DEPOSITIONAL RECORD OF A MAJOR TECTONIC TRANSITION IN NORTHERN ALASKA: MIDDLE DEVONIAN TO MISSISSIPPIAN RIFT-BASIN MARGIN DEPOSITS, UPPER KONGAKUT RIVER REGION, EASTERN BROOKS RANGE, ALASKA

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ABSTRACT

Middle Devonian to Lower Mississippian terrigenous clastic strata in the upper Kongakut River region record a period of geologic history that is not preserved elsewhere in the northeastern Brooks Range. The succession contains shallow-marine, fluvial, and lacustrine(?) deposits, with locally interbedded mafic volcaniclastic rocks. The earliest deposits contain early Middle Devonian (Eifelian) shallow-marine invertebrate fossils and unconformably overlie complexly polydeformed chert and phyllite of Cambrian to Ordovician age. Although the terrigenous clastic succession includes two low-angle unconformities, all contractional structures resulted from the Cretaceous(?) to Tertiary formation of the northeastern Brooks Range.

Thus, major mid-Paleozoic contractional deformation in this part of the Arctic is constrained to pre-Middle Devonian time. The succession probably is the proximal equivalent of thick Upper Devonian to Lower Mississippian marine and fluvial strata of the Endicott Mountains allochthon to the south. The uppermost deposits of the succession are equivalent to thin Lower Mississippian fluvial strata that unconformably overlie pre-Middle Devonian rocks in the autochthon to the north. The succession is interpreted to have been deposited at the margin of the rift-basin that became the late Paleozoic-early Mesozoic passive continental margin of northern Alaska. The lower part of the succession is interpreted to overlie the rift-onset unconformity and record syn-rift deposition. The upper part of the succession is interpreted to overlie the post-rift unconformity and record regional transgression due to thermal subsidence.

INTRODUCTION

The Ellesmerian Sequence of northern Alaska (Lerand, 1973; Grantz et al., 1981; Hubbard et al., 1987) is the depositional record of a mid-Paleozoic to Early Cretaceous south- to southwest-facing passive continental margin (Dutro, 1981; Moore et al., 1992). Throughout much of the region, an angular unconformity at the base of the sequence marks an abrupt change from polydeformed rocks below to rocks above that were not deformed until the late Mesozoic-Cenozoic formation of the Brooks Range. The character and timing of this tectonic transition are poorly understood. The unconformity is underlain in most places by a lithologically heterogeneous assemblage of low-grade metasedimentary and metavolcanic rocks intruded locally by Lower to Middle Devonian granites (Dillon et al., 1987).

Multiple generations of folds, faults, and penetrative structures in this assemblage record the last mid-Paleozoic orogeny in Arctic Alaska, which has been assumed to be coeval with the Late Devonian to Early Mississippian Ellesmerian orogeny of the Canadian Arctic Islands (Lerand, 1973; Grantz et al., 1981).

Devonian to Mississippian terrigenous clastic rocks record the tectonic transition from mid-Paleozoic orogeny to late Paleozoic passive-margin deposition. Tailleur et al. (1967) named the thick succession of Upper Devonian and Lower Mississippian shale, sandstone, and

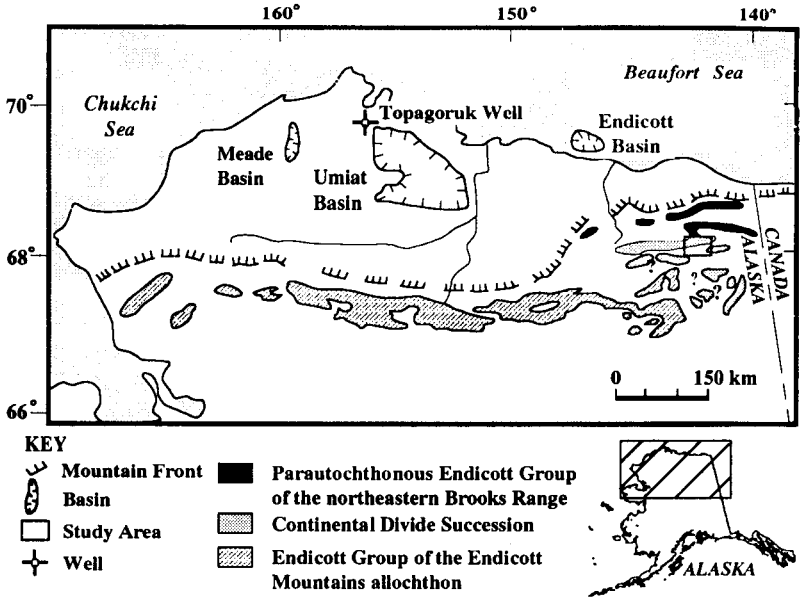

Fig.1. Generalized geologic map of northern Alaska showing outcrop exposures of Middle Devonian to Mississippian terrigenous clastic rocks in the northern Brooks Range and coeval basins in the subsurface to the north. Map adapted from Brosge et al. (1988), their Figure 14.1. The study area in the upper Kongakut River area is shown in a box.

