Quaternary Geology of the Lower Crandall Valley, Park County, Wyoming

Stephen Dornbos
Department of Geology, College of Wooster, Wooster, OH 44691
Faculty sponsor: Lori Bettison-Varga, College of Wooster

Jonathan Payne
Department of Geology, Williams College, 947 Main St., Williamstown, MA 01267
Faculty sponsor: David Dethier, Williams College

INTRODUCTION

During the Pinedale glaciation the Clarks Fork outlet glacier of the Yellowstone ice sheet extended down the valley of the Clarks Fork of the Yellowstone River in Park County, Wyoming, and deposited numerous moraines. This outlet glacier also filled parts of several tributary valleys of the Clarks Fork (Parsons 1939), including Crandall Valley. During Pinedale time in Crandall Valley there was also a valley glacier which originated in the Absaroka Range near the eastern border of Yellowstone National Park. The goal of our project was to determine the temporal and spatial relationships between the Clarks Fork outlet glacier and the Crandall valley glacier. We attempted to determine the extent of both Clarks Fork ice and Crandall ice in Crandall Valley, and the relative timing of these ice advances. In addition, we mapped the surficial geology and geomorphology of Crandall Valley. The major features mapped included drift, slumps, earthflows, and post-glacial fluvial features such as gorges and stream terraces.

METHODS

We performed all fieldwork on foot during day hikes into the Crandall Valley from the North Crandall trail and the Crandall Creek trail. During the fieldwork, glacial and post-glacial geomorphic features were mapped and studied. These features included moraines, areas covered by drift, slumps, earthflows, fluvial deposits, and ice-smoothed bedrock. We made boulder counts (of clasts >50 cm) and pebble counts (of clasts <50 cm) to determine the probable origin of drift (see Table 1). The locations and compositions of glacial erratics were recorded on 1:24,000 topographic maps of the Hunter Peak and Hurricane Mesa quadrangles.

DISCUSSION

Glaciers in Crandall Valley:

According to Pierce (1979), ice entered the Crandall Valley from several divides at the western end of the Crandall Creek drainage. His reconstructions suggest that the ice was 121 m (400') thick at the Hoodoo Creek divide, the ice was 242 m (800') thick at the Papoose Creek divide, and 151 m (500') thick entering the valley at the Timber Creek divide. Pierce found striations indicating that ice flowed into the Crandall Valley at the North Fork divide as well. These ice masses, flowing eastward down Crandall Valley, may have filled much of Crandall Valley before the Clarks Fork lobe of the Greater Yellowstone Ice Sheet arrived at the mouth of the valley. The two glaciers would then have been flowing in opposite directions, Crandall ice moving moving east, Clarks Fork ice moving west, colliding near the mouth of Crandall Valley.

The composition and morphology of the moraines at locations #1, #2, and #4, and the lowest moraine at location #3, indicate that Clarks Fork ice was the last ice present in these locations. Granitic boulders are present at all four locations (see Figure 1). Absaroka intrusive erratics mingle with the granitic erratics west of where the North Fork flows into Crandall Creek (location #3). The easternmost Absaroka intrusive was found east of Wyoming 296 at location #9, beyond the mouth of Crandall Valley. Many Absaroka intrusives can also be found several kilometers to the west, between locations #3 and #6. North of the North Fork, at an elevation of 2176 m (7200') is a 3 m Absaroka intrusive rock. Its high elevation above the valley floor indicates that the Crandall ice which deposited it was at least 200 m thick. This thickness of ice and the presence of Absaroka intrusive erratics east of the mouth of Crandall Valley, indicate that Crandall ice must have at one time reached at least to the valley mouth, if not into the Clarks Fork Valley (see Figure 1).

The four Crandall moraines at locations #3 and #6 were deposited by the last Crandall ice at the eastern end of Crandall Valley. The moraines probably resulted from the thinning of Crandall ice while this ice was in contact with the Clarks Fork ice. The contact of the two ice masses best explains the mixing of high concentrations of granitic erratics and Absaroka intrusive erratics, and the close proximity of Clarks Fork and Crandall moraines. The till at location #5, approximately 5 km west of the valley mouth, contains nearly exclusively Absaroka volcanic boulders, with the exception of a 1 m gneissic erratic (see Table 1). The lack of any limestone boulders suggests that Crandall ice must have deposited this till. The Crandall ice at this location would have travelled nearly exclusively over Absaroka bedrock, precluding the presence of limestone in its till deposits. Had Clarks Fork ice been the last ice present at this location, large quantities of limestone would be expected due to the extensive limestone cliffs immediately east of location #5.

If Crandall ice was blocked at the valley mouth by Clarks Fork ice, it would have been forced to the south into the Lodgepole Creek drainage, due to the presence of Clarks Fork ice at the divide northwest of Hunter Peak and the wall of Clarks Fork ice at the valley mouth. Although the interface between the ice masses undoubtedly changed over time, there is a sharp boundary between areas where there are granitic erratics from the Beartooth plateau adjacent to areas containing abundant Absarock intrusive erratics, but no granitic rocks.

