The History and Philosophy of Glaciology

Tom Pering, Department of Geography, University of Reading

Abstract

This article discusses the birth of modern glaciology from its initial roots in observations by explorers to glaciology on other planets including the founding fathers Ignace Venetz, Jean de Charpentier, Louis Agassiz, and James Forbes. The first know recorded observations of glaciers was in 1544 and 1574, scientific study of glaciers only really started during the 18th century, and many of the scientific ideas and theories of glaciers including ice movement formed in the 19th century are still in use today. Modern glaciology is now mostly focused around climate change.

Glaciology, History, Philosophy, Glaciers, Venetz, Charpentier, Agassiz, Forbes

Glaciology could be perceived in two ways; it could be that the term “Glaciology” is solely exclusive to that of studying glaciers or it could be to the more widespread study of ice and snow (Knight, 1999). Perhaps it would seem apt to return to the origin of the word “glacies”, which is from the Latin to mean ice, so from the root meaning of the word maybe Glaciology is more widespread than only the study of glaciers, one thing is for certain however - ice and snow play a key role with glaciers and the environments in which they exist.

The first known recorded observations of glaciers was in 1544 by Sebastian Munster and 30 years later by Josias Simler in 1574 (Seligman, 1949), however scientific study of the topic was not to started until the 18th century, unless perhaps the scientific studies of Robert Boyle in his Experimental History of Cold can be included under the term Glaciology (The Royal Society, 1666). Many cursory observations were made by explorers and/or philosophers following this and even sketches made (Fig. 1), the first of these was a Mr. Muraltus who in a letter to a fellow of the Royal Society attempted to describe the formation of the glacial ice - *"The Snow, melted by the heat of the Summer, other snow being faln within a little while after, is hardened into ice"* [Original English]. Mr. Muraltus also remarks on several other experiences such as a loud cracking sound (Muraltus, 1669). After this in 1673 an anonymous writer described further on that which was noted on by Muraltus in 1669

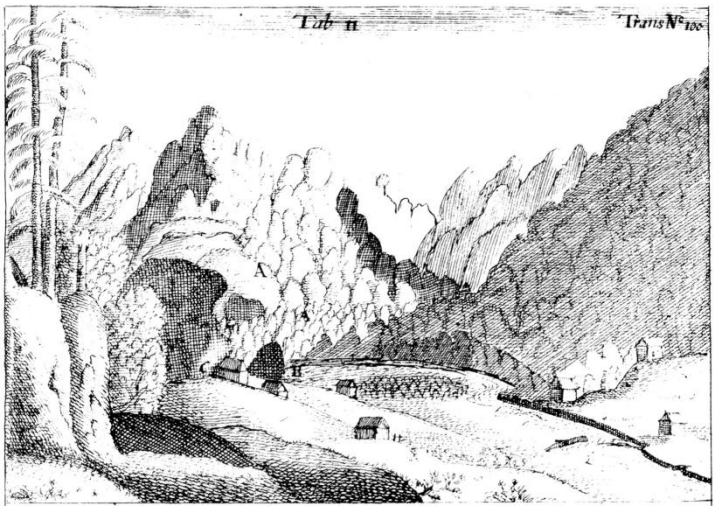

Fig. 1 Early drawing of a Glacier (Anon, 1673)

and goes further by describing known phenomena of glaciers such as crevasses (which he calls rivulets) and illustrates his findings in a sketch of the glacier shown earlier in Fig. 1 (Anon, 1673). William Burnet intrigued by the previous articles by Muraltus (1669) and Anon (1673) decided to visit the location for himself and made some basic observations again on the ice of the "icy mountain" in a letter (Burnet, 1709). During this period exploration was also on the rise particularly in the arctic area around the sea ice, and observations were made by ships captains and crew on the ice which they were encountering, an anonymous writer in 1675 on a voyage north of Russia to Japan shows that they had a relatively good knowledge of the sea ice of the Arctic. The writer also gave an effective description of the process of "Calving" - *"upon the approach of the Summer, froft breaketh, and the Ice, which was congealed near forty or fifty leagues to the fhoar, breaks off from the land and floats up and down in the Sea."* [Original English] (Anon, 1675).

