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Female Cartographers: Historical Obstacles and Successes

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FEMALE CARTOGRAPHERS:

HISTORICAL OBSTACLES AND SUCCESSES

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By

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ABSTRACT

For much of history, women have lived in male-dominated societies, which has limited their participation in society. The field of cartography has been largely populated by men, but despite cultural obstacles, there are records of women significantly contributing over the past 1,000 years. Historically, women have faced coverture, stereotypes, lack of opportunities, and lack of recognition for their accomplishments. Their involvement in cartography is often a result of education or valuable experiences, availability of resources, a supportive community or mentor, hard work, and luck regardless of when and where they lived.

This research divides women before and after the turn of the 20th century. Around this time, women started to receive more freedoms and rights in society but still experienced life differently than their male counterparts. Although largely ignored, there has recently been more interest in studying the forgotten women of cartographic history. This research aims to show how women were able to overcome historical obstacles and the importance of their contributions to the field in the hope that more researchers will understand and appreciate the female half of cartographic history.

ACKNOWLEDGEMENTS

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VITA

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HISTORY OF FEMALE CARTOGRAPHERS

For much of history, women have lived in male-dominated societies, which has limited their participation in society. The field of cartography has been largely populated by men, but despite cultural obstacles, there are records of women significantly contributing over the past 1,000 years. Some had supportive men in their lives, others came from wealth and privilege, some found supportive groups of like-minded individuals, and others stumbled into the field quite by accident. Generally, the women cartographers known today had education or experience with maps or related subjects, access to resources needed to create maps, and some type of external support or mentor. This research aims to illuminate the historical hardships these women had to overcome and how their contributions have paved the way for more women to participate in cartography.

HISTORICAL OBSTACLES

The English common law of coverture began at least in the 13th century, although exact dates are unknown due to historical lack of interest in the matter (Erickson, 2005). Coverture designated married women as "feme covert," differentiating them from "feme sole," unmarried women. Feme covert were required to give their estate and all other property to their husband, giving the man full ownership of the couple's possessions (Collier, 2014). Married women surrendered their property and any future earnings, as well as the right to enter into contracts without their husband's consent (Fernández, 2014, p. 42).

Although only England legally enforced coverture, there were similar restrictions on women in other countries documented throughout the 17th century. For example, southwest Germany required women to have male guardians with authority over her property, offered few opportunities to participate in the economy (all with low wages), and favored men in marital disputes (Larson, 2015, p. 92). The American colonies resisted many English practices, such as coverture and equity jurisdiction. The latter allowed a judge to use common sense to come to a fair conclusion when strictly following the laws would have led to injustice (Federal Judicial Center, 2020). Women in England were typically better served by equity courts, so even without coverture, colonial women had difficulty maintaining property autonomy (Larson, 2015, p. 94).

Just as feme sole were offered more freedom, such as not requiring a male escort, widows had their own set of rules. A widow was given one third of the family's freeholding, which meant she owned more than before (Erickson, 2005). Women were then able to use the new capital available to them to support themselves, both through geography and other disciplines. A widow might carry on work similar to her late husband or sell the business to an established cartographer, although she was still a single woman in danger of not being able to support herself in a patriarchal society. Some widows, such as Mary Ann Rocque (1725~1770), were successful in using their late husband's connections and companies to produce maps.

Another subgroup of women in history, in addition to unmarried women, married women, and widows, was nuns. Prior to the English Reformation of the 16th century, Catholicism permeated throughout European society by widespread "customary observance…in an automatic, ritualized fashion" (Haigh, 1981). This general acceptance of the Church's practices, if not religion, meant there were plenty of resources available for those involved in the Church, such as nuns in cloisters. Following the Reformation, religiosity became a matter of personal choice and participation. Funds for convents were now largely procured from interested parties, so those that flourished had connections such as Archdukes Albert and Isabella of Flanders (Bowden, 2005, p. 367). These well-endowed institutions invited new members and schoolgirls with the resources for proper educations, although the degree of freedom offered to individuals differed between convents based on their ideals and goals (Bowden, 2005, p. 368).

Both because it was difficult and the benefits were low due to limited property rights, very few women worked outside of the house in Europe and the US prior to the

20th century (Fernández, 2014, p. 40). However, this does mean that women were prominent workers for family businesses operated within the home, and early map publishing was one such business. Starting in the 16th century, maps were produced privately at a professional's home studio. Women in the family were assigned to tasks such as coloring and engraving, and then became involved in paper making and printing processes in the 18th century (van den Hoonaard, 2013, pp. 53, 271). They were trusted with superfluous artistic jobs, granting women exposure to only half of the map making process. Cartography is often described as a field that synthesizes science with art (Krygier, 1995). This was the early introduction of women into cartography, where they would eventually be able to participate in all aspects of map making.

By breaking into the larger economy, women gained an avenue to influence society culturally and academically. Women became prominent educators in the US during the 18th century, another route for their involvement in cartography (LeQuire, 2016). Emma Willard (1787-1870) began teaching at age 17; ten years later, she was teaching from her home and advocating for the education of women and encouraging them to teach (Tikkaken, 2020). In addition to being one of the first normal schools aimed at preparing women for teaching, she developed teaching methods that incorporated maps (van den Hoonaard, 2013, p. 59). Globes and maps were used in the classroom to describe natural phenomena and social and cultural patterns, and blank maps were used for students to demonstrate understanding of a lesson. Willard created beautifully detailed maps and infographics to teach her students geography and history (Figure 1).

