Changes in Stratigraphic Nomenclature by the U.S. Geological Survey, 1968

By GEORGE V. COHEE, ROBERT G. BATES, *and* WILNA B. WRIGHT

CONTRIBUTIONS TO STRATIGRAPHY

GEOLOGICAL SURVEY BULLETIN 1294-A

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1970

CONTENTS

ILLUSTRATIONS

CONTRIBUTIONS TO STRATIGRAPHY

CHANGES IN STRATIGRAPHIC NOMENCLATURE BY THE U.S. GEOLOGICAL SURVEY, 1968

By George V. Cohee, Robert G. Bates, and Wilna B. Wright

LISTING OF NOMENCLATURAL CHANGES

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

One of the significant nomenclature changes in 1968 was the adoption by the U.S. Geological Survey of Holocene to replace Recent (Cohee, 1968). Holocene, meaning "wholly recent" and referring to the percentage of living organisms, originally was proposed as a "stage" following the Pleistocene "stage" by the Portuguese committee to the Third International Congress of 1885 (Morrison and others, 1957).

At the annual meeting of the American Commission on Stratigraphic Nomenclature, November 22, 1967, the Commission endorsed the use of Holocene instead of Recent and expressed the hope that the term "Holocene" would be adopted officially by various geological organizations. The formal term "Recent" was ambiguous in referring to sedimentary deposits, fossils, and present-day shells involving "Recent" or recent time. Holocene was given series rank equal to that of the Pleistocene because both vertebrate and invertebrate faunas reflect marked changes between Pleistocene and Holocene Epochs and the archaeological record provides means for subdividing Holocene deposits.

Changes in stratigraphic nomenclature

Name	Age	Location	Revision and reference
Ajibik Quartzite	middle Precambrian	Michigan	Ajibik Quartzite placed in the Menominee Group of the Animikie Series. Age changed from Precambrian to middle Precambrian. (Gair and Thaden, 1968.)
Alcova Limestone Member (of Chugwater Formation).	Triassic	Wyoming	Alcova Limestone Member of Chugwater Formation raised in rank to Alcova Limestone of Chugwater Group. (Pipiringos, 1968.)
Altonian Substage	Pleistocene	Illinois and Wisconsin	Altonian Substage of Frye and Willman (1960) adopted as basal substage of the Wisconsinan Stage. (Frye and others, 1968.)
Ames Limestone Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Ames is considered the top member of the Glenshaw Formation. (Roen and others, 1968.)
Ammonia Tanks Member (of Timber Mountain Tuff.)	early Pliocene	Nevada	Age changed from Pliocene to early Pliocene. (Kistler, 1968.)
Amsden Formation	Late Mississippian and Early and Middle Pennsylvanian.	Wyoming	Age changed from Early and Middle Pennsylvanian to Late Mississippian and Early and Middle Pennsylvanian. (Mallory, 1967.)
Apache Canyon Formation (of Bisbee Group)	Early Cretaceous	Southeastern Arizona	Apache Canyon Formation of Tyrrell (1957) adopted. Overlies Willow Canyon Formation; underlies Shellenberger Canyon Formation. (Finnell, this report, p. A32.)
Apsey Conglomerate Member (of Galiuro Volcanics).	Miocene	Arizona	Apsey Conglomerate Member adopted; overlies Hells Half Acre Tuff Member and underlies andesite of Table Mountain. (Krieger, 1968a.)
Aquia Formation	Paleocene	Maryland, Delaware, and Virginia.	Age changed from Eocene to Paleocene. (Hazel, 1968.)
Aravaipa Member (of Galiuro Volcanics)	Miocene	Arizona	Aravaipa Member adopted. (Krieger, 1968a.)
Arikaree Formation	early Miocene	North Dakota, South Dakota, Colorado, Montana, Nebraska, and Wyoming.	Age changed from early and middle Miocene to early Miocene. (Sato and Denson, 1967.)
Bachelor Mountain Rhyolite	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Banner Formation	Late Mississippian (Meramec)	Nevada	Banner Limestone of Granger and others (1957) adopted as Banner Formation. (Coats, 1969.)
Bardstown Member (of Drakes Formation)	Late Ordovician (Cincinnatian).	North-central Kentucky	Bardstown Member adopted as middle member of Drakes Formation in north-central Kentucky. (Peterson, this report, A36.)
Bates Mountain Tuff	Oligocene or Miocene	Nevada	Bates Mountain Tuff adopted. (Stewart and McKee, 1968).
Bathtub Formation	Early Cretaceous	Southeastern Arizona	Bathtub Formation adopted (Drewes, 1968.)
Bell Springs Member (of Nugget Sandstone)	Triassic(?)	Wyoming	Bell Springs Member adopted as basal member of Nugget Sandstone. (Pipiringos, 1968.)
Belted Range Tuff	late Miocene	Nevada	Age changed from Miocene and Pliocene(?) to late Miocene. (Noble and others, 1968.)
Bentley Formation	Pleistocene	Texas	Bentley Formation extended into Texas. (Wilson, 1967).

Bigford Member (of Mount Selman Formation)	middle Eocene	Southern Texas	In the Rio Grande embayment south of Frio River, the Bigford Member of the Mount Selman Formation is raised to formation rank, and the Mount Selman Formation is abandoned. (Eargle, 1968.)
Big Rock Conglomerate Member (of Kiawa Mountain Formation).	Precambrian	New Mexico	Big Rock Conglomerate Member of Barker (1958) adopted. (Barker, this report, p. A21.)
Birch Creek Schist	Precambrian or Paleozoic	Alaska	Birch Creek Schist restricted. Some of the rocks formerly assigned to the Birch Creek Schist now assigned to the Keevy Peak Formation. (Wahrhaftig, 1968.)
Birmingham Shale Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is con-considered of group rank and consists of the Casselman and Glenshaw Formations, and the Birmingham is considered the basal member of the Casselman Formation. (Roen and others, 1968.)
Bisbee Group	Early Cretaceous	Southeastern Arizona	In the Empire and Santa Rita Mountains, the Bisbee Group includes (ascending order): Glance Conglomerate, Willow Canyon, Apache Canyon, Shellenberger Canyon, and Turney Ranch Formations (Finnell, this report, p. A28.)
Black Mingo Formation	Paleocene and Eocene	North Carolina and South Carolina.	Age changed from Eocene to Paleocene and Eocene. (Hazel, 1968.)
Blanco Basin Formation	early Eocene	Southwestern Colorado	Age changed from Oligocene(?) to early Eocene. (Steven and others, 1967.)
Bluefield Formation	Late Mississippian	Virginia and West Virginia	Indian Mills Sandstone Member of Reger and Price (1926) adopted as member of Bluefield Formation. (Englund, 1968a.)
Blue Mesa Tuff	late Oligocene	Colorado	Blue Mesa Tuff adopted. (Olson and others, 1968.)
Bluestone Formation (of Pennington Group)	Late Mississippian and Early Pennsylvanian.	Virginia and West Virginia	Formation divided into (ascending order): Pride Shale, Glady Fork Sandstone, gray, red, Bramwell, and upper members. Age changed from Late Mississippian to Late Mississippian and Early Pennsylvanian. (Englund, 1968a.)
Bossier Formation (of Cotton Valley Group)	Late Jurassic	Texas, Louisiana, and Arkansas.	Subsurface. The Bossier is expanded to include all the dark-gray shale above the lower member of the Smackover Formation and below the Schuler Formation. (Dickinson, 1968.)
Bouse Formation	Pliocene	Southwestern Arizona	Bouse Formation adopted. (Metzger, 1968).
Bramwell Member (of Bluestone Formation)	Late Mississippian	Virginia and West Virginia	Bramwell Member adopted. (Englund, 1968a.)
Brayman Shale	Late Silurian	New York	Age changed from Silurian to Late Silurian. (Pavlides and others, 1968.)
Brightseat Formation	Paleocene	Maryland	Brightseat Formation made basal formation of Pamunkey Group. (Hazel, 1968.)
Bronco Volcanics	Late Cretaceous	Southeastern Arizona	Age changed from Cretaceous or early Tertiary to Late Cretaceous. (Hayes and Drewes, 1968.)
Brush Creek Limestone Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Brush Creek is considered a member of the Glenshaw Formation. (Roen and others, 1968.)
Brynt Draw Member (of Popo Agie Formation)	Late Triassic	Wyoming	Brynt Draw adopted as basal member of Popo Agie Formation. (Pipiringos, 1968.)

Changes in stratigraphic nomenclature—Continued

Name	Age	Location	Revision and reference
Buffalo Sandstone Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Buffalo is considered a member of the Glenshaw Formation. (Roen and others, 1968.)
Bull Ridge Member (of Madison Limestone)	Early Mississippian (early Meramec).	West-central Wyoming	Bull Ridge adopted as upper member of the Madison Limestone. (Sando, 1968.)
Bunker Andesite	Oligocene	Southern Colorado	Name changed to Bunker Trachyandesite; age changed from Eocene to Oligocene. (Steven and Epis, 1968.)
Burnett Formation (of Puget Group)	Eocene	Washington	Name abandoned. Lower part now assigned to Carbonado Formation and upper part to Spiketon Formation. (Gard, 1968.)
Burns Formation (of Silverton Volcanic Group)	Oligocene	Colorado	Age changed from middle and late Tertiary to Oligocene. (Luedke and Burbank, 1968.)
Bursum Formation (of Magdalena Group)	Early Permian	New Mexico	Formation restricted, geographically, to vicinity of Oscura Mountains, central New Mexico. (Bachman, 1968.)
California Creek Member (of Totatlanika Schist).	Mississippian(?)	Alaska	California Creek Member adopted. (Wahrhaftig, 1968.)
Camarones Sandstone	Late Cretaceous	Puerto Rico	Camarones Sandstone adopted. (Pease, 1968a.)
Cambridge Limestone Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Cambridge is considered a member of the Glenshaw Formation. (Roen and others, 1968.)
Camden Chert	Early Devonian	Kentucky, Tennessee, and Alabama.	Age changed from Early and Middle Devonian to Early Devonian. (Boucot and Johnson, 1968.)
Campbell Mountain Member (of Bachelor Mountain Rhyolite).	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Cancel Breccia	Early to Late Cretaceous	Puerto Rico	Cancel Breccia adopted. (Pease, 1968a.)
Canelo Hills Volcanics	Late Triassic and Early Jurassic.	Southeastern Arizona	Age changed from Triassic and Jurassic to Late Triassic and Early Jurassic. (Hayes and Drewes, 1968.)
Cantwell Formation	Paleocene	Alaska	Age changed from Early Cretaceous to Paleocene. (Wolfe and Wahrhaftig, this report, p. A41.)
Carbonado Formation (of Puget Group)	middle(?) Eocene	Washington	Carbonado Formation revised to include the Wilkeson Formation (abandoned) and the lower part of the Burnett Formation (abandoned). Age changed from Eocene to middle(?) Eocene. (Gard, 1968.)
Cardiff Conglomerate	Ordovician(?)	Maryland and Pennsylvania	Cardiff Conglomerate changed to Cardiff Metaconglomerate. (Southwick and Fisher, 1967.)
Carpenter Ridge Tuff	Oligocene	Colorado	Carpenter Ridge Tuff adopted. (Olson and others, 1968.)
Carraízo Breccia	Late Cretaceous	Puerto Rico	Carraízo Breccia adopted. (Pease, 1968a.)
Cash Creek Quartzite	Early or Middle Ordovician	Idaho	Cash Creek Quartzite adopted. (Hobbs and others, 1968.)

Casper Formation	Early, Middle, and Late Pennsylvanian and Early Permian.	Southern Wyoming	Age changed from Pennsylvanian and Permian to Early Pennsylvanian through Early Permian. (Mallory, 1967.)
Casselman Formation (of Conemaugh Group)	Late Pennsylvanian	Pennsylvania and Ohio	Casselman Formation of Flint (1965) adopted wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized. In those areas, the Conemaugh is considered a group and includes the Glenshaw and Casselman Formations. Members of the Casselman (in ascending order) are: Birmingham Shale, Elk Lick Limestone, Morgantown Sandstone, Clarksburg Limestone, Connellsville Sandstone, Summerhill Sandstone, and Wilmore Sandstone. (Roen and others, 1968.)
Cerro Gordo Lava	Early to Late Cretaceous	Puerto Rico	Cerro Gordo Formation of Lidiak (1965) adopted as Cerro Gordo Lava. (Pease, 1968a.)
Chesterfield Range Group	Late Mississippian	Utah	Chesterfield Range Group extended into northeastern Utah. (Sando, 1967.)
Chinquapin Metabasalt Member (of South Fork Mountain Schist).	Late(?) Cretaceous	Northwestern California	Chinquapin Metabasalt Member adopted. (Blake and others, 1967.)
Chocolay Group (of Animikie Series)	middle Precambrian	Michigan	In the Marquette area, the Chocolay Group includes (in ascending order): Enchantment Lake Formation (new), Mesnard Quartzite, Kona Dolomite, and Wewe Slate. (Gair and Thaden, 1968.)
Chugwater Formation	Triassic	Wyoming	Chugwater Formation raised to group rank; includes (in ascending order): Red Peak Formation, Alcova Limestone, Crow Mountain Sandstone (locally Jelm Formation), and Popo Agie Formation. (Pipiringos, 1968.)
Chute Creek Member (of Totatlanika Schist)	Mississippian(?)	Alaska	Chute Creek Member adopted. (Wahrhaftig, 1968.)
Cibao Formation	late Oligocene and early Miocene.	Puerto Rico	Age changed from Oligocene and Miocene to late Oligocene and early Miocene. (Briggs, 1968.)
Claiborne Group	middle Eocene	Texas	Cook Mountain Formation in Texas restricted to eastern and central parts; replaced by Laredo Formation in Rio Grande embayment south of Frio River. (Eargle, 1968.)
Clamgulchian Stage (Floral)	Miocene(?) and Pliocene	South-central Alaska	Clamgulchian Stage (Floral) adopted. (Wolfe and others, 1966.)
Clarksburg Limestone Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Clarksburg is considered a member of the Casselman Formation. (Roen and others, 1968.)
Clayton Mine Quartzite	Middle Ordovician or older	Idaho	Clayton Mine Quartzite adopted. (Hobbs and others, 1968.)
Clear Creek Formation	Early Devonian	Illinois, Missouri, and Kentucky.	Age changed from Early and Middle Devonian to Early Devonian. (Boucot and Johnson, 1968.)
Clyde Formation	Early Permian (Leonard)	Texas	Age changed from Early Permian (Leonard?) to Early Permian (Leonard). (Myers, 1968.)
Coalmont Formation	Paleocene and Eocene	Colorado	In the southwestern part of the North Park area, the Middle Park Formation is reduced in rank and made the basal member of the Coalmont Formation. (Hail, 1968.)
Cockeysville Marble (of Glenarm Series)	late Precambrian(?)	Maryland, Pennsylvania, and Delaware.	Age changed from early Paleozoic(?) to late Precambrian(?) (Southwick and Fisher, 1967.)
Compeau Creek Gneiss	early Precambrian	Michigan	Compeau Creek Gneiss adopted. (Gair and Thaden, 1968.)

370-838—70——2

Changes in stratigraphic nomenclature—Continued

Name	Age	Location	Revision and reference
Conejos Quartz Latite	Oligocene or older	Colorado	Age changed from middle or late Tertiary to Oligocene or older. (Olson and others, 1968.)
Conemaugh Formation	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and includes two formations, the Glenshaw (basal) and Casselman Formations. The Ames is the top member of the Glenshaw. (Roen and others, 1968.)
Conestoga Limestone	Early Ordovician	Pennsylvania	Age changed from Late Cambrian and Early Ordovician to Early Ordovician. (Meisler and Becher, 1968.)
Connellsville Sandstone Member (of Conemaugh Formation)	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Connellsville is considered a member of the Casselman Formation. (Roen and others, 1968.)
Continental Granodiorite	Precambrian	Southeastern Arizona	Continental Granodiorite adopted. (Drewes, 1968.)
Cook Mountain Formation (of Claiborne Group)	middle Eocene	Texas	Cook Mountain Formation in Texas restricted to eastern and central parts; replaced by Laredo Formation in Rio Grande embayment south of Frio River. (Eargle, 1968.)
Copper Creek Granodiorite	Late Cretaceous and (or) early Tertiary.	Arizona	Age changed from Late(?) Cretaceous or Tertiary to Late Cretaceous and (or) early Tertiary. (Krieger, 1968b.)
Crab Orchard Formation	Early and Middle Silurian	Kentucky	Lulbegrud Clay, Waco Limestone, and Estill Clay, all of Foerste (1905), adopted. Formation includes (in ascending order): Plum Creek, Oldham, Lulbegrud Shale, Waco, and Estill Shale Members. (Simmons, 1967.)
Creede Formation	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Crow Mountain Sandstone Member (of Chugwater Formation).	Late Triassic	Wyoming	Crow Mountain Sandstone Member raised to formation rank. Included in Chugwater Group. (Pipiringos, 1968.)
Darwin Sandstone Member (of Amsden Formation).	Late Mississippian	do	Age changed from Early Pennsylvanian to Late Mississippian. (Mallory, 1967.)
Devils Hole Formation	late Eocene	South-central Colorado	Age changed from Miocene(?) to late Eocene. (Steven and Epis, 1968.)
Dewitt Formation	Miocene and Pliocene	Eastern Texas	Formation was named by Deussen (1914). In subsequent work by Deussen the name was not used nor was it ever used by any other author. Abandoned for nonuse.
Diamond Peak Formation	late Mississippian and Early Pennsylvanian.	Nevada	Age changed from Mississippian to Late Mississippian and Early Pennsylvanian in the Carlin-Pinon Range area. (Smith and Ketner, 1968.)
Dillon Mesa Tuff	late Oligocene	Colorado	Dillon Mesa Tuff adopted. (Olson and others, 1968.)
Dixville Formation	Middle Ordovician	Maine and New Hampshire	Dixville Formation of Green (1964) adopted. (Harwood and Berry, 1967.)
Drakes Formation	Late Ordovician (Cincinnatian).	North-central Kentucky	Bardstown Member adopted as middle member of Drakes Formation in north-central Kentucky. Overlies Rowland

			Member and underlies Saluda Dolomite Member. (Peterson, this report, p. A36.)
Eagle Valley Evaporite	Pennsylvanian and Permian	Colorado	Name changed from Eagle Valley Evaporite to Eagle Valley Formation. (Bartleson and others, 1968.)
Elephant Head Quartz Monzonite	Late Cretaceous	Southeastern Arizona	Elephant Head Quartz Monzonite adopted. (Drewes, 1968.)
Elk Lick Limestone Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Elk Lick is considered a member of the Casselman Formation. (Roen and others, 1968.)
Ella Dolomite	Middle Ordovician	Idaho	Ella Dolomite adopted. (Hobbs and others, 1968.)
Ellensburg Formation	late Miocene and early Pliocene.	Oregon	Ellensburg Formation extended from Washington into north-central Oregon. (Waters, 1968.)
El Ocho Formation	Early to Late Cretaceous	Puerto Rico	El Ocho Formation adopted. (Pease, 1968a.)
El Pico Clay (of Claiborne Group)	middle Eocene	Southern Texas	El Pico Clay adopted for the former upper unnamed member of the Mount Selman Formation (abandoned) in the Rio Grande embayment south of Frio River. (Eargle, 1968.)
Enchantment Lake Formation (of Chocolay Group, Animikie Series).	middle Precambrian	Michigan	Enchantment Lake Formation adopted. (Gair and Thaden, 1968.)
Esch Creek Glaciation	Holocene	Alaska	Esch Creek Glaciation adopted. (Sainsbury, 1967.)
Estill Shale Member (of Crab Orchard Formation).	Middle Silurian	Kentucky	Estill Clay of Foerste (1905) adopted as Estill Shale Member. (Simmons, 1967.)
Eureka Tuff (of Silverton Volcanic Group)	Oligocene	Colorado	Age changed from middle and late Tertiary to Oligocene. (Luedke and Burbank, 1968.)
Ewing Limestone Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Ewing is considered a member of the Glenshaw Formation. (Roen and others, 1968.)
Fajardo Formation	Late Cretaceous	Puerto Rico	Fajardo Formation replaced by Rio Piedras Siltstone in Naranjito quadrangle. (Pease, 1968b.)
Falls Mills Sandstone Member (of Hinton Formation).	Late Mississippian	Virginia and West Virginia	Falls Mills Sandstone Member of Reger and Price (1926) adopted. (Englund, 1968a.)
Farisita Conglomerate	late Eocene	South-central Colorado	Age changed from Oligocene(?) to late Eocene. (Steven and Epis, 1968.)
Farmdale Silt	late Pleistocene	Illinois and Wisconsin	Farmdale Silt of Frye and Willman (1960) adopted. (Frye and others, 1968.)
Farmdalian Substage (of Wisconsinan Stage)	do	do	Farmdalian Substage of Frye and William (1960) adopted. Overlies Altonian Substage and underlies Woodfordian Substage. (Frye and others, 1968.)
Farmers Creek Rhyolite	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Figuera Volcanics	late Paleocene or early Eocene	Puerto Rico	Figuera Volcanics abandoned; replaced by Guaracanal Andesite. (Pease, 1968a.)
Fish Canyon Tuff	late Oligocene	Colorado	Fish Canyon Tuff adopted. (Olson and others, 1968.)
Fisher Quartz Latite	Oligocene	do	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Fleming Formation	Miocene	Louisiana and Texas	Fleming Formation, previously abandoned, reinstated. (Anders and others, 1968.)

