Quaternary History of Sunlight Creek Near White Mountain, Park County, Wyoming

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Introduction

The back-filling of tributary valleys by Rocky Mountain glaciers must have been common during the Pleistocene, but little is known about the response of tributary streams to the back-fill glaciers. The Clarks Fork glacier back-filled Sunlight Creek in Wisconsin times damming the drainage of the creek and forming Glacial Lake Sunlight(Parsons, 1939). As the climate warmed and the lake level was raised by increased meltwater from the alpine glaciers at the head of Sunlight Creek, the northern lake spillway eroded into the terminal moraine of the back-fill glacier enough to cause a catastrophic drainage of the lake(Ballard, 1973), cutting a lake burst terrace into the valley floor and establishing Sunlight Creek in its modern channel. Over time the stream has cut a total of seven erosional surfaces into the till deposited by the glacier. By correlating these strath terraces the history of Sunlight Creek since the back-filling has been interpreted.

Geologic Setting

The research area is located 65 km southeast of Cooke City, Montana and east of the Yellowstone National Park boundary. Sunlight Creek flows southwest to northeast through Sunlight Basin into the Clarks Fork of the Yellowstone River, which serves as the local base level for Sunlight Creek(Figure 1). The Clarks Fork has deeply entrenched itself into the granite bedrock over which it flows. Base level lowering is causing Sunlight Creek to incise granite at the confluence with the Clarks Fork. As the creek erodes headwardly it crosses the contacts between the Archean granite and flat-lying Cambrian sandstone, shale, and limestone. The bedrock channel is probably the most striking feature of the modern morphology, but this channel is buried several kilometers upstream by till deposited by the Clarks Fork glacier as it flowed up Sunlight Basin during the Quaternary period.

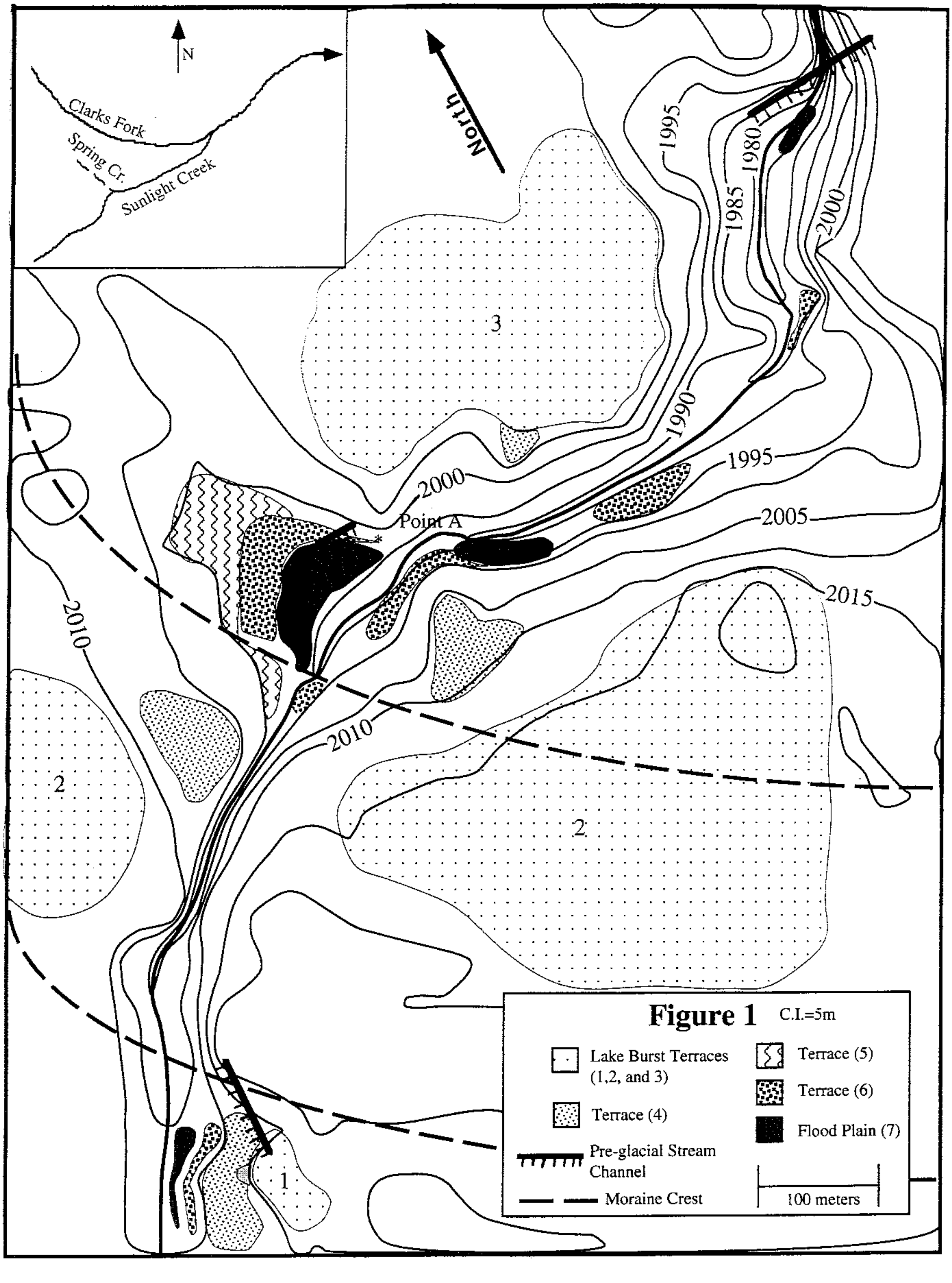
As the Clarks Fork glacier flowed down valley it turned to the northeast at Dead Indian Hill and continued down the Clarks Fork valley. The valley "abruptly narrows" near Dead Indian Hill constricting the ice. The narrow valley at Dead Indian Hill caused the ice to slow down, and the glacier was discharging at a slower rate than it was accreting. As a result a distributary glacier flowed into Sunlight Basin(Parsons, 1939). This "back-fill" glacier flowed upstream approximately 7 km and 600 vertical meters up into Sunlight Basin. The glacier blocked the drainage of runoff from alpine glaciers at the head of Sunlight Creek and its tributaries. This water ponded at the ice terminus and became an ice-dammed lake.

