Cenozoic Stratigraphy in Western Montana: Current Status and A Way Forward

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ABSTRACT

Lithostratigraphy is an approach currently used by some for Cenozoic stratigraphy in western Montana. Cenozoic lithostratigraphic units are part of the Bozeman Group, with lower Tertiary strata placed in the Renova Formation and upper Tertiary deposits comprising the Sixmile Formation. The characterizing lithologic features of this two-fold formal lithostratigraphy are that strata within the Renova Formation are predominantly fine-grained and the Sixmile Creek Formation contains mainly coarsegrained rocks. The difficulty in applying this stratigraphy is that basin strata lithology commonly exhibit abrupt lateral lithologic changes, with predominantly fine- and coarse-grained units being often repeated throughout the stratigraphic column. Consequently, Bozeman Group lithostratigraphy does not provide a solid mappable basis for working with Cenozoic strata and has resulted in muddled geologic interpretations for these basins.

A way forward for western Montana Cenozoic stratigraphy is the use of sequence stratigraphy. Cenozoic continental strata in western Montana basins can be separated into five sequences that can be delineated in the field based upon unconformable relationships with other strata and by their capping of mature paleosols. In ascending order, approximate age ranges for these informally designated sequences are: $(1) \sim 54$ to 44 Ma, (2) ~38 to 32 Ma, (3) ~27 to 21 Ma, (4) ~16 to 4 Ma, and (5) ~2 Ma to present time. A regional unconformity separates an early Eocene paleolandscape from the overlying five Cenozoic sequences. The early Eocene unconformity and Sequence 1 are delineated by ultisols; all other younger sequence boundaries have bounding calcic paleosols. The sequences are presently age constrained by existing isotopic ages and by North American Land Mammal ages derived from contained fossil vertebrate assemblages. A new effort to more tightly age constrain the sequences includes six ⁴⁰Ar/³⁹Ar isotopic ages ranging from about ~ 28 Ma to 2 Ma for tuffs in the Blacktail-Ruby valleys, southwest Montana, and ten tuff samples from other southwest Montana localities that are currently undergoing isotopic age analysis. Ultimately, Cenozoic sequence stratigraphy provides a better framework for both inter- and intra-valley correlation and yields a more accurate basin formation time frame.

Western Montana Cenozoic Sequence Lithologies

The lithology of Tertiary strata present in western Montana Cenozoic basins commonly exhibit abrupt lateral lithologic changes, with predominantly fineand coarse-grained units being often repeated throughout the Cenozoic stratigraphic column. A few lithology examples are shown here for the 5 Cenozoic sequences that we herein delineate:



Sequence 1 ash-flow tuff, Deer Lodge Valley.



Sequence 2

Sequence 2 mudstone and cryptic grus channels, Little Pipestone area, Jefferson Valley.

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Western Montana valleys typically consist of multiple depositional basins that contain continental Tertiary deposits. The specific valleys noted in the above figure are those in which some stratigraphic/paleontologic work on Tertiary deposits has been done.

equence



Sequence 4 mudstone near Whitehall, in the Jefferson Valley.



Sequence 3 conglomerate and coarse-grained sandstone strata, Toston Valley (Sixmile Creek type section).



Tertiary conglomerate and mudstone in Sequence 2 in the lower Ruby Valley, southwestern Montana.



Sequence 4 conglomerate and coarse-grained sandstone, Beaverhead Valley.

Sequence 3



Sequence 3 paper shale overlain by calcic paleosol, Townsend Valley.



Epoch	Ma	North America Land Mammal Ages		
Pleistocene	-0.01 1.75	Rancholabrean Irvingtonian		
Pliocene	- 5.3	Hemphillian		
Miocene		Clarendonian		
		Barstovian		
		Hemingfordian		
	23.8	Arikareean		
Oligocene		Whitneyan Orellan		
Eocene	• 33.7	Chadronian		
		Duchesnian		
		Uintan		
	54 0	Bridgerian		
		Wasatchean		
Paleocene	· J-1.0	Clarkforkian		
		Tiffanian		
		Iorrejonian		

Cenozoic sequence distribution in western Montana can be separated into tectonic episodes. This type of diagram is made possible when Cenozoic deposits are tightly age constrained rather than mapped as lithostratigraphic units.



			1	· · · · · · · · · · · · · · · · · · ·	Γ	r	1
		Easting -	Northing -				
Sample		NAD 27	NAD 27				
Name	General Location	Zone 12	Zone 12	Longitude	Latitude	Rock Type	Age Analysis
							40 20
							⁴⁰ Ar/ ³⁹ Ar; Mean
							age = 10.395
	Upper Ruby - Robb						<u>+</u> 0.083 Ma -
TVI	Creek	410973	4986896	-112.13097	45.0318	Tuff	sanidine (SEM)
							⁴⁰ Ar/ ³⁹ Ar; Mean
							age = 10.384
							+0.080 Ma
							sanidine (SEM);
							10.458 <u>+</u> 0.006
	East Fork of						Ma - plagiocalse
TVM	Blacktail Creek	405185	4974225	-112.20206	44.91701	Tuff	(SD)
							40 30
							⁴⁰ Ar/ ³⁹ Ar; Mean
							age = 9.474
							<u>+</u> 0.052 Ma
							sanidine (SEM);
	East Fork of						9.683 <u>+</u> 0.267 Ma
TVN	Blacktail Creek	405100	4974420	-112.20317	44.91875	Tuff	plagioclase (SD)
							⁴⁰ Ar/ ³⁹ Ar; 2.042
	Upper Ruby -					Ash-flow	<u>+</u> 0.010 Ma -
TVL	Ledford Creek	411415	4984380	-112.12492	45.00921	tuff	sanidine (SEM)
							40
							⁴⁰ Ar/ ³⁹ Ar; 28.327
7	Blacktail Deer						<u>+</u> 0.314 Ma -
TVR	Creek	392890	4971760	-112.35727	44.89308	Tuff	biotite (SEM)
							⁴⁰ K/ ⁴⁰ Ar; 5.89 <u>+</u>
	Blacktail Deer						0.23 Ma; whole
	-		-				-

Blacktail - Ruby ⁴⁰Ar/³⁹Ar Isotopic Ages and Locality Data



Tuff samples from southwestern Montana locations noted in above image are currently undergoing isotopic age analyses (⁴⁰Ar/³⁹Ar) at the New Mexico Geochronology Research Laboratory, Socorro, New Mexico.



Ultisol - Sequence 1 Top

An ultisol marks the top of Sequence 1 in the Butte - Rocker area, southwestern Montana..

Calcic Pedocomplex

Paleosol profiles at sequence boundaries are often stacked and comprise pedocomplexes where two or more paleosols are separated over large areas by a thin deposit of C horizon material, and where they are overlain and underlain by larger amounts of strata that contain weak to no evidence of soil development.

Calcic paleosols mark the Sequences 2/4 boundary in the lower Madison Valley, southwestern Montana.



Calcic pedocomplexes delineate the boundary between Sequences 3/4 in the Ruby Valley, southwestern Montana