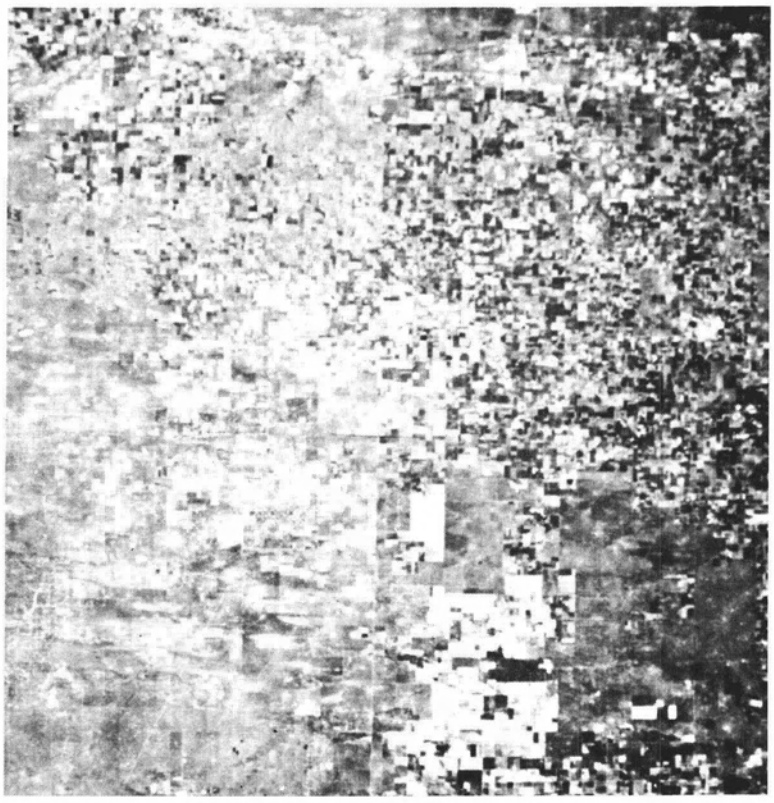

FIG. 1. Apollo 26A-3807 with principal at 33° 42′N., 103° 01′W. Black-and-white print made from 70-mm color-infrared transparency (courtesy NASA, Houston). The lineation across the photograph from top to bottom is the boundary line between the states of New Mexico (left) and Texas.

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An Apollo Photo and the Texas-New Mexico Line

The state-line signature on the photo does *not* result from the political differences in the management of groundwater between the two states.

(Abstract on next page)

INTRODUCTION

APOLLO 9 PHOTOGRAPH 26A-3807A, the color infrared frame of scene 3807, covers an area of approximately 10,000 square miles of West Texas and eastern New Mexico (Figure 1). The altitude of the spacecraft at exposure, made at 10:30 CST on March 12, 1969, was about 119 nautical miles and the principal point is at 33°42′N., 103°01′W.

Picture 3807A was only one of many such photos made over the southwestern United States as part of the SO-65 experiment; however, only the New Mexico-Texas state line

signature on 3807 has stimulated comment, confusion, and argument amongst geologists, hydrologists, agriculturalists and politicians to be the subject of a Congressional debate. It is, therefore, the purpose of this report to judge the comments, clarify the confusion, and settle the arguments concerning the state line signature.

Previous Interpretations

The very obvious New Mexico-Texas state line signature, trending north-south through the center of AS9-26A-3807A, was first discussed by F. A. Rayner (1970). Rayner, Manager of the High Plains Underground Water Conservation District No. 1, Lubbock, Texas, wrote:

> Since the soils are similar, if not identical, in the area immediately adjacent to the State line; since the Ogallala Formation and the Ogallala aquifer—which, for the most part, covers the entire area of this photograph—does not recognize a man-made line established hundreds of thousands of years after their deposition; since there is no sharp change in the climate conditions at the State line; since the same type of enterprising farmer could have settled in New Mexico as easily as in Texas; since the State line is, for the most part, not physically evident on the land surface (not a road or a fence line); then what could account for the difference between New Mexico and Texas as revealed by the Apollo 9 photograph? The answer, the one thing that does change across a state line—*the form of government*—and, in this case, the form of government concerned with groundwater basin management.
>
> In Texas, the landowner is also the owner of the groundwater tarrying beneath his property, and he can use his groundwater for any beneficial purpose, as long as he does not abuse this privilege by wasting some. In New Mexico, the groundwater is the property of the State and the landowner (in declared basins) can only develop such water (for other than domestic or stock purposes) by securing a permit to do so from the New Mexico State Engineer.
>
> This difference in the types of groundwater basin management is our interpretation as the primary reason for the distinct appearance of the Texas-New Mexico State line on this photograph; . . .