Changes in stratigraphic nomenclature—Continued

Name	Age	Location	Revision and reference
Fort Crittenden Formation	Late Cretaceous	Southeastern Arizona	Fort Crittenden Formation of Stoyanow (1949) adopted. (Drewes, 1968.)
Fraction Tuff	middle Miocene	Nevada	Age changed from late Miocene to middle Miocene. (Anderson and Ekren, 1968.)
Frailes Formation	Late Cretaceous	Puerto Rico	The Frailes Formation, as used by Kaye (1959), is not a mappable unit in the report area and is included in the revised Guaynabo Formation, except for La Muda Limestone Member which is raised to formation rank. (Pease, 1968a.)
Franklinian Stage (Floral)	early Eocene	West-central Washington	Franklinian Stage (Floral) adopted. (Wolfe, 1968.)
Fultonian Stage (Floral)	middle Eocene	do	Fultonian Stage (Floral) adopted. (Wolfe, 1968.)
Galiuro Volcanics	Miocene	Arizona	Includes (in ascending order): Holy Joe, Aravaipa, Hells Half Acre Tuff, and Apsey Conglomerate Members. Age changed from middle Tertiary or younger to Miocene. (Krieger, 1968b.)
Gallatin Group	Late Cambrian	Wyoming and Montana	Grove Creek Formation reduced to member rank and made upper member of Snowy Range Formation. Group includes (in ascending order): Pilgrim Limestone and Snowy Range Formation. (Pierce and Nelson, 1968.)
Gardner Canyon Formation	Triassic	Southeastern Arizona	Gardner Canyon Formation adopted. (Drewes, 1968.)
Ghost Rocks Formation	Paleocene and Eocene	Southern Alaska	Ghost Rocks Formation adopted. (Moore, 1969.)
Glady Fork Sandstone Member (of Bluestone Formation).	Late Mississippian	Virginia and West Virginia	Glady Fork Sandstone Member of Reger and Price (1926) adopted. (Englund, 1968a.)
Glenarm Series	late Precambrian(?)	Maryland, Pennsylvania, New Jersey, Delaware, and Virginia.	Age changed from early Paleozoic(?) to late Precambrian(?). In Maryland the following units are excluded from the Glenarm Series: Ijamsville Phyllite, Marburg Schist, Silver Run Limestone, Urbana Phyllite, and Wakefield Marble. In Maryland the following units are included in the Glenarm Series: Setters Formation, Cockeysville Marble, and the Wissahickon Formation (revised). (Southwick and Fisher, 1967.)
Glenshaw Formation (of Conemaugh Group)	Late Pennsylvanian	Pennsylvania and Ohio	Glenshaw Formation of Flint (1965) adopted wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized. In those areas, the Conemaugh is considered a group and includes the Glenshaw and Casselman Formations. Members of the Glenshaw (in ascending order) are: Uffington Shale, Mahoning Sandstone, Brush Creek Limestone, Buffalo Sandstone, Cambridge Limestone, Ewing Limestone, Saltsburg Sandstone, and Ames Limestone. (Roen and others, 1968.)
Glory Hole Volcanics	Late Cretaceous and (or) early Tertiary.	Arizona	Age changed from Late(?) Cretaceous to early Tertiary to Late Cretaceous and (or) early Tertiary. (Krieger, 1968b.)
Grape Creek Limestone Member (of Clyde Formation).	Early Permian (Leonard)	Texas	Age changed from Early Permian (Leonard?) to Early Permian (Leonard). (Myers, 1968.)

Gringo Gulch Volcanics	Paleocene(?)	Southeastern Arizona	Gringo Gulch Volcanics adopted. (Drewes, 1968.)
Grossman Formation	Devonian or Mississippian	Nevada	Grossman Formation adopted. (Coats, 1969.)
Grosvenor Hills Volcanics	late(?) Oligocene	Southeastern Arizona	Grosvenor Hills Volcanics adopted. (Drewes, 1968.)
Grouse Canyon Member (of Belted Range Tuff)	late Miocene	Nevada	Age changed from Miocene and Pliocene(?) to late Miocene (Noble and others, 1968.)
Grouse Canyon Member (of Indian Trail Formation).	do	do	Age changed from Miocene and Pliocene(?) to Miocene. (Kistler, 1968.)
Grove Creek Formation	Late Cambrian	Wyoming and Montana	Grove Creek Formation reduced to member rank and made upper member of Snowy Range Formation. (Pierce and Nelson, 1968.)
Guaracanal Andesite	Paleocene	Puerto Rico	Guaracanal Andesite adopted; replaces Figuera Volcanics which was abandoned. (Pease, 1968a.)
Guaynabo Formation	Late Cretaceous	do	Redefined to include parts of the Frailes Formation as used by Kaye (1959) and to exclude the younger La Muda Member. Includes Martín González Lava and Leprocomio Siltstone Members. Age changed from Late Cretaceous(?) to Late Cretaceous. (Pease, 1968a.)
Hackett Sandstone Member (of Hinton Formation).	Late Mississippian	Virginia and West Virginia	Hackett Sandstone Member of Reger and Price (1926) adopted. (Englund, 1968a).
Hance Formation (of Breathitt Group)	Middle Pennsylvanian	Tennessee	Ivydell Sandstone Member adopted as member of Hance Formation. (Englund, 1968b.)
Hauser Lake Gneiss	Precambrian	Washington and Idaho	Hauser Lake Gneiss adopted. (Weis, 1968.)
Hells Half Acre Tuff Member (of Galiuro Volcanics).	Miocene	Southeastern Arizona	Hells Half Acre Tuff Member adopted, underlies Apsey Conglomerate Member. (Krieger, 1968a.)
Henson Formation	Oligocene	Colorado	Age changed from middle and late Tertiary to Oligocene. (Luedke and Burbank, 1968.)
Hildreths Formation	Devonian(?)	Maine	Hildreths Formation adopted. (Osberg and others, 1968.)
Hinsdale Formation	late Tertiary	Colorado	Age changed from Pliocene(?) to late Tertiary. (Steven and others, 1967.)
Hinton Formation	Late Mississippian	Virginia and West Virginia	Hinton Formation in Virginia and West Virginia divided into (in ascending order): Stony Gap Sandstone Member, Hackett Sandstone Member, Little Stone Gap Member, Neal Sandstone Member, middle shale member, Tallery Sandstone Member, Pratter Shale Member, Falls Mills Sandstone Member, and upper shale member. (Englund, 1968a.)
Holocene Epoch	Quaternary	United States	Holocene Epoch adopted to replace Recent Epoch as the second and younger epoch in the Quaternary Period. (Cohee, 1968.)
Holy Joe Member (of Galiuro Volcanics)	Miocene	Arizona	Holy Joe Member adopted. (Krieger, 1968b.)
Homerian Stage (Floral)	Miocene and Pliocene(?)	South-central Alaska	Homerian Stage (Floral) adopted. (Wolfe and others, 1966.)
Horseshoe Shale Member (of Amsden Formation).	Late Mississippian and Early Pennsylvanian.	Wyoming	Horseshoe Shale Member adopted. (Mallory, 1967.)
Huerto Formation	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Ijamsville Phyllite	early Paleozoic(?)	Maryland	Ijamsville Phyllite is excluded from the Glenarm Series. (Southwick and Fisher, 1967.)
Indian Hills Volcanics (of Alder Group)	Precambrian	Arizona	Indian Hills Volcanics abandoned. Rocks previously assigned to the Indian Hills Volcanics are now assigned to the Green Gulch Volcanics. (Anderson and Creasey, 1967.)
Indian Mills Sandstone Member (of Bluefield Formation).	Late Mississippian	Virginia and West Virginia	Indian Hills Sandstone Member of Reger and Price (1926) adopted. (Englund, 1968a).

Changes in stratigraphic nomenclature—Continued

Name	Age	Location	Revision and reference
Indian Trail Formation	Miocene	Nevada	Age changed from Miocene and Pliocene(?) to Miocene. (Kistler, 1968.)
Iron River Iron-Formation Member (of Michigamme Slate).	Precambrian	Michigan and Wisconsin	Iron River Iron-Formation Member abandoned. (James and others, 1968.)
Ivydell Sandstone Member (of Hance Formation).	Middle Pennsylvanian	Northeastern Tennessee	Ivydell Sandstone Member adopted. (Englund, 1968b.)
James Run Gneiss	late Precambrian(?)	Maryland	James Run Gneiss adopted. (Southwick and Fisher, 1967.)
Jawbone Conglomerate Member (of Kiawa Mountain Formation).	Precambrian	New Mexico	Jawbone Conglomerate Member of Barker (1958) adopted. (Barker, this report, p. A21.)
Jeffersonville Limestone	Early and Middle Devonian	Indiana and Kentucky	Age changed from Middle Devonian to Early and Middle Devonian. (Boucot and Johnson, 1968.)
Jelm Formation	Late Triassic	Wyoming	Jelm Formation assigned to the Chugwater Group; limited geographically to areas south of the Wind River basin. Members are Red Draw and Sips Creek. (Pipiringos, 1968.)
Jim Mountain Member (of Wapiti Formation)	early(?) and middle (?) Eocene.	Northwestern Wyoming	Jim Mountain Member adopted. (Nelson and Pierce, 1968.)
Jobos Formation	Eocene(?)	Puerto Rico	Jobos Formation adopted. (Nelson, 1967.)
Josephine Canyon Diorite	Late Cretaceous	Southeastern Arizona	Josephine Canyon Diorite adopted. (Drewes, 1968.)
Junction Creek Sandstone	Late Jurassic	Colorado	Junction Creek Sandstone reduced to member rank as Junction Creek Member of the Wanakah Formation. (Hansen, 1968.)
Kane Wash Tuff	Miocene	Nevada	Kane Wash Formation of Cook (1965) adopted as Kane Wash Tuff. (Noble, 1968.)
Kanouse Sandstone	Early Devonian	New York and New Jersey	Age changed from Early and Middle Devonian to Early Devonian. (Boucot and Johnson, 1968.)
Keevy Peak Formation	Precambrian or Paleozoic	Alaska	Keevy Peak Formation adopted for rocks that were previously part of Birch Creek Schist. (Wahrhaftig, 1968.)
Kiawa Mountain Formation	Precambrian	New Mexico	Kiawa Mountain Formation of Barker (1958) adopted. (Barker, this report, p. A21.)
Kinnikinic Quartzite	Middle Ordovician	Idaho	Age changed from Late Ordovician to Middle Ordovician. (Ruppel, 1968.)
Kinnikinic Quartzite	do	Central Idaho	Kinnikinic Quartzite restricted to uppermost pure well-sorted quartzite of Middle Ordovician age in central Idaho. (Hobbs and others, 1968.)
Kodiak Formation	Cretaceous	Southern Alaska	Kodiak Formation adopted. (Moore, 1969.)
Kokoruda Ranch Complex	Tertiary or Cretaceous	Western Montana	Kokoruda Ranch Complex adopted. (Smedes, 1966.)
Kona Dolomite	middle Precambrian	Michigan	Kona Dolomite is placed in the Chocolay Group (Animikie Series). (Gair and Thaden, 1968.)
Kummerian Stage (Floral)	early Oligocene	West-central Washington	Kummerian Stage (Floral) adopted. (Wolfe, 1968.)
La Garita Quartz Latite	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Lake Fork Quartz Latite	Oligocene or older	Colorado	Name changed to Lake Fork Formation; age changed from Miocene(?) to Oligocene or older. (Olson and others, 1968.)

LaMuda Limestone Member (of Frailes Formation).	Late Cretaceous	Puerto Rico	LaMuda Limestone Member raised to formation rank, La Muda Formation. (Pease, 1968a.)
Laredo Formation (of Claiborne Group)	middle Eocene	Texas	In the Rio Grande embayment south of the Frio River, the Laredo Formation replaces the Cook Mountain Formation which is restricted to eastern and central Texas north of the Frio River. (Eargle, 1968.)
Leprocomio Limestone Member (of Frailes Formation).	Late Cretaceous	Puerto Rico	Leprocomio Limestone Member of Frailes Formation revised to Leprocomio Siltstone Member of Guaynabo Formation. (Pease, 1968a.)
Lexington Limestone	Middle and Late Ordovician	Kentucky	Age changed from Middle Ordovician to Middle and Late Ordovician. (Cressman, 1967).
Lighthouse Point Member (of Mona Schist)	early Precambrian	Michigan	Lighthouse Point Member adopted. (Gair and Thaden, 1968.)
Little Elk Granite	Precambrian	South Dakota	Little Elk Granite of Taylor (1935) adopted. (Zartman and Stern, 1967.)
Little Flat Formation (of Chesterfield Range Group).	Late Mississippian	Northeastern Utah and southeastern Idaho.	Formation extended into northeastern Utah. (Sando, 1967.)
Littleton Formation	Early Devonian	New Hampshire	Age of the Littleton, in its type area only, changed from Late Silurian(?) and Early Devonian to Early Devonian. (Boucot and Johnson, 1968.)
Loues Formation	Precambrian	South Dakota	Loues Formation adopted. (Redden, 1968.)
Loveland Loess	Pleistocene	Wisconsin and Illinois	Loveland Loess changed to Loveland Silt in Illinois and Wisconsin. (Frye and others, 1968.)
Lubbe Creek Formation	Early Jurassic	Alaska	Lubbe Creek Formation adopted. (MacKevett, 1969.)
Lulbegrud Shale Member (of Crab Orchard Formation).	Middle Silurian	Kentucky	Lulbegrud Shale Member of Foerste (1905) adopted. (Simmons, 1967.)
Lyons Valley Member (of Popo Agie Formation).	Late Triassic	Wyoming	Lyons Valley Member adopted. (Pipiringos, 1968.)
McClure Mountain Complex	Precambrian or Cambrian	Colorado	McClure Mountain Complex adopted. (Shawe and Parker, 1967.)
Mackay Granite	early Tertiary	Idaho	Mackay Granite adopted. (Nelson and Ross, 1968.)
Madera Canyon Granodiorite	Late Cretaceous	Southeastern Arizona	Madera Canyon Granodiorite adopted. (Drewes, 1968.)
Madison Limestone	Early Mississippian (early Meramec).	West-central Wyoming	Bull Ridge adopted as upper member of the Madison Limestone. (Sando, 1968.)
Madrid Formation	Silurian or Devonian	Maine	Madrid Formation of Cariani (1959) adopted. (Osberg and others, 1968.)
Mahoning Sandstone Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Mahoning is considered a member of the Glenshaw Formation. (Roen and others, 1968.)
Mamey Lava Member (of Camarones Sandstone).	Late Cretaceous	Puerto Rico	Mamey Lava Member adopted. (Pease, 1968a.)
Mammoth Mountain Rhyolite	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Mancos Shale	Late Cretaceous	New Mexico	Semilla Sandstone Member adopted; overlies Greenhorn Limestone Member and underlies Juana Lopez Member in San Juan Basin. (Dane and others, 1968.)
Marburg Schist	early Paleozoic(?)	Maryland and Pennsylvania	Marburg Schist is excluded from Glenarm Series. (Southwick and Fisher, 1967.)

Changes in stratigraphic nomenclature—Continued

Name	Age	Location	Revision and reference
Martín González Lava Member (of Guaynabo Formation).	Late Cretaceous	Puerto Rico	Martín González Lava Member adopted. (Pease, 1968a.)
Mayflower Hill Formation	Early Silurian	Maine	Mayflower Hill Formation adopted. (Osberg and others, 1968.)
Menominee Group	middle Precambrian	Michigan	Ajibik Quartzite and Siamo Slate placed in Menominee Group in the Marquette area. (Gair and Thaden, 1968.)
Mesnard Quartzite (of Chocolay Group, Animikie Series).	do	do	Mesnard Quartzite placed in Chocolay Group. Former age was Precambrian. Formation restricted to the relatively thick and massive vitreous quartzite. The lower part of the former Mesnard is placed in the Enchantment Lake Formation (new). (Gair and Thaden, 1968.)
Middle Park Formation	Paleocene	Colorado	In the southwestern part of the North Park area, the Middle Park Formation is reduced in rank and made the basal member of the Coalmont Formation. (Hail, 1968.)
Milligen Formation	Early Mississippian	Idaho	Age changed from Devonian(?) and Early Mississippian to Early Mississippian. (Sandberg and others, 1967.)
Mingo Formation (of Breathitt Group)	Middle Pennsylvanian	Tennessee	Pioneer Sandstone of Glenn (1925) adopted as Pioneer Sandstone Member of Mingo Formation. (Englund, 1968b.)
Minnelusa Formation	Early, Middle, and Late Pennsylvanian and Early Permian.	Wyoming	Age changed from Pennsylvanian and Permian to Early, Middle, and Late Pennsylvanian and Early Permian. (Mallory, 1967.)
Mona Schist	early Precambrian	Michigan	Mona Schist divided into Lighthouse Point Member and unnamed lower member. (Gair and Thaden, 1968.)
Monacillo Formation	Late Cretaceous	Puerto Rico	Trujillo Alto Limestone reduced in rank and made member of the Monacillo Formation. (Pease, 1968a).
Monroe Canyon Limestone	Mississippian	Northeastern Utah and southeastern Idaho.	Monroe Canyon Limestone extended into northeastern Utah. (Sando, 1967.)
Montgomery Formation	Pleistocene	Texas and Louisiana	Montgomery Formation extended into Texas. (Wilson, 1967.)
Moose Creek Member (of Totatlanika Schist)	Mississippian(?)	Alaska	Moose Creek Member adopted. (Wahrhaftig, 1968.)
Morgan Formation	Early and Middle Pennsylvanian.	Wyoming	Age changed from Middle Pennsylvanian to Early and Middle Pennsylvanian. (Mallory, 1967.)
Morgantown Sandstone Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member of the Glenshaw Formation can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Morgantown is considered a member of the Casselman Formation. (Roen and others, 1968.)
Morton Gneiss	Precambrian	Minnesota	Morton Gneiss of Theil and Dutton (1935) adopted. (Stern and others, 1966.)
Morton Loess	Pleistocene	Illinois and Wisconsin	Morton Loess of Frye and Willman (1960) adopted. (Frye and others, 1968.)
Mountain City Formation	Carboniferous(?)	Nevada	Mountain City Formation of Granger and others (1957) adopted. (Coats, 1969.)