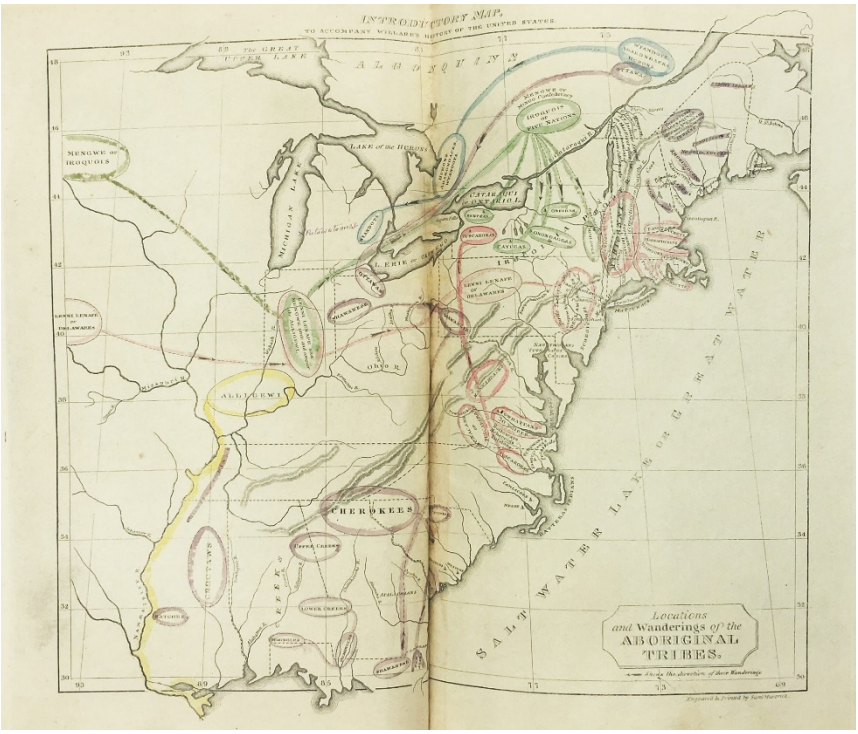

Figure 1. Emma Willard created the first printed map of the migrations of Native American tribes (Willard, 1829).

Coverture was observed in English law through the 19th century, and it still has a lasting impact on cultures today. For example, this began the tradition of married women taking the surname of their husband, though that did not spread to other parts of Europe until 200 years ago (Erickson, 2005). It permeated into historical perspectives on women, where they are often viewed as incapable of independence. However, there are many examples of capable women, including cartographers, working within constraints such as coverture and completing great, if uncelebrated, accomplishments.

Women rarely received due recognition for their work. This can be seen in the private map studios of the 16th through 18th centuries, where women completed labors such as engraving and coloring, but their names were not included in any credits (van den Hoonaard, 2013, p. 271). This suggests their work was seen to have little value by the

professional cartographers. Interestingly, female engravers are credited throughout 17th and 18th century records in Europe, particularly France (van den Hoonaard, 2013, p. 49).

Even for other geographic accomplishments, there are often many years or even decades before a woman will receive praise or even just credit for contributions to the field. For example, Marie Tharp (1920-2006) did not receive scientific recognition for her contributions to oceanography until 1997, roughly 20 years after her *Ocean Floor* panorama (Figure 2) was published (van den Hoonaard, 2013, p. 95). While a lack of recognition will not stop people like Tharp from continuing their passions, such recognition could have had positive effects on their careers because humans naturally crave acknowledgement of their accomplishments, and not necessarily in a formal setting. For example, Virginia Farrer (1628-1668) and Stine Aas (1791-1863) had fathers that encouraged them to pursue cartography, an informal acknowledgement of their abilities that helped them be successful in their careers.

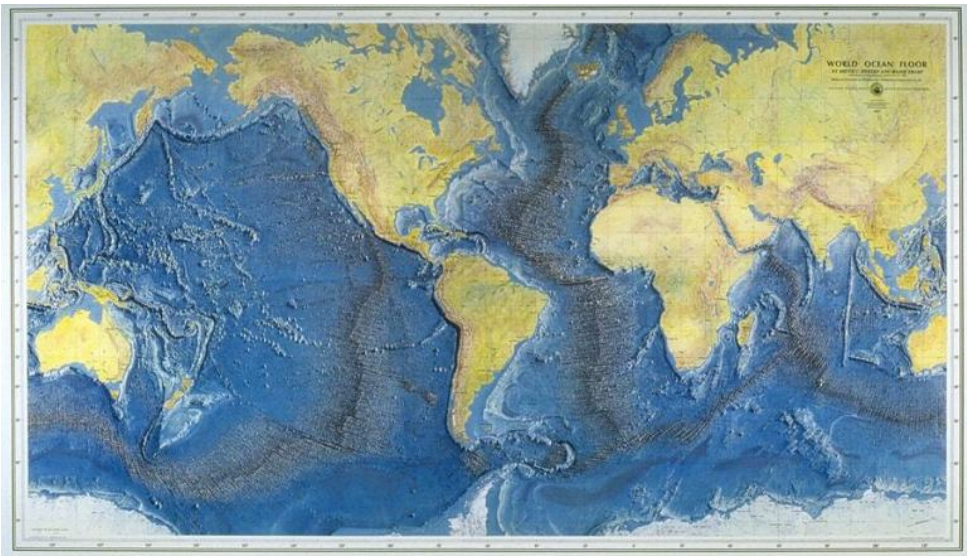

Figure 2. Marie Tharp contributed to this relief world map of the ocean floor. In addition to discovering and mapping previously unknown oceanic ridges, this research helped lead to the acceptance of tectonic plates and continental drift (Maxwell, 2013).

World War I showed a global shift in the perception of women in society. This was the start of the women's suffrage movement, which focused on their participation in electoral processes and became a part of the larger social movement for women's rights and equality (Dolton, 2014, p. 31). During the second World War, the United States Army Map Service focused on educating women for mapping operations. These Military Mapping Maidens were respected contributors to the success of the war (Anderson, 2015).

Gender stereotypes are still prevalent today, and they impact the underrepresentation of women in STEM (science, technology, engineering, and math). Obviously hostile sexism would repel women from STEM, but benevolent sexism – such as believing a woman requires a man's assistance for a difficult problem – can also "impair women's cognitive abilities and undermine their confidence and motivation" (Kuchynka, et al., 2018, p. 74). In addition to sexist stereotypes, women in STEM also face institutional barriers such as poor family leave policies and a lack of relatable mentors (Cavanaugh, 2017, p. 8).

