back into the main body of water in a process called backwash, sediment gets pulled back as well. Backwash is only affected by gravity and therefore is receded perpendicular to the shoreline. The diagonal forward movement and perpendicular back movement of sediment, results in a net movement down shore (Easterbrook, 1999). Consequently, sediment is unable to move around a jetty and creates an accretion zone. Since there is no new deposition of sediment, the opposite side of the jetty erodes back, creating a typically rockier coastline. Figure 6 illustrates the process of longshore drift and sediment transport.

Figure 6 Sediment travels along the shore in a zigzag pattern due to the angle waves come in at and retreat. The placement of the jetty clearly inhibits further sediment movement.

Within eyesight there were several outcrops of bedrock sandstone. Bayfield’s outcrops of sandstone became heavily valued in the early 1900’s for its unique reddish brown coloration. The exposed sandstone in the vicinity appeared to be Chequamegon Sandstone, one of three Bayfield varieties. The breakdown of Chequamegon sandstone through shoreline erosion is one component of the beach’s sand composition. Other sand components were distributed by glaciation and include quartz, feldspar, olivine, hornblende, and augite (rock brochure). The
substrate on the beach was also sorted by size. Sand and finer material are distributed along the water’s edge, while cobble sized rocks appeared 1.5 meters into the water. Wave action sorts the substrate by performing work on it. Heavier materials can only be carried so far, while finer materials have less mass and are able to move closer to the wave’s furthest breaking point on shore. Driftwood also lines the beach as far back as the main vegetation growth (7 to 10 meters). At one time the driftwood was deposited there from turbulent storm waves. The seemingly far distance the driftwood is from the water can also be attributed by the near record low water levels the lake is experiencing right now. According to the National Oceanic and Atmosphere Association, Lake Superior is approaching its record low for this time of year, almost half a meter lower than its normal level (NOAA).

Another common coastal process is the emptying of stream water into Lake Superior (Figures 7-A and B). Coastal cities often manipulate how water is transported to the lake. The town of Bayfield built a surface water system as a measure to help alleviate flooding. The goal of a surface water system is to keep flood water out of a populated area by channeling it away. Surface water systems effectively transport water out faster than the natural ground by having considerably less friction. The flow rate is also faster because surface water systems are a direct route to the lake, rather than a meandering path.
Stop 3 Apostle Island’s National Seashore Headquarters

At 3:14, we arrived at the Apostle Islands National Seashore Headquarters for our third stop of the day (Figure 8). The Apostle Islands National Seashore Headquarters was established 36 years ago when the Apostle Islands officially became a nationally funded seashore. Before the islands addition as a national seashore, the area was devoted to fishing, shipping, excavating, and logging industries. A key component to the shipping and fishing industries were seven lighthouses which sit on six of the islands. Lighthouses were manned 24hrs a day to help keep a torch lit and keep boats from running aground. Nowadays, GPS navigation has since replaced the lighthouse.

The islands are a unique habitat for plants and animals because they are isolated from the mainland. Ironically, the islands that were inhabited are home to some of the only virgin tree...
stands in the area. The people who lived in the lighthouses preserved the virgin timber because it maintained the natural beauty. As well as having some of the oldest trees, the islands have thick undergrowth because there isn’t a dense deer population to eat the underbrush. Migratory birds also use the islands as a waypoint when they travel. Gull Island holds the largest migratory bird population. Bears and other animals take advantage of winter ice to travel out to the islands. During the summer months they can travel to other islands by swimming. Stockton Island is where the majority of bears live and holds the highest bear population per area than any another place.

As mentioned before, the Bayfield area was once heavily excavated for its unique brown sandstone. At one time, quarries were located on Basswood, Hermit and Stockton Islands. The headquarters building is made up of this brown sandstone which became a popular building material in the upper Midwest soon after the infamous Chicago fire in the late 19th century.

**Stop 4: Northern Great Lakes Visitors Center**

At 4:30 we arrived at stop 4 to take in as much as we could before they closed at 5:00. The visitor’s center had a lot of exhibits to offer that catered to all ages.
Figure 9 Built in 1995, the Northern Great Lakes Visitors center is located just outside of Ashland, WI and is open year round to the public.