370-838—70——3

Mount Selman Formation (of Claiborne Group)	middle Eocene	Texas	Mount Selman Formation abandoned, and former members of formation raised to formation rank. In eastern and central Texas, they include (in ascending order): Reklaw Formation, Queen City Sand, and Weches Formation. In the Rio Grande embayment south of the Frio River, they include (in ascending order): Bigford Formation and El Pico Clay (new). (Eargle, 1968.)
Mount Wrightson Formation	Triassic	Southeastern Arizona	Mount Wrightson Formation adopted. (Drewes, 1968.)
Mystic Creek Member (of Totatlanika Schist)	Mississippian(?)	Alaska	Mystic Creek Member adopted. (Wahrhaftig, 1968.)
Nantahala Slate	early Paleozoic(?)	North Carolina, Tennessee, and Georgia.	Age designated as early Paleozoic(?). (King and others, 1968.)
Naranjito Formation	Paleocene	Puerto Rico	Naranjito Formation adopted. (Pease, 1968a.)
Narrow Cape Formation	Miocene	Southern Alaska	Narrow Cape Formation adopted. (Moore, 1969.)
Neal Sandstone Member (of Hinton Formation)	Late Mississippian	Virginia and West Virginia	Neal Sandstone Member adopted as substitute for Avis Sandstone of Reger and Price (1926). Name Avis preoccupied by reason of use in Texas. (Englund, 1968a.)
Nelson Formation	do	Nevada	Nelson Amphibolite of Granger and others (1957) adopted as Nelson Formation. (Coats, 1969.)
Newman Lake Gneiss	Precambrian	Eastern Washington	Newman Lake Gneiss adopted. (Weis, 1968.)
New River Formation	Early Pennsylvanian	Pennsylvania, Virginia, and West Virginia.	Pineville Sandstone Member of Hennen and Gawthrop (1915) adopted. (Englund, 1968a).
Nizina Mountain Formation	Middle and Late Jurassic	Alaska	Nizina Mountain Formation adopted. (MacKevett, 1969.)
Northcraft Formation	late Eocene	Washington	Northcraft Formation placed in Puget Group. (Gard, 1968.)
North Haven Greenstone	Middle Ordovician(?)	Maine	Age changed from Cambrian(?) to Middle Ordovician(?). (Pavlides and others, 1968.)
Nugget Sandstone	Triassic(?) and Jurassic(?)	Wyoming	Bell Springs Member of Triassic(?) age adopted as basal member. Age changed from Early Jurassic to Triassic(?) and Jurassic(?). (Pipiringos, 1968.)
Nussbaum Alluvium	Pleistocene	Colorado	Age changed from Pleistocene(?) to Pleistocene. (Soister, 1967.)
O'Brien Creek Formation	middle Eocene	Northeastern Washington	Age changed from Eocene(?) to middle Eocene. (Yates and Engels, 1968.)
Ohanapecosh Formation	Oligocene	Washington	Age changed from late Eocene to Oligocene. (Wolfe, 1968.)
Ortega Quartzite	Precambrian	New Mexico	Ortega Quartzite of Barker (1958) adopted. (Barker, this report, p. A21.)
Outlet Tunnel Member (of La Garita Quartz Latite).	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Pah Canyon Member (of Paintbrush Tuff)	late Miocene	Nevada	Age changed from Miocene(?) and Pliocene to late Miocene. (Kistler, 1968.)
Paintbrush Tuff (of Piapi Canyon Group)	do	do	Age changed from Miocene(?) and Pliocene to late Miocene. (Kistler, 1968.)
Pájaros Tuff	Early to Late Cretaceous	Puerto Rico	Pájaros Tuff adopted. (Pease, 1968a).
Palm Spring Formation	Pliocene and Pleistocene	Southeastern California	Age changed from middle and late Miocene to Pliocene and Pleistocene. (Allen and others, 1968.)
Pamunkey Group	Paleocene and Eocene	Maryland, Delaware, and Virginia.	Brightseat Formation added as basal formation of group; age changed from Eocene to Paleocene and Eocene. (Hazel, 1968.)
Pantano Formation	early Oligocene to early Miocene.	Southeastern Arizona	Pantano Formation of Tolman as defined by Brennan (1962) adopted. (Finnell, this report, p. A35.)
Paspotansa Greensand Marl Member (of Aquia Formation).	Paleocene	Maryland and Virginia	Age changed from early Eocene to Paleocene. (Hazel, 1968.)

Changes in stratigraphic nomenclature—Continued

Name	Age	Location	Revision and reference
Penters Chert	Early Devonian	Arkansas	Age changed from Early or Middle Devonian to Early Devonian. (Boucot and Johnson, 1968.)
Peoria Loess	Pleistocene	Illinois and Wisconsin	Peoria Loess of Frye and Willman (1960) adopted. (Frye and others, (1968).)
Perry Mountain Formation	Silurian(?)	Maine	Perry Mountain Formation of Cariani (1959) adopted. (Osberg and others, 1968.)
Peters Creek Quartzite	late Precambrian(?)	Virginia and Pennsylvania	Peters Creek Quartzite abandoned in Maryland; remains in good usage in Pennsylvania and Virginia. (Southwick and Fisher, 1967.)
Phoenix Park Member (of La Garita Quartz Latite).	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Piapi Canyon Group	late Miocene and early Pliocene.	Nevada	Age changed from Miocene(?) and Pliocene to late Miocene and early Pliocene. (Kistler, 1968.)
Picayune Formation	Oligocene	Colorado	Age changed from middle and late Tertiary to Oligocene. (Luedke and Burbank, 1968.)
Piña Siltstone Member (of El Ocho Formation)	Early to Late Cretaceous	Puerto Rico	Piña Siltstone Member adopted. (Pease, 1968a).
Pine Butte Member (of Sundance Formation)	Late Jurassic	Wyoming	Lower sandstone beds removed from Redwater Shale Member and named Pine Butte Member. (Pipiringos, 1968.)
Pineville Sandstone Member (of New River Formation).	Early Pennsylvanian	Virginia and West Virginia	Pineville Sandstone Member of Hennen and Gawthrop (1915) adopted. (Englund, 1968a.)
Pioneer Sandstone Member (of Mingo Formation).	Middle Pennsylvanian	Tennessee	Pioneer Sandstone Member of Glenn (1925) adopted. (Englund, 1968b.)
Piper Gulch Monzonite	Triassic	Southeastern Arizona	Piper Gulch Monzonite adopted. (Drewes, 1968.)
Piscataway Indurated Marl Member (of Aquia Formation).	Paleocene	Maryland and Virginia	Age changed from early Eocene to Paleocene. (Hazel, 1968.)
Pitts Meadow Granodiorite	Precambrian	Colorado	Pitts Meadow Granodiorite adopted. (Hansen, 1968.)
Popo Agie Member (of Chugwater Formation)	Late Triassic	Wyoming	Raised in rank to Popo Agie Formation of Chugwater Group. Formation redefined and restricted to analcime-rich beds of Keller (1952). (Pipiringos, 1968.)
Poxono Island Formation	Late Silurian	Northeastern Pennsylvania, northwestern New Jersey, and southeastern New York.	Poxono Island Shale of White (1882) adopted as Poxono Island Formation. (Epstein and others, 1967.)
Pratter Shale Member (of Hinton Formation)	Late Mississippian	Virginia and West Virginia	Pratter Shale Member adopted. (Englund, 1968a.)
Pride Shale Member (of Bluestone Formation)	do	do	Pride Shale Member of Reger and Price (1926) adopted. (Englund, 1968a.)
Pringle Andesite	Oligocene	Southern Colorado	Name changed from Pringle Andesite to Pringle Latite; age changed from Tertiary to Oligocene. (Steven and Epis, 1968.)
Puget Group	Eocene and Oligocene(?)	Washington	In Pierce County the revised Puget Group includes (in ascending order): the Carbonado, Northcraft, and Spiketon Formations. The Wilkeson and Burnett Formations, formerly in Puget Group, are abandoned. (Gard, 1968.)
Do	early Eocene to early Oligocene.	do	In King County the age of the Puget Group is changed from Eocene and Oligocene(?) to (1) early Eocene to

			early Oligocene in the Green River area, and (2) middle Eocene to early Oligocene in the Tiger Mountain area. (Wolfe, 1968.)
Quadrant Quartzite	Middle Pennsylvanian (Des Moines).	Wyoming	Age changed from Pennsylvanian to Middle Pennsylvanian (Des Moines). (Mallory, 1967.)
Queen City Sand Member (of Mount Selman Formation).	middle Eocene	Texas	Queen City Sand Member of Mount Selman Formation raised to formation rank, Queen City Sand; Mount Selman Formation abandoned. (Eargle, 1968.)
Raging River Formation	do	Washington	Age changed from middle and late(?) Eocene to middle Eocene. (Wolfe, 1968.)
Rainier Mesa Member (of Timber Mountain Tuff).	early Pliocene	Nevada	Age changed from Pliocene to early Pliocene. (Kistler, 1968.)
Ramshorn Slate	Ordovician(?)	Idaho	Age changed from Early Ordovician to Ordovician(?). (Hobbs and others, 1968.)
Ranchester Limestone Member (of Amsden Formation).	Early and Middle Pennsylvanian.	Wyoming	Ranchester Limestone Member adopted. (Mallory, 1967.)
Rangeley Formation	Silurian(?)	Maine	Rangeley Conglomerate of Smith (1923) adopted as Rangeley Formation. (Osberg and others, 1968.)
Ravenian Stage (Floral)	late Eocene	West-central Washington	Ravenian Stage (Floral) adopted. (Wolfe, 1968.)
Recent Epoch	Quaternary	United States	Recent Epoch abandoned and replaced by Holocene Epoch as second and younger epoch of the Quaternary Period. (Cohee, 1968.)
Red Draw Member (of Jelm Formation)	Late Triassic	Wyoming	Red Draw Member adopted. (Pipiringos, 1968.)
Red Peak Member (of Chugwater Formation)	Early Triassic	do	Raised to formation rank, Red Peak Formation of Chugwater Group. (Pipiringos, 1968.)
Redwater Shale Member (of Sundance Formation).	Late Jurassic	do	Lower sandstone beds removed from Redwater Shale Member and named Pine Butte Member. (Pipiringos, 1968.)
Reklaw Member (of Mount Selman Formation).	middle Eocene	Texas	Reklaw Member of Mount Selman Formation raised to formation rank, Reklaw Formation; Mount Selman Formation abandoned. (Eargle, 1968.)
Renton Formation (of Puget Group)	late Eocene and early Oligocene.	Washington	Age changed from late Eocene and Oligocene(?) to late Eocene and early Oligocene. (Wolfe, 1968.)
Reservation Hill Formation	Pennsylvanian(?) and Permian(?).	Nevada	Reservation Hill Formation adopted. (Coats, 1969.)
Richland Loess	late Pleistocene	Illinois and Wisconsin	Richland Loess of Frye and Willman (1960) adopted. Age is late Wisconsinan. (Frye and others, 1968.)
Ridgway Till	Pleistocene	Colorado	Age changed from Paleocene to Pleistocene. (Steven and others, 1967.)
Río de la Plata Sandstone	Late Cretaceous	Puerto Rico	Río de la Plata Sandstone of Lidiak (1965) adopted. (Pease, 1968a.)
Río Matón Limestone Member (of Robles Formation).	Early and Late Cretaceous	do	Age changed from Late Cretaceous to Early and Late Cretaceous. (Pease, 1968b.)
Río Piedras Siltstone	Paleocene and Eocene(?)	do	Río Piedras Siltstone adopted. (Pease, 1968a.)
Rocket Wash Member (of Thirsty Canyon Tuff).	Pliocene	Nevada	Rocket Wash Member adopted. (Noble and others, 1968.)
Root Glacier Formation	Late Jurassic	Southern Alaska	Root Glacier Formation adopted. (MacKevett, 1969.)
Rosita Andesite	Oligocene	Southern Colorado	Name changed from Rosita Andesite to Rosita Formation; age changed from Eocene to Oligocene. (Steven and Epis, 1968.)
Roslyn Formation	middle Eocene	Washington	Age changed from Eocene to middle Eocene. (Wolfe, 1968.)
Roxana Silt	late Pleistocene	Illinois and Wisconsin	Roxana Silt of Frye and Willman (1960) adopted as basal unit of Wisconsinan Stage. Age is early Wisconsinan (Altonian). (Frye and others, 1968.)

Changes in stratigraphic nomenclature—Continued

Name	Age	Location	Revision and reference
Salero Formation	Late Cretaceous	Southeastern Arizona	Salero Formation adopted. (Drewes, 1968.)
Sallisaw Formation	Early Devonian	Oklahoma	Age changed from Early or Middle Devonian to Early Devonian. (Boucot and Johnson, 1968.)
Saltsburg Sandstone Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Saltsburg is considered a member of the Glenshaw Formation. (Roen and others, 1968.)
San Juan Formation	Oligocene or older	Colorado	Age changed from middle or late Tertiary to Oligocene or older. (Olson and others, 1968.)
Sanpoil Volcanics	middle Eocene	Northeastern Washington	Age changed from Eocene(?) to middle Eocene. (Yates and Engels, 1968.)
San Sebastián Formation (of Río Guatemala Group).	middle Oligocene	Puerto Rico	Age changed from Oligocene to middle Oligocene. (Briggs, 1968.)
Santa Olaya Lava	Late Cretaceous	Puerto Rico	Santa Olaya Lava of Lidiak (1965) adopted. (Pease, 1968a.)
Sapinero Mesa Tuff	Oligocene	Colorado	Sapinero Mesa Tuff adopted. (Olson and others, 1968.)
Saturday Mountain Formation	Middle Ordovician and younger.	Idaho	Age changed from Late Ordovician to Middle Ordovician and younger. (Ruppel, 1968.)
Schoharie Grit	Early Devonian	New York	Name changed to Schoharie Formation. (Boucot and Johnson, 1968.)
Schuler Formation (of Cotton Valley Group)	Late Jurassic	Texas, Louisiana, and Arkansas.	Schuler Formation redefined to include all rocks between the top of the Buckner Formation and the base of the Cretaceous rocks, except for the Q tongue of the Bossier Formation. (Dickinson, 1968.)
Seldovian Stage (Floral)	Oligocene(?) and Miocene	South-central Alaska	Seldovian Stage (Floral) adopted. (Wolfe and others, 1966.)
Semilla Sandstone Member (of Mancos Shale)	Late Cretaceous	New Mexico	Semilla Sandstone Member adopted. (Dane and others, 1968.)
Setters Formation (of Glenarm Series)	late Precambrian(?)	Maryland, Pennsylvania, and Delaware.	Age changed from early Paleozoic(?) to late Precambrian(?). (Southwick and Fisher, 1967.)
Shallow Creek Quartz Latite	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Sheep Creek Member (of Totatlanika Schist)	Mississippian(?)	Central Alaska	Sheep Creek Member adopted. (Wahrhaftig, 1968.)
Shellenberger Canyon Formation (of Bisbee Group).	Early Cretaceous	Southeastern Arizona	Shellenberger Canyon Formation of Tyrrell (1957) adopted. (Finnell, this report, p. A32.)
Sheppard Granite	Eocene	Northeastern Washington	Age changed from Tertiary to Eocene. (Yates and Engels, 1968.)
Siamo Slate	middle Precambrian	Michigan	Placed in Menominee Group of Animikie Series. Age changed from Precambrian to middle Precambrian. (Gair and Thaden, 1968.)
Siletz River Volcanic Series	early and middle Eocene	Western Oregon	Name changed from Siletz River Volcanic Series to Siletz River Volcanics. (Snavely and others, 1968.)
Silver Run Limestone	early Paleozoic(?)	Maryland	Silver Run Limestone is excluded from Glenarm Series. (Southwick and Fisher, 1967.)
Silverton Volcanic Group	Oligocene	Colorado	Age changed from middle and late Tertiary to Oligocene. (Luedke and Burbank, 1968.)

Sips Creek Member (of Jelm Formation)	Late Triassic	Wyoming	Sips Creek Member adopted. (Pipiringos, 1968.)
Sitkalidak Formation	Eocene	South-central Alaska	Sitkalidak Formation adopted. (Moore, 1969.)
Sitkinak Formation	Oligocene	do	Sitkinak Formation adopted. (Moore, 1969.)
Smalls Falls Formation	Silurian(?)	Maine	Smalls Falls Formation of Furlong (1960) adopted. (Osberg and others, 1968.)
Snowshoe Mountain Quartz Latite	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Snowy Range Formation	Late Cambrian	Wyoming and Montana	Grove Creek Formation reduced to member rank and made upper member of Snowy Range Formation. (Pierce and Nelson, 1968.)
South Fork Mountain Schist	Late(?) Cretaceous	Northwestern California	South Fork Mountain Schist adopted. (Blake and others, 1967.)
Spiketon Formation (of Puget Group)	late(?) Eocene	Washington	Spiketon Formation adopted. (Gard, 1968.)
Squaw Gulch Granite	Jurassic	Southeastern Arizona	Squaw Gulch Granite adopted. (Drewes, 1968.)
Star Peak Formation	Early to Late Triassic	Nevada	Age changed from Middle and Late Triassic to Early to Late Triassic. (Silberling, 1968.)
Steens Basalt	middle(?) and late Miocene	Oregon	Age changed from middle Pliocene to middle(?) and late Miocene. (Walker and Swanson, 1968.)
Stockade Wash Member (of Paintbrush Tuff)	late Miocene	Nevada	Age changed from Miocene(?) and Pliocene to late Miocene. (Kistler, 1968.)
Sugarloaf Quartz Latite	Late Cretaceous	Southeastern Arizona	Age changed from Cretaceous or Tertiary to Late Cretaceous. (Hayes and Drewes, 1968.)
Sulphur Well Member (of Lexington Limestone)	Middle Ordovician	Central Kentucky	Sulphur Well Member of McFarlan (1943) adopted. (Cressman, 1968.)
Summerhill Sandstone Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Summerhill is considered a member of the Casselman Formation. (Roen and others, 1968.)
Sundance Formation	Late Jurassic	Wyoming	Two new members adopted—Pine Butte between Lak and Redwater and Windy Hill at top of formation. (Pipiringos, 1968.)
Sykesville Formation	Paleozoic	Pennsylvania	Sykesville Formation abandoned in Maryland. Rocks are now included in boulder gneiss lithofacies of Wissahickon Formation. Sykesville Formation still in good usage in Pennsylvania. (Southwick and Fisher, 1967.)
Tallery Sandstone Member (of Hinton Formation).	Late Mississippian	Virginia and West Virginia	Tallery Sandstone Member of Reger and Price (1926) adopted. (Englund, 1968a.)
Talpa Limestone Member (of Clyde Formation)	Early Permian (Leonard)	Texas	Age changed from Early Permian (Leonard?) to Early Permian (Leonard). (Myers, 1968.)
Telluride Formation	early Eocene	Colorado	Age changed from Oligocene(?) to early Eocene. (Steven and others, 1967.)
Temporal Formation	Early Cretaceous	Southeastern Arizona	Temporal Formation adopted. (Drewes, 1968.)
Tiger Mountain Formation (of Puget Group)	middle and late Eocene	Washington	Age changed from middle(?) and late Eocene to middle and late Eocene. (Wolfe, 1968.)
Timber Mountain Tuff (of Piapi Canyon Group).	early Pliocene	Nevada	Age changed from Pliocene to early Pliocene. (Kistler, 1968.)
Tiva Canyon Member (of Paintbrush Tuff)	late Miocene	do	Age changed from Miocene(?) and Pliocene to late Miocene. (Kistler, 1968.)
Tlevak Basalt	Tertiary or Quaternary	Southeastern Alaska	Tlevak Basalt adopted. (Eberlein and Churkin, this report, p. A25.)

Changes in stratigraphic nomenclature—Continued

Name	Age	Location	Revision and reference
Topopah Spring Member (of Paintbrush Tuff)	late Miocene	Nevada	Age changed from Miocene(?) and Pliocene to late Miocene. (Kistler, 1968.)
Totatlanika Schist	Mississippian(?)	Central Alaska	Stratigraphically restricted to exclude rocks assigned to Keevy Peak Formation. Subdivided into five newly named members (in ascending order): Moose Creek, California Creek, Chute Creek, Mystic Creek, and Sheep Creek. (Wahrhaftig, 1968.)
Treasure Mountain Formation	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Trident Member (of Three Forks Formation)	Late Devonian	Montana, Wyoming, and Idaho.	Extended to Idaho. (Sandberg and others, 1967.)
Trout Peak Trachyandesite	late Eocene	Wyoming	Trout Peak Trachyandesite adopted. (Nelson and Pierce, 1968.)
Trujillo Alto Limestone	Late Cretaceous	Puerto Rico	Trujillo Alto Limestone reduced in rank and made member of Monacillo Formation. (Pease, 1968a.)
Tub Spring Member (of Belted Range Tuff)	late Miocene	Nevada	Age changed from Miocene and Pliocene(?) to late Miocene. (Noble and others, 1968.)
Tub Spring Member (of Indian Trail Formation).	Miocene	do	Age changed from Miocene and Pliocene(?) to Miocene. (Kistler, 1968.)
Tugidak Formation	Pliocene	South-central Alaska	Tugidak Formation adopted. (Moore, 1969.)
Tukwila Formation	late Eocene and early Oligocene.	Washington	Age changed from late Eocene to late Eocene and early Oligocene. (Wolfe, 1968.)
Turney Ranch Formation (of Bisbee Group)	Early Cretaceous	Southeastern Arizona	Turney Ranch Formation of Tyrrell (1957) adopted. Top formation of Bisbee Group. (Finnell, this report, p. A33).
Twocreekan Substage	late Pleistocene	Illinois and Wisconsin	Twocreekan Substage of Frye and Willman (1960) adopted as second youngest substage of Wisconsinan Stage. Overlies Woodfordian Substage and underlies Valderan Substage. (Frye and others, 1968.)
Uffington Shale Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Uffington is considered a member of the Glenshaw Formation. (Roen and others, 1968.)
Upham Dolomite Member (of Montoya Dolomite).	Middle Ordovician	New Mexico	Age changed from Middle and Late Ordovician to Middle Ordovician. (Bachman, 1968.)
Urbana Phyllite	early Paleozoic(?)	Maryland	Urbana Phyllite excluded from Glenarm Series. (Southwick and Fisher, 1967.)
Uyak Formation	Triassic	South-central Alaska	Uyak Formation adopted. (Moore, 1969.)
Valderan Substage	late Pleistocene	Illinois and Wisconsin	Valderan Substage of Frye and Willman (1960) adopted as uppermost substage of Wisconsinan Stage. (Frye and others, 1968.)
Vanderlehr Formation	Precambrian	South Dakota	Vanderlehr Formation adopted. (Redden, 1968.)

