Early Temporal Development of the Sevier Foreland Basin, Wyoming: The Transition From Cratonic Margin to a Fully Partitioned Foreland Basin

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Hehe Jiang, Samuel A. Michalak, Gary D. Johnson, Edward E. Meyer
Department of Earth Sciences, Dartmouth College, Hanover, NH

Abstract

During the medial Jurassic, North American convergence with the ancestral Farallon Plate, lead to the initiation of a broadly defined Sevier foreland foldbelt and associated foreland basin. In Wyoming, biostratigraphy, facies correlations, sediment isopach characteristics, site-specific FT, U-Pb and K-Ar dates on pyroclastic units have constrained a general picture of this basin development. Of particular importance in this evolution is the recognition of foreland basin partitioning into a migrating foredeep, forebulge, and back bulge.

In this study, two positions of relative stasis in forebulge development during medial- and late- Jurassic have been recognized from sediment isopach data. The Sevier forebulge in central Wyoming appears to have undergone little oscillation of position from Bajocian to Oxfordian, whereas a migration of several hundred kilometers easterly occurred during the late Oxfordian to Kimmerdigian. Detailed micro-scale facies analysis and regional teprachronology have been applied to provide additional evidence for this basin partitioning and evolution.

In central Wyoming, deposition of medial and late Jurassic sediments occurred in dominantly shallow marine environments represented by the highly cyclic nature of the Sundance Sea stratigraphic record which thins easterly. This thinning is interpreted to occur primarily over the forebulge, with structurally higher positions of the forebulge being expressed through peritidal and terrestrial facies, including sub-tidal thrombolites, storm-induced shallow-water tempestites, salt crystal casts in supratidal facies, paleosols, aeolianites, ventifacts, karst and sabkha fabrics.

Numerous outcrops containing multiple horizons of tuffs have been identified within these marine, transitional and terrestrial sediments. Interestingly, the two stages of forebulge stasis appear to coincide with pulses of arc-related volcanism to the west, indicated by primarily tuffs, bentonites and bentonitic mudstones preserved in these source-medial to source-distal sediments. This pyroclastic record has served as a facies-independent temporal control on the sedimentary record, and in turn constrains the tectonic significance of the facies mosaic found within these evolving foreland basin.elements.

Geological Settings

Beginning in the late Triassic and continuing until the late Cretaceous, eastward-dipping subduction of the ancestral Pacific Plate led to the formation of the Cordilleran Arc along the western margin of North America. To the east of the subduction related magmatism, a transition from cratonic basin to retro-arc foreland basin sedimentation began during the early to middle Jurassic. As a result of eustatic fluctuations, this foreland basin became inundated by an epicontinental seaway known as the Sundance Sea. Sediments deposited during this period within the foreland basin in Wyoming indicate a subtidal shallow marine environment within the Twin Creek and Hardin Troughs, with peritidal and even subaerial conditions existing farther to the east in central Wyoming.

