The Crandall Conglomerate: a fluvial deposit, Clarks Fork of the Yellowstone River Valley, Wyoming

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INTRODUCTION

Location. The Crandall Conglomerate crops out in the Clarks Fork of the Yellowstone River Valley in northwestern Wyoming, between the Beartooth and the Absaroka Mountains. The conglomerate was deposited in a paleovalley system incised at least 160 m into Paleozoic strata. The Heart Mountain Fault cuts the Crandall Conglomerate, cleanly slicing some clasts. Conglomerate exposures in the footwall follow the Laramide-age Blacktail Fold-thrust (Di Benedetto, 1998, this volume) in the Cambrian Pilgrim Limestone (Figure 1). This project is a study of the Crandall stratigraphy and sedimentology with limited thin section petrologic analysis.

Age of the Crandall. The conglomerate must be younger than 350 ma because the youngest clasts in the conglomerate are Mississippian in age (Pierce, 1973). Only one tectonic episode after 350 Ma, the Laramide orogeny, had enough influence to cause stream incision and clastic deposition in the study area (DeCelles, *et al.*, 1991). No volcanic clasts are observed in the conglomerate, therefore the it must be older than the volcanic rocks in the study area (Absarokas ~50 Ma). Therefore, the Crandall must have been deposited in the late Paleocene to early Eocene between the start of the Laramide orogeny and the start of Absaroka volcanism. The paleovalley was incised after the formation of the Blacktail Fold (Di Benedetto, 1998).

DATA

Stratigraphy. The conglomerate is a subaerial, fluvial conglomerate composed of about 95% well rounded limestone clasts. These clasts were derived from the units through which the paleofluvial system cut, from granitic basement rock through the Mississippian Madison Limestone (Pierce, 1973). Sedimentary structures are rare and no woody debris or organic matter is observed in the conglomerate. Clay sediment is generally sparse throughout the conglomerate.

Overall the outcrops have a red color which comes from red lithic granules of clay, quartz, and calcite and from iron oxide staining in the matrix. The matrix is 80% granules or pebbles, of which 95% are limestone. The sand size and smaller fraction consists of 45% quartz, 50% limestone, 2% microcline feldspar and 3% accessory minerals. Most of the matrix finer than granule size is not well sorted or rounded. There are large blocks over a meter in diameter in several of the outcrops, none of which are well rounded. These are interpreted as debris fallen down from the side of the valley walls. Imbrication and crude crossbedding used to measure paleocurrents are rare and often poorly developed.

Classification of the conglomerate deposits gives 8 facies: very fine to fine sandstone (VFS-FS), very coarse to coarse sandstone (VCS-CS), granule conglomerate (GC), pebble conglomerate (PC), cobble conglomerate (CC), boulder conglomerate (BC), cobble stringer (CST) and angular conglomerate (AC). Further subclassification of the above facies categoris includes matrix-supported facies (i.e., GCm) facies containing and sedimentary structures (i.e., GCb).

Synthesis. Conglomeratic deposits do not fall into specific categories but exist along a continuum (Figure 2). An increase in organization connects all of the flow types from debris flow to stream flow. Each facies has a stand-alone interpretation based solely on sediment characteristics, but further classification of the facies by the degree of organization along the continuum yields three distinct facies associations. Association A (PC, VCS-CS, GC, CST, BCb, and VFS-FS) has a high degree of organization. Association B (CCm, CC, and CCb) is less organized and association C (GCm and PCm) is most disorganized.

This organizational classification from sediment characteristics is reflected by the stratigraphic relation of facies in the section (Figure 3). This stratigraphic relation supports a distinction between groups of organizationally-related facies. The high degree of sorting seen in association A reflects the general characteristics of deposits of normal braided streams. The less organized association B and C facies are characteristic of mass flow deposits.

