Contributions to Stratigraphy 1965

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STEWART L. UDALL, *Secretary*

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William T. Pecora, *Director*

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Changes in Stratigraphic Nomenclature by the U.S. Geological Survey 1964

By GEORGE V. COHEE *and* WALTER S. WEST

CONTRIBUTIONS TO STRATIGRAPHY

GEOLOGICAL SURVEY BULLETIN 1224-A

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UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

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CONTRIBUTIONS TO STRATIGRAPHY

CHANGES IN STRATIGRAPHIC NOMENCLATURE BY THE U.S. GEOLOGICAL SURVEY, 1964

By George V. Cohee and Walter S. West

LISTINGS OF NOMENCLATURAL CHANGES

In the following listings, the changes in stratigraphic nomenclature are grouped together in the categories of (1) new names adopted, (2) previously used names adopted, (3) names revised, (4) changes in age designation, (5) names reinstated, and (6) names abandoned. The stratigraphic names involved in change are listed alphabetically under each category. The age of the unit, the area in which the name is employed, the title of the report, and the publication in which the change is described are given.

NEW NAMES ADOPTED FOR OFFICIAL USE IN U.S. GEOLOGICAL SURVEY REPORTS

Name	Age	Location	Report in which new name is adopted: Title and authorship	Report in which new name is adopted: Publication (U.S. Geol. Survey except as indicated)	Year of publication
Allingtown Metadiabase	Ordovician(?)	Connecticut	Nomenclature and age of formations in the Ansonia quadrangle, Fairfield and New Haven Counties, Connecticut, by C. E. Fritts.	This report, p. A30	
Ammonia Tanks Member (of Timber Mountain Tuff) (of Piapi Canyon Group).	Pliocene	Nevada	Paintbrush Tuff and Timber Mountain Tuff of Nye County, Nevada, by P. P. Orkild.	This report, p. A50	
Belted Range Tuff	Miocene or Pliocene	do	Belted Range Tuff of Nye and Lincoln Counties, Nevada, by K. A. Sargent, D. C. Noble, and E. B. Ekren.	This report, p. A33	
Big Pole Formation (of Pony Trail Group).	Mesozoic	do	Geology of the Frenchie Creek quadrangle, north-central Nevada, by L. J. P. Muffler.	Bull. 1179	1964 [1965]
Bottle Lake Quartz Monzonite	Devonian	Maine	Reconnaissance bedrock geology of the Wabassus Lake quadrangle, Maine, by D. M. Larrabee.	Map MF-282	1964
Browns Pass Quartz Monzonite	Precambrian	Colorado	Denny Creek Granodiorite Gneiss, Browns Pass Quartz Monzonite, and Kroenke Granodiorite, Mount Harvard quadrangle, Colorado, by Fred Barker and M. R. Brock.	This report, p. A25	
Burney Basalt	Early Pleistocene	California	Geologic map of the Prospect Peak quadrangle, California, by G. A. Macdonald.	Map GQ-345	1964
Canelo Hills Volcanics	Triassic and Jurassic	Arizona	Lower Mesozoic extrusive rocks in southeastern Arizona; the Canelo Hills Volcanics, by P. T. Hayes, F. S. Simons, and R. S. Raup.	Bull. 1194-M	1965
Cathedral Mountain Formation	Early Permian (Leonard).	Texas	New Permian stratigraphic units in the Glass Mountains, west Texas, by G. A. Cooper and R. E. Grant.	Am. Assoc. Petroleum Geologists Bull., v. 48, no. 9.	1964
Decie Ranch Member (of Skinner Ranch Formation).	do	do	do	do	1964
Denny Creek Granodiorite Gneiss	Precambrian	Colorado	Denny Creek Granodiorite Gneiss, Browns Pass Quartz Monzonite, and Kroenke Granodiorite, Mount Harvard quadrangle, Colorado, by Fred Barker and M. R. Brock.	This report, p. A23	
Draper Formation (of Lake Bonneville Group).	Pleistocene	Utah	Lake Bonneville: Quaternary stratigraphy of eastern Jordan Valley south of Salt Lake City, Utah, by R. B. Morrison.	Prof. Paper 477	1965
Dry Lake Member (of Thirsty Canyon Tuff).	Pliocene	Nevada	Thirsty Canyon Tuff of Nye and Esmeralda Counties, Nevada, by D. C. Noble, R. E. Anderson, E. B. Ekren, and J. T. O'Connor.	Prof. Paper 475-D	1964
Dutton Creek Formation	Paleocene	Wyoming	The Foote Creek and Duton Creek Formations, two new formations in the north part of the Laramie basin, Wyoming, by H J.	Bull. 1194-K	1965

			Hyden, H. McAndrews, and R. H Tschudy.		
Foote Creek Formation	Late Cretaceous and Paleocene.	do	do	do	1965
Frenchie Creek Rhyolite (of Pony Trail Group).	Mesozoic	Nevada	Geology of the Frenchie Creek quadrangle, north-central Nevada, by L. J. P. Muffler.	Bull. 1179	1964 [1965]
Gold Flat Member (of Thirsty Canyon Tuff).	Pliocene	do	Thirsty Canyon Tuff of Nye and Esmeralda Counties, Nevada, by D.C. Noble, R. E. Anderson, E. B. Ekren, and J. T. O'Connor.	Prof. Paper 475–D	1964
Grier Limestone Member (of Lexington Limestone).	Middle Ordovician	Kentucky	Geology of the Tyrone quadrangle, Kentucky, by E. R. Cressman.	Map GQ–303	1964
Hoskin Lake Granite	Precambrian	Wisconsin	Marinette Quartz Diorite and Hoskin Lake Granite of northeastern Wisconsin, by W. C. Prinz.	This report, p. A54	
Kirkham Hollow Volcanics	middle Pliocene or younger.	Idaho	Geology of the Garns Mountain quadrangle, Bonneville, Madison and Teton Counties, Idaho, by M. H. Staatz and H. F. Albee.	Bull. 1205	1965
Kootznahoo Formation	Paleocene through Miocene.	Alaska	Reconnaissance geology of Admiralty Island, Alaska, by E. H. Lathram, J. S. Pomeroy, H. C. Berg, and R. A. Loney.	Bull. 1181–R	1965
Kroenke Granodiorite	Precambrian	Colorado	Denny Creek Granodiorite Gneiss, Browns Pass Quartz Monzonite, and Kroenke Granodiorite, Mount Harvard quadrangle, Colorado, by Fred Barker and M. R. Brock.	This report, p. A26	
Labyrinth Canyon Member (of Thirsty Canyon Tuff).	Pliocene	Nevada	Thirsty Canyon Tuff of Nye and Esmeralda Counties, Nevada, by D. C. Noble, R. E. Anderson, E. B. Ekren, and J. T. O'Connor.	Prof. Paper 475–D	1964
Lawton Clay Member (of Vashon Drift).	Pleistocene	Washington	Stratigraphy and chronology of late interglacial and early Vashon glacial time in Seattle area, Washington, by D. R. Mullineaux, H. H. Waldron, and Meyer Rubin.	Bull. 1194–O	1965
Little Cottonwood Formation (of Lake Bonneville Group).	do	Utah	Lake Bonneville: Quaternary stratigraphy of eastern Jordan Valley south of Salt Lake City, Utah, by R. B. Morrison.	Prof. Paper 477	1965
Logan Gulch Member (of the Three Forks Formation).	Late Devonian	Montana and Wyoming.	Nomenclature and correlation of lithologic subdivisions of the Jefferson and Three Forks Formations of southern Montana and northern Wyoming, by C. A. Sandberg.	Bull. 1194–N	1965
Love Ridge Quartz Monzonite	Devonian	Maine	Bedrock geologic map of the Big Lake quadrangle, Maine, by D. M. Larrabee.	Map GQ–358	1964
Maltby Lakes Volcanics	Ordovician(?)	Connecticut	Nomenclature and age of formations in the Ansonia quadrangle, Fairfield and New Haven Counties, Connecticut, by C. E. Fritts.	This report, p. A31	
Maple Mountain Formation (of Hovey Group).	Silurian	Maine	Hovey Group, a redefined stratigraphic name for the Hovey Formation of northeast Maine, by Louis Pavlides.	Bull. 1194–B	1964
Marinette Quartz Diorite	Precambrian	Wisconsin	Marinette Quartz Diorite and Hoskin Lake Granite of northeastern Wisconsin, by W. C. Prinz.	This report, p. A53	
Mashel Formation	Miocene	Washington	The Mashel Formation of southwestern Pierce County, Washington, by K. L. Walters.	This report, p. A55	

NEW NAMES ADOPTED FOR OFFICIAL USE IN U.S. GEOLOGICAL SURVEY REPORTS—Continued

Name	Age	Location	Report in which new name is adopted: Title and authorship	Report in which new name is adopted: Publication (U.S. Geol. Survey except as indicated)	Year of publication
Matagamon Sandstone	Early Devonian	Maine	The Matagamon Sandstone: a new Devonian formation in north-central Maine, by D. W. Rankin.	Bull. 1194–F	1965
Nine Lake Formation (of Hovey Group).	Ordovician or Silurian.	do	Hovey Group, a redefined stratigraphic name for the Hovey Formation of northeast Maine, by Louis Pavlides.	Bull. 1194–B	1964
Oronoque Member (of Derby Hill Schist).	Ordovician(?)	Connecticut	Nomenclature and age of formations in the Ansonia quadrangle, Fairfield and New Haven Counties, Connecticut, by C. E. Fritts.	This report, p. A30	
Pah Canyon Member (of Paintbrush Tuff) (of Piapi Canyon Group).	Miocene(?) and Pliocene.	Nevada	Paintbrush Tuff and Timber Mountain Tuff of Nye County, Nevada, by P. P. Orkild.	This report, p. A49	
Paintbrush Tuff (of Piapi Canyon Group).	do	do	do	This report, p. A45	
Pocamoonshine Gabbro-Diorite	Devonian	Maine	Bedrock geologic map of the Big Lake quadrangle, Maine, by D. M. Larrabee.	Map GQ–358	1964
Pony Trail Group	Mesozoic	Nevada	Geology of the Frenchie Creek quadrangle, north-central Nevada, by L. J. P. Muffler.	Bull. 1179	1964 [1965]
Poplar Tank Member (of Skinner Ranch Formation).	Early Permian (Leonard).	Texas	New Permian stratigraphic units in the Glass Mountains, west Texas, by G. A. Cooper and R. E. Grant.	Am. Assoc. Petroleum Geologists Bull., v. 48, no. 9.	1964
Pungo River Formation	middle Miocene	North Carolina	The Pungo River Formation, a new name for middle Miocene phosphorites in Beaufort County, North Carolina, by J. O. Kimrey.	Southeastern Geology, v. 5, no. 4.	1964
Road Canyon Member (of Word Formation).	Early and Late Permian (Guadalupe).	Texas	New Permian stratigraphic units in the Glass Mountains, west Texas, by G. A. Cooper and R. E. Grant.	Am. Assoc. Petroleum Geologists Bull., v. 48, no. 9.	1964
Salyer Formation	late Miocene	Nevada	Salyer and Wahmonie Formations of southeastern Nye County, Nevada, by F. G. Poole, W. J. Carr, and D. P. Elston.	This report, p. A40	
Skinner Ranch Formation	Early Permian (Leonard).	Texas	New Permian stratigraphic units in the Glass Mountains, west Texas, by G. A. Cooper and R. E. Grant.	Am. Assoc. Petroleum Geologists Bull., v. 48, no. 9.	1964
Sod House Tuff (of Pony Trail Group).	Mesozoic	Nevada	Geology of the Frenchie Creek quadrangle, north-central Nevada, by L. J. P. Muffler.	Bull. 1179	1964 [1965]
South Pass Formation	late Miocene to middle Pliocene.	Wyoming	South Pass Formation on the southwest flank of Wind River Mountains, Wyoming, by N. M. Denson, H. D. Zeller, and E. V. Stephens.	This report p. A27	

Stephens Passage Group	Late Jurassic and Early Cretaceous.	Alaska	Reconnaissance geology of Admiralty Island, Alaska, by E. H. Lathram, J. S. Pomeroy, H. C. Berg, and R. A. Loney.	Bull. 1181-R	1965
Sullivan Peak Member (of Skinner Ranch Formation).	Early Permian (Leonard).	Texas	New Permian stratigraphic units in the Glass Mountains, west Texas, by G. A. Cooper and R. E. Grant.	Am. Assoc. Petroleum Geologists Bull., v. 48, no. 9.	1964
Thirsty Canyon Tuff	Pliocene	Nevada	Thirsty Canyon Tuff of Nye and Esmeralda Counties, Nevada, by D. C. Noble, R. E. Anderson, E. B. Ekren, and J. T. O'Connor.	Prof. Paper 475-D	1964
Timber Mountain Tuff (of Piapi Canyon Group).	do	do	Paintbrush Tuff and Timber Mountain Tuff of Nye County, Nevada, by P. P. Orkild.	This report, p. A49	
Trail Ridge Member (of Thirsty Canyon Tuff).	do	do	Thirsty Canyon Tuff of Nye and Esmeralda Counties, Nevada, by D. C. Noble, R. E. Anderson, E. B. Ekren, and J. T. O'Connor.	Prof. Paper 475-D	1964
Trident Member (of Three Forks Formation).	Late Devonian	Montana and Wyoming.	Nomenclature and correlation of lithologic subdivisions of the Jefferson and Three Forks Formations of southern Montana and northern Wyoming, by C. A. Sandberg.	Bull. 1194-N	1965
Wabassus Quartz Monzonite	Devonian	Maine	Bedrock geologic map of the Big Lake quadrangle, Maine, by D. M. Larrabee.	Map GQ-358	1964
Wagon Bed Formation	Eocene	Wyoming	Tertiary geology of the Beaver Divide area, Fremont and Natrona Counties, Wyoming, by F. B. Van Houten.	Bull. 1164	1964
Wahmonie Formation	late Miocene and early Pliocene.	Nevada	Salyer and Wahmonie Formations of southeastern Nye County, Nevada, by F. G. Poole, W. J. Carr, and D. P. Elston.	This report, p. A40	
Washakie Point Glaciation or Till	Pleistocene	Wyoming	Three pre-Bull Lake tills in the Wind River Mountains, Wyoming, reinterpreted, by G. M. Richmond.	Prof. Paper 501-D	1964
Wildcat Valley Sandstone	Early and Middle(?) Devonian.	Virginia	Wildcat Valley Sandstone (Devonian) of southwest Virginia, by R. L. Miller, L. D. Harris, and J. B. Roen.	Prof. Paper 501-B	1964
Witts Springs Formation	Early Pennsylvanian (Morrow).	Arkansas	The Witts Springs Formation of Morrow age in the Snowball quadrangle, north-central Arkansas, by E. E. Glick, S. E. Frezon, and Mackenzie Gordon, Jr.	Bull. 1194-D	1964 [1965]

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Argentine Limestone Member (of Wyandotte Limestone) (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Nebraska, Iowa, and Kansas.	Newell, 1935	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Beirdneau Sandstone Member (of Jefferson Formation).	Late Devonian	Utah	Williams, 1948	Geology of the Paradise quadrangle, Cache County, Utah, by T. E. Mullens and G. A. Izett.	Bull. 1181-S	1964
Bisher Limestone	Middle Silurian	Kentucky	Foerste, 1917	Geology of the Charters quadrangle, Kentucky, by R. H. Morris.	Map GQ-293	1965
Block Limestone Member (of Cherryvale Formation) (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Nebraska, Iowa, and Kansas.	Newell, 1935	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Boyle Limestone	Middle Devonian	Kentucky	Foerste, 1906	Geology of the Dunville quadrangle, Kentucky, by C. H. Maxwell.	Map GQ-367	1965
Canville Limestone Member (of Dennis Limestone) (of Kansas City Group) of (Missouri Series).	Late Pennsylvanian	Nebraska, Iowa, and Kansas.	Jewett, 1932	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Cherry Valley Limestone Member (of Marcellus Shale).	Middle Devonian	New York	Clarke, 1903	A new species of the rugose coral genus *Nalivkinella* from the Middle Devonian of eastern Pennsylvania, by W. A. Oliver, Jr.	Jour. Palenotology, v. 38, no. 5.	1964
Crab Orchard Formation	Early and Middle Silurian.	Kentucky	Linney, 1882	Geology of the Charters quadrangle, Kentucky, by R. H. Morris.	Map GQ-293	1965
Devils Hollow Member (of Cynthiana Formation).	Middle Ordovician	do	McFarlan and White, 1948.	Geology of the Tyrone quadrangle, Kentucky, by E. R. Cressman.	Map GQ-303	1964
Dockendorff Group	Early Devonian	Maine	Boucot, Field, Fletcher, Forbes, Naylor, and Pavlides, 1964.	Outline of the stratigraphic and tectonic features of northeast Maine, by Louis Pavlides, Ely Mencher, R. S. Naylor, and A. J. Boucot.	Prof. Paper 501-C	1964
Edmunds Hill Andesite (of Dockendorff Group).	do	do	Gregory, 1899	do	do	1964
Fontana Shale Member (of Cherryvale Formation) (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Nebraska, Iowa, and Kansas.	Newell, 1935	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]

Frisbie Limestone Member (of Wyandotte Limestone) (of Kansas City Group) (of Missouri Series).	do	do	do	do	do	1964 [1965]
Furnace Limestone	Paleozoic	California	Vaughan, 1922	Geologic map of the Lucerne Valley quadrangle, San Bernardino County, California, by T. W. Dibblee, Jr.	Map I-426	1964
Gartra Grit Member (of Ankareh Formation).	Late Triassic	Utah	Thomas and Krueger, 1946.	Geology of the Mount Aire quadrangle, Utah, by M. D. Crittenden, Jr.	Map GQ-379	1965
Hay Ranch Formation	middle Pliocene to middle Pleistocene.	Nevada	Regnier, 1960	Geology of the Frenchie Creek quadrangle, north-central Nevada, by L. J. P. Muffler.	Bull. 1179	1964 [1965]
Hedgehog Formation (of Dockendorff Group).	Early Devonian	Maine	Gregory, 1900	Outline of the stratigraphic and tectonic features of northeast Maine, by Louis Pavlides, Ely Mencher, R. S. Naylor, and A. J. Boucot.	Prof. Paper 501-C	1964
Hyrum Dolomite Member (of Jefferson Formation).	Late Devonian	Utah	Williams, 1948	Geology of the Paradise quadrangle, Cache County, Utah, by T. E. Mullens and G. A. Izett.	Bull. 1181-S	1964
Island Creek Shale Member (of Wyandotte Limestone) (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Nebraska, Iowa, and Kansas.	Newell, 1935	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Kneeling Nun Rhyolite Tuff	Miocene(?)	New Mexico	Kuellmer and others, 1953.	Geologic map of the Santa Rita quadrangle, New Mexico, by R. M. Hernon, W. R. Jones, and S. L. Moore.	Map GQ-306	1964
Leatham Formation	Early Mississippian	Utah	Holland, 1952	Geology of the Paradise quadrangle, Cache County, Utah, by T. E. Mullens and G. A. Izett.	Bull. 1181-S	1964
Loyd Sandstone Member (of Mancos Shale).	Late Cretaceous	Colorado	Konishi, 1959	Meeker and Loyd Sandstone Members of the Mancos Shale, Moffat and Rio Blanco Counties, Colorado, by J. R. Dyni and H. L. Cullins.	Bull. 1194-J	1965
Meeker Sandstone Member (of Mancos Shale).	do	do	do	do	do	1965
Old Woman Sandstone	Tertiary	California	Shreve *in* Richmond, 1960.	Geologic map of the Lucerne Valley quadrangle, San Bernardino County, California, by T. W. Dibblee, Jr.	Map I-426	1964
Pancho Rico Formation	early Pliocene	do	Reed, 1925	pper Miocene and Pliocene marine stratigraphy in southern Salinas Valley, California, by D. L. Durham and W. O. Addicott.	Bull. 1194-E	1964

PREVIOUSLY USED NAMES ADOPTED FOR OFFICIAL USE IN U.S. GEOLOGICAL SURVEY REPORTS—Continued

Name	Age	Location	Original authorship	Report in which name is adopted: Title and authorship	Report in which name is adopted: Publication (U.S. Geol. Survey except as indicated)	Year of publication
Perham Formation	Late Silurian	Maine	Boucot, Field, Fletcher, Forbes, Naylor, and Pavlides, 1964.	Outline of the stratigraphic and tectonic features of northeast Maine, by Louis Pavlides, Ely Mencher, R. S. Naylor, and A. J. Boucot.	Prof. Paper 501-C	1964
Quindaro Shale Member (of Wyandotte Limestone) (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Nebraska, Iowa, and Kansas.	Newell, 1935	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Quivira Shale Member (of Cherryvale Formation) (of Kansas City Group) (of Missouri Series).	do	do	do	do	do	1964 [1965]
Reeves Limestone Member (of Maitlen Phyllite).	Cambrian	Washington	Fyles and Hewlett, 1959.	Geologic map and sections, Deep Creek area, Stevens and Pend Oreille Counties, Washington, by R. G. Yates.	Map I-412	1964 [1965]
Rossland Group	Jurassic	do	Frebold and Little, 1962.	do	do	1964
Rubio Peak Formation	Miocene (?)	New Mexico	Hernon, Jones, and Moore, 1953.	Geologic map of the Santa Rita quadrangle, New Mexico, by R. M. Hernon, W. R. Jones, and S. L. Moore.	Map GQ-306	1964
Saragossa Quartzite	Paleozoic	California	Vaughan, 1922	Geologic map of the Lucerne Valley quadrangle, San Bernardino County, California, by T. W. Dibblee, Jr.	Map I-426	1964
Sheppard Granite	Tertiary	Washington	Daly, 1912	Geologic map and sections, Deep Creek area, Stevens and Pend Oreille Counties, Washington, by R. G. Yates.	Map I-412	1964
Stark Shale Member (of Dennis Limestone) (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Nebraska, Iowa, and Kansas.	Jewett, 1932	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Sugarlump Tuffs	Miocene(?)	New Mexico	Kuellmer and others, 1953.	Geologic map of the Santa Rita quadrangle, New Mexico, by R. M. Hernon, W. R. Jones, and S. L. Moore.	Map GQ-306	1964
Swanback Formation (of Dockendorff Group).	Early Devonian	Maine	Fletcher, 1960	Outline of stratigraphic and tectonic features of northeast Maine, by Louis Pavlides, Ely Mencher, R. S. Naylor, and A. J. Boucot.	Prof. Paper 501-C	1964

Wea Shale Member (of Cherryvale Formation) (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Nebraska, Iowa, and Kansas.	Newell, 1935	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Westerville Limestone Member (of Cherryvale Formation) (of Kansas City Group) (of Missouri Series).	do	do	Bain, 1898	do	do	1964 [1965]
Willimantic Gneiss	pre-Pennsylvanian	Connecticut	Gregory, 1906	Bedrock geology of the Willimantic quadrangle, Connecticut, by G. L. Snyder.	Map GQ-335	1964

