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# LATE CENOZOIC ALLUVIAL DEPOSITS OF THE UPPER SAFFORD VALLEY, GRAHAM COUNTY, ARIZONA

By

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## INTRODUCTION

The Safford Valley lies along the Gila River between Coolidge Dam and the mouth of Bonita Creek (figs. 1.1 and 7.1). Previous reports on the alluvial deposits of this valley by Schwennessen (1919) and Knechtel (1938) give two essentially different interpretations of the relationships of the fine-grained deposits in the central part of the valley and the conglomerate deposits around the margins. This report presents additional data regarding these deposits and an alternative hypothesis regarding their relationships. In addition, some recent fossil discoveries refine their generally accepted geologic ages. The information presented in this paper is based on data collected for a thesis study (Van Horn, 1957).

The Safford Valley is bounded on both the northeast and southwest flanks by mountains (fig. 7.1). On the northeast the Gila Mountains, composed largely of volcanic rocks, rise to a maximum altitude of between 6,000 and 7,000 feet. On the southwest side the Pinaleno, Santa Teresa, and Turnbull Mountains, composed of schist, gneiss, granite, and some volcanic rocks, form a somewhat higher boundary. Mount Graham, the highest point, rises to an altitude of more than 10,000 feet. The altitude at Solomonsville, in the bottom land along the Gila River, is about 3,000 feet. This altitude decreases westward along the Gila River at a rate of about 10 feet per mile to Coolidge Dam, where the altitude of the river is about 2,350 feet.

From the contact of the central alluvial deposits with the crystalline rocks of the bounding mountains, a series of three terraces descends in steplike progression, decreasing in altitude toward the Gila River. The highest terrace is well preserved only locally, as along the northeast front of the Graham Mountains. The middle terrace forms the broad surface that is most conspicuous in the Safford Valley. The lower terrace is well developed along the Gila River and its major tributaries.

A semiarid climate prevails in the valley. Records for the period 1948 to 1956 show an average yearly rainfall of 7.20 inches (Smith, 1956). Vegetation along the Gila River and its tributary washes, where the water table is close to the surface, consists of willow, cottonwood, sycamore, and saltcedar trees. On the mesas, where the depths to the water table are greater, the vegetation consists of yucca, mesquite, creosote bush, ocotillo, prickly pear, and barrel cactus. Areas of intermediate altitude in the Graham Mountains support trees—

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1/ University of Arizona, Tucson.

