DRAINAGE CONTROLS IN THE AUSTIN CHALK CUESTA AREA OF DALLAS, TEXAS*

E. F. Blakemore, Jr.

The Austin chalk cuesta is a prominent topographic feature which trends northeast across central Texas from Austin through Waco and Dallas. The escarpment is formed through differential erosion of beds at the contact between the Austin chalk and Eagle Ford shale, the overlying chalk forming the cuesta. The area described in this paper is situated 6 miles west of Dallas, south of the Trinity River Cross Valley. Relief in this area is approximately 100 feet.

Cedar and scrub oak thrive upon the loose rocky soil of the escarpment. In the eastern portion of the area, trees are scarce and generally confined to stream valleys where rocky soils are developed. Mesquite and cactus are confined to the western part of the area, which is underlain by the Eagle Ford shale. Thus the dip slope of the cuesta, the cuesta front, and the lowland developed on the shale are apparent on the aerial mosaic, chiefly because of differences in vegetation.

The portion of the Austin cuesta included in this area has been sculptured by streams whose development has been largely controlled by joints and faults. Faulting, the dominant control, has influenced development of longitudinal valleys, whereas jointing has controlled the development of tributary side valleys trending around N 65° E.

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Stratigraphy

The Austin chalk in this area occurs in beds from a few inches to eight or ten feet thick, separated by thin parting of calcareous shale. Where massive and fresh, the chalk is grey, fine grained rock, which turns white on weathering. The lower 60 feet of the chalk is exposed. In this area the Eagle Ford is a dark grey shale, with interbedded flags varying in thickness from six inches to one foot.

Configuration of the Escarpment

When shown on small scale maps the cuesta presents a smooth, west face with few irregularities. However, when mapped on a large scale as on the mosaic (Fig. 1) irregularities become not only numerous and prominent but the dominant feature of the escarpment. On the mosaic, the bold face of the cuesta is outlined by trees growing just below the crest. Two principal types of irregularities are at once apparent: (1) the lobes or tongues of chalk separated by valleys whose longitudinal axes trend north or a few degrees west of north; and (2) indentures making gullies whose longitudinal axes trend plus or minus N 65° E.

Hereafter, the term lobe will be used to designate the long tongues of chalk extending generally N 10° W. Gulleys and valleys that are developed into and cut the face of the escarpment will be called indentures, in order to distinguish them from other gulleys and valleys on the dip slope of the cuesta and on the shale.

The escarpment may be traced on the aerial mosaic. The lobe in the northeastern corner has had its northern end removed through operations of the Trinity Portland Cement Co., whose quarry may be seen on the aerial mosaic. Immediately to the west are three prominent lobes separated from one another by deep indentures. The axes of the indentures and lobes are N 10° W. Upon the lobes themselves are several smaller indentures with axes N 65° E and a few with axes the same as the large indentures, N 10° W. Two smaller lobes not so readily apparent upon the mosaic, due partly to their size and partly to the absence of trees upon their flanks, are found just north of the intersection of the contact and the Ft. Worth Pike. These are readily discernible upon the map.

South from the Ft. Worth Pike, immediately east of the Cement Company spur of the Santa Fe Railroad, the cuesta front is dominated largely by two indentures, one facing north and one facing south. The valley thus formed has an axis trending N 10° W. Three indentures with axes N 65° E are developed east from this valley.

West of this valley and traversed by Jefferson Avenue and the Ft. Worth Interurban is another large lobe terminated by four small lobes. At the extreme southwest another large indenture is the dominant feature. Further west the appearance of the cuesta face is similar to that shown in the mosaic although topographic expression of structural control is not so evident.

Stream Patterns

An examination of the mosaic and map shows that obsequent streams developed on the face of the cuesta have two dominant directions, N 10° W and N 65° E. Several exceptions to this general statement will be considered later.

The streams that drain onto the Eagle Ford shale from the escarpment flow northward in conformity with the general slope of the area. These streams meander upon the shale, but not on the chalk. The meanders that were observed on the chalk were right angle bends controlled by master jonts.

Structure

The Austin chalk and Eagle Ford shale in this area dip gently to the southeast at fifty feet to the mile. Folds of extremely low amplitude are common in the Austin and are usually terminated by high angle faults of small displacement. Such gentle folds were not observed in the Eagle Ford although they may be present. Bedding in the Eagle Ford is indistinct, and good exposures, such as appear in the Austin which is quarried locally for cement and road material, is unavailable.

Fig. 1. Aerial mosaic of the Austin Chalk Cuesta Area of Dallas, Texas.