Waccamaw Formation	late Miocene to early Pliocene.	North Carolina and South Carolina.	Age changed from early Pliocene to late Miocene to early Pliocene. (Swain, 1968.)
Waco Member (of Crab Orchard Formation)	Middle Silurian	Kentucky	Waco Limestone of Foerste (1905) adopted. (Simmons 1967.)
Wahmonie Formation	late Miocene	Nevada	Age changed from Miocene and Pliocene to late Miocene. (Kistler, 1968.)
Wakefield Marble	early Paleozoic(?)	Maryland and Pennsylvania	Wakefield Marble excluded from Glenarm Series. (Southwick and Fisher, 1967.)
Walnut Gap Volcanics	Late Triassic	Southeastern Arizona	Age changed from Triassic or Jurassic to Late Triassic. (Hayes and Drewes, 1968.)
Wanakah Formation	Late Jurassic	Colorado	Junction Creek Sandstone reduced in rank to Junction Creek Member of Wanakah Formation. (Hansen, 1968.)
Wapiti Formation	early(?) and middle(?) Eocene.	Northwestern Wyoming	Wapiti Formation adopted. (Nelson and Pierce, 1968.)
Wason Park Rhyolite	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Waterville Formation	Silurian (?)	Maine	Waterville Shale, as used by Perkins and Smith (1925), adopted as Waterville Formation. (Osberg and others, 1968.)
Webb Formation	Early Mississippian	Nevada	Webb Formation adopted. (Smith and Ketner, 1968.)
Weber Sandstone	Middle and Late Pennsylvanian and Permian.	Wyoming	Age changed from Pennsylvanian and Permian to Middle and Late Pennsylvanian and Permian. (Mallory, 1967.)
Weches Greensand Member (of Mount Selman Formation).	middle Eocene	Eastern and central Texas	Weches Greensand Member (of Mount Selman Formation) raised in rank to Weches Formation; Mount Selman abandoned. (Eargle, 1968.)
Wedron Formation	late Pleistocene	Illinois and Wisconsin	Wedron Formation of Frye and Willman (1960) adopted. Age is late Wisconsinan (Woodfordian). (Frye and others, 1968.)
Wehutty Formation	Precambrian	North Carolina, Tennessee, and Georgia.	Wehutty Formation adopted. (Hernon, 1969.)
West Elk Breccia	Oligocene or older	Colorado	Age changed from Miocene(?) to Oligocene or older. (Olson and others, 1968.)
Westerly Granite	Late Pennsylvanian or younger.	Connecticut and Rhode Island.	Age changed from Pennsylvanian or younger to Late Pennsylvanian or younger. (Feininger, 1968.)
Wewe Slate	middle Precambrian	Michigan	Wewe Slate placed in Chocolay Group, Animikie Series. Age changed from Precambrian to middle Precambrian. (Gair and Thaden, 1968.)
Wilkeson Formation (of Puget Group)	Eocene	Washington	Wilkeson Formation abandoned; strata assigned to the Carbonado Formation (revised). (Gard, 1968.)
Williamson Canyon Volcanics	Late Cretaceous and (or) early Tertiary.	Arizona	Age changed from Late(?) Cretaceous or Tertiary to Late Cretaceous and (or) early Tertiary. (Krieger, 1968b.)
Willow Canyon Formation (of Bisbee Group)	Early Cretaceous	Southeastern Arizona	Willow Canyon Formation of Tyrrell (1957) adopted. (Finnell, this report, p. A31.)
Willow Creek Member (of Bachelor Mountain Rhyolite).	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Wilmore Sandstone Member (of Conemaugh Formation).	Late Pennsylvanian	Pennsylvania and Ohio	Wherever the Ames Limestone Member (of the Glenshaw Formation) can be recognized, the Conemaugh is considered of group rank and consists of the Casselman and Glenshaw Formations, and the Wilmore is considered a member of the Casselman Formation. (Roen and others, 1968.)

Changes in stratigraphic nomenclature—Continued

Name	Age	Location	Revision and reference
Windy Gulch Member (of Bachelor Mountain Rhyolite).	Oligocene	Colorado	Age changed from middle or late Tertiary to Oligocene. (Steven and others, 1967.)
Windy Hill Sandstone Member (of Sundance Formation).	Late Jurassic	Wyoming	Windy Hill Sandstone Member adopted. (Pipiringos, 1968.)
Winnebago Drift	late Pleistocene	Northern Illinois	Winnebago Drift of Frye and Willman (1960) adopted. Age is Wisconsinan (Altonian). (Frye and others, 1968.)
Wisconsinan Stage	do	Illinois and Wisconsin	Wisconsinan Stage of Frye and Willman (1960) adopted. Includes (in ascending order): Altonian, Farmdalian, Woodfordian, Twocreekan, and Valderan Substages. (Frye and others, 1968.)
Wissahickon Formation (of Glenarm Series)	late Precambrian(?)	Pennsylvania, New Jersey, Delaware, Maryland, and Virginia.	Age changed from early Paleozoic(?) to late Precambrian(?); in Maryland includes strata formerly assigned to Peters Creek and Sykesville Formations which have been abandoned there. (Southwick and Fisher, 1967.)
Woodfordian Substage	late Pleistocene	Illinois and Wisconsin	Woodfordian Substage of Frye and Willman (1960) adopted. Overlies Farmdalian Substage and underlies Twocreekan Substage. (Frye and others, 1968.)
Woodruff Formation	Early to Late Devonian	Nevada	Woodruff Formation adopted. (Smith and Ketner, 1968.)
Yakima Basalt	late Miocene and early Pliocene.	Oregon	Yakima Basalt extended into north-central Oregon. (Waters 1968.)
Yucca Mountain Member (of Paintbrush Tuff)	late Miocene	Nevada	Age changed from Miocene(?) and Pliocene to late Miocene. (Kistler, 1968.)
Zooks Corner Formation	Cambrian	Pennsylvania	Zooks Corner Formation adopted. (Meisler and Becher, 1968.)

ORTEGA QUARTZITE AND THE BIG ROCK AND JAWBONE CONGLOMERATE MEMBERS OF THE KIAWA MOUNTAIN FORMATION, TUSAS MOUNTAINS, NEW MEXICO

By Fred Barker

The Tusas Mountains of northern New Mexico contain extensive exposures of Precambrian quartzite and conglomerate. In a reconnaissance investigation Just (1937, p. 43, and pl. III) applied the name Ortega Quartzite to these rocks for their exposures from Ojo Caliente to Jawbone Mountain (T. 29 N., R. 6 E.) with the type locality in the Ortega Mountains. In a more recent study in the Las Tablas, Canon Plaza, Burned Mountain, and Mule Canyon 7½-minute quadrangles, Barker (1954, 1958) subdivided Just's Ortega Quartzite. In conformance with this work, the name Ortega Quartzite is applied only to the 14,000- to 20,000-foot-thick, lower part of this very thick section of quartzite and conglomerate as exposed in the center of section 25, T. 27 N., R. 8 E., and to the west and southwest. The base of the Ortega Quartzite is not exposed in the Tusas Mountains. The strata overlying the redefined Ortega Quartzite are named the Kiawa Mountain Formation, after the exposures at Kiawa Mountain, the type locality (secs. 3–5, 8–10, T. 27 N., R. 6 E.; Barker, 1958). The uppermost part of the Kiawa Mountain Formation is not preserved in the Tusas Mountains.

The lowest unit of the Kiawa Mountain Formation in the Las Tablas quadrangle is a pebble conglomerate and is named the Big Rock Conglomerate Member (Barker, 1958) for exposures about 0.2 to 1 mile north and northwest of Big Rock. The type locality is in the SE¼ sec. 27, T. 27 N., R. 8 E. About 15 miles to the northwest, in the Burned Mountain quadrangle, the basal part of the Kiawa Mountain Formation is pebble conglomerate, fine-grained conglomerate, and quartzite and is named the Jawbone Conglomerate Member (Barker, 1958). The type locality is in the N½ sec. 19, T. 29 N., R. 7 E. Excellent exposures of this member are found at Jawbone Mountain which lies in the northwest corner of the Burned Mountain quadrangle and in the northeast corner of the Cebolla quadrangle. The stratigraphic relations of these two conglomerates are not known; however, there is a possibility that the Jawbone is younger than the Big Rock (Barker, 1958, pl. 1).

The Ortega Quartzite, restricted, and the Kiawa Mountain Formation and its two members, the Big Rock and Jawbone Conglomerate Members, are herein adopted.

The Kiawa Mountain Formation consists principally of quartzite and contains some units of conglomerate and amphibolite. The quartzite layers are light blue to gray, dense, vitreous, and typically very fine grained to medium grained. Layers containing granules and

370-838—70——4

pebbles of quartz and, less commonly, of ferruginous chert or iron-formation occur throughout. At Kiawa Mountain and to the northwest, the quartzite consists of 90 to 98 percent quartz with minor amounts of hematite, kyanite, manganian andalusite, rutile, and other minerals. Northeast of Kiawa Mountain, in the canyon of Spring Creek, the quartzite is feldspathic and muscovitic. South of Kiawa Mountain, on La Jarita Mesa, the quartzite of this formation grades into the Petaca Schist of Just (1937, p. 43), which is a muscovitic quartzose schist. The Petaca Schist is only found adjacent to the pegmatite bodies of the Petaca District, and Just ascribes the muscovite in the schist to emanations from the pegmatites.

The quartzite layers of the Kiawa Mountain Formation are intensively folded, and so their thickness cannot be measured accurately. However, they are estimated to be 5,000 to 10,000 feet thick (Barker, 1958, p. 10).

The Big Rock Conglomerate Member consists of interlayered gray quartzose conglomerate and pebbly quartzite. The clasts are of quartz and jasper, and they generally range from ½ to 5 inches in maximum dimension. The matrix of both rock types typically is $\frac{1}{16}$ to 4 mm (millimeters) in grain size and shows a mosaic fabric. Quartz forms 60 to 80 percent; microcline and muscovite are next in abundance; and biotite, garnet, and hematite are accessory in the matrix. Both current bedding and cross-stratification are common in the Big Rock Conglomerate Member. This member is intricately folded, and is estimated to be 100 to 200 feet thick near Big Rock. It pinches out to the southeast. To the northwest it also apparently pinches out; here, however, this conglomerate was intruded by Precambrian rhyolite and later was partly covered by Tertiary conglomerate (Barker, 1958, pl. 1), so its stratigraphic relations are obscured.

The Jawbone Conglomerate Member is comprised of interlayered, gray to light gray, vitreous, massive, quartzose conglomerate, quartzite, and pebbly conglomerate. Granules and well-rounded pebbles of quartz and jasper of ¼ to 1 inch in grain size form the coarsest part of the conglomerates. The matrix of the conglomerate and the quartzite consists of recrystallized quartz, mostly ⅛ to 1 mm in grain size, and accessory kyanite, hematite, rutile, and muscovite. Bedding and cross-stratification may be seen in many outcrops of the Jawbone. Because this member is folded, its thickness may not be directly measured; however, it probably is at least 500 feet thick and may be more than 2,000 feet thick.

REASONS FOR ABANDONMENT OF THE PORTAGE GROUP

By WALLACE DE WITT, JR.

In our study of the stratigraphy of the Upper Devonian rocks in western and west-central New York (Pepper, de Witt, and Colton, 1956; Colton and de Witt, 1958; de Witt and Colton, 1959; de Witt, 1960), we were more or less continuously entangled with the old "classic" nomenclature which was introduced in the fourth geological district by James Hall (1839, p. 322) and in the third geological district by Lardner Vanuxem (1842, p. 172). Not long after we began to study the rocks of the West Falls Formation—the rocks above the Sonyea Formation and below the Java Formation (Pepper, de Witt, and Colton, 1956)—we realized that the many usages of the name Portage as proposed by geologists during the past 125 years and the correlation of the units involved with the name were a source of confusion and difficulty. At different times, the name Portage had been applied to a single lithologic unit (Luther, 1897), to a group of several lithologic units (Hall, 1840, p. 391; 1843, p. 224), to a series of rocks in a time sense (Tilton and others, 1927, p. 88–90), and in parts of Kentucky, New York, Pennsylvania, and West Virginia to a magnafacies that included most of the marine Upper Devonian rocks. The name was given not only to a group of rocks exposed along the Genesee River in western New York but also to the upper massive sandstone unit within that group (Hall, 1843).

The relationship of the stratigraphic units that make up the Portage Group of Hall (1839) along the Genesee River in the fourth geological district and the units in the Portage or Nunda Group of Vanuxem (1842), about 75 miles to the east near Ithaca in the third geological district, illustrates some of the confusion surrounding the name Portage. Hall and Vanuxem believed the two groups were correlative.

In the type area along the Genesee River, Hall's Portage Group (1839) consisted of the strata above the Gardeau or Lower Fucoidal Group and below the Chemung Group. The Portage consisted of a thin basal sandstone, the Table Rock Sandstone of Chadwick (1933), a medial unit of intercalated shale and sandstone, and a thick upper massive sandstone. These units make up the upper part of our West Falls Formation at the Genesee. The upper massive sandstone is the Nunda Sandstone Member of our West Falls, and the two lower units make up the West Hill Member and the upper part of the Gardeau Shale Member of the West Falls.

In 1842 Vanuxem defined his Portage or Nunda Group near Ithaca as including the Sherburne Flagstone and Shale, the Cashaqua Shale, and the Gardeau and Portage Groups of the previous State reports. Vanuxem drew the top of his Portage Group at the base of the overlying Ithaca Group. Our study of these Upper Devonian rocks showed that in the vicinity of Ithaca, the strata in the basal part of Vanuxem's Ithaca Group are the Renwick Shale Member, Ithaca Member, and West River Shale Member of our Genesee Formation. These strata are equivalent at the Genesee River to rocks which comprise the upper half of our Genesee Formation—the upper part of Hall's Genesee Slate. Thus, the strata near Ithaca that Vanuxem assigned to the Portage Group are not the lateral equivalents of Hall's Portage on the Genesee but are separated from the Portage beds by the lower part of the West Falls Formation and all the subjacent Sonyea Formation. The strata that compose the upper part of the West Falls Formation on the Genesee, Hall's Portage Group, change facies to the east; and if present in the Ithaca area, the equivalents of Hall's Portage Group occur in the upper part of the Chemung rocks well south and southwest of Ithaca. In their respective districts, both Hall and Vanuxem defined the top of their Portage Group largely by paleontologic criteria. They were not aware that because of changes in lithology the equivalents of Hall's original Portage Group lay within a dissimilar facies with a different fauna in the Ithaca area. If the original definition of the group (Hall, 1839) is strictly followed, none of Vanuxem's Portage at Ithaca is Portage because all the strata are older than the beds originally assigned to the group by Hall.

In 1843 Hall added to the problem by expanding his Portage Group on the Genesee to include the following units in descending order: Gardeau or Lower Fucoidal Group, Cashaqua Shale, and Sherburne Flagstones. The Sherburne Flagstones, the Sherburne Flagstone Member of our Genesee Formation, feathers out of the sequence to the east of the Genesee River in the area between Seneca and Cayuga Lakes and is unrepresented by coarse-grained rocks on the Genesee. As redefined by Hall, his expanded Portage Group includes the upper half of our Genesee Formation and all the younger Sonyea and West Falls Formations.

In the years between 1843 and 1943, the use of Portage Group, Portage Formation, or Portage Series, spread widely across the Appalachian basin as attempts were made by many geologists to synthesize the Upper Devonian stratigraphy of this area. Correlations were proposed partly on the basis of similar lithology and stratigraphic position but more commonly on the presence of similarity of faunas. Usage of the name Portage became so varied that each author was more or less obliged to redefine the unit in each paper. The wide latitude of usage of Portage increased the misunderstanding surrounding the unit. A glance through the papers of the New York Geological Survey and particularly the writing of G. H. Chadwick will illustrate many of the changes in the usage of Portage during the past 125 years.

From these and much other data, we concluded that the name Portage was largely invalid because of the multitudinous usages in the past. Furthermore, within the framework of stratigraphic nomenclature which we have proposed for the Upper Devonian rocks in the western half of New York, Portage need not be recognized in a formal sense. Consequently, we abandoned use of Portage rather than continue to compound the confusion surrounding the name by attempting to rigorously redefine the stratigraphic unit. The limitation on the length of text accompanying oil and gas charts (Pepper and others, 1956; Colton and de Witt, 1958) precluded a lengthy discussion of the stratigraphic nomenclature and possible revision; also, some of the most cogent reasons in favor of abandoning Portage as a group or formation were not clearly evident until we had completed work on the Sonyea Formation and the Genesee Formation.

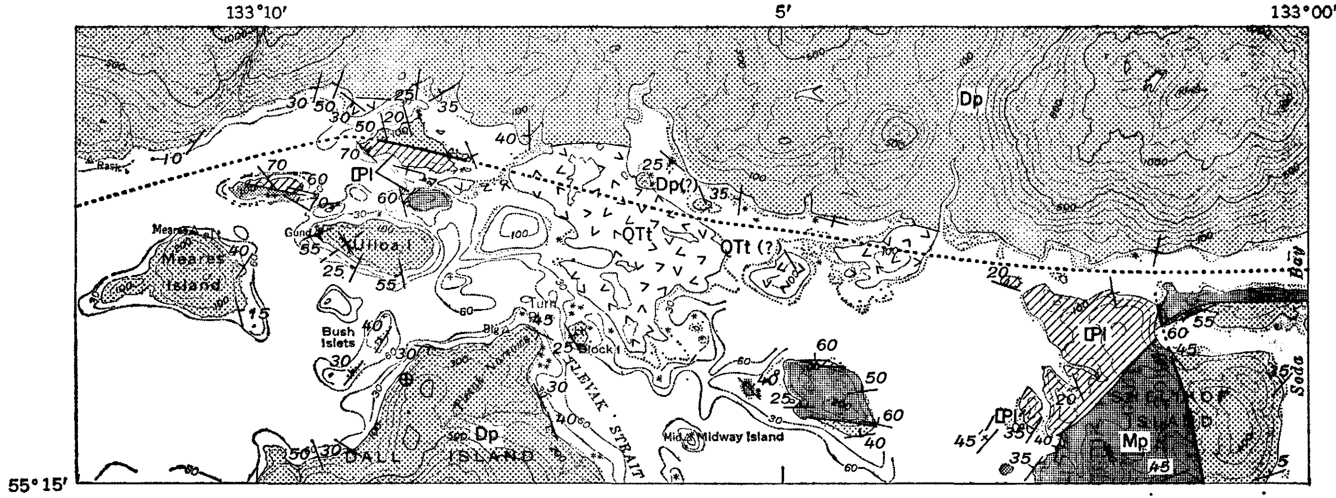
The New York Geological Survey did not include the Portage among the stratigraphic units recognized in the Upper Devonian sequence in the text of the most recent issue of the State geologic map (New York State Museum and Science Service Geological Survey, 1962). The New York Survey included the rocks that made up Hall's expanded Portage Group (Hall, 1843) as parts of our Genesee, Sonyea, and West Falls Formations. On the map, our formations were given group status. Clearly the action of the New York Geological Survey indicates the intent to abandon the Portage. Similarly Rickard's correlation chart of the Devonian rocks in New York (Rickard, 1964) does not contain the Portage as a recognized stratigraphic unit. Rickard shows in the chart that the "Chagrin" ("Portage") is a depositional phase—a gray shale, siltstone, limestone, and calcareous nodule facies—which is present at different places in several of the groups of strata in the Upper Devonian sequence in western New York.

TLEVAK BASALT, WEST COAST OF PRINCE OF WALES ISLAND, SOUTHEASTERN ALASKA

By G. Donald Eberlein and Michael Churkin, Jr.

A number of small islands off the west coast of Prince of Wales Island at the latitude of Ketchikan (fig. 1) are underlain by one or more basalt flows. These flows are best exposed along the shoreline. The flows make up a new formation, here named the Tlevak Basalt for its occurrence in the vicinity of Tlevak Strait (fig. 1). The basalt is probably flat lying, and the low relief of the shoreline exposes only a few feet of lava at any locality.