It was not until the works of Scheuchzer in 1705 that basic scientific research was even started, the results of his journey's in the Alps were published in 1708 in his book "Ouresiphoites Helveticus, sive itinera alpina tria" (Seligman, 1949). Kuhn in 1787 was the next person cited frequently to have played a big part in the development of glacial theory, proposing that glaciers may be the reason for the presence of erratics (Kuhn, 1787). However at this point the philosophers and explorers of the time only speculated and observed in a deductive way, they did not conduct even the most basic research to supplement some of the theories which had been proposed. This changed in 1804 when Benjamin Count visited the glaciers at Chamouny and observed what he calls a curious phenomenon – *"At the surface of a solid mass of ice, of vast thickness and extent, we discovered a pit, perfectly cylindrical, about seven inches in diameter, and more than four feet deep; quite full of water"*. Count then goes on to attempt to explain this phenomenon in relation to his experiments on the propagation of heat in fluids, he however does not come to any definitive conclusions (Count, 1804).This phenomenon which Count describes is what I believe to be referred to in modern times as cryoconite holes (Brandt et al. 2009; Fountain et al. 2004), even since this observation in 1804 by Count, research on this topic has not been conducted thoroughly until the last 10 or so years – despite the knowledge of what they are.

Fig. 2 Louis Agassiz (Wikimedia, 2005).

In my opinion there were possibly 4 people who started the increased interest in glaciers and research upon them and could be considered the founding fathers of glaciology. These people were Ignace Venetz, Jean de Charpentier, Louis Agassiz (Fig. 2), and James Forbes. However there were several people doing work on similar theories at relatively the same time. The reason for this is that; Venetz and de Charpentier were doing research on glacial erratics and proposed the theory that glacial ice advance could be the reason for this (Dana, 1886; Marcou, 1886). It was

then de Charpentier who passed on his ideas to his mentee Louis Agassiz who in his article “Etudes sur les glaciers” fully proposed the idea of an Ice Age. Louis Agassiz then interested Forbes in the study of glaciers and so the topic of glaciology took off (Agassiz, 1840; Marcou, 1886; Dana, 1886; Seligman, 1949; Flint, 1968; Bolles, 1999). However they were by no means the first people to start the first scientific studies on glaciers with a few such as Gruner and de Saussure who proposed a theory of glacial motion which was later elaborated on in studies by Forbes (Forbes, 1846b).

All of this was occurring in an era of great exploration in line with ontological thought and reasoning (exploration was deemed of great importance to the furthering of the knowledge of the British people (Anon, 1832)), with most of the exploration originating from the United Kingdom with explorers such as Captain Cook who is thought to have discovered Antarctic in 1772 (Borchgrevnik, 1901; Scott, 1905), Sir John Ross who was involved in exploration around the arctic area and Sir James Clark Ross (Anon, 1832). Sir James Clark Ross then went on to find the magnetic North Pole and map some of the shores of Antarctica, which was a key aspect of geography at the time (Ross, 1982).

So began the great rush of observations and investigations on glaciers with huge amounts of interest, notably after the speech of Agassiz at Neuchâtel on July 24th 1937 known as “le Discours de Neuchâtel” (Flint, 1968). There were 3 main topics of research to begin with; the idea of an Ice Age, the movement of the glacial ice and the structure of the glacial ice. Drawing on some earlier work, James Forbes in his “Illustrations of the Viscous Theory of Glacier Motion” in parts 1, 2 and 3 did extensive work on the movement of glaciers and made accurate conclusions to theories which we still use today, he also produced a theory on the formation of crevasses related to the movement of the ice. Fig. 3 shows his diagrams illustrating the similarities between lava flow and that of glaciers and his attempt at making a comparison. These similarities were first noted by a Mrs Clarke and M. Rendu (Bishop of Annecy) during an eruption of Mt. Vesuvius in the early 1820s. (Forbes, 1846a, b, c). .