STRATIGRAPHIC NAMES REVISED

Name	Age	Location	Revision	Report in which usage is revised: Title and authorship	Report in which usage is revised: Publication (U.S. Geol. Survey except as indicated)	Year of publication
Alpine Member (of Little Cottonwood Formation) (of Lake Bonneville Group).	Pleistocene	Utah	Formerly Alpine Formation of Lake Bonneville Group in Jordan Valley. Alpine Formation in good usage elsewhere in Utah.	Lake Bonneville: Quaternary stratigraphy of eastern Jordan Valley south of Salt Lake City, Utah, by R. B. Morrison.	Prof. Paper 477	1965
Benton Shale	Early and Late Cretaceous.	Colorado	Mowry Shale Member included in Benton Shale in in report area.	Geology of northwestern North Park, Colorado, by W. J. Hail, Jr.	Bull. 1188	1965
Birdbear Member (of Jefferson Formation).	Late Devonian	Montana	Birdbear made member of Jefferson Formation in report area. Birdbear Formation in good usage elsewhere.	Bedrock geology of the Sawtooth Ridge quadrangle, Montana, by M. R. Mudge.	Map GQ-381	1965
Bonneville Member (of Little Cottonwood Formation) (of Lake Bonneville Group).	Pleistocene	Utah	Formerly Bonneville Formation of Lake Bonneville Group in Jordan Valley. Bonneville Formation in good usage elsewhere in Utah.	Lake Bonneville: Quaternary stratigraphy of eastern Jordan Valley south of Salt Lake City, Utah, by R. B. Morrison.	Prof. Paper 477	1965
Boulder River Sandstone Member (of Frontier Formation).	Late Cretaceous	Montana	Reassignment from member of Colorado Shale to member of Frontier Formation.	Correlation of Cretaceous and lower Tertiary rocks near Livingston, Montana, by A. E. Roberts.	Prof. Paper 525-B	1965
Brothers Volcanics (of Stephens Passage Group).	Late Jurassic and Early Cretaceous.	Alaska	Brothers Volcanics assigned to Stephens Passage Group.	Reconnaissance geology of Admiralty Island, Alaska, by E. H. Lathram, J. S. Pomeroy, H. C. Berg, and R. A. Loney.	Bull. 1181-R	1965
Buffalo Wallow Formation	Late Mississippian	Kentucky	Vienna Limestone made a member of the Buffalo Wallow Formation in Kentucky.	Geology of the Rome quadrangle, Kentucky, by M. D. Crittenden, Jr., and R. K. Hose.	Map GQ-362	1962
Cane Hill Formation	Mississippian and Early Pennsylvanian.	Arkansas	Formerly Cane Hill Member of the Hale Formation in report area. Age changed from Pennsylvanian to Mississippian and Early Pennsylvanian.	The Witts Springs Formation of Morrow age in the Snowball quadrangle, north-central Arkansas, by E. E. Glick, S. E. Frezon, and Mackenzie Gordon, Jr.	Bull. 1194-D	1964

Chapman Sandstone (of Dockendorff Group).	Early Devonian	Maine	Chapman Sandstone included in Dockendorff Group.	Outline of the stratigraphic and tectonic features of northeast Maine, by Louis Pavlides, Ely Mencher, R. S. Naylor and A. J. Boucot.	Prof. Paper 501-C	1964
Clayton Limestone (of Midway Group).	Paleocene	Mississippi	Formerly Clayton Formation, which remains in good usage outside of report area.	Surface and subsurface stratigraphic sequence in southeastern Mississippi, by D. H. Eargle.	Prof. Paper 475-D	1964
Cook Mountain Limestone (of Claiborne Group).	middle Eocene	do	Formerly Cook Mountain Formation, which remains in good usage outside of report area.	do	do	1964
Cortlandt Complex	unknown	New York	Formerly Cortlandt Series	Reaction between mafic magma and pelitic schist, Cortlandt, New York, by Fred Barker.	Am. Jour. Science, v. 262, no. 5.	1964
Curdsville Limestone Member (of Lexington Limestone).	Middle Ordovician	Kentucky	Formerly Curdsville Limestone of Lexington Group.	Geology of the Tyrone quadrangle, Kentucky, by E. R. Cressman.	Map GQ-303	1964
Dawson Formation	Late Cretaceous and Paleocene.	Colorado	Dawson Formation in report area. Dawson Arkose in good usage elsewhere.	Records of wells and test holes, water analyses, and physical properties of water-bearing materials for the Denver basin, Colorado, by J. A. McConaghy, G. H. Chase, A. J. Boettcher, and T. J. Major.	Basic Data Report 15	1964
Dennis Limestone (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Nebraska and Iowa.	Winterset Limestone Member placed in Dennis Limestone.	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Derby Hill Schist	Ordovician(?)	Connecticut	Oronoque Member made a member of the Derby Hill Schist.	Nomenclature and age of formations in the Ansonia quadrangle, Fairfield and New Haven Counties, Connecticut, by C. E. Fritts.	This report, p. A30	
Duluth Gabbro Complex	Late Precambrian	Minnesota	Formerly Duluth Gabbro	Ground and surface water in the Mesabi and Vermilion Iron Range area, northeastern Minnesota, by R. D. Cotter, H. L. Young, L. R. Petri, and C. H. Prior.	Water Supply Paper 1750-A.	1965
Dunn Brook Formation (of Hovey Group).	Ordovician or Silurian.	Maine	Formerly Dunn Brook Member (Early Silurian age) of Hovey Formation.	Hovey Group, a redefined stratigraphic name for the Hovey Formation of northeast Maine, by Louis Pavlides.	Bull. 1194-B	1964
Flood Shale Member (of Blackleaf Formation) (of Colorado Group).	Early Cretaceous	Montana	Formerly Flood Member of Blackleaf Formation.	Bedrock geology of the Sawtooth Ridge quadrangle, Montana, by M. R. Mudge.	Map GQ-381	1965

STRATIGRAPHIC NAMES REVISED—Continued

Name	Age	Location	Revision	Report in which usage is revised: Title and authorship	Report in which usage is revised: Publication (U.S. Geol. Survey except as indicated)	Year of publication
Grouse Canyon Member (of Belted Range Tuff).	Miocene or Pliocene	Nevada	Member of Belted Range Tuff except in eastern part of Nevada Test Site where it remains a member of the Indian Trail Formation of Oak Spring Group. Redefined to include only the upper part of the original unit throughout its extent.	Belted Range Tuff of Nye and Lincoln Counties, Nevada, by K. A. Sargent, D. C. Noble, and E. B. Ekren.	This report, p.A36	
Hess Formation	Early Permian (Leonard).	Texas	Formerly Hess Limestone Member of Leonard Formation.	New Permian stratigraphic units in the Glass Mountains, west Texas, by G. A. Cooper and R. E. Grant.	Am. Assoc. Petroleum Geologists Bull., v. 48, no. 9.	1964
Hovey Group	Ordovician or Silurian.	Maine	Formerly Hovey Formation of Early Silurian (?) and Early Silurian age.	Hovey Group, a redefined stratigraphic name for the Hovey Formation of northeast Maine, by Louis Pavlides.	Bull. 1194-B	1964
Jefferson Formation	Late Devonian	Utah	Jefferson Formation divided into the Hyrum Dolomite Member (at bottom) and the Beirdneau Sandstone Member (at top) in report area.	Geology of the Paradise quadrangle, Cache County, Utah, by T. E. Mullens and G. A. Izett.	Bull. 181-S	1964
Do	do	Montana	Formation includes Birdbear Member in report area.	Bedrock geology of the Sawtooth Ridge quadrangle, Montana, by M. R. Mudge.	Map GQ-381	1965
Lake Bonneville Group	Pleistocene	Utah	Lake Bonneville Group redefined to include Draper Formation (top) and Little Cottonwood Formation (bottom).	Lake Bonneville: Quaternary stratigraphy of eastern Jordan Valley south of Salt Lake City, Utah, by R. B. Morrison.	Prof. Paper 477	1965
Lexington Limestone	Middle Ordovician	Kentucky	Formerly Lexington Group	Geology of the Tyrone quadrangle, Kentucky, by E. R. Cressman.	Map GQ-303	1964
Logana Member (of Lexington Limestone).	do	do	Formerly Logana Formation of Lexington Group.	do	do	1964
Maitlen Phyllite	Early or Middle Cambrian.	Washington	Reeves Limestone Member made a member of Maitlen Phyllite.	Geologic map and sections, Deep Creek area, Stevens and Pend Oreille Counties,	Map I-412	1964

				Washington, by R. G. Yates.		
Mancos Shale	Late Cretaceous	Colorado	Meeker Sandstone Member and Loyd Sandstone Member made members of Mancos Shale in report area.	Meeker and Loyd Sandstone Members of the Mancos Shale, Moffat and Rio Blanco Counties, Colorado, by J. R. Dyni and M. L. Cullins.	Bull. 1194-J	1965
Mowry Shale Member (of Benton Shale).	Early Createaceous	do	Mowry Shale made a member of Benton Shale in report area.	Geology of northwestern North Park, Colorado, by W. J. Hail, Jr.	Bull. 1188	1965
Newman Limestone	Late Mississippian	Kentucky	Ste. Genevieve and St. Louis Limestones made members of Newman Limestone in report area.	Geology of the Shopville quadrangle, Kentucky, by N. L. Hatch, Jr.	Map GQ-282	1964
Piapi Canyon Group	Miocene(?) and Pliocene.	Nevada	Formerly Piapi Canyon Formation of Oak Spring Group. Age was early Pliocene or younger.	Paintbrush Tuff and Timber Mountain Tuff of Nye County, Nevada, by P. P. Orkild.	This report, p. A44	
Provo Member (of Little Cottonwood Formation) (of Lake Bonneville Group).	Pleistocene	Utah	Formerly Provo Formation of Lake Bonneville Group in Jordan Valley. Provo Formation in good usage elsewhere in Utah.	Lake Bonneville: Quaternary stratigraphy of eastern Jordan Valley south of Salt Lake City, Utah, by R. B. Morrison.	Prof. Paper 477	1965
Pryor Conglomerate Member (of Kootenai Formation).	Early Cretaceous	Montana	Reassignment—is a member of the Kootenai Formation as well as of the Cloverly Formation.	Correlation of Cretaceous and lower Tertiary rocks near Livingston, Montana, by A. E. Roberts.	Prof. Paper 525-B	1965
Quadrant Sandstone	Pennsylvanian	Montana and Wyoming.	Quadrant Sandstone used in report area. Quadrant Formation or Quartzite in good usage elsewhere.	Preliminary geologic map of the Tepee Creek quadrangle, Montana-Wyoming, by I. J. Witkind.	Map I-417	1964
Rainier Mesa Member (of Timber Mountain Tuff) (of Piapi Canyon Group).	Pliocene	Nevada	Formerly Rainier Mesa Member of Piapi Canyon Formation of Oak Spring Group. Age was Pliocene or younger.	Paintbrush Tuff and Timber Mountain Tuff of Nye County, Nevada, by P. P. Orkild.	This report, p. A50	
Ste. Genevieve Limestone Member (of Newman Limestone).	Late Mississippian	Kentucky	Made member of Newman Limestone in report area. Ste. Genevieve Limestone in good usage elsewhere.	Geology of the Shopville quadrangle, Kentucky, by N. L. Hatch, Jr.	Map GQ-282	1964
St. Louis Limestone Member (of Newman Limestone).	do	do	Made member of Newman Limestone in report area. St. Louis Limestone in good usage elsewhere.	do	do	1964
Sappington Member (of Three Forks Formation).	Late Devonian and Early Mississippian.	Montana and Wyoming.	Formerly Sappington Sandstone Member of Three Forks Formation.	Nomenclature and correlation of lithologic subdivisions of the Jefferson and Three Forks Formations of southern Montana and northern Wyoming, by C. A. Sandberg.	Bull. 1194-N	1965

STRATIGRAPHIC NAMES REVISED—Continued

Name	Age	Location	Revision	Report in which usage is revised		Year of publication
				Title and authorship	Publication (U.S. Geol. Survey except as indicated)	
Seymour Canal Formation (of Stephens Passage Group).	Late Jurassic and Early Cretaceous.	Alaska	Seymour Canal Formation assigned to Stephens Passage Group.	Reconnaissance geology of Admiralty Island, Alaska, by E. H. Lathram, J. S. Pomeroy, H. C. Berg, and R. A. Loney.	Bull. 1181–R	1965
Spearhead Member (of Thirsty Canyon Tuff).	Pliocene	Nevada	Formerly Spearhead Rhyolite of Pliocene(?) age.	Thirsty Canyon Tuff of Nye and Esmeralda Counties, Nevada, by D. C. Noble, R. E. Anderson, E. B. Ekren, and J. T. O'Connor.	Prof. Paper 475–D	1964
Stockade Wash Member (of Paintbrush Tuff) (of Piapi Canyon Group).	Miocene(?) and Pliocene.	do	Formerly Stockade Wash Member of Piapi Canyon Formation of Oak Spring Group. Former age was Pliocene or younger.	Paintbrush Tuff and Timber Mountain Tuff of Nye County, Nevada, by P. P. Orkild.	This report, p. A45	
Taft Hill Member (of Blackleaf Formation) (of Colorado Group).	Early Cretaceous	Montana	Formerly Taft Hill Glauconitic Member of Blackleaf Formation.	Bedrock geology of the Sawtooth Ridge quadrangle, Montana, by M. R. Mudge.	Map GQ–381	1965
Tallahatta Siltstone (of Claiborne Group).	middle Eocene	Mississippi	Formerly Tallahatta Formation. Tallahatta Formation in good usage except in area of report.	Surface and subsurface stratigraphic sequence in southeastern Mississippi, by D. H. Eargle.	Prof. Paper 475–D	1964
Three Forks Formation	Late Devonian and Early Mississippian.	Montana and Wyoming.	Three Forks Formation divided into (ascending order): Logan Gulch, Trident, and Sappington Members in report area.	Nomenclature and correlation of lithologic subdivisions of the Jefferson and Three Forks Formations of southern Montana and northern Wyoming, by C. A. Sandberg.	Bull. 1194–N	1965
Tiva Canyon Member (of Paintbrush Tuff) (of Piapi Canyon Group).	Miocene(?) and Pliocene.	Nevada	Formerly Tiva Canyon Member of Piapi Canyon Formation of Oak Spring Group. Age formerly early Pliocene or younger.	Paintbrush Tuff and Timber Mountain Tuff of Nye County, Nevada, by P. P. Orkild.	This report, p. A45	
Topopah Spring Member (of Paintbrush Tuff) (of Piapi Canyon Group).	do	do	Formerly Topopah Spring Member of Piapi Canyon Formation of Oak Spring Group. Age was Pliocene or younger.	do	This report, p. A49	

Tub Spring Member (of Belted Range Tuff).	Miocene or Pliocene	do	Member of Belted Range Tuff except in eastern part of Nevada Test Site where it remains a member of the Indian Trail Formation of Oak Spring Group.	Belted Range Tuff of Nye and Lincoln Counties, Nevada, by K. A. Sargent, D.C. Noble, and E. B. Ekren.	This report, p. A34	
Vashon Drift	Pleistocene	Washington	Vashon Drift divided into Lawton Clay Member (at base) and Esperance Sand Member (at top).	Stratigraphy and chronology of late interglacial and early Vashon glacial time in Seattle area, Washington, by D. R. Mullineaux, H. H. Waldron, and Meyer Rubin.	Bull. 1194–0	1965
Vaughn Member (of Blackleaf Formation) (of Colorado Group).	Early Cretaceous	Montana	Formerly Vaughn Bentonitic Member of Blackleaf Formation.	Bedrock geology of the Sawtooth Ridge quadrangle, Montana, by M. R. Mudge.	Map GQ–381	1965
Vienna Limestone Member (of Buffalo Wallow Formation).	Late Mississippian	Kentucky	Formerly Vienna Limestone	Geology of the Rome quadrangle, Kentucky, by M. D. Crittenden, Jr., and R. K. Hose.	Map GQ–362	1965
Winona Marl (of Claiborne Group).	middle Eocene	Mississippi	Formerly Winona Sand or Formation and remains as such outside of report area.	Surface and subsurface stratigraphic sequence in southeastern Mississippi, by D. H. Eargle.	Prof. Paper 475–D	1964
Winterset Limestone Member (of Dennis Limestone) (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Nebraska and Iowa.	Formerly Winterset Limestone of Pennsylvanian age.	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Word Formation	Early and Late Permian (Guadalupe).	Texas	Road Canyon Member replaces the "First Limestone" member of P. B. King (1931).	New Permian stratigraphic units in the Glass Mountains, west Texas, by G. A. Cooper and R. E. Grant.	Am. Assoc. Petroleum Geologists Bull., v. 48, no. 9.	1964
Yucca Mountain Member (of Paintbrush Tuff) (of Piapi Canyon Group).	Miocene (?) and Pliocene.	Nevada	Formerly Yucca Mountain Member of Piapi Canyon Formation of Oak Spring Group. Age was early Pliocene or younger.	Paintbrush Tuff and Timber Mountain Tuff of Nye County, Nevada, by P. P. Orkild.	This report, p. A49	

CHANGES IN AGE DESIGNATION

Name	Age		Location	Report in which age designation is changed		Year of publication
	New	Former		Title and authorship	Publication (U.S. Geol. Survey except as indicated)	
Andrews Mountain Member (of Campito Formation).	Precambrian and Early Cambrian.	Precambrian(?) and Early Cambrian.	California	Precambrian and Lower Cambrian formations in the Last Chance Range area, Inyo County, California, by J. H. Stewart.	This report, p. A63	
Ansonia Gneiss	Devonian	Ordovician or Devonian.	Connecticut	Nomenclature and age of formations in the Ansonia quadrangle, Fairfield and New Haven Counties, Connecticut, by C. E. Fritts.	This report, p. A32	
Battleground Schist	Ordovician to Mississippian.	Precambrian(?) or Paleozoic(?).	North Carolina and South Carolina.	Provisional geologic map of the crystalline rocks of South Carolina, by W. C. Overstreet and Henry Bell, 3d.	Bull. 1183	1965
Bedford Shale or Formation.	Devonian or Mississippian.	Mississippian	Kentucky, Ohio Michigan, Pennsylvania, and West Virginia.	Geology of the Charters quadrangle, Kentucky, by R. H. Morris.	Map GQ-293	1965
Berea Sandstone or Formation.	do	do	do	do	do	1965
Bessemer Granite	Ordovician to Mississippian.	Precambrian	North Carolina and South Carolina.	Provisional geologic map of the crystalline rocks of South Carolina, by W. C. Overstreet and Henry Bell, 3d.	Bull. 1183	1965
Bethany Falls Limestone Member (of Swope Limestone) (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Blacksburg Schist	Ordovician to Mississippian.	Cambrian(?)	North Carolina and South Carolina.	Provisional geologic map of the crystalline rocks of South Carolina, by W. C. Overstreet and Henry Bell, 3d.	Bull. 1183	1965
Bokan Mountain Granite	Late Triassic or Early Jurassic.	Cretaceous(?) and Tertiary(?).	Alaska	Potassium-argon and lead-alpha ages of some plutonic rocks, Bokan Mountain area, southeastern Alaska, by M. A. Lanphere, E. M. MacKevett, Jr., and T. W. Stern.	Science, v. 145, no. 3633.	1964
Bonner Springs Shale (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]

Campito Formation	Precambrian and Early Cambrian.	Precambrian(?) and Early Cambrian.	California	Precambrian and Lower Cambrian formations in the Last Chance Range area, Inyo County, California, by J. H. Stewart.	This report p. A63	
Cannery Formation	Early Permian	Permian	Alaska	Reconnaissance geology of Admiralty Island, Alaska, by E. H. Lathram, J. S. Pomeroy, H. C. Berg, and R. A. Loney.	Bull. 1181–R	1965
Captain Creek Limestone Member (of Stanton Limestone) (of Lansing Group) (of Missouri Series).	Late Pennsylvanian	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by *R. D. Miller.*	Prof. Paper 472	1964 [1965]
Catoctin Formation	late Precambrian(?)	late Precambrian	Virginia	Chemistry of greenstones of the Catoctin Formation in the Blue Ridge of central Virginia, by J. C. Reed, Jr.	Prof. Paper 501–C	1964
Chanute Shale (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Chase Group	Early Permian	Permian	Kansas	Petrography of evaporites from the Wellington Formation near Hutchinson, Kansas, by C. L. Jones.	Bull. 1201–A	1965
Cherryvale Formation (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Cherryville Quartz Monzonite.	Mississippian(?) to Permian(?).	Devonian(?)	North Carolina and South Carolina.	Provisional geologic map of the crystalline rocks of South Carolina, by W. C. Overstreet and Henry Bell, 3d.	Bull. 1183	1965
Deep Spring Formation	Precambrian	Precambrian(?)	California	Precambrian and Lower Cambrian formations in the Last Chance Range area, Inyo County, California, by J. H. Stewart.	This report, p. A62	
Douglas Island Volcanics (of Stephens Passage Group).	Late Jurassic and Early Cretaceous.	Jurassic(?) to Early Cretaceous (?).	Alaska	Reconnaissance geology of Admiralty Island, Alaska, by E. H. Lathram, J. S. Pomeroy, H. C. Berg, and R. A. Loney.	Bull. 1181–R	1965
Draytonville Conglomerate Member (of Kings Mountain Quartzite).	Ordovician to Mississippian.	Cambrian	North Carolina and South Carolina.	Provisional geologic map of the crystalline rocks of South Carolina, by W. C. Overstreet and Henry Bell, 3d.	Bull. 1183	1965
Drum Limestone (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Eleana Formation	Devonian and Mississippian.	Mississippian to Early Pennsylvanian.	Nevada	Age of the Eleana Formation (Devonian and Mississipian) in the Nevada Test Site, by F. G. Poole, P. P. Orkild, Mackenzie Gordon, Jr., and Helen Duncan.	This report, p. A51	

CHANGES IN AGE DESIGNATION—Continued

Name	Age: New	Age: Former	Location	Report in which age designation is changed: Title and authorship	Report in which age designation is changed: Publication (U.S. Geol. Survey except as indicated)	Year of publication
Ely Springs Dolomite	Middle and Late Ordovician.	Late Ordovician	Nevada and California.	Middle and lower Ordovician formations in southernmost Nevada and adjacent California, by R. J. Ross.	Bull. 1180-C	1964
Esopus Shale, Grit, Siltstone.	Early Devonian	Early or Middle Devonian.	New York, Pennsylvania and New Jersey.	The Devonian colonial coral genus *Billingsastraea* and its earliest known species, by W. A. Oliver, Jr.	Prof. Paper 483-B	1964
Eudora Shale Member (of Stanton Limestone) (of Lansing Group) (of Missouri Series).	Late Pennsylvanian	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Farley Limestone Member (of Wyandotte Limestone) (of Kansas City Group) (of Missouri Series).	do	do	do	do	do	1964 [1965]
Gaffney Marble	Mississippian	Cambrian(?)	North Carolina and South Carolina.	Provisional geologic map of the crystalline rocks of South Carolina, by W. C. Overstreet and Henry Bell, 3d.	Bull. 1183	1965
Galesburg Shale (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Henderson Gneiss	Ordovician to Devonian.	Precambrian or early Paleozoic.	North Carolina and South Carolina.	Provisional geologic map of the crystalline rocks of South Carolina, by W. C. Overstreet and Henry Bell, 3d.	Bull. 1183	1965
Hermosa Formation	Middle and Late Pennsylvanian.	Middle Pennsylvanian.	Utah	Geology and uranium deposits of Elk Ridge and vicinity, San Juan County, Utah, by R. Q. Lewis, Sr., and R. H. Campbell.	Prof. Paper 474-B	1965
Hickory Creek Shale Member (of Plattsburg Limestone) (of Lansing Group) (of Missouri Series).	Late Pennsylvanian.	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Hines Tongue (of Reed Dolomite).	Precambrian	Precambrian (?)	California	Precambrian and Lower Cambrian formations in the Last Chance Range area, Inyo County, California, by J. H. Stewart.	This report, p. A62	

