GEOLOGY OF THE TURNER FALLS AREA, WITH EMPHASIS ON THE COLLINGS RANCH CONGLOMERATE, ARBUCKLE MOUNTAINS, OKLAHOMA

By

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"I am the vine, you are the branches; he who abides in Me, and I in him, he bears much fruit; for apart from Me you can do nothing." John 15 : 5 (NAS)

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CHAPTER I

INTRODUCTION

Statement of Purpose

The Washita Valley fault zone, one of the major structural features of southern Oklahoma, was formed probably during the rifting stage of the Southern Oklahoma Aulacogen in Late Precambrian to Early Cambrian time. Following the sagging stage of the aulacogen in Cambrian through Mississippian time, the fault was reactivated when the aulacogen reached deformation stage (Wickham, 1978). This deformation is recorded, among other Pennsylvanian geologic features, by the Pennsylvanian Collings Ranch Conglomerate exposed at Turner Falls area of the Arbuckle Mountains (Figure 1).

The purpose of this investigation is primarily reconstruction of the Pennsylvanian tectonic-stratigraphic evolution of the Turner Falls area as recorded in the Collings Ranch Conglomerate. Therefore, this study describes and interprets the structural geology, sedimentary environment, and petrology of the Pennsylvanian Collings Ranch basin and its relationship with the Washita Valley fault zone. The research was undertaken not only to investigate the incompletely examined Collings Ranch basin and the sedimentary rock unit in the basin, the Collings Ranch Conglomerate, but also to add to the overall knowledge of the geology of the Arbuckle Mountains, Oklahoma.

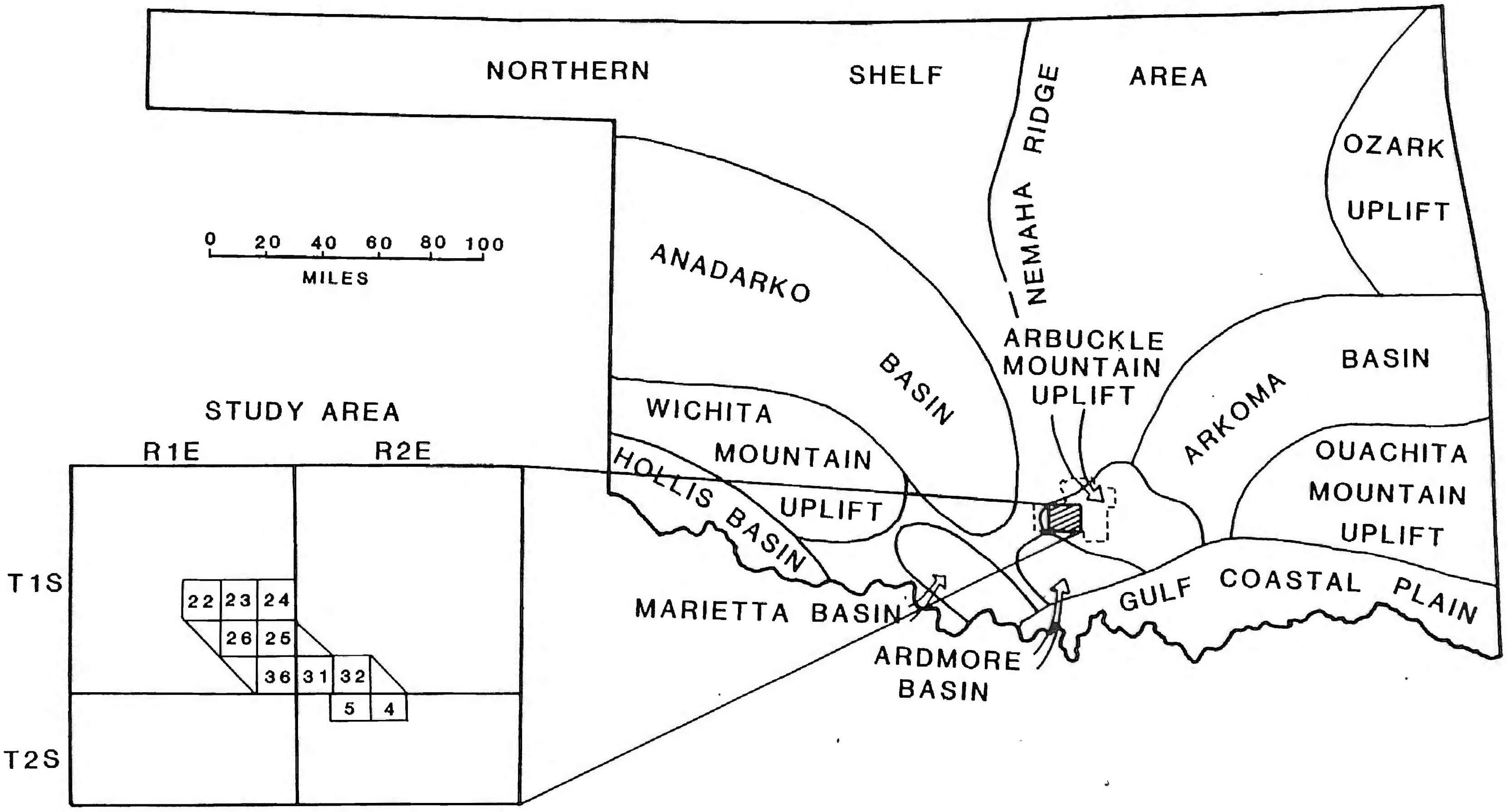

Figure 1. Tectonic map of Oklahoma with location of study area.

Location of the Study Area

The Arbuckle uplift is, roughly, a triangular feature covering approximately 720 square miles in south-central Oklahoma. The study area is situated in west-central Murray County (Figures 1 and 2), near the western edge of the Arbuckle Mountains. The study covers all or portions of Sections 23, 24, 25, 26, 27, 35, and 36, T. 1 S., R. 1 E., Sections 30, 31, and 32, T. 1 S., R. 2 E., and Sections 4 and 5, T. 2 S., R. 2 E. (Figure 1).

Methods of Study

Necessary to the stated objectives of this study, the following is accomplished:

1. Remapping of the Turner Falls area of the Arbuckle Mountains (Plate I) in detail greater than the mapping by Ham et al., (1954).
2. Construction of structural cross-sections through the study area utilizing the geologic map of the Turner Falls area (Plate II).
3. Measurement of imbrications in the conglomerate to infer the direction of paleocurrents (Plate III).
4. Measurement of a detailed stratigraphic section of the Collings Ranch Conglomerate (Figure 17).
5. Identification of the lithology of the fragments in the Collings Ranch Conglomerate, their probable parent formations, probable geologic ages, and probable source areas.
6. Observation and recording of evidence necessary to infer depositional environment of the conglomerate.
7. Careful examination of at least 30 thin-sections from both fragments and matrix of the conglomerate.

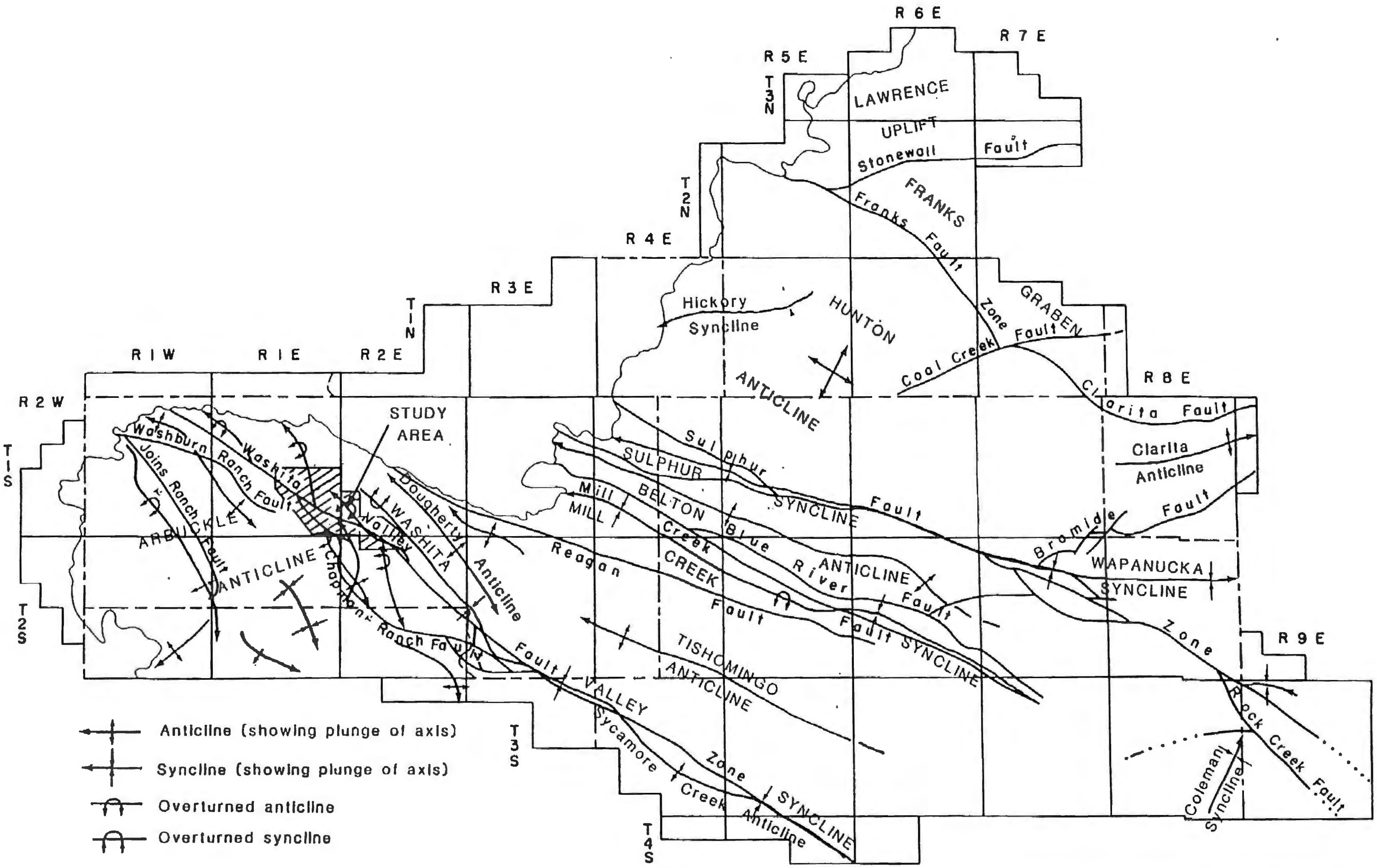

Figure 2. Index map of Arbuckle Mountains showing principal structural features and location of study area (modified after Ham et al., 1954).

Regional Geology

The set of uplifts and basins in southern Oklahoma (Figure 3), is termed the Southern Oklahoma Aulacogen (Hoffman, Dewey, and Burke, 1974). The term was first defined by Soviet geologist Nikolai Schatski as a transverse linear graben-like trough of anomalously thick sediments at a high angle to a major mountain chain.

Burke and Dewey (1973), and Hoffman, Dewey, and Burke (1974), recognized that aulacogens possess distinctive characteristics which separate them from other structures. They explained the origin of aulacogens using the concept of hot spots and and plate tectonics. In the rifting stage of aulacogen formation the lithosphere is expanded and uplifted forming a thermally driven welt over a hot spot. The uplift gives way to fracturing of the crust, and a rift-rift-rift triple-junction develops. The rifting process is accompanied by igneous and volcanic activities. During the stage of subsidence, volcanism ceases and a broad basinal structure is superimposed upon the failed arm of the rift system. Because the failed arm (basin) represents a mechanically weak zone in the lithosphere, it subsides at a faster rate than that of the surrounding craton and receives more sediment. This intercratonic basin accumulates a thick sedimentary sequence consisting of marine carbonates and sandstone overlain by marine and nonmarine shale, sandstone and conglomerate. Vertical adjustments on subsiding fault blocks may produce unconformities during deposition. The deformation stage of an aulacogen is associated with an episode of renewed faulting, folding and coarse-clastic deposition, which is related to a collision of convergent continental margins.

The Southern Oklahoma Aulacogen, like all aulacogens, went through

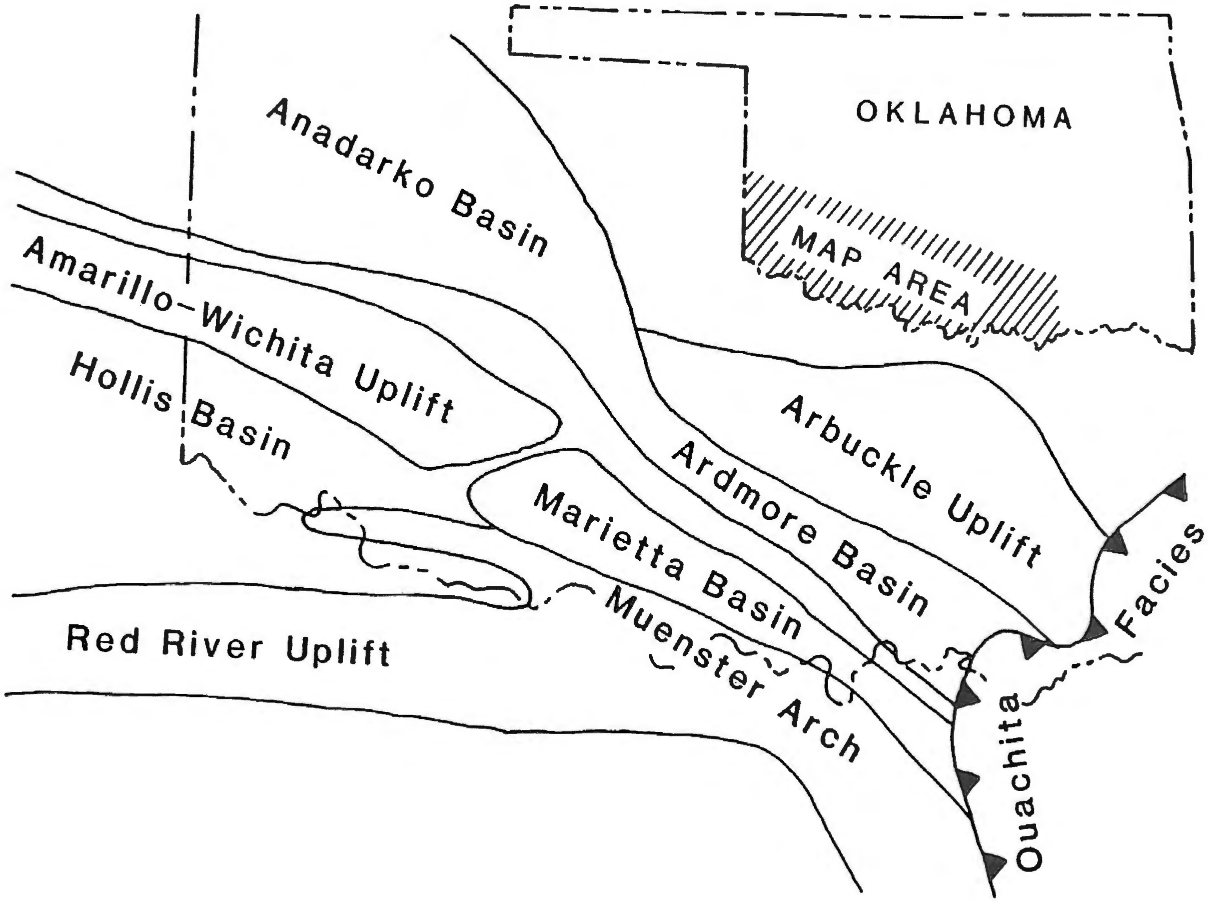

Figure 3. Locations of major uplifts and basins associated with the Southern Oklahoma Aulacogen (from Wickham, 1978).

the three phases of formation (Figure 4). It began sometime during the Late Precambrian and Early Cambrian, probably as a rift valley with steep basement faults bounding the structure (Webster, 1980).

