Changes in Stratigraphic Nomenclature by the U.S. Geological Survey, 1972

GEOLOGICAL SURVEY BULLETIN 1394-A

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By GEORGE V. COHEE *and* WILNA B. WRIGHT

CONTRIBUTIONS TO STRATIGRAPHY

GEOLOGICAL SURVEY BULLETIN 1394-A

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1974

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress catalog-card No. 73-600312

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 — Price $1.00 (paper cover)
Stock Number 2401-02450

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By GEORGE V. COHEE and WILNA B. WRIGHT

LISTING OF NOMENCLATURAL CHANGES

In the following table, stratigraphic names adopted, revised, reinstated, or abandoned are listed alphabetically. The age of the unit, the revision, and the area involved, along with the author's name and date of publication of the report, are given. The publication in which the changes in nomenclature were made are listed in the references at the end of this publication. The capitalization of age terms in the age column follows official usage.

The following formal designations of Precambrian time are now in use by the U.S. Geological Survey:

Precambrian Z—base of Cambrian to 800 m.y.
Precambrian Y—800 m.y. to 1,600 m.y.
Precambrian X—1,600 m.y. to 2,500 m.y.
Precambrian W—older than 2,500 m.y.

The scheme of subdivisions has been devised simply to facilitate depiction and analysis of the Precambrian history of the United States. The time boundaries have been chosen so as to split as few of the known epochs of sedimentation, orogeny, and plutonism as possible. The boundaries do not correspond intentionally to geologic events. The scheme is intended as an interim measure, pending development of an internationally accepted standard.

For depiction on maps, only the letter designations (W, X, Y, Z) will be shown as map symbols, and lowercase letters will indicate the group or formation names as appropriate. If a unit extends across the boundary between letter-designated units, both letters, the younger first, will be used in the map symbol. When geochronologic data are not adequate for unit assignment, only the general term Precambrian and the symbol p€ will be used. Rock units and events within a major time unit such as W, X, Y,

Name	Age	Location
Abrams Mica Schist	Devonian or older Paleozoic.	Northwestern California
Absaroka Volcanic Supergroup.	Eocene	Northwestern Wyoming and south-central Montana.
Ahorn Sandstone/Quartzite (of Belt Supergroup).	Precambrian Y	Montana
Alboroto Rhyolite (of Potosi Volcanic Group).	Middle and late Tertiary.	Southwestern Colorado
Alcova Limestone (of Chugwater Group).	Triassic	Wyoming
Alpena Limestone	Middle Devonian	Northeastern Michigan
Altyn Limestone (of Ravalli Group) (of Belt Supergroup).	Precambrian Y (pre-Ravalli).	Northwestern Montana
Adorno Formation (of Auld Lang Syne Group).	Late Triassic	Northwestern Nevada
Andover Granite	Precambrian(?) to Silurian(?).	Northeastern Massachusetts.
Andrews Schist	Cambrian(?)	North Carolina, Georgia, and Tennessee.
Ankareh Formation/Shale/Red Beds.	Early and Late Triassic.	Northeastern Utah, southeastern Idaho, and southwestern Wyoming.
Anvil Ferruginous Chert Member (of Ironwood Iron-formation) (of Menominee Group).	Precambrian X	Northwestern Michigan and northern Wisconsin.
Apache Leap Tuff	Miocene	South-central Arizona
Appekunny Argillite (of Ravalli Group) (of Belt Supergroup).	Precambrian Y	Northwestern Montana
Ashnola Gabbro	Cretaceous	North-central Washington.

or Z, keyed to geochronologic data as available, will be shown on map explanations by simple sequential arrangement.

The previously used age designations for the Precambrian are given in the table because they were used by the authors in reports submitted to the Geologic Names Committee before the new scheme was adopted.

Revision and reference
Age changed from Devonian to Devonian or older Paleozoic. (Hotz and others, 1972.)
Absaroka Volcanic Supergroup adopted and divided into three groups (ascending): Washburn, Sunlight, and Thorofare Creek (all new). (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)
Ahorn Sandstone/Quartzite abandoned; replaced by Bonner Quartzite and McNamara Formation. (Mudge, 1972.)
Name Alboroto Rhyolite abandoned; replaced by Fish Canyon Tuff. Potosi Volcanic Group with other named formations remains in good usage outside report area. (Steven and others, this report, p. A77.)
Tentatively extended into Wyoming and in that area only reduced in rank to Alcova(?) Limestone Member of Chugwater Formation. (Love and Albee, 1972.)
Age changed from Devonian to Middle Devonian. (Flower and Gordon, 1972.)
Altyn Limestone removed from Ravalli Group of Belt Supergroup and designated as pre-Ravalli or lower Belt. Age changed from Ravalli to pre-Ravalli. (Harrison, 1972.)
Andorno Formation of Compton (1960) adopted as formation of Auld Lang Syne Group (new). Overlies Singas Formation; underlies Mullinix Formation. (Burke and Silberling 1973.)
Age changed from late Carboniferous to Precambrian(?) to Silurian(?). (Castle and Theodore, 1972.)
Age changed from Early Cambrian to Cambrian(?). (Hadley and Nelson, 1971.)
Geographically restricted from Uinta Mountains region of northeastern Utah where Mahogany and Chinle Formations are used. Usage remains unchanged elsewhere. (Stewart and others, 1972b.)
Name changed from Anvil Ferruginous Chert Member to Anvil Member. Age changed from middle Precambrian to Precambrian X. (Schmidt and Hubbard, 1972.)
Age changed from Tertiary to Miocene. (Cornwall and others, 1971.)
Name changed from Appekunny Argillite to Appekunny Formation. (Harrison, 1972).
Ashnola Gabbro of Daly (1906) adopted. (Staatz and others, 1971.)

Name	Age	Location
Attean Quartz Monzonite	Ordovician(?)	West-central Maine
Auld Lang Syne Group	Late Triassic and Jurassic(?).	Northwestern Nevada
Bachelor Mountain Tuff	late Oligocene	Southwestern Colorado
Badwater Greenstone	middle Precambrian	Northwestern Michigan and northeastern Wisconsin.
Bancroft Limestone	Middle Cambrian	Southeastern Idaho and northern Utah.
Bates Mountain Tuff	early Miocene	Central Nevada
Bay of Pillars Formation	late Early and Late Silurian.	Southeastern Alaska
Bay Point Formation	late Pleistocene	Southern California
Beecher Island Member (of Pierre Shale).	Late Cretaceous	Western Kansas and northeastern Colorado.
Belle Fourche Shale	Late Cretaceous	South-central Wyoming.
Belt Supergroup	Precambrian Y	Northwestern and west-central Montana, northern Idaho, and northeastern Washington.
Benchmark Iron-formation (of Nemo Group).	middle Precambrian	West-central South Dakota.
Berino Member (of Magdalena Formation).	Middle Pennsylvanian	New Mexico and Texas

Revision and reference

Attean Quartz Monzonite adopted. Intrudes unnamed granofels and diorite and unconformably underlies unnamed Upper Silurian metasedimentary rocks. (Albee and Boudette, 1972.)

Auld Lang Syne Group adopted. Overlies Natchez Pass Formation (of Star Peak Group); underlies Tertiary volcanic rocks. Includes (ascending): in northern East Range, Grass Valley, Dun Glen, Winnemucca, and Raspberry Formations; in southern Tobin Range, Osobb, Dun Glen, and Winnemucca Formations; and, in southern Santa Rosa Range, Grass Valley, Winnemucca, O'Neill, Singas, Andorno, and Mullinix Formations (upper four formations not new). (Burke and Silberling, 1973.)

Reduced in rank to Bachelor Mountain Member of Carpenter Ridge Tuff. Member divided into (ascending): Willow Creek Bed, Campbell Mountain Bed, and Windy Gulch Bed (all reduced in rank). Upper of two members of Carpenter Ridge; overlies unnamed outflow member. (Steven and others, this report, p. A79.)

Geographically extended into northeastern Wisconsin. (Dutton, 1971.)

Bancroft Limestone adopted and considered the western equivalent of Ute Limestone. Overlies Lead Bell Shale (new) or its Cub Tongue (new) to the east; underlies Blacksmith Limestone. (Oriel and Armstrong, 1971.)

Bates Mountain Tuff stratigraphically restricted in Shoshone, Toiyabe, Simpson Park, Toquima, and Monitor Ranges in central Nevada. Unit 5, uppermost cooling unit of Sargent and McKee (1969), removed from Bates Mountain and assigned to informally-named unit. (Grommé and others, 1972.)

Age changed from Late Silurian to late Early and Late Silurian. No known Middle Silurian yet recognized within Bay of Pillars. (Ovenshine and Brew, 1972.)

Bay Point Formation of Hertlein and Grant (1939) adopted. Overlies Lindavista Formation. (Moore, 1972.)

Beecher Island Shale Member of Elias (1931) adopted as Beecher Island Member. Uppermost member of Pierre; overlies unnamed and Salt Grass members. (Gill and others, 1972.)

In south-central Wyoming, Belle Fourche Shale assigned as lowermost of three members of Frontier Formation; underlies unnamed member. Other formational and member ranks remain good usage elsewhere. (Merewether and Cobban, 1972.)

Belt Supergroup divided into (ascending): pre-Ravalli or lower Belt (formation(s) only, not group); Ravalli Group; middle Belt carbonate rock (formation only, not group); and Missoula Group. (Harrison, 1972.)

Benchmark Iron-formation adopted as upper of two new formations of Nemo Group (newly adopted of Runner, 1934). Unconformably(?) overlies Boxelder Creek Quartzite of Nemo; unconformably underlies Estes Conglomerate (also newly adopted of Runner, 1934). (Bayley, 1972.)

Berino Member of Nelson (1940) adopted. Overlies La Tuna Member; underlies Bishop Cap Member. (Harbour, 1972.)

Name	Age	Location
Big Dome Formation	late Miocene	Southeastern Arizona
Big Pole Formation (of Pony Trail Group).	Late(?) Jurassic	North-central Nevada
Big Sandy Formation	late(?) Pliocene	West-central Arizona
Bishop Cap Member (of Magdalena Formation).	Middle Pennsylvanian	New Mexico and Texas
Bolsa Quartzite	Middle Cambrian	Southeastern Arizona
Bonanza Latite	Oligocene	Southwestern Colorado
Bonner Quartzite (of Missoula Group) (of Belt Supergroup).	Precambrian Y	West-central Montana
Borden Formation	Early Mississippian	North-central Kentucky
Bouchard Formation (of Missoula Group) (of Belt Supergroup).	Precambrian Y	West-central Montana
Boxelder Creek Quartzite (of Nemo Group).	middle Precambrian	West-central South Dakota.
Brasstown Schist	Cambrian(?)	North Carolina, Georgia, and Tennessee.
Brigham Quartzite/Group	late Precambrian to Middle Cambrian.	North-central Utah and southeastern Idaho.
Browns Canyon Formation	Oligocene and Miocene	Colorado
Buck Mountain Quartzite	middle Precambrian	West-central South Dakota.

Revision and reference

Big Dome Formation adopted. Its rocks formerly included in Gila Conglomerate, term now geographically restricted from Ray-San Manuel area, east Pinal County. Conformably overlies Apache Leap Tuff or, where missing, unconformably overlies San Manuel Formation, unconformably underlies Quiburis Formation. (Krieger and others, this report, p. A54.)

Age changed from Mesozoic (Jurassic?) to Late(?) Jurassic. (Smith, this report, p. A83.)

Big Sandy Formation adopted. Unconformably overlies unnamed Tertiary sedimentary and volcanic rocks and Precambrian granitic rocks; unconformably underlies Quaternary sedimentary deposits. (Sheppard and Gude, 1972.)

Bishop Cap Member of Nelson (1940) adopted. Overlies Berino Member; underlies unnamed uppermost member. (Harbour, 1972.)

Geographically restricted to area of southeastern Arizona where Abrigo Formation is recognized. (Hayes, 1972.)

Name changed from Bonanza Latite to Bonanza Tuff. (Bruns and others, 1971.)

Geographically extended by replacing Greenhorn Mountain and Lupine Quartzites; Greenhorn Mountain and Lupine now abandoned. (Harrison, 1972.)

Borden Formation in north-central Kentucky includes (ascending): New Providence Shale, Kenwood Siltstone, Nancy Holtsclaw Siltstone, and Muldraugh Members. (Kepferle, 1972.)

Bouchard Formation abandoned; replaced by Garnet Range Formation of Missoula Group. (Harrison, 1972.)

Boxelder Creek Quartzite adopted as lower of two new formations of Nemo Group (newly adopted of Runner, 1934). Unconformably overlies Little Elk Granite; unconformably underlies(?) Benchmark Iron-formation of Nemo. (Bayley, 1972.)

Age changed from Early Cambrian to Cambrian(?). (Hadley and Nelson, 1971.)

In Bancroft quadrangle of southeastern Idaho, Brigham Quartzite divided into (ascending): Kasiska Quartzite Member, Windy Pass Argillite Member, and Sedgwick Peak Quartzite Member (all three new). In Soda Springs quadrangle (next quadrangle east), Brigham is not divided into members. In Idaho age becomes younger eastward: in Portneuf Range and to the west, age is Precambrian to late Early Cambrian; in Bear River Range, age is early Middle Cambrian and older. Brigham Group usage in Utah is unchanged. (Oriel and Armstrong, 1971.)

Age changed from Miocene to Oligocene and Miocene. (Leopold and MacGinitie, 1972.)

Buck Mountain Quartzite adopted. Separated from underlying Roberts Draw Limestone (new) by metagabbro dikes and sills; conformably underlies Gingrass Draw Slate (new). (Bayley, 1972.)

Name	Age	Location
Bull Ridge Member (of Madison Limestone).	Late Mississippian	West-central Wyoming.
Burke Formation (of Ravalli Group) (of Belt Supergroup).	Precambrian Y	Idaho
Butano Sandstone	Eocene	California
Calliham Sandstone Member (of Whitsett Formation) (of Jackson Group).	late Eocene	South-central Texas
Campbell Mountain Member (of Bachelor Mountain Tuff).	late Oligocene	Southwestern Colorado.
Canaan Peak Formation	Late Cretaceous and Paleocene(?).	South-central Utah
Cane Valley Limestone Member (of Fort Payne Formation).	Early Mississippian	South-central Kentucky
Capens Formation	Silurian	West-central Maine
Cardiff Metaconglomerate	Precambrian	Pennsylvania and Maryland.
Carpenter Ridge Tuff	late Oligocene	Southwestern Colorado.
Cathedral Cliffs Formation	Eocene	Northwestern Wyoming and south-central Montana.
Cave Basalt	Holocene	Southwestern Washington.
Cayuse Limestone (of Belt Supergroup).	Precambrian Y	Montana
Central Plateau Member (of Plateau Rhyolite).	Pleistocene	Montana, Idaho, and Wyoming.

Revision and reference

Geographically extended into Beartooth Mountains in northwestern Wyoming and south-central Montana. In northern third of area in Montana, Bull Ridge reassigned to Mission Canyon Limestone of Madison Group; in southern two-thirds, Bull Ridge remains member of Madison Limestone. (Sando, this report, p. A82.)

Geographically extended into Montana and Washington. (Harrison, 1972.)

Geographically restricted to west side of San Andreas fault. (Clarke and Nilsen, 1972.)

Calliham Sandstone Member, the stratigraphic equivalent of the Tordilla Sandstone Member (not new) of the Whitsett, recognized east of Conquista Creek in Atascosa and McMullen Counties. Overlies Dubose Member; underlies Fashing Clay Member. (Eargle, 1972.)

Reduced in rank to Campbell Mountain Bed of Bachelor Mountain Member (also reduced in rank) of Carpenter Ridge Tuff. Overlies Willow Creek Bed; underlies Windy Gulch Bed. Age changed from Oligocene to late Oligocene. (Steven and others, this report, p. A79.)

Canaan Peak Formation adopted. Unconformably overlies Kaiparowits Formation; conformably underlies or locally intertongues with Pine Hollow Formation (new) or, where Pine Hollow is missing, unconformably underlies Wasatch Formation. (Bowers, 1972.)

In south-central Kentucky, Cane Valley Limestone Member adopted as uppermost of three members of Fort Payne Formation; overlies Knifley Sandstone Member (new). (Kepferle and Lewis, this report, p. A63.)

Age changed from Silurian or Early Devonian to Silurian. (Espenshade, 1972.)

Assigned to Glenarm Series, underlying Wissahickon Formation (quartzite facies) and overlying Peach Bottom Slate; metaconglomerate lithofacies of Wissahickon of Southwick and Fisher (1967) abandoned and included in Cardiff. Age changed from Ordovician(?) to latest Precambrian. (Higgins, 1972.)

Divided into (ascending): unnamed outflow member and Bachelor Mountain Member (reduced in rank). Bachelor Mountain includes (ascending): Willow Creek Bed, Campbell Mountain Bed, and Windy Gulch Bed (all reduced in rank.) (Steven and others, this report, p. A78.)

Assigned to Washburn Group (new) of Absaroka Volcanic Supergroup (new). Interfingers with and underlies Lamar River Formation (new). (Smedes and Prostka, 1972.)

Cave Basalt adopted; flowed down stream valley incised in older pyroclastic flow deposits. (Greeley and Hyde, 1972.)

Cayuse Limestone abandoned; replaced by Helena Dolomite. (Mudge, 1972.)

Central Plateau Member adopted. Includes 18 informally named separate flows and domes; other unexposed ones may also exist. Overlies Obsidian Creek, Upper Basin, and Mallard Lake Members (all new) of Plateau Rhyolite; Lava Creek Tuff (new); and some older units. Underlies surficial sediments of late Pleistocene age. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)

Name	Age	Location
Chickies Quartzite/Slate	latest Precambrian	Southeastern Pennsylvania.
China Mountain Formation (of Koipato Group).	Early Triassic	Northwestern Nevada
Chopawamsic Formation	Late Cambrian to Late Ordovician.	Northern Virginia
Chugwater Formation/ Group.	Triassic only in report area.	Northwestern Wyoming
Cleopatra Member (of Deception Rhyolite) (of Ash Creek Group).	Precambrian (Yavapai).	Central Arizona
Clinchfield Sand	late Eocene	Georgia
Clinton Formation	Middle Silurian	Eastern Pennsylvania
Cochetopa Park Member (of Nelson Mountain Tuff).	late Oligocene	Southwestern Colorado
Coldwater Sandstone	late Eocene	Southern California
Conejos Formation (of Potosi Volcanic Group).	Oligocene and older(?).	Colorado, New Mexico
Conquista Clay Member (of McElroy Formation) (of Jackson Group.)	late Eocene	South-central Texas
Copper Harbor Conglomerate.	middle Keweenawan	Northwestern Michigan and northern Wisconsin.
Copper Queen Limestone Member (of Abrigo Limestone/Formation).	Late Cambrian	Southeastern Arizona
Coronado Quartzite	Middle (locally only) and Late Cambrian.	Southeastern Arizona and southwestern New Mexico.
Correo Sandstone Membei (of Chinle Formation).	Late Triassic	West-central New Mexico.
Coyote Hills Formation	late Pleistocene	Southern California

Revision and reference

Name changed to Chickies Formation and its Hellam Conglomerate Member name changed to Hellam Member. Age changed from Early Cambrian to latest Precambrian. (Higgins, 1972.)

In southern Tobin Range, assigned to Koipato Group as its uppermost formation. Overlies Rochester Rhyolite. Age changed from Early and Middle(?) Triassic to Early Triassic. (McKee and Burke, 1972.)

Assigned to Glenarm Series, underlying Quantico Slate and overlying Wissahickon Formation in northern Virginia Piedmont. Age changed from Cambrian or Ordovician to Late Cambrian to Late Ordovician; correlated with James Run Formation in Maryland Piedmont. (Higgins, 1972.)

In northwestern Wyoming, Chugwater Formation divided into (ascending): Red Peak, Alcova(?) Limestone, and Popo Agie Members (all reduced in rank in that area only). (Love and Albee, 1972.)

Cleopatra Quartz Porphyry of Fearing (1962) adopted as Cleopatra Member, middle unit of Deception Rhyolite. (Anderson and Nash, 1972.)

Clinchfield Sand of Carver (1966) adopted. Overlies Lisbon Formation; underlies Ocala Limestone. (Herrick, 1972.)

Clinton Formation abandoned in eastern Pennsylvania (Bake Oven Knob to Delaware Water Gap) and replaced by Lizard Creek Member (new) of Shawangunk Formation. Clinton remains in correct usage as formation, shale, or group elsewhere. (Epstein and Epstein, 1972.)

Cochetopa Park Member adopted as uppermost member of Nelson Mountain Tuff; overlies unnamed outflow member. (Steven and others, this report, p. A81.)

Coldwater Sandstone of Kew (1924), informally-named unit of Tejon Formation, adopted as formation at expense of name Tejon in report area. Overlies Cozy Dell Shale; underlies Sespe Formation. (Vedder, 1972.)

Geographically extended into New Mexico. (Butler, 1971.)

Conquista Clay Member of McElroy (now abandoned) reassigned as member of Whitsett Formation. Overlies Dilworth Sandstone Member (reassigned from McElroy to Whitsett); underlies Deweesville Sandstone Member (new). (Eargle, 1972.)

Age changed from late Keweenawan to middle Keweenawan. Base of upper Keweenawan changed from bottom to top of Copper Harbor (bottom of Nonesuch Shale). (White, 1972.)

Regionally where some beds are dolomitized, name changed from Copper Queen Limestone Member to Copper Queen Member. (Hays, 1972.)

Name changed from Coronado Quartzite to Coronado Sandstone. Geographically extended southeastward in Arizona and into southwestern New Mexico; age in these extended areas is Middle and Late Cambrian. (Hayes, 1972.)

Reduced in rank to Correo Sandstone Bed and assigned to Petrified Forest Member of Chinle Formation. (Stewart and others, 1972a.)

Coyote Hills Formation adopted. Unconformably underlies La Habra Formation (Yerkes, 1972.)

Name	Age	Location
Cozy Dell Shale	middle or late Eocene	Southern California
Crater Mountain Dacite	Tertiary	Wyoming
Crescent Hill Basalt (of Sunlight Group) (of Absaroka Volcanic Supergroup).	Eocene	Northwestern Wyoming
Crooks Canyon Granodiorite.	Precambrian	Central Arizona
Crooks Complex	Precambrian	Arizona
Cub Tongue (of Lead Bell Shale); Cub Shale Member (of Ute Limestone).	Middle Cambrian	Southeastern Idaho and northern Utah.
Cutter Member (of Montoya Dolomite).	Late Ordovician	New Mexico and Texas
Daly Creek Member (of Sepulcher Formation) (of Washburn Group) (of Absaroka Volcanic Supergroup).	middle Eocene	Northwestern Wyoming and south-central Montana.
Deadman Pass Glaciation/ Till.	Pleistocene	Eastern California
Deception Rhyolite (of Ash Creek Group).	Precambrian (Yavapai).	Central Arizona
Dellet Sand Member (of Moodys Branch Formation) (of Jackson Group).	late Eocene	Alabama and Georgia
Deweesville Sandstone Member (of Whitsett Formation) (of Jackson Group).	late Eocene	South-central Texas
Dilworth Sandstone Member (of McElroy Formation) (of Jackson Group).	late Eocene	South-central Texas
Dinner Creek Welded Tuff	Miocene	Southeastern Oregon
Donner Lake Glaciation/ Till.	Pleistocene	Northern California

Revision and reference

Cozy Dell Shale Member of Tejon Formation of Kerr and Schenck (1928) adopted and raised in rank to Cozy Dell Shale at expense of name Tejon in report area. Overlies Matilija Sandstone; underlies Coldwater Sandstone. (Vedder, 1972.)

Crater Mountain Dacite of Fisher (1967) adopted. (Fisher, 1972.)

Crescent Hill Basalt of Howard (1937) adopted as formation of Sunlight Group (new) of Absaroka Volcanic Supergroup (new). Restricted to north-central Yellowstone National Park. Overlies and partly intertongued with Sepulcher Formation (new); underlies Langford Formation (new). (Smedes and Prostka, 1972.)

Crooks Canyon Granodiorite adopted, and rocks of Crooks Complex (now abandoned) now included in part of renamed Crooks Canyon. In place intrudes older gabbro and Green Gulch and Spud Mountain Volcanics; elsewhere is in fault contact with Iron King Volcanics or is covered in part by Tertiary sedimentary and volcanic rocks. (Anderson and Blacet, 1972.)

Crooks Complex abandoned, and its rocks now included in part of renamed Crooks Canyon Granodiorite. (Anderson and Blacet, 1972.)

Cub Tongue adopted as uppermost unit of Lead Bell Shale (new); farther east it is reassigned and adopted as Cub Shale Member, lowermost unit of Ute Limestone where twofold subdivision is possible. (Oriel and Armstrong, 1971.)

Geographically extended into western Texas. (Harbour, 1972.)

Daly Creek Member of Sepulcher Formation (new) of Washburn Group (new) of Absaroka Volcanic Supergroup (new) adopted. Overlies Lost Creek Tuff Member or conglomerate facies of Sepulcher; underlies Fortress Mountain Member (new.) (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)

Deadman Pass Till/Glaciation of Curry (1966) adopted. (Dalrymple, 1972.)

Cleopatra Quartz Porphyry of Fearing (1926) adopted as Cleopatra Member, middle unit of Deception Rhyolite. (Anderson and Nash, 1972.)

Dellet Sand of Stenzel (1952) adopted as Dellet Sand Member of Moodys Branch Formation. (Herrick, 1972.)

Deweesville Sandstone Member adopted. Overlies Conquista Clay Member; underlies Dubose Member. (Eargle, 1972.)

Dilworth Sandstone Member of McElroy (now abandoned) reassigned as basal member of Whitsett Formation. Overlies Manning Clay (raised in rank from member of McElroy); underlies Conquista Clay Member (reassigned from McElroy to Whitsett). (Eargle, 1972.)

Dinner Creek Welded Ash-Flow Tuff of Kittleman and others (1965) adopted as Dinner Creek Welded Tuff; underlies Hunter Creek Basalt. (Greene and others, 1972.)

Donner Lake Glaciation/Till of Birkeland (1964) adopted. (Birkeland and Janda, 1971.)

Name	Age	Location
Dothan Formation	Late Jurassic	Northwestern California and southwestern Oregon.
Drinkwater Basalt	Pliocene	Southeastern Oregon
Dubose Member (of Whitsett Formation) (of Jackson Group).	late Eocene	South-central Texas
Dun Glen Formation	Late Triassic	Northwestern Nevada
Edna Mountain Formation	Late Permian	North-central and northeastern Nevada.
Elba Quartzite	late Precambrian(?)	Southern Idaho and northwestern Utah.
Elk Creek Basalt Member (of Sepulcher Formation/ of Lamar River Formation) (of Washburn Group) (of Absaroka Volcanic Supergroup).	early or early middle Eocene.	Northwestern Wyoming and south-central Montana.
El Paso Limestone	Late Cambrian (locally only) and Early Ordovician.	Southeastern Arizona and southwestern New Mexico (limited extent).
Empire Formation (of Missoula Group) (of Belt Supergroup).	Precambrian Y	Montana
Estes Conglomerate	middle Precambrian	West-central South Dakota.
Equity Quartz Latite	late Oligocene	Southwestern Colorado
Fairport Chalky Shale Member (of Carlile Shale).	Late Cretaceous	Western Kansas
Falls River Basalt	Pleistocene	Idaho and Wyoming
Farmington Canyon Complex.	Precambrian X	Northwestern Utah
Faulconer Bed (of Perryville Limestone Member) (of Lexington Limestone).	Middle Ordovician	Central Kentucky

Revision and reference

Age changed from Late Jurassic and Early Cretaceous(?) to Late Jurassic. (Coleman, 1972.)

