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Critical Literature Review

(ANTA602)

Mapping the End of the World

Technology and Antarctic Cartography

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Abstract

Maps are used either as a way to communicate knowledge or, in the display of data, as a way to synthesize knowledge. Throughout history cartography has been used for both of these purposes and the result is that maps have become objects that tell a story, not only of the geography of a place but the also politics and power of that era. Antarctic cartography is an excellent example of this as the exploration of the continent has been confined to a period of rapid technological change. The interplay between technology and the use of cartography as a means of communicating or synthesizing knowledge is reflected in the literature that describes these events. The following study reviews a range of literature and discusses how the interaction between technology, cartography and knowledge in the history of Antarctica is represented in these texts.

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1. Background

"I saw ahead a splendid peak, with the slate grey of its rock clearly visible. As we drew near, a second, then a third, lifted its summit above the horizon. I counted 14 in all… Here was something to put on a map: a fine new laboratory for research."

- Richard E. Byrd in 1929, upon seeing Antarctica from the air.

Quoted in (Cameron, 1974).

The insatiable curiosity of mankind and our need to make sense of our surroundings has led us to explore and map our world in great detail. The development of technology has allowed us to view (and thus map) our world in many different ways, increasing our knowledge of the Earth's phenomena and processes.

Robinson (1960, p. v), defines cartography as "the conceptual planning and designing of the map as a medium for communication or research." While this is not the only definition of cartography it highlights a two-way nature in the use of maps as tools. Maps are used either as a way to communicate knowledge or, in the display of data, as a way to synthesize knowledge. Throughout history cartography has been used for both of these purposes and the result is that maps have become "fascinating objects which tell a multitude of stories" and in describing the geography of a place, also give a reflection of the politics and power of the era (Byrne, 2011).

2. Review Focus

Antarctic cartography is an excellent example of this as the discovery and exploration of the continent has been confined almost entirely to the modern era, a time when humankind is experiencing rapid technological change. The corresponding growth in our knowledge of the continent and the development of Antarctic cartography has matched (if not bettered) this pace. The interplay between technology and the use of cartography as a means of communicating or synthesizing knowledge is reflected in the literature that describes these events. The following study will review a range of literature and discuss how the interaction between technology, cartography and knowledge in the history of Antarctica is represented in these texts.

3. Discussion

The literature roughly divides the history of Antarctica into three eras, each with unique cartographic representations reflecting the knowledge and technology of the day. These are explored below. A fourth era has also been added to explore the future role of technology in Antarctic cartography.

3.1. Looking for Antarctica: Dispelling the Myth of Terra Incognita

Antarctica proper was not discovered until the end of the 18th century but its existence was first predicted over 2000 years ago by Greek philosophers (Patton, 2011). Aristotle initiated the concept of a spherical globe and theorized that there must be a southern landmass to balance the land in the north. He also noted that as the traveller moved north or south the constellations changed, giving rise to the concept of latitude which was later expanded upon in '*Geography*', the famous work by Ptolemy (Martin, 1996).

Another school of thought proposed that the spherical earth consisted of climatic zones, with frigid poles to the north and south, and extreme heat at the equator that no man could survive (Patton, 2011). While it is clear that this theory was partly disproved when mankind crossed safely below the equator, no mention is made that suggests the opposite to be true; the extreme cold at the South Pole would prevent man from venturing near for two millennia.

Figure 1: World Map After Macrobius, Ambrosius Aurelius Theodosius Macrobius, 1492.
Retrieved from www.sl.nsw.gov.au/events/exhibitions/2011/finding_antarctica

Macrobius, a fifth century Roman philosopher combined the ideas of climatic zones and a large southern landmass into a map which is recognisable as the world we know today, a remarkable feat for theories based on logic rather than fact (see Figure 1). Cameron (1974, p. 22) notes that the ancient philosophers use of logic and rational thinking enabled them use maps to synthesize knowledge that, although not entirely accurate, correctly described some of the world's features. These maps remained in use until the 18th century, a testament to the legitimacy of their predictions.

