



## SPQ Module 20 - Ice Flows



When Ray, Richard & Kevin received their sleds in Southern Chili they opened them with excitement, and Kevin remarked “they look like little canoes”. It is perhaps appropriate that the team is proceeded with ‘little canoes’ because - if you use your imagination - they in fact travelled up the widest river in the world. For if you define a river as a body of water that flows down hill then they are on a massive frozen river of ice that flows gradually off the highlands of central Antarctica into the Southern Ocean.

### Did You Know?

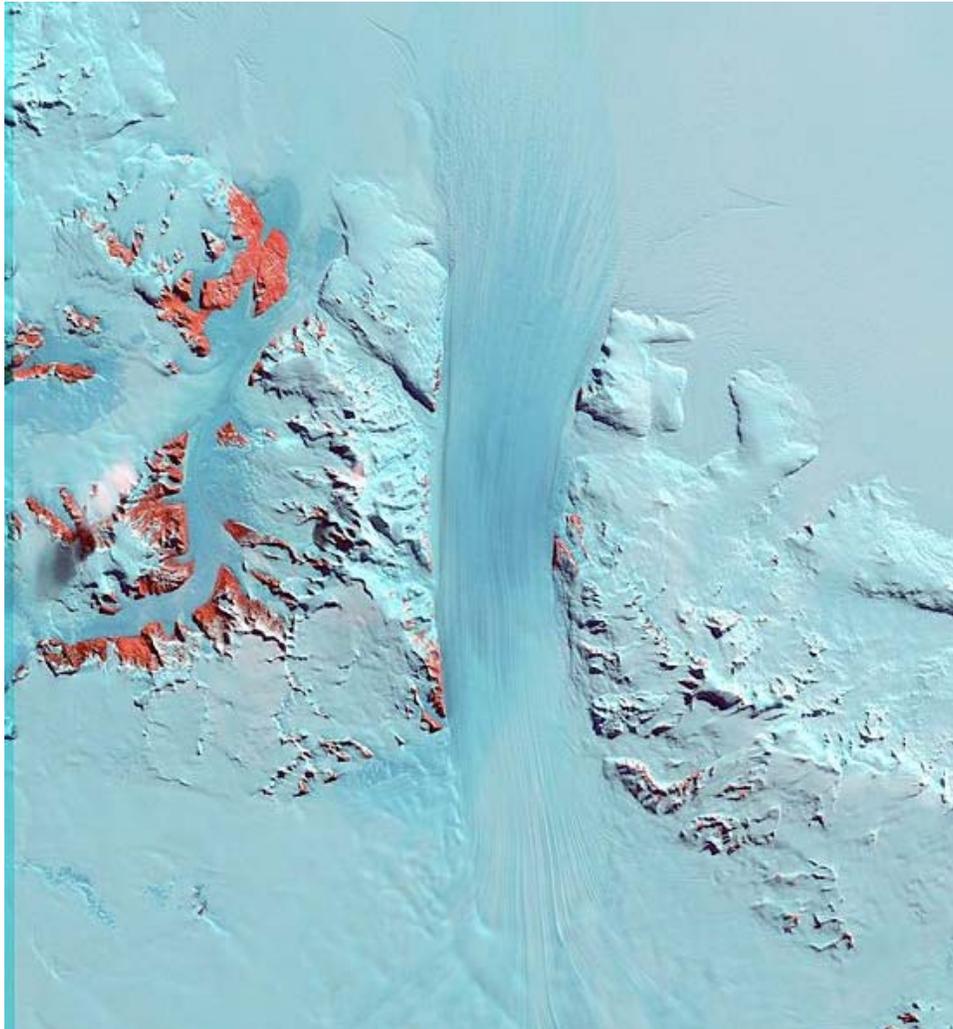
The expedition sleds are made of Kevlar, a light weight material that is very strong and is also used to make police vests.