One exhibit of particular interest to us explained how the Great Lakes came to be. According to the signage, it all started more than a billion years ago when a deep rift developed in the earth’s crust exposing what is known as a hot spot. The land began to sag in this hot spot, and for some reason it eventually cooled, leaving a depression in the land. The geologic record then shows evidence of a shallow sea covering this area. (We were later able to see evidence of the sea bed in the exposed bedrock at stop 5). Overtime the sea receded and the earth went through a number of climate changes. Occurring every 40,000 to 100,000 years, ice ages came and went. During the ice ages, massive ice sheets up to 3200 meters thick scoured the Superior basin as they advanced and retreated. The last ice age began retreating around 14,000 years ago. Figure 10 shows the sequence of ice movement from when the ice began to retreat. It is important to keep in mind that the ice did not just begin retreating in one day. The ice continued to advance and retreat over the last 14,000 years but resulted in a net retreat. The massive weight of the ice sheets depressed the ground further and the glacial melt water filled in what we now know as the great lakes about 3,500 years ago.

The water level of the lakes was significantly higher a few thousand years ago. In fact, there was a time when the water was 600 feet higher than it is today. During this time period the drainage of the lakes took a different route than the St. Lawrence Seaway they uses today. The great lakes drained out the western tip of Lake Superior to what is now the St. Croix River. As we drove around the Superior region, many of the long slow hills we were driving over were actually former coastline escarpments to Lake Superior. All around the area there was evidence of the glacial outwash as well.
Figure 10 The sequence of glacial retreat over the past 14,000 years. (http://www.glerl.noaa.gov/pr/ourlakes/background.html)

Figure 11 The slow gradient of what once used to be the shoreline of Lake Superior.
Stop 5: Montreal River and Lake Superior: Upper Peninsula, Michigan

Our fifth stop of the excursion was into the Upper Peninsula of Michigan. Here we stopped at 6:00pm to notice and observe where the Montreal River empties into Lake Superior. The weather here was still nice with no wind and clear skies. The temperature was mild by this time at 20 degrees Celsius. From our initial stopping point we could locate the Keweenaw Peninsula the east which is a remnant of a 1.1 billion year old mid continent rift, very similar to what is taking place in the East African Rift Valley today. To the north and west lied Lake Superior and the Apostle Islands. Here we walked down to the shoreline following the brownstone cliffs until we reached a portion of the beach where as far as we could see was vertically layered cliffs of the brownstone.

In this area there were several clues that lead us to believe the area we were standing on once used to be an ocean. One of the most obvious clues was the water ripple marks fossilized in the prehistoric silt and sand. Figure 12 shows the distinct rippling bands familiar to any sandy beach. Ripple marks do not necessarily mean there was an ocean here. However, our second clue is a clear indication with distinct white bands running vertically down the cliff. These alternating layers were tidal bars which represented various layers of sandstone and rock made of clays and silts (Figure 13). These layers had been vertically uplifted and tilted which most likely occurred during the 1.1 billion year old rifting event. At a close up level of analysis the individual striations within the sandstone are typical tidal patterns. Bands of silt represented slack water, better known as low tide; and sand represented active water, known as high tide.

After observing the brownstone cliffs we walked back up the Montreal River to a waterfall where this vertical uplift was again evident. Here we saw evidence of what the river had cut out
when it reached bedrock and had created a large pool which eroded the sandstone creating a large natural amphitheatre type cliff (Figure14).

Figure 12 distinct shoreline ripples from the Paleozoic period.

**Summary:**

In conclusion we departed Eau Claire, Wisconsin on October 2nd, 2006 to study the geomorphic landscape and geologic history of the Lake Superior region. We studied several important and prominent figures on the landscape and tried to determine how they formed and why they were here. There were five stops which were the makeup of the excursion, each have its own uniqueness. The Lake Superior regions very complex and very interesting history make it a perfect spot to see many geomorphic processes in action as well as a unique geologic history that can only be found in this location. After an entire day in the field studying we furthered our awareness of the geomorphic landscape and enhanced our abilities to interpret these features.
Figure 13 Bands of white sandstone tidal bars uplifted along the shores of Lake Superior.

Figure 14 Montreal River waterfall eroded nearly 100 meters from the original escarpment line on the shore of Lake Superior.
Bibliography


(http://www.glerl.noaa.gov/pr/ourlakes/background.html)