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MAP SHOWING OUTCROPS OF PRE-QUATERNARY ASH-FLOW TUFFS AND VOLCANICLASTIC ROCKS, BASIN AND RANGE PROVINCE, ARIZONA

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INTRODUCTION

This map report is one of a series of geologic and hydrologic maps covering all or parts of States within the Basin and Range province of the western United States. Other map reports in this series contain information on subjects that characterize the geohydrology of the province, including the ground-water hydrology, ground-water quality, surface distribution of selected rock types, tectonic conditions, areal geophysics, Pleistocene lakes and marshes, and mineral and energy resources. This work is a part of the U.S. Geological Survey's program for geologic and hydrologic evaluation of the province to identify potentially suitable environments for further study relative to storage of high-level nuclear waste (Bedinger, Sargent, and Reed, 1984).

This map report, prepared from published geologic maps and reports, utilizing the project guidelines defined by Sargent and Bedinger (1984), shows the occurrence of pre-Quaternary ash-flow tuffs and volcaniclastic rocks in the Basin and Range province in Arizona. The Description of Map Units includes the geologic and radiometric age, thickness, lithologic character, and sources of data of outcrop areas within outlined and numbered areas in counties of the study area. The known calderas and cauldrons are also described. The radiometric ages of the rock units are only those which are available and do not necessarily represent the entire age range of the units.

DESCRIPTION OF MAP UNITS

[To convert feet (ft) to meters, multiply feet by 0.3048;
to convert miles (mi) to kilometers, multiply miles by 1.609;
to convert cubic miles (mi^3) to cubic kilometers, multiply cubic miles by 4.168]

Part A.--TUFFS AND VOLCANICLASTIC ROCKS

County-area number	Map symbol	Geologic unit	Geological and radiometric age in millions of years (m.y.)	Lithology and comments	References for county area
			COCHISE COUNTY (C)		
C-1	Tt	Weatherby Canyon Ignimbrite	Tertiary	Ash-flow tuff of rhyolitic and trachytic composition, at least 3,000 ft thick. Rocks dip 15° E.	Gillerman, 1968; Wilson and others, 1969
	Tv	Volcanic rocks	Tertiary	Lava flows, tuffs, agglomerates, and breccias of silicic composition.	
C-2	Kv	Volcanic rocks	Late to Early Cretaceous	Welded volcanic breccia; represents solidified throat of eruptive vent. Cut by many porphyritic intrusions.	Drewes, 1980; Erickson, 1968
C-3	Tv	Rhyolite Canyon Formation	Miocene 24.7 to 25.6 m.y.	Mostly welded rhyolite ash-flow tuffs but includes somme air-fall tuff and a rhyodacite lava flow about 100 ft thick in upper part.	Drewes, 1981, 1982; Marjaniemi, 1968
		Faraway Ranch Formation	Oligocene 28 m.y.	Chiefly rhyodacite lava flows and welded ash-flow tuff but includes some intrusive masses, air-fall tuff and tuffaceous sandstone. Ash-fall tuff in upper part about 800 ft thick.	
C-4	Tt	Pearce Volcanics	Miocene or late Oligocene	Andesite and rhyolite flows and some rhyolitic tuff and tuff-breccia over 3,000 ft thick. Highly deformed.	Drewes, 1980; Gilluly, 1956
	Kt	Sugarloaf Quartz Latite	Late Cretaceous	Rhyodacite tuff and welded tuff. Thickness commonly 65 to 660 ft.	
C-5	Kv	Uncle Sam Porphyry and Bronco Volcanics	Late Cretaceous	Rhyodacite and quartz latite tuff and welded tuff; includes local intrusive bodies. Uncle Sam Porphyry considered intrusive body of Gilluly (1956). Bronco Volcanics also contains andesitic lava flows.	Drewes, 1980; Gilluly, 1956
C-6	Tt	S 0 Volcanics	Eocene 47±2 m.y.	Interbedded quartz latite tuffs and hornblende andesite flows. Upper tuff member, 1,000 ft maximum thickness. Middle hornblende andesite member, 300 to 1,000 ft thick. Lower member, tuffs and interbedded water-laid sandstones, 1,600 ft thick.	Drewes, 1980; Gilluly, 19567