Drinkwater Basalt of Bowen, Gray, and Gregory (1963) adopted. (Green and others, 1972.)

Rocks previously included as uppermost unit of Dubose Member (Tordilla Sandstone of Eargle (1959)) removed from Dubose, adopted, and raised in rank to Tordilla Sandstone Member of Whitsett Formation. (Eargle, 1972).

Assigned to Auld Lang Syne Group (new). (Burke and Silberling, 1973.)

Geographically extended into northeastern Nevada in thrust plate with horizontal displacement of about 96 miles. (Coats and Gordon, 1972.)

Elba Quartzite of Armstrong (1968) adopted. (Compton, 1972.)

Elk Creek Basalt of Howard (1937) adopted as Elk Creek Basalt Member: of lower part of Sepulcher Formation (new) in northwestern and north-central part of Yellowstone National Park; of Lamar River Formation (new) in northeastern and eastern part. Absent in southern Washburn Range. Assigned to Washburn Group (new) of Absaroka Volcanic Supergroup (new). (Smedes and Prostka, 1972.)

In southeastern Arizona and southwestern New Mexico where Coronado Sandstone is mapped, age of El Paso Limestone changed from Early Ordovician to Late Cambrian and Early Ordovician; replaces lower part of former Longfellow Limestone (now abandoned). (Hayes, 1972.)

Empire Formation no longer included in Missoula Group and reassigned to Ravalli Group. (Mudge, 1972.)

Estes System of Runner (1934) adopted and redefined by dividing into two units (ascending): Estes Conglomerate and Roberts Draw Limestone (new name). Estes unconformably overlies Benchmark Iron-formation (new name) and unconformably underlies Roberts Draw. (Bayley, 1972.)

Equity Quartz Latite as originally named reinstated and reduced in rank for intracaldera rocks (completely equivalent) as Equity Member of Rat Creek Tuff. Upper member of Rat Creek; overlies unnamed outflow member. Age changed from Miocene to late Oligocene. (Steven and others, this report, p. A80.)

Name changed to Fairport Chalk Member in area of report. (Gill and others, 1972.)

Falls River Basalt adopted. Overlies Lava Creek Tuff (new) with apparent conformity; underlies upper Pleistocene glacial deposits or Central Plateau Member (new) of Plateau Rhyolite (not new). (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)

Age changed from Precambrian to Precambrian X. (Crittenden, 1972.)

Faulconer Limestone Member of Perryville Formation of Foerste (1912) adopted as Faulconer Bed, basal unit of Perryville Limestone Member of Lexington Limestone. (Cressman, 1972.)

Name	Age	Location
Fish Canyon Tuff	late Oligocene	Southwestern Colorado
Flathead Sandstone	Middle Cambrian	Wyoming and Montana
Fortification Basalt Member (of Muddy Creek Formation).	Pliocene	Arizona and Nevada
Fort Payne Formation	Early Mississippian	South-central Kentucky
Fortress Mountain Member (of Sepulcher Formation) (of Washburn Group) (of Absaroka Volcanic Supergroup).	middle Eocene	Northwestern Wyoming and south-central Montana.
Frenchie Creek Rhyolite (of Pony Trail Group).	Late(?) Jurassic	North-central Nevada
Frontier Formation	Late Cretaceous	South-central Wyoming
Funston Limestone	Early Permian	Kansas and Oklahoma
Gale Hills Formation	Cretaceous(?) and Tertiary.	Southeastern Nevada
Galiuro Volcanics	early Miocene	Southeastern Arizona
Garnet Range Formation/Quartzite (of Missoula Group) (of Belt Supergroup).	Precambrian Y	West-central Montana
Gastineau Channel Formation.	late Pleistocene and early Holocene.	Southeastern Alaska
Gila Conglomerate/Formation/Group.	Pliocene and Pleistocene.	Southeastern Arizona and southwestern New Mexico.
Gilpins Falls Member (of James Run Formation).	Late Cambrian	Maryland
Gingrass Draw Slate	middle Precambrian	West-central South Dakota.
Glenarm Series	latest Precambrian to Late Ordovician.	Pennsylvania, New Jersey, Delaware, Maryland, and Virginia.
Golden Valley Formation	Paleocene and Eocene	North Dakota

Revision and reference

Fish Canyon Tuff divided into (ascending): unnamed outflow member, La Garita Member (reduced in rank), and Phoenix Park Member (reassigned). (Steven and others, this paper, p. A77.)

Geographically extended into east-central Idaho. (Witkind, 1972.)

Age changed from Pliocene(?) to Pliocene. (Anderson and others, 1972.)

In south-central Kentucky, divided into (ascending): New Providence Shale Member, Knifley Sandstone Member (new), and Cane Valley Limestone Member (new). (Kepferle and Lewis, this report, p. A63.)

Fortress Mountain Member adopted as uppermost member of Sepulcher Formation (new) of Washburn Group (new) of Absaroka Volcanic Supergroup (new). Overlies Daly Creek Member (new); underlies Mount Wallace Formation (new) or andesite lavas of Sepulcher. (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)

Age changed from Mesozoic (Jurassic?) to Late(?) Jurassic. (Smith, this report, p. A83.)

In south-central Wyoming, Frontier divided into (ascending): Belle Fourche Shale Member (newly assigned), unnamed member, and Wall Creek Sandstone Member (newly redefined). (Merewether and Cobban, 1972.)

Age changed from Permian to Early Permian. (Sohn, 1972.)

Age changed from Cretaceous(?) or Tertiary(?) to Cretaceous(?) and Tertiary. (Anderson and others, 1972.)

Age changed from Miocene to early Miocene. (Krieger and others, this paper, p. A62.)

Garnet Range Formation replaces usage of Bouchard Formation (now abandoned) of Missoula Group (Harrison, 1972.)

Gastineau Channel Formation adopted. (Miller, 1973.)

Gila Conglomerate/Group geographically restricted from San Manuel area; east Pinal County, Ariz., and replaced by Big Dome Formation (new). San Manuel and Quiburis Formations removed from Gila Group, and Sacaton Formation abandoned, thus removing Gila from group rank anywhere. (Krieger and others, this report, p. A54.)

Gilpins Falls Member adopted. (Higgins, 1971.)

Gingrass Draw Slate adopted. Conformably overlies Buck Mountain Quartzite (new name); conformably underlies Hay Creek Greenstone, lower of two newly named formations of Windy Flats Group (new name). Bayley, 1972.)

Glenarm now consists of (ascending): Setters Formation, Cockeysville Marble, Peach Bottom Slate, Cardiff Metaconglomerate, Wissahickon Formation, James Run and Chopawamsic Formations (correlatives), and Quantico Slate. Age changed from late Precambrian(?) to latest Precambrian to Late Ordovician. (Higgins, 1972.)

Age changed from Eocene to Paleocene and Eocene. (Leopold and MacGinitie, 1972.)

Name	Age	Location
Golmeyer Creek Volcanics	Eocene	South-central Montana
Golmeyer Creek Volcanics	Eocene	Southwestern Montana
Grainger Formation	Early Mississippian	Eastern Kentucky
Grass Valley Formation	Late Triassic	Northwestern Nevada
Greenhorn Mountain Quartzite (of Belt Supergroup).	Precambrian Y	West-central Montana
Green Mountain Conglomerate.	Paleocene	Central and north-eastern Colorado.
Greyson Shale (of Missoula Group) (of Belt Supergroup).	Precambrian Y	Montana
Grinnell Formation/Argillite (of Ravalli Group) (of Belt Supergroup).	Precambrian Y	Northwestern Montana
Hanson Creek Formation	Middle(?) and Late Ordovician and Early Silurian.	North-central Nevada
Hat Creek Basalt	Holocene	Northern California
Haupu Formation	Pliocene	Hawaii, Kauai Island
Hay Creek Greenstone (of Windy Flats Group).	middle Precambrian	West-central South Dakota.
Hebron Formation	Devonian or older	Connecticut
Helena Dolomite (of Missoula Group) (of Belt Supergroup).	Precambrian Y	West-central and northwestern Montana.
Helena Dolomite/Formation (of Belt Supergroup).	Precambrian Y	West-central Montana
Hellam Conglomerate Member (of Chickies Quartzite).	Precambrian	Southeastern Pennsylvania.
Henderson Gneiss	Paleozoic(?)	North Carolina, South Carolina, and Georgia.
High Creek Limestone	Middle Cambrian	Southeastern Idaho and northern Utah.

Revision and reference

Assigned to Washburn Group (new) of Absaroka Volcanic Supergroup (new) as lowermost formation in north Gallatin Range. Locally underlies Hyalite Peak Volcanics. (Smedes and Prostka, 1972.)

Golmeyer Creek Volcanics of Chadwick (1969) adopted; overlies Cathedral Cliffs(?) Formation. (Roberts, 1972.)

Maccrady Shale and Price Formation reduced in rank and made member of Grainger Formation in eastern Kentucky. (Alvord and Miller, 1972.)

Assigned to Auld Lang Syne Group (new). (Burke and Silberling, 1973.)

Greenhorn Mountain Quartzite abandoned; replaced by Bonner Quartzite of Missoula Group of Belt Supergroup. (Harrison, 1972.)

Green Mountain Conglomerate of LeRoy (1946) adopted. Disconformably overlies Denver Formation; upper contact is erosional. (Scott, 1972.)

Greyson Shale no longer included in Missoula Group and reassigned to Ravalli Group. (Mudge, 1972.)

Grinnell Formation/Argillite abandoned; replaced by Spokane Formation/Shale of Ravalli Group. (Harrison, 1972.)

Age changed from Middle(?) and Late Ordovician to Middle(?) and Late Ordovician and Early Silurian. (Mullens and Poole, 1972.)

Hat Creek Basalt of Anderson (1940) adopted. (Anderson and Gottfried, 1972.)

Age changed from Pliocene(?) to Pliocene. (Doell, 1972.)

Hay Creek Greenstone adopted as lower of two new formations of Windy Flats Group (new name). Conformably overlies Gingrass Draw Slate (new name); conformably underlies Reausaw Slate, new upper formation of Windy Flats. (Bayley, 1972.)

Age changed from Ordovician or older to Devonian or older. (Lundgren and others, 1971.)

Helena Dolomite no longer included in Missoula Group and presently unassigned to any group; remains middle carbonate unit of Belt Supergroup. Cayuse Limestone abandoned and replaced by Helena. (Mudge, 1972.)

Geographically extended into northwestern Montana replacing Siyeh Limestone of Belt Supergroup. Siyeh now abandoned. Called Helena Dolomite where carbonate rock in eastern part of Belt basin; called Helena Formation where clastic in western part. (Harrison, 1972.)

Name changed to Hellam Member of Chickies Formation. Age changed from Early Cambrian to latest Precambrian. (Higgins, 1972.)

Age changed from late Precambrian or Paleozoic to Paleozoic(?). (Hadley and Nelson, 1971.)

High Creek Limestone adopted for use in Egbert Canyon area as the westward replacement of former Langston Limestone (now redefined as Langston Dolomite and restricted to the east side of Bear River Range). Overlies and underlies Spence Tongue (now redefined) and Cub Tongue (new) of Lead Bell Shale (new), respectively; intertongues with the Lead Bell to the west. (Oriel and Armstrong, 1971.)

Name	Age	Location
Hilgard Stade/Till (of Tioga Glaciation).	Pleistocene	Central California
Hinton Formation	Late Mississippian	Virginia
Hite Bed (of Church Rock Member) (of Chinle Formation).	Late Triassic	Southeastern Utah
Hoadley Formation (of Belt Supergroup).	Precambrian Y	Montana
Hobard Glaciation/Till	Pleistocene	Eastern California
Hog Island Granodiorite	late Early or early Middle Devonian.	West-central Maine
Holbrook Member (of Moenkopi Formation).	Early and Middle(?) Triassic.	Northeastern Arizona
Holtsclaw Sandstone	Early Mississippian	North-central Kentucky
Horse Spring Formation	Miocene (locally)	Nevada (Clark County)
Huckleberry Formation (of Belt Supergroup).	Precambrian (post-Belt).	Northeastern Washington.
Huckleberry Ridge Tuff (of Yellowstone Group).	early Pleistocene	Montana, Idaho, and Wyoming.
Humbug Mountain Conglomerate.	Early Cretaceous	Southwestern Oregon
Humbug Mountain Conglomerate.	Early Cretaceous	Southwestern Oregon
Hunter Creek Basalt	Miocene	Southeastern Oregon
Hyalite Peak Volcanics	Eocene	Southwestern Montana
Hyalite Peak Volcanics	Eocene	South-central Montana
Idavada Volcanics	Miocene and early and middle Pliocene.	Northern Nevada and southern Idaho.
Jacaquas Group	Late Cretaceous to middle Eocene.	Northwestern Puerto Rico and Isla Desecheo.
Jackson Group	late Eocene	Tennessee, Louisiana, Mississippi, Alabama, Texas, Arkansas.

Revision and reference
Hilgard Glaciation of Birman (1964) adopted as Hilgard Stade/Till of Tioga Glaciation. (Birkeland and Janda, 1971.)
Little Stone Gap Member and Stony Gap Sandstone Member of Hinton Formation in Virginia assigned to Pennington Formation in eastern Kentucky. (Alvord and Miller, 1972.)
Hite Bed of Stewart, Williams, Albee, and Raup (1959) adopted as uppermost sandstone and conglomerate bed of Church Rock Member of Chinle Formation. (Stewart and others, 1972a.)
Hoadley Formation abandoned; replaced by (ascending): Snowslip, Shepard, and Mount Shields Formations. (Mudge, 1972.)
Hobart Till/Glaciation of Birkeland (1964) adopted. (Dalrymple, 1972.)
Hog Island Granodiorite adopted. Intrudes Seboomook Formation, unnamed conglomerate unit, and Attean Quartz Monzonite (new). (Albee and Boudette, 1972.)
Age changed from Triassic to Early and Middle(?) Triassic. (Stewart and others, 1972b.)
Holtsclaw Sandstone revised to Holtsclaw Siltstone, reduced in rank and assigned to Borden Formation as member in north-central Kentucky. (Kepferle, 1972.)
Age changed from Miocene(?) to Miocene in Clark County only. (Anderson and others, 1972.)
Age changed from Precambrian (Belt) to Precambrian (post-Belt). Geographically extended into northwestern Idaho. (Harrison, 1972.)
Huckleberry Ridge Tuff adopted as basal formation of Yellowstone Group. Underlies Lava Creek or Mesa Falls Tuffs, both of Yellowstone Group (both new); overlies Cretaceous sandstones and shales. Includes three widely mappable informal members. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)
Humbug Mountain Conglomerate of Koch (1966) adopted. Overlies Otter Point Formation. (Hunter and others, 1970.)
Assigned to Myrtle Group. (Coleman, 1972.)
Hunter Creek Basalt of Kittleman and others (1965) adopted. Overlies Dinner Creek Welded Tuff; underlies Tims Peak Basalt. (Greene and others, 1972.)
Hyalite Peak Volcanics of Chadwick (1969) adopted; unconformably overlies Cathedral Cliffs(?) Formation. (Roberts, 1972.)
Assigned to Washburn Group (new) of Absaroka Volcanic Supergroup (new) as uppermost formation in north Gallatin Range. Locally overlies Golmeyer Creek Volcanics. (Smedes and Prostka, 1972.)
Age changed from early and middle Pliocene to Miocene and early and middle Pliocene. (Leopold and MacGinitie, 1972.)
Jacaguas Group extended into northwestern Puerto Rico and Isla Desecheo, and Río Culebrinas Formation included therein. (Seiders and others, 1972.)
In south-central Texas, Jackson Group revised to include four formations (ascending): Caddell Formation, Wellborn Sandstone, Manning Clay (raised in rank from lowermost member of McElroy), and Whitsett Formation (revised to include middle and uppermost members of McElroy). McElroy Formation abandoned. (Eargle, 1972.)

Name	Age	Location
James Run Gneiss	Late Cambrian to Late Ordovician.	Maryland
James Run Formation	Late Cambrian to Late Ordovician.	Maryland
Jim Mountain Member (of Wapiti Formation) (of Sunlight Group) (of Absaroka Volcanic Supergroup.)	early middle Eocene	Northwestern Wyoming
Juncal Formation	early and middle Eocene.	Southern California
Junction Butte Basalt	early Pleistocene	Northwestern Wyoming
Kasiska Quartzite Member (of Brigham Quartzite).	Precambrian	Southeastern Idaho
Kenwood Sandstone	Early Mississippian	North-central Kentucky
Keweenawan Series	Precambrian Y	Northwestern Michigan, northern Wisconsin, and northeastern Minnesota.
Kintla Argillite (of Missoula Group) (of Belt Supergroup).	Precambrian Y	Northwestern Montana
Knifley Sandstone Member (of Fort Payne Formation).	Early Mississippian	South-central Kentucky
Koipato Group	Early Triassic	Northwestern Nevada
Kuzitrin Formation	Devonian(?)	Western Alaska

Revision and reference

Name changed to James Run Formation. James Run assigned as uppermost formation of Glenarm Series in Susquehanna River and central Maryland Piedmont areas, overlying Wissahickon Formation. Includes former Relay Quartz Diorite of Knopf and Jonas (1929), James Run Gneiss of Southwick and Fisher (1967), Baltimore paragneiss and Baltimore Gabbro of Hopson (1964), and Baltimore Gneiss dome of Southwick and Owens (1968). Age changed from Precambrian(?) to Late Cambrian to Late Ordovician; correlated with Chopawamsic Formation in northern Virginia Piedmont. (Higgins, 1972.)

Gilpins Falls Member (new) adopted. (Higgins, 1971.)

Assigned with its formation affiliate to Sunlight Group (new) of Absaroka Volcanic Supergroup (new). (Smedes and Prostka, 1972.)

Juncal Formation of Page, Marks, and Walker (1951) adopted at expense of name Tejon in report area. Overlies Sierra Blanca Limestone or Upper Cretaceous strata; underlies Matilija Sandstone. (Vedder, 1972.)

Junction Butte Basalt adopted; at type locality consists of three or four thick informally named flows. Unconformably overlies Absaroka Volcanic Supergroup (new) and Paleozoic and Precambrian rocks; locally underlies Huckleberry Ridge Tuff (conformably), Mount Jackson Rhyolite, or Lava Creek Tuff (all new) but is commonly eroded at top. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)

Kasiska Quartzite Member adopted as basal of three new members of Brigham Quartzite. Underlies Windy Pass Argillite Member (new). (Oriel and Armstrong, 1971.)

Kenwood Sandstone revised to Kenwood Siltstone, reduced in rank, and assigned to Borden Formation as member in north-central Kentucky. (Kepferle, 1972.)

Base of upper Keweenawan changed from bottom to top of Copper Harbor Conglomerate (bottom of Nonesuch Shale). (White, 1972.)

Kintla Argillite abandoned; name Kintla has been used for one or more units of Missoula Group. In Glacier Park area its rocks reassigned to lower part of Mount Shields Formation; elsewhere its rocks included in parts of Miller Peak, Striped Peak, and Mount Shields Formations. (Harrison, 1972.)

In south-central Kentucky, Knifley Sandstone Member adopted as middle of three members of Fort Payne Formation. Overlies New Providence Shale Member; underlies Cane Valley Limestone Member (new). (Kepferle and Lewis, this paper, p. A63.)

In southern Tobin Range, China Mountain Formation assigned as uppermost formation of Koipato Group, overlying Rochester Rhyolite. Weaver Rhyolite remains uppermost formation of Koipato in Humboldt Range, but does not occur in Tobin Range. Age changed from Permian and Early Triassic to Early Triassic. (McKee and Burke, 1972.)

Kuzitrin Formation abandoned; its rocks now included in part of Tigaraha Schist and slate of York region. (Sainsbury, 1972.)

Name	Age	Location
La Garita Tuff	late Oligocene	Southwestern Colorado
Lake Creek Member (of Pierre Shale).	Late Cretaceous	Western Kansas
Lamar River Formation (of Washburn Group) (of Absaroka Volcanic Supergroup).	late early to early middle Eocene.	Northwestern Wyoming and south-central Montana.
Langford Formation (of Thorofare Creek Group) (of Absaroka Volcanic Supergroup).	early middle Eocene	Northwestern Wyoming and south-central Montana.
Langston Formation/ Limestone.	Middle Cambrian	Southeastern Idaho and northern Utah.
La Tuna Member (of Magdalena Formation).	Early Pennsylvanian	New Mexico and Texas
Lava Creek Tuff (of Yellowstone Group).	late Pleistocene	Montana, Idaho, and Wyoming.
Lead Bell Shale	Middle Cambrian	Southeastern Idaho and northern Utah.
Lewis Canyon Rhyolite	Pleistocene	Northwestern Wyoming
Libby Formation (of Missoula Group) (of Belt Supergroup).	Precambrian Y	Northwestern Montana
Limerick Greenstone (of Koipato Group).	Early Triassic	Northwestern Nevada
Lindavista Formation	early Pleistocene	Southern California

Revision and reference
Reduced in rank to member of Fish Canyon Tuff. Outlet Tunnel Member of La Garita abandoned; its rocks now included in La Garita Member. La Garita overlies unnamed outflow member of Fish Canyon and underlies Phoenix Park Member (reassigned to Fish Canyon). (Steven and others, this report, p. A77.)
Lake Creek Shale Member of Elias (1931) adopted as Lake Creek Member. Overlies Weskan Member; underlies Salt Grass Member. (Gill and others, 1972.)
Lamar River Formation of Washburn Group (new) of Absaroka Volcanic Supergroup (new) adopted in Absaroka and Washburn Ranges. Underlies Wapiti Formation; interfingers with Sepulcher (new) and Cathedral Cliffs Formations. Includes Elk Creek Basalt Member (included in Sepulcher Formation in north-central Yellowstone National Park.) (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)
Langford Formation adopted and assigned to Thorofare Creek Group (new) of Absaroka Volcanic Supergroup (new) as lowermost formation. Overlies Trout Peak Trachyandesite, Mount Wallace Formation (new), or Wapiti Formation; underlies Two Ocean Formation (new). Includes Promontory Member (new). (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)
Langston Formation/Limestone redefined as Langston Dolomite and restricted to the east side of Bear River Range. Correlates with High Creek Limestone and Lead Bell Shale (both new) to the west, intertonguing with the High Creek. (Oriel and Armstrong, 1971.)
La Tuna Member of Nelson (1940) adopted. Lowermost member of Magdalena; underlies Berino Member. (Harbour, 1972.)
Lava Creek Tuff adopted as upper formation of Yellowstone Group and divided into two major informal members. Around margins of Yellowstone plateau commonly overlies Huckleberry Ridge Tuff (new); underlies most of younger Pleistocene basalt and rhyolite units in and near Yellowstone National Park. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)
Lead Bell Shale adopted. To the south includes Spence Tongue (formerly Spence Shale Member of Ute Limestone) at base and Cub Tongue (new and considered Cub Shale Member of Ute Limestone to the east) at top. Between the two tongues are High Creek Limestone (new) on the west and Langston Dolomite (formerly Langston Formation or Limestone, now redefined) on the east. Overlies Twin Knobs Formation (new) or its eastern counterpart, Naomi Peak Tongue (formerly a limestone member of the Langston Formation of Maxey (1958)); grades upward into Bancroft Limestone (new). (Oriel and Armstrong, 1971.)
Lewis Canyon Rhyolite adopted. Overlies Huckleberry Ridge Tuff (new) and Paleozoic and Mesozoic sedimentary rocks; underlies Lava Creek Tuff (new). (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)
Geographically extended into northern Idaho and northeastern Washington. (Harrison, 1972.)
Age changed from Permian to Early Triassic. (McKee and Burke, 1972.)
Lindavista terrace material of Hanna (1926) adopted as Lindavista Formation. Overlies San Diego Formation; underlies Bay Point Formation. (Moore, 1972).

Name	Age	Location
Little Stone Gap Member (of Hinton Formation).	Late Mississippian ----	Western Virginia and eastern Kentucky.
Liveoak Shale Member (of Tejon Formation).	middle and late Eocene-	Southern California ---
Lizard Creek Member (of Shawangunk Formation).	Middle Silurian -------	Eastern Pennsylvania and western New Jersey.
Longfellow Limestone ----	Ordovician -----------	Southeastern Arizona -
Lost Creek Tuff Member (of Sepulcher Formation) (of Washburn Group) (of Absaroka Volcanic Supergroup).	late early Eocene -----	Northwestern Wyoming and south-central Montana.
Lupine Quartzite (of Missoula Group) (of Belt Supergroup.)	Precambrian Y -------	West-central Montana -
Maccrady Shale ----------	Early Mississippian ---	Eastern Kentucky ----
McElroy Formation (of Jackson Group).	late Eocene -----------	South-central Texas ---
McMonnigal Limestone ---	Silurian and Devonian -	Central Nevada -------
McNamara Formation/ Argillite (of Missoula Group) (of Belt Supergroup).	Precambrian Y -------	West-central Montana -
Madison River Basalt -----	Pleistocene -----------	Montana and Wyoming-
Madrid Formation --------	Silurian(?) ----------	Maine --------------
Magdalena Group --------	Pennsylvanian and locally Permian.	Texas and New Mexico-
Mahogany Member (of Ankareh Formation).	Early Triassic --------	North-central and northeastern Utah and southwestern Wyoming.
Makaweli Formation ------	Pliocene -------------	Hawaii, Kauai Island --
Mallard Lake Member (of Plateau Rhyolite).	Pleistocene ----------	Northwestern Wyoming

Revision and reference

Little Stone Gap Member of Hinton Formation in western Virginia assigned to Pennington Formation in eastern Kentucky. (Alvord and Miller, 1972.)

Liveoak Member of Marks (1941, 1943) adopted as Liveoak Shale Member of Tejon Formation. Overlies Uvas Conglomerate Member; underlies Metralla Sandstone Member. (Nilsen, 1972.)

Lizard Creek Member newly defined and adopted. Overlies Minsi Member (new) of Shawangunk; underlies Bloomsburg Red Beds or Tammany Member (new) of Shawangunk. (Epstein and Epstein, 1972.)

Longfellow Limestone abandoned; its rocks now included in (ascending): El Paso Limestone and Second Value Dolomite. (Hayes, 1972.)

Lost Creek Trachyte of Howard (1937) adopted as Lost Creek Tuff Member of Sepulcher Formation (new) of Washburn Group (new) of Absaroka Volcanic Supergroup (new). Overlies Elk Creek Basalt Member, prevolcanic rocks, or conglomerate facies of Sepulcher; underlies Daly Creek Member (new) or andesite lavas of Sepulcher. (Smedes and Prostka, 1972.)

Lupine Quartzite abandoned; replaced by Bonner Quartzite of Missoula Group. (Harrison, 1972.)

Maccrady Shale reduced in rank and made member of Grainger Formation in eastern Kentucky. (Alvord and Miller, 1972.)

McElroy Formation abandoned. Its lowermost member, Manning Clay, raised to formational rank in Jackson Group; its middle and uppermost members, Dilworth Sandstone and Conquista Clay, reassigned to Whitsett Formation. (Eargle, 1972.)

McMonnigal Formation of Kay (1960) adopted as McMonnigal Limestone as used by Kay and Crawford (1964). Overlies Roberts Mountains Formation; partly correlative with Tor Limestone. (McKee and others, 1972.)

Replaces Sloway Formation of Missoula (now abandoned). (Harrison, 1972.)