Hutchinson Salt Member (of Wellington Formation) (of Sumner Group).	Early Permian (Leonard).	Permian	Kansas	Petrography of evaporites from the Wellington Formation near Hutchinson, Kansas, by C. L. Jones.	Bull. 1201-A	1965
Imperial Formation	late *Miocene* or early Pliocene.	early Miocene	*California*	Evolution and distribution of the genus *Mya* and Tertiary migrations of Mollusca, by F. S. MacNeil.	Prof. Paper 483-G	1965
Indian Trail Formation.	Miocene and Pliocene (?).	late Miocene or early *Pliocene*.	Nevada	Paintbrush Tuff and Timber *Mountain* Tuff of Nye County, Nevada, by P. P. Orkild.	This report, p. A45	
Iola Limestone (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian.	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Kansas City Group (of Missouri Series).	do	do	do	do	do	1964 [1965]
Kings Mountain Quartzite.	Ordovician to Mississippian.	Cambrian	North Carolina and South Carolina.	Provisional geologic map of the crystalline rocks of South Carolina, by W. C. Overstreet and Henry Bell, 3d.	Bull. 1183	1965
Lane Shale (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian.	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Lansing Group (of Missouri Series).	do	do	do	do	do	1964 [1965]
Lousetown Formation	Pliocene (?) and Pleistocene.	late Pliocene or early Pleistocene.	Nevada	Rocks, structure, and geologic history of Steamboat Springs thermal area, Washoe County, Nevada, by D. E. White, G. A. Thompson, and C. H. Sandberg.	Prof. Paper 458-B	1964
Mapleton Sandstone	early Middle Devonian.	Late Devonian	Maine	Ouline of the stratigraphic and tectonic features of northeast Maine, by Louis Pavlides, Ely Mencher, R. S. Naylor, and A. J. Boucot.	Prof. Paper 501-C	1964
Merriam Limestone Member (of Plattsburg Limestone) (of Lansing Group) (of Missouri Series).	Late Pennsylvanian	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Meshik Formation	Oligocene or Miocene	Miocene	Alaska	Evolution and distribution of the genus *Mya* and Tertiary migrations of Mollusca, by F. S. MacNeil.	Prof. Paper 483-G	1965
Ninnescah Shale (of Sumner Group).	Early Permian (Leonard).	Permian	Kansas	Petrography of evaporites from the Wellington Formation near Hutchinson, Kansas, by C.L. Jones.	Bull. 1201-A	1965
Ogallala Formation	late *Miocene* and Pliocene.	Pliocene	Eastern Wyoming and Nebraska	South Pass Formation on the southwest flank of Wind River Mountains, Wyoming, by N. M. Denson, H. D. Zeller, and E. V. Stephens.	This report, p. A29	

CHANGES IN AGE DESIGNATION—Continued

Name	Age: New	Age: Former	Location	Report in which age designation is changed: Title and authorship	Report in which age designation is changed: Publication (U.S. Geol. Survey except as indicated)	Year of publication
Prospect Gneiss	Devonian	Ordovician or Devonian.	Connecticut	Nomenclature and age of formations in the Ansonia quadrangle, Fairfield and New Haven Counties, Connecticut, by C. E. Fritts.	This report, p. A32	
Redwall Limestone	Early and Late Mississippian.	Mississippian	Arizona	Stratigraphic importance of corals in the Redwall Limestone, northern Arizona, by W. J. Sando.	Prof. Paper 501-C	1964
Reed Dolomite	Precambrian	Precambrian (?)	California	Precambrian and Lower Cambrian formations in the Last Chance Range area, Inyo County, California, by J. H. Stewart.	This report, p. A62	
Retreat Group	Middle(?) Devonian	Silurian and Devonian.	Alaska	Reconnaissance geology of Admiralty Island, Alaska, by E. H. Lathram, J. S. Pomeroy, H. C. Berg, and R. A. Loney.	Bull. 1181-R	1965
Rico Formation	Pennsylvanian and Permian.	Pennsylvanian and Permian(?).	Utah, Arizona, and New Mexico.	Geology and uranium deposits of Elk Ridge and vicinity, San Juan County, Utah, by R. Q. Lewis, Sr. and R. H. Campbell.	Prof. Paper 474-B	1965
Rock Lake Shale Member (of Stanton Limestone) (of Lansing Group) (of Missouri Series).	Late Pennsylvanian	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Schoharie Grit	Early Devonian	Early or Middle Devonian.	New York	The Devonian colonial coral genus *Billingsastraea* and its earliest known species, by W. A. Oliver, Jr.	Prof. Paper 483-B	1964
South Bend Limestone Member (of Stanton Limestone) of Lansing Group) (of Missouri Series).	Late Pennsylvanian	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Spring Hill Limestone Member (of Plattsburg Limestone) (of Lansing Group) (of Missouri Series).	do	do	do	do	do	1964 [1965]
Stanton Limestone (of Lansing Group) (of Missouri Series).	do	do	do	do	do	1964 [1965]

Steamboat Hills Rhyolite	Pliocene(?) and Pleistocene.	Pliocene or Pleistocene.	Nevada	Rocks, structure, and geologic history of Steamboat Springs thermal area, Washoe County, Nevada, by D. E. White, G. A. Thompson, and C. H. Sandberg.	Prof. Paper 458-B	1964
Stoner Limestone Member (of Stanton Limestone) (of Lansing Group) (of Missouri Series).	Late Pennsylvanian	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Sumner Group	Early Permian (Leonard).	Permian	Kansas	Petrography of evaporites from the Wellington Formation near Hutchinson, Kansas, by C. L. Jones.	Bull. 1201-A	1965
Swope Limestone (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Tintic Quartzite	Early and Middle Cambrian.	Early Cambrian	Utah	Geology of the Mount Aire quadrangle, Utah, by M. D. Crittenden, Jr.	Map GQ-379	1965
Tulare Formation	Pliocene and Pleistocene.	Pliocene and Pleistocene(?).	California	Alluvial fans and near-surface subsidence in western Fresno County, California, by W. B. Bull.	Prof. Paper 437-A	1964
Vilas Shale (of Lansing Group) (of Missouri Series).	Late Pennsylvanian.	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Wellington Formation (of Sumner Group).	Early Permian (Leonard).	Permian	Kansas and Oklahoma.	Petrography of evaporites from the Wellington Formation near Hutchinson, Kansas, by C. L. Jones.	Bull. 1201-A	1965
White Mountain Plutonic Volcanic Series.	Early Jurassic or Late Triassic.	do	New Hampshire	Distribution of thorium and uranium in three early Paleozoic plutonic series of New Hampshire, by J. B. Lyons.	Bull. 1144-F	1964
Whiteside Granite	Ordovician to Devonian.	late Carboniferous(?)	North Carolina and South Carolina.	Provisional geologic map of the crystalline rocks of South Carolina, by W. C. Overstreet and Henry Bell, 3d.	Bull. 1183	1965
Wyandotte Limestone (of Kansas City Group) (of Missouri Series).	Late Pennsylvanian.	Pennsylvanian	Nebraska and Iowa	Geology of the Omaha-Council Bluffs area, Nebraska-Iowa, by R. D. Miller.	Prof. Paper 472	1964 [1965]
Yorkville Quartz Monzonite.	Permian	Early Mississippian (?).	North Carolina and South Carolina.	Provisional geologic map of the crystalline rocks of South Carolina, by W. C. Overstreet and Henry Bell, 3d.	Bull. 1183	1965

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STRATIGRAPHIC NAMES REINSTATED

Name	Age	Location	Report in which name is reinstated: Title and authorship	Report in which name is reinstated: Publication (U.S. Geol. Survey except as indicated)	Year of publication
Little Valley Limestone	Mississippian	Virginia	Suggestions for prospecting for evaporite deposits in southwest Virginia, by C. F. Withington.	Prof. Paper 525-B	1965

STRATIGRAPHIC NAMES ABANDONED

Name	Age	Location	Report in which name is abandoned: Title and authorship	Report in which name is abandoned: Publication (U.S. Geol. Survey except as indicated)	Year of publication
Benson Limestone (of Lexington Group).	Middle Ordovician	Kentucky	Geology of the Tyrone quadrangle, Kentucky, by E. R. Cressman.	Map GQ-303	1964
Dinwoody Lake Till and Glaciation.	Pleistocene	Wyoming	Three pre-Bull Lake tills in the Wind River Mountains, Wyoming, reinterpreted, by G. M. Richmond.	Prof. Paper 501-D	1964
Jessamine Limestone (of Lexington Group).	Middle Ordovician	Kentucky	Geology of the Tyrone quadrangle, Kentucky, by E. R. Cressman.	Map GQ-303	1964
Oak Spring Group	Eocene to Pliocene or younger.	Nevada	Paintbrush Tuff and Timber Mountain Tuff of Nye County, Nevada, by P. P. Orkild.	This report, p. A44	
Potlatch Member (of Three Forks Formation).	Late Devonian	Montana, Wyoming, North Dakota, and South Dakota.	Nomenclature and correlation of lithologic subdivisions of the Jefferson and Three Forks Formations of southern Montana and north-Wyoming, by C. A. Sandberg.	Bull. 1194-N	1965
Saddleback Mountain Member (of Hovey Formation).	Early Silurian (?)	Maine	Hovey Group, a redefined stratigraphic name for the Hovey Formation of northeast Maine, by Louis Pavlides.	Bull. 1194-B	1964
Split Rock Formation	early and middle Miocene.	Wyoming	Application and use of the name Arikaree Formation for lower and middle Miocene rocks in Granite Mountains area of central Wyoming, by N. M. Denson.	This report, p. A70	
Survey Butte Member (of Piapi Canyon Formation) (of Oak Spring Group).	Pliocene or younger	Nevada	Paintbrush Tuff and Timber Mountain Tuff of Nye County, Nevada, by P. P. Orkild.	This report, p. A49	
Symonds Formation	Early Cretaceous (?)	Alaska	Reconnaissance geology of Admiralty Island, Alaska, by E. H. Lathram, J. S. Pomeroy, H. C. Berg, and R. A. Loney.	Bull. 1181-R	1965

DENNY CREEK GRANODIORITE GNEISS, BROWNS PASS QUARTZ MONZONITE, AND KROENKE GRANODIORITE, MOUNT HARVARD QUADRANGLE, COLORADO

By FRED BARKER and M. R. BROCK

Three plutonic rocks of Precambrian age in the Mount Harvard quadrangle, Colorado, are here named Denny Creek Granodiorite Gneiss, Browns Pass Quartz Monzonite, and Kroenke Granodiorite. Part of the rock assigned to the Denny Creek was previously called Pikes Peak Granite by Stark (1935) and Stark and Barnes (1935), a designation now known to be erroneous; another part and the other two intrusive rocks and all the enclosing schists and gneisses, were assigned by them to the "Sawatch schist and migmatite". The Denny Creek Granodiorite Gneiss, the oldest of the three plutonic rocks, and the Kroenke Granodiorite, the youngest, form batholiths that extend beyond the boundaries of the Mount Harvard quadrangle (fig. 1). The Browns Pass Quartz Monzonite forms two stocks in the central part of the quadrangle but thus far has not been recognized outside the quadrangle.

The Browns Pass Quartz Monzonite discordantly intrudes the Denny Creek Granodiorite Gneiss both in the Denny Creek drainage basin and at contacts of the small stock lying about 2 miles north of Cottonwood Pass (fig. 1). Xenoliths of the granodiorite gneiss lie in the quartz monzonite along parts of the contacts of these two intrusives. The Kroenke Granodiorite intrudes the Denny Creek Granodiorite Gneiss along many miles of contact (fig. 1) and sharply transects the foliation of the granodiorite gneiss. Although the Browns Pass Quartz Monzonite and the Kroenke Granodiorite are nowhere in contact, the Browns Pass is partly syntectonic whereas the Kroenke is posttectonic; moreover, on the south side of Texas Creek, the Kroenke batholith crosscuts and brecciates gneisses and schists that 1 mile to the south contain syntectonic well-foliated sills and dikes of the Browns Pass unit. The Browns Pass Quartz Monzonite evidently is the older of the two.

DENNY CREEK GRANODIORITE GNEISS

The Denny Creek Granodiorite Gneiss is named for the exposures along Denny Creek at altitudes of 10,800–11,000 feet. This area is here designated as the type area. This formation consists of gneissic biotite granodiorite and biotite-quartz diorite and underlies much of the west-central and north-central parts of the quadrangle (fig. 1). It is medium to dark gray, is well foliated, and consists of lenticular single grains and aggregates of medium- to coarse-grained plagioclase and quartz and, also, augen of pale-pink microcline perthite; the grains, aggregates, and augen are set in a continuous schistose matrix

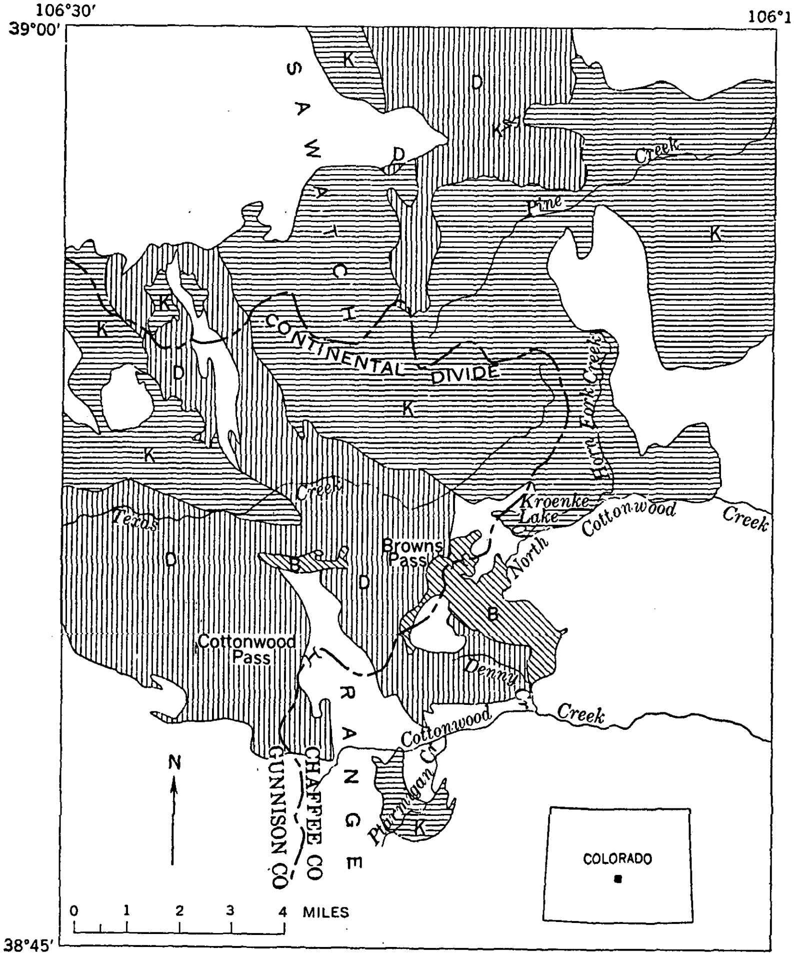

FIGURE 1.—Generalized distribution of major Precambrian intrusive rocks, Mount Harvard quadrangle, Colorado. D, Denny Creek Granodiorite Gneiss; B, Browns Pass Quartz Monzonite; K, Kroenke Granodiorite.

of fine-grained biotite that, in addition, commonly contains either hornblende or muscovite. Proportions of minerals, especially microcline, differ from one hand specimen to the next in most parts of the batholith so that quartz diorite and granodiorite are closely intermixed in many outcrops. The plagioclase commonly is andesine, rimmed with oligoclase, and is slightly to markedly sericitized. The biotite is pleochroic, X being straw yellow and Y and Z dark brown to dark green. The hornblende is pleochroic, X being golden yellow brown, Y green, and Z bluish green. Chemical and modal analyses

TABLE 1.—*Chemical and modal analyses of Denny Creek Granodiorite Gneiss, Browns Pass Quartz Monzonite, and Kroenke Granodiorite, Mount Harvard quadrangle, Colorado*

	Denny Creek Granodiorite Gneiss			Browns Pass Quartz Monzonite			Kroenke Granodiorite		
	Bf-1	Bf-17	Bf-18	Bf-20	Bf-76	Bf-141	Bf-111	Bf-176	Bf-196
Chemical Analyses [Analyses by E. S. Daniels]									
SiO_2	58.11	59.14	61.73	69.71	65.04	74.17	70.80	68.32	66.88
Al_2O_3	16.29	14.65	15.66	14.02	15.14	14.12	15.71	16.60	16.88
Fe_2O_3	3.45	3.06	2.88	1.78	1.96	.41	.70	.85	1.07
FeO	5.85	7.13	4.12	2.36	3.60	.63	1.26	1.98	2.20
MgO	2.14	2.54	1.48	.80	1.65	.18	.62	.97	1.20
CaO	5.17	4.23	2.91	1.91	3.34	.96	2.40	2.74	3.01
Na_2O	2.97	2.58	3.00	2.82	3.07	3.76	5.05	5.67	5.45
K_2O	2.29	2.57	4.38	4.32	3.40	5.01	2.48	1.51	1.98
H_2O+	1.19	1.46	1.83	.97	.93	.44	.50	.66	.50
H_2O-	.12	.08	.10	.14	.21	.18	.10	.05	.05
TiO_2	1.52	1.67	1.05	.66	.95	.11	.26	.38	.52
P_2O_5	.49	.45	.35	.25	.35	.04	.08	.11	.15
MnO	.19	.17	.11	.08	.08	.05	.03	.04	.05
CO_2	.02	.02	.01	.06	.02	.02	.01	.03	.03
Cl	.02	.03	.03	.02	.02	.02	.01	.02	.03
F	.13	.10	.09	.10	.24	.01	.06	.06	.08
Subtotal	99.95	99.88	99.73	100.00	100.00	100.11	100.07	99.99	100.08
Less O	.05	.05	.05	.05	.10	.00	.03	.03	.04
Total	99.90	99.83	99.68	99.95	99.90	100.11	100.04	99.96	100.04
Mode [Analyses by R. C. Bucknam]									
Plagioclase	50	49	47	31	32.5	36.5	53	63.5	63.5
Potassic feldspar	--------	--------	15	29.5	17.5	28	10	1	1.5
Quartz	25.5	22	21	29.5	29.5	32	30	25	22
Biotite	21	18	14	5.5	16.5	3.5	4.5	9	12
Hornblende	--------	8	.5	--------	--------	--------	--------	--------	--------
Muscovite	--------	--------	--------	1.5	--------	Trace	1	--------	--------
Sphene	1.5	Trace	Trace	Trace	1.5	--------	.5	Trace	Trace
Magnetite and ilmenite	1.5	2.5	1	1.5	1	--------	.5	Trace	.5
Epidote	--------	--------	--------	.5	Trace	Trace	Trace	1	--------
Allanite	--------	--------	Trace	--------	Trace	--------	Trace	Trace	--------
Apatite	Trace	Trace	Trace	.5	.5	Trace	Trace	Trace	.5
Zircon	Trace	Trace	Trace	Trace	Trace	--------	Trace	Trace	Trace

Bf- 1. Gneissic biotite-quartz diorite, 0.1 mile north of Pass Creek, 11,040 ft altitude.
Bf- 17. Gneissic biotite-hornblende-quartz diorite, 100 ft east of north fork of Denny Creek, 10,970 ft altitude.
Bf- 18. Gneissic biotite-hornblende granodiorite, 150 ft east of north fork of Denny Creek, 10,970 feet altitude.
Bf- 20. Leucoquartz monzonite, 0.25 mile southeast of Browns Pass, 11,960 ft altitude.
Bf- 76. Biotite-quartz monzonite, 0.18 mile north of Peak 12,955; 12,760 ft altitude.
Bf-141. Alaskite, ridge between north fork of Denny Creek and Delaney Gulch, 0.1 mile north of 12,320,ft closed contour, 12,300 ft altitude.
Bf-111. Leucogranodiorite, northwest side of Peak 12,778; 12,220 ft altitude; 0.4 mile west-northwest of Kroenke Lake.
Bf-176. Leucoquartz diorite, 0.12 mile southeast of Lake Rebecca, 12,270 ft altitude.
Bf-196. Biotite-quartz monzonite, north side of canyon of Pine Creek, 0.11 mile northeast of Peak 11,391; 11,150 ft altitude.

of three typical varieties of the granodiorite gneiss are presented in table 1.

BROWNS PASS QUARTZ MONZONITE

The Browns Pass Quartz Monzonite, named for exposures west and southeast of Browns Pass (fig. 1), here designated the type area, consists of three rock types that, from oldest to youngest, are (1) buff medium- to coarse-grained foliated homogeneous biotite-quartz monzonite (sample Bf–76, table 1), found northeast of Browns Pass; (2) pink to buff coarse-grained massive to foliated quartz monzonite and granite (sample Bf-20, table 1), found southeast to west of Browns Pass and also in the small stock north of Cottonwood Pass; and (3) buff fine- to medium-grained massive alaskite (sample Bf–141, table 1), found as dikes southeast of Browns Pass. The plagioclase of the different varieties ranges from median andesine to calcic oligoclase, and much of it has been altered to sericite. The potassic feldspar is well-twinned slightly perthitic microcline. The biotite is typically pleochroic, X being straw yellow and Y and Z dark olive brown. Chemical and modal analyses of the Browns Pass Quartz Monzonite are shown in table 1.

KROENKE GRANODIORITE

The Kroenke Granodiorite, named for excellent exposures west of Kroenke Lake, the type area, consists of quartz diorite, granodiorite, and quartz monzonite in a sharply discordant body that underlies much of the drainage areas of Pine Creek, North Cottonwood Creek, and the uppermost reaches of Texas Creek, and a small pluton in the Ptarmigan Creek drainage area in the southern part of the quadrangle. It ranges in composition from quartz monzonite to quartz diorite, but these types are so similar in outcrop and hand specimen that one cannot be distinguished from the other in the field. The rocks are mostly quartz diorite in the Pine Creek drainage area and granodiorite and quartz monzonite from Horn Fork Creek to Texas Creek. They are white, light gray, or buff and fine to medium grained; the rocks are commonly foliated and contain single grains and wisplike clusters of biotite but in many areas are massive. They range from homogeneous forms to banded forms consisting of alternating biotite-rich and quartz feldspar-rich laminae. The granodiorite contains swarms of amphibolite inclusions in some places.

Plagioclase in the Kroenke Granodiorite is calcic oligoclase or sodic andesine. Microcline is well twinned and slightly perthitic to nonperthitic. The biotite is pleochroic, X being straw yellow or pale brownish green and Y and Z dark olive green or greenish brown. The biotite commonly is partly altered to chlorite and typically is intergrown with apatite, epidote, sphene, magnetite, and allanite. In the vicinity of amphibolite inclusions the rocks contain hornblende. Three chemical and modal analyses are shown in table 1.

SOUTH PASS FORMATION ON THE SOUTHWEST FLANK OF WIND RIVER MOUNTAINS, WYOMING

By NORMAN M. DENSON, HOWARD D. ZELLER, and E. VERNON STEPHENS

The name South Pass Formation is here used for a generally conglomeratic sequence of rocks that includes beds of sandstone, limestone, and volcanic ash; the rocks have a combined average thickness of about 350 feet. The formation unconformably overlies rocks of early and middle Miocene, early and middle Eocene, and Precambrian ages in the vicinity of South Pass, Fremont County, Wyo. (fig. 2).

The rocks in the South Pass Formation were first described by Comstock (1874) as beds of conglomerate, sandstone, and marl near South Pass, Wyo.; however, his names South Pass Group and South Pass Beds (Comstock, 1874, chart opposite p. 102 and p. 130, respectively) were never formally defined, and these names have not been used by other geologists working in the area (Wilmarth, 1938, p. 2032). A section of the rock sequence showing stratigraphic and structural relations is exposed along the Continental Divide near South Pass (alt 7,550 ft); therefore, the authors believe that the name South Pass, given to these beds by Comstock, should be retained as a formation name. The area around South Pass in Tps. 28 and 29 N. and Rs. 98 through 103 W. is herein designated as the type area.

The South Pass Formation is composed dominantly of a basal pinkish-gray pebble-to-boulder conglomerate having a matrix of fine-grained tuffaceous sandstone and siltstone that locally contains pebbles of moss agate. Locally the conglomerate is interbedded with very coarse grained arkosic sandstone and is overlain by fine- to coarse-grained laminated strongly fluorescent sandstone as much as 200 feet thick and fresh-water limestone and volcanic ash as much as 15 feet thick. The thickness of the formation ranges from 0 to more than 500 feet. More than 100 feet of this formation is exposed along many north-facing escarpments on the south side of the Sweetwater River near the center of the map area. There the South Pass Formation is heterogeneous and includes boulders and cobbles of Precambrian metamorphic and igneous rocks set in a matrix consisting of both fine-grained tuffaceous siltstone, reworked from the White River Formation (Oligocene), and tuffaceous sandstone, which is from the lower and middle Miocene sequence.