PAST FEMALE CARTOGRAPHERS

From the 10th to 14th centuries, most women were entirely focused on various domestic tasks (van den Hoonaard, 2013, p. 30). Nuns did not have such obligations, and, as this was a time when the church held much power, were the most likely to have the time, education, and resources to produce maps and other works. During the Middle Ages, many maps were developed within the Church at monasteries and cloisters. This led to the development of "T-and-O" maps (see Figure 3), which placed Jerusalem in the center (Wright, 2014, p. 83). The earliest records of female map making dates to the year 975, with many illustrations by the Spanish nun Ende (García-Tejedor, 2020). Her most noteworthy accomplishment was her world map, *Girona Beatus* (Figure 4). It is a detailed "T-and-O" map with religious imagery such as including "Paradise" as a physical place, and decorative Adam and Eve figures (Castle, 2016).

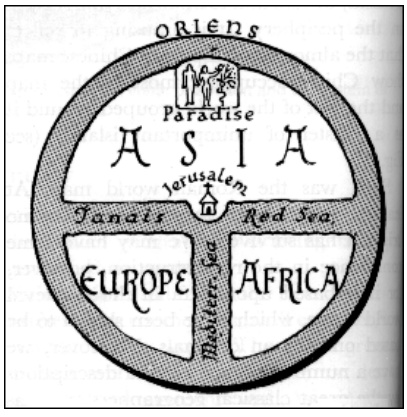

Figure 3. T-O maps were prevalant for about 1,000 years until the 17th century. They divided the Earth between Asia, Europe, and Africa (Seville, 7th Century).

Figure 4. This T-O world map is the earliest record of female cartography (Ende, 975).

A second woman from this time period has cartographic work attributed to her as well: Herrad of Hohenbourg. During the 12th century, Herrad was the Abbess of Loraine and compiled the *Hortus Deliciarum* for the nuns of the abbey (Kitzinger, 1982). Translated as *The Garden of Delights*, this is the first encyclopedia attributed to a woman (see Figure 5). Her education comes through her synthesis of various Byzantium and Western elements in many illustrations, and she includes "symbolic representations of space" (van den Hoonaard, 2013, p. 30) likely from experience with geography.

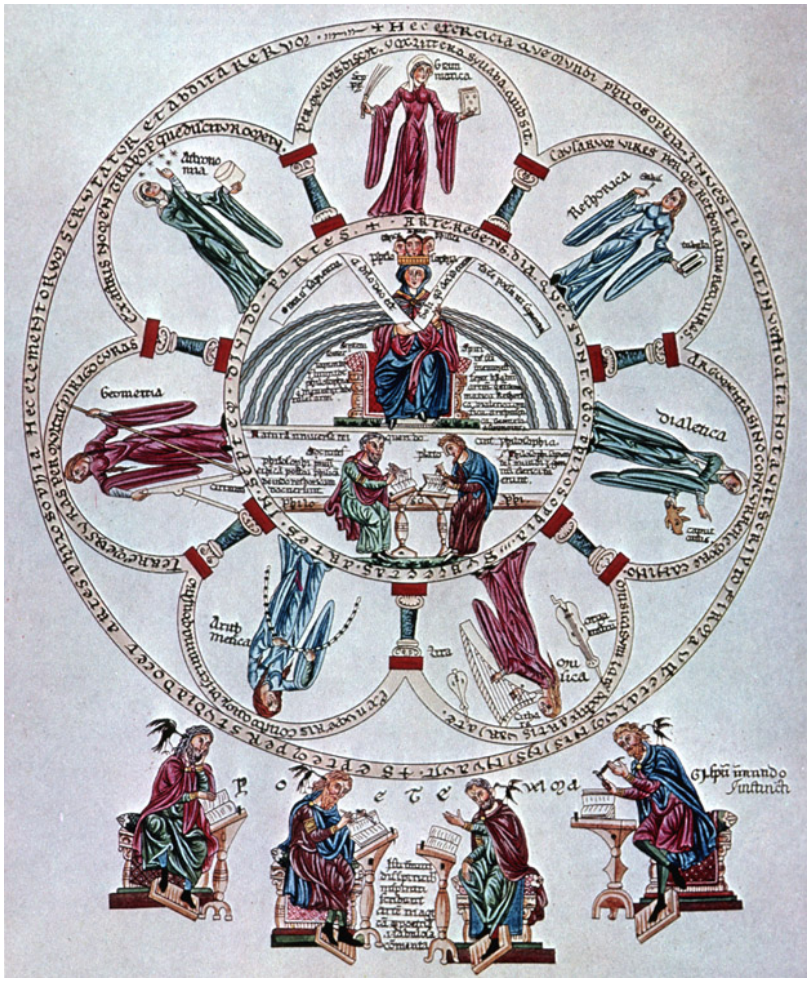

Figure 5. Although Herrad's Hortus Deliciarum was destroyed, some records of her work still exists. "Seven Liberal Arts" shows not only her artistic abilities, but also how Herrad used cartographic elements such as space and proximity to convey ideas (Herrad, 1170).

Obviously, if there were only obstacles, no woman would have ever broken into the field of cartography. An interesting commonality among some early successful women was having a supportive father, a personal mentor invested in the woman's success. This is exemplified in the life of Virginia Farrer (1628-1668), who worked with her father, John Ferrar (1588-1657). John Ferrar and his own father, Nicholas Ferrar (1592-1637), had both been prominent and well-connected members of the Virginia Company. Prior to that, Nicholas Ferrar had studied medicine, served in British

Parliament, was a deacon in the Church of England, and established a school at home where Virginia Farrer received her education (Editors of Encyclopaedia Britannica, 1998). Having these two men in her family set Virginia Farrer up for success, primarily through the reception of good education, but also because she could take advantage of their connections. Farrer aided in the compilation of *A mapp of Virginia* (Figure 6) based off her father's manuscript (Ferrar, Farrer, Goddard, & Overton, 1667). There are five known drafts from the initial manuscript in 1650 to the final map in 1967, and after 1652, the map authorship changed from John to Virginia. She added decorations such as the portrait of Sir Francis Drake and made corrections such as removing the mythical northwest passage believed to connect the Atlantic and Pacific Oceans (Verner, 1950, pp. 282-283).

