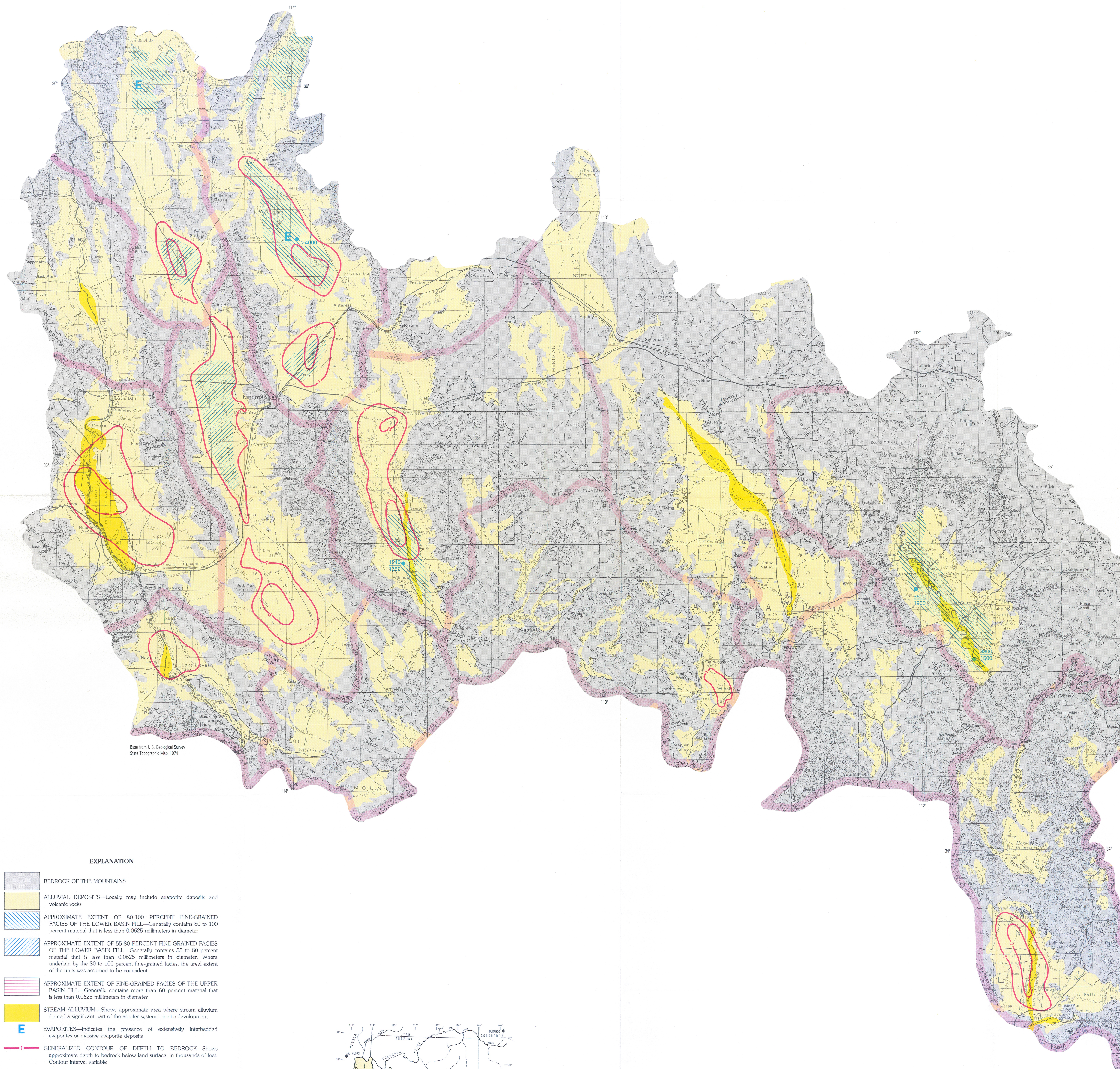

Base from U.S. Geological Survey State Topographic Map, 1974

Geology modified from Wilson and others (1969)

EXPLANATION

BEDROCK OF THE MOUNTAINS

ALLUVIAL DEPOSITS—Locally may include evaporite deposits and volcanic rocks

APPROXIMATE EXTENT OF 80–100 PERCENT FINE-GRAINED FACIES OF THE LOWER BASIN FILL—Generally contains 80 to 100 percent material that is less than 0.0625 millimeters in diameter

APPROXIMATE EXTENT OF 55–80 PERCENT FINE-GRAINED FACIES OF THE LOWER BASIN FILL—Generally contains 55 to 80 percent material that is less than 0.0625 millimeters in diameter. Where underlain by the 80 to 100 percent fine-grained facies, the areal extent of the units was assumed to be coincident

APPROXIMATE EXTENT OF FINE-GRAINED FACIES OF THE UPPER BASIN FILL—Generally contains more than 60 percent material that is less than 0.0625 millimeters in diameter

STREAM ALLUVIUM—Shows approximate area where stream alluvium formed a significant part of the aquifer system prior to development

E EVAPORITES—Indicates the presence of extensively interbedded evaporites or massive evaporite deposits

1 GENERALIZED CONTOUR OF DEPTH TO BEDROCK—Shows approximate depth to bedrock below land surface, in thousands of feet. Contour interval variable

1700 / 1850 WELL THAT PENETRATES THE LOWER BASIN FILL—Selected well from which data about the fine-grained facies of the lower basin fill were available. Upper number, 1700, is altitude of top of facies. Lower number 1850, is thickness of facies National Geodetic Vertical Datum of 1929

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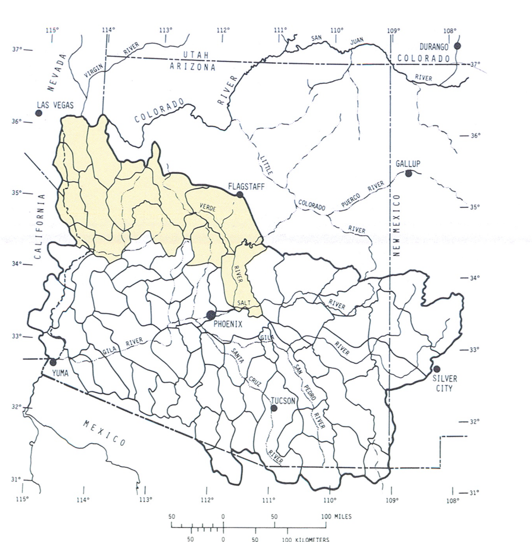

INDEX MAP SHOWING STUDY AREA AND BASINS

SCALE 1:500 000

CONTOUR INTERVAL 500 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

INTRODUCTION

An objective of the Southwest Alluvial Basins, Regional Aquifer-System Analysis (Swab/RASA) Project was to describe the generalized physical character of the principal aquifer systems in the basins. The study area includes about 82,000 mi^2 and was divided into 72 basins that represent, for the most part, separate ground-water systems. The area is characterized by sharply rising mountains that separate broad alluvial basins. The bedrock of the mountains is relatively impermeable. The alluvial deposits in the basins constitute the aquifer systems of the area and have distinct textural similarities within groups of basins. Ground-water flow modeling provides an important tool for analyzing the basin aquifer systems; however, certain basic geologic information is necessary for the development of the models. The purposes of this atlas are to provide generalized geologic information necessary for modeling the basins and to discuss regional similarities in the physical and hydraulic characteristics of aquifer materials.