Middle Cambrian volcanism consisted of massive rhyolite extrusions (Carlton Group) at least 4500 ft. (1370 m) thick into a graben south of the Washita Valley fault zone (Pruatt, 1975). The rhyolites appear to be truncated against the fault zone and no rhyolitic rock fragments have been found in the Reagan Sandstone to the north. This suggests that during or after Carlton volcanism, the area north of the fault zone remained structurally and topographically high while the area to the south was low. This interpretation, in turn, demonstrates that the Washita Valley fault zone was an active normal fault during the Middle Cambrian (Pruatt, 1975).

The second stage began in Late Cambrian when the aulacogen became a broad downwarp with the cessation of volcanism and the accumulation of a thick sedimentary sequence. A prolonged period of marine carbonate deposition began with the Upper Cambrian Timbered Hills and Arbuckle Groups and persisted through the Lower Paleozoic to the Middle Devonian Hunton Group (Figure 5). Sandstones of the lower part of the Simpson Group represent the largest single influx of clastics during this time. Sedimentation consisted of dolomite with interbedded sandstone and shale on the craton grading into deeper water limestone with interbedded dolomite, sandstone, and shale toward the aulacogen. The carbonate rocks generally are unbroken by major unconformities, indicating relative stability within the aulacogen during the carbonate deposition. Numerous unconformities recorded in the Hunton Group are most likely a result of minor vertical adjustments of aulacogen-elements during subsidence (Wickham, 1978).

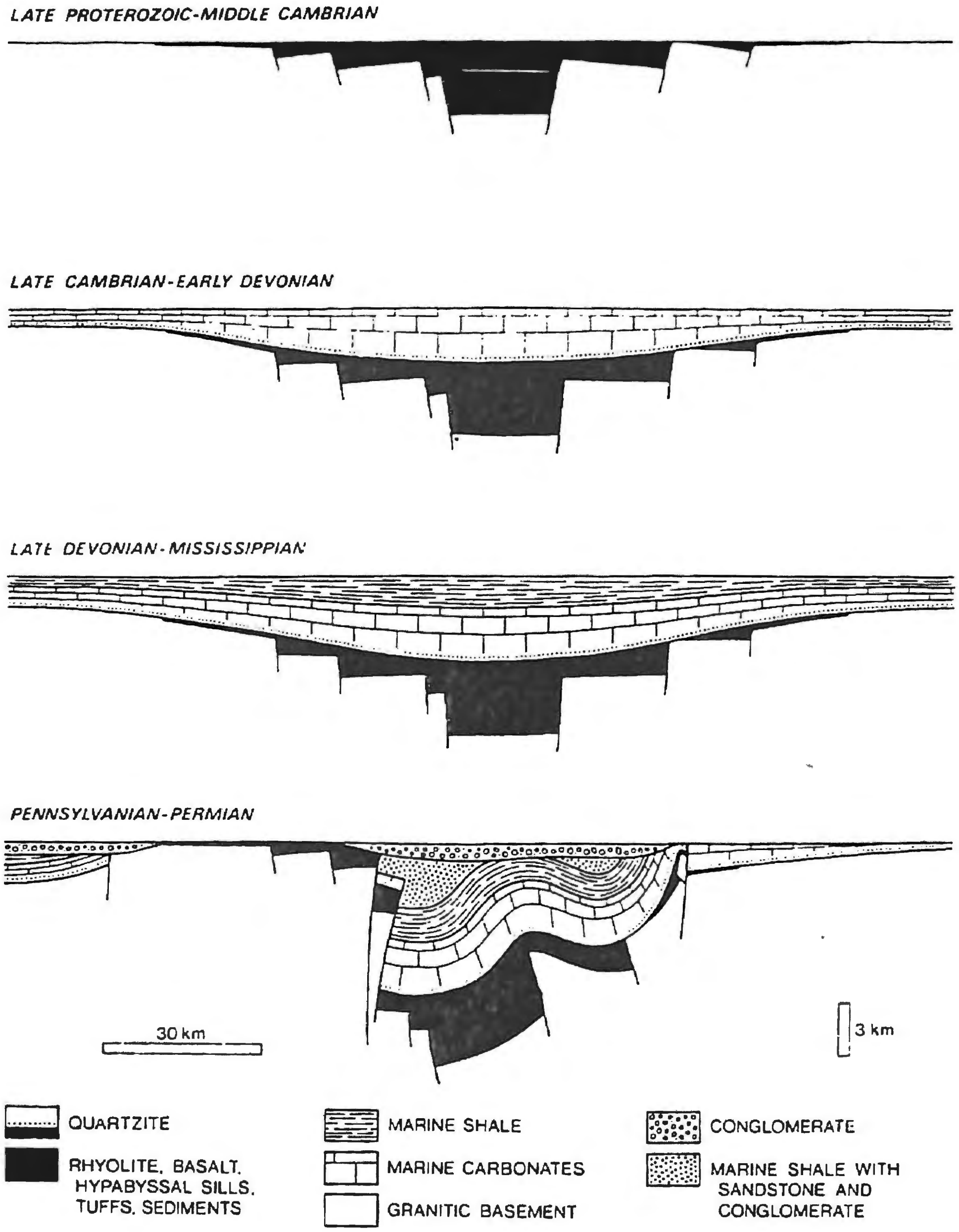

Figure 4. Schematic cross-sections showing evolution of the Southern Oklahoma Aulacogen (from Hoffman, Dewey, and Burke, 1974).

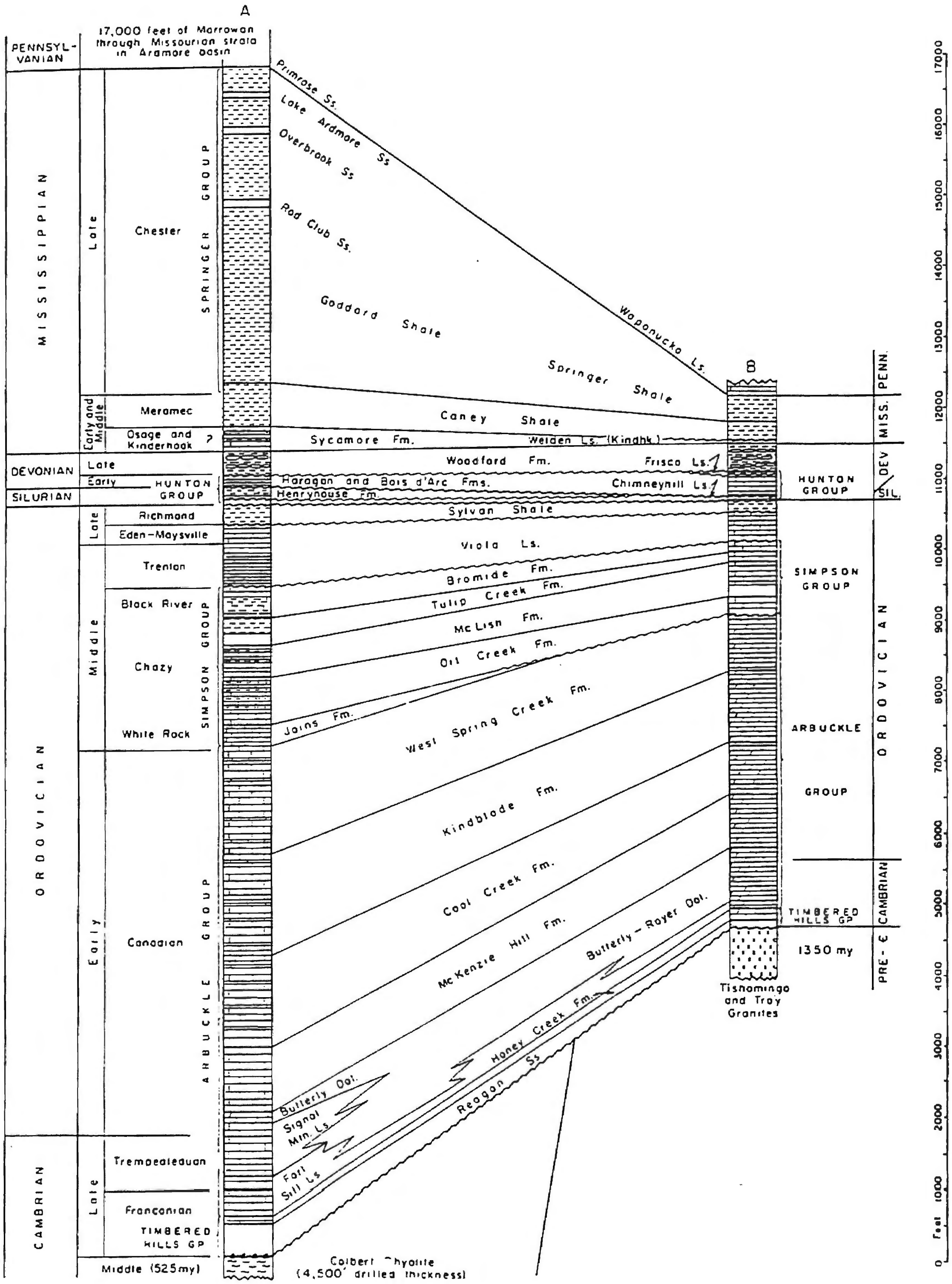

Figure 5. Pre-Pennsylvanian stratigraphic columns in; (A) Arbuckle anticline and Ardmore basin; and (B) craton (from Ham, 1978).

Sedimentation patterns changed radically beginning with the Upper Devonian Woodford Formation and continuing through the Upper Mississippian Springer Formation (Figure 5). This marked the stage in development of the aulacogen which may be related to convergence of two continental margins, which created the Ouachita foldbelt. As a result, the pre-Pennsylvanian strata are 17,000 ft. (5,200 m) thick in the aulacogen and only 7,500 ft. (2,300 m) on the craton (Figure 5), (Wickham et al., 1976).

The Pennsylvanian deformation marked the final stage in development of the aulacogen in southern Oklahoma. This deformation was dominated by displacements along major high-angle fault zones. Many of these faults apparently originated as normal faults at least as long ago as Cambrian time, and were displaced horizontally and vertically in Pennsylvanian time as the Ouachita foldbelt was deformed (Wickham, 1978). Deformation occurred in two major pulses. The Wichita orogeny began in late Morrowan and continued into the Atokan. This phase of the orogeny is characterized by en- echelon folds and faults. The Washita Valley fault, which was the northern boundary of the aulacogen in the Cambrian, may have been reactivated during this time as a strike-slip fault (Tanner, 1967).

The second phase of the deformation stage, the Arbuckle orogeny, began in early Desmoinesian and was recorded by the Deese and Franks conglomerates in the Arbuckle Mountains. These rocks were derived from the first great period of uplift in the Arbuckle Mountains, which began as broad domal folding of the Hunton anticline. These conglomerates were closely folded, locally overturned, and faulted by later Pennsylvanian pulsations of the Arbuckle orogeny (Wickham, 1978).

Major faulting and intense compression continued into Virgilian time. Two orogenic pulses of Virgilian age are made evident by two orogenic conglomerates, derived chiefly from pre-Pennsylvanian limestones of the

Arbuckle anticline. The older one, the focus of this investigation, is the mid-Virgilian Collings Ranch Conglomerate. The younger one is the late Virgilian Vanoss Conglomerate. Slight additional folding and faulting, some of which displaced the Collings Ranch Conglomerate, persisted into Early Permian time.

Previous Investigations

Part 1 - Washita Valley Fault Zone

Geologic investigations in the Arbuckle Mountains began as early as the turn of the century. The first comprehensive investigation was published by Taff (1904). He described the general geology of the area and interpreted the Washita Valley fault as a gravity (normal) fault.

Dott (1934) proposed that overthrusting was the dominant process in the formation of the Arbuckle Mountains. He interpreted the Washita Valley fault zone as a major overthrust dipping to the south. In his interpretation the Arbuckle anticline was thrust over the Tishomingo anticline. Lehman (1945) mapped several erratic blocks and suggested that they might be outliers of an overthrust sheet generated during the late Pennsylvanian folding and uplift of the Arbuckle anticline.

Ham (1951) was the first investigator to conclude that the Washita Valley fault had a strike-slip component much greater than its dip-slip component. He proposed three miles (5 km) of left-lateral movement along the fault based on the offset of two anticlines (whose axial trends were significantly related to the fault trend). Tomlinson (1952) described the Washita Valley fault as a "propeller fault", a fault dipping oppositely on each side of a hinge point. The northwestern segment dips southwestward beneath the Carlton Rhyolite. and the southeastern segment dips northeastward beneath the Tishomingo Granite, where Tomlinson recognized a maximum of 11,000 ft. (3,400 m) of stratigraphic down throw across the fault.

Dunham (1955) mapped the structurally complex area on the north side of the western Arbuckle Mountains and concluded that five distinct tectonic pulsations were recorded there. He noted that the northwest trending en-echelon faults in the Lake Classen area are branches of the Washita Valley fault zone, with most of these faults being strike-slip or oblique-slip faults. Ham (1956) noted that one of the major problems in the structural interpretation of the Arbuckle Mountains concerned the nature of the Washita Valley, Reagan, and Sulphur fault zones. Based on field observations and subsurface data, Ham concluded that both the Washita Valley and Reagan faults have strike-slip components. He proposed that the Tishomingo anticline moved northwestward between the Washita Valley fault and Reagan fault zones.

W. F. Tanner (1963) considered the Arbuckle Mountains to be part of a large right-lateral wrench-fault system extending from the Texas Panhandle through southern Oklahoma. Although he did not mention the Washita Valley fault zone specifically, in this interpretation the fault zone would be considered as one of the right-lateral wrench-faults of the region. The role of pre-existing basement faults in controlling both sedimentation and later deformation in southern Oklahoma was discussed by Ham, Denison, and Merritt (1964). This work suggests a Precambrian origin for these basement faults, which are the normal faults formed in response to the opening stage of the Southern Oklahoma Aulacogen.

J. H. Tanner (1967) studied the subsurface distribution of basal Oil Creek and basal McLish sandstone members (Simpson Group) on both sides of the Washita Valley fault zone. He assumed a quiet tectonic environment for deposition of the sandstone members and concluded that the facies change (i. e., the limit of basal sandstone units) had been offset approximately40 miles (65 km) by left-slip movement along the subsurface extension of the Washita Valley fault.

Walper (1970) considered the Arbuckle Mountains to be part of the Wichita Megashear, a left-lateral wrench zone trending N75^{0}W and extending from central Florida through southern Oklahoma to southern Utah. He identified the Wichita Megashear as one of three large-scale major linaments which dominated the Late Paleozoic-Early Mesozoic geology of the Mid-Continent region.

Booth (1978) studied secondary structures associated with the Washita Valley fault zone, and deduced that en-echelon folds, synthetic and antithetic fractures, horizontal slickensides, and dissimilar stratigraphic relationships along this fault zone were compatible with the wrench fault model of Wilcox, Harding, and Seely (1973). The orientations of these secondary structural features indicate a left-slip sense of displacement, in general agreement with Ham (1951 and 1956), W. F. Tanner (1963), and J. H. Tanner (1967). Carter (1979), using stratigraphic profiles and isopach data from the Hunton Group, suggested that approximately 20 miles (32 km) of left-slip has occurred along the Washita Valley fault zone since Middle Devonian, which is about half of the left-lateral movement proposed by J. H. Tanner (1967). Carter assigns this movement to the Middle to Upper Pennsylvanian (Desmoinesian-Virgilian) orogeny.