Cameron goes on to describe the next thousand years as "more a recession in cartography than of advancement" as the rational thinking of the philosophers was supressed by the "chaos of barbarian invasions and the stultifying doctrines of the Christian church." This view of medieval cartography is strongly opposed by Murray (2005) in his paper *Mapping Terra Incognita*. He argues that cartographers during this era looked 'inward' at what was known and tried to make sense of their place in the world using a mixture of symbolic, religious, historical and geographical elements. As the theorised southern landmass was not explained by religion there was no reason to include it in cartography. The resulting maps showed a subjective world view quite different to modern cartography which is largely objective and Murray argues that the two should not be compared.

Figure 2: Typus Orbis Terrarum, Abraham Ortelius, 1587. Retrieved from www.commons.wikimedia.org/wiki/File:Typus_Orbis_Terrarum.jpg

In the 15th century pressure on resources encouraged explorers to adopt more of an 'outward looking world view' and the work of Ptolemy and Aristotle became influential again (Martin, 1996). The explorers of Age of Discovery were driven by the desire to find the great southern continent Terra Incognita, which they believed to be rich in resources. During the next 200 years vast tracts of land were discovered and although none turned out to be Terra Incognita the hope of finding it did not fade until Cook returned from his circumnavigation of the Antarctic region in 1775 (Patton, 2011).

There are a number of theories explaining the Western World's obsession with the mythical southern land and these reflect the technology available during that era. Cameron (1974, p. 24) in his book *Antarctica: The Last Continent* describes the Age of Discovery as "a period of frustration and uncertainty" where sailors made many efforts to locate the southern continent but were "thwarted by the enormous distances they had to travel, and by the fact that when they did make a landfall their navigation was nothing like good enough for them to fix their whereabouts accurately." At the time navigation had advanced to the point where accurate measures of latitude could be made using a sextant or celestial navigation charts, however there was no method for accurately plotting longitude.

With no evidence to refute the southern landmass cartographers simply integrated new information provided by explorers into their maps, using the approximate location of land to form the coastline of Terra Incognita. An example of this is Abraham Ortelius' map Typus Orbis Terrarum (see Figure 2) which joins the partially discovered coastline of Australia to that of Terra Del Feugo on the opposite side of the Southern Hemisphere. Murray (2005) suggests that the 'gap filling' not only showed a yearning for complete knowledge of the world but that it was used as a political statement of possession. Some maps of this era included notes claiming the land for their country, such as Oronce Fine's note, "Recently discovered but not yet fully explored" (in Murray, 2005).

The end of the Age of Discovery came with the Captain James Cooks southern voyages. His achievements were built upon technological developments in navigation (Patton, 2011). Maps of magnetic variation developed by Edmund Halley in the early 18th century made improved navigational accuracy and were used by Cook on his first voyage in1768-1771 which discovered New Zealand and Australia. But it was only with the invention of the

marine chronometer that longitude could be measured with significant accuracy (Martin, 1996). Harrisons No4 Chronometer was the first time piece ever built that could withstand the extreme environments that ships presented (Cameron, 1974). It was first used on Cook's second voyage 1772-1775 and it would revolutionise the way in which the world was represented in maps as Cook's voyage (see figure 3) finally proved that Terra Incognita could never be as large or as habitable as once hoped (Patton, 2011). Skelton (1958) noted that Cook's success was not solely due to the chronometer, and that Cook used his instruments "with a meticulous accuracy which was in itself an innovation." This explains why, to this day, his maps and charts are held in such high regard.

