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Marie Tharp: Discoverer of the Rift Valley of the Mid-Atlantic Ridge and Inventor of Marine Cartography

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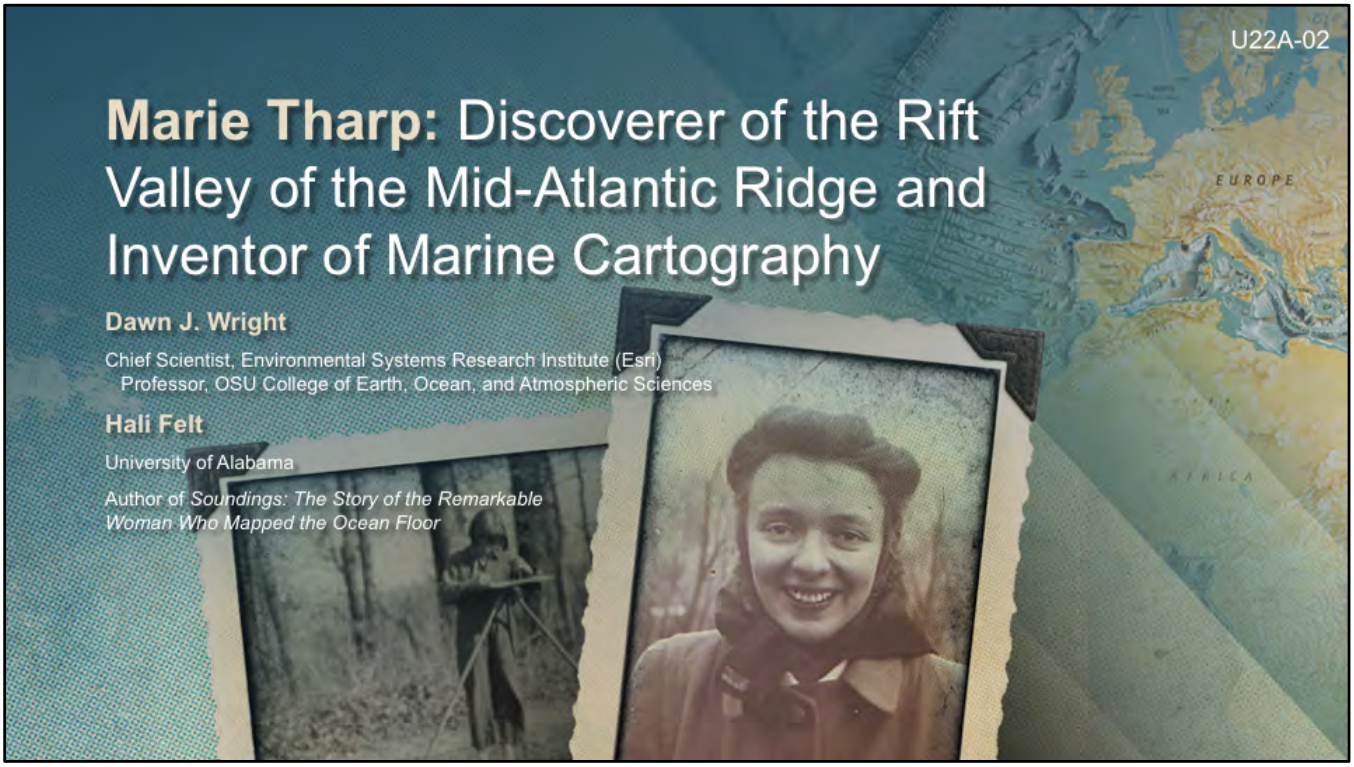


I'm deeply honored to deliver this tribute, in collaboration with Hali Felt who has written the definitive biography, to **Marie Tharp**, a woman with a background and training unusual for her time in both geology and mathematics, coupled with art. A woman who had the courage of her convictions and of her intellect to posit one of the most fundamental proofs of continental drift: a rift valley caused by the faulting of seafloor spreading. But because she was a woman, her contributions were belittled or outright ignored *at the time*.