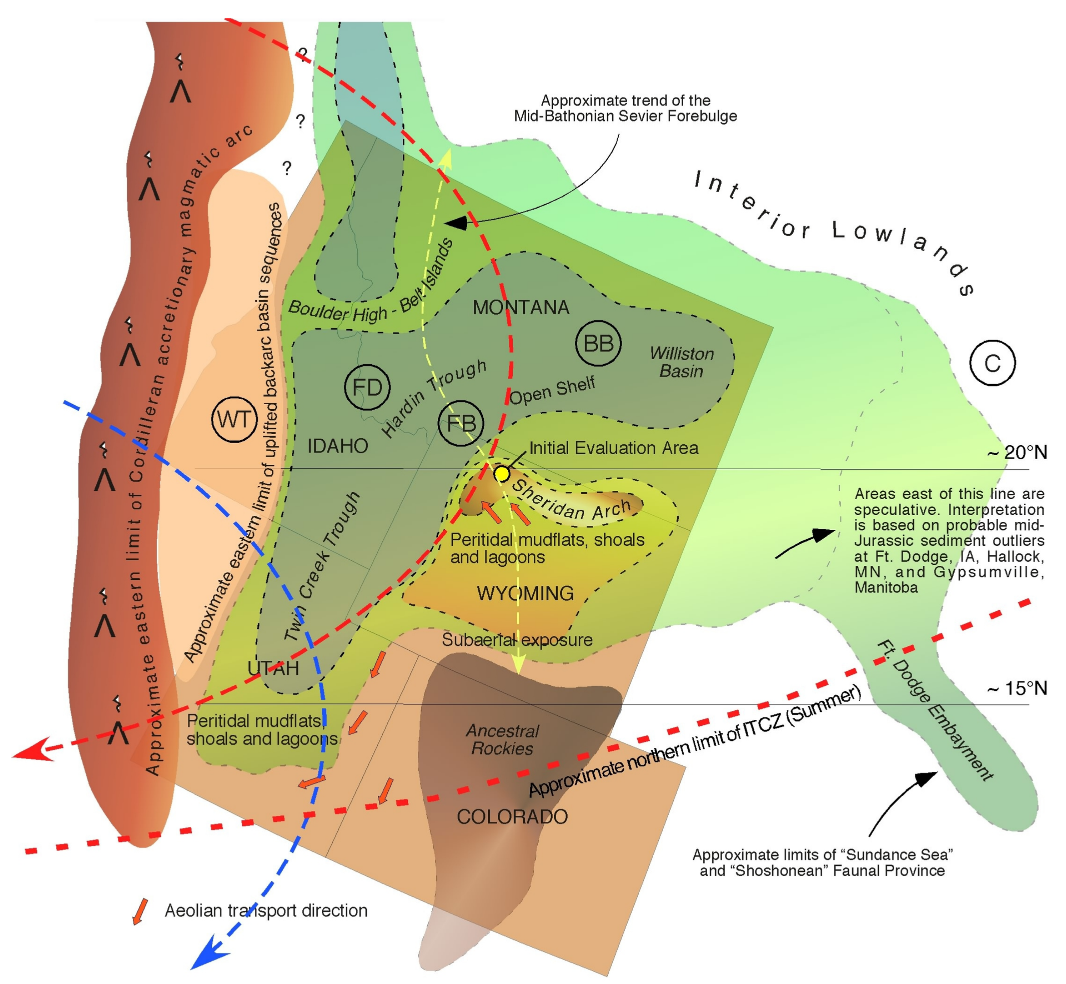


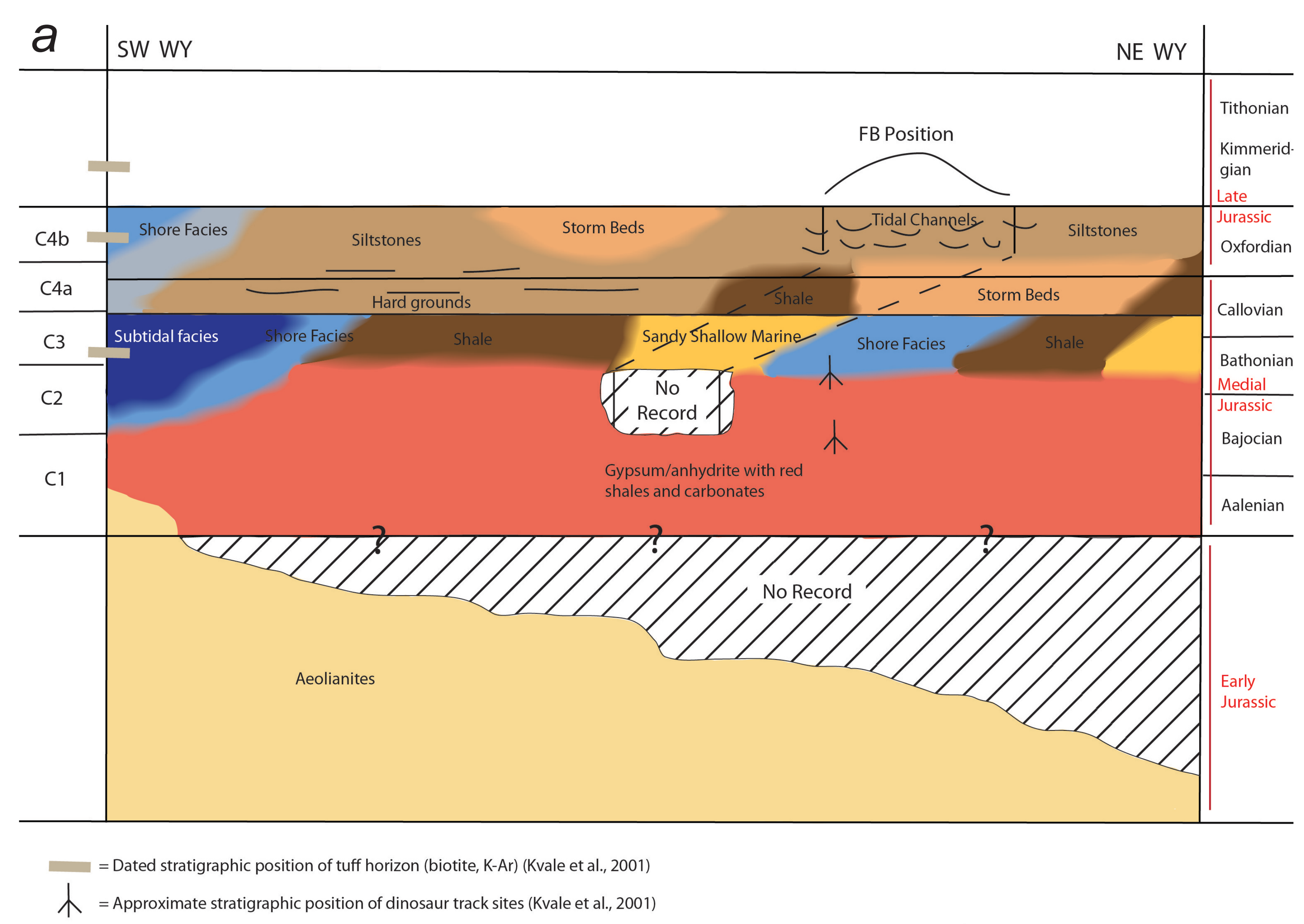
***Fig.1** Paleogeographic reconstruction of the Cordilleran arc and Western Interior Basin in Middle Jurassic (Bathonian, 167 Ma). Compiled from the interpretations of Wright (1971), Imlay (1980), Kocurek and Dott (1983), Blakey et al. (1988), Brenner and Peterson (1994), and this research. Terminology: wedge top (WT), foredeep (FD), forebulge (FB), backbulge (BB), and craton (C).*