DISCUSSION

Facies model. Paleocene uplift led to rapid downcutting followed by infilling of coarse fluvial deposits. The facies model is a proximal braided mountain stream confined to a valley with steep walls. This stream experienced intermittent episodic flooding that would account for a majority (75%) of the deposits. The sediment

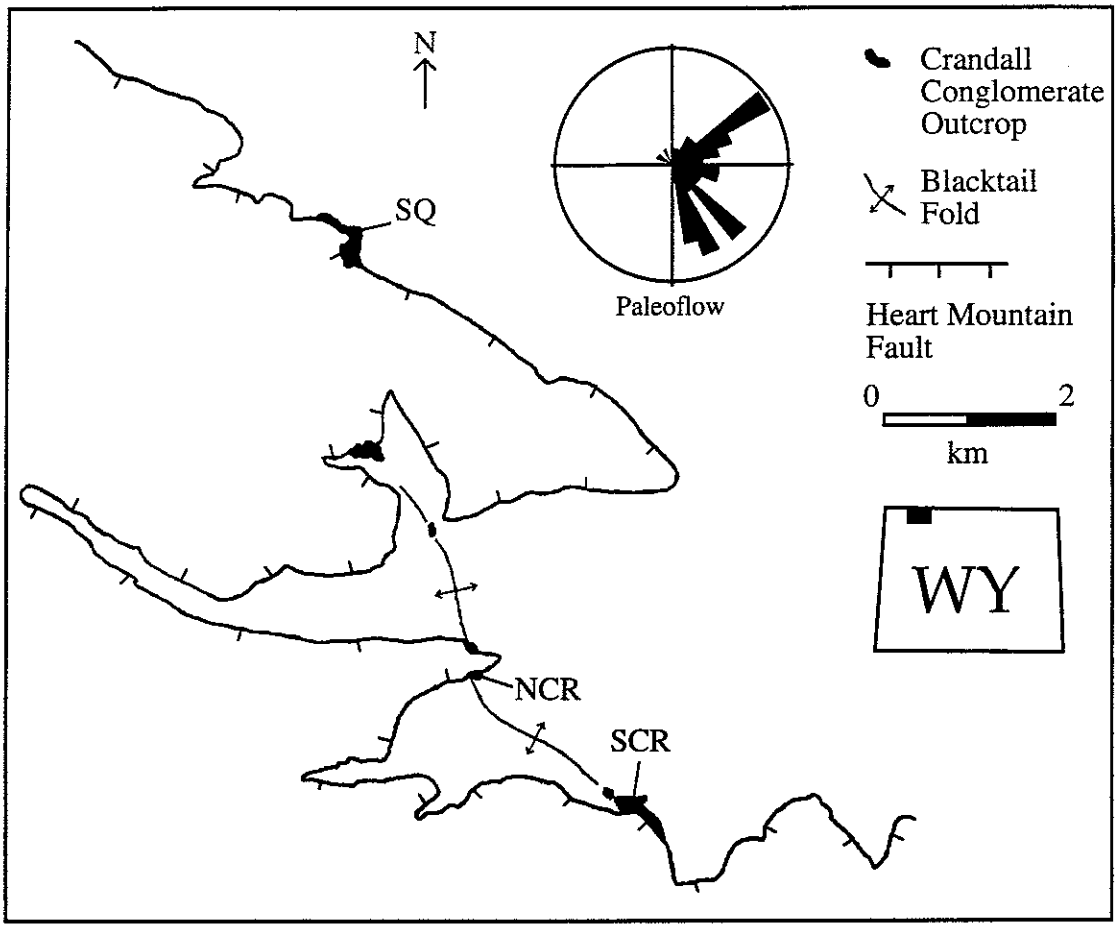
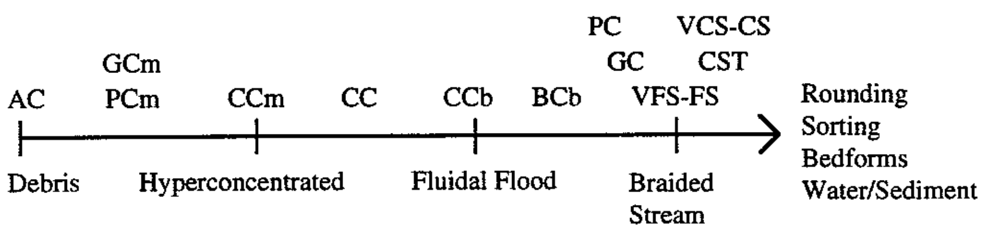