https://agu.confex.com/agu/fm18/meetingapp.cgi/Paper/366409
ABSTRACT: By the latter half of the 20th century the technologies behind SONAR, marine gravity, and marine magnetics had advanced to the point that the complexities of the ocean floor and beneath could be unraveled in unprecedented detail. Hence, scientists would finally be able to provide conclusive evidence for plate tectonics by way of plausible, proven physical mechanisms. But it took a young woman with an unusual background in geology, mathematics, and art to use that info to posit one of the most fundamental proofs of continental drift: a rift valley caused by the faulting of seafloor spreading. She did this while a researcher at Columbia University, in the lab of the iconic Maurice "Doc" Ewing, founder of the Lamont Geological Observatory. Along with geologist Bruce Heezen, she began the first systematic, comprehensive attempt to map the entire ocean floor. Heezen collected the data at sea, while Tharp developed a truly unique process for translating millions of these ocean-sounding records into a single drawing. During this process, she discovered the rift valley of the Mid-Atlantic Ridge, which Heezen at first discounted, holding incorrectly to his expanding Earth theory. Tharp's name was absent from the 1956 scientific paper that released this discovery to the world, and she was not given proper recognition for this and many other accomplishments until decades later. In 1968, she finally had the opportunity to go to sea, and performed the first ever shipboard processing and plotting of bathymetric data. During this time, Tharp and Heezen also formed a successful partnership with Austrian landscape painter Heinrich Berann to produce several panoramas of the ocean floor, leading to some of the most widely-recognized and beloved images in all of modern Earth science. Indeed, as her first, long-time employer, Doc Ewing, invented the field of marine geophysics, Tharp invented the field of marine cartography. Her story in words, data, and maps is a story that must continue be told for the future of science as well as the past. It is a remarkable testament to persistence, conviction, and courageous innovation.