The Antarctic Ice Cap is composed of 14.1 million square Kilometers of perpetually shifting, flowing ice. To put the size of the Antarctic Ice Cap in perspective the entire land mass of Canada and the United States are both smaller at 9.9 million square kilometers, and 9.2 million square kilometers respectively. Remarkably the entire volume of the Antarctic Ice Cap, estimated to be 30 million cubic kilometers, was built one little snow flake at a time.

Indeed glaciers form when the amount of snow accumulating in a location exceeds the amount that melts during the summer months. In a place like Antarctica where the summer temperatures do not go above freezing there is very little melt, and the glaciers grow. The weight of this accumulating snow on that which lies underneath gradually compresses it into ice.

Currently almost ten percent of the world’s land mass is covered in glaciers, locking up about 75% of the world’s fresh water in ice. Most of these glaciers are found in the Antarctic and Greenlandic ice caps, although there are a scattering of glaciers found in the mountainous and northern regions of the world. During the last ice age, about 20,000 years ago, almost one third of the world’s land mass was covered in ice, including nearly all of Canada, and much of northern Asia and

**Europe. With all this extra water frozen in ice the sea level at that time was about 400 feet lower than it is today.**



**Figure 2: Byrd Glacier, Antarctica from Landsat. Byrd Glacier is a fifteen mile wide, one hundred mile long rock-floored ice stream located in southern Antarctica. (Source: NASA). This long, unique ice feature plunges through a deep valley in the Transatlantic Mountains and into the Ross Ice Shelf. This ice stream speeds as a river of ice at a rate of one half mile per year (Source: NASA).**

**Given that the Antarctic Ice Cap is up to five kilometers thick it clearly has taken a long time to build one snow flake at a time. The exact age of the Antarctic Ice Cap is unknown. It is believed that the ice cap started as individual glaciers in the Mountains of Eastern Antarctica that grew in size, gradually coalescing into one large ice cap and burying many of the mountains in the process. It is thought this started well over 15 million years ago.**

**There are two main categories of glaciers, continental and alpine. Alpine glaciers are those found in mountain valleys or forming a cap over a mountainous region, such as one finds in the Rocky Mountains or the Canadian far North. Continental glaciers are found in only two locations in the world, Greenland and Antarctica. The Antarctic Ice Cap which covers 98% of the continent is composed of a huge**

central mass of ice that is continuous with, and feeds outlet glaciers that flow through the highland mountain ranges to the sea.

Ice will not flow without the force to propel it forward, a force in the case of glaciers that is created by the collective weight of ice on itself. Indeed, the principal cause of glacial flow is the weight or pressure of ice pushing down upon itself. The amount of ice required to create enough pressure to cause the flow of ice below is about 50 meters (160 feet), which deforms ice below causing what is referred to as 'plastic flow'.