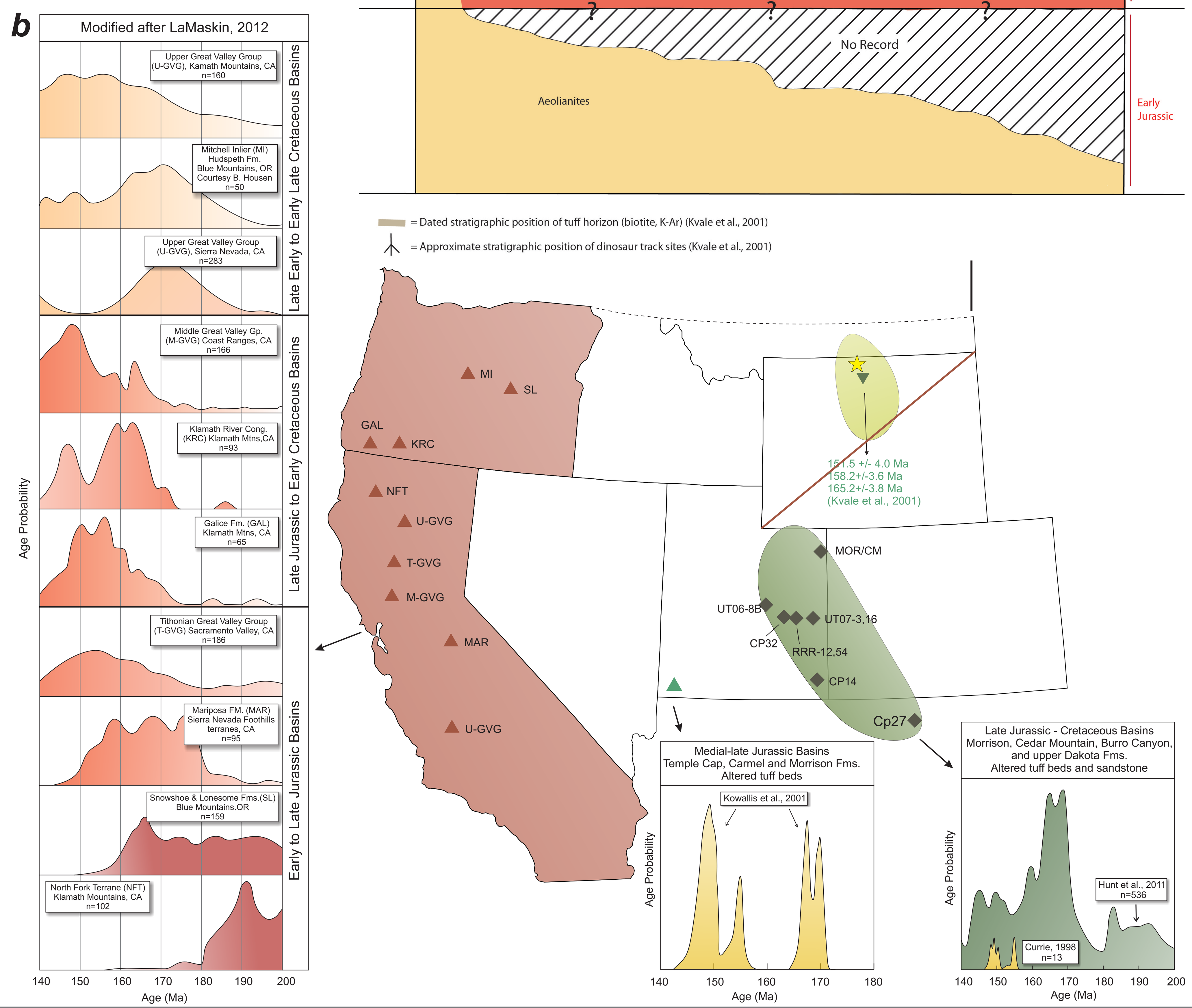
Spatial and Temporal Evidence

In recent decades, researchers have put a considerable amount of effort into dating Jurassic-Cretaceous sandstones and tuff layers across the western US. By compiling the ages of these volcanic events, two pulses of higher frequency volcanism are evident. When compared with facies distributions within the Wyoming portion of the foreland basin, these pulses occured coeval with the lateral migration of shoaling, peritidal, and subaerial facies. Deposition in these environments is interpreted to have been controlled by the location of the structurally higher forebulge within the foreland basin. Therefore, the eastward migration of these environments from the Bajocian to Kimmerdgian, combined with the increased frequency of volcanism in the magmatic arc to the west, is taken as evidence for the eastward migration of the forebulge during that time.

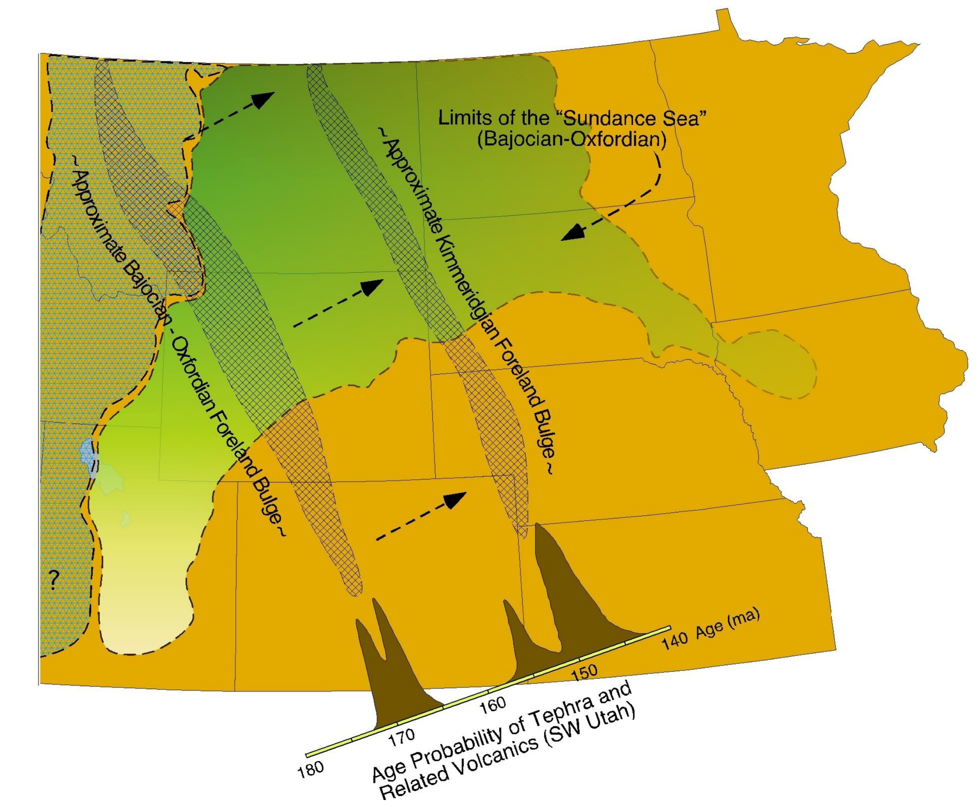
***Fig. 2a** Space – Time diagram displaying lithofacies from SW to NE Wyoming (as indicated in Fig.2b) during the early, medial, and earliest Late Jurassic. Forebulge position and migration from the Bajocian to Oxfordian interpreted from the presence of subaerial and shallowing facies. Data compiled from Buscher, 2003; Kvale, 2001; McKee et al, 1956; Peterson, 1972. C1-C4b interval nomenclature adopted from Buscher, 2003.*