Figure 6. Virginia Farrer contributed to this mapp of Virginia based off her father's manuscript (Ferrar, Farrer, Goddard, & Overton, 1667).

Mary Ann Rocque (born Mary Ann Scalé) was born around 1725 and died sometime after her retirement in 1770. She married John Rocque, Chorographer to the Prince of Wales, in 1751, and took over his surveying and map-publishing business after his death in 1762 (MapForum, 2006). Although she lived in the peak of oppressive coverture practice in the UK, the rights granted to her as a widow allowed her to use her skills and knowledge to keep the large business successful for nearly a decade (van den Hoonaard, 2013). Most notable is her 1765 publication *A Set of Plans and Forts in America* (Figure 7), although it is sometimes still accredited to her husband. However, the title page of the 30-page document reads:

> *Published according to the Act of Parliament, by Mary Ann Rocque Topographer to His Royal Highness the Duke of Gloucester in the Strand.*

This subtitle shows that Rocque was a respected cartographer during her life. Due to her marriage to John Rocque, Mary Ann Rocque had the necessary connections and resources to produce these maps for a royal audience after his death.

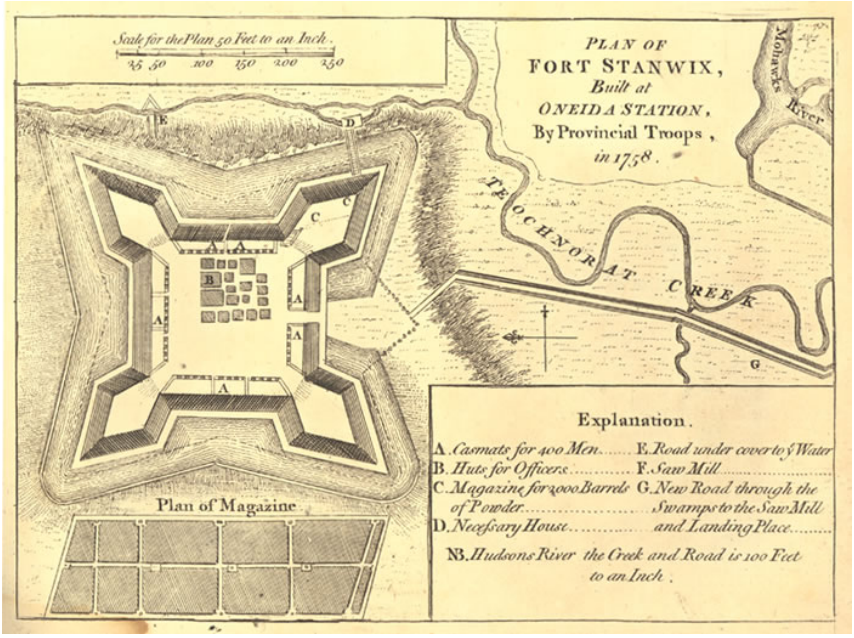

Figure 7. This plan of Fort Stanwix is one of thirty maps drawn by Mary Ann Rocque in "A Set of Plans and Forts in America" (Rocque, 1765).

In Norway, Kirstine Colban (1791-1863), known as Stine Aas, was the daughter of the town's pastor. He encouraged the help of "clever women," such as his own wife, who was skilled with herbal remedies. In addition to getting an education and travelling with her father, this was the perfect environment to support Aas's cartographic skills, and she completed her first map at the age of 23 (van den Hoonaard, 2013, p. 66). Aas's lasting contribution to the field were her drawn and painted perspective maps (see Figure 8). Rather than displaying the map from above, she displayed geographically accurate information from a single perspective point. This would be an early example of 3D renderings of the real world in a 2D format. Her art was highly respected, as she was a woman acquainted with cultured society, and had many paintings on display at the Museum of Lofoten (van den Hoonaard, 2013, p. 67).

Figure 8. Stine Aas was an artist, poet, and cartographer, and is most well known for her watercolor perspective maps (van den Hoonaard, 2013, p. 66).

Shanawdithit, born 1801, was the last member of the native Beothuk tribe that inhabited the island of Newfoundland from the 16th century to her death in 1829 (Holly, 2000, pp. 79-80). Shanawdithit became a well-known map maker of history quite by misfortune. She was found with her mother and sister by fur trappers in 1823 after the rest of the tribe had died of tuberculosis and European violence (Newfoundland and Labrador Heritage, 2008). When her mother and sister died of tuberculosis later that year, Shanawdithit became the last known Beothuk. During the last year of her life, she created drawings and maps with William Epps Cormack (1796-1868), with whom she built a strong relationship despite aversion between the English and Native Americans (Brown, 2000, p. 26). She illustrated the lives of the Beothuk, and her maps show Beothuk encampments and events between the tribe and Europeans (Polack, 2013).

Shanawdithit's cartography is bold and simple, with symbology that resembles what they represent (Figure 9). For example, she denoted encampments with triangles and events between the tribe and Europeans with human figures. She even visually separated the two groups, with yellow or red for the Beothuks and gray or black for the Europeans (Polack, 2013).