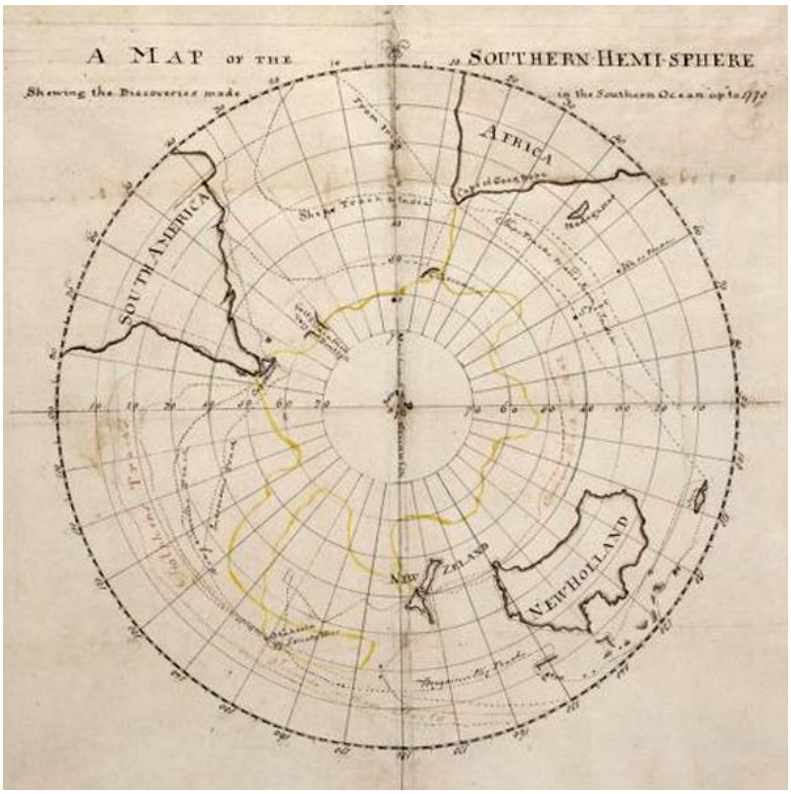

Figure 3: Map of the Southern Hemisphere Showing the Discoveries made up to 1770, James Cook, 1772. Retrieved from www.sl.nsw.gov.au/events/exhibitions/2011/finding_antarctica

3.2. Looking at Antarctica: Mapping the Continent

Cook's attention to detail was to have another important, although unintentional, impact upon our knowledge of the south. Within 30 years of his return many voyages were setting out for the Antarctic searching for riches of another kind, seals. Cook had noted an abundance of seals and whales in the Southern Ocean and as the supply of seals in the Arctic was nearly exhausted, sealers looked South for new hunting grounds. Over the next 50 years there were many ships in the Southern Ocean, slaughtering millions of seals in the race for profit (Martin, 1996).

Apart from an abundance of fur hats the sealing expeditions contributed little to the knowledge of the continent. Sealing was a highly competitive industry and to protect their supply of seals from other operators "the sealers kept the whereabouts of any new lands they sighted to themselves," (Cameron, 1974). The actions of the sealers highlight the importance of creating maps to communicate knowledge. Since they did not keep any records of their voyages, an important part of Antarctica's history was lost. Martin (1996) noted that this would have further political consequences, "they [the sealers] did not regard the claiming of discovered lands as significant and the priority of first discovery, an important first step in establishing political control, was lost."

