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Map of Arizona showing selected alluvial, structural, and geomorphic features

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MAP OF ARIZONA SHOWING SELECTED ALLUVIAL,

STRUCTURAL, AND GEOMORPHIC FEATURES

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Credits:

Base from U.S. Geological Survey, Arizona, 1:1,000,000, 1927.

Sources of geologic data were compiled from the standard publications in geology, including Arizona Bureau of Mines publications, U.S. Geological Survey publications, Arizona Geological Society publications including the Arizona highway geologic map (Cooley, 1967), unpublished information obtained from numerous geologists, and information obtained from field reconnaissance and inspection of aerial photographs and LANDSAT-1 imagery by M. E. Cooley during 1963-74. All measurements given in English units; to convert to metric use the following formula: 1 foot = 0.305 meter.

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EXPLANATION FOR PLATE 1

Sedimentary deposits

Division A

Unconsolidated flood-plain alluvium, channel deposits, deposits along the lower toeslopes of bajadas, slope-wash deposits, small areas of alluvial fan deposits, lacustrine deposits of Wilcox Playa and Red Lake, and some terrace deposits principally in the Mesa-Florence-Marana area. The thickness is as much as 600 feet in the Gulf of California embayment and 300 feet in the Phoenix basin, and generally less than 100 feet elsewhere. Principally in parts of the Colorado Plateau and central and southeastern Arizona, the deposits are slightly dissected, mainly by erosion which has occurred since 1870. Deposits cover central areas of broad valleys that display only a slight amount of dissection in south-central and southwestern Arizona; in the Colorado Plateau and mountainous regions of Arizona the deposits form narrow outcrops along the main drainages. All deposits are structurally undeformed.

Division B

Generally weakly cemented valley-fill deposits of southeastern Arizona, including the Gila Formation near Safford and Duncan (Knechtel, 1936, 1938; Schwennesen, 1921; Morrison, 1965), Gila Conglomerate (Creasey, 1967) and St. David Formation (Gray, 1967) near Benson, Fort Lowell Formation (Davidson, 1970), basin fill (Davidson, 1961; Cooley and Davidson, 1963, Pashley, 1966), basin-fill gravel (Drewes, 1972), upper unit of basin fill (Brown and others, 1966), younger valley fill (Cooley, 1968), and deposits called the Benson beds near Benson. Division B is closely related and lithologically similar to Division C; some exposures are assigned somewhat arbitrarily to either Division B or Division C. Where differentiated, Division C is the lower part and Division B is the upper part of a widespread sequence of late Tertiary to early Quaternary age valley-fill deposits. In the central part of some of the valleys the Division C-Division B contact may be gradational, but along the sides of valleys this contact may be unconformable. In a few valleys the Division B deposits are more than 1,000 feet thick. The deposits accumulated mainly in closed basins. Division B is recognized in the large valleys of southeastern Arizona, but equivalent deposits in western Arizona are included with Divisions E and H and locally with Division C. Division B deposits generally are nearly horizontal in the central parts of valleys or have been tilted slightly (less than 5°) in places along the valley sides, are not cut by conspicuous joints, and locally are displaced by small normal faults.