Madison River Basalt adopted. Mainly overlies eroded Lava Creek Tuff (new) but locally overlies flows of Roaring Mountain Member (new) of Plateau Rhyolite; in places, deeply mantled by upper Pleistocene glacial deposits. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)

Age changed from Silurian or Devonian to Silurian(?). (Moench, 1971.)

Reduced to formation rank in northern Franklin Mountains. Divided into (ascending): La Tuna, Berino, and Bishop Cap Members and unnamed uppermost member. Remains in good usage as group rank elsewhere. (Harbour, 1972.)

Mahogany Member raised to formation rank in and Ankareh Formation geographically restricted from Uinta Mountains region, northeastern Utah and southwestern Wyoming. Member usage remains unchanged in north-central Utah. (Stewart and others, 1972b.)

Age changed from Pliocene(?) to Pliocene. (Doell, 1972.)

Mallard Lake Member adopted as lowermost of six members of Plateau Rhyolite. Overlies Lava Creek Tuff (new); underlies Upper Basin and Central Plateau Members (both new) of Plateau. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)

Name	Age	Location
Manning Clay Member (of McElroy Formation) (of Jackson Group).	late Eocene	South-central Texas
Maroon Formation	Pennsylvanian and Permian.	Central Colorado
Marsh Formation (of Missoula Group) (of Belt Supergroup).	Precambrian Y	West-central Montana
Matilija Sandstone	middle or late Eocene	Southern California
Maywood Formation	Middle and Late Devonian.	Montana
Meagher Limestone	Middle Cambrian	Montana
Mesa Falls Tuff (of Yellowstone Group).	Pleistocene	South-central Montana and east-central Idaho.
Metralla Sandstone Member (of Tejon Formation).	late Eocene	Southern California
Michigamme Slate	middle Precambrian	Northwestern Michigan and northeastern Wisconsin.
Midnight Peak Formation	Cretaceous	North-central Washington.
Miller Peak Argillite/ Formation (of Missoula Group) (of Belt Supergroup).	Precambrian Y	West-central Montana
Minersville Tuff Member (of Needles Range Formation).	middle Tertiary	Southwestern Utah
Minsi Member (of Shawangunk Formation).	Late Ordovician(?) and Early Silurian.	Eastern Pennsylvania and western New Jersey.
Mission Canyon Limestone (of Madison Group).	Early and Late Mississippian.	Northwestern Wyoming and south-central Montana.

Revision and reference

Manning Clay Member of McElroy (now abandoned) raised to formational rank in Jackson Group as Manning Clay. Overlies Wellborn Sandstone; underlies Whitsett Formation. (Eargle, 1972.)

In the White River Plateau and McCoy-Eagle areas, Maroon Formation stratigraphically restricted to rocks below Weber Sandstone or State Bridge Formation. Two unnamed members and South Canyon Creek Member, formerly in upper part of Maroon Formation, now included in overlying State Bridge Formation. (Stewart and others, 1972b.)

Marsh Formation abandoned; its rocks divisible into Snowslip, Shepard, and Mount Shields Formations of Missoula. (Harrison, 1972.)

Matilija Sandstone Member of Tejon Formation of Kerr and Schenck (1928) adopted and raised in rank to Matilija Sandstone at expense of name Tejon in report area. Overlies Juncal Formation; underlies Cozy Dell Shale. (Vedder, 1972.)

Age changed from Late Devonian and Late(?) Devonian to Middle and Late Devonian. (Mudge, 1972.)

Geographically extended into east-central Idaho. (Witkind, 1972.)

Mesa Falls Tuff adopted as middle formation of Yellowstone Group. Overlies Huckleberry Ridge Tuff (new) and older units; most commonly underlies Lava Creek Tuff (new). (Christiansen and Blank, 1972.)

Metralla Sandstone Member of Marks (1941, 1943) adopted as member of Tejon Formation. Overlies Liveoak Shale Member; underlies Reed Canyon Siltstone Member. (Nilsen, 1972.)

Geographically extended into northeastern Wisconsin. (Dutton, 1971.)

Midnight Peak Formation of Barksdale (1948) adopted. (Staatz and others, 1971.)

Name changed from Miller Peak Argillite/Formation to Miller Peak Formation only and geographically restricted to Missoula-St. Regis-Superior area. Replaces Spruce Formation (now abandoned) in St. Regis-Superior area. Also Kintla Argillite (now abandoned) included in part of Miller Peak. (Harrison, 1972.)

Minersville Tuff of Mackin (1960) adopted as Minersville Tuff Member, uppermost member of Needles Range Formation; overlies Wah Wah Springs Tuff Member. (Grommé and others, 1972.)

Minsi Member of Shawangunk Formation newly defined and adopted. Overlies Weiders Member (new) of Shawangunk or Martinsburg Formation (Pen Argyl or Ramseyburg Members); underlies Lizard Creek Member (new) of Shawangunk. (Epstein and Epstein, 1972.)

Bull Ridge Member of Madison Limestone geographically extended into Beartooth Mountains area in northwestern Wyoming and south-central Montana; in northern third of area in Montana, Bull Ridge reassigned to Mission Canyon Limestone of Madison Group; in southern two-thirds, Bull Ridge remains member of Madison Limestone. (Sando, 1972.)

Name	Age	Location
Missoula Group (of Belt Supergroup).	Precambrian Y	Northwestern and west-central Montana, northern Idaho, and northwestern Washington.
Missoula Group (of Belt Supergroup).	Precambrian Y	Northwestern Montana.
Monk Formation	Precambrian (post-Belt).	Northeastern Washington.
Mono Basin Glaciation/Till	Pleistocene	Central California
Mono Basin Glaciation	Pleistocene	East-central California.
Montoya Group	Middle and Late Ordovician.	Southern New Mexico
Moodys Branch Formation (of Jackson Group).	late Eocene	Alabama, Mississippi, Georgia, Louisiana.
Mount Davis Volcanics	Miocene	Arizona and Nevada
Mount Givens Granodiorite	Late Cretaceous	East-central California.
Mount Jackson Rhyolite	Pleistocene	Southwestern Montana and northwestern Wyoming.
Mount Shields Formation (of Missoula Group) (of Belt Supergroup).	Precambrian Y	Northwestern Montana.
Mount Shields Formation (of Missoula Group) (of Belt Supergroup).	Precambrian Y	West-central and northwestern Montana.
Mount Wallace Formation (of Sunlight Group) (of Absaroka Volcanic Supergroup).	middle Eocene	Northwestern Wyoming and south-central Montana.

Revision and reference
Formations of Missoula Group changed as follows: 1. In northwestern and west-central Montana, Bouchard Formation abandoned and replaced by Garnet Range Formation; Greenhorn Mountain Quartzite of Belt Supergroup and Lupine Quartzite abandoned and replaced by geographically extended Bonner Quartzite; Sloway Formation abandoned and replaced by McNamara Formation. 2. In northwestern Montana, Marsh Formation abandoned and replaced by Snowslip, Shepard, and Mount Shields Formations; Kintla Formation abandoned and replaced by lower part of Mount Shields Formation. 3. In west-central Montana, Spruce Formation abandoned and replaced by geographically restricted Miller Peak Formation (name changed from Miller Peak Argillite/Formation to Formation only). 4. By geographical extension, Libby Formation extended into northern Idaho and northeastern Washington; Striped Peak Formation extended into northwestern Montana and northeastern Washington. 5. Name of Purcell Basalt changed to Purcell Lava. (Harrison, 1972.)
In Sun River Canyon area, Missoula Group includes (ascending): Snowslip, Shepard, and Mount Shields Formations, Bonner Quartzite, and McNamara Formation. Greyson Shale, Empire and Spokane Formations no longer included in Missoula and reassigned to Ravalli Group; Helena Dolomite no longer included in Missoula and presently unassigned to any named group. (Mudge, 1972.)
Geographically extended into northern Idaho. (Harrison, 1972.)
Mono Basin Glaciation of Sharp and Birman (1963) adopted as Mono Basin Glaciation/Till. (Birkeland and Janda, 1971.)
Name changed to Mono Basin Drift; Mono Basin Glaciation remains in good usage. (Crandell, 1972.)
Geographically extended into Morenci area, southeastern Arizona; its lower part (Second Value Dolomite) replaces former upper part of Longfellow Limestone (now abandoned). (Hayes, 1972.)
Dellet Sand of Stenzel (1952) adopted as Dellet Sand Member of Moodys Branch Formation. (Herrick, 1972.)
Age changed from Tertiary to Miocene. (Anderson and others, 1972.)
Age changed from Cretaceous to Late Cretaceous. (Bateman and Wones, 1972.)
Mount Jackson Rhyolite adopted. Conformably underlies Lava Creek Tuff (new) in areas near Yellowstone caldera wall. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)
Shields Formation of Childers(1963) adopted as Mount Shields Formation. Overlies Shepard Formation; underlies Bonner Quartzite. (Mudge, 1972.)
Kintla Argillite (now abandoned) included in lower part of Mount Shields Formation in Glacier Park area. Mount Shields geographically extended southward to Helena and Butte area. (Harrison, 1972.)
Mount Wallace Formation adopted and assigned to Sunlight Group (new) of Absaroka Volcanic Supergroup (new) as lowermost formation. Underlies Langford Formation (new); underlies or interfingers with Wapiti Formation in some areas. Includes Slough Creek Member (new). (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)

Name	Age	Location
Muddy Creek Formation	Pliocene	Arizona and Nevada
Mullinix Formation (of Auld Lang Syne Group).	Late Triassic and (or) Jurassic.	Northwestern Nevada
Murphy Marble	Cambrian(?)	North Carolina, Georgia, Tennessee.
Myrtle Group	Late Jurassic and Early Cretaceous.	Southwestern Oregon
Nahant Gabbro	early Paleozoic	Massachusetts
Nancy Member (of Borden Formation).	Early Mississippian	Kentucky
Nantahala Slate	Cambrian(?)	Georgia, North Carolina, and Tennessee.
Naomi Peak Tongue (of Twin Knobs Formation).	Middle Cambrian	Idaho and Utah
Napali Formation	Pliocene	Hawaii, Kauai Island
Needle Mountain Granodiorite.	Tertiary	Wyoming
Needles Range Formation	Tertiary	Southwestern Utah and eastern Nevada.
Nelson Mountain Tuff	late Oligocene	Southwestern Colorado
Nemo Group	middle Precambrian	West-central South Dakota.
Neruokpuk Formation	Precambrian(?), Cambrian, and post-Cambrian pre-Mississippian.	Northeastern Alaska
Newland Limestone/Formation (of Piegan Group) (of Belt Supergroup).	Precambrian Y	Northern Idaho, northwestern and west-central Montana.
New Providence Shale Member (of Borden Formation).	Early Mississippian	South-central Kentucky

Revision and reference

Age changed from Pliocene(?) to Pliocene. (Anderson and others, 1972.)

Mullinix Formation of Compton (1960) adopted as uppermost formation of Auld Lang Syne Group (new). Overlies Andorno Formation. (Burke and Silberling, 1973.)

Age changed from Early Cambrian to Cambrian(?). (Hadley and Nelson, 1971.)

Humbug Mountain Conglomerate assigned to Myrtle Group. (Coleman, 1972.)

Nahant Gabbro reinstated; its rocks no longer included in Salem Gabbro-Diorite. (Bell and Dennen, 1972.)

Nancy Member extended into north-central Kentucky. Overlies New Providence Shale Member, or, to the east, Kenwood Siltstone Member; underlies Holtsclaw Siltstone Member, or, to the west, Muldraugh Member. (Kepferle, 1971.)

Age changed from early Paleozoic(?) to Cambrian(?). (Hadley and Nelson, 1971.)

Naomi Peak Limestone Member of Langston Formation of Maxey (1958) adopted as Naomi Peak Tongue, uppermost unit of Twin Knobs Formation (new). Underlies Spence Tongue (formerly Spence Shale Member of Ute Limestone) of Lead Bell Shale (new). (Oriel and Armstrong, 1971.)

Age changed from Pliocene(?) to Pliocene. (Doell, 1972.)

Needle Mountain Granodiorite of Fisher (1967) adopted. (Fisher, 1972.)

Needles Range Formation divided into two members (ascending): Wah Wah Springs and Minersville Tuff. (Grommé and others, 1972.)

Divided into (ascending): unnamed outflow member and Cochetopa Park Member (new). Overlies Rat Creek Tuff; underlies Snowshoe Mountain Tuff. (Steven and others, this report, p. A80.)

Nemo System of Runner (1934) adopted as Nemo Group. Divided into two new formations (ascending): Boxelder Creek Quartzite and Benchmark Iron-formation. Unconformably overlies Little Elk Granite; unconformably underlies Estes Conglomerate (also newly adopted of Runner, 1934). (Bayley, 1972.)

Age changed from Late Devonian or older to Precambrian(?), Cambrian, and post-Cambrian pre-Mississippian. (Dutro and others, 1972.)

Removed from Piegan Group (now abandoned) and assigned to lower part of Belt Supergroup. Age changed from Precambrian (Piegan) to Precambrian (pre-Ravalli). (Harrison, 1972.)

In south-central Kentucky, New Providence Shale Member included as lowermost member of Fort Payne Formation; underlies Knifley Sandstone Member (new). New Providence Shale remains in good usage as member of Borden Formation in central and north-central Kentucky. (Kepferle and Lewis, this report, p. A63.)

Name	Age	Location
Norrie Ferruginous Chert Member (of Ironwood Iron-formation) (of Menominee Group).	Precambrian X	Northwestern Michigan and northwestern Wisconsin.
Obsidian Creek Member (of Plateau Rhyolite).	Pleistocene	Wyoming
Olokele Formation	Pliocene	Hawaii, Kauai Island
O'Neill Formation (of Auld Lang Syne Group).	Late Triassic	Northwestern Nevada
Ophir Formation/Shale	Middle Cambrian	Utah
Oquirrh Formation	Early Pennsylvanian to Early Permian.	Utah
Osobb Formation	Late Triassic	Northwestern Nevada
Osprey Formation	Pleistocene	Montana, Idaho, and Wyoming.
Otter Point Formation	Late Jurassic	Southwestern Oregon
Outlet Tunnel Member (of La Garita Tuff).	late Oligocene	Southwestern Colorado
Overton Fanglomerate	Tertiary	Southwestern Nevada
Pacific Creek Tuff Member (of Trout Peak Trachyandesite) (of Sunlight Group) (of Absaroka Volcanic Supergroup).	middle Eocene	Northwestern Wyoming
Palms Quartzite (of Menominee Group).	Precambrian X	Northwestern Michigan and northwestern Wisconsin.
Park Shale	Middle Cambrian	Wyoming and Montana
Park City Group	Permian	Utah, Colorado, Idaho, Montana, and Wyoming.
Patsy Mine Volcanics	Miocene	Arizona and Nevada
Peach Bottom Slate	latest Precambrian	Pennsylvania and Maryland.

Revision and reference

Name changed from Norrie Ferruginous Chert Member to Norrie Member. Age changed from middle Precambrian to Precambrian X. (Schmidt and Hubbard, 1972.)

Obsidian Creek Member adopted. Overlies mainly Lava Creek Tuff (new) or partly lies between flows of Swan Lake Flat Basalt (new); underlies younger members of Plateau Rhyolite. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)

Age changed from Pliocene(?) to Pliocene. (Doell, 1972.)

O'Neill Formation of Compton (1960) adopted as formation of Auld Lang Syne Group (new). Overlies Winnemucca Formation, underlies Singas Formation. (Burke and Silberling, 1973.)

Age changed from Early and Middle Cambrian to Middle Cambrian. (Baker, 1972.)

Shingle Mill Limestone Member (new) of Oquirrh Formation of Middle Pennsylvanian (Des Moinesian) age adopted. Upper part of Oquirrh Formation, elsewhere of late Late Pennsylvanian and Early Permian age, missing in report area. Formation locally includes 4 units: type Bridal Veil Limestone Member at base, Shingle Mill Limestone Member and two unnamed units. (Baker, 1972.)

Assigned to Auld Lang Syne Group (new). (Burke and Silberling, 1973.)

Name changed from Osprey Formation to Osprey Basalt. Tower Creek Gravel Member removed from Osprey and not used in this report. (Christiansen and Blank, 1972.)

Otter Point Formation of Koch (1966) adopted. Underlies Humbug Mountain Conglomerate. (Hunter and others, 1970.)

Outlet Tunnel Member of La Garita Tuff abandoned; its rocks now included in La Garita Member (reduced in rank and assigned to Fish Canyon Tuff). (Steven and others, this report, p. A78.)

Age changed from Cretaceous(?) or Tertiary(?) to Tertiary. (Anderson and others, 1972.)

Pacific Creek Tuff Member of upper part of Trout Peak Trachyandesite of Sunlight Group (new) of Absaroka Volcanic Supergroup (new) adopted. (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)

Name changed from Palms Quartzite to Palms Formation. Age changed from middle Precambrian to Precambrian X. (Schmidt and Hubbard, 1972.)

Geographically extended into east-central Idaho. (Witkind, 1972.)

Geographically extended into Pequop Mountains area, northeastern Nevada. (Yochelson and Fraser, 1973.)

Age changed from Tertiary to Miocene. (Anderson and others, 1972.)

Assigned as lowermost formation of Glenarm Series in Susquehanna River area, underlying Cardiff Metaconglomerate. Age is changed from Ordovician(?) to latest Precambrian. (Higgins, 1972.)

Name	Age	Location
Pence Ferruginous Slate Member (of Ironwood Iron-formation) (of Menominee Group).	Precambrian X	Northwestern Michigan and northwestern Wisconsin.
Pennington Formation	Late Mississippian	Eastern Kentucky
Perryville Limestone Member (of Lexington Limestone).	Middle Ordovician	Central Kentucky
Phoenix Park Member (of La Garita Tuff).	late Oligocene	Southwestern Colorado
Piedra Rhyolite (of Potosi Volcanic Group).	middle and late Tertiary.	Southwestern Colorado
Piegan Group (of Belt Supergroup).	Precambrian Y	Idaho and Montana
Pierre Shale	Late Cretaceous	Western Kansas
Pine Hollow Formation	Paleocene(?)	South-central Utah
Pitchfork Formation	middle Eocene	Northwestern Wyoming
Plateau Rhyolite	Pleistocene	Montana, Idaho, and Wyoming.
Plymouth Ferruginous Chert Member (of Ironwood Iron-formation) (of Menominee Group).	Precambrian X	Northwestern Michigan and northwestern Wisconsin.
Plympton Formation (of Park City Group).	Permian	Utah
Pony Trail Group	Late(?) Jurassic	North-central Nevada
Popo Agie Formation (of Chugwater Group).	Late Triassic	Northwestern Wyoming
Port Clarence Limestone	Early and Late Ordovician, Middle and Late Silurian and Devonian.	Western Alaska
Port Deposit Gneiss	Late Cambrian to Late Ordovician.	Maryland

Revision and reference

Name changed from Pence Ferruginous Slate Member to Pence Member. Age changed from middle Precambrian to Precambrian X. (Schmidt and Hubbard, 1972.)

Little Stone Gap Member and Stony Gap Sandstone Member of Hinton Formation in Virginia assigned to Pennington Formation in eastern Kentucky. (Alvord and Miller, 1972.)

Faulconer Limestone Member of Perryville Formation of Foerste (1912) adopted as Faulconer Bed, basal unit of Perryville Limestone Member. (Cressman, 1972.)

Phoenix Park Member of La Garita Tuff reassigned to Fish Canyon Tuff. Uppermost of three members of Fish Canyon; overlies La Garita Member (reduced in rank). (Steven and others, this report, p. A78.)

Name Piedra Rhyolite abandoned; replaced by Carpenter Ridge Tuff. Potosi Volcanic Group with other named formations remains in good usage outside report area. (Steven and others, this report, p. A79.)

Piegan Group abandoned. Its rocks now included in Spokane and Empire Formations of Ravalli Group and Siyeh Limestone, Helena Dolomite, and Wallace Formation (all three stratigraphic equivalents), presently unassigned to any named group(s). (Mudge, 1972.)

In western Kansas, Pierre Shale divided into (ascending): Sharon Springs, Weskan, Lake Creek, Salt Grass, unnamed, and Beecher Island Members. Pierre Shale usage elsewhere is unchanged. (Gill and others, 1972.)

Pine Hollow Formation adopted. Conformably overlies or locally intertongues with Canaan Peak Formation (new); conformably underlies pink limestone member of Wasatch Formation. (Bowers, 1972.)

Assigned to Sunlight Group (new) of Absaroka Volcanic Supergroup (new). Interfingers with Wapiti Formation; seemingly correlates with Aycross Formation in southern Absaroka Range. (Smedes and Prostka, 1972.)

Plateau Flows of Boyd (1961) adopted as Plateau Rhyolite. Divided into six new members: Mallard Lake, Obsidian Creek, Roaring Mountain, Upper Basin, Central Plateau, and Shoshone Lake Tuff. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)

Name changed from Plymouth Ferruginous Chert Member to Plymouth Member. Age changed from middle Precambrian to Precambrian X. (Schmidt and Hubbard, 1972.)

Geographically extended into Pequop Mountains area, northeastern Nevada. (Yochelson and Fraser, 1973.)

Age changed from Mesozoic (Jurassic?) to Late(?) Jurassic. (Smith, this report, p. A83.)

Geographically extended into northwestern Wyoming and in that area only reduced in rank to Popo Agie Member of Chugwater Formation. (Love and Albee, 1972.)

Port Clarence abandoned; its rocks now included in informal limestone units referred to only by system represented. (Sainsbury, 1972.)

Geographically restricted to area of its type locality near Port Deposit, Md., extending unknown distance along strike into Harford County, Md. Age changed from early Paleozoic(?) to Late Cambrian to Late Ordovician. (Higgins, 1972.)

Name	Age	Location
Potosi Volcanic Group	Oligocene and Miocene	Central San Juan caldera complex area southwestern Colorado.
Price Formation	Early Mississippian	Eastern Kentucky
Promontory Member (of Langford Formation) (of Thorofare Creek Group) (of Absaroka Volcanic Supergroup).	early middle Eocene	Northwestern Wyoming
Purcell Basalt (of Missoula Group) (of Belt Supergroup).	Precambrian Y	Northwestern Montana
Quadrant Sandstone	Middle Pennsylvanian	East-central Idaho, Wyoming, and Montana.
Quantico Slate	Middle and Late Ordovician.	Northern Virginia
Quiburis Formation (of Gila Group).	middle Pliocene	Southeastern Arizona
Raspberry Formation	Late Triassic	Northwestern Nevada
Rat Creek Tuff	late Oligocene	Southwestern Colorado
Rattler Granodiorite	Late Cretaceous	South-central Arizona
Ravalli Group (of Belt Supergroup).	Precambrian Y	Northwestern Montana
Ravalli Group (of Belt Supergroup).	Precambrian Y	Northeastern Washington, northern Idaho, northwestern and west-central Montana.
Reausaw Slate (of Windy Flats Group).	middle Precambrian	West-central South Dakota.
Recess Peak Glaciation/ Till.	Holocene	Central California
Red Peak Formation (of Chugwater Group).	Early Triassic	Northwestern Wyoming

Revision and reference

Names Alboroto and Piedra Rhyolites of Potosi Volcanic Group abandoned; their rocks replaced by Fish Canyon and Carpenter Ridge Tuffs, respectively. Potosi Volcanic Group not used in report area, but remains in good usage with other named formations elsewhere. (Steven and others, this report, p. A77.)

Price Formation reduced in rank and made member of Grainger Formation in eastern Kentucky. (Alvord and Miller, 1972.)

Promontory Member of Langford Formation (new) of Thorofare Creek Group (new) of Absaroka Volcanic Supergroup (new) adopted. (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)

Name changed from Purcell Basalt to Purcell Lava. (Harrison, 1972.)

Geographically extended into east-central Idaho. (Witkind, 1972.)

Assigned as uppermost formation of Glenarm Series in northern Virginia Piedmont, overlying Chopawamsic Formation. Age changed from Ordovician to late Middle and Late Ordovician. (Higgins, 1972.)

Removed from Gila Group (no longer of group rank) and no longer included in any named group. Age changed from Pliocene and Pleistocene to middle Pliocene (Hemphillian). (Krieger and others, this report, p. A55.)

Assigned to Auld Lang Syne Group (new). (Burke and Silberling, 1973.)

Divided into (ascending): unnamed outflow member and Equity Member (former Equity Quartz Latite reinstated and reduced in rank). (Steven and others, this report, p. A80.)

Rattler Granodiorite adopted; intrudes Paleozoic sedimentary rocks and is intruded by many Laramide dikes. (Cornwall and others, 1971.)

In San Juan River Canyon area, Greyson Shale and Empire and Spokane Formations no longer included in Missoula Group and reassigned to Ravalli Group. (Mudge, 1972.)

Grinnel Formation/Argillite of Ravalli abandoned; replaced by Spokane Formation/Shale (geographically extended into northwestern Montana). Altyn Limestone removed from Ravalli and assigned to lower part of Belt Supergroup (pre-Ravalli). Burke, Revett, and St. Regis Formations of Ravalli geographically extended into Montana and Washington. Name of Appekunny Argillite of Ravalli changed to Appekunny Formation. (Harrison, 1972.)

Reausaw Slate adopted as upper of two new formations of Windy Falls Group (new name). Conformably overlies Hay Creek Greenstone, new lower formation of Windy Flats; unconformably(?) underlies Roubaix Formation (newly adopted of Berg, 1946.) (Bayley, 1972.)

Recess Peak glacial stage of Wahrhaftig (1962) adopted as Recess Peak Glaciation/Till as defined by Birman (1964). (Birkeland and Janna, 1971.)

Geographically extended into northwestern Wyoming and in that area only reduced in rank to Red Peak Member of Chugwater Formation. (Love and Albee, 1972.)

Name	Age	Location
Reed Canyon Siltstone Member (of Tejon Formation).	late Eocene	Southern California
Reese Formation	Eocene(?)	Northwestern Wyoming and south-central Montana.
Revett Formation (of Ravalli Group) (of Belt Supergroup).	Precambrian Y	Idaho
Rib Hill Formation	Early Permian	Eastern Nevada
Río Culebrinas Formation	middle Eocene	Northwestern Puerto Rico and Isla Desecheo.
Roaring Mountain Member (of Plateau Rhyolite).	Pleistocene	Southwestern Montana and northwestern Wyoming.
Roberts Draw Limestone	middle Precambrian	West-central South Dakota.
Roberts Mountains Formation.	Early Silurian to Early Devonian.	North-central Nevada
Rochester Rhyolite (of Koipato Group).	Early Triassic	Northwestern Nevada
Roubaix Formation	middle Precambrian	West-central South Dakota.
Sacaton Formation (of Gila Group).	Pleistocene	Southeastern Arizona
St. Regis Formation (of Ravalli Group) (of Belt Supergroup).	Precambrian Y	Idaho
Salem Gabbro-Diorite	Precambrian(?)	Massachusetts
Salmon Hornblende Schist	Devonian or older Paleozoic.	Northwestern California
Salt Grass Member (of Pierre Shale).	Late Cretaceous	Western Kansas
Sangre de Cristo Formation.	Permian (Wolfcampian)—in report area only.	Northeastern New Mexico.

Revision and reference

Reed Canyon Silt Member of Marks (1941, 1943) adopted as Reed Canyon Siltstone Member, uppermost member of Tejon Formation. Overlies Metralla Sandstone Member. (Nilsen, 1972.)

Reese Formation abandoned. Its rocks now included in Cretaceous sandstone and conglomerate and parts of the Sepulcher Formation (conglomerate facies lens and lower and middle units of Lost Creek Tuff Member.) (Smedes and Prostka, 1972.)