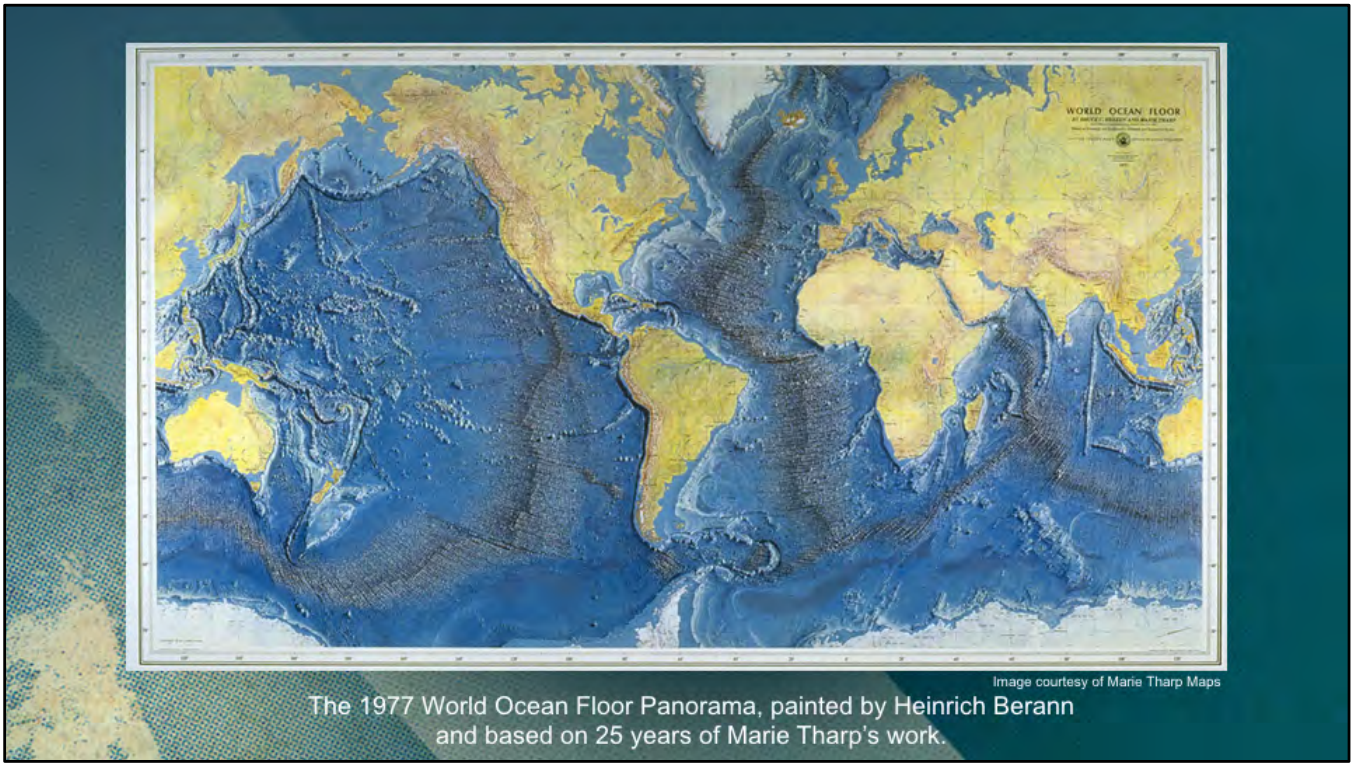


Image courtesy of Marie Tharp Maps

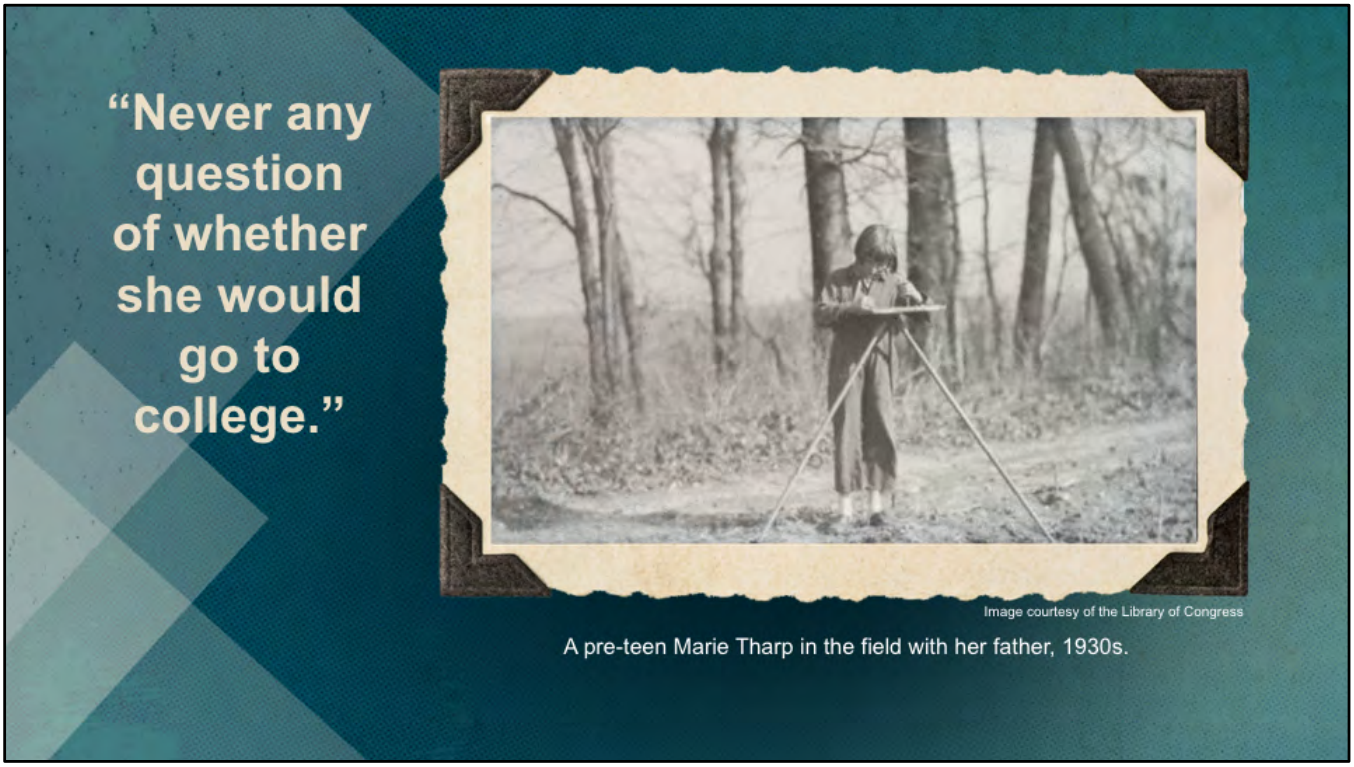
The 1977 World Ocean Floor Panorama, painted by Heinrich Berann and based on 25 years of Marie Tharp's work.