Division C

Generally weakly to firmly cemented valley fill of southeastern Arizona and equivalent deposits along mountain fronts or in valleys elsewhere. Division C deposits have been referred to as the Gila or Gila(?) Conglomerate (Group or Formation) by many writers (Gilbert, 1875; Schwartz, 1953; Gilluly, 1956; Creasey and others, 1961; N. P. Peterson, 1962; Heindl, 1963; Krieger, 1968). Division C includes many deposits which have been referred to as deformed gravel or conglomerate (Davidson, 1961; Cooley and Davidson, 1963), lower unit of the basin fill (Brown and others, 1966), older valley fill (Cooley, 1968) Tinaga Formation (upper part) (Davidson, 1970), and Big Dome and Quiburis Formations (Krieger, 1974) in southeastern Arizona; Verde Formation (Jenkins, 1923; Twenter and Metzger, 1963), Perkinsville Formation (Lehner, 1958), Big Sandy Formation (Sheppard and Gude, 1972), Willow Springs deposits (Young, 1967) near Peach Springs; basin fill (Krieger, 1965) and Walnut Grove beds (Lance, 1960) near Prescott in the mountainous region of central and northwestern Arizona; and Bidahochi Formation (Reagan, 1924; Repenning and others, 1958) and the younger gravel (Finnell, 1967) near the Mogollon Rim west of Show Low. Thickness of Division C is more than 2,000 feet in many valleys of the Basin and Range province and at least 800 feet in the Colorado Plateau. Possible thickness of about 4,000 feet is in the deeper parts of the Phoenix basin where halite has accumulated, but thickness is mainly 1,200-1,500 feet along the lower Gila River between the Phoenix basin and Gulf of California embayment. The thickness variations suggest that some subsidence in central Arizona accompanied by some upwarping in the surrounding regions (including the Colorado Plateau) occurred during and since the deposition of Division C. Deposits in the Basin and Range province generally accumulated in closed basins where some limestone, halite, and gypsum were deposited. Lack of evaporites in the deposits (Bidahochi Formation) in the Colorado Plateau suggests that drainage there was external. Division C is exposed mainly in valleys that have been uplifted and subjected to considerable erosion (that removed or limited the accumulation of younger deposits) in the Colorado Plateau and in the mountainous regions of the State, in saddles between mountain ranges, and on pediments or structural benches flanking some of the mountain ranges. Division C has been tilted and displaced by normal faults. The amount of displacement differs locally, but usually it is in hundreds of feet, much less than are the displacements of older deposits and volcanic rocks. The amount of tilting generally is less than 10°, but in places it is as much as 25°. Well-formed joints are present in most exposures. All the Division C deposits accumulated in valleys that were formed after the main structural episode that produced the mountain chains and valleys of the Basin and Range province.

Division E

Generally weakly cemented deposits of silty to coarse gravel referred to by Metzger, Loeltz, and Irelan (1973), Metzger and Loeltz (1973), and Olmsted, Loeltz, and Irelan (1973) as the older alluvium and the esturine Bouse Formation in the valleys along the Colorado River in western Arizona. The older alluvium includes much rounded, dense, siliceous gravel which is the oldest detritus transported by the antecedent Colorado River downstream of Lake Mead. Division E deposits in the centers of the valleys are more than 1,000 feet thick with the maximum thickness occurring near Yuma. Deposits may be tilted slightly along the mountain fronts, but they are nearly horizontal in the center of the valleys. Locally, jointing is common. All deposits of Division E accumulated in valleys formed by the structural episode that resulted in the present topograhy of the Basin and Range province.

Division F

Generally firmly cemented claystone to conglomerate, with some limestone, evaporites, and tuffaceous sediments in the valleys of the Colorado River in western Arizona. Division F includes the Muddy Creek Formation and Hualapai Limestone (Longwell, 1936) near Lake Mead, Kinter Formation (Olmsted and others, 1973) near Yuma, and fanglomerate (underlying the Bouse Formation) (Metzger and others, 1973; Metzger and Loeltz, 1973) near Blythe and Needles. In many valleys the deposits are more than 2,000 feet thick. In places the deposits are tilted at more than 30°, displaced by normal faults, and display conspicuous joints. Deposits of Division F accumulated in valleys formed along the western edge of the Colorado Plateau (after the formation of the western rim of the Plateau) near Lake Mead, after and perhaps during the late part of the structural episode that produced the topography of the Basin and Range province, and before some of the strike-slip faulting that has occurred in the Lake Mead area.

