Terraces in Okanogan County

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We are all familiar with the prominent sedimentary benches (called "terraces" by geologists) along the flanks of the Okanogan Valley and elsewhere in the County. They occur intermittently from southern British Columbia to the valley mouth at Brewster and then down the Columbia River to the latitude of Lake Chelan. These features are ubiquitous also occurring up tributary valleys of the Okanogan and along the Columbia River.

When and how the terraces formed has been a source of contention over the years. There are two theories on their origin, both relying on the retreat of the Pleistocene ice sheet in our area, known as the *Okanogan Lobe.* The Lobe deposited the *Withrow Moraine,* a swell of glacial debris extending from Chelan to Coulee City pushed by the last glacial surge climaxing some 18,000 years ago. The ice then retreated and was mostly gone about 12,000 years ago. The earliest theory to account for these features held that the terraces to the south along the Columbia River, are the remnants of a giant delta deposited in an extensive now extinct lake occupying the upper Columbia basin named Lake Lewis (after the explorer) by Lt. Thomas W. Symon in 1882[1] where they were referred to as "the great terrace" occurring up to 600 feet or more above the present Columbia River.[2,3] The theoretical Lake Lewis was supposedly fed by the melting Okanogan Lobe and blocked by an ice dam further south. As knowledge of terraces became better known up the Okanogan Valley in the 1930s the term "great terrace" also migrated north,[4,5] but their genesis was now reinterpreted as being local "ice marginal deposits" instead of purely stream and deltaic deposits associated with a huge lake to the south (for which there is no other evidence apart from the terraces themselves). In modern parlance these "ice marginal deposits" are called *kame terraces* being lake and stream sediments deposited along the flanks of a shrinking glacier and the adjacent newly exposed highlands. *Kame* is the glacial geologist's term for sediments deposited directly from a melting glacier and kames usually form ridges and domes - sediments deposited in the irregularities and depressions on top of the shrinking glacier - or a blanket of debris derived from below and within the glacial ice. (Kame deposits often contain *kettles* or surface depressions where stranded remnants of ice interrupted kame deposition.)

A few noteworthy terraces are mentioned here: In the Methow Valley a large low terrace dominates the area where SR 20 enters the Valley (The Tice Ranch covers much of it) and the subdivision Edelweiss, further up the Valley, and higher in elevation, was diagnosed as a "kame terrace" by the late geologist Julian Barksdale (personal comm. Late 1970s). A few miles south of Edelweiss, directly across from the mouth of Wolf Creek, a 400 foot high two-stepped terrace defines the northwest margin of the Methow Valley. In the Omak area the most extensive terrace is the four-mile-plus wide Pogue Flat/Sand Flat terrace complex, which has several levels, just north of town. The Sand Flat level is the lowest and to the east bordering the Okanogan River. All that sand, incidentally, is from wind-blown sand dunes that developed after the ice melted. The Pogue Flat terrace sediments were most likely derived from the Conconully drainage system to the west (Fig. 1) and probably consists, at least in greater or lesser part, of glacial lake deposits. Figure 2 is a "great terrace" looming in the background over the town of Pateros. Finally, between Nespelem and Grand Coulee dramatic stair step terraces can be seen across the Columbia (Fig. 3). There are at least a dozen individual levels in this complex. Though they occur in Douglas County we see them from Okanogan County looking southwest from highway 155 (we can share a bit of this grandeur that is mostly ours with Douglas County).

Figure 1 – Pogue Flat/Sand Flat terrace complex looking west across the Okanogan River from Wannacut Basin. This wide terrace extends from the Okanogan River for about four miles west to the foothills of the Cascades. The basement rocks poking through the west edge of Sand Flat is Coleman Butte.

Figure 2 – The "Great Terrace" at Pateros.

Figure 3 – Terrace complex between Grand Coulee and Nespelem looking west from Hwy 155.

The "great terrace" at Pateros (Fig. 2) and the multi-stepped one north of Grand Coulee (Fig. 3) and across the Columbia as seen from Goose Flats (Fig. 4) are assumed to have formed along the flanks of retreating ice that filled the Columbia Gorge at the end of the Pleistocene. The numerous steps on these suggest that they were made by the kame terrace mechanism because the lake delta theory cannot account for the steps.

Figure 4 – Looking south from Goose Flats to a "great terrace" complex (background) across the Columbia River. One can make out 10 to 12 individual steps from the valley floor to the flattened ridge top on the horizon.

