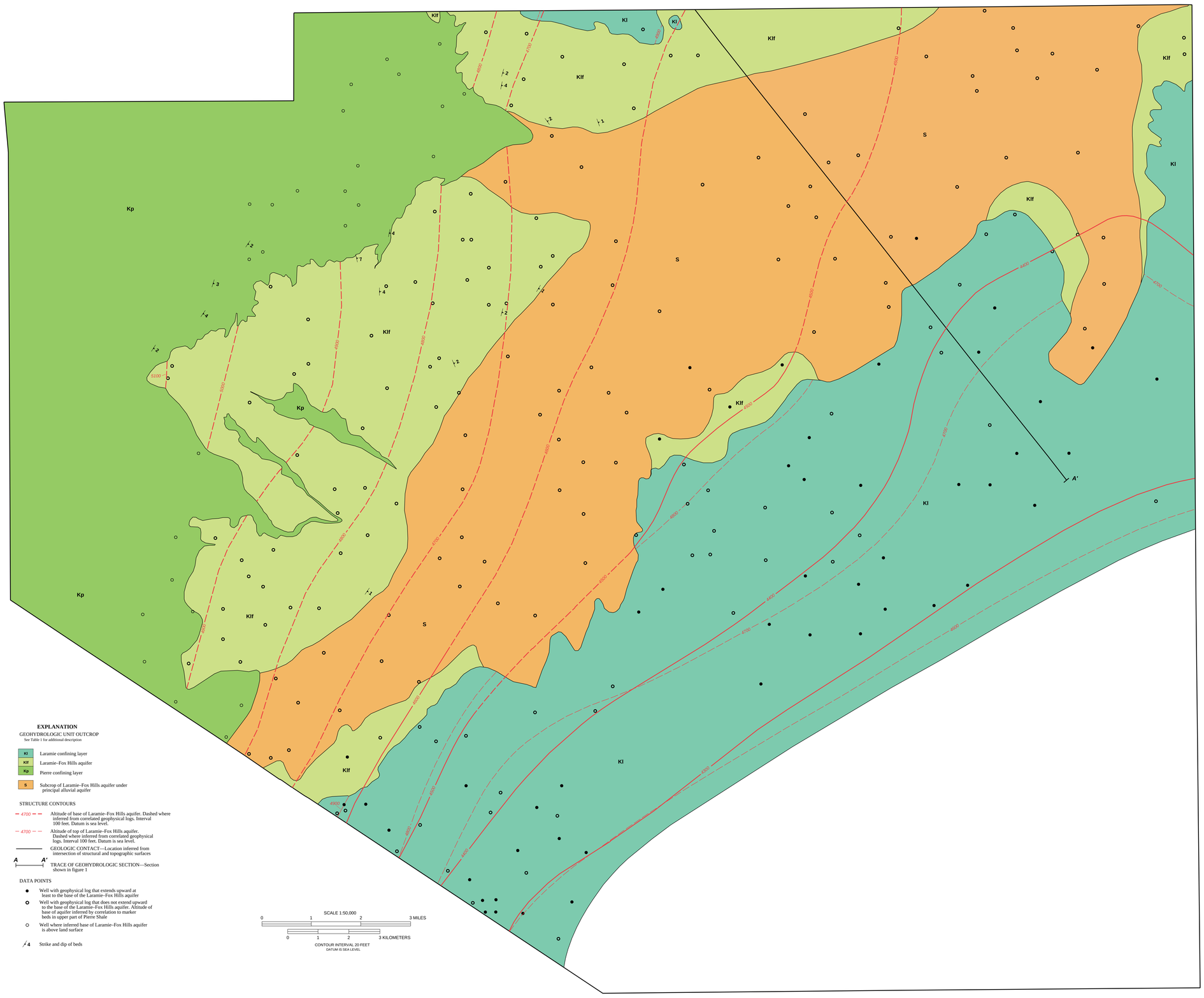


Base from U.S. Geological Survey
1:50,000 County map for Weld County

FIGURE 3. Structure, outcrop, and subcrop of the Laramie–Fox Hills aquifer in the Platteville area

Structure

The structure of the base of the Laramie–Fox Hills aquifer north of Boulder was mapped using data from geophysical logs primarily from oil and gas wells. In the eastern part of the area, the Laramie–Fox Hills aquifer is deep enough to be fully represented in the geophysical logs recorded below the surface casing in the wells. Farther to the west near the outcrop, the Laramie–Fox Hills aquifer is shallower and typically is present within cased intervals of the wells. In these areas, the depth to the base of the aquifer was inferred by correlation to marker beds in the Pierre Shale at horizons below the surface casing and at depths 10 to 700 feet below the base of the aquifer. The top of the D sandstone member of the Pierre Shale (Kiteley, 1978) served as the principal marker bed.