Division H

A hetergeneous assortment of generally weakly consolidated slope-wash deposits, including small areas of virtually undissected alluvial fan deposits, dissected alluvial fan deposits, terrace deposits, flood-plain alluvium, colluvium, and caliche. Deposits generally form a thin but widespread mantle on Divisions B, C, E, and F in valleys of the Basin and Range province that display slight to moderate dissection. Locally, caliche may be well cemented and forms the topmost layer of the deposits. Some of the deposits in central and western Arizona are equivalent to Division B of southeastern Arizona. Locally, deposits may be displaced by small normal faults.

Division K

Generally firmly cemented, often tuffaceous, silty to gravelly deposits that are exposed at isolated localities mainly in the highly dissected valleys or along flanks of mountain ranges in southern, central, and western Arizona. These deposits are associated with or overlie silicic flows and tuffs of Stage 4 volcanics and are associated with or underlie the basaltic Stage 3 volcanics. Some of the deposits have been referred to as the Gila Conglomerate (Anderson and others, 1955; D. W. Peterson, 1962); the fluvial gravels of Division K are similar, but slightly more indurated and involved more in structural movements than are the gravels, including the deposits called the Gila Conglomerate, of Division C. Deposits of Division K include the gravel of Nogales (Drewes, 1972), the Tanaje Formation (lower part) (Davidson, 1970), and the Faraway Ranch Formation (Sabins, 1957) in southeastern Arizona; the Indian Butte and Rock Peak Conglomerates (Sell, 1968) in central Arizona; the Daniels and Batamore Conglomerates (Gilluly, 1946) and the Muggins beds (Wilson, 1962) in southwestern Arizona; the Blue Mountain and Robber's Roost Gravels (Koons, 1948a, b) and Buck and Doe Conglomerate of Gray (1964) and Young (1967) in northwestern Arizona; the Hickey Formation (Anderson and Creasey, 1958) and type A gravel (Price, 1950) in north-central Arizona; and a gravelly deposit on White Mesa (Cooley and others, 1969; Hunt, 1969) in northeastern Arizona. Limited amounts of surface and subsurface data indicate that locally the deposits may be more than 1,000 feet thick. Some of the deposits are less than 300 feet thick in mountainous regions of the State. The deposits are moderately tilted; some outcrops show dips of more than 30°. Many of the deposits are offset hundreds to a few thousand feet by normal faults. Some of Division K deposits are related to the present valleys, but most were deposited in valleys that were developed before or during the structural episode that formed the topography of the Basin and Range province.

Division M

Generally firmly cemented claystone to conglomerate that occur in isolated outcrops mainly on the flanks of uplands or underlie thick sequences of volcanic rocks of Stages 4 and 5. A tuffaceous matrix and a few tuff, gypsum, or limestone beds are present in some of the deposits. At many localities the composition of the gravel and the direction of transport measurements indicate that the source for the deposits was not from the adjacent mountains. Division M deposits accumulated in basins or valleys that largely predate the present topographic features. Division M includes the Whitetail Conglomerate (Ransome, 1904), Sil Murk Formation (Heindl and Armstrong, 1963), Antelope Peak and Yellow Peak Conglomerates (Sell, 1968), and red beds exposed in the Papago Buttes near Phoenix in central Arizona; Helmet Fanglomerate (Cooper, 1960), Pantano Formation (Brennan, 1962), Mineta Formation of Chew (1962), and San Manuel Formation (Heindl, 1963; Krieger, 1974) in southeastern Arizona; Locomotive Fanglomerate (Gilluly, 1946) and red beds of the Laguna Mountains (Olmsted and others, 1973) near Yuma in southwestern Arizona; Dry Beaver Creek rocks (Twenter and Metzger, 1963) in north-central Arizona; and the upper sedimentary formation of Wrucke (1961), Chuska Sandstone (Gregory, 1917), and rim gravel of Finnell (1967) in northeastern Arizona. Division M has a maximum known thickness of more than 10,000 feet near Tucson, but elsewhere the thickness ranges from a few hundred to a few thousand feet. The deposits may be tilted steeply and locally overturned, are displaced by large normal faults, and locally displaced by relatively small-scale thrust (or gravity) faults.