The kame terrace concept accounts for the sometimes multiplicity of terraces, one above the other like stair steps (Figs 1, 2, and 5). With each successive shrinking of the glacier, lower terraces were formed until, just before the ice entirely disappeared, the last and lowest terrace was created (Fig. 6). These last terraces are usually more extensive than the higher older ones because the valley floor became wider and accommodated extensive lakes and wandering stream channels as the ice shrunk - in addition to having an abundant source of ready-made sediments from the higher older terraces above. Finally, when the ice disappeared altogether in a given area, a deepened river channel was developed by outflow from melting ice further north or from normal stream activity such as occurs today. *Alluvial fans*, a separate depositional phenomenon than terrace formation, are often formed at the bases of the lower terraces on the valley floors, and sometimes on higher terraces. These are fan shaped features with their apexes at the mouths of seasonal (ephemeral) streams.

Figure 5 – Looking north at a three tiered terrace up Johnson Creek.

Most of the source material for all the terraces is *till*, unsorted sediments of all sizes eroded by glacial ice creating features known as *moraines*, physically pushed till along the edges of the ice (lateral moraines), and everywhere beneath the ice (ground moraines). The Withrow moraine is a terminal moraine marking the southernmost extent of the Okanogan Lobe. The terraces were shaped by a re-working of this till of unconsolidated sands, gravels, and boulders in stream and lake environments as the ice melted. Where it wasn't re-worked by water, *diamicton* was deposited directly when the ice melted. Diamicton is a poorly sorted sediment dominated by glacial flour - very fine clay size "dust" created by the milling of rock beneath the parent glacier together with various sized rocks of various compositions coming from the local geological formations as well as from Canada hundreds of miles to the north. The ultra-fine glacial flour seems to occur everywhere in the sediments blanketing our region. It is not difficult getting your truck stuck in the stuff on occasion but it is also a natural mineral fertilizer and in it plants, crops, and orchards grow well. Most of the kame terrace sediments were deposited by stream and lake environments between the retreating glacial ice and adjacent newly emerging land at various elevations. But the diamictons in these terraces were dropped en masse when the ice melted. The rounding of the ever present boulders in and on the terraces was done mostly by sub-glacial processes. As the ice flowed and plucked chunks of rock from below, they would be rounded as if in a huge slow moving rock tumbler. The larger rocks, being three times the density of the ice, would remain at the bottom of the glacier and act as scouring tools and be rounded in the process. On dark fine grained boulders one can often see glacial striations. A little figuring shows that under 7,000 feet of ice, pressures greater than 2,000 psi (pounds per square inch) prevail and active abrasion, erosion, and rounding of boulders is assured as well as the production of very fine glacial flour.

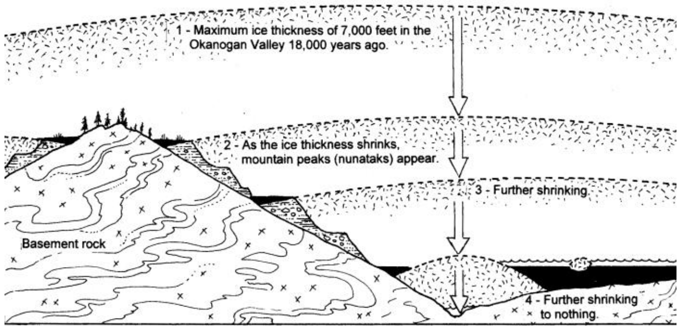

Figure 6 – Schematic cross section of the Okanogan Lobe showing successive shrinking of the ice and development of kame terraces. Black represents kame deposits for each ice level. The arrow indicates inflow of sediment supply to the lower terraces from the higher ones. Note the little iceberg on the last terrace. It will eventually become a kettle.

So, to summarize the composition of these kame terraces, they can be a combination of (a) the original unstratified till, (b) re-worked stratified lacustrine (lake) and fluvial (stream) beds, and (c) poorly sorted diamicton. On their flattened tops there may be hummocks of kame and depressions known as kettles.

The lower terraces are often very broad (Tice Ranch and Pogue Flat terraces) or show great thicknesses (along the Columbia at Pateros and north of Grand Coulee). But there are also terraces at high elevations (as would be expected in the kame terrace theory). In the north county Molson area there are terraces at 3,500 feet elevation and the writer thinks he sees a small terrace on the west flank of Omak Mountain at about 4,500 feet elevation as viewed south from the road towards Browns Pass north of Wannacut Basin. But, again, the higher terraces tend to be small and the lower terraces tend to be large.

There are many terraces in our area. Take a peek as you travel about and consider the ice that formed them. Glacial surges have happened more than 30 times in the past 1.8 million years each lasting between 40 to 100 thousand years divided by warm climate intervals called interglacial stages of 10,000 to 15,000 years. We are presently living in the last of the many interglacial stages. Ours started about 12,000 years ago. In all likelihood, the ice will move in from Canada once again - soon. Any time now!

1. Symon, T. W. (1882), Rept. of an Examination of the Columbia River: 47th Congress, 1st Session, Ex Doc. No. 186.
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3. Dawson, G. M. (1898), Glacial Phenomena in Okanogan Co., Washington: Amer. Geol., v. 22:203-217 pp.

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