Changes in Stratigraphic Nomenclature by the U.S. Geological Survey, 1969

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

CONTRIBUTIONS TO STRATIGRAPHY

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CONTENTS

ILLUSTRATIONS

TABLES

CONTRIBUTIONS TO STRATIGRAPHY

CHANGES IN STRATIGRAPHIC NOMENCLATURE BY THE U.S. GEOLOGICAL SURVEY, 1969

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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.

Name	Age	Location	Revision and reference
Abrams Mica Schist	Devonian	California and Oregon	Age changed from Carboniferous to Devonian. (Lanphere and others, 1969.)
Aguas Buenas Limestone Member (of Fajardo Formation).	Early Cretaceous	Central Puerto Rico	Aguas Buenas Limestone Member removed from Fajardo Formation and placed in Torrecilla Breccia. (Briggs, 1969.)
Albemarle Group	Ordovician(?)	North Carolina	Albemarle Group redefined. McManus Formation abandoned and Yadkin Graywacke reduced in rank to a member of the Millingport Formation. Group now consists of (ascending): Tillery, Cid, and Millingport Formations. Age changed from early Paleozoic to Ordovician(?). (Stromquist and Sundelius, 1969.)
Alta Formation	Miocene	Nevada	Age changed from Oligocene(?) to Miocene. (Whitebread and Hoover, 1968.)
Amchitka Formation	early Tertiary	Southwestern Alaska	Amchitka Formation restricted; all rocks in northern Amchitka Island formerly included in Amchitka Formation are now assigned to Chitka Point Formation. Age changed from Tertiary or older to early Tertiary. (Carr and others, this report, p. A16.)
Apache Leap Tuff	Tertiary	Arizona	Apache Leap Tuff adopted. (Peterson, D. W., 1969.)
Apple Ranch Member (of Word Formation).	Early Permian (Guadalupe).	West Texas	Member incorrectly spelled in naming paper; correct spelling is Appel Ranch Member. (Cooper and Grant, 1969.)
Arcente Member (of Lake Valley Limestone).	Early Mississippian	South-central New Mexico.	Arcente Member of Laudon and Bowsher (1941) adopted. (Bachman and Myers, 1969.)
Arundel Formation (of Potomac Group).	Early Cretaceous	Maryland	Age changed from Late Cretaceous to Early Cretaceous. (Hazel, 1969.)
Atwell Gulch Member (of Wasatch Formation).	Late Paleocene and early Eocene(?).	Northwestern Colorado	Atwell Gulch Member adopted as basal member of Wasatch Formation in Piceance Creek basin. (Donnell, 1969.)
Badin Greenstone (of Tater Top Group).	early Paleozoic	North Carolina	Name abandoned. (Stromquist and Sundelius, 1969.)
Baird Group	Middle(?) and Late Devonian.	Northern Alaska	Baird Group adopted. (Tailleur and others, 1967.)
Bald Peak Basalt	Pliocene	Western California	Bald Peak Basalt reassigned from Berkeley Group (abandoned) to Contra Costa Group. (Radbruch, 1969.)
Banco Bonito Member (of Valles Phyolite).	Pleistocene	North-central New Mexico.	Banco Bonito Member adopted as upper member. (Bailey and others, 1969.)
Bandelier Tuff (of Tewa Group).	Pleistocene	North-central New Mexico.	Bandelier Tuff divided into two members (ascending): Otowi Member and Tshirege Member. (Bailey and others, 1969.)
Banjo Point Formation	late Eocene or Oligocene	Southwestern Alaska	Age changed from Oligocene(?) to late Eocene or Oligocene. (Carr and others, this report, p. A18.)
Barrancas Limestone Member (of Magueyes Formation).	Early Cretaceous	Central Puerto Rico	Barrancas Limestone Member adopted. (Briggs, 1969.)
Barros Tuff Member (of Torrecilla Breccia).	Early Cretaceous	Central Puerto Rico	Barros Tuff adopted as upper member of Torrecilla Breccia. (Briggs, 1969.)
Basic City Shale Member (of Tallahatta Formation).	middle Eocene	Western Tennessee	Basic City Shale Member extended to western Tennessee in subsurface. (Moore and Brown, 1969.)
Battleship Rock Member (of Valles Rhyolite).	Pleistocene	North-central New Mexico.	Battleship Rock Member adopted. (Bailey and others, 1969.)
Bearhead Rhyolite (of Keres Group).	middle Pliocene	North-central New Mexico.	Bearhead Rhyolite adopted. Includes Peralta Tuff Member. (Bailey and others, 1969.)

Beartooth Butte Formation	Early Devonian	Idaho, Montana, and Wyoming.	Beartooth Butte Formation extended into Idaho. (Sandberg and Mapel, 1967.)
Beckers Butte Member (of Martin Formation).	Early or Middle Devonian.	Arizona	Beckers Butte Member changed to Beckers Butte Sandstone Member. (Poole and others, 1967.)
Beirdneau Sandstone Member (of Jefferson Formation).	Late Devonian	Utah	Beirdneau Sandstone Member raised in rank to Beirdneau Formation in Utah. (Poole and others, 1967.)
Beirdneau Formation	Late Devonian	North-central Utah	Beirdneau Formation changed to Beirdneau Sandstone in report area; Beirdneau Formation used elsewhere. (Mullens, 1969.)
Bellevue Tongue (of Grant Lake Limestone).	Late Ordovician	Kentucky	Bellevue Limestone Member of McMillan Formation in Ohio extended into Kentucky as Bellevue Tongue of Grant Lake Limestone. (Swadley, 1969.)
Belt Series	Precambrian	Idaho, Montana, eastern Washington.	Belt Series revised to Belt Supergroup. (Robinson and others, 1968.)
Berkeley Group	Pliocene	Western California	Berkeley Group abandoned; rocks assigned to Contra Costa Group. (Radbruch, 1969.)
Biederman Argillite (of Kandik Group).	Early Cretaceous	East-central Alaska	Biederman Argillite adopted as middle formation of Kandik Group. (Brabb, 1969.)
Big Spencer Rhyolite	Early Devonian	Maine	Big Spencer Rhyolite adopted. (Rankin, 1968.)
Black Cat Member (of Traveler Rhyolite).	Early Devonian	Maine	Black Cat Member adopted. (Rankin, 1968.)
Blacksmith Limestone	Middle Cambrian	North-central Utah	Blacksmith Limestone changed to Blacksmith Dolomite in report area; Blacksmith Limestone used elsewhere. (Mullens, 1969.)
Bloomsburg Red Beds	Middle and Late Silurian.	Southeastern Pennsylvania.	Age changed from Late Silurian to Middle and Late Silurian. (Epstein and Epstein, 1967.)
Blue Hill Granite Porphyry.	Devonian(?)	Massachusetts	Age changed from Devonian or Carboniferous to Devonian(?). (Chute, 1969.)
Botijas Limestone Member (of Coamo Formation).	Late Cretaceous	Central Puerto Rico	Botijas Limestone Member removed from Coamo Formation and placed in Pozas Formation. (Briggs, 1969.)
Brigham Quartzite	late Precambrian to Middle Cambrian.	Southeastern Idaho	Age changed from late Precambrian and Early Cambrian to late Precambrian to Middle Cambrian. (Armstrong, 1969.)
Broadway Alluvium	Pleistocene	Colorado	Broadway Alluvium extended from central Colorado into southeastern Colorado. (Sharps, 1969.)
Butte Quartz Monzonite	Late Cretaceous	Montana	Age changed from Late Cretaceous or Paleocene to Late Cretaceous. (Robinson and others, 1968.)
Buttle Member (of Monterey Shale).	late Miocene	California	Buttle Diatomite Member of Monterey Formation (Mandra, 1969) adopted as Buttle Member of Monterey Shale. (Durham, 1968.)
Calico Peak Porphyry	early Tertiary(?)	Southwestern Colorado	Age changed from Tertiary to early Tertiary(?). (Pratt and others, 1969.)
Canadian Provincial Series.	Early Ordovician	United States	Canadian is reinstated as a provincial series; as presently used will be equivalent to Lower Ordovician Series. (N. F. Sohl, written commun., 1969.)
Canovas Canyon Rhyolite (of Keres Group).	early(?) Pliocene	North-central New Mexico.	Canovas Canyon Rhyolite adopted. (Bailey and others, 1969.)
Chico Formation	Late Cretaceous	Central California	Chico Formation not used in area of report. Strata southwest of the Chabot fault assigned to underlying Knoxville Formation. Northeast of the Chabot fault the strata are divided into (ascending): Joaquin Miller Formation (new), Oakland Conglomerate (restricted), Shephard Creek Formation (new), Redwood Canyon Formation (new), unnamed shale unit, and Pinehurst shale (new). (Case, 1968.)

Name	Age	Location	Revision and reference
Chilhowee Group	Early Cambrian and Early Cambrian(?).	Tennessee, Virginia, Maryland, West Virginia, North Carolina, and Pennsylvania.	Chilhowee Group extended into eastern Pennsylvania. (Drake, 1969.)
Chinle Formation	Late Triassic	Eastern Arizona and Western New Mexico.	Mesa Redondo Member of Cooley (1958) adopted as member of Chinle Formation. (Repenning and others, 1969.)
Chititu Formation	Late Cretaceous	Southern Alaska	Chititu Formation adopted. (Jones and MacKevett, 1969.)
Chitka Point Formation	Miocene	Southwestern Alaska	Chitka Point Formation expanded to include all rocks in northern Amchitka Island formerly included in the Amchitka Formation. Age changed from Pliocene or Pleistocene to Miocene. (Carr and others, this report, p. A18.)
Church Rock Member (of Chinle Formation).	Late Triassic	Northeastern Arizona, southwestern Colorado, and southeastern Utah.	Church Rock Member extended into southwestern Colorado. (Shawe and others, 1968.)
Cid Formation (of Albemarle Group).	Ordovician(?)	North Carolina	Cid Formation adopted: includes an unnamed lower member and Flat Swamp Member. Replaces, in part, the McManus Formation which has been abandoned. (Stromquist and Sundelius, 1969.)
Cimarron Ridge Formation	Late Cretaceous	Southwestern Colorado	Cimarron Ridge Formation adopted. (Dickinson and others, 1968.)
Circle Creek Rhyolite	early Pliocene	Northern Nevada	Circle Creek Rhyolite adopted. (Coats, 1968.)
Claiborne Group	Eocene	Western Tennessee	Memphis Sand adopted as basal formation of group in western Tennessee. (Moore and Brown, 1969.)
Clinton Formation	Middle Silurian	Southeastern Pennsylvania	Clinton Formation equivalent included in Shawangunk Conglomerate in southeastern Pennsylvania. (Epstein and Epstein, 1967.)
Clover Fork Sandstone Member (of Wise Formation).	Pennsylvanian	Southwestern Virginia and southeastern Kentucky.	Clover Fork Sandstone Member adopted. (Miller, 1969.)
Cloverly Formation	Early Cretaceous	Northeastern Utah	Cloverly Formation extended into northeastern Utah on north flank of Uinta Range. (Schell, 1969.)
Coahuila Series	Early Cretaceous	Texas, Louisiana, Mississippi, Alabama, and Arkansas.	Coahuila Series of Imlay (1944) adopted as a provincial series in the Gulf Coast region. (Maher and Applin, 1968.)
Coamo Formation	Late Cretaceous	Central Puerto Rico	Botijas Limestone Member and Revés Member removed from Coamo Formation and placed in Pozas Formation. (Briggs, 1969.)
Cochiti Formation	early to middle Pliocene.	North-central New Mexico.	Cochiti Formation adopted. (Bailey and others, 1969.)
Coeymans Limestone (Formation).	Early Devonian	Pennsylvania	Coeymans Limestone or Formation made a member of Helderberg Formation in report area. Coeymans Limestone or Formation used elsewhere. (Wood and others, 1969.)
Conejos Quartz Latite	Oligocene or older	Colorado	Name changed everywhere to Conejos Formation. (Lipman and others, 1969.)
Contra Costa Group	Pliocene	Western California	Contra Costa Group of Ham (1952) adopted; replaces Berkeley Group (abandoned). Includes (ascending): Orinda, Moraga, and Siesta Formations and Bald Peak Basalt. (Radbruch, 1969.)
Cook Mountain Formation	middle Eocene	Western Tennessee	Cook Mountain Formation extended into western Tennessee in subsurface. (Moore and Brown, 1969.)
Cooper Arroyo Sandstone Member (of Mancos Shale).	Late Cretaceous	New Mexico	Cooper Arroyo Sandstone Member adopted. (Landis and Dane, 1967.)

