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ABSTRACT

The Atoka Formation (Pennsylvanian) of northwestern Arkansas is a complex succession of sandstone and shale units. Sandstone units in surface sections near the base of the formation in northern Crawford and southern Washington Counties may be correlated with units in the subsurface of the Arkoma Basin. The basal sandstone units of the Atoka Formation as recognized in the Arkoma Basin are correlated with thin, discontinuous sandstones within the Trace Creek Member of the Bloyd Formation in surface exposures to the north. Vertical grain size profiles, electric log profiles and the configuration of thickness trends suggest that lower Atoka sandstone units accumulated as linear coastal sand bodies that prograded southeastward.

INTRODUCTION

The Atoka Formation (Atokan) of northwest Arkansas is a complex succession of sandstone and shale units overlying the Bloyd Formation (Morrowan). On the northern Arkansas structural platform, strata of the formation are essentially horizontal and are truncated northward by the present erosion surface. South of the structural platform the Atoka Formation thickens into the Arkoma Basin and the Bloyd-Atoka boundary is encountered only in the subsurface. Sandstone units within the lower part of the formation are important reservoirs for natural gas in the basin and a distinct unit nomenclature is applied by petroleum geologists concerned with structural and stratigraphic mapping (Haley and Hendricks, 1972). North of the Arkoma Basin surface studies have resulted in subdivision of the Atoka Formation into locally mappable units (Lamb, 1974), but the correlation of surface units with those of the basin has not been accomplished.

Data obtained from four surface sections, one core, and 59 electric well logs (Fig. 1) serve as a basis for delineating several major sandstone units within the lower part of the Atoka Formation and establishing a tentative correlation between surface and subsurface units. Lithic characteristics of several units have been established by surface studies (Hoover, 1976, Kelly, 1977). These characteristics appear to continue into the subsurface of the basin and suggest that the sandstone units accumulated as linear coastal sand bodies that prograded southeastward.

STRATIGRAPHY

The Kessler Limestone and Trace Creek Shale Members are the uppermost units of the Bloyd Formation in surface successions of northwest Arkansas (Henbest, 1962). The Kessler Limestone ranges from two to 30 feet in thickness (Williams, 1975) and is stratigraphically the highest distinctive limestone unit in the Pennsylvanian succession. It is continuous southward into the Arkoma Basin (Fig. 2).

The Trace Creek Shale overlies the Kessler Limestone and ranges from 20 to 125 feet thick in surface exposures of central and southern Washington County (Henbest, 1962). The member is composed of silty shale with discontinuous intervals of sandstone ranging up to 10 feet in thickness. The Trace Creek Shale thickens southward in Washington County but the name is not normally applied to intervals within the subsurface of the Arkoma Basin. The member is directly overlain by strata of the Atoka Formation assigned here to unit B.

Strata now assigned to the Atoka Formation were definitively mapped as the Winslow Formation by Purdue (1907) in Washington and Crawford Counties. The name Winslow was synonomized with the earlier named Atoka Formation of Oklahoma by Croneis (1930) and has largely been abandoned. Purdue (1907) also named and mapped the Bloyd Formation in Washington and Crawford Counties. He defined the Bloyd-Atoka (Winslow) boundary as the base of a sandstone unit ranging from 40 to 80 feet in thickness and lying 60 to 75 feet above the Kessler Limestone. It is this definition of the Bloyd-Atoka boundary (formerly Bloyd-Winslow boundary) that is adhered to in mapping surface exposures of Pennsylvanian strata (Zachry and Haley, 1975).

Measured sections of surface exposures incorporating approximately 700 feet of Kessler, Trace Creek and Atoka strata were obtained at Blackburn Creek and Purdue Hollow (Fig. 1). Sandstone units within the succession are informally grouped into Units B, D, and E (Fig. 3) for purposes of discussion. Units A and C are recognized only in the subsurface of Crawford County. Each major unit represents one or more sandstone units that are regionally persistent and can be correlated basinward.

Unit B includes the basal sandstone unit and second unit of the Atoka Formation. These intervals are individually mappable on the surface throughout central and southern Washington County (Hoover, 1976, Kelly, 1977). The basal unit forms a distinctive bluff and ranges from 20 to 89 feet in thickness. The second sandstone unit is thinner, less distinct and may be composed of several sandstone beds separated by thin intervals of shale.

Unit D is a persistent sandstone unit easily mappable in surface outcrops. It is separated from Unit B by an interval of shale

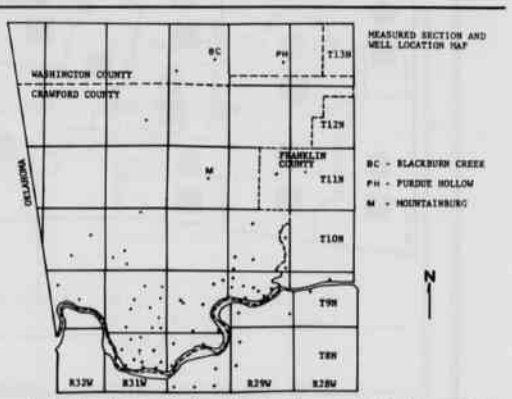

Figure 1. Well and measured section location map. Blackburn Creek and Purdue Hollow are measured surface sections. Mountainburg is a cored well and unlabled dots are natural gas wells from which electric logs were obtained.

approximately 110 feet thick (Fig. 2). A thick interval of shale approximately 200 feet thick overlies Unit D (Fig. 2). The shale unit is persistent in surface and subsurface sections and forms one of the most distinctive intervals in the lower Atoka Formation. It is overlain by a succession of sandstone units here designated Unit E (Fig. 2).

