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MAP SHOWING OUTCROPS OF THICK, DOMINANTLY ARGILLACEOUS SEDIMENTARY AND METASEDIMENTARY 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. The map reports contain detailed 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 Basin and Range province to identify potentially suitable regions for further study relative to storage of high-level nuclear waste (Bedinger, Sargent, and Reed, 1984).

This map was prepared from published geologic maps and reports, utilizing the project guidelines defined in Sargent and Bedinger (1984). For this study, argillaceous sedimentary and metasedimentary rocks include shale, claystone, mudstone, siltstone, argillite, slate, and schist. The argillaceous units commonly contain interbeds of non-argillaceous rocks, such as sandstone and limestone, which were deposited with the argillaceous rocks. The project guidelines call for mapping outcropping argillaceous rock units 500 ft or more thick, but because argillaceous rocks may impede the movement of groundwater and commonly have sorptive properties, locally units of lesser thickness were included. Because argillaceous units commonly are too thin to map separately, they have been included with thicker formations or groups on the geologic map, for example, the Pioneer Shale is included in outcrops of the Apache Group, but generally only the shale is discussed. In the Description of Map Units the geologic age, lithologic character, thickness, and sources of data are described for the argillaceous units in arbitrarily outlined and numbered areas in counties of the study area.

DESCRIPTION OF MAP UNITS
[To convert feet (ft) to meters, multiply feet by 0.3048]

County-area number	Map symbol	Geologic unit	Geologic and radiometric age in millions of years (m.y.)	Lithology and comments	References for county area
			COCHISE COUNTY		
CH-1	Kb	Bisbee Group, undivided	Late Early Cretaceous	In southeast part of Arizona, Bisbee Group, although undivided on most geologic maps, is divisible into, from top to bottom: Cintura Formation (600 to 3,000 ft); mainly siltstone and mudstone, locally much feldspathic to arkosic sandstone and quartzite, and minor claystone, limestone, conglomerate, and graywacke; top of formation eroded. Mural Limestone (60 to 800 ft); upper member of limestone interbedded with mudstone and siltstone; lower member of interbedded mudstone, siltstone, limestone, and sandstone. Mural thins to north and northwest and not readily recognizable north of Tombstone. Morita Formation (700(?) to 4,200 ft); siltstone and mudstone dominant but commonly much feldspathic sandstone, especially in upper part; less common is claystone, conglomerate, and limestone. In Dos Cabezas and northern Chiricahua Mountains, formation grades laterally into underlying Glance Conglomerate. Glance Conglomerate (0 to 3,600 ft); boulder- to pebble-conglomerate in matrix of sandy mudstone or sandstone; in Huachuca Mountains contains unit of andesitic lava as much as 1,500 ft thick. Bisbee Group is more than 5,000 ft thick.	Cooper, 1959, 1960; Drewes, 1980, 1981, 1982; Drewes and Williams, 1973; Gilluly, 1956; Hayes, 1970a, 1970b, 1982; Hayes and Landis, 1964; Hayes and Raup, 1968; Hayes and others, 1965; Sabins, 1957a, 1957b
	Js	Canelo Hills Volcanics, lower member	Jurassic 144 m.y.	Red mudstone, sandstone, and conglomerate, and intercalated rhyodacite volcanic rocks; thick basal limestone conglomerate locally in Canelo Hills; as much as 1,900 ft thick. Correlative with lower member of Canelo Hills Volcanics of Hayes and others (1965) which was designated as Triassic and Jurassic age by Hayes and others (1965) and as Triassic by Drewes (1980). The 144 m.y. date (Drews, 1980), however, would place it in the Jurassic.	

CH-2	Kb	Bisbee Formation	Late Early Cretaceous	In this area the four-fold division of Bisbee Group, discussed above, is not readily evident because the Mural Limestone thins rapidly north of Mule Mountains and apparently is missing north of Tombstone. Consequently, Morita and Cintura Formations, which are lithologically very similar, are not distinguishable. Glance Conglomerate, however, is present at base of Bisbee. Bisbee is principally interbedded sandstone, mudstone or shale, and quartzite, minor limestone, and conglomerate. Glance Conglomerate is a few feet to more than 1,000 ft thick. Bisbee is as much as 15,000 ft thick, but generally thinner.	Cooper, 1960; Cooper and Silver, 1964; Gilluly, 1956
CH-3	Ya	Apache Group: Pioneer Shale	Middle Proterozoic	Dripping Spring Quartzite and Pioneer Shale comprise most of the Apache Group in this area. Dripping Spring is mostly quartzite, Barnes Conglomerate Member, as much as 60 ft thick, at base. Pioneer, below the Barnes, is sandy shale containing few interbeds of quartzite. Scanlan Conglomerate Member (0 to 30 ft) occurs at base. Pioneer is 150 to 300 ft thick.	Cooper and Silver, 1964; Drewes, 1974
			GILA COUNTY		
G-1	Ya	Apache Group: Mescal Limestone and Dripping Spring Quartzite	Middle Proterozoic	Apache Group includes, in descending order, unnamed basalt flows, Mescal Limestone, Dripping Spring Quartzite, and Pioneer Shale. Mescal Limestone contains upper member, probably less than 100 ft thick, mainly of siliceous siltstone or argillite and lower cherty dolomite member, average thickness of 225 ft. Upper member confined to northern Gila County. Dripping Spring Quartzite generally north of Globe contains upper siltstone member, 180 to 420 ft thick, mostly of arenaceous, in part arkosic siltstone, and several, locally very thick beds of feldspathic to arkosic tuffaceous sandstone, and some orthoquartzite. Southward, this member becomes increasingly more sandy and quartzitic. Remainder of Dripping Spring is quartzite and conglomerate. Thickness is 325 to 700 ft.	Bergquist and others, 1981; Finnell, 1966; Granger and Raup, 1959, 1969; Shride, 1967; Wilson and others, 1969
		Pioneer Shale	Middle Proterozoic	Pioneer Shale, mostly tuffaceous siltstone or silty mudstone; lower one-half contains arkose, which occurs in greatest volume in thick sections. Formation thins to zero edge in northwest Gila County, and eastern outcrops of Apache Group on geologic map were terminated along the general limit of unit. Thickness, 0 to 500 ft. Stratigraphic details of Apache Group in areas east of Globe and generally south of Salt River relatively unknown.	