For many of marine geologists and geophysicists, STILL our favorite map of the ocean floor and seen on the walls of many venerable oceanographic research institutions.

A father's influence

Image courtesy of Robert Brunke

Marie Tharp's father, William, was a surveyor with the U.S. Soil Survey; at an early age, William began taking Marie into the field, encouraging her to "read nature" 1920s

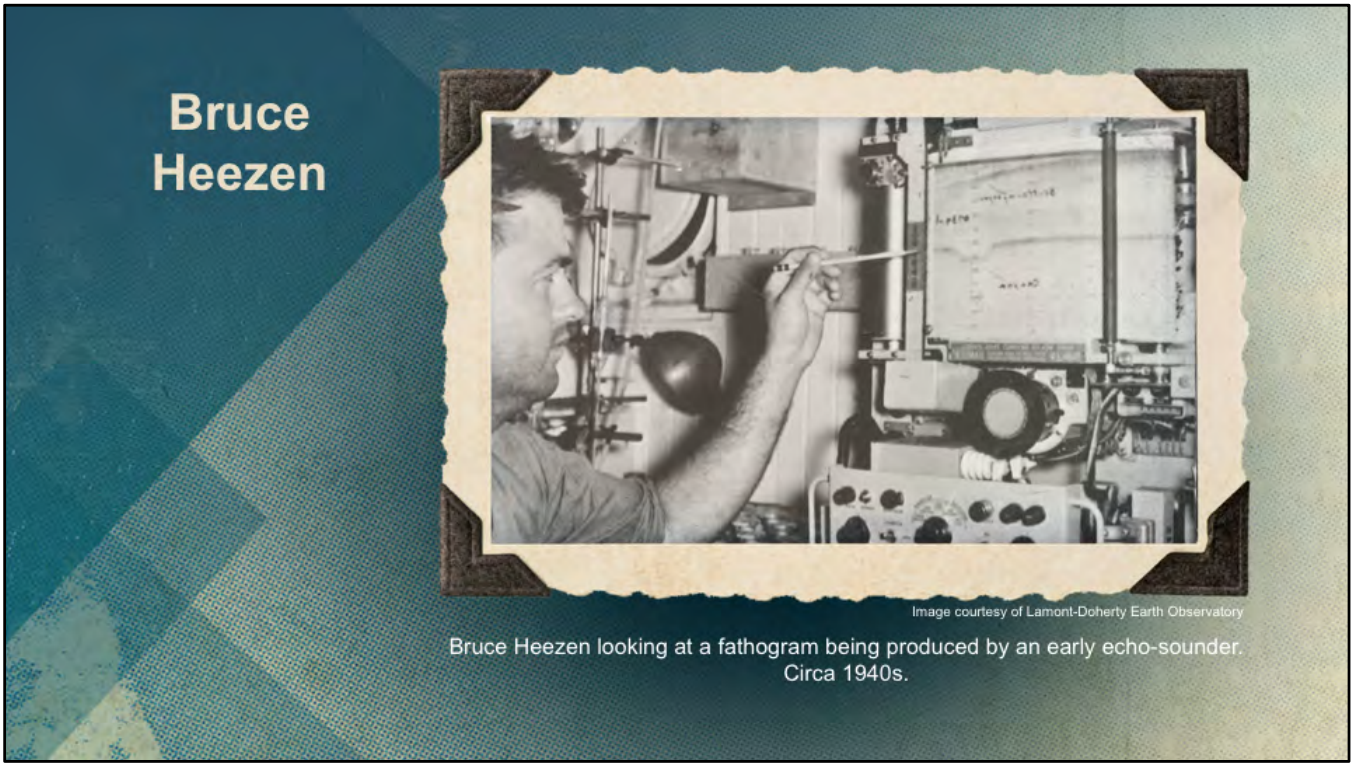