Data used to construct the maps and geologic sections were obtained from published reports on geologic and hydrologic investigations; from well logs on file at the Arizona Department of Water Resources, University of Arizona, U.S. Geological Survey, and other agencies; and from surface- and borehole-geophysical investigations. The geologic data were used to develop a generalized picture of the regional character of the basin sediments.

The data on the maps indicate the general size and shape of the individual basins. The textural character of the sediments in most basins is shown by the approximate areal distributions of three alluvial facies—(1) the coarse-grained facies, (2) the fine-grained facies, and (3) the intermediate facies. The coarse-grained facies consists of unconsolidated stream alluvium associated with the major surface drainages; the fine-grained facies consists of 55 percent or more of material less than 0.0625 mm in diameter. The intermediate facies is the part of the alluvial deposits not included in the fine- or coarse-grained facies and consists of a heterogeneous mixture of gravel, sand, silt, and clay of intermediate grain size. The extent of the coarse-grained stream alluvium is shown only where it was saturated and was a significant factor in the predevelopment flow system. The three major alluvial facies of significantly different hydraulic characteristics represent a first approximation of the physical characteristics of the aquifer system that may control the ground-water flow system within each basin.

The hydraulic characteristics of the sediments are related to their average grain size. The stream alluvium stores large quantities of water that is readily released from storage; hydraulic conductivity commonly ranges from about 30 to as much as 1,000 ft/d, and specific yield ranges from 15 to 25 percent. The fine-grained alluvial deposits have a high porosity and store large quantities of water; however, wells finished in these sediments have low yields because water is not readily released from storage. The fine-grained sediments have low hydraulic conductivity, commonly being less than 10 ft/d (fig. 1); specific yield probably ranges from less than 1 to 10 percent (fig. 2). The alluvial facies of intermediate grain size, which is the major water-yielding component of the aquifer systems in most of the area, has intermediate values of hydraulic conductivity; specific yield ranges from 5 to 25 percent.

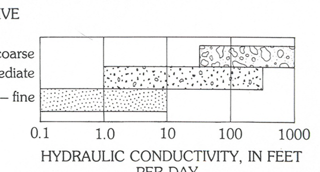

FIGURE 1.—Approximate range in hydraulic conductivity for the three alluvial facies differentiated by relative grain size.

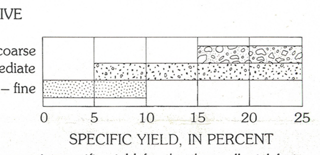

Figure 2.—Approximate range in specific yield for the three alluvial facies differentiated by relative grain size.

AQUIFER LIMITS

The basins in the study area were formed as a result of the tectonic events associated with the Basin and Range structural disturbance. The tectonic events are thought to have begun between 15 and 12 m.y. (million years) ago in the western part of the area (Shafiqullah and others, 1980) and between 12 and 10 m.y. ago in the eastern part (Scarborough and Peirce, 1978). The bedrock that forms the mountains is relatively impermeable in contrast to the alluvial deposits and acts primarily as a barrier to ground-water flow in the study area. Thus, the bedrock distributions effectively delineate the extent of the alluvial aquifer laterally and with depth.

A map showing estimated depth to bedrock was constructed by Oppenheimer and Sumner (1980) under a contract with the U.S. Geological Survey as part of the Swab/RASA study. The analysis was based on two-dimensional gravity modeling. For this atlas, the depth-to-bedrock contours, in places, have been modified and generalized on the basis of additional well data and gravity modeling to show thicknesses of 1,000, 5,000, and 10,000 ft of alluvial deposits. The contours are intended to indicate the general basin shape and size and should not be construed to represent exact depth to bedrock.

The results of gravity modeling indicate that buried pediments or bedrock benches along the margins of the basins in the western part of the study area generally are extensive. The extent is illustrated by the distance of the 1,000-foot-thickness contour from the bedrock-alluvium contact (sheet 2). Basins in the rest of the study area generally have less extensive bedrock benches. The buried bedrock benches probably indicate the locations of the basin-bounding faults relative to the present mountain fronts and the areal extent of the central elongated troughs that form the basins. The locations of these bedrock structures are significant in defining the areal extent of the aquifer system within a basin and in estimating the volume of water in storage within individual basins.

The contours of depth to bedrock greater than 1,000 ft are only an estimate of the structural shape of a basin. The vertical extent of the basin aquifers has been approximated through gravity modeling; however, the practical vertical limit of the basin aquifer system probably is governed more by the economics of ground-water withdrawal. The presence of fine-grained sediments, low well yields, and variable chemical quality of ground water may also limit the effective thickness of the aquifer by restricting development to only a fraction of total thickness. Within the study area, ground-water withdrawal from depths of more than 2,000 ft below the land surface is rare.

AQUIFER MATERIALS

The aquifer system within most basins includes unconsolidated to highly consolidated sediments that range in age from early Tertiary to Holocene. A typical sequence of sediments in most basins consists of pre-Basin and Range deposits, basin-fill deposits that can be divided into a lower unit and an upper unit, and stream alluvium. The depositional environment for each unit is markedly different within an individual basin and also for an individual unit from basin to basin. The result is time-equivalent units throughout the study area that are different in physical characteristics and in vertical and lateral extents.

Pre-Basin and Range Deposits

The oldest sediments were deposited before the Basin and Range disturbance and consist of moderately to highly consolidated continental deposits. The sediments, which typically are structurally disturbed, range from silt, clay, claystone, and limestone to gravel and conglomerate and include interbedded volcanics in places. The pre-Basin and Range deposits probably occur at depth within many basins but are of minor importance as part of the aquifer systems. Data on the nature of the pre-Basin and Range sediments are available only for areas of outcrop on the edges of the basin and from a few deep test holes drilled within the basins.

Basin-Fill Deposits

The basin-fill deposits form the major aquifers of the area. The sediments are grouped into two generalized geohydrologic units—lower basin fill and upper basin fill. The units are differentiated on the basis of grain size, presence or absence of evaporites, degree of consolidation and deformation, age, and water-bearing characteristics. In many basins the contact between the lower and upper basin-fill units in the subsurface is difficult to determine because of lithologic similarities, gradational changes between the units, or lack of adequate data.

The lower basin-fill sediments—deposited during and after the Basin and Range disturbance—typically consist of weakly to highly consolidated gravel, sand, silt, and clay and in places contain interbedded evaporites and volcanic rocks. The lower basin fill generally unconformably overlies pre-Basin and Range deposits, generally represents deposition within a closed-basin environment, and was deformed by normal faulting. The sediments differ in character in various parts of the area.

The upper basin-fill sediments were deposited during and after the transition from a closed-basin environment to an integrated-drainage environment. The upper basin fill typically consists of unconsolidated to moderately consolidated gravel, sand, silt, and clay and includes basalt flows in some areas. The sediments are coarse grained near the mountains and grade to fine grained at the basin centers. Evaporites generally are not present in the upper basin fill. Normal faulting has only slightly affected the upper basin fill.