Generally the basalt is strongly jointed and forms thin subhorizontal slabs. In places there are well-developed closely spaced concentric fractures along which the rock weathers spheroidally. Locally, the



Base from U.S. Geological Survey
Craig (B-4) quadrangle
Alaska, 1951

0 ½ 1 2 3 MILES

CONTOUR INTERVAL 100 FEET
DATUM IS MEAN SEA LEVEL

Geology by Michael Churkin, Jr.,
G. D. Eberlein, and
A. K. Armstrong, 1966

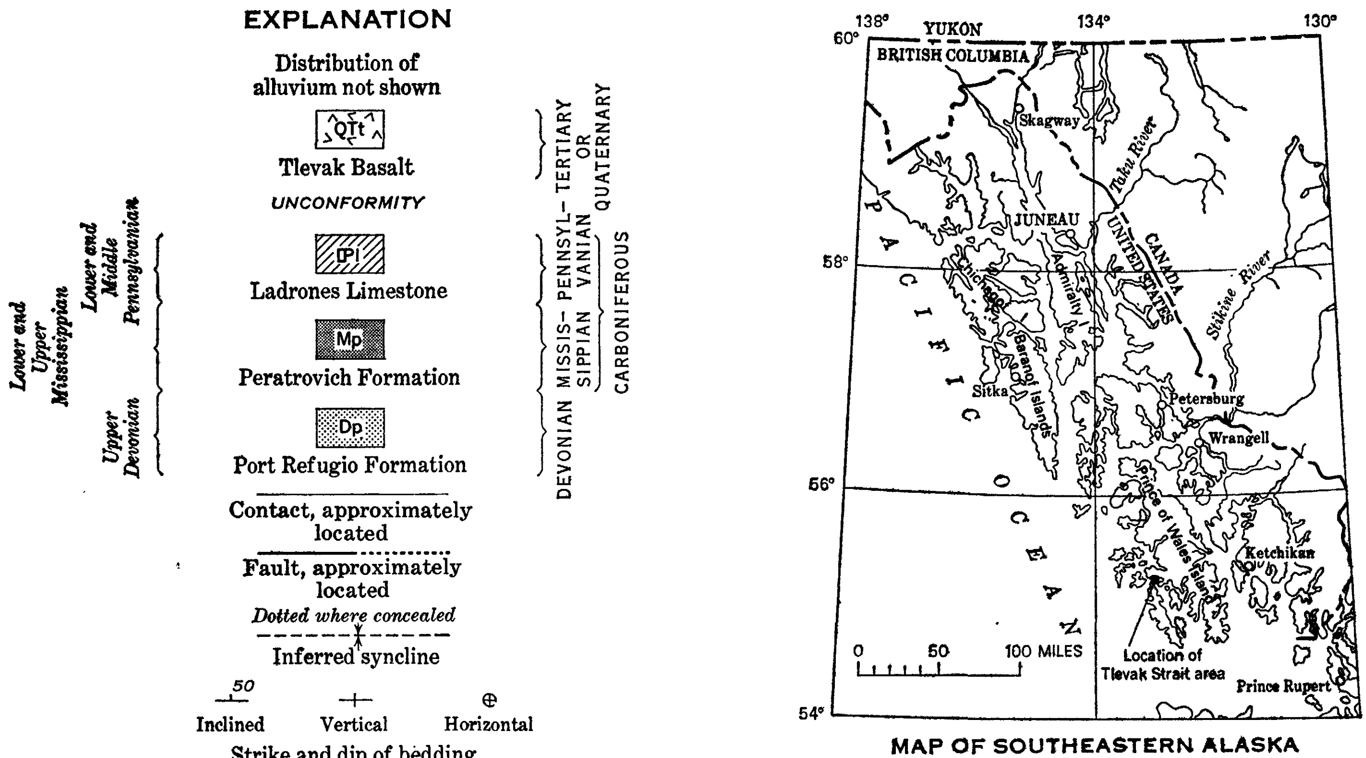


FIGURE 1.—The Tlevak Strait area, southeastern Alaska.

basalt has vertical columnar joints that are transected by the subhorizontal fracture system.

In contrast to the Paleozoic formations which predominate in this region, several of which contain basaltic volcanic rocks, the Tlevak Basalt is remarkably fresh and contains phenocrysts of olivine and plagioclase (labradorite) in an intergranular groundmass of labradorite microlites, olivine, and subordinate clinopyroxene. The rock has a normative mode and may be classified as olivine basalt according to the scheme of Yoder and Tilley (1962).

On the south shore of a small unnamed island about 1 mile northwest of the north entrance to Tlevak Strait, the Tlevak Basalt unconformably overlies steeply dipping beds of the Ladrones Limestone. Elsewhere, in discontinuous exposures, the Tlevak apparently overlies the Port Refugio and Peratrovich Formations. The Tlevak Basalt thus appears to rest unconformably upon Pennsylvanian, Mississippian, and Upper Devonian formations. A small area of similarly fresh olivine basalt is exposed along the northeast shore of Trocadero Bay about 9 miles northeast of the area of this report. This olivine basalt may overlie a formation older than the Port Refugio, the Descon Formation.

The top of the Tlevak Basalt is not exposed, and its total thickness is uncertain. Judging from its inferred gross subhorizontal structure and the maximum relief adjacent to shoreline exposures, it is probably less than 100 feet thick.

The Tlevak Basalt is demonstrably younger than the Ladrones Limestone and therefore is post-Pennsylvanian. It is tentatively assigned a Tertiary or Quaternary age because of its freshness and general lack of deformation.

FORMATIONS OF THE BISBEE GROUP, EMPIRE MOUNTAINS QUADRANGLE, PIMA COUNTY, ARIZONA

By Tommy L. Finnell

A thick sequence of shale, sandstone, conglomerate, and limestone of Early Cretaceous age is widespread in southeastern Arizona. Outcrops of these sedimentary rocks in the Mule Mountains near Bisbee (fig. 2) were called the Bisbee beds by Dumble (1902, p. 706). Later, they were designated the Bisbee Group by Ransome (1904, p. 56), who distinguished the Glance Conglomerate at the base, the Morita Formation, the Mural Limestone, and the Cintura Formation at the top. However, in areas north of the Mule Mountains, such as the Tombstone Hills and the Dragoon Mountains (Gilluly, 1956, p. 74), and to the northwest in the Mustang Mountains (Hayes and Raup, 1968), no lithologic equivalent of the Mural Limestone occurs, and the Bisbee was mapped as a formation with a basal conglomerate

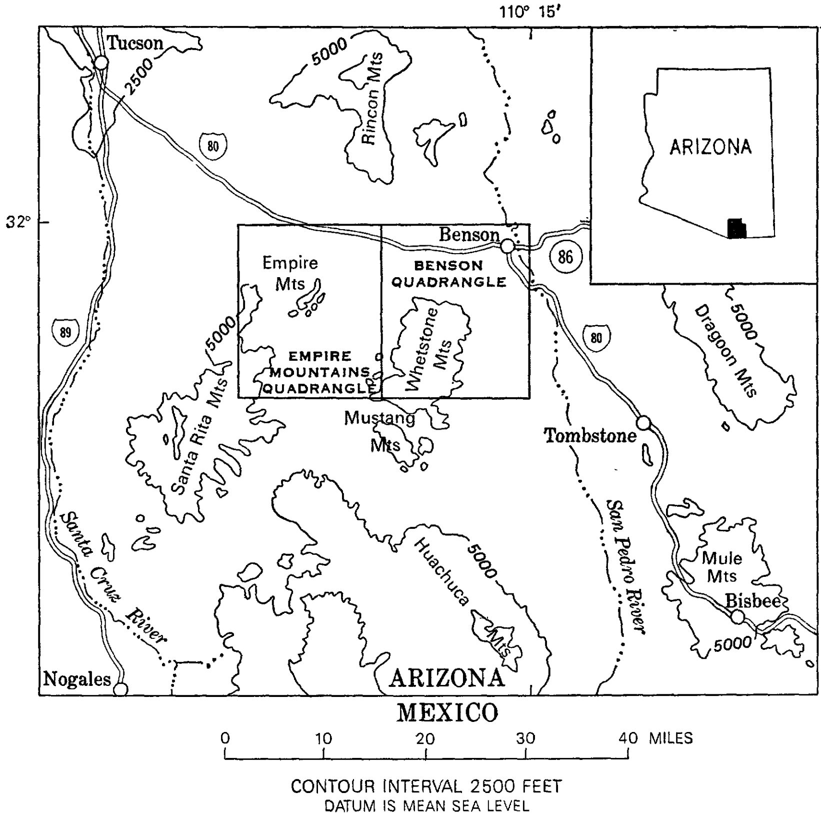


FIGURE 2.—Empire Mountains area, Arizona.

member. Cretaceous strata in the Whetstone Mountains, called Bisbee Group by Tyrrell (1957; 1965) and Bisbee(?) Formation by Creasey (1967), are partly correlative with the Bisbee Group in its type area (Hayes and Drewes, 1968, p. 55); but, in the absence of an equivalent to the Mural Limestone, Tyrrell divided the group into the Willow Canyon Formation at the base, the Apache Canyon Formation, the Shelleburg Canyon Formation, and the Turney Ranch Formation at the top. Schafroth (1968, p. 60–64) recognized the same formations in the Empire and northern Santa Rita Mountains. Recent detailed studies confirm that the formations recognized by Tyrrell are also valid units in the Empire Mountains quadrangle, and the names are therefore adopted for use as described below. However, both earlier workers included the Glance Conglomerate as a member of the Willow Canyon Formation, whereas I have chosen to map the Glance as a separate formation. Hence, the Willow Canyon Formation in the Empire Mountains quadrangle is restricted to those beds that occur stratigraphically above the Glance Conglomerate and below the Apache Canyon Formation. Also, the Shelleburg Canyon Formation of Tyrrell (1957) is here called Shellenberger Canyon Formation so that the spelling will be the same as that shown on the 1958 edition of the U.S. Geological Survey topographic map of the Benson quadrangle.

GLANCE CONGLOMERATE

The Glance Conglomerate, the basal formation of the Bisbee Group, consists of as much as 5,600 feet of pebble to boulder conglomerate and sedimentary breccia of variable lithology. In general, two types of conglomerate occur in the Glance. One is composed mainly of limestone and dolomite fragments and is present along the south, east, and north flanks of the Empire Mountains; the other is composed mainly of quartzite and granitoid fragments and is only present in the northern part of the range where it conformably overlies the limestone conglomerate.

The limestone conglomerate ranges in thickness from 1 to 400 feet and consists of closely packed subangular to subrounded fragments of limestone and dolomite as much as 3 feet across set in a matrix of reddish-brown to gray calcareous sandstone and sandy siltstone. In places, tabular blocks of Paleozoic formations as much as 1,000 feet across are embedded in the conglomerate.

The quartzite-granitoid conglomerate is as much as 5,200 feet thick, and it consists of closely packed angular to subangular fragments of quartzite and gneissic quartz diorite as much as 3 feet across set in a matrix of reddish-brown to greenish-gray sandstone and sandy siltstone. The quartzite fragments are most numerous at the base, giving way gradually upward to the quartz diorite fragments.

The Glance rests on an erosional unconformity of widely variable relief. Along the south and east flanks of the Empire Mountains, the surface of unconformity has irregularities measured in tens of feet that are reflected in the variations of thickness of the conglomerate. In the northern part of the range, however, the unconformity was cut over a mass of Precambrian granitoid and metamorphic rocks that stood several thousand feet higher than the floor of the basin of Bisbee deposition. There, the Glance consists of debris eroded from the highland and deposited along the basin margin. This Glance grades southward by intertonguing into the Willow Canyon, Apache Canyon, and the lower 1,000 feet of the Shellenberger Canyon Formations; all of them are part of a conformable sequence above the limestone conglomerate to the south. Therefore, the upper contact of the Glance in the southern part of the range is placed at the top of the highest conglomerate bed that is overlain by siltstone or sandstone that contains only a few thin beds of conglomerate, but in the area of intertonguing to the north, tongues of conglomerate are shown as Glance where they exceed 20 feet in thickness; otherwise, such tongues are arbitrarily not mapped separately.

WILLOW CANYON FORMATION

The Willow Canyon Formation was named by Tyrrell (1957) for exposures along Willow Canyon on the west flank of the Whetstone Mountains, and he described the type section in the SE¼ sec. 25, T. 18 S., R. 18 E. The upper member of Tyrrell's Willow Canyon Formation in the type section is similar to the upper 1,000 feet of the Willow Canyon Formation (restricted) in the Empire Mountains, where the formation is at least 3,000 feet thick. Because the lithology of the Willow Canyon Formation is more varied in the Empire Mountains, reference section there is designated that extends from the S½ sec. 18 to the NW¼ sec. 29, T. 18 S. R., 17 E. The reference section contains the lower two-thirds of the formation on the northwest side of a zone of normal strike faults and the upper three-fourths on the southeast side, and it shows the typical lithologic types of the formation.

The Willow Canyon Formation in the reference section consists predominantly of an alternating sequence of sandstone and siltstone that erodes to valleys and ridges of moderate relief. The sandstone is light yellowish gray, light pinkish gray, and light yellowish brown, arkosic, crossbedded, and locally conglomeratic. The pebbles and cobbles in the conglomeratic sandstone are well rounded and composed mainly of quartzite and some granodiorite and quartz diorite. The siltstone is commonly dark reddish brown in the lower two-thirds of the formation and olive gray to greenish gray in the upper one-third. A few thin beds of silty limestone and calcareous sandstone occur in the upper 300 feet of the formation, and a shaly siltstone about 250 feet below the top contains fossil gastropods of the genus *Viviparus* (W. A. Cobban, written commun., 1966), a long-ranging fresh-water form.

The contact with the overlying Apache Canyon Formation is placed arbitrarily at the horizon above which limestone is a dominant part of the lithology. Thus, some thin limestone beds are included in the Willow Canyon Formation. The Willow Canyon is at least 3,000 feet thick in the southern part of the Empire Mountains, but northward it grades laterally into the Glance Conglomerate by intertonguing and is absent along the north side of the range.

APACHE CANYON FORMATION

The Apache Canyon Formation was named by Tyrrell (1957) for exposures in Apache Canyon on the west flank of the Whetstone Mountains. He described the type section at that locality extending from the base in the SW¼NW¼ sec. 31, T. 18 S., R. 19 E., to the top in the NW¼NW¼ sec. 1, T. 19 S., R. 18 E.

The Apache Canyon Formation in the Empire Mountains and the western part of the Whetstone Mountains consists of thinly laminated to thick-bedded silty limestone, black shale, siltstone, and arkosic sandstone in an alternating sequence that erodes to low-rounded ridges and valleys. The limestone is generally dark gray to black and exhibits laminae as little as a millimeter thick of black limestone alternating with gray silty limestone that forms a distinctive lithologic type unlike any Paleozoic limestone in the region. The shales are dark-gray to black fissile shales intercalated with the limestone beds. Siltstone is dark gray to orange and red, calcareous, and thin bedded to massive. Massive red siltstone about 200 feet above the base contains a bed of gypsum about 2 feet thick, and some limestone beds above the gypsum contain numerous siltstone casts of what may have been gypsum crystals. The upper half of the Apache Canyon contains several beds of sandstone as much as 15 feet thick. The sandstone is yellowish gray, yellowish brown, and olive gray, fine to very coarse grained, partly crossbedded and partly massive, and arkosic. Biscuit-shaped bodies of silty limestone as much as 3 feet across and half a foot thick occur here and there in the limestone and shale beds.

The Apache Canyon Formation grades upward through increasing amounts of sandstone and siltstone into the Shellenberger Canyon Formation, the upper contact in the Empire Mountains being placed at the top of the uppermost limestone that is more than 3 feet thick and that is overlain by siltstone and sandstone containing only a few beds of limestone. The Apache Canyon Formation is at least 1,600 feet thick in the Empire Mountains but only 550 to 740 feet thick in the type area (Tyrrell, 1957, p. 101). Like the Willow Canyon Formation it intertongues northward with the Glance.

SHELLENBERGER CANYON FORMATION

The Shellenberger Canyon Formation was named by Tyrrell (1957) for exposures along the northeast-trending part of Shellenberger Canyon on the southwest flank of the Whetstone Mountains. Tyrrell (1957) described the type section of the Shellenberger Canyon Formation as extending from the base in the NE¼NE¼ sec. 34, T. 18 S., R. 18 E., to the top in the SW¼NE¼ sec. 4, T. 19 S., R. 18 E.

The Shellenberger Canyon Formation in the Empire and Whetstone Mountains consists of an alternating sequence of shale, siltstone, sandstone, and a little limestone that erodes to valleys and ridges of moderate relief. The shale and siltstone are commonly shades of olive brown, olive gray, and greenish gray although in a few places they are reddish brown. Small bits of carbonized plant fragments are present in many of the somber-hued shales and siltstones, and silicified logs as much as 5 feet in diameter abound in some beds. The sandstone is olive brown, olive green, olive gray, and pinkish gray, fine to very coarse grained, arkosic, massive to crossbedded and lenticular. Some of the sandstone beds are conglomeratic and contain pebbles of quartzite and chert as much as an inch in diameter. One sandstone bed about 500 to 800 feet below the top of the formation has a distinctive basal conglomerate as much as a foot thick that contains well-rounded pebbles of black and red chert. The siltstone above this sandstone contains a calcareous zone about 2 to 10 feet thick that contains scattered well-rounded pebbles and cobbles of limestone and quartzite.

Limestone is mainly restricted to the lower 1,300 feet of the formation; some of it is laminated like that in the Apache Canyon Formation and some is thin bedded. Two beds about 1,000 and 1,300 feet above the base are composed of pelecypod and gastropod shells in a matrix of calcite, sand, and silt. Fossils of an Early Cretaceous dinosaur (Miller, 1964, p. 378) were obtained by Moore and Miller (1960, p. 59–60) from a shaly bed between the shell beds in the Empire Mountains, and a fossil clam *Trigonia* n. sp., was found in calcareous siltstone that overlies a similar shell bed in the Whetstone Mountains (Tyrrell, 1957).

The contact of the Shellenberger Canyon Formation with the overlying Turney Ranch Formation in both ranges is placed at the top of a light-brown sandstone that is overlain by red shale and siltstone that contains nodules of gray limestone and that is overlain in turn by light yellowish-gray to light pinkish-gray sandstone. The Shellenberger Canyon generally ranges in thickness from 3,950 to 4,330 feet, but to the north, the lower 1,000 feet of the formation grades into the Glance Conglomerate.

TURNEY RANCH FORMATION

The Turney Ranch Formation was named by Tyrrell (1957) for its typical exposures immediately north and west of Turney Ranch in the Whetstone Mountains. This ranch is now known as the Clyne Ranch and is located in secs. 21, 22, and 27, T. 19 S., R. 18 E., just inside the southeast corner of the Empire Mountains quadrangle. The described type section extends from the base in the SE¼NW¼ sec. 11, T. 19 S., R. 18 E., to the top in the SW¼ sec. 15, T. 19 S., R. 18 E.

The Turney Ranch Formation in the Empire and Whetstone Mountains consists of red siltstone and shale alternating with light-pinkish-gray sandstone. It erodes to valleys and ridges of moderate relief. The siltstone and shale are various shades of red and purplish red though locally gray near nodules of limestone. Some beds are calcareous. In places, gradations from red fine-grained sandstone into siltstone and finally into shale occur both vertically and laterally. The sandstone is light pinkish gray to pale orange, medium to coarse grained, arkosic, and crossbedded. Lenses of pebble conglomerate containing chert and quartzite pebbles set in an arkosic matrix occur here and there in the sandstone beds. Scour-and-fill structures a few inches deep occur at the base of some of the sandstone beds.

In the type area, the Turney Ranch Formation is overlain with angular unconformity by upper Cenozoic gravel deposits. In the Empire Mountains, tilted and faulted Turney Ranch beds are locally overlain with angular discordance by conglomerate and andesitic breccia that are probably of Late Cretaceous age, for they are very similar to the lower part of the Salero Formation which has been assigned a Late Cretaceous age by Drewes (1968) on the basis of potassium-argon age determinations of the upper part of the formation. The Turney Ranch Formation is at least 3,200 feet thick in the type area. Its original thickness cannot be determined because its top is eroded.

AGE

The formations of the Bisbee Group in the Empire and Whetstone Mountains are all part of a conformable sequence and are considered to be of the same general age. The only fossils that are diagnostic as to age are of an Early Cretaceous dinosaur and of the mollusk *Trigonia,* all from the Shellenberger Canyon Formation near the middle of the sequence. Tyrrell (1957) submitted specimens of *Trigonia* to Prof. A. A. Stoyanow, who determined that they are a new species that is not represented in the fauna from the Bisbee Group in the type area. However, Stoyanow considered that the beds containing *Trigonia* in the Whetstone Mountains are probably no older than the upper Trinity Group (Upper Cretaceous) and that they were deposited in the same sea as the Bisbee Group in the Bisbee area. The Bisbee Group in the Empire Mountains quadrangle rests unconformably on a variety of older rocks, the youngest of them being sedimentary and volcanic rocks that are probably equivalent to the Gardner Canyon Formation of Triassic age (Drewes, 1968). The Bisbee is overlain with a strong angular unconformity by sedimentary and volcanic rocks that are similar to the Salero Formation of Late Cretaceous age. These geologic relations, together with the meager fossil evidence, indicate that the Bisbee Group in this area was probably deposited during Early Cretaceous time.

