STRATIGRAPHIC AND STRUCTURAL POSITION OF CENOZOIC FOSSIL LOCALITIES IN ARIZONA

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INTRODUCTION

The Cenozoic era in Arizona was a time of complex geological activity. Structural movements, intrusive and volcanic igneous activity, erosion, and sedimentation all acted upon pre-existing geologic features to form the present plateaus, mountains, valleys, and drainage patterns. Because of the scarcity of known fossils in Cenozoic continental sediments the sequence of events is understood in only the most general way. Discovery of several new fossil localities during the last ten years warrants the development of an outline of Cenozoic history which may be useful as a guide for further work.

The following account discusses most of the important Cenozoic fossil localities in the state. The information is not completely documented, as all localities discussed have been, or will be covered in more complete reports. Information on new localities has been gathered through the cooperation of several organizations, including the Geology Department, State Museum, and Geochronology Laboratories of the University of Arizona, the Museum of Northern Arizona, and the U. S. Geological Survey. Several grants have aided the work, and will be acknowledged in more detailed publications. The present compilation has resulted directly from the interest in Cenozoic problems arising from the Utilization of Arid Lands project, sponsored by the Rockefeller Foundation. This report draws freely on the work of several colleagues, chief of whom are John W. Harshbarger, Leopold A. Heindl, and Charles A. Repenning.

SUMMARY OF CENOZOIC FOSSIL LOCALITIES

No fossils are reported in Arizona from beds dated between Upper Cretaceous and Lower Miocene, so the interpretation of Early Cenozoic history must be largely inferential. It is likely that sedimentation in some parts of southern Arizona continued from Upper Cretaceous into early Cenozoic time, but direct evidence is lacking (Wood, 1959). Relatively fewfossil localities are known from the Miocene, Pliocene, and Pleistocene, but the distribution and stratigraphic relationships of these throw some light on the later Cenozoic history of Arizona. These localities are listed below, in numerical order as shown on Figure 1.

1. Rampart Cave
2. Coconino Caverns
3. Anita
4. Shonto
5. Charlie Day Spring
6. Cameron
7. Black Falls
8. Joseph City
9. Goodwater Wash
10. White Cone
11. Graywater Wash
12. Snowflake
13. Richville
14. Wikieup
15. Anderson Mine
16. Walnut Grove
17. Tonto Basin
18. Wellton
19. Red Knolls
20. Flat Tire Claim
21. Tusker Claim
22. Bingham Ranch
23. Atravesada
24. Willccx
25. Tucson Brickyard
26. Benson
27. Curtis Ranch
28. Sonoita
29. Papago Springs Cave
30. Pyatt Cave
31. Comosi Wash
32. Ventana Cave
33. Lehner Ranch
34. Naco
35. Double Adobe

MIOCENE FOSSIL LOCALITIES

Two Miocene fossil localities are known, one near Wellton, east of Yuma, and one in the San Pedro Valley near Redington. They are designated on Figure 1 as localities 18 and 23 respectively. The material from both localities is sparse and poorly preserved, but there is little doubt that both are of approximately Lower Miocene age, certainly no older than Upper Oligocene or younger than Middle Miocene. Both localities are in deposits that have been highly deformed, and probably predate the last major thrust faulting and mountain building in the areas of occurrence (Chew, 1951; Lance and Wood, 1958). Beds believed to be at least partly correlative with the Miocene formations occur in other parts of southern Arizona, and appear to have been deposited in basins that did not necessarily coincide with the present intermontaine valleys. The Pantano formation near Tucson is a unit of this type (Brennan, 1957).

LOWER AND MIDDLE PLIOCENE FOSSIL LOCALITIES

All vertebrate fossils of known or supposed Lower or Middle Pliocene ages, south of the Colorado Plateau, are in fine-grained lacustrine or floodplain deposits within existing valleys. Locality 16, the Walnut Grove fauna, contains diagnostic fossils of Lower Pliocene age. Localities 14, 15, 17, and 22 are either Lower or Middle Pliocene. Locality 28 is based on a fossil tooth of a horse, Neohipparion, from a well near Sonoita (Stirton, 1945), and is probably Middle Pliocene.

The Pliocene fossil occurrences in central and southern Arizona are in sedimentary rocks that seem to have been laid down by essentially continuous deposition in the modern basins. Much of the basin fill is fine-grained, and ranges in thickness up to two or three thousand feet in some places. The fine-grained deposits extend to the margins of the basins at numerous localities (Lance, 1959). They locally bury erosion surfaces cut on the bedrock of the mountain blocks. Such surfaces include well-developed pediments, now exposed by erosion at several localities, such as 17 and 22.

Locally the Pliocene sediments are warped, tilted, or broken by high-angle faults, but the deformation is not great in most places. There is no known evidence of any major faulting of bordering mountain blocks during or following deposition in such basins as Tonto, Safford, and Benson. The Walnut Grove beds are tilted to twenty degrees or more, and the beds containing the Wikieup fauna are faulted against the Aquarius Cliffs on the east. These relationships, and those of probable Pliocene sediments in the Agua Fria and lower Verde Valleys suggest that regional uplift in central Arizona continued during the Pliocene.