Stream Alluvium

Stream alluvium is an important part of the aquifer in only a few places. The deposits are typically well-sorted sandy gravel with some silt and, where saturated, have large water-yielding and storage capacities. The stream alluvium along the flood plains of the Salt, Gila, and Colorado Rivers is areally extensive and in some places exceeds 300 ft in thickness. The predevelopment perennial-flow conditions of these rivers sustained shallow water levels in extensive adjacent areas. In the central part of the study area, the stream alluvium has been largely dewatered as a result of ground-water withdrawal.

REGIONAL PATTERNS OF AQUIFER MATERIALS

The aquifer systems of the study area represent a variety of geohydrologic environments. For the purpose of discussing the regional patterns, the basins are grouped into five general categories: (1) central, (2) southeast, (3) west, (4) Colorado River, and (5) highland (fig. 3).

The fine-grained facies in the upper and lower basin-fill sediments exert a major control on the general movement and availability of ground water within the basins. The distributions of the fine-grained facies influence several aquifer characteristics including well yields, ground-water quality, potential for aquifer compaction and associated land subsidence and earth fissuring, existence of perched water zones, and occurrence of areal recharge.

Regional patterns of the occurrence of the fine-grained facies are illustrated in this atlas. The facies differ in physical character, composition, continuity, and stratigraphic position throughout the study area owing to variations in the tectonic and depositional history. The regional similarities and differences are illustrated through the use of geologic sections and profiles of specific basins (sheet 4).

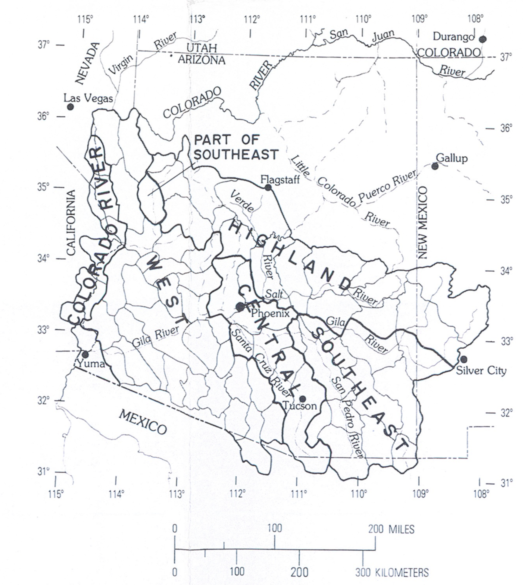

FIGURE 3.—Categories of basins based on regional patterns of aquifer lithology.

Lower Basin Fill

The fine-grained facies of the lower basin fill generally consists of middle Miocene to Pliocene mudstone, siltstone, and evaporites. The facies are divided into deposits that contain 80 to 100 percent fine-grained sediments and those that contain 55 to 80 percent fine-grained sediments. These sediments have significant differences in their ability to store and transmit water and in their compaction properties.

The 80 to 100 percent fine-grained sediments generally were deposited in the central parts of actively subsiding basins and occur primarily in the central and southeast basins. (See geologic sections for Avra Valley, Salt River Valley, and Safford, San Simon, Eloy, Tucson, Willcox, and lower San Pedro basins.) The 80 to 100 percent fine-grained sediments also occur in a few basins in the northwestern part of the study area. The fine-grained sediments generally are more than 1,000 ft thick at the basin centers and nearly 5,000 ft thick in Avra Valley. Exact locations of where the fine-grained sediments change to coarse-grained sediments toward the basin margins are difficult to discern owing to the lack of data. The fine-grained sediments, however, probably occur in fault contact with older coarse-grained deposits at depth in many basins. Data indicate that small thicknesses—less than 500 ft—of the 80 to 100 percent fine-grained facies may be present in most of the west basins. Massive evaporites are associated with these deposits in the central part of the area and in a few basins adjacent to the Colorado Plateau. (See geologic sections for Safford and Eloy basins.) Disseminated gypsum or gypsiferous mudstone occurs in the other basins in which these fine-grained sediments are present. (See geologic section for Avra Valley.)

Facies with 55 to 80 percent fine-grained sediments were generally deposited under nontectonic conditions and occur mainly in the west and central basins. (See geologic sections for Gila Bend basin and McMullen Valley.) The thickness of the moderately fine-grained facies at the basin centers ranges from several hundred feet to more than 1,000 ft. The sediments become progressively coarser toward the mountain fronts. The 55 to 80 percent fine-grained facies also overlie the 80 to 100 percent fine-grained sediments in several of the central basins. (See geologic sections for Salt River Valley and Tucson basin.)

In basins traversed by the Colorado River, the lower basin-fill fine-grained facies consist of marine-estuarine deposits laid down in an ancestral embayment of the Gulf of California. These sediments have been named the Bouse Formation by Metzger (1968). (See geologic section for Mohave basin.) Delineation of this unit is not included on the maps because of the few data available and because of its negligible effect on ground-water flow in those basins.

Upper Basin Fill

Sediments in the upper basin fill range from late Pliocene to Pleistocene in age and typically consist of greater than 60 percent fine-grained sediments in the basin centers. The fine-grained facies is known to occur in most of the central basins and consists primarily of brown clay and silt less than 1,000 ft thick that grade into coarser-grained sediments toward the mountains. (See geologic sections for Avra Valley, Salt River Valley, and Tucson basin.) In the southeast basins the fine-grained facies typically consists of more than 300 ft of fluviolacustrine reddish-brown silt and clay, blue-green clay, and limestone. (See geologic sections for Safford, San Simon, and Willcox basins.) Integrated drainage had been established in most of the west basins prior to deposition of the upper basin fill. The west basins do not contain a fine-grained facies of the upper basin fill.

The intermediate- to coarse-grained facies of the upper basin fill is less consolidated and generally has better hydraulic characteristics than a comparable facies of the lower basin fill. The unit is the primary source of water in the basins of central Arizona. In the west basins, the upper basin fill generally is above the water table; in most southeast basins, part of the unit has been removed by erosion.

Stream Alluvium

Coarse-grained stream alluvium formed an important part of the aquifer system along perennial streams prior to development. These streams included the Colorado, Gila, Salt, Verde, and San Pedro Rivers and selected reaches of the Santa Cruz and Big Sandy Rivers. The textural character of stream alluvium ranges from boulders and gravel to minor amounts of lacustrine clay. The general lateral extent of the hydrologically significant parts of these deposits is shown on the maps. The vertical extent generally is small, as illustrated on most of the geologic sections. The aquifer systems in basins along the Colorado River consist primarily of stream alluvium. Owing to the coarse nature of these stream sediments, infiltration from the Colorado River is large and local pumpage from the stream sediments originates as infiltrated surface water.

The alluvial aquifer systems of the highland basins consist principally of stream alluvium. The sediments are present in the flood plains of the streams that drain the area and are of limited areal extent. These aquifers are only minor parts of the entire system of regional aquifers in the consolidated sedimentary rock sequences that dominate the highland area but are important for small water supplies for domestic and stock use.