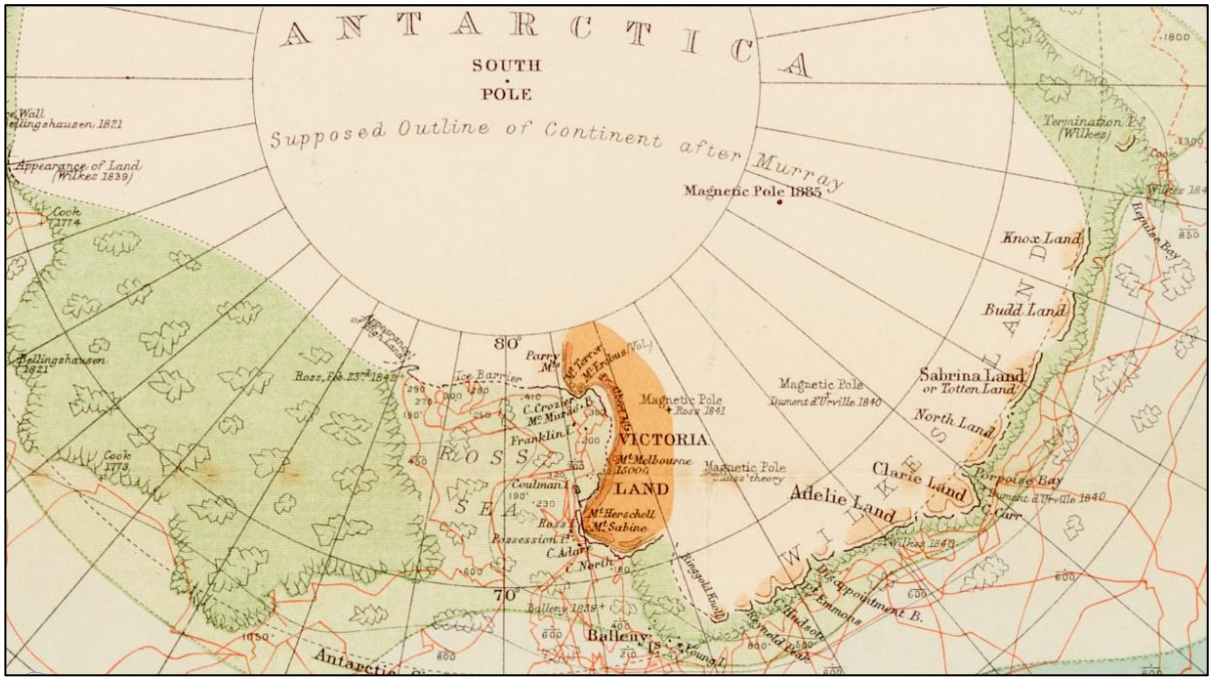

Figure 4: Detail of the Ross Sea region. Approximation of the extent of the continent is shown in white, green colouring shows approximate extent of pack ice, orange colouring indicates mountainous areas. Map of Known Regions of Antarctica from Antarctic Exploration: A Plea for a National Expedition, Sir Clements R. Markham, 1898. Rerieved from www.sl.nsw.gov.au/events/exhibitions/2011/finding_antarctica

The first recorded sighting of Antarctica was made by Faddei Bellingshausen in 1820 during his high-latitude circumnavigation of the pole (Cameron, 1974). Over the next 50 years a number of expeditions voyaged to the Southern Ocean, many sighted land and made landings. It was around this time the name Antarctica came into popular use to describe the land discovered after two thousand years of speculation and searching. The explorers diligently recorded their findings and stretches of the Antarctic coastline were mapped, slowly carving the continent from its buffer of ice (see Figure 4) (Patton, 2011). This period is arguably the most important in the history of the continent but since there were no great technological developments during the time and mostly piecemeal discovery of land; the Antarctic literature tends to skip quickly over these

years. However the explorers of the period; Palmer, Weddell, Wilkes, Ross and d'Urville have left their names, the names of their loved ones, their leaders and their ships as a permanent reminder of their achievements in the south.

In 1895 the International Geographical Congress drew attention back to Antarctica. The President; Clements Markham declared that Antarctica was "the greatest piece of exploration still to be undertaken" (Markham, 1898). He urged that scientific teams be sent there at once "in view of the vast addition to knowledge which would result." National Governments were encouraged to fund expeditions with the goal of exploring and mapping the interior and the resulting Heroic Age of Antarctic exploration began. The resulting maps record many dramatic journeys taken by national expeditions and the scientific observations recorded on these voyages brought advances in the knowledge of Antarctica and the Southern Ocean (Guzman-Gutierrez, 2010).

Cameron (1974) marks this as a turning point in Antarctic history as "the search for land was finally superseded by the more altruistic search for knowledge." In this era maps of past exploration were an important means of communicating information. They were often used as visual aid when explorers lobbied for expedition funding. Figure 4 shows one example of these maps, it was presented by Markham as a part of his address to the International Geographical Congress in 1895 (Markham, 1898). The literature reviewed makes little mention of the technology used to survey the land explored during this time. This is a strange omission as surveying tools such as the theodolite were important in making accurate surveys of Antarctica.

Increased government funding and involvement in science and exploration in Antarctica led to serious political interest of the region. Between 1908 and 1943 nine territorial claims were made in Antarctica, with the basis of claim dependent on scientific activity and maps generated by the interested parties. Dodds (2002, p. 202) noted that for Britain, during its struggle with Argentina and Chile, maps were "essential symbols of possession…the more detailed the map, the greater the sense of ownership and control."