Fig. 2b** Merged detrital zircon U-Pb and K-Ar chronometric data from various sedimentary basins that are source-proximal to source-distal to the Cordilleran arc in the Western USA. Two major episodes of arc volcanism in medial, and late Jurassic can be recognized. The star mark will be our future work location. For details, see **Fig. 4





Foreland Basin Evolution



It appears that the position of the forebulge may slightly oscillate towards and away from the craton during Bajocian to Oxfordian time, suggesting a very sensitive teleconnection to the evolving volcanic arc system to the west. The transition from cratonic basin to retro-arc foreland basin of the Western Interior Basin was initiated as a result of the activities of Cordilleran arc around 170 Ma. Two pulses of volcanism in medial and late Jurassic resulted in the formation and subsequent migration of the forebulge. The formation of the forebulge in central Wyoming appears to coincide with a pulse of active arc-related volcanism preserved in the tuff layers in the middle Jurassic Temple Cap and Carmel Formations of southwestern Utah between 171 and 166 Ma. The subsequent eastward migration can be attributed to an additional pulse from 155-148 Ma, which led to the development of extensive tuff beds in the late Jurassic Morrison Formation.

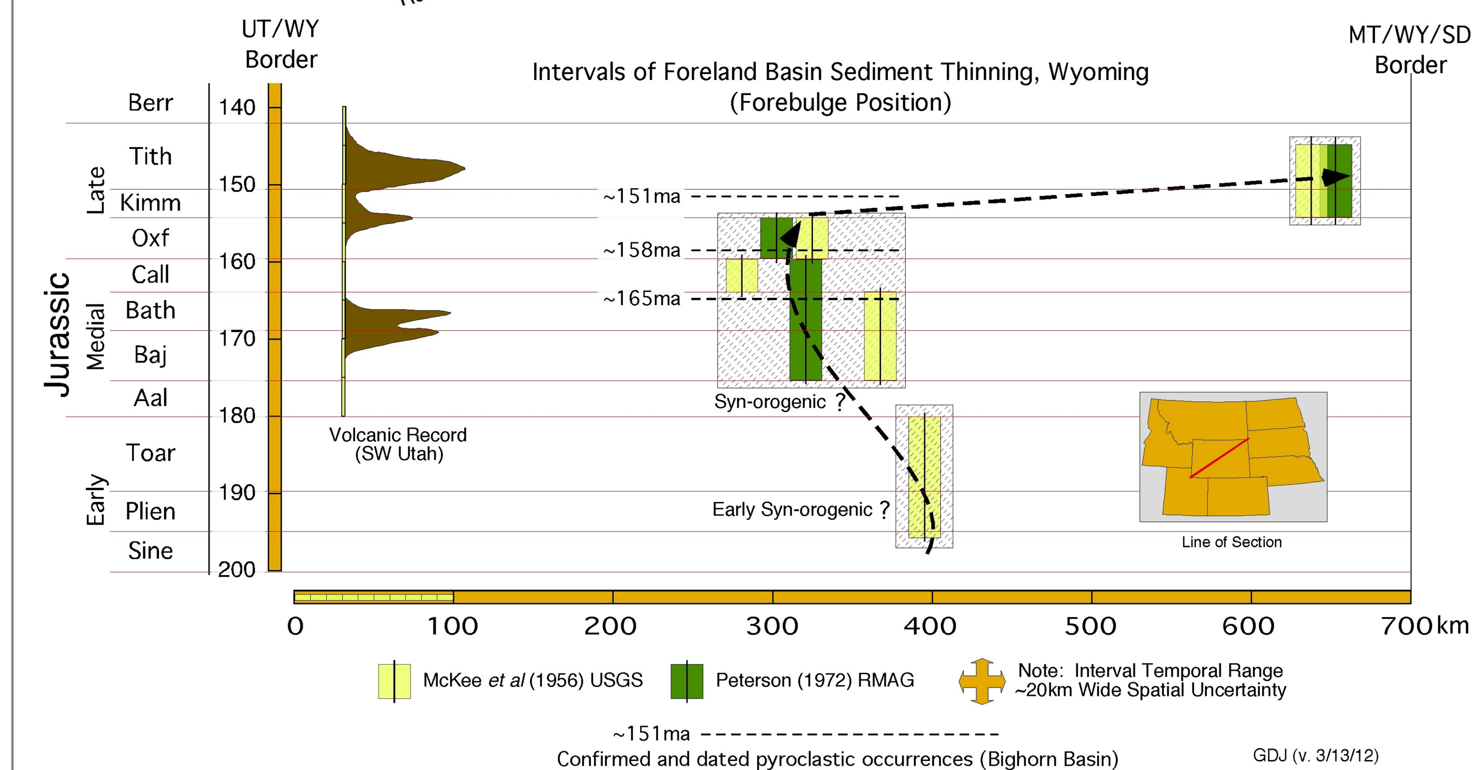