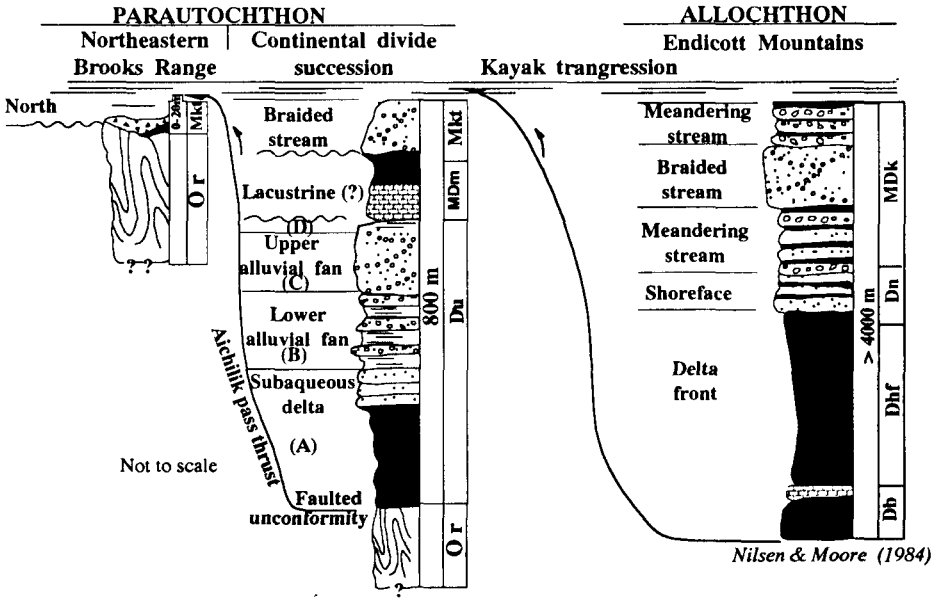

Fig.2. Generalized stratigraphic columns showing depositional setting for the three successions of Middle Devonian to Mississippian terrigenous clastic rocks. Allochthonous succession: Beaucoup Formation (Db), Hunt Fork Shale (Dhf), Noatak Sandstone (Dn), and Kanayut Conglomerate (MDk). Parautochthonous continental divide succession: Ulungarat formation (Du), Mangaqtaaq formation (MDm), and Kekiktuk Conglomerate (Mkt). Parautochthonous northeastern Brooks Range succession: Romanzof chert (Or) and Kekiktuk Conglomerate (Mkt).

conglomerate in the central Brooks Range the Endicott Group and extended the name to include the Mississippian conglomerate in the northeastern Brooks Range. These rocks crop out along the entire east-west axis of the Brooks Range and are recognized in the North Slope subsurface (Fig.1). Within the Endicott Group, Mull et al. (1976) and Nilsen (1981) recognized separate and distinct thin autochthonous and thick allochthonous stratigraphic successions (Fig.2). The top of the Endicott Group in both successions is formed by the transgressive Kayak Shale, which in each succession underlies platform carbonate rocks of the Lisburne Group (Bowsher and Dutro, 1957; Tailleur et al., 1967). The thin Kekiktuk Conglomerate underlies the Kayak Shale and unconformably overlies pre-Middle Devonian rocks in the autochthonous succession (Brosge et al., 1962; Nilsen, 1981). A much thicker and conformable Upper Devonian to Lower Mississippian clastic succession underlies the Kayak Shale in the allochthonous succession (Nilsen and Moore, 1984; Brosge et al., 1988). Tailleur et al. (1967), Nilsen and Moore (1984), and Brosge et al. (1988) have suggested a genetic relationship between the autochthonous and allochthonous Endicott successions, but thrust faults at the base of the allochthonous succession make correlations difficult.

Our recent studies in the upper Kongakut River region of the eastern Brooks Range (Fig.1) have defined a third, different but apparently related, Middle Devonian to Lower Mississippian clastic succession below the Kayak Shale (Anderson, 1993; Anderson and Wallace, 1991) (Fig.2). These deposits record a period of geologic history that is not preserved elsewhere in the northeastern Brooks Range. This parautochthonous succession is important because it occupies a geographic position between the autochthonous and allochthonous Endicott successions (Fig.1) and provides critical clues to the tectonic setting during Middle Devonian to Early Mississippian time.