Copley Greenstone	Early(?) Devonian	California	Age changed from Devonian(?) to Early(?) Devonian. (Poole and others, 1967.)
Corcoran Clay Member (of Tulare Formation.	Pleistocene	California	Age changed from late Pliocene and Pleistocene(?) to Pleistocene. (Lofgren and Klausing, 1969.)
Crystal Pass Limestone Member (of Sultan Limestone).	Late Devonian	Nevada	Age changed from Middle and Late Devonian to Late Devonian. (Poole and others, 1967.)
Dawson Arkose	Late Cretaceous and Paleocene.	Colorado	A rhyolite tuff of early Oligocene age is removed from the top of the Dawson Arkose and treated as a separate unnamed formation. A 20- to 30-foot grit unit overlying the rhyolite is assigned to the overlying Castle Rock Conglomerate. (Izett and others, 1969.)
Dedham Granodiorite	Precambrian(?)	Massachusetts and Rhode Island.	Age changed from pre-Carboniferous to Precambrian(?). (Chute, 1969.)
Deer Canyon Member (of Valles Rhyolite).	Pleistocene	North-central New Mexico.	Deer Canyon Member adopted. (Bailey and others, 1969.)
Del Rio Clay	Late Cretaceous	Texas	Del Rio Clay reinstated for use south and west of Colorado River; Grayson Marl used east and north of Colorado River. (Freeman, 1968.)
Dixville Formation	Middle Ordovician	New Hampshire and Maine.	Magalloway Member of Green (1968) adopted as upper member of Dixville Formation. (Harwood, 1969.)
Dona Ana Member (of Lake Valley Limestone).	Early Mississippian	South-central New Mexico.	Dona Ana Member of Laudon and Bowsher (1941) adopted. (Bachman and Myers, 1969.)
Dothan Formation	Late Jurassic and Early Cretaceous.	Northwestern California and southwestern Oregon.	Age changed from Late Jurassic to Late Jurassic and Early Cretaceous. (Hotz, 1969.)
Drip Tank Member (of Straight Cliffs Formation).	Late Cretaceous	Utah	Drip Tank Member adopted. (Peterson, Fred, 1969.)
El Cajete Member (of Valles Rhyolite).	Pleistocene	North-central New Mexico.	El Cajete Member adopted. (Bailey and others, 1969.)
Eleana Formation	Late Devonian to Late Mississippian.	Southern Nevada	Age changed from Devonian and Mississippian to Late Devonian to Late Mississippian. (Gordon, 1969.)
Eli Limestone (of Baird Group).	Late Devonian	Northern Alaska	Eli Limestone adopted. (Tailleur and others, 1967).
El Rechuelos Rhyolite (of Polvadera Group).	early Pleistocene or older.	North-central New Mexico.	El Rechuelos Rhyolite adopted as upper formation of Polvadera Group. (Bailey and others, 1969.)
El Vado Sandstone Member (of Mancos Shale).	Late Cretaceous	New Mexico	El Vado Sandstone Member adopted. (Landis and Dane, 1967.)
Endicott Group	Late Devonian and Early and Late Mississippian.	Northern Alaska	Endicott Group adopted. (Tailleur and others, 1967.)
Englewood Formation	Late Devonian and Early Mississippian.	South Dakota, Wyoming, and Montana.	Age changed from Devonian and Mississippian to Late Devonian and Early Mississippian. (Sandberg and Mapel, 1967.)
Ervay Carbonate Rock Member (of Park City Formation).	Late Permian	Wyoming	Name changed from Ervay Carbonate Rock Member to Ervay Member. (Schroeder, 1969.)
Esopus Formation	Early Devonian	Southeastern Pennsylvania.	Esopus Formation adopted for area of report. Esopus Shale or Siltstone remain in good usage elsewhere. (Epstein and Epstein, 1967.)
Everts Formation	Late Cretaceous	Montana	Everts Formation adopted. (Fraser and others, 1969.)
Fajardo Formation	Early Cretaceous	Central Puerto Rico	Augas Buenas Limestone Member removed from Fajardo Formation and made basal member of Torrecilla Breccia. (Briggs, 1969.)
Flat Swamp Member (of Cid Formation).	Ordovician(?)	North Carolina	Adopted as upper member of the Cid Formation. (Stromquist and Sundelius, 1969.)

Name	Age	Location	Revision and reference
Flour Island Formation (of Wilcox Group).	early Eocene	Western Tennessee	Flour Island Formation adopted as upper formation of Wilcox Group in the subsurface of western Tennessee. (Moore and Brown, 1969.)
Floyd Church Member (of Millingport Formation).	Ordovician(?)	North Carolina	Floyd Church Member adopted. (Stromquist and Sundelius, 1969.)
Ford Lake Shale	Late Devonian to Late Mississippian.	East-central Alaska	Ford Lake Shale adopted. (Brabb, 1969.)
Forestdale Marble	Early Cambrian	Western Vermont	Age changed from Precambrian to Early Cambrian. (Cady, 1968.)
Fort Pillow Sand (of Wilcox Group).	early Eocene	Western Tennessee	Fort Pillow Sand adopted as middle formation of Wilcox Group in subsurface of western Tennessee. (Moore and Brown, 1969.)
Garden City Formation	Early Ordovician	North-central Utah	Name changed to Garden City Limestone in report area; Garden City Formation remains in good usage elsewhere. (Mullens, 1969.)
Gilpin Peak Tuff	Oligocene	Southwestern Colorado	Age changed from middle and late Tertiary to Oligocene. (Steven and Schmitt, 1969.)
Glenn Shale	Middle Triassic to Early Cretaceous.	East-central Alaska	Glenn Shale adopted. (Brabb, 1969.)
Grand Mesa Formation	Pleistocene (Pinedale? Glaciation).	Western Colorado	Grand Mesa Formation adopted. (Yeend, 1969.)
Grayson Marl	Late Cretaceous	Texas	Grayson Marl restricted to use east and north of Colorado River; Del Rio Clay reinstated for use south and west of Colorado River. (Freeman, 1968.)
Greenvale Cove Formation	Late Ordovician(?)	Western Maine	Greenvale Cove Formation adopted. (Moench, 1969.)
Grubstake Formation	late Miocene	Alaska	Grubstake Formation adopted. (Wahrhaftig and others, 1969.)
Guaje Member (of Bandelier Tuff).	Pleistocene	North-central New Mexico.	Guaje Member reduced in rank to Guaje Pumice Bed and made part of Otowi Member of Bandelier Tuff. (Bailey and others, 1969.)
Gunners Cove Formation	late Eocene or Oligocene.	Southwestern Alaska	Age changed from Oligocene(?) to late Eocene or Oligocene. (Carr and others, this report, p. A19.)
Hardwick Granite	Late Devonian(?)	New Hampshire and Massachusetts.	Age changed from late Carboniferous or post-Carboniferous to Late Devonian(?). (Collings and others, 1969.)
Harlan Sandstone	Pennsylvanian	Southwestern Virginia	Harlan Sandstone changed to Harlan Formation in area of report. Harlan Sandstone remains in good usage elsewhere. (Miller, 1969.)
Hayes Canyon Member (of Devils Gate Limestone).	Late Devonian	Nevada	Age changed from Middle and Late Devonian to Late Devonian. (Poole and others, 1967.)
Healy Creek Formation	late(?) Oligocene to early Miocene.	Alaska	Healy Creek Formation adopted. (Wahrhaftig and others, 1969.)
Heart Lake Conglomerate	Pliocene or Pleistocene	Wyoming	Heart Lake Conglomerate adopted. (Love and Keefer, 1969.)
Helderberg Formation	Early Devonian	Pennsylvania	Helderberg Group or Limestone revised to Helderberg Formation in report area. Includes (ascending): Coeymans, New Scotland, and Mandata Members. Helderberg Group or Limestone remains in good usage elsewhere. (Wood and others, 1969.)
Helena Formation (of Belt Supergroup).	Precambrian	Western Montana	Helena Formation accepted for Mission Mountains area; Helena Dolomite remains in good usage elsewhere. (Harrison and others, 1969.)
Hoback Formation	Paleocene and Eocene	Wyoming	Hoback Formation of Eardley and others (1944) adopted. (Oriel, 1969.)
Holcomb Quartz Monzonite	Late Cretaceous	Southern California	Age changed from Cretaceous(?) to Late Cretaceous. (Hewett and others, 1969.)

Hosston Formation	Early Cretaceous	Alabama, Louisiana, Mississippi, Arkansas, and Texas.	Hosston Formation assigned to Coahuila Series. (Maher and Applin, 1968.)
Hualpai Limestone	Pliocene(?)	Northwestern Arizona and southwestern Nevada	Spelling changed to Hualapai in accordance with a 1960 decision by the Board on Geographic Names. (Hunt, 1969.)
Hunter Mountain Quartz Monzonite.	Early Jurassic	East-central California	Age changed from Triassic or Jurassic to Early Jurassic. (Ross, 1969.)
Hunt Fork Shale	Late Devonian	Northern Alaska	Hunt Fork Shale assigned to Endicott Group. (Tailleur and others, 1967.)
Hyrum Dolomite Member (of Jefferson Formation).	Middle and Late Devonian.	Utah	Hyrum Dolomite Member raised in rank to Hyrum Dolomite in Utah; age in Utah is Middle and Late Devonian. Remains member of Jefferson Formation of Late Devonian age elsewhere. (Poole and others, 1967.)
Idavada Volcanics	early Pliocene	Northern Nevada and southern Idaho.	Idavada Volcanics extended into northern Nevada. (Coats, 1968.)
Ironside Dolomite Member (of Sultan Limestone).	Middle Devonian	Nevada	Age changed from Middle and Late Devonian to Middle Devonian. (Poole and others, 1967.)
Jackson Formation	Eocene	Tennessee, Kentucky, Mississippi, Texas, Louisiana, Georgia, Alabama, and Arkansas.	Query removed from Jackson Formation in Tennessee; formation extended into western Kentucky. (Olive and Finch, 1969.)
Jefferson Formation	Late Devonian	Idaho, Montana, Utah, and Wyoming.	Beirdneau and Hyrum Members excluded from Jefferson Formation and made separate formations in Utah. (Poole and others, 1967.)
Joaquin Miller Formation	Late Cretaceous	California	Joaquin Miller Formation adopted. (Case, 1968.)
John Henry Member (of Straight Cliffs Formation).	Late Cretaceous	Utah	John Henry Member adopted. (Peterson, Fred, 1969.)
Kanayut Conglomerate	Late Devonian	Northern Alaska	Kanayut Conglomerate assigned to Endicott Group. (Tailleur and others, 1967.)
Kandik Formation	Early Cretaceous	East-central Alaska	Kandik Formation raised to group rank; includes (ascending): Keenan Quartzite, Biederman Argillite, and Kathul Graywacke. (Brabb, 1969.)
Kate Peak Formation	Miocene and Pliocene(?)	Nevada	Age changed from Miocene or early Pliocene to Miocene and Pliocene(?). (Whitebread and Hoover, 1968.)
Kathul Graywacke (of Kandik Group).	Early Cretaceous	East-central Alaska	Kathul Graywacke adopted as upper formation of Kandik Group. (Brabb, 1969.)
Kayak Shale	Early Mississippian	Northern Alaska	Kayak Shale assigned to Endicott Group. (Tailleur and others, 1967.)
Keenan Quartzite (of Kandik Group).	Early Cretaceous	East-central Alaska	Keenan Quartzite adopted as basal formation of Kandik Group. (Brabb, 1969.)
Kekiktuk Conglomerate	Late(?) Devonian or Mississippian.	Northern Alaska	Kekiktuk Conglomerate assigned to Endicott Group. (Tailleur and others, 1967.)
Kennicott Formation	Early Cretaceous	Southern Alaska	Formation redefined and restricted to original definition of Rohn (1900). (Jones and MacKevett, 1969.)
Keokee Sandstone Member (of Wise Formation).	Pennsylvanian	Southwestern Virginia	Keokee Sandstone Member adopted. (Miller, 1969.)
Keres Group	early and middle Pliocene	North-central New Mexico.	Keres Group adopted; includes (ascending): unnamed basalt, Canovas Canyon Rhyolite, Paliza Canyon Formation, and Bearhead Rhyolite. (Bailey and others, 1969.)
Keyser Limestone	Late Silurian and Early Devonian.	Pennsylvania, West Virginia, and Maryland.	Age changed from Late Silurian and Early Devonian(?) to Late Silurian and Early Devonian. (Wood and others, 1969.)