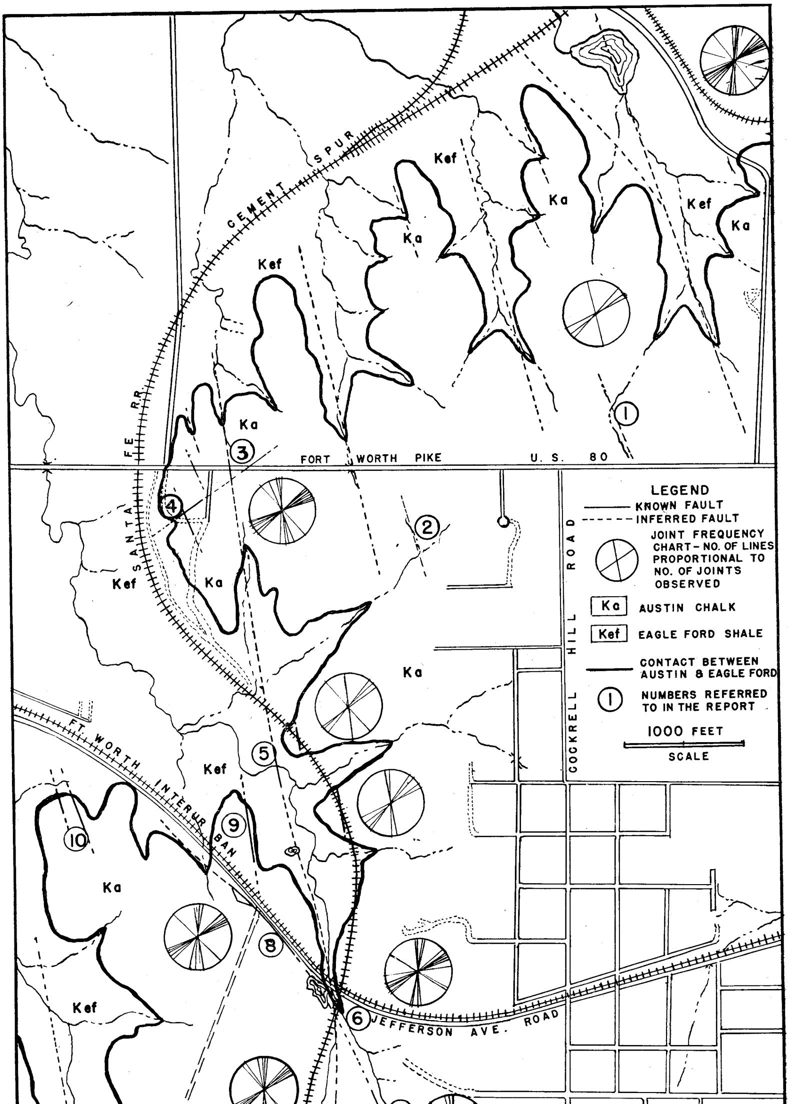

Fig. 2. Map of Austin Chalk Cuesta Area on same scale as aerial mosaic (Fig. 1).

The gently dipping chalk and shale are traversed by a number of faults and joints. These are especially noticeable in the chalk although close examination reveals their presence in the shale. Joints with N 65° E strike are easily seen in flaggy members of the shale.

The faulting in this area may be related to the Balcones system. A zone of faulting, which has been determined but not yet identified as an extension of the Balcones system, lies about twenty miles east of this area. Sellards and Baker have said of the Balcones system in Northeast Texas:

> "This zone (Balcones) has not been definitely recognized north of McLennan or Hill Counties. However, Barton reports that he has traced a zone of much fracturing and minor faulting northward from Waco passing near Italy in Ellis County, east of Whiterock Reservoir in Dallas County, and near McKinney in Collin County. (Letters of March 9 and 27, 1934.) . . . Small faulting is not uncommon over a wide belt north of Waco. That noted by Hill between Whitney and Aquilla in Hill County and by Brantly near Venus as the Johnson-Ellis County line is possibly west of the principal Balcones zone."

The west Dallas area is not as far west as Venus, nor is it as far east as the principal zone of Balcones faulting. However, the general trend of faults in the Dallas area is the same as that of the Balcones system, and the proximity of these two zones suggests that they are related.

Faulting may be attributed to compaction of the underlying shale, or to slumping along the cuesta front, though faulting in response to this weakening would be localized and of small consequence.

Faults may be single or closely grouped in zones of considerable fracture. The predominant strike of these fault zones is N 10° W. Isolated faults are of the normal type with small displacement and a strike either of the master joints or major fault zones.

A typical fault zone exposed in a quarry in the area shows clearly the principal zone of faulting with its grid of small faults and joints developing a zone of weakness in the chalk easily attacked by erosion. Curving outward from the principal zone are several branching faults that may explain instances in other areas where vertical displacement ceases and jointing begins.