MIDDLE DEVONIAN TO MISSISSIPPIAN LITHOSTRATIGRAPHY

In the upper Kongakut River region, the Aichilik pass thrust juxtaposes two distinct stratigraphic successions of Devonian to Lower Mississippian clastic rocks (Fig.2). In the footwall, thin, laterally discontinuous Lower Mississippian Kekiktuk Conglomerate overlies polydeformed Romanzof chert (informal name, unit OCcp of Reiser et al., 1980) on a high-angle unconformity. This is typical of the relationship throughout the northeastern Brooks Range to the north, where the Kekiktuk Conglomerate unconformably overlies pre-Middle Devonian rocks (Bird and Molenaar, 1987; Norris, 1986; Blodgett et al., 1991). In the overlying thrust sheets to the south, a much thicker Middle Devonian to Mississippian clastic succession includes two formations absent in the footwall succession. This southern succession, informally referred to here as the continental divide succession, is distinct because the Mississippian Kekiktuk Conglomerate overlies Middle to Upper(?) Devonian and Mississippian(?) rocks on a low-angle unconformity. This thick succession of Middle Devonian to Mississippian rocks includes the Ulungarat and Mangaqtaaq formations (informal units, Anderson, 1993), which are separated by a low-angle unconformity. These units lack the polydeformation that characterizes the Romanzof chert in the footwall succession and contain clasts apparently derived from the Romanzof chert. For these reasons, the continental divide succession is interpreted to have unconformably overlain the Romanzof chert. This unconformity is not observed in the study area because the base of the continental

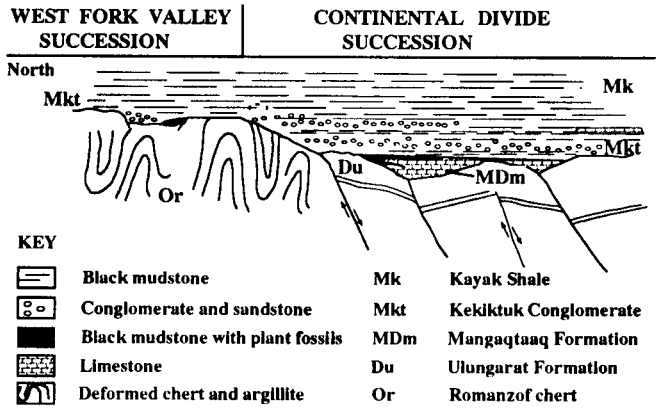

Fig.3. Schematic restoration of Mississipian depositional system showing deposition of Mangaqtaaq formation within localized restricted setting created by down-dropped fault blocks. Mangaqtaaq formation is overlain by retrograding fluvial system of the Kekiktuk Conglomerate and marine transgression recorded by the Kayak Shale.

the formation. We favor a lacustrine interpretation based on stratigraphic position between fluvial deposits, limited lateral extent, and lack of definitive marine fauna.

Kekiktuk Conglomerate

The Kekiktuk Conglomerate is an upward-fining and -thinning succession of chert and quartz pebble-to-cobble breccia and conglomerate, fine- to coarse-grained sandstone, and interbedded black shale. In the upper Kongakut River area, the formation is 0-200 m thick and contains coal, petrified wood, and Early Mississippian plant fossils. In the northern part of the area, the Kekiktuk Conglomerate overlies the Romanzof chert with high-angle discordance, whereas to the south it overlies the Ulungarat formation or, locally, the Mangaqtaaq formation with low-angle discordance. The top of the formation is gradational with, and intertongues(?) with, black mudstone and siltstone of the Kayak Shale. Correlation of the northern and southern successions and assignment to the Kekiktuk Conglomerate is based on lithologic similarity, the presence of distinctive purple-raspberry-colored chert clasts in both areas, and stratigraphic position below the Kayak Shale.

In the south, thick multistory and multilateral, amalgamated, channelized conglomerate and sandstone cycles in an overall fining-upward succession characterize the initial deposits of the Kekiktuk Conglomerate. Overlying deposits of the Kekiktuk Conglomerate intertongue(?) with black mudstone and siltstone interpreted to be Kayak Shale in an overall succession 180-200 m thick. Successive conglomerate and sandstone intervals thin and fine upward. In the north, where the formation directly overlies Romanzof chert, outcrops of the Kekiktuk Conglomerate are discontinuous but laterally persistent and generally are less than 15 m thick. A thick Kekiktuk Conglomerate succession 20 km west of the study area contains interbedded volcaniclastic rocks (Anderson et al., 1993).