The two Pliocene localities known from the Colorado Plateau, numbers 10 and 11, are in the Bidahochi formation and obviously predate the present course of the Little Colorado River, and also probably the major downcutting of the Grand Canyon. These relationships are treated more fully in a forthcoming paper (Repenning, et. al., in preparation).

UPPER PLIOCENE AND LOWER PLEISTOCENE LOCALITIES

The dating of vertebrate faunas near the Pliocene-Pleistocene boundary is in dispute, but the details are not important to the present discussion. It is sufficient to note that all of the localities in southern Arizona shown as hollow squares are probably of Lower Pleistocene age, and that they are in deposits that are continuous with underlying beds that probably represent Pliocene deposition. At localities 21 and 27, Middle Pleistocene faunas are found in beds within these sequences, so that the bulk of the valley fill appears to represent deposition extending through a large part of Pliocene time and continuing into Middle Pleistocene.

The best known fauna in the Upper Pliocene and Lower Pleistocene age group is that from the San Pedro Valley near Benson (Gidley, 1924; Gazin, 1940), but generally similar faunas are known from the San Rafael Valley (Quinn, 1957), and the Safford area (Knechtel, 1938).

The Snowflake fauna, locality 12, is in lacustrine or stream deposits that underlie some of the volcanic rocks along the Mogollon Rim. The deposits may represent a late, marginal facies of the Bidahochi formation. Although the age is shown as Upper Pliocene or Lower Pleistocene it is a maximum age, and the fossils might actually represent a younger part of the Pleistocene. The Anita fauna, number 3, is in a fissure in Kaibab limestone on the Coconino Plateau.

MIDDLE AND LATE PLEISTOCENE LOCALITIES

Only two localities shown on Figure 1 are of known Middle Pleistocene age. There are 21 and 27 in the Safford and San Pedro Valleys. Both occur in the upper part of the sequences forming the bulk of the basin fill in both valleys and predate the cycle of downcutting that is still in progress. Both faunas are believed to be late Kansan or early Yarmouthian, in terms of the North American glacial chronology (Lance, 1958).

All late Pleistocene localities listed are either from caves or occur in surficial deposits. Localities 6, 7, 8, and 9 are in gravels on the Wupatki erosion surface in the valley of the Little Colorado River. Locality 4 is in stream alluvium along Shonto Wash. Number 5 is from a spring deposit at Tuba City. Fossil accumulation in the spring may have started in Early Pleistocene, but certainly extended into Late Pleistocene time. The Richville fauna, number 13, is in gravels near the Little Colorado headwaters. All of these localities on the Plateau are related to deposits formed after the present cycle of downcutting began, following cessation of Bidahochi lake deposition. Locality 1 postdates much of the cutting of Grand Canyon.

Localities of Upper Pleistocene age in southern Arizona are in terrace or pediment gravels, floodplain deposits, caves, or late Pleistocene lake deposits. Ventana Cave (32), Lehner Ranch (33), Naco (34), and Whitewater Draw (35), are associated with artifacts. An age of less than eleven thousand years is indicated for them by several carbon dates.

SUMMARY OF CENOZOIC HISTORY

The ages and stratigraphic relationships of Cenozoic deposits in Arizona as outlined above support certain generalizations about the Cenozoic history of the state. Some of the following conclusions are based on field observations not discussed above.

1. Orogeny in southern Arizona was largely continuous from near the end of the Cretaceous into Miocene time. The last major compressional deformation and the formation of the present basin-and-range topography were post-Lower Miocene.

2. The central mountainous area and the Colorado Plateau were uplifted in an epeirogenic movement that started in or slightly before Miocene, and was largely completed toward the end of Miocene or in early Pliocene.

3. Volcanic activity was intermittent during a large part of the Cenozoic, particularly in central Arizona and the Mogollon Rim area, where basaltic lavas were erupted as early as Miocene and continued into Recent time.

4. Major drainageways in Arizona developed after the Laramide uplift of mountains in Utah and Colorado, and extended generally southwest across the state by Middle Cenozoic time (Repenning, et. al., in preparation; see also Melton, this volume). This drainage produced erosion surfaces older than the Bidahochi formation on the Plateau, and perhaps some features now preserved in central and southern Arizona.

5. The southwesterly drainage from the Plateau region was disrupted in Miocene time by uplift of the central mountainous region. Gorges were cut in the rising mountains before complete disruption occurred, and some of these gorges form a part of the present drainage system. Formation of the present basin-and-range topography in the southern part of the state was also essentially a Miocene event, and some of the disrupted drainage was diverted into newly

formed basins. Pediments and other erosion surfaces were locally developed before the Pliocene basin fill accumulated.