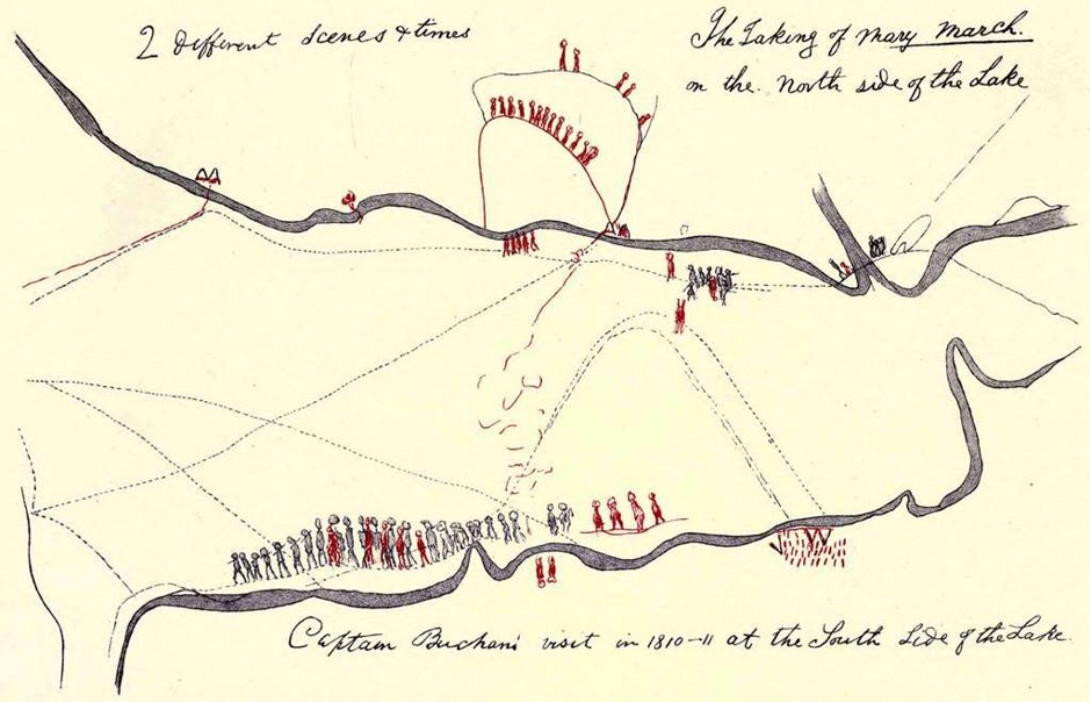

Figure 7. One of Shanawdithit's 10 maps described two different scenes: the north shore shows the taking of her aunt, Mary March, by European furriers in 1819 and the south shore shows Captain Buchan visiting in 1811 (Polack, 2013) . The Beothuk are denoted in red and the Europeans in black (Bliss, 2016).

Shanawdithit's relationship with Cormack was imperative to her creation of these drawings. She was his subordinate in every way: female, Native American, and servant. The explorer was working on a Beothuk history center, so he aimed to teach her English and learn about her people (Bliss, 2016). It is important to consider the language barrier and power dynamic between the two when viewing Shanawdithit's sketches alongside Cormack's inscriptions. For example, the Beothuk viewed the arrival of the Europeans

as hostile and would have likely not used a simple word like "visit" to describe their presence. Likewise, "Mary March" is a European name given to one of the Beothuk women. So, while her sketches are from the Beothuk's point of view, the inscriptions are inherently European.

The sketches Shanawdithit created in 1828 have been highly studied since. Geologist James Howley (1847-1918) aided in preliminary European surveys of Newfoundland in 1867 and gained an interest in the Beothuk that used to inhabit the area (Story, 1998). In addition to other artifacts and talking with people that had met Shanawdithit, he used her sketches to write a comprehensive study on the extinct tribe, *The Beothucks or Red Indians* (1915). In it, he includes praise for her geographic accuracy as well as detailed reports on the events she mapped (Howley, 1915, p. 226). Even today, her maps are indispensable knowledge for people investigating the interaction of Native American and European cultures. For example, her artistic skills were indicative of the Beothuk, but she had the opportunity to sketch with European paper and pencils (Polack, 2013). Despite not having formal mapping lessons, her experiences were indispensable knowledge and her artistic inclination made it possible for her to preserve them.

FEMALE CARTOGRAPHY THROUGH THE 20TH AND 21ST CENTURIES

Through the 1890's, Florence Kelley (1859-1932) was one of many women politically and socially engaging in reformation. She fled her husband with her two children and lived in the Hull House, a women's social settlement in Chicago, in 1891, and developed lasting professional relationships with the founders, Jane Addams (1860-1935) and Julia Lathrop (1858-1932) (Sklar, 1985, pp. 658-660). At the Hull House, Kelley utilized thematic maps (see Figure 10), which gained popularity with John Snow's cholera mapping in 1854, to display economic and demographic data of Chicago and the fight against poverty in the city (van den Hoonaard, 2013, pp. 76-77). The Hull House was an incredible source of support for women at a time when society was a man's institution, and social settlements like it allowed for women such as Kelley to succeed in an environment that often limited their opportunities (Sklar, 1985, p. 659). The Hull House was able to support Kelley and her children during a time in her life that could have ruined her financially forever, exhibiting the life-changing roles these types of communal social nets could play for those with short-term hardships.