C-7	Tv	Volcanic rocks	Miocene and late Oligocene	Rhyolitic to rhyodacitic lava flows, welded tuff, and pyroclastic rocks, includes some intercalated epiclastic rocks.	Drewes, 1980
C-8	Tv	Breccia of Hog Canyon	Early Miocene to late Oligocene	Laharic breccia.	Deal and others, 1978; Hayes, 1982
		Volcanic rocks	Late Oligocene 24.2±0.5 and 27.1±1.5 m.y.	Compound cooling unit, locally containing intercalated rhyolite lava flows. Also includes rhyolite ash-flow tuff of Guadalupe Canyon. Fills Geronimo Trail cauldron in Peloncillo Mountains. About 1,400 ft thick; base not exposed.	

GRAHAM COUNTY (GM)

GM-1	Tv	Volcanic rocks	Tertiary	Lava flows, tuffs, breccias, and agglomerates, intermediate in composition.	Wilson and others, 1969
GM-2	Tv	Galiuro Volcanics	Tertiary	Upper unit of rhyolite welded ash-flow tuff intercalated with breccias and lava flows. Lower unit of andesite flows.	Blacet and Miller, 1978; Wilson and others, 1969
	TKv	Volcanic rocks	Tertiary and Cretaceous	Lava flows, pyroclastics, and volcanic conglomerates, andesitic to rhyolitic in composition.	
GM-3	Tt	Galiuro Volcanics, ash-flow tuff unit	Miocene	Largely welded ash-flow tuffs, as much as 2,100 ft thick along front of Galiuro Range.	Creasey and others, 1981
GM-4	Tv	Volcanic rocks	Tertiary	Lava flows, tuffs, breccias, and agglomerates, silicic to intermediate composition.	Wilson and others, 1969
	TKv	Volcanic rocks	Tertiary and Cretaceous	Volcanic rocks, andesitic to rhyolitic in composition.	
GM-5	Tt	Lithic tuffs	Tertiary	Lithic tuffs and minor interbedded rhyolitic flows, more than 700 ft thick. Tuffs well indurated and include some welded tuff. Extensively faulted. Approximately correlative with tuffs in Datil Formation.	Morrison, 1965; Wilson and others, 1969
	Tv	Volcanic rocks	Tertiary	Lava flows, tuffs, breccias, and agglomerates of intermediate composition.	

			GREENLEE COUNTY (G)		
G-1	Tv	Volcanic rocks	Tertiary 23.3±0.7 and 24.9±0.7 m.y.	Rhyolitic, welded ash-flow tuffs, some peralkaline; associated pyroclastic and fluviatile deposits. Tuffs range in thickness from 300 to about 1,000 ft. Tuffs overlain by laharic breccia about 2,000 ft thick.	Ratté and others, 1969
	Tt	Rhyolite of Red Mountain	Tertiary	Rhyolite lava flows, intrusive rhyolites, and two cooling units of rhyolitic ash-flow tuffs at base. Tuffs are more than 700 ft thick. Unit as much as 1,700 ft thick.	
G-2	Tv	Volcaniclastic deposits	Miocene	Mudflow breccia as much as 200 ft thick.	Ratté and Hedlund, 1981
		Rhyolite of Mule Creek	Miocene 17.7±0.6 m.y.	Rhyolite lava flows and non-welded ash-flow tuff; total thickness as much as 800 ft.	
		Rhyolite of Hell's Hole	Oligocene	Autobrecciated rhyolite flows and breccias.	
	Tt	Bloodgood Canyon Rhyolite	Oligocene	Densely welded, rhyolitic ash-flow tuff, 100 to 150 ft thick.	
			LA PAZ COUNTY (LP)		
LP-1	Tv	Volcanic rocks	Middle Tertiary 15 to 25 m.y.	Typical section from top to bottom: Vesicular basalt flows, ash and cinder deposits, ash-flow tuff and breccia, and basal arkosic conglomerate. Tuffs in southern part of area are thick and welded to partly welded.	Miller, 1970; Reynolds, 1980; Scarborough, Robert B., Arizona Bureau of Geology and Mineral Technology, written commun., 1982
LP-2	Tt	Tuffs	Tertiary	Ash-flow tuffs, sedimentary rocks, andesite lava flows, and air-fall tuffs.	Scarborough, Robert B., Arizona Bureau of Geology and Mineral Technology, written commun., 1982