The interval from the top of the Kessler Member to the top of Unit D increases in thickness southward from 400 feet in the Blackburn Creek section to approximately 600 feet in the Jeffreys No. 1 well near the Arkansas River (Fig. 2). The increased thickness is related to the development of additional sandstone units southward. Thin sandstone units above the Kessler Limestone in the Mountainburg well thicken southward to approximately 100 feet in the Newman No. 1 and Jeffreys No. 1 wells. These sands designated Unit A (Fig. 2) directly overlie the Kessler or are separated from it by a thin interval of shale throughout southern Crawford County. Sand Unit C appears in the Ellis No. 1 well and thickens southward into multiple units in the Newman and Jeffreys wells (Fig. 2). Unit D also thickens southward and displays multiple unit development. Shale units in the succession maintain relatively constant thicknesses southward from the outcrop.

In subsurface studies the base of Unit A is widely regarded as the base of the Arkoma Formation in the Arkoma Basin by industrial geologists. Northward this unit thins and is correlated with thin discontinuous sandstone units within the Trace Creek Member of the Bloyd Formation. The base of Unit B in the Arkoma Basin is correlated with the base of the Atoka Formation in surface exposures.

DEPOSITIONAL ENVIRONMENTS

Surface exposures of sandstone units within the lower Atoka Formation display grain size profiles that become coarser upward. Thin, ripple-marked sandstone beds interbedded with shale grade upward into thick, shale-free beds that are characterized by horizontal stratification. Hoover (1976) and Kelly (1977) defined elongate belts of thickened strata within surface exposures of Unit B in Washington County. These belts trend southwestward.

An isopachous map of Unit B in the subsurface of Crawford County depicts southwest-trending belts of thickened strata (Fig. 3). Sand units in the subsurface display spontaneous potential and gamma ray curves, suggesting that upward gradations from shale to sandstone characterize their bases and abrupt sandstone-shale boundaries characterize their tops.

These patterns, apparent in surface and subsurface sections, are consistent with the conclusion that the sandstone units of the lower Atoka Formation accumulated in linear prograding coastal sand bodies dominated by attached beach or barrier island environments.

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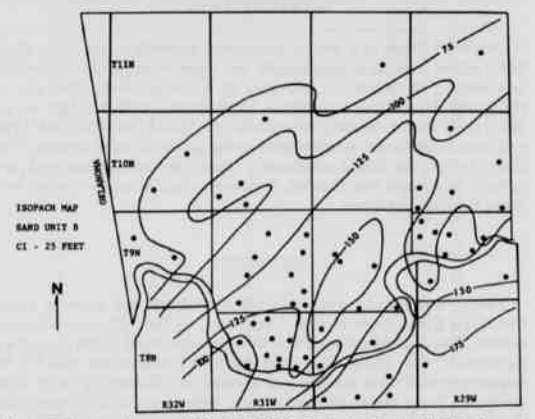

Figure 3. Isopach map of Sand Unit B. Dots indicate distribution of natural gas wells from which electric logs were obtained.

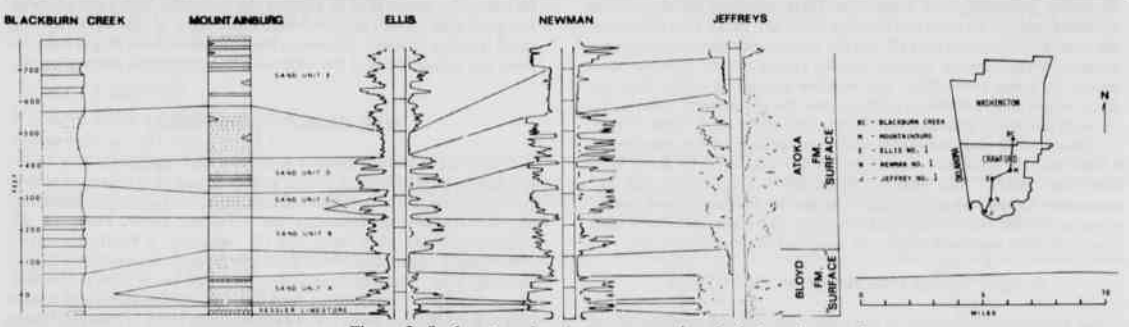

Figure 2. Surface to subsurface cross-section depicting the correlation of lower Atoka sand units.