PANTANO FORMATION

By Tommy L. Finnell

The Pantano Formation, herein adopted, was introduced by C. F. Tolman in unpublished data on the geology of the Tucson 30-minute quadrangle prepared for the U.S. Geological Survey about 1912. The first published detailed description of the Pantano, other than a brief reference by King (1939, p. 1692), was by Brennan (1962, p. 46–53). In this report Brennan selected and described the type section along the south side of U.S. Highway 80 (now Interstate 10) extending from about the east line of sec. 2, T. 17 S., R. 17 E. (top of section), westward along the highway to the center of the W½ sec. 31, T. 16 S., R. 17 E., in the Empire Mountains quadrangle, southeastern Arizona. Detailed mapping has revealed that several normal faults repeat parts of the Pantano Formation in Brennan's type section. Also at least three angular unconformities within the formation omit certain stratigraphic units from the type section.

The Pantano Formation is readily divisible into five units that have a combined thickness of at least 6,400 feet:

Unit 1, the lowest unit, is faulted against vertical beds of the Bisbee Formation of Early Cretaceous age along Interstate 10, but it lies on eroded edges of Tertiary or Cretaceous volcanic and sedimentary rocks in Barrel Canyon near State Highway 83 about 11 miles south-southwest of the town of Pantano. It consists of reddish-brown bouldery mudstone and siltstone, conglomeratic sandstone, conglomerate, and at least one rhyolite tuff of probable ash-flow origin. The sandstone and conglomerate are mostly in poorly defined layers, but in places they form alternating beds as much as 2 feet thick. This unit is at least 1,600 feet thick.

Unit 2 is red and yellowish-gray mudstone alternating with fine conglomerate and conglomeratic sandstone of the same colors; in the upper 100 feet it contains at least four beds of olive-gray partly oolitic sandy argillaceous limestone. The whole unit is about 500 feet thick.

Unit 3 is massive to poorly bedded reddish-brown conglomerate with a few mudstone and coarse-grained sandstone partings. It pinches out against the lower units a few hundred feet south of the type section but extends northward for at least 2 miles. It is at least 2,500 feet thick.

Unit 4 is a flow of dark-purplish-gray andesite called Turkey-Track Porphyry by Cooper (1961) because of the large plagioclase phenocrysts. The upper part of the flow is eroded, and it thins to a featheredge about 300 feet south of the highway.

Unit 5 locally contains a dark-purplish-gray volcanic conglomerate at the base. Where present, this grades up into purplish-gray and yellowish-brown conglomerate and coarse conglomeratic sandstone that grade upward and northward into fine-grained tuffaceous sandstone, siltstone and gypsiferous claystone containing a few interbeds of sandstone, and angular conglomerate or monolithologic breccia.

At least three tuff beds occur near the middle. The unit is at least 1,800 feet thick.

The subangular to well-rounded pebbles, cobbles, and boulders in the Pantano Formation were mainly derived from the Bisbee Formation, but partly from the Precambrian, Paleozoic, lower Tertiary(?), and Upper Cretaceous rocks of the region. In unit 3, boulders and cobbles of rhyodacite welded tuff identical in appearance to an Upper Cretaceous welded tuff are a conspicuous but minor constituent.

The surface upon which the Pantano Formation was deposited had considerable relief, as indicated by apparent depositional thinning and pinch-out of the lower units. Local deformation during deposition is suggested by angular unconformities between some of the units. For example, unit 5 rests on the andesite flow (unit 4) along the highway, but about half a mile to the south, it rests unconformably on limestone of unit 2.

In places, faulted and tilted beds of the Pantano are overlain by generally flat-lying gravel deposits of Pliocene(?) and Pleistocene age. The Pliocene(?) gravels are light pinkish gray to light yellowish gray, and they may have covered the entire type area of the Pantano Formation at some earlier time for remnants of these gravels are known to overlie the upper four units.

No indigenous fossils have been found in the Pantano Formation, although its Paleozoic and Lower Cretaceous clasts are fossiliferous. However, its age can be deduced from radiometric dating. Dates on minerals from the rhyolite tuff of unit 1 have been determined by Damon and Bikerman (1964, p. 69) as follows:

Sanidine (K-Ar) 36.7 ± 1.1 m.y.

Biotite (K-Ar) 32.8 ± 2.7 m.y.

P. E. Damon (written commun. 1966) determined the radiometric age of plagioclase from the andesite flow to be 24.4 ± 2.6 m.y. (K-Ar). On this basis, the Pantano Formation seems to range in age from early Oligocene to early Miocene.

BARDSTOWN MEMBER OF THE DRAKES FORMATION IN CENTRAL KENTUCKY

By Warren L. Peterson

Prepared in cooperation with the Kentucky Geological Survey

The Drakes Formation of Late Ordovician age consists of two members at its type locality in south-central Kentucky: the Rowland Member and the overlying Preachersville Member (Weir and others, 1965). In the vicinity of Bardstown, Ky., the Drakes Formation is divided into three members: the lowest, the Rowland Member, is closely similar to the Rowland in south-central Kentucky; the highest is the Saluda Dolomite Member; the middle member is herein named the Bardstown Member for exposures in the vicinity of Bardstown, Nelson County, Ky. The type section (fig. 3) is in Nelson County, Ky., in the southwest quarter of the Maud quadrangle in a roadcut along U.S. Highway 150, 1.35 miles northwest of Fredericktown, Washington County, Ky., and 0.95 mile from the west border of the quadrangle (lat 37°46′20″ N.; long 85°21′30″ W.).

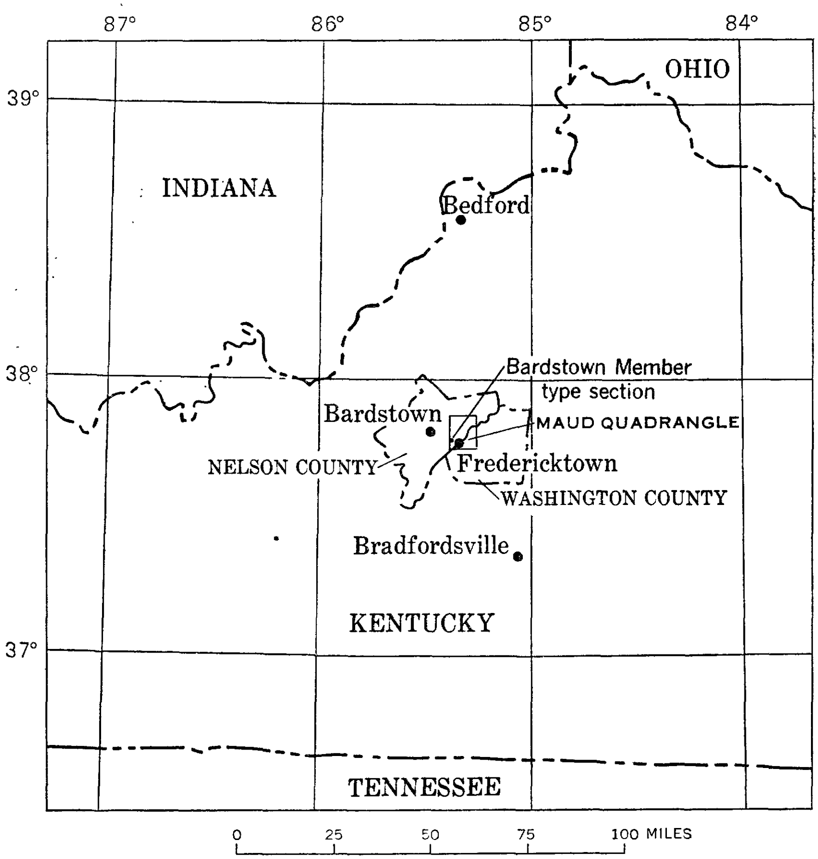


FIGURE 3.—Location of the type section of the Bardstown Member of the Drakes Formation.

About 90 percent of the Bardstown Member consists of fine- to medium-grained, gray to greenish-gray muddy limestone that contains scattered to abundant fossils and fossil fragments. Weathered rock is yellowish gray with a shaly aspect. Samples of the matrix yielded 27 to 50 percent insoluble residue. Beds are discontinuous and lenticular and commonly 1 to 8 inches thick. About 10 percent of the member is gray bioclastic and coquinoidal limestone composed of whole fossils and fossil fragments in a fine-grained to very coarse grained matrix cemented in part by sparry calcite. The matrix is predominantly calcitic fossil debris, with variable amounts of noncarbonate silt and clay. It occurs commonly in ½- to 3-inch-thick discontinuous beds, lenses, and knots with rough to smooth surfaces that form thin ledges in gully exposures or slump as resistant blocks. A small percentage of the member is calcareous shale (containing more than 50 percent insoluble residue) that is physically indistinguishable from the muddy limestone.

Fossils in the Bardstown Member are principally brachiopods, bryozoans, pelecypods, gastropods, horn corals, and colonial corals. Horn corals ("*Streptelasma*") are sparse to abundant and, in the vicinity of Bardstown, are probably restricted to this member. The colonial corals are *Tetradium* (with tiny rectangular corallites) and *Foerstephyllum*, *Favistella*, and *Caleopecia* (with larger hexagonal corallites) (Browne, 1964). The corals with hexagonal corallites occur in heads as much as 4 feet across. The colonial coral heads are concentrated in two to four layers in the middle two-thirds of the unit. Locally, layers as much as 4 feet thick are 25 to 50 percent coral heads. The coral layers in the Bardstown Member are probably correlatives of the Otter Creek coral bed, which occurs at the base of the Preachersville Member of the Drakes Formation in east-central Kentucky (Simmons and Oliver, 1967). Massive coral layers in some exposures were called the "Bardstown coral reef" by Foerste (1903). Fossils in the Bardstown Member have been listed by Butts (1915), Browne (1964, 1965), and Hatfield (1968) under different formation names discussed in another part of this paper.

The top of the Bardstown Member is placed where the muddy fossiliferous limestone grades abruptly into dolomite of the overlying Saluda Dolomite Member. The contact is not obvious but can be located by application of dilute hydrochloric acid. The contact at the base of the Bardstown Member is commonly sharp or gradational through a few inches. In some places, however, the basal contact is gradational by interlayering through an interval up to 4 feet thick. The contact is placed at the base of rock with abundant fossils.

The Bardstown Member is commonly 25 to 35 feet thick but ranges in thickness from 12 to 40 feet within a 15-mile radius of the type section. It is recognizable along the outcrop northward to near Bedford, Trimble County, Ky., and southward and southeastward at least as far as Bradfordsville, Marion County, Ky.

The Bardstown Member has previously been called the unnamed member of the Drakes Formation by Peterson (1966, 1967, 1968).

Approximately the same unit was designated the Liberty Limestone by Nosow (1959, fig. 10), the Liberty Formation by Butts (1915), the Liberty Formation and lower part of the Whitewater Formation by Browne (1964), and part of the Tanners Creek Formation by Hatfield (1968). The Liberty Limestone (or Formation) which was named in Indiana (Nickels, 1903) has been recognized in Kentucky only on a faunal basis, and the name is, therefore, considered inappropriate for a rock-stratigraphic unit in Kentucky. The name Tanners Creek Formation defined by Fox (1962) at Tanners Creek, Dearborn County, Ind., was rejected for use in Indiana by Brown and Lineback (1966) because of the lack of a regionally traceable base. The name is not considered usable in Kentucky for the same reason. The rocks of the Bardstown Member have been considered to be of Richmond (Late Ordovician) age by all writers.

Drakes Formation at type section of the Bardstown Member of the Drakes Formation

[Section measured in the southwest quarter of the Maud quadrangle, Nelson County, in roadcut along U.S. Highway 150, 1.35 miles northeast of Fredericktown, Washington County, Ky., lat 37°46′20″ N.; long 85°21′30″ W.]

	Thickness (feet)
Brassfield Dolomite (basal part only):	
22. Dolomite, light-gray to light-brown, fine- to medium-grained	4+
Drakes Formation:	
Saluda Dolomite Member:	
21. Shale, grayish-green, silty and clayey; contains no megafossils; poorly exposed	2. 3–2. 8
20. Dolomite similar to unit 19 with abundant *Tetradium* heads; in part recrystallized, flattened parallel to bedding	4. 2–4. 7
19. Dolomite, greenish-gray; color banded parallel to bedding on surface into 1 to 2 inch bands of yellowish brown, reddish brown, dark gray, and grayish green; banding probably reflects faint bedding; very fine grained; slightly silty and clayey; unfossiliferous except for poorly preserved dolomitized cylindrical bryozoans; some recrystallized calcitic bryozoans in upper 2 feet; dolomite pebbles in upper 2 feet; worm bored throughout; forms massive, jutting rounded ledge	6. 3
18. Dolomite, greenish-gray, very fine grained, massive; less resistant than overlying dolomite, silty and clayey; contains no megafossils; worm bored in lower 3 feet; upper 3 to 6 inches slightly indented and less resistant	7. 3
Total Saluda Dolomite Member	20. 6
Bardstown Member:	
17. Limestone, greenish-gray, muddy, fine-grained; contains scattered to abundant fossils and fossil fragments; in faint beds about 2 inches thick; worm bored; contains sparse thin beds, lenses, and knots of purer, more re-	

	Thickness (feet)
Drakes Formation—Continued	
Bardstown Member—Continued	
sistant gray fossiliferous limestone; fossils include brachiopods, cylindrical bryozoans, gastropods, pelecypods, and horn coral	7.6
16. Limestone, greenish-gray, muddy; contains colonial coral heads as much as 2 feet in diameter; coral heads tend to occur closely packed in parts of unit and sparsely in other parts	4.3
15. Limestone, greenish-gray, muddy, fine-grained; contains sparse to abundant fossils and fossil fragments; in beds 1 to 5 inches thick; less abundant but more resistant limestone makes up about 20 percent of rock, is medium gray, has medium- to coarse-grained matrix and abundant fossils and fossil fragments in beds, lenses, and knots as much as 2 inches thick; minor olive-gray shale occurs interbedded with limestone; all gradations occur from nearly pure limestone to calcareous shale. Fossils include brachiopods, cylindrical bryozoans, horn corals, gastropods, pelecypods, and scattered colonial coral heads	7.2
14. Limestone, greenish-gray, muddy; contains scattered fossils; colonial coral heads as much as 2 feet in diameter sparse to abundant	1.9–2.5
13. Limestone and minor shale; similar to unit 15	4.7–5.3
12. Limestone and shale; limestone is greenish gray, contains patches of unidentified dark-green mineral, is muddy, fine to medium grained, in beds 1 to 6 inches thick with undulating surfaces; fossils generally sparse; lowest bed contains brachiopods and bryozoans; small gastropods found near top. Shale is olive gray, calcareous, weakly fissile; contains no megafossils, in partings and beds as much as 1½ inches thick. Rock in unit has similarities to both Bardstown and Rowland lithologies	3.0
Total Bardstown Member	29.3
Rowland Member:	
11. Limestone, greenish-gray, medium grained; abundant small fossil fragments; single bed faintly parted into 1-inch layers	1.5
10. Limestone, greenish-gray to grayish-green, very fine grained, silty and clayey, dolomitic, thinly laminated; parted into 1- to 2-inch layers; contains no megafossils; weakly resistant; weathers with shaly aspect; some mud-cracked rock found in float	16.8
9. Limestone, greenish-gray; similar to unit 10 but contains scattered to abundant fossil fragments and ostracode shells; in beds 1 to 11 inches thick; no conspicuous laminations; forms resistant outcropping ledge	5.9
8. Limestone; similar to unit 10	12.2
7. Shale, olive-gray, calcareous, silty, clayey, weakly fissile; contains no megafossils	.3

	Thickness (feet)
Drakes Formation—Continued	
Rowland Member—Continued	
6. Limestone, greenish-gray, impure, very fine grained, laminated; parts into ½- to 1½-inch layers; contains some fossil fragments in upper part; more resistant to weathering than units such as 10	4.9
5. Limestone similar to unit 4 in beds as much as 1 inch thick and limestone similar to unit 3 mostly as thin partings	1.0
4. Limestone, light-olive-gray, fine- to medium-grained; contains pebbles of greenish-gray limestone; single bed with smooth top and bottom; contains no megafossils	.3
3. Limestone, grayish-green; conspicuously green on outcrop, silty and clayey, very fine grained; contains sparse small brachiopods, bryozoans, and fossil fragments; weathers shaly	1.8
2. Shale, dark-olive-gray, calcareous, clayey, silty, weakly fissile; contains no megafossils	.3
Total Rowland Member	45.0
Grant Lake Limestone:	
1. Limestone and shale (not measured).	

THE CANTWELL FORMATION OF THE CENTRAL ALASKA RANGE

By Jack A. Wolfe and Clyde Wahrhaftig

NAME AND TYPE AREA

The Cantwell Formation was first described by Eldridge (1900, p. 16) as the Cantwell Conglomerate from exposures in the canyon of the Nenana River, then called the Cantwell River. Its type locality is considered to be the east wall of the canyon of the Nenana River from the mouth of Slime Creek northward for about 7 or 8 miles in the Healy C–4 quadrangle (fig. 4, loc. 1). This type locality agrees with Eldridge's original text (1900, p. 1) but not with his map (map 3) nor with the statement in Wahrhaftig (1958, p. 8), both of which are in error.

DISTRIBUTION

The Cantwell Formation occupies a large synclinorium extending along the center of the Alaska Range from the headwaters of the Wood River westward to the Muldrow Glacier (fig. 4). Brooks and Prindle (in Brooks, 1911) and Reed (1961) have mapped bodies of the Cantwell farther southwest along the north base of the range. Capps (1933) mapped a large area of the Cantwell Formation on the south side of the Denali fault between Foggy Pass and Anderson Pass, an area separated from the main body of the Cantwell by a belt of Paleozoic and Triassic rocks along the north side of the fault.

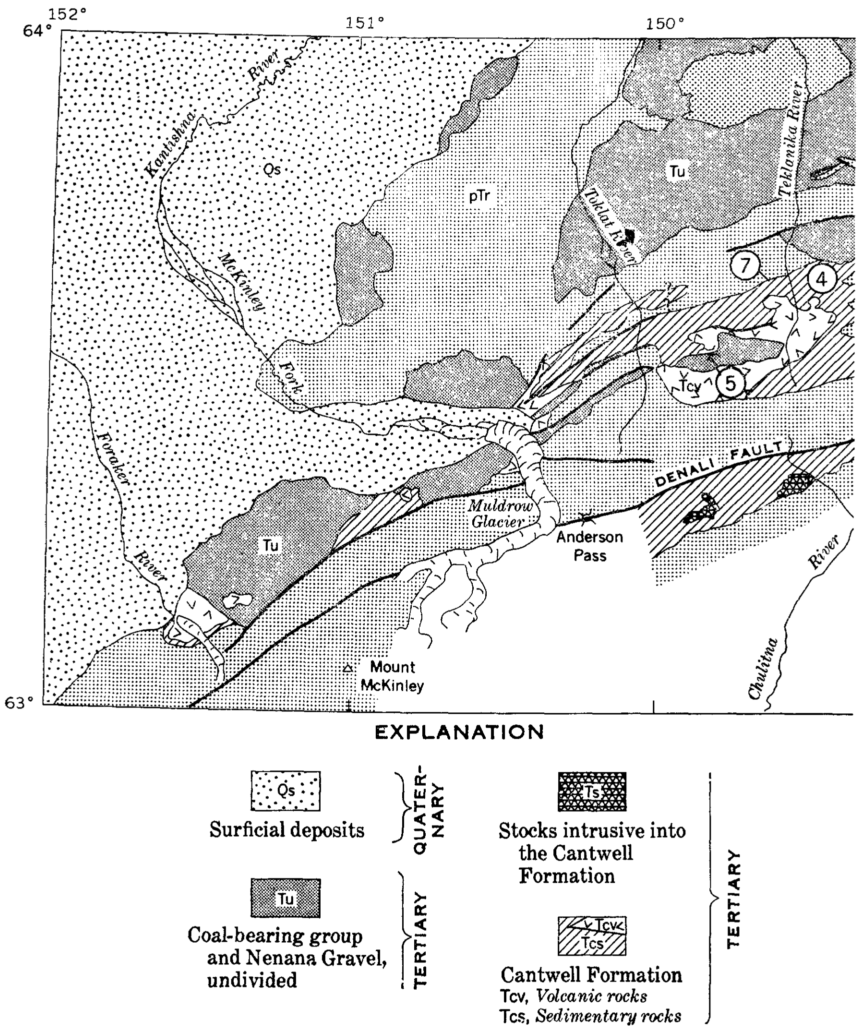
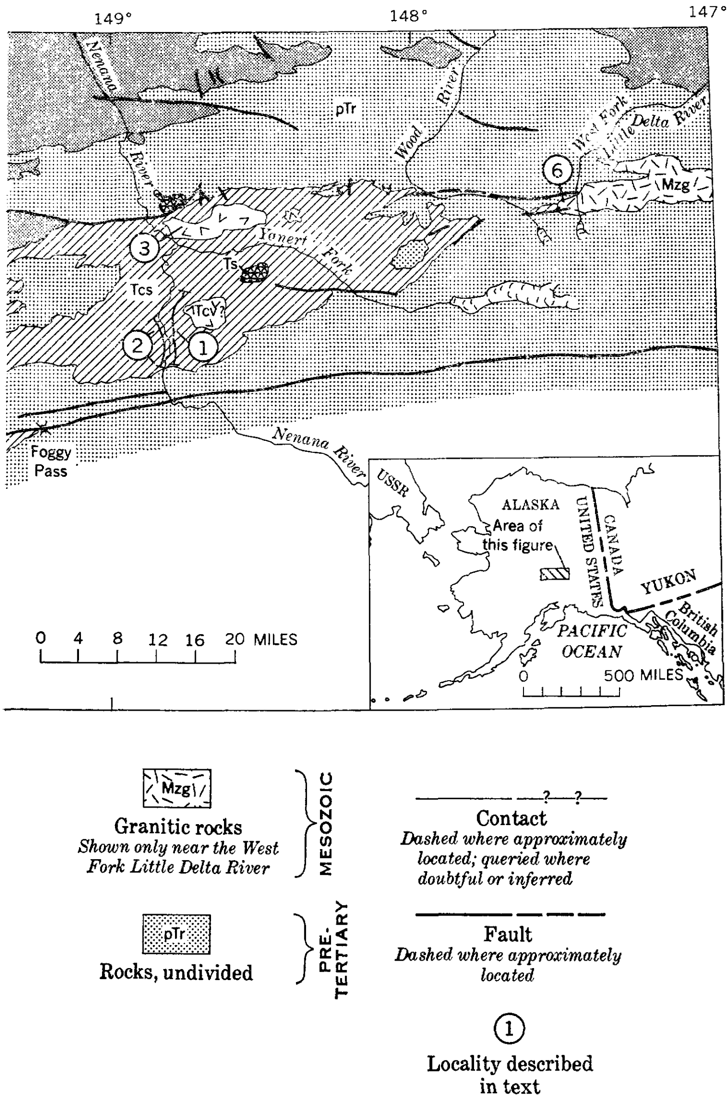


FIGURE 4.—Geologic sketch map of the central Alaska Range showing distribu-
text. Geology modified from Reed (1961, pl. 1),



tion of the Cantwell Formation, related formations, and localities referred to in Wahrhaftig (1958, pl. 1), and Capps (1912, pl. 2).