Pinedale Hypothesis One:

The Crandall valley glacier was the first glacier present in Crandall Valley during Pinedale time. The valley glacier extended to or perhaps a kilometer beyond the mouth of Crandall Valley. This glacier then retreated, and the Clarks Fork outlet glacier advanced down the Clarks Fork Valley. The Clarks Fork ice met the Crandall ice in Crandall Valley, near the mouth, forcing the Crandall ice toward Lodgepole Creek. Eventually the two ice masses melted down and left recessional moraines near the confluence of Crandall Creek and the North Fork. This hypothesis explains best the position of the erratics, both granitic and Absaroka intrusive, in the valley. The only high concentrations of granitic erratics are at locations #1 and #3, at low elevations in the eastern end of the valley (see Table 1). The number and percentage of granitic erratics decreases from a high of 83.5% granitic and gneiss boulders at location #1 (eastern end of the valley), to 1.9% granitic and gneiss rocks at location #5 (5 km to the west). Even the nominal presence of granitic rocks, however, means that Clarks Fork ice must have reached, at some time, as far upstream as these erratics can be found. The rare granitics upvalley may be the result of a Bull Lake or early Pinedale advance of Clarks Fork ice into Crandall Valley before Crandall ice occupied Lower Crandall Valley.

Pindale Hypothesis Two:

An alternative hypothesis which necessitates fewer advances and retreats of the two ice masses, involves the overriding of Crandall ice by the thicker Clarks Fork ice. The minor presence of granitic rocks several kilometers upstream of the known contact between the Clarks Fork and Crandall glaciers could be the result of Clarks Fork ice flowing over the top of Crandall ice already present in the valley. A few granites would have been by the Clarks Fork ice over the Crandall ice, and deposited as the combined ice masses melted. The Crandall drift present with the granitic rocks is consistent because the Crandall ice was the ice in contact with the valley floor.

MASS WASTING

Large landslides are the dominant feature of the post-glacial history of Crandall Valley. The Crandall and Clarks Fork glaciers deposited huge volumes of drift in the lower part of the valley. During deglaciation, lateral support was removed from the valley sides. The combination of large volumes of meltwater, and impermeable shale layers underlying the Pilgrim and Meagher Limestones created the ideal situation for slumps and earthflows. The weakness of the shale layers caused them to fail, sliding and flowing along with blocks of the overlying limestone and till. The earthflows on the north side of the North Fork have been reactivated as the North Fork downcut through the earthflow debris covering the valley bottom.

CONCLUSIONS

The presence of granitic erratics upvalley of the apparent limit of Clarks Fork ice in Crandall Valley can be explained in two ways. Clarks Fork ice may have been the first ice present in the valley during the early Pinedale or late Bull Lake glaciation, and advanced at least 6 km west of the valley mouth. During the Pinedale, Crandall ice advanced to, or possibly beyond, the valley mouth. Partial retreat of Crandall ice allowed the Clarks Fork lobe to flow into the mouth of Crandall Valley. The two glaciers merged, depositing in the process large volumes of drift along the boundary between the ice masses. The Clarks Fork Glacier may have overridden the lower Crandall Valley Glacier for a period of time.

At the end of the Pinedale the glaciers thinned and separated. The Clarks Fork outlet glacier left ample evidence of its presence as the most recent glacier in the mouth of Crandall Valley, and the Crandall Glacier deposited lateral moraines west of the confluence of the North Fork and Crandall Creek.

Deglaciation resulted in extensive mass wasting of the valley walls, which continues at a slower rate to the current day. The Holocene has also seen the formation of stream terraces, and even bedrock gorges, as Crandall Creek and its tributaries continue to adjust to the changing climate and vegetation.

The latest significant change in Crandall Valley occurred in 1988 as most of the trees in the lower section of the valley burned as a result of the Yellowstone fires. The loss of vegetation has led to increased rates of erosion and deposition which have and will affect to an unknown extent the course of the fluvial system.

REFERENCES CITED

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Table 1.

Table 1A - Boulder Counts (> 50 cm) in Lower Crandall Valley

Location	Granitic rocks	Gneisses	Volcanic Rocks	Limestone	Sandstone
#1	11.6%	71.9%	12.9%	1.2%	1.2%
#2	1.4%	15.3%	59.7%	23.6%	0.0%
#3	0.0%	10.4%	23.4%	65.0%	0.0%
#4	1.9%	5.6%	34.0%	58.6%	0.0%
#5	0.0%	1.9%	98.1%	0.0%	0.0%
#6	0.0%	1.7%	26.7%	69.9%	1.7%

Table 1B - Pebble Counts (< 50 cm) in Lower Crandall Valley

Location	Granitic rocks	Volcanic Rocks	Limestone	Sandstone
#1	2.0%	34.0%	64.0%	2.0%
#4	0.0%	13.0%	87.0%	0.0%
#7	0.0%	52.0%	48.0%	0.0%

Figure 1 - Crandall Creek Drainage