Figure 1: Footwall outcrops and the Blacktail Fold. Labelled outcrops were studied in detail: Squaw Creek outcrop (SQ), North Crandall Creek outcrop (NCR), and South Crandall Creek outcrop (SCR). Rose diagram of cobble imbrication shows paleoflow direction to the east (number of measurments = 55, circle = 13%).

Figure 2: Classification of facies on a continuum of flows going from debris flow to braided stream flow. Scale shows an increase in rounding, sorting, bedforms, and ratio of water to sediment in the flow; facies and flow types are placed into the continuum based on these characteristics.



supplied to make the mass flow deposits was derived from the valley floor, already reworked to some degree by normal stream flow, as evidenced by its well-rounded nature and lack of clay- and silt-sized sediment. The VFS-FS layers are interpreted within this framework as slackwater deposits. These layers could record some in situ soil formation or they may represent resedimented soil, based on the intense red color and relative abundance of clay-sized particles. The sediment source for this conglomerate is local as evidenced by the lithology of the clasts, the relative angularity of the finer sediment, and the presence of more delicate minerals such as micas.

Climate. Tectonic activity and climate combine to affect erodability of bedrock, sediment size, stream discharge, and the amount of vegetation (Kraus and Middleton, 1987). While it is hard to determine wheather topography or arid climate is responsible for charactersitsics of the Crandall Conglomerate, it can certainly be established that these characteristics are not typical of a humid environment conglomerate. The Crandall is a coarse conglomerate which is more typical of arid climates; humid climates tend to create small quartzose sediment (Miall, 1983). There is also no organic matter observed in the Crandall Conglomerate. Since much of the deposit is catastrophic, one would expect that if woody debris existed, it would get caught in these flows and buried before decay. Arid climates also tend to be hostile to vegetation, which could account for this lack of organic matter.

Aggradation model. A raise in base level is the most common mechanism for initiation of aggradation in fluvial systems. Coarse grained deposits can be aggraded by an alternative method. High bed roughness from larger sediment slows down stream flow, which keeps the smaller sediment out of suspension, and increases the resisting power of the sediment, so that it is hard for even a faster flow to reach the critical threshold of the finer sediment. This leads to greater aggradation and less sediment load being carried by the stream (Bull, 1988). This is plausible for the Crandall because of the common angular boulders and the large clast size.

Tectonically-influenced deposition often covers a short time span because the high accumulation rate creates thickly bedded deposits with little erosion in between (Smith, 1987). The Crandall Conglomerate is thickly bedded and the sediments are immature, evidenced by the poor sorting and angularity of the smaller sediment. The sediment spent little time being reworked by streamflow, as evidenced by the small percentage of streamflow deposits. It is therefore inferred that the time span of deposition for the conglomerate was short.

CONCLUSION

Since the Crandall Conglomerate does not include any clasts from later than the Mississippian Madison limestone, the conglomerate valley was eroded into an older pediment surface at the stratigraphic level of the Madison limestone. This was during the late Paleocene, after the formation of the Blacktail Fold by Laramide tectonics and during uplift of the Beartooth Mountains (Figure 4). The Blacktail fold caused fracturing and weakening of the rocks at the topographic surface, which the Crandall Conglomerate paleovalley exploited. As tectonism slowed in the early Eocene, the valley filled with conglomeratic deposits from a proximal mountain stream experiencing episodic flooding because of the combination of steep topography and dry climate. Finally, in the middle Eocene, Absaroka volcanism started and the Heart Mountain Faulting event (Beutner and Craven, 1996) cut the conglomerate and transported part of it to the SE.