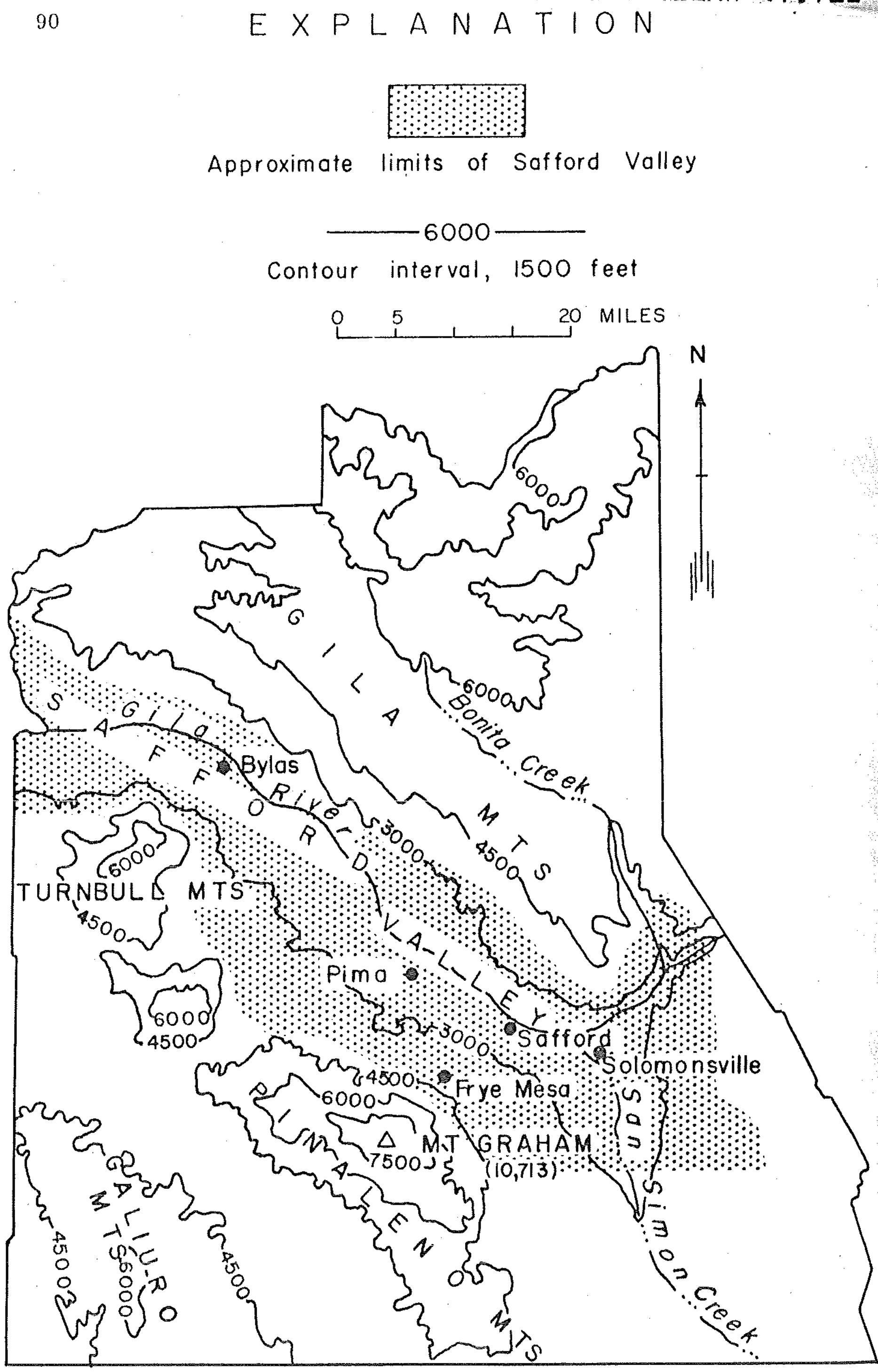


Figure 7.1.--Generalized topography of Graham County, Ariz.

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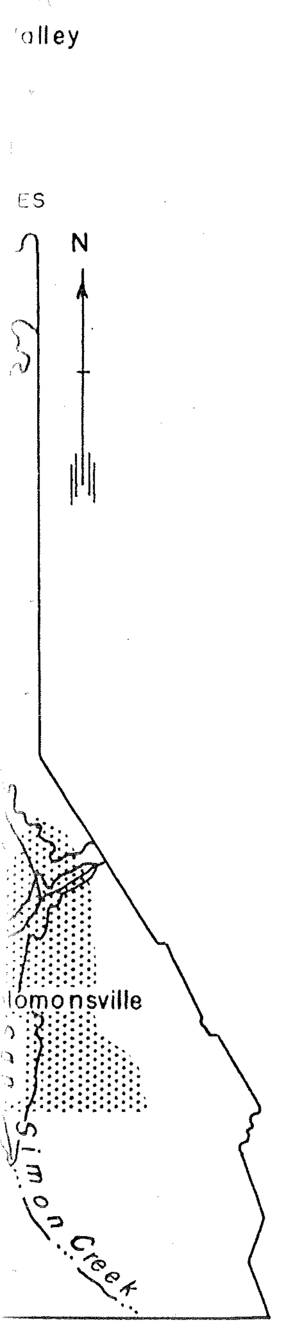

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such as juniper and live oak. The higher areas are covered by pine forests.

## LATE CENOZOIC ALLUVIAL DEPOSITS

The late Cenozoic deposits occurring in this area were divided into three units by Knechtel (1938)—the Gila Conglomerate of late Pliocene age at the bottom, overlain successively by Pleistocene(?) terrace gravels and Quaternary alluvium. This general subdivision is continued in this report, but the units are designated, respectively, as the Solomonsville Beds of Pliocene and Pleistocene age, terrace gravels of Pleistocene age, and Quaternary alluvium.

### Solomonsville Beds

The lowest unit of the alluvial fill forms the bulk of deposits in the Safford Valley and consists of poorly to moderately well-consolidated conglomerate, sandstone, siltstone, marls, tuff, and diatomite. These deposits extend the entire width of the valley from the Graham Mountains on the southwest to the Gila Mountains on the northeast. In most places they are covered with Pleistocene terrace gravels or more recent alluvium. The best exposures are along the steep sides of gravel-capped mesas, which are remnants of dissected terraces. These deposits are here designated as the Solomonsville Beds, named for the town of Solomonsville in whose general vicinity they are well developed.