Phillips (1983) proposed that folded Ordovician through Mississippian rocks along the north side of the Washita Valley fault system in the western Arbuckles Mountains actually are gravity slides that were emplaced in the Early or Middle Pennsylvanian and folded isoclinally during the Late

Pennsylvanian Arbuckle orogeny. He further proposed that in the Lake Classen area the major slide fault and the Washita Valley fault share the same trace with recognizable seperate movements. Granath and Morgan (1985) responded in disagreement to Phillips (1983). They contend that virtually all of the features that prompted Phillips to redraw cross-sections of the western Arbuckle Mountains are diagnostic of the more conventional and less problematic wrench-fault interpretation of the area. They further suggested that elements of surface geology which Phillips used to support his interpretation are "either equivocal insofar as separating gravity slides from compressional deformation or are problematic enough to be a poor foundation." Finally, they note that Phillips' conclusions raise problems in terms of regional geology and tectonics, -- specifically, the nature of basement-involved faulting in the central and eastern Arbuckle Mountains.

Brown (1984) suggested that palinspastic restoration of the Arbuckle anticline by removal of shortening due to folds and faults reveals little, if any, need of 40 miles (65 km) of left-lateral slip along the Washita Valley fault system as suggested by J. H. Tanner (1967). He concluded that the entire 40 miles (65 km) of apparent offset can be accounted for by southwest to northwest reverse dip-slip movement along a major fault, which he names the "Arbuckle thrust". Brown, as with Phillips (1983)), opted for a more problematic interpretation of the region, whereas elements in the region characteristic to wrenching remain unresolved if explanation is based upon the idea of major thrusting.

Part II - Collings Ranch Conglomerate

W. E. Ham (1954) conducted the first detailed study of the conglomerate cropping out along U. S. Highway 77 near Turner Falls and proposed the name "Collings Ranch", which was taken from Ellsworth Collings, whose property included much of the conglomerate west of Highway 77. Ham noted that the Collings Ranch Conglomerate is a limestone boulder conglomerate, with most of the detrital material consisting of clasts from the Cambrian-Ordovician Arbuckle Group, which crops out in a fault-bounded synclinal graben. From the character of the rocks comprising the conglomerate, Ham (1956) later concluded that the source areas were the Arbuckle and Tishomingo anticlines.

Dunham (1955) desribed the Collings Ranch Conglomerate as being intensiey faulted and noted that faults which cut pre-Collings Ranch strata also cut the Collings Ranch Conglomerate. However, both Ham's (1954) mapping and this study indicate that some faults cut younger strata, but do not cut the Collings Ranch Conglomerate.

Wickham (1978) was the first geologist to suggest that the Collings Ranch Conglomerate is preserved in a basin formed as a result of extension in the area where the Washita Valley fault bends left. Brown (1984) later suggested the same origin for the Collings Ranch basin.

Glahn and Laury (1985) suggested that the abundance of vertical pressure-solution seams in the conglomerate indicate that horizontal principal stresses may have been more significant than vertical loading in the compaction of the conglomerate.

CHAPTER II

COLLINGS RANCH CONGLOMERATE

Geologic Setting

The Collings Ranch Conglomerate is located on the northeastern flank of the most westerly fold of the Arbuckle Mountains-- the Arbuckle anticline (Figure 2). It is situated in a nortwest-southeast trending, divergent strike-slip (pull-apart) basin which formed in response to left-stepping along the Washita Valley fault zone. The basin, which is bisected by U. S. Highway 77, is approximately 4 miles (6.5 km) in length and ranges from about 0.2 miles (0.3 km) at the east end to slightly more than1 mile (less than 2 km) in the west-central portion (Plate I). The Collings Ranch Conglomerate overlies steeply dipping Ordovician strata in the north and is bounded on the south by the throughgoing main strand of the Washita Valley fault zone.

Stratigraphy

An understanding of the stratigraphy of an area is vital when attempting any form of structural analysis. Therefore, before dealing with the structural aspects of the area, a brief review of the stratigraphic description of the rocks exposed in the study area is presented. For a more detailed review the reader is referred to Ham (1978) and Fay (1969).

Timbered Hills Group

The upper Cambrian Timbered Hills Group is divided into two formations (Figure 5). At the base the Reagan Sandstone, Late Cambrian, is feldspathic and glauconitic, medium-to-fine grained sandstone. It ranges from 75 ft. (23 m) to 450 ft. (135 m) thick. The Honey Creek Formation overlies the Reagan Sandstone. It is predominantly a trilobite-rich pelmatozoan limestone, which is about 100 ft. (30 m) thick in the Arbuckle anticline. The limestone grades into a sequence of fossiliferous sandy dolomites about 225 ft. (70 m) thick on the craton (Ham, 1978).

Arbuckle Group

Rocks of the Arbuckle Group are of shallow-water marine deposits containing trilobites, brachiopods, mollusks, pelmatozoans, sponges, and graptolites. In the Arbuckle anticline the strata consist dominantly of interbedded thin carbonate mudstones, intraclast calcarenites, oolitic calcarenites, stromatolites, and laminated dolomites or dolomitic limestones (Ham, 1978). The lower Arbuckle Group rocks of Cambrian age are the Fort Sill Limestone, Royer Dolomite, and the Signal Mountain Formation. The upper Arbuckle Group rocks of Ordovician age are the Butterly Dolomite, McKenzie Formation, Cool Creek Formation, Kindblade Formation, and the West Spring Ceek Formation (Figure 5). The Arbuckle Group is as thick as 6,700 ft. (2050 m).

Simpson Group

Overlying the Arbuckle Group is the middle Ordovician Simpson Group (Figure 5). It is divided into five formations which include, from oldest to youngest, the Joins, Oil Creek, McLish, Tulip Creek, and Bromide Formations. The Joins Formation is mostly limestone. The Oil Creek Formation includes a basal sandstone, overlain by interbedded shales and fossiliferous limestones. The McLish, Tulip Creek, and Bromide Formations each contain basal sandstone units overlain by skeletal calcarenites. Maximal thickness of the Simpson Group is in the Arbuckle anticline, where nearly 2,300 ft. (700 m) are exposed (Ham, 1978).

Viola Limestone

Above the Simpson Group is the widespread Viola Limestone of middle Ordovician age (Figure 5). The formation is divided into a lower unit of siliceous carbonate laminates, a middle unit of burrowed skeletal mudstones, and an upper unit of pelmatazoan calcarenite. The formation ranges in thicknesses of 600 ft. (180 m) to 900 ft. (275 m) in the Arbuckle anticline and 350 ft. (105 m) to 400 ft. (120 m) thick in the cratonic elements of the Arbuckle Mountains (Ham, 1978).

Sylvan Shale

The late Ordovician Sylvan Shale is a dark, greenish-gray shale that is unconformable upon the Viola Limestone (Figure 5). The shale is also well-laminated and contains abundant graptolites and chitinozoans. It ranges from 150 ft. (45 m) to 175 ft. (50 m) in thickness on the shelf to a maximum of 325 ft. (100 m) in the Ardmore Basin (Ham, 1978).

Pull-Apart Basin Theory

Because the Collings Ranch Conglomerate is widely recognized as having been deposited in a pull-apart basin, a brief review of pull-apart basins is desirable. For a more exhaustive discussion of pull-apart basin development see Rodgers (1980), Mann et al. (1983), and Aydin and Nur (1982,1985).

The term "pull-apart" was first used by Burchfiel and Stewart (1966) to describe the central part of Death Valley, California, in which two sides of Death Valley were pulled apart and a half-graben produced between them. To most geologists, the term "pull-apart" retains a meaning similar to the interpretation of Death Valley: a depression produced by extension at a discontinuity or "step" along a throughgoing strike-slip fault. Left-stepping fault discontinuities, (i.e., an observer looks left along the fault to see the next, approximately parallel fault strand) results in pull-apart basin for sinistral (left-lateral) strike-slip faults and compressional uplifts or "push-ups" for dextral (right-lateral) strike-slip faults. Pull-apart basins are also known as rhombochasms, tectonic depressions, wrench grabens, rhomb grabens, and releasing bends.

Models for Pull-apart Basin Development

Mann et al., (1983) described several models for pull-apart basin development:

> The most simplistic model of pull-apart basin development was proposed for active pull-aparts along the Dead Sea Fault System in Israel and the Hope Fault Zone in New Zealand: a basin nucleates between discontinuous and parallel strike-slip faults and evolves into a sharp pull-apart (Figure 6A), whose width remains fixed and is determined by the initial master fault separation ('S' in Figure 6A). Modification of this model was performed as geologists studying the Hope Fault Zone in New Zealand recognized the tendency of master faults to be non-parallel with their strikes differing by several degrees. Furthermore, the two master faults were not overlapping but

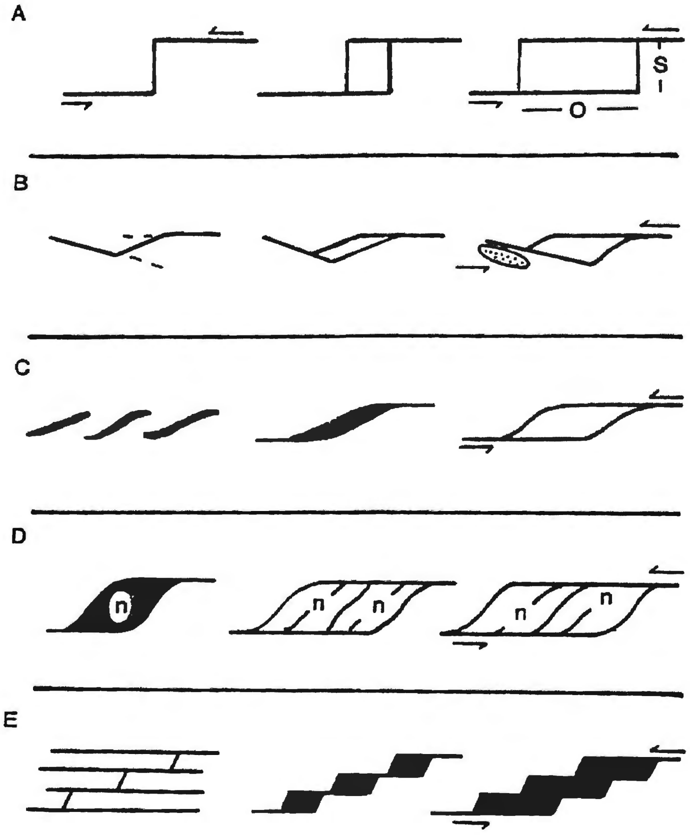

Figure 6. Models of pull-apart basin development. 'S' in model "A" designates master fault separation and 'O' designates master fault overlap; 'n' in model "D" designates area of normal faulting (after Mann et al., 1983).

were connected by a short oblique fault segment, which makes a 10-15 degree angle with the master faults (Figure 6B). Opening across the oblique median fault creates a narrow gap on one side of the basin and an overlap or bulge on the other.

Based on shear box experiments, it has been proposed that pull-apart basins are structurally analogous to en echelon extensional fractures produced during the formation of a strike-slip fault in a clay model experiments (Figure 6C). As the shear fractures joined to form a throughgoing fault, an alternating series of compressional positive areas and extensional negative or pull-apart like areas developed .

Rodgers (1980), using a model based on the elastic dislocation theory, simulated fault patterns of pull-apart basins developed between lengthening, parallel master faults (Figure 6D). His model suggests pull-apart development is controlled by: (1) the amount of master fault overlap; (2) the amount of master fault separation; and (3) whether the faults intersect the surface. An initial basin configuration of no overlap is assumed; the ends of the master faults are connected by a zone of normal faulting ('n' in Figure 6D). Increasing fault overlap or basin length results in two distinct zones of normal faulting at the distal ends of the basin. It is important to note that the relevance of theoretical models to actual pull-aparts is questionable because the fault patterns predicted by the models only apply to the initiation of faulting and not to subsequent faulting, which may reactivate older faults rather than form new ones. Moreover, shapes of basins and secondary fault patterns shown in Figure 6D apply only to the basement rocks of the pull-apart.

Aydin and Nur (1982), proposed two models for pull-apart development based on a worldwide compilation of the dimensions of 62 active pull-apart basins associated with major strike-slip faults. These basins ranged from tens of meters to tens of kilometers in length. A plot of log of basin length (basin overlap) against log of basin width (fault separation) for the 62 basins showed a well defined linear correlation between the basin length and width with a ratio of approximately three. Two possible mechanisms suggested for the increase in width and uniform basin length/width ratios regardless of basin size are: (1) coalescing of adjacent pull-aparts into a single wider basin (Figure 6E); and (2) formation of new faults strands parallel to existing ones.

Structural Geology

That the Pennsylvanian Collings Ranch Conglomerate records a period of deformation in the Southern Oklahoma Aulacogen is a long established conclusion. This portion of the thesis examines the structural setting of the conglomerate.

The Collings Ranch Conglomerate is characterized by extensive faulting; it is in angular unconformity upon the Viola Limestone and older formations. Faulting and erosion have isolated the conglomerate outcrop from other formations of Pennsylvanian or later age. The conglomerate is faulted to such an extent that the outer part of its outcrop is a fault-surface in more places than it is a surface of unconformity. Where contacts are unconformable, the Collings Ranch Conglomerate overlies steeply dipping rocks of the Arbuckle anticline. Unconformable contacts are most conspicous in the NW 1/4, Sec. 25, NE 1/4 , Sec. 26, and the north-central portion of Sec. 36, T. 1 S., R. 1 E., as well as the south-central portion of Sec. 30, T. 1 S., R. 2 E., (Plate I). In these areas the conglomerate dips 5°-25°, whereas the underlying strata dip about 70° or more. Exposed bedrock beneath the conglomerate are the West Spring Creek Formation of the

Arbuckle Group (Lower Ordovician); Joins, Oil Creek, McLish, Tulip Creek, and Bromide Formations of the Simpson Group (Middle Ordovician); and the Viola Limestone (Middle Ordovician) (Plate I).

The Collings Ranch Conglomerate is bounded on the northeast by the Classen fault and an unconformable contact. The Classen fault, which is a strand of the Washita Valley fault zone, is a northwest-southeast trending fault oblique to the Washita Valley fault and it joins it in the northwest portion of Sec. 4, T. 2 S., R. 2 E.(Plate I). The unconformity is where younger conglomerate deposits conceal the fault. This unconformable contact is seen clearly in the Interstate 35 roadcut of the NE 1/4, Sec. 31, T. 1 S., R. 2 E. (Figure 7), and at the bluff overlooking the Assemblies of God Youth Camp, SW 1/4, Sec. 30, T. 1 S., R. 2 E.. West of the youth camp, the type of contact between the conglomerate and Viola Limestone becomes less obvious. Outcrop behind the Turner Falls Inn along U. S. Highway 77, SW 1/4, SW 1/4, Sec. 30, T. 1 S., R. 2 E., offers an excellent exposure to examine the nature of the contact between the Collings Ranch Conglomerate and the Viola Limestone (Figure 8). The conglomerate strikes 113° and dips 19° to the south, whereas the limestone strikes 130° and is approximately vertical. The contact is a normal fault, dipping about 55° to the southwest, with the Collings Ranch Conglomerate on the downthrown block. The type of contact now present, the normal fault, may not have always been this way. If the originally unconformable contact was faulted and then eroded, the fault contact within the conglomerate would be exposed at the surface (Figure 9).

Strike-slip faulting of the Washita Valley fault zone is responsible for the overwhelming majority of deformation in the study area. Where the Washita Valley fault zone consists of two main branches, the main strand bounds the Collings Ranch Conglomerate to the south but the north strand cuts through the conglomerate (Plate I). The two strands are almost

Figure 7. Angular unconformity between the Pennsylvanian Collings Ranch Conglomerate (top of photograph) and vertical Ordovician Viola Limestone (bottom of photograph), I-35 roadcut.

