

throughout. Although no fault plane can now be seen, spatial considerations indicate that the valley was eroded (in Permian time) along a branch of the Blue Creek Canyon Fault (fig. 154).

Fold Patterns

West of the Blue Creek Canyon Fault, within the Lawtonka Graben, Ordovician members of the Arbuckle Group are comprehensively folded (Barthelman, 1968; Babaei, 1980). Fold trends throughout most of the graben are N. 50° W. Anomalous trends occur adjacent to the Blue Creek Canyon Fault (see below) and in the southwestern part of the graben, where the Saddle Mountain Syncline bends from N. 40° W. to N. 70° E. (Barthelman, 1968). Folding is present in the Blue Creek Horst but is less intense than in the graben (Harlton, 1951, 1963; Brookby, 1969); in general, fold trends are similar to the dominant trend in the graben.

Close to Blue Creek Canyon, two orders of fold size are present: major first-order folds have amplitudes of 600 to 3,000 ft; minor second-order folds have amplitudes of 5 to 30 ft. First-order folds trend N. 20° W. adjacent to the Blue Creek Canyon Fault, but tend to become more westerly (N. 50° W.) in the western part of the area. All folds plunge to the northwest at angles of 18° to 32° (fig. 154).

In the vicinity of the Blue Creek Canyon Fault, first-order folds are asymmetrical, with the steeper (and more disturbed) limb to the east (fig. 60). Immediately adjacent to the fault, some beds on the downthrown side are overturned and generally dip more than 60°.

Fold types include parallel folds and similar folds, with the latter type usually associated with the tighter, closed folds. The larger folds generally tend to parallel one another. Measurements of bed-thickness variation in similar folds (fig. 61) indicate thickness changes of 2:1 to 4:1 (Babaei, 1980). Some folds show disharmony as a consequence of parallel form. An *en-echelon* fold pattern is present in the first-order folds. Because of the consistent plunge of folds in the area, this *en-echelon* pattern can be seen clearly in both lateral and vertical dimensions (figs. 62, 63). Structural terraces are developed in the slack areas between such *en-echelon* folds.

Minor second-order folds (figs. 61, 64) are more variable in orientation than their major folds. They are developed in two principal positions relative to major first-order-fold geometry: in the hinge zones of first-order folds, and in the slack areas between *en-echelon* folds.

In areas close to the Blue Creek Canyon Fault, where folds are closed with steep limbs, some minor-fold axes show cleavage. This cleavage involves recrystallization of calcite from compression in well-defined cleavage planes perpendicular to principal stress (fig. 156). In addition, quartz grains in limestones generally are cataclastically shattered by tension joints normal to compressional stress (fig. 65); calcite fragments (for example, pellets) show con-



Figure 60. View northward, showing trace of Blue Creek Canyon Fault following line of tree-filled gully. East (right) of fault are Cambrian formations on western limb of hanging-wall anticline; this limb is greatly disturbed by small, east-trending faults. West of fault are north-plunging folds in Ordovician Cool Creek Formation; eastern limb of syncline closest to fault has been partly overridden by fault movement. F1, F2, F3: lower, middle, and upper members of Fort Sill Formation; S, Signal Mountain Formation; C, Cool Creek Formation.



Figure 61. Similar fold developed in Cool Creek limestone. Fold is a minor second-order syncline plunging steeply northward. Bed X is approximately 2.75 times thicker in hinge zone than it is on limb. Scale shown by quarter (see arrow).



Figure 62. View eastward, showing geometry of first-order folds developed in graben immediately west of Blue Creek Canyon Fault (B). Note how north-plunging anticline (Z) bifurcates, "sprouting" two anticlines (X and Y) at a higher structural level. Fold X becomes major structure seen in figure 161 when traced northwestward. Spatially above sharp axis of fold Z, a structural terrace (U) (or "broad-bottomed" syncline) develops to north. R, Carlton Rhyolite; C, Cambrian rocks of hanging-wall anticline.