Geographically extended into Montana and Washington. (Harrison, 1972.)

Rib Hill Formation used in report area; Rib Hill Sandstone remains in good usage elsewhere. (Hope, 1972.)

Río Culebrinas Formation made part of Jacaquas Group in northwestern Puerto Rico and Isla Desecheo. (Seiders and others, 1972.)

Roaring Mountain Member adopted. Overlies Lava Creek Tuff (new), Swan Lake Flat Basalt (new), and parts of Obsidian Creek Member (new) of Plateau Rhyolite; underlies flows and is cut by dikes of Madison River Basalt (new) or upper Pleistocene and Holocene surficial deposits. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)

Roberts Draw Limestone adopted; formerly upper part of Estes System of Runner (1934) (now redefined and reduced in rank to Estes Conglomerate, former lower part of Runner's Estes). Conformably overlies Estes Conglomerate; separated from overlying Buck Mountain Quartzite (new name) by metagabbro dikes and sills. (Bayley, 1972.)

Age changed from Early to Late Silurian to Early Silurian to Early Devonian. (Smith, this report, p. A83.)

Age changed from Permian to Early Triassic. (McKee and Burke, 1972.)

Roubaix Group of Berg (1946) adopted and reduced in rank to Roubaix Formation. Unconformably(?) overlies Reausaw Slate (new name): unconformably underlies Deadwood Formation. (Bayley, 1972.)

Sacaton Formation abandoned; its rocks presently referred to by informal names. (Krieger and others, this report, p. A54.)

Geographically extended into Montana and Washington. (Harrison, 1972.)

Nahant Gabbro reinstated; its rocks no longer included in Salem Gabbro-Diorite. (Bell and Dennen, 1972.)

Age changed from Devonian to Devonian or older Paleozoic. (Hotz and others, 1972.)

Salt Grass Shale Member of Elias (1931) adopted as Salt Grass Member. Overlies Lake Creek Member; underlies unnamed and Beecher Island members. (Gill and others, 1972.)

In report area, San Miguel County of northeastern New Mexico, age changed to Early Permian (Wolfcampian) only; remains Late Pennsylvanian and Early Permian elsewhere. (Baltz, 1972.)

Name	Age	Location
San Manuel Formation (of Gila Group).	early(?) Miocene -----	Southeastern Arizona -
Santiago Peak Volcanics --	Late Jurassic and Early Cretaceous(?).	Southern California ---
Sardine Formation -------	middle Miocene to early Pliocene.	Oregon -------------
Second Value Dolomite (of Montoya Group).	Middle and Late Ordovician.	Southwestern New Mexico.
Sedgwick Peak Quartzite Member (of Brigham Quartzite).	Early Cambrian ------	Southeastern Idaho ---
Sepulcher Formation (of Washburn Group) (of Absaroka Volcanic Supergroup).	early and middle Eocene.	Northwestern Wyoming and south-central Montana.
Sharon Springs Member (of Pierre Shale).	Late Cretaceous ------	Western Kansas ------
Sharpners Pond Tonalite --	Precambrian(?) to Silurian(?).	Northeastern Massachusetts.
Shawangunk Formation ---	Late Ordovician(?) and Early and Middle Silurian.	Pennsylvania, New Jersey, and New York.
Shedhorn Sandstone ------	Permian ------------	Wyoming and Montana -
Shingle Mill Limestone Member (of Oquirrh Formation).	Middle Pennsylvanian -	Utah --------------
Shnabkaib Member (of Moenkopi Formation).	Early Triassic --------	Southwestern Utah and northwestern Arizona.
Shoshone Lake Tuff Member (of Plateau Rhyolite).	Pleistocene ----------	Northwestern Wyoming
Sierra Blanca Limestone --	early Eocene ---------	Southern California ---

Revision and reference

Geographically extended from San Manuel area to Ray area. Removed from Gila Group(no longer of group rank) and no longer included in any named group. Age changed from middle(?) Tertiary to early(?) Miocene. (Krieger and others, this report, p. A54.)

Age changed from Late Jurassic(?) to Early Cretaceous(?) to Late Jurassic and Early Cretaceous(?). (Kennedy and Moore, 1971.)

Age changed from middle and late Miocene to middle Miocene to early Pliocene. (Hampton, 1972.)

Geographically extended into Morenci area, southeastern Arizona; replaces upper part of former Longfellow Limestone (now abandoned). (Hayes, 1972.)

Sedgwick Peak Quartzite Member adopted as uppermost of three new members of Brigham Quartzite. Conformably overlies Windy Pass Argillite Member; underlies Twin Knobs Formation (new). (Oriel and Armstrong, 1971.)

Sepulcher Formation of Washburn Group (new) of Absaroka Volcanic Supergroup (new) adopted in Absaroka and Washburn Ranges. Underlies Wapiti Formation, Mount Wallace Formation (new), or Crescent Hill Basalt; interfingers with Lamar River Formation (new). Divided into (approximate ascending): conglomerate facies, Elk Creek Basalt and Lost Creek Tuff Members, Daly Creek and Fortress Mountain Members (new), and andesite lavas. Rocks formerly included in Reese Formation (now abandoned) now included in conglomerate facies and lower and middle units of Lost Creek Tuff Member of Sepulcher. (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)

In western Kansas, Sharon Springs is redefined to exclude top part now placed in overlying Weskan Member; is basal member of Pierre. Sharon Springs usage elsewhere is unchanged. (Gill and others, 1972.)

Age changed from pre-Carboniferous to Precambrian(?) to Silurian(?). (Castle and Theodore, 1972.)

Clinton Formation and Tuscarora Sandstone abandoned in area of report (Bake Oven Knob to Delaware Water Gap) and replaced by Shawangunk Formation. Shawangunk divided into four members (ascending): Weiders and Minsi (Tuscarora Sandstone as used by Swartz and Swartz, 1931), Lizard Creek (Clinton Formation as used by Swartz and Swartz, 1931), and Tammany (all newly defined and adopted). Age changed from Early and Middle Silurian to Late Ordovician(?) and Early and Middle Silurian. (Epstein and Epstein, 1972.)

Geographically extended into east-central Idaho. (Witkind, 1972.)

Shingle Mill Limestone Member adopted; overlies and underlies unnamed units of Oquirrh Formation. (Baker, 1972.)

Geographically extended into southern Nevada. (Stewart and others, 1972b.)

Shoshone Lake Tuff Member adopted; lies between two flows of Central Plateau Member (new) but in places is covered by younger rhyolite flows. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)

Sierra Blanca Limestone of Nelson (1925) adopted. Overlies Upper Cretaceous strata; underlies Juncal Formation. (Vedder, 1972.)

Name	Age	Location
Silver Plume Granite	Precambrian	Colorado
Singas Formation (of Auld Lang Syne Group).	Late Triassic	Northwestern Nevada
Siyeh Limestone (of Belt Supergroup).	Precambrian Y	Northwestern Montana
Skolai Group	Early Permian(?) and Early Permian.	Souhtern Alaska
Slough Creek Tuff Member (of Mount Wallace Formation) (of Sunlight Group) (of Absaroka Volcanic Supergroup).	middle Eocene	Northwestern Wyoming and south-central Montana.
Sloway Formation (of Missoula Group) (of Belt Supergroup).	Precambrian Y	West-central Montana
Snowslip Formation (of Missoula Group) (of Belt Supergroup).	Precambrian	Northwestern Montana
Sod House Tuff (of Pony Trail Group).	Late(?) Jurassic	North-central Nevada
South Canyon Creek Member (of Maroon Formation).	Permian	Central Colorado
Spence Shale Member (of Ute Limestone).	Middle Cambrian	Southeastern Idaho and northeastern Utah.
S. P. Lava Flow	Holocene	North-central Arizona
Spokane Formation/Shale (of Ravalli Group) (of Belt Supergroup).	Precambrian Y	West-central Montana
Spruce Formation (of Missoula Group) (of Belt Supergroup).	Precambrian Y	West-central Montana
State Bridge Formation	Permian and Early Triassic.	Central Colorado
Station Creek Formation	Early Permian(?)	Southern Alaska
Stone Cabin Formation	middle Tertiary	Eastern Nevada

Revision and reference

In Tungsten quadrangle, name changed to Silver Plume Quartz Monzonite. (Gable, 1972.)

Singas Formation of Compton (1960) adopted as formation of Auld Lang Syne Group (new). Overlies O'Neill Formation; underlies Andorno Formation. (Burke and Silberling, 1973.)

Siyeh Limestone abandoned; replaced by Helena Dolomite/Formation of Belt Supergroup. (Harrison, 1972.)

Age changed from Permian(?) and Permian to Early Permian(?) and Early Permian. (MacKevett and Smith, 1972.)

Slough Creek Tuff Member of Mount Wallace Formation (new) of Sunlight Group (new) of Absaroka Volcanic Supergroup (new) adopted. (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)

Sloway Formation abandoned; replaced by McNamara Formation/Argillite of Missoula. (Harrison, 1972.)

Snowslip Formation of Childers (1963) adopted. Overlies Helena Dolomite; underlies Shepard Formation. (Mudge, 1972.)

Age changed from Mesozoic (Jurassic?) to Late(?) Jurassic. (Smith, this report, p. A83.)

Reassigned as middle member of State Bridge Formation. Overlies unnamed lower member (Permian); underlies unnamed upper member (Lower Triassic). (Stewart and others, 1972b.)

Redefined and reassigned as Spence Tongue of Lead Bell Shale (new). Overlies Naomi Peak Tongue (formerly a limestone member of Langston Formation of Maxey (1958), now redefined) of Twin Knobs Formation (new); underlies High Creek Limestone (new). (Oriel and Armstrong, 1971.)

S. P. Flow of Colton (1937) adopted as S. P. Lava Flow. (Schaber and Brown, 1972.)

Geographically extended replacing Grinnell Formation/Argillite in northwestern Montana; Grinnell now abandoned. (Harrison, 1972.)

Spruce Formation abandoned; replaced by Miller Peak Formation of Missoula. (Harrison, 1972.)

State Bridge Formation of Donner (1949) adopted; includes rocks formerly in upper part of Maroon Formation. Divided into (ascending): unnamed lower member and South Canyon Creek Member (Permian) and unnamed upper member (Lower Triassic). Unconformably overlies Weber Sandstone, Maroon Formation, or Precambrian rocks: unconformably underlies Chinle Formation. (Stewart and others, 1972b.)

Age changed from Permian(?) to Early Permian(?). (McKevett and Smith, 1972.)

Stone Cabin Tuff/Formation of Cook (1960, 1965) adopted as Stone Cabin Formation. (Grommé and others, 1972.)

Name	Age	Location
Stones Switch Sandstone Member (of Whitsett Formation) (of Jackson Group).	late Eocene	South-central Texas
Stony Gap Sandstone Member (of Hinton Formation).	Late Mississippian	Western Virginia and eastern Kentucky.
Striped Peak Formation (of Missoula Group) (of Belt Supergroup).	Precambrian Y	Northern Idaho
Stuart Fork Formation	Paleozoic and Triassic(?).	Northern California
Sunlight Group (of Absaroka Volcanic Supergroup).	middle Eocene	Northwestern Wyoming and south-central Montana.
Swan Lake Flat Basalt	Pleistocene	Northwestern Wyoming
Table Mountain Shoshonite	Paleocene	Central and northeastern Colorado.
Tahoe Glaciation	Pleistocene	Northeastern California
Tammany Member (of Shawangunk Formation).	Middle Silurian	Eastern Pennsylvania and western New Jersey.
Teapot Mountain Porphyry	Paleocene	South-central Arizona
Tejon Formation	middle and late Eocene	Southern California
Tenaya Stade/Till (of Tioga Glaciation).	Pleistocene	Central California
Tepee Trail Formation	middle and late Eocene	Northwestern Wyoming
Thaynes Formation	Early Triassic	Utah, Wyoming, Idaho, and Montana.
Thorofare Creek Group (of Absaroka Volcanic Supergroup).	middle and late Eocene	Wyoming and Montana

Revision and reference

Stones Switch Sandstone Member abandoned; its rocks now included in Deweesville Sandstone Member (new). (Eargle, 1972.)

Stony Gap Sandstone Member of Hinton Formation in western Virginia assigned to Pennington Formation in eastern Kentucky. (Alvord and Miller, 1972.)

Geographically extended into northwestern Montana and northeastern Washington. Kintla Argillite (now abandoned) included in part of Striped Peak. (Harrison, 1972.)

Stuart Fork Formation of Davis and Lipman (1962) adopted; overthrust northwestward on greenstone-chert terrane. (Hotz, 1973.)

Sunlight Group adopted as middle of three groups of Absaroka Volcanic Supergroup (new). Overlies Washburn Group (new) or prevolcanic rocks; underlies or interfingers with Thorofare Creek Group (new). Divided into (ascending): Mount Wallace Formation and its Slough Creek Tuff Member (both new), Crescent Hill Basalt, Wapiti Formation and its Jim Mountain Member, Pitchfork Formation (interfingering equivalent of Wapiti), and Trout Peak Trachyandesite and its Pacific Creek Member (new). (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)

Swan Lake Flat Basalt adopted. Conformably overlies Lava Creek Tuff (new) and locally underlies Plateau Rhyolite flows. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)

Table Mountain Basalt of Cross (1896) adopted as Table Mountain Shoshonite; interlayed with Denver Formation. (Scott, 1972.)

Name changed to Tahoe Drift in this report; Tahoe Glaciation/Till remains in good usage. (Crandel, 1972.)

Tammany Member of the Shawangunk adopted as uppermost of four newly defined members. Overlies Lizard Creek Member (new) of Shawangunk; underlies Bloomsburg Red Beds. (Epstein and Epstein, 1972.)

Age changed from early Tertiary(?) to Paleocene. (Cornwall and others, 1971.)

In its type area, San Emigdio Mountains, includes (ascending): Uvas Conglomerate Member, Liveoak Shale Member, Metralla Sandstone Member, and Reed Canyon Siltstone Member. Age changed from late Eocene to middle and late Eocene. (Nilsen, 1972.)

Tenaya Glaciation of Sharp and Birman (1963) adopted as Tenaya Stade/Till of Tioga Glaciation. (Birkeland and Janda, 1971.)

Assigned to Thorofare Creek Group (new) of Absaroka Volcanic Supergroup (new). Unconformably overlies Aycross Formation or Two Ocean Formation (new); unconformably underlies Wiggins Formation. (Smedes and Prostka, 1972.)

Geographically extended into Pequop Mountains area, northeastern Nevada. (Yochelson and Fraser, 1973.)

Thorofare Creek Group adopted as uppermost of three groups of Absaroka Volcanic Supergroup (new). Overlies or interfingers with Sunlight Group (new), Washburn Group (new), or prevolcanic rocks. Divided into (ascending): Langford and its Promontory Member, Two Ocean (all three new), Tepee Trail, and Wiggins Formations. (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)

Name	Age	Location
Thumb Formation	Cretaceous(?) and Tertiary.	Nevada
Tigaraha Schist	Precambrian	Western Alaska
Tims Peak Basalt	Miocene and Pliocene	Southeastern Oregon
Tioga Glaciation	Pleistocene (Wisconsin).	Northeastern California
Tor Limestone	latest(?) Silurian and Devonian.	Central Nevada
Tordilla Sandstone Member (of Whitsett Formation) (of Jackson Group).	late Eocene	South-central Texas
Tortilla Quartz Diorite	Late Cretaceous	South-central Arizona
Tower Creek Gravel Member (of Osprey Formation).	Pleistocene	Montana, Idaho, and Wyoming.
Treasure Mountain Tuff (of Potosi Volcanic Group).	Oligocene	Colorado and New Mexico.
Trout Peak Trachyandesite.	middle Eocene	Northwestern Wyoming
Turner Sandy Member (of Carlile Shale).	Late Cretaceous	South Dakota and Wyoming.
Tuscarora Sandstone	Early Silurian	Eastern Pennsylvania
Twin Knobs Formation	Middle Cambrian	Southeastern Idaho and Northern Utah.
Two Ocean Formation (of Thorofare Creek Group) (of Absaroka Volcanic Supergroup).	middle Eocene	Northwestern Wyoming
Tyler Slate (of Baraga Group(?)).	Precambrian X	Northwestern Michigan and northwestern Wisconsin.

Revision and reference

Age changed from Cretaceous(?) to Cretaceous(?) (lower part) and Tertiary (upper part). (Anderson and others, 1972.)

Age changed from early Paleozoic or older to Precambrian. (Sainsbury, 1972.)

Tims Peak Basalt of Kittleman and others (1965) adopted; overlies Hunter Creek Basalt. (Greene and others, 1972.)

Name changed to Tioga Drift in this report; Tioga Glaciation remains in good usage. (Crandell, 1972.)

Tor Formation of Kay (1960) adopted as Tor Limestone as used by Kay and Crawford (1964). Mainly overlies Antelope Valley Limestone; partly correlative with McMonnigal Limestone. (McKee and others, 1972.)

Rocks previously included as uppermost unit of Dubose Member, (Tordilla Sandstone of Eargle (1959)), removed from Dubose, adopted, and raised in rank to Tordilla Sandstone Member of Whitsett Formation. Overlies Dubose Member; underlies Fashing Clay Member; stratigraphic equivalent of Calliham Sandstone Member. (Eargle, 1972.)

Tortilla Quartz Diorite adopted. Consists of small stocklike masses that are cut by rhyodacite porphyry and that intrude all rocks older than and including Naco Limestone. (Cornwall and others, 1971.)

Tower Creek Gravel Member removed from Osprey and not used in report area. Its rocks included in the Junction Butte (new) and Osprey Basalts and rocks of The Narrows area. (Christiansen and Blank, 1972.)

Geographically extended into New Mexico. (Butler, 1971.)

Assigned to Sunlight Group (new) of Absaroka Volcanic Supergroup (new) as uppermost formation. Overlies and interfingers with Wapiti Formation; underlies and interfingers with Langford Formation (new). Includes Pacific Creek Tuff Member (new) in upper part. Age changed from late Eocene to middle Eocene. (Smedes and Prostka, 1972.)

Geographically extended into South Dakota. (Cobban, 1971.)

Tuscarora Sandstone abandoned in eastern Pennsylvania (Bake Oven Knob to Delaware Water Gap) and replaced by Weiders and Minsi Members (new) of Shawangunk Formation. Tuscarora remains in correct usage elsewhere. (Epstein and Epstein, 1972.)

Twin Knobs Formation adopted; divided into three informal members plus Naomi Peak Tongue as upper tongue (formerly Naomi Peak Limestone Member of Langston Formation of Maxey (1958)). Overlies and intertongues with Brigham Quartzite; underlies Lead Bell Shale (new) or its Spence Tongue (formerly Spence Shale Member of the Ute Limestone. (Oriel and Armstrong, 1971.)

Two Ocean Formation adopted and assigned to Thorofare Creek Group (new) of Absaroka Volcanic Supergroup (new). Overlies Langford Formation (new); unconformably underlies Tepee Trail or Wiggins Formations. (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)

Name changed from Tyler Slate to Tyler Formation. Age changed from middle Precambrian to Precambrian X. Possibly assigned to Baraga Group. (Schmidt and Hubbard, 1972.)

Name	Age	Location
Undine Falls Basalt	Pleistocene	Southwestern Montana and northwestern Wyoming.
Upper Basin Member (of Plateau Rhyolite).	Pleistocene	Wyoming
Ute Limestone	Middle Cambrian	Northeastern Utah and southeastern Idaho.
Uvas Conglomerate Member (of Tejon Formation).	middle Eocene	Southern California
Valleytown Formation	Cambrian(?)	North Carolina, Georgia, and Tennessee.
Wah Wah Springs Tuff Member (of Needle Range Formation).	middle Tertiary	Southwestern Utah
Waimea Canyon Volcanic Series.	Pliocene	Hawaii, Kauai Island
Wall Creek Sandstone Member (of Frontier Formation).	Late Cretaceous	South-central Wyoming
Wapiti Formation	early middle Eocene	Northwestern Wyoming
Wasatch Formation	Paleocene and Eocene	Central Utah
Washburn Group (of Absaroka Volcanic Supergroup).	early and middle Eocene.	Northwestern Wyoming and south-central Montana.
Weaver Rhyolite (of Koipato Group).	Early Triassic	Northwestern Nevada

Revision and reference

Undine Falls Basalt adopted. Conformably underlies Lava Creek Tuff (new); overlies Mount Jackson Rhyolite (new) or Cretaceous shales and sandstones. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)

Upper Basin Member adopted. Overlies Mallard Lake Member (new) of Plateau Rhyolite and Lava Creek Tuff (new); underlies Central Plateau Member (new) of Plateau Rhyolite. (Christiansen and Blank, 1972; U.S. Geol. Survey, 1972.)

Redefined to exclude Spence Shale Member (now Spence Tongue of Lead Bell Shale (new)). Cub Shale Member (new) adopted as basal unit of redefined Ute and considered Cub Tongue of Lead Bell to the west. Geographically restricted as eastern equivalent of Bancroft Limestone (new). (Oriel and Armstrong, 1971.)

Uvas Conglomerate Member of Marks (1941, 1943) adopted as basal member of Tejon Formation. Underlies Liveoak Shale Member. (Nilsen, 1972.)

Age changed from Early Cambrian to Cambrian(?). (Hadley and Nelson, 1971.)

Wah Wah Springs Tuff of Mackin (1960) adopted as Wah Wah Springs Tuff Member, lowermost member of Needles Range Formation; underlies Minersville Tuff Member. (Grommé and others, 1972.)

Age changed from Pliocene(?) to Pliocene. (Doell, 1972.)

Redefined and geographically extended into south-central Wyoming as uppermost of three members of Frontier Formation; overlies unnamed middle member. (Merewether and Cobban, 1972.)

Geographically extended into south-central Montana. Assigned with its Jim Mountain Member to Sunlight Group (new) of Absaroka Volcanic Supergroup (new). Overlies Lamar River, Cathedral Cliffs, or Willwood Formations; interfingers with Pitchfork Formation (and Mount Wallace (new) in some areas); unconformably underlies or interfingers with Trout Peak Trachyandesite. (Smedes and Prostka, 1972.)

Rocks previously mapped as lower Wasatch by many geologists are included in two newly adopted formations: Canaan Peak Formation of Late Cretaceous and Paleocene(?) age and Pine Hollow Formation of Paleocene(?) age. (Bowers, 1972.)

Washburn Group adopted as lowermost of three groups of Absaroka Volcanic Supergroup (new); present only in northern part of volcanic field. Unconformably overlies rocks of Precambrian to Paleocene age; underlies Sunlight Group (new) in areas; elsewhere underlies Thorofare Creek Group (new). Divided into (approximate or interfingers with ascending): In Absaroka and Washburn Ranges—Sepulcher Formation (new) and its conglomerate facies, Elk Creek Basalt and Lost Creek Tuff Members, Daly Creek and Fortress Mountain Members (new), and andesite lavas; Lamar River Formation (new) and its Elk Creek Basalt Member; and Cathedral Cliffs Formation. In northern Gallatin Range—Golmeyer Creek and Hyalite Peak Volcanics. (Smedes and Prostka, 1972; U.S. Geol. Survey, 1972.)

Age changed from Permian(?) and Early Triassic to Early Triassic. (McKee and Burke, 1972.)

Name	Age	Location
Weiders Member (of Shawangunk Formation).	Late Ordovician(?) and Early Silurian.	Eastern Pennsylvania
Weskan Member (of Pierre Shale).	Late Cretaceous	Western Kansas
Whisky Quartzite	Devonian	West-central Maine
Whiteside Granite	Devonian(?)	North Carolina and South Carolina.
Whitetail Conglomerate	Oligocene	Arizona
Whitsett Formation (of Jackson Group).	late Eocene	South-central Texas
Wiggins Formation	middle and late Eocene	Northwestern Wyoming
Willow Creek Member (of Bachelor Mountain Tuff).	Oligocene	Southwestern Colorado
Windous Butte Formation	middle Tertiary	Eastern Nevada
Windy Flats Group	middle Precambrian	West-central South Dakota.
Windy Gulch Member (of Bachelor Mountain Tuff).	Oligocene	Southwestern Colorado
Windy Pass Argillite Member (of Brigham Quartzite).	Precambrian(?)	Southeastern Idaho
Winnemucca Formation	Late Triassic	Northwestern Nevada
Wissahickon Formation (of Glenarm Series).	latest Precambrian to Early Ordovician.	Pennsylvania, New Jersey, Delaware, Maryland and Virginia.

Revision and reference
Weiders Member adopted as newly defined basal member of Shawangunk Formation. Overlies Pen Argyl Member of Martinsburg Formation; underlies Minsi Member (new) of Shawangunk. (Epstein and Epstein, 1972.)
Weskan Shale of Elias (1931) redefined and adopted as Weskan Member. Basal part modified to include part of underlying Sharon Springs Member; underlies Lake Creek Member. (Gill and others, 1972.)
Age changed from Silurian or Early Devonian to Devonian. (Espenshade, 1972.)
Age changed from Precambrian(?) to Devonian(?). (Hadley and Nelson, 1971.)
Age changed from Tertiary to Oligocene. (Cornwall and others, 1971.)
Whitsett Formation revised to include seven members (ascending): Dilworth Sandstone (reassigned from abandoned McElroy Formation); Conquista Clay (reassigned from McElroy); Deweesville Sandstone (new) (replacing Stones Switch Sandstone Member, now abandoned); Dubose; Tordilla Sandstone and Calliham Sandstone (restricted), stratigraphic equivalents; and Fashing Clay. As uppermost formation of Jackson Group, Whitset overlies Manning Clay (raised in rank from member of McElroy). (Eargle, 1972.)
Assigned to Thorofare Creek Group (new) of Absaroka Volcanic Supergroup (new) as uppermost formation. Unconformably overlies Tepee Trail or Two Ocean (new) Formations. Age changed from middle and late Eocene and Oligocene to middle and late Eocene. (Smedes and Prostka, 1972.)
Reduced in rank to Willow Creek Bed of Bachelor Mountain Member (also reduced in rank) of Carpenter Ridge Tuff. Basal bed of Bachelor Mountain; underlies Campbell Mountain Bed. Age changed from Oligocene to late Oligocene. (Steven and others, this report, p. A79.)
Windous Butte Tuff/Formation of Cook (1960, 1965) adopted and redefined as Windous Butte Formation. Stratigraphically restricted from Cook's usage by removing overlying tuff of Pancake Summit; underlies Needles Range Formation. (Grommé and others, 1972.)
Windy Flats Group adopted. Divided into two newly named formations (ascending): Hay Creek Greenstone and Reausaw Slate. Conformably overlies Gingrass Draw Slate (new name); unconformably(?) underlies Roubaix Formation (newly adopted of Berg, 1946). (Bayley, 1972).
Reduced in rank to Windy Gulch Bed of Bachelor Mountain Member (also reduced in rank) of Carpenter Ridge Tuff. Uppermost bed of Bachelor Mountain; overlies Campbell Mountain Bed. Age changed from Oligocene to late Oligocene. (Steven and others, this report, p. A79.)
Windy Pass Argillite Member adopted as middle of three new members of Brigham Quartzite. Overlies Kasiska Quartzite Member; underlies Sedgwick Peak Quartzite Member. (Oriel and Armstrong, 1971.)
Assigned to Auld Lang Syne Group (new). (Burk and Silberling, 1973.)
Metaconglomerate lithofacies of Wissahickon of Southwick and Fisher (1967) abandoned and included in Cardiff Metaconglomerate; Conowingo gneiss made informal unit of diamictite facies of Wissahickon. Age changed from late Precambrian(?) to latest Precambrian to Early Ordovician. (Higgins, 1972.)