Name	Age	Location	Revision and reference
Kingsport Formation	Early Ordovician	Eastern Tennessee	Mascot Dolomite and Kingsport Formation revised and Longview Dolomite abandoned in eastern Tennessee. The revised Kingsport Formation contains all the strata previously assigned to the Longview Dolomite plus the lower part of the old Kingsport Formation. The revised Mascot Dolomite contains the upper part of the old Kingsport Formation plus all the strata previously assigned to the old Mascot Dolomite. Kingsport Formation remains unchanged elsewhere. (Harris, 1969.)
Knox Group	Late Cambrian and Early Ordovician.	Eastern Tennessee	Longview Dolomite abandoned in eastern Tennessee; strata now included in Kingsport Formation, revised. Group consists of (ascending): Copper Ridge Dolomite, Chepultepec Dolomite, Kingsport Formation (revised), and Mascot Dolomite (revised). Knox Group remains unchanged elsewhere. (Harris, 1969.)
Kokoruda Ranch Complex	Late Cretaceous	Montana	Age changed from Tertiary or Cretaceous to Late Cretaceous. (Doe and others, 1968.)
Kugururok Formation	Late Devonian	Northern Alaska	Kugururok Formation assigned to Baird Group. (Tailleur and others, 1967.)
Lake Valley Limestone	Early Mississippian	South-central New Mexico.	Lake Valley Limestone revised; Dona Ana and Arcente Members of Laudon and Bowsher (1941) adopted. Formation includes (ascending): Andrecito, Alamogordo, Nunn, Tierra Blanca, Arcente, and Dona Ana Members. Age changed from Mississippian to Early Mississippian. (Bachman and Myers, 1969.)
Lands End Formation	Pleistocene (Bull Lake? Glaciation).	Western Colorado	Lands End Formation adopted. (Yeend, 1969.)
Landslide Creek Formation.	Late Cretaceous	Montana	Landslide Creek Formation adopted. (Fraser and others, 1969.)
Langston Limestone	Middle Cambrian	Southeastern Idaho	Langston Formation used in report area; Langston Limestone remains in good usage elsewhere. (Armstrong, 1969.)
Lead Camp Limestone	Pennsylvanian	South-central New Mexico	Lead Camp Limestone adopted. (Bachman and Myers, 1969.)
Leatham Formation	Late Devonian and Early Mississipian.	Idaho and Utah	Age changed from Early Mississippian to Late Devonian and Early Mississippian. Formation extended into Idaho. (Sandberg and Mapel, 1967.)
Leona Rhyolite	Pliocene(?)	Western California	Age changed from early or middle Pleistocene to Pliocene(?). (Radbruch, 1969.)
Lignite Creek Formation	middle Miocene	Alaska	Lignite Creek Formation adopted. (Wahrhaftig and others, 1969.)
Lobato Basalt (of Polvadera Group).	middle Pliocene	North-central New Mexico.	Lobato Basalt adopted as basal formation of Polvadera Group. (Bailey and others, 1969.)
Lone Mountain Dolomite	Silurian and Early Devonian.	Utah	Age changed from Silurian to Silurian and Early Devonian. (Poole and others, 1967.)
Longview Dolomite	Early Ordovician	Eastern Tennessee	Longview Dolomite abandoned in eastern Tennessee. Strata previously assigned to the Longview is now assigned to the Kingsport Formation, revised. Longview Dolomite remains unchanged elsewhere. (Harris, 1969.)
Louisiana Limestone	Late Devonian	Missouri	Age changed from Mississippian to Late Devonian. (Sando and others, 1969.)
Lousetown Formation	Pliocene and Pleistocene	Nevada	Age changed from Pliocene(?) and Pleistocene to Pliocene and Pleistocene. (Whitebread and Hoover, 1968.)
Louviers Alluvium	Pleistocene	Colorado	Louviers Alluvium extended from central Colorado into southeastern Colorado. (Sharps, 1969.)

Love Ranch Formation	early Tertiary	South-central New Mexico	Love Ranch Formation of Kottlowski and others (1956) adopted. (Bachman and Myers, 1969.)
McCann Hill Chert	Early, Middle(?), and Late Devonian.	East-central Alaska	Age changed from Middle and Late Devonian to Early, Middle(?), and Late Devonian. (Churkin and Brabb, 1967.)
MacColl Ridge Formation	Late Cretaceous	Southern Alaska	MacColl Ridge Formation adopted. (Jones and MacKevett, 1969.)
McManus Formation (of Albemarle Group).	early Paleozoic	North Carolina	McManus Formation abandoned. Rocks now included in Cid and Millingport Formations. (Stromquist and Sundelius, 1969.)
Magalloway Member (of Dixville Formation).	Middle Ordovician	New Hampshire and Maine.	Magalloway Member of Green (1968) adopted as upper member of Dixville Formation. (Harwood, 1969.)
Magothy Formation	Late Cretaceous	New Jersey	Amboy stoneware clay of Kümmel and Knapp (1904) removed from top of Raritan and placed at base of Magothy Formation. (Owens and Sohl, 1969.)
Magueyes Formation	Early and Late Cretaceous.	Puerto Rico	Barrancas Limestone Member adopted. Age changed from Early(?) and Late Cretaceous to Early and Late Cretaceous. (Briggs, 1969.)
Mahantango Formation	Middle Devonian	Pennsylvania	Montebello Sandstone Member of Mahantango Formation adopted. (Wood and others, 1969.)
Mancos Shale	Late Cretaceous	New Mexico	Mancos Shale in northern New Mexico is divided into (ascending): Graneros Shale Member, Greenhorn Limestone Member, lower shale unit with Cooper Arroyo Sandstone Member (new) at top of lower third of unit, El Vado Sandstone Member (new), and upper shale unit. (Landis and Dane, 1967.)
Mandata Formation	Early Devonian	Pennsylvania	Mandata Formation made a member of Helderberg Formation in report area. Mandata Formation in good usage elsewhere. (Wood and others, 1969.)
Maravillas Formation	Late Cretaceous	Central Puerto Rico	Toyosa Member adopted as upper member of Maravillas Formation in Orocovis quadrangle. (Briggs, 1969.)
Marcum Hollow Sandstone Member (of Wise Formation).	Pennsylvanian	Southwestern Virginia and southeastern Kentucky.	Marcum Hollow Sandstone Member adopted. (Miller, 1969.)
Mascot Dolomite	Early Ordovician	Eastern Tennessee	Mascot Dolomite and Kingsport Formation revised and Longview Dolomite abandoned in eastern Tennessee. The revised Kingsport Formation contains all the strata previously assigned to the Longview Dolomite plus the lower part of the old Kingsport Formation. The revised Mascot contains the upper part of the old Kingsport plus all the strata previously assigned to the Mascot. Mascot Dolomite remains unchanged elsewhere. (Harris, 1969.)
Mattapan Volcanic Complex	Devonian(?)	Massachusetts	Age changed from Devonian or Carboniferous to Devonian(?). (Chute, 1969.)
Meister Member (of Devils Gate Limestone).	Middle and Late Devonian.	Nevada	Age changed from Middle Devonian to Middle and Late Devonian. (Poole and others, 1967.)
Memphis Sand (of Claiborne Group).	middle Eocene	Western Tennessee	Memphis Sand adopted as basal formation of Claiborne Group in subsurface of western Tennessee; replaces "500-foot sand" of earlier workers. (Moore and Brown, 1969.)
Meridian Sand Member (of Tallahatta Formation).	middle Eocene	Tennessee, Alabama, and Mississippi.	Meridian Sand Member extended into western Tennessee in subsurface. (Moore and Brown, 1969.)
Mesa Redondo Member (of Chinle Formation).	Late Triassic	Arizona	Mesa Redondo Member of Cooley (1958) adopted. (Repenning and others, 1969.)
Millingport Formation (of Albemarle Group).	Ordovician(?)	North Carolina	Millingport Formation adopted; includes (ascending): Floyd Church and Yadkin Members. Replaces, in part, McManus Formation which has been abandoned. (Stromquist and Sundeline, 1969.)

Name	Age	Location	Revision and reference
Molina Member (of Wasatch Formation).	Eocene	Northwestern Colorado	Molina Member adopted as middle member of Wasatch Formation in Piceance Creek basin. (Donnell, 1969.)
Monmouth Group	Late Cretaceous	New Jersey	Tinton Sand Member of Red Bank Sand raised to formation rank and made top formation of Monmouth Group. (Minard, 1969.)
Montebello Sandstone Member (of Mahantago Formation).	Middle Devonian	Pennsylvania	Montebello Sandstone Member adopted. (Wood and others, 1969.)
Monterey Shale	early, middle, and late Miocene.	California	Buttle Diatomite Member (Mandra, 1960) of Monterey Shale adopted as Buttle Member of Monterey Shale. (Durham, 1968.)
Moonshine Creek Formation	Early and Late Cretaceous (Albian and Cenomanian).	Southern Alaska	Moonshine Creek Formation adopted. (Jones and MacKevett, 1969.)
Moosalamoo Phyllite	Early Cambrian	Western Vermont	Age changed from Precambrian to Early Cambrian. (Cady, 1968.)
Moraga Formation (Tuff)	Pliocene	Western California	Moraga Formation or Tuff removed from Berkeley Group (abandoned) and assigned to Contra Costa Group. (Radbruch, 1969.)
Morrow Mountain Rhyolite (of Tater Top Group).	early Paleozoic	North Carolina	Morrow Mountain Rhyolite abandoned. (Stromquist and Sundelius, 1969.)
Narrow Canyon Limestone	Early Mississippian	Utah and Nevada	Age changed from Late Devonian and Early Mississippian to Early Mississippian. (Poole and others, 1967.)
Newburyport Quartz Diorite.	Precambrian(?)	Massachusetts and New Hampshire.	Age changed from pre-Carboniferous to Precambrian(?). (Chute, 1969.)
New Scotland Limestone (Formation).	Early Devonian	Pennsylvania	New Scotand Limestone or Formation made a member of Helderberg Formation in report area. New Scotland Limestone or Formation in good usage elsewhere. (Wood and others, 1969.)
Noatak Sandstone	Late Devonian and Early Mississippian.	Northern Alaska	Noatak Sandstone assigned to Endicott Group. (Tailleur and others, 1967.)
Nounan Limestone	Middle and Late Cambrian.	North-central Utah	Nounan Dolomite accepted remains in good usage elsewhere. (Mullens, 1969.)
Nussbaum Alluvium	Pleistocene	Colorado	Nussbaum Alluvium extended from central Colorado into southeastern Colorado as far as the Kansas State line. (Sharps, 1969.)
Oakland Conglomerate Member (of Chico Formation).	Late Cretaceous	California	Oakland Conglomerate Member as used by Lawson (1914) is revised. Oakland strata southwest of the Chabot fault are assigned to the Knoxville Formation. Strata below the prominent conglomerate layers of the Oakland Conglomerate are removed from the Oakland and named the Joaquin Miller Formation. The Oakland Conglomerate is used in a more restricted sense than that used by Lawson and is raised to formation rank. Chico Formation is not used in report. (Case, 1968.)
Old Breastworks Formation (of Wilcox Group).	early Eocene	Western Tennessee	Old Breastworks Formation adopted as basal formation of Wilcox Group in the subsurface of western Tennessee. (Moore and Brown, 1969.)
Orinda Formation	Pliocene	Western California	Orinda Formation assigned to Contra Costa Group as basal formation. (Radbruch, 1969.)
Osprey Formation	Pleistocene	Yellowstone Park area of Idaho, Wyoming, and Montana.	Osprey Formation adopted. (Pierce, K. L., and others, this report, p. A30.)
Otowi Member (of Bandelier Tuff).	Pleistocene	North-central New Mexico.	Guaje Member reduced in rank to Guaje Pumice Bed and made part of Otowi Member. (Bailey and others, 1969.)