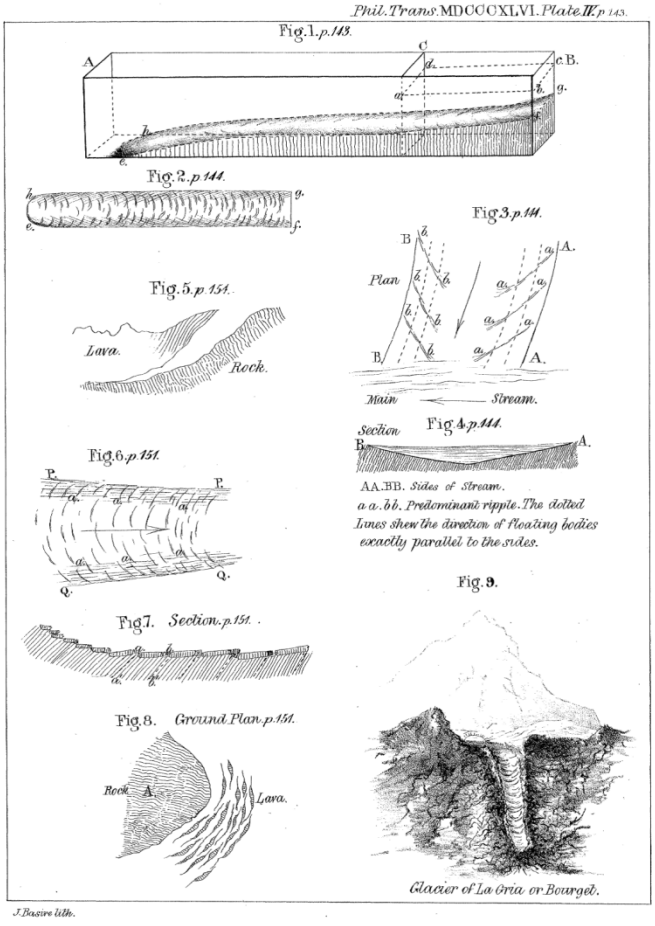

Fig. 3 The Similarities between lava and glacial flow. (Forbes, 1846a)

Work on glaciers then continued over the next 30 years on glacier related topics with the name of John Tyndall cropping up frequently in the field with research on the main themes of motion and structure of the glacial ice. In Fig.4 is a sketch by Tyndall which he used to illustrate his work on moraines. Work at this time on the veined structure of the glacial ice was done by Thomson who drew on ideas initially proposed by both Forbes and Tyndall (Tyndall and Huxley, 1857; Thomson, 1859; Tyndall, 1859). From roughly 1865 onwards increased research was starting to appear on glaciers in relatively unexplored areas such as New Zealand, Greenland and the USA (Packard, 1867). Even in Lebanon where a Rev. Thomson noted traces of glacial erosion on the side of Mt. Lebanon (Thomson, 1880) and in 1887 a glacier was discovered in Colorado on Hague's Peak which shows the extent to which glaciers were researched was only in its teenage years (Stone, 1887).

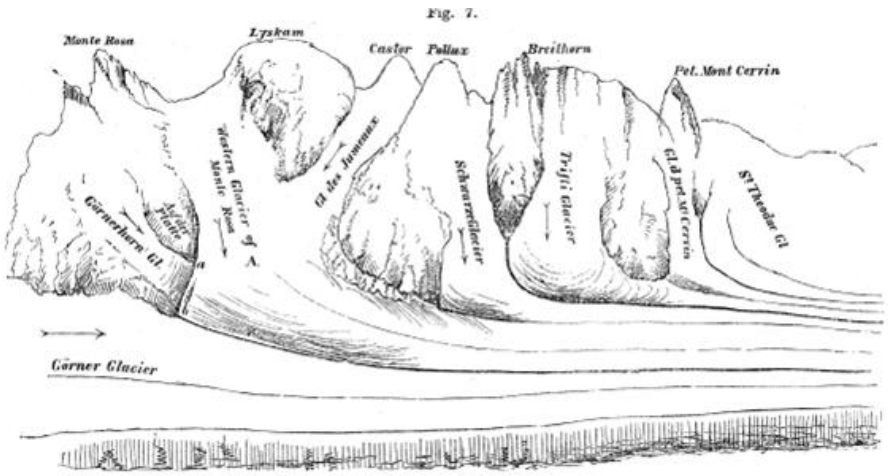

Fig. 4 Tyndall's work on moraines. (Tyndall, 1859)

Between 1830 and 1870 is arguably when the main concepts of Glaciology were polished as theories, this could perhaps be identified as a paradigm where the framework of glaciology was put down for others to use. At the same time geographical societies were growing throughout the world, in 1830 there were 3 geographical societies (London, Paris and Berlin), 16 in 1867 and 79 in 1882. Lord Aberdare of the Royal Geographical Society used this information in the yearly speech on the progress of Physical Geography and I think he summed up the reason for the growth in Geographical societies excellently – *"This remarkable growth may in part be accounted for by the enlarged education and increasing intelligence of mankind, which inspire a keener and more vivid interest in all branches of human knowledge."*. Due to the nature of increased exploration, the Royal Geographical society thought about training explorers in geographical related subjects so they could do scientific research in the field. It seems very much within the policies of the Royal Geographical Society to further geographical knowledge, however they failed in a bid to introduce physical geography into schools in 1884 (Aberdare, 1884). It would seem that this marked increase in physical geography was the reason for the quick developments within Glaciology.