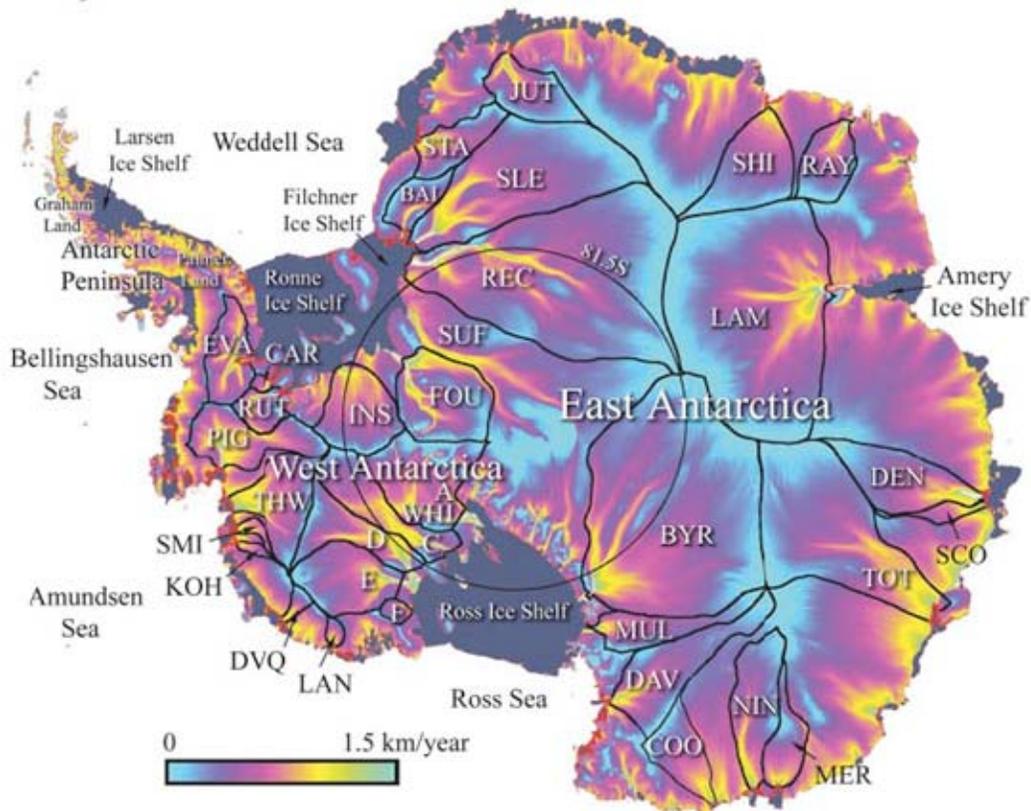


Figure 2: Rate of glacier motion on Antarctica (Source: NASA).

Glaciers flow at different speeds depending on a number of properties including the composition of the terrain over which they are travelling, the depth of the glacier, and the incline down which they are travelling. Antarctic ice flows more rapidly when it falls from the high plateau down to the ocean. Areas of greater incline such as are traversed by the Beardmore and Axel Heiberg glaciers over which Scott and Amundsen travelled tend to travel faster.

