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Robert P. Sharp
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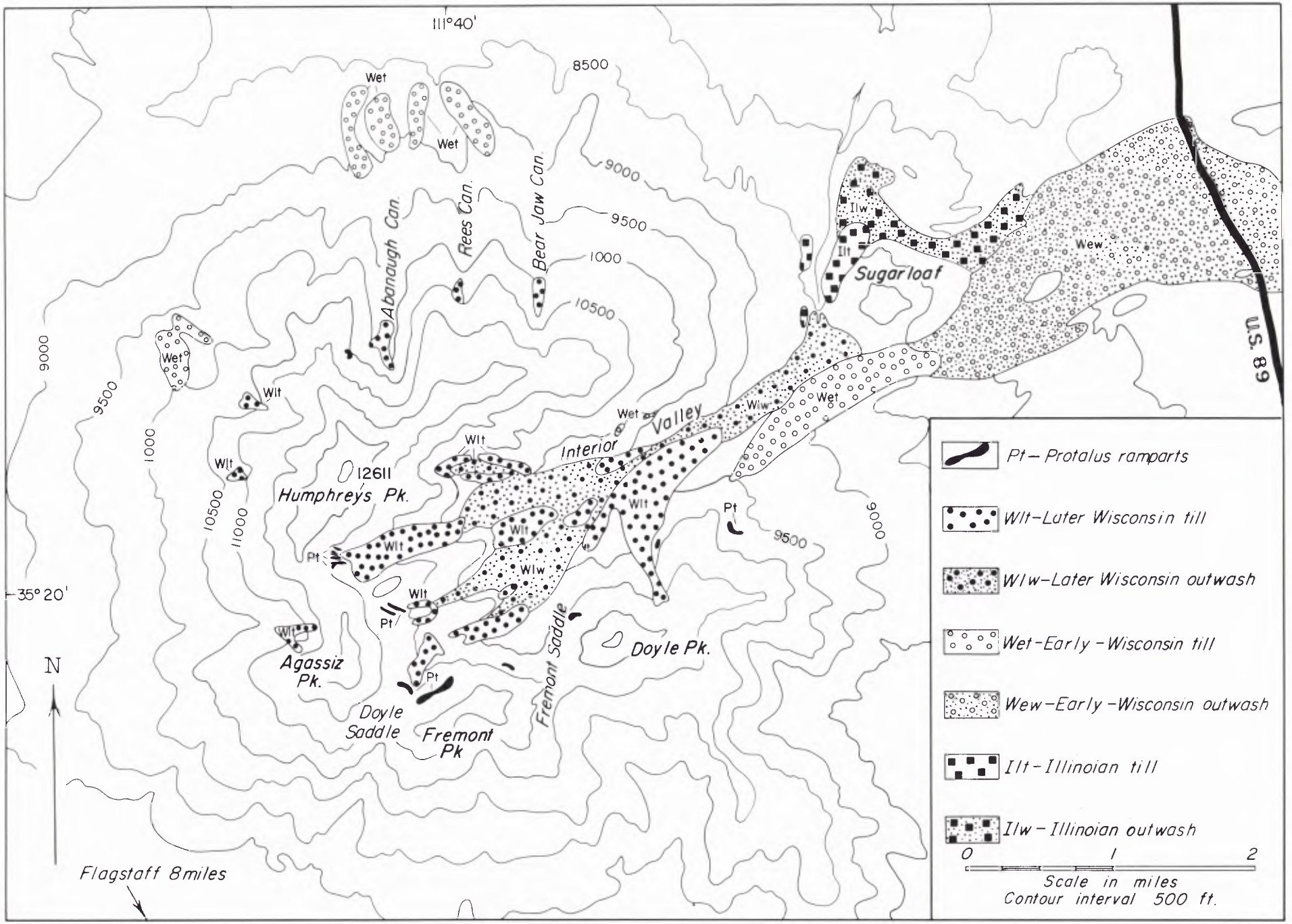


Figure 1. — Glacial deposits on San Francisco Mountain, Arizona.

THE PLEISTOCENE GLACIATION OF SAN FRANCISCO MOUNTAIN, ARIZONA

by **ROBERT P. SHARP**
California Institute of Technology

INTRODUCTION

Evidence of glaciation on the high peaks of southwestern Unied States has long been a matter of geological interest (Atwood, 1905, p. 276-279; Johnson, 1910; Ellis, 1935, p. 24-25; Smith and Ray, 1941). These isolated instances of glaciers far south of the more generally glaciated areas indicate the nature of the Pleistocene environment in these areas and provide a useful basis for chronological correlation and reference. The three outstanding examples of such outlying glaciated peaks in the southwest are Sierra Blanca in New Mexico, San Gorgonio in California, and San Francisco in Arizona. Of these San Francisco Mountain, 12,611 feet high, 9 miles north of Flagstaff affords the best and most complete record of glacial history, at least as yet reported. The information presented here is based on work done in 1940 and reported more fully in an earlier publication (Sharp, 1942).