Figure 8. Normal fault contact between the Collings Ranch Conglomerate and Viloa Limestone. The fault has a dip about 55^0 to the SW.

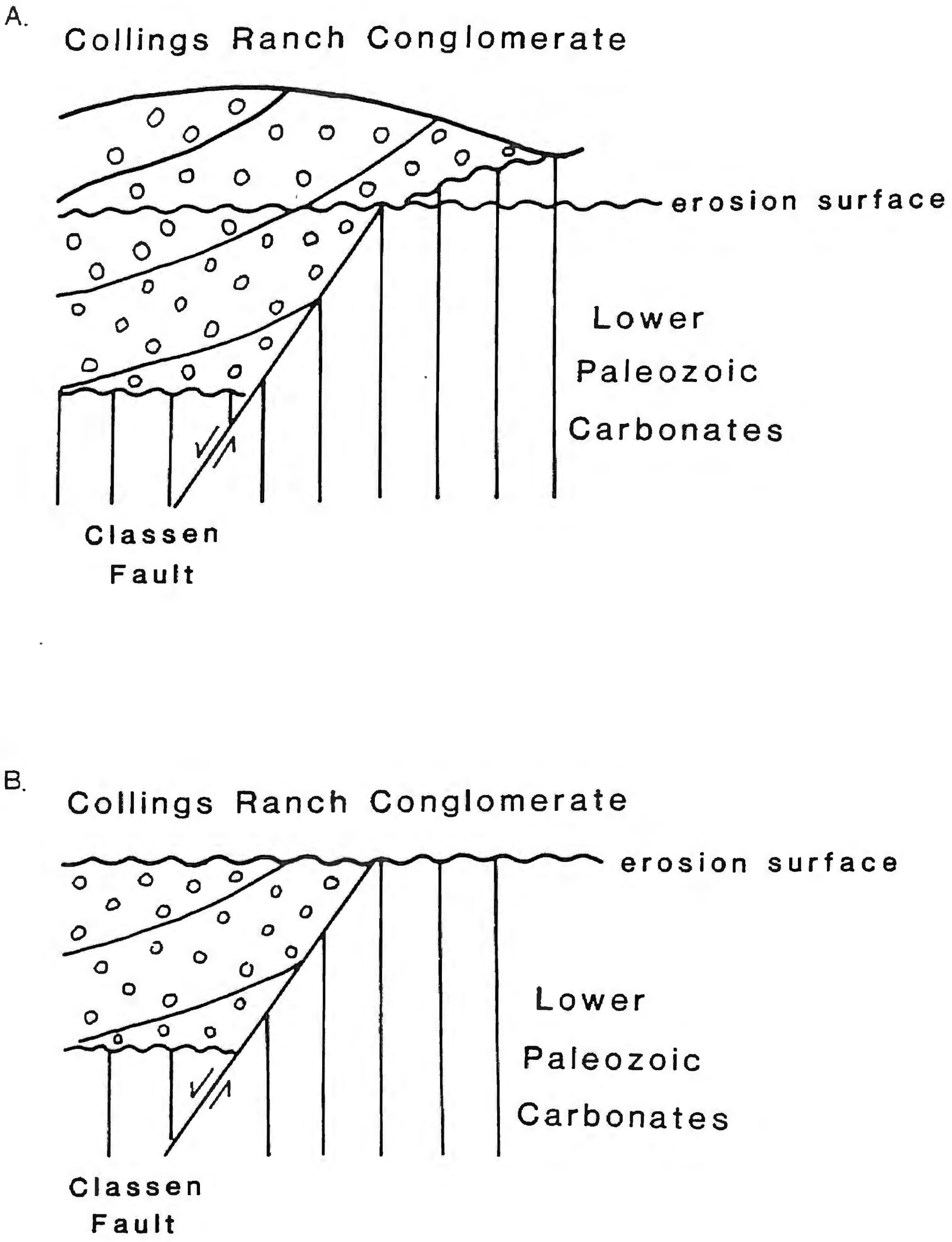

Figure 9. Sketch of field relationship between Collings Ranch Conglomerate and Viola Limestone; (A) before and (B) after erosion.

vertical and join approximately 1/5 of a mile (0.3 km) east of I-35, Sec. 31, T. 1 S., R. 2 E.. The Washita Valley fault is visible at the hairpin curves of Highway 77, Sec. 36, T. 1 S., R. 1 E. and the north branch is clearly detectable in the northwest-trending syncline of the I-35 roadcut, Sec. 31, T. 1 S., R. 2 E. (Plate I and Figure 10). The point at which these two strands join is in the region where "left-stepping" along the Washita Valley fault zone is well pronounced. However, this left-stepping can be mapped about 2 miles southeast of the point where the faults join. In left-lateral wrench systems left-stepping will result in the formation of a releasing bend (Figure 11), but in a right-lateral wrench system left-stepping will result in a restraining bend. Releasing bends result in the formation of pull-apart basins, which range in scale from small sag ponds to large rhombochasms. Hence, the basin in which the Collings Ranch Conglomerate was deposited, which is situated immediately north of the Washita Valley fault, is deduced to have formed in response to left- stepping along the Washita Valley fault zone.

Slickensides are scarce on fractures of branches of the fault zone. However, slickensides that do exist, in general, indicate stike-slip displacement with some vertical component. Numerous splays of the Washita Valley fault also cut the Collings Ranch Conglomerate. These are especially prominent in Sec. 36, T. 1 S., R. 1 E., as well as the entire northwest portion of the study area (Plate I). These smaller and less prominent faults, as well as the Washita Valley fault, have vertical or nearly vertical fault planes and their expressions on aerial photographs are essentially straight. Strike-slip faulted contacts between the conglomerate and older strata are characterized not only by vertical fault planes, but also by some brecciation of the older strata. At these faulted

Figure 10. Top photograph is of main strand of the Washita Valley fault zone. Breccia zone in center. Collings Ranch Conglomerate to left (north) and Arbuckle Limestone to right (south). Bottom photograph is of north strand of the Washita Valley fault zone, which cuts through the conglomerate.

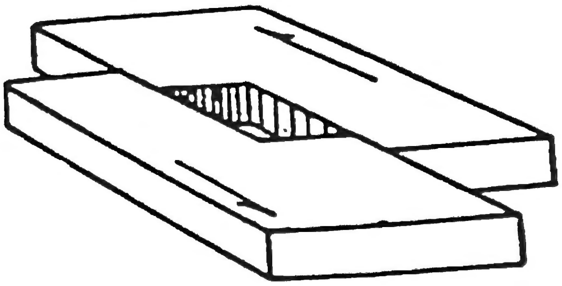

Figure 11. Pull-apart basin developed along a releasing bend in a left-lateral strike-slip fault (modified from Crowell, 1974).

contacts the lower Paleozoic strata generally dip greater than 60°, whereas the conglomerate dips generally less than 25° (Plate I).

Southeastward from the area of the well pronounced left-stepping, the Washita Valley fault zone is composed of a single vertical fault to the locality where it branches into two strands, in the south-central portion of Sec. 32, T. 1 S., R. 2 E. (Plate I). The northern strand, the throughgoing main strand of the Washita Valley fault zone, trends southeasterly and dips southward with a well pronounced reverse separation (Figure 12). The reverse separation is along the northern edge of a small, approximately 1-mile by 0.5-mile (1.5 km by 0.8 km), convergent (transpressional) zone (Plate I). This area of convergence is delineated by the reverse seperation on the northern branch and left-lateral movement along the southern strand (Figure 13). A stereonet plot of axial-plane strike and plunge measurements taken from the folds within the Arbuckle Group exposed in the region of convergence, with the axial planes being roughly parallel with the strike of the main strand of the Washita Valley fault zone (Figure 14), indicate that folding occurred during the period of convergence, which was later than the left-lateral movement (Pybas and Cemen, 1987).

Folds

The Collings Ranch Conglomerate is folded into a relatively broad, gently plunging, northwest-southeast trending syncline. Within the conglomerate several well defined folds were recognized. Particularly prominent are two north-trending synclines that plunge southward at low angles, in NE 1/4 Sec. 26, and north-central Sec. 25, T.1 N., R. 1 E. (Plate I). Most, if not all, folding took place contemporaneously with tectonism of the Arbuckle uplift. Evidence for this is visible in the syncline exposed along

Figure 12. Reverse separation along the main strand of the Washita Valley fault zone. Arbuckle Limestone (top of photograph) is thrust over the Collings Ranch Conglomerate (bottom of photograph). The fault dips southward.

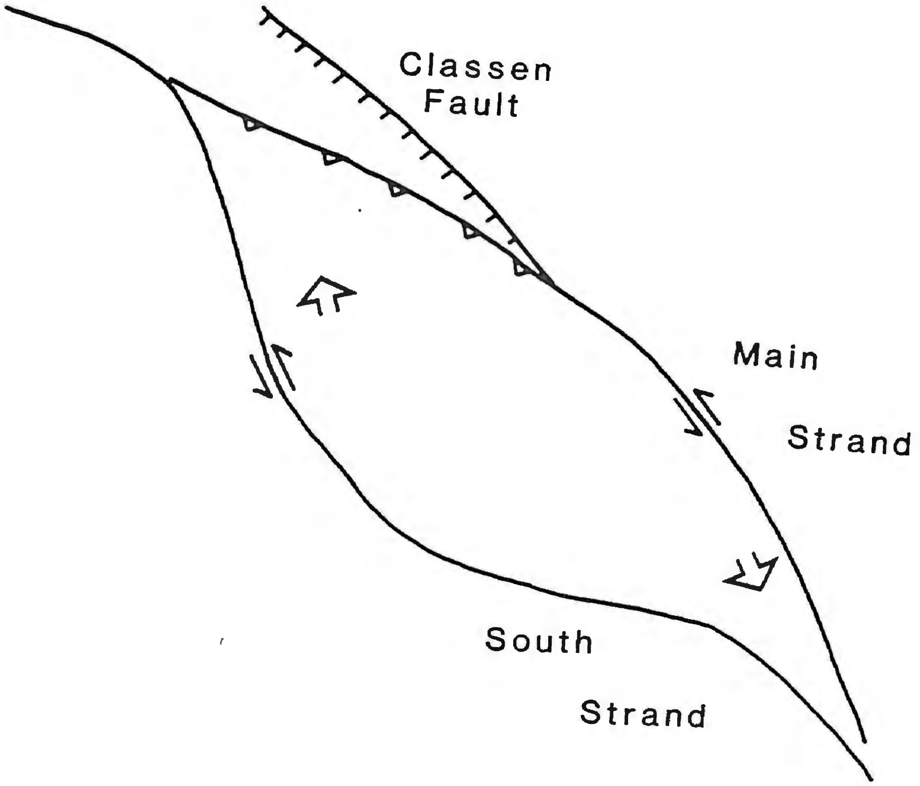

Figure 13. Sketch of Washita Valley fault zone showing reverse separation along the main strand. Large arrows show movement of blocks.

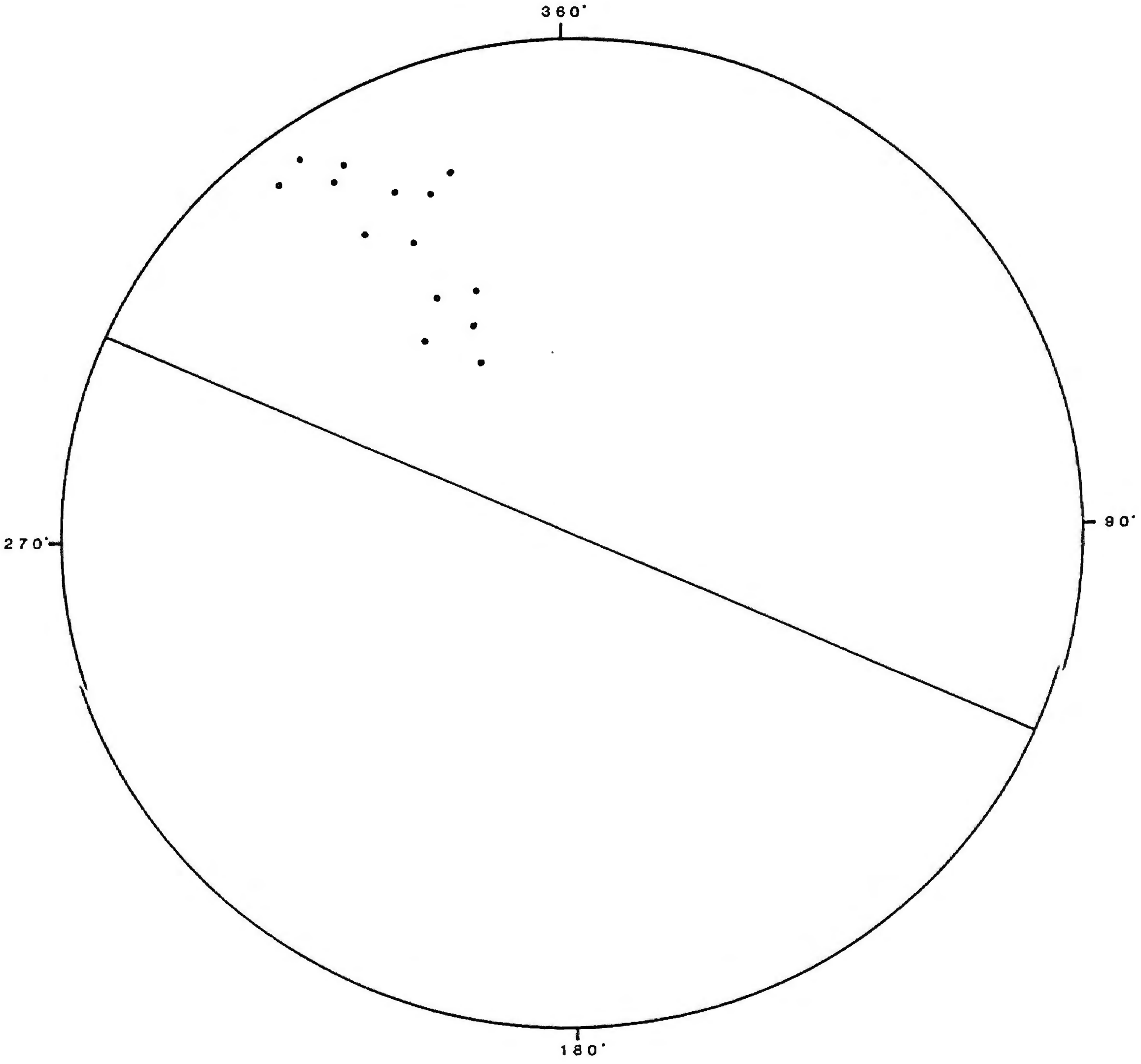

Figure 14. Stereonet of axial-plane strike and plunge measurements of folds within the Arbuckle Group, in the region of convergence.

Interstate 35, sec.31, T.1 S., R 2 E. (Figure 15). The syncline is a flexural slip fold showing well developed shear zones with rotated, unbroken clasts (Figure 16) and slickensides perpendicular to the strike of bedding. The fault surfaces with slickensides do not truncate clasts and are restricted to the matrix. This indicates the syncline was formed prior to cementation of the conglomerate and contemporaneous with tectonism and deposition (Pybas and Cemen, 1986).