Division R

Firmly to well-cemented sedimentary, igneous (excluding volcanic rocks), and metamorphic rocks older than Division M deposits that range in age from Precambrian to early Tertiary. Outcrops of the sedimentary rocks are indicated by the symbol R whereas outcrops of the igneous and metamorphic rocks are indicated by contacts that do not contain a symbol. Division R rocks are displaced by large-scale normal and thrust faulting.

Volcanic rocks

Stage 1

Basalt flows, cinder cones, and fragmental rocks mainly in the San Francisco, White Mountains, and Unkaret volcanic fields of northern Arizona; volcanic rocks in San Bernardino Valley in southeastern Arizona; and several flows that overlie Division C deposits in central Arizona. Many of the cinder cones show little effect from erosion, and outlines of many flows are recognized easily. Some of the basalt is interbedded with Division B deposits. Locally, the rocks are displaced by small normal faults.

Stage 1A

Flows and fragmental rocks of rhyolite to andesite. Few welded tuffs are present near Flagstaff. Outlines of some of the individual flows are easily discerned.

Stage 2

Basalt flows, cinders, and fragmental rocks. Few highly eroded cinder cones are recognized. Some of the basalt is interbedded with Division C deposits. Rocks are displaced generally by small normal faults.

Stage 2A

Flows, tuffs, and welded tuffs of rhyolite to andesite that probably are age equivalents of Stages 2 and 3. Locally, the rocks are tilted and are displaced by normal faults.

Stage 3

Basalt, andesitic basalt, and basaltic andesite and tuff, includes basalts of Hickey Formation (Anderson and Creasey, 1958) in north-central Arizona. In places, the rocks are interbedded with or overlie Division K deposits. Form the capping layer on many mountain ranges in central and southern Arizona. Areas around the vents may be updomed. Locally thickness may be as much as 1,500 feet. Rock may be tilted steeply and displaced by large normal faults which were part of the structural episode that formed the mountains and valleys of the Basin and Range province.

Stage 4

Mainly rhyolite, dacite, and andesite flows, tuffs, and welded tuffs. This stage was the main emplacement of the thick sequences of welded tuffs in the Basin and Range province, such as the Datil volcanics of east-central Arizona and west-central New Mexico, dacite near Superior and rhyolite in the Superstition Mountains in central Arizona, the Galiuro and Chiricahua Mountains in southeastern Arizona, Sauceda and Kofa Mountains in southwestern Arizona, and Black Mountains in northwestern Arizona. Rocks may be tilted steeply and are displaced by large normal faults.

Stage 5

Andesitic to basaltic andesite, sometimes referred to as the red-speckled andesite or blue basalt (Sell, 1968). Rocks have a limited distribution in south-central Arizona. Where present, they form the basal beds of the middle Tertiary volcanic sequence, referred to on this map as Stages 3, 4, and 5. Locally, the rocks are tilted steeply and displaced by large normal faults.

Stage 6

Rhyolite to andesite flows, tuffs, and welded tuffs emplaced mainly in southeastern Arizona during the Laramide (Late Cretaceous to early Tertiary) orogeny. Locally, accumulations of the rocks are a few thousand feet thick. Rocks may be tilted steeply and displaced by large normal and thrust (gravity) faults.

Stage 7

Rhyolite to andesite flows, tuffs, and welded tuffs of pre-Laramide orogeny (Mesozoic age). Rocks may be tilted steeply and are displaced by large normal and thrust (gravity) faults.

Alluvial fans

Alluvial fan deposits of late Pleistocene and Holocene age shown on the map are virtually undissected except for some erosion that has occurred mainly during Holocene time. The distribution of the alluvial fans was obtained from LANDSAT-1 imagery, aerial photographs, and ground investigation. The alluvial fans are concentrated along the sides of valleys displaying slight amount of dissection or along drainages in the center of some of the valleys. The position of the fans suggests that they are in part the result of structural warping--upwarping of the uplands and mountainous regions and downwarping of adjacent lowlands and valley areas.