LITHOLOGY

The Cantwell Formation consists predominantly of interbedded conglomerate, sandstone, argillite, shale, and coal but also contains volcanic rocks, especially near its top. The Cantwell is intruded by an abundance of sills and dikes ranging in composition from diabase to rhyolite and by monzonite stocks as much as 3 to 4 miles across.

At two localities the Cantwell Formation is clearly younger than large intrusive bodies.(1) At the pass between the headwaters of the Wood River and the West Fork Little Delta River (fig. 4, loc. 6), it rests unconformably on granodiorite and quartz monzonite at the west end of a large batholith which was traced eastward by Capps (1912, pl. 2) as far as Delta Creek, a distance of 30 miles; the granodiorite beneath the contact has been weathered to grus for a thickness of 20 feet.(2) On the east side of the Muldrow Glacier, dikes believed to be feeders to the volcanic rocks of the Cantwell Formation cut the intrusive body underlying Mount Eielson (Reed, 1933).

The Cantwell Formation is generally moderately well consolidated and is locally very well indurated. Some beds in the formation are extremely well sorted pebble conglomerate consisting of quartz, chert, quartzite, and argillite pebbles with little or no matrix. Few of the pebbles are less than half, or more than twice, the median size. The pebbles are indented and moulded against each other, possibly as a result of solution and redeposition of silica under tectonic pressure; the conglomerate therefore has negligible porosity.

Coal in the Cantwell Formation is generally of bituminous rank, even where beds are tightly folded and the conglomerate compressed, as in the vicinity of mafic dikes.

Dark flows and rhyolite tuffs occupy an open syncline centered on Mount Fellows (fig. 4, loc. 3). A belt of predominantly silicic volcanic rocks is exposed at the top of the formation from Double Mountain (fig. 4, loc. 4) westward to the Muldrow Glacier. These silicic volcanic rocks give Polychrome Pass (fig. 4, loc. 5) its color variety. In both the Mount Fellows and Polychrome Pass areas, the volcanic rocks are at the top of the section, yet only 1,000 to 3,000 feet of sedimentary rocks lies between the volcanic rocks and the base of the formation. The volcanic rocks at Mount Fellows and Polychrome Pass may be equivalent to lower parts of the Cantwell Formation at other places, or they may have erupted in areas where highlands in the pre-Cantwell topography rose a few thousand feet above the base of the formation elsewhere.

The lithology of the clasts in the Cantwell Formation varies from place to place, suggesting that the formation was derived from at least three different sources. In the type area along the Nenana River, the sandstone and conglomerate are predominantly dark gray and consist largely of argillite, chert, quartzite, and quartz grains and pebbles. The source of this dark-gray facies was probably south of the Alaska Range, possibly in the Mesozoic rocks in the Talkeetna Mountains or the southern Alaska Range. Along the north edge of the area of outcrop of the Cantwell east of the Nenana River, this facies interfingers with light-brown to white sandstone and conglomerate consisting largely of schist fragments derived from the Birch Creek and Totatlanika Schists immediately to the north. From the vicinity of Polychrome Pass (fig. 4, loc. 5) westward, the dark-colored Cantwell is replaced by light-brown conglomerate and sandstone that consist largely of clasts of gray limestone in a light-brown matrix of unknown composition and origin. The westward limit of this light-colored limestone-bearing facies is unknown. Its source could have been the area of Devonian limestone near the crest of the range (and on the north side of the Denali fault) immediately south of its area of outcrop.

The limestone-bearing facies has not been mapped in the Cantwell Formation south of the Denali fault, as this body has not been visited since Capps' reconnaissance in 1930. A study of this facies and its correlation with facies north of the fault might give information on the lateral displacement of the fault since Paleocene time.

THICKNESS

The total thickness of the Cantwell Formation, whose upper surface has been eroded, is unknown. Generally, the thickness ranges from 2,000 to 5,000 feet. The maximum thickness is about 10,000 feet in a reference section (fig. 4, loc. 2) in the walls of the Nenana Canyon between Clear Creek and Carlo (Wahrhaftig, 1958, pl. 3) but may include an unknown thickness of sills.

AGE

The Cantwell Formation has had a varied history of age assignments. Eldridge (1900, p. 16), when first describing the Cantwell, was unable to assign an age to the formation. Brooks (1911, p. 78–83), who, with Prindle, mapped the Cantwell Formation from Mount McKinley to the Nenana River (fig. 4), correlated it on the basis of lithologic similarity with the Nation River Formation, then considered to be of Carboniferous age; but Brooks, in making this correlation had to explain away as faulted inliers beds containing plant remains which he had collected and which F. H. Knowlton reported to be Tertiary.

Moffit (1915) found plant fossils in rocks about 15 miles east of the Nenana that are similar to those of the type area. Knowlton and Hollick (in Moffit, 1915, p. 48) assigned these fossils to the Eocene but noted that Brooks' collections were similar. For 20 years there-after, geologists working in Alaska were troubled by the fact that both the Cantwell Formation and an apparently much younger coal-bearing formation of the Nenana coal field to the north contained plants of supposed Eocene age.

In 1936, Ralph Chaney made new collections in the Cantwell at another highly fossiliferous locality and determined the fossils to be Cretaceous in age (Chaney, 1937), the age for the Cantwell quoted by Capps (1940, p. 118). In a further refinement of its age, Imlay and Reeside (1954, p. 235), noting the similarity of the plant species identified from the Cantwell by Chaney to those in the Upper Cretaceous Chignik Formation of the Alaska Peninsula and the Lower Cretaceous Melozi and Kaltag Formations of western Alaska, placed the Cantwell in the Lower Cretaceous Albian Stage.

Fossil plants have been collected from several localities in the Cantwell Formation, but only one locality, that of Chaney's collections, has furnished well-preserved and abundant material. Reexamination of Chaney's collections (Univ. of California Museum Paleont. loc. P3654—loc. 7 of fig. 4) indicates that the following taxa are present:

Glyptostrobus? sp.
Metasequoia occidentalis (Newb.) Chan.
Sparganium antiquum (Newb.) Berry
Planera microphylla Newb.
Cocculus flabella (Newb.) Wolfe
Cissus sp. aff. *C. marginata* (Lesq.) R. W. Br.
Grewiopsis auriculaecordatus (Holl.) Wolfe
Dicotylophyllum flexuosa (Newb.) Wolfe

All these named species are indicators of a Tertiary age; *Cissus marginata* is known from both Upper Cretaceous and Paleocene rocks (Brown, 1962). The species of *Planera*, *Cocculus*, *Grewiopsis*, and *Dicotylophyllum* were recorded from the Chickaloon Formation of the Cook Inlet region (Wolfe and others, 1966) and from other rocks thought or known to be of Paleocene age. Inasmuch as the particular species of these four genera have not been found in rocks younger than Paleocene, we therefore consider the known fossil plants to be indicative of a Paleocene age for the Cantwell Formation.

REFERENCES CITED

Allen, C. R., and others, 1968, The Borrego Mountain, California, earthquake of 9 April 1968—A preliminary report: Seismol. Soc. America Bull., v. 58, no. 3, p. 1183–1186; California Div. Mines and Geology Mineral Inf. Service, v. 21, no. 7, p. 103–106.

Anders, R. B., McAdoo, G. D., and Alexander, W. H., Jr., 1968, Ground-water resources of Liberty County, Texas: Texas Water Devel. Board Rept. 72, 140 p.

Anderson, C. A., and Creasey, S. C., 1967, Geologic map of the Mingus Mountain quadrangle, Yavapai County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ–715, scale 1:62,500.

Anderson, R. E., and Ekren, E. B., 1968, Widespread Miocene igneous rocks of intermediate composition, southern Nye County, Nevada [abs.]: Geol. Soc. America Spec. Paper 101, p. 384.

Bachman, G. O., 1968, Geology of the Mockingbird Gap quadrangle, Lincoln and Socorro Counties, New Mexico: U.S. Geol. Survey Prof. Paper 594–J, 43 p.

Barker, Fred, 1954, Pre-Cambrian and Tertiary geology of the Las Tablas quadrangle, New Mexico: Pasadena, California Inst. Technology unpub. Ph. D. dissert. 230 p.

——— 1958, Precambrian and Tertiary geology of Las Tablas quadrangle, New Mexico: New Mexico Bur. Mines and Mineral Resources Bull. 45, 104 p.

Bartleson, B. L., Bryant, Bruce, and Mutschler, F. E., 1968, Permian and Pennsylvanian stratigraphy and nomenclature, Elk Mountains, Colorado, *in* Geological Survey research 1968: U.S. Geol. Survey Prof. Paper 600–C, p. C53–C60.

Blake, M. C., Jr., Irwin, W. P., and Coleman, R. G., 1967, Upside-down metamorphic zonation, blueschist facies, along a regional thrust in California and Oregon, *in* Geological Survey research 1967: U.S. Geol. Survey Prof. Paper 575–C, p. C1–C9.

Boucot, A. J., and Johnson, J. G., 1968, Brachiopods of the Bois Blanc Formation in New York: U.S. Geol. Survey Prof. Paper 584–B, 27 p.

Brennan, D. J., 1962, Tertiary sedimentary rocks and structures of the Cienega Gap area, Pima County, Arizona, *in* Cenozoic geology of Arizona—A symposium: Arizona Geol. Soc. Digest, v. 5, p. 4, 45–57.

Briggs, R. P., 1968, Geologic map of the Arecibo quadrangle, Puerto Rico: U.S. Geol. Survey Misc. Geol. Inv. Map I–551.

Brooks, A. H., 1911, The Mount McKinley region, Alaska, with descriptions of the igneous rocks and of the Bonnifield and Kantishna districts, by L. M. Prindle: U.S. Geol. Survey Prof. Paper 70, 234 p.

Brown, G. D., Jr., and Lineback, J. A., 1966, Lithostratigraphy of Cincinnatian Series (Upper Ordovician) in southeastern Indiana: Am. Assoc. Petroleum Geologists Bull., v. 50, no. 5, p. 1018–1023.

Brown, R. W., 1962, Paleocene flora of the Rocky Mountains and Great Plains: U.S. Geol. Survey Prof. Paper 375, 119 p.

Browne, R. G., 1964, The coral horizons and stratigraphy of the upper Richmond Group in Kentucky west of the Cincinnati Arch: Jour. Paleontology, v. 38, no. 2, p. 385–392.

——— 1965, Some upper Cincinnatian (Ordovician) colonial corals of north-central Kentucky: Jour. Paleontology, v. 39, no. 6, p. 1177–1191.

Butts, Charles, 1915, Geology and mineral resources of Jefferson County, Kentucky: Kentucky Geol. Survey, ser. 4, v. 3, pt. 2, 270 p.

Capps, S. R., 1912, The Bonnifield region, Alaska: U.S. Geol. Survey Bull. 501, 64 p.

——— 1933, The eastern portion of Mount McKinley National Park: U.S. Geol. Survey Bull. 836–D, p. 219–300.

——— 1940, Geology of the Alaska Railroad region: U.S. Geol. Survey Bull. 907, 201 p.

Cariani, A. R., 1959, The geology of the Anson quadrangle, Maine [abs.]: Dissert. Abs., v. 19, no. 10, p. 2577.

Chadwick, G. H., 1933, The Great Catskill delta, and revision of late Devonic succession: Pan-Am. Geologist, v. 60, no. 2, p. 91–107.

Chaney, R. W., 1937, Age of the Cantwell Formation [abs.]: Geol. Soc. America Proc. 1936, p. 355–356.

Coats, R. R., 1969, Upper Paleozoic formations of the Mountain City area, Elko County, Nevada, *in* Cohee, G. V., Bates, R. G., and Wright, W. B., Changes in stratigraphic nomenclature by the U.S. Geological Survey, 1967: U.S. Geol. Survey Bull. 1274–A, p. A22–A27.

Cohee, G. V., 1968, Holocene replaces Recent in nomenclature usage of the U.S. Geological Survey: Am. Assoc. Petroleum Geologists Bull., v. 52, no. 5, p. 852.

Colton, G. W., and de Witt, Wallace, Jr., 1958, Stratigraphy of the Sonyea Formation of Late Devonian age in western and west-central New York: U.S. Geol. Survey Oil and Gas Inv. Chart OC–54.

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

Cooper, J. R., 1961, Turkey-track porphyry—A possible guide for correlation of Miocene rocks in southeastern Arizona: Arizona Geol. Soc. Digest, v. 4, p. 17–33.

Creasey, S. C., 1967, Geologic map of the Benson quadrangle, Cochise and Pima Counties, Arizona: U.S. Geol. Survey Misc. Geol. Inv. Map I–470.

Cressman, E. R., 1967, Geologic map of the Georgetown quadrangle, Scott and Fayette Counties, Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–605, scale 1:24,000.

——— 1968, Geologic map of the Salvisa quadrangle, central Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–760.

Damon, P. E., and Bikerman, Michael, 1964, Potassium-argon dating of post-Laramide plutonic and volcanic rocks within the Basin and Range province of southeastern Arizona and adjacent areas: Arizona Geol. Soc. Digest, v. 7, p. 63–78.

Dane, C. H., Kauffman, E. G., and Cobban, W. A., 1968, Semilla Sandstone a new member of the Mancos Shale in the southeastern part of the San Juan Basin, New Mexico: U.S. Geol. Survey Bull. 1254–F, 21 p.

Deussen, Alexander, 1914, Geology and underground waters of the southeastern part of the Texas Coastal Plain: U.S. Geol. Survey Water-Supply Paper 335, 365 p.

de Witt, Wallace, Jr., 1960, Java Formation of Late Devonian age in western and central New York: Am. Assoc. Petroleum Geologists Bull., v. 44, no. 12, p. 1933–1936.

de Witt, Wallace, Jr., and Colton, G. W., 1959, Revised correlations of lower Upper Devonian rocks in western and central New York: Am. Assoc. Petroleum Geologists Bull., v. 43, no. 12, p. 2810–2828.

Dickinson, K. A., 1968, Upper Jurassic stratigraphy of some adjacent parts of Texas, Louisiana, and Arkansas: U.S. Geol. Survey Prof. Paper 594–E, 25 p.

Drewes, Harald, 1968, New and revised stratigraphic names in the Santa Rita Mountains of southeastern Arizona: U.S. Geol. Survey Bull. 1274–C, 15 p.

Dumble, E. T., 1902, Notes on the geology of southeastern Arizona: Am. Inst. Mining Engineers Trans., v. 31, p. 696–715.

Eargle, D. H., 1968, Nomenclature of formations of the Claiborne Group, middle Eocene, Coastal Plain of Texas: U.S. Geol. Survey Bull. 1251–D, 25 p.

Eldridge, G. H., 1900, A reconnaissance in the Sushitna basin and adjacent territory, Alaska, in 1898: U.S. Geol. Survey 20th Ann. Rept., pt. 7, p. 1–29.

Englund, K. J., 1968a, Geologic map of the Bramwell quadrangle, West Virginia–Virginia: U.S. Geol. Survey Geol. Quad. Map GQ–745, scale 1:24,000.

——— 1968b, Geology and coal resources of the Elk Valley area, Tennessee and Kentucky: U.S. Geol. Survey Prof. Paper 572, 59 p.

Epstein, A. G., Epstein, J. B., Spink, W. J., and Jennings, D. S., 1967, Upper Silurian and Lower Devonian stratigraphy of northeastern Pennsylvania, New Jersey, and southeasternmost New York: U.S. Geol. Survey Bull. 1243, 74 p.

Feininger, Tomas, 1968, The updip termination of a large dike of Westerly Granite and the regional distribution of the Westerly and Narragansett Pier Granites in Rhode Island and Connecticut, *in* Geological Survey research 1968: U.S. Geol. Survey Prof. Paper 600–D, p. D181–D185.

Flint, N. K., 1965, Geology and mineral resources of southern Somerset County, Pennsylvania: Pennsylvania Geol. Survey, 4th ser. Bull. C56A, 267 p.

Foerste, A. F., 1903, The Richmond Group along the western side of the Cincinnati anticline in Indiana and Kentucky: Am. Geologist, v. 31, no. 6, p. 333–361.

——— 1905, Silurian clays, with notes on clays of the Waverly and Irvine formations [of Kentucky]: Kentucky Geol. Survey Bull. 6, p. 143–178.

Fox, W. T., 1962, Stratigraphy and paleoecology of the Richmond Group in southeastern Indiana: Geol. Soc. America Bull., v. 73, no. 5, p. 621–642.

Frye, J. C., and Willman, H. B., 1960, Classification of the Wisconsinan Stage in the Lake Michigan glacial lobe: Illinois State Geol. Survey Div. Circ. 285, 16 p.

Frye, J. C., Willman, H. B., Rubin, Meyer, and Black, R. F., 1968, Definition of Wisconsinan Stage: U.S. Geol. Survey Bull. 1274–E, 22 p.

Furlong, I. E., 1960, The geology of the Farmington quadrangle [Maine] [abs.]: Dissert. Abs., v. 21, no. 4, p. 848.

Gair, J. E., and Thaden, R. E., 1968, Geology of the Marquette and Sands quadrangles, Marquette County, Michigan: U.S. Geol. Survey Prof. Paper 397, 77 p.

Gard, L. M., Jr., 1968, Bedrock geology of the Lake Tapps quadrangle, Pierce County, Washington: U.S. Geol. Survey Prof. Paper 388–B, 33 p.

Gilluly, James, 1956, General geology of central Cochise County, Arizona: U.S. Geol. Survey Prof. Paper 281, 169 p.

Glenn, L. C., 1925, The northern Tennessee coal field, included in Anderson, Campbell, Claiborne, Fentress, Morgan, Overton, Pickett, Roane, and Scott counties: Tennessee Div. Geology Bull. 33–B, 478 p.

Granger, A. E., and others, 1957, Geology and mineral resources of Elko County, Nevada: Nevada Bur. Mines Bull. 54, 190 p.

Green, J. C., 1964, Stratigraphy and structure of the Boundary Mountain anticlinorium in the Errol quadrangle, New Hampshire–Maine: Geol. Soc. America Spec. Paper 77, 78 p.

Hail, William J., Jr., 1968, Geology of southwestern North Park and vicinity, Colorado: U.S. Geol. Survey Bull. 1257, 119 p.

Hall, James, 1839, Third annual report of the fourth geological district of the State of New York: New York Geol. Survey Ann. Rept. 3, p. 287–339.

——— 1840, Fourth annual report of the survey of the fourth geological district [New York]: New York Geol. Survey Ann. Rept. 4, p. 389–456.

——— 1843, Geology of New York, Part IV, comprising the survey of the fourth geological district: Albany, New York Geol. Survey, 683 p.

