Depositional environments and provenance of arkosic sandstone, Park shale, middle Cambrian, Bridger Range, southwestern Montana
by Jenny Christine Fryxell

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Earth Science
Montana State University

Abstract:
Middle Cambrian strata of southwestern Montana are a transgressive regressive package of rocks consisting of fine-grained elastics and carbonates. The rocks represent the Sauk sequence and in ascending order are: The Flathead Sandstone, Wolsey Shale, Meagher Limestone, Park Shale, Pilgrim Limestone and Snowy Range Formation. Quartz/feldspar-rich zones occur in the Flathead, Wolsey, Meagher, and Park Shale.

Quartz/feldspar-rich zones in the upper third of the Meagher, a flat-pebble conglomerate with a coarse, detrital, silt-sized matrix at the top of the Meagher, and abrupt increases in the stratagraphic thickness of the Meagher and Hasmark Formations near the Idaho/ Montana border, reflect increasing tectonic instability and shallowing of the sea during late Meagher/early Park time. The arkosic interval of the Park represents the culmination of tectonic instability and disruption of the marginal-shelf environment. Renewed tectonic instability most likely occurred along pre-existing zones of structural weakness.

The arkosic sandstones of the Park are restricted to the northern half of the Bridger Range and to the lower 30 m of the Park shale. The arkosic interval of the Park consists of two major facies: a quartz/orthoclase-rich facies with locally developed flat-pebble conglomerate, and a calcareous, fossiliferous, arkosic, glauconite-rich sandstone.

The arkosic sandstones of the Park Shale were deposited in a shallow-water near-shore island complex. The abrupt, sporadic occurrence, and lateral discontinuity of the quartz/orthoclase-rich facies indicates catastrophic sedimentation followed by a rapid return to mud sedimentation. The abundance of glauconite, carbonate and fossils in the glauconite-rich facies suggests deposition in a stable, quiet, shallow-water, marginal-shelf environment.

The sporadic occurrence of sandstone throughout the arkosic interval suggests periodic rejuvenation of a granite gneiss source rock. During subaerial exposure of the source rock, a weathered zone or profile developed. This weathered zone was a source of clastic detritus for both arkosic sandstone facies.

By latest Park/earliest Pilgram time, erosion of the source area, increasing tectonic stability and an effective rise in eustatic sea level had re-established stable, marginal-shelf conditions.

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Date May 28, 1982

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of the requirements for the degree

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MASTER OF SCIENCE

in

Earth Science

Approved:

Chairperson, Graduate Committee

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MONTANA STATE UNIVERSITY
Bozeman, Montana

May, 1982

ACKNOWLEDGMENTS

Great appreciation is extended to Dr. Donald L. Smith (Committee Chairman), Dr. Stephan G. Custer, and Dr. John Montagne of the Reading Committee, who provided much guidance and counseling.

Great appreciation is extended to the following people:

Drs. Don Winston, S. A. Graham and Christina Lochman-Balk, for allowing access to unpublished data, thin sections, and for their many helpful discussions on Cambrian sedimentation and stratigraphy in southwestern Montana.

Ann Satterlee, Brent Anderson and Pete Brittingham, who ably assisted me in the field; Jim Franks and Greg Mohl for their expertise in photography and drafting; Elinor Bryant for typing numerous drafts of the thesis; Jim and Bea Taylor for allowing access to their land in the Bridger Range.

Special thanks go to Earl Cassidy for his editorial comments and moral support; to my family without whose financial and moral support graduate school would not have been possible.

To my father and grandfather, whose love of geology and learning were a source of inspiration and example, I dedicate this thesis.

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ABSTRACT

Middle Cambrian strata of southwestern Montana are a transgressive regressive package of rocks consisting of fine-grained clastics and carbonates. The rocks represent the Sauk sequence and in ascending order are: The Flathead Sandstone, Wolsey Shale, Meagher Limestone, Park Shale, Pilgrim Limestone and Snowy Range Formation. Quartz/feldspar-rich zones occur in the Flathead, Wolsey, Meagher, and Park Shale.