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DESCRIPTION AND GENERALIZED DISTRIBUTION OF AQUIFER MATERIALS IN THE ALLUVIAL BASINS OF ARIZONA AND ADJACENT PARTS OF CALIFORNIA AND NEW MEXICO

By
Geoffrey W. Freethey, D. R. Pool, T. W. Anderson, and Patrick Tucci

1986

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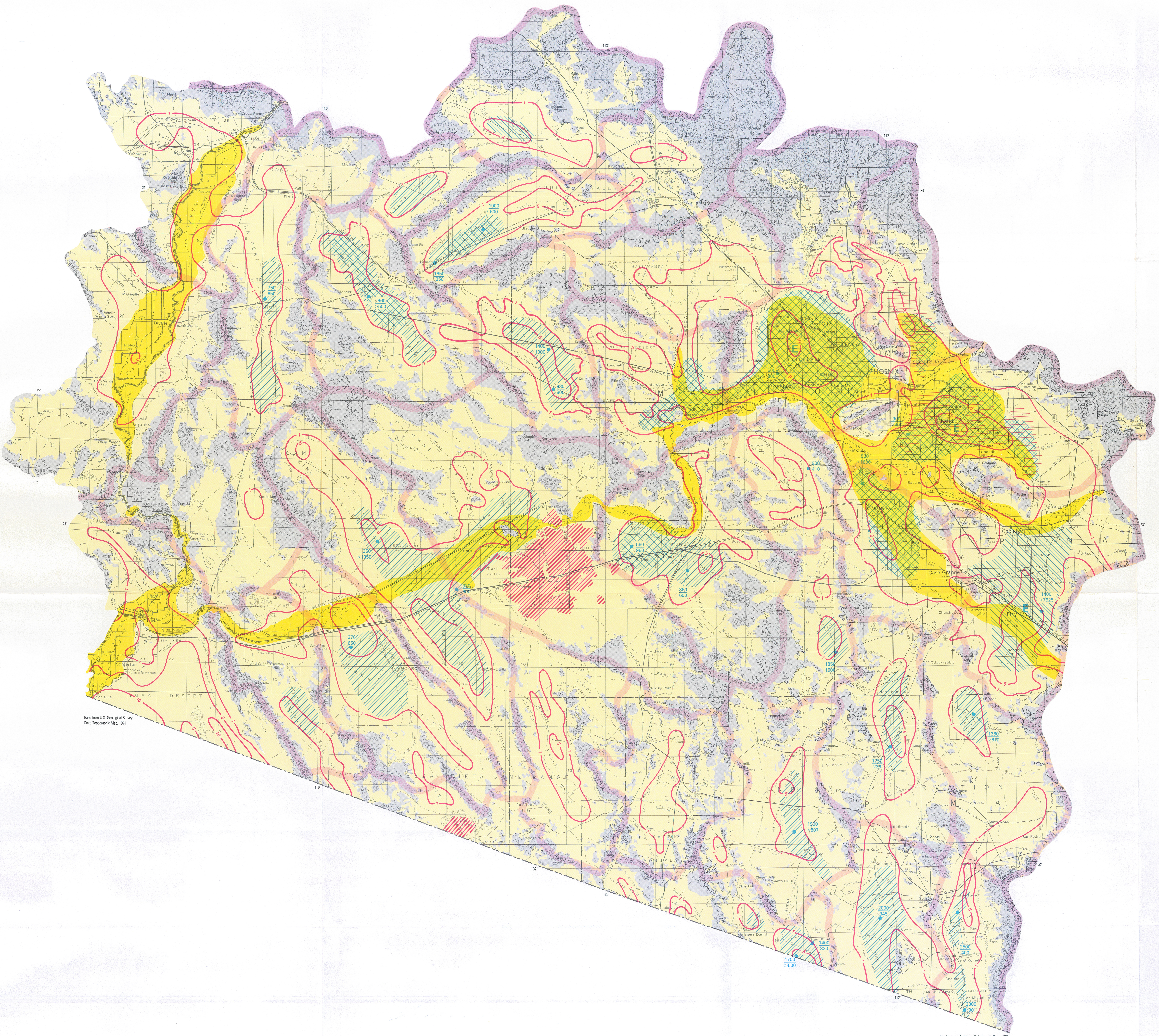

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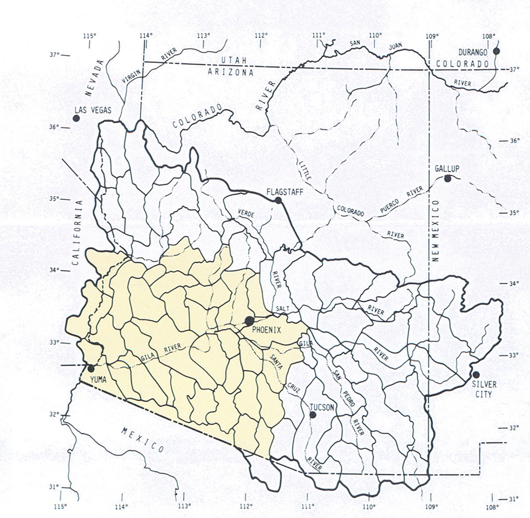

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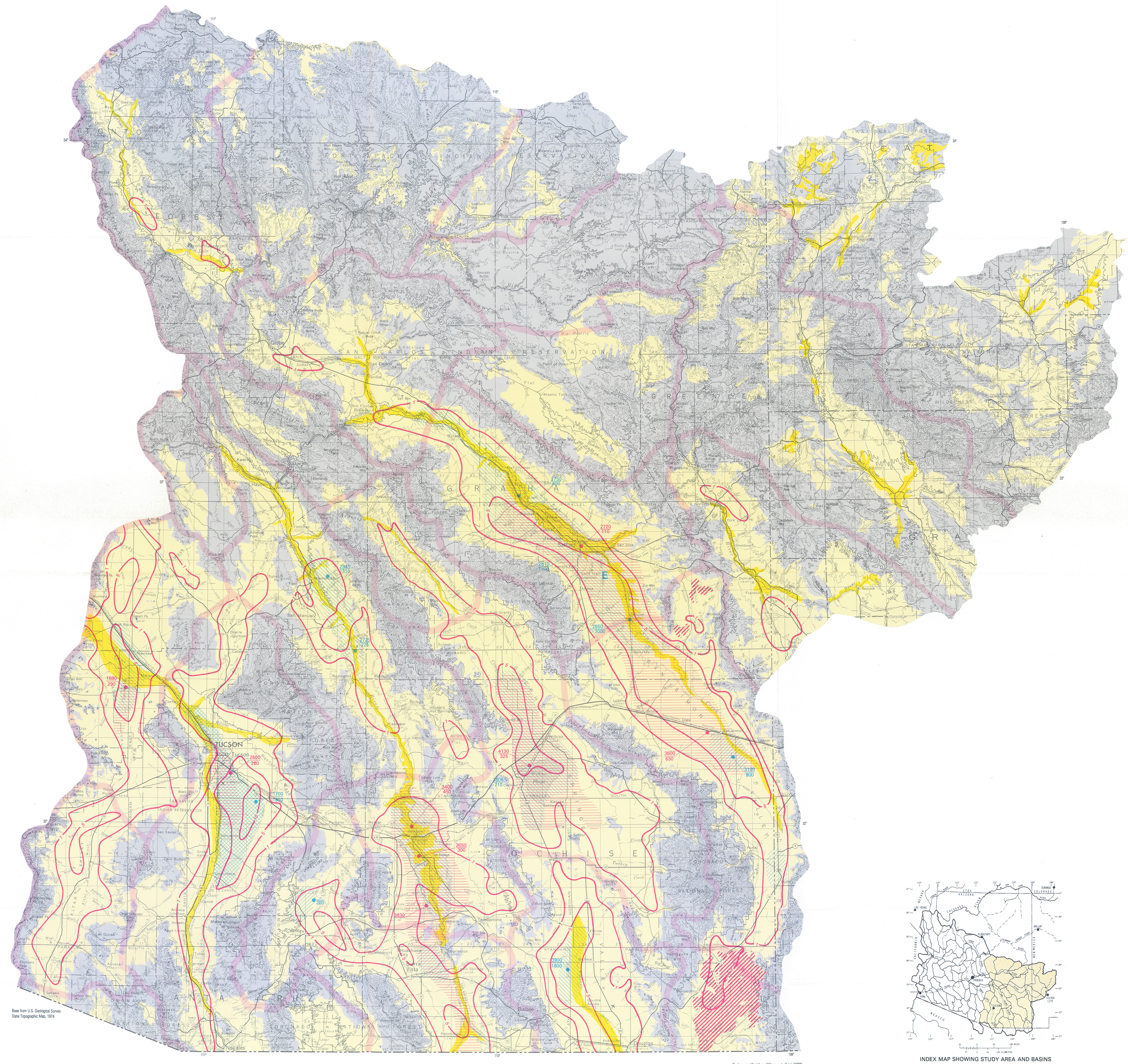