G-2	Ya	Apache Group: Pioneer Shale	Middle Proterozoic	Pioneer Shale: Siltstone member, 135 to 350 ft thick, tuffaceous siltstone, shale, and fine arkose and arkosic quartzite; quartzite and arkosic sandstone more abundant around Globe. Arkose member, 25 to 265 ft thick, quartzite and arkose and some thin siltstone layers. Scanlan Conglomerate Member, 0.5 to 12 ft thick, conglomeratic sandstone. Pioneer Shale thins eastward across area, and thickness ranges from 165 to about 450 ft.	Creasey and others, 1974; Peterson, D. W., 1960, 1962, 1969; Peterson, N. P., 1954, 1961, 1962; Peterson, N. P., and others, 1951
G-3	Ya	Apache Group: Dripping Spring Quartzite	Middle Proterozoic	Dripping Spring Quartzite mostly quartzite, but north of Riverside includes an upper siltstone member 450 to 500 ft thick containing interbeds of shale and arkosic sandstone. Formation 450 to 700 ft thick.	Cornwall and others, 1971; Peterson, N. P., 1961; Ransome, 1919; Wilden, 1964
		Pioneer Shale	Middle Proterozoic	Mostly tuffaceous sandy siltstone and arkosic sandstone in thin to thick beds; thin Scanlan Conglomerate Member at base. Pioneer as much as 650 ft thick and wedges out east of Gila River.	
				MOHAVE COUNTY	
M-1	Cbt	Bright Angel Shale and Tapeats Sandstone	Middle and Early Cambrian	About 500 ft of green and red shale of the Bright Angel Shale overlies 250 ft of red to tan sandstone and quartzite of the Tapeats Sandstone. Formations mapped together in this area.	Moore, 1972
				PIMA COUNTY	
PM-1	Ya	Apache Group: Pioneer Shale	Middle Proterozoic	Pioneer Shale (447 to 515 ft): Upper member, 365 ft, crystal tuff and slate. Middle member, 80 to 135 ft, pebbly sandstone or quartzite. Scanlan Conglomerate Member, 2 to 15 ft, quartz-pebble conglomerate at base.	Creasey, 1967a; Creasey and Theodore, 1975; Wilson and others, 1969
PM-2	Kb(?)	Amole Arkose	Early Cretaceous	Amole Arkose of Tucson Mountains correlative with Bisbee Group of southeast Arizona (Hayes, 1970a). Amole mostly arkose commonly interbedded with shale and some limestone; a 500-ft-thick shale unit in upper one-third of formation. Amole is at least 2,275 ft thick.	Brown, 1939; Drewes, 1980; Hayes, 1970a; Wilson and others, 1969

