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Tectonose Dimentologic Significance of the Upper Cretaceous Foreland Basin Siliciclastics: Western Interior, USA

Nazrul I. KHANDAKER[1,2]

1 The City University of New York – York College
2 Dept. of Earth and Physical Sciences, Jamaica, New York, NY 11451 USA

The Upper Cretaceous Frontier Formation exposed along the western margin of the western interior foreland basin is composed of clastic sediments that were deposited during the initial late Cretaceous transgressive-regressive phases of the Western Interior Seaway across Wyoming (Figure 1). Current study is aimed at providing attendees with the best practices associated with tectonic, lithofacies and sedimentologic interpretation of foreland basin sequences and emphasizing the need for utilizing field, structural, geochemical, and compositional data for reconstructing a viable scenario connected with foreland basin sedimentary packages. An attempt will be made to compare documented sedimentological findings with foreland basins located in the northeast of Qinghai-Tibet Plateau.

The lithofacies belonging to the Frontier Formation are subdivided into three distinct units which are, in ascending order: the lower Frontier unit, characterized by bioturbated sandstone, mudstone, bentonitic mudstone, and chert-pebble conglomerate; the middle Frontier unit, a thick sequence of sandstone, carbonaceous mudstone, bentonites, and chert-andesite-granite-quartzite pebble conglomerate; and the upper Frontier unit which incorporates thick beds of sandstone, siltstone, and bioturbated mudstone. Lateral as well as vertical variation in lithofacies is pronounced and sediment-fill is asymmetric. The basal sandstone (Peay sandstone) is composed of relatively thin layers of very fine to fine grained, bioturbated sandstone interbedded with irregularly laminated dark gray and poorly bioturbated mudstone. Small-scale trough-cross-stratification and minute intraformational rip-up clasts are also present within this sandy facies. The middle Frontier sandstones are generally less well-sorted than those of the basal sandstones; although the grain size coarsens up section within this middle unit. In addition, the middle Frontier sandstones consist of low-angle, trough cross-stratification, plant debris, and thin beds of lignite. The upper Frontier unit is composed of thick beds of fine to medium-grained sandstone. Ripple bedding is common in this unit. Carbonaceous shale, sideritized mudstone, root traces, and plant remains are frequently observed within this unit. Small horizontal to inclined burrows (Ophiomorpha) are encountered in the outcrop.

The basal, middle, and upper Frontier sandstone in north-central Wyoming (Figure 1), particularly in Bighorn Basin, consist of subequal amounts of quartz and rock fragments and subordinate amounts of feldspar. The identified lithic components are almost entirely composed of chert and other grains of sedimentary/volcaniclastic origin. Rock fragment, particularly chert is extremely important for deciphering ultimate provenance since chert is very stable and immobile trace element data obtained from chert may reveal distinct source for sediment contribution to the foreland basin sandstone. Based on local geologic setting, it is highly possible that chert within the Frontier sandstones was derived from the erosion of Permian Tensleep or Phosphoria Formations. QFL (quartz, feldspar, and lithics) data obtained from representative Frontier sandstone samples also reveal characteristic differences in QFL mode suggesting significant implications concerning provenance and the geometry of the depositional basin. The basal Frontier (Peay sandstone) sandstone with its generally consistent patterns in QFL roughly suggests the existence of a depositional basin with very little topographic or structural irregularity and presumably a homogeneous upland source area to the northwest (Figure 1). On the contrary, local intrabasinal control in the form of intraforeland uplifts associated with a dissimilar source terrain to the northwest