Methods

Stream Terrace Correlation

Field observation throughout the study area was the basis for initially defining the number of terrace surfaces along this stretch of Sunlight Creek. It is important to note that although there is a deposition of up to 2 m of stratified fluvial cobbles, gravels, sands, and fine sediments on each of the terraces, these surfaces are erosional. The oldest and highest surfaces(1,2,3) are broad and flat erosional surfaces that can be identified over the entire field area at heights of twenty, twenty-five, and thirty meters above the stream (Figure 1). The three surfaces record three catastrophic drainages of Glacial Lake Sunlight.. The catastrophic drainage of the lake was stated to have occurred multiple times according to Ballard (1973). These surfaces are distinct from the glacial morphology of the rest of the basin which consists of hummocky morainal topography. These terraces have a lower slope than the other terrace surfaces. The continuity of this erosional surface is interupted by the incision of the stream and the recessional moraines left by the back-fill glacier.

The fourth terrace level is a direct result of the stream encountering the Pilgrim Limestone at the northeastern extent of the field area. The stream was eroding at what is assumed to be a relatively fast rate as it adjusted to the base level of the Clarks Fork, over 400 m below the top of the bedrock bench. Sunlight Creek's incision was delayed considerably by the bedrock obstacles as it eroded a limestone gorge at Spring Creek The response of the stream was to develop a broad meander in the center of the field area and a laterally extensive terrace tread, which is most apparent inside the meander. This terrace(4) is 15 m above the water surface. The next younger and topographically lower terrace level(5) is at an elevation of 5 m above Sunlight Creek. This terrace is areally expansive considering that it is unpaired and there are no other surfaces at this same level. It is assumed that like terrace 4 it is related to the stream incising the resistant limestone above Spring Creek. The lowest terrace level(6)


N
Clarks Fork
Spring Cr.
Sunlight Creek
North
1995
1980
1985
2000
3
1990
1995
2000
Point A
2005
2015
2010
2010
2
2
1
Figure 1 C.I.=5m
Lake Burst Terraces (1,2, and 3)
Terrace (4)
Pre-glacial Stream Channel
Moraine Crest
Terrace (5)
Terrace (6)
Flood Plain (7)
100 meters

is a 1-2 m terrace that may be a relict flood plain, and can be found throughout most of the map area. 600 m upstream from the gorge the terrace is littered with fallen trees no older than 50 years of age and nearer the valley wall the trees are 25 to 40 years old, indicating a recent flood event. In the stratified layers of the this terrace, at point A 2 m above the water surface (Figure 1), a log was dated by radiocarbon methods at 235 ± 55 years before present. This date can be used to determine a recent rate if incision for Sunlight Creek. When the stream cut through the limestone bench the rate of incision increased to 8.5 mm/yr from a previous average rate of 1.7 mm/yr. The final surface is the modern flood plain (7). The flood plain is littered with glacial erratics being eroded out of the till but the stream's bedload consists of sands and cobbles. The flood plain is below the water surface during storm events and spring run-off.

Grain Size and Lithologic Analysis

As Sunlight Creek's rate of incision changed over time, so has the depositional character. The terraces of Sunlight Creek are classified as inset terraces. This means that the oldest terraces are also the highest terraces and all subsequent younger terraces are lower and inset between these older terraces(Richards, 1982). By looking at the veneer of sediment deposited at several levels the depositional trend may be defined. Pebble counts and sediment samples for lab analysis were taken at ten points ranging from the high lake burst terrace (1) to the modern flood plain (7). The working hypothesis was that as the stream cut its early terraces it was reworking the glacial till, high in carbonates with some granites and low volcanic content. Over time the stream has reached a state of relative equilibrium with the morainal topography and is depositing mostly volcanics eroded from an upstream source. Therefore, the volcanic content increased while the carbonate percentages declined and the granitics would all but disappear. To test the hypothesis pebble counts were done at sampling points chosen for lateral and vertical variability.