Ottauquechee Formation	Middle and Late Cambrian.	Vermont	Age changed from Middle Cambrian to Early Ordovician to Middle and Late Cambrian. (Cady, 1968.)
Paine Shale Member (of Lodgepole Limestone).	Early Mississippian	Montana, Idaho, and Wyoming.	Paine Shale Member extended into southeastern Idaho and western Wyoming. (Sando and others, 1969.)
Paiute Monument Quartz Monzonite.	Middle Jurassic	California	Paiute Monument Quartz Monzonite adopted. (Ross, 1969.)
Paliza Canyon Formation (of Keres Group).	early to middle Pliocene.	North-central New Mexico.	Paliza Canyon Formation adopted. (Bailey and others, 1969.)
Panther Seep Formation	Late Pennsylvanian	New Mexico	Panther Seep Formation of Kottlowski and others (1956) adopted. (Bachman and Myers, 1969.)
Partridge Formation	Middle Ordovician	New Hampshire	Age changed from Late Ordovician(?) to Middle Ordovician. (Cady, 1968.)
Paspotansa Greensand Marl Member (of Aquia Formation).	Paleocene	Virginia and Maryland	Name changed from Paspotansa Greensand Marl Member to Paspotansa Member. (Hazel, 1969.)
Patapsco Formation (of Potomac Group).	Early Cretaceous	Pennsylvania, Virginia, Maryland, and Delaware.	Age changed from Late Cretaceous to Early Cretaceous. (Hazel, 1969.)
Peralta Tuff Member (of Bearhead Rhyolite).	middle Pliocene	North-central New Mexico.	Peralta Tuff Member of Stearns (1953) adopted. (Bailey and others, 1969.)
Pinehurst Shale	Paleocene	California	Pinehurst Shale adopted. (Case, 1968.)
Pinyon Peak Limestone	Late Devonian	Nevada	Age changed from Late Devonian and Early Mississippian to Late Devonian. (Poole and others, 1967.)
Piscataway Indurated Marl Member (of Aquia Formation).	Paleocene	Virginia and Maryland	Name changed from Piscataway Indurated Marl Member to Piscataway Member. (Hazel, 1968.)
Pogy Member (of Traveler Rhyolite).	Early Devonian	Maine	Pogy Member adopted. (Rankin, 1968.)
Polvadera Group	middle Pliocene to early Pleistocene.	North-central New Mexico.	Polvadera Group adopted. Includes (ascending): Lobato Basalt, Tschicoma Formation, and El Rechuelos Rhyolite. (Bailey and others, 1969.)
Popovich Formation	Devonian	Nevada	Popovich Formation of Hardie (1966) adopted. (Akright and others, 1969.)
Potomac Group	Early Cretaceous	New Jersey, Virginia, Pennsylvania, Delaware, and Maryland.	Age changed from Early and Late Cretaceous to Early Cretaceous. (Hazel, 1969.)
Pozas Formation	Late Cretaceous	Central Puerto Rico	Botijas Limestone Member and Revés Member removed from Coamo Formation and placed in Pozas Formation. Río Bauta (new) adopted as member. (Briggs, 1969.)
Puye Conglomerate	middle and late Pliocene	North-central New Mexico.	Name changed to Puye Formation; age changed from Pliocene(?) to middle and late Pliocene. (Bailey and others, 1969.)
Quimby Formation	Late Ordovician(?)	Western Maine	Quimby Formation adopted. (Moench, 1969.)
Quincy Granite	Devonian(?)	Massachusetts and Rhode Island.	Age changed from Mississippian(?) to Devonian(?). (Chute, 1969.)
Rangeley Formation	Early Silurian(?)	Western Maine	Age changed from Silurian(?) to Early Silurian(?). (Moench, 1969.)
Raritan Formation	Late Cretaceous	New Jersey	Amboy stoneware clay of Kümmel and Knapp (1904) removed from top of Raritan and added to base of Magothy. (Owens and Sohl, 1969.)
Reany Creek Formation	middle Precambrian	Michigan, northern peninsula.	Reany Creek Formation adopted. (Puffett, 1969.)

Name	Age	Location	Revision and reference
Red Bank Sand	Late Cretaceous	New Jersey	Red Bank Sand subdivided into the Shrewsbury Member (top) and Sandy Hook Member. Tinton Sand Member excluded from Red Bank Sand and raised in rank to Tinton Sand. (Minard, 1969.)
Redondo Creek Member (of Valles Rhyolite).	Pleistocene	North-central New Mexico.	Redondo Creek Member adopted. Bailey and others, 1969.)
Red Pine Shale (of Uinta Mountain Group).	Precambrian	Northeastern Utah	Red Pine Shale of Williams (1953) adopted as uppermost formation of Uinta Mountain Group. (Wallace and Crittenden, 1969.)
Redwood Canyon Formation	Late Cretaceous	California	Redwood Canyon Formation adopted. (Case, 1968.)
Revés Member (of Pozas Formation).	Late Cretaceous	Central Puerto Rico	Name changed from El Revés to Revés Member. Removed from Coamo Formation and placed in Pozas Formation. (Briggs, 1969.)
Río Bauta Member (of Pozas Formation).	Late Cretaceous	Central Puerto Rico	Río Bauta Member adopted. (Briggs, 1969.)
Río Guatemala Group	middle Oligocene to early Miocene.	Northwestern Puerto Rico.	Age changed from Oligocene to middle Oligocene to early Miocene. (Monroe, 1969.)
Río Maton Limestone Member of Robles Formation).	Early Cretaceous	Central Puerto Rico	Age changed from Early and Late Cretaceous. (Briggs, 1969.)
Road River Formation	Early Ordovician to Early Devonian.	East-central Alaska	Age changed from Ordovician and Silurian to Early Ordovician to Early Devonian. (Churkin and Brabb, 1967.)
Robbins Chapel Sandstone Member (of Wise Formation).	Pennsylvanian	Southwestern Virginia	Robbins Chapel Sandstone Member adopted. (Miller, 1969.)
Rocky Flats Alluvium	Pleistocene	Colorado	Rocky Flats Alluvium extended from central Colorado into southeastern Colorado. (Sharps, 1969.)
Salem Gabbro-Diorite	Precambrian(?)	Massachusetts	Age changed from pre-Carboniferous to Precambrian(?). (Chute, 1969.)
Salmon Hornblende Schist	Devonian	California and Oregon	Age changed from Carboniferous to Devonian. (Lanphere and others, 1969.)
Salmontrout Limestone	Early Devonian	East-central Alaska	Age changed from Middle Devonian to Early Devonian. (Churkin and Brabb, 1967.)
Sanctuary Formation	early or middle Miocene or both.	Alaska	Sanctuary Formation adopted. (Wahrhaftig and others, 1969.)
San Diego Member (of Maravillas Formation).	Late Cretaceous	Central Puerto Rico	Name changed from San Diego Member to San Diego Tuff Member. (Briggs, 1969.)
Sandy Hook Member (of Red Bank Sand).	Late Cretaceous	New Jersey	Sandy Hook Member of Redbank Formation of Olsson (1963) adopted as lower member of Red Bank Sand. (Minard, 1969.)
Santa Fe Formation	Miocene(?) and Pliocene	New Mexico and Colorado.	Age changed from Miocene and Pliocene to Miocene(?) and Pliocene. (Bailey and others, 1969.)
Schoharie Formation	Early Devonian	New Jersey, New York, and Pennsylvania.	Schoharie Formation extended into northeastern Pennsylvania and northwestern New Jersey. (Epstein and Epstein, 1969.)
Schulze Formation	Early(?) and Late Cretaceous.	Southern Alaska	Schulze Formation adopted. (Jones and MacKevett, 1969.)
Selinsgrove Limestone	Middle Devonian	Pennsylvania	Selinsgrove Limestone of White (1883) adopted. (Wood and others, 1969.)
Sevy Dolomite	Late Silurian and Early Devonian.	Utah and Nevada	Sevy Dolomite of Early Devonian age in Stansbury Mountains, northern Deep Creek Mountains, Thomas and Dugway Ranges, Utah; of Late Silurian and Early Devonian age in Confusion Range, Utah, and Pahranagat Range, Nevada. (Poole and others, 1967.)

Sharon Syenite	Devonian or older	Massachusetts	Age changed from Carboniferous or older to Devonian or older. (Chute, 1969.)
Shawangunk Conglomerate	Early and Middle Silurian.	Pennsylvania, New York, and New Jersey.	Shawangunk Conglomerate extended into southeastern Pennsylvania. Includes equivalent of Clinton Formation and Tuscarora Sandstone. (Epstein and Epstein, 1967.)
Sheep Mountain Quartz Latite.	Oligocene	Southwestern Colorado	Name changed to Sheep Mountain Formation; age changed from Miocene to Oligocene. (Steven and Schmitt, 1969.)
Shephard Creek Formation	Late Cretaceous	California	Shephard Creek Formation adopted. (Case, 1968.)
Shire Member (of Wasatch Formation).	Eocene	Northwestern Colorado	Shire Member adopted as upper member of Wasatch Formation in Piceance Creek basin. (Donnell, 1969.)
Shrewsbury Member (of Red Bank Sand).	Late Cretaceous	New Jersey	Shrewsbury Member of Redbank Formation of Olsson (1963) adopted as upper member of Red Bank Sand. (Minard, 1969.)
Siesta Formation	Pliocene	Western California	Siesta Formation removed from Berkeley Group (abandoned) and assigned to Contra Costa Group. (Radbruch, 1969.)
Simonson Doloimte	Early and Middle Devonian.	Nevada	Age changed from Middle Devonian to Early and Middle Devonian. (Poole and others, 1967.)
Skajit Limestone	Middle(?) and Late Devonian.	Alaska	Skajit Limestone assigned to Baird Group. (Tailleur and others, 1967.)
Sligo Formation	Early Cretaceous	Alabama, Louisiana, Mississippi, Arkansas, and Texas.	Sligo Formation assigned to Coahuila Series. Maher and Applin, 1968.)
Slocum Alluvium	Pleistocene	Colorado	Slocum Alluvium extended from central Colorado into southeastern Colorado. (Sharps, 1969.)
Smoky Hollow Member of Straight Cliffs Formation).	Late Cretaceous	Utah	Smoky Hollow Member adopted. (Peterson, Fred, 1969.)
St. Charles Formation	Late Cambrian	Southeastern Idaho	St. Charles Formation used in report area; St. Charles Limestone remains in good usage elsewhere. (Armstrong, 1969.)
Step Conglomerate	Permian	East-central Alaska	Step Conglomerate adopted. (Brabb, 1969.)
Stowe Formation	Early Ordovician	Vermont	Age changed from Late Cambrian(?) and Early Ordovician to Early Ordovician. (Cady, 1968.)
Straight Cliffs Formation.	Late Cretaceous	Utah	Straight Cliffs Formation divided into four members (ascending): Tibbet Canyon, Smoky Hollow, John Henry, and Drip Tank Members. (Peterson, Fred, 1969.)
Suntrana Formation	middle Miocene	Alaska	Suntrana Formation adopted. (Wahrhaftig and others, 1969.)
Swauk Formation	Late Cretaceous and Paleocene.	Washington	Age changed from Eocene to Late Cretaceous and Paleocene. (Cater, 1969.)
Tater Top Group	early Paleozoic	North Carolina	Tater Top Group abandoned. (Stromquist and Sundelius, 1969.)
Teutonia Quartz Monzonite.	Late Cretaceous	Southern California	Age changed from Late Cretaceous or early Tertiary to Late Cretaceous. (Hewett and others, 1969.)
Tewa Group	Pleistocene	North-central New Mexico.	Age changed from Pleistocene(?) to Pleistocene. (Bailey and others, 1969.)
Texas Canyon Quartz Monzonite.	early Tertiary	Arizona	Age changed from early Tertiary(?) to early Tertiary. (Anderson, 1968.)
Tibbet Canyon Member (of Straight Cliffs Formation).	Late Cretaceous	Utah	Tibbet Canyon Member adopted. (Peterson, Fred, 1969.)
Tierra Redonda Formation.	early and middle Miocene.	California	Tierra Redonda Formation adopted. (Durham, 1968.)
Tillery Formation	Ordovician(?)	North Carolina	Age changed from early Paleozoic to Ordovician(?). Stromquist and Sundelius, 1969.)

Name	Age	Location	Revision and reference
Tinemaha Granodiorite	Early Jurassic	California	Age changed from Jurassic or Cretaceous to Early Jurassic. (Ross, 1969.)
Tinton Sand	Late Cretaceous	New Jersey	Tinton Sand Member removed from Red Bank Sand and made a separate formation. (Minard, 1969.)
Tippipah Limestone	Early Pennsylvanian	Southern Nevada	Age changed from Early Pennsylvanian and Early Permian(?) to Early Pennsylvanian. (Gordon, 1969.)
Tomstown Dolomite	Early Cambrian	Pennsylvania, Maryland, Virginia, and West Virginia.	Name changed from Tomstown Dolomite to Tomstown Formation. (Hosterman, 1969.)
Torrecilla Breccia	Early Cretaceous	Central Puerto Rico	Torrecilla Breccia adopted: includes (ascending): Aguas Buenas Limestone Member, main body of formation, and Barros Tuff Member. (Briggs, 1969.)
Totavi Lentil (of Puye Formation).	middle and late Pliocene.	North-central New Mexico.	Formerly Totavi Lentil of Puye Conglomerate. Age changed from Pliocene(?) to middle and late Pliocene. (Bailey and others, 1969.)
Tower Creek Conglomerate	Pleistocene	Yellowstone Park area of Idaho, Wyoming, and Montana.	Reduced to member rank and name changed to Tower Creek Gravel Member of Osprey Formation (new). Age changed from Pliocene to Pleistocene. (Pierce, K. L., and others, this report, p. A32.)
Toyosa Member (of Maravillas Formation).	Late Cretaceous	Central Puerto Rico	Toyosa Member adopted as upper member of Maravillas Formation in Orocovis quadrangle (Briggs, 1969.)
Traveler Rhyolite	Early Devonian	Maine	Traveler Rhyolite adopted. Includes Black Cat and Pogy Members. (Rankin, 1968).
Trident Member (of Three Forks Formation).	Late Devonian	Idaho, Montana, and Wyoming.	Two parts of Trident Member, separated by unconformity, recognized in east-central Idaho as equivalent to Logan Gulch and Trident Members of Montana. (Sandberg and Mapel, 1967.)
Trout Valley Formation	Early Devonian	Maine	Trout Valley Formation adopted. (Rankin, 1968.)
Tsadaka Formation	middle and late(?) Miocene.	Alaska	Tsadaka Formation adopted. (Wahrhaftig and others, 1969.)
Tsankawi Pumice Bed (of Tshirege Member of Bandelier Tuff).	Pleistocene	North-central New Mexico.	Tsankawi Pumice Bed adopted. (Bailey and others, 1969.)
Tschicoma Formation (of Polvadera Group).	middle to late Pliocene	North-central New Mexico.	Tschicoma Formation made middle formation of Polvadera Group (new). (Bailey and others, 1969.)
Tshirege Member (of Bandelier Tuff).	Pleistocene	North-central New Mexico.	Tsankawi Pumice Bed (new) adopted as lower part of Tshirege Member. (Bailey and others, 1969.)
Tuscarora Sandstone	Early Silurian	Pennsylvania	Tuscarora Sandstone equivalent included in Shawangunk Conglomerate in southeastern Pennsylvania. (Epstein and Epstein, 1967.)
Union Springs Shale Member (of Marcellus Shale).	Middle Devonian	Pennsylvania and New York.	Member extended into southeastern Pennsylvania. (Epstein and Epstein, 1967.)
Uwharrie Formation	Ordovician(?)	North Carolina	Age changed from early Paleozoic to Ordovician(?). (Stromquist and Sundelius, 1969.)
Valentine Limestone Member (of Sultan Limestone).	Late Devonian	Nevada	Age changed from Middle and Late Devonian to Late Devonian. (Poole and others, 1967.)
Valle Grande Member (of Valles Rhyolite).	Pleistocene	North-central New Mexico.	Valle Grande Member adopted. (Bailey and others, 1969.)
Valles Rhyolite (of Tewa Group).	Pleistocene	North-central New Mexico.	Valles Rhyolite divided into six members (ascending): Deer Canyon, Redondo Creek, Valle Grande, Battleship Rock, El Cajete, and Banco Bonito Members. (Bailey and others, 1969.)