The South Pass Formation fills preexisting valleys and forms pediment and coalescing alluvial fanlike deposits along both flanks at the southern end of the Wind River Mountains. The heterogeneity of the rocks and the abrupt changes in lithology along the outcrop are

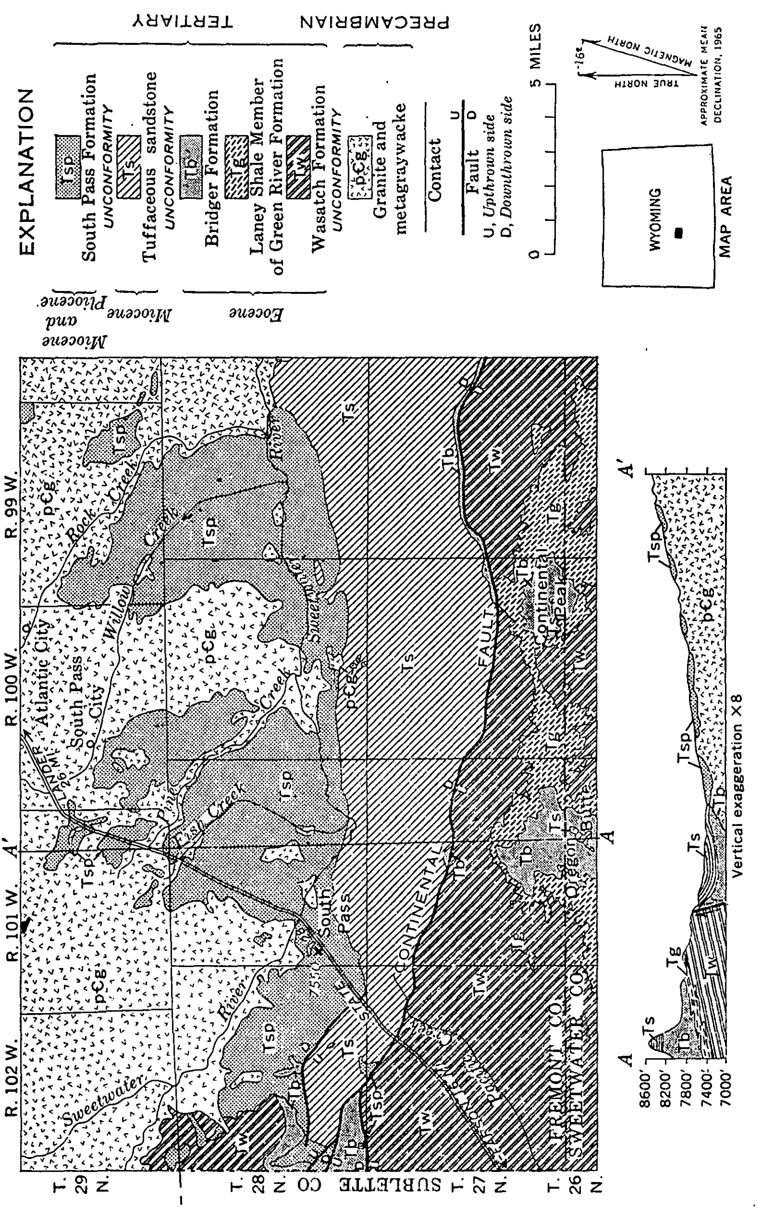

FIGURE 2.—South Pass area, Wyoming.

distinguishing characteristics of the unit and probably represent torrential, short-duration deposition following major uplift of the Wind River Mountains at the end of middle Miocene time. The formation has been mapped as irregular, discontinuous patches in an area of about 350 square miles which extends from the mouth of Rock Creek northwestward to a point near the head of Big Sandy Creek in T. 30 N., 104 W.—a distance of about 40 miles. The rocks herein referred to as the South Pass Formation have been designated as post-Bridgerian (McGrew and others, 1959, fig. 1), as basal part of the White River (Nace, 1939, pl. 1), and as middle or upper Eocene (Love and others, 1955).

Although the exact age of the South Pass Formation is unknown, it is no older than the lower and middle Miocene rocks which it overlies near the west-central edge of the map area. At various places in the area, the South Pass also overlies the Bridger (middle Eocene) and Wasatch (early Eocene) Formations and in addition Precambrian granite and metagraywacke. Northwest of the area in figure 2, in T. 30 N., R. 104 W., and along the northeast flank of the Wind River Mountains in Tps. 29 and 30 N., Rs. 98 and 99 W., the formation rests on the beveled edge of as much as 800 feet of the White River Formation (Oligocene). The South Pass Formation is overlain by pediment gravel and alluvium of Quaternary age.

Four miles west of the map area, near the McCann Ranch (SW¼ T. 28 N., R. 103 W., and NW¼ T. 27 N., R. 103 W.), and in the SW cor. T. 28 N., R. 102 W. (fig. 2), the formation is offset by movement along the Continental fault and the beds are tilted as much as 45°. The cementation of the basal conglomerate is noticeably greater along the Continental fault whereas elsewhere the conglomerate is generally semiconsolidated. If the latest movement along the Continental fault is post-middle Pliocene, which regional evidence indicates (Love, 1954, p. 1312), the South Pass Formation may be considered as late Miocene to middle Pliocene in age. Because the South Pass Formation can be traced eastward discontinuously into fossiliferous rocks assigned to the Ogallala Formation (upper Miocene and Pliocene) in southeastern Wyoming and because it has lithologic, stratigraphic, and structural relations similar to those of the Ogallala, a correlation between the two formations is suggested.

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NOMENCLATURE AND AGE OF FORMATIONS IN THE ANSONIA QUADRANGLE, FAIRFIELD AND NEW HAVEN COUNTIES, CONNECTICUT

By CRAWFORD E. FRITTS

The names and geologic ages of most of the formations in this area are discussed by Fritts (1962a, b). Additions to the nomenclature and revisions of geologic ages are discussed briefly here.

The Oronoque Member of the Derby Hill Schist is named here for the unincorporated community of Oronoque (pronounced Or-o-noke') in the northwestern part of the adjacent Milford quadrangle. The type locality of this member is a long roadcut at the intersection of the Merritt Parkway and State Route 110 on the west bank of the Housatonic River about 1,300 feet south of the Ansonia quadrangle. The rocks exposed there are in the kyanite zone of regional metamorphism and are similar to rocks mapped as part of the Oronoque Member just north of the Far Mill River in the western part of Pine Rock Park in the Ansonia quadrangle. Abundant quartz-rich paragneiss, or siliceous metatuff, distinguishes this member from the predominant schist of the Derby Hill Schist, which is also well exposed just north of the Far Mill River. Farther north near Shelton and Derby the entire formation is highly sheared; the Oronoque Member there is difficult to recognize but presumably is in the upper part of the formation, and grades into the predominant schist. Rocks of the Oronoque Member in zones of low-grade metamorphism in the eastern part of the Ansonia and Milford quadrangles are also difficult to recognize, but in at least some places there the rocks appear to contain more primary (nonintroduced) silica than the underlying phyllites, which probably are equivalent to the main part of the Derby Hill Schist. The Oronoque Member, especially the upper part, also contains subordinate impure limestone of metasedimentary origin and amphibolite and greenschist, which probably represent mainly metavolcanic rocks similar to those found in the overlying Maltby Lakes Volcanics.

The names Maltby Lakes Volcanics and Allingtown Metadiabase were chosen in consultation with John Rodgers and J. E. Sanders of Yale University, whose students, Holdaway [1] and Burger,[2] mapped rocks of pre-Triassic age in the western part of the New Haven quadrangle during the period 1957–62 when work by the present writer was in progress in the Mount Carmel, Southington, Ansonia, and Milford quadrangles. The rocks mapped by Holdaway and

[1] Holdway, M. J., 1958, The bedrock geology of the Maltby Lakes area [Conn.]: Yale Univ. unpub. senior thesis.

[2] Burger, H. R., 1962, Stratigraphy and structure of the Milford Group, New Haven quadrangle, Connecticut: Yale Univ. unpub. senior thesis.

Burger formerly were included in the Milford Chlorite Schist (Rice and Gregory, 1906), a name recently abandoned (Fritts, 1962a).

A threefold division of the Milford Chlorite Schist was made by Burger. A southeastern unit, which Burger called the Savin Schist, consists mainly of chloritic phyllite similar to that exposed near Savin Rock in the New Haven quadrangle. This unit extends southwestward across the northwest corner of the Woodmont quadrangle and into the Milford quadrangle, where it is interpreted as low-grade Derby Hill Schist (Fritts, 1965). A central unit, which Burger called the Allingtown Formation, consists of abundant metadiabase intruded into phyllitic metasedimentary rocks. This unit extends southwestward into the southeast corner of the Ansonia quadrangle and into the adjacent Milford quadrangle, where the metasedimentary rocks are mapped separately as low-grade Oronoque Member of the Derby Hill Schist. Burger's northwestern unit, which includes rocks mapped previously by Holdaway near the Maltby Lakes Reservoirs in the New Haven quadrangle, consists mainly of metavolcanic rocks but contains subordinate metasedimentary rocks and minor intrusive metadiabase similar to that characteristic of Burger's Allingtown Formation. This northwestern unit of predominantly metavolcanic rocks also extends southwestward into the Ansonia and Milford quadrangles, where it lies above the Derby Hill Schist and unconformably below the Wepawaug Schist. The present writer uses the name Maltby Lakes Volcanics for the metavolcanic rocks and the name Allingtown Metadiabase only for intrusive metadiabase or metabasalt which is probably younger than both the Derby Hill Schist and the Maltby Lakes Volcanics.

The unit of rocks mapped as Maltby Lakes Volcanics is named here for the Maltby Lakes Reservoirs near State Route 34 in the New Haven quadrangle; this locality is also designated the type locality. The unit contains a distinctive basal pyroclastic schist, characterized by numerous lapilli and bomblike masses of metabasalt, but consists mainly of a thick sequence of greenschists and amphibolites. The rocks probably represent metamorphosed marine tuffs and(or) lava flows. The formation also contains minor metasedimentary schists and impure limestones. The stratigraphic position occupied by the Maltby Lakes Volcanics is comparable to that of the Barnard Volcanic Member of the Mississquio Formation of Doll, Cady, Thompson, and Billings (1961) in Vermont. The age of the Maltby Lakes Volcanics, therefore, probably is Ordovician(?). The basal pyroclastic schist is well exposed at the type locality and was mapped by Holdaway and Burger (see footnotes 1 and 2, p. A30) as a separate unit, although they did not identify it as a metamorphosed pyroclastic rock. They also mapped several thin but apparently distinctive greenschist and amphibolite units now known to be stratigraphically above the pyroclastic schist and below the Wepawaug Schist. The thin stratigraphic units beneath the Wepawaug, however, have not been mapped separately in the Ansonia and Milford quadrangles mainly because of a scarcity of outcrops in these areas and in the southwestern part of the New Haven quadrangle. In the Ansonia and Milford quadrangles, therefore, the name Maltby Lakes Volcanics is used for all metavolcanic (extrusive) rocks and subordinate metasedimentary rocks that are underlain by the Derby Hill Schist and are overlain unconformably by the Wepawaug Schist.

The Allingtown Metadiabase is named here for the community of Allingtown (spelled Allington on recent topographic maps of the New Haven quadrangle) just southwest of the city of New Haven on U.S. Highway 1. This is also the type locality of the formation. The rock is a metamorphosed porphyritic diabase or basalt, which forms numerous closely spaced sills and gently inclined dikes in the metasedimentary rocks interpreted by the writer as low-grade Oronoque Member of the Derby Hill Schist. Dikes of similar porphyritic rocks also intruded the Maltby Lakes Volcanics sometime before metamorphism but are not known to have intruded the Wepawaug Schist. The age of the metadiabase therefore is probably Ordovician.

The age of the Prospect and Ansonia Gneisses formerly was reported as Ordovician or Devonian (Fritts, 1962a); however, the age of the Ansonia now is believed to be Devonian, because in this quadrangle the rock appears to be a gneissic equivalent of the Woodbridge Granite. The Woodbridge intruded the Wepawaug Schist of Silurian and Devonian age before the climax of progressive regional metamorphism in Middle to Late Devonian time (Fritts, 1962b). The regional distribution of the Prospect Gneiss (Fritts, 1962a, fig. 128.1) suggests that this intrusive rock was emplaced mainly along the eastern flank of a north-trending line of domes, such as the Waterbury dome, after initial folding of the Wepawaug Schist and underlying metasedimentary rocks but before emplacement of the Ansonia Gneiss, which crosscuts the Prospect. Thus the age of the Prospect Gneiss also is reported here as Devonian.

BELTED RANGE TUFF OF NYE AND LINCOLN COUNTIES, NEVADA

By K. A. Sargent, D. C. Noble, and E. B. Ekren

As the result of mapping about 2,000 square miles north and west of the Nevada Test Site during the past two years, problems in naming the volcanic rock units have developed that cannot be solved by use of the previous nomenclature applied to rocks within the Test Site. Volcanic rocks, more than 10,000 feet thick and equivalent in age to the Indian Trail Formation (Poole and McKeown, 1962), have been divided into more than 20 mappable units, some of which are several thousand feet thick. In contrast, the Indian Trail Formation in the Test Site is only about 1,000 feet thick and is subdivided into an informal lower member and the Tub Spring and Grouse Canyon Members (Hinrichs and Orkild, 1961; Poole and McKeown, 1962). Though some age equivalence is certain, use of the name Indian Trail Formation for the thick sequence of volcanic rocks north of the Test Site would imply lithologic and genetic relations that do not exist and would preclude the development of a reasonable nomenclature for the rocks north of the Test Site. For these reasons, the name Indian Trail Formation is here restricted geographically to the eastern part of Nevada Test Site, that is, east of long 116°15′ (fig. 3).

The recent geologic mapping has shown that the Tub Spring and Grouse Canyon Members underlie a large area north and west of the Test Site. As the Indian Trail Formation is restricted to the Test Site, the lateral extensions of the rocks of the Tub Spring and Grouse Canyon Members are no longer parts of a formal stratigraphic unit outside the Test Site; therefore, north and west of the Nevada Test Site, the Tub Spring and Grouse Canyon Members are placed in a new formation herein named the Belted Range Tuff (fig. 4).

BELTED RANGE TUFF

The Belted Range Tuff crops out over a broad area in the southern parts of the Belted and Kawich Ranges and in the vicinity of Pahute Mesa (fig. 3). In addition, the Grouse Canyon Member is present over an extensive area west of that shown on figure 3. The formation is best exposed in the southern part of the Belted Range, which is designated the type area. At most places the Belted Range Tuff unconformably overlies local informal units of tuff and lava and is unconformably overlain by tuff, lava, the Paintbrush Tuff, the Timber Mountain Tuff, or the Thirsty Canyon Tuff (p. A44; Noble and others, 1964). Many of the lava flows that underlie or overlie the tuff in the southern part of the Belted and Kawich Ranges have a soda-rhyolite composition and are genetically related to the tuff.

Both the Tub Spring and Grouse Canyon Members are compound cooling units of comenditic (peralkaline soda-ryholite) ash-flow tuff. Rocks of both members are peralkaline. Soda-rich sanidine is the dominant phenocryst mineral in rocks of both members; fayalite, apatite, zircon, and sodic iron-rich clinopyroxene are minor ubiquitous phenocrysts. The Grouse Canyon Member is virtually quartz

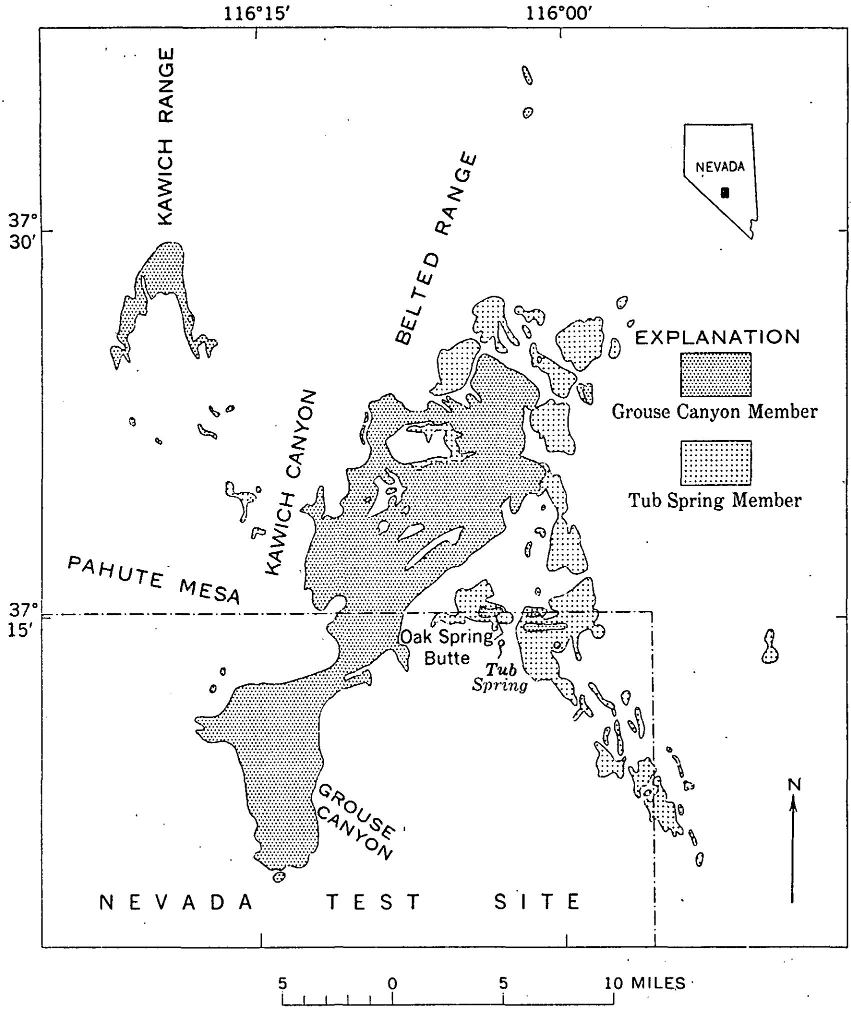
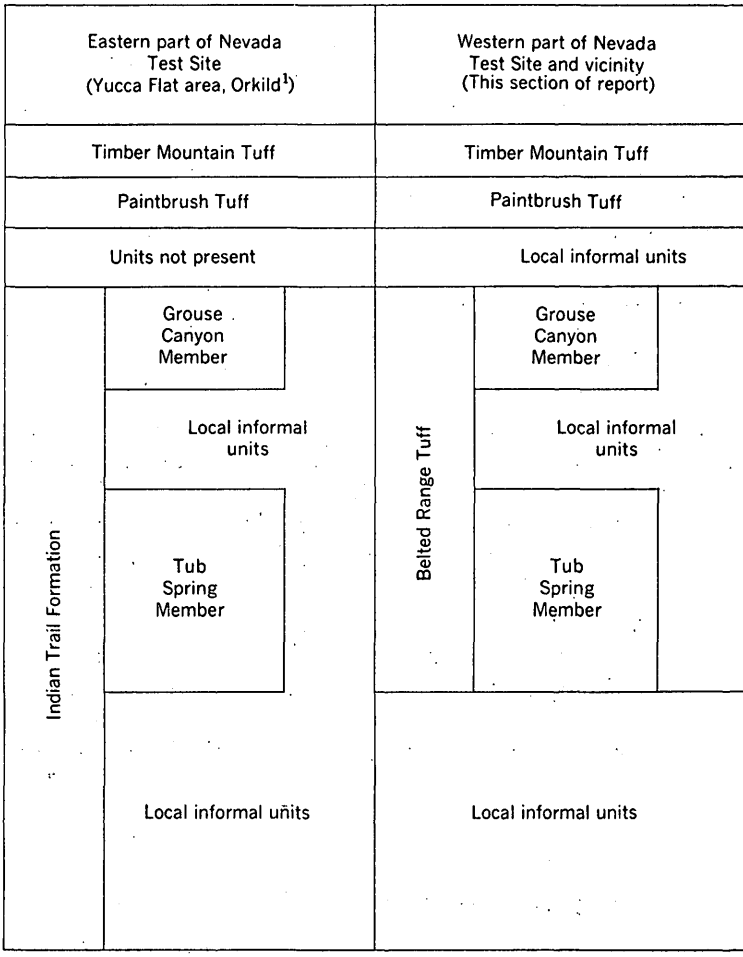


FIGURE 3—Distribution of the Tub Spring and Grouse Canyon Members of the Belted Range Tuff in the northeastern part of the Nevada Test Site and the southeastern part of the Las Vagas Bombing and Gunnery Range.

free, whereas the Tub Spring Member contains abundant quartz phenocrysts.

TUB SPRING MEMBER

At the type locality, Tub Spring (fig. 3), the Tub Spring Member is approximately 250 feet thick; north of Oak Spring Butte the member is locally 300 feet thick. Rocks of the member are typically buff or bluish gray but locally are brick red. The degree of welding



[1] See p. A44–A51.

FIGURE 4.—Stratigraphic nomenclature of Indian Trail Formation and Belted Range Tuff.

ranges from poor to dense. At most outcrops the member is devitrified, but poorly welded vitric tuff, in many places partly to completely zeolitized, commonly occurs at the base and top of the member; vitrophyre is locally present where the member is thick and densely welded. Phenocrysts compose approximately 20–25 percent of the member. Acicular crystals of acmite and sodic amphibole of vapor-phase origin are typical of poorly welded parts. The member locally contains large fragments of reddish-brown or buff pumice and lithic fragments of rhyolite, welded tuff, and Paleozoic sedimentary rocks.

GROUSE CANYON MEMBER

At Grouse Canyon, the type locality (fig. 3), the Grouse Canyon Member is 80 feet thick; north of Oak Spring Butte it has a maximum thickness of approximately 300 feet. The member, as originally described by Hinrichs and Orkild (1961), is composed of an upper part of ash-flow tuff and a lower part of ash-fall and reworked tuff. Although the upper part of the member was described as a simple cooling unit (Poole and McKeown, 1962), further work has demonstrated that it is a compound cooling unit. In most places the unit is densely welded and, with the exception of a thin basal vitrophyre, is almost everywhere devitrified. Gas cavities containing vapor-phase crystals of sodic amphibole are common. Rocks of the cooling unit range from greenish to bluish gray to gray buff and brown and locally are brick red. The various ash flows composing the compound cooling unit contain from less than 0.1 to approximately 20 percent phenocrysts, and average 5 percent.

The ash-fall and reworked tuffs composing the lower part of the Grouse Canyon Member are indistinguishable from ash-fall and reworked tuffs locally intercalated with lavas both above and below the member. Correlation of such tuffs over distances of several miles is uncertain; the lower part of the member is, therefore, no longer retained anywhere as a part of the member; these tuffs are treated as informal units of the formation.

On the basis of the data given on page A51, the Belted Range Tuff is of Miocene or Pliocene age.

SALYER AND WAHMONIE FORMATIONS OF SOUTHEASTERN NYE COUNTY, NEVADA

By F. G. Poole, W. J. Carr, and D. P. Elston

A Tertiary sequence of lava flows, volcanic breccia, tuff, and sandstone is exposed in the southern part of the Nevada Test Site. Part of this sequence of rocks is divided into two new formations here named the Salyer and Wahmonie Formations. The Salyer Formation, which crops out in an area exceeding 300 square miles that is centered near Mount Salyer and Cane Spring (fig. 5), is best exposed in the Cane Spring quadrangle. Its maximum exposed thickness is nearly 2,000 feet at its type area in the vicinity of Mount Salyer and Cane Spring (fig. 6). The original volume of the Salyer was at least 20 cubic miles.