Cross-sections

Five cross-sections were constructed through the study area. Information from Ham et al. (1954) and Dunham's (1955) mapping of strata peripheral to the Collings Ranch Conglomerate was used in addition to the observations made during this investigation. Due to the focus of this study, the structural geology of the Collings Ranch Conglomerate, limitations were inherent to constructing geologic cross-sections. Specifically these include imprecise knowledge of stratigraphic thicknesses of geologic units peripheral to the Collings Ranch Conglomerate. In addition, Ham et al. (1954) illustrated combined units of a group, without determining where one formation ends and another begins; but Dunham (1955) differentiated among individual formations. Consequently, I have made particular assumptions-- specifically that each formation present is at its maximal thickness in the study area, unless indicated otherwise by Dunham (1955). Therfore, the cross-sections may not reflect the true thicknesses of the Paleozoic formations in the area.

Cross-sections A-A', B-B', and C-C' (Plate II), constructed across the northwest and central portions of the study area, illustrate the anticlinal structure of the underlying strata. They also show that each vertical

Figure 15. Interstate-35 syncline.

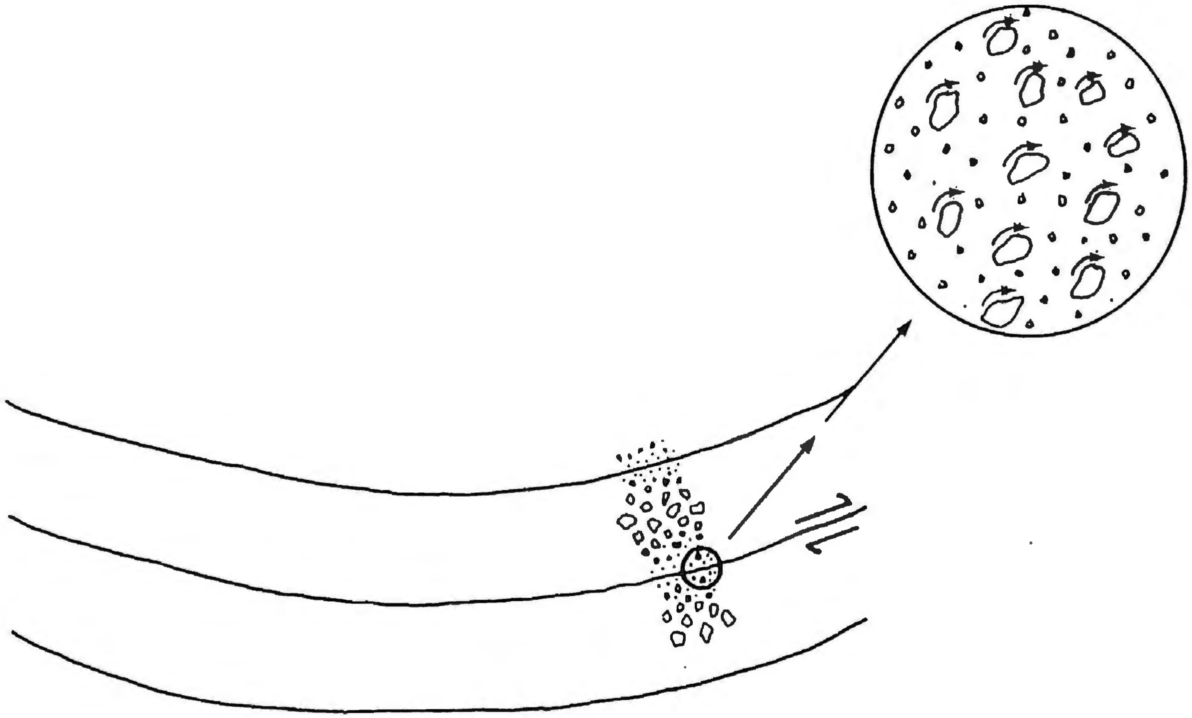

Figure 16. Sketch of flexural slip fold showing shear zone with rotated and unbroken clasts.

strike-slip fault has an undetermined component of dip-slip. The amount of displacement on the Classen normal fault is also at a maximum along the cross-section A-A'. The normal displacement along the fault decreases progressively southeastward (Plate II, cross-sections B-B' and C-C').

Cross-section D-D' illustrates overturned and steeply dipping formations of the Simpson Group in contact with the gently dipping Collings Ranch Conglomerate. Here the Classen fault shows less separation than to the northeast, and it joins the main strand of the Washita Valley fault zone in the subsurface. Cross-section E-E' is through the zone of convergence. It illustrates reverse movement of the Washita Valley fault, where Ordovician Arbuckle Group carbonates were thrust over the Collings Ranch Conglomerate at an angle of about 30°.

Tectonic and Depositional History

The Collings Ranch Conglomerate records unusual conditions which permitted the erosion of limestone as pebbles, cobbles, and boulders rather than its usual removal by dissolution. This implies sharp uplift and locally high relief, best achieved along a fault scarp, such as that which could have prevailed along the Washita Valley fault system during Pennsylvanian time. Logically, then, the resulting conglomerate, the Collings Ranch, is interpreted as an alluvial-fan deposit. The characteristics of the conglomerate, all common to alluvial-fan deposits, support this idea quite conclusively. These include; a) the boulder to cobble size of clasts; b) the angularity of clasts; c) poor sorting of the clasts; d) nearby source area; and e) silt to clay matrix with red color. Also, the conglomerate contains a limited suite of sedimentary structures, primarily imbricate structures in channel deposits, but cross bedding is quite rare. Moreover, the presence of red clay (hematite precipitate) and absence of organic matter suggest that sedimentation was in an oxidizing environment, not subjected to reducing conditions.

Conventionally, there is a limited number of depositional processes which act upon alluvial fans; this seems to have been true of the Collings Ranch Conglomerate. The absence of distinguishable braided streams as well as the rarity of fine sediments indicate that deposition was accomplished primarily by channel fill and sieve deposits in the proximal region of the fan. It is possible that finer, braided stream deposits once existed but have since been eroded. However, considering the basin's size, the basin's proximity to the source area, and the likely arid climate, that these factors probably precluded the development of braided streams.

Ham (1954) estimated the restored thickness of the Collings Ranch Conglomerate to be 2000 ft. (610 m) to 3000 ft. (915 m). He made these calculations for the conglomerate in the west-central part of Sec.32 and the SE 1/4, NE 1/4, Sec. 31, T. 1 S., R. 2 E. (Plate I). It is likely that the actual thickness is very near the estimate of Ham's. The Collings Ranch Conglomerate has been penetrated in two locations by drillers searching for oil. It is reported (Robert Allen, personal commun.,1986) that drillers recorded a thickness of about 900 ft. (275 m) for the conglomerate in the central portion of Sec. 25, T. 1 S., R. 1 E., and a thickness of 1600 ft. (490 m) in the NW 1/4, SW 1/4 , Sec. 31, T. 1 S., R. 2 E.. The second location is near the area of left-stepping of the Washita Valley fault; consequently, one could expect to find the maximal thickness of conglomerate in this region of basin opening. Therefore, it is certain that the restored thickness of the conglomerate is greater than 1600 ft. (490 m) and may be as much as the 3000 ft. (915 m) suggested by Ham (1954).

Paleocurrents

A total of 143 paleocurrent measurements of the long-axis orientation of clast imbrications was taken from six localities within the Collings Ranch Conglomerate (Plate III). The imbrications demonstrate a pattern of basin filling from the margins. The predominant transport in the central and western portion of the basin was from the south-southwest; in the eastern portion of the basin the predominant transport was from the north. Analysis of maximum clast size failed to yield a sense of transport direction. The reasons for this are (1) that large clasts are quite common throughout the basin because of proximity of clasts to source areas, and (2) that in most cases, outcrops could be examined only in two dimensions.

Petrology

The Collings Ranch is poorly sorted, subangular to subrounded, limestone boulder conglomerate. It is well cemented and generally well stratified in thick, parallel-bedded layers. Where exposed along Interstate 35, bedding is separated by shear zones formed during syndepositional deformation of the conglomerate (Figure 17). In the absence of shear zones bedding is distinguished by rock fragment size and amount of matrix present. Pressure-solution and imbricate structures are common throughout the conglomerate but fossils are noticeably absent.

Rock fragments making up the conglomerate range from angular sand-sized grains to subangular boulders 3 feet in diameter (Figure 18). Boulders and cobbles generally constitute approximately 60-80 per cent of the rock, the remaining part being an interstitial matrix of pebble and sand fragments bound by a calcic cement. Hematite is distributed throughout the carbonate

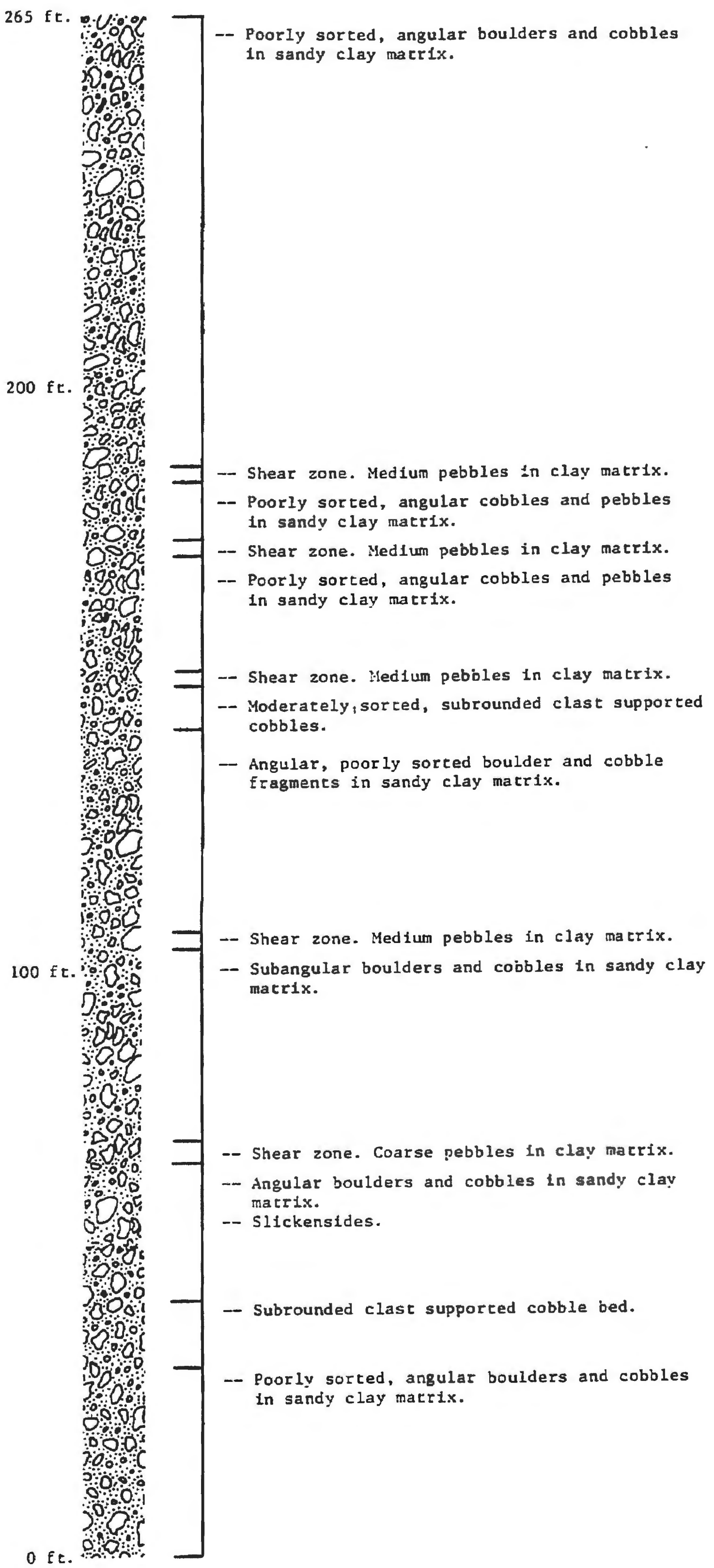

Figure 17. Columnar section of the Collings Ranch Conglomerate at I-35 roadcut.

Figure 18. Outcrop photograph of the Collings Ranch Conglomerate. Rock fragments making up the conglomerate range from angular sand-sized grains to subangular boulders.

matrix. Though the hematite occurs in minor amounts, it is responsible for the predominantly dark red color of the Collings Ranch Conglomerate, indicating deposition and diagenesis in subaerial conditions.

Fragments of the McKenzie Hill, Cool Creek, Kindblade, and West Spring Creek Formations, which compose the lower Ordovician portion of the Arbuckle Group, are most of the detrital material in the conglomerate (Ham, 1954). Fine-grained dolomitic limestones, peloidal limestones, algal or stromatolitic limestones, intraformational conglomerates, and sandy limestones are abundant.

Rock fragments younger than Arbuckle Group also are present. They include parts of the Viola Limestone (Late Ordovician), Simpson Group (Middle Ordovician), and Hunton Group (Late Ordovician-Early Silurian). The oldest rocks present, only sparsely found, are Cambrian dolomites from the Butterly and Royer Formations (Ham, 1954).

Petrography

In addition to the lithologies described macroscopically, detrital quartz and chert were observed in thin-section analysis. Diagenetic constituents include hematite, sparry calcite, dolomite, illite, and kaolinite (Table 1).

Limestone clasts comprise up to 85% of total constituents. These include micrite, dismicrite, biomicrite, sandy micrite, oosparite, pelsparite, biosparite, and sparite. Some of the limestone fragments have been extensively fractured in-situ and recemented with sparite (Figure 19). The large majority of all clasts show evidence of some degree of pressure solution (Figure 20). Sutured grain boundaries are common; they are the result of extensive pressure solution. This suggests that post-depositional

TABLE I

COLLINGS RANCH CONGLOMERATE THIN-SECTION DATA

Sample	Detrital Carbonate Fragments %	Detrital Chert Fragments %	Detrital Quartz Fragments %	Authigenic Calcium Carbonate Cement %	Authigenic Hematite %	Authigenic Illite Clay %
1	69	T	T	22	8	
2	55	T	2	39	3	
3	55	1	1	35	8	
4	76	T	2	18	3	
5	82		4	12	2	
6	87	6		5	2	
7	70	2	1	19	7	T
8	75			19	6	
9	82	T	1	14		2
10	65	1	2	25	7	
11	72	2	3	17	6	
12	65	2	2	23	8	
13	66	1	2	24	7	
14	68	3	2	19	8	
15	65	T	T	29	5	
16	80		T	15	4	
17	88	T	T	4	7	
18	81	1	T	12	5	
19	64		T	30	5	
20	70			23	7	
21	60		T	30	9	
22	91		T	6	2	T
23	77		1	17	5	
24	78		T	14	7	
25	75	1	1	16	7	
26	70	1	2	18	9	
27	72		4	17	7	
28	57	T	5	27	10	
29	58		7	26	9	
30	65		4	24	7	

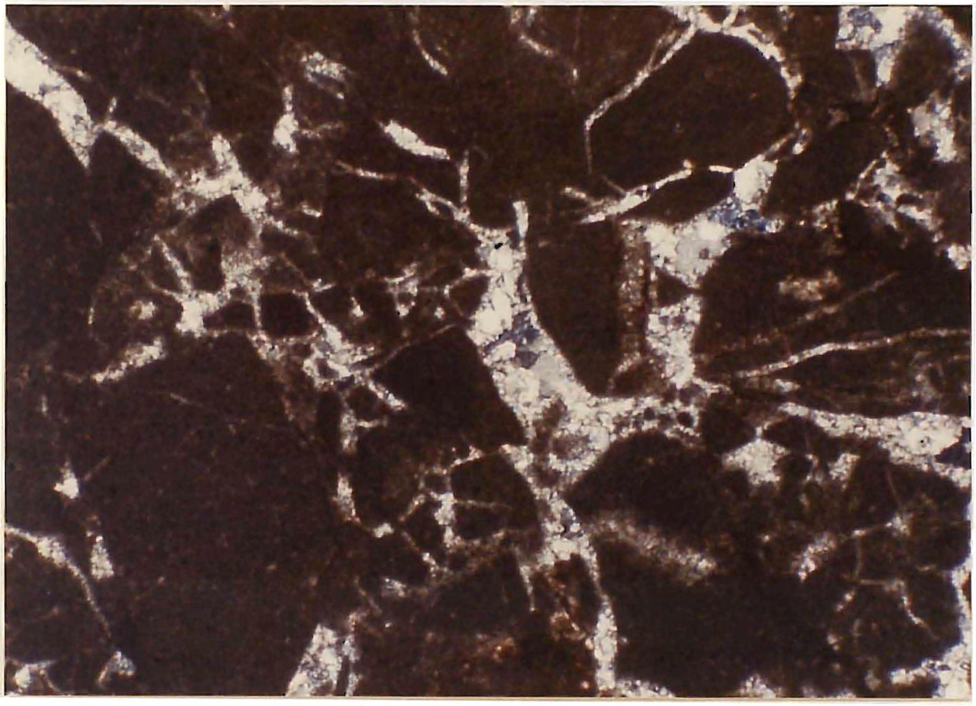

Figure 19. Limestone fragment fractured in-situ and recemented with sparite. (x20, crossed-nicols).

