DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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MAP SHOWING OUTCROPS OF BASALTIC ROCKS OF EARLY QUATERNARY AND TERTIARY AGE, BASIN AND RANGE PROVINCE, SOUTHERN CALIFORNIA

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INTRODUCTION

This map reoprt 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 is a part of the U.S. Geological Survey's program for geologic and hydrologic evaluation of the province to identify prospective regions for further study relative to isolation 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). As used in this study, basaltic rocks include basaltic andesite and basalt. The map shows the known occurrences of basaltic rocks largely of Tertiary age. Locally, however, where basalts of Quaternary age were not differentiated from those of Tertiary age, the younger basalts have been included on the map. The Description of Map Units includes the geologic and, if available, radiometric age; lithology; thickness where available; and sources of data for the basaltic units in outlined and numbered areas within the counties of the study area. No information was available on the rock outcrops that are unnumbered. The listed radiometric ages do not necessarily represent the entire age range of a unit.

DESCRIPTION OF MAP UNITS
[To convert feet (ft) to meters, multiply feet by 0.3048;
to convert miles (mi) to kilometers, multiply miles by 1.6091]

County-area number	Map symbol	Geologic and radiometric age in millions of years (m.y.)	Lithology and comments	References for county area
			IMPERIAL COUNTY (IM)	
IM-1	Tb	Miocene 13.2±2.5 m.y.	Basalt of Black Mountain: Fine-grained, vesicular, augite-olivine-basalt flows. Flows overlie volcaniclastic conglomerate and are as much as 200 ft thick.	Crowe, 1978; Henshaw, 1942; Morton, 1977
IM-2	Tb	Tertiary	Basalt flows, petrologically similar to the basalt of Black Mountain (See IM-1); overlie Tertiary sedimentary and volcanic rocks.	Crowe, 1978; Morton, 1977
			INYO COUNTY (IN)	
IN-1	Tb	Miocene 10.8±1.0 and 10.9±0.2 m.y.	Deep Springs Valley basalt: Scoriaceous and vesicular olivine-basalt and andesitic basalt flows. Overlies monzonite, tuffaceous sandstone, sandstone, and conglomerate. Cross-sectional thickness as much as 300 ft (McKee, 1968).	Dalrymple, 1963; McKee, 1968; McKee and Nelson, 1967; Robinson and others, 1968; Strand, 1967
IN-2	Tb	Miocene 9.6±0.2 m.y.	Coyote Flat basalt: Olivine-basalt flows, dikes, and necks. Cross-sectional thickness 0 to more than 500 ft (Bateman, 1965).	Bateman, 1965; Dalrymple, 1963; Elliott and McKee, 1982
IN-3	Tb	Pliocene and Miocene 3.0±1.2 to 6.8±3.9 m.y.	Locally scoriaceous olivine basalt, andesite and trachyandesite flows, agglomerate, and cinder cones. Locally overlies basaltic fanglomerate; unit as much as 1,000 ft thick.	Burchfiel, 1969; Langenheim and others, 1982a; McAllister, 1956; Nelson, 1971; Ross 1967, 1970
IN-4	QTb	Quaternary and Tertiary	Olivine basalt of Oak Creek: Aphanitic olivine-basalt flows as much as 300 ft thick in cross section (Moore, 1963). Cross section also shows unit overlain by alluvium and for 2 mi in the subsurface.	Du Bray, 1981; Moore, 1963
IN-5	Tb	Pliocene and Miocene 4.05±0.15 to 6.04±0.20 m.y.	Porphyritic, olivine-basalt flows, dikes, agglomerate, and cinder cones. Locally interbedded tuff and lapilli tuff of basaltic to andesitic composition. Partly overlain by Quaternary basalt flows; unit more than 500 ft thick.	Hall, 1971; Luedke and Smith, 1981; McAllister, 1956; Stinson, 1977b
IN-6	Tb	Pliocene and Miocene 4.03±0.12 and 7.16±0.22 m.y.	Funeral Formation: Andesite and basalt member, olivine-basalt flows and agglomerate as much as 200 ft thick.	Denny and Drewes, 1965; Drewes, 1963; Luedke and Smith, 1981; McAllister, 1970, 1973
		Tertiary	Scoriaceous and porphyritic andesite and basalt flows and intrusives included in Greenwater Volcanics; interbedded with sediments of Copper Canyon Formation, and clastics and evaporites of Furnace Creek Formation, and in unnamed volcanic unit below Furnace Creek Formation. Flows in Furnace Creek Formation are highly altered and fragmented. Overall thickness in any one of the formations as much as 500 ft.	