The Kekiktuk Conglomerate is of pre-late or late Tournaisian (Early Mississippian) age. This age is based on the late Tournaisian age of the lowest interval of the overlying Kayak Shale and on Early Mississippian plant fossils recovered from fine-grained intervals of the Kekiktuk Conglomerate (Robert Spicer, pers. commun., 1991).

Regional relationships from south to north in the Kekiktuk Conglomerate suggest a northward-retrograding fluvial to marginal-marine system (Fig.3). Based on lithologic similarity, the closest source for these sediments is the Romanzof chert exposed beneath the sub-Kekiktuk unconformity to the north. To the south in the continental divide succession, the thick, braided-channel system and overlying succession of intertonguing black mudstone and fining-upward channelized sandstone intervals record migration of a retrograding fluvial system across a swampy delta plain or, alternatively, progradational pulses in a retrograding fluvial-deltaic system.

In the north, where it is deposited with high-angle discordance over complexly deformed Romanzof chert, the Kekiktuk Conglomerate is characterized by thin, laterally discontinuous colluvium deposits; small debris-flow deposits; and deposits of small, coarse-bedload streams. The associated black mudstone with plant fossils and coal, which underlies, interfingers laterally with, and overlies, the Kekiktuk deposits, is interpreted to be swampy flood plain deposits. Kekiktuk deposition in this area may have been synchronous with the Kayak transgression. Rising sea level transgressed over the previous source area, cutting off the sediment supply and ending coarse-grained terrigenous clastic deposition.

Kayak Shale

The Kayak Shale is a micaceous, dark-gray to black, organic-rich, very finely fissile, locally silty mudstone that conformably overlies, and locally intertongues(?) with, the Kekiktuk Conglomerate. Beds of sandstone and argillaceous limestone are locally enclosed in the black shale. Coal is locally present in the lower Kayak Shale, and abundant organic matter consisting of woody and coaly material is present throughout the succession.

Significant lateral facies variations characterize the lower Kayak Shale. Abrupt changes in composition and organization coincide with a threefold increase in thickness toward the south. Original depositional

thicknesses are uncertain because of detachment folding and associated structural thickening. In the northern part of the area, the formation is less than 100 m thick and composed of black shale with interbedded argillaceous limestone in the upper part. To the south, the formation is 300-400 m thick and includes intervals of sandstone and argillaceous limestone within the black shale. The top of the Kayak Shale is gradational with the overlying platform carbonate of the Lisburne Group.

The Kayak Shale in the upper Kongakut River region is of late Tournaisian to Visean (Early to Late Mississippian) age based on trilobites, conodonts, and plant spores (G. Hahn, written commun., 1990; A. Harris, written communs., 1989, 1990, 1991, 1992; J. Utting, Geological Survey of Canada, written communs., 1990, 1991).

The Kayak Shale is a marginal-marine to marine black shale deposited under anaerobic conditions. Characteristically, the lowermost deposits of the Kayak Shale are organic-rich mudstone with abundant plant fossils and coal. These basal deposits are the same whether overlying the relatively planar upper surface of the Kekiktuk braided-channel system in the south, intertonguing with the Kekiktuk Conglomerate in the central area, or onlapping Romanzof chert paleohighs in the north. The association of black shale, plants, and coal indicates a stagnant, swampy setting. Stratigraphic position below limestone containing a marine fauna indicates a coastal setting. These relationships suggest that Kayak deposition began in a low, swampy coastal-plain setting. Interbedding of Kekiktuk Conglomerate fluvial channel-fill deposits in the lower Kayak Shale suggests that the majority of coarse-grained clastic sediments were tied up in the fluvial system that crossed this coastal area. The overall upward-thinning and -fining of the Kekiktuk intervals suggest that nonmarine terrigenous clastic dispersal systems retrograded in response to decreased amounts of sediment supplied to the system and/or relative sea-level rise. The Kayak Shale records a major marine transgression along the southwestern margin of Arctic Alaska.