In the early 20th century the map of Antarctica was beginning to take on a familiar shape, but land based exploration could only go so far. Vast tracts of coast and areas of the interior remained unexplored were man could not easily reach with a dog team and sled

(Dodds K. , 1997). The first aeroplane flights were made in Antarctica by Hubert Wilkins in 1928 and by Richard Byrd 1929. Their initial testing proved that the use of planes and aerial photography would be a powerful cartographic tool. Cameron (1974) noted that "from now on the Antarctic continent would be mapped and opened up almost exclusively by air." By 1957 and the signing of the Antarctic Treaty much of the coastline of Antarctica had been mapped and the only regions yet unexplored were deep in the interior of the continent (see Figure 5) (Patton, 2011).

Dodds (1997) discusses the aeroplane's role in the development of knowledge. He argued that aerial photography offered new forms of cartographical representation and these new views could help explain (amongst other things) the geological origins of the continent. Dodds' observation suggests a change in the way humankind was using maps. For the last 200 years maps had been used primarily as a way to communicate knowledge gained on journeys of discovery. With the use of aerial photography maps would increasingly be used as a way to synthesize knowledge, for example deriving the Antarctic coastline from a series of aerial images mosaicked together.

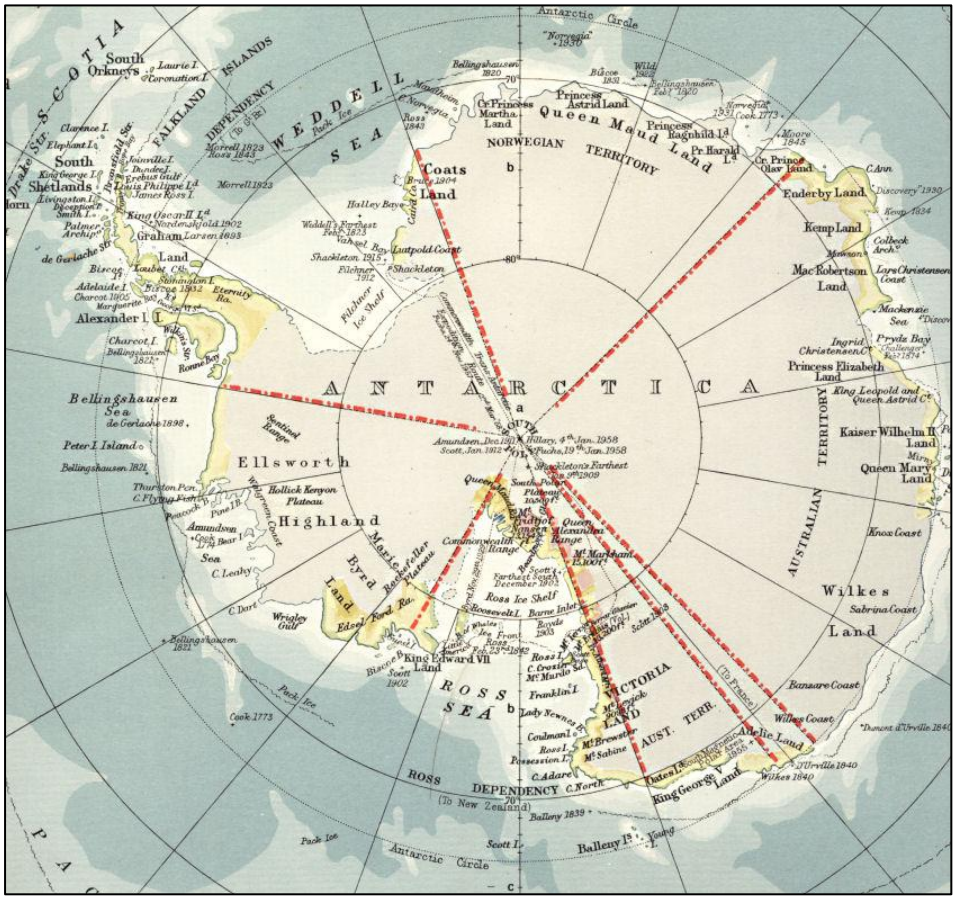

Figure 5: Detail of Antarctica, Readers Digest Atlas, c1960. Retrieved from http://home.anthonyholmes.com/Blog.nsf/dx/what-is-it-with-maps.htm?opendocument&comments

3.3. Looking into Antarctica: Explaining Antarctica's Features and Processes

The use of aeroplanes and aerial photography in Antarctica was the first in a rapid succession of technological developments that was to completely change the field of cartography. Muller (1991) in his book '*Advances in Cartography'* states that "the gentle slopes of progress in the first half of the [20th] century…is now replaced by giant steps which probably justifies the claim for a new cartography." Remote Sensing, Geographic Information Systems (GIS) and the internet have transformed the way we create and communicate maps to such an extent that it is almost unrecognisable from its previous form.