Abstract: *Ground-truth studies of Apollo photo 26A-3807A show a correlation between Pleistocene eolian sheet sands, tillable soils, availability of irrigation water and agricultural development. Areas of near-surface Pliocene caliche, although underlain by saturated Ogallala aquifer, are not tillable, whereas areas of Pleistocene eolian sand underlain by saturated Ogallala aquifer exhibit an agricultural signature indentical on either side of the New Mexico-Texas state line. Thus, the differences in land use management on either side of the state line are mainly the result of the juxtaposition of irrigation water and tillable soil, although heritage factors have also probably exerted some influence. The distinct appearance of the New Mexico-Texas state line is principally due to paved Texas State Highway 769 and manicured right-of-way, to barbed wire fences, graded section lines and New Mexico State Highway 348. In no way does the state-line signature on Apollo 3807 result from the political differences in management of groundwater between New Mexico and Texas.*

Rayner's (1970) statement was then picked up by Dickson (1970) and, during the last four years, even NASA and USGS representatives have been using AS9-26A-3807A to illustrate how the politics of water management influence agricultural development. This is what I have termed *political resolution* (Reeves, 1972), for field evidence illustrates that the differences in water management between Texas and New Mexico have had little or no bearing on the spatial signature of the state line.

During the course of this investigation it became clear that two different questions were being asked about Apollo photo 26A-3807A. For example, the question "Why the difference in intensity of cultivation from New Mexico to Texas?" is different from asking "Why does the state line, which is supposed to be a political entity and not physically evident, have such a recognizable signature?" My purpose was therefore to answer satisfactorily both questions by field investigation rather than by only office interpretation of the photo itself.