Transition with “there was never any question of whether she would go to college”

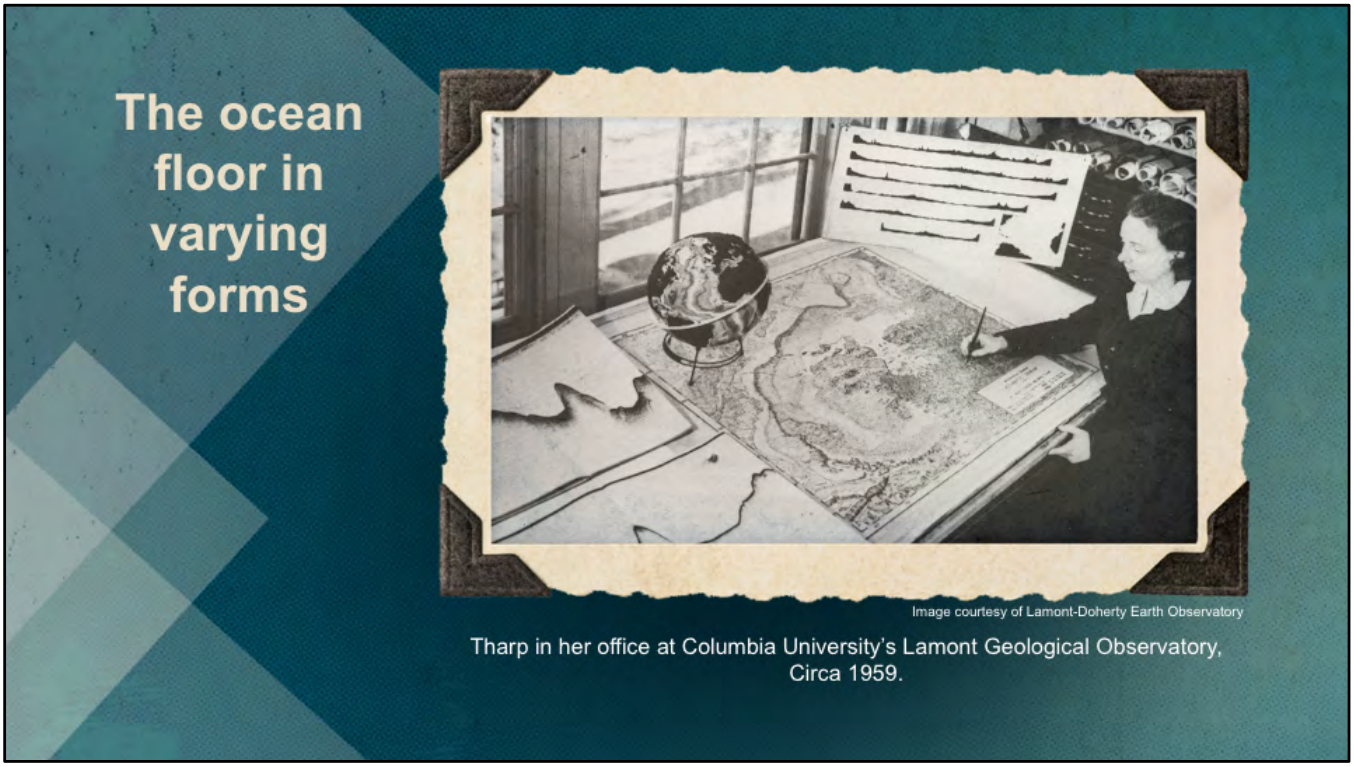
Tharp graduated from Ohio University in 1943 with bachelor degrees in English and Music along with four minors
Next, an accelerated master degree in Petroleum Geology
Second bachelor's degree in mathematics from U. of Tulsa while working as a geology assistant for Stanolind Oil