Overlying the Salyer is the Wahmonie Formation, which crops out in an area exceeding 500 square miles centered near its type area at Wahmonie Flat (fig. 5). The Wahmonie is best exposed in the Cane Spring and Skull Mountain quadrangles. Its maximum exposed thickness is 3,500 feet near Wahmonie Flat (fig. 6). The original volume of the Wahmonie was at least 25 cubic miles.

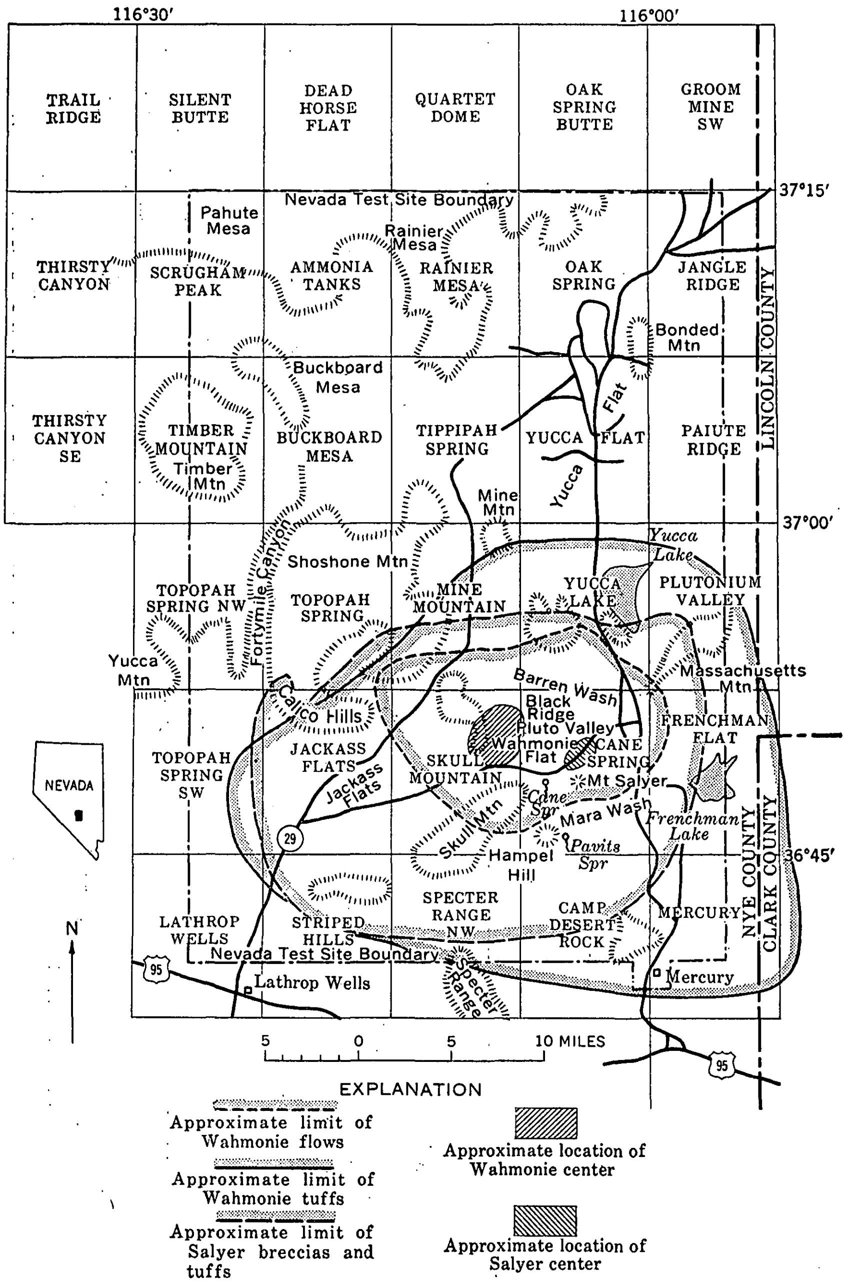
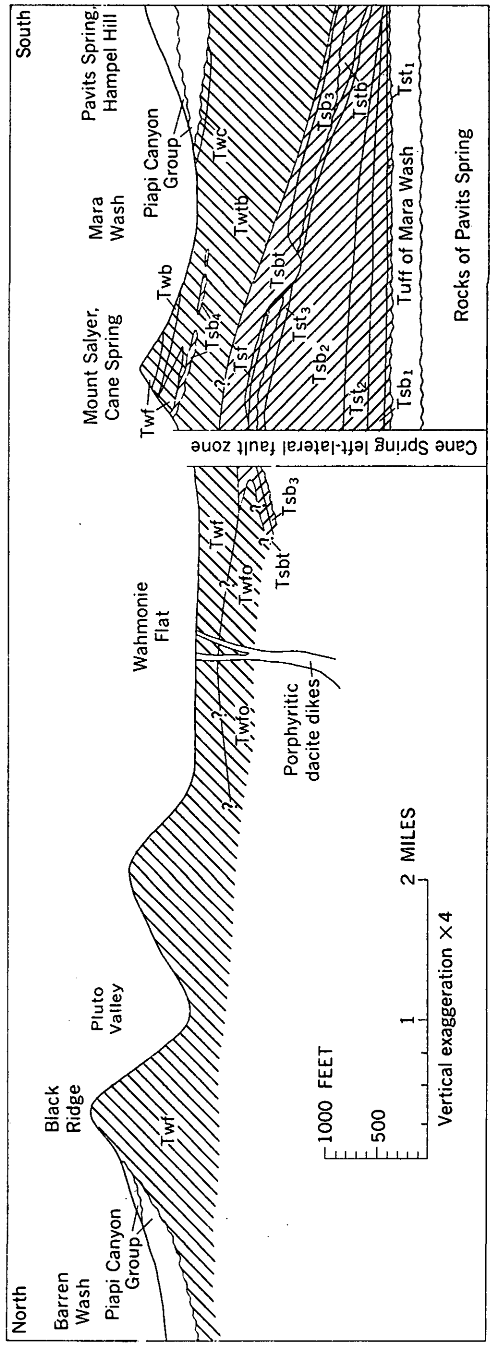


FIGURE 5.—Map of Nevada Test Site showing topographic quadrangles and approximate distribution of Salyer and Wahmonie Formations.



South
Pavits Spring, Hampel Hill
Mara Wash
Piapi Canyon Group
Mount Salyer, Cane Spring
Twf
Twb
Twc
Twtb
Tsb₄
Tsf
Tsbt
Tst₃
Tsb₃
Tstb
Tsb₂
Tst₂
Tsb₁
Tst₁
Tuff of Mara Wash
Rocks of Pavits Spring
Cane Spring left-lateral fault zone
Wahmonie Flat
Twfo
Porphyritic dacite dikes
Pluto Valley
Black Ridge
Barren Wash
North
1000 FEET
500
1
2 MILES
Vertical exaggeration ×4

FIGURE 6.—Partly restored generalized north-south section in the Cane Spring quadrangle showing relations between volcanic units. Explanation of symbols given below:

Wahmonie Formation (ruled pattern slanted to left):

- Unit 5 (Twf): many lava flows and thin interflow tuffs
- 4 (Twc): conglomerate and lithic tuff-breccia
- 3 (Twb): lithic breccia
- 2 (Twtb): interbedded tuff, sandstone, lithic tuff-breccia, and pumice agglomerate
- 1 (Twfa): older lava flows

Salyer Formation (ruled pattern slanted to right):

- Unit 10 (Tsb_4): breccia flow
- 9 (Tsbt): interbedded lithic breccia, breccia flow, lithic tuff-breccia, tuff, and sandstone
- 8 (Tsf): lava flow
- 7 (Tsb_3): breccia flow
- 6 (Tstb): biotite tuff
- 5 (Tst_3): interbedded tuff, sandstone, siltstone, and claystone
- 4 (Tsb_2): breccia flows
- 3 (Tst_2): interbedded tuff, sandstone, lithic tuff-breccia, and lithic breccia
- 2 (Tsb_1): breccia flow
- 1 (Tst_1): tuffaceous claystone

The type section of the Salyer Formation is a composite of partial sections in the area from Cane Spring to Mount Salyer to Hampel Hill (figs. 5, 6). The type localities are as follows: Units 1 to 3, a north-trending ridge near the head of Mara Wash about 1¼ miles south of Cane Spring; units 4, 5, 9, 10, a northeast-trending ridge about half a mile southeast of Cane Spring; unit 6, about 1 mile northeast of Hampel Hill; units 7 and 8, about three-fourths of a mile west of Mount Salyer. As only part of unit 9 is present on the ridge half a mile southeast of Cane Spring, a well-exposed section extending for about half a mile northeast from Mount Salyer also is considered the type locality for this unit.

The type section of the Wahmonie Formation is also a composite of partial sections found on the east and south sides of Wahmonie Flat, at Mount Salyer, and in the area between Cane Spring and Hampel Hill (figs. 5, 6). The type localities are as follows: Unit 1, a small exposure on a low ridge about 1¼ miles northwest of Cane Spring; unit 2, on a northeast-trending ridge about half a mile southeast of Cane Spring and around Hampel Hill; unit 3, at Mount Salyer; unit 4, on the northwest side of Hampel Hill; unit 5, incomplete sections at the east end of Wahmonie Flat and on the north side of Skull Mountain.

STRATIGRAPHIC RELATIONS

In general the Salyer and Wahmonie Formations occur in the middle part of the Tertiary volcanic sequence at the Nevada Test Site (Poole and McKeown, 1962, fig. 80.2). In the type area the Salyer Formation unconformably overlies yellowish zeolitized rhyolitic tuffs of Mara Wash and underlies the Wahmonie Formation (fig. 6). The Wahmonie is older than most of the Paintbrush Tuff (see p. A44) of the Piapi Canyon Group. On Skull Mountain the Wahmonie is directly overlain by the Topopah Spring Member of the Paintbrush. Northwest of Wahmonie Flat a late flow of the Wahmonie occurs between the Topopah Spring and Tiva Canyon Members of the Paintbrush.

Although the Salyer Formation is in general overlain by the Wahmonie, one unit of the Salyer (Tsb_4, fig. 6) intertongues with the tuffs of the Wahmonie south of Cane Spring.

LITHOLOGIC DESCRIPTION

In some areas the Salyer and Wahmonie are not easily separated, but generally rocks of the Wahmonie are more mafic, contain primary hornblende, are less altered, and consist mainly of lava flows and related tuffs, whereas the rocks of the Salyer Formation are more acidic, contain primary pyroxene and secondary hornblende, are more altered, and consist of breccia flows and interstratified tuff, sandstone, and volcanic breccia.

The Salyer Formation is divided into 10 informal units and the Wahmonie into 5 informal units, as described and illustrated on figure 6. Unless otherwise stated, contacts between units are sharp or abruptly gradational.

The following definitions are for terms used in the stratigraphic sections of the Wahmonie and Salyer Formations.

Lithic tuff-breccia. An extrusive multilithic breccia that is composed of fragments of angular to rounded older volcanic rock and sparse pre-Cenozoic sedimentary rock contained in a matrix of lapilli and ash tuff.

Lithic breccia. A breccia similar to lithic tuff-breccia except that it has a matrix of finely fragmented previously formed volcanic rock. In addition, lithic breccia includes some monolithic breccia.

Pumice agglomerate. An extrusive monolithic rock that is composed mainly of angular to rounded pumice blocks and lapilli in a matrix of ash tuff.

Breccia flow. Lava flows that are almost entirely composed of angular to subrounded fragments of altered previously solidified lava contained in a less altered lava matrix of similar composition. Most fragments probably formed prior to, rather than during, emplacement of unit. Fragments occur throughout entire flow body.

Flow breccia. An extrusive breccia on the margins of lava flows, formed by the breaking up of lava that was solidifying as it moved. The matrix is solidified lava and comminuted flow rock.

Composite sections of Wahmonie and Salyer Formations

[Maximum measured thickness is given]

	Thickness (feet)
Wahmonie Formation:	
5. Black, gray, red, purple, and olive rhyodacitic to dacitic lava flows and related thin interflow tuffs and breccias. Lavas are flow banded, sheeted, porphyritic, glassy to stony, and contain about 40 percent phenocrysts of labradorite, orthopyroxene, clinopyroxene, hornblende, biotite, and magnetite. Fine-grained mafic inclusions are common. Intense hydrothermal alteration is common locally in Wahmonie Flat and Pluto Valley. Individual flows are as much as 800 ft thick. Contacts with older units are poorly exposed in Wahmonie Flat area. Unit 5 intertongues with unit 2 and contains at least one major erosional unconformity	3, 500+
4. Conglomerate or lithic tuff-breccia consisting of porphyritic stony and glassy flow-banded rhyodacite and dacite cobbles and boulders in a gray tuffaceous sandy matrix. Unit 4 is present only in the southwestern part of the Cane Spring quadrangle	50
3. Gray to pinkish-gray lithic breccia consisting of dense to vesiculated, glassy to devitrified blocks crudely stratified in 1- to 2 ft-thick zones. This unit has a few thin local interbeds of tuff and sandstone	270

	Thickness (feet)
Wahmonie Formation—Continued	
2. Interbedded tuff, sandstone, lithic tuff-breccia, and pumice agglomerate. The tuff is white, gray, pink, green, and brown; locally contains abundant lithic inclusions of volcanic rock and is partly zeolitized and is generally well bedded. The sandstone is white, gray, or red, very fine to coarse grained, thinly laminated to thick bedded. Lithic tuff-breccia consists of red, purple, and gray blocks of volcanic rock in gray to green tuff matrix. Many breccia zones are crudely stratified, and some are glassy and similar to some of the breccia of unit 3. The pumice agglomerate consists of gray to tan pumice in a lapilli and ash matrix. The pumice contains 25 percent phenocrysts of plagioclase, biotite, and some hornblende and quartz. Silicified conifer wood is common at several places in unit 2. Unit 2 contains a lens of unit 10 of the Slayer, and its basal contact is locally gradational with unit 9 of the Salyer. Relations with unit 5 of the Wahmonie north of the Cane Spring fault are not clear	1,700
1. Red, purple, and brown rhyodacitic lava flows, commonly hydrothermally altered. This unit probably does not occur south of the Cane Spring fault	100+
Salyer Formation:	
10. Purple and red breccia flow, petrographically like other breccia flows of the Salyer. The breccia contains 30 percent phenocrysts of andesine-labradorite, partly altered biotite, altered pyroxene, and secondary hornblende, hematite, quartz, and plagioclase. Crudely sorted and locally layered. The unit occurs as a tongue within the Wahmonie Formation in the Cane Spring area	50
9. Interbedded lithic breccia, breccia flow, lithic tuff-breccia, tuff, and sandstone. Top of unit is a gray to green glassy breccia flow as thick as 320 ft. The rocks of this unit contain about 30 percent phenocrysts of labradorite, hypersthene, and biotite. Middle of unit 9 is a lithic breccia as thick as 280 ft that contains large blocks of volcanic rock and a few pieces of Paleozoic carbonate rock. Lower part of unit is gray, pink, and yellow lithic tuff-breccia, crudely bedded locally. At the base of the unit is a widespread gray and green interbedded tuff and sandstone as thick as 90 ft. A major erosional unconformity is at the base. Upper contact is gradational in Cane Spring area	700
8. Purplish lava flow and minor flow breccia. Flow is holocrystalline-porphyritic rock that contains 25 percent phenocrysts of labradorite and altered biotite. Lower contact is locally gradational with unit 7	50
7. Purplish- to reddish-brown breccia flow, similar to unit 10 but thicker. Major erosional unconformity at base transects some earlier structures	450
6. Gray, pink, and orange biotite tuff that contains volcanic rock fragments. Unit is probably two ash-flow tuffs separated by a persistent thin stratified tuff zone. Widespread red-brown sandstone layer is at top. Unit is not present in the Salyer type section near Cane Spring	200

	Thickness (feet)
Salyer Formation—Continued	
5. Interbedded tuff, sandstone, siltstone, and claystone. The tuff is mainly olive, green, yellow, and red porphyritic ash and pumice. Reddish-brown and green tuff, containing conspicuous white altered pumice lumps, marks base of unit. Sandstone and siltstone are gray, green, red, and brown, tuffaceous, pebbly, very fine to very coarse grained. Claystone is pinkish gray, silty, sandy, and pebbly, and contains abundant small fragments of volcanic rocks, and a few small pieces of pre-Cenozoic sedimentary rocks in the lower part	150
4. Breccia flows, purple and red in lower part, grading upward through pale red, pale purple, and pale yellow zones into yellow and olive. Lower part similar to units 7 and 10. Reddish blocks as large as 20 ft across occur in upper part of this unit. Several red-brown breccia zones are in upper part of unit	1, 000
3. Pink, brown, gray, and red interbedded tuff, sandstone, lithic tuff-breccia, and lithic breccia. A blood-red sandstone 1–3 ft thick marks the top of unit 3. The lithic tuff-breccia and lithic breccia contain blocks of volcanic rock and some pre-Cenozoic sedimentary rocks. A widespread breccia zone as much as 15 ft thick in the upper part of unit 3 contains pre-Cenozoic rock fragments	250
2. Mottled purplish, reddish, and brownish breccia flow similar to units 7, 10, and lower part of unit 4	150
1. Reddish-orange to purplish tuffaceous claystone that locally contains pebbles of pre-Cenozoic sedimentary rocks; weathers to soft clayey slope	35

CHEMICAL COMPOSITION

Rocks of the Salyer and Wahmonie sequence grade upward chemically and mineralogically from acidic to intermediate composition. Plots of the major elements against silica for rocks of the Wahmonie through the Salyer generally form smooth curves along a differentiation trend common to many volcanic sequences. Chemical analyses and norms of several breccia flows and a lava flow indicate that the Salyer Formation is dellenitic to rhyodacitic in composition. See Nockolds (1954). Lavas of the Wahmonie are modally dacite and andesite, but chemical analyses and norms of several lava flows indicate that the lower part of the Wahmonie is rhyodacite and that the upper part is dominantly dacite. The chemical and mineralogical similarities of the Salyer and Wahmonie strongly suggest that the two formations are comagmatic.

AGE

The Salyer and Wahmonie Formations are dated as late Miocene and as late Miocene and early Pliocene(?), respectively, primarily on potassium-argon age determinations. The Topopah Spring Member of the Paintbrush Tuff (see p.A45–A47), which directly overlies the Wahmonie, has been dated at 13.3 million years ±0.5 million years (R. W. Kistler, written commun., 1963). The lower and upper part of the Wahmonie, however, have been dated by the same method by Kistler (written commun., 1963) at 12.9 million years ±0.5 million years and 12.5 million years ±0.5 million years, respectively. The precision error in these dates may account for the apparent age inversion, as the dates of the Topopah and Wahmonie are only 0.4–0.8 million years apart, less than the possible error. Present data, therefore, place the Wahmonie very close to the Miocene-Pliocene Epoch boundary (Kulp, 1961), and as the Salyer underlies the Wahmonie its age is tentatively considered to be late Miocene.

PAINTBRUSH TUFF AND TIMBER MOUNTAIN TUFF OF NYE COUNTY, NEVADA

By Paul P. Orkild

Various names have been applied to the Tertiary rocks in the Nevada Test Site since the turn of the century. In 1907 Ball (p. 31–34) described some of the Tertiary rocks as rhyolite and latite flows and correlated other with the "Siebert tuff (lake beds)" (Spurr, 1905, p. 51–55). Fifty years later the Tertiary volcanic rocks in the eastern part of the Nevada Test Site were named the Oak Spring Formation by Johnson and Hibbard (1957, p. 367) (fig. 7). In 1957 Hansen, Lemke, Cattermole and Gibbons (1963, p. A7) divided the Oak Spring Formation at Rainier Mesa into numbered units (fig. 8). Hinrichs and Orkild (1961, p. D96) divided the Oak Spring Formation in the Yucca Flat area into seven named members and one informal member. In 1962 Poole and McKeown (p. C60, C61) raised the Oak Spring in the Nevada Test Site to the rank of a group and included two formations in it (fig. 8).

Additional detailed mapping of the Test Site and vicinity since 1962 has resulted in new stratigraphic information that requires another revision of the stratigraphic nomenclature of the Tertiary rocks. The use of Oak Spring Group for all Tertiary rocks in the Test Site is no longer practicable because the Tertiary rocks have been divided into a large number of units which have complex relations among the units. This group, therefore, is herein abandoned. Rock-stratigraphic units that have similar chemical and mineralogical composition and mode of deposition constitute the major genetic units and are given formational rank. New data have shown that the Piapi Canyon Formation includes two lithologically dissimilar sequences of volcanic rocks that have different source areas. As each sequence is comprised of several units, the Piapi Canyon Formation herein is redefined and raised to the rank of group. It includes two new forma-

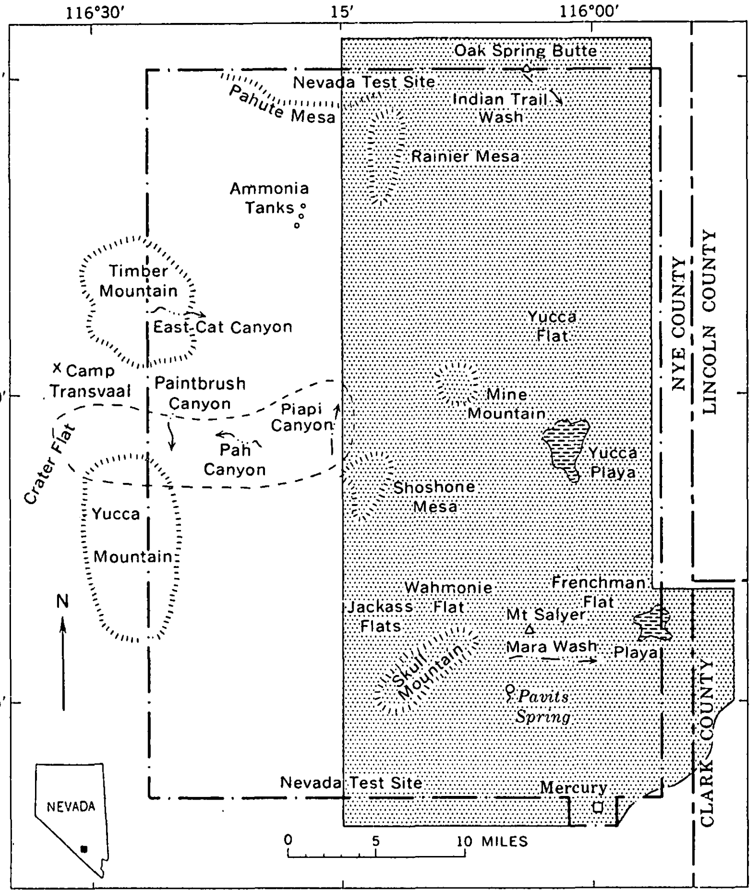


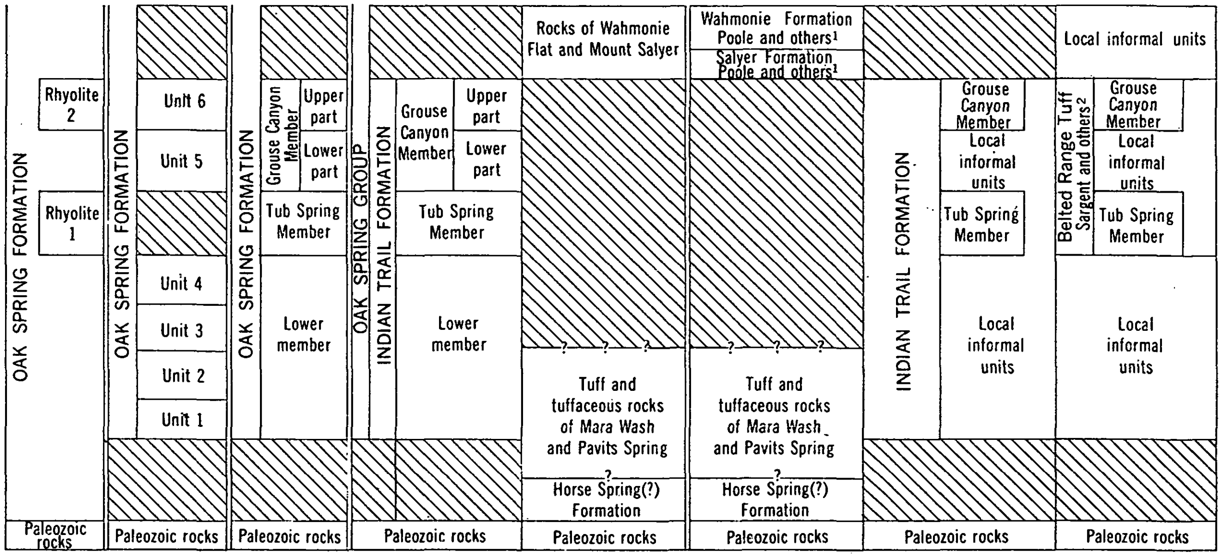
FIGURE 7.—Nevada Test Site and vicinity showing localities referred to in text. Area mapped by Johnson and Hibbard (1957) shown by stipple. The surface and subsurface distribution of Pah Canyon Member of the Paintbrush Tuff is enclosed by dashed line.

tions here named the Paintbrush Tuff and the overlying Timber Mountain Tuff (fig. 8). The rank of the older Indian Trail Formation is unchanged. The names Piapi Canyon Group and Indian Trail Formation, however, are restricted to the areas where they were originally used: namely, the Yucca Flat and Frenchman Flat areas (figs. 7, 9). This is the area (eastern part of Nevada Test Site) mapped by Johnson and Hibbard (1957).