The fine-grained deposits predominate in the central part of the valley and grade outward into coarser sandstone and conglomerate. The beds are horizontal or dip at very small angles; nowhere were any dips observed to be more than 3°. Generally, the individual beds of the finer deposits are very thin, and many are less than a foot thick. Commonly, they contain evidence of desiccation in the form of halite, mud cracks, and gypsum.

Deep well logs (Knechtel, 1938) suggest that, in the vicinity of Pima and Safford, similar fine-grained deposits extend down to about 1,200 feet above sea level. The highest altitude at which these fine-grained deposits are located is about 3,580 feet above sea level. This indicates that the thickness of these deposits may be as much as 2,400 feet.

The finer grained sequence of the Solomonsville Beds grades into and intertongues with coarser beds. Along the Gila Mountains, the coarser materials are predominantly sandy siltstone and pebbly sandstone with occasional lenses of subangular pebble conglomerate. The transition zone from coarse to fine material is narrow. Eastward toward the mouth of Bonita Creek and westward toward the Graham Mountains the transition zone is broad, and the material abutting the mountains is predominantly pebble to boulder conglomerate.

The Solomonsville Beds are nearly everywhere covered by thin deposits of Pleistocene terrace gravels or Quaternary alluvium, or by a veneer of gravelly rubble. In the vicinity of Frye Mesa, however, they are overlain by several hundred feet of silty sandstone with interbedded gravel and boulder conglomerate. The diatom flora from the Solomonsville Beds were examined by Lohman (in Knechtel, 1938), who states that they lived in warm, somewhat saline lake water. Molluscan fossils (Mansfield, in Knechtel, 1938) indicate fresh-water conditions. The occurrence of fossil capybara suggests warm, moist conditions because living forms are found along river banks of the southern tropic region and the warmer part of the southern temperate zone (J. F. Lance, oral communication, 1957).

Knechtel (1936) postulates a lacustrine origin for these sediments on the basis of (1) the character of the diatom flora, (2) the presence of thin limestone beds containing fresh-water molluscan fossils, (3) extensive layers of tuff, presumably laid down in quiet water, and (4) the predominance of clay beds.

It is suggested that the upper Solomonsville Beds were deposited in a lake that was affected by fluctuating climatic conditions. Periods when the lake contained fresh water were followed by periods of partial or total desiccation.

Heavy mineral studies of very fine silt or coarse silt indicate that the materials in the Solomonsville Beds were derived from the mountains bounding the valley at the present time. This relationship suggests that fault blocks involved in the formation of the basin became the source of many of the sediments accumulated in the basin. The abundance of fine sediments suggests, however, that the relief between the bounding highlands and the basin of deposition was not great.

## Correlation

At the confluence of Bonita Creek and the Gila River, there is a sequence of volcanic rock and conglomerate which is one of the four sections designated as the Gila Conglomerate by Gilbert (1875). Knechtel (1936) includes the fine-grained deposits of the central part of the Safford Valley in the Gila Conglomerate, because he postulates that they interfinger and originated simultaneously with the Gila Conglomerate.

At the mouth of Bonita Creek, the following sequence of units exists from bottom to top: (1) eroded basalt flow; (2) volcanic conglomerate containing no visible fragments of granite or quartzite; and (3) a similar conglomerate containing conspicuous fragments of red granite and white to maroon quartzite in addition to volcanic material. The upper conglomerate containing granite and quartzite is locally separated from the lower conglomerate by an erosional unconformity (Heindl, 1960b). The upper conglomerate intertongues with pink, sandy to silty beds which are locally depositional on an erosional surface cut on the lower conglomerate. The pink, sandy to silty beds intertongue with the finer grained sequence of siltstone, marl, diatomite, tuff, and claystone of the Solomonsville Beds. The relationship of the lower conglomerate with finer grained deposits below the surface is not demonstrable.