Columbia University

- Hired initial as a general draft, promoted to a research assistant, tried to quit (see *Soundings* for details)
- Ended up working exclusively with Bruce



Bruce Heezen



This shows Tharp at work, and you can see here all of the different ways that Tharp and Heezen tried to show people the ocean floor.
Tharp's name was absent from the 1956 scientific paper that released the discovery of mid-Atlantic rift valley to the world. However, her name was allowed to appear on the landmark 1959 Geological Society of America special paper, The Floors of the Oceans: 1. The North Atlantic.
And in 1961, M. N. Hill, writing for The Geographical Review, "recognized it as a 'brilliant compilation of much of the information from the North Atlantic' and said that the authors 'presented a farsighted interpretation of its meaning (p. 124).'"

Tharp's process

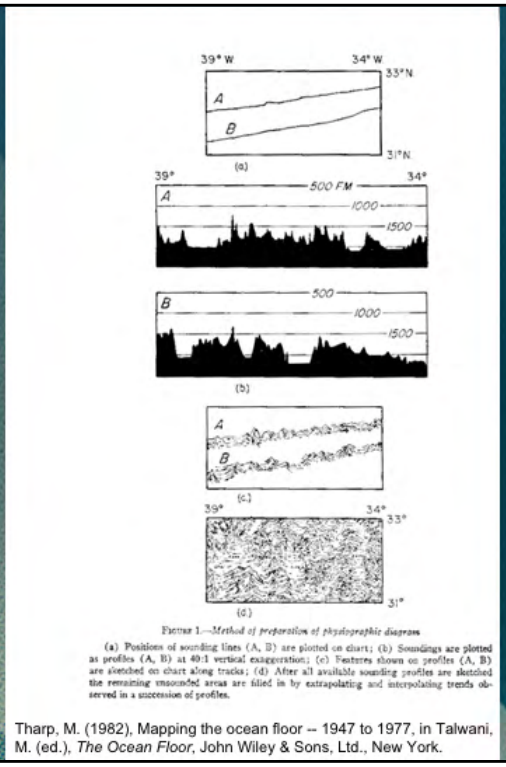


FIGURE 1.—*Method of preparation of physiographic diagram*

(a) Positions of sounding lines (A, B) are plotted on chart; (b) Soundings are plotted as profiles (A, B) at 40:1 vertical exaggeration; (c) Features shown on profiles (A, B) are sketched on chart along tracks; (d) After all available sounding profiles are sketched the remaining unsounded areas are filled in by extrapolating and interpolating trends observed in a succession of profiles.

Tharp, M. (1982), Mapping the ocean floor -- 1947 to 1977, in Talwani, M. (ed.), *The Ocean Floor*, John Wiley & Sons, Ltd., New York.

- Ship tracks to bathymetric profiles with huge vertical exaggeration (40:1). The VE allowed her to identify the rift valley that was her huge discovery
- After that, she turned the profiles into sketches
- Still had blank spaces—what to do there?
- Tharp's recounting of her process (as depicted in Felt's biography) shows that she did not simply stumble upon these features—although she had very little exact data to work with she was incredibly gifted in interpolation, extrapolation, and hypothesizing

Filling in the gaps artistically

Image courtesy of Marie Tharp Maps

A close-up of Panel 4 in prior slide. Actual size is about 2 square inches.

