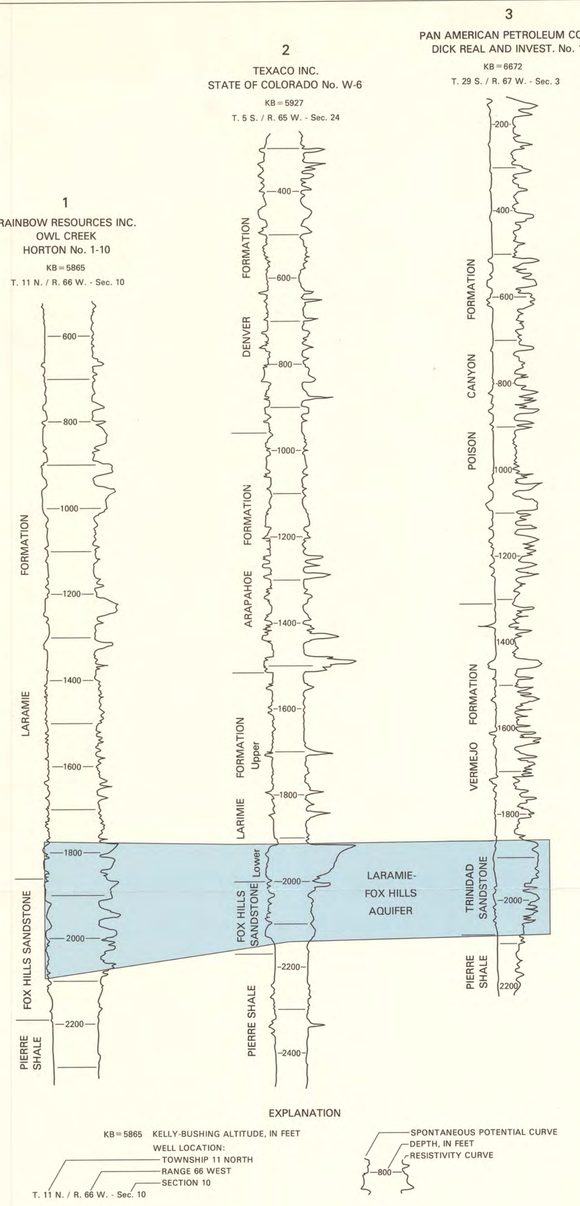

Figure 5.—Borehole electric logs showing typical correlation of Laramie-Fox Hills aquifer in eastern Colorado.

LARAMIE-FOX HILLS AQUIFER

Geology

The Laramie-Fox Hills aquifer occurs in the basal sandstone units of the Cretaceous Laramie Formation and the upper sandstone and siltstone units of the underlying Cretaceous Fox Hills Sandstone (fig. 5). The Laramie-Fox Hills is an aquifer in Colorado that is part of the Great Plains confining system (fig. 2) of the central United States. The aquifer is commonly 200 to 300 ft thick and consists of relatively thin siltstone and sandstone units interlayered with shale in the lower part of the aquifer and one or more sandstone units 40 to 100 ft thick near the top of the aquifer.

The Fox Hills Sandstone is 150 to 200 ft thick and is composed of fine- to medium-grained, olive-brown to orange-tan, poorly consolidated sandstone and siltstone deposited with interlayed shale and claystone in a marine deltaic or barrier-bar environment. The Fox Hills conformably overlies the Pierre Shale, and the transitional contact between the two units is difficult to distinguish in most areas. The lower part of the Fox Hills typically consists of relatively soft, sandy shale interbedded with thin, upward-coarsening layers of fossiliferous and concretionary sandstone. The upper 50 ft of the unit commonly consist of medium-bedded to massive, soft to hard sandstone interbedded with thin layers of shale. The base of the Laramie-Fox Hills aquifer is indistinct in some areas and is commonly chosen to include most of the thicker sandstone and siltstone units in the lower part of the Fox Hills Sandstone. Where present, localized sandstone layers at the top of the Pierre Shale may be included in the aquifer; however, the Pierre Shale is generally considered to be the base of the Laramie-Fox Hills aquifer because of its great thickness and minimal hydraulic conductivity.