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foot per day (ft/d)	0.3048	meter per day (m/d)

INDEX MAP SHOWING STUDY AREA AND BASINS

SCALE 1:500 000

CONTOUR INTERVAL 500 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

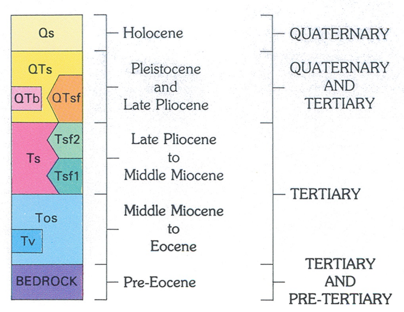
DESCRIPTION AND GENERALIZED DISTRIBUTION OF AQUIFER MATERIALS IN THE ALLUVIAL BASINS OF ARIZONA AND ADJACENT PARTS OF CALIFORNIA AND NEW MEXICO

By
Geoffrey W. Freethey, D. R. Pool, T. W. Anderson, and Patrick Tucci

1986

EXPLANATION

CORRELATION OF GEOLOGIC SECTION UNITS



DESCRIPTION OF SECTION UNITS

STREAM ALLUVIUM

- **Qs** Unconsolidated alluvial deposits along major streams and washes; includes eolian sands in Willcox basin

UPPER BASIN FILL

- **QTs** Unconsolidated to moderately consolidated alluvial deposits. Grades from coarse- to fine-grained sediments toward the center of most basins
- **QTsf** Basin-center fine-grained facies. Greater than 60 percent fine-grained sediments. Lake deposits in Willcox, Safford, and San Simon basins
- **QTb** Basalt flows

LOWER BASIN FILL

- **Ts** Weakly to highly consolidated fanglomerate and alluvial deposits found on the perimeter of most basins. In some places grades rapidly into the fine-grained facies near major basin faults. Underlies the fine-grained facies over extensive areas of many basins
- **Tsf2** Basin-center fine-grained facies, weakly to moderately consolidated silt and clay, generally 55 to 80 percent fine-grained sediments
- **Tsf1** Basin-center fine-grained facies, moderately consolidated silt and clay, greater than 80 percent fine-grained sediments; gypsiferous in many places. Deposited in the central graben of actively subsiding basins. May be in fault contact with older rocks on the margins of the graben. Includes extensively interbedded or massive evaporites in Avra Valley, and Safford, San Simon, and Eloy basins

PRE-BASIN AND RANGE

- **Tos** Moderately to highly consolidated fanglomerate and alluvial deposits and interbedded volcanics that are highly structurally disturbed. Deposited in basins that existed before the Basin and Range structural disturbance and that had a different areal extent than the present-day basins
- **Tv** Undifferentiated volcanic rocks interbedded with pre-Basin and Range sediments

BEDROCK

- **BEDROCK** Pre-Eocene igneous and metamorphic rocks and pre-Tertiary sedimentary rocks