Structure mapping of the base of the Laramie–Fox Hills aquifer (figs. 2, 3, and 4) indicates a gentle eastward dip with a broad low synclinal arch near Greeley and steepening dips to the west associated with the Laramide uplift of the Rocky Mountains. Few faults have been mapped in the Laramie–Fox Hills aquifer northeast of Longmont, and any vertical offset across unmapped faults in this area may be small in comparison to the 100-foot structure-contour interval. The more steeply dipping beds near Nunn (northern part of fig. 2) may be associated with vertical offset on unmapped faults.

Extensive faulting between Boulder and Firestone (fig. 4) has been documented from surficial mapping and from mine maps of the Boulder–Weld coal field (Spencer, 1961, 1986; Colton and Lowrie, 1973; Myers and others, 1975). As much as 500 feet of vertical offset on some faults has been reported (Spencer, 1961), but most faults have less than 200 feet of offset. Primarily dip-slip movement on the faults has broken the Laramie–Fox Hills aquifer into a series of northeast-trending narrow horst and graben blocks. Where fault offset has disrupted the lateral continuity of the aquifer, large ground-water-level differences have been noted between adjacent fault blocks (Schneider, 1980). It is probable that many other faults also exist in this area but are unrecognized because they were not encountered during mining and are not visible in outcrop.

Detailed mapping of the structure of the base of the Laramie–Fox Hills aquifer in individual fault blocks generally was not feasible in spite of the dense distribution of geophysical log data east of Boulder. The structure contours shown in figure 4 represent the trend of the structure and are drawn without offset at faults. Users who need information on the altitude or depth of the base of the Laramie–Fox Hills aquifer at a specific site in the Boulder–Weld coal field are referred to the data base to find well data that are close to their site and within the same fault block. Some investigators (Spencer, 1961, for example) have mapped Pierre Shale outcrops in some horst blocks, but mine maps and other geologic mapping contradict this interpretation, and the bedrock geology of the fault blocks in general remains poorly defined and largely concealed by overburden.

The structure of the top of the Laramie–Fox Hills aquifer was mapped (figs. 2, 3, and 4) using geophysical log data from oil and gas wells, from water wells, and, in the Boulder–Weld coal field, from coal-exploration test holes. In the eastern part of the area north of Boulder, the top of the aquifer generally is deep enough to be recorded on geophysical logs from oil and gas wells. To the west, the top of the aquifer may be obscured by surface casing, in which case the aquifer top was inferred from the altitude of the base of the aquifer and available aquifer-thickness data.

In most of the area north of Boulder, the thickness of the Laramie–Fox Hills aquifer is relatively uniform over large areas, ranging from about 260 to 320 feet. However, east of Frederick, thick sandstones in what may be delta-plain paleochannels in the Laramie section of the aquifer causes aquifer thickness to range from about 200 to 300 feet within as little as one-half mile (fig. 5). The inferred paleochannels have a general east-west alignment and are separated by thinner areas with minimal sandstone thickness in the Laramie section.

In southeastern Boulder County (fig. 4), a westward thickening in the lower part of the Fox Hills Sandstone is produced by a facies change in this interval. Fine-grained deposits in the upper Pierre Shale in eastern Boulder County and Adams County become increasingly interbedded with sandstone to the west, and these deposits become predominately sandstone to the west of the facies line shown in figures 4 and 6 where the sandstones correlate with the Fox Hills Sandstone. As a result, the Laramie–Fox Hills aquifer thickens from about 200 feet east of the line approximating this facies change to as much as 400 feet west of the line. Weimer (1973) reported more than 340 feet of Fox Hills Sandstone in a core hole in T.1N., R.69W., sec. 7 about 6 miles northeast of Boulder.

South of Boulder, large vertical offset on the Golden Fault and other nearby reverse and thrust faults have produced steeply dipping to overturned beds in the Denver Basin aquifers and older Paleozoic and Mesozoic rocks. The steeply dipping beds generally are nearly horizontal a short distance east of the outcrop (figs. 7 and 8). As a result, the Laramie–Fox Hills aquifer may be overlain by the shallower Arapahoe, Denver, or Dawson aquifers near the Laramie–Fox Hills outcrop, and well data for the deeply buried Laramie–Fox Hills aquifer may be too sparse to enable structure contouring. Greater availability of data for the basal Arapahoe aquifer enabled contouring of this unit in areas away from the steeply dipping beds.

