Hertha Ayrton
Serendipitous Sedimentologist

Danita Brandt*[1]

HERTHA WHO?

Long celebrated among electrical engineers for her contributions to electric-arc lighting, Hertha Marks Ayrton (1854–1923) is not widely recognized among geoscientists despite her pioneering work on the formation of sand ripples. Interestingly, a Google Doodle (Nichols, 2016) highlighted her work on ripple formation rather than her more widely known work in electrical engineering and sparked (pun intended) this Rock Stars profile. The story of how Mrs. Ayrton came to study ripples is a reminder of how chance and circumstance, impelled by curiosity and creativity, can shape scientific discovery. Her persistence in the face of societal strictures on women's place in science and society resonates even today.

MENTORS AND MATH

Born to Alice Theresa Moss, a seamstress from Portsea, Hampshire, England, and Levi Marks, a Jewish refugee from Tsarist Poland, Phoebe Sarah Marks (Hertha's birth name, and "Sarah" to her family) faced what might easily have been debilitating hardship from her earliest years. Sarah's father, a jeweler and watchmaker died when she was seven, leaving seven children—with the eighth on the way—and a family in debt. Sarah's mother might have kept her eldest daughter home to help care for her siblings, but, in stark contrast to prevailing Victorian views, Alice Marks held that "women have the harder battle to fight in the world," and because of this, needed a "better education than men" (Mason, 1991, p. 201). Thus, she sent her nine-year-old daughter to live with her wealthier sisters in London (Mason, 1991).

Staying with her aunts afforded Sarah opportunities that would have been out of her reach in Portsea. She learned French, Latin, Greek, and Hebrew, studied music and art, and discovered an innate talent for mathematics. Visitors to the London house included the author George Eliot and educator Madame Barbara Bodichon, a cofounder of Girton, the first girls' college at Cambridge University. Both women recognized Sarah's intellectual potential and made Sarah's enrollment at Girton financially possible. It was during this time of self-actualization that, at a friend's suggestion, Sarah assumed the name Hertha, the Teutonic goddess of Earth. As befit her adopted name, Hertha was not the demure Victorian woman of stereotype but an outspoken, creative, free-thinker who was not afraid to challenge limits imposed by prevailing societal sentiments about suitable pursuits for women.

Figure 1. Hertha Aryton in her home laboratory with a wave tank. Published with permission from the Mistress and Fellows, Girton College, Cambridge, UK.

* brandt@msu.edu
[1] Department of Earth & Environmental Sciences, Michigan State University, East Lansing, Michigan 48824, USA
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While at Girton, Hertha demonstrated a proclivity for tinkering, which culminated in 26 patents over her lifetime. Hertha found an outlet for her love of math by forming a mathematics club and submitting problems and solutions to a mathematics journal.

After earning a certificate in mathematics at Cambridge (women were not allowed to receive degrees from Cambridge until 1923), Hertha taught mathematics in London while at the same time attending a night course at a nearby college, pursuing an interest in electricity. A year later she and the physics instructor, a young widower, William (Will) Ayrton, married. Will Ayrton was a pioneer in electrical engineering as well as a pioneer in progressive attitudes about equal opportunities for women. By all accounts, the Ayrtons had an equal partnership in their shared research interests in electrical engineering and shared attitudes about the role of women in science and society. Both recognized the tendency for women's contributions in male-female partnerships to be overlooked. Will Ayrton was explicit in emphasizing his spouse's independence and originality as a researcher (Tattersall and McMurran, 1995).

As was the fashion in scientific presentations of the day, Hertha's talks were accompanied by demonstrations, first, of the workings of the electric arc and, later, using wave tanks to demonstrate the development of ripples. Although the popular media regarded her gender as much a novelty as her demonstrations, Hertha's scientific colleagues accorded her the courtesy of regarding her as a peer, responsible for addressing questions about her methods and assumptions. Growing up with six brothers may have inured her to the "masculine criticism" she faced and which she handled with aplomb (Sharp, 1926).