## Sedimentary Relationships

The data here presented show that fine-grained deposits of the central part of the Solomonsville Beds grade mountainward into coarser deposits. To the east, the coarser deposits of the Solomonsville Beds overlie an erosional surface cut on older conglomerate (Heindl, 1960b). To the west, the coarser deposits of the Solomonsville Beds underlie a thick sequence of younger conglomerate. In short, while the fine-grained deposits do grade into coarser materials toward the mountains locally, they are not necessarily the equivalent of

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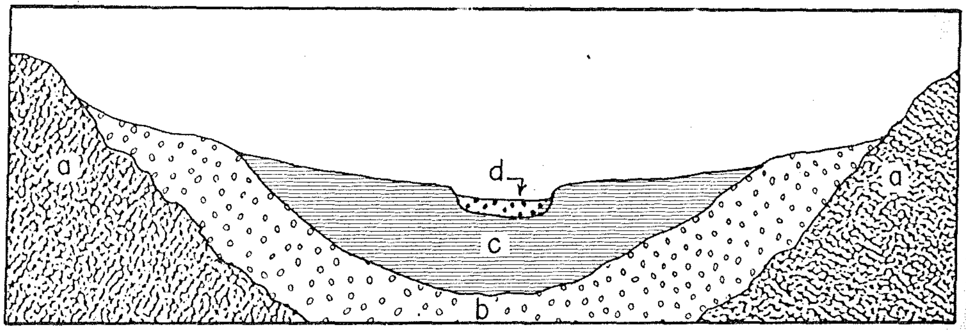
Schwennesen (1919) postulated that the "lake apparently came into existence after the alluvial slopes (of Gila Conglomerate) had been considerably eroded" and that the lake-bed deposits are younger than the belt of conglomerate deposits around the periphery of the valley (fig. 7.2A). Knechtel (1938) postulates that the "stream sediments exposed in the high marginal hilly belts are equivalent in geologic age to the lake sediments of the central part of the valley and are not an older formation underlying the lake beds" and assigns both the lake-bed and coarse alluvial deposits to the Gila Conglomerate (fig. 7.2B). The data presented in this report suggest that the relationships of the deposits are those shown in figure 7.2C. The erosional unconformity at the base of the Solomonsville Beds and their difference in composition from the underlying conglomerate support their separation into two units. Furthermore, the pattern of the present outcrops of volcanic rocks at the head of the Safford Valley suggests the possibility of a bedrock barrier between the sites of deposition of the lower conglomerate and unexposed units of the fine-grained deposits underlying Safford Valley. In the Frye Mesa area, the coarse boulder conglomerate is above the Solomonsville Beds and differs sharply in texture, degree of oxidation, and type of matrix. Thus the coarse marginal deposits in one area include conglomerate of both the Solomonsville Beds and of older deposits, whereas on the other side of the valley the exposed coarse material includes conglomerate of both the Solomonsville Beds and younger deposits.

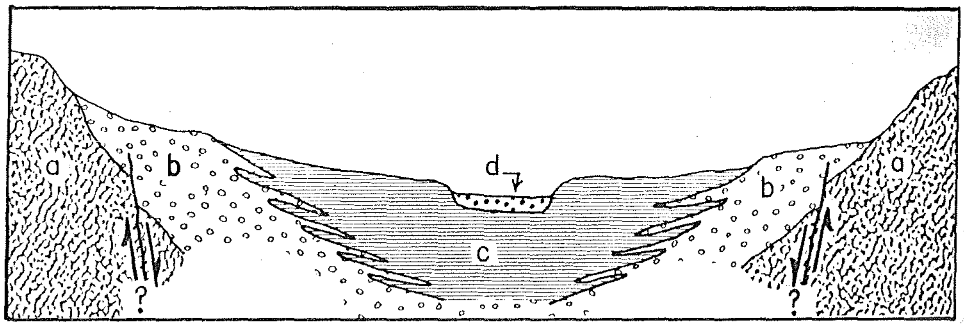
## Age

Gilbert (1875) considered the conglomerate at the mouth of Bonita Creek to be of Quaternary age. Gazin (in Knechtel, 1938) considered a vertebrate faunal assemblage of Nannippus sp., Plesippus sp., and Rhynchotherium(?) sp. from the fine-grained deposits of the Solomonsville Beds to be Blancan. At the time Gazin identified these fossils, the Blancan fauna was considered to be late Pliocene in age. At the present time, the Blancan fauna and its correlatives are considered to be at least in part of lower Pleistocene age (J. F. Lance, oral communication, 1957). Recently, a younger assemblage of vertebrate fossils has been located in the same general vicinity, less than 100 feet stratigraphically above Nannippus remains. The younger assemblage included Equus (Equus) sp. and Hydrochoerus sp. There is no significant break in the sequence of deposition in this area, nor is there any marked difference in the types of materials encountered. Equus (Equus) is at least post-early Kansan (J. F. Lance, oral communication, 1957), and the stratigraphy indicates that deposition was continuous from the time represented by the Blancan fauna into the time represented by Equus (Equus). An alternative hypothesis is that Nannippus survived into post-Blancan time. The exposed Solomonsville Beds span the Pliocene to Pleistocene boundary and extend up into at least Kansan time.