Name	Age	Location
Woodside Shale/Formation/ Siltstone/Redbeds.	Early Triassic	Utah, Idaho, Wyoming, and Montana.
Yale Member (of Ironwood Iron-formation) (of Menominee Group).	Precambrian X	Northwestern Michigan and northwestern Wisconsin.
Yellowstone Group	Pleistocene	Montana, Idaho, and Wyoming.

BIG DOME FORMATION AND REVISED TERTIARY STRATIGRAPHY IN THE RAY-SAN MANUEL AREA, ARIZONA

By MEDORA H. KRIEGER, HENRY R. CORNWALL, and NORMAN G. BANKS

Terminology used in the past for Cenozoic alluvial deposits, formerly included in the Gila Conglomerate, in the Ray-San Manuel area, eastern Pinal County, Ariz., is clarified and revised according to new data. The term Gila Conglomerate or Group is not used in this area, and the Sacaton Formation is abandoned. In their place we apply, (1) the name San Manuel Formation to the oldest deformed sedimentary unit of early Miocene age, (2) Big Dome Formation (new name) to the mildly deformed sedimentary rocks of late Miocene age that overlie the San Manuel Formation, and (3) Quiburis Formation to the essentially undeformed sedimentary rocks of middle Pliocene age, deposited in the closed basin now occupied by the San Pedro River.

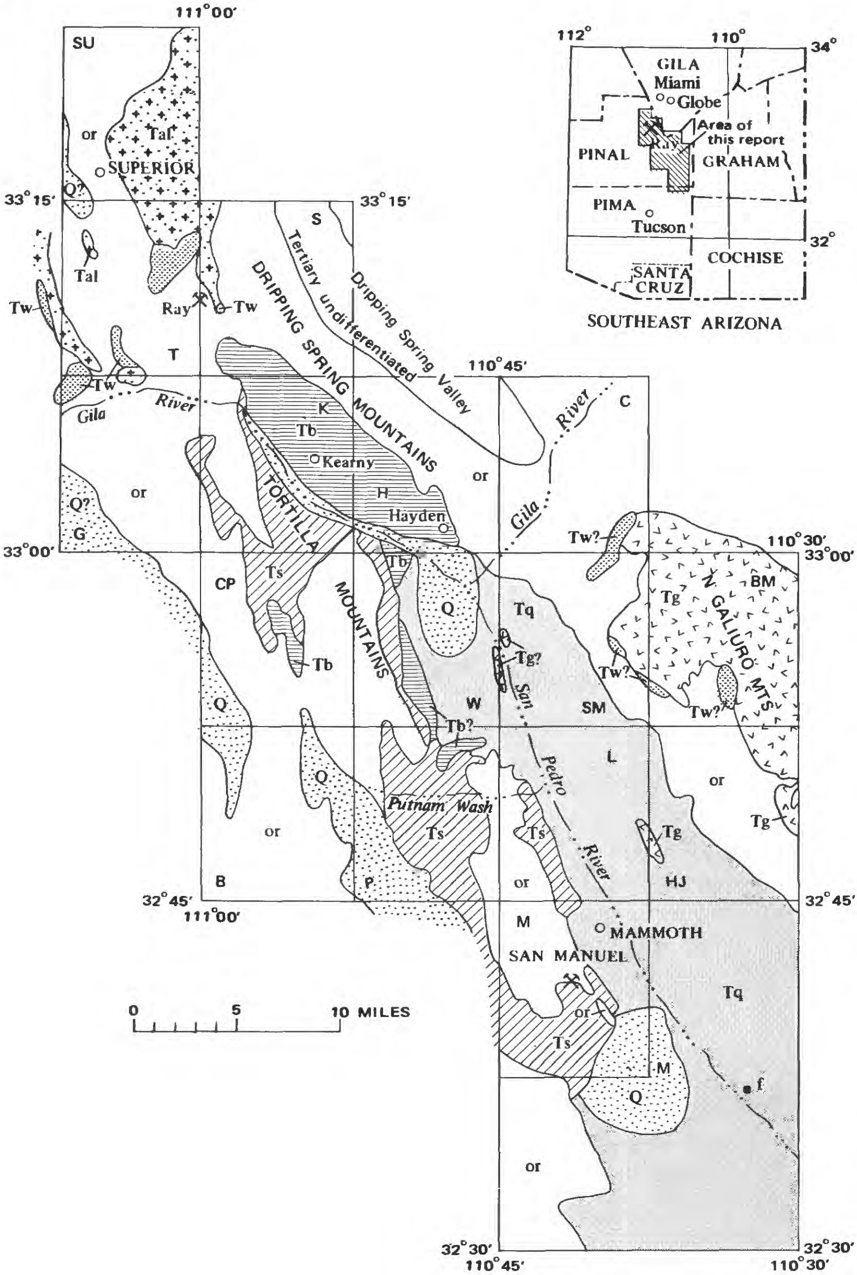
The oldest known Tertiary sedimentary deposit in the area is the Whitetail Conglomerate (Ransome, 1903, 1919), named for exposures in the Globe-Miami area (fig. 1). The Whitetail Conglomerate is overlain by the Apache Leap Tuff (Peterson, 1969), formerly called dacite, in the Globe-Ray area. Where the Apache Leap Tuff is absent (southeast of Ray, fig. 1), the term Gila Conglomerate in the past has been applied to all the post-early Tertiary alluvial deposits.

Heindl (1963), on the basis of work in the San Manuel area, proposed that the Gila Conglomerate be there raised to group status to include three units, the San Manuel, Quiburis, and Sacaton Formations, each believed to have been laid down during

Revision and reference
Name changed from Woodside Shale/Formation/Siltstone/Redbeds to Woodside Sandstone in east-central Idaho only; usage remains unchanged elsewhere. (Witkind, 1972.)
Age changed from middle Precambrian to Precambrian X. (Schmidt and Hubbard, 1972.)
Yellowstone Tuff redefined and raised in rank to Yellowstone Group. Divided into three new formations (ascending): Huckleberry Ridge Tuff, Mesa Falls Tuff, and Lava Creek Tuff. Age changed from Pliocene to Pleistocene. (Christiansen and Blank, 1972.)

development of one large structural basin. Recent mapping by the authors, however, indicates that the alluvial deposits in the area between Ray and San Manuel were deposited in basins that developed at different times; the K-Ar mineral ages seem to support this interpretation. These deposits are now divided into three sedimentary formations: the San Manuel, Big Dome, and Quiburis Formations. The unnamed Pleistocene and Holocene alluvial and pediment gravels, in part correlative with Heindl's (1963) Sacaton Formation and originally included in his Gila Group, were deposited after inception of the present through drainage along the Gila and San Pedro Rivers. The San Manuel Formation (Heindl, 1963; Krieger, 1973a, b, and d; Cornwall and Krieger, unpub. data, Kearny quadrangle) is the oldest of these deposits and was laid down in a basin that clearly predates the one in which the youngest, the Quiburis Formation (Heindl, 1963; Krieger, 1973a), was deposited. The middle formation, herein named the Big Dome Formation, rests unconformably on the San Manuel Formation, is clearly younger than the Apache Leap Tuff, and probably was deposited before major high-angle faulting produced the structurally closed basin in which the Quiburis Formation was deposited. The San Manuel Formation consists of alluvial, lacustrine(?), and playa deposits, the Big Dome Formation is alluvial, and the Quiburis Formation consists of a lakebed and an alluvial facies.

K-Ar mineral dates (fig. 2) indicate that the Whitetail Conglomerate near Ray is in part at least Oligocene in age; the San Manuel Formation, early(?) Miocene; the Apache Leap Tuff, middle Miocene; and the Big Dome, late Miocene. The Quiburis Formation is considered middle Pliocene on the basis of vertebrate fossils of Hemphillian age (Krieger, 1973a).



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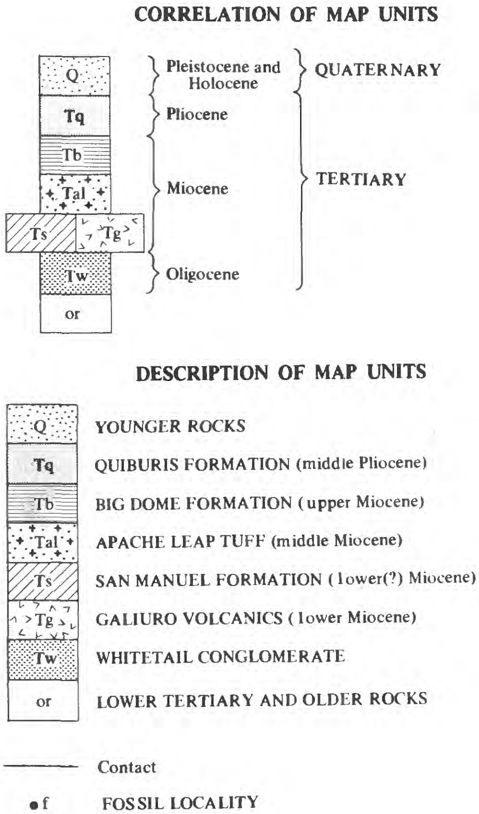
SANTA CRUZ
SOUTHEAST ARIZONA

FIGURE 1.—Generalized geologic map showing quadrangles and other features referred to in text, sources of data, and approximate ages of formations. (See facing page.) Geologic quadrangle maps are abbreviated as follows: B, Black Mountain (Krieger, 1973c); BM, Brandenburg Mountain (Krieger, 1968a); C, Christmas (SW¼) (Willden, 1964); CP, Crozier Peak (Krieger, 1973b); G, Grayback (Cornwall and Krieger, unpub. data); H, Hayden (Banks and Krieger, unpub. data); HJ, Holy Joe Peak (Krieger, 1968b); K, Kearny (Cornwall and Krieger, unpub. data); L, Lookout Mountain (Krieger, 1968c); M, Mammoth (7½-minute, Creasey, 1965; 15-minute, Creasey, 1967); P, Putnam Wash (Krieger, 1973d); SM, Saddle Mountain (Krieger, 1968d); S, Sonora (Cornwall and others, 1971); Su, Superior (Peterson, 1969); T, Teapot Mountain (S. C. Creasey and D. W. Peterson, unpub. data); W, Winkelman (Krieger, 1973a). Hayden, Kearney, and Sonora quadrangles are part of the Ray 15-minute quadrangle (Ransome, 1919 and 1923). See also Heindl (1963) for part of Mammoth quadrangle.



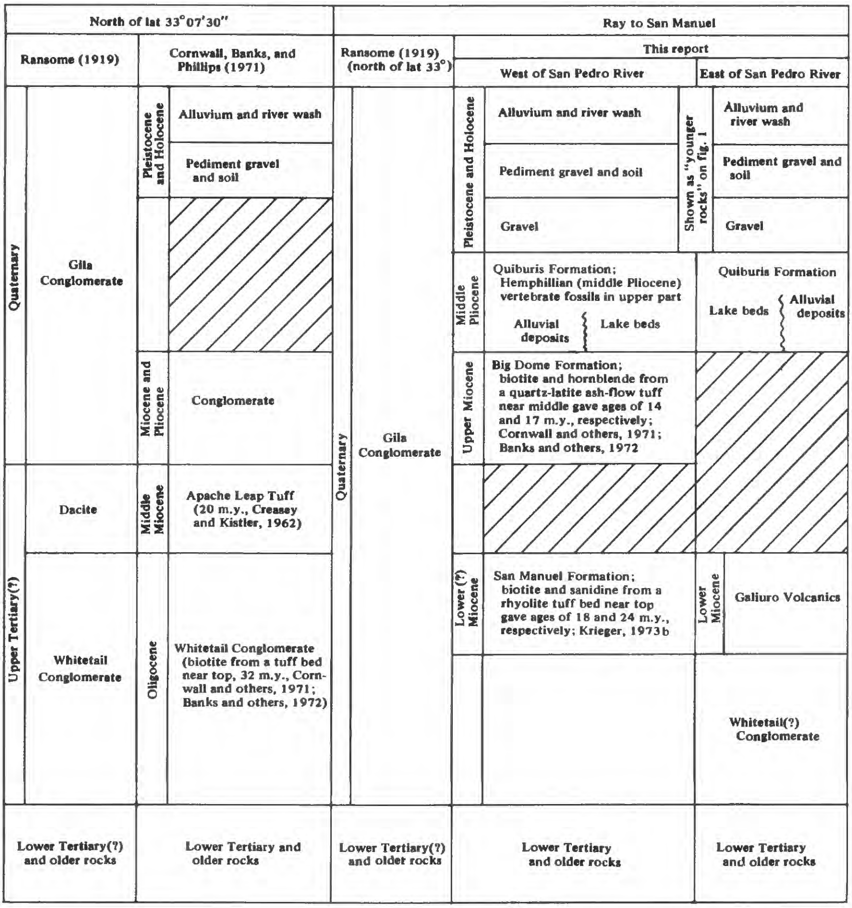
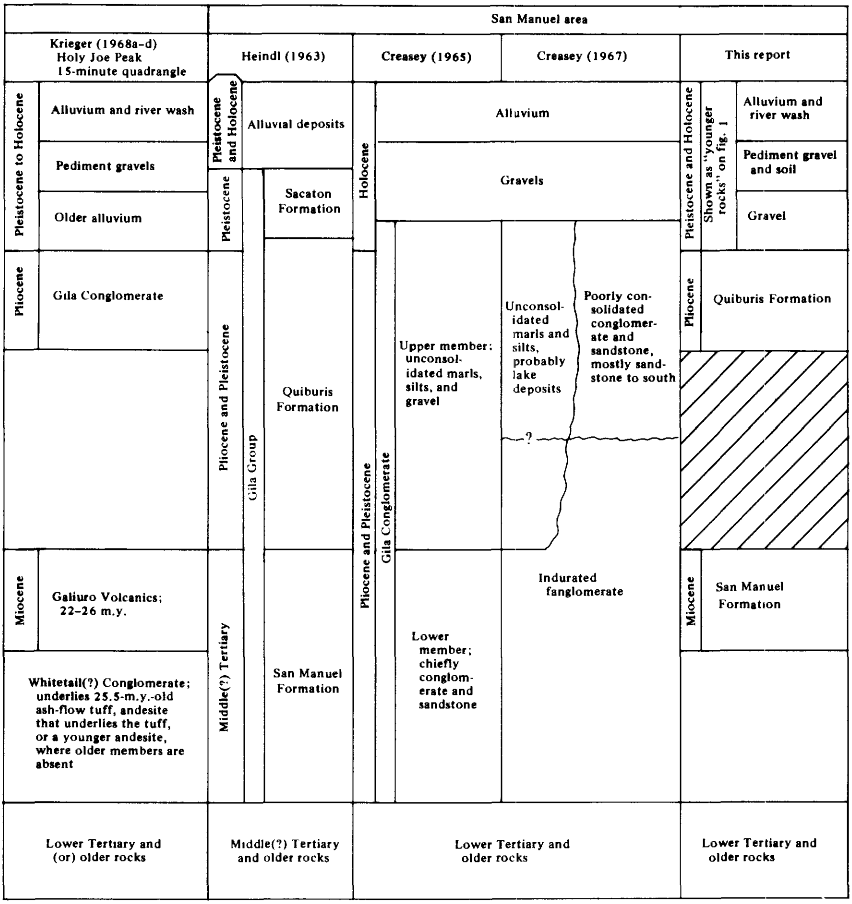


FIGURE 2.—Terminology and age assignments

Our terminology and correlations are presented in figure 2, together with those previously used by other writers. Of these units, the Big Dome Formation is new, and its description follows.

BIG DOME FORMATION

Alluvial deposits of late Miocene age southeast of Ray are here named the Big Dome Formation for exposures at its type locality,



suggested in this and other reports.

Big Dome (W½ sec. 25, T. 3 S., R. 13 E.), on the west side of Mineral Creek, Sonora quadrangle (fig. 3). Continuous outcrops of the formation are found from near Ray to Hayden along the north side of the Gila River. Isolated exposures of the formation are found west of the San Pedro River and south of the Gila River (fig. 1).

The formation has been separated into four lithofacies (fig. 3) and includes at least two thin tuff beds. At the type locality the Big Dome Formation is about 400 feet thick and is composed of clasts of schists, diorite, granite, sedimentary rocks, and diabase of Precambrian age, Paleozoic sedimentary rocks, and Mesozoic and Tertiary intrusive and extrusive rocks, including fragments of the Apache Leap Tuff. This facies is referred to as the facies containing diverse clasts. In the eastern part of the Kearny quadrangle and western part of the Hayden quadrangle, where the formation may be thicker than 600 feet, this facies is composed largely of clasts of Paleozoic limestones and Apache Leap Tuff, in a matrix of fine-grained arkosic sandstone derived from the Ruin Granite (Precambrian). A second facies west of Big Dome and along and south of the Gila River (fig. 3) is composed largely of clasts derived from the Ruin Granite, except for the northwestern-

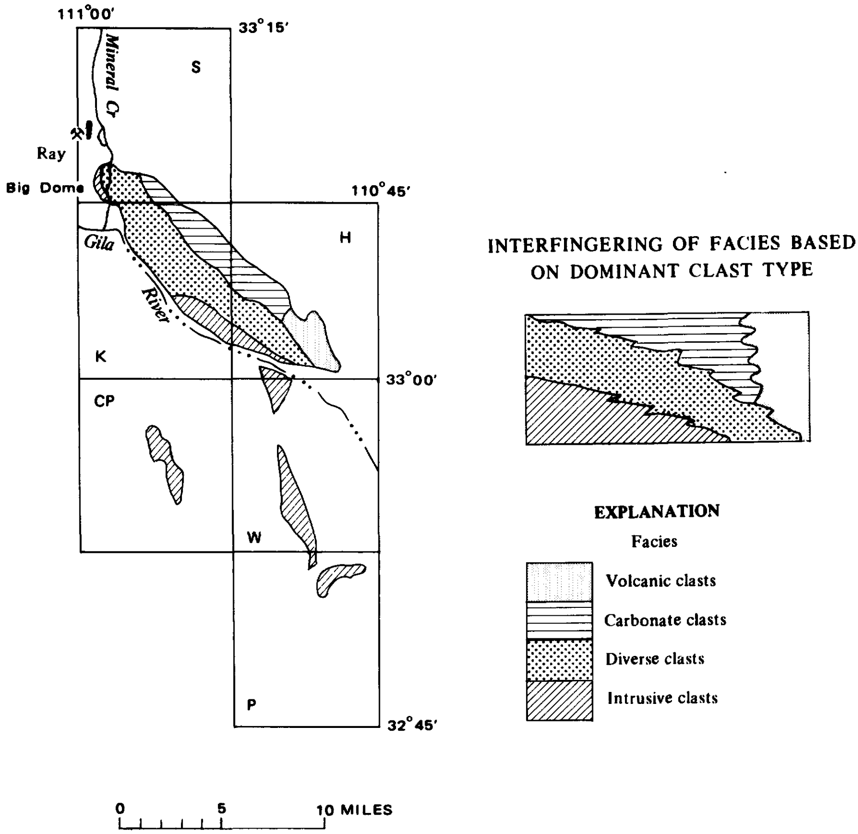


FIGURE 3.—Distribution of lithofacies of the Big Dome Formation. See fig. 1 for quadrangle names.

most exposures which flank the Tortilla Quartz Diorite (Cretaceous) ; in these exposures, clasts of the diorite are also abundant. This facies is referred to as the facies containing intrusive clasts. The facies containing diverse clasts grades northeastward into a third facies (fig. 3), referred to as the facies containing carbonate clasts; this facies is composed predominantly of boulders, cobbles, and pebbles of the Paleozoic limestones which form most of the southwestern flank of the Dripping Spring Mountains. To the southeast, the facies containing carbonate clasts interfingers with a fourth facies (fig. 3) containing abundant mafic volcanic clasts derived from the Williamson Canyon Volcanics. For about 2 miles northwest of Hayden, this mafic facies contains less than 1 percent carbonate clasts, even though the cliffs on the adjacent flank of the Dripping Spring Mountains are composed of Paleozoic limestones.

An ash-flow tuff interbedded in the facies containing intrusive clasts is exposed discontinuously for about 4 miles parallel to and north of the Gila River in the Kearny and Hayden quadrangles. Small exposures of this tuff in the Kearny quadrangle occur within the facies containing carbonate clasts. The tuff also was intersected in the carbonate facies in a drill hole in the western part of the Hayden quadrangle. The 0- to 20-foot-thick ash-flow tuff is a quartz latite and is largely nonwelded. Biotite and hornblende from the tuff yielded K-Ar ages of 14 and 17 m.y., respectively (Cornwall and others, 1971; Banks and others, 1972). A rhyolite lapilli tuff, zero to at least 50 thick, is interbedded in the Big Dome Formation 200 to 300 feet above the ash-flow tuff. It is widely distributed in the northeastern part of the Kearny quadrangle in the facies containing intrusive, diverse, and carbonate clasts. These occurrences demonstrate that the three conglomerate facies coexisted at the time of the eruption of the tuffs.

RELATION TO OTHER FORMATIONS

The Big Dome Formation overlies both the San Manuel Formation and the Apache Leap Tuff. In exposures on the east side of the Gila River, a mile east of Mineral Creek, the Big Dome Formation lies unconformably on the San Manuel Formation. Similar relations were observed near the center of the Crozier Peak quadrangle. The Big Dome Formation conformably overlies the Apache Leap Tuff at Ray. Elsewhere, and especially in the facies composed of diverse clasts, the abundance of clasts of Apache Leap Tuff demonstrates the younger age of the Big Dome. These mapped relations are supported by the isotopic ages.

It is not certain if the Big Dome Formation grades laterally or upward into the Quiburis Formation (middle Pliocene), but the following relations suggest that it does neither. The Big Dome Formation does not contain the evaporites or extensive lakebed facies found in the Quiburis. Deformation of the Quiburis is local and involves only minor faulting and drag along faults, but folding and regional tilting are common in the Big Dome Formation. Outcrops of the Big Dome that are known to be downfaulted are found at higher elevations than the outcrops of the Quiburis. Finally, outcrops of the Quiburis that are athwart extensions of faults that displace the Big Dome Formation are not visibly disturbed.

PROBLEMS IN CORRELATING THE SAN MANUEL FORMATION AND WHITETAIL CONGLOMERATE

The isotopic age for the Whitetail Conglomerate (32 m.y.) is older than the isotopic ages for the San Manuel Formation (24 m.y., sanidine; 18 m.y., biotite). The samples dated were collected from a rhyolite tuff bed in the upper parts of both formations, and it is not known whether the lower parts of the San Manuel Formation are as old as existing or eroded parts of the Whitetail Conglomerate. We consider the San Manuel Formation to be older than the Apache Leap Tuff because no clasts from the tuff have been observed in the San Manuel Formation; furthermore, we consider the sanidine age to be more nearly geologically correct than the biotite age. The San Manuel Formation and Whitetail Conglomerate are in part lithologically dissimilar. Although both formations contain alluvial material, the San Manuel Formation contains, in addition, playa deposits and interbedded megabreccias. Nothing similar has been reported from the Whitetail Conglomerate.

In the northern Galiuro Mountains, an ash-flow tuff in the lower part of the Galiuro Volcanics has been dated at 25.5 m.y. Conglomerates beneath this tuff were tentatively correlated with the Whitetail Conglomerate by Krieger (1968a, b, d). On the basis of present data, the Galiuro Volcanics and underlying conglomerates could be the time equivalents of the San Manuel.

KNIFLEY SANDSTONE AND CANE VALLEY LIMESTONE: TWO NEW MEMBERS OF THE FORT PAYNE FORMATION (LOWER MISSISSIPPIAN) IN SOUTH-CENTRAL KENTUCKY

By Roy C. Kepferle and Richard Q. Lewis, Sr.

Work done in cooperation with the Kentucky Geological Survey

The Fort Payne Formation of Early Mississippian age in south-central Kentucky contains as many as four mappable subdivisions, only three of which are here named. Two of these subdivisions in the upper part of the Fort Payne are named the Knifley Sandstone Member and the Cane Valley Limestone Member. A third subdivision in the basal part of the Fort Payne is recognized as correlative with the New Providence Shale Member of the Borden Formation and is called here the New Providence Shale Member of the Fort Payne Formation. The members were mapped as lithologic units at a scale of 1:24,000 as part of the cooperative geologic mapping program of the U.S. Geological Survey and the Kentucky Geological Survey (fig. 4; Lewis, 1963; Lewis and Thaden, 1963, 1964, 1965; Maxwell, 1964, 1965; Maxwell and Turner, 1964; Taylor, 1963, 1965a, b, 1966; Taylor and others, 1968; Thaden and others, 1961).

The Fort Payne Formation in south-central Kentucky is mainly an olive-gray to dark-gray rock commonly described in the field as a clayey, cherty, and quartzose siltstone. Petrographic study (Sedimentation Seminar, 1972) indicates that the rock is a dolomitic siltstone or silty dolomite (dolosiltstone) that is locally calcitic, clayey, and silicified. Quartz geodes, commonly less than 4 inches in diameter, are sparse. Calcareous pelmatozoan debris in stringers and lenticles is rare to common in beds less than a foot thick. The rock is commonly medium to very thick bedded. Weathering reduces the beds to thin shaly chips that locally spall from smooth massive surfaces. The thickness of the Fort Payne Formation ranges in the study area from 185 to 355 feet. A greenish-gray clay shale at the base ranges in thickness from less than 1 foot to nearly 100 feet. Mapping has shown that it is continuous with the New Providence Shale Member of the Borden Formation (Taylor and Lewis, 1971). However it persists over a wider area than most other lithologic units characteristic of the Borden Formation. To reflect its identity, we recommend that the basal clay shale be called the New Providence Shale Member of the Fort Payne Formation.

The Knifley Sandstone Member of the Fort Payne Formation is named for exposures near Knifley, Adair County, Ky. (section 1, fig. 4). The type section is in a high bluff on the north side of Green River Lake opposite Fisher Bend. The geometry can best be summarized as a northwest-trending prism of sandstone on and in the dolomitic siltstone of the Fort Payne Formation. The sandstone body is about 25 miles long and 6 miles wide, and attains a thickness of 250 feet. The sandstone is high in the Fort Payne Formation in the east and descends stratigraphically in the

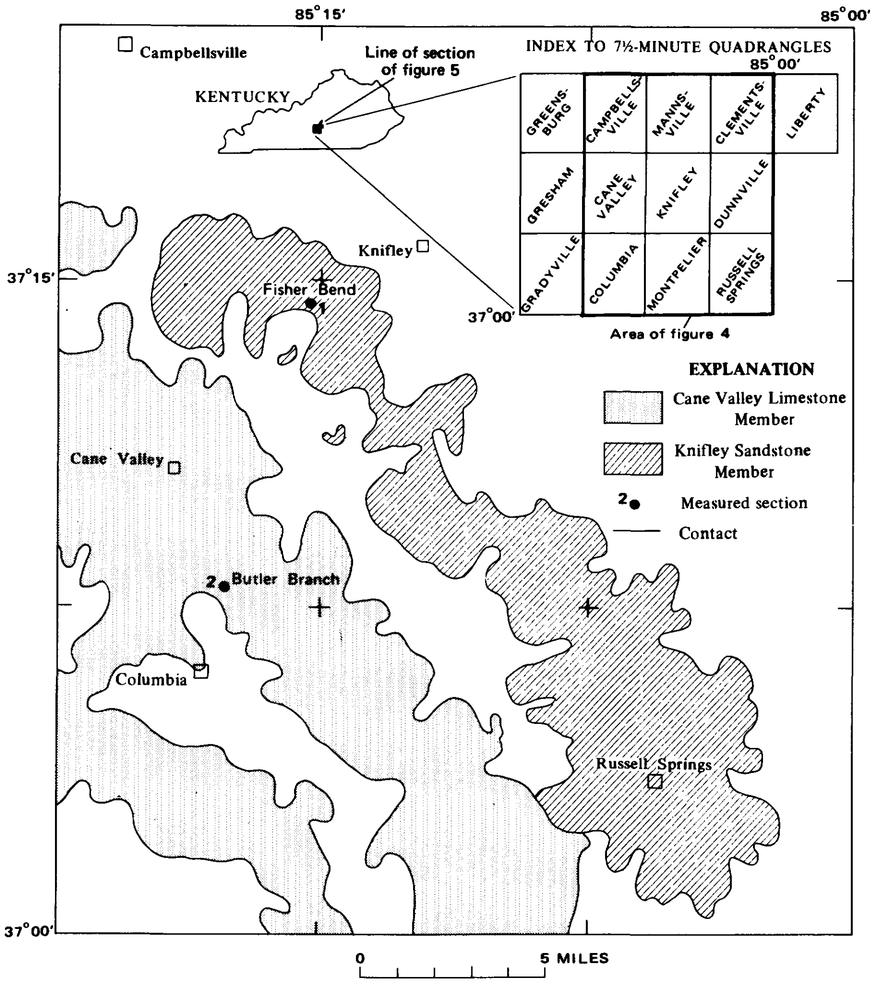


FIGURE 4.—Location of type sections of Knifley Sandstone and Cane Valley Limestone Members of the Fort Payne Formation, south-central Kentucky.

section westward, where it finally pinches out or grades into the adjacent dolosiltstone and limestone.