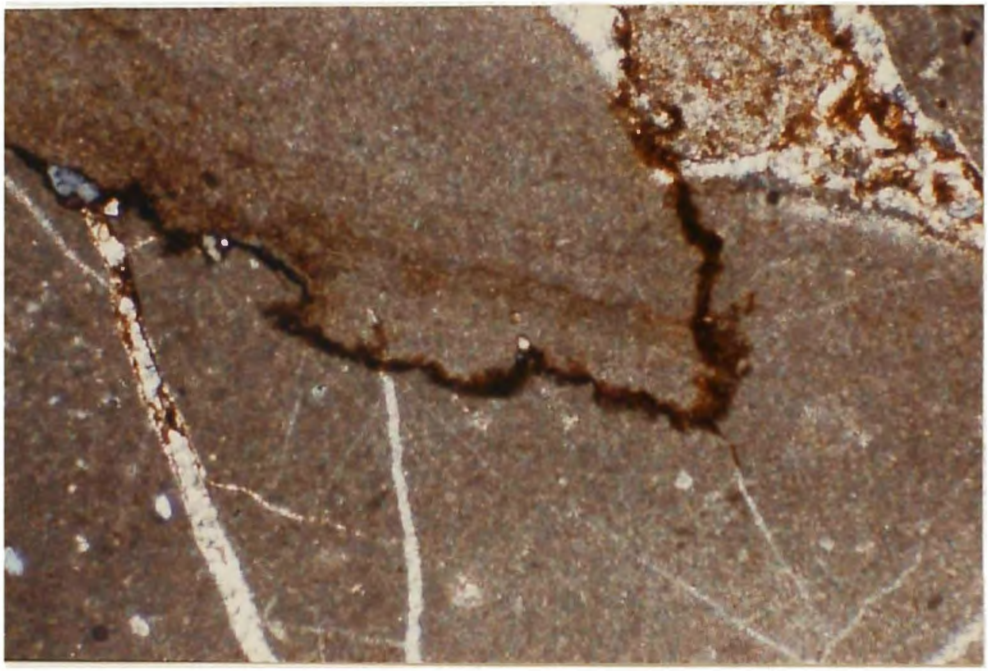

Figure 20. Pressure solution seam filled with hematite. (x20 plane polarized).

deformation other than compaction has influenced the conglomerate. Presumedly, this deformation was associated with late movement along the Washita Valley Fault system.

Quartz occurs primarily in minor amounts ranging from traces to 4%. The quartz is monocrystalline and well rounded; average grain size is approximately .5 mm. Some quartz grains have been replaced by calcite. The quartz most likely originated from a quartz-rich limestone unit of the Ordovician Cool Creek Formation, Arbuckle Group. Detrital chert occurs chiefly in amounts ranging from traces to 2%. The chert is highly angular and displays varying degrees of alteration to carbonate.

Sparry calcite is both a cementing agent and a product of recrystallization of surrounding limestone grains (Figure 21). The large amount of spar is due to the extensive pressure solution within the rock. In some instances sutured grain boundaries are all that is left of what once were grains. The grains underwent complete dissolution and recrystallization to sparry calcite. Stylolites and sutured grain boundaries generally are outlined by hematite. Some sparry crystals are as large as 1 mm, indicating slow growth conditions. The extensiveness of the sparry calcite indicates (1) compaction alone could not have been responsible for the extensive pressure solution and subsequent recrystallization of the limestone clasts, and (2) recrystallization of sparry calcite effectively halted any further diagenesis, except in small, isolated areas. The extensive pressure solution is a result of post-depositional deformation, primarily folding, associated with movements of the Washita Valley fault system. As discussed earlier, post-depositional deformational effects are clearly seen in the I-35 syncline, where clasts are rotated and unbroken, indicating that movement was after deposition but prior to cementation (Pybas and Cemen, 1986).

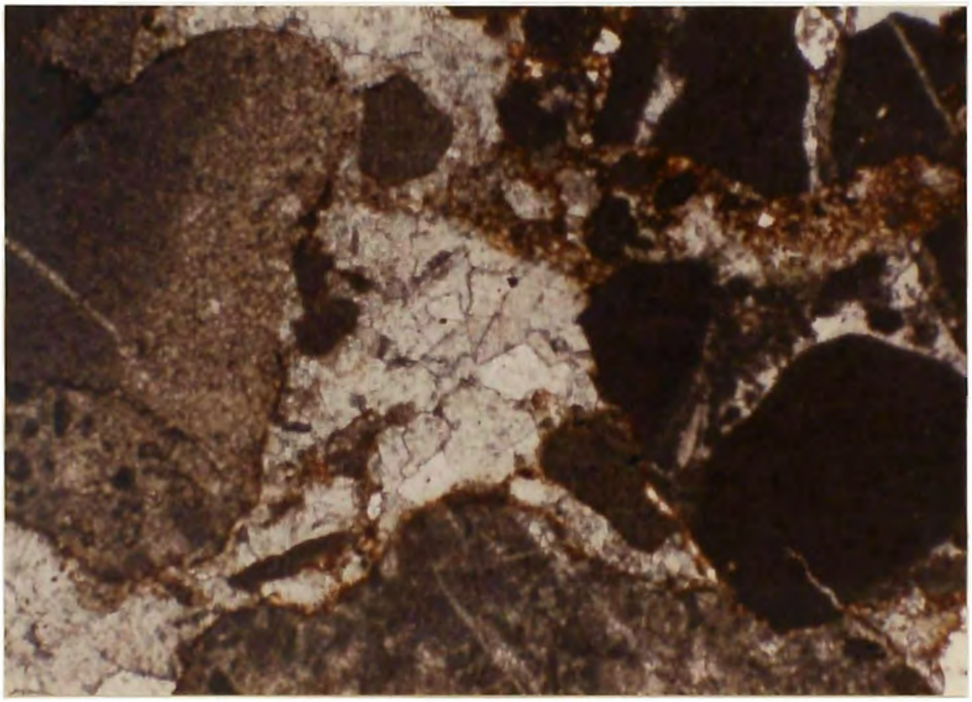

Figure 21. Sparry calcite as cementing agent.
(x20, plane-polarized).

Authigenic hematite is both a grain-liner and pore-filler (Figure 22). Grain-lining hematite is the more common, in some cases coating all visible grains. Hematite also is present in stylolite zones and sutured grain boundaries. On the average, hematite comprises, 7-8% of the rock.

Thin-section analysis appears to indicate the presence of authigenic dolomite. Well defined rhomboidal carbonate grains, characteristic of dolomite, are preserved with hematite incorporated within the zone boundaries (Figure 23). However, staining of the carbonate indicated that the rhombohedra were calcitic and not dolomitic. These rhomboidal carbonate grains probably were once indeed dolomitic but seem to have been dedolomitized. Certainly the diagenetic fluids were sufficiently rich in calcium to accomplish dedolomitization, as made evident by the large amount of sparry calcite precipitation.

Clay minerals occur only in trace amounts and are observed in the form of illite in only three samples. The illite fills the pores with a very fine wisp-like shape. Very minor amounts of kaolinite was also detected.

No porosity could be identified in thin-section. If porosity is present in the Collings Ranch it is probably as microporosity. The nonporous nature of the Collings Ranch Conglomerate may cause the formation to be a good cap rock for oil trappped in the underlying units.

Diagenesis

Hematite precipitation was the earliest diagenetic event to effect the Collings Ranch Conglomerate. The scenario at the time was probably one of shallow burial in an oxidizing environment. Dolomitization soon followed the hematite precipitation. Hematite incorporated within zone boundaries of the rhomboidal carbonate grains indicate dolomitization began before the

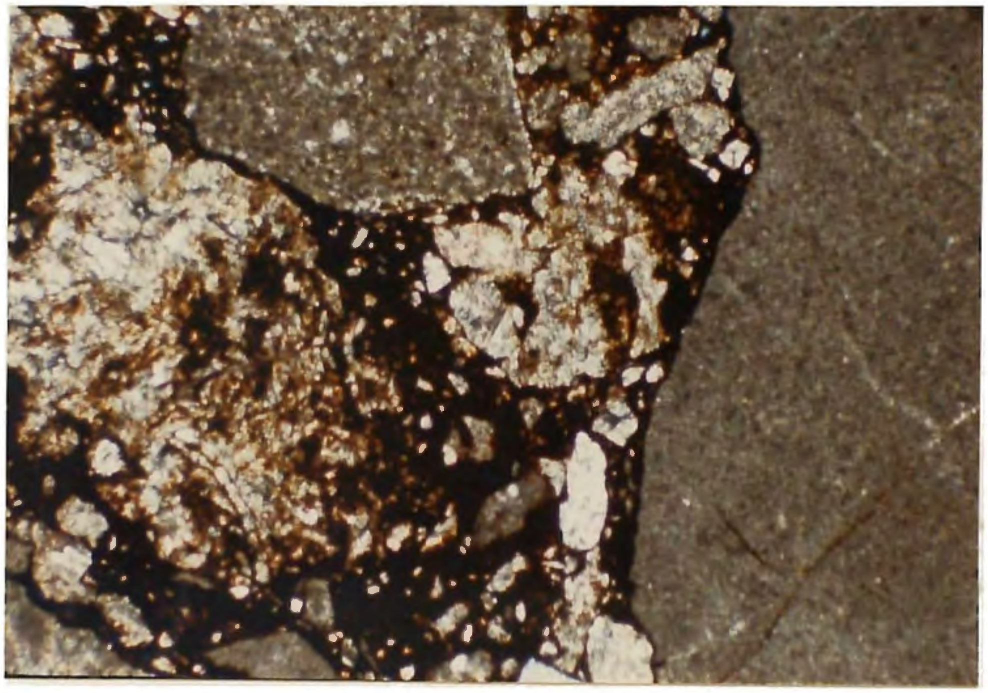

Figure 22. Authigenic hematite is both a grain-liner and pore-filler. (x20, plane-polarized).

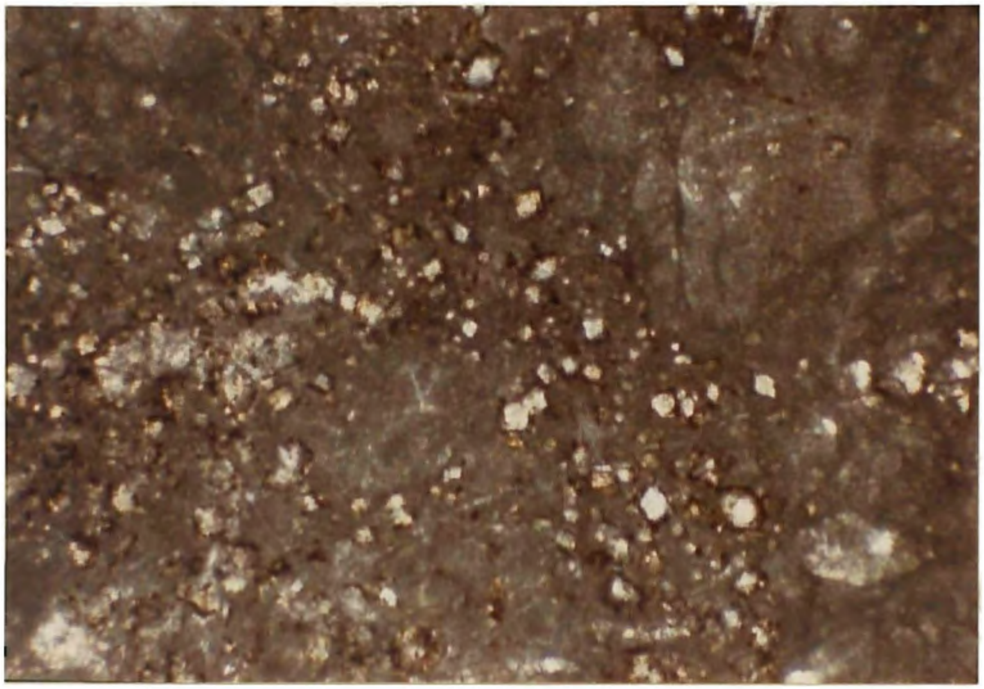

Figure 23. Rhomboidal carbonate grains with hematite incorporated within the zone boundaries. (x20, plane-polarized).

conclusion of hematite precipitation. Compaction and tectonic activity contributed to extensive dissolution of the carbonate fragments, releasing great amounts of calcium into the diagenetic fluids.

Dedolomitization occurs where carbonate-rich waters with a high Ca^{2+}/Mg^{2+} ratio flow through dolomitized rocks. deGroot (1967) concluded from experimental work that the process of dedolomitization requires not only solutions with a high Ca^{2+}/Mg^{2+} ratio, but also rapid flow solutions, temperatures below 50^{0} C and pressures below 0.5 atm. These conditions indicate near surface processes. As dissolution of carbonate fragments progressed, greater and greater concentrations of calcium were added to the formation water leading to both dedolomitization and precipitation of sparry calcite. The large amounts of calcium in formation water caused a shift in the pH of the water towards a more basic solution. However, the pH never became so basic that complete dissolution and replacement of silica took place.

Sparry calcite growth also acted to redistribute hematite. As calcite precipitated and "grew" away from the clasts it was cementing, the calcite pushed or incorporated hematite. Recrystallization and precipitation of the sparry caclcite were so complete that they destroyed any remaining porosity and halted circulation of ground water, thus effectively halting any further diagenesis except in isolated areas, as seen by the presence of illite.

Comparison was made of the amount of hematite present in the older beds (those lower in the stratigraphic section) and younger beds (those higher in the section). If sedimentation was sporadic, with periods of no deposition or burial (oxididizing conditions persisting for some time), one could expect to find a significantly greater amount of hematite present locally. However, there are no isolated areas of large hematite precipitation, indicating that sedimentation was quite steady. This is as expected because rapid sedimentation and burial are typical of alluvial fan deposits.

CHAPTER III

TECTONIC COMPARISON

The purpose of this discussion is to compare the structural characteristics of the Collings Ranch Conglomerate basin with the structure of the strike-slip basins described by Nilsen and McLaughlin (1985). The basins studied by Nilsen and McLaughlin are much larger and more complex in depositional facies than the Collings Ranch basin. Even so, the structure of the different basins is strikingly similar, enough so to warrant this discussion.