Quartz/feldspar-rich zones in the upper third of the Meagher, a flat-pebble conglomerate with a coarse, detrital, silt-sized matrix at the top of the Meagher, and abrupt increases in the stratagraphic thickness of the Meagher and Hasmark Formations near the Idaho/Montana border, reflect increasing tectonic instability and shallowing of the sea during late Meagher/early Park time. The arkosic interval of the Park represents the culmination of tectonic instability and disruption of the marginal-shelf environment. Renewed tectonic instability most likely occurred along pre-existing zones of structural weakness.

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The arkosic sandstones of the Park Shale were deposited in a shallow-water near-shore island complex. The abrupt, sporadic occurrence, and lateral discontinuity of the quartz/orthoclase-rich facies indicates catastrophic sedimentation followed by a rapid return to mud sedimentation. The abundance of glauconite, carbonate and fossils in the glauconite-rich facies suggests deposition in a stable, quiet, shallow-water, marginal-shelf environment.

The sporadic occurrence of sandstone throughout the arkosic interval suggests periodic rejuvenation of a granite gneiss source rock. During subaerial exposure of the source rock, a weathered zone or profile developed. This weathered zone was a source of clastic detritus for both arkosic sandstone facies.

By latest Park/earliest Pilgram time, erosion of the source area, increasing tectonic stability and an effective rise in eustatic sea level had re-established stable, marginal-shelf conditions.

INTRODUCTION

Location

The study area is located in the Bridger Range, directly north of Bozeman, Montana (Fig. 1). The Bridger Range, which is an asymmetric, eastward verging, anticlinal uplift bounded on the west by a normal fault, trends north-south for 26 miles. The Park Shale crops out along the western flank of the Bridgers, the southeastern limb of the Horseshoe Hills, and to the south along the northwestern flank of the Gallatin Range (Fig. 1).

Purpose

The arkosic sandstones of the Park represent an interesting stratigraphic-sedimentologic problem which has not been previously addressed. Middle Cambrian rocks in the study area are dominated by fine-grained clastic and carbonate rocks which total 498 m. Feldspar-rich sandstone and siltstone beds occur in the Flathead Sandstone, Wolsey Shale, and Park Shale. Quartz/feldspar sandstone stringers are present in the Meagher Limestone. The occurrence of these arkose-rich intervals, in a stratigraphic section consisting of fine-grained clastic and carbonate material, represents a local disruption of the stable, marginal-shelf environment. This study was a: (1) description of the stratigraphy and areal distribution