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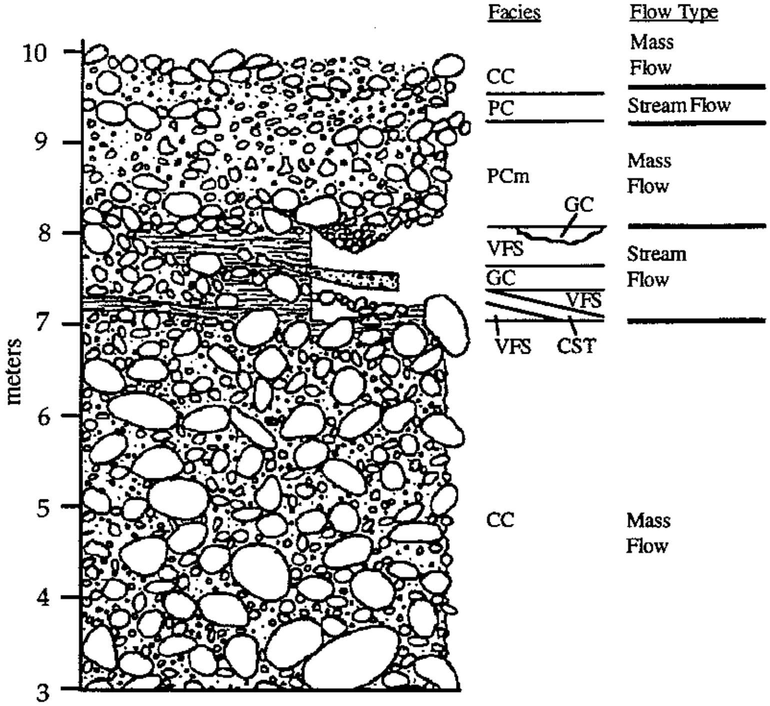

Figure 3: Sample stratigraphic section from the Squaw Creek outcrop. Facies are labeled along with a further classification into stream flow versus mass flow categories.

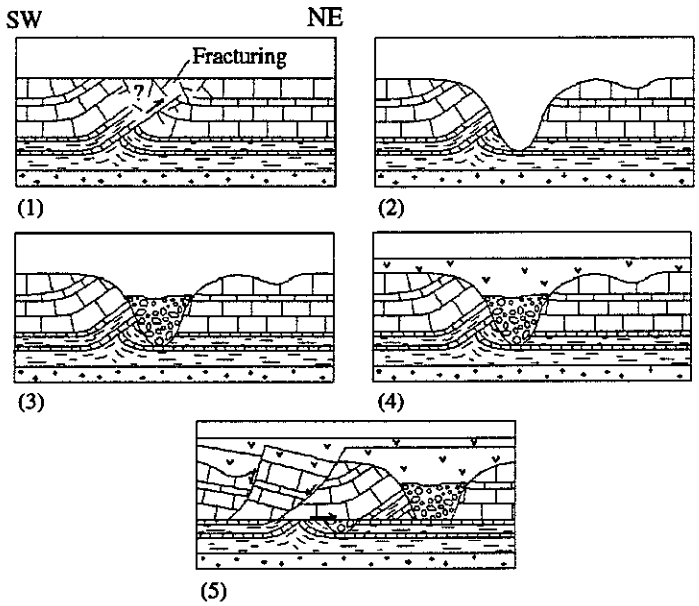

Figure 4: The history of the Crandall conglomerate. (1) Paleocene — The formation of the Blacktail fold and erosion to create a pediment surface to the level of the Mississippian Madison Limestone. (2) Late Paleocene — Uplift of the pediment surface and erosion into it by a stream system. (3) Early Eocene — Pause in uplift and cessation of downcutting. Crandall conglomerate is deposited in the paleovalley system. (4) Early middle Eocene — First Absaroka volcanics are erupted and cover the erosion surface and Crandall conglomerate. (5) Middle Eocene — Heart Mountain Faulting event causes movement and normal faulting in the hanging wall to the southeast. Volcanism continues.