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Proglacial Sedimentation in the Loss Creek Valley, Southwestern Vancouver Island, British Columbia

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A stratigraphic study was conducted on an exposure located in the lower reaches of Loss Creek on Vancouver Island. Four areas were identified in the 72 m high exposure. The lowest unit is composed of 17 m of laminated clays (Unit 1). The next exposure is a 3 m bed of poorly-sorted sand and gravel with a–b planes dipping toward the valley floor (slumped deposit). These are overlain by 37 m of sand and silt rhythmites (Unit 2), followed by 15 m of trough cross-bedded, coarse sands and gravels, with the beds oriented east to west (Unit 3). The coarsening-upwards sequence is interpreted as a proglacial deposit of lacustrine clays, outwash sands, and braided stream gravels, partly buried by a post-depositional slump. Other deposits at lower elevations and up-valley suggest the area is characterized by a complicated sequence of alternating clay, sand, and gravel layers. These results do not support past research indicating that a single post-Vashon maximum resurgence of the Juan de Fuca ice lobe formed a 460 m ice dam at the mouth of Loss Creek. It seems more likely that the region experienced multiple sequences of advance and retreat phases. Further research is necessary to fully decipher the complex glacial history of this area.

Introduction

A small section of sediments exposed in a roadcut on the north side of the mouth of the Loss Creek Valley, Vancouver Island, was logged to reconstruct its depositional history. This location was first noted by Alley and Chatwin (1979) in a large scale study of southwestern Vancouver Island; however, details of specific deposits in the Loss Creek area were limited. This paper examines the roadcut exposure in detail and describes the sedimentary record. The observations are then related to the literature on the glacial history of Loss Creek.

Study Area

Loss Creek is 16 km in length and runs east-west along the Leech River Fault on the west coast of Vancouver Island (Figure 1). The creek originates approximately 620 m above sea level (asl) and has created steep valley sides (48°) by preferential erosion along the fault. The bedrock north of the fault is mainly schists of the Leech River Formation, while the bedrock to the south is predominately Metchosin Volcanics (Muller, 1980). The region receives an average annual precipitation of 2228 mm (Pojar et al., 1991).

The study site is approximately 3.5 km from the mouth of the creek on the north side of the Loss Creek Valley (48° 29′ 50″ N latitude; 124° 15′ 30″ W longitude). To reach the site from Victoria, turn right off the Port Renfrew Highway (#14) just before the bridge over Loss Creek, and then left at the wooden bridge 500 m further upstream. The roadcut is found along the north side of the road, beginning approximately 300 m up from the wooden bridge, and ending 700 m further in an abandoned gravel pit. Elevation ranges from approximately 110 m asl at the bridge to about 250 m asl at the abandoned gravel pit.

Glacial History

Southern Vancouver Island has endured a more "complicated" sequence of glaciations than other regions in British Columbia (Halstead, 1968; Armstrong and Clague, 1977; Alley and Chatwin, 1979; Clague, 1980; Hicock et al., 1981). The advance of the Fraser glaciation began approximately 29,000 years B.P. The Victoria area was overridden by ice sometime after 17,000 years B.P., with the ice maximum occurring sometime after 15,000 years B.P. (Keddie, 1979). Constrained by the Olympic Mountains to the south, the ice in the

Figure 1 Study site location, Loss Creek Valley, Vancouver Island, British Columbia.

Strait of Georgia split into two lobes. One lobe flowed southeastward into the Puget Lowlands, while the other flowed westward along the Juan de Fuca Strait (Armstrong et al., 1965). Glaciers in the Vancouver Island mountains expanded and coalesced with the Cordilleran ice sheet during the glacial maximum (Alley and Chatwin, 1979).

Approximately 15,000 years B.P. there was a global rise in temperature and a subsequent glacial retreat (Heusser, 1973). Deglaciation occurred through downwasting, and by 13,110 ± 130 years B.P. the island uplands were ice free (Alley and Chatwin, 1979). By 12,000 years B.P. the Victoria area was ice free but submerged by a eustatic sea level rise to the estimated marine limit at about 75 m (Linden and Schurer, 1988). Subsequent isostatic rebound was rapid and sea level reached its present level about 11,700 ± 170 years B.P. (Linden and Schurer, 1988). Between 11,700 and 5,000 years B.P. relative sea level dropped by at least another 9 m (Mathews et al., 1970; Duffus et al., 1978) as a result of isostatic uplift. Since this time, however, a eustatic rise in sea level has seen the coastline return to normal levels (Clague et al., 1981).