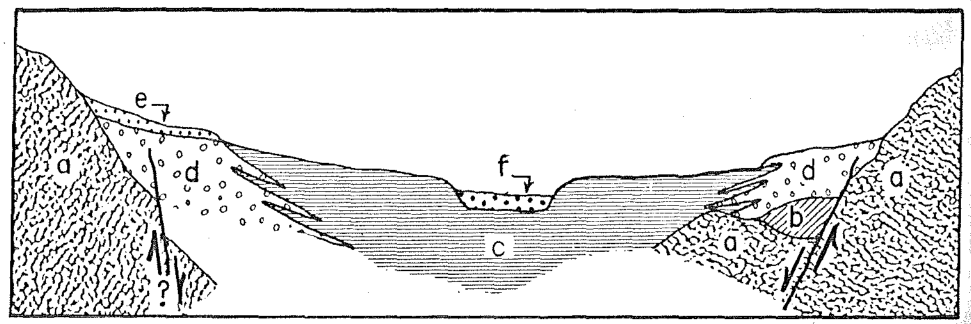
Some 2,200 feet of Solomonsville Beds or older finer grained deposits are present locally below the stratigraphic level of the Blancan fauna, and it is probable that the lower part of these deposits is of middle or upper Pliocene age.




A. After Schwennesen, 1919: (a) Pre-Quaternary igneous and sedimentary rocks; (b) Gila Conglomerate; (c) lake beds; and (d) Recent alluvium.




B. After Knechtel, 1936: (a) Undifferentiated metamorphic and igneous rocks; (b) sand and gravel, fanglomerate phase, and (c) fine-grained lacustrine phase of Gila Conglomerate; (d) Quaternary alluvium.




C. This report: (a) Undifferentiated metamorphic, intrusive, volcanic, and older sedimentary rocks; (b) alluvial conglomerate, older than Solomonsville beds; (c) fine-grained phase and (d) coarse-grained phase of Solomonsville beds; (e) conglomerate younger than Solomonsville beds and older than (f) late Quaternary alluvium.

Figure 7. 2. --Hypothetical sections of the Safford Valley, Arizona, showing three interpretations of sedimentary relationships of the alluvial fill: (A) after Schwennesen, 1919; (B) after Knechtel, 1936; and (C) this report.

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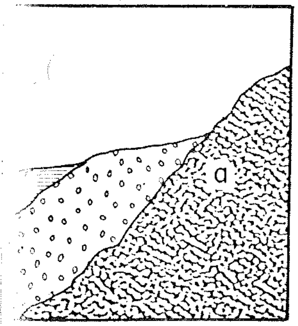


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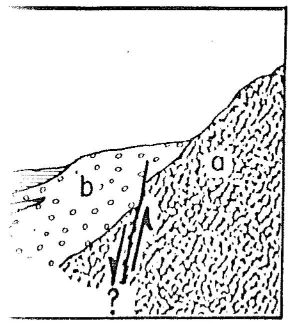


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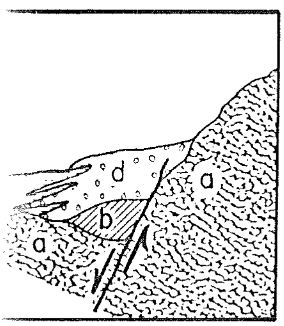


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## Pleistocene Terrace Gravels

The dissection of terraces which slope toward the central part of the valley has left steep, gravel-capped mesas standing above the level of the present washes. The gravel capping locally has a caliche cement. The composition of the fragments generally reflects the composition of the nearest mountains, but in some of the more central deposits there are rounded pebbles of quartzite and silicified mudstone of unknown origin. The larger fragments are generally subrounded to subangular. Along the flanks of the mountains, fragments several feet in diameter occur. There is a decrease in the size of fragments and the thickness of this unit toward the central part of the valley. The maximum thickness of the gravels observed in the central part of the valley is about 30 feet. Thicker sequences probably occur nearer to the mountains.