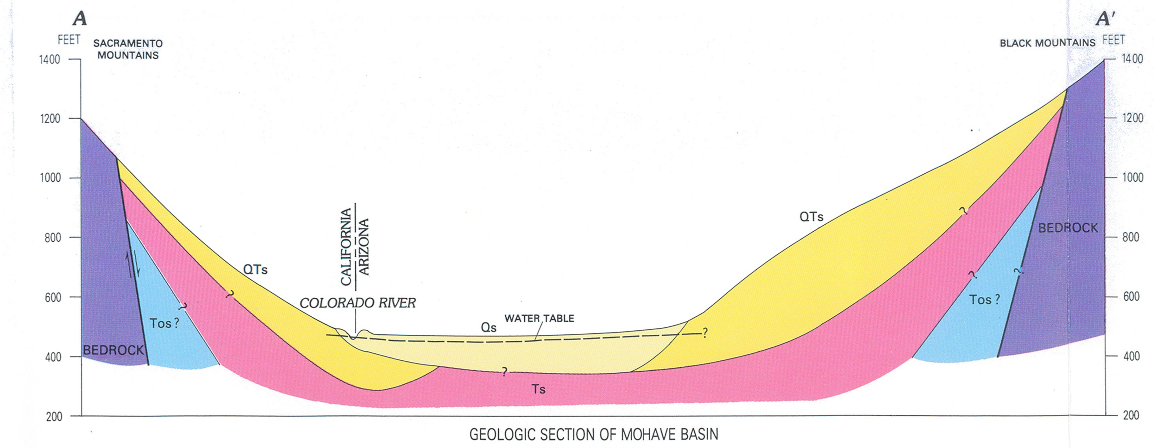
———?— CONTACT—Queried where uncertain

FAULT SHOWING RELATIVE MOVEMENT—Queried where uncertain

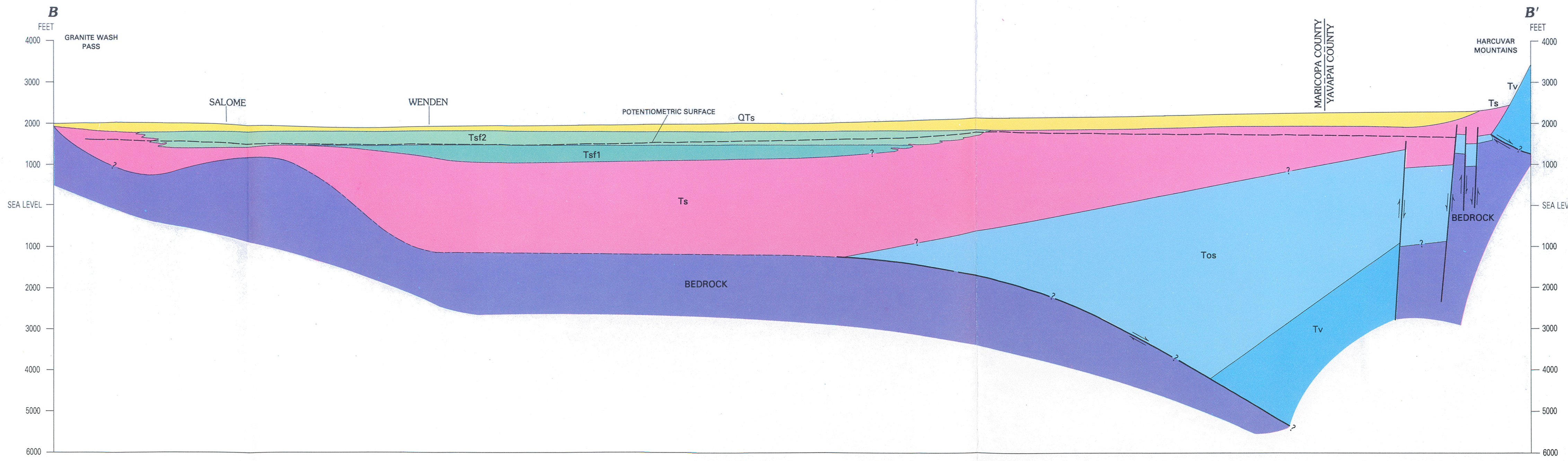
FACIES CHANGE—Queried where uncertain

– – – – BEDROCK CONTACT INFERRED FROM GRAVITY-DATA MODELING

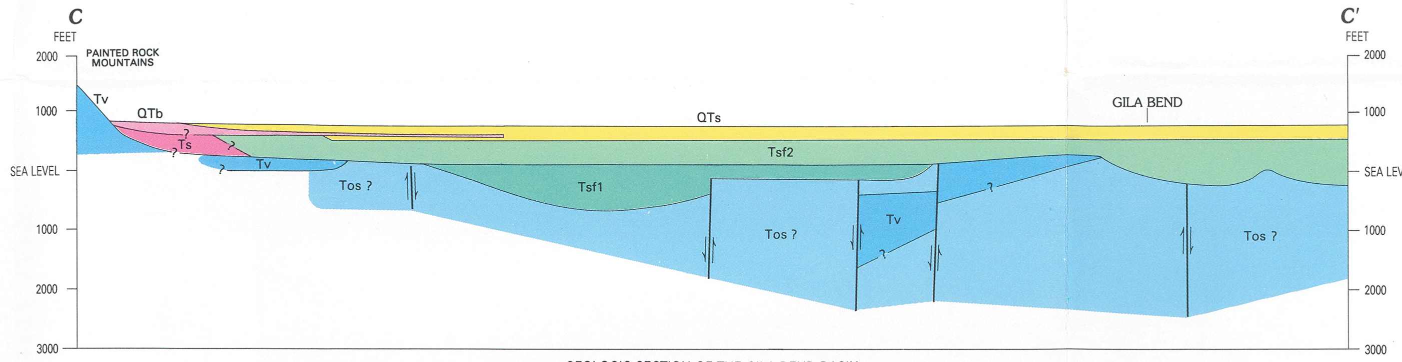
— — — — WATER-TABLE OR POTENTIOMETRIC SURFACE—Represents altitude of potentiometric surface based on most recent available information