Faults of this type showing a complex zone of faulting were observed only with an approximately N 10° W strike. Numerous faults with a strike paralleling that of the principal joint system were observed but none with a complex zone of faulting as the north trending faults. Several small faults were observed without any apparent relation to the principal strike of the faults but as they may be considered a part of the curved branching faults, they are not a discordant factor.

Curved jointing was observed also in the chalk, some of the curved joints making complete noses connecting sets of parallel joints. No explanation of curved jointing will be attempted in this report but such phenomena are the logical explanation for isolated joints that do not conform to the two general strike systems.

Joints and Faults Controlling Stream Development

The escarpment in general faces west but in the Dallas area a portion faces north toward the Trinity River which cuts the cuesta at this point. This north-facing escarpment developed by the river permits optimum development of fault-controlled streams. Along the west-facing scarp, obsequent streams must first intersect fault zones before the faults can exercise a control in stream development.

The three prominent lobes and indentures north of the Ft. Worth Pike are the outstanding examples of sculpture of the escarpment by streams developed along fault zones. As the face of the cuesta retreats, obsequent streams develop headwardly along the fault zones. The size of these obsequent valleys depends not only upon the size of the fault controlling it, but also upon the drainage captured on the dip slope of the cuesta. This factor would tend to aid the north flowing obsequent streams as they have the opportunity to intersect consequent streams at right angles, and thereby capture more drainage.

The tributary streams which cut back into the lobes develop along joints. As can be seen from the joint frequency charts (Fig. 2), the master set has an average strike of N 65° E. The indentures into the lobes have axes which roughly parallel this strike. Streams from the west sides of the indentures follow this strike more closely than those from the east because they are already flowing down the slope while the eastern tributaries would be forced to flow up the main valley should they maintain the same direction after leaving the chalk.

These main lobes are cut into smaller lobes at their extremities. This is due to stream action along fault zones, the streams having a smaller drainage area than the main drainage systems. At point 1 on the map, a tributary stream may be seen turning from N 65° E to N 10° W upon intersection with a fault zone. An indenture controlled by this same fault may be seen at the extremity of this lobe.

East of the Santa Fe Railroad and south of the Ft. Worth Pike is the large valley whose axis is N 10° W. The valley is drained by a stream entering at its center and having a tributary both north and south. In this instance, the stream gullied headward in an easterly direction into the escarpment until it intersected the fault zone. It then sent tributaries both north and south along the fault zone, still eroding headward along the joint strike. At the head of one of these joint tributaries (2 on the map) it again turns up a fault zone. The southern tributary cut headward along the fault zone until it beheaded the stream seen in the southeast portion of the map. After capturing this drainage the stream having the greatest volume became the dominant stream of the area.

The upper portion of the stream divided seemingly in response to a branching fault of considerable magnitude. The fault controlling the valley is plainly visible at points 3, 5, 6, 7 on the map. At point 5, the fault is seen in the Eagle Ford with small drag folds in the fault zone. Jointing controls all of the gullies of the south tributary. At the point 7 on the map these small gullies can be seen leading off N 65° E. In the field this joint control is apparent in the exposed chalk.

Though in a number of instances stream development along faults and joints can be recognized in the field, more often weathering and stream deposition has obscured the faults at the point where the larger streams cross the contact of the shale and chalk. However, many small indentures upon the lobes show faults in their center and give proof as to their origin. These may be found at points 4, 9, 10. At point 7 is one of the three excellent examples in this area of right angle meandering in response to master jointing. The stream bed is on exposed bed rock and the master joint is plainly visible with a spring issuing at its intersection with the stream.

The lobe immediately west of the Santa Fe Railroad and traversed by the Ft. Worth Interurban has four small lobes at its north end. Here numerous good examples of indenturing due to faulting may be found. The faults are distinguishable by vein fillings of calcite. Although not numerous these fillings may be found projecting a few inches above the bottom of small beginning indentures. The second lobe to the west has been cut off through a zone of weakness along a branching fault. This fault is plainly visible in the road cut directly east of the lobe (point 8 on map).

There are a few indentures on the lobes north of the Ft. Worth Pike with axes trending about N 40° W. As can be seen in the joint frequency charts there are a number of joints with this strike suggesting possibly these indentures are controlled by this set. The writer does not feel sufficient evidence is present in the field to justify this conclusion and prefers to consider the indentures exceptions to the general controlled drainage.

Conclusions

Jointing and faulting as a control of stream development has long been recognized. However, in the literature, the majority of cases are cited as incidental observations.

Faulting and jointing in the Dallas area, where the Trinity River has cut its valley through the Austin chalk cuesta, has controlled the drainage patterns on the face of the escarpment. Faults trending N 10° W have exerted the dominant control, developing similar lobes and indentures. Jointing has played the lesser role of controlling tributary streams aligned N 65° E. Several exceptions are present but the control is the dominant feature and clearly recognizable in the field.

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