The Laramie Formation is an alluvial and deltaic continental deposit consisting of two members: a predominantly sandstone lower member and a predominantly shale and claystone upper member. The lower member is generally 100 to 200 ft thick and consists of tan to light, yellow-gray or white, relatively clean, fine- to medium-grained sandstone interbedded with lignitic shale and coal. The sandstone generally occurs as one to three distinct, thin-bedded to massive units 40 to 100 ft thick separated by 5 to 40 ft of shale and claystone. The Laramie sandstone beds are separated from beds of the upper Fox Hills Sandstone by 10 to 50 ft of sandy shale. Although Soister (1978) states that, "The Fox Hills Sandstone can generally be distinguished from the Laramie's sandstone beds by its finer grain size, greater amount of ferruginous material, higher mica content, and marine fossils," some authors (Kiteley, 1978; Kirkham and others, 1980) include the Laramie sandstone beds as part of the Fox Hills Sandstone in subsurface mapping. In this report the top of the uppermost thick sandstone is considered to be the top of the Laramie-Fox Hills aquifer without regard to the formational designation (fig. 5).

The upper member of the Laramie Formation consists of 300 to 900 ft of interlayered fresh- to brackish-water shale and siltstone, lignitic shale, coal seams, and thin, lenticular beds of fine- to medium-grained sandstone. This part of the Laramie Formation is commonly 300 to 400 ft thick in the central Denver Basin and thickens to about 900 ft in the northern part of the Denver Basin. (The structural depression in the Cretaceous rocks north of Greeley is referred to in this report as the northern part of the Denver Basin. The depression south of Greeley is called the central Denver Basin.) A sandstone sequence overlying the Laramie Formation has been mapped as the Arapahoe Formation to the south of Greeley (log 2, fig. 5), but not to the north (log 1, fig. 5), although geophysical well logs in this area also appear to show the presence of this unit north of Greeley.

The Trinidad Sandstone and the Vermejo Formation of the Raton Basin stratigraphically correlate with the Fox Hills Sandstone and Laramie Formation of the Denver Basin and are considered here to form a dissected remnant of the Laramie-Fox Hills aquifer. Like the Fox Hills Sandstone, the Trinidad Sandstone conformably overlies the Pierre Shale, but it does not contain the predominantly shaley lower member that is common in the Fox Hills Sandstone. The Trinidad Sandstone is a fine- to medium-grained, buff to gray, moderate- to well-cemented sandstone 100 to 300 ft thick interlayered with minor amounts of shale; it was deposited in marine and littoral environments. The overlying Vermejo Formation consists of interlayed fine- to medium-grained, buff to gray-green sandstone, buff to dark-gray siltstone, dark, lignitic shale, and numerous coalbeds. The formation ranges in thickness from less than 50 ft southeast of Trinidad to more than 500 ft near Spanish Peaks (Johnson and Wood, 1956). Near Walsenburg, shale predominates in the lower part of the Vermejo, and electric logs of wells in this area appear similar to those of the shaley upper member of the Laramie Formation in the Denver Basin (log 3, fig. 5). Near Walsenburg, the top of the aquifer is considered to be within the Vermejo Formation. Elsewhere in the Raton Basin, the Vermejo Formation contains numerous layers of sandstone 5 to 30 ft thick, and shale is less prevalent. In these areas the aquifer likely extends through the Vermejo Formation into the overlying Raton Formation, as indicated by Geldon (1984).

Tertiary and Quaternary erosion has removed the strata that comprise the Laramie-Fox Hills aquifer from all positive areas adjacent to the three basins in which the aquifer is found, and the South Platte River has nearly dissected the aquifer into two parts along the positive area east of Greeley. All three basins are asymmetrical, having steeply dipping to overturned or fault-truncated beds along the western margins and relatively flat-lying beds along the eastern margins (figs. 6 and 7). The basin axes have northerly trends and generally are located within 10 to 20 mi of the western edges of the basins. The altitude of the base of the aquifer ranges from less than 3,800 ft above sea level in the northern Denver Basin, and from less than 3,500 ft in the central Denver and Raton Basins, to 5,000 to 8,000 ft above sea level in the outcrops along the western edges of the basins. The water-yielding formations outcrop or subcrop beneath Quaternary alluvial or eolian deposits in a narrow band along the eastern and western margins of the Raton Basin (fig. 8) and discontinuously along the western margin of the Denver Basin (fig. 9). In other places along the western margin of the Denver Basin, the aquifer is truncated by faults that separate the basin from the Front Range. Extensive outcrops and subcrops in the Denver Basin occur along the eastern margin and in a 10- to 30-mi-wide zone on either side of the South Platte River. Near the axes of the basins, the aquifer is overlain by Upper Cretaceous or Tertiary sedimentary rocks that are as much as 1,500 ft thick near the Colorado-Wyoming border, as much as 2,900 ft thick south of Castle Rock, and as much as 4,000 ft thick north of Spanish Peaks in the Raton Basin. Growth faulting northwest of Denver and intrusion of stocks, dikes, and sills near Spanish Peaks locally have altered the structure and hydrologic continuity of the aquifers. In other areas, the aquifer has been affected little by faulting or volcanism.