The Knifley is very fine grained, silty, argillaceous and dolomitic sandstone that is gray to light gray where fresh and yellowish brown and brownish red where weathered. The most conspicuous bedding structures visible in the field are continuous surfaces, from 5 to 10 feet apart, similar to features termed "master bedding planes" by Schwarzacher (1958). The bedding planes are well exposed along the bluffs of Green River Lake, where they dip southwestward, locally as much as 10°. We believe they are initial depositional features. Poorly defined horizontal bedding and some obscure ripple bedding are the most abundant sedimentary structures. X-radiography confirms obscure field evidence of widespread disruption (bioturbation) of most small-scale sedimentary structures by burrowing organisms (Sedimentation Seminar, 1972). Bedding-plane traces of clay-rich worm(?) trails resembling *Scalarituba missouriensis* Weller are abundant parallel to bedding; *Zoophycos*(?) is common locally. Crinoidal debris, poorly preserved gastropods, and brachiopods are also common locally.

The Cane Valley Limestone Member of the Fort Payne Formation is named for Cane Valley, Adair County, Ky. (section 2, fig. 4). The type section is in a quarry along Butler Branch, about 3.5 miles south-southeast of Cane Valley and 1.8 miles north of Columbia on Kentucky Highway 55. The Cane Valley Limestone Member lies mainly west of and parallel to the Knifley Sandstone Member and is made up of two somewhat coalescing limestone bodies (fig. 4). The limestone offlaps the western part of the Knifley Sandstone Member and, like the Knifley, descends stratigraphically in the section westward, where it finally pinches out or grades into the adjacent dolomitic siltstone (fig. 5).

The Cane Valley Limestone Member is chiefly limestone, interbedded with dolomitic siltstone and silty, dolomitic shale. The limestone is yellowish gray and brownish gray to medium dark gray and consists of well to poorly sorted skeletal grains derived from bryozoan and crinoidal debris. The grains commonly range in size from silt to coarse sand, but locally fragments are as much as an inch in diameter. The matrix is commonly sparry calcite; finely comminuted fossil debris and dolomite are abundant in some beds. Quartzose sand and silt grains are present in most of the limestone; glauconite grains are present in trace amounts. Silicification of grains, matrix, or complete beds is common. The dolomitic siltstone and shale are similar to siltstone and shale making up the major part of the Fort Payne Formation. The coarse skeletal limestone is well bedded and commonly contains crossbeds in sets less than 10 inches thick, whereas the finer grained limestone is more commonly planar bedded and ripple bedded. Crossbedding foresets in the quarry (section 2, fig. 4) generally dip 5°–10° southward. Master bedding planes in the limestone, like those in the Knifley Sandstone Member, show depositional dip to the southwest, generally between 2° and 5°.

Depositional offlap to the west brings both the Knifley Sandstone and the Cane Valley Limestone Members of the Fort Payne Formation in direct contact with the overlying Salem and Warsaw Formations. Where the Cane Valley Limestone Member is in contact with the overlying Salem and Warsaw Formations the limestones can be distinguished with difficulty, using multiple criteria, no one of which is an infallible guide: glauconite concentrations, blocky chert, and brachiopod, blastoid, echinoid, bryozoan, and coral remains are somewhat more common in the basal limestone of the Salem and Warsaw Formations than in the Cane Valley Limestone Member of the Fort Payne Formation.

The nature of the contact between the Knifley Sandstone Member of the Fort Payne Formation and the overlying Salem and Warsaw Formations is obscure because of poor exposures in critical areas. Maxwell and Turner (1964) stated that in the Cane Valley quadrangle the sandstone is "in part equivalent to the Salem and Warsaw Formations and seems to be partially equivalent to the St. Louis Limestone as well." Lewis and Thaden (1963) noted in the Russell Spring quadrangle that the combined thickness of the sandstone and the underlying part of the Fort Payne Formation is greater than the thickness of the Fort Payne in adjacent quadrangles where the sandstone is absent. These thickness relations and the seeming equivalency of part of the sandstone and the St. Louis, Salem, and Warsaw Formations may be a consequence of differential compaction: sandstone, being less compactible, more nearly retains the original depositional thickness than do the surrounding fine-grained rocks of the Fort Payne Formation.

Regional stratigraphic relations are summarized in figure 5. The Knifley Sandstone and the Cane Valley Limestone Members of the Fort Payne Formation lie southwest of and parallel to the distal edge of the wedge of terrigenous clastic sedimentary units that make up most of the Borden Formation to the north and east. These Borden units, in ascending order, include the New Providence Shale Member as redefined by Kepferle (1971) and the

Nancy and Halls Gap Members (Weir and others, 1966). This wedge of terrigenous clastics overlies black carbon-rich shale, the New Albany or Chattanooga Shale of Devonian age, and underlies a persistent zone of abundant silt-sized glauconite, the Floyds Knob Formation of Stockdale (1931, p. 193; 1939). This glauconitic zone is overlain on the northeast by partly silicified, clayey, silty dolosiltstone and limestone of the Muldraugh Member of the Borden Formation. In most of the study area the entire sequence above the black shale is included in the Fort Payne Formation.

As the clay and silt shale and siltstone forming the terrigenous clastic wedge thin southwestward across a zone from 4 to 8 miles

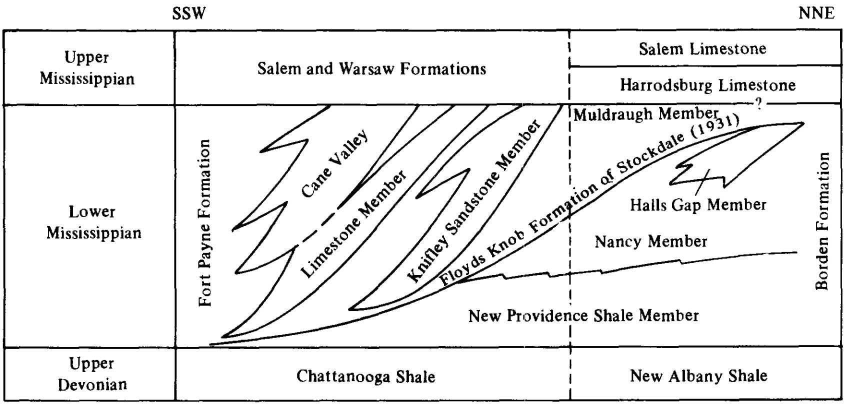


FIGURE 5.—Diagrammatic section showing relation of the Fort Payne and Borden Formations in south-central Kentucky. Line of section shown on index, fig. 4.

wide, the overlying dolomitic siltstone and limestone unit thickens by an equal amount. The thickening is accompanied by a stratigraphic drop in the position of the glauconitic beds. This zone, mapped in the area to the north of the study area, has been called the Borden delta front by Peterson and Kepferle (1970, p. D50). They project the front southwestward "to at least a few miles southeast of Campbellsville, Ky., where roadcuts along Kentucky Highways 70 and 76 expose the glauconitic zone and show that it drops stratigraphically to the southwest. The front probably continues farther southeast and coincides with a southeasterly trending line of lithologic change across which the carbonate-poor Borden Formation on the northeast passes laterally into the stratigraphically equivalent, and carbonate-rich, Fort Payne Formation on the southwest" (Peterson and Kepferle, 1970, p. D53). This statement implies that recognition of the position of the front is requisite to placing the boundary between the Borden and Fort Payne Formations on other than an arbitrary basis.

MEASURED SECTIONS

SECTION 1.—*Fisher Bend*

[Type section of the Knifley Sandstone Member of the Fort Payne Formation. Section measured at east end of bluff above Green River Lake opposite Fisher Bend, about 9 miles north of Columbia. Base of section in Carter coordinate 1-I-51; 500 ft from east line, 3,450 ft from north line of Cane Valley quadrangle (Maxwell and Turner, 1964); 2,145,050 ft east, 330,700 ft north, Kentucky coordinate system, south zone, Adair County, Ky. Measured by S. V. Hrabar and P. E. Potter using Jacob staff and tape, Jan. 2, 1969]

	Thickness (ft)
Lower Mississippian:	
Fort Payne Formation (incomplete):	
Knifley Sandstone Member (incomplete):	
7. Sandstone, yellowish-gray to light-olive-gray, very fine grained; horizontally bedded; weathers massive; obscurely ripple laminated; small quartz geodes abundant near base. Top of section covered 18 ft below top of hill	90+
6. Sandstone, as above, irregularly bedded; quartz geodes abundant in some horizons; bioturbated; grades downward into siltstone	108
Total Knifley Sandstone Member	198+
5. Siltstone, dolomitic, light-gray, irregularly and thinly bedded; shaly weathering	28
4. Siltstone, light-gray, massive, bioturbated	5
3. Shale, silty, dolomitic, light-gray; hackly fracture, poorly bedded	27
2. Siltstone, dolomitic, light-gray, weathers yellowish brown; hackly fracture, poorly defined bedding; gradational with underlying unit	12
1. Shale, silty, dolomitic, calcareous, light-gray; hackly fracture, poorly bedded; scattered brachiopods; more blocky in upper 12 ft; base covered	36+
Total Fort Payne Formation	306+

Base of bluff elevation 635 ft. Base of Fort Payne Formation at elevation 620 ft inferred from structure contours (Maxwell and Turner, 1964).

SECTION 2.—*Butler Branch*

[Type section of the Cane Valley Limestone Member of the Fort Payne Formation. Upper part of section measured on face of Shamrock Stone quarry and hill to west of Kentucky Highway 55 along Butler Branch about 3.5 miles south-southeast of Cane Valley and 1.8 miles north-northeast of Columbia. Base of exposed section at elevation 711 ft (by hand level) at top of diamond-drill hole in Carter coordinate 8–G–51; 12,200 ft from the east line, 3,800 ft from the south line of the Cane Valley quadrangle (Maxwell and Turner, 1964); 2,133,650 ft east, 292,250 ft north, Kentucky coordinate system, south zone, Adair County, Ky. Surface section measured by R. Q. Lewis, Sr., using hand-level and tape, April 13, 1972; drill-core section from log by W. L. Helton]

	Thickness (ft)
Lower Mississippian:	
Fort Payne Formation (incomplete):	
Cane Valley Limestone Member (incomplete):	
10. Siltstone, dolomitic, cherty, medium-gray to brown, interbedded with limestone; thick bedded; bedding locally indistinct; contains abundant quartz geodes 1–4 in. in diameter, and irregular chert nodules. Top covered; mapped as limestone, about 20 ft below Salem and Warsaw Formations (Maxwell and Turner, 1964)	17+
9. Limestone, medium- to dark-gray and bluish-gray; mottled on fresh surface; weathers brownish gray; medium to coarse grained; consists of light-gray fossil fragments, particularly crinoid stem segments, in a darker groundmass; thick bedded; bedding somewhat obscure; stylolitic	18
8. Siltstone, dolomitic, calcareous, medium-gray; irregular wavy bedding laminae; contains small dark carbonaceous fragments and irregular masses and individual crystals of microcrystalline pyrite	6
7. Limestone, clayey, cherty, dark-bluish-gray, fine- to medium-grained; grains are mostly crinoid debris in a dark silt-size matrix; crossbedded; beds 6–14 in. thick in sets 10–15 ft thick; sets dip southward from 2° to 5°; beds dip as steeply as 10°; interbedded with some dark-gray to olive-gray calcareous silty shale in beds 1–3 in. thick. Upper 28 feet partly covered by spoil	73
6. Siltstone, dolomitic, dark-gray to olive-gray, thin-bedded, poorly exposed to top of drill hole at base	8
(Remainder of section modified in part from log of core by W. L. Helton.)	
5. Siltstone, dolomitic, gray to brown, slightly calcareous	9
4. Limestone, silty, gray, fine- to medium-grained; interbedded with sparse clay shale layers and several chert layers as much as 2 in. thick	72
3. Limestone, glauconitic, silty, gray, fine-grained; probably correlative with the Floyds Knob Formation of Stockdale (1931)	4
Total Cane Valley Limestone Member	207+

SECTION 2.—*Butler Branch*—Continued

	Thickness (ft)
Lower Mississippian—Continued	
Fort Payne Formation (incomplete)—Continued	
New Providence Shale Member:	
2. Siltstone and shale, glauconitic, green, slightly calcareous; contains abundant pyrite and scattered phosphatic nodules; probably correlative with the Maury Formation in Tennessee	2
Total Fort Payne Formation	290+
Upper Devonian:	
Chattanooga Shale (incomplete):	
1. Shale, silty, black, carbonaceous, fissile, pyritic, to base of diamond-drill hole	2+

METADIABASE SILLS IN NEGAUNEE IRON-FORMATION NEAR NATIONAL MINE, MICHIGAN

By GEORGE C. SIMMONS

Metadiabase of Precambrian X age intrudes rocks of the Marquette Range Supergroup (Cannon and Gair, 1970) in the Marquette synclinorium and iron district, Michigan. The bodies are most numerous in the Negaunee Iron-formation and are very prominent in that part of the iron-formation which is south of the cities of Ishpeming and Negaunee, and east of the community of National Mine (fig. 6), where metadiabase crops out on many ridges and knobs. The original ophitic texture of the intrusive rocks commonly is well preserved, but few original minerals remain; calcic plagioclase has been saussuritized and albitized, and pyroxene has been converted to actinolite, tremolite, and chlorite. Many tabular bodies of metadiabase are approximately concordant with bedding in the Negaunee Iron-formation and are considered sills. This paper proposes names for two sills that are useful markers for subdividing and mapping the iron-formation; the work is a continuation of an earlier study (Gair and Simmons, 1970) in which four other sills in the Negaunee Iron-formation were named.

The two newly named sills are in a syncline on the south side of the Marquette synclinorium; neither sill has been recognized on the north side of the synclinorium. The relation of the sills to the previously named sills is shown in the columnar section (fig. 7).

TILDEN LAKE SILL

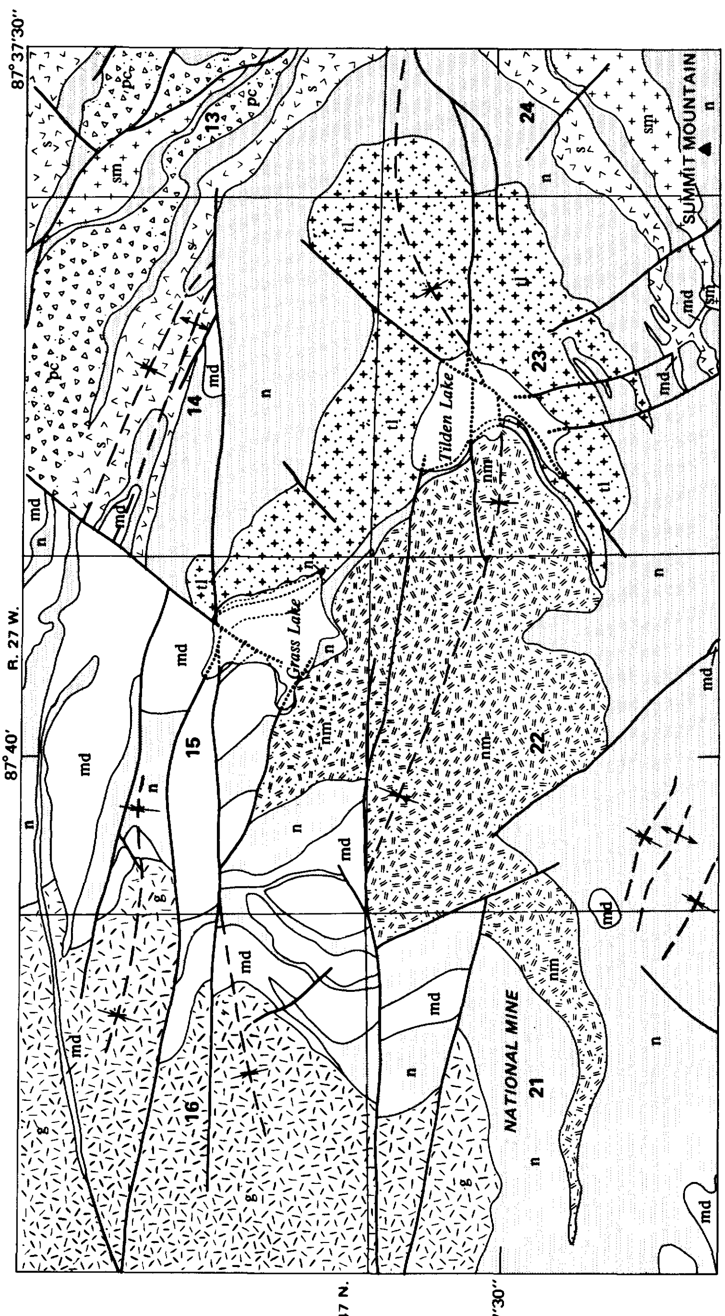
The Tilden Lake sill is named for Tilden Lake in sec. 23, T. 47 N., R. 27 W. (fig. 6); the sill crops out prominently in bluffs and on hills on the north, east, and south sides of the lake. East of Tilden Lake the sill is in the axial part of a west-trending syncline, and it is there that the sill is thickest, about 1,000 feet, as calculated from the mapped width of the sill and the measured dips of overlying and underlying iron-formation.

The sill has been mapped along strike for about 3 miles. From its easternmost exposure near the corner common to secs. 13, 14, 23, and 24, the sill has been mapped southwestward on the south limb of the syncline for more than a mile, and northward on the north limb of the syncline for about a mile and a half. On the south limb of the fold, the sill bifurcates near the center of sec. 23 into a thick upper tongue and a thin lower tongue. The lower tongue wedges out in the SW¼ of the section, and the upper tongue continues westward, pinching out in the eastern part of sec. 22. On the north limb of the syncline toward the northwest, the sill crosses the SW¼ of sec. 14 into the SE¼ of sec. 15 where it is truncated by a northeast-trending fault. The sill may continue northwestward, but cannot be distinguished from lithologically similar bodies of metadiabase because of the structural complications. Drill-hole data suggest that the sill consists of two parts in the SE¼ of sec. 15, a thick lower tongue which crops out on the east side of Grass Lake, and a thin upper tongue which is unexposed.

The Tilden Lake sill is separated from the underlying Suicide sill in secs. 13, 14, 23, and 24 by 400–700 feet of iron-formation (Gair and Simmons, 1970) and is separated from the overlying National Mine sill by 70–80 feet of iron-formation.

NATIONAL MINE SILL

The National Mine sill is named for the community of National Mine in sec. 21, T. 47 N., R. 27 W. The sill crops out in scattered exposures, mostly ½ to 1½ miles east of the town, and also in a band along the southern outskirts of the town (fig. 6). West of Tilden Lake the sill is in the trough of the same syncline in which the Tilden Lake sill is folded. The maximum thickness of the National Mine sill is indeterminable; where thick sections of the sill are present, the top of the sill is either missing because of erosion, or unknown because of poor exposures or faulting; for example, a fault cuts off the top of the sill in the northeastern part of sec.


87°37'30"
R. 27 W.
87°40'
T. 47 N.
46°27'30"
SUMMIT MOUNTAIN
Tilden Lake
Grass Lake
NATIONAL MINE
13
14
15
16
21
22
23
24
0
1/2
1 MILE

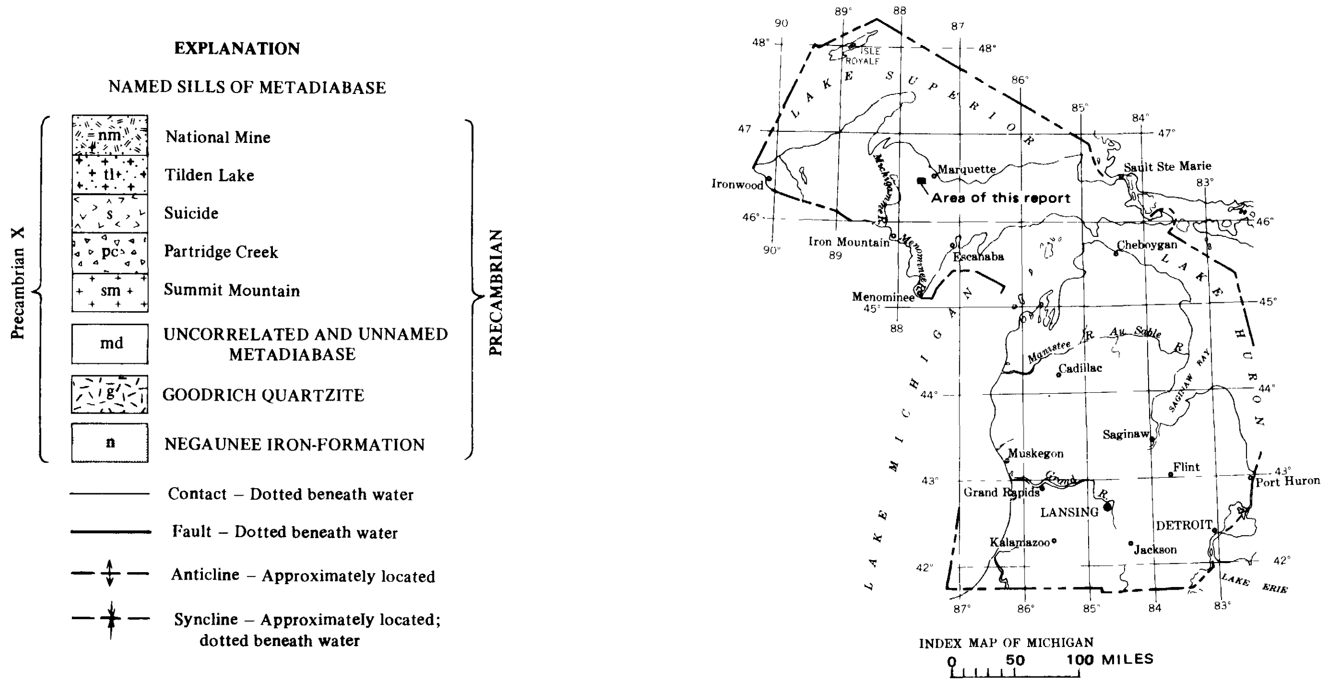


FIGURE 6.—Geologic map of Precambrian X metadiabase sills in Negaunee Iron-formation near National Mine, Mich.

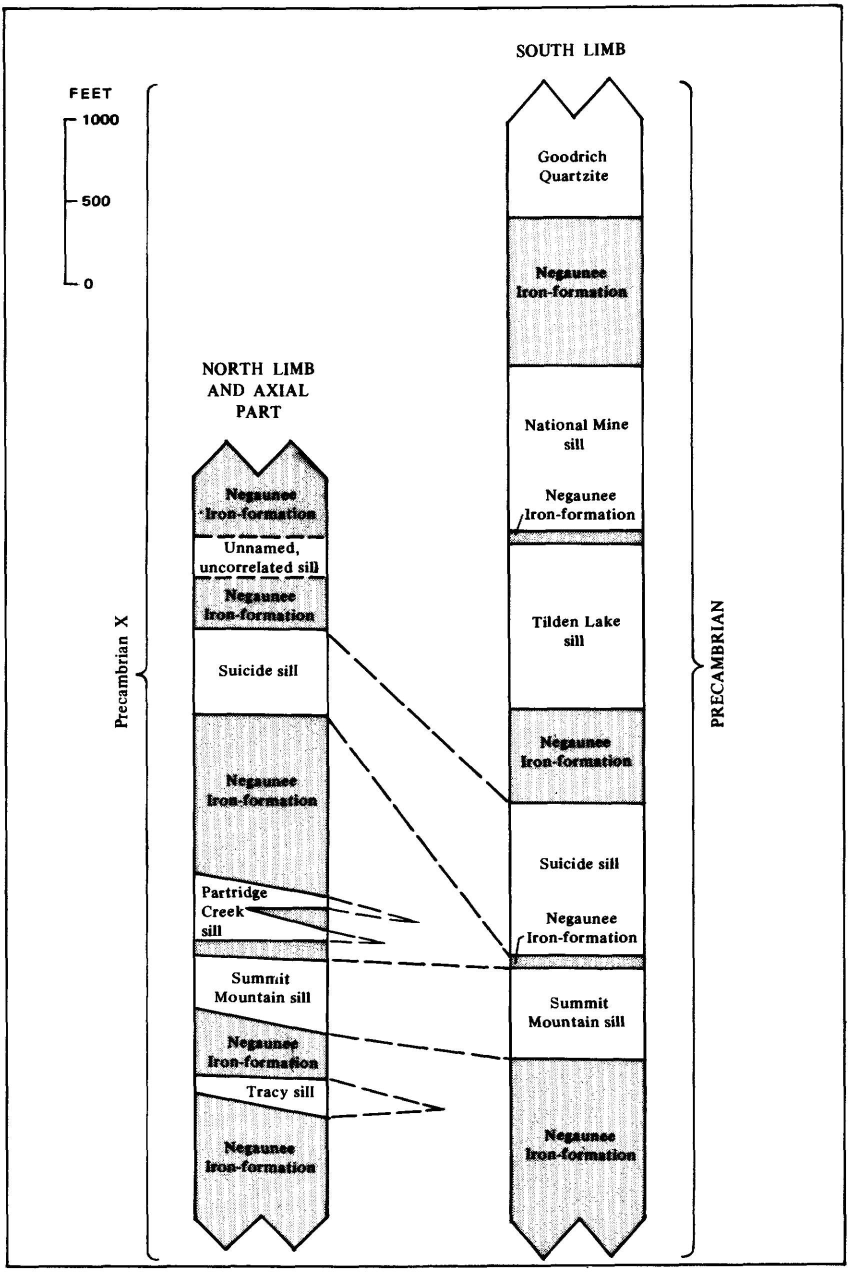


FIGURE 7.—Columnar sections of metadiabase sills in the Negaunee Iron-formation in the Marquette synclinorium.