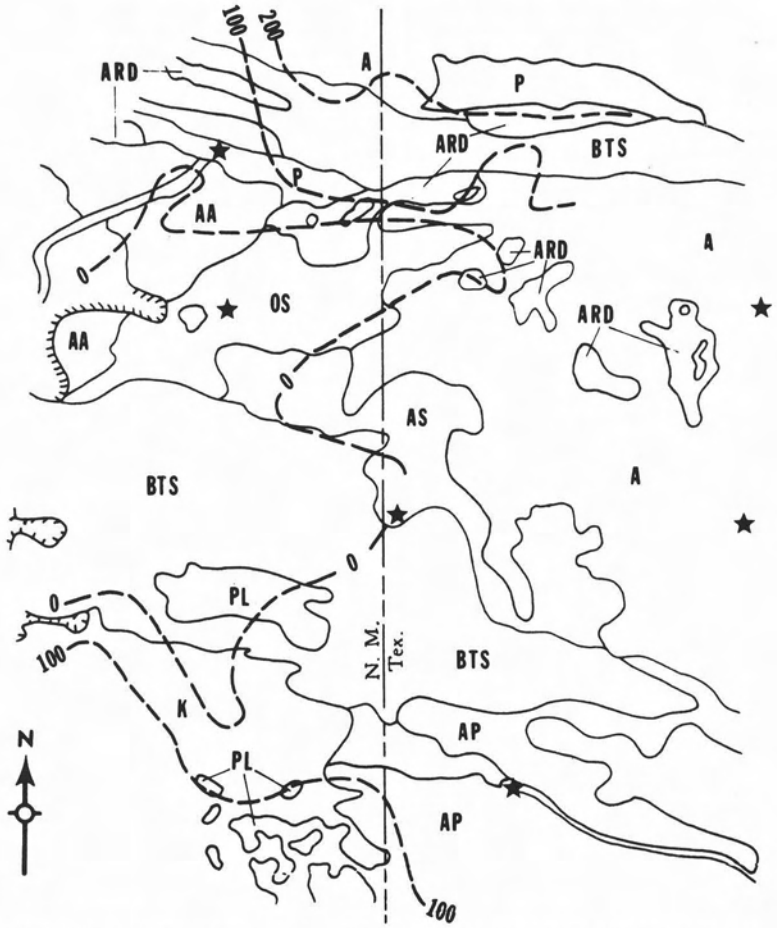

FIG. 2. General soils map from Apollo 26A-3807A. The dashed lines represent the saturated thickness of the Ogallala Aquifer (courtesy S. E. Reynolds, New Mexico State Engineer). *AA*—Amarillo and Arvana sandy loams, *ARD*—Arch and Drake loams, *P*—Portales loams, *OS*—Olton and Stegall loams, *BTS*—Brownfield, Tivoli and Springer loamy sands, *K*—Kimbrough loam, *AP*—Amarillo loamy sand and Patricia sand, *AS*—Amarillo and Springer loamy sand, *PL*—Portales and Lea loams, *A*—Amarillo sandy loam.

FIELD EVIDENCE

During the 1969-1971 period I mapped the geology of the west half (New Mexico part) of the 1:250,000 AMS Brownfield sheet on 1:62,500 BW photos for the New Mexico Bureau of Mines as part of the Texas Geologic Atlas Project. Because frame 3807 more or less covers the Brownfield sheet, ground-truth studies of 26A-3807 were concurrently conducted.

The principal textural changes on 3807 are clearly the result of agricultural development. Plowed fields, including those receiving pre-plant irrigation, are various shades of brown and gray and the irrigated winter wheat and rye are recorded as faint red spots on the color-IR frame (3807A). The stabilized and active dune areas are mottled light blue to blue-gray on the color-IR, and salt crusts of the large playas are white: those basins with water are opaque to dark blue.

SOILS AND GEOLOGY

Figure 2 illustrates a general soils map and Figure 3, a general geologic map of 26A-3807. Notice that the principal cultivated areas are on soils (Amarillo, Arvana, Olton, Portales, Lea and combinations) formed on Pleistocene eolian sands. Distribution of the Pleistocene sands has been due to prevailing southwesterly winds, thus such sands thin to the west and south. Agricultural development is therefore non-existent in the southwest part of 26A-3807 because of the absence

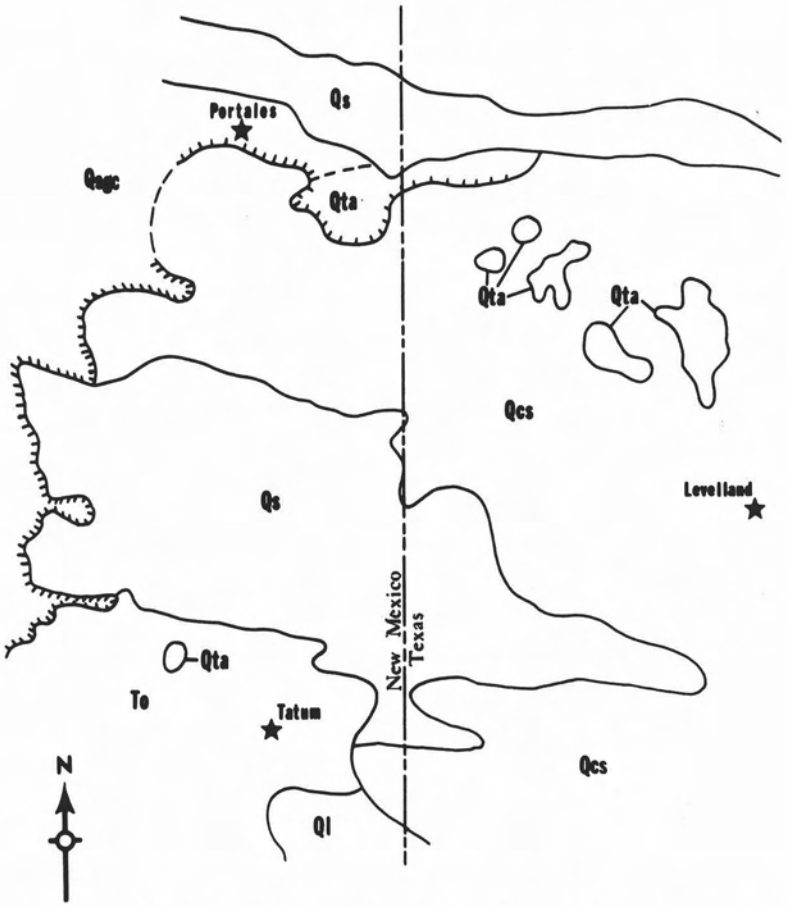

FIG. 3. General geologic map from Apollo photo 26A-3807A. Compare to Figure 2. *Qs*—Quaternary sand, *Qsgc*—Quaternary sand, gravel, caliche, *Qta*—Wisconsin Tahoka Formation, *Qcs*—Illinoian "cover sands", *Ql*—Pre-Illinoian sand, *To*—Tertiary Ogallala Formation.

