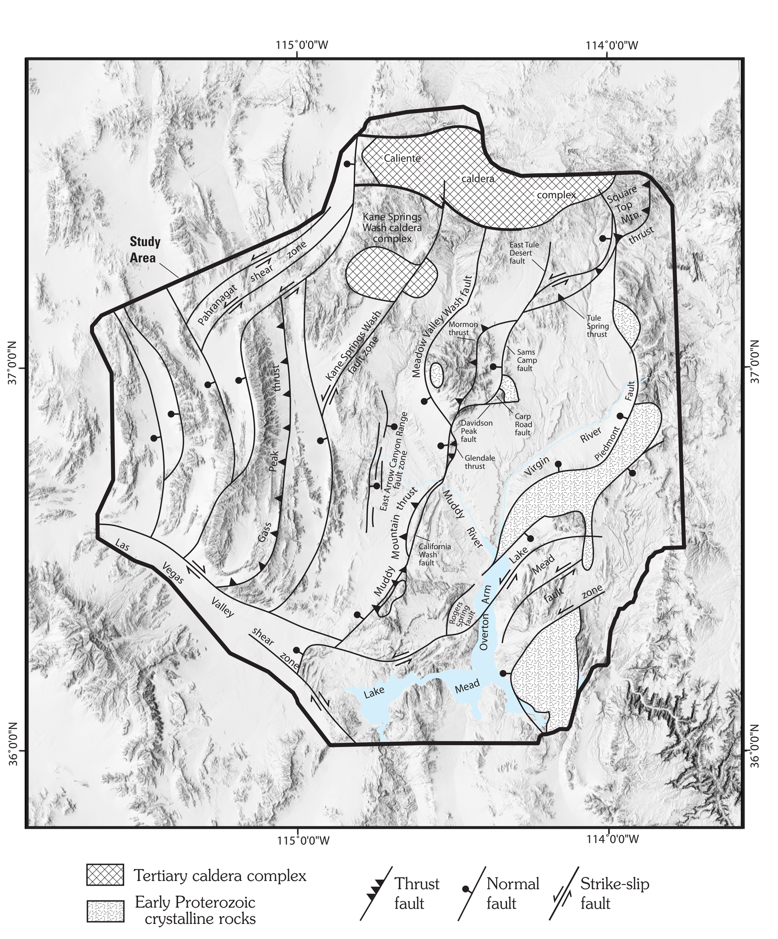


Figure 5. Generalized map of the principal structural features in the study area.

This Report	Page and others (2005a): Pintwater, Desert, Sheep, and Las Vegas Ranges	Clover and N. Delamar Mountains	S. Delamar and N. Meadow Valley Mountains	Arrow Canyon Range and S. Meadow Valley Mountains	Tule Springs Hills, Mormon and Muddy Mountains	Beaver Dam and Virgin Mountains, and Lake Mead area
Ku	Not Exposed	Not Exposed	Not Exposed	Not Exposed	Ku Willow Tank Fm. Baseline Ss.	Ku Willow Tank Fm. Baseline Ss. (NV); Iron Springs Fm. Cedar Mtn. Fm. (UT)
Ju		Jam Aztec Ss. Kayenta Fm. Moenave Fm.			Jam Aztec Ss. Kayenta Fm. Moenave Fm.	Jct Carmel Fm. Temple Cap Fm. (UT); Jam Aztec Ss. Kayenta Fm. Moenave Fm. (NV); Navajo Ss. (UT, AZ)
Ŧu		Ŧu Chinle Fm. Moenkopi Fm.	Ŧu Chinle Fm. Moenkopi Fm.		Ŧu Chinle Fm. Moenkopi Fm.	Ŧu Chinle Fm. Moenkopi Fm.
Pkt		Pkt Kaibab Fm. Toroweap Fm.	Pkt Kaibab Fm. Toroweap Fm.		Pkt Kaibab Fm. Toroweap Fm.	Pkt Kaibab Fm. Toroweap Fm.
Pr		Pr Lower Permian redbeds	Pr Lower Permian redbeds		Pr Lower Permian redbeds	Pr Lower Permian redbeds
PMu		PMb Bird Spring Fm. Indian Springs Fm.	PMb Bird Spring Fm. Indian Springs Fm.	PMb Bird Spring Fm. Indian Springs Fm.	PMb Bird Spring Fm. Indian Springs Fm.	PIPc Pakoon Dol. Callville Ls.
MDu	MDu Joana Ls. Pilot Sh. Guilmetle Fm.	Not Exposed	Msc Scotty Wash Qtz. and Chairman Sh.; MDu Joana Ls. Guilmette Fm.	Mm Monte Cristo Gp.; MDu Crystal Pass Ls. Guilmette Fm.	Mm Monte Cristo Gp.; MDu Sultan Ls.	Mr Redwall Ls.; Dtb Temple Butte Fm.
DSu	DSu Simonson Dol. Sevy Dol. Laketown Dol.		DSu Simonson Dol. Sevy Dol. Laketown Dol.	DSu Simonson Dol. Sevy Dol. Laketown Dol.	Absent	Absent
O€u / SOu	Oes Ely Springs Dol.; Oe Eureka Qtz.; O€p Pogonip Gp.		Oes Ely Springs Dol.; Oep Eureka Qtz. Pogonip Gp.	Oes Ely Springs Dol.; Oep Eureka Qtz. Pogonip Gp.	SOu Laketown Dol. Ely Springs Dol. Eureka Qtz. Pogonip Gp.; Op Pogonip Gp. (Muddy Mtns.)	
€u	€n Nopah Fm.; €bk Bonanza King Fm.	€n Nopah Fm.; €hp Highland Peak Fm.	€n Nopah Fm.; €bk Bonanza King Fm.	€n Nopah Fm.	€nb Nopah Fm. Bonanza King Fm.	€n Nopah Fm.; €m Muav Ls.
PzZu / €Zu	€c Carrara Fm.; €Zw Wood Canyon Fm.	€cp Lyndon Ls. Chislom Sh. Pioche Sh.; €Zw Wood Canyon Fm.	Not Exposed	Not Exposed	€bt Bright Angel Sh. Tapeats Ss.	€bt Bright Angel Sh. Tapeats Ss.
PzZu / Zs	Zs Stirling Qtz.	Zs Stirling Qtz.			Absent	Absent
PzZu / Zj	Zj Johnnie Fm.	Not Exposed				
Xu	Not Exposed				Xu	Xu

Table 1. Relationships between bedrock map units (Mesozoic-Proterozoic) in the cross sections and geologic map of Page and others (2005a).

GEOLOGIC CROSS SECTIONS OF PARTS OF THE COLORADO, WHITE RIVER, AND DEATH VALLEY REGIONAL GROUND-WATER FLOW SYSTEMS, NEVADA, UTAH, AND ARIZONA

By
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and Victoria E. Langenheim

2006