Research upon glaciers during the 19th century, was mostly conducted in a deductive manner, particularly in the earlier period of the century especially up to the 1840s. Most of the research leading up to this point (1840) was mere observation of phenomena and attempting to explain it without any input of a scientific methodology for example Count (1804). Beyond 1840 scientists started putting forward

hypotheses and theories to do with glaciers; however their assumptions were based for the most part on observation and guesswork. Despite all this the theories which they created are still the ones which we use today. Research at this time was conducted by lumpers who only looked at and analysed the broad major themes of glaciology without specialising and further sub-categorizing a specific one.

The next 30 or 40 years saw diminished interest (the reason for this reduction is said by Browne (1882) to be due to satisfactory theories for glaciers being established) in the subject of Glaciology directly to do with glaciers with more emphasis on the exploration of Antarctic and the icy lands within which it lies in line with the trend of physical geography at the time. Examples of these Antarctic explorers are Carsten Borchgrevink (Fig. 5) who was the first person to spend a winter in Antarctica and the famous Captain Robert Scott (aptly known as Scott of the Antarctic). Borchgrevink spent time exploring the ice and traversing glaciers such as the Dugdale and Sir John Murray Glacier (Borchgrevink, 1901). Scott of the Antarctic, experienced many a phenomena associated with ice during his exploration, he even named some lateral moraine which they discovered, ironically they called the formation “the eskers” as they were originally thought to be eskers (Scott, 1905). This exploration fits in with the general trend of physical geography at the time, with an emphasis on discovering new concepts and theories whilst furthering the knowledge of mankind (and of course the influence of the British Empire).

Fig. 5 Carsten Borchgrevink. (Mill, 1905)

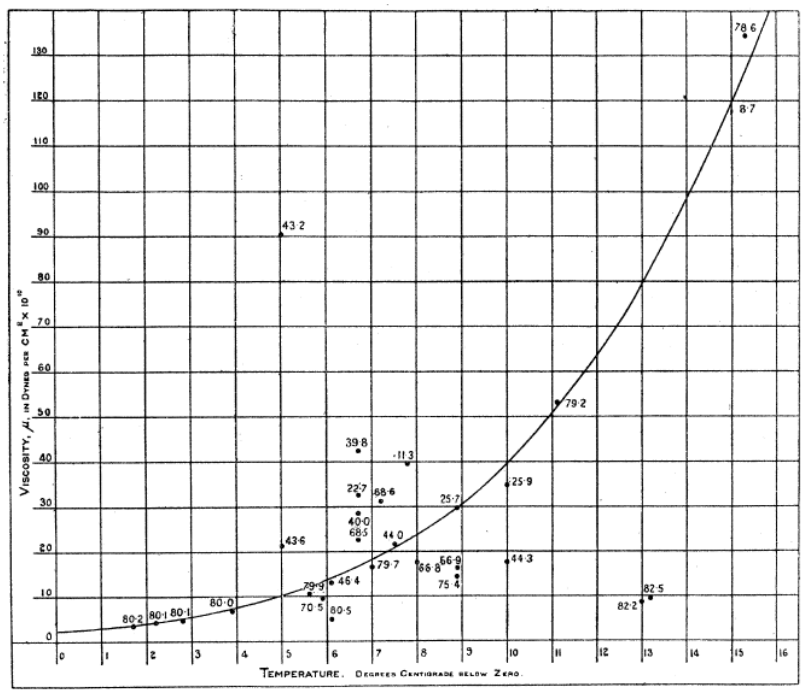

Fig. 6 The Viscosity of Ice (Deeley, 1908)

During this diminished period of research on Glaciology there was little research done however people were starting to realise there was little data and scientific analysis on any of the concept of glaciers, one of the first to do this was Deeley who recognised the fact of this with regard to the viscosity of ice, so he proceeded to make calculations and graphs (Fig. 6) to show this fact (Deeley, 1908). The beginning of the 20th century could mark the start of a transition from how research is conducted, while still holding some of the characteristics of the past years, new ideas and principles are being introduced like the beginnings of a

structure to the text (although still one flowing text), and calculations, analysis or evidence to back up a theory.