***Fig. 3** A time-space diagram of forebulge position and subsequent migration. Two general episodes (hatchered) are evident from data presented in sediment isopach maps from McKee et al (1956) and Peterson (1972). The pre-orogenic position of the distal edge of the evolving foreland basin in pre-Bajocian time is indicated as well as the syn-orogenic positions interpreted from each of these two sources. The confirmed and dated pyroclastic occurrences is from our investigations.*

Conclusions and Future Work

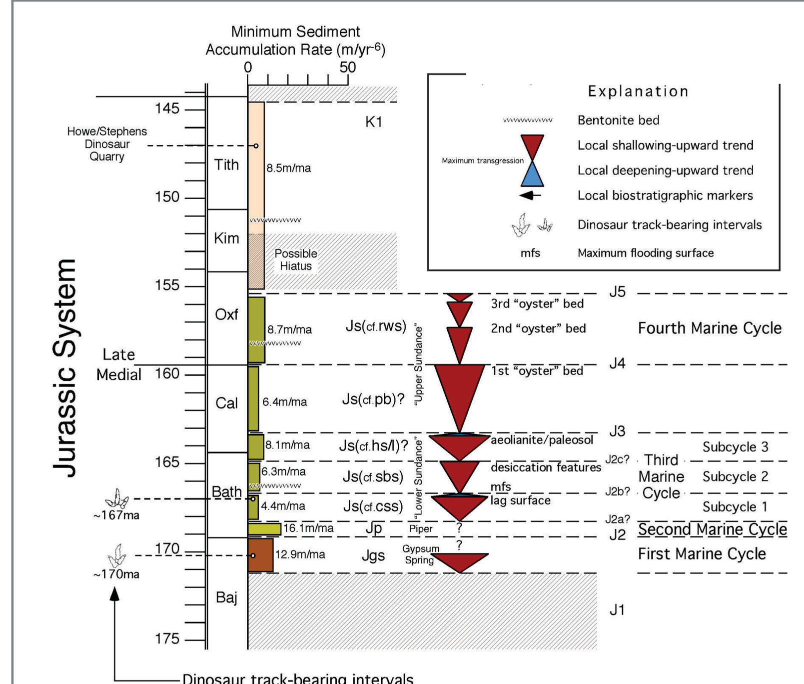


***Fig. 4** Medial and late Jurassic chronostratigraphy for the northeastern Bighorn Basin, Wyoming. Shallowing upward cycles have been recognized in the middle Jurassic*

1. There are at least two forebulge migration episodes during the medial and late Jurassic, each of which can be related to Cordilleran arc volcanism.

2. The location of shallowing facies within the foreland basin can be used as an indicator of the position of the structurally higher forebulge. The eastward migration of these facies between the Bajocian and Oxfordian is interpreted as evidence of the migration of the forebulge during this time.

3. There is a need for more detailed, higher precision analysis to constrain the exact timing of forebulge migration within the Jurassic foreland basin. The construction of a facies-independent pyroclastic chronology throughout the basin, especially the source-distal areas, will provide a much higher degree of temporal control.

4. More detailed sedimentologic analysis is needed on the lower-most medial Jurassic and early Jurassic deposits to determine when the initiation of foreland basin development began and how that change is reflected in the sedimentary record.

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