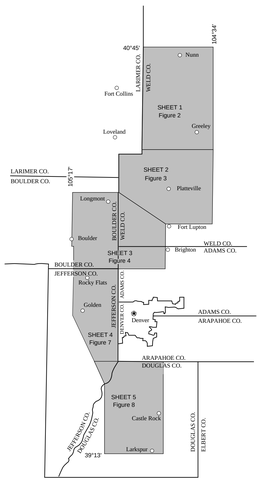
Geophysical logs and construction reports, primarily for water wells located in approximately 25 townships along the western margin of the Denver Basin, were reviewed in an effort to better define the contact of the Arapahoe aquifer with the underlying Laramie Formation in the area between Rocky Flats on the north (fig. 7) and Larkspur on the south (fig. 8). About 120 geophysical logs were found suitable for use in structural mapping.

In northern Jefferson County, the Arapahoe aquifer is more fine grained and less permeable than the aquifer in most other parts of the Denver Basin. Between Rocky Flats and Leyden (fig. 7), the aquifer is primarily shale and can be divided into three members. The upper member, which is poorly exposed in outcrop and erosionally thinned, is 0 to 300 feet thick, and consists of shale and thin, interbedded siltstone and fine sandstone. The middle member, consisting of 150 to 250 feet of shale, is difficult to differentiate from shales in the upper Laramie Formation. The lower member consists of 50 to 100 feet of shale and interbedded siltstone and sandstone but also is difficult to differentiate on some geophysical logs. Farther to the east, all three members become more coarse grained, shales in the middle member become interbedded with sandstone, and the upper and lower members coarsen and thicken to form a more uniformly permeable aquifer.

The base of the Arapahoe aquifer in the greater Denver Basin correlates with the base of the lower shale, siltstone, and sandstone member in the Rocky Flats–Leyden area. However, the base of the Arapahoe aquifer is poorly defined in the Rocky Flats–Leyden area because the lower member cannot be consistently identified in geophysical logs. As a result, the outcrop and structure of the base of the aquifer are poorly defined in the Rocky Flats–Leyden area. A better definition of the Arapahoe aquifer outcrop and structure can be produced from structural contouring on the base of the upper member, which is more consistently identifiable. There are few water-yielding beds in the Arapahoe Formation below the upper member, so the base of the upper member is the practical if not the stratigraphic base of the aquifer in the Rocky Flats–Leyden area. The structure of the base of the upper member (fig. 7) generally is consistent with the Arapahoe Formation geologic mapping and lithologic investigations prepared for Rocky Flats as part of the geologic characterization of the site (EG&G Rocky Flats, 1995).

In the remainder of the area south of Boulder, the base of the Arapahoe aquifer is defined as the base of the lower shale, siltstone, and sandstone member or as the base of the first sandstone bed greater than 10 feet thick above the shallowest coal in the Laramie Formation. In some cases, multiple thin sandstones are present immediately below the thick sandstone and are included as part of the Arapahoe aquifer. The interval between the base of the Arapahoe aquifer and the top of the Laramie–Fox Hills aquifer (Laramie confining layer, table 1) varies in thickness across the study area from about 400 feet to as much as 800 feet in the Rocky Flats–Leyden area, where the lower Arapahoe is primarily shale.

The base of the Arapahoe aquifer generally dips steeply eastward near the basin-bounding faults and becomes more flat lying farther to the east. The aquifer is offset across several faults in Douglas County (fig. 8) where vertical displacements of as much as several hundred feet may be present. Complex fault patterns and lack of well data make detailed structural relations difficult to discern in this area. Near Rocky Flats and near Lakewood (fig. 7), the base of the Arapahoe aquifer is deformed into broad northwest-trending anticlinal and synclinal structures. A reverse fault may be present along the western flank of the anticline near Rocky Flats, but the predominant feature is that of compressional folds aligned approximately orthogonal to the predominant northeast trend of faulting in the Boulder–Weld coal field.



STRUCTURE, OUTCROP, AND SUBCROP OF THE BEDROCK AQUIFERS ALONG THE WESTERN MARGIN OF THE DENVER BASIN, COLORADO

by
S.G. Robson, George Van Slyke, and Glenn Graham

1998

Cyan Magenta Yellow Black