21. The lack of sufficient structural data including the attitudes of adjacent iron-formation from which the position of the base of the sill could be projected also precludes precise calculations of the present thickness. Nevertheless, cross sections drawn on the basis of limited data suggest a thickness of about 700 feet in the axial part of the syncline; and on the south limb of the syncline, southeast of National Mine and near the section line common to secs. 21 and 22, the sill has a calculated thickness of 800 feet, based on the mapped outcrop width and dip of adjacent iron-formation.

The National Mine sill has been recognized in secs. 15, 21, 22, and 23. From its easternmost exposure in sec. 23, the sill extends westward along the axis of the syncline across the northern part of sec. 22 where it underlies more than one-half square mile. From sec. 22 the sill extends northwestward on the north limb of the syncline into the south-central part of sec. 15, where it is offset or truncated by a west-northwest-trending fault; the sill has not been identified on the north side of the fault. From the west-central part of sec. 22 the National Mine sill extends westward on the south limb of the syncline for 1 mile to the western part of sec. 21, where it pinches out. On the south limb of the fold the National Mine sill is overlain by approximately 900 feet (calculated thickness) or iron-formation that separates the sill from the unconformable contact of the Goodrich Quartzite with the Negaunee Iron-formation.

ASH-FLOW STRATIGRAPHY AND CALDERA STRUCTURES IN THE SAN JUAN VOLCANIC FIELD, SOUTHWESTERN COLORADO

By T. A. STEVEN, P. W. LIPMAN, and J. C. OLSON

A recurrent problem in regional volcanic studies in the San Juan Mountains, Colo. (Steven and others, 1973), has been to match outflow facies and intracaldera facies of individual ash-flow sheets. Outflow rocks generally are relatively thin and widespread, whereas intracaldera rocks commonly form cylinders of densely welded tuff several kilometers thick. The earliest erupted materials formed the outflow sheet; after sufficient ash was erupted to initiate subsidence, the later ash flows tended to pond within the concurrently subsiding caldera. Differences in thickness commonly cause differences in degree of welding, crystallization, and alteration; the thick intracaldera units commonly have granophyric textures (Smith, 1960, p. 152) and are propylitized. In compositionally zoned units, outflow rocks tend to be more silicic and to contain fewer phenocrysts than their intracaldera equivalents.

In establishing detailed stratigraphic nomenclature for local areas in the San Juan Mountains, Steven and Ratté (1964; 1965) working in the central San Juan caldera complex area, and Olson, Hedlund, and Hansen (1968) working in the outflow area to the north have duplicated names for two of the most widespread Tertiary ash-flow sheets in the field: the intracaldera La Garita and Bachelor Mountain Tuffs in the central San Juan Mountains are now known to be equivalents of the outflow Fish Canyon and Carpenter Ridge Tuffs, respectively, in the northern part of the field. In addition, miscorrelated intracaldera and outflow facies of the younger Rat Creek and Nelson Mountain Tuffs caused confusion in structural as well as stratigraphic interpretations

TABLE 1.—*Major ash-flow units in the San Juan volcanic field*

- Sunshine Peak Tuff (22.5 m.y.)
- Snowshoe Mountain Tuff (older than 26.4 m.y.)
- Nelson Mountain Tuff
  - Cochetopa Park Member
  - Outflow member
- Rat Creek Tuff
  - Equity Member
  - Outflow member
- Wason Park Tuff
- Mammoth Mountain Tuff (26.7 m.y.)
- Carpenter Ridge Tuff
  - Bachelor Mountain Member
    - Windy Gulch Bed
    - Campbell Mountain Bed
    - Willow Creek Bed
  - Outflow member
- Fish Canyon Tuff (27.8 m.y.)
  - Phoenix Park Member
  - La Garita Member
  - Outflow member

Sapinero Mesa Tuff
Dillon Mesa Tuff
Blue Mesa Tuff
Tuff cf Ute Ridge (28.4 m.y.)
	— age relations uncertain —	Tuff of Masonic Park (28.2 m.y.)
		Treasure Mountain Tuff
		    Ra Jadero Member
		    Ojito Creek Member
		    La Jara Canyon Member
		        (29.8 m.y.)

(Steven and Ratté, 1964; 1965). In correcting these matters, we have conformed to a pattern of stratigraphic nomenclature that has grown through use in the San Juan Mountains. We have used the names applied to the widespread outflow rocks as the formational designations. Where it is advantageous to distinguish between outflow and intracaldera rocks, the outflow rocks are most conveniently referred to either by the formational name, or by the informal description of outflow member, whereas the intracaldera rocks are given formal member status, generally using the same names originally applied to the rocks.

The major ash-flow units in the San Juan volcanic field are given in table 1. Ages in millions of years are from Lipman, Steven, and Mehnert (1970), and H. H. Mehnert (written commun., 1971).

FISH CANYON (AND LA GARITA) TUFF

The Fish Canyon (and La Garita) Tuff was erupted from the La Garita caldera near the center of the San Juan volcanic field. The rock is a distinctive crystal-rich quartz latite ash-flow tuff in which phenocrysts of plagioclase, sanidine, quartz, biotite, and hornblende make up nearly half of most rocks, and accessory sphene is characteristic. This ash-flow tuff is the largest and most extensive in the San Juan field. The unit had an original area of at least 15,000 km^2, and a volume in excess of 3,000 km^3; its age has been determined by K-Ar methods to be 27.8 m.y. (Lipman and others, 1970, p. 2339–2340).

The intracaldera La Garita Tuff and outflow Fish Canyon Tuff were nearly everywhere included in the Alboroto Rhyolite by Larsen and Cross (1956, pl. 1). Locally, other units were included as well. In outflow areas along the north side of the volcanic field, the La Garita-Fish Canyon rocks made up only the upper Alboroto of Larsen and Cross (1956, p. 137), whereas the lower Alboroto consists of the Blue Mesa, Dillon Mesa, and Sapinero Mesa Tuffs (Olson and others, 1968, p. C9). In the central San Juan area, on the other hand, recurrent subsidence and filling of calderas juxtaposed many thick masses of intracaldera welded tuff whose complex stratigraphic and structural relations have only recently been determined (Steven and others, 1973). In this area, Larsen and Cross included many units of widely differing ages in their Alboroto, largely because of erroneous correlations based on topographic position and superficial lithologic similarity. Although Larsen and Cross probably intended their Alboroto to include largely rocks in the general stratigraphic position of the Fish Canyon and La Garita Tuffs, enough older and younger units were included in one place or another to make use of the name Alboroto difficult without engendering more confusion. Therefore the name Alboroto is herein abandoned.

We propose that the formational name applied to the widespread outflow rocks, the Fish Canyon Tuff (Olson and others, 1968, p. C20), be retained for the whole ash-flow sheet derived from the La Garita caldera. The widely exposed outflow rocks are commonly most conveniently referred to either by the formational name, or by the informal designation of outflow member, whereas the intracaldera rocks generally are referred to more specifically, and the formal name of La Garita originally given to them (Steven and Ratté, 1964, p. D57) is retained in reduced rank as the La Garita Member of the Fish Canyon Tuff.

In the original description of the La Garita succession in the Creede district, Steven and Ratté (1964, p. D57) defined two subunits, the Outlet Tunnel and Phoenix Park Members. The rocks included in the Outlet Tunnel Member are equivalent to the large mass of intracaldera rocks here referred to the La Garita Member of the Fish Canyon Tuff, and the name Outlet Tunnel is now superfluous and is herein abandoned. The Phoenix Park Member, on the other hand, consists of three small densely welded ash flows of typical Fish Canyon aspect; the three flows are interlayered with the younger Bachelor Mountain–Carpenter Ridge Tuffs. These minor local rocks have always posed problems of genetic association and stratigraphic designation, and these cannot be resolved here. Until new data are available, however, it seems most convenient to follow past usage and retain tentatively the Phoenix Park Member of the Fish Canyon Tuff.

CARPENTER RIDGE (AND BACHELOR MOUNTAIN) TUFF

The Carpenter Ridge (and Bachelor Mountain) Tuff spread over about the same area as the Fish Canyon Tuff just described (about 15,000 km^2), but is less than half as voluminous. It was derived from the Bachelor caldera, in the central part of the San Juan volcanic field. Nearly all rocks in this unit are crystal-poor rhyolites. The Carpenter Ridge Tuff overlies the Fish Canyon

Tuff and underlies the Mammoth Mountain Tuff (table 1). Its age is intermediate between the 27.8 m.y. determined for the older Fish Canyon Tuff and the 26.7 m.y. for the younger Mammoth Mountain Tuff (Lipman and others, 1970, p. 2340).

The Carpenter Ridge Tuff is one of six major ash-flow sheets included by Larsen and Cross (1956, p. 146–157) in the Piedra Rhyolite; through errors in correlating some rocks in this succession, including the Carpenter Ridge Tuff, Larsen and Cross divided their Piedra into four informal members—three silicic lava flow units and a tuff unit near the top of the volcanic succession. They correlated the lower part of the Bachelor Mountain Tuff (intracaldera equivalent of the Carpenter Ridge Tuff) and at least two other thick intracaldera accumulations with the older Alboroto Rhyolite. Recent work (Steven and Ratté, 1964; 1965; Lipman and others, 1970; Steven and others, 1973; T. A. Steven, and P. W. Lipman unpub. data) has shown that all six units are ash-flow tuffs and that each sheet had its source in a separate caldera.

In choosing a single formational name for the Carpenter Ridge–Bachelor Mountain assemblage of rocks, we believe that one of the several well-known names already in use should be retained. Inasmuch as Larsen and Cross recognized that their Piedra Rhyolite consisted of several units, it seems unwarranted to restrict this name to any one of these—and particularly to one whose position in their sequence is especially uncertain. Therefore the name Piedra is herein abandoned. In conformity with usage established for other major ash-flow formations in the San Juan volcanic field, we propose that the name applied to the outflow rocks, the Carpenter Ridge Tuff (Olson and others, 1968, p. C23–26), be applied to the whole ash-flow sheet derived from the Bachelor caldera. The widespread outflow rocks similarly are referred to informally as the outflow member of the Carpenter Ridge Tuff. The intracaldera rocks are reduced in rank and the name Bachelor Mountain Member of the Carpenter Ridge Tuff is applied to the same assemblage of rocks originally called Bachelor Mountain Rhyolite by Steven and Ratté (1964, p. D57). Steven and Ratté further subdivided the Bachelor Mountain sequence into the successively younger Willow Creek, Campbell Mountain, and Windy Gulch Members, which have been useful in delineating the detailed geology of the Creede mining district. These names are retained, and the stratigraphic units are reduced in rank to formally named beds of the Bachelor Mountain Member.

RAT CREEK AND NELSON MOUNTAIN TUFFS

The Rat Creek and Nelson Mountain Tuffs are lithologically similar, compositionally zoned ash-flow sheets derived in close succession from nearby calderas. Rocks of equivalent composition in each formation, particularly the quartz latitic rocks, are so similar that they cannot easily be distinguished, whereas rocks of contrasting composition within either formation vary widely in appearance. As a result, during local detailed studies in the Creede mining district, Steven and Ratté (1964, p. D60–D61; 1965, p. 37) mistakenly correlated intracaldera quartz latitic Rat Creek Tuff in the core of the San Luis caldera with virtually identical Nelson Mountain Tuff across a fault. The correct interpretation became apparent only after broad regional studies provided the proper geologic context.

Specifically, the Equity Quartz Latite, which Emmons and Larsen (1923, p. 32–33) assigned to their Alboroto Group, was considered by Steven and Ratté (1964, p. D61; 1965, p. 37) to be laterally equivalent to the Nelson Mountain Tuff, which is near the top of the Piedra Rhyolite succession of Emmons and Larsen (1923, p. 59) and Larsen and Cross (1956, p. 155). Steven and Ratté considered the name Equity to be superfluous and suggested that it be abandoned. Subsequent regional mapping by T. A. Steven and P. W. Larsen (Steven and others, 1973; unpub. data) has shown instead that the former Equity assemblage is the densely welded intracaldera member of the Rat Creek Tuff, which accumulated within the subsiding core of the San Luis caldera concurrently with eruption. The transition from virtually nonwelded crystal-poor rhyolitic ash to densely welded crystal-rich quartz latite is near the top of the outflow sheet of Rat Creek Tuff, and has been preserved only locally, where as exposed intracaldera Rat Creek Tuff is entirely densely welded quartz latite completely equivalent to the Equity Quartz Latite as originally named.

In consequence, we have subdivided the Rat Creek Tuff into outflow and intracaldera members in the same way that we subdivided the Fish Canyon and Carpenter Ridge Tuffs. The outflow member is left without formal designation, and the name Equity is reinstated for the intracaldera rocks as the Equity Member of the Rat Creek Tuff.

The Nelson Mountain Tuff was erupted from the Cochetopa Park caldera shortly after the Rat Creek Tuff was erupted from the San Luis caldera, and the two caldera cycles overlapped in time. Nelson Mountain eruptions began with crystal-poor rhyolite, which accumulated in small amounts near the source; the material soon changed to crystal-rich quartz latite, which was deposited widely in the central San Juan Mountains. The Cochetopa Park caldera collapsed after the main Nelson Mountain eruptions had ceased. The caldera did not form a complete circular structure, but subsided as a horseshoe-shaped trap door, hinged on the southwest, with a medial ridge extending northeast well out beyond the middle of the basin.

Renewed minor pyroclastic eruptions filled the Cochetopa Park caldera with ash-flow tuff and reworked sandy tuff; the name Cochetopa Park Member of the Nelson Mountain Tuff is here proposed for these rocks. A small volume (less than 10 km^3) of densely welded ash-flow tuff beds accumulated near the hinge line on the southwest side of the caldera. At least three such beds, and perhaps several more, are exposed locally. All are plagioclase-biotite-pyroxene quartz latites similar in composition to the earlier Nelson Mountain Tuff. Southeast of the medial ridge, the basin was largely filled by nonwelded ash-flow tuff having prominent lapilli and blocks of white pumice in a finer ash matrix. In places this soft, loose material has been quarried as a source of pumice. Northwest of the medial ridge, the basin was largely filled with reworked sandy tuff deposited by streams, with a few beds of air-fall tuff interlayered. Most of the sand consists of crystals of feldspar, biotite, and pyroxene winnowed from primary ash. The ash-flow and stream-sediment facies intertongue in the northern and northeastern part of the filled basin, about on trend with the medial ridge.

The heterogeneous Cochetopa Park Member is surmounted by a younger rhyolite lava flow, which was erupted through the caldera fill near the center of the basin. This flow, which forms the prominent topographic feature, Cochetopa Dome, is not included in the Cochetopa Park Member.

The Cochetopa Park Member has not been deeply eroded, and exposures are poor. Also, the member consists largely of laterally equivalent facies of contrasting types, so that no representative type section is available at any one place. A typical densely welded tuff forms a minor mesa cap just north of the county road, about 2,000 feet west of the McDonough Ranch headquarters on the west side of Cochetopa Park. The soft ash-flow tuffs in the eastern part of the Cochetopa Park caldera are best exposed in streambanks, roadcuts, and quarry walls along Archuleta Creek from its confluence with Cochetopa Creek upstream for 3–4 miles. The stream-sediment facies is exposed largely in roadcuts along the county road between McDonough Ranch and Cochetopa Creek.

BULL RIDGE MEMBER OF MISSION CANYON LIMESTONE, BEARTOOTH MOUNTAINS, SOUTHERN MONTANA

By WILLIAM J. SANDO

The Bull Ridge Member was named by Sando (1968) to include the youngest beds of the Madison Limestone in central Wyoming. Recent field studies in the Beartooth Mountains of northern Wyoming and southern Montana (Sando, 1972) have shown that this member can be recognized in the Mission Canyon Limestone of the Madison Group.

In the Beartooth Mountains, the Madison Group, which includes the Lodgepole Limestone and the overlying Mission Canyon Limestone, extends from Livingston at the north end of the mountains southward to the Boulder River. South of the Boulder River, the Lodgepole and Mission Canyon Limestones are not recognized as discrete formations, and the entire sequence of Mississippian carbonate rocks is included in the Madison Limestone.

The type section of the Bull Ridge Member is at Bull Lake in the Wind River Range, Fremont County, Wyo. The member is recognized in the Wind River, Owl Creek, and Bighorn Mountains of central Wyoming. It includes a lower unit of silty dolomite, siltstone, and shale that commonly contains carbonate breccia; this unit is interpreted as a leached evaporitic sequence. Beds above the solution zone are limestone and dolomite partly or completely brecciated by collapse. The upper carbonate beds contain a widespread invertebrate fauna of early Meramecian age (*Diphyphyllum* Zone). The member is underlain by an unnamed cliff-forming unit of limestone and dolomite that has a widespread solution zone at its base and is overlain by the Amsden Formation. In central Wyoming, the Bull Ridge Member ranges from about 40 to 120 feet thick but is absent in some parts of the area because of post-Madison, pre-Amsden erosion.

In the Beartooth Mountains the lithic sequence of the Bull Ridge Member is essentially the same as it is in central Wyoming. However, several thin silty zones have been noted above the main solution zone at its base. As in central Wyoming, the carbonate beds contain the *Diphyphyllum* fauna of early Meramecian age. The member ranges from about 10 to 120 feet thick in the Beartooth Mountains. Some of the variation in thickness is due to the influence of post-Madison, pre-Amsden erosion.

AGE OF PONY TRAIL GROUP IN THE CORTEZ MOUNTAINS, EUREKA COUNTY, NEVADA

By J. FRED SMITH, JR.

The Frenchie Creek Rhyolite in the Cortez Mountains, Frenchie Creek, Pine Valley and Carlin quadrangles, Eureka County, Nev., is considered to be of Late Jurassic age on the basis of a 151 ± 3 m.y. date on biotite from a flow in this formation (R. L. Armstrong, letter to L. J. P. Muffler, 1972). The Frenchie Creek and underlying Sod House Tuff and Big Pole Formation were included in the Pony Trail Group by Muffler (1964, p. 20–39), who considered the group to be of Mesozoic age and probably Jurassic. All three formations are now considered Jurassic, and probably Upper Jurassic.

AGE OF THE ROBERTS MOUNTAINS FORMATION IN THE PINE VALLEY QUADRANGLE, NEVADA

By J. FRED SMITH, JR.

The Roberts Mountains Formation, exposed in a thrust slice in the Pine Valley quadrangle, Elko and Eureka Counties, Nev., is dated as Early Devonian in that area. This age is established on the basis of graptolite collections reexamined by W. B. N. Berry, who assigns the graptolites to the Lower Devonian *Monograptus uniformis* zone (W. B. N. Berry, letter to R. J. Ross, Oct. 16, 1972).

REFERENCES

Albee, A. L., and Boudette, E. L., 1972, Geology of the Attean quadrangle, Somerset County, Maine, *with a section on* Geologic interpretation of the aeromagnetic map, by J. W. Allingham and A. L. Albee: U.S. Geol. Survey Bull. 1297, 110 p.

Alvord, D. C., and Miller, R. L., 1972, Geologic map of the Elkhorn City quadrangle, Kentucky-Virginia, and part of the Harman quadrangle, Pike County, Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–951.

Anderson, A. T., and Gottfried, David, 1972, Hat Creek Basalt, California; similarity to continental- and oceanic-type basalts [abs.]: EOS, v. 53, no. 4, p. 547.

Anderson, C. A., 1940, Hat Creek lava flow [Calif.]: Am. Jour. Sci., v. 238, no. 7, p. 477–492.

Anderson, C. A., and Blacet, P. M., 1972, Precambrian geology of the northern Bradshaw Mountains, Yavapai County, Arizona: U.S. Geol. Survey Bull. 1336, 82 p.

Anderson, C. A., and Nash, J. T., 1972, Geology of the massive sulfide deposits at Jerome, Arizona—a reinterpretation: Econ. Geology, v. 67, no. 7, p. 845–863.

Anderson, R. E., Longwell, C. R., Armstrong, R. L., and Marvin, R. F., 1972, Significance of K-Ar ages of Tertiary rocks from the Lake Mead region, Nevada-Arizona: Geol. Soc. America Bull., v. 83, no. 2, p. 273–288.

Armstrong, R. L., 1968, Mantled gneiss domes in the Albion Range, southern Idaho: Geol. Soc. America Bull., v. 79, no. 10, p. 1295–1314.

Baker, A. A., 1972, Geologic map of the Bridal Veil Falls quadrangle, Utah: U.S. Geol. Survey Geol. Quad. Map GQ–998.

Baltz, E. H., 1972, Geologic map and cross sections of the Gallinas Creek area, Sangre de Cristo Mountains, San Miguel County, New Mexico: U.S. Geol. Survey Misc. Geol. Inv. Map I–673.

Banks, N. G., Cornwall, H. R., Silberman, M. L., Creasey, S. C., and Marvin, R. F., 1972, Chronology of intrusion and ore deposition at Ray, Arizona: Part I, K-Ar ages: Econ. Geology, v. 67, no. 7, p. 864–878.

Barksdale, J. D., 1948, Stratigraphy in the Methow quadrangle, Washington: Northwest Science, v. 22, no. 4, p. 164–176.

Bateman, P. C., and Wones, D. R., 1972, Geologic map of the Huntington Lake quadrangle, central Sierra Nevada, California: U.S. Geol. Survey Geol. Quad. Map GQ–987.

Bayley, R. W., 1972, Preliminary geologic map of the Nemo district, Black Hills, South Dakota: U.S. Geol. Survey Misc. Geol. Inv. Map I–712.

Bell, K. G., and Dennen, W. H., 1972, Plutonic series in the Cape Ann area [abs.]: Geol. Soc. America Abs. with Programs, v. 4, no. 1, p. 2.

Berg, J. R., 1946, Pre-Cambrian geology of the Galena-Roubaix district, Black Hills, South Dakota: South Dakota Geol. Survey Rept. Inv. 52, 50 p.

Birkeland, P. W., 1964, Pleistocene glaciation of the northern Sierra Nevada, north of Lake Tahoe, California: Jour. Geology, v. 72, no. 6, p. 810–825.

Birkeland, P. W., and Janda, R. J., 1971, Clay mineralogy of soils developed from Quaternary deposits of the eastern Sierra Nevada, California: Geol. Soc. America Bull., v. 82, no. 9, p. 2495–2514.

Birman, J. H., 1964, Glacial geology across the crest of the Sierra Nevada, California: Geol. Soc. America Spec. Paper 75, 80 p.

Bowen, R. G., Gray, W. L., and Gregory, D. C., 1963, General geology of the northern Juntura Basin, [Chap.] 2 *in* The Juntura Basin—Studies in history and paleoecology: Am. Philos. Soc. Trans. 1963, v. 53, pt. 1, p. 22–34.

Bowers, W. E., 1972, The Canaan Peak, Pine Hollow, and Wasatch Formations in the Table Cliff region, Garfield County, Utah: U.S. Geol. Survey Bull. 1331–B, 39 p.

Boyd, F. R., 1961, Welded tuffs and flows in the rhyolite plateau of Yellowstone Park, Wyoming: Geol. Soc. America Bull., v. 72, no. 3, p. 387–426.

Bruns, D. L., Epis, R. C., Weimer, R. J., and Steven, T. A. 1971, Stratigraphic relations between Bonanza center and adjacent parts of the San Juan volcanic field, south-central Colorado, *in* James, H. L., ed., Guidebook of the San Luis Basin, Colorado: New Mexico Geol. Soc. Ann. Field Conf. Guidebook No. 22, p. 183–190.

Burke, D. B., and Silberling, N. J., 1973, The Auld Lang Syne Group, of Late Triassic and Jurassic(?) age, north-central Nevada: U.S. Geol. Survey Bull. 1394–E (in press).

Butler, A. P., Jr., 1971, Tertiary volcanic stratigraphy of the eastern Tusas Mountains, southwest of the San Luis Valley, Colorado-New Mexico, *in* James, H. L., ed., Guidebook of the San Luis Basin, Colorado: New Mexico Geol. Soc. Ann. Field Conf. Guidebook No. 22, p. 289–300.

Cannon, W. F., and Gair, J. E., 1970, A revision of stratigraphic nomenclature for middle Precambrian rocks in northern Michigan: Geol. Soc. America Bull., v. 81, no. 9, p. 2843–2846.

Carver, R. E., 1966, Stratigraphy of the Jackson Group (Eocene) in central Georgia: Southeastern Geology, v. 7, no. 2, p. 83–92.

Castle, R. O., and Theodore, T. G., 1972, Some genetic implications of the phase composition of a simple New England pegmatite, *in* Geological Survey Research 1972: U.S. Geol. Survey Prof. Paper 800–B, p. B105–B117.

Chadwick, R. A., 1969, The northern Gallatin Range, Montana, northwestern part of the Absaroka-Gallatin volcanic field: Wyoming Univ. Contr. Geology, v. 8, no. 2, pt. 2, p. 150–166.

Childers, M. O., 1963, Structure and stratigraphy of the southwest Marias Pass area, Flathead County, Montana: Geol. Soc. America Bull., v. 74, no. 2, p. 141–163.

Christiansen, R. L., and Blank, R. H., Jr., 1972, Volcanic stratigraphy of the Quaternary rhyolite plateau in Yellowstone National Park: U.S. Geol. Survey Prof. Paper 729–B, 18 p.

Clarke, Samuel and Nilsen, T. H., 1972, Postulated offsets of Eocene strata along the San Andreas fault zone, central California [abs.]: Geol. Soc. America Abs. with Programs, v. 4, no. 3, p. 137–138.

Coats, R. R., and Gordon, Mackenzie, Jr., 1972 Tectonic implications of the presence of the Edna Mountain Formation in northern Elko County, Nevada, *in* Geological Survey research 1972: U.S. Geol. Survey Prof. Paper 800–C, p. C85–C94.

Cobban, W. A., 1971, New and little-known ammonites from the Upper Cretaceous (Cenomanian and Turonian) of the western interior of the United States: U.S. Geol. Survey Prof. Paper 699, 24 p.

Coleman, R. G., 1972, The Colebrooke Schist of southwestern Oregon and its relation to the tectonic evolution of the region: U.S. Geol. Survey Bull. 1339, 61 p.

Colton, H. S., 1937, The basaltic cinder cones and lava flows of the San Francisco Mountain volcanic field, Ariz.: Mus. Northern Arizona Bull. 10, 50 p.

Compton, R. R., 1960, Contact metamorphism in the Santa Rosa Range, Nevada: Geol. Soc. America Bull., v. 71, no. 9, p. 1383–1416.

——— 1972, Geologic map of the Yost quadrangle, Box Elder County, Utah, and Cassia County, Idaho: U.S. Geol. Survey Misc. Geol. Inv. Map I–672.

Cook, E. F., 1960, Great Basin ignimbrites [Nevada-Utah], *in* Geology of east-central Nevada: Intermountain Assoc. Petroleum Geologists, 11th Ann. Field Conf. 1960 Guidebook, p. 134–141.

——— 1965, Stratigraphy of Tertiary volcanic rocks in eastern Nevada: Nevada Bur. Mines Rept. 11, 61 p.

Cornwall, H. R., Banks, N. G., and Phillips, C. H., 1971, Geologic map of the Sonora quadrangle, Pinal and Gila Counties, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ–1021.

Crandell, D. R., 1972, Glaciation near Lassen Peak, northern California, *in* Geological Survey Research 1972: U.S. Geol. Survey Prof. Paper 800–C, p. C179–C188.

Creasey, S. C., 1965, Geology of the San Manuel area, Pinal County, Arizona: U.S. Geol. Survey Prof. Paper 471, 64 p.

——— 1967, General geology of the Mammoth quadrangle, Pinal County, Arizona: U.S. Geol. Survey Bull. 1218, 94 p.

Creasey, S. C., and Kistler, R. W., 1962, Age of some copper-bearing porphyries and other igneous rocks in southeastern Arizona, *in* Short papers in geology, hydrology, and topography: U.S. Geol. Survey Prof. Paper 450–D, p. D1–D5.