Lithologic and grain size analyses were done based on the techniques of Wray(1986) at terrace levels 2,4,6, and 7. A comparison of levels 4 and 7 supports the hypothesis and identifies a trend in the depositional character of Sunlight Creek over time. Pebble counts were done at both levels for coarse grained sediments, and sieve and hydrometer analyses were done for the fines. Plots of size distribution indicate that the lower surfaces are better sorted. The sorting differences may be caused by the variation in lithology of the deposits on different surfaces due to differences in sediment source as time progressed. When the stream was depositing terrace 4 it was reworking the till. Till is very poorly sorted and when briefly reworked by fluvial processes it remains poorly sorted(Gale and Hoare, 1991). Lithologic analysis reveals that the volcanic content of the alluvial deposits increases through time. The volcanic content of the sediments are 18.1%, 53%, and 91% for levels 2, 4, and 7, respectively. Overall, the sediments deposited by Sunlight Creek are better sorted and higher in volcanic content as one moves down through the section.

Discussion

As the climate warmed the back-fill glacier may have melted in place at a greater rate than it retreated, leaving behind ice stagnation and recessional features. The inflow of melt water from alpine glaciers increased and the lake over-topped the moraine and began to drain around the ice mass left in Sunlight Basin. The northern and southern spillway flowed over till that had been deposited earlier by the glacier. As the two spillways competed for the drainage of the lake by eroding into the moraine the southern spillway encountered bedrock. The northern spillway continued to erode unabated into the till and capture the drainage of the lake. The remnant channel of the abandoned spillway can still be seen to the south. The northern spillway was superimposed into Sunlight Creek's interglacial or preglacial channel where it still flows to date, except at the limestone gorge just upstream from Spring Creek. Here the stream was superimposed onto limestone bedrock that served as the preglacial interfluve between Spring Creek and Sunlight Creek. The vertical contact between glacial till and bedrock can be seen at this bedrock bench, as well as glacial striae on the top of the bedrock, giving a relative date of preglacial to this feature. The stream cut the postglacial gorge across this till-bedrock contact. After the northern spillway had captured the drainage it eroded into the moraine dam enough to catastrophically drain the lake at least three times. The morphological evidence of this is the "lake-burst" terraces (1,2, &3) eroded into the glacial features on the northern valley floor(Fig. 1).

Ives and Kirby(1964) state that "it seems unsatisfactory to frame a genetic classification around morphology without considering details of preglacial landscape." In the case of Sunlight Creek the main factor allowing the northern lake spillway to capture the drainage of Glacial Lake Sunlight was the interglacial or preglacial channel of Sunlight Creek. Being filled with unconsolidated till made it easier to incise than the bedrock bench underlying the southern spillway. According to Schumm(1973): "As erosion [progresses] upstream, the main channel [becomes] a conveyor of upstream sediment in increasing quantities." This behavior translates into lithologic changes in the terrace gravels of Sunlight Creek. As the sediment source moves upstream the lithologies change from that of the till deposited by the back-fill glacier, granite and carbonates, to an upstream source containing volcanics. As the source of sediment is moved farther upstream from the point of deposition it follows that the sediment being deposited in the study area will have been subjected to fluvial sorting over a greater distance and time. Thus, the older deposits will be less well sorted than the younger deposits.

Stream terraces are indicators of previous levels of the stream. The terraces are left above the level of the water when a knickpoint retreats past the surface. For example, when Sunlight Creek eroded through the limestone bench at Spring Creek it encountered a less resistant shale, and the rate of incision into the bedrock increased and a knickpoint formed. As Sunlight Creek headwardly eroded, the knickpoint retreated upstream leaving a terrace(6) above the stream. The creation of each terrace level could be related to this process of knickpoint retreat. Each episode is a result of the stream encountering a resistant obstacle keeping it at a given level long enough for a floodplain to form. When the stream eroded through that resistant material into a less resistant material a knickpoint would form and retreat upstream eventually leaving a terrace tread above Sunlight Creek.

There are three major episodes in the postglacial Quaternary history of Sunlight Creek. The first is the catastrophic drainage of Glacial Lake Sunlight. The morphology in the field area reveals three surfaces affiliated with three separate drainages of the lake. As the stream was establishing itself in the modern channel it was superimposed onto a limestone bench upstream of Spring Creek. The response of the stream was to create terraces 4, 5, and 6 as it eroded the bedrock obstacle. This initial encounter with the bedrock is the second major event in Sunlight Creek's modern history. Sunlight Creek eventually eroded through the limestone and into the underlying shale. The final episode is illustrated by terrace 6, left above the flood plain when the incision into the incompetent shale created a knickpoint. Further research should be done on the entire length of Sunlight Creek to better determine the Quaternary history.

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