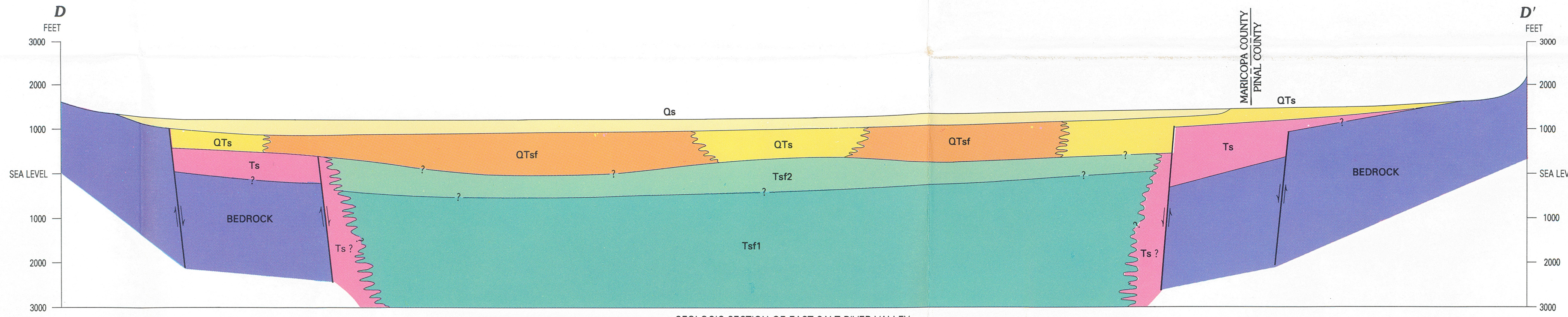
GEOLOGIC SECTION OF MOHAVE BASIN
VERTICAL EXAGGERATION X 25



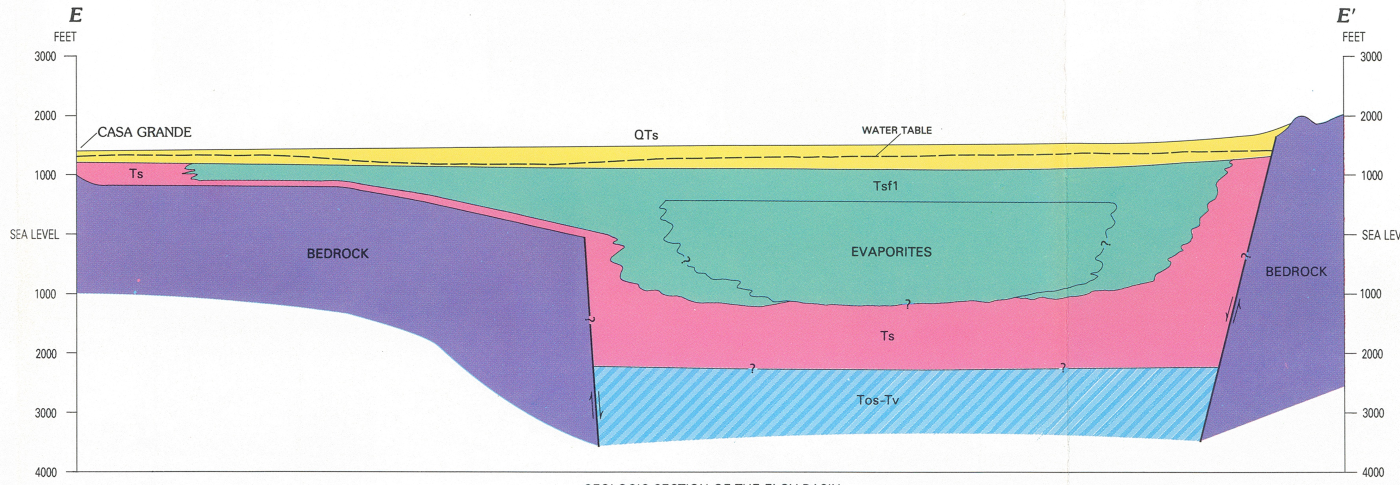
GEOLOGIC SECTION OF McMULLEN VALLEY



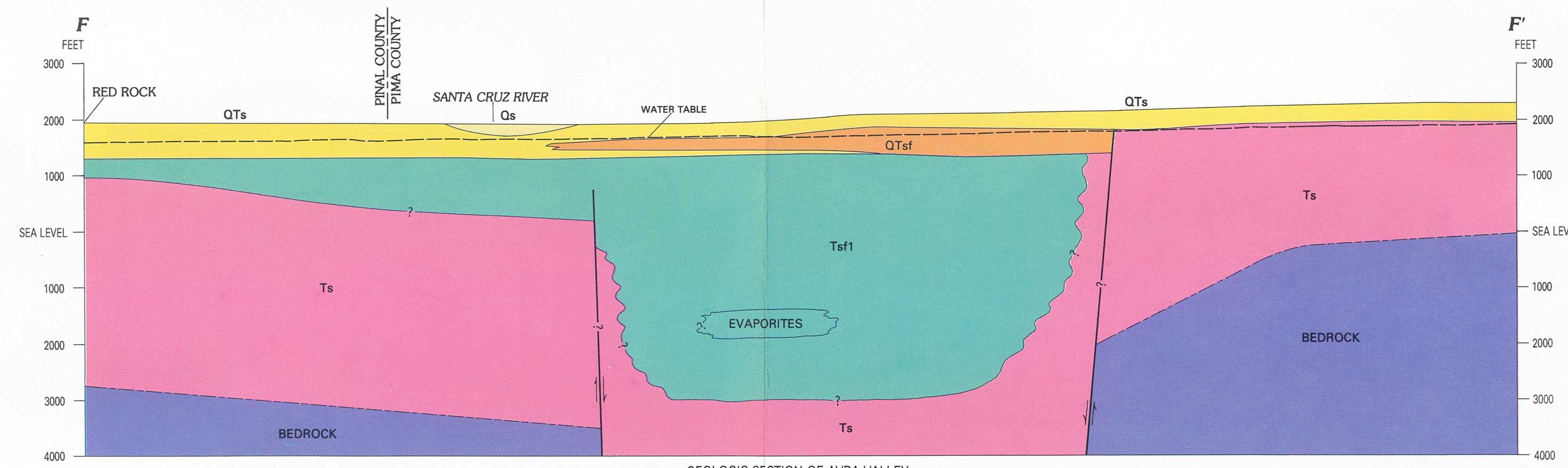
GEOLOGIC SECTION OF THE GILA BEND BASIN



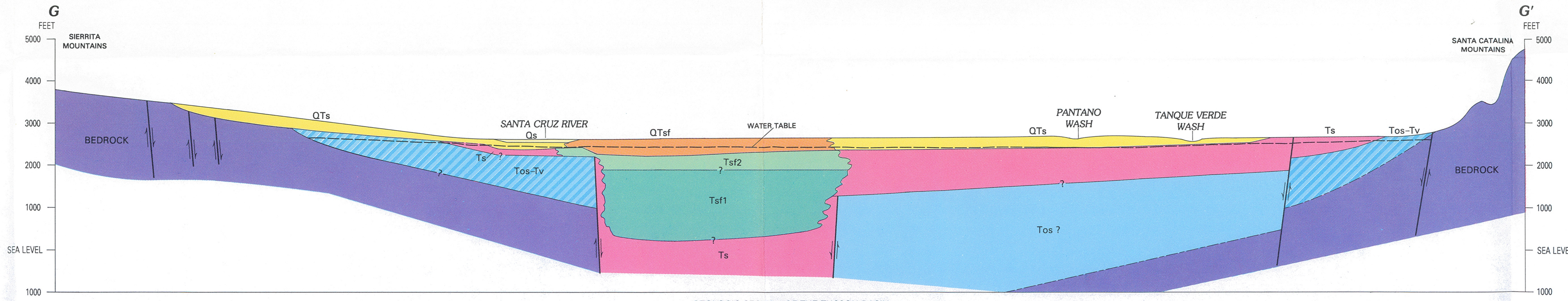
GEOLOGIC SECTION OF EAST SALT RIVER VALLEY



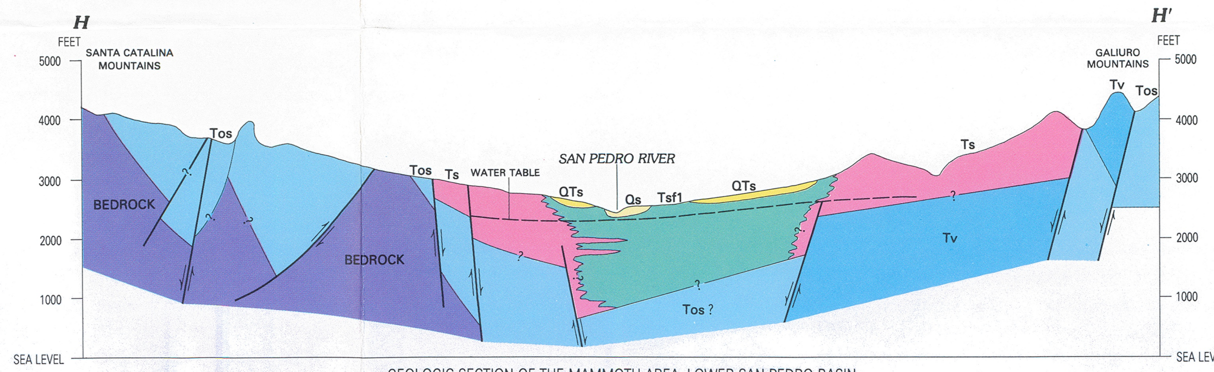
GEOLOGIC SECTION OF THE ELOY BASIN



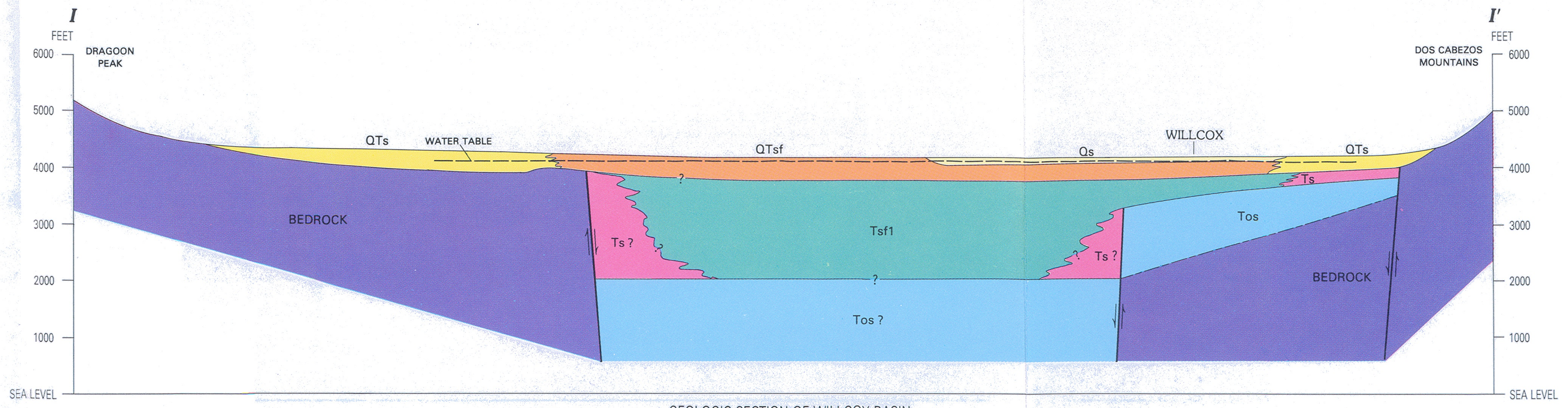
GEOLOGIC SECTION OF AVRA VALLEY



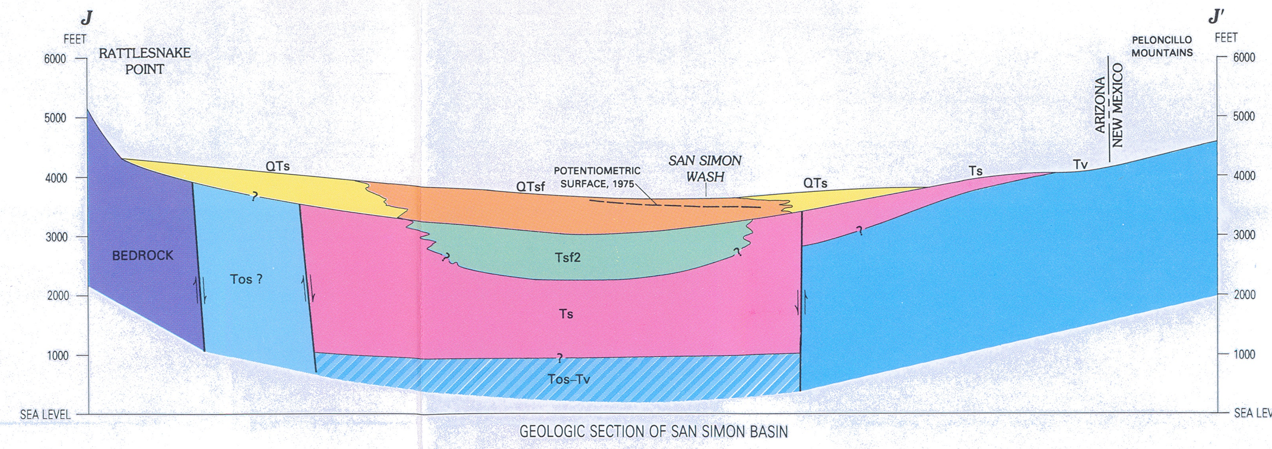
GEOLOGIC SECTION OF THE TUCSON BASIN