PM-3	Jp, Jpc	Pitoikam Formation and metamorphic rocks of Chutum Vaya (Jpc)	Early Jurassic	Pitoikam Formation: Chiltepines Member, mostly shale containing thin beds of arkose, quartzite, and in basal part, conglomerate. Contreras Conglomerate Member (0 to 4,400 ft), boulder conglomerate interbedded with thin sandstones and siltstones. Lower conglomerate member (1,300 to 6,000(?) ft), alternating beds of conglomerate, sandstone, and siltstone. Chiltepines Member of Pitoikam may be sourceward equivalent of Bisbee Group to east. Rocks of Chutum Vaya, metamorphosed in Middle or Late Jurassic, are metamorphosed phase of Pitoikam Formation and underlying Ali Molina Formation, and consist of metasedimentary and metavolcanic and metaplutonic rocks. Pitoikam and metamorphic rocks of Chutum Vaya are at least 9,200 ft thick.	Haxel, May, and others, 1980, 1982; Haxel, Wright, and others, 1980; Hayes, 1970a; Heindl and Fair, 1965
PM-4	Mzsh	Mesozoic shale	Mesozoic (Lower Cretaceous and possibly Triassic)	Shale and some limestone and siltstone and a basal conglomerate. Rocks near Oro Blanco in Arivaca quadrangle, southwest of Tucson, are correlative with Lower Cretaceous Bisbee Group, but rocks south and west of Arivaca more likely are Triassic (Hayes, 1970a); there are, however, no confirmed Triassic rocks in southern Arizona (Robert B. Scarborough, Arizona Bureau of Geology and Mineral Technology, written commun., 1984).	Hayes, 1970a; Keith and Theodore, 1975
PM-5	Kb	Bisbee Group	Late Early Cretaceous	Bisbee Group (top to bottom): Turney Ranch Formation (1,500 to 3,200 ft), mudstone, siltstone, and arkosic to quartzitic sandstone. Shellenberger Canyon Formation (1,000 to 4,300 ft), mudstone, siltstone, arkosic sandstone, graywacke, and few thin limestones in lower part. From Empire Mountains lower part of Shellenberger Canyon Formation grades northward into Glance Conglomerate. Apache Canyon Formation (550 to 2,000 ft), mostly siltstone, shale, and arkosic sandstone, but includes silty limestone in Empire Mountains and few thin limestone beds to west in Santa Rita Mountains. Formation grades northward into Glance Conglomerate and is missing north of Empire Mountains. Willow Canyon Formation (2,200 to 3,600 ft), arkosic sandstone and conglomeratic sandstone and siltstone, and some mudstone; grades into Glance Conglomerate. Glance Conglomerate (1 to 5,600 ft), pebble to boulder conglomerate; greatest thickness in Empire Mountains. Rocks on southwest flank of Whetstone Mountains quite thick and composed of significant proportion of argillaceous sediments.	Creasey, 1967b; Drewes, 1971a, 1971b, 1971c, 1977, 1980; Finnell, 1971; Hayes, 1970a

	Trg	Gardiner Canyon Formation	Triassic	Mudstone in upper part and siltstone below; in northern outcrops interbeds of sandstone, conglomerate, and one lithic tuff; few limestones in lower part. Thickness, as much as 1,200 ft. Designated as Triassic by Drewes (1980), but placement of Jurassic-Triassic boundary at 208 m.y. (Palmer, 1983), would assign it to the Jurassic.	
			PINAL COUNTY		
P-1	Ya	Apache Group	Middle Proterozoic	No formational descriptions.	Wilson and others, 1969
P-2	Ya	Apache Group: Dripping Spring Quartzite	Middle Proterozoic	Upper 200 ft of Dripping Spring consist of thin beds of siltstone interbedded with feldspathic to arkosic quartzite; remainder is mostly quartzite and conglomerate. Thickness 350 to 500 ft.	Krieger, 1968, 1974a, 1974b, 1974c; Ransome, 1919
		Pioneer Shale	Middle Proterozoic	Mainly interbedded tuffaceous siltstone, mudstone, and arkosic sandstone; includes conglomerate as much as 30 ft thick at base. Formation is as much as 300 ft thick; thins eastward and is missing east of the San Pedro River, and outcrops of Apache Group are not shown on map beyond that point.	
P-3	Ya	Apache Group: Dripping Spring Quartzite	Middle Proterozoic	Dripping Spring Quartzite (825 to 975 ft); Upper Member (528 to 595 ft), mostly thick units of siltstone, mudstone, or both containing, in part, thin beds of arkosic quartzite. A thick quartzite bed occurs at the top and locally a thick sandstone bed at the base. Middle member (206 to 402 ft), quartzite. Barnes Conglomerate Member (24 to 45 ft), conglomeratic quartzite.	Blacet and others, 1978; Dockter and Keith, 1978; Heindl and McClymonds, 1964
		Pioneer Formation	Middle Proterozoic	Mostly siltstone or mudstone and generally thin interbeds of quartzite in lower one-half to two-thirds.	
			SANTA CRUZ COUNTY		
SC-1	Kb	Bisbee Formation	Late Early Cretaceous	Mainly siltstone and mudstone, and some sandstone and limestone, and a basal conglomerate a few tens to as much as 300 ft thick. Formation is more than 3,000 ft thick; top is eroded.	Simons, 1972, 1974; Drewes, 1980
SC-2	Kb	Bisbee Group, undifferentiated	Lower Cretaceous	Arkose, siltstone, sandstone, conglomerate, and some limestone.	Drewes, 1980; Hayes, 1970b; Hayes and others, 1965
	Trs	Canelo Hills Volcanics, lower member	Triassic	Dominantly red beds, sandstone, and minor conglomerate in northern Canelo Hills. Southward, clastic rocks are subordinate to interbeds of thin silic flows and tuffs. As much as 2,000 ft thick. Correlative with Gardiner Canyon Formation of Santa Rita Mountains.	

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