			MARICOPA COUNTY (MA)		
MA-1	Tt	Tuffs	Miocene to Oligocene 16 to 26 m.y.	In Vulture Mountains, tuffs and associated andesitic flows and volcanic sandstone; total thickness about 1,500 ft, of which tuffs comprise 650 ft. At Vulture Peak, welded tuff, 70 ft thick at top of section.	Rehrig and others, 1980; Scarborough, Robert B., Arizona Bureau of Geology and Mineral Technology, written commun., 1982
		Tuffs	Middle Tertiary	Partly welded rhyolite ash-flow tuff.	
MA-2	Tt	Tuffs	Miocene to Oligocene 15 to 25 m.y.	Ash-flow tuff, flow breccia, and ash and cinder deposits capped by vesicular basalt flows. East of Sugarloaf Mountain, unit consists of tuffs, ash-flow tuffs, andesites, and redbeds. In Big Horn, Saddle, and Eagletail Mountains, includes rhyolite and andesite flows. Total thickness over 2,000 ft. Unit highly faulted; locally more than 1,000 ft of displacement.	Denis, 1971; Scarborough, Robert B., Arizona Bureau of Geology and Mineral Technology, written commun., 1982; Wilson and others, 1969
MA-3	Tv	Volcanic rocks	Tertiary	Tuffs and associated flows, breccias and agglomerates of intermediate composition.	Denis, 1971; Wilson and others, 1969
	TKv	Volcanic rocks	Tertiary(?) and Cretaceous	Tuffs and lava flows, rhyolitic and andesitic in composition. In Gila Bend Mountains, highly deformed and locally intensely fractured.	Denis, 1971; Wilson and others, 1969
MA-4	Tt	Tuffs	Miocene	Welded to non-welded tuffs.	Tucker, 1980
MA-5	Tv	Volcanic rocks	Tertiary	Rhyolitic to andesitic lava flows and tuffs.	Wilson and others, 1969
			MOHAVE COUNTY (MO)		
MO-1	Tv	Volcanic rocks	Tertiary	Rhyolitic ash-flow tuffs and interbedded basalt flows, agglomerates, and gravel. Several hundred feet thick. Near Dolan Springs in northeast part of area, predominantly volcanic sediments and poorly consolidated tuffs.	Gillespie and Bentley, 1971; Wilson and others, 1969
MO-2	Tv	Volcanic rocks	Tertiary	In descending order: Tuff and andesite about 200 ft thick; rhyolitic lava flows, tuff, and agglomerate 350 to 575 ft thick; and basalt flows as much as 1,000 ft thick.	Gillespie and Bentley, 1971

MO-3	Tt	Peach Springs Tuff	Miocene 17 to 18 m.y.	Trachytic ash-flow tuff. Single cooling unit; upper part densely welded. Probable source area in Black Mountains. Thickness 30 to 120 ft.	Suneson, 1980; Young and Brennan, 1974
MO-4	Tv	Volcanic rocks	Miocene	Rhyolitic lava flows, pyroclastic rocks, and volcanic sediments interbedded with zeolitized tuffs, each about 100 ft thick.	Shackelford, 1976; Suneson, 1980

PIMA COUNTY (PM)