(Modified from Davidson, 1973)



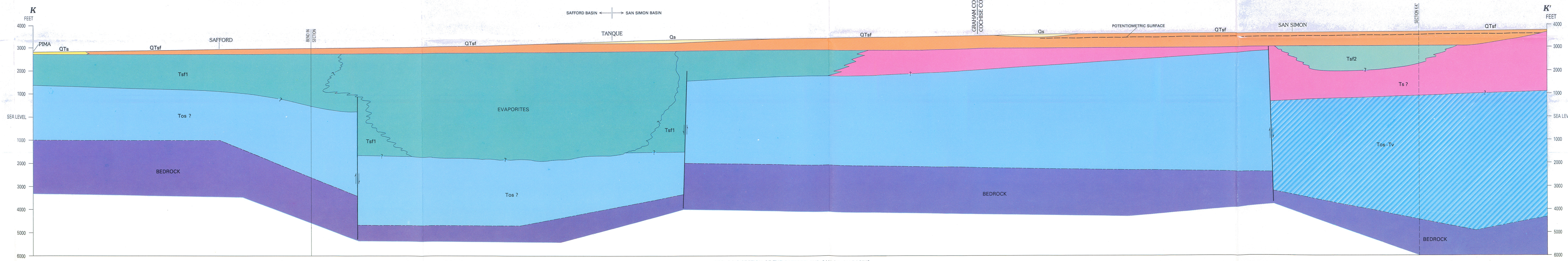
GEOLOGIC SECTION OF THE MAMMOTH AREA, LOWER SAN PEDRO BASIN
(Modified from Heindl, 1963)



GEOLOGIC SECTION OF WILLCOX BASIN



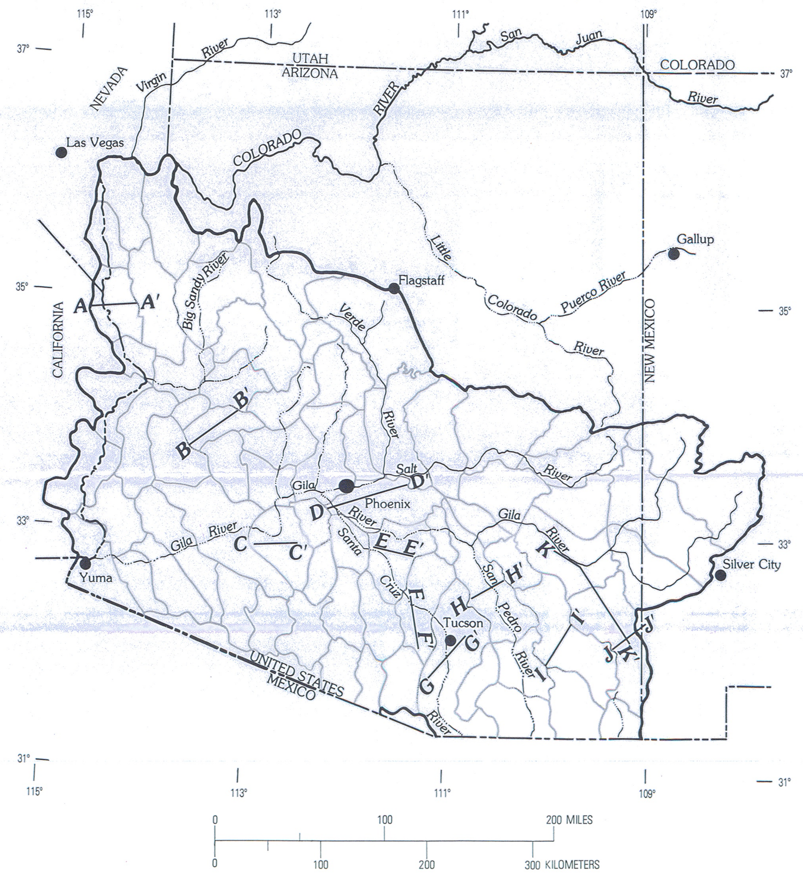
GEOLOGIC SECTION OF SAN SIMON BASIN



GEOLOGIC SECTION OF THE SAFFORD AND SAN SIMON BASINS

SCALE 1:125 000

NATIONAL GEODETIC VERTICAL DATUM OF 1929
VERTICAL SCALE EXAGGERATION X 5



EXPLANATION

A ——— A' LINE OF SECTION—Approximately located
BOUNDARY OF BASIN

MAP SHOWING STUDY AREA AND LOCATION OF GEOLOGIC SECTIONS

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