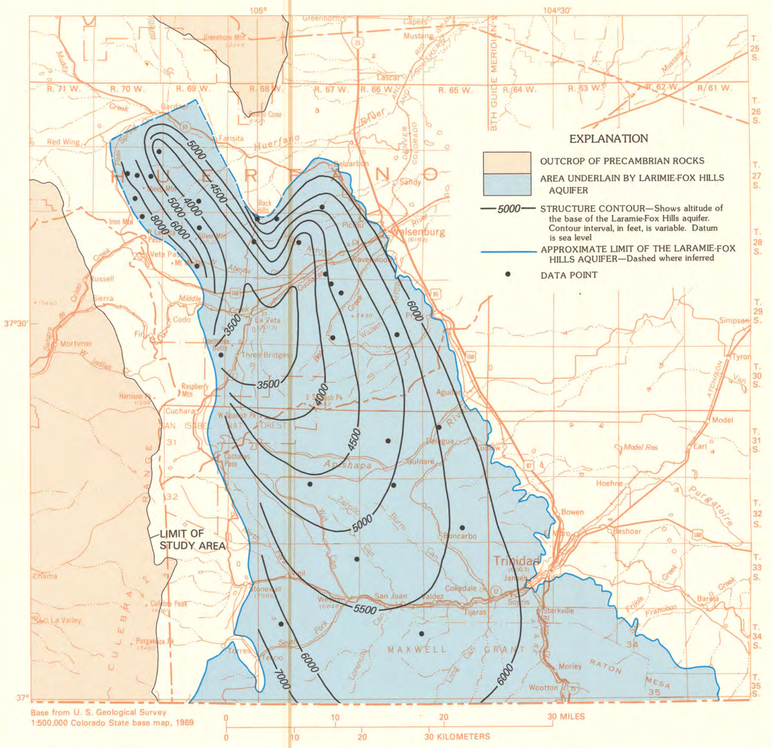

Figure 7.—Altitude and configuration of the base of the Laramie-Fox Hills aquifer in the Raton Basin.

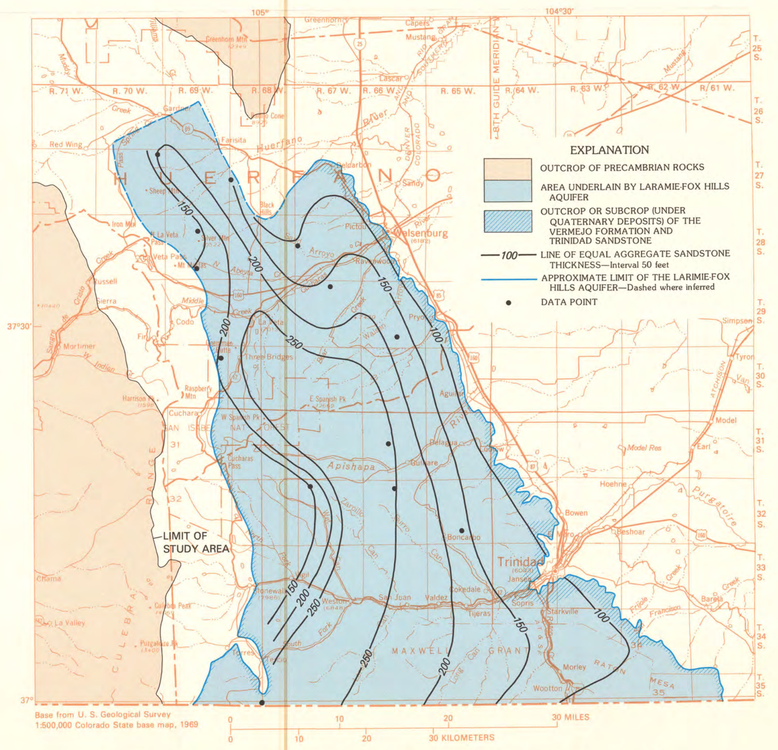

Figure 8.—Aggregate sandstone thickness for the Laramie-Fox Hills aquifer in the Raton Basin.