SEDIMENTOLOGY AND SUFFRAGE

Hertha was well-established in the electrical engineering community by the time she turned her attention to ripple marks. In the autumn of 1901, the Ayrtons relocated to the seaside to facilitate Will's convalescence from chronic fatigue and insomnia. Away from her home laboratory, yet perpetually intellectually restless, Hertha sought an outlet for her creative research energies and found it in observations of sand ripples during walks along the shore.

A number of mathematicians and scientists, including Cambridge professor George Darwin (one of Charles' sons), had investigated ripple formation and the relationship between sand ripples, the waves that form them, and the substrate on which they form; still, these phenomena were not well understood. After a summer of sketching ripples in the field and attempting to reproduce them in the bathtub (relocated to the sitting room of their rented lodging for the purpose), Hertha returned to their London home and began a series of experiments, constructing wave tanks of different sizes, equipping the largest with rollers and an electric motor to rock the tank, and creating ripples on a sand substrate (Fig. 1). A key to her success in understanding ripple formation was making visible the vortices in the water. Hertha found black ink (used by George Darwin) unsatisfactory and experimented with various substances, initially settling on moistened black pepper and, later, aluminum powder. Hertha showed that the origin of symmetrical wave ripples was not dependent on irregularities in the substrate and frictional forces between sand grains and the substrate, as previously thought, but was a predictable outcome of the action of vortices within the wave.

Hertha's ability to make the invisible visible, through ingenious public demonstrations, earned the respect of even her skeptics (Sharp, 1926). Hertha made history with the results of this work, when, in 1904, she became the first woman to read her own paper, "Origin and Growth of Ripple-mark," in front of the Royal Society.

While chipping away at the barriers to women's membership and participation in a stodgy scientific society through her scientific work, Hertha worked to dismantle other barriers to women in Victorian British society. Hertha and her daughter Barbara participated in demonstrations calling for women's right to vote. Some of the demonstrations turned confrontational and at one of these Barbara was among the activists sent to prison. Of this incident, Hertha wrote to a friend, "Barbie is in Holloway [prison]…I am very proud of her" (Mason, 1991, p. 211).

PATRIARCHY AND PERSISTENCE

Throughout her life, Hertha confronted personal and professional obstacles that might have overwhelmed a less resilient person. Her ability to prevail was facilitated through a combination of inheritance (her mother's fortitude and her father's mechanical skills), circumstance (those wealthy aunts and benefactors), and serendipity (Will Ayrton happened to be teaching that night course), but the factor that perhaps best explains the mark she made on science and society is "persistence."

Hertha nearly breached the ramparts of the Royal Society (founded in 1662), becoming, in 1902, the first woman nominated for membership. She was rejected on a Victorian-era technicality—as a married woman, she had no legal personhood separate from her husband, and the Society ruled that it could only admit "persons." It would be four decades before a second woman was nominated and accepted for membership. However, in 1906, Hertha became the first woman awarded the Royal Society's Hughes medal, the highest honor bestowed by the society, for original discovery in the physical sciences, recognizing her work on both the electric arc and sand ripples. It would be 102 years before the next woman received this award.

Today, a new generation has access to multiple sources of her life story, including a book of notable women scientists for young readers (Ignotofsky, 2016) and a play by American playwright Lauren Gunderson (2019) that centered on the friendship between Hertha and Marie Curie.

Electrical engineer Rollo Appleyard's letter to Hertha after she was awarded the Hughes medal reflected the shifting attitudes about women in science at the beginning of the twentieth century: "Your good work has literally left

'footprints in the sands of time' and it will give many men, and what is of more importance, many women, courage to take heart again, to improve general knowledge and their own lives by looking into what is" (Sharp, 1926, p. 186). Just don't call her a "woman scientist." In a 1919 interview, Hertha said, "Personally I do not agree with sex being brought into science at all. The idea of 'women and science' is entirely irrelevant. Either a woman is a good scientist, or she is not; in any case she should be given opportunities, and her work should be studied from the scientific, not the sex, point of view" (Sharp, 1926, p. 182).

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