Cressman, E. R., 1972, Geologic map of the Danville quadrangle, Mercer and Boyle Counties, Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–985.

Crittenden, M. D., Jr., 1972, Willard thrust and Cache allochthon, Utah: Geol. Soc. America Bull., v. 83, no. 9, p. 2871–2880.

Cross, C. W., 1896 Igneous formations, Chap. 5 *in* Emmons, S. F., Cross, C. W., and Eldridge, G. H., Geology of the Denver Basin in Colorado: U.S. Geol. Survey Mon. 27, p. 279–315.

Curry, R. R., 1966, Glaciation about 3,000,000 years ago in the Sierra Nevada: Science, v. 154, no. 3750, p. 770–771.

Dalrymple, G. B., 1972, Potassium-argon dating in geomagnetic reversals and North American glaciations, *in* Bishop, W. W., and Miller, J. A., eds., Calibration of hominoid evolution: Edinburgh, Scottish Academic Press, p. 107–134.

Daly, R. A., 1906, The Okanogan composite batholith of the Cascade Mountain system: Geol. Soc. America Bull., v. 17, p. 329–376.

Davis, G. A., and Lipman, P. W., 1962, Revised structural sequence of pre-Cretaceous metamorphic rocks in the southern Klamath Mountains, California: Geol. Soc. America Bull., v. 73, no. 12, p. 1547–1552.

Doell, R. R., 1972, Paleomagnetism of lava flows from Kauai, Hawaii: Jour. Geophys. Research, v. 77, no. 5, p. 862–876.

Donner, H. F., 1949, Geology of the McCoy area, Eagle and Routt Counties, Colorado: Geol. Soc. America Bull., v. 60, no. 8, p. 1215–1247.

Dutro, J. T., Jr., Brosgé, W. P., and Reiser, H. N., 1972, Significance of recently discovered Cambrian fossils and reinterpretation of the Neruokpuk Formation, northeastern Alaska: Am. Assoc. Petroleum Geologists Bull., v. 56, no. 4, p. 808–815.

Dutton, C.E., 1971, Geology of the Florence area, Wisconsin and Michigan: U.S. Geol. Survey Prof. Paper 633, 54 p.

Eargle, D. H., 1959, Stratigraphy of Jackson Group (Eocene), south-central Texas: Am. Assoc. Petroleum Geologists Bull., v. 43, no. 11, p. 2623–2635.

——— 1972, Revised classification and nomenclature of the Jackson Group (Eocene), south-central Texas: Am. Assoc. Petroleum Geologists Bull., v. 56, no. 3, p. 561–566.

Elias, M. K., 1931, The geology of Wallace County, Kansas: Kansas Geol. Survey Bull. 18, 254 p.

Emmons, W. H., and Larsen, E. S., 1923, Geology and ore deposits of the Creede district, Colorado: U.S. Geol. Survey Bull. 718, 198 p.

Epstein, J. B., and Epstein, A. G., 1972, The Shawangunk Formation (Upper Ordovician(?) to Middle Silurian) in eastern Pennsylvania: U.S. Geol. Survey Prof. Paper 744, 45 p.

Espenhade, G. H., 1972, Geology of the Moxie pluton in the Moosehead Lake—Jo-Mary Mountain area, Piscataquis County, Maine: U.S. Geol. Survey Bull. 1340, 40 p.

Fearing, J. L., Jr., 1926, Some notes on the geology of the Jerome district, Arizona: Econ. Geology, v. 21, no. 8, p. 757–773.

Fisher, F. S., 1967, Geology of the Stinkingwater mining region, Park County, Wyoming—Pt. 1, General geology and petrology of Tertiary intrusive rocks: Wyoming Univ. Contr. Geology, v. 6, no. 1, p. 71–86.

——— 1972, Tertiary mineralization and hydrothermal alteration in the Stinkingwater mining region, Park County, Wyoming: U.S. Geol. Survey Bull. 1332–C, 33 p.

Flower, R. H., and Gordon, Mackenzie, Jr., 1972, New Nephriticeratidae (Nautiloidea) from the Devonian of Maryland, Pennsylvania, and Indiana, *in* Geological Survey Research 1972: U.S. Geol. Survey Prof. Paper 800–D, p. D45–D50.

Foerste, A. F., 1912, *Strophomena* and other fossils from Cincinnatian and Mohawkian horizons, chiefly in Ohio, Indiana, and Kentucky: Denison Univ. Sci. Lab. Bull. 17, p. 171–172.

Gable, D. J., 1972, Geologic map of the Tungsten quadrangle, Boulder, Gilpin, and Jefferson Counties, Colorado: U.S. Geol. Survey Geol. Quad. Map GQ–978.

Gair, J. E., and Simmons, G. C., 1970, Metadiabase sills in Negaunee Iron-formation south of Negaunee, Michigan, *in* Cohee, G. V., Bates, R. G., and Wright, W. B., Changes in stratigraphic nomenclature by the U.S. Geological Survey, 1969: U.S. Geol. Survey Bull. 1324–A, p. A24–A30.

Gill, J. R., Cobban, W. A., and Schultz, L. G., 1972, Stratigraphy and composition of the Sharon Springs Member of the Pierre Shale in western Kansas: U.S. Geol. Survey Prof. Paper 728, 50 p.

Greeley, Ronald, and Hyde, J. H., 1972, Lava tubes of the Cave Basalt, Mount St. Helens, Washington: Geol. Soc. America Bull., v. 83, no. 8, p. 2397–2418.

Greene, R. C., Walker, G. W., and Corcoran, R. E., 1972, Geologic map of the Burns quadrangle, Oregon: U.S. Geol. Survey Misc. Geol. Inv. Map I–680.

Grommé, 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: Geol. Soc. America Bull., v. 83, no. 6, p. 1619–1638.

Hadley, J. B., and Nelson, A. E., 1971, Geologic map of the Knoxville quadrangle, North Carolina, Tennessee, and South Carolina: U.S. Geol. Survey Misc. Geol. Inv. Map I–654.

Hampton, E. R., 1972, Geology and ground water of the Molalla-Salem Slope area, northern Willamette Valley, Oregon: U.S. Geol. Survey Water-Supply Paper 1997, 83 p.

Hanna, M. A., 1926, Geology of the La Jolla quadrangle, California: California Univ., Dept. Geol. Sci. Bull., v. 16, no. 7, p. 187–246.

Harbour, R. L., 1972, Geology of the northern Franklin Mountains, Texas and New Mexico: U.S. Geol. Survey Bull. 1298, 129 p.

Harrison, J. E., 1972, Precambrian Belt basin of northwestern United States: Its geometry, sedimentation, and copper occurrences: Geol. Soc. America Bull., v. 83, no. 5, p. 1215–1240.

Hayes, P. T., 1972, Stratigraphic nomenclature of Cambrian and Lower Ordovician rocks of easternmost southern Arizona and adjacent westernmost New Mexico: U.S. Geol. Survey Bull. 1372–B, 21 p.

Heindl, L. A., 1963, Cenozoic geology in the Mammoth area, Pinal County, Arizona: U.S. Geol. Survey Bull. 1141–E, 41 p.

Herrick, S. M., 1972, Age and correlation of the Clinchfield Sand in Georgia: U.S. Geol. Survey Bull. 1354–E, 17 p.

Hertlein, L. G., and Grant, U. S., 4th, 1939, Geology and oil possibilities of southwestern San Diego County [Calif.]: California Jour. Mines and Geology, v. 35, no. 1, p. 57–78.

Higgins, M. W., 1971, Depth of emplacement of James Run Formation pillow basalts and the depth of deposition of part of the Wissahickon Formation, Appalachian Piedmont, Maryland: Am. Jour. Sci. v. 271, no. 4, p. 321–332.

——— 1972, Age, origin, regional relations, and nomenclature of the Glenarm Series, central Appalachian Piedmont: a reinterpretation: Geol. Soc. America Bull., v. 83, no. 4, p. 989–1026.

Hope, R. A., 1972, Geologic map of the Spruce Mountain quadrangle, Elko County, Nevada: U.S. Geol. Survey Geol. Quad. Map GQ–942.

Hopson, C. A., 1964, The crystalline rocks of Howard and Montgomery Counties, *in* The geology of Howard and Montgomery Counties: Baltimore, Maryland Geol. Survey, p. 27–215.

Hotz, P. E., 1973, Blueschist metamorphism in the Yreka-Fort Jones area, Klamath Mountains, California: U.S. Geol. Survey Jour. Research, v. 1, no. 1, p. 53–61.

Hotz, P. E., Thurber, H. K., Marks, L. Y., and Evans, R. K., 1972, Mineral resources of the Salmon-Trinity Alps Primitive Area, California: U.S. Geol. Survey Bull. 1371–B, 267 p.

Howard, A. D., 1937, History of the Grand Canyon of the Yellowstone: Geol. Soc. America Spec. Paper 6, 159 p.

Hunter, R. E., Clifton, H. E., and Phillips, R. L., 1970, Geology of the stacks and reefs off the southern Oregon coast: Ore-Bin, v. 32, no. 10, p. 185–201.

Kay, Marshall, 1960, Paleozoic continental margin in central Nevada, western United States: Internat. Geol. Cong., 21st Copenhagen, Rept., pt. 12, p. 94–103.

Kay, Marshall, and Crawford, J. P., 1964, Paleozoic facies from the miogeosynclinal to the eugeosynclinal belt in thrust slices, central Nevada: Geol. Soc. America Bull., v. 75, no. 5, p. 425–454.

Kennedy, M. P., and Moore, G. W., 1971, Stratigraphy and structure of the area between Oceanside and San Diego, California: geologic road log, *in* W. A. Elders, ed., Geological excursions in southern California: California Univ. (Riverside Campus) Mus. Contr. no. 1, p. 149–166.

Kepferle, R. C., 1971, Members of the Borden Formation (Mississippian) in north-central Kentucky: U.S. Geol. Survey Bull. 1354–B, 18 p.

——— 1972, Geologic map of the Brooks quadrangle, Bullitt and Jefferson Counties, Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–961.

Kerr, P. F., and Schenck, H. G., 1928, Significance of the Matilija overturn [Santa Ynez Mountains, California]: Geol. Soc. America Bull., v. 39, no. 4, p. 1087–1102.

Kew, W. S. W., 1924, Geology and oil resources of a part of Los Angeles and Ventura Counties, California: U.S. Geol. Survey Bull. 753, 202 p.

Kittleman, L. R., Green, A. R., Hagood, A. R., Johnson, A. M., McMurray, J. M., Russell, R. G., and Weeden, D. A., 1965, Cenozoic stratigraphy of the Owyhee region, southeastern Oregon: Oregon Univ. Mus. Nat. History Bull. 1, 45 p.

Knopf, E. B., and Jonas, A. I., 1929, Geology of the crystalline rocks: Maryland Geol. Survey, Baltimore County [rept.], p. 97–199.

Koch, J. G., 1966, Late Mesozoic stratigraphy and tectonic history, Port Orford-Gold Beach area, southwestern Oregon coast: Am. Assoc. Petroleum Geologists Bull., v. 50, no. 1, p. 25–71.

Krieger, M. H., 1968a, Geologic map of the Brandenburg Mountain quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ–668.

——— 1968b, Geologic map of the Holy Joe Peak quadrangle, Pinal County, Arizona: U.S. Geol. Survey, Geol. Quad. Map GQ–669.

——— 1968c, Geologic map of the Lookout Mountain quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ–670.

——— 1968d, Geologic map of the Saddle Mountain quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ–671.

——— 1973a, Geologic map of the Winkelman quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ–1106 (in press).

——— 1973b, Geologic map of the Crozier Peak quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad Map GQ–1107 (in press).

——— 1973c, Geologic map of the Black Mountain quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad Map GQ–1108 (in press).

——— 1973d, Geologic map of the Putnam Wash quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Map GQ–1109 (in press).

Larsen, E. S., Jr., and Cross, Whitman, 1956, Geology and petrology of the San Juan region, southwestern Colorado: U.S. Geol. Survey Prof. Paper 258, 303 p.

Leopold, E. B., and MacGinitie, H. D., 1972, Development and affinities of Tertiary floras in the Rocky Mountains, *in* Alan Graham, ed., Floristics and paleofloristics of Asia and eastern North America: New York, Elsevier Pub. Co., p. 147–200.

LeRoy, L. W., 1946, Stratigraphy of the Golden-Morrison area, Jefferson County, Colorado: Colorado School Mines Quart., v. 41, no. 2, 115 p.

Lewis, R. Q., Sr., 1963, Geologic features of the Mississippian Plateau, south-central Kentucky: Geol. Soc. Kentucky, field trip, 1963: [Lexington] Kentucky Geol. Survey, 28 p.

Lewis, R. Q., Sr., and Thaden, R. E., 1963, Geology of the Columbia quadrangle, Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–249.

——— 1964, Geology of the Montpelier quadrangle, Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–337.

——— 1965, Geology of the Russell Springs quadrangle, Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–383.

Lipman, P. W., Steven, T. A., and Mehnert, H. H., 1970, Volcanic history of the San Juan Mountains, Colorado, as indicated by potassium-argon dating: Geol. Soc. America Bull., v. 81, no. 8, p. 2327–2352.

Love, J. D., and Albee, H. F., 1972, Geologic map of the Jackson quadrangle, Teton County, Wyoming: U.S. Geol. Survey Misc. Geol. Inv. Map I–769–A.

Lundgren, Lawrence, Jr., Ashmead, Lawrence, Snyder, G. L., 1971, The bedrock geology of the Moodus and Colchester quadrangles: Connecticut Geol. and Nat. History Survey Quadrangle Rept. 27, 24 p.

McKee, E. H., and Burke, D. B., 1972, Fission-track age bearing on the Permian-Triassic boundary and time of the Sonoma orogeny in north-central Nevada: Geol. Soc. America Bull., v. 83, no. 7, p. 1949–1952.

McKee, E. H., Merriam, C. W., and Berry, W. B. N., 1972, Biostratigraphy and correlation of the McMonnigal and Tor Limestones, Toquima Range, Nevada: Am. Assoc. Petroleum Geologists Bull., v. 56, no. 8, p. 1563–1570.

MacKevett, E. M., Jr., and Smith, J. G., 1972, Geologic map of the McCarthy B–4 quadrangle, Alaska: U.S. Geol. Survey Geol. Quad. Map GQ–943.

Mackin, J. H., 1960, Structural significance of Tertiary volcanic rocks in southwestern Utah: Am. Jour. Sci., v. 258, no. 2, p. 81–131.

Marks, J. G., 1941, Stratigraphy of the Tejon formation in its type area, Kern County, California [abs.]: Geol. Soc. America Bull., v. 52, no. 12, p. 1922.

——— 1943, Type location of the Tejon formation: California Div. Mines Bull. 118, p. 534–538.

Maxey, G. B., 1958, Lower and Middle Cambrian stratigraphy in northern Utah and southeastern Idaho: Geol. Soc. America Bull., v. 69, no. 6, p. 647–687.

Maxwell, C. H., 1964, Geology of the Knifley quadrangle, Kentucky: U.S. Geol. Survey Quad. Map GQ–294.

——— 1965, Geology of the Dunnville quadrangle, Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–367.

Maxwell, C. H., and Turner, W. B., 1964, Geology of the Cane Valley quadrangle, Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–369.

Merewether, E. A., and Cobban, W. A., 1972, Unconformities within the Frontier Formation, northwestern Carbon County, Wyoming: U.S. Geol. Survey Prof. Paper 800–D, p. D57–D66.

Miller, R. D., 1973, Gastineau Channel Formation, a composite glaciomarine deposit near Juneau, Alaska: U.S. Geol. Survey Bull. 1394–C (in press).

Moench, R. H., 1971, Geologic map of the Rangely and Phillips quadrangles, Franklin and Oxford Counties, Main: U.S. Geol. Survey Misc. Geol. Inv. Map I–605.

Moore, G. W., 1972, Offshore extension of the Rose Canyon fault, San Diego, California, *in* Geological Survey research 1972: U.S. Geol. Survey Prof. Paper 800–C, p. C113–C116.

Mudge, M. R., 1972, Pre-Quaternary rocks of the Sun River Canyon area, northwestern Montana: U.S. Geol. Survey Prof. Paper 663–A, 142 p.

Muffler, L. J. P., 1964, Geology of the Frenchie Creek quadrangle, north-central Nevada: U.S. Geol. Survey Bull. 1179, 99 p.

Mullens, T. E., and Poole, F. G., 1972, Quartz-sand-bearing zone and Early Silurian age of the Hanson Creek Formation in Eureka County, Nevada, *in* Geological Survey research 1972: U.S. Geol. Survey Prof. Paper 800–B, p. B21–B24.

Nelson, L. A., 1940, Paleozoic stratigraphy of Franklin Mountains, west Texas, *in* DeFord and Lloyd, eds., West Texas-New Mexico symposium: Am. Assoc. Petroleum Geologists Bull., v. 24, no. 1, p. 157–172.

Nelson, R. N., 1925, Geology of the hydrographic basin of the upper Santa Ynez River, California: California Univ., Dept. Geol. Sci. Bull., v. 15, no. 10, p. 327–396.

Nilsen, T. H., 1972, Stratigraphy and sedimentation of the Tejon Formation, San Emigdio Mountains, California [abs.]: Pacific Petroleum Geologist Newsletter, Pacific Sec., Am. Assoc. Petroleum Geologists, v. 26, no. 1, p. 5.

Olson, J. C., Hedlund, D. C., and Hansen, W. R., 1968, Tertiary volcanic stratigraphy in the Powderhorn-Black Canyon region, Gunnison and Montrose Counties, Colorado: U.S. Geol. Survey Bull. 1251–C, 29 p.

Oriel, S. S., and Armstrong, F. C., 1971, Uppermost Precambrian and lowest Cambrian rocks in southeastern Idaho: U.S. Geol. Survey Prof. Paper 394, 52 p.

Ovenshine, A. T., and Brew, D. A., 1972, Separation and history of the Chatham Strait fault, southeast Alaska [abs.]: Internat. Geol. Cong., 24th, Montreal, 1972, Abstracts, p. 94–95.

Page, B. M., Marks, J. G., and Walker, G. W., 1951, Stratigraphy and structure of mountains northeast of Santa Barbara, California: Am. Assoc. Petroleum Geologists Bull., v. 35, no. 8, p. 1727–1780.

Peterson, D. W., 1969, Geologic map of the Superior quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ–818.

Peterson, W. L., and Kepferle, R. C., 1970, Deltaic deposits of the Borden Formation in central Kentucky, *in* Geological Survey research 1970: U.S. Geol. Survey Prof. Paper 700–D, p. D49–D54.

Ransome, F. L., 1903, Geology of the Globe copper district, Arizona: U.S. Geol. Survey Prof. Paper 12, 168 p.

——— 1919, The Copper deposits of Ray and Miami, Arizona: U.S. Geol. Survey Prof. Paper 115, 192 p.

——— 1923, Description of the Ray quadrangle (Arizona): U.S. Geol. Survey, Geol. Atlas Folio 217.

Roberts, A. E., 1972, Cretaceous and early Tertiary depositional and tectonic history of the Livingston area, southwestern Montana: U.S. Geol. Survey Prof. Paper 526–C, 20 p.

Runner, J. J., 1934, Pre-Cambrian geology of the Nemo district, Black Hills, South Dakota: Am. Jour. Sci., 5th ser., v. 28, no. 167, p. 353–372.

Sainsbury, C. L., 1972, Geologic map of the Teller quadrangle, western Seward Peninsula, Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I–685.

Sando, W. J., 1968, A new member of the Madison Limestone (Mississippian) in Wyoming: Geol. Soc. America Bull., v. 79, no. 12, p. 1855–1858, 2 figs.

——— 1972, Madison Group (Mississippian) and Amsden Formation (Mississippian and Pennsylvanian) in the Beartooth Mountains, northern Wyoming and southern Montana; Montana Geol. Soc. 21st Ann. Field Conf., Sept. 22–24, 1972, Guidebook, p. 57–63.

Sargent, K. A., and McKee, E. H., 1969, The Bates Mountain Tuff in northern Nye County, Nevada: U.S. Geol. Survey Bull. 1294–E, 12 p.

Schaber, G. G., and Brown, W. E., Jr., 1972, Long-wavelength radar images of northern Arizona—A geologic evaluation, *in* Geological Survey Research 1972: U.S. Geol. Survey Prof. Paper 800–B, p. B175–B181.

Schmidt, R. G., and Hubbard, H. A., 1972, Field trip A; Penokean orogeny in the central and western Gogebic region, Michigan and Wisconsin: Inst. Lake Superior Geology, Abs. and Field Guides, No. 18, 27 p.

Schwarzacher, Walter, 1958, The stratification of the Great Scar limestone in the Settle district of Yorkshire: Liverpool and Manchester Geol. Jour., v. 2, pt. 1, p. 124–142.

Scott, G. R., 1972, Geologic map of the Morrison quadrangle, Jefferson County, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I–790–A.

Sedimentation Seminar, 1972, Sedimentology of the Mississippian Knifley Sandstone and Cane Valley Limestone of south-central Kentucky: Kentucky Geol. Survey ser. 10, Rept. Inv. no. 13, 30 p.

Seiders, V. M., Briggs, R. P., and Glover, Lynn, III, 1972, Geology of Isla Desecheo, Puerto Rico, with notes on the great southern Puerto Rico fault zone and Quaternary stillstands of the sea: U.S. Geol. Survey Prof. Paper 739, 22 p.

Sharp, R. P., and Birman, J. H., 1963, Additions to classical sequence of Pleistocene glaciations, Sierra Nevada, California: Geol. Soc. America Bull., v. 74, no. 8, p. 1079–1086.

Sheppard, R. A., and Gude, A. J., III, 1972, Big Sandy Formation near Wikieup, Mohave County, Arizona: U.S. Geol. Survey Bull. 1354–C, 10 p.

Smedes, H. W., and Prostka, H. J., 1972, Stratigraphic framework of the Absaroka Volcanic Supergroup in the Yellowstone National Park region: U.S. Geol. Survey Prof. Paper 729–C, 33 p.

Smith, R. L., 1960, Zones and zonal variations in welded ash flows: U.S. Geol. Survey Prof. Paper 354–F, p. 149–159.

Sohn, I. G., 1972, Late Paleozoic ostracode species from the conterminous United States: U.S. Geol. Survey Prof. Paper 711–B, 15 p.

Southwick, D. L., and Fisher, G. W., 1967, Revision of stratigraphic nomenclature of the Glenarm Series in Maryland: Maryland Geol. Survey Rept. Inv. 6, 19 p.

Southwick, D. L., and Owens, J. P., 1968, Geologic map of Harford County: Maryland Geol. Survey County Geol. Map CG–M–1.

Staatz, M. H., Weis, P. L., and others, 1971, Mineral resources of the Pasayten Wilderness Area, Washington: U.S. Geol. Survey Bull. 1325, 255 p.

Stenzel, H. B., 1952, Transgression of the Jackson Group, *in* Mississippi Geol. Soc. Guidebook, 9th Field Trip, Sept. 1952: p. 36–43.

Steven, T. A., Lipman, P. W., Hail, W. J., Jr., Barker, E., and Luedke, R. G., 1973, Geologic map of the Durango quadrangle, southwestern Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I–764.

Steven, T. A., and Ratté, J. C., 1964, Revised Tertiary volcanic sequence in the central San Juan Mountains, Colorado, *in* Short papers in geology and hydrology: U.S. Geol. Survey Prof. Paper 475–D, p. D54–D63.

——— 1965, Geology and structural control of ore deposition in the Creede district, San Juan Mountains, Colorado: U.S. Geol. Survey Prof. Paper 487, 90 p.

Stewart, J. H., Poole, F. G., and Wilson, R. F., 1972a, Stratigraphy and origin of the Chinle Formation and related Upper Triassic strata in the Colorado Plateau region: U.S. Geol. Survey Prof. Paper 690, 336 p.

——— 1972b, Stratigraphy and origin of the Triassic Moenkopi Formation and related strata in the Colorado Plateau region, *with a section on* Sedimentary petrology by R. A. Cadigan: U.S. Geol. Survey Prof. Paper 691, 195 p.

Stewart, J. H., Williams, G. A., Albee, H. F., and Raup, O. B., 1959, Stratigraphy of Triassic and associated formations in part of the Colorado Plateau region: U.S. Geol. Survey Bull. 1046–Q, p. 487–576.

Stockdale, P. B., 1931, The Borden (Knobstone) rocks of southern Indiana: Indiana Dept. Conserv., Div. Geology, Pub. 98, 330 p.

——— 1939, Lower Mississippian rocks of the east-central interior: Geol. Soc. America, Spec. Pub. 22, 248 p.

Swartz, C. K., and Swartz, F. M., 1931, Early Silurian formations of southeastern Pennsylvania: Geol. Soc. America Bull., v. 42, no. 3, p. 621–662.

Taylor, A. R., 1963, Geology of the Gradyville quadrangle, Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–233.

——— 1965a, Geology of the Gresham quadrangle, Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–421.

——— 1965b, Geologic map of the Campbellsville quadrangle, southern Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–448.

——— 1966, Geologic map of the Mannsville quadrangle, south-central Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–562.

Taylor, A. R., and Lewis, R. Q., Sr., 1971, Geologic map of the Liberty quadrangle, Casey County, Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–946.

Taylor, A. R., Luft, S. J., and Lewis, R. Q., Sr., 1968, Geologic map of the Greensburg quadrangle, Green and Taylor Counties, Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–739.

Thaden, R. E., Lewis, R. Q., Sr., Cattermole, J. M., and Taylor, A. R., 1961, Reefs in the Fort Payne Formation of Mississippian age, south-central Kentucky, *in* Geological Survey research, 1961: U.S. Geol. Survey Prof. Paper 424–B, p. B88–B90.

U.S. Geological Survey, 1972, Geologic map of Yellowstone National Park: U.S. Geol. Survey Misc. Geol. Inv. Map I–711.

Vedder, J. G., 1972, Revision of stratigraphic names for some Eocene formations in Santa Barbara and Ventura Counties, California: U.S. Geol. Survey Bull. 1354–D, 12 p.

Wahrhaftig, Clyde, 1962, Geomorphology of the Yosemite Valley region, California, *in* Geologic guide to the Merced Canyon and Yosemite Valley, California: California Div. Mines and Geology Bull. 182, p. 33–46.

Weir, G. W., Gualtieri, J. L., and Schlanger, S. O., 1966, Borden Formation (Mississippian) in south- and southeast-central Kentucky: U.S. Geol. Survey Bull. 1224–F, 38 p.

White, W. S., 1972, The base of the upper Keweenawan, Michigan and Wisconsin: U.S. Geol. Survey Bull. 1354–F, 23 p.

Willden, Ronald, 1964, Geology of the Christmas quadrangle, Gila and Pinal Counties, Arizona: U.S. Geol. Survey Bull. 1161–E, 64 p.

Witkind, I. J., 1972, Geologic map of the Henrys Lake quadrangle, Idaho and Montana: U.S. Geol. Survey Misc. Geol. Inv. Map I–871–A.

Yerkes, R. F., 1972, Geology and oil resources of the western Puente Hills area, southern California: U.S. Geol. Survey Prof. Paper 420–C, 63 p. [1973.]

Yochelson, E. L., and Fraser, G. D., 1973, Interpretation of depositional environment in the Plympton Formation (Permian), southern Pequop Mountains, Nevada, from physical stratigraphy and a faunule: U.S. Geol. Survey Jour. Research, v. 1, no. 1, p. 19–32.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1973 O—543–579/52