PM-1	Tv	Ajo Volcanics	Middle Tertiary	Non-resistent andesite and rhyolitic tuffs, lava flows and breccias. Diagenetic zeolite alteration common in rhyolitic units. Rocks dip 10° to 35° E.	Gilluly, 1937; May and others, 1980; Shafiqullah and others, 1980
PM-2	Tt	Tuffs	Tertiary	Ash-flow tuffs, not extensively welded. Possible caldera in southwestern Pima County (not shown on map).	Scarborough, Robert B., Arizona Bureau of Geology and Mineral Technology, written commun., 1982; oral commun., 1983
PM-3	Tt	Tuffs	Tertiary	Welded biotite-latite ash-flow tuff in northern part of area. In southern part, welded porphyritic rhyodacite tuff.	Briskey and others, 1978; Dockter and Keith, 1978
PM-4	Tv	Laharic breccia	Tertiary	Laharic breccia and andesitic lava flows. Southernmost outcrop contains some welded tuff.	Rytuba and others, 1978; Wilson and others, 1969
PM-5	Tt	Tuffs	Tertiary	Dacitic and andesitic tuffs and lava flows overlain by volcanic breccia and conglomerate.	Haxel and others, 1978; Johnson and others, 1975
	Kv	Sil Nakya Formation	Cretaceous	Welded rhyodacite ash-flow tuffs and lava flows, siltstone, and sandstone; correlative with Roskruge Volcanics dated at 71 and 74 m.y.	
	Kt	Tuffs	Cretaceous	Densely welded ash-flow tuff containing abundant fragments of Jurassic quartz monzonite.	
	Jt	Tuffs	Jurassic	Hematite-rich, rhyolitic(?), welded, ash-flow tuff, locally prominent eutaxitic foliation.	
PM-6	TKt	Tuffs	Tertiary and/or Cretaceous	Rhyolitic tuffs, lava flows, and volcanic sediments. Tuffs grade laterally into poorly consolidated ash.	May and Haxel, 1980

PM-7	TKt	Roskruge Volcanics, Silver Bell Formation and Mount Lord Ignimbrite	Early Eocene to Late Cretaceous	Roskruge Volcanics, in Roskruge Mountains, include welded quartz-latite and dacite ash-flow tuffs and breccia units. Formation is about 4,000 ft thick, tuffs at base, about 1,800 ft thick. Silver Bell Formation in Silver Bell Mountains is laharic breccias, andesite and dacite lava flows, and autoclastic breccias. Mount Lord Ignimbrite in eastern Silver Bell Mountains; welded ash-flow tuff, lithic-vitric tuff, an minor intrusives. Rocks in Silver Bell Mountains dip 20^0 to 40^0 NE.	Bikerman, 1967; Johnson and others, 1975; Watson, 1964
PM-8	Tt	Rhyodacite of Kohi Kug	Tertiary	Rhyodacitic to rhyolitic, welded, ash-flow tuff and tuff breccia together with minor lava flows and conglomerate.	Haxel and others, 1980
	KJt	Chiuli Shaik Formation	Cretaceous or Jurassic	Upper part, rhyodacite tuff, andesitic lava flows, and flow breccias. Lower part, sedimentary rocks.	
PM-9	Tt	Formation of Tinaja Peak	Miocene and Oligocene	Rhyolite and rhyodacite tuffs, tuff breccia, and andesitic flows; tuff at base of formation zeolitized, and tuffs in Cerro Colorado Mountains partly welded.	Cooper, 1973; Drewes, 1980; Hayes and Drewes, 1968; Keith and Theodore, 1975
	Kt	Demetrie Volcanics and Red Boy Rhyolite	Late Cretaceous	Rhyolite tuffs and lava flows. Demetrie Volcanics are north of Tinaja Peak. Red Boy Rhyodacite in Sierrita Mountains.	
	Rt	Oxframe Volcanics	Triassic	Rhyolite and rhyodacite tuffs and lava flows, 1,000 ft thick.	
PM-10	Tv	Volcanic rocks	Miocene and late Oligocene	Lithologically similar to area C-7.	Brown, 1939; Drewes, 1980
	Kt	Cat Mountain Rhyolite	Cretaceous	Rhyolitic tuff, lava flows, and mudflows.	
PM-11	Tv	Volcanic rocks	Miocene and late Oligocene	Lithologically similar to area C-7	Drewes, 1980
	Kt	Tuff	Late Cretaceous	Rhyodacite tuff and welded tuff. Thickness commonly 65 to 660 ft.	