PAINTBRUSH TUFF

The Paintbrush Tuff includes the Stockade Wash, Topopah Spring, and Tiva Canyon Members of Hinrichs and Orkild (1961), the Yucca

Eastern part of Nevada Test Site (Modified from Johnson and Hibbard, 1957)	Rainier Mesa area (Modified from Hansen and others, 1963)	Yucca Flat area (Modified from Hinrichs and Orkild, 1961)	Eastern part of Nevada Test Site (Modified from Poole and McKeown, 1962): Yucca Flat area	Eastern part of Nevada Test Site (Modified from Poole and McKeown, 1962): Frenchman Flat area	Nevada Test Site and Vicinity (This section of report): Frenchman Flat area	Nevada Test Site and Vicinity (This section of report): Yucca Flat area	Nevada Test Site and Vicinity (This section of report): Western and northern areas
				Basalt of Skull Mtn.	Basalt of Skull Mtn.		
					Ammonia Tanks Member	Ammonia Tanks Member	Ammonia Tanks Member*
							Tuff of Transvaal*
							Tuff of Cat Canyon*
	Unit 8	Rainier Mesa Member	Rainier Mesa Member	Rainier Mesa Member	Rainier Mesa Member	Rainier Mesa Member	Rainier Mesa Member
		Tiva Canyon Member	Tiva Canyon Member	Tiva Canyon Member	Tiva Canyon Member	Tiva Canyon Member	Tiva Canyon Member
							Yucca Mountain Member
						Pah Canyon Member	Pah Canyon Member*
		Topopah Spring Member	Topopah Spring Member	Topopah Spring Member	Topopah Spring Member	Topopah Spring Member	Topopah Spring Member
		Stockade Wash Member	Stockade Wash Member			Stockade Wash Member	Stockade Wash Member
	Unit 7	Survey Butte Member	Survey Butte Member	Survey Butte Member	Bedded tuff	Bedded tuff	Bedded tuff
					Timber Mountain Tuff	Timber Mountain Tuff	Timber Mountain Tuff
					Paintbrush Tuff	Paintbrush Tuff	Paintbrush Tuff
OAK SPRING FORMATION	OAK SPRING FORMATION	OAK SPRING FORMATION	PIAPI CANYON FORMATION	PIAPI CANYON FORMATION	PIAPI CANYON GROUP	PIAPI CANYON GROUP	
			OAK SPRING GROUP				



[1] See p. A36. [2] See p. A32.

FIGURE 8.—Stratigraphic nomenclature for Tertiary volcanic rocks of the Nevada Test Site. Asterisk (*) indicates new stratgraphic unit; crosshatching, units not present. No age relations implied between columns.

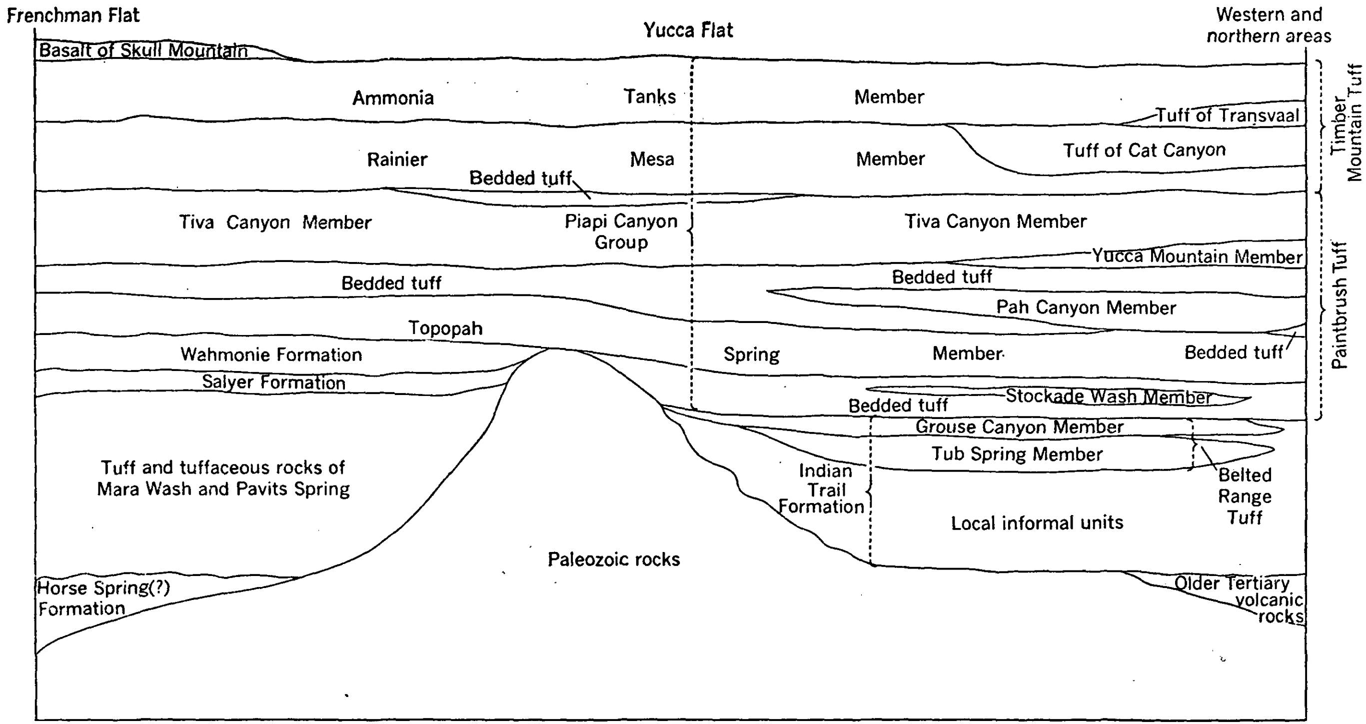


FIGURE 9.—Schematic diagram of the Tertiary volcanic rocks.

Mountain Member of Lipman and Christiansen (1964), and a new member herein defined as the Pah Canyon Member. These rocks are all similar in mineralogy, chemistry, and areal distribution. The type locality of this formation is in Paintbrush Canyon, which is located 2½ miles northeast of Yucca Mountain (fig. 7).

The Survey Butte Member has been a useful term for certain rocks in the eastern part of the Nevada Test Site. As additional data have become available, however, positive correlation of similar rocks in the same stratigraphic interval has become increasingly difficult as rocks are found farther from the type locality of the member. This difficulty results partly from the fact that the rocks of this member are derived from many sources. To avoid the connotation of positive correlation and implies genetic relations, therefore, the name Survey Butte Member is here abandoned. Rocks in this stratigraphic interval will hereafter be designated as bedded tuff of Paintbrush Tuff.

PAH CANYON MEMBER

The Pah Canyon Member of the Paintbrush Tuff is here named for Pah Canyon (fig. 7). The member is a simple cooling unit of rhyolitic ash-flow tuff and is 280 feet thick at the type section at Pah Canyon. It has a maximum thickness of 300 feet at Yucca Mountain, but generally ranges from 40 to 180 feet in thickness. In most outcrops the member includes a basal zone of ash-fall tuff; this tuff is generally less than 3 feet thick but is locally as much as 15 feet thick. In much of the area of outcrop, the member consists of light-gray to light-brown partly to densely welded devitrified ash-flow tuff containing 5–15 percent phenocrysts of biotite, alkali feldspar, and plagioclase; quartz and clinopyroxene are very rare. The tuff of this member is characterized by abundant small pumice and felsic lithic inclusions and by abundant biotite. The member is conformable with both the underlying Topopah Spring Member and the overlying Yucca Mountain Member.

TIMBER MOUNTAIN TUFF

The well-exposed Timber Mountain Tuff attains its maximum thickness in the Timber Mountain region (fig. 7), which is the type area for the formation. It is unconformable on the Paintbrush Tuff. The formation includes the Rainier Mesa Member formerly of the Oak Spring Formation described by Hinrichs and Orkild (1961); this member is overlain by two informal members and one formal member, which are, in ascending order: tuff of Cat Canyon, tuff of Transvaal, and Ammonia Tanks Member.

The Rainier Mesa Member and Ammonia Tanks Member have greater areal extent than any other members of the Timber Mountain Tuff. They are nearly coextensive and crop out in approximately a

330° arc around Timber Mountain. The tuff of Cat Canyon is limited to Timber Mountain, and the tuff of Transvaal is restricted to an area southwest of Timber Mountain near Camp Transvaal (fig. 7).

Preliminary study indicates that the four members of the Timber Mountain Tuff have similar chemical and mineralogical compositions. These similarities suggest that the members are comagmatic. Phenocrysts, which comprise 10–40 percent of the rock, include quartz, alkali feldspar, plagioclase, and biotite.

RAINIER MESA MEMBER

The Rainier Mesa Member is well exposed in Piapi Canyon and on Pahute Mesa (fig. 7). The member is a compound cooling unit of rhyolitic to quartz latitic ash-flow tuff containing abundant phenocrysts. Mafic minerals are generally most abundant in the upper or quartz latite part of the cooling unit.

TUFF OF CAT CANYON

The tuff of Cat Canyon is best exposed in Cat Canyon on the east flank of Timber Mountain (fig. 7). The tuff consists of a lower composite ash-flow sheet as much as 2,850 feet thick and an upper compound ash-flow cooling unit 0–150 feet thick (terminology of Smith, 1960). Despite its considerable thickness, tuff of Cat Canyon is confined to the collapsed area of the Timber Mountain caldera (Byers and others, 1963).

TUFF OF TRANSVAAL

The tuff of Transvaal crops out south and southwest of Camp Transvaal, an abandoned mining camp 5 miles southwest of Timber Mountain (fig. 7). The tuff consists of a lower nonwelded rhyolitic ash-flow tuff 0–200 feet thick and an upper compound cooling unit of rhyolitic ash-flow tuff which locally is as much as 300 feet thick.

AMMONIA TANKS MEMBER

The newly named Ammonia Tanks Member is well exposed both a quarter of a mile north of Ammonia Tanks (fig. 7), the type locality for the member, and for several miles along the south rim of Pahute Mesa (fig. 7). The member is a composite cooling unit of rhyolitic to quartz latitic ash-flow tuff which locally reaches a thickness of almost 300 feet in the vicinity of Pahute Mesa but in most places ranges in thickness from 50 to 200 feet. At the type locality the member is 250 feet thick. The lower 5–20 feet of the member is composed of light-gray or pink vitric ash-fall tuff containing about 15 percent white pumice fragments. The basal vitric zone is overlain in much of the area by pink to reddish-purple moderately to densely welded generally devitrified ash-flow tuff containing abundant phenocrysts.

The Ammonia Tanks Member is characterized by wedge-shaped sphene crystals as large as 1 mm and by locally abundant reddish-brown porphyritic lithic fragments derived mainly from the underlying Rainier Mesa Member.

AGE

The age of the Oak Spring Group of Poole and McKeown (1962, p. C61), as indicated by plant, invertebrate, and vertebrate fossils, ranges from Eocene to Pliocene.

Potassium-argon age determinations of biotite and sanidine from various units in the Piapi Canyon Group have been made by R. W. Kistler (written commun., 1963), but the data are incomplete; adequate discussion of the results is beyond the scope of this paper. The data do provide, however, an interim and tentative basis for dating the formations. The base of the Indian Trail Formation in the northern part of the Test Site is about 16 million years old; the age of its top is unknown but is older than 13.5 million years. The Paintbrush Tuff ranges from about 13.5 to 12.5 million years in age, and the Timber Mountain Tuff has an age of about 10.5 million years. Translation of these potassium-argon dates to epochs in the geologic scale must be done somewhat arbitrarily because of the inconsistent placement of epochs recorded in the literature (Holmes, 1947, p. 145; Kulp, 1961; and Evernden and others, 1964). Using Kulp's geologic time scale, in which the Miocene-Pliocene boundary is between 12 to 14 million years before the present, the Indian Trail Formation is Miocene and Pliocene(?) rather than Miocene or Pliocene as given in Poole and McKeown (1962, p. C62), the Paintbrush Tuff is Miocene(?) and Pliocene, and the Timber Mountain Tuff is Pliocene.

AGE OF THE ELEANA FORMATION (DEVONIAN AND MISSISSIPPIAN) IN THE NEVADA TEST SITE

By F. G. Poole, P. P. Orkild, Mackenzie Gordon, Jr., and Helen Duncan

Field investigations in the Nevada Test Site by the authors and colleagues in August 1961 provided considerably more extensive fossil collections from the Eleana Formation than were available when an earlier paper on the formation was prepared (Poole and others, 1961). These collections provided a more reliable basis for dating than the previous collections from which the Eleana was dated as Mississippian and Early Pennsylvanian.

The Eleana was divided into ten informal units lettered A (at the base) through J (at the top). As mapped, unit A contains faunal assemblages that cannot be younger than early Late Devonian (Frasnian). The Devonian corals originally collected were fragmentary specimens in the matrix of a limestone conglomerate. Laboratory study did not establish that these specimens were not derived from older rocks and redeposited in beds of Mississippian age; hence, the age of unit A was given as Mississippian, even though it was suggested that unit A might be as old as Lake Devonian. Field study later revealed, however, that layers containing *Atrypa* occur between the conglomeratic coral beds. Inasmuch as *Atrypa* is not known in rocks younger than the lower Upper Devonian and as no fossils characteristic of the Mississippian have been found in unit A, it seems safe to conclude that unit A is of Devonian age.

Units B to G of the Eleana Formation have not yielded fossil collections that provide evidence for precise dating. The authors have recognized no undoubtedly Early Mississippian assemblages in the Eleana; however, several collections which contain fossils that cannot be older than Late Mississippian also contain some fossils that probably were derived from beds of Early Mississippian age.

In 1964 Gordon and Duncan completed a detailed study of the fossils collected from the upper part of the Eleana and the lower beds of the overlying Tippipah Limestone. Information gained from their work indicates that units H, I, and J are of Late Mississippian age and that no rocks of Pennsylvanian age are included in the formation. The basal beds of the Tippipah Limestone, at a locality in the C. P. Hills northwest of Frenchman Flat, 2.2. miles southwest of Yucca Pass in the Yucca Lake quadrangle, contain goniatites (*Branneroceras*, *Bisatoceras*, and *Boesites?*) indicative of Early Pennsylvanian age.

One collection from unit H or I in the Eleana in the foothills of Quartzite Ridge, in the Oak Spring quadrangle, was originally considered to be of Pennsylvanian age because the only identifiable fossils belonged to a species of the horn coral *Lophophyllidium*, a genus generally considered to be diagnostic of Pennsylvanian and Permian age. The author's later collection from the same locality yielded, among other fossils, the lithostrotionoid coral *Siphonodendron* (*Cionodendron*) sp. and the brachiopod *Reticulariina* cf. *R. spinosa* (Meek and Worthen), which are characteristic Late Mississippian fossils. Moreover, at another locality specimens of *Lophophyllidium* were associated with an extensive assemblage of corals, bryozoans, and brachiopods among which the critical elements for dating purposes are forms of early Late Mississippian age (*Zaphrentites* aff. *Z. californicus* (Tischler) *Cyathaxonia* n. sp., *Antiquatonia* sp., *Auloprotonia*? sp., and *Semicostella* n. sp.).

Several collections made from conglomeratic limestone beds in unit I of the Eleana indicate that at least some of the fossils were derived from erosion of considerably older rocks. A stromatoporoid and corals of Devonian aspect associated with corals and brachiopods indicative of both Early and Late Mississippian age provide evidence of such reworking; however, the conglomeratic layers containing mixed associations occur well below unit J, which carries goniatites (*Cravenoceras hesperium* Miller and Furnish and *C. merriami* Youngquist, which are typical of the *Eumorphoceras bisulcatum* zone) and other fossils characteristically found in late Late Mississippian faunas in the Great Basin. The faunal assemblages in which these goniatites occur seem to be natural associations that are not contaminated by elements diagnostic of the Pennsylvanian or of the pre-Late Mississippian.

MARINETTE QUARTZ DIORITE AND HOSKIN LAKE GRANITE OF NORTHEASTERN WISCONSIN

By William C. Prinz

Much of northern Wisconsin is underlain by granitic rocks of Precambrian age; these rocks compose the so-called Wisconsin batholith. The U.S. Geological Survey, as part of its restudy of the Menominee district, has mapped a small part of the northern edge of the batholith in northern Marinette County and Florence County, Wis. Two units recognized within the batholith—Marinette Quartz Diorite and Hoskin Lake Granite (Prinz, 1959)—are here adopted for use by the Geological Survey. Cain (1963) has mapped the extension of these two units to the south and has distinguished several other granitic units.

Marinette Quartz Diorite forms a pluton of about 12 square miles, mainly in Marinette County. The diorite is here named for that county. It had previously been referred to as biotite-hornblende-quartz diorite by Lyons (Emmons and others, 1953, pl. 16 and p. 108). Good exposures of Marinette Quartz Diorite occur south of Niagara, Wis., in the NW¼ sec. 22 and SW¼ sec. 15, T. 38 N., R. 20 E., and along the Chicago, Milwaukee, St. Paul and Pacific Railroad in the S½NE¼ sec. 18, T. 38 N., R. 20 E.

Typical Marinette Quartz Diorite is medium grained, is massive or slightly foliated, and consists of 40–50 percent oligoclase, 0–20 percent potassium feldspar, 10–30 percent quartz, and 20–30 percent prochlorite, biotite, or hornblende. The texture of the rock is hypidiomorphic to allotriomorphic granular consisting of large subhedral to anhedral plates of plagioclase and flakes of biotite or chlorite and consisting of finer grained interstitial grains of quartz and potassium feldspar. Commonly, the oligoclase shows normal zoning and has cores as calcic as andesine; most plagioclase is partly altered to sericite or epidote. Most potassium feldspar is unaltered and shows microcline grid twinning. The major mafic constituent of the quartz diorite is either prochlorite or biotite, and some biotitic samples also contain hornblende. Ubiquitous accessory minerals are magnetite, zircon, and apatite; pyrite, calcite, and tourmaline are found locally.

Hoskin Lake Granite forms an arucate-shaped intrusion of at least 20 square miles that in most places lies between metabasalts of the Quinnesec Formation to the north and Marinette Quartz Diorite to the south. It is here named for Hoskin Lake which lies within the granite pluton in the NE¼ sec. 23, T. 38 N., R. 19 E. Previous workers referred to this unit as porphyritic granite or granite porphyry. Good exposures are found almost everywhere within the mapped limits of the unit; those exposures near the county secondary roads in the S½ sec. 12 and N½ sec. 13, T. 38 N., R. 19 E., and the NE¼ sec. 17, T. 38 N., R. 20 E. are readily accessible.

Most Hoskin Lake Granite is coarse grained and porphyritic, having large subhedral, white, gray, or flesh-colored microcline phenocrysts as long as 2½ inches; the phenocrysts are set in a matrix of partially sericitized oligoclase, quartz, microcline, and biotite. In many places the phenocrysts are more or less oriented to form a crude foliation. Chlorite and some hornblende occur with the biotite, and epidote is a sparse alteration product of oligoclase. Zircon, apatite, and subhedral to euhedral sphene, in places altered to leucoxene, are ubiquitous accessory minerals; allanite, monazite, tourmaline, calcite, magnetite, and pyrite are also present in some of the granite. Commonly, half the granite consists of microcline phenocrysts; locally, however, the number of phenocrysts diminishes, and the granite grades into almost nonporphyritic coarse-grained quartz monzonite identical with the matrix of the porphyritic granite.

Hoskin Lake Granite intrudes Marinette Quartz Diorite, and both units intrude metabasalts of the Quinnesec Formation. The contacts between metabasalt and granite or quartz diorite are sharp. The contacts between granite and quartz diorite are generally gradational, because near most of them the granite contains many quartz diorite inclusions and the quartz diorite is cut by many stringers and dikes of granite.

The age of neither the Marinette Quartz Diorite nor the Hoskin Lake Granite is known with certainty. Intrusive relations show that these rocks are younger then the Quinnesec Formation, which is considered to be of early Precambrian age, and Hoskin Lake Granite is intruded by unmetamorphosed diabase dikes of Keweenawan age (late Precambrian). Their age relation to the Animikie metasedimentary rocks (middle Precambrian) is controversial, Prinz (1959) considered them both to be pre-Animikie, whereas R. W. Bayley (written commun., 1960), who has restudied the eastern part of the Menominee district in Dickinson County, Mich., concluded that they are post-Animikie.

MASHEL FORMATION OF SOUTHWESTERN PIERCE COUNTY, WASHINGTON

By Kenneth L. Walters

The name Mashel Formation is given herein to a sequence of unconsolidated fluvial and lacustrine deposits of Miocene age that unconformably underlie Pleistocene deposits and overlie consolidated rocks in southwestern Pierce County, Wash.

J. E. Sceva proposed in 1955 (written commun.) that these deposits be named after the Mashel River (fig. 10), in whose valley walls they are exposed.

CHARACTER AND THICKNESS

The Mashel Formation consists of a predominantly fine-grained upper part and a coarse-grained lower part. The upper part is composed mostly of clay and sand. The clay is predominantly

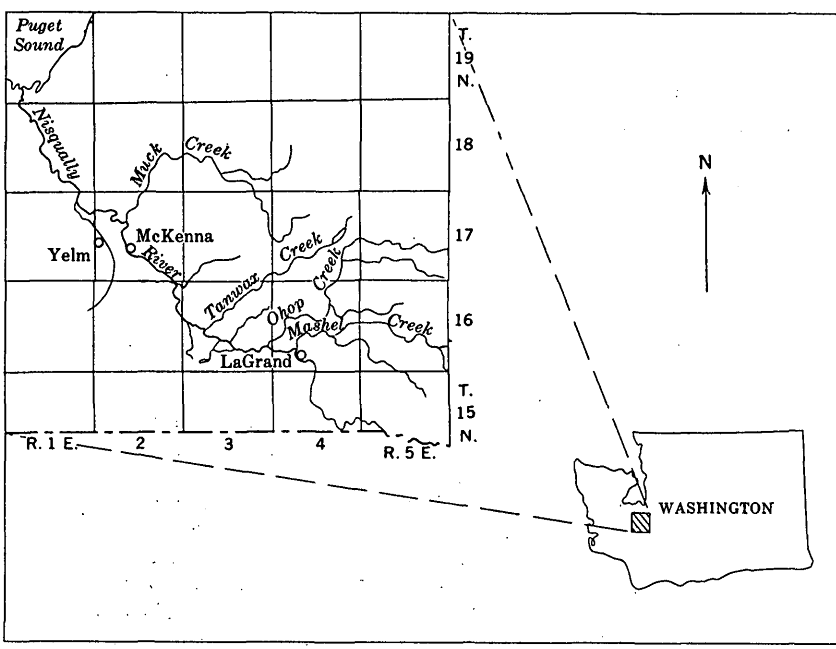


FIGURE 10.—Southwestern Pierce County area, Washington.

light colored and commonly contains plant material ranging in degree of preservation from unidentifiable fragments to whole leaves and sections of logs. The sandy phases of the upper part of the formation contain tuffaceous material, pumice, and volcanic ash.