Verdos Alluvium	Pleistocene	Colorado	Verdos Alluvium extended from central Colorado into southeastern Colorado. (Sharps, 1969.)
Wasatch Formation	Paleocene and Eocene	Northwestern Colorado	In Piceance Creek basin, formation is divided into three members (ascending): Atwell Gulch, Molina, and Shire Members. (Donnell, 1969.)
Westwood Granite	Precambrian(?)	Massachusetts	Age changed from pre-Carboniferous to Precambrian(?). (Chute, 1969.)
Whitetail Conglomerate	Tertiary	Arizona	Age changed from Tertiary(?) to Tertiary. (Peterson, D. W., 1969.)
Wiggins Formation	Eocene and Oligocene	Northwestern Wyoming	Age changed from Oligocence to Eocene and Oligocene. (Pierce and Nelson, 1969.)
Wilcox Group	Eocene	Western Tennessee	In the subsurface of western Tennessee, the Wilcox Group is divided into three formations (ascending): Old Breastworks Formation, Fort Pillow Sand, and Flour Island Formation. (Moore and Brown, 1969.)
Willoughby Limestone	Silurian	Alaska	Age changed from Middle Devonian to Silurian. (Churkin, 1968.)
Windy Gap Volcanic Member (of Middle Park Formation).	Late Cretaceous(?)	Colorado	Age changed from Late Cretaceous to Late Cretaceous(?). (Izett, 1968.)
Wise Formation	Pennsylvanian	Southwestern Virginia and southeastern Kentucky.	Four resistant sandstones within the Wise have been named and adopted as members of the Wise. They are (ascending): Robbins Chapel, Keokee, Clover Fork, and Marcum Hollow Sandstone Members. In addition to these named members, the Wise contains numerous other less persistent unnamed units. (Miller, 1969.)
Woodhurst Limestone Member (of Lodgepole Limestone).	Mississippian	Montana, Idaho, Utah, and Wyoming.	Woodhurst Limestone Member extended into southeastern Idaho, northeastern Utah, and western Wyoming. (Sando and others, 1969.)
Yadkin Graywacke	Ordovician(?)	North Carolina	Yadkin Graywacke reduced in rank to Yadkin Member of Millingport Formation. Age changed from early Paleozoic to Ordovician(?). (Stromquist and Sundelius, 1969.)
Yellowstone Tuff	Pliocene or Pleistocene.	Wyoming and Montana	Yellowstone Tuff of Boyd (1961) adopted. (Witkind, 1969.)
Yellowstone Tuff	Pleistocene	Wyoming and Montana	Age changed from Pliocene or Pleistocene to Pleistocene. (Fraser and others, 1969.)

AGE AND STRATIGRAPHIC RELATIONS OF AMCHITKA, BANJO POINT, AND CHITKA POINT FORMATIONS, AMCHITKA ISLAND, ALEUTIAN ISLANDS, ALASKA

By W. J. CARR, W. D. QUINLIVAN, and L. M. GARD, JR.

Detailed reconnaissance mapping in 1966 and 1967 of Amchitka and Rat Islands in the western Aleutian Islands (fig. 1) supplemented an original study by Powers, Coats, and Nelson (1960) and has resulted in some modifications of the ages and stratigraphy of the rocks. Two formations, the Banjo Point and overlying Chitka Point, are here slightly redefined; the Amchitka Formation is areally restricted and subdivided into two informal units. Several potassium-argon dates are now available for the Chitka Point, one for the East Cape intrusive complex and three for younger intrusive rocks. Age of a fossil pollen collection from the Chitka Point Formation agrees well with the radiometric dates. New fossil collections from the Banjo Point Formation provide a better basis for dating.

AMCHITKA FORMATION

As defined by Powers, Coats, and Nelson (1960), the Amchitka Formation includes rocks of diverse type and age. Rocks of the northwest part of Amchitka formerly mapped as Amchitka Formation are petrographically like and stratigraphically continuous with the Chitka Point Formation. The Amchitka Formation of eastern Amchitka is retained, with some changes in contacts with other formations (fig. 1), but it is divided into two informal units: (1) older breccias, overlain by (2) the pillow lavas and breccias of Kirilof Point. Both units are present in drill holes in the central part of Amchitka.

The older breccias, which constitute the lower part of the Amchitka Formation, are the oldest rocks exposed on Amchitka Island; the base is not exposed. The older breccias are restricted in outcrop to the eastern part of Amchitka Island, mainly between Constantine Harbor and the dioritic intrusive rocks of East Cape. The unit consists of fine- to coarse-grained sedimentary breccias and minor interbedded sandstone, siltstone, and claystone composed of volcanic debris. The rocks are generally propylitically altered. The degree of alteration increases erratically eastward toward the intrusive complex, and strongly metamorphosed older breccias occur within and adjacent to the intrusive masses. Numerous dikes, including many of hornblende

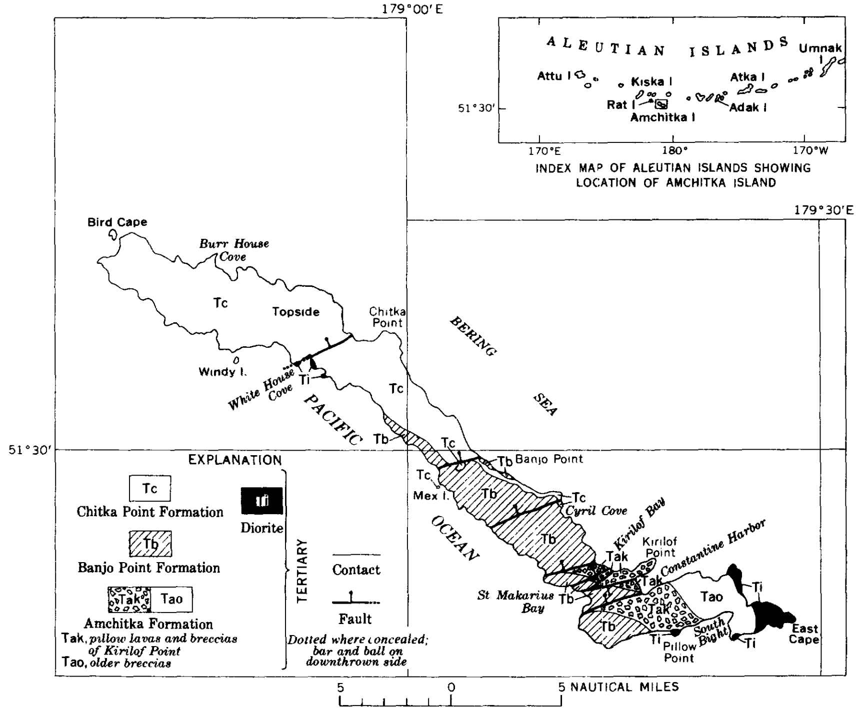

FIGURE 1.—Geologic sketch map of Amchitka Island.

andesite, cut the breccias on the eastern part of Amchitka Island. A maximum thickness of about 4,000 feet of the older breccias may be exposed; however, because of numerous dikes and sills that intrude the section and the possibility of fault repetition, this estimate is probably too high.

The Kirilof Point unit consists of glassy generally monolithologic breccia and tuff breccia, subordinate pillow lava flows, and very minor bedded volcanic sedimentary rocks, most of which were probably deposited in a submarine environment. The lower contact of the unit is exposed 1.6 miles east of Pillow Point at the base of a locally glassy lava and breccia sequence and at the top of a thin layer of sedimentary rocks. The lateral continuity of this contact and its stratigraphic and petrographic significance have not yet been determined. Compositionally some of the rocks of the Kirilof Point unit are less mafic than others known on Amchitka Island; Powers, Coats, and Nelson (1960) published an analysis of hydrated glassy breccia from Kirilof Point which indicates that the rock is a latite. Most other Kirilof Point rocks analyzed in the current study are a little less silicic. The Kirilof Point unit is about 3,500 feet thick in the vicinity of Pillow Point and ranges from about 1,450 to 3,650 feet thick in drill holes in central Amchitka.

BANJO POINT AND CHITKA POINT FORMATIONS

The Banjo Point Formation consists mainly of breccias, sedimentary rocks, and minor pillow lavas of basaltic composition and submarine deposition. Hornblende-andesite and basalt sills and dikes intrude the formation in places. The Banjo Point is more nearly conformable with the underlying Amchitka Formation than reported by Powers, Coats, and Nelson (1960) but is overlain with considerable angular discordance by the Chitka Point Formation. The Banjo Point remains virtually as defined by Powers, Coats, and Nelson (1960) except for a few changes in its boundaries with the Chitka Point Formation. Outcrops near White House Cove and Burr House Cove, too small to be shown in figure 1, are probably Banjo Point Formation. Largely because of the major erosional unconformity between the two formations, no complete section of Banjo Point is exposed. The formation is a maximum of about 3,600 feet thick in a drill hole west of Kirilof Bay.

Rocks called Chitka Point Formation are here restricted to subaerial hornblende and pyroxene-andesite lava flows, breccias, tuffs, and conglomerate in the northwestern two-thirds of Amchitka (fig. 1). Excluded from the Chitka Point, as mapped by Powers, Coats, and Nelson (1960), are basaltic breccias, now included in the Banjo Point Formation and extending southeastward along the Pacific Coast from about lat 51°32′ N. The contact previously shown (Powers and others, 1960) between Chitka Point and Banjo Point Formations on the Pacific Coast is no longer considered a formational boundary. Included in the Chitka Point Formation by the present authors are all rocks previously mapped by Powers, Coats, and Nelson (1960) as Amchitka Formation on the northwest part of the island, and some small areas previously mapped by them as Banjo Point Formation along the Bering Sea Coast between about 51°30′ N. and Cyril Cove. All these rocks are hornblende or pyroxene-bearing andesites typical of the Chitka Point and are stratigraphically continuous with it. The Chitka Point ranges in thickness from a featheredge near the middle of Amchitka to a minimum of 4,000 feet in a drill hole 2 miles south of Chitka Point; about 1,100 feet are exposed in the vicinity of Topside.

Thus we restrict the Banjo Point to basaltic rocks of generally submarine deposition and the Chitka Point to andesitic rocks of mostly subaerial deposition, each unit representing a distinct episode of eruptive activity separated by uplift and erosion.

AGE

On the basis of Foraminifera and mollusks, Powers, Coats, and Nelson (1960, p. 538) assigned an Oligocene or Miocene age to the Banjo Point Formation. All their fossil material appears to be from beds assigned to the Banjo Point in the current study. Recently MacNeil (1967, p. 37) assigned an age of Oligocene(?) to the Banjo Point on the basis of a further evaluation of fossils in it and in similar beds on nearby Rat Island. Microfossils (table 1) collected by the authors and R. H. Morris from the Banjo Point and Amchitka Formations supplement the original collections which were made by Powers, Coats, and Nelson (1960) and which were studied by Todd (1953) and MacNeil (1967). Studies of the Foraminifera by R. L. Pierce permit refinement of the original ages for these formations. The Banjo Point Formation and similar beds on Rat Island (Gunners Cove Formation) are designated as late Eocene or Oligocene on the basis of mollusks and numerous microfossils from several localities (table 1). Age of the Amchitka Formation is less certain; it underlies the Banjo Point with general conformity, and the one fossil collection from it (table 1) contains only two genera not found in the Banjo Point; the species are not identified.