Hansen, W. R., 1968, Geologic map of the Black Ridge quadrangle, Delta and Montrose Counties, Colorado: U.S. Geol. Survey Geol. Quad. Map GQ-747, scale 1:24,000.

Harwood, D. S., and Berry, W. B. N., 1967, Fossiliferous lower Paleozoic rocks in the Cupsuptic quadrangle, west-central Maine, *in* Geological Survey research 1967: U.S. Geol. Survey Prof. Paper 575-D, p. D16-D23.

Hatfield, C. B., 1968, Stratigraphy and paleoecology of the Saluda Formation (Cincinnatian) in Indiana, Ohio, and Kentucky: Geol. Soc. America Spec. Paper 95, 34 p.

Hayes, P. T., and Drewes, Harald, 1968, Mesozoic sedimentary and volcanic rocks of southeastern Arizona, *in* Arizona Geol. Soc., Southern Arizona Guidebook 3—Geol. Soc. America, Cordilleran Sec., 64th Ann. Mtg., Tuscon, 1968: Tucson, Ariz., Arizona Geol. Soc., p. 49-58.

Hayes, P. T., and Raup, R. B., 1968, Geologic map of the Huachuca and Mustang Mountains, southeastern Arizona: U.S. Geol. Survey Misc. Geol. Inv. Map I-509.

Hazel, J. E., 1968, Ostracodes from the Brightseat Formation (Danian) of Maryland: Jour. Paleontology, v. 42, no. 1, p. 100-142.

Hennen, R. V., and Gawthrop, R. M., 1915, Wyoming and McDowell Counties: West Virginia Geol. Survey, 783 p.

Hernon, R. M., 1969, The Wehutty Formation of North Carolina, *in* Cohee, G. V. Bates, R. G., and Wright, W. B., Changes in stratigraphic nomenclature by the U.S. Geological Survey, 1967: U.S. Geol. Survey Bull 1274-A, p. A49-A52.

Hobbs, S. W., Hays W. H., and Ross, R. J., Jr., 1968, The Kinnikinic Quartzite of central Idaho—redefinition and subdivision: U.S. Geol. Survey Bull. 1254-J, 22 p.

Imlay, R. W., and Reeside, J. B., Jr., 1954, Correlation of the Cretaceous formations of Greenland and Alaska: Geol. Soc. America Bull., v. 65, no. 3, p. 223-246.

James, H. L., Dutton, C. E., Pettijohn, F. J., and Wier, K. L., 1968, Geology and ore deposits of the Iron River-Crystal Falls district, Iron County, Michigan: U.S. Geol. Survey Prof. Paper 570, 134 p.

Just, Evan, 1937, Geology and economic features of the pegmatites of Taos and Rio Arriba Counties, New Mexico: New Mexico School of Mines Bull. 13, 73 p.

Kaye, C. A., 1959, Geology of the San Juan metropolitan area, Puerto Rico: U.S. Geol. Survey Prof. Paper 317-A, 48 p.

Keller, W. D., 1952, Analcime in the Popo Agie member of the Chugwater formation [Wyo.]: Jour. Sed. Petrology, v. 22, no. 2, p. 70-82.

King, P. B., Neuman, R. B., and Hadley, J. B., 1968, Geology of the Great Smoky Mountains National Park, Tennessee and North Carolina: U.S. Geol. Survey Prof. Paper 587, 23 p.

King, R. E., 1939, Geological reconnaissance in northern Sierra Madre Occidental of Mexico: Geol. Soc. America Bull., v. 50, no. 11, p. 1625-1722.

Kistler, R. W., 1968, Potassium-argon ages of volcanic rocks in Nye and Esmeralda Counties, Nevada [abs.]: Geol. Soc. America Spec. Paper 101, p. 406.

Krieger, M. H., 1968a, Geologic map of the Brandenburg Mountain quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ-668, scale 1:24,000.

——— 1968b, Geologic map of the Holy Joe Peak quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ-669, scale 1:24,000.

Lidiak, E. G., 1965, Petrology of andesitic, spilitic, and keratophyric flow rock, north-central Puerto Rico: Geol. Soc. America Bull., v. 76, no. 1, p. 57–88.

Luedke, R. G., and Burbank, W. S., 1968, Volcanism and cauldron development in the western San Juan Mountains, Colorado, *in* Symposium on Cenozoic volcanism in southern Rocky Mountains: Colorado School Mines Quart., v. 63, no. 3, p. 175–208.

Luther, D. D., 1897, The stratigraphic position of the Portage sandstones in the Naples Valley and the adjoining region: New York State Geol. Survey Ann. Rept. 15, p. 13–14.

MacKevett, E. M., Jr., 1969, Three newly named Jurassic formations in the McCarthy C–5 quadrangle, Alaska, *in* Cohee, G. V., Bates, R. G., and Wright, W. B., Changes in stratigraphic nomenclature by the U.S. Geological Survey, 1967: U.S. Geol. Survey Bull. 1274–A, p. A35–A49.

Mallory, W. W., 1967, Pennsylvanian and associated rocks in Wyoming: U.S. Geol. Survey Prof. Paper 554–G, 31 p.

McFarlan, A. C., 1943, Geology of Kentucky: Lexington, Ky., Univ. Kentucky, 531 p.

Meisler, Harold, and Becher, A. E., 1968, Carbonate rocks of Cambrian and Ordovician age in the Lancaster quadrangle, Pennsylvania: U.S. Geol. Survey Bull. 1254–G, 14 p.

Metzger, D. G., 1968, The Bouse Formation (Pliocene) of the Parker-Blythe-Cibola area, Arizona and California, *in* Geological Survey research 1968: U.S. Geol. Survey Prof. Paper 600–D, p. D126–D136.

Miller, H. W., Jr., 1964, Cretaceous dinosaurian remains from southern Arizona: Jour. Paleontology, v. 38, no. 2, p. 378–384.

Moffit, F. H., 1915, The Broad Pass region, Alaska: U.S. Geol. Survey Bull. 608, 80 p.

Moore, G. W., 1969, New formations on Kodiak and adjacent islands, Alaska, *in* Cohee, G. V., Bates, R. G., and Wright, W. B., Changes in stratigraphic nomenclature by the U.S. Geological Survey, 1967: U.S. Geol. Survey Bull. 1274–A, p. A27–A35.

Moore, R. A., and Miller, H. W., Jr., 1960, A dinosaur-bearing section of Cretaceous rocks in the Empire Mountains, Pima County, Arizona: Arizona Geol. Soc. Digest, v. 3, p. 57–61.

Morrison, R. B., and others, 1957, In behalf of the Recent: Am. Jour. Sci. v. 255, no. 6, p. 385–393.

Myers, D. A., 1968, *Schwagerina crassitectoria* Dunbar and Skinner, 1937, a fusulinid from the upper part of the Wichita Group, Lower Permian, Coleman County, Texas, *in* Geological Survey research 1968: U.S. Geol. Survey Prof. Paper 600–B, p. B133–B139.

Nelson, A. E., 1967, Geologic map of the Utuado quadrangle, Puerto Rico: U.S. Geol. Survey Misc. Geol. Inv. Map I–480, scale 1:20,000.

Nelson, W. H., and Pierce, W. G., 1968, Wapiti Formation and Trout Peak Trachyandesite, northwestern Wyoming: U.S. Geol. Survey Bull. 1254–H, 11 p.

Nelson, W. H., and Ross, C. P., 1968, Geology of part of the Alder Creek mining district, Custer County, Idaho: U.S. Geol. Survey Bull. 1252–A, 30 p.

New York State Museum and Science Service, Geological Survey, 1962, Geologic map of New York, 1961: New York State Mus. and Sci. Service, Geol. Survey, Map and Chart Ser. 5, 5 map sheets, scale 1:250,000. and text.

Nickels, J. M., 1903, The Richmond Group in Ohio and Indiana and its subdivisions, with a note on the genus *Strophomena* and its type: Am. Geologist, v. 32, p. 202–218.

Noble, D. C., 1968, Kane Spring Wash volcanic center, Lincoln County, Nevada [abs.]: Geol. Soc. America Spec. Paper 101, p. 411.

Noble, D. C. Bath, G. D., Christiansen, R. L., and Orkild, P. P., 1968, Zonal relations and paleomagnetism of the Spearhead and Rocket Wash Members of the Thirsty Canyon Tuff, southern Nevada, *in* Geological Survey research 1968: U.S. Geol. Survey Prof. Paper 600–C, p. C61–C65.

Noble, D. C., Sargent, K. A., Mehnert, H. H., Ekren, E. B., and Byers, F. M., Jr., 1968, Silent Canyon volcanic center, Nye County, Nevada [abs.]: Geol. Soc. America Spec. Paper 101, p. 412–413.

Nosow, Edmund, 1959, [Guidebook] Stratigraphy of Nelson County and adjacent areas, field trip, May 8–9, 1959: Lexington, Kentucky Geol. Survey, 37 p.

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

Osberg, P. H., Moench, R. H., and Warner, Jeffrey, 1968, Stratigraphy of the Merrimack synclinorium in west-central Maine, *in* Zen, E–An, White, W. S., Hadley, J. B., and Thompson, J. B., Jr., eds., Studies of Appalachian geology—northern and maritime: New York, Intersci. Publishers, p. 241–253.

Pavlides, Louis, Boucot, A. J., and Skidmore, W. B., 1968, Stratigraphic evidence for the Taconic orogeny in the northern Appalachians, *in* Zen, E–An, White, W. S., Hadley, J. B., and Thompson, J. B., Jr., eds., Studies of Appalachian geology—northern and maritime: New York, Intersci. Publishers, p. 61–82.

Pease, M. H., Jr., 1968a, Cretaceous and lower Tertiary stratigraphy of the Naranjito and Aguas Buenas quadrangles and adjacent areas, Puerto Rico: U.S. Geol. Survey Bull. 1253, 57 p.

——— 1968b, Geologic map of the Naranjito quadrangle, Puerto Rico: U.S. Geol. Survey Misc. Geol. Inv. Map I–508, scale 1:20,000.

Pepper, J. F., de Witt, Wallace, Jr., and Colton, G. W., 1956, Stratigraphy of the West Falls Formation of Late Devonian age in western and west-central New York: U.S. Geol. Survey Oil and Gas Inv. Chart OC–55.

Perkins, E. H., and Smith, E. S. C., 1925, Contributions to the geology of Maine, No. 1; a geological section from the Kennebec River to Penobscot Bay: Am. Jour. Sci., 5th ser., v. 9, p. 204–228.

Peterson, W. L., 1966, Geologic map of the New Haven quadrangle, Nelson and Larue Counties, Kentucky: U.S. Geol. Survey Geol. Quad Map GQ–506, scale 1:24,000.

——— 1967, Geologic map of the Lebanon Junction quadrangle, central Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–603, scale 1:24,000.

——— 1968, Geologic map of the Cravens quadrangle, Bullitt and Nelson Counties, Kentucky: U.S. Geol. Survey Geol. Quad Map GQ–737, scale 1:24,000.

Pierce, W. G., and Nelson, W. H., 1968, Geologic map of the Pat O'Hara Mountain quadrangle, Park County, Wyoming: U.S. Geol. Survey Geol. Quad. Map GQ–755, scale 1:62,500.

Pipiringos, G. N., 1968, Correlation and nomenclature of some Triassic and Jurassic rocks in south-central Wyoming: U.S. Geol. Survey Prof. Paper 594–D, 26 p.

Ransome, F. L., 1904, The geology and ore deposits of the Bisbee quadrangle, Arizona: U.S. Geol. Survey Prof. Paper 21, 168 p.

Redden, J. A., 1968, Geology of the Berne quadrangle, Black Hills, South Dakota: U.S. Geol. Survey Prof. Paper 297–F, p. 343–408.

Reed, J. C., 1933, The Mount Eielson district, Alaska: U.S. Geol. Survey Bull. 849, p. 231–287.

Reed, J. C., Jr., 1961, Geology of the Mount McKinley quadrangle, Alaska: U.S. Geol. Survey Bull. 1108–A, 36 p.

Reger, D. B., and Price, P. H., 1926, Mercer, Monroe, and Summers Counties: West Virginia Geol. Survey [County Rept.], 963 p.

Rickard, L. V., 1964, Correlation of the Devonian rocks in New York State: New York State Mus. and Sci. Service, Geol. Survey Map and Chart Ser. 4.

Roen, J. B., Kent, B. H., and Schweinfurth, S. P., 1968, Geologic map of the Monongahela quadrangle, southwestern Pennsylvania: U.S. Geol. Survey Geol. Quad. Map GQ–743, scale 1:24,000.

Ruppel, E. T., 1968, Geologic map of the Leadore quadrangle, Lemhi County, Idaho: U.S. Geol. Survey Geol. Quad. Map GQ–733, scale 1:62,500.

Sainsbury, C. L., 1967, Upper Pleistocene features in the Bering Strait area, *in* Geological Survey research 1967: U.S. Geol. Survey Prof. Paper 575–D, p. D203–D213.

Sandbery, C. A., Mapel, W. J., and Huddle, J. W., 1967, Age and regional significance of basal part of Milligen Formation, Lost River Range, Idaho, *in* Geological Survey research 1967: U.S. Geol. Survey Paper 575–C, p. C127–C131.

Sando, W. J., 1967, Mississippian depositional provinces in the northern Cordilleran region *in* Geological Survey research 1967: U.S. Geol. Survey Prof. Paper 575–D, p. D29–D38.

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

Sato, Yoshiaki, and Denson, N. M., 1967, Volcanism and tectonism as reflected by the distribution of nonopaque heavy minerals in some Tertiary rocks of Wyoming and adjacent States, *in* Geological Survey research 1967: U.S. Geol. Survey Prof. Paper 575–C, p. C42–C54.

Schafroth, D. W., 1968, Stratigraphy of some Cretaceous formations of southeastern Arizona, *in* Arizona Geol. Soc., Southern Arizona Guidebook 3—Geol. Soc. America, Cordilleran Sec., 64th Ann. Mtg., Tucson, 1968: Tucson, Arizona Geol. Soc., p. 59–67.

Shawe, D. R., and Parker, R. L., 1967, Mafic-ultramafic layered intrusion at Iron Mountain, Fremont County, Colorado: U.S. Geol. Survey Bull. 1251–A, p. A1–A28.

Silberling, N. J., 1968, Effects of basement relief beneath Triassic rocks of the Humboldt Range and nearby parts of northwestern Nevada [abs.]: Geol. Soc. America Spec. Paper 101, p. 334–335.

Simmons, G. C., 1967, Geologic map of the Palmer quadrangle, east-central Kentucky: U.S. Geol. Survey Geol. Quad. Map GQ–613, scale 1:24,000.

Simmons, G. C., and Oliver, W. A., Jr., 1967, Otter Creek coral bed and its fauna, east-central Kentucky: U.S. Geol. Survey Bull. 1244–F, 13 p.

Smedes, H. W., 1966, Geology and igneous petrology of the northern Elkhorn Mountains, Jefferson and Broadwater Counties, Montana: U.S. Geol. Survey Prof. Paper 510, 116 p.

Smith, E. S. C., 1923, The Rangeley conglomerate [Maine]: Am. Jour. Sci., 5th ser., v. 5, p. 147–154.

Smith, J. F., Jr., and Ketner, K. B., 1968, Devonian and Mississippian rocks and the date of the Roberts Mountains thrust in the Carlin-Pinon range area, Nevada: U.S. Geol. Survey Bull. 1251–I, 18 p.

Snavely, P. D., Jr., MacLeod, N. S., and Wagner, H. C., 1968, Tholeiitic and alkalic basalts of the Eocene Siletz River Volcanics, Oregon Coast Range: Am. Jour. Sci., v. 266, no. 6, p. 454–481.

Soister, P. E., 1967, Relation of Nussbaum Alluvium (Pleistocene) to the Ogallala Formation (Pliocene) and to the Platte-Arkansas divide, southern Denver basin, Colorado, *in* Geological Survey research 1967: U.S. Geol. Survey Prof. Paper 575–D, p. D39–D46.

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

Stern, T. W., Goldich, S. S., and Newell, M. F., 1966, Effects of weathering on the U-Pb ages of zircon from the Morton Gneiss, Minnesota: Earth and Planetary Sci. Letters, v. 1, no. 6, p. 369–371.

Steven, T. A., and Epis, R. C., 1968, Oligocene volcanism in south-central Colorado, *in* Symposium on Cenozoic volcanism in southern Rocky Mountains: Colorado School Mines Quart., v. 63, no. 3, p. 241–258.

Steven, T. A., Mehnert, H. H., and Obradovich, J. D., 1967, Age of volcanic activity in the San Juan Mountains, Colorado, *in* Geological Survey research 1967: U.S. Geol. Survey Prof. Paper 575–D, p. D47–D55.

Stewart, J. H., and McKee, E. H., 1968, Geologic map of the Mount Callaghan quadrangle, Lander County, Nevada: U.S. Geol. Survey Geol. Quad. Map GQ–730, scale 1:62,500.

Stoyanow, A. A., 1949, Lower Cretaceous stratigraphy in southeastern Arizona: Geol. Soc. America Mem. 38, 169 p.

Swain, F. M., 1968, Ostracoda from the upper Tertiary Waccamaw Formation of North Carolina and South Carolina: U.S. Geol. Survey Prof. Paper 573–D, 37 p.

Taylor, G. L., 1935, Pre-Cambrian granites of the Black Hills: Am. Jour. Sci., 5th ser., v. 29, no. 171, p. 278–291.

Thiel, G. A., and Dutton, C. E., 1935, The architectural, structural, and monumental stones of Minnesota: Minnesota Geol. Survey Bull. 25, 160 p.

Tilton, J. L., and others, 1927, Hampshire and Hardy Counties [West Virginia]: West Virginia Geol. Survey [County Rept.], 624 p.

Tyrrell, W. W., Jr., 1957, Geology of the Whetstone Mountain area, Cochise and Pima Counties, Arizona: New Haven, Conn., Yale Univ. unpub. Ph. D. dissert.

——— 1965, Geology of the Whetstone Mountain area, Cochise and Pima Counties, Arizona [abs.]: Dissert. Abs., v. 25, no. 6, p. 3516.

Vanuxem, Lardner, 1842, Geology of New York, Part III, comprising the survey of the third geological district: Albany, New York Geol. Survey, 306 p.

Wahrhaftig, Clyde, 1958, Quaternary geology of the Nenana River valley and adjacent parts of the Alaska Range: U.S. Geol. Survey Prof. Paper 293–A, p. 1–78.

——— 1968, Schists of the central Alaska Range: U.S. Geol. Survey Bull. 1254–E, 22 p.

Walker, G. W., and Swanson, D. A., 1968, Summary report on the geology and mineral resources of the Poker Jim Ridge and Fort Warner areas of the Hart Mountain National Antelope Refuge, Lake County, Oregon: U.S. Geol. Survey Bull. 1260–M, 16 p.

Waters, A. C., 1968, Reconnaissance geologic map of the Madras quadrangle, Jefferson and Wasco Counties, Oregon: U.S. Geol. Survey Misc. Geol. Inv. Map I–555.

Weir, G. W., Greene, R. C., and Simmons, G. C., 1965, Calloway Creek Limestone and Ashlock and Drakes Formations (Upper Ordovician) in south-central Kentucky: U.S. Geol. Survey Bull. 1224–D, 36 p.

Weis, P. L., 1968, Geologic map of the Greenacres quadrangle, Washington and Idaho: U.S. Geol. Survey Geol. Quad. Map GQ–734, scale 1:62,500.

White, I. C., 1882, The geology of Pike and Monroe Counties: Pennsylvania Geol. Survey, 2d, Rept. G–6, 407 p.

Wilson, C. A., 1967, Ground-water resources of Austin and Waller Counties, Texas: Texas Water Devel. Board Rept. 68, 231 p.

Wolfe, J. A., 1968, Paleogene biostratigraphy of nonmarine rocks in King County, Washington: U.S. Geol. Survey Prof. Paper 571, 33 p.

Wolfe, J. A., Hopkins, D. M., and Leopold, E. B., 1966, Tertiary stratigraphy and paleobotany of the Cook Inlet region, Alaska: U.S. Geol. Survey Prof. Paper 398–A, 29 p.

Yates, R. G., and Engels, J. C., 1968, Potassium-argon ages of some igneous rocks in northern Stevens County, Washington, *in* Geological Survey research 1968: U.S. Geol. Survey Prof. Paper 600–D, p. D242–D247.

Yoder, H. S., Jr., and Tilley, C. E., 1962, Origin of basalt magmas—An experimental study of natural and synthetic rock systems: Jour. Petrology, v. 3, pt. 3, p. 342–532.

Zartman, R. E., and Stern, T. W., 1967, Isotopic age and geologic relationships of the Little Elk Granite, northern Black Hills, South Dakota, *in* Geological Survey research 1967: U.S. Geol. Survey Prof. Paper 575–D, p. D157–D163.

O