Overlays of earthquake epicenters

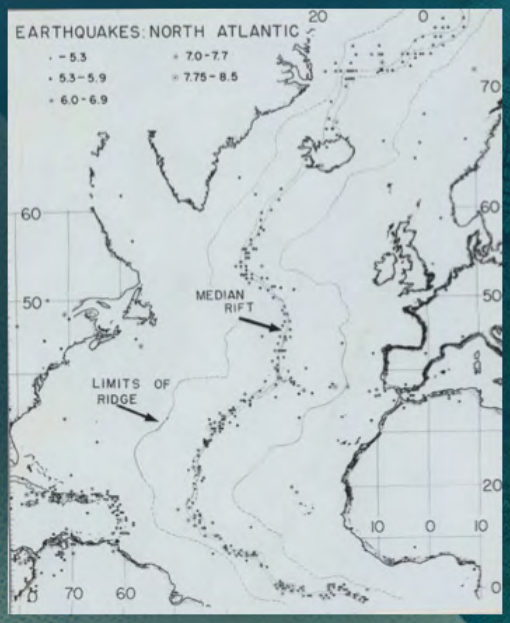
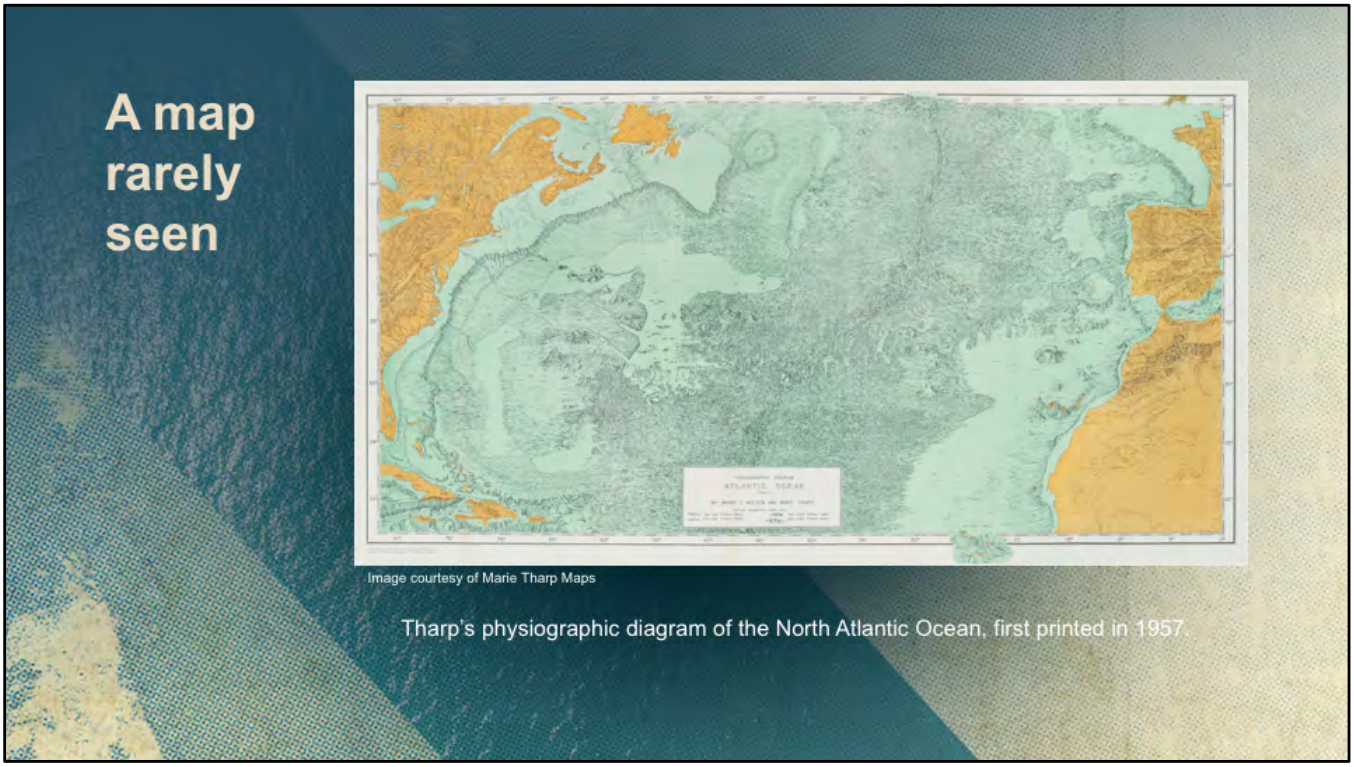