Nilsen and McLaughlin (1985) compared three basins of different age and size whose tectonic and depositional characteristics suggest a similar origin and history. The basins surveyed are the Devonian Hornelen Basin in western Norway, the Miocene and Pliocene Ridge Basin of southern California, and the three Little Sulphur Creek Basins of northern California, the ages of which are poorly known, but believed to be Pliocene (Figure 24).

The Hornelen Basin formed as a result of Devonian strike-slip faulting. The basin is bounded on the north and south by east-striking faults, and the northern fault is considered to have been a zone of major right-slip movement. The northern basin-margin fault is considered to be the dominant fault that controlled sedimentation within the basin. The basin is 37 to 44 miles (60 to 70 km) long, 9 to 16 miles (15 to 25 km) wide and occupies an area of 775 square miles(1,250 km2) with a cumulative sediment fill of 82,000 feet (25,000 m). It forms a broad east-plunging

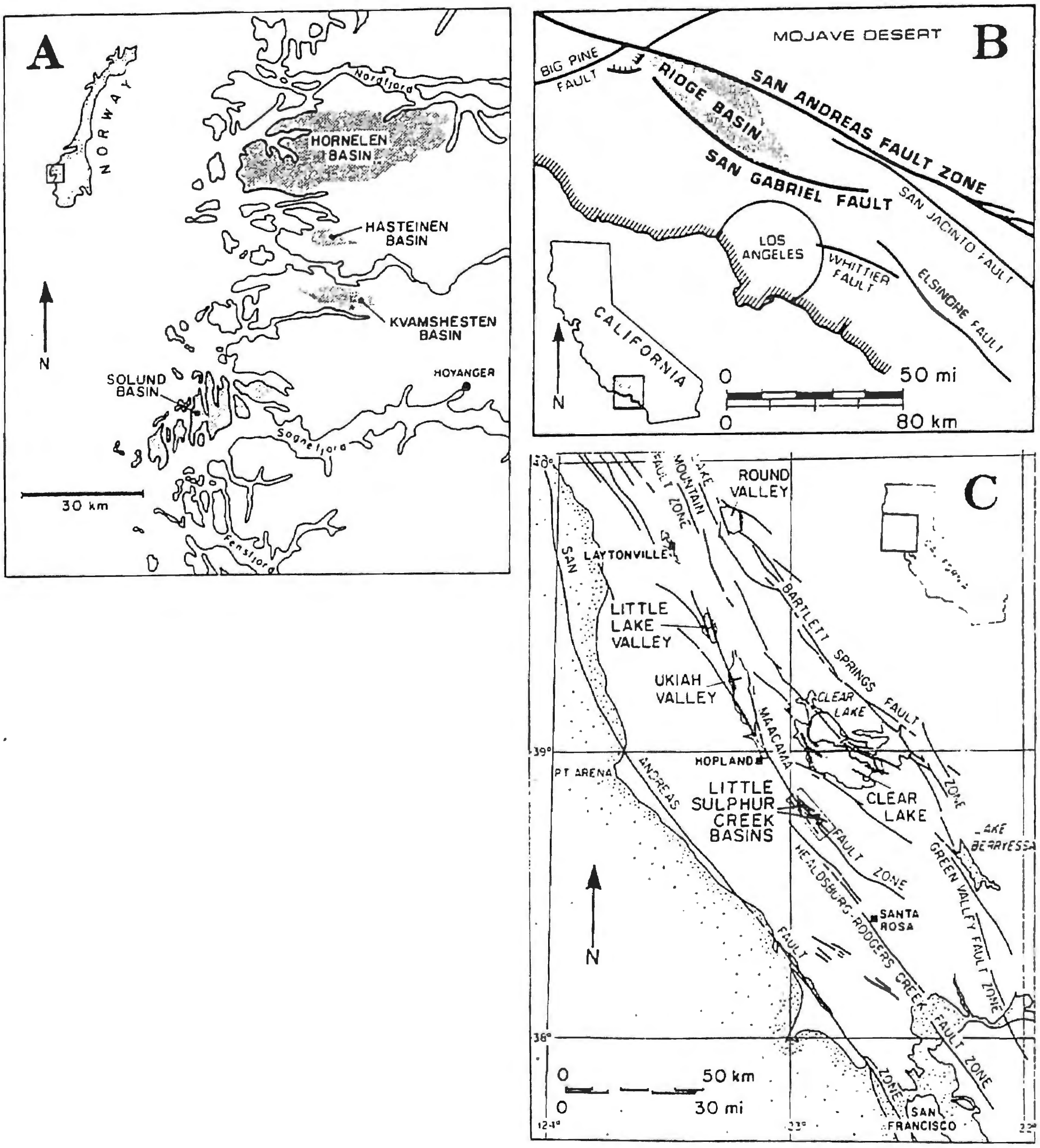

Figure 24. Index map showing the locations of the Hornelen, Ridge, and Little Sulphur Creek Basins (from Nilsen and McLaughlin, 1985).

syncline in which the synclinal axis is located close to the northern basin margin (Nilsen and McLaughlin, 1985).

The Ridge Basin is located between the San Andreas and San Gabriel faults in southern California (Figure 24B). The basin developed as a stretched and sagged crustal wedge northeast of the San Gabriel fault in the area where the fault has a curvilinear trace. The basin is 19 to 25 miles (30 to 40 km) long, 4 to 9 miles (6 to 15 km) wide, and covers an area of about 250 square miles (400 km2) with a cumulative sediment fill of 23,000 to 36,000 feet (7,000 to 11,000 m). The sedimentary fill has been folded into a broad asymmetric northwest-plunging syncline (Nilsen and McLaughlin, 1985).

The three Little Sulphur Creek Basins, which developed along the Maacama fault zone, form part of a large number of Neogene nonmarine sedimentary basins in northern California (Figure 24C). The basins extend along the Maacama fault zone for about 8 miles (13 km). They are bounded on the southwest by branching splays of the active right-lateral Maacama fault zone. Conjugate thrusts that strike west and northwest, and left-lateral splays that also strike northwest, intersect the main northwest-striking fault zone, separating the basin into three distinct 1 to 1 1/4 mile-(1.5 to 2.0 km)-wide pull-apart basins. The basins have a cumulative sedimentary fill of approximately 16,400 feet (5000 m) (Nilsen and McLaughlin, 1985).

From this synopsis of the tectonic framework of the Hornelen, Ridge, and Little Sulphur Creek Basins, and despite important differences in age, size, thickness of basin fill, and regional setting, the three basins clearly possess characteristics similar to each other and to the Collings Ranch basin. The Ridge, Little Sulphur Creek, and Collings Ranch basins are especially similar. Though similarities exist between the Hornelen and Collings Ranch basins, it is important to note the that two basins are also significantly different in that formation and deformation of the Hornelen Basin was influenced by two major fault zones, not just one.

The similarities are summarized as follows; (1) The four basins are elongate parallel to the orientation of a major controlling strike-slip fault, in the case of the Collings Ranch Basin, the left-lateral Washita Valley fault zone; (2) Alluvial-fan deposits are along the margins of each basin. However, the alluvial-fan deposits of the Hornelen, Ridge, and Little Sulphur Creek Basins are more complex, whereas alluvial-fan deposits represent the sole mode of deposition in the Collings Ranch basin; (3) The basins were formed initially by extension, and the fill of each basin is characterized by syndepositional deformation. The amount of offset along the margins of the Hornelen Basin is unknown, but the San Gabriel and Maacama faults have known offsets of more than 35 miles (60 km) and about 12 miles (20 km) respectively. The Washita Valley fault has an offset that is probably more than 3 miles (5 km) as proposed by Ham (1951), but not more than 20 miles (32 km) as proposed by Carter (1979); (4) In each basin, the major controlling strike-slip fault is throughgoing and forms a continuous bounding margin to the basin; (5) Each basin has a length to width ratio of between 3 : 1 and 5 : 1. For the Collings Ranch basin this ratio is about 4 : 1; (6) Finally, each basin was folded into a relatively broad, gently plunging syncline, although subsidiary folds have been mapped.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The Collings Ranch Conglomerate is a limestone, cobble-to-boulder conglomerate derived from primarily Ordovician rocks of the Arbuckle and Tishomingo anticlines. It is a late Pennsylvanian orogenic product of the Arbuckle uplift, resulting from deformation of the Southern Oklahoma Aulacogen. The conglomerate is situated in a small pull-apart basin that developed along the Washita Valley fault zone, as a result of left-stepping along the left-lateral Washita Valley fault zone. The Collings Ranch Conglomerate is an alluvial fan deposit folded into a relatively broad, gently dipping syncline. Deposition was contemporaneous with deformation of the conglomerate. Paleocurrent measurements of the long-axis orientation of clast-imbrications indicate that the predominant transport direction was from south to north, with some from north to south transportation. The conglomerate underwent shallow-burial diagenesis with sparry calcite being the cementing agent. Hematite gives the unit its characteristic red color.

The conglomerate is intensely faulted, primarily by strike-slip faults associated with the Washita Valley fault zone. Later movement along the Washita Valley fault resulted in development of a small convergent (transpressional) region that is marked by Arbuckle Group rocks thrust over the Collings Ranch Conglomerate. Despite important differences in age, size, thickness of basin fill, and regional setting, the Collings Ranch basin has a geologic history similar to that of the Hornelen Basin of Norway, and the Ridge andLittle Sulphur Creek Basins of California.

Characteristic of the Collings Ranch basin are the following:

1. Basin formation adjacent to a significant strike-slip fault, with that fault forming the most prominent basin margin.
2. Basin alignment elongate parallel to the major controlling strike-slip fault.
3. The depositional environment was an alluvial fan.
4. The basin is synclinal in overall structure, and the basin fill shows syndepositional depositional features.
5. The basin was formed initially by extension, followed by transpressional processes that contributed to the deformation of the basin.

These criteria define the chief characteristics of the Collings Ranch basin. Clearly, larger, more complex pull-apart basins will have many more traits than these. However, these characteristics can be expected to be found in every basin of strike-slip (pull-apart) origin. Of course, not all of these criteria are applicable only to strike-slip basins.

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VITA

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Master of Science

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GEOLOGIC MAP OF THE TURNER FALLS AREA

PLATE I

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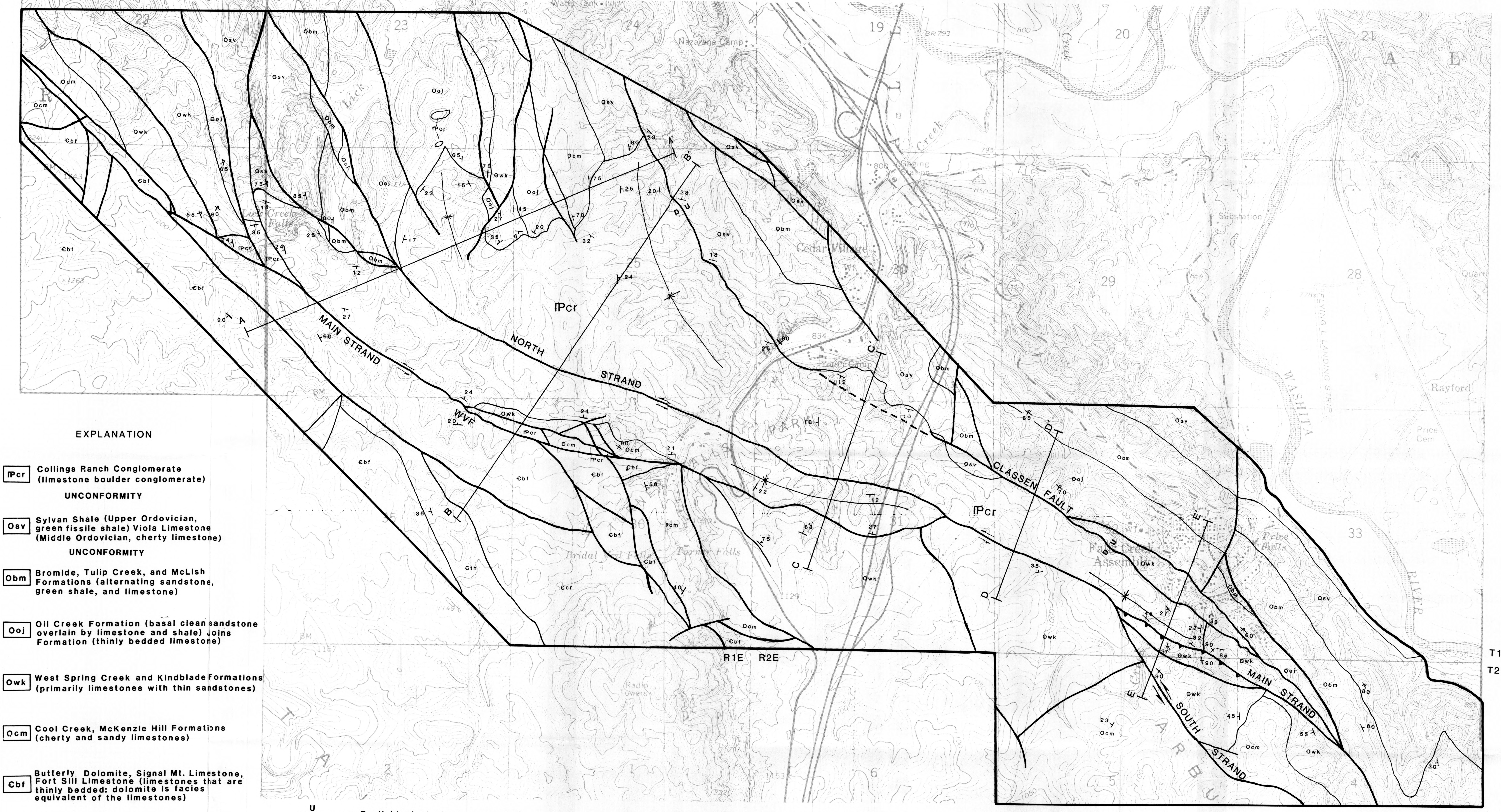


EXPLANATION

Age	Group	Symbol	Description
Late Pennsylvanian		IPcr	Collings Ranch Conglomerate (limestone boulder conglomerate)
			UNCONFORMITY
Middle and Late Ordovician		Osv	Sylvan Shale (Upper Ordovician, green fissile shale) Viola Limestone (Middle Ordovician, cherty limestone)
			UNCONFORMITY
	Simpson Group	Obm	Bromide, Tulip Creek, and McLish Formations (alternating sandstone, green shale, and limestone)
		Ooj	Oil Creek Formation (basal clean sandstone overlain by limestone and shale) Joins Formation (thinly bedded limestone)
Early Ordovician	Arbuckle Group	Owk	West Spring Creek and Kindblade Formations (primarily limestones with thin sandstones)
		Ocm	Cool Creek, McKenzie Hill Formations (cherty and sandy limestones)
Late Cambrian		Cbf	Butterly Dolomite, Signal Mt. Limestone, Fort Sill Limestone (limestones that are thinly bedded: dolomite is facies equivalent of the limestones)
		Cth	Timbered Hills Group (Reagan Sandstone at base overlain by Honey Creek Formation, primarily limestone)
Mid-Cambrian		Ccr	Colbert Porphyry (pink rhyolite porphyry)