Previous Research

Alley and Chatwin (1979) present evidence to resolve a controversy regarding the extent of ice flow on southern Vancouver Island and in the Strait of Juan de Fuca during the late Pleistocene. They contend that Vancouver Island was overtopped by ice during the Fraser maximum. Deglaciation occurred by downwasting and as a result most upland areas were free of ice before 13,000 years B.P. A glacial resurgence in the Strait of Juan de Fuca and upland valleys resulted in ice dammed lakes along the southwestern coast of Vancouver Island.

Glaciolacustrine deposits in Loss Creek indicate that a 460 m post-Vashon dam occurred along the southwestern coast of Vancouver Island. Alley and Chatwin state that the dam was caused by the short-lived resurgence of ice up the Juan de Fuca Strait sometime before 12,000 years B.P. (Alley and Chatwin, 1979; Howes and Nasmith, 1983). The glaciolacustrine beds identified by Alley and Chatwin were located on the south side of the Loss Creek Valley. They identified the beds as being continuous between 150–610 m asl. Based on these observations, the extent of the dam at the mouth of Loss Creek was assumed to be at least 610 m high. This continuous clay unit is essential to Alley and Chatwin's (1979) interpretation that a post-Vashon maximum resurgence occurred, causing an ice dam at the mouth of Loss Creek.

Additional evidence was cited by Alley and Chatwin (1979) in support of their theory. First, a zone of ice contact sediments forms a prominent kame terrace deposit which occurs along the coastal slope (Alley and Chatwin, 1979). Secondly, indications along the coast show that the ice flow had a west–northwest orientation and extended to 200 m asl (Alley and Chatwin, 1979).

Observations

A 72 m section of sediment was studied on the north side of the Loss Creek valley. The sedimentary units are described in ascending order and a schematic representation of the exposure is given in Figure 2 (Keene, 1982; Gardiner and Dackcombe, 1983).

Figure 2 A 72 metre stratigraphic section on the north side of Loss Creek Valley.

Unit 1

Unit 1 directly overlies bedrock and is found between 178 m asl and 195 m asl. The unit consists of laminated grey and brown clays and silts interbedded with minor amounts of fine to medium sands. Beds are laterally continuous and range in thickness from less than a centimetre to 50 cm. Rounded dropstones are evident throughout the unit. Soft sediment deformation structures, such as flames, are prominent in many beds in the lower 10 metres of the clays (Figure 3).

Poorly–sorted sands and gravels

A bed of poorly-sorted, medium to coarse sand and gravel is found between 195 and 198 m asl. Clasts are rounded to subrounded. Dominant lithologies include schists and granite. Most clasts are 1 to 20 cm in diameter with the largest clasts reaching 40 cm. Fabric analysis on the dip of the a–b planes at the upslope end of the exposure gives an S1 value of 0.79, a trend of 23°, and a plunge of 9.3° for the principal eigenvector. Clast fabrics in the central part of the exposure have an S1 value of 0.56, a trend of 350°, and a plunge of 18°. At the lower end of the section fabrics have an S1 value of 0.71, a trend of 11.6°, and a plunge of 12°.

Figure 3 Soft sediment deformation structures in Unit 1.

Figure 4 Rhythmites of sand and silt in Unit 2.

Unit 2

Rhythmites, composed primarily of sand and silt, form a gradually coarsening-upwards sequence in unit 3 (Figure 4). This unit is the largest of all the units, extending between 198 and 235 m asl. The sands are primarily medium to coarse grained. There are thin laminae of fine sand and silt within some of the rhythmites. Rounded dropstones up to 15 cm in diameter are found randomly within the unit. An undated tree branch was found *in situ* approximately 3.5 m below the upper contact. The lower contact is abrupt and conformable.

Unit 3

This unit is found above 235 m asl and ends at approximately 250 m asl. Trough cross-bedded, clean, gray sands and gravels characterize this unit (Figure 5). The sands are medium to coarse grained. The clasts in the gravels are subrounded to rounded, with a dominant size in the range of 1-10 cm. The largest gravel clasts are 60–80 cm in diameter. Clasts are imbricated with the a–b planes dipping to the east. Clast lithologies of schists, granites, and low grade metamorphics indicate a southern Vancouver Island provenance. The basal contact is gradational, fining downwards to silty sands.

Figure 5 Cross–bedded sands and gravels in Unit 3.