The principal site of glaciation was the large "Interior Valley" which drains northeastward from the central part of the mountain and which was especially favored for glacier development by the high peaks and basins in its headwater area and by its northeastward exposure. Glaciers also formed in a half-dozen smaller valleys high on the west and northwest slopes of the San Francisco Mountain cone. Unfortunately, almost nothing of the glacial relations can be seen by the highway tourist. The one exception is a large area of outwash crossed by U. S. Highway 89 on the route north to Cameron (Fig. 1).

Evidence of 3 distinct glaciations has been found and mapped in the Interior Valley. The two younger of these glacial episodes are confidently regarded respectively as late and early phases of the Wisconsin. The third and oldest glaciation is possibly Illinoian. Each glaciation is represented by clearly identifiable moraines and associated outwash deposits.

ILLINOIAN GLACIATION

The evidence for this stage consists of lateral moraine remnants (Fig. 2) and outwash deposits at the mouth of the Interior Valley near Sugarloaf (Fig. 1). The Illinoian Glacier was 4¾ miles long and terminated at an elevation of 8500 feet. The ice may have been as much as 1000 feet thick and possibly a little of it spilled out of the Interior Valley onto the south side of the mountain by way of Fremont Saddle.



Figure 2. — Illinoian lateral moraine at west base of Sugarloaf looking east-northeast.



Figure 3. — View eastward from head of north branch of Interior Valley showing back side of late Wisconsin recessional moraine, forested ridge in foreground, early Wisconsin lateral moraine (AA) in mid-distance, and late Pleistocene basaltic cones beyond.

The till remnants near Sugarloaf are perched on bedrock shoulders 350 to 370 feet above the present valley floor. These shoulders are regarded as remnants of the ancient Illinoian valley, and this is one of the principal reasons for regarding the till as old as Illinoian. A considerable area of Illinoian outwash lying northeast and east of the lateral moraine at Sugarloaf (Fig. 1) has locally been worked for sand and gravel.

Assignment of this stage to the Illinoian is by no means certain, but the deposits are probably pre-Wisconsin, and they do not look as old as glacial accumulations in other western mountains commonly attributed to the Kansan (Blackwelder, 1931, p. 918). The age of pre-Wisconsin glaciations in western mountains is still largely an unsettled problem, but Nelson (1954, p. 341) has tentatively dated a pre-Wisconsin glaciation in the Frying Pan drainage of Colorado as possibly Illinoian on the basis of quantitative field data.

EARLY WISCONSIN GLACIATION

This glaciation corresponds most closely to the Tahoe of far Western Mountains (Blackwelder, 1931, p. 884-895). The evidence for it consists of a number of lateral moraines and a considerable area of outwash. The Interior Valley glacier of this phase was fully 4 miles long, at least 600 feet thick, and extended to a terminus near the west base of Sugarloaf at 8600 feet elevation.

The principal features are a huge lateral moraine forming the south wall of the Interior Valley below the 9500-foot contour (Fig. 3) and a large area of outwash east-northeast of Sugarloaf. This outwash is crossed by U. S. Highway 89, and a gravel pit in it east of the highway yielded good specimens of striated stones.

LATE WISCONSIN GLACIATION

The glaciers of this episode correspond to those commonly termed Tioga in far Western Mountains (Blackwelder, 1931, p. 881-884). The features attributed to this glaciation in the Interior Valley consist of terminal, medial, recessional and ground moraines, outwash deposits, striated bedrock surfaces, and cirques. At this time the Interior Valley glacier was 2¾ miles long and terminated at 9000



Figure 4. — Late Wisconsin medial moraine between north and south branches of Interior Valley.

feet elevation. The terminal moraine, only narrowly and shallowly notched by the axial stream, is a large irregular mass of blocky debris completely choking the valley. A prominent medial moraine was formed off the tip of the spur seperating the two principal branches of the Interior Valley (Fig. 4).

Four major cirques fed the Interior Valley glacier and about ½ mile below the cirque between Humphreys and Agassiz peaks a large recessional moraine fills the valley from wall to wall, rising abruptly 500 feet above the canyon floor on its downstream face. Other end moraines were formed in the south branch of the Interior Valley. These are regarded as recessional phases of the late Wisconsin glaciation rather than the product of readvances during other still younger Wisconsin glaciations.

Well-developed protalus ramparts on the floors of some of the high cirques may be indicative of post-Wisconsin episodes of refrigeration.

ADDITIONAL CONSIDERATIONS

The glaciers of San Francisco Mountain suggest that Pleistocene orographic snowline lay at an elevation between 11,000 and 11,300 feet. The present snowline lies above the top of the highest peak, 12,611 feet.

The large area of early Wisconsin outwash crossed by U. S. Highway 89 extends eastward under basaltic flows of Colton's (1937, p. 23-28) 3rd volcanic stage. This suggests that the 3rd and subsequent volcanic stages 4 and 5 are all younger than early Wisconsin. The construction of San Francisco Peak itself must have been completed not later than the Illinoian. The cone may actually be considerably older and could have been affected by still earlier Pleistocene glaciers but the evidence has been destroyed or not found.

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