6. Continuing structural movement, volcanic activity, and diversion of waters by overflow during the Pliocene resulted in complex changes of the drainage pattern. The reduction of stream gradients or blocking of the valleys allowed the deposition of hundreds to thousands of feet of sediments during much of the Pliocene. The fine-grained character and stratigraphic relationships of these sediments suggests that much of the material was brought into the valleys by through-flowing rivers. The absence of coarse fan material in sediments along the margins of many basins is puzzling. Conditions were certainly not favorable for the development of such deposits during most of the Pliocene and Early Pleistocene.

7. Sedimentation in some of the valleys of east-central and southeastern Arizona ona continued until Middle Pleistocene time. Regional tilting, or basin filling to overflow levels initiated the downcutting that is still in progress. Such valleys as the Agua Fria and Hassayampa in central Arizona have probably been undergoind dissection for a long time, probably as a result of drainage change caused by Pliocene faulting.

8. Coarse deposits in the form of alluvial fans and pediment gravels were shed from the mountains in Middle and Late Pleistocene and covered the fine-grained Pliocene and Lower Pleistocene beds. If these coarse deposits resulted from climatic change, the change does not seem to account for the transition from conditions of aggradation to degradation; it merely influenced the type of sediments that were laid down. However, climatic fluctuation may have controlled the rate of erosion, resulting in the multiple erosion surfaces in valleys such as the Santa Cruz, San Pedro, Gila, Tonto, Verde, and Big Sandy. Such surfaces include both pediments and river terraces cut on the soft Tertiary and early Quaternary beds. Bedrock pediments now exposed in some valleys appear to be Miocene surfaces that are being exhumed.

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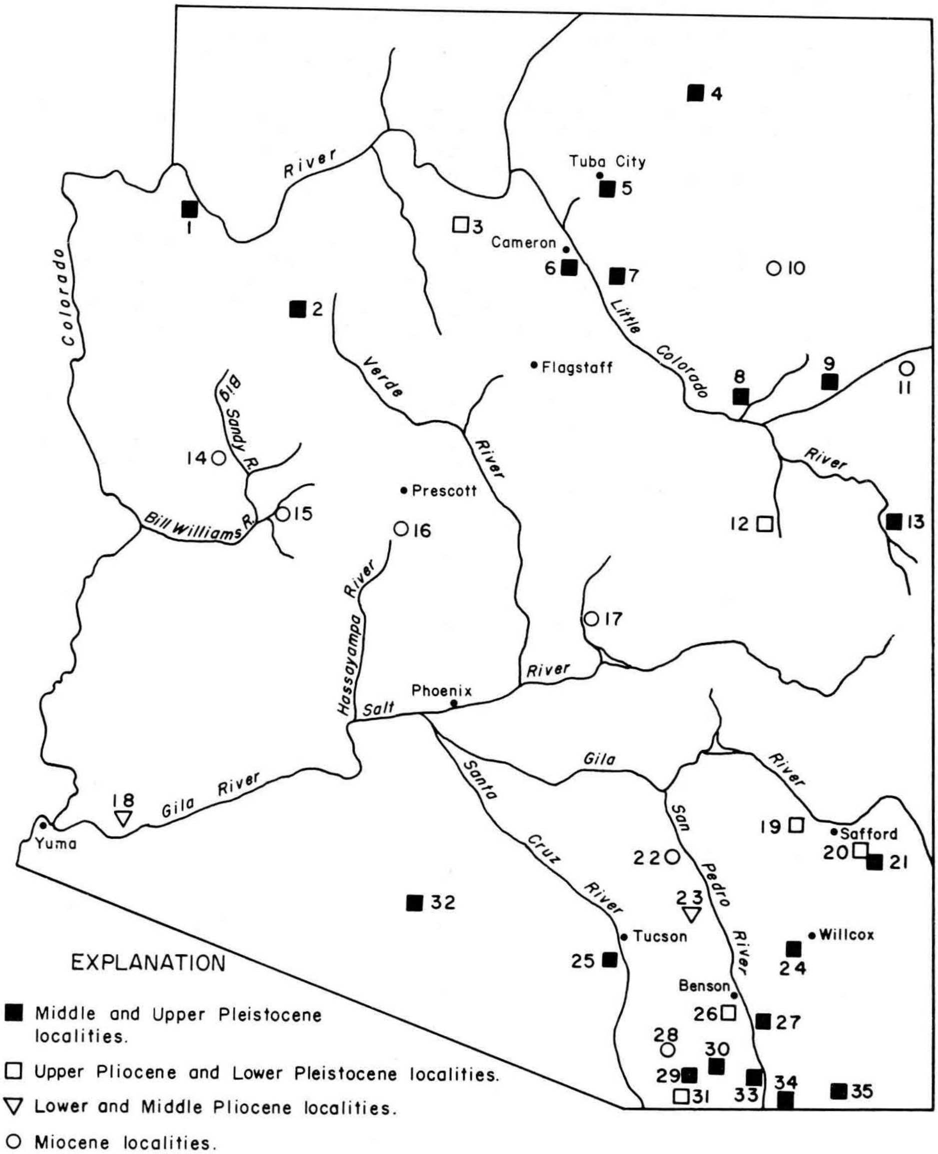

Figure 1.-- Cenozoic fossil localities in Arizona.