Discussion

Deposition of Clays

Lacustrine sediments in unit 1 provide evidence of a lake created by a dam at the mouth of Loss Creek. It has been suggested that ice advancing up the Juan de Fuca Strait dammed drainages on southwestern Vancouver Island (Alley and Chatwin, 1979). However, a kame terrace deposited by ice in the Strait also could have created a dam. Kame deposits between sea level and elevations at 200 m have been identified by Alley and Chatwin (1979). Water levels in the Loss Creek Valley lake must have been at least as high as the elevation of the unit 1 sediments.

Deposition of poorly–sorted sands and gravels

The contact between units 1 and 2 is hidden under a coarse, homogeneous bed showing evidence of slump movement. Fabric analyses at various lateral positions show a general correspondence in the orientation of the clasts. The fabrics trend and plunge towards the base of the valley floor providing evidence that mass movement from the upper slope reworked the sediment sometime after the original sequence was laid down.

Characteristics of Sand Rhythmites

The third unit is the thickest (37 m) and contains coarse silt and sand rhythmites. Beds are scoured and draped around dropstones and some of the rhythmite layers are of uneven thickness. These attributes, together with the grain–size, indicate that the depositional environment was characterized by higher velocity and greater turbulence than the clay unit below. Upon close inspection, some laminations contain zones with minor erosional contacts and climbing ripple cross–laminations. These features indicate pulses of water of differing strengths, moving in a direction from east to west according to the direction of the climbing ripples.

Braided Stream Deposition

The uppermost beds contain the features and textures of classical braided stream deposits (Easterbrook, 1993). This unit completes the overall coarsening-upward sequence at the site. The trough cross-bedding, absence of fines, and imbrication of the clasts downvalley, provide evidence for a braided stream environment. Interbedding structures and the size of the sands, gravels and cobbles lend further support to this interpretation. The imbrication of the clasts strongly suggests a transport direction downvalley, or westward.

Interpretation

Deposition at this site indicates a general coarsening-upwards from lacustrine clays through outwash silts and sands to braided stream sands and gravels. The change in grain-size from clay to gravel suggests a depositional environment where velocity continually increased over time.

A common scenario associated with a coarsening-upwards sequence in glaciated terrain is the advance of an ice front (Boggs, 1987). Flow velocity would increase as the site became more proximal to an advancing ice body. Proximal streams are generally coarser and steeper and flow velocity would increase as the source approached the area of the study site. This model is the simplest and most logical interpretation for the section under investigation.

Although simple, this interpretation is not consistent with the literature for this area. Alley and Chatwin (1979) identified a 460 m thick bed of glaciolacustrine sediments ranging from 150 to 610 m asl on the south side of the valley. As this study's elevations range from 110 to 250 m asl on the north side of the valley, it is unclear how it could fit into the chronology stated by Alley and Chatwin (1979). Apparently, the Alley and Chatwin (1979) sediments were observed as many discontinuous sections of clays over a 4 km stretch along the valley (Steve Chatwin, personal communication, 1994). After field verification, it was found that although glaciolacustrine clays were found in many locations along the length of the valley, they were always separated from one another or in contact with other types of sediment. Therefore, since the area is characterized by a complicated sequence of alternating clay, sand, and gravel layers, rather than continuous clays, Alley and Chatwin's single resurgence theory is not supported.

Instead, the layered deposits seem to support a sequence of advances and retreats. This interpretation is consistent with much of the literature regarding the controversial history of deglaciation around Victoria and the Puget Lowlands (Hicock et al., 1981; Booth and Hallet, 1993). Although this study gives details for only a single coarsening-upwards sequence, there is evidence of other sequences up and down the valley (Alley and Chatwin, 1979) and from field verifications in this study. Successive coarsening-upward sequences would be interpreted as repeated proglacial facies, indicating multiple phases in the advance and retreat of ice moving westwards down the Loss Creek Valley.

Conclusion

Observations at the Loss Creek site focused on a coarsening-upward sequence of glaciofluvial sediments that were interpreted as a proglacial facies. Further investigations revealed other beds of glaciofluvial material along the length of the valley. This evidence suggests multiple glacial advances and retreats resulting in repeated coarsening-upwards sequences originally initiated by damming. Indications from the literature suggest ice dams in the Juan de Fuca Strait or kame terrace dams at the mouth of Loss Creek as the most probable causes of lake formation within the Loss Creek Valley (Alley and Chatwin, 1979).

The interpretation of the Loss Creek sediments presented in this paper suggests that the controversy concerning ice extent during the Fraser glaciation of southwestern Vancouver Island may not have been properly resolved. A broader stratigraphic study of this valley and others will be necessary to fully understand the sequences of sediments on southwestern Vancouver Island.

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