of cultivatable soil. The soil that is present (Kimbrough), averaging about 6 to 12 inches thick, is immediately underlain by the petrocalcic Ogallala (Pliocene) *caprock* caliche, thus is too thin to be plowed.

In the south-central part of 26A-3807 are scattered cultivated areas. These represent agricultural developments on remnant linear patches of a pre-Illinoian cover sand preserved in Pliocene dune swales. A mature 16 to 40 inches of soil, the Portales-Lea-Stegall association, has developed in the topographically lower swales, thus allowing limited cultivation.

Trending east-west through the south-central part of 26A-3807 is a belt of younger Quaternary sands marked by the Brownfield-Tivoli-Springer (BTS) soils association (Figures 1, 2, 3). This area is not cultivated principally because the sands lack soil development and are subject to drifting. Secondly, the underlying Ogallala aquifer is dry.

IRRIGATION WATER

The influence of available irrigation water is dramatically shown on 26A-3807. As shown on Figure 2, nearly all of the Texas part of the photo contains some available irrigation water, whereas the central part of the New Mexico portion of the photo has no available irrigation water. However, the absence of irrigation water in itself only reduces the density of agricultural development, as in the northwestern part of the photo where dryland farming occurs, incidenatlly on the first available soils amenable to development (Olton and Stegall). Yet the absence of suitable soil, regardless of whether there is irriga-

tion water present, entirely eliminates agricultural practices, as in the southwest part of the photo.

The northwestern and south-central parts of the photo encompass the Portales and Lea County basins where use of the groundwater is directed by the New Mexico State Engineer. The fact that no difference in the density of cultivation occurs between the Portales Basin (where both irrigation water and tillable soil are present) and parts of West Texas illustrate that the differences in water management between the states has little to do with agricultural activities.

PHYSICAL AND PHILOSOPHICAL FACTORS

Although Rayner (1970) discounted physical evidence for the state line signature on 26A-3807A, ground-truth studies reveal that the state line is marked by paved Texas State Highway 769 and manicured right-of-way (total width of 140 feet), bordered by two barbed wire fences, from the center of the photo south. In the northern half of the photo the state line is alternatively marked by a barbed wire fence, graded section-line roads, and New Mexico State Highway 348.

Another factor marking the state line on 26A-3807 are cultivated field terminations. This, I expect, results from cultural as well as natural aspects. For instance, West Texas is essentially an area of widespread irrigation potential whereas eastern New Mexico contains only sporadic, readily available irrigation water. Secondly, West Texans, for the last few generations, have been mainly farmers whereas those families in New Mexico have retained the ranching image. Thus, cultivation has been pushed by the Texans westward to the state line, even in those areas having little available irrigation water (compare parts of Figures 1 and 2), whereas the ranchers of New Mexico have resisted plowing of the prairie.

CONCLUSIONS

The unusual New Mexico-Texas state line signature shown on Apollo orbital photograph 26A-3807A is the result, principally, of paved Texas State Highway 769 and right-of-way which runs from the center of the photo south. The state line signature in the northern part of the photo results from barbed wire fences, graded section-line roads, and New Mexico State Highway 348. The striking difference in land-use practices between New Mexico and Texas are the result of, first, the availability of tillable soils followed by the availability of irrigation water and finally land-use heritage.

Although it has been suggested that the unusual signature of the New Mexico-Texas state line, as well as the differences in land management between the two states, results from the " . . . difference in the types of groundwater basin management . . . " (private in Texas, State-owned in New Mexico), documented field evidence shows otherwise. Secondly, the intensity of agricultural development in New Mexico to the north and south of the photo boundaries, in State-managed water districts where tillable soil and irrigation water are in juxtaposition, is as great as in parts of Texas. Thus, this illustrates that political philosophies of water management have played no part in land use practices between the two states.

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