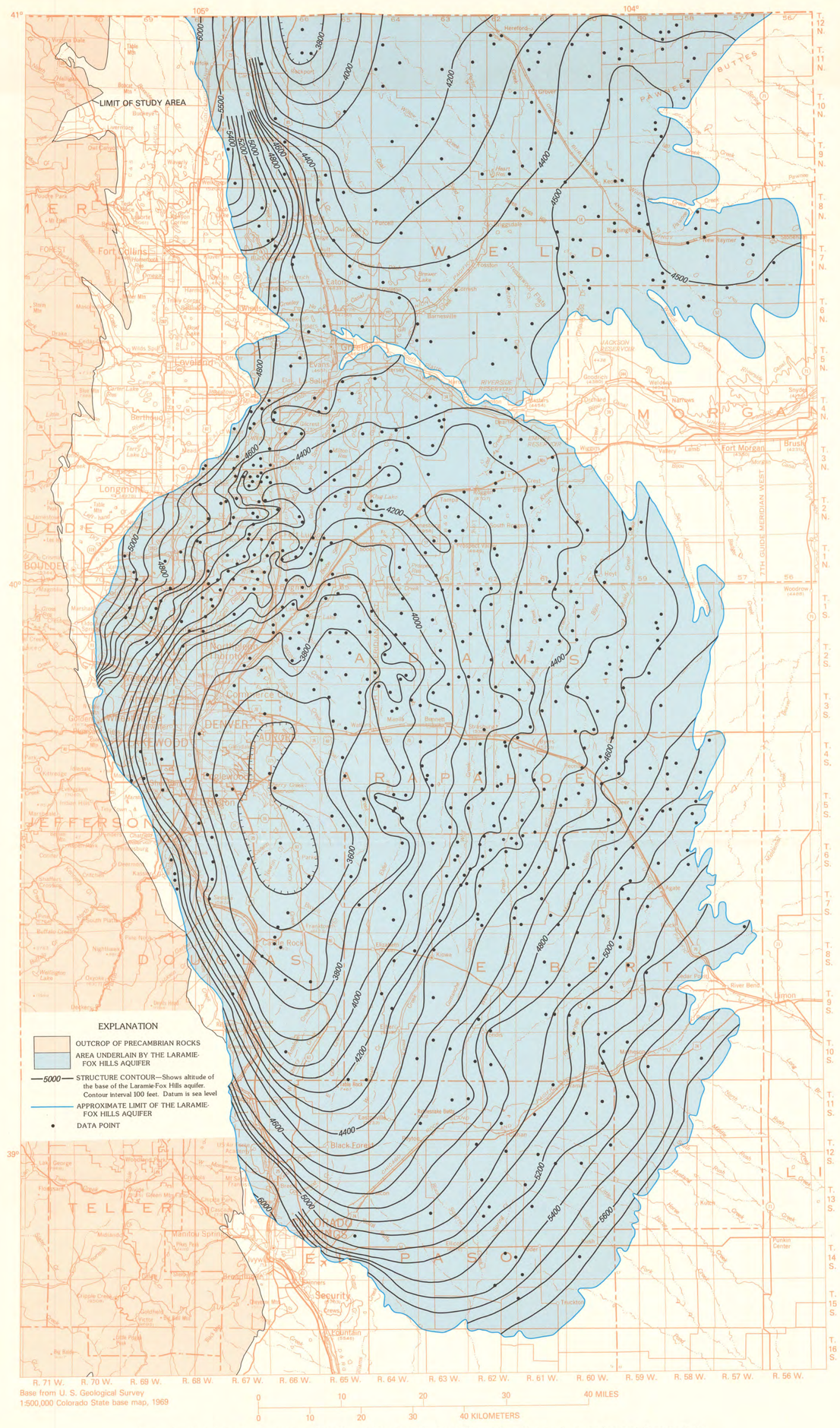

Figure 6.—Altitude and configuration of the base of the Laramie-Fox Hills aquifer in the northern and central Denver Basin.