SUMMARY AND CONCLUSIONS

In northern Alaska, the strata unconformably overlain by Middle Devonian to Mississippian terrigenous clastic deposits record one or more major early Paleozoic contractional orogenic events. Structures in the unconformably overlying strata postdate the Paleozoic orogeny and record only contractional deformation associated with late Mesozoic to Cenozoic evolution of the Brooks Range. Throughout the northeastern Brooks Range, the youngest rocks beneath the unconformity are of Early Devonian age (Norris, 1986; Blodgett et al., 1991) and the oldest rocks above the unconformity are in the Lower Mississippian Kekiktuk Conglomerate (Bird and Molenaar, 1987). However, in the upper Kongakut River area, the oldest strata unconformably overlying polydeformed rocks are the Eifelian (early Middle Devonian) shallow-marine deposits of the Ulungarat formation. This relationship constrains the age of the last major early Paleozoic orogeny to pre-Middle Devonian time.

Upper Devonian to Mississippian terrigenous clastic rocks of northern Alaska have previously been interpreted to have been deposited in the foreland basin of a mid-Paleozoic orogenic belt (e.g. Nilsen, 1981). However, more recent interpretations suggest deposition in a rift to passive-margin setting (Moore et al., 1992; Anderson, 1993). In the upper Kongakut River area, Middle Devonian to Mississippian clastic rocks of the continental divide succession are interpreted to record a rift to passive-margin transition at the rift-basin margin (Anderson, 1993; Anderson and Wallace, 1991). The unconformity at the base of the succession marks a major change in tectonic setting and is interpreted to be a rift-onset unconformity. The succession overlying the unconformity is characterized by (1) abrupt facies changes; (2) abrupt southward thickening associated with local evidence of active tectonism; (3) multiple unconformities merging toward the basin margin to the north; (4) locally derived clastic deposits; and (5) closely associated shallow-marine, nonmarine, lacustrine(?), and, to the west, volcaniclastic deposits. These characteristics are consistent with syntectonic deposition in a rift setting. In the Kongakut River area, each of the contacts between the three nonmarine formations in the continental divide succession is marked by a low-angle discordance (Fig.2). Such low-angle discordance may record concurrent deposition and normal faulting and is typical of syn-rift deposits seaward of the tectonic hinge zone of a passive margin (Hutchinson and Klitgord, 1988).

Syn-rift deposition began with the shallow-marine to nonmarine Middle to Upper(?) Devonian Ulungarat formation. The Upper Devonian and/or Lower Mississippian Mangaqtaaq formation locally unconformably overlies the Ulungarat formation and is a succession of interbedded algal packstone and locally sourced terrigenous clastic deposits. Deposition of the unit between nonmarine fluvial deposits, its limited lateral extent, and the presence of blue-green algae characteristic of a restricted setting suggest a lacustrine setting. Alternatively, a restricted shallow-marine setting is possible. In either case, the restricted setting and bounding low-angle unconformities are consistent with syn-rift deposition over downdropped fault blocks (Fig.3).

The Lower Mississippian Kekiktuk Conglomerate overlies the Ulungarat or Mangaqtaaq on a low-angle erosional unconformity that is interpreted to be the post-rift unconformity. Deposition of the Kekiktuk Conglomerate began with braided fluvial deposits. Successively higher intervals of the Kekiktuk Conglomerate backstep progressively northward toward the basin margin and are overlain by coastal-plain to marine deposits of the Kayak Shale (Fig.3). Thin Kekiktuk Conglomerate and Kayak Shale onlap pre-Middle Devonian rocks at the basin margin and over

a regional paleohigh to the north, probably recording a shift to thermal subsidence that was slower and of more regional extent than the tectonic subsidence during rifting. The probable source terrain for the clastic rocks is the Romanzof chert, which apparently was exposed to erosion in the north from Middle Devonian to Early Mississippian time. The clasts in the Middle Devonian and Lower Mississippian clastic rocks are dominantly radiolarian chert and argillaceous chert with varying amounts of vein quartz and resemble rocks in the Romanzof chert. Close proximity to a source terrain is suggested by the coarse grain size and textural immaturity of the deposits.

The thick Middle Devonian to Mississippian continental divide succession probably is the proximal record of a progradational fluvial clastic depositional system that reached its maximum extent with deposition of the Upper Devonian to Lower Mississippian allochthonous Endicott Group to the south and southwest. A genetic relationship between the continental divide succession and the allochthonous Endicott Group is indicated by similarity in lithology, provenance, paleocurrent direction, and stratigraphic position as part of the south- to southwest-prograding, nonmarine, coarse-grained depositional system beneath the transgressive Kayak Shale. The Lower Mississippian Kekiktuk Conglomerate and Kayak Shale form the uppermost part of the continental divide succession but unconformably overlie polydeformed pre-Middle Devonian rocks to the north. Together, these terrigenous clastic deposits reflect rifting in Middle Devonian to Early Mississippian time to form the late Paleozoic-early Mesozoic south- to southwest-facing passive continental margin of Arctic Alaska.

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