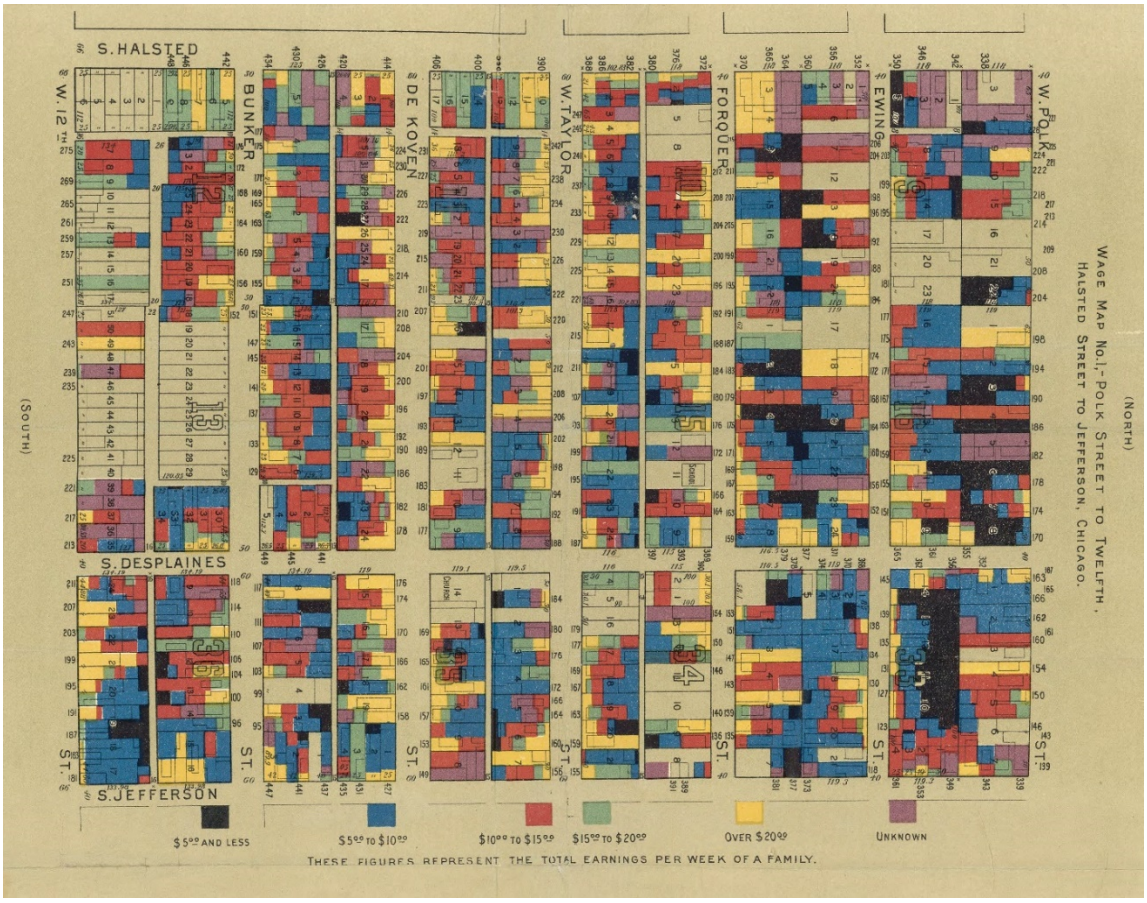

Figure 8. Florence Kelley contributed to this map, one of many in the "Hull-House Maps and Papers" publication (Residents of Hull-House, 1895). Thematic maps were becoming a popular way to convey information, and other maps contained information such as nationality and language. It is interesting to note that the residents of the Hull House used this color scheme while a contemporary cartographer would have utilized a monochromatic color scheme for quantitative data.

The 20th century was a time of transition for women to become more independent, but some successful women were still influenced by their fathers, including Swedish engraver Olga Herlin (1875-1965). Her father, Claes Ewald Reinhold Herlin, worked as an engraver and engineer for the Swedish Survey Office, where topographic maps were developed for military purposes since 1805 (van den Hoonaard, 2013, p. 50). Olga's father taught her topography and engraving on Sundays until the office hired her as their

first female worker in 1890, where she was highly respected for 55 years before retirement (Iko, 2018). She travelled to improve her skills and developed more efficient engraving methods.

Olga Herlin's career was definitely impacted because of her gender. Even when she attained a formal regular position as an engraver 37 years after she was hired, she was paid less than her male counterparts (Iko, 2018). Luckily, the second time she petitioned for higher pay, Herlin had the support of the first female member of Swedish parliament, Kerstin Hesselgren (1872-1962). Hesselgren worked to improve the working conditions of women and petitioned for Herlin in 1928 to receive higher wages based on her previous work (Frangeur, 2018). Additionally, part of the reason Herlin was able to have such a successful career was because she never married at a time when the government did not employ married women (van den Hoonaard, 2013, p. 50).

Since women were receiving more freedoms and rights by the 20th century, a bad father would not ruin a competent daughter, although he could offer unanticipated opportunities. Phyllis Pearsall (1906-1996) was a child when her father, Alexander Gross, started selling maps from his oil-lamp stores for the profit, and this was where she drew her first maps. She was writing articles and painting portraits in England when Gross, who had abandoned her at 14 to work in the United States, asked her to publish his company's world map (Bond, 1996). She got lost in London while delivering to a customer because of, ironically, outdated street maps, and began her "A-Z" map of London (Figure 11). During 1935, Pearsall walked the streets of London from 5 am to midnight recording street names and house numbers and published 10,000 up-to-date maps herself in 1936 (Knowles, 2003). She continued publishing maps through her

Geographers' A-Z Map Company until her death, and the company continues to publish reliable maps (Lyall, 1996). Pearsall's fortitude, mapping skills, and business competency earn her a place in any contemporary cartographic discussion.