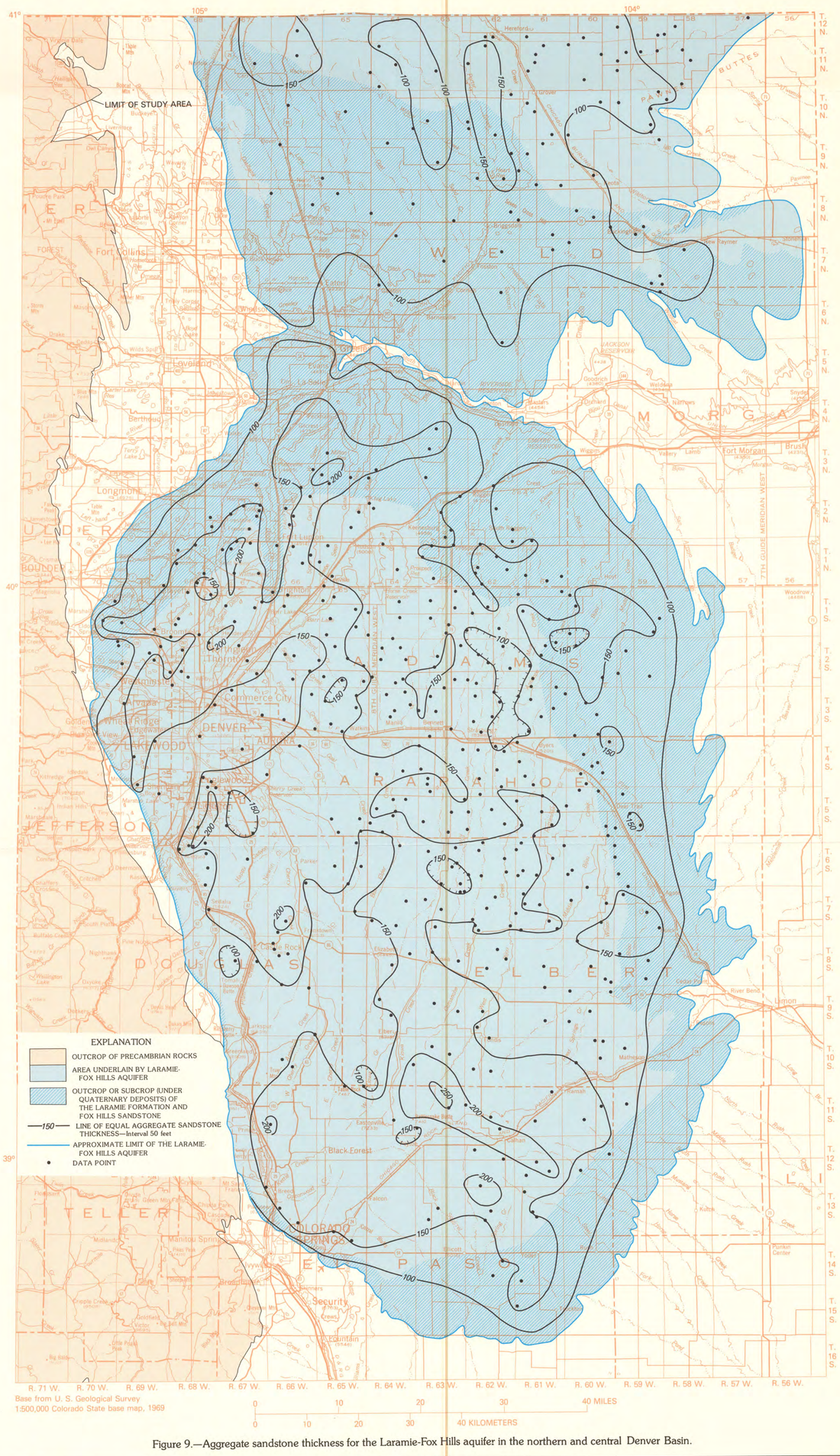

Figure 9.—Aggregate sandstone thickness for the Laramie-Fox Hills aquifer in the northern and central Denver Basin.

GEOLOGY AND HYDROLOGY OF THE DEEP BEDROCK AQUIFERS IN EASTERN COLORADO

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