IN-7	Tb	Pliocene	Basalt of Silver Mountain: Slightly porphyritic basalt flows and pyroclastics in western one-half of the area.	Duffield and Bacon, 1981
	Tb	Pliocene 3.56±0.10 m.y.	Basalt of Upper Centennial Flat: Slightly porphyritic basalt flows and pyroclastics. Interbedded with pyroclastics and sediments of Coso Formation.	
IN-8	Tb	Pliocene 2.98±0.12 to 3.66±0.08 m.y.	Basalt of Petroglyph Canyon: Moderately porphyritic, locally vesicular basalt flows and pyroclastics. Columnar and platy jointing. Flows 10 to 16 ft thick and as much as 500 ft in aggregate thickness. Crops out in central part of area.	Duffield and Bacon, 1981; Stinson, 1977a
		3.10±0.22 and 3.67±0.16 m.y.	Basalt and minor andesite flows and pyroclastics; flows 5 to 70 ft thick. Located in southern part of area.	
		3.60±0.08 and 3.64±0.11 m.y.	Basalt of Coso Peak: Porphyritic basalt flows and pyroclastics overlie quartz monzonite. Overlain by and interbedded with the basalt of Petroglyph Canyon. Cross-sectional thickness as much as 500 ft (Stinson, 1977).	
IN-9	Tb	Pliocene 2.06±0.34 m.y.	Basalt of Rose Valley: Cinder cone deposits and porphyritic basalt flows, locally containing granite xenoliths.	Duffield and Bacon, 1981
IN-10	Tb	Tertiary	Basalt and andesite flows, local plugs and dikes. Cross-sectional thickness 0 to 250 ft (Smith and others, 1968).	Jennings and others, 1962; Smith and others, 1968
			KERN COUNTY (KE)	
KE-1	Tb	Pliocene	Fine-grained porphyritic basalt flows; dip 35° west. Interbedded with sediments of Ricardo Formation and fanglomerate of Funeral Formation. Cross-sectional thickness 0 to 1,000 ft (Samsel, 1962).	Dibblee, 1967b; Morton, 1977; Samsel, 1962; Troxel and Morton, 1962
KE-2	Tb	Miocene	Basalt flows, dikes, and sills, interbedded with pyroclastics of Kinnick Formation and siltstone of Bopesta Formation; dip 35° northwest; weathers to sand-sized fragments. Cross-sectional thickness 0 to 800 ft (Dibblee and Louke, 1970).	Dibblee 1959, 1967b; Dibblee and Louke, 1970; Troxel and Morton, 1962
KE-3	Tb	Early Miocene(?)	Saddleback Basalt: Fine-grained, massive basalt flows; maximum exposed thickness 200 ft. Cross sections show unit continuous in subsurface for more than 8 mi and as thick as 600 ft (Dibblee, 1958b).	Dibblee, 1958a, 1958b, 1967b; Jennings and others, 1962; Troxel and Morton, 1962
KE-4	Tb	Miocene(?) and Oligocene(?)	Basalt flows within tuff breccia of Gem Hill Formation. Flows dip south, are locally vesicular, and locally have fracture partings. Thickness 0 to 200 ft.	Dibblee, 1963, 1967b; Jennings and Strand, 1969