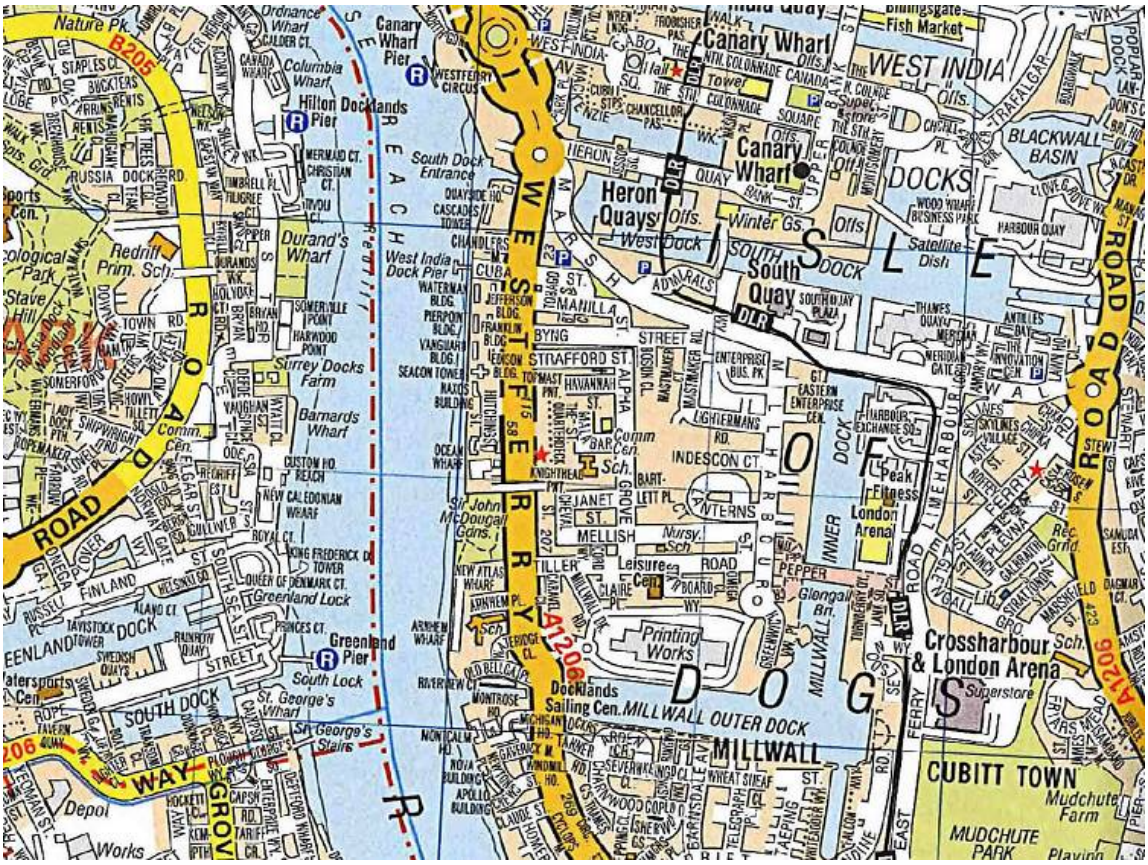

Figure 9. An excerpt of Phyllis Pearsall's 1936 "A-Z" street atlas that quickly became a staple for every Londoner (Bouteba & Turner, 2016).

Another area with the ability to support women was academic. As the draft brought many young men to serve in World War II, universities began accepting women, and Marie Tharp (1920-2006) became a research assistant at Columbia University's Lamont Geological Laboratory in 1948 (Blakemore, 2016). The lab was using physics, chemistry, and sonar to research the ocean floor, which was assumed to be flat. Not allowed on the research vessel, Tharp interpreted the sonar data to map the ocean's

cartography and discovered the Mid-Atlantic Ridge. Her male partner that collected the data, Bruce Heezen, initially dismissed her findings as "girl talk," especially since Wegner's 1915 theory on continental drift was still seen as controversial (Blakemore, 2016). However, once they discovered earthquake epicenters matching up to the ridge, Heezen accepted and published the findings under his name in 1956.

Working through the 1950's, Tharp's life exemplifies many of the barriers to women in cartography. Without the help of modern computers, she spent hours over sonar soundings plotting each latitude and longitude by hand. Despite carrying the majority of the data analysis load, she received little credit, if any, among her geography colleagues until 1997. She participated in very few research trips and did not give scientific presentations (Wolf, 2012). However, like other female cartographers, she had a supportive father. He worked as a soil surveyor for the U.S. Department of Agriculture, and that may have been an early introduction to the scientific world at a time when very few women were involved in it (Blakemore, 2016).

Figure 10. Marie Tharp analyzed sonar readings to map the ocean floor in the 1950's (Blakemore, 2016).

There were four schools that fostered prominent female cartographic communities in their PhD programs during the mid-1900's: The Universities of Wisconsin, Washington, Kansas, and UCLA (van den Hoonaard, 2013, pp. 103-104). Arthur Robinson (1915-2004), who developed the global Robinson projection for Rand McNally in 1963, inspired and advised graduate students, many of them women, at the University of Wisconsin-Madison from 1945 to 1980 (University of Wisconsin - Madison, 2020). These universities offered the three keys to success – education, resources, and mentorship – in one community of likeminded individuals.

One of the most pioneering women in academic cartography was Mei-Ling Hsu (1932-2009), a graduate student advised by Robinson (van den Hoonaard, 2013, pp. 109-

111). Born in China in 1932, her family escaped to Taiwan. After receiving her B.A. there, she was encouraged to study in the US, where she was the first woman to write a cartographic dissertation, nineteen years after the first dissertation in the field. As with any female in a male-dominated field, she was the only woman when she began teaching in the Department of Geography at the University of Minnesota. During her time there, Hsu was a respected scholar in cartographic symbolization and map projections, and helped develop the cartography and GIS department at the University of Minnesota (American Association of Geographers, 2009).

These types of academic communities, such as the one fostered by Robinson, were an incredibly supportive environment for early female cartographers. Women and minorities still face difficulty acquiring STEM degrees, but Russell (2017) found that bringing these types of students together allows them to overcome shared hardships so more can major in high-paying STEM fields. They are not underrepresented in these fields entirely because of lack of interest, but the inability to participate due to stereotypes and poor mentorship (Russell, 2017). Robinson, by successfully advising one woman, was able to advise more women as his department gained a reputation as a supportive environment at a time when there were few women in academia. Even though he was male, Robinson mentored these women who may have otherwise not pursued geography, providing a solution to a large barrier facing many women in STEM fields: finding an advisor (Cavanaugh, 2017). As was seen in the Hull House, oppressed groups desire places with people similar to them so they can overcome challenges with the support of others.

Although there have been great strides in the path to gender equality in the workforce, there is still a deficiency of women in STEM fields. For example, Figure 13 shows the discrepancy between the percentage of women in all jobs (48%) and those in STEM jobs (24%). There is still a gendered wage gap for women in STEM, although it is less than non-STEM jobs (Beede, et al., 2011, p. 8). Among the women that do pursue STEM, more than half study physical and earth sciences (Beede, et al., 2011, p. 6). Even when there are groups of women studying together, such as the ones under Robinson, there is evidence that receiving mentorship from the same gender is beneficial. Additionally, seeing female mentors promotes the idea that STEM careers are appropriate for women (Cavanaugh, 2017, p. 9). In addition to accessible mentors, comprehensive family leave policies could encourage women to join STEM fields. Since women are more likely to have struggles balancing personal and professional life, family friendly policies have more of an impact on their careers than their male counterparts (Cavanaugh, 2017, pp. 12-13).