There is nothing to indicate a significant age difference between the Banjo Point and the upper part of the Amchitka Formation—the breccias and pillow lavas of Kirilof Point—but because of the meager fauna and fact that the lower contact of the formation is not exposed, the authors prefer to assign an age of early Tertiary to the Amchitka Formation.

A coal sample from the Chitka Point Formation yielded numerous pollen and spores which were studied by Estella Leopold

TABLE 1.—*Distribution of Foraminifera in the Amchitka, Gunners Cove, and Banjo Point Formations, Amchitka and Rat Islands, Alaska*

	Amchitka Formation	Gunners Cove Formation WJC70A67[2]	Banjo Point Formation			
	69LG10[1]	(M337)	69LG6[3]	69LG7[4]	69LC8[5]	69LG9[6]
Cassidulina globosa Hantken	X			X		X
sp. cf. *C. galvinensis* Cushman and Frizzell		X	X			
Globigerina sp.	X					X
sp. cf. *G. eocaena* Gümbel						X
(?) *Globorotalia* sp. aff. *G. pseudobulloides* Plummer	X					
Bolivina sp.	X					
Oridorsalis umbonatus (Ruess)	X		X			

TABLE 1.—*Distribution of Foraminifera in the Amchitka, Gunners Cove, and Banjo Point Formations, Amchitka and Rat Islands, Alaska*—Continued

	Amchitka Formation 69LG10[1]	Gunners Cove Formation WJC70A67[2] (M337)	Banjo Point Formation			
			69LG6[3]	69LG7[4]	69LC8[6]	69LG9[6]
Gyroidina sp. c. *G. Soldanii octocamerata* Cushman and G. D. Hanna	X		X	X		X
Cibicides sp. cf. *C. sandiegensis* Cushman and M. A. Hanna		X	X	X		
sp. cf. *C. hodgei* Cushman and Schenck			X			X
hodgei Cushman and Schenck					X	
sp. cf. *C. haydoni* (Cushman and Schenck)						X
sp.			X		X	
Nonion sp. aff. *N. planatus* Cushman and Thomas		X	X			
Plectofrondicularia vaughani Cushman			X			
sp. cf. *P. packardi multilineata* Cushman and Simonson			X			X
packardi packardi Cushman and Schenck						X
sp.						X
Guttulina sp. cf. *G. problema* d'Orbigny			X			
problema d'Orbigny						X
Planularia sp. aff. *P. markleyana* Church			X			
Uvigerina elongata Cole			X	X		X
Nodosaria sp. cf. *N. pyrula* d'Orbigny			X			
holserica Schwager						X
sp.(?)					X	
Dentalina consobrina d'Orbigny						X
(?)*amchitkaensis* Todd						X
sp.			X			
Sigmorphina sp. cf. *S. schencki* Cushman and Ozawa			X			
Melonis cf. *M. umbilicatulus* (Montagu)						X
(?)*Melonis* sp.				X	X	
Alabamina sp. cf. *A. kernensis* Smith				X		
kernensis Smith						X
Bulimina schencki Beck						X
Glandulina laevigata ovata (Cushman and Applin)						X
Angulogerina hannai Beck						X
Globorotaloides sp. cf. *G. suteri* Bolli						X
Radiolaria	X					

[1] Locality 69LG10: Amchitka Formation, pillow lavas and breccias of Kirilof Point, Kirilof Bay, Amchitka Island; lat 51°24′45″ N., long 179°14′30″ E.
[2] Locality WJC70A67 (near M337 original collection made by H. A. Powers): Gunners Cove Formation, southeast side of Gunners Cove, Rat Island; lat 51° 48′40″ N., long 178°19′ E.
[3] Locality 69LG6: Banjo Point Formation, south side St. Makarius Bay, Amchitka Island; lat 51°22′40″, long 179°13′10″ E.
[4] Locality 69LG7: Banjo Point Formation, 1.6 miles northwest of Mex Island, south coast of Amchitka Island; lat 51°29′38″ N., long 179°01′25″ E.
[5] Locality 69LG8: Banjo Joint Formation, Banjo Point, north coast of Amchitka Island; lat 51°28′36″ N., long 179°08′15″ E.
[6] Locality 69LG9: Banjo Point Formation, Clam Point (same stratigraphic horizon that contained *Chlamys* aff. *C. washburnei* Arnold (Powers, and others, 1960, p. 537), south coast of Amchitka Island; lat 51°24′32″ N., long 179°09′44″ E.

TABLE 2.—*Pollen and spores from Amchitka Island, Alaska*

[Identified by Estella Leopold. Sample 68 M–1 from a thin coal seam in volcanic breccia of the Chitka Point Formation, lat 51°32′ N., long 178°58′ E., Pacific coast of Amchitka]

	Number	*Percent*
Taxodiaceae-Cupressaceae-Taxaceae	21	17.2
Sequoia type	1	.8
Pinus	8	6.5
Alnus p6	2	1.6
p5	27	22.2
p4	13	10.5
Picea	2	1.6
Betula	3	2.5
Corylus type	1	.8
Juglans	2	1.6
Pterocarya	2	1.6
Ulmus?	1	.8
Ostrya-Carpinus	3	2.5
Populus type	4	3.3
Corylus type	1	.8
Ericales, cf. *Rhododendron*	3	2.5
Dicot pollen, mangled, broken	13	10.5
Polypodiaceae	1	.8
Monocots undet.	12	10.0
Undet. fern spores	2	1.6
Total	122	......

NOTE.—Seen but not in count:
Tsuga heterophylla
Quercus
cf. *Fagus*

(table 2). She reported that "the sample count contains 6.5 percent of deciduous broadleaved trees now exotic to Alaska, and about a fifth of the generic list includes forms foreign to the region*** the age is Miocene, probably middle to late."

Seven potassium-argon dates on rocks from Amchitka Island are listed in table 3. Radiogenic dating is hampered by scarcity of fresh holocrystalline material for whole-rock analysis and of rocks containing minerals with sufficient potassium for dating of mineral separates.

Three dates were obtained on lava flows of the Chitka Point Formation at different localities in central and northwestern Amchitka. All represent flows in the upper part of the Chitka Point. The youngest date obtained, 12.4±1.1 m.y. (million years), may be slightly too young because of the presence of a very small amount of noncrystalline material in the groundmass. Of the three dates, the one considered most reliable (14.1±1.1 m.y.) because of the freshness and relatively coarse texture of the rock was obtained on an andesite flow in a quarry near the middle of Amchitka. On the basis of these dates and the pollen collection (table 2), we assign an age of Miocene to the Chitka Point, previously dated (Powers and others, 1960) as Tertiary or Quaternary.

A date of 15.8±0.7 m.y. was obtained on a biotite-bearing phase of the East Cape pluton. This complex of dioritic rocks intrudes rocks as young as the upper unit of the Amchitka Formation, and fossils indicate that the Banjo Point Formation is also older than the East Cape plutonic complex.

TABLE 3.—*Potassium-argon dates on rocks from Amchitka Island, Alaska*

Sample	Rock type, location	Material analyzed	Stratigraphic relations	Age $\times 10^6$ years [1]
WJC–87A–66	Hornblende andesite dike between Pillow Point and South Bight; lat 51°21′55″N., long 179°20′40″E.	Hornblende	Intrudes Amchitka Formation.	2.7±3.0
69 Amc–12	Basaltic andesite dike, west side of Kirilof Bay; lat 51°26′N., long 179°14′E.	Whole rock	Intrudes Banjo Point Formation.	8.9±0.6
WJC–1–67	Basalt dike(?), point on north side of St. Makarius Bay; lat 51°23′30″N., long 179°12′50″E.	do	do	10.2±1.1
69 Amc–15	Pyroxene andesite lava flow on ridge 2 miles north of Windy Island; lat 51°36′N., long 178°48′E.	do	Upper part of Chitka Point Formation.	12.4±1.1
69 Amc–17	Hornblende andesite lava flow, Mex Island; lat 51°28′30″N., long 179°02′30″E.	do	do	13.2±1.2
69 Amc–2	Hornblende andesite lava flow quarry, central Amchitka; lat 51°31′N., long 179°02′E.	do	Upper part of Chitka Point Formation.	14.1±1.1
69–Amc–11	Biotite-hornblende granodiorite; lat 51°23′N., long 179°25′E.	Biotite	Intrusive dioritic complex of East Cape. Parts of complex intrude upper and lower units of Amchitka Formation.	15.8±0.7

[1] All dates determined by Geochron Laboratories, Inc. Mineral separations by D. R. Miller.

Emplacement of the East Cape pluton appears to be concurrent with a mid-Miocene change from predominantly submarine volcanic deposition to uplift, followed by mostly subaerial andesitic volcanism along the insular ridge. The possibility of a major mid-Tertiary uplift of the Aleutian Arc was pointed out several years ago by Gates, Fraser and Snyder (1954).

Dates (table 3) of 8.9±0.6 and 10.2±1.1 m.y. were obtained on intrusive rocks that appear to belong to a Pliocene episode of basaltic activity that followed eruption of the Chitka Point. Both samples are from northeast-trending bodies that are probably dikes in the Banjo Point Formation.

A date obtained on hornblende from a dike that is part of a swarm that postdates the East Cape plutonic complex is probably not very reliable because of the small amount of hornblende in the sample. However, intrusive rocks of intermediate composition apparently were emplaced relatively late in the island's history.

CAESARS HEAD QUARTZ MONZONITE IN THE WESTERN CAROLINA PIEDMONT

By JARVIS B. HADLEY and ARTHUR E. NELSON

The name Caesars Head Quartz Monzonite is hereby proposed for several irregularly shaped bodies of granitic rock that occupy about 500 square miles in the southeastern part of the Knoxville 2-degree quadrangle (Hadley and Nelson, in press). These bodies invade a terrane of older paragneiss and schist, which is the principal country rock throughout a large part of the Piedmont province of southwestern North Carolina and northwestern South Carolina.

The type locality of the Caesars Head Quartz Monzonite is on Hogback Mountain in Greenville County, S.C. It is also exposed on the high ridge to the southwest, including Glassy Mountain, Old Indian Mountain, and Chestnut Mountain (Tigerville quadrangle, South Carolina and North Carolina). Good exposures of most of the varieties of the unit can be found along the paved road between State Route 11 and U.S. Highway 25 near Poinsett Reservoir and along the improved but unpaved road across Glassy Mountain and Hogback Mountain, as far as Vaughns Gap. The name is taken from exposures along U.S. Highway 276 in the vicinity of the summit known as Caesars Head in the northwestern part of Greenville County, S.C.

The plutonic intrusive rocks included in this unit consist largely of biotite quartz monzonite and biotite granodiorite, medium to coarse grained, ranging from equigranular to inequigranular and porphyroblastic. The feldspars are principally microcline and oligoclase or sodic andesine, whose relative proportions vary greatly from place to place. Microcline and quartz monzonite are most abundant in the western bodies; conversely, much of the rock in the eastern outcrop areas in granodiorite. Abundant well-crystallized epidote and sphene are characteristic accessory constituents, and small amounts of muscovite and magnetite are generally present. All saprolite samples tested yielded zircon in moderate quantities. The dark minerals are commonly segregated in discontinuous folia accompanied by various degrees of schistosity; locally, however, the rocks are virtually nonfoliated.

Contacts between the Ceasars Head Quartz Monzonite and the surrounding paragneiss and schist, as revealed by reconnaissance mapping and observations, largely along roads, are broadly concordant but locally discordant to the foliation of both intrusive and country rock. Concordant to semiconcordant lenses of paragneiss locally included in the quartz monzonite show gradational rather than sharply defined boundaries. More definitive information about the structural relations of the Caesars Head Quartz Monzonite awaits detailed study in favorable localities.

Much of the Caesars Head Quartz Monzonite, particularly in the western bodies, resembles the granitic or less foliated phase of the Henderson Gneiss, and the mapped boundaries between these two units are everywhere gradational and obscure. The age of the surrounding paragneiss and schist is not known, although these rocks are probably not older than late Precambrian and not younger than Silurian. Microscopic textural and mineral relationships suggest that the Caesars Head Quartz Monzonite was emplaced before the climax of the regional deformation and well before the peak of thermal activity and recrystallization in the rocks. Its age, therefore, is presumably younger than late Precambrian and at least as old as Carboniferous, the date of the last major metamorphism as indicated by potassium-argon and rubidium-strontium ages reported from the surrounding region (Kulp and Eckelmann, 1961).