The origin of these deposits has never been satisfactorily explained. The writer is of the opinion that these gravels were emplaced in the following manner. Following the deposition of the Solomonsville Beds, fan deposits accumulated at the base of the mountains, extending outward and thinning toward the center of the valley. This is suggested by the deposits of Frye Mesa, about 9 miles southwest of Safford, where pebbly conglomerate in a greenish silty matrix resembling materials of the Solomonsville Beds first alternate with and finally give way entirely to gravelly, well-oxidized boulder conglomerate. The oxidation, coarseness, and sedimentary structure of these higher beds suggest they were deposited in a period more arid than that of the Solomonsville deposits. There may have been a mixing of the fan material with material being deposited by overloaded streams toward the central part of the valley.

No fossils have been found in these deposits in this area and their geologic age can only be inferred. Similar deposits in other valleys have produced fossils of Pleistocene age (J. F. Lance, oral communication, 1957). These deposits are tentatively assigned to the Pleistocene because they are younger than the Solomonsville Beds of Pliocene and Pleistocene age and were formed before the deposition of the flood-plain alluvium along the Gila River.

## Quaternary Alluvium

A sequence of sands, silts, and gravels is present in the central part of the valley underlying the lowland plain along the Gila River. This alluvium was deposited in a trough cut into the Solomonsville Beds after the deposition of the Pleistocene terrace gravels. The Quaternary alluvium is not well exposed because it is nearly everywhere covered by soil. Its lithology and depth, however, are known from the drillers' logs of many wells; its depth generally ranges from about 60 to 100 feet. These river flood-plain deposits are assigned a late Quaternary age, spanning the Pleistocene-Recent boundary on the basis of similar deposits in the Southwest (Hunt, 1953).

# GEOLOGIC HISTORY

The Solomonsville Beds were deposited in a lake formed in a depression with interior drainage or limited outflow. This depression was probably the result of faulting which continued during the deposition of the Solomonsville Beds.

This is inferred from the fact that the sediments derived from the highlands surrounding the basin are finer than would be expected had great relief existed, yet about 2,400 feet of fine-grained sediments accumulated in this basin. The youngest fossils found so far in these beds are post-early Kansan (J. F. Lance, oral communication, 1957). Since the youngest fossils occur about 2,200 feet above the lowest recognized lake deposits, the tectonic activity which produced the basin must have started considerably prior to the Kansan age, perhaps in middle or late Pliocene.

After the deposition of the Solomonsville Beds, the possible combination of a renewed uplift of the mountains on the southwest side of the valley and increasing aridity resulted in the deposition of coarse alluvial fan material that spread from the mountains, thinning toward the central part of the valley. Subsequently, the basin was breached and at least three cycles of erosion related to the drainage of the Gila River followed. These resulted in the development of the three prominent erosion surfaces in the valley. The last of these cut to a depth of about 100 feet below the middle surface. This channel then filled with river alluvium to a depth of about 100 feet to form the flood plain of the inner valley of the Gila River.

## SUMMARY

The alluvial deposits of the upper Safford Valley are composed of the Solomonsville Beds of Pliocene and Pleistocene age, Pleistocene terrace deposits, and Quaternary alluvium. The Solomonsville Beds form a unit that includes fine-grained deposits in the central part of the valley and coarse-grained deposits along the foot of the mountains. They are not, however, the only coarse-grained alluvial deposits along the margins. At the east end, in the Bonita Creek area, they overlie an erosion surface cut on older alluvial deposits which have a different composition. On the southwest side, the conglomerates of the Solomonsville Beds underlie younger, coarser boulder conglomerate that is distinct in its texture, matrix, and degree of oxidation.

The age of the Solomonsville Beds transcends the Pliocene-Pleistocene boundary. *Hydrochoerus* sp. and *Equus* (*Equus*) sp. of at least post-early Kansan age are stratigraphically about 100 feet above a Blancan faunal assemblage of *Nannippus* sp., *Plesippus* sp., and *Rhynchotherium*(?) sp. of probable Pliocene to Pleistocene age. There is no break in deposition between the two faunal localities. Since there are about 2,200 feet of lake-bed or fine-grained deposits underlying the horizon of the lowest of these faunal localities, the earliest of these deposits may be as old as middle Pliocene.

(Ed. note: Considerable additional work in the Safford Valley has been done since 1958 under the "Utilization of Arid Lands" study by the University of Arizona under a grant by the Rockerfeller Foundation and by the University in cooperation with the U.S. Geological Survey. Some of the work in progress pertinent to Van Horn's report has been discussed in preliminary reports by Davidson, 1960; Harbour, 1960; Hollander, 1960; Seff, 1960; and Wood, 1960. Some of the work in the west end of the Safford Valley has been summarized by Marlowe, 1960a and 1960b.)