			LOS ANGELES COUNTY (LA)	
LA-1	Tb	Miocene or Oligocene	Basalt of Vasquez Formation: Fine-grained basalt flow, locally amygdaloidal. Flow overlies syenite and is overlain by andesite flow-breccia, as much as 200 ft thick.	Dibblee, 1960b
			MONO COUNTY (MO)	
MO-1	Tb	Pliocene to Miocene	Basalt of Murphy Spring Tuff Breccia: Scoriaceous basalt flows. Basalt of Rancheria Tuff Breccia: Porphyritic, olivine-basalt flows and dikes; forms western outcrop area.	Chesterman and Gray, 1975; Kleinhampl and others, 1975
MO-2	Tb	Pliocene 2.6 to 4.5 m.y.	Highly vesicular, aphanitic, alkali(?) olivine basalt and olivine-basalt flows, breccia, scoria, and dikes; locally interbedded with tuff; individual flows 0 to 50 ft thick. Map contours indicate aggregate thickness as much as 1,500 ft (Krauskopf and Bateman, 1977).	Crowder and others, 1972; Gilbert and others, 1968; Kleinhampl and others, 1975; Krauskopf and Bateman, 1977
MO-3	Tb	Tertiary	Vesicular, scoriaceous olivine-basalt flows underlain by andesite. Flows 25 to 50 ft thick; aggregate thickness as much as 700 ft.	Pakiser and others, 1964
MO-4	Tb	Pliocene and Miocene(?) 3.17±0.30 to 3.32±0.07 m.y.	Owens Gorge basalt: Scoriaceous, porphyritic, vesicular olivine-basalt flows. Overlain by Bishop Tuff and underlain by Wheeler Crest Quartz Monzonite (Triassic) at Owens River Gorge exposure. Thickness 0 to 400 ft.	Dalrymple, 1963; Krauskopf and Bateman, 1977; Luedke and Smith, 1981; McKee and Donahoe, 1981; Rinehart and Ross, 1957
MO-5	Tab	Pliocene 3.1±0.1 m.y.	Andesite to andesitic basalt.	Luedke and Smith, 1981; Strand, 1967
MO-6	Tba	Pliocene 2.6±0.1 m.y.	McGee Mountain basalt: Fine-grained basaltic andesite flows, rubbly and locally scoriaceous, partly overlain by boulder deposits. Map contours indicate unit is more than 80 ft thick (Langenheim and others, 1982b).	Dalrymple, 1963; Langenheim and others, 1982b
MO-7	Tb	Pliocene	Olivine-basalt flows, locally scoriaceous. Cross-sectional thickness as much as 175 ft (Nelson, 1966).	Krauskopf, 1971; Nelson, 1966
			RIVERSIDE COUNTY (RI)	
RI-1	Tb	Miocene(?)	Basalt member of Coachella Fanglomerate and flows within Painted Hill Formation: Massive basalt and olivine basalt; overlies gneiss; 0 to 100 ft thick.	Dibblee, 1967g; Luedke and Smith, 1981; Rogers, 1965, 1967
RI-2	QTb	Quaternary and Tertiary 0 to 5 m.y.	Basaltic rocks.	Luedke and Smith, 1981

SAN BERNARDINO COUNTY (SB)				
SB-1	Tb	Tertiary	Basalt and andesite flows, and locally plugs and dikes. Cross-sectional thickness 0 to 250 ft (Smith and others, 1968).	Jennings and others, 1962; Smith and others, 1968
SB-2	Tb	Tertiary 10 to 16+ m.y.	Mount Davis Volcanics: Rhyolite dikes, plugs, domes, flows, and also, bedded pyroclastics in lower part in northern Castle Mountains. Described in Nevada as basaltic to rhyolitic lavas.	Anderson and others, 1972; Bingler and Bonham, 1973; Luedke and Smith, 1981
SB-3	Tb	Pliocene 2.55±0.58 m.y.	Black Mountain Basalt: Vesicular basalt flows; unconformably overlies sediments of Barstow Formation and volcanics of Pickhandle Formation. Overlain partly by alluvium. Flows 0 to 180 ft thick. This unit comprises most outcrops in area.	Burke and others, 1982; Dibblee, 1968
		Miocene 13.6 to 18.9±1.3 m.y.	Basalt and olivine-basalt flows interbedded with sediments of Barstow Formation and volcanics of Pickhandle and Jackhammer Formations. Crops out only in several small areas but more extensive in subsurface.	
SB-4	Tb	Miocene	Barstow Formation: Three highly altered olivine-basalt flows interbedded with sandstone and conglomerate in lower member of the Barstow. Flows 0 to 20 ft thick.	Byers, 1960; Dibblee, 1968
		Miocene	Alvord Peak Basalt: Nonporphyritic basalt and minor andesite flows, overlie tuffaceous beds of Clews Fanglomerate and overlain by sediments and volcanics of Spanish Canyon Formation and locally by Barstow Formation. Flows dip gently northwestward and are 0 to 400 ft in aggregate thickness. Unit comprises northern part of area.	
SB-5	TJb	Tertiary to Jurassic(?)	Basalt flows, dip 40° east, overlain by dacite and quartz latite, underlain by quartz latite. Thickness from stratigraphic column is 600 ft.	Barca, 1966
SB-6	Tb	Early Miocene or older	Red Buttes Quartz Basalt: Closely jointed quartz basalt flows, dip gently west to southwest. In northern and central Kramer Hills, unit overlain by fanglomerate and underlain by 360 ft of extremely weathered olivine basalt. Unit in southwestern Kramer Hills overlain by alluvium and underlain by clay shale and quartz monzonite. Unit is as much as 300 ft thick and probably correlative with Saddleback Basalt of area KE-3.	Dibblee, 1960a, 1967b; Rogers, 1967
SB-7	Tb	Miocene	Agglomerate, tuff, tuff breccia, welded tuff, and volcanic conglomerate. Unit is possibly basaltic (E. J. Bortugno, California Division of Mines and Geology, written commun., 1982).	Dibblee, 1970; Rogers, 1967
SB-8	Tb	Miocene or Oligocene	Basalt flows, breccia, and fanglomerate. Flows grade into andesite; interlayered with andesite, andesite breccia, and tuff breccia; dips in varied directions. Cross-sectional thickness more than 500 ft.	Dibblee and Bassett, 1966a