U
D
Fault (dashed where concealed) D downthrown side U upthrown side

Relative movment arrows

Thrust fault, teeth on upthrown side

Strike and dip of beds

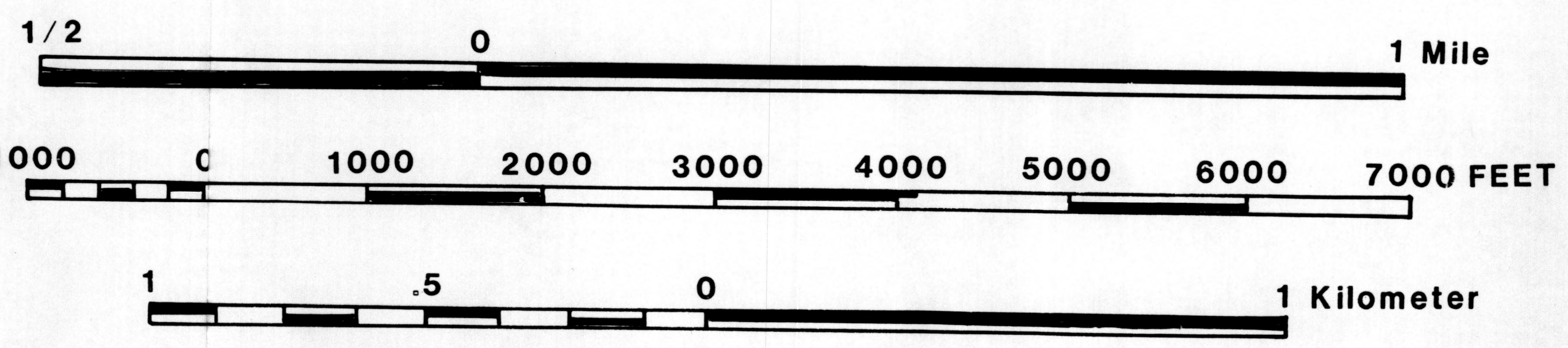
Vertical beds

Overturned beds

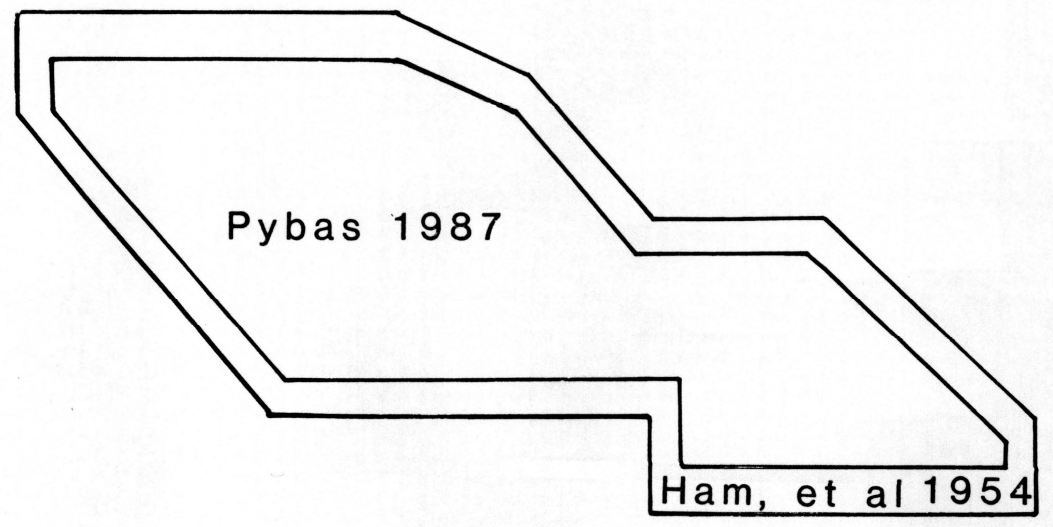
Normal syncline

Lines of cross sections

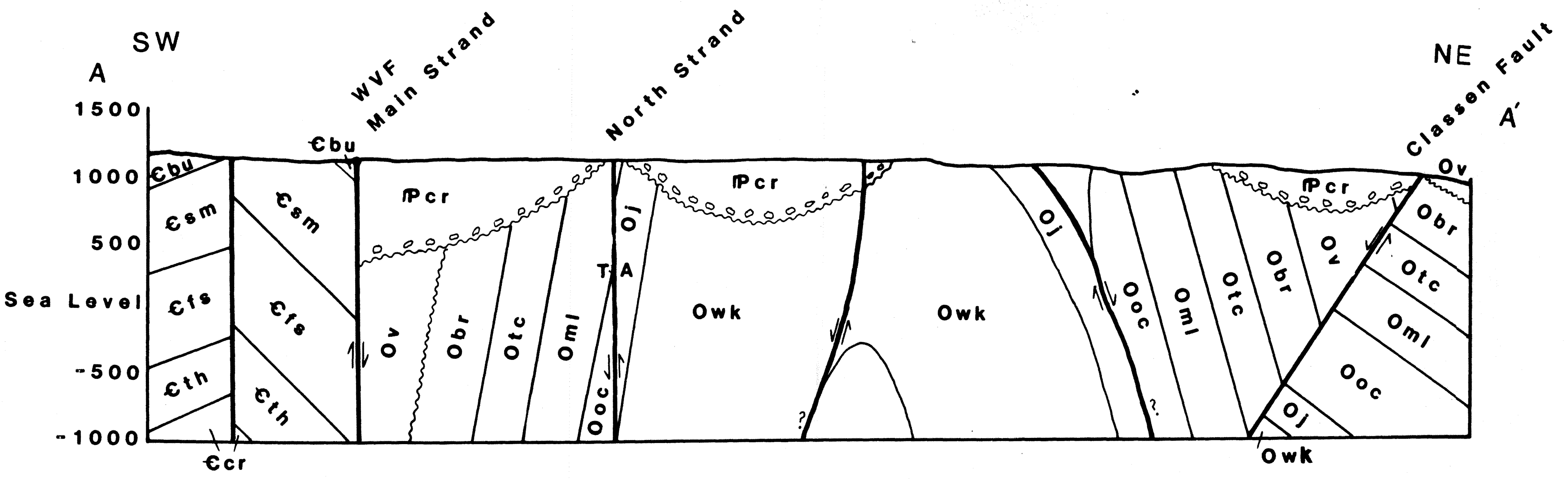
SCALE

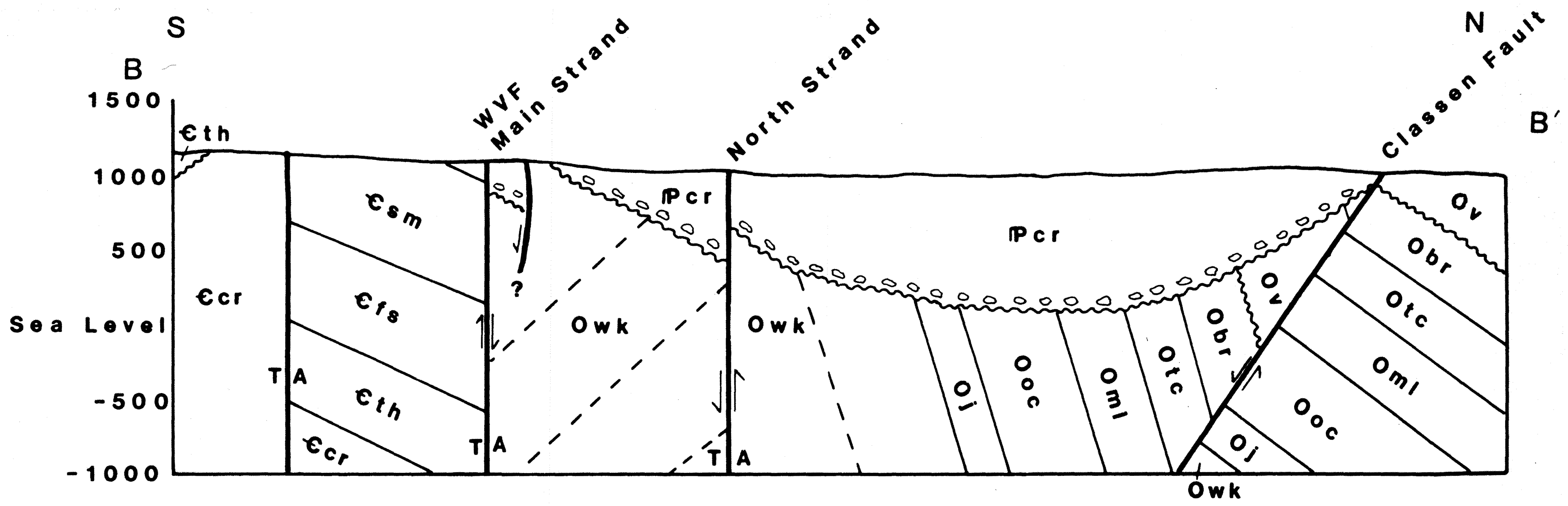


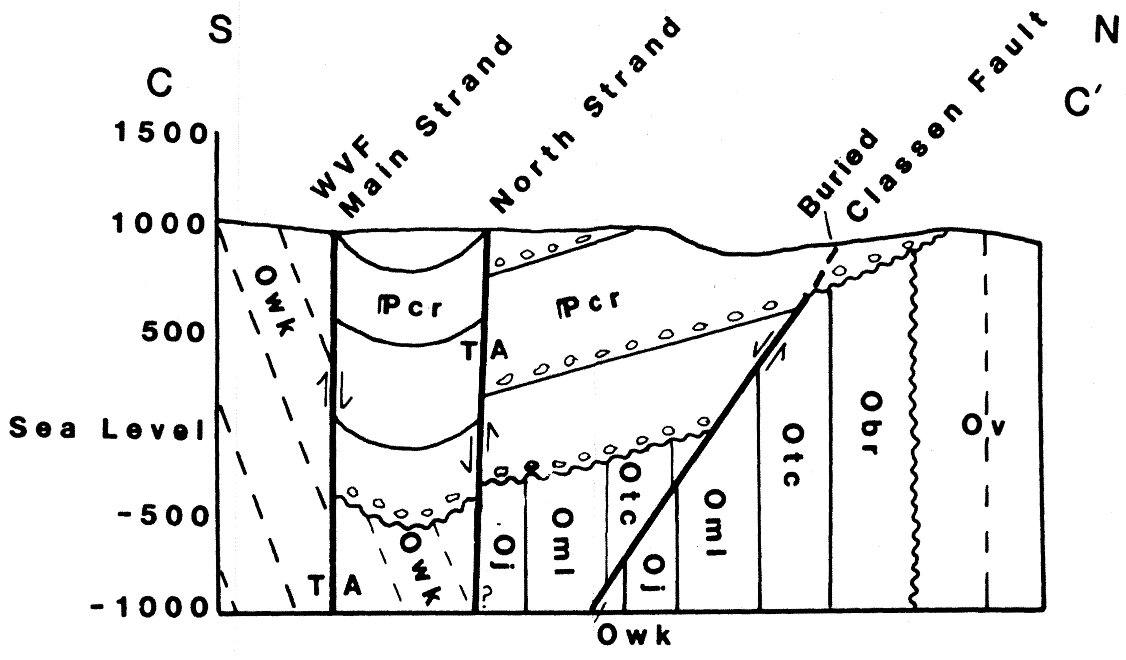
CONTOUR INTERVAL 10 FEET

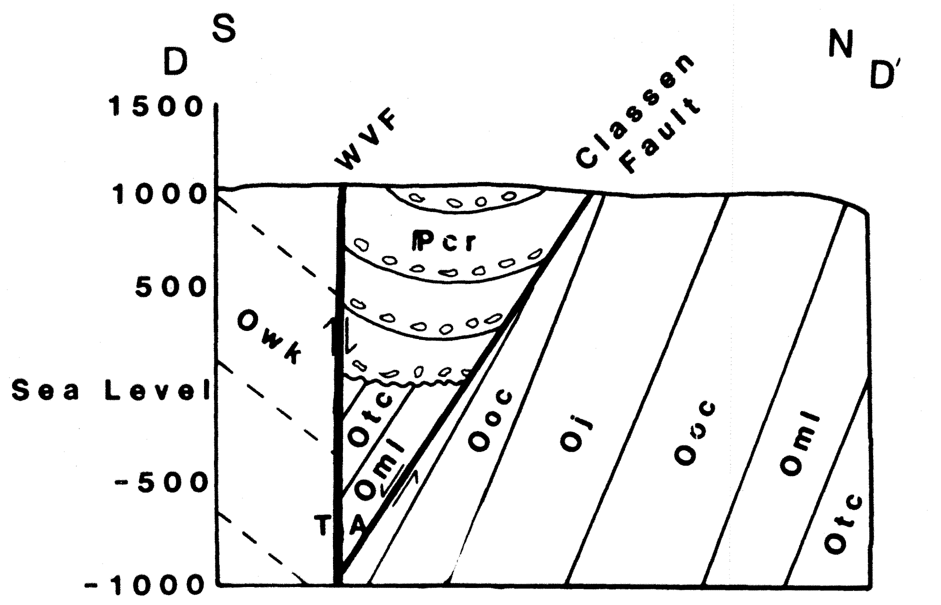


CROSS-SECTIONS









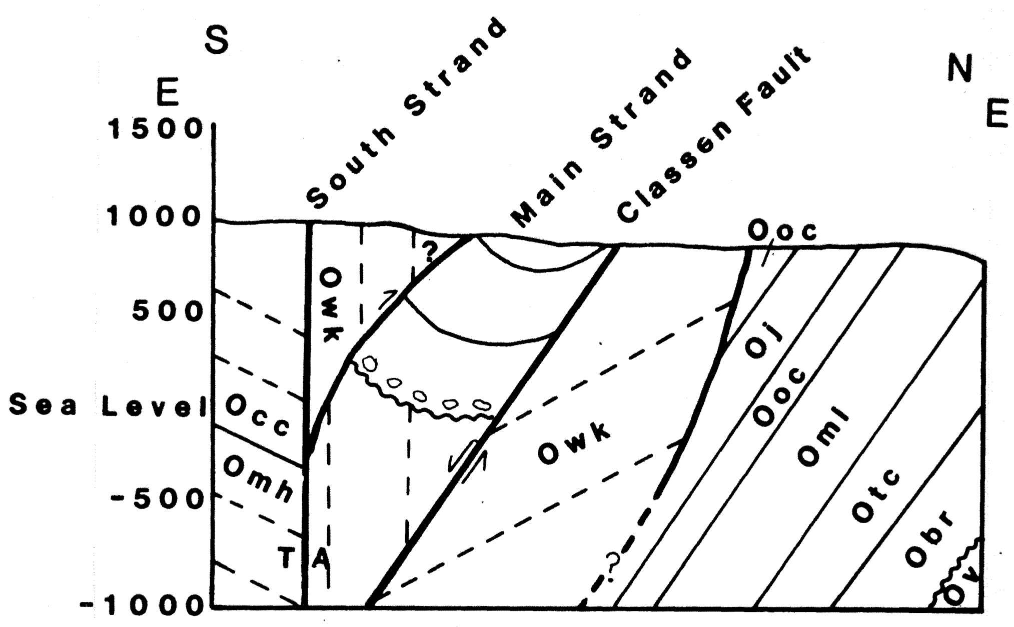


PLATE II

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LEGEND

Pennsylvanian		IPcr	Collings Ranch Conglomerate
			UNCONFORMITY
Late		Os	Sylvan Shale
		Ov	Viola Limestone
			UNCONFORMITY
Ordovician Middle	SIMPSON GROUP	Obr	Bromide Fm.
		Otc	Tulip Creek Fm.
		Oml	McLish Fm.
		Ooc	Oil Creek Fm.
		Oj	Joins Fm.
Early	ARBUCKLE GROUP	Owk	West Spring Creek and Kindblade Fm.
		Occ	Cool Creek Fm.
		Omh	McKenzie Hill Fm.
Cambrian Late		Ꞓbu	Butterly Dolomite
		Ꞓsm	Signal Mt. Limestone
		Ꞓfs	Fort Sill Limestone
		Ꞓth	Timbered Hills Group
Middle		Ꞓcr	Colbert Rhyolite

PALEOCURRENT DIRECTIONS FROM IMBRICATE STRUCTURES

PLATE III

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