Pediments

Pediments shown on the map are defined as gently planate surfaces that have formed principally on granitic rocks ranging in age from early Tertiary to Precambrian, or bevelled strata as young as Division K deposits or Stage 4 volcanic rocks. Most of the pediments are overlain by remnants of Divisions B or C deposits. These pediments are rather old and many of them appear to be exhumed features that were formed mainly during Miocene to early Quaternary time. Since early Quaternary time, most of the pediments and their overlying deposits have been subjected to dissection. In places, such as east of Florence, shallow canyons have been trenched by streams below the level of the pediments. The pediments and their overlying deposits have been tilted and in places displaced by normal faults. Some of the pediments have formed on features resembling structural benches that are present along the lower flanks of a few mountain ranges.

Fault or inferred fault

Includes known normal faults, inferred normal faults, and possibly some thrust or gravity faults. Many faults in the basins and on the flanks of basins are inferred from the structural attitude of the outcropping sedimentary and volcanic rocks, from geophysical surveys, from the distribution of the exposures and the thickness of the late Tertiary and Quaternary valley-fill deposits, and from the distribution of pediments. Most of this faulting took place during the Miocene Epoch

Direction of strike and dip

Anticline

Monocline

Axis of folded structure of Late Cretaceous to early Tertiary age in the sedimentary rocks in the Colorado Pleateau

Inferred synclinal axis of late Quaternary age in central Arizona

Direction of sediment transport of Divisions A, B, C, E, F, and H

Volcanic domal structures of Stages 3 and 5

Contact of the consolidated rocks and Divisions K and M

Contact between the divisions of the valley-fill deposits

Map showing generalized facies of the valley-fill deposits--Divisions B, C, E, and F--in southern and western Arizona and directions of sediment transport of Divisions K and M.

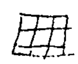
Mainly sand and gravel

Mainly clay, silt, and sand with minor amounts of gravel

Limestone

Gypsiferous siltstone

Deposits of sand and rounded gravel brought in by the Colorado River of the older alluvium of Metzger and others (1973) and Olmsted and others (1973)



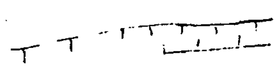
Evaporites, including halite, not exposed but present in the subsurface

Prevalley-fill sedimentary, igneous, and metamorphic rocks. Volcanic rocks associated with the valley-fill deposits are not shown on the map

Division K

Division M

Direction of sediment transport of deposits laid down by drainages that largely predate the present topography. In much of the State the direction of flow of these ancient drainages is opposite to that of the modern streams. Comparison can be made of the direction of sediment transport of Divisions K and M with that indicated by the facies distribution and the directions of sediment transport (shown on the large map) of Divisions B, C, E, and F, which were deposited in valleys (some of which were closed basins) and had a source principally in the surrounding mountains or uplands that comprise the present topography of the Basin and Range province



Canyon or escarpment, including the Mogollon Rim, covered or partly covered by Divisions K or M deposits and exhumed during post-Divison K late Tertiary and Quaternary time

Map showing height of terraces and thickness of flood-plain alluvium in southern Arizona

100
x

Approximate height in feet of late Pleistocene-age terraces capped by well-rounded gravel above the level of the Gila, Salt, and Santa Cruz Rivers

Reaches of the Gila, Salt, and Santa Cruz Rivers where late Pleistocene-age terraces are not present. In this area gravel deposits that are lateral equivalents of the gravel capping the terraces elsewhere are overlain by Holocene-age alluvium

• 200

Approximate thickness in feet of late Quaternary-age flood-plain alluvium as determined from logs of water wells. Differences in the thickness of the flood-plain alluvium and the presence or absence and the heights of the terraces suggest that some downwarping has taken place in the Phoenix basin in relation to the surrounding regions during late Quaternary time

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