METADIABASE SILLS IN NEGAUNEE IRON-FORMATION SOUTH OF NEGAUNEE, MICHIGAN

By J. E. Gair and G. C. Simmons

The Negaunee Iron-Formation (Van Hise and Bayley, 1895; Leith and others 1935) of middle Precambrian age (James, 1958, p. 33–35) in the Marquette synclinorium and iron district, Michigan, is intruded by large bodies of mafic igneous rock. The bodies are most numerous and crop out in prominent ridges and knobs south and southwest of the city of Negaunee, in the axial part of the synclinorium. In early reports, the mafic rock was called diorite (Van Hise and Bayley, 1897; Van Hise and Leith, 1911), but it is now recognized as metadiabase similar to that in other Precambrian areas of upper Michigan (Gair and Wier, 1956, p. 60–61; Bayley, 1959, p. 65–67; Gair and Thaden, 1968, p. 51). Original diabasic texture of the mafic rock generally is well preserved, but virtually none of the original minerals remain. Through low-grade regional metamorphism, calcic plagioclase has been saussuritized and albitized, and pyroxene has been converted to tremolitic and actinolitic amphibole and chlorite. Many large, roughly tabular bodies of metadiabase are conformable, or nearly so, with bedding of the Negaunee Iron-Formation and are considered sills. This paper proposes names for four such sills that are particularly useful markers for subdividing the iron-formation. The named sills are mainly south of Negaunee in the western part of the Palmer and the eastern part of the Ishpeming quadrangles (fig. 2).

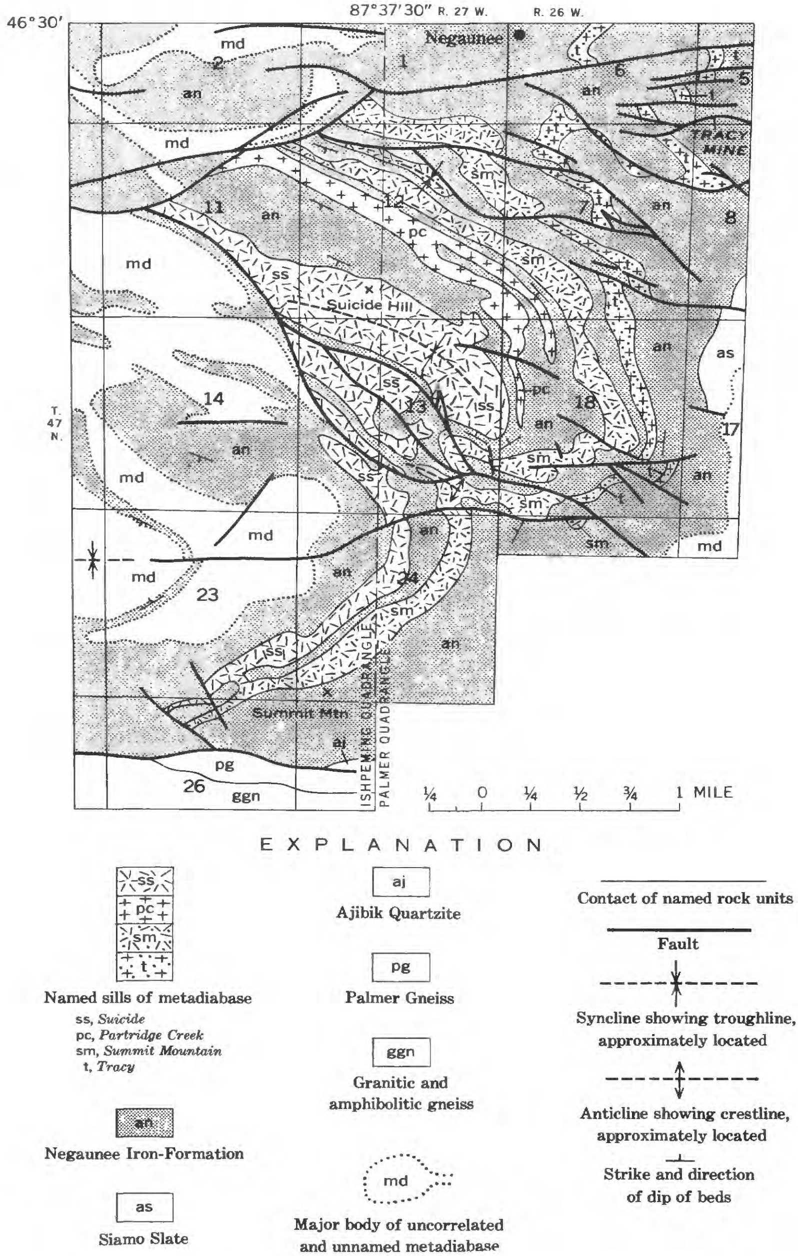

FIGURE 2.—Distribution of middle Precambrian metadiabase sills south of Negaunee, Mich.

The named sills are each 2½ miles or more in mapped length and 200 feet or more in maximum thickness and extend westward along the north and south limbs from the axial part of the synclinorium. One sill wedges between two of the others in the axial part of the synclinorium, and this arrangement suggests that the sills may have been emplaced during folding. However, emplacement of the sills would necessarily have been early during the folding at the close of middle Precambrian time because they are offset and because some are repeated by faults that are approximately synchronous with the folds. Low-angle crosscutting of the iron-formation by the sills is indicated both by small local thickness variations in iron-formation between sills and by larger thickness variations across a distance of several miles from one flank of the synclinorium to the other (fig. 2). The named sills from lower to higher in the stratigraphic section are the Tracy, Summit Mountain, Partridge Creek, and Suicide (fig. 3).

TRACY SILL

The Tracy sill is named for the Tracy mine, which is a short distance north of a prominent outcrop of the sill in the NE¼ sec. 7 and the NW¼ sec. 8, T. 47 N., R. 26 W. The name has previously been used informally by local mining company geologists (J. W. Avery, Jones & Laughlin Steel Corp., oral commun, 1964). The sill has a thickness at the type locality of 200–250 feet, determined both by drilling and calculations from mapped width and the dip of nearby iron-formation. The base of the sill is 1,100–1,200 feet above the base of the Negaunee Iron-Formation. The sill extends from the city of Negaunee in sec. 6, west for an unknown distance on the north limb of the Marquette synclinorium and south across the axial part of the synclinorium to the SW¼ sec. 18, T. 47 N., R. 26 W., where it terminates against a fault. Drill data suggest that the sill is present in the subsurface for a short distance west of the fault, but apparently it pinches out near the southwest corner of the section and updip before reaching the surface. It is extensively sliced by faults, especially in secs. 5, 6 and 7. It should be pointed out that the relations shown in the SW¼ sec. 5 and the SE¼ sec. 6 (fig. 2) are based entirely on the interpretation of drill data.

SUMMIT MOUNTAIN SILL

The Summit Mountain sill is named for Summit Mountain in the SW¼ sec. 24, T. 47 N., R. 27 W. (fig. 2).[1] The sill crops out on

[1] Summit Mountain (1,885 feet) is the highest point in the Marquette district.

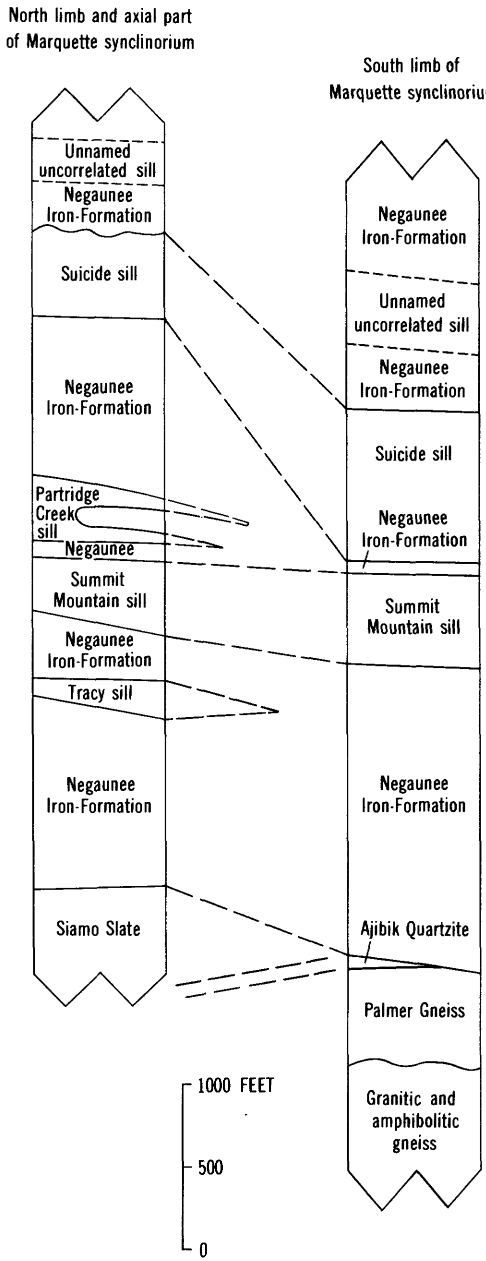

FIGURE 3.—Columnar sections of middle Precambrian metadiabase sills in Negaunee Iron-Formation.

the north side of the mountain, near the crest. A stratigraphically higher sill—the Suicide sill named and discussed below—is exposed in a parallel belt a short distance to the north, near the base of the mountain. At the type locality, the Summit Mountain sill is underlain by 1,800 feet of iron-formation, which to the south is in normal stratigraphic contact with underlying Ajibik Quartzite, the Siamo Slate having pinched out to the east, and in fault contact with Palmer Gneiss. To the northeast, in the axial part of the Marquette synclinorium, the sill is separated from the underlying Tracy sill by 120–340 feet of iron-formation.

At its type locality the Summit Mountain sill has an approximate thickness of 560 feet, calculated from an outcrop width of 800 feet and a dip of 45° in adjacent iron-formation. To the northeast in the axial part of the synclinorium, the average thickness of the sill is about 500 feet. The sill thins southwest of the type locality, so that a mile away, at its termination against a fault, it is 140 feet thick.

The Summit Mountain sill has a mapped linear extent of more than 7 miles. From its type locality on the southeast limb of an open syncline that plunges west-northwest, the sill continues 1 mile to the southwest and is truncated by a fault, as mentioned above. The sill extends northeast from the type locality to sec. 18, T. 47 N., R. 26 W., where it turns north and then northwest to its known limit against a fault in secs. 1, 11, and 12, T. 47 N., R. 27 W. The curved belt, concave to the west, marks the closure of a major west-plunging syncline. The sill is extensively sliced and repeated by faults in the SE¼ sec. 13, T. 47 N., R. 27 W., in the south part of sec. 18, T. 47 N., R. 26 W., and in the north part of sec. 12, T. 47 N., R. 27 W.

PARTRIDGE CREEK SILL

The Partridge Creek sill is named for Partridge Creek which flows a few hundred feet southwest of a ridge containing large exposures of the sill near the center of sec. 12, T. 47 N., R. 27 W. There at the type locality the sill is about 380 feet thick, judging by outcrop width and the dip of adjacent iron-formation, and the base of the sill is separated from the top of the Summit Mountain sill by an 80-foot thickness of iron-formation. The stratigraphic separation of the sills ranges from 70 to 140 feet across the area. The Partridge Creek sill extends about 1 mile northwest of the type locality, thins slightly in that distance, and is cut off by a fault. Its possible correlative farther west is unknown. Southeast of the type locality, in the SE¼ sec. 12, the sill splits into two layers, the lower of which is about 100 feet thick and the upper, about 200 feet thick. The two layers are separated by a maximum thickness of about 150 feet of iron-formation. To the southeast, the layers gradually change strike from southeast to south in the axial part of the synclinorium. They pinch out in sec. 18, T. 47 N., R. 26 W., the upper layer extending about half a mile farther south than the lower layer. Near the southeast corner of sec. 12, T. 47 N., R. 27 W., the upper layer thickens markedly and passes into an irregular dike which cuts upward across the iron-formation.

SUICIDE SILL

The Suicide sill is named for Suicide Hill[2] in the south-central part of sec. 12, T. 47 N., R. 27 W. The upper part of the hill contains numerous exposures. At the type locality the sill occupies a west-northwest-trending syncline in which the upper contact of the sill has been removed by erosion. The part of the sill remaining has an approximate thickness of 580 feet, calculated from the mapped width of the sill between its base and the synclinal axis, and from the dip of adjacent iron-formation. South of the type locality in the axial part of the synclinorium, the thickness of the sill is indeterminate because of faulting. South of that area, the sill passes southwestward without structural complication across sec. 24, north of Summit Mountain, and across the SE¼ sec. 23, T. 47 N., R. 27 W.. Along that belt, near the boundary between the Ishpeming and Palmer quadrangles, the sill has a maximum thickness of 630 feet calculated from the mapped width and an assumed dip to the northwest of 45°. At its type locality, the Suicide sill is separated from the underlying Partridge Creek sill by 940 feet of iron-formation. Two miles to the south, on the north side of Summit Mountain, because of the pinchout of the Partridge Creek sill and also apparently because of gradual crosscutting of the iron-formation, the Suicide sill is separated from the underlying Summit Mountain sill by only 100–250 feet of iron-formation. West of Summit Mountain in the SE¼ sec. 23, the Summit Mountain and Suicide Sills are connected by a large dike of metadiabase.