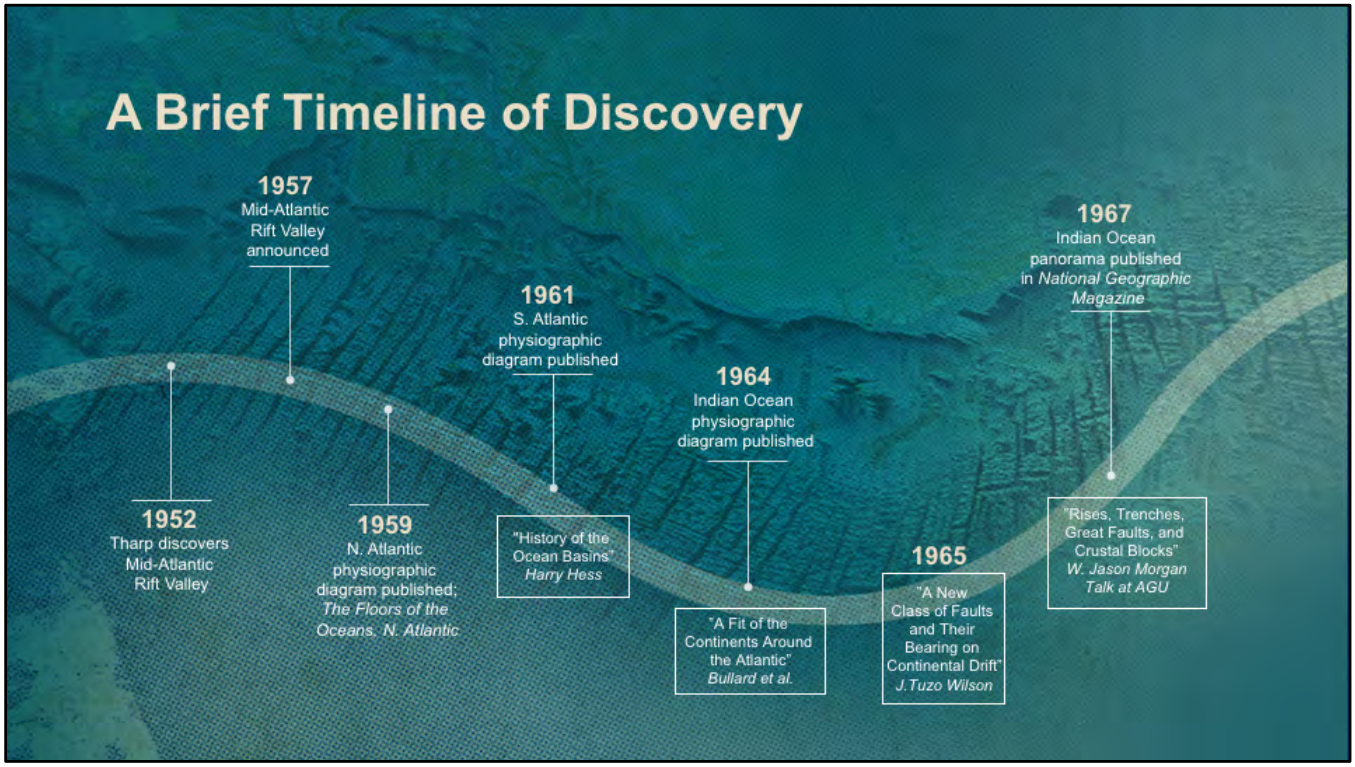


Image courtesy of the Library of Congