DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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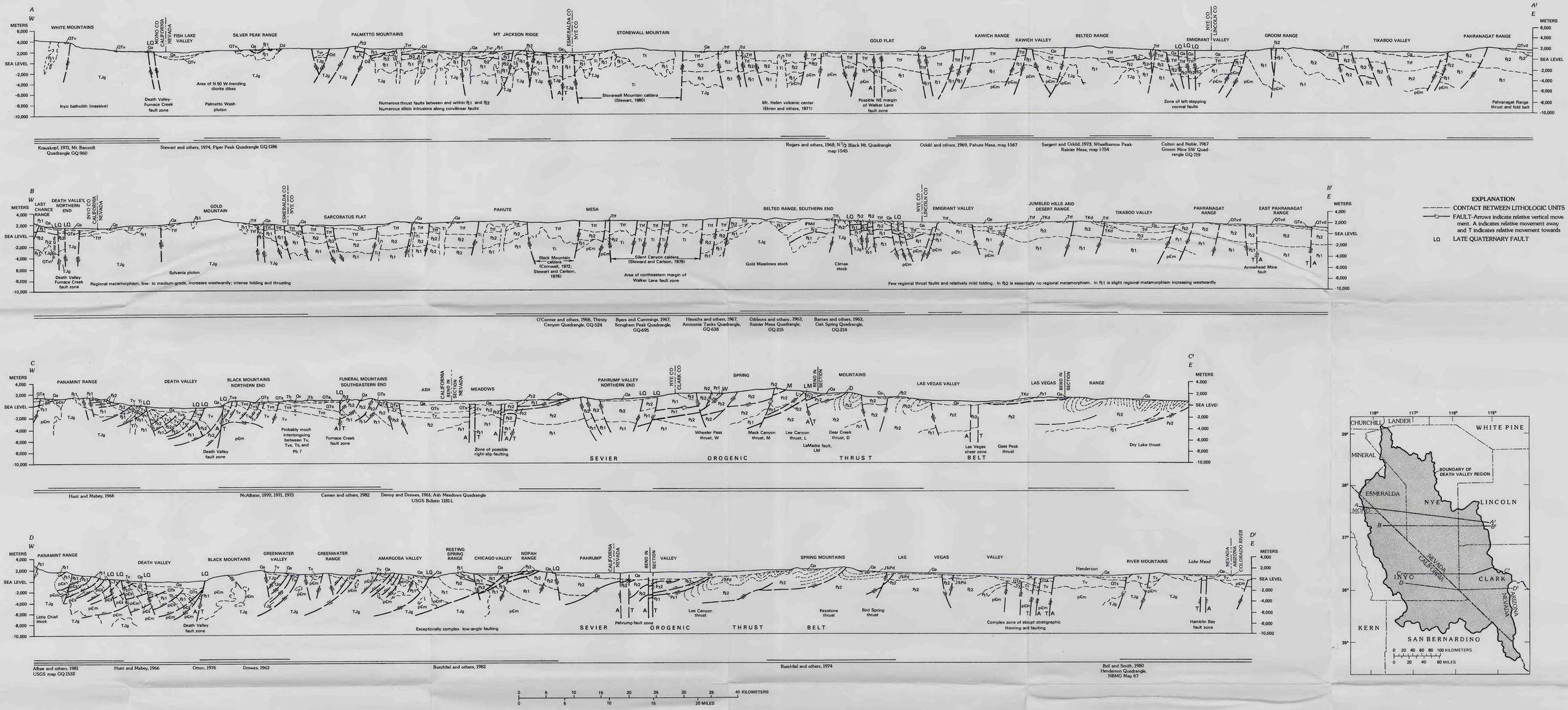
PLATE 2



EXPLANATION

CONTACT BETWEEN LITHOLOGIC UNITS

FAULT-Arrows indicate relative vertical movement. A indicates relative movement away and T indicates relative movement towards

LQ LATE QUATERNARY FAULT

GEOLOGIC SECTIONS IN THE DEATH VALLEY REGION-APPROACHES, GEOLOGIC CONSIDERATIONS, AND CONSTRAINTS

The extreme diversity and variation of lithologic types and structure, and the overprinting of various deformational, intrusive, and metamorphic events render the Basin and Range province, relative to most other regions, very difficult to illustrate quantitatively by geologic sections.

Several approaches were utilized rather uniformly in section construction:

(1) Because no direct subsurface data, such as bore-hole data, are available, all lines are interpreted, and hence are dashed. Question marks are not used.

(2) Relative certainty of subsurface geology, as based on availability and quality of geological and geophysical data and as determined by the author, is indicated along the base of all sections.

(3) All sections, regardless of supportive data available, are drawn to at least 3,000 meters below sea level.

(4) Original geologic mapping was consulted as widely as possible. Many USGS geologic quadrangle maps are referenced along the sections. Coverly and 1 × 2 degree geologic maps provided the "background geology" where no specific published geologic maps are readily available.

(5) Bouguer gravity profiles constructed for each section were utilized in geologic interpretation (Chapman and others, 1971; Healey, Wahl, and Currey, 1980; Healey, Wahl, and Oliver, 1980; Healey and others, 1981; Kane and others, 1979).

General geologic considerations applied to section compilation are:

(1) The delineation of lithologic units was influenced by:

a. Scale of sections (1:250,000);

b. Variations in hydraulic conductivity, porosity, and other characteristics of major rock types as determined by the USGS Basin and Range Province Working Group (Sargent and Bedinger, 1983, USGS Circular 904-B); and

c. Age and pre-established formation designation.

(2) In general, lithologic types discriminated where possible in the sections include:

a. Intrusive rocks - silicic and mafic;
b. Extrusive rocks - silicic and mafic, flows and tuffs;
c. Fine-grained detrital sedimentary rocks - shale and low-grade metamorphic equivalent;
d. Coarse-grained detrital sedimentary rocks - sandstone and conglomerate;
e. Alluvium and other unconsolidated sedimentary rocks;
f. Evaporites;
g. Carbonate sedimentary rocks - limestone and dolomite; and
h. Metamorphic rocks - gneissic basement complexes and metavolcanic rocks.

(3) Geologic structures encountered are basically low-angle and high-angle faults, and variously folded and tilted beds. Modern basin-and-range topography in the Death Valley region is regarded as controlled essentially by normal-slip or normal diagonal-slip faults. These Pliocene to historic faults are superimposed on all older structures. Near the surface, their dips are steep; at greater depths, they are believed to become increasingly listric.

(4) Thrust faults, single or imbricate, prevail widely in pre-Cenozoic stratified rocks. Only major zones of faulting are identified.

(5) Late Quaternary faults are specifically marked.

(6) Major regional changes occur in:

a. Lithologic facies, especially exemplified by Ordovician, Mississippian, and Tertiary rocks;
b. Structural style, especially in instability of thrusting and folding; and
c. Metamorphism, especially in grade and extent.

(7) Volcanic and thermal features are indicated by:

a. Calderas, known and inferred;
b. Dike swarms;
c. Volcanic rocks of Quaternary age; and
d. Active thermal springs.

General constraints on section compilation include:

(1) Time and resources allowed a general and reconnaissance approach. An exhaustive literature search could not be carried out.

(2) Emphasis was necessarily directed to actual location, configuration, size, depth, and so forth, of the major lithologic units and to the identification of major zones of deformation (mainly fracturing). All other related, important, and interesting geological-geophysical aspects necessary to and spawned by section compilation had to be kept in perspective, used where appropriate, but passed over in many cases.

INDICATION OF RELATIVE CERTAINTY OF SUBSURFACE GEOLOGY ON SECTIONS
(At a scale of 1:250,000, to 3,000 meters below sea level)

Geologic data and control are relatively good based on geologic mapping at scales 1:24,000 to 1:125,000 of wide range of types and ages of rocks and structures and based in places on definitive gravity data.

Geologic data and control are generally reconnaissance based on relatively modern regional mapping at scale 1:250,000. Local structure and lithology are not specifically known. Most subsurface geology is highly inferred to totally schematic.

Geologic data and control are either lacking or very sparse and uncertain. These areas are usually covered by relatively undeformed Quaternary sediments or Tertiary volcanic rocks. Subsurface geology is purely schematic.

GEOLOGIC SECTION A-A', MONO COUNTY, CALIFORNIA, AND ESMERALDA, NYE, AND LINCOLN COUNTIES, NEVADA

STRATIGRAPHIC UNITS

Qa Alluvium and minor playa clay; Quaternary; <1,500 meters

QTv Basalt flows; Quaternary and Pliocene (?); <600 meters; White Mountains area (Krauskopf, 1971; Stewart and others, 1974)

QTvd Flows and tuffs undifferentiated with interbedded volcanic sediments and lake clay and silt; Quaternary, Pliocene, and Miocene; <300 meters; Pahranagat Range (Tschanz and Pampeyan, 1970), includes some sedimentary rocks probably equivalent to Pliocene Panaca and Muddy Creek Formations)

Ttf Tuff, mostly unwelded, minor welded tuff, lava flows of silicic and intermediate composition and minor volcaniclastic interbeds; Pliocene, Oligocene(?), and Miocene; <3,000 meters; areas in eastern half of cross section (includes numerous volcanic units mapped by many geologists; see references)

Tt Welded tuff, Pliocene, Oligocene, and Miocene; <3,000 meters; Stonewall Mountain (Cornwall, 1972)

Tvr Silicic to intermediate flows, tuffs, and minor intrusives; Pliocene to Miocene; <1,500 meters; Palmetto Mountains area (Albers and Stewart, 1972)

Td Continental clastic rocks, fanglomerate; Oligocene; <900 meters; west of Mount Helen volcanic center (Ekren and others, 1971)

Ti Silicic intrusives, domes, necks, dikes; Pliocene and Miocene; major ranges and in association with inferred calderas

TJg Granitic intrusives, granite to diorite; Tertiary to Jurassic; regional shallow "basement" in White Mountains and Silver Peak Range, Sierra Nevada "outliers"

Od Shale-slate- phyllite, chert, minor limestone and quartzite; Ordovician; <900 meters; Silver Peak Range and Palmetto Mountains (Albers and Stewart, 1972; Steward and others, 1974, ilver Palmetto Formation). Highly contorted and thrust faulted and generally metamorphosed to low grade

Pz2 Limestone with minor dolomite, shale, and sandstone; Pennsylvanian to Lower Cambrian; <8,000 meters; from Palmetto Mountains to Pahranagat Range (many authors as indicated). Includes many formations generally from Tippipah Limestone to upper half of Carrara Formation or Pioche Shale. Nearly all carbonates in Pahranagat Range (>90%). Contains 1,800 meters of clastic wedge of Eleana Formation in central part of section. Complexity of thrust faulting and folding within the Pz2 unit decreases from west to east

Pz1 Shale-slate-phyllite, quartzite with minor limestone and dolomite; Cambrian and Precambrian; 4,500-6,000 meters; widespread (Albers and Steward, 1972, and Cornwall, 1972, and other authors as indicated). Includes several formations from lower half of Carrara to Johnnie Formations in southern Nye County, and Harkless to Wyman Formations in Esmeralda County, and Prospect Mountain Quartzite in Lincoln County

pCm Gneiss and schist; Precambrian (?) Rogers and others, 1968, their gneiss and schist of Trappman Hills, exposed 8 kilometers north of geologic section)

GEOLOGIC SECTION B-B', INYO COUNTY, CALIFORNIA, AND ESMERALDA, NYE, AND LINCOLN COUNTIES, NEVADA

STRATIGRAPHIC UNITS

Qa Alluvium and minor playa clay; Quaternary; <1,200 meters

QTa Older alluvium, mainly gravels, semi-lithified; Pleistocene and Pliocene; 900 meters

QTvi Basaltic pipe intrusion; Pleistocene and Pliocene. Vent is 4 kilometers to south

QTvd Volcanic rocks undifferentiated, silicic-mafic flows and tuffs, and continental detrital rocks; Quaternary, Pliocene, and Miocene; <600 meters; Pahranagat Range (Tschanz and Pampeyan, 1970), includes some sedimentary rocks probably equivalent to Pliocene Panaca and Muddy Creek Formations)

Ttf Tuff, mostly unwelded, minor welded tuff, lava flows of silicic and intermediate composition, and minor volcaniclastic interbeds; Pliocene, Miocene, and Oligocene(?); <2,100 meters; widespread occurence (includes numerous formations - see references). Probably greater volume of tuff than flow within calderas. Includes Thirsty Canyon and Timber Mountain and Paintbrush Tuffs, and others

TKd Coarse continental clastic rocks, fanglomerate, lithified gravels, and so forth; Tertiary and Cretaceous(?) <600 meters; Jumbled Hills and Desert Range (Tschanz and Pampeyan, 1970, their unit TKc, older clastic rocks)

Ti Intrusive volcanic rocks, mainly silicic calderas and subcaldera masses; Tertiary

TJg Granitic intrusive rocks, mainly quartz monzonite to quartz diorite; Tertiary and Jurassic; western part of section as Sierra Nevada "outliers" and in Bethel Range (Albers and Stewart, 1972; Gibbons and others, 1963; Barnes and others, 1963)

PMd Shale, argillite, quartzite, conglomerate (95%), and limestone (5%); Pennsylvanian and Mississippian; <2,400 meters; Bethel Range (Barnes and others, 1963)

Pz2 Limestone with minor dolomite, shale and sandstone, Permian to Middle Cambrian; <7,600 meters; widespread occurrence (many authors as indicated) Includes many formations from Bird Spring or Tippipah Limestone to Pioche Shale or upper half of Carrara Limestone. In eastern part of section, Pz2 is nonmetamorphosed; in western part, it is recrystallized and pervasively regionally metamorphosed to low to medium grade. Complexity, extent, and degree of thrusting and folding increase from east to west

Pz1 Shale-slate-schist, quartzite, with minor limestone and dolomite; Cambrian and Precambrian; 4,500-7,600 meters; widespread but mainly in deep subsurface (Albers and Stewart, 1972; Cornwal, 1972; Tschanz and Pampeyan, 1970)

pCm Gneiss and schist; Precambrian; interpreted to occur at relatively shallow depth (1,500-4,500 meters) beneath one area of Pahute Mesa, Emigrant Valley, and Pahranagat Range

GEOLOGIC SECTION C-C', INYO COUNTY, CALIFORNIA, AND NYE AND CLARK COUNTIES, NEVADA

STRATIGRAPHIC UNITS

Qa Alluvium; Quaternary; <900 meters

QTa Continental detrital sedimentary rocks - older alluvium, conglomerate, sandstone, minor shale and tuff; Quaternary and Pliocene; <450 meters; Cottonwood Mountains (Streitz and Stinson, 1974, their units QP and Qc)

Qv Basalt flows, agglomerate, and cinder cones; Quaternary; <150 meters; Black Mountains (McAllister, 1970; Jennings, 1975)

QTs Sandstone, conglomerate, minor shale, basalt, tuff, and playa sediments; Quaternary to Miocene(?); <2,100 meters; Death Valley to Ash Meadows (Hunt and Mabey, 1966; equivalent in part to Funeral Formation, Furnace Creek Formation, and older sedimentary rocks)

Tb Basalt flows; Pliocene; <300 meters; Black Mountains (McAllister, 1973, part of Funeral Formation; Streitz and Stinson, 1974)

Tvs Sandstone and conglomerate, tuff and silicic and mafic flows; Pliocene to Oligocene(?); <1,500 meters; Death Valley to Funeral Mountains (Hunt and Mabey, 1966, and McAllister, 1970; partially equivalent to Furnace Creek Formation and older sedimentary and volcanic rocks, including Artist Drive Formation)

Tv Silicic pyroclastic rocks and flows undifferentiated, minor volcaniclastic rocks; Pliocene(?) to Oligocene(?); <2,100 meters; Death Valley area and western side of Amargosa Desert (Hunt and Mabey, 1966, in part equivalent to Artist Drive Formation and possibly Greenwater Volcanic)

Ti Dikes and other small intrusions; Tertiary; Panamint Range (Hunt and Mabey, 1966)

TKd Limestone, sandstone, locally minor tuffs and shales; Tertiary to Cretaceous(?); <300 meters; Las Vegas Range (Longwell and others, 1965, Horse Spring Formation)

TJg Granitic intrusive rocks, granite to diorite, mainly granodiorite; Tertiary to Jurassic

Pz2 Limestone and dolomite, minor (<10%) shale and sandstone; Permian(?) and Pennsylvanian to Cambrian; <6,700 meters; widespread (many authors as references, Bird Spring Formation through Carrara Formation)

Pz1 Sandstone, quartzite, siltstone, shale, minor (10%) limestone and dolomite; Precambrian to Cambrian; <4,500 meters; widespread in high thrust sheets and deep in subsurface (many authors; lower half of Carrara Formation through Johnnie Formation)

pCs Conglomerate, quartzite; Precambrian; <1,500 meters; Panamint Range (Hunt and Mabey, 1966, Pahrump Group, mainly Kingston Peak Formation)

pCm Gneiss and schist; Precambrian; Panamint Range and Black Mountains

GEOLOGIC SECTION D-D', INYO COUNTY, CALIFORNIA, AND NYE AND CLARK COUNTIES, NEVADA

STRATIGRAPHIC UNITS

Qa Alluvium; Quaternary; <1,500 meters

QTs Sandstone, conglomerate, shale, playa sediments, minor tuff and basalt flows, locally much bedded and interstitial gypsum; Quaternary to Miocene(?); <2,100 meters; Death Valley, Las Vegas Valley (Hunt and Mabey, 1966, equivalent in part to Funeral Formation, Furnace Creek Formation, and older sedimentary rocks; Longwell and others, 1965, their unit Tmc - Muddy Creek Formation, contains much local gypsum)

Tv Silicic and intermediate flows, flow breccias, and pyroclastic rocks and basalt flows; Pliocene(?) to Oligocene(?); <2,100 meters; Death Valley area, Greenwater Range, River Mountains area (Hunt and Mabey, 1966; in part equivalent to Artist Drive Formation and possibly Greenwater Volcanic; Anderson, 1971)

TJg Granitic intrusive rocks, granite to diorite; Tertiary to Jurassic

JEPd Sandstone, shale, with minor conglomerate, minor limestone (20%), and minor gypsiferous clastic rocks; Jurassic(?), Triassic to Permian; <3,000 meters; Spring Mountains area (Burchfiel and others, 1974; Longwell and others, 1965; Wright and others, 1981; includes Aztec, Chinle, and Moenkopi Formations, Kaibab Limestone, and Toroweap Formation)

Pz2 Limestone and dolomite, minor (<10%) shale and sandstone; Permian (?) to Cambrian; <4,000 meters; Resting Spring Range to Las Vegas Valley (Burchfiel and others, 1974, 1982; Longwell and others, 1965; Wright and others, 1981; many formations from Bird Spring Formation through upper half of Carrara Formation)

Pz1 Sandstone, quartzite, siltstone, shale, minor (10%) limestone and dolomite; Cambrian to Precambrian <4,500 meters; wide spread in high thrust sheets and deep in subsurface (many authors, lower half of Carrara Formation through Johnnie Formation). Pz1 in Panamint Range is not mainly clastic; there it is 75% dolomitic and 25% clastic or detrital

pCs Quartzite, argillite, conglomerate, shale, dolomite (10%), diabase sills (5%); Precambrian; 3,500 meters Panamint Range (Albee and others, 1981; Hunt and Mabey, 1966; Pahrump Group of very variable lithology and thickness; generally mildly metamorphosed)

pCm Gneiss and schist; Precambrian; Panamint Range, Black Mountains, and deep subsurface in River Mountains area

GEOLOGIC SECTIONS OF THE DEATH VALLEY REGION, NEVADA AND CALIFORNIA