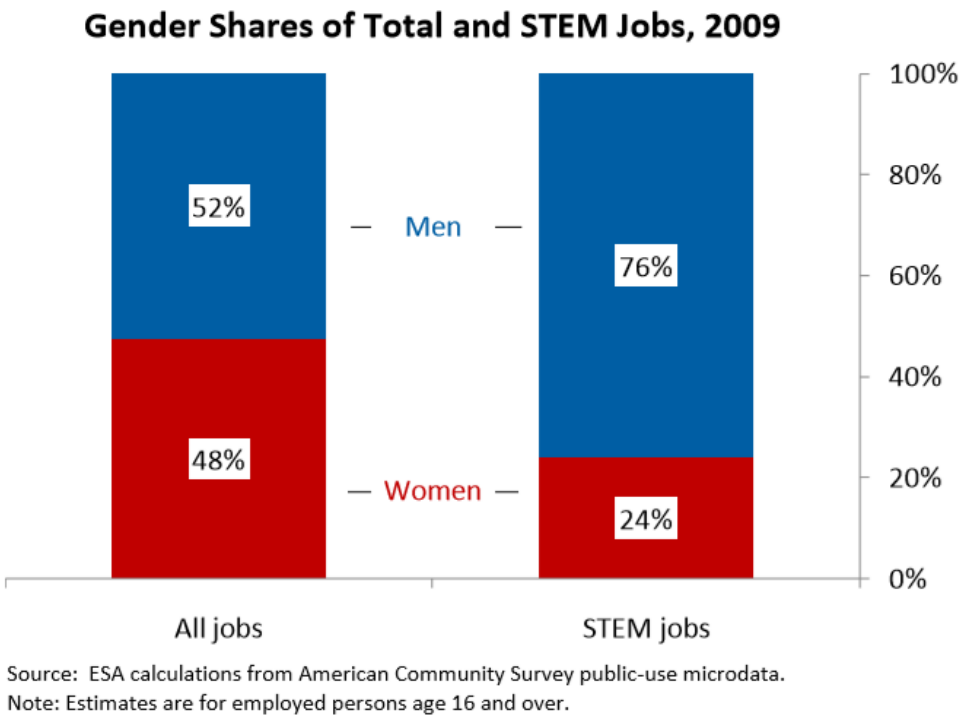

Figure 11. Women in the US only make up a quarter of the STEM workforce, while they occupy half of jobs in the total workforce (Beede, et al., 2011, p. 1)

As technology has evolved, so has the way people make and interact with maps. OpenStreetMap (OSM) is an open-source, community developed online map of the world where users can tag locations. It started in 2004 by UK-based Steve Coast, and this large-scale project has been growing ever since. However, Rachel Levine, a GIS operations and training coordinator with the American Red Cross, estimated that only 2-5% of OSM contributors were female and the majority are retired men (Holder, 2018). It might be expected that online crowdsourcing would encourage almost equal participation due to ease of access, but circumstances mean that many women are still excluded from cartography.

As the saying goes, write what you know, and that is precisely what OSM users do. Therefore, in 2018, there were plenty of bar and sport arena tags, but not a single

fertility clinic. It is not that these places do not exist, but rather that people are not going to spend time locating and tagging a building they have no interest or stakes in. For example, if instead the majority of contributors were women, there would likely be an underrepresentation of strip clubs and far more than the 10 abortion specialists tagged.

In 2011, OSM rejected the addition of a "childcare" tag, likely due to a group of men not considering how that might help other people. OSM added the tag in 2013, and within five years was used more than 12,000 times (Holder, 2018). This is not to say that men don't understand the importance of fertility clinics and daycares, but rather that individuals, regardless of gender, don't spend time thinking about places with which they do not interact.

Levine has also seen how this has impacted underdeveloped countries where women have limited protected rights. For example, a public toilet may or may not have facilities for women, so would require an additional tag of "female public toilet" to be accurate. Of course, if these women do not have the resources to add a tag, the only way to get that information would be if a man added it, which would be highly unlikely since people will likely only tag what they care about. Levine advocates for recruiting more female mappers, especially in these underdeveloped countries, in order to gather a more complete and accurate world picture (Holder, 2018). This would create a net of mentors to foster the necessary education to make these communities safer for women.

Today, Levine coordinates Missing Maps for the American Red Cross (American Red Cross, 2020). This open-source map works with OSM by taking community input, but focuses on areas with limited information that humanitarian organizations can use to better serve vulnerable people during crises (Missing Maps, 2020). She led one of 20

feminist map-a-thons during International Women's Day in 2018, which encouraged male, female, new, and old cartographers to participate (Holder, 2018). The volunteers led by Levine worked on a map of escape routes and shelters for an NGO that protects girls under threat of genital mutilation in Tanzania (Bliss, 2018). These map-a-thons are a contemporary community that can foster and support aspiring female cartographers, as can be seen by the fact that Levine herself was inspired to pursue cartography after attending one in Atlanta in 2012.

At Esri's annual conference in February 2020, 36% of the 38 speakers were women (Esri, 2020). On the surface this could seem discouraging, but it is important to remember that only 24% of STEM jobs are filled by women (see Figure 13). While still a minority to the male speakers, they represented more than their gender's share. This shows that there are successful women in the field today that are willing to share their knowledge, as well as platforms allowing them to do so.

CONCLUSION

Despite systematic and cultural obstacles, many women in history overcame such difficulties to produce cartographic contributions that are still studied. Women that were most likely to succeed in pursuing cartography had an availability of resources, education or valuable experiences, and a supportive mentor or community. Although there have been great strides in the involvement of women in cartography and related fields, there are still obstacles to women pursuing STEM fields today. As these obstacles are identified and overcome, cartography and related STEM fields will hopefully better host female contributors despite their gender. The sources of these obstacles may change, but by nurturing their education, expanding their resources, and fostering healthy mentorships and communities, the success of women in cartography can continue to flourish.

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