The lower part of the formation is composed mostly of iron-stained medium- to coarse-grained poorly cemented gravel of predominantly dark volcanic rock types. Most of the granitic pebbles, where present, are badly decomposed and crumble if struck with a hammer.

The greatest thickness of the Mashel observed is about 225 feet. The total thickness may be in excess of 500 feet. Locally, the fine-grained upper part may be more than 400 feet thick.

The following section, measured by the author and Grant E. Kimmel, is designated the type section. An excellent but rather inaccessible section of the formation was measured by J. E. Sceva and B. A. Liesch in the north bluff of the Mashel River about 1,350 feet east of a power transmission line, near the center of sec. 20, T. 16 N., R. 4 E.

Type section of Mashel Formation measured along Weyerhaeuser Road descending from Mashel Prairie to Mashel River, SE¼SW¼ sec. 20 and NE¼NW¼ sec. 29, T. 16 N., R. 4 E.

	Thickness (feet)
Vashon Drift:	
Gravel, coarse-grained.	
Mashel Formation:	
Clay, massive, rusty; weathers white to cream; contains organic material. Lower few inches contains streaks of fine sand	7
Sand, medium, angular to subangular, tan; composed of clear quartz, biotite, muscovite, and miscellaneous dark rock fragments; includes thin beds of silty clay that contain a small amount of organic material and lenses of partly decomposed pebbles having a purple hue	14
Clay, massive, cream to white; has rusty streaks; contains bits of organic material; becomes silty and sandy near base	7
Sand, medium, angular to subangular; contains bits of organic material	2
Clay, massive, cream to white; contains organic material	1.5
Sand	1.9
Clay, cream to white; contains wood and leaves near base (fossil loc. 4)	3
Sand, gray if wet; contains silt and clay; grades laterally into coarse sand and gravel	3.8
Lignite	0.7
Clay, massive; appears waxy on fractures; contains scattered organic material and fragments of tuff; has same thin sand beds	14
Covered	22
Gravel, coarse, and boulders, rusty: contains interstratified lenses of sand and blocks of clay that are as much as 5 ft across; has some granitic boulders, badly decomposed; base not exposed	75

Section of Mashel Formation measured in north bluff of Mashel River near the center of sec. 20, T. 16 N., R. 4 E.

[Measured September 12, 1953 by J. E. Sceva and B. A. Liesch]

	Thickness (feet)
Mashel Formation:	
Sand, silty, stratified, light-brown	32
Sand and fine gravel, stratified	4
Sand, fine, cemented, light-brown	15
Conglomerate; composed of small white pumice pebbles	6
Sand, stratified, rusty-red	6
Clay and silt, gray	12
Sand, crossbedded, gray; contains many streaks of white pumice pebbles	25
Sand, silty, brown	5
Sand and gravel, rusty; composed predominately of pink and gray andesite	10
Sand, silt, and ash	2
Ash, hard, brittle, brown	1
Tuff, hard, green	4
Sand, rusty, brown	10
Clay, and fine sand, silty, laminated	5
Clay, gray, and fine sand	12
Silt, sand, and clay	5
Lignite	1
Sand, silt, and clay, stratified, gray	44
Gravel, basaltic, cemented, rusty; base not exposed	15

AGE AND CLIMATIC IMPLICATIONS

Floras collected by the author and Grant E. Kimmel from the Mashel at the localities indicated in the following table were identified by Jack A. Wolfe of the U.S. Geological Survey:

Flora	Locality 1	2	3	4
Pinus ponderosa Lawson	------	------	×	------
Populus trichocarpa Torrey and Gray	------	------	×	------
Salix hesperia (Knowl.) Condit	------	×	×	------
sp., n. sp	------	------	------	×
Carya simulata (Knowl.) Brown	------	×	------	------
Pterocarya mixta (Knowl.) Brown	×	×	------	------
sp., n. sp	×	×	------	------
Alnus relata (Knowl.) Brown	------	------	------	×
sp., n. sp	------	×	------	------
sp., cones	------	×	------	×
Betula lacustris MacGinitie	------	×	------	------
Fagus sanctieugeniensis Hollick	------	×	------	------
Quercus chrysolepis Liebmann	------	×	×	------
Ulmus speciosa Newberry	------	×	------	------
Zelknova oregoniana (Knowl.) Brown	------	×	------	------
Mahonia reticulata (MacG.) Brown	------	×	------	------
Cinnamomum sp., n. sp	------	×	------	------
Persea lanceolata (Berry) Brown	×	×	×	------
Platanus dissecta Lesquereux	------	------	×	------
sp., n. sp	×	------	------	------
Acer sp., n. sp	------	×	------	×
macrophyllum Pursh	------	------	×	------
Paulownia columbiana Smiley	------	------	×	------
Cornus sp., n. sp	------	×	------	------
Fraxinus sp	------	------	------	×

1. Tanwax Lake quadrangle, SW¼SE¼ sec. 22, T. 17 N., R. 4 E., on east shoulder of Clear Lake highway, 478 ft north of Golden Road junction. Altitude about 675 ft.
2. Eatonville quadrangle, SE¼NE¼ sec. 25, T. 16 N., R. 3 E., on southeast side of Weyerhaeuser logging road, in bluff southeast of Ohop Creek, 260 ft northeast of bend in road at creek level. Altitude about 525 ft.
3. Eatonville quadrangle, NW¼SE¼ sec. 18 T. 16 N., R. 4 E., on west side of State highway 7, in bluff west of Ohop Valley.
4. Eatonville quadrangle, NW¼NW¼ sec. 29, T. 16 N., R. 4 E., on northwest shoulder of Weyerhaeuser logging road, in bluff west of Mashel River. Altitude about 525 ft.

Wolfe (written commun., 1961) assigned the flora from locality 2, and also that from locality 1, a probable late middle Miocene age. He considered the flora from locality 3 to be no older than late Miocene and that from locality 4 to be either late middle or late Miocene.

The climate at the time of deposition of the Mashel Formation, according to Wolfe, was probably warmer than at present, and there may have been at least as much precipitation. The flora from locality 3 represents a climate somewhat cooler than that represented by the flora from locality 2.

DISTRIBUTION

The Mashel Formation is well exposed in the bluffs along the lower Mashel River, the Ohop Valley, the south valley wall of Tanwax Creek, and along the Nisqually River valley from near LaGrande to the mouth of Tanwax Creek. The formation is typically exposed in sec. 20 and 29, T. 16 N., R. 4 E., along a logging road descending from Mashel Prairie to the Mashel River. Near McKenna, in the Nisqually River valley, the Mashel disappears under younger formations.

Similar unconsolidated Miocene deposits of fluvial and lacustrine origin containing pumice and volcanic ash are reported in the vicinity of Voight Creek southeast of Orting (Mullineaux and others, 1959) and in the valley walls of the Green River in King County, Wash. (Glover, 1941, p. 138).

MODE OF DEPOSITION

The Mashel Formation probably was deposited in a piedmont environment during and after the uplift of the ancestral Cascade Range. The areal distribution of the lower part of the formation is not known, but the deposition of much of the gravel was probably limited to areas marginal to the upland, except along northwest-trending drainage lines that may have been in existence on the lowland before the uplift took place. Early in the development of the piedmont plain underlain by the Mashel, sand was deposited in the area midway between the upland and the center of the lowland; silt and clay were deposited near the center of the lowland. As the upland area was eroded and the lowland was aggraded, the area in which gravel was being deposited was reduced in size, and fine-grained material was deposited closer to the upland front.

PRECAMBRIAN AND LOWER CAMBRIAN FORMATIONS IN THE LAST CHANCE RANGE AREA, INYO COUNTY, CALIFORNIA

By John H. Stewart

About 8,000 feet of conformable strata of Precambrian and Early Cambrian age are exposed in the Last Chance Range area (fig. 11). The strata in the northern part of the range and nearby areas are assigned to the Deep Spring Formation of Precambrian age, the Campito Formation of Precambrian and Early Cambrian age, the Poleta, Harkless, Saline Valley, Mule Spring Formations of Early Cambrian age, and the Emigrant(?) Formation of Middle and Late Cambrian age (fig. 12). The strata exposed farther south in the range are assigned to the Wood Canyon Formation of Precambrian and Early Cambrian age, the Zabriskie Quartzite of Early Cambrian age, and the Carrara Formation of Early and Middle Cambrian age (fig. 12).

The nomenclatural differences between the northern and southern parts of the area reflect a change in the lithologic character of the

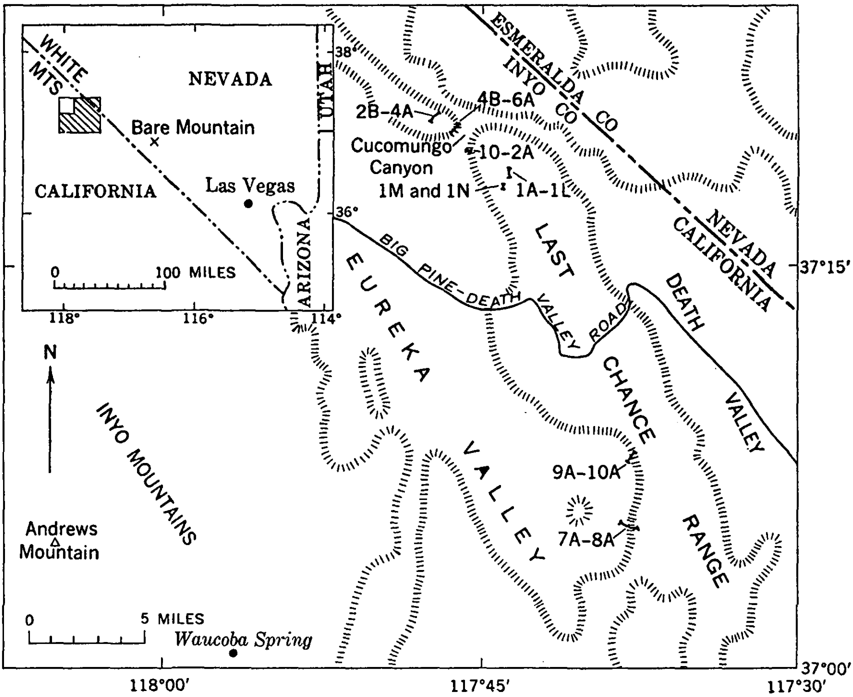


FIGURE 11.—Map showing location of measured sections in the Last Chance Range area, Inyo County, Calif. Numbers and letters refer to units in figures 13 and 14.

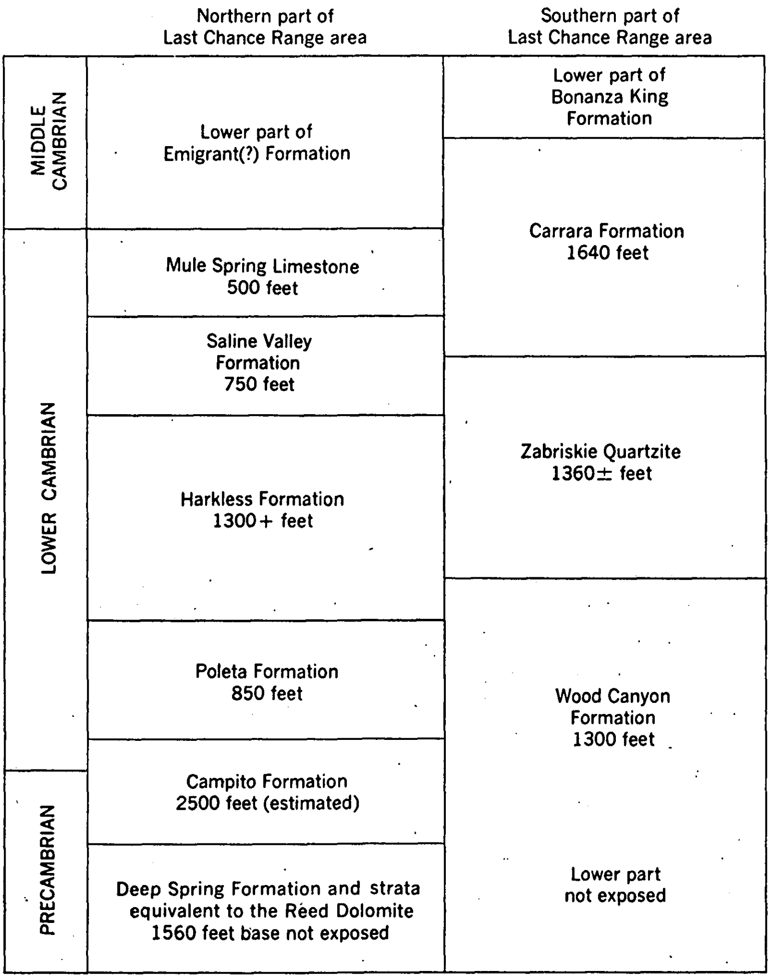


FIGURE 12.—Precambrian and Lower Cambrian formations identified in the Last Chance Range area, Inyo County, Calif.

strata. The strata in the northern part of the area contain more siltstone and limestone, and less quartzite, than comparable strata in the southern part of the area. The terms "Deep Spring" "Campito," "Poleta," "Harkless," "Saline Valley," and "Mule Spring," indicate the lithologic similarity of the strata in the northern part of the Last Chance Range area to the rocks in the stratigraphic sections to the west and north of the Last Chance Range in the Inyo and White Mountains in California (Nelson, 1962) and in Esmeralda County, Nev. (Albers and Stewart, 1962; McKee and Moiola, 1962) where these terms are used. The terms "Wood Canyon," "Zabriskie," and "Carrara" indicate the close lithologic similarity of the strata in the southern part of the Last Chance Range area to the rocks in the stratigraphic sections to the south and east of the Last Chance Range, in southern Nevada and adjoining parts of California (Nolan, 1929; Hazzard, 1937; Cornwall and Kleinhampl, 1961; Barnes and Palmer, 1961; Barnes and others, 1962) where these terms are generally used.

The author's study is based on reconnaissance geologic mapping of much of the Last Chance Range area and on measurement of detailed stratigraphic sections in the southern and northern parts of the area. Parts of the Last Chance Range area have been mapped by Whetten (1959) and McKee (1962), and their studies were helpful in the present geologic study in the area. McKee and Moiola (1962) mentioned briefly some of the exposures of Precambrian and Cambrian strata in the range directly northwest of the Last Chance Range. The present study is part of a continuing investigation of the correlation of the Precambrian and Lower Cambrian strata in the southern Great Basin.

Strata assigned to the Deep Spring Formation (fig. 13), including at the base some strata considered to be equivalent to the Reed Dolomite, are exposed in badly faulted sections in the northern part of the Last Chance Range. These are the oldest rocks exposed in the range, and the total section exposed amounts to about 1,560 feet. Unit 1A (fig. 13) consists of yellowish-brown fine- to medium-grained quartzite, minor siltstone, and, in the upper part, some limestone. Units 1B through 1L consist of gray and grayish-orange limestone, sandy limestone containing scattered fine to medium quartz grains, and minor amounts of dolomite, quartzite, and siltstone. Unit 1M consists of yellowish-gray quartzite and greenish-gray siltstone; unit 1N, of limestone and minor amounts of dolomite and siltstone; unit 1O, mostly of dark siltstone and quartzite similar to that in the Campito Formation; and unit 1P, of limestone and dolomite.

Correlation of units 1A to 1L with described units (Nelson, 1962) in the Inyo and White Mountains is uncertain. Some or all of units 1A to 1L must correlate with Nelson's (1962, p. 141; 1963) lower member of the Deep Spring Formation. Units 1A through 1L total 913 feet in the Last Chance Range as compared with only 496 feet (C. A. Nelson, written commun., 1963) for the lower member near Andrews Mountain (fig. 11) in the Inyo Mountains; thus the section exposed in the Last Chance Range probably extends down into rocks laterally equivalent to the Reed Dolomite, the formation underlying the Deep Spring Formation in the Inyo and White Mountains. This correlation is supported by the lithologic similarity of unit 1A with the Hines Tongue of the Reed Dolomite as described by Nelson (1962, p. 141). The dolomite that forms the top of the Reed Dolomite in the Inyo and White Mountains may be represented by limestone in the section in the Last Chance Range.

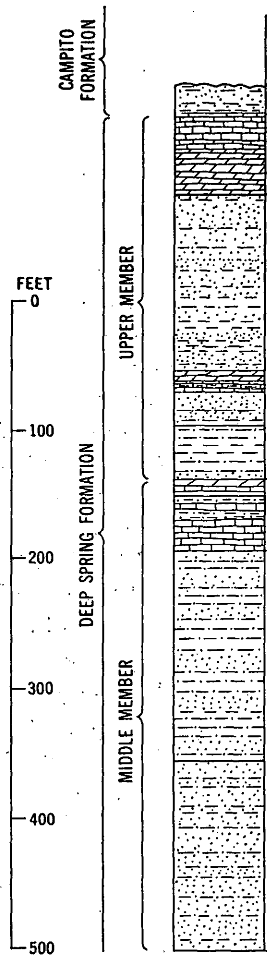
Units 1M and 1N are considered to correlate with Nelson's (1962, p. 141, 1963) middle member of the Deep Spring Formation, and units 1O and 1P with his upper member of that formation.

The Campito Formation consists of olive-gray, greenish-gray, dark-greenish-gray, and medium-gray very fine grained quartzite and siltstone and conformably overlies the Deep Spring Formation. The formation is extensively exposed in the northern part of the area. The thickness is estimated to be about 2,500 feet, although little significance can be placed on this figure because faulting in the area makes accurate measurements of the thickness impossible. Both the quartzitic Andrews Mountain Member and the overlying thinner and silty Montenegro Member (Nelson, 1962, p. 141) were recognized in the northern part of the area.

The Poleta Formation conformably overlies the Campito Formation and is divided into a lower member (unit 3A, fig. 14) of archeocyathid-bearing limestone; a middle member (units 3B–3E, fig. 14) of greenish-gray and olive-gray siltstone, minor limestone, and, in the upper part, some quartzite; and an upper member (unit 3F, fig. 14) of limestone. Division of the formation into three members follows the practice of McKee and Moiola (1962, p. 534–535) although Nelson (1962, p. 142) originally divided the formation into only two members; the upper two members of McKee and Moiola correspond to the upper member of Nelson. The middle member contains the trilobite *Nevadella* (identified by A. P. Palmer, written commun., 1963) in the basal 181 feet of unit 3C. Rare *Scolithus* (worm borings) occur in the upper part of the middle member. The Poleta Formation is about 850 feet thick.

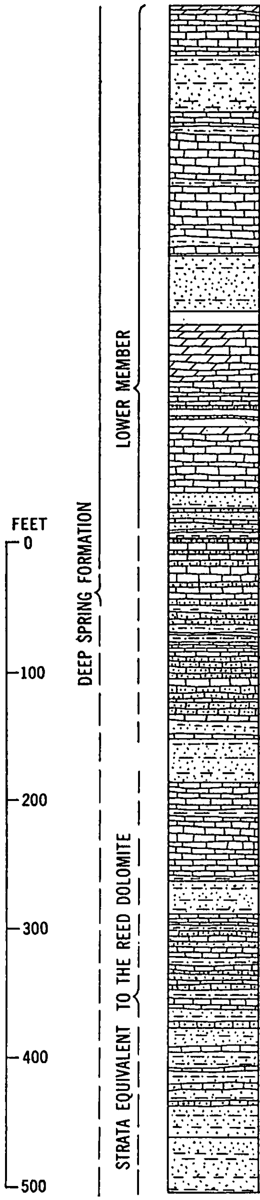
The Harkless Formation is not completely exposed in any one section in the Last Chance Range area. The lower 580 feet (unit 4A, fig. 14) of the formation is exposed 1 mile northwest of Cucomungo Canyon (fig. 11). There the strata which lie conformably on the Poleta Formation consist of greenish-gray and grayish-olive siltstone containing layers of quartzite in a few places. Trilobites that probably can be designated *Fremontia*(?) and *Paedeumias*(?) (identified by C. A. Nelson, written commun., 1964) occur in this section about 280 feet above the base of the Harkless Formation. Along Cucomungo Canyon, about 1,300 feet of the Harkless Formation are exposed conformably below the Saline Valley Formation. Parts of this section are highly faulted. The strata consist mostly of grayish-purple, pale-red, yellowish-gray, and greenish-gray fine- to medium-grained quartzite containing numerous siltstone layers from one-quarter inch to several feet thick. Unit 4C is a particularly conspicuous siltstone unit. Unit 4D is composed of dolomite and lime-

UNITS 1A–1N MEASURED IN SEC. 31 AND 32 (UNSURVEYED), T. 7 S., R. 39 E.
UNITS 1O–2A MEASURED IN SEC. 24, T. 7 S., R. 38 E.



Unit	Thickness (feet)	Description
2A		Olive-gray to medium-dark-gray siltstone
1P	61	Yellowish-gray and light-gray dolomite in basal 35 ft; overlain by very pale orange limestone
1O	223	Greenish-gray, olive-gray, and medium-gray siltstone, yellowish-gray, greenish-gray, and medium-gray very fine to fine-grained quartzite; silty limestone, siltstone and dolomite from 69 to 85 ft above base
1N	55	Gray limestone, very pale orange dolomite in top 6 ft, some siltstone in middle
1M	310	Yellowish-gray very fine to fine-grained quartzite and greenish-gray siltstone. Amount of quartzite decreases upward

FIGURE 13.—Columnar section of Deep Spring Formation and related



1L	38	Gray limestone, very pale orange dolomite in top 8 ft
1K	43	Grayish-yellow limy sandstone, gray sandstone and olive-gray siltstone
1J	110	Grayish-orange limestone containing pisolites in top 5 ft; rare greenish-gray siltstone
1I	54	Olive-gray very fine grained quartzite, rare gray siltstone
1H	128	Gray limestone, gray and yellowish-brown dolomite as 5 ft layer 46 ft above base and replacing limestone in top 45 ft; rare sandy limestone in middle
1G	35	Gray sandy limestone and limestone, yellowish-gray quartzite, and olive-gray siltstone
1F	155	Gray limestone and sandy limestone, minor siltstone, and rare quartzite
1E	35	Yellowish-brown fine- to medium-grained quartzite and greenish-gray siltstone
1D	77	Gray limestone, oolitic in top 10 ft; rare siltstone
1C	25	Olive-gray siltstone and yellowish-gray fine-grained quartzite
1B	87	Gray limestone and sandy limestone, minor quartzite and siltstone
1A	127+	Yellowish-brown fine- to medium-grained quartzite minor greenish-gray siltstone, and minor gray limestone in upper half

strata in northern Last Chance Range area, Inyo County, Calif.

NORTHERN PART OF THE LAST CHANCE RANGE AREA, UNITS 2B-4A MEASURED IN SEC. 15, T. 7 S., R. 38 E., UNITS 4B-6A MEASURED IN SECS. 14 AND 23, T. 7 S., R. 38 E.