Satellite data first became available for use by civilians in 1960 but it was not until 1963 that the first useful observation was made over Antarctica, the low resolution photos showed an iceberg calving off the Amery Ice Shelf (Lubin & Massom, 2006). In another 10 years data was available from the newly launched LANDSAT-1, the Multi-Spectral Sensors (MSS) were a new development but the data received was used immediately in new cartographic applications (see figure 6 below) (Manning, 1988). The benefits were clear from their beginnings; remote sensing allowed the instantaneous coverage of large regions with reliable and repetitive coverage over a long period (Lubin & Massom, 2006).

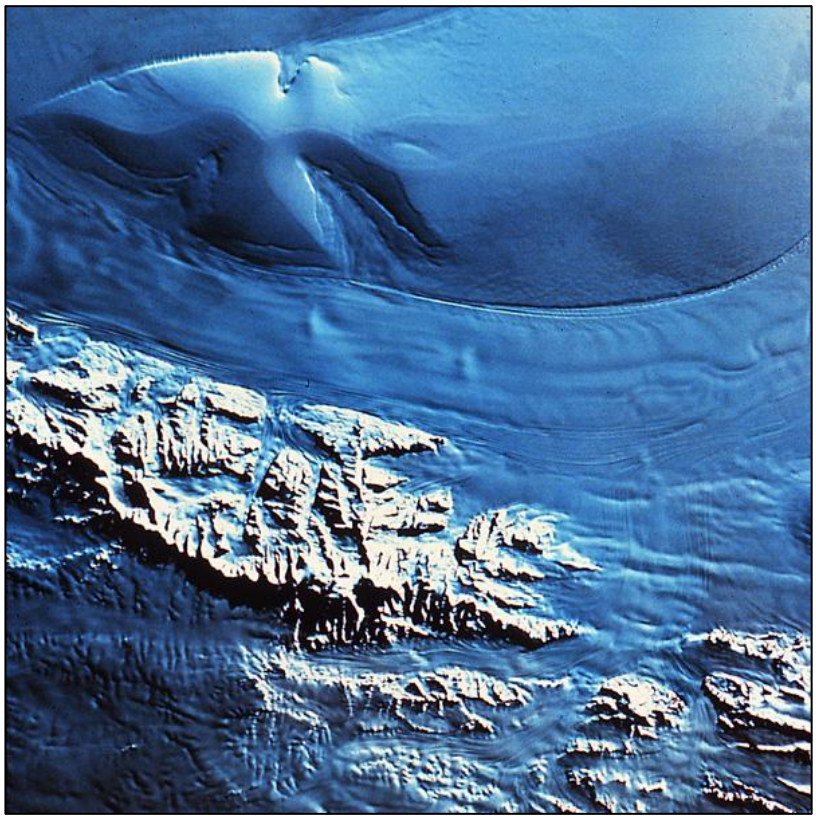

Figure 6: LANDSAT 1 Multi-Spectral Sensor Image of the Ellsworth Mountains, Antarctica. Retrieved from www.pubs.usgs.gov/prof/p1386b).

Mankind was finally able to completely map the Antarctic continent and fill in the last 'blanks' on the earth's surface (Murray, 2005). Satellite technology however, took our knowledge of the continent much further. "Today the visible is being mapped along with the invisible, the moving as well as the static." (Murray, 2005). Satellites are increasingly supplying the data we used to map our world and today it would be difficult to find an Antarctic scientist not using some form of remote sensing data in their research (Lubin, Ayres, & Hart, 2006). Scientists from all disciplines use satellite data to create maps from which they derive much knowledge of both global processes and mesoscale processes (Comiso, 1991).