The mapped linear extent of the Suicide sill is more than 4 miles. From its type locality, it extends more than a mile to the northwest where it is truncated by a fault in the central part of sec. 11. About a mile southeast of the type locality, it closes around the nose of the northwest-plunging syncline. South of the syncline in the axial part of the Marquette synclinorium, the sill

[2] Suicide Hill is the site of an internationally known ski jump of the same name.

appears in several segments bounded by faults; to the southwest, it terminates against a fault.

Near the common west corner of secs. 13 and 24, the Suicide sill is overlain by 400–700 feet of iron-formation that separates it from an unnamed overlying sill. The possible correlation of the unnamed sill with others (fig. 2) west and northwest of the named bodies and possible correlations of some of the unnamed bodies with the named sills cannot be established because of structural complications and inadequate exposures.

THE OSPREY FORMATION (PLEISTOCENE) AND ITS TOWER CREEK GRAVEL MEMBER, YELLOWSTONE NATIONAL PARK

By KENNETH L. PIERCE, ROBERT L. CHRISTIANSEN, and GERALD M. RICHMOND

Recent geologic mapping in Yellowstone National Park has demonstrated that interlayered upper Cenozoic basalts and gravels of several different ages can be recognized. The only previous regional geologic studies of broad scope in this area, made in the late 19th and early 20th centuries (Hague and others, 1896, 1899; Hague, unpub. data, 1904), did not distinguish consistently among these sequences. Although later studies, which were focused on certain topical problems or on only parts of the area (for example, Howard, 1937; Boyd, 1961; Brown, 1961), established many of the relations among these units, a comprehensive stratigraphy has awaited detailed regional mapping. This paper distinguishes one of the basalt-gravel sequences as the Osprey Formation, consisting of two members—a basalt member and the Tower Creek Gravel Member.

OSPREY FORMATION

The Osprey Formation is here defined as that sequence of basalts and gravels, interlayered in locally varied proportions, which fills or partly fills a canyon paleotopography cut both in the upper part of the Yellowstone Tuff and in conformably overlying basalts in the region of northern Yellowstone National Park (fig. 4). On the nose between Lava Creek Canyon and Sheepeater Canyon, the Osprey Formation rests unconformably on both the upper part of the Yellowstone Tuff and the basalt which conformably overlies the tuff. The oldest deposit overlying the Osprey Formation is till of probable late Bull Lake age. The known extent of the Osprey Formation is indicated in figure 4. The formation is well exposed along the west side of Sheepeater Canyon, where the flank of Bunsen Peak is incised by the Gardner River. In this area, Boyd (1961,

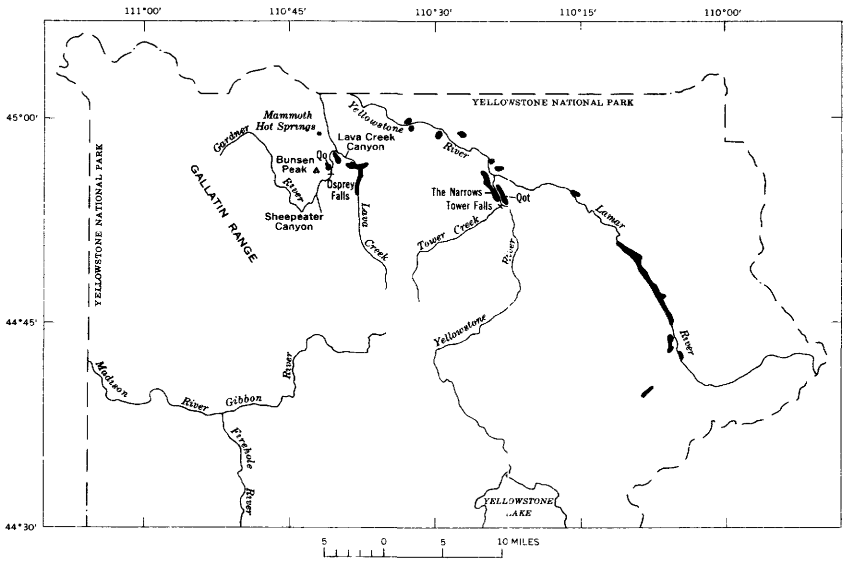

FIGURE 4.—Northern part of Yellowstone National Park and location of areas underlain by Osprey Formation (black), type section of Osprey Formation (Qo), and type section of Tower Creek Gravel Member (Qot).

p. 402) recognized that the basalts and gravels here defined as the Osprey Formation postdate both the Yellowstone Tuff and the basalts that conformably overlie the tuff on the east rim of the canyon.

The type section of the Osprey Formation is designated as the cliff exposure on the west side of Sheepeater Canyon, 3,200 feet almost due north of Osprey Falls and just east of the closest approach in this vicinity of the Bunsen Peak Road to the rim of the canyon. The section is about 200 feet thick. It consists mainly of six flows of columnar-jointed basalt, several of which are separated by as much as 20 feet of gravel, particularly in the lower part of the section and at the base. The section rests on an eroded Eocene intrusive body which forms Bunsen Peak.

For convenience in mapping and in order to provide the maximum possible consistency with previously used stratigraphic nomenclature, the two lithologic facies of the formation are recognized as members.

BASALT MEMBER

The basalt member is designated informally to include all the basalt flows of the Osprey Formation. The basalts are olivine tholeiites characterized by a low content of alkali metals, notably of potassium. Sparse plagioclase phenocrysts occur in most of the flows; olivine is present in the groundmasses. The basalts typically are very fine grained, dense, and nearly black. Columnar jointing is exceptionally well developed in many flows.

TOWER CREEK GRAVEL MEMBER

The Tower Creek Gravel Member of the Osprey Formation is here defined to include all gravel and other sediments associated with the Osprey Formation. The type section is the exposure on the east side of The Narrows of the Yellowstone River Canyon directly across from Calcite Springs and 5,800 feet N. 30° W. of the mouth of Tower Creek. It is described in figure 5. At the type section the Tower Creek Gravel rests on Eocene volcanic breccias and is overlain by Pinedale Till (fig. 5). The gravel is mainly cobble sized and occurs in massive subhorizontal beds. The cobbles are about 65 percent Eocene volcanic rocks, 5–15 percent quartz-bearing rhyolite, 5–25 percent upper Cenozoic basalt, and 5–15 percent quartzite and Precambrian crystalline rocks. All the quartz-bearing rhyolite clasts we have observed in the type Tower Creek Gravel Member are Yellowstone Tuff. One distinctive type of clast is purplish-gray to bluish-gray welded tuff with abundant white collapsed pumice inclusions containing conspicuously large phenocrysts; this lithology is characteristic of the upper part of the Yellowstone Tuff in the nearby drainage area.

The name Tower Creek Conglomerate was first used on the map legend of sheets 10, 12, and 17 of the atlas for the Yellowstone National Park monograph (Hague and others, 1899). Several years earlier, Hague and others (1896, p. 3 and Canyon Sheet) described these deposits and named them the Canyon Conglomerate. At a locality "just north of Tower Creek" Hague and others noted that (1) the conglomerate does not contain rhyolite cobbles, (2) the conglomerate and associated basalt are pre-rhyolite in age, and (3) vertebrate remains collected from the conglomerate were identified by O. C. Marsh as being from a Pliocene horse. The identification of these vertebrate remains, now lost, has never been confirmed. Jones and Field (1929, p. 275), however, concluded on the basis of physiographic relations that the basalt and gravel in the Tower Falls area are much younger than the rhyolite.

Gravel previously referred to the Tower Creek Conglomerate was shown to be of two different ages by A. D. Howard (1937, p. 36–80). On the east side of the Yellowstone River in The Narrows area he observed only gravel bearing more than 5 percent rhyolite. On the west side he observed that some gravel contained

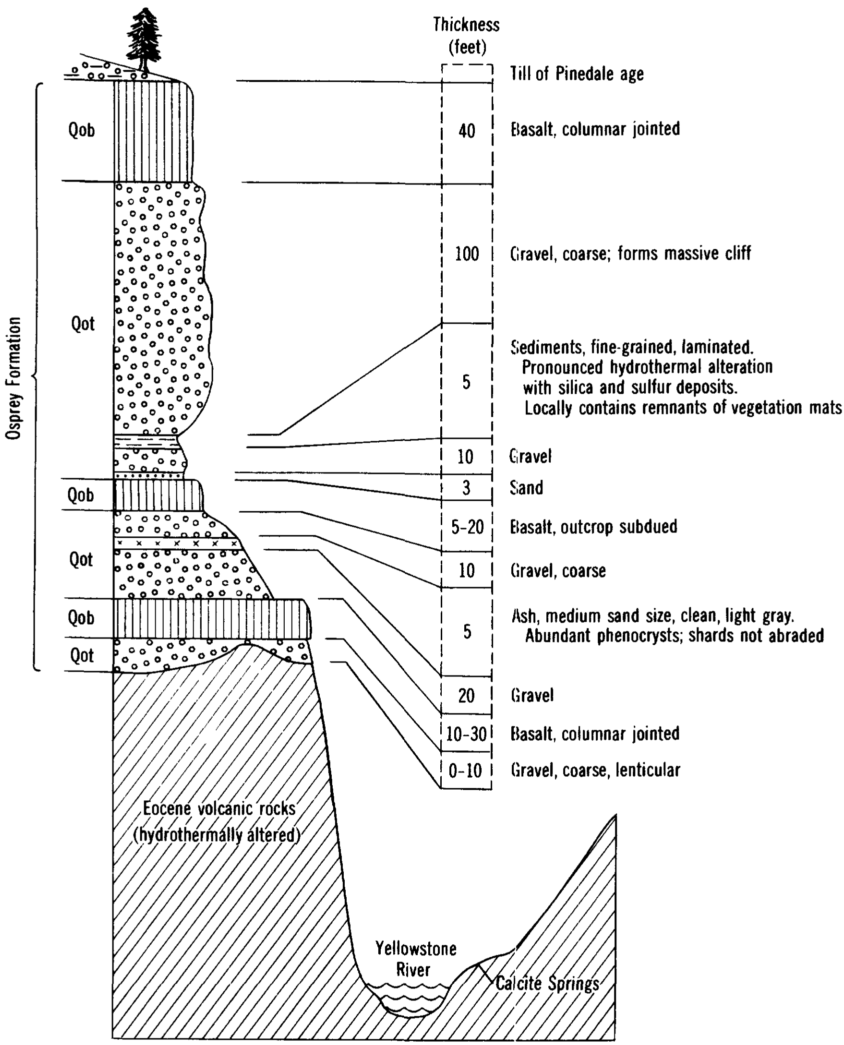

FIGURE 5.—Type section of Tower Creek Gravel Member. Measured by rough hand leveling by K. L. Pierce at the type locality across the Yellowstone River from Calcite Springs, Yellowstone National Park, Wyo. Qot, Tower Creek Gravel Member; Qob, basalt member.

more than 5 percent rhyolite but that other gravel contained 1 percent or less. C. W. Brown (1961, p. 1182–1183) reported that he failed to find rhyolite in the gravel on either side of the river. Our field studies support Howard's conclusion and demonstrate the presence of two different ages of gravel and associated basalt. The younger gravel contains readily discernible (more than 5 percent) cobbles of rhyolite, mainly from the upper part of the Yellowstone Tuff; the older gravel contains few cobbles of rhyolite and none of Yellowstone Tuff. The basalt that overlies the older gravel underlies the upper part of the Yellowstone Tuff.

By restricting the name Tower Creek Gravel Member to gravel of the Osprey Formation, which generally contains clasts identified as coming from the upper part of the Yellowstone Tuff, we have selected the most conspicuous and extensive gravel exposed in the Tower Falls area. We exclude gravel older than the tuff: for example, that exposed beneath the basalt flow of Overhanging Cliff on the west side of The Narrows in the Tower Falls area. We exclude also deposits previously mapped as Tower Creek Conglomerate in the Gallatin Range in northwestern Yellowstone Park (Hague and others, 1899, sheets 10 and 17), which in fact are associated with rocks of the Absaroka volcanic field of Eocene age (H. W. Smedes, oral commun., 1970). We use the term gravel rather than conglomerate in the formal name because many of the deposits are friable, and the local induration is the result of hydrothermal alteration rather than diagenetic cementation. In other places, hydrothermal alteration has induced both decomposition and disintegration of clasts and matrix.

AGE

The Osprey Formation lies on a paleotopography cut in or through the upper part of the Yellowstone Tuff. The interlayered gravel contains pebbles or cobbles of that tuff in all localities observed, including the type section. The formation is, therefore, younger than the upper part of the Yellowstone Tuff. The upper part is the younger of two ash-flow cooling units of the Yellowstone Tuff in Yellowstone Park and has been dated as 600,000 years old by potassium-argon determinations on sanidine phenocrysts (J. D. Obradovich, written commun., 1969). As the Osprey Formation occurs in canyons cut in the tuff, the formation is probably of considerably younger age. Glacial deposits of probable late Bull Lake age overlie the Osprey Formation just north of the type locality. The formation is therefore of Pleistocene age.

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