* Corresponding author. E-mail: nkhandaker@york.cuny.edu

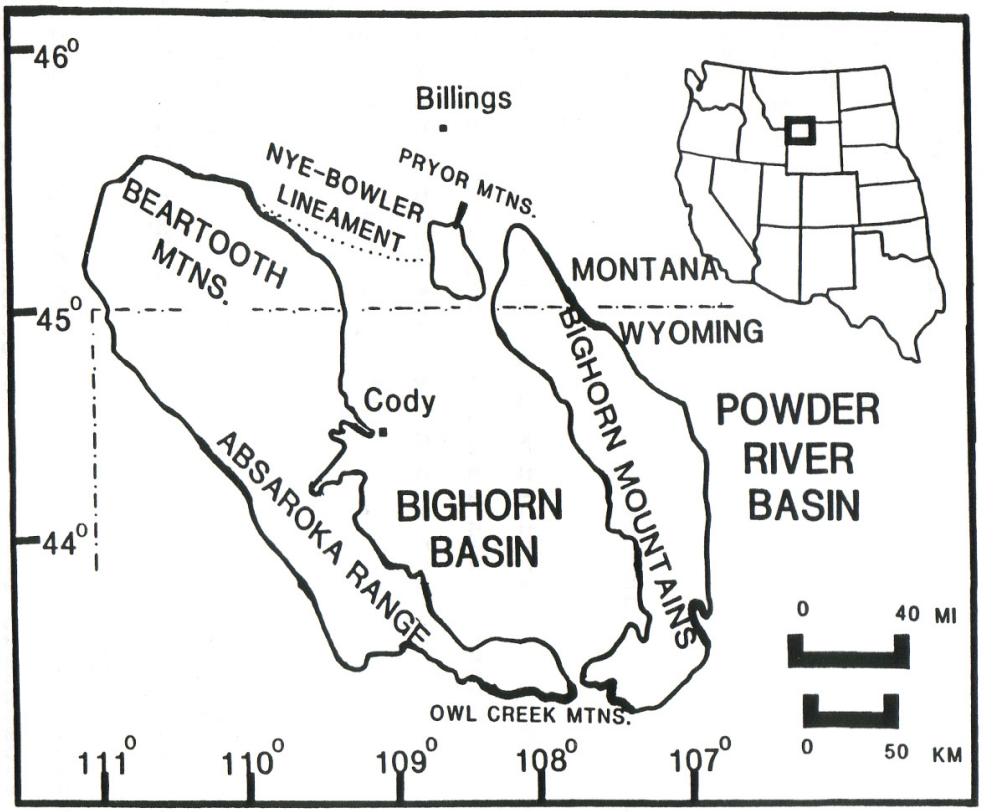

Figure 1. Location map of study area

must have exerted significant control on the establishment of final mineralogy of upper Frontier sandstones. Geochemical investigations of the whole rock andesite clasts and bentonite allowed more precise definition of character, tectonic setting, and evolutionary stage of sedimentary distributive provinces. Bentonites and andesites are strongly enriched in Sr and Ba, but only mildly enriched in heavy rate earth element (HREE) and high field strength elements (HFSE). These analyzed rocks have trace elements characteristics similar in a general way to those of "typical" orogenic volcanic; they show some significant differences in detail.

Composition of volcaniclasts and paleocurrent data indicate a proximal sediment source for the extrabasinal detritus within the frontier formation. The products of this volcanism constitute an assemblage of deep crustal-to-mantle- (?) derived rocks, and their compositions record time-integrated enrichment in light rare elements (LREE) over heavy rare earth elements (HREE). The localization of the volcanism in the late Cretaceous, however, is related to the development of fractures, some of which resulted from reactivation of old fracture zones in response to incipient Laramide orogeny. Subsequent propagation of this fracture zone in a northwest-southeast trend apparently controlled the distinctive andesite dispersal within the foreland basin proper. Temporal variations in sandstone composition and clast lithology within the frontier indicate an evolving northwesterly source terrain comprised of Precambrian crystalline rocks, a Paleozoic sedimentary sequence in a back-arc fold-and-thrust belt, and volcanic rocks of a late Cretaceous continental-arc. Sedimentation within the foreland basin was influenced by both intra-and extrabasinal conditions. Recognition of this intrabasinal structure-controlled sedimentation is very important as it provides a better mechanism for estimating the relative roles of autocyclic and allocyclic constraints on foreland basin sedimentation. In view of the renewed interest in estimating the relative influence of basin margin

tectonics versus intraforeland structural setting on the sediment dispersal within a rapidly subsiding foreland basin, one should always keep in mind on the significant role of autocyclic phenomenon on foreland basin sedimentation. Geochemical data for the bentonites indicate that the volcanism in the northerly source area changed in character with time and point to an increase in the degree of partial melting and a decrease in crustal involvement with time. Finally, facies patterns, hydrodynamic structures, ichnofaunal assemblages, and the geometry of the individual units strongly suggest sedimentation at a fluctuating shoreline with intermittent influxes of terrigenous components into a rapidly subsiding foreland basin.

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Key words: Foreland basin, Cretaceous, Western Interior, Tectonics, Provenance, Geochemical signatures

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