PINAL COUNTY (PL)

PL-1	Tt	Geronimo Head Formation; Apache Leap Tuff; Superstition Tuff	Miocene	Geronimo Head Formation consists of rhyolite tuffs, rhyolite, quartz latite, and basalt lava flows, 1,400 ft thick; age 16 to 21 m.y. Apache Leap Tuff occurs south, east, and northeast of Superior, and is quartz latite or rhyodacite ash-flow tuff; average thickness 500 ft but reaches 2,000 ft thick east of Suerior; age, 20 m.y. Siphon Draw Member of Superstition Tuff is densely welded and devitrified tuff, 2,525 ft thick; age, 24.5±0.5 m.y. Dogie Spring Member and Canyon Lake Member both are as much as 590 ft thick.	Creasey and others, 1975; Peterson, 1960, 1968, 1979; Sheridan, 1978; Stuckless and Sheridan, 1971
PL-2	Tv	Tuffs and volcanic rocks	Tertiary	Ash-flow tuff associated with latite flows and silicified tuffaceous mudstone, sandstone, and sedimentary breccia.	Bergquist and others, 1978; Blacet and others, 1978
PL-3	Tv	Volcanic rocks	Tertiary	Tuff, lava flow, breccia, and agglomerate of intermediate composition.	Wilson and others, 1969
PL-4	Tt	Tuffs of Galiuro Volcanics	Tertiary	Welded ash-flow tuffs in Galiuro Volcanics from 75 to 550 ft thick. Northernmost outcrops are welded tuffs interbedded with lava flows; total thickness, several thousand feet.	Creasey and Krieger, 1978; Krieger, 1968a, 1968b, 1979; Simons, 1964; Willden, 1964
	TKv	Williamson Canyon Volcanics and other volcanics	Early Tertiary and Late Cretaceous	Massive andesitic breccia, agglomerate, tuff, flow breccia, mudflow, and volcanic and non-volcanic sediments; extensively altered. As much as 1,000 ft thick. Unit occurs west of the Tablelands, and to the east and north of the Tablelands, other volcanic units contain thousands of feet of laharic breccias, sediments, and water-worked tuff.	

SANTA CRUZ COUNTY (SC)					
SC-1	Tv	Volcanic rocks	Miocene and late Oligocene	Lithologically similar to area C-7.	Drewes, 1980; Nelson, 1968; Percious, 1968
	Kt	Tuff	Late Cretaceous	Rhyodacite tuff and welded tuff. Thickness commonly 65 to 660 ft.	
SC-2	Tt	Tuff	Oligocene 23 to 27 m.y.	Rhyolitic and rhyodacitic welded tuff, lava flows, pyroclastic rocks, and intercalated epiclastic rocks.	Drewes, 1980
	Kt	Tuff	Late Cretaceous	Rhyodacite tuff and welded tuff. Thickness commonly 65 to 660 ft.	
SC-3	$\overline{R}$t	Mount Wrightson Formation	Triassic 220 m.y.	Rhyodacite welded tuffs, lava flows, and agglomerates; also contains sandstone and quartzite lenses. total thickness 10,000 ft.	Drewes, 1980; Hayes and Drewes, 1968
SC-4	Kt	Tuff	Late Cretaceous	Rhyodacite tuff and welded tuff. Thickness commonly 65 to 660 ft.	Drewes, 1971, 1980; Hayes and Raup, 1968; Marvin and others, 1973; Simons, 1964; Wilson and others, 1969
	J$\overline{R}$t	Canelo Hills Formation	Jurassic and Triassic	Canelo Hills Volcanics, largely in Canelo Hills. Upper part, rhyolite welded tuff, several hundred to 6,000 ft thick. Middle part, rhyolite lava as much as 1,000 ft thick. Basal part, 1,900 ft of interlayered rhyolite lava, tuffs, and sedimentary rocks. In Huachuca Mountains, unit is rhyodacite tuffs and lavas, several thousand feet thick. In Mustang Mountains, rhyolite flows and minor welded tuff, as much as 500 ft thick. In Patagonia Mountains, rhyolite tuff, welded tuff, lava, sandstone, and conglomerate, as much as 1,000 ft thick.	
	$\overline{R}$t	Volcanic rocks	Triassic 220 m.y.	Rhyolitic to andesitic lava and pyroclastic rocks and intercalated sandstone, quartzite, and some conglomerate. Thickness as much as 10,000 ft.	
YAVAPAI COUNTY (YA)					
YA-1	Tt	Tuffs	Tertiary	Air-fall tuffs; boundary of area inferred. Shown on State Geologic Map (Wilson and others, 1969) as basalt.	Scarborough, Robert B., Arizona Bureau of Geology and Mineral Technology, written commun., 1982; Wilson and others, 1969