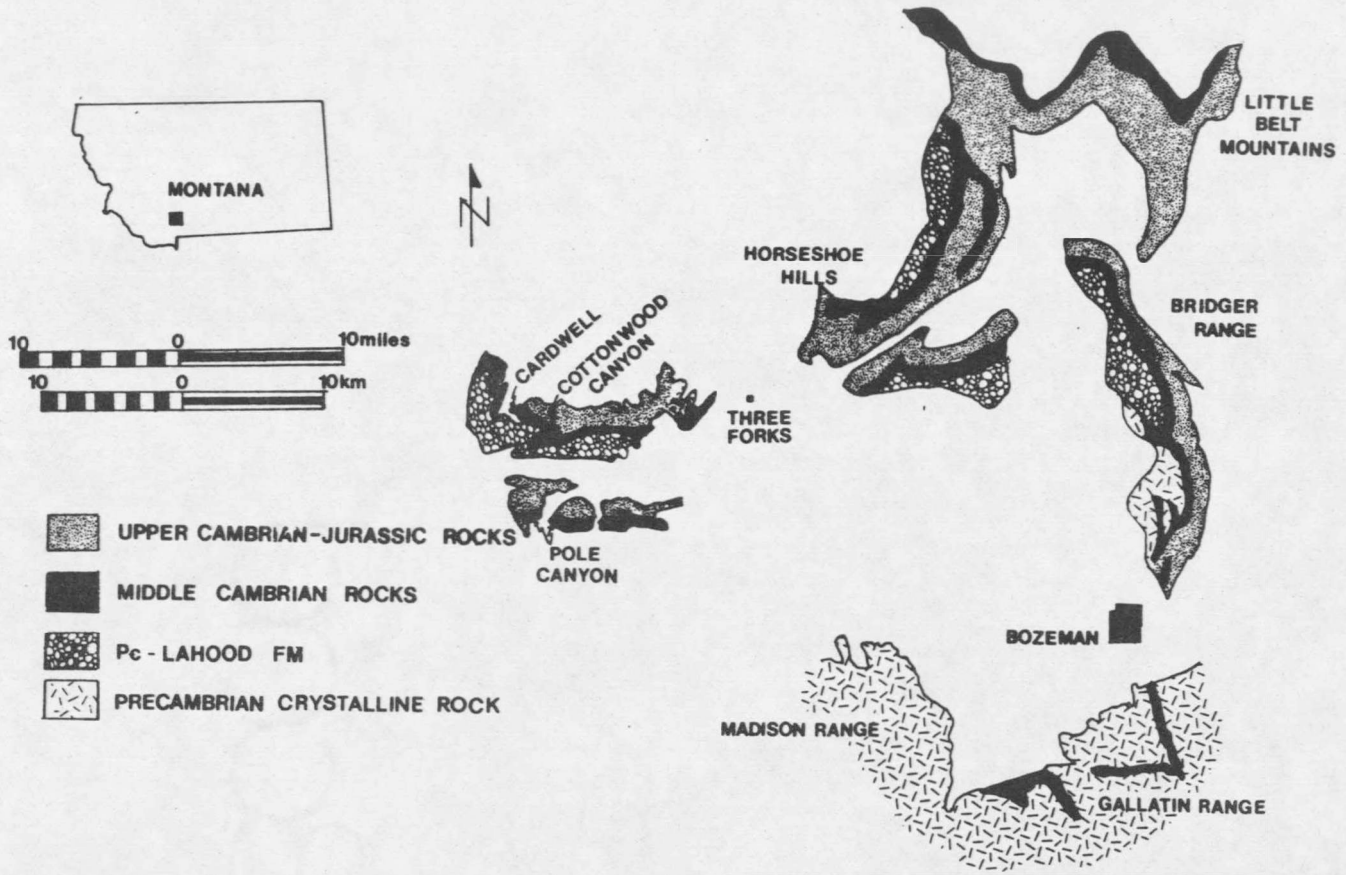

Figure 1. Distribution of Middle Cambrian rocks referred to in the text. Author's measured sections lie along strike in the northern half of the Bridger Range, and in the Horseshoe Hills. Section locations shown in Figure 7.

of the arkose, (2) details petrographic characteristics of the arkoses and (3) develops a depositional model that explains the occurrence of arkose in a stratigraphic sequence consisting of fine-grained clastic and carbonate rocks.

Procedure

Field studies of the Park arkosic interval were conducted during the summers of 1980 and 1981. Field work entailed locating, measuring, and sampling arkosic sandstone outcrops. Exposures are poor as the shale tends to slump badly. As a result, the best outcrops are in very steep, southeast-facing or northwest-facing slopes. In addition, interpretation of field data was hampered by the sporadic occurrence of outcrops along strike in the Bridger Range, the total lack of Cambrian outcrops to the east, and the lack of outcrops for seven miles to the west.

Later, representative handsamples and thin sections were studied using binocular and petrographic microscopes. Samples from selected areas of Precambrian crystalline rock, Flathead Sandstone, Wolsey shale and Meagher Limestone were also examined in thin section. Estimates of mineral percentages were obtained both petrographically and by staining samples using the method proposed by Bailey and Stevens (1960) for selective staining K-feldspar and plagioclase.

REGIONAL SETTING

Sedimentary Tectonics

The structural and stratigraphic framework of western Montana evolved in Precambrian Y time during Belt sedimentation (McMannis, 1965). Sediments were deposited in the Belt Basin, a large epicratonic trough, which formed a northwest-southeast-trending reentrant along the eastern margin of the Cordilleran miogeosyncline (Fig. 2). The basin swung inland at its southeasternmost extent, forming the east-west trending Belt Embayment. The embayment was bounded on the north by the North American craton and on the south by the Dillon Block (Hartison and others, 1974). The Dillon Block is essentially the same tectonic province as the Paleozoic Wyoming shelf of Sloss (1950).

The northern margin of the Block is coincident with the Paleozoic shelf break and is defined by the east-west trending Willow Creek fault zone. This zone is thought to represent a major Precambrian structural discontinuity which is still active today and which probably influenced Paleozoic and Mesozoic sedimentation patterns as well (Sloss, 1950; Bonnet, 1979).

Depositional patterns of Cambrian through Mississippian formations, Jurassic formations, and parts of Cretaceous sections are thicker in east-west zones. These depositional patterns closely