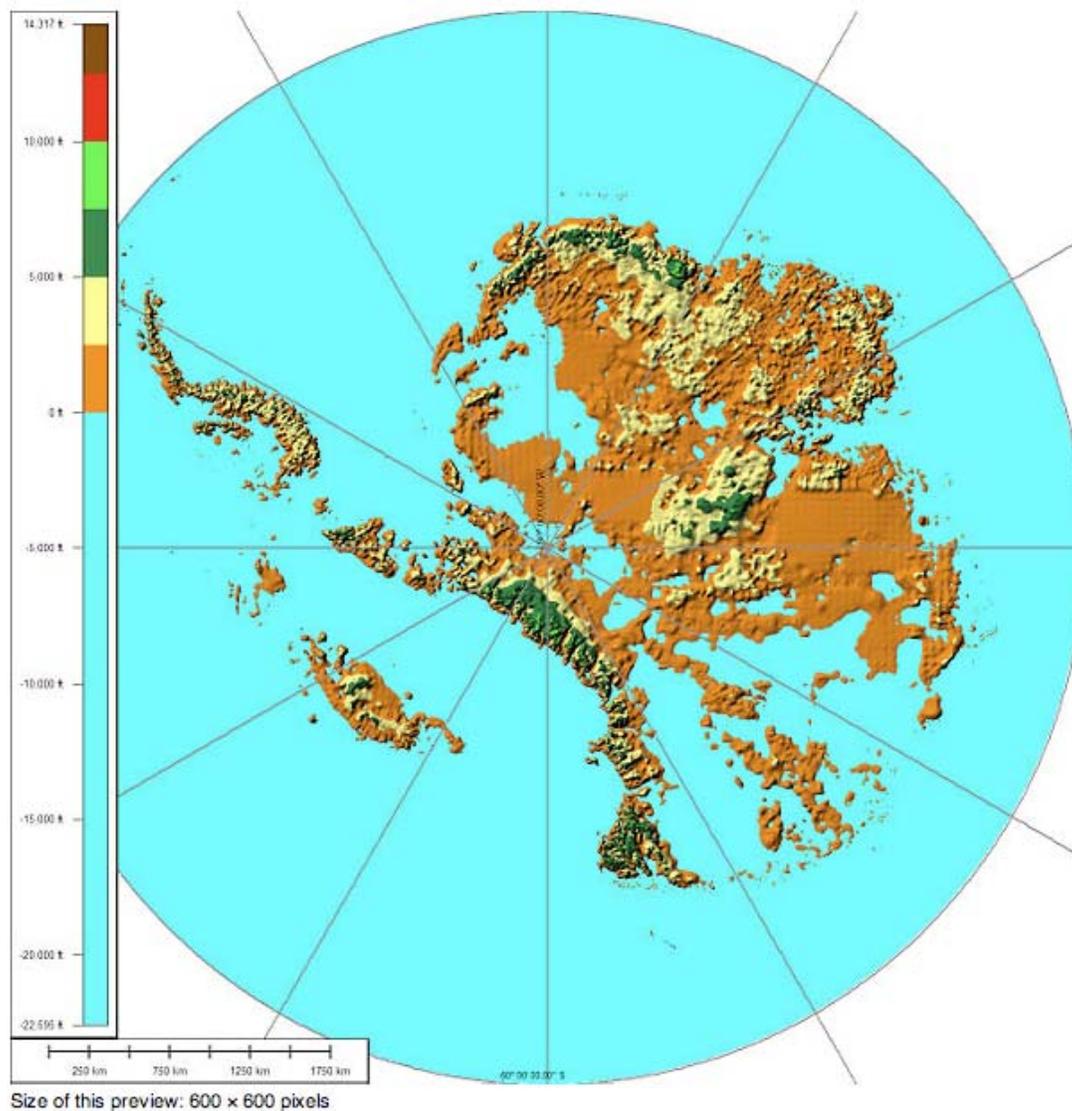
### **Did You Know?**

**The Kutiah Glacier in Pakistan holds the record for the fastest glacial surge. In 1953, it raced more than 12 kilometers in 3 months, averaging about 112 meters per day.**

**Glaciers that travel over a wet surface tend to flow more rapidly. Water underfoot appears to serve as a lubricant, allowing the glacier to glide with greater ease over the surface below. All antarctic glaciers were once thought to be 'dry glaciers' meaning that they do not travel on a bed of water, but the discovery of the subglacial lake and river system in Antarctica has revealed that this is not strictly so. In fact scientists in Antarctica have been able to demonstrate that glaciers speed up when they flow over some of the newfound subglacial lakes on the continent.**

**The flow of glaciers over land shapes the landscape by gouging valleys and transporting rock. The very weight of ice also has a profound effect on the terrain. Scientists estimate that the massive weight of the Antarctic Ice sheet compresses the land mass of the continent by as much as 2.5 kilometers. In other words, if the ice were removed from the continent the land underneath would be expected to rise by as much as 2.5 kilometers. This process is called isostatic rebound. Evidence for isostatic rebound is found in other places in the world, such as Northern Canada, which were once covered by glaciers.**

**Stripped of ice the Antarctic continent would look very different. Significant areas of land upon which the Antarctic Ice Cap lies are in fact below sea level. With the ice gone these areas would be filled with ocean, leaving a continent quite different in contour from that we now recognize as Antarctica. Scientific projections of an ice free continent demonstrate a complex and broken land mass with many surrounding islands.**



**Figure 3: The subglacial topography of Antarctica. The map is not corrected for sea level rise or isostatic rebound, which would occur if the Antarctic ice sheet completely melted to expose the bedrock surface (source: Cristellaria, Wikimedia Commons).**

**For the entire length of their trek to the South Pole Ray, Richard and Kevin have been travelling ‘upstream’ against the flow of the ice over which they have been travelling. When they reached their destination they considered jumping in their canoe-like sleds and allow the flow of the ice to carry them back to the coast of the continent. After some consideration they chose to fly instead.**