YA-2	Tt	Grayback Mountain Rhyolite Tuff and volcanic rocks	Tertiary	Grayback Mountain Rhyolite Tuff is welded ash-flow tuff, as much as 500 ft thick southwest of town of Bagdad. In Black Mountains, mainly bedded rhyolite and basalt and some ash-flow tuff.	Anderson and others, 1955; Otton, 1981; Scarborough, Robert B., Arizona Bureau of Geology and Mineral Technology, written commun., 1982
YA-3	Tv	Volcanic rocks	Tertiary	Tuffs, lava flows, agglomerates, and breccias of intermediate composition.	Wilson and others, 1969
YA-4	Tv	Volcanic rocks	Miocene	Ash-flow tuffs, andesites, and mudflows capped by basalt flows. Ash-flows are thin and moderately welded. Locally faulted and tilted.	Scarborough, and Wilt, 1979

YUMA COUNTY (YU)

YU-1	Tt	Tuffs	Tertiary	Thick, moderately welded ash-flow tuffs in Kofa and Castle Dome Mountains. Several hundred feet of massive tuff in Tank Mountains. Possible caldera in Kofa Mountains; age, 15 to 20 m.y.	Armstrong and Yost, 1958; Jones, 1915; Scarborough, Robert B., Arizona Bureau of Geology and Mineral Technology, written commun., 1982; oral commun., 1983
YU-2	Tt	Tuffs	Tertiary	Mostly massive, rhyolitic and andesitic tuffs, and lesser amounts of lava flows and agglomerates.	Armstrong and Yost, 1958; Scarborough, Robert B., Arizona Bureau of Geology and Mineral Technology, written commun., 1982
YU-3	Tv	Tuffs	Tertiary	Ash-flows, partially welded.	Scarborough, Robert B., Arizona Bureau of Geology and Mineral Technology, written commun., 1982

Part B.--CALDERAS AND CAULDRONS

Name	Description	References
Faraway Ranch caldera	Maximum thickness of 2,000 ft of Faraway Ranch Formation ascribed to deposition in possible caldera in northern Chiricahua Mountains called Faraway Ranch caldera.	Marjaniemi, 1969
Geronimo Trail	Formed about 20 m.y. (Miocene) ago by eruption of tuff of Guadalupe Canyon, about 1,300 ft thick. Cauldron bordered by three concentric zones of ring fractures and moat deposits, and appears somewhat resurgently domed; extends into New Mexico.	Deal and others, 1978; Erb, 1978; Hayes, 1982
Rodeo cauldron	Formed by eruption of 3,300 ft of tuff of Black Mountain 26 m.y. (Oligocene) ago. Outline is projection of cauldron from adjacent Peloncillo Mountains, New Mexico.	Deal and others, 1978; Marjaniemi, 1969
Turkey Creek caldera	A deeply eroded caldera 13 mi in diameter; age, 25 m.y. (Oligocene). Source area for estimated 100 mi^3 of volcanic material, including ash-flows in Rhyolite Canyon Formation.	Marjaniemi, 1968, 1969
	GREENLEE COUNTY	
Red Mountain caldera	Two- to three-mi diameter caldera of composite andesitic volcano; later filled by rhyolite of Red Mountain. Miocene age.	Ratté and others, 1969
	PINAL COUNTY	
Goldfield cauldron	Comprised of at least three structural blocks tilted northeastward. Tuff units relatively thin in southwest half of cauldron. Collapse occurred with eruption of Geronimo Head tuffs. Age, 15 to 16 m.y. (Miocene).	Sheridan, 1978; Stuckless and Sheridan, 1971
Haunted Canyon caldera	Three-mile-diameter caldera.	Peterson, 1960, 1968
Superstition cauldron	Resurgent cauldron filled with thick, welded tuff; forms broad dome broken by central graben. Collapse occurred with eruption of Siphon Draw Member of Superstition Tuff. Age, 25 m.y. (Miocene).	Sheridan, 1978; Stuckless and Sheridan, 1971
Tortilla caldera	Arcuate graben filled with lahar, capped with rhyolitic lava. Age, less than 15 m.y. (Miocene).	Sheridan, 1978

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