Description	Thickness (feet)	Unit
Greenish-gray siltstone and minor yellowish-brown limestone		6A
Gray limestone; scarce *Girvanella*; forms cliff	300±	5C
Medium-gray and olive-gray thin-bedded limestone; scarce *Girvanella*. Contains *Bonnia* sp., *Peachella iddingsi* (Walcott), *Paedeumias* sp., and *Bristolia* n. sp. in upper part	94	5B
Gray limestone; scarce to abundant *Girvanella*	116	5A
Greenish-gray siltstone	48	4I
Gray limestone, minor greenish-gray siltstone; 7-ft quartzite at top	124	4H
Greenish-gray siltstone	34	4G
Gray and yellowish-gray limestone and silty limestone; sandy limestone at base. Contains *Wanneria* sp., *Paedeumias*? sp., and *Salterella* in lower part	65	4F
Pinkish-gray and grayish-red-purple quartzite	480	4E
Gray and yellowish-brown dolomite and limestone; contains *Salterella*	19	4D
Greenish-gray siltstone and minor quartzite layers	28	4C
Grayish-purple, pale-red, yellowish-gray, and greenish-gray fine- to medium-grained vitreous quartzite; contains layers of greenish-gray and medium-gray siltstone ¼ inch to several feet thick	1250	4B
Break in section; some strata may be duplicated or some may be missing		
Dark-greenish-gray and grayish-olive siltstone and rare greenish-gray, grayish-purple, and medium-gray very fine to medium-grained vitreous quartzite layers from 1 in to 9 ft thick. *Fremontia*? and *Paedeumias*? occur 280 ft above base	580	4A
Gray limestone	73	3F
Medium-to olive-gray siltstone and minor yellowish-gray quartzite. Scarce *Scolithus* tubes	86	3E
Yellowish-brown very fine grained quartzite and minor siltstone, limy sandstone, and sandy limestone	109	3D
Greenish-gray and olive-gray siltstone, and minor yellowish-brown and medium-gray limestone and yellowish-brown very fine grained quartzite. *Nevadella* occurs in basal 181 ft. Archeocyathids at base	340	3C
Very pale orange limestone and grayish-olive siltstone	54	3B
Very pale orange and yellowish-gray limestone. Abundant pelmatozoa debris locally and some archeocyathids	189	3A
Dark-greenish-gray siltstone and very fine grained quartzite		2B

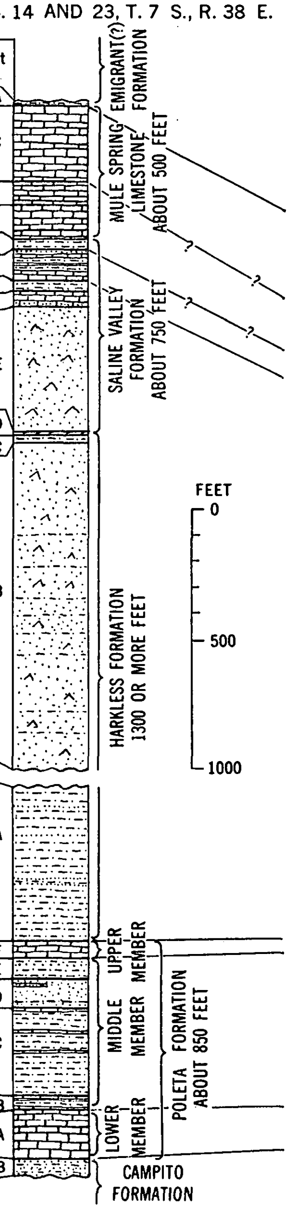
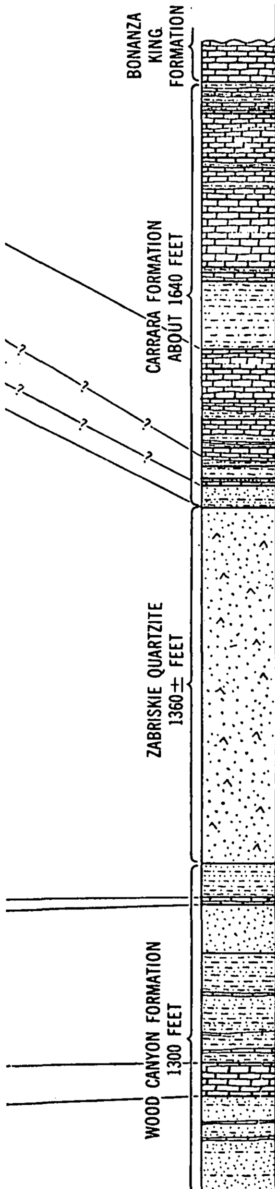


FIGURE 14.—Columnar sections and correlations of Lower Cambrian

SOUTHERN PART OF THE LAST CHANCE RANGE AREA, UNITS 7A–8A MEASURED IN SECS. 7 AND 8 (UNSURVEYED), T. 10 S., R. 40 E., UNITS 9A–10A MEASURED IN SEC. 29, 30, 31, AND 32 (UNSURVEYED), T. 9 S., R. 40 E.



Unit	Thickness (feet)	Description
10A	unmeasured	Gray limestone
9N	115	Gray and yellowish-brown limestone and minor silty limestone and limy siltstone
9M	176	Gray limestone; conspicuous white band at base
9L	163	Yellowish-gray and medium-gray limestone, minor silty limestone and siltstone
9K	250	Gray limestone; white band at top, locally oolitic. Common *Girvanella* in lower half
9J	23	Gray limy siltstone
9I	44	Gray limestone
9H	240	Greenish-gray phyllitic siltstone, scarce thin yellowish-brown or gray limestone layers
9G	200	Gray limestone. Common *Girvanella* throughout; forms prominent cliff
9F	82	Gray limestone; mostly phyllitic siltstone in lower half
9E	112	Gray limestone and minor phyllitic siltstone in lower part. Some *Girvanella*
9D	71	Gray limestone with minor siltstone in lower part. *Girvanella* at top
9C	47	Greenish-gray phyllitic siltstone, minor limestone
9B	32	Gray limestone and dolomitic limestone; sandy limestone at top
9A	88	Yellowish-brown very fine to fine-grained quartzite, minor phyllitic siltstone
8A	1360±	Medium-dark-gray to grayish-purple fine- to medium-grained rarely coarse-grained vitreous quartzite; laminated and minor small-scale cross-strata. Minor siltstone and conspicuous cross-strata in lower 88 ft. Cut by fault about 950 ft above base
7F	124	Dark-greenish-gray siltstone. Quartzite layers minor in lower part and dominant at top. Contains *Paedeumias*?
7E	28	Gray limestone
7D	194	Yellow-brown and yellow-gray very fine grained quartzite. Abundant *Scolithus* tubes
7C	424	Greenish-gray to medium-gray phyllitic siltstone, and minor yellowish-brown and medium-gray very fine sandstone and yellowish-brown and medium-gray limestone. Limestone contains pelmatozoa debris and, in basal 140 ft, archeocyathids. A few *Scolithus* tubes. *Nevadella*? occurs in basal 10 ft
7B	123	Very pale orange and yellowish-gray limestone. Archeocyathids and pelmatozoa debris
7A	407	Yellowish-brown very fine grained quartzite, minor greenish-gray and gray phyllitic siltstone. Two thin limestone beds in upper half, the lower limestone bed contains archeocyathids and pelmatozoa debris

strata in the Last Chance Range area, Inyo County, Calif.

stone and contains *Salterella* in places; the unit is considered to correlate with a fairly persistent limestone found at the top of the Harkless Formation directly below the Saline Valley Formation in the Waucoba Spring area of the Inyo Mountains.

Unfortunately the strata of the Harkless Formation exposed 1 mile northwest of Cucomungo Canyon cannot be matched with any of the strata of that formation exposed along Cucomungo Canyon, and a small amount of strata may be missing between the two stratigraphic sections. The two sections may possibly overlap, however, and the difference in lithologic character may be due to abrupt facies changes coupled with thrust faulting; such faulting would bring unrelated facies into close juxtaposition. Thrust faults have been recognized in the vicinity of Cucomungo Canyon and one, at least, may occur between the section in Cucomungo and the section a mile to the northwest; critical outcrops are, however, covered by younger strata.

The Saline Valley Formation as exposed in Cucomungo Canyon is about 750 feet thick and consists, in the lower part, of pinkish-gray and grayish-red-purple quartzite (unit 4E) and, in the upper part (units 4F–4I), of gray limestone and greenish-gray siltstone, a few layers of sandy limestone near the base, and a layer of quartzite near the top. The quartzite in the lower part of the Saline Valley Formation is very similar to that in the Harkless Formation, and the two formations apparently can be separated only if the intervening carbonate layer (unit 4D) is between them. *Salterella* and the trilobites *Wanneria* sp. and *Paedeumias*? sp. have been collected and identified by A. R. Palmer (written commun., 1963) from the lower part of the unit 4F of the Saline Valley Formation in Cucomungo Canyon.

The Mule Spring Limestone (units 5A–5C, fig. 14) conformably overlies the Saline Valley Formation. It is about 510 feet thick and consists of gray limestone commonly containing algal structures (*Girvanella*). The trilobites *Bonnia* sp., *Peachella iddingsi* (Walcott), *Paedeumias* sp., and *Bristolia* n. sp. have been collected and identified by A. R. Palmer (written commun., 1963) from the upper part of unit 5B of the Mule Spring Limestone in Cucomungo Canyon.

The Mule Spring Limestone is overlain by, and is partly or entirely in thrust contact with a thick and badly faulted sequence of generally thin-bedded limestone and cherty limestone containing some dolomite and siltstone units. A siltstone unit may occur at the base of this sequence directly above the Mule Spring Limestone (fig. 14), although the outcrop showing this relationship is small and faulted. This thick sequence above the Mule Spring Limestone has not been studied critically but is probably assignable to the Emigrant Formation of

Middle and Late Cambrian age, a formation overlying the Mule Spring Limestone in Esmeralda County, Nev. (Albers and Stewart, 1962, p. D27; McKee and Moiola, 1962, p. 536–537). Trilobites collected in this limestone sequence near Cucomungo Canyon by A. R. Palmer and the author have been identified as Middle Cambrian in age (A. R. Palmer, written commun., 1963).

In the southern Last Chance Range, the upper 1,300 feet of the Wood Canyon Formation (units 7A–7F, fig. 14) is exposed. The exposed section consists of very fine grained quartzite, greenish-gray and gray siltstone, and yellowish-brown and gray limestone. Archeocyathids and pelmatozoan debris occur in a thin limestone bed 177 feet below the top of unit 7A, throughout much of unit 7B, and in the basal part of unit 7C. One specimen of a poorly preserved trilobite, identified as possibly *Nevadella* (A. R. Palmer, written commun., 1963), was found in the basal 10 feet of unit 7C. Trilobite remains, possibly in part *Paedeumias* (A. R. Palmer, written commun., 1963), are locally common in unit 7F. *Scolithus* (worm borings) occur in the upper half of unit 7C and are abundant in unit 7D. Units 7B through 7E are correlative with the Poleta Formation of the northern Last Chance Range. This correlation is substantiated by similar thicknesses and sequences of units, as well as by similar fossil occurrences.

The Zabriskie Quartzite (unit 8A, fig. 14) in the southern Last Chance Range consists of medium-dark-gray to grayish-purple fine-to medium-grained vitreous quartzite that is coarse grained in a few places. The quartzite is mostly laminated but locally contains small-scale cross strata. The lower 88 feet contains a minor amount of siltstone, and the quartzite is conspicuously cross stratified. The measured thickness of the Zabriskie Quartzite is about 1,360 feet, although a prominent fault cuts the unit about 950 feet above its base and makes the exact thickness uncertain.

The Zabriskie Quartzite correlates clearly with the quartzite in the Harkless Formation and with that in the lower part of the Saline Valley Formation of the northern part of the Last Chance Range area. Much of the quartzite in the northern part of the area, however, contains thin layers of siltstone, which are not present in the Zabriskie Quartzite. These siltstone layers represent a change to a more silty facies within this part of the sequence to the north. This facies change is most noticeable in the lower part of the Harkless Formation. The basal 580 feet (unit 4A) of the Harkless Formation 1 mile northwest of Cucomungo Canyon is dominantly siltstone and contains only a few thin layers of quartzite. These quartzite layers are tongues of the Zabriskie Quartizite, and the siltstone, except in the basal 100–200 feet, is probably a lateral equivalent of the Zabriskie Quartzite, but of a different facies.

The Carrara Formation (units 9A–9N, fig. 14) is 1,640 feet thick in a measured section in the southern part of the Last Chance Range area. It consists of gray limestone, commonly containing *Girvanella*, greenish-gray phyllitic siltstone, and yellowish-brown silty limestone. Units 9G and 9K form persistent cliffs, whose tops mark vertical lithologic changes that divide the Carrara Formation into three mappable units or members. Unit 9A is intermediate in lithologic type from the Zabriske Quartzite below to the Carrara Formation above. It is included with the Carrara Formation because a similar, and probably correlative unit, has been included in the type Carrara Formation (Cornwall and Kleinhampl, 1961) on Bare Mountain. The Carrara Formation is overlain by the Bonanza King Formation, a thick formation of Middle and Late Cambrian age composed of dolomite and limestone.

The Carrara Formation of the southern part of the Last Chance Range area contains correlatives of the upper part of the Saline Valley Formation, all the Mule Spring Limestone, and the lower part of the Emigrant(?) Formation of the northern part of the Last Chance Range area (fig. 14). Some of the quartzite in unit 9A of the Carrara Formation in the southern part of the Last Chance Range area may correlate with the quartzite at the top of unit 4H of the Saline Valley Formation in Cucomungo Canyon in the northern part of the area. Part of unit 9E and all of units 9F and 9G of the Carrara Formation probably correlate with the Mule Spring Limestone in Cucomungo Canyon. The remainder of the Carrara Formation is correlative with the lower part of the Emigrant(?) Formation, of the northern part of the area.

MIOCENE AND PLIOCENE ROCKS OF CENTRAL WYOMING

By Norman M. Denson

A widespread succession of light-gray fossiliferous tuffaceous siltstone and fine-grained sandstone extends from the vicinity of the Alcova Dam westward along the north side of the Seminoe, Ferris, and Green Mountains to the southern terminus of the Wind River Range—a distance of about 85 miles. Love (1961) applied the term Split Rock Formation to this succession and some associated rocks because fossiliferous Miocene rocks in eastern Wyoming are difficult to correlate with named formations and groups in Nebraska and because the lower and middle Miocene rocks of the Granite Mountains area can not be mapped continuously into the type area of the Arikaree in northwestern Nebraska.

Recent studies and regional mapping by the author from northwestern Nebraska into central Wyoming and local studies by Harshman (1964) in the Shirley Basin, Stephens (1964) at Crooks Gap, Rich

(1962) at Clarkson Hill, and Zeller, Soister, and Hyden (1956) in the Gas Hills indicate that most of the rocks originally assigned to the Split Rock Formation in the Granite Mountains area are laterally equivalent and remarkably similar lithologically and chemically to the rocks in eastern Wyoming and northwestern Nebraska described and first assigned by Darton (1899) to the Arikaree Formation. Furthermore, the upper part of the Split Rock Formation at its type locality includes rocks lithologically very similar to the lower part of the Ogallala Formation and, for this reason, is here assigned to that part of the Ogallala. In other areas the lower part of the Split Rock includes the upper part of the White River Formation (Oligocene). A correlation chart of Miocene and Pliocene rocks of central Wyoming follows:

<table>
<tr><th colspan="4">Love (1961)</th><th colspan="3">This report</th></tr>
<tr><th>Series</th><th>Age</th><th>Formation</th><th>Subdivision</th><th>Formation</th><th>Age</th><th>Series</th></tr>
<tr><td>Pliocene</td><td>Early or middle Pliocene</td><td>Moonstone</td><td></td><td rowspan="2">Ogallala</td><td rowspan="2">Pliocene and late Miocene</td><td rowspan="2">Pliocene and Miocene</td></tr>
<tr><td rowspan="5">Miocene</td><td rowspan="4">Middle Miocene</td><td rowspan="5">Split Rock</td><td>Upper porous</td></tr>
<tr><td>---Local fauna[1]---
sandstone
sequence</td><td rowspan="3">Arikaree</td><td rowspan="3">Middle and early Miocene</td><td rowspan="3">Miocene</td></tr>
<tr><td>Silty sandstone sequence</td></tr>
<tr><td>Clayey sandstone sequence</td></tr>
<tr><td>Early Miocene</td><td>----Vertebrate fossils[2]-----
Lower porous sandstone sequence</td><td>White River (upper part)</td><td>Late Oligocene</td><td>Oligocene</td></tr>
</table>

[1] "Split Rock local fauna" of middle Miocene age (Love, 1961, p. 19)

[2] *Merycoides cursor* Douglass of early Miocene (Gering) age (Rich, 1962, p. 506)

Rocks of widely different lithologies and ages were originally assigned to the Split Rock Formation in two measured sections at the type locality. They include middle Miocene rocks (sec. 36, T. 29 N.,

R. 90 W.), assigned in this report to the Arikaree, as well as Pliocene rocks (secs. 25 and 36, T. 29 N., R. 89 W.) that are here referred to as the Ogallala Formation. The lower of these two distinct stratigraphic units contains many middle Miocene vertebrate fossils ("Split Rock local fauna" of Love and others) and was assigned by Love (1961, p. 19) to the upper porous sandstone sequence of the Split Rock Formation. Rocks below the local fauna are composed predominantly of wind-blown buff and tan fine- to medium-grained poorly bedded sandstone having abundant tiny rounded grains of bluish-gray magnetite. Lateral persistence in lithology and the general absence of coarse detritus and locally derived debris from the surrounding highland are outstanding characteristics of rocks below the local fauna at the type locality of the Split Rock and elsewhere over the whole region.

Conformably overlying the middle Miocene windblown sandstone at the type locality are Pliocene rocks which Love (1961, p. 17, 18) also assigned to the Split Rock. The rocks comprising this stratigraphic unit consist mostly of thin beds of relatively pure white pumicite, pumiceous limestone, sandstone, claystone, and tuff which grade mountainward into fanlike deposits of coarse-grained sandstone, conglomerate, and gravel. The basal contact becomes an unconformity near the mountains. Most of the rocks contain a preponderance of volcanic ash. These volcanic-rich rocks have yielded many species of diatoms and spores (Love, 1961, p. 17, 20, 21) and have been traced eastward to the vicinity of the Pathfinder Reservoir where they have yielded vertebrate fossils determined by P. O. McGrew to be of Pliocene age (J. D. Love, oral commun., 1964). These rocks range from a few feet to at least 300 feet in thickness and are assigned on the basis of lithologic similarity and age to the Ogallala Formation; some vertebrate paleontologists (Wood and others, 1941, p. 27) consider the oldest of several Ogallala local faunas to be of latest Miocene age, whereas others (for example, Schultz and Falkenbach, 1949, p. 80, 83) believe that all the Ogallala is Pliocene.

The Oligocene-Miocene (White River-Arikaree) contact along the eastern and northeastern margins of the Granite Mountains area was drawn by Rich (1962, pl. 7, p. 503–506) at the base of a persistent and wide-spread conglomerate that is 150–600 feet thick. Love (1961, p. 9–12) referred to it as the lower porous sandstone sequence. Areal mapping by the writer from the Granite Mountains eastward into the Shirley Basin now indicates that this widespread conglomeratic succession is a lateral equivalent of a conglomerate, 300–350 feet thick, that some previous workers (Love and others, 1955) assigned to the Miocene and Pliocene, but that Harshman (1964) correctly mapped as an upper coarse-grained member of the Oligocene White

River Formation. At several localities in the Shirley Basin, this conglomeratic sequence has yielded Oligocene (Brule) vertebrate fossils from its lower and middle parts (Harshman, oral commun. 1965; Whitmore, F. C., Jr., and Lewis, G. E., written commun., 1962, 1963). Rocks identical to the Arikaree in the Clarkson Hill area overlie the conglomerate and were mapped by Rich (1962, pl. 7) as Miocene. In the eastern and northeastern parts of the Granite Mountains area, these thick conglomerates directly overlie fossiliferous lower Oligocene (Chadron) rocks and are assigned herein for the first time to the upper part of the White River. At many places in the Shirley Basin, light-gray calcareous sandstone at the base of the Arikaree directly overlies Harshman's upper coarse-grained member of the White River Formation. In the eastern part of the Granite Mountains and in the Shirley Basin, conglomerates occur at the base of the Arikaree but are not widespread; these conglomerates are largely channellike lenticular deposits generally less than 60 feet thick. At many localities the conglomerates are interbedded with fine- to medium-grained light-gray calcareous sandstone lithologically similar to that in the lower part of the Arikaree, from which early Miocene fossils have been reported in the Granite Mountains (Rich, 1962, p. 506).

The following analyses are presented to show the striking similarity in chemical composition of the Miocene rocks on the west and east sides of the Laramie Range.

Rapid rock analyses of very fine grained tuffaceous sandstone of Miocene age

[Method described by Shapiro and Brannock (1956)]

	Lower and middle Miocene sandstone in central Wyoming (average thickness 1,000 ft)			Arikaree Formation in southeast Wyoming and northwest Nebraska (average thickness 700 ft)		
	Range (5 analyses)		Average	Range (10 analyses)		Average
	From—	To—		From—	To—	
SiO_2	65.1	74.3	69.7	66.8	75.8	71.9
Al_2O_3	10.7	12.5	11.7	10.5	13.2	11.9
K_2O	2.0	4.2	3.1	2.3	3.8	2.9
Fe_2O_3	2.2	3.1	2.5	2.2	3.4	2.7
CaO	1.6	2.6	2.3	1.2	3.1	2.3
Na_2O	1.3	2.0	1.6	1.4	2.4	2.0
MgO	1.3	2.6	1.9	.9	1.7	1.3
TiO_2	.21	.32	.26	.30	.46	.37
P_2O_5				.02	.12	.07
MnO				.04	.08	.06
H_2O	5.2	11.0	7.3	2.7	7.3	4.50
Sum			100.33			100.00

The Moonstone Formation defined by Love (1961, p. 25–35) for some lower or middle Pliocene rocks in the Granite Mountains area is a sufficiently distinctive lithologic unit to warrant a separate rock-stratigraphic designation; however, the white uranium-bearing shale, green tuff, bedded chalcedony, and finely-laminated tuffaceous arenites, algal reefs, and lenticular beds of conglomerate to which Love applied the term Moonstone are present only locally in the Granite Mountains. These rocks occur principally in an area of about 50 square miles in and adjacent to T. 30 N., R. 89 W. Elsewhere in the region a succession of rocks lithologically similar to those assigned to the Moonstone is not present. The term Moonstone, therefore, has limited use as a rock-stratigraphic designation and is referred to in this report as part of the Ogallala.

In summary, the lower and middle Miocene rocks of the Granite Mountains area of central Wyoming are composed largely of wind-blown fine- to medium-grained tuffaceous sandstone having thin and relatively unimportant interbeds of limestone, tuff, and conglomerate. These rocks average about 1,000 feet in thickness and constitute an easily recognized lithogenetic unit. This widespread unit has been mapped discontinuously from the vicinity of Oregon Buttes along the southwest flank of the Wind River Mountains through central and southeastern Wyoming into northwestern Nebraska. Because this unit is strikingly similar lithologically to the Arikaree Formation as defined by Darton and because the rocks that constitute it are unconformably overlain and underlain at most places by rocks that can properly be assigned to the Ogallala and White River Formations, respectively, the term Arikaree is applied here in central Wyoming with the same meaning given it by Darton in 1899. Since 1899, Arikaree has been used for Miocene (unrestricted) rocks in Wyoming by the U.S. Geological Survey, although the stratigraphic and chronologic range elsewhere has been restricted. As indicated in this report, the term "Split Rock Formation" is not regionally useful or meaningful and, therefore, is abandoned.

The Moonstone, originally defined to include some lower or middle Pliocene rocks in the Granite Mountains area, is referred to in this report as part of the Ogallala because of its limited areal extent.

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