Figure 7: Australia's Maritime Jurisdiction, 2008. Retrieved from www.ga.gov.au/marine/jurisdiction/map-series.html

There is some concern that advances in technology and the growth in our knowledge of Antarctic Resources will disrupt the governance system of Antarctica as a "new territorialism is sustained by national and thematic cartography." (Guzman-Gutierrez, 2010). With this, we again see the importance of maps as a form of communication and as a political statement. In response to Part IV of UNCLOS[1] 1982, Australia has charted

[1] United Nations Convention on the Law of the Sea.

the extent of the continental shelf within its territorial claim in Antarctica (see Figure 7). In doing so Australia walked a political tightrope as they could be seen to be in breach of the Antarctic Treaty System, even though the mapping was within their rights under UNCLOS. Upon submission Australia made a specific request to UNCLOS that they not take any action in regard to this continental shelf claim. The request to 'not communicate' their knowledge has allowed Australia to avoid serious political fallout. (Murray, 2005)

With the large amount of data created by remote sensors a range of tools was then needed to process the data into meaningful information. Geographic Information Systems (GIS) were developed in response to this demand and are the tool most commonly used today to convert satellite data into maps (Sui & Morrill, 2004). Muller (1991) stated that GIS has enabled the map to function as an "abstract algebra paradigm" where a range of mathematical functions are used in the GIS toolbox for spatial analysis and modelling. GIS has become an invaluable tool for modern Cartographers, who use spatial analysis to display data created by satellites in a way we can all understand.

Figure 8: Streetview of Shackletons Hut in Antarctica, Google, 2012. Retrieved from http://googleblog.blogspot.co.nz/2012/07/become-antarctic-explorer-with.html

The above developments demonstrate how technology has improved our methods for synthesizing knowledge from maps. However Wilbanks (2004) emphasises the importance of technology in the communication of knowledge through maps. The widespread use of the internet has revolutionised the way people share information. Today, anybody with access to the internet can view a map of anywhere in the world

within seconds. Recently Google has finished a project photographing a number of significant locations in Antarctica such as the Ceremonial South Pole and Shackleton's Hut for its 'Streetview' application. Now anyone interested can 'fly' to Antarctica and explore areas that were before reserved for the lucky few that travel south (Google, 2012). The accessibility of Antarctic resources online has facilitated the circulation of knowledge through all levels of society.

3.4. Looking towards the Antarctic future

The rate of technological change in the last 60 years has been exponential and there is no reason to suggest that development will slow down in the near future. New developments in remote sensing will go hand in hand with improvements in GIS analysis. Some of the latest satellite deployments will focus solely on polar research, highlighting the need to understand Antarctica's natural processes and its contribution to the global climate (Lubin & Massom, 2007). As the earth faces the effects of climate change these interactions will become extremely important and so we need to better understand the earth systems to increase the accuracy of our predictive climate models (Lubin & Massom, 2007).

Another goal of the polar research community is to make remote sensing data freely available to all. Currently, many researchers are facing price barriers as they try to access data. The removal of this barrier will stimulate research and add to the knowledge base of Antarctica (Lubin, Ayres, & Hart, 2006). Researchers should keep in mind that it is also their responsibility to ensure the knowledge they create using this data is freely available to all consumers.

The same paper also highlights the need to train future cartographers and scientists in remote sensing, its applications and GIS analysis. This will equip the next generation of scientists with the tools they will need to make a worthy contribution.

4. Conclusion

Literature chronicling the search for Terra Incognita and the discovery of Antarctica suggests that in earlier times technology enabled mankind to expand his knowledge, thus changing the way maps were drawn to make sense of our world. They also give many examples of how maps have been used to make political statements in the South, or conversely, that the failure to produce maps can result in no political statement at all and a loss of knowledge important to the history of the Continent.

The 'new cartography' that has come about as a result of rapid technological change over the last 50 years suggests a shift in the relationship between knowledge and cartography. The literature highlights that maps are now increasingly used to display complex data and from GIS analysis, new knowledge of earth systems is formed. It is no less important though, to use maps to communicate knowledge to a wide audience.

The relationship between technology and the use of cartography to create or communicate data is touched on lightly in a range of literature however future studies could further examine the relationship in greater detail. The examples of politically motivated mapping in Antarctica are particularly interesting and examination of the types of political messages presented over time would present a fascinating perspective of history.

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