SB-9	Tb	Miocene	Scoriaceous basalt flow interbedded with fine-grained sediments. As much as 100 ft thick.	Bassett and Kupfer, 1964; Dibblee, 1967c; Dibblee and Bassett, 1966b
		Miocene or Oligocene	Basalt breccia, dips moderately in various directions and locally grades into fanglomerate. Cross-sectional thickness as much as 900 ft (Dibblee and Bassett, 1966b). Crops out in southern one-half of area.	
SB-10	QTb	Quaternary and Tertiary 2.03±1.2 and 2.1±0.2 m.y.	Basaltic rocks.	Bassett and Kupfer, 1964; Bishop, 1963; Dibblee, 1967c; Dibblee and Bassett, 1966b; Rogers, 1967
	Tb	Miocene	Agglomerate, tuff, tuff breccia, welded tuff, and volcanic conglomerate. Unit is possibly basaltic (E. J. Bortugno, California Division of Mines and Geology, written commun., 1982).	
SB-11	Tb	Miocene and Oligocene	Basalt of Tropico Group: Massive, fine-grained, locally vesicular basalt flows and sills which grade to andesite; dips 30° southwest; overlies granite. Cross-sectional thickness more than 1,000 ft (Dibblee, 1970).	Dibblee, 1964a, 1964b, 1970; Dibblee and Bassett, 1966a
SB-12	Tb	Miocene to Oligocene	Locally vesicular, crumbly weathering basalt flows, dip 30° southwest; interbedded with fanglomerate, andesite, and dacite. Cross-sectional thickness greater than 1,000 ft.	Dibblee, 1964b
SB-13	QTb	Quaternary and Tertiary	Basalt of Lava Bed Mountains: Slightly to moderately vesicular basalt flows, overlies tuff breccia and partly overlain by fanglomerate and gravel; 0 to 200 ft thick.	Bassett and Kupfer, 1964; Dibblee, 1966, 1967c; Luedke and Smith, 1981
	Tb	Pliocene 2.1±0.2 and 2.03±1.2 m.y.	Basalt flows and cones, overlie alluvium and locally playas.	
		Miocene or Oligocene	Fine-grained, massive basalt flows, interlayered with tuff breccia and fanglomerate; dip gently in various directions. Cross-sectional thickness as much as 600 ft (Dibblee, 1967c). Located in northeast part of area.	
SB-14	QTb	Quaternary and Tertiary	Basalt of Malpais Crater: Fine-grained, vesicular basalt flows 0 to 100 ft thick; underlain and partly overlain by alluvium; located in northern part of area. Elsewhere, fine-grained, massive basalt flows overlie the Tertiary Old Woman(?) Sandstone and pre-Tertiary quartz monzonite. Cross-sectional thickness as much as 500 ft (Dibblee, 1967e).	Dibblee, 1964a, 1964b, 1964c, 1967d, 1967e, 1967f, 1967g
SB-15	QTb	Quaternary and Tertiary	Basalt of Ash Hill: Vesicular basalt flows and dikes. Flows overlie Tertiary sediments and volcanics and are partly overlain by alluvium. Cross-sectional thickness as much as 500 ft (Dibblee, 1967a).	Dibblee, 1966, 1967a
	Tb	Miocene or Oligocene	Massive, vesicular basalt flows, locally brecciated, and interbedded with tuff breccia and rhyolitic felsite. Flows dip gently in various directions. Cross-sectional thickness more than 1,000 ft (Dibblee, 1966).	

SB-16	Tb	Miocene(?)	Olivine basalt of Mopah Range: Vesicular olivine-basalt flows, scoriaceous at base; interbedded with tuffaceous sediments; 0 to 300 ft thick.	Calzia and Morton, 1980; Carr and others, 1980
		Miocene	Basalt of Vidal Valley: Vesicular basalt exposed only on west side of Mopah Range; 0 to 400 ft thick.	
		Miocene 14.5±0.3 to 17.4±0.4 m.y.	Basalt in northeast part of area.	
			SAN DIEGO COUNTY (SD)	
SD-1	Tba	Miocene 16.9±0.5 m.y.	Alverson Andesite: Vesicular basalt and andesite flows, breccia, and intercalated volcaniclastics; overlies sediments of Split Mountain Formation. Flows 0 to 50 ft thick, aggregate thickness as much as 500 ft.	Hoggatt, 1979; Strand, 1962

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