In 1938, Fleming recognised the fact that research on glaciers had taken a back foot during the previous 20 or 30 years, it was for this reason that the Association for Snow and Ice was founded in 1937 to try and increase interest in glaciology (Fleming, 1938), how useful this was is hard to tell due to the start of WWII in 1939. During this war period research was few and far between with only notes and analysis on current and past knowledge, demonstrated by papers such as - Notes on Glacial Erosion and Stones Stripes by Hay (1943). After the war a major change in the way papers were referenced occurred with the appearance of a near Harvard System, referencing technique, which allowed others work and ideas to be recognised fully, the previous method used for recognising other people's work was the use of mentioning them in the text or by using footnotes – for example Tyndall (1859), who used footnotes. The paper by Lewis (1947) had basic sections and a reference list at the end however by the 1960s research papers had taken the full appearance that they do in modern papers with an abstract and full Harvard style referencing exampled by Stenborg (1969) who was researching a topic which had previously not been covered. However to illustrate the little advances that modern glaciology had acquired a paper written in 1977 by Evans draws on research done as early as 1850 by an author called Helland (Evans, 1977).

This post war period of glacial research kept up with the changes occurring in geographical investigations throughout physical geography at the time and with the quantitative revolution. More time was spent on analysing results and conducting in depth studies to see if discoveries could be statistically proven. There was definitely a change overall from a deductive way of reasoning to an inductive way of reasoning, post WWII, evidenced by an approach which is quantifiable. It is clear that work at this time was increasingly conducted by splitters who wanted to specialise and separate broader themes into more specific ones.

Since the 1990s there has been a dramatic change in research priority in the area of glaciology to coincide with current events such as global warming and space research. Multiple papers have been published on the effects of the warming of glaciers on their ice and the further effects on their natural environments (Motyka et al. 2002; Vuille et al. 2008; Owen et al. 2009; Kaplan et al. 2009). New areas of study have however appeared, in Antarctica

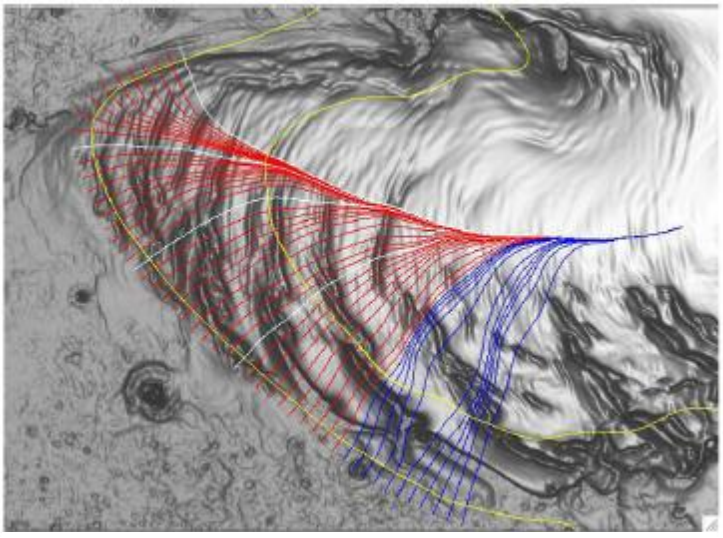

Fig. 7 Image showing analysis of the evidence of ice flow on Mars. (Winebrenner et al. 2008)

a giant sub-glacial lake called Lake Vostok was discovered in 1970 by scientists from Cambridge University, roughly 200km long and 50km wide, taking a sample from the lake for possible signs of life and for other scientific reasons has not been possible for preservation and expense reasons, therefore Lake Vostok is untouched since its discovery (Monastersky, 1996). Relatively recent research has been done on the layers of ice above Lake Vostok for signs of microbial cells which was a success (Abyzov et al. 2001).Despite all this the biggest advance I believe in the topic of Glaciology in recent time has to be that of ice and space. The major examples of this are that of Mars and evidence of previous ice movement on the surface (Winebrenner et al. 2008) (Fig. 7) and perhaps the current presence of ice on Mars, and places such as the moon Europa. With the discovery of Lake Vostok beneath Antarctica, the possibility of life beneath the ice on Europa has been surmised and hypothesised (Abyzov et al. 2006) even a way to return an ice or water sample (from the Sea hypothesised to be beneath) from Europa in the form of an Ice Clipper mission (McKay, 2002).

In conclusion, glaciology has had an extremely interesting history and seems to follow the major trends of physical geography throughout its passage also. Early on in the history of glaciology research was done by observation whilst in more modern times it is done through investigation. With the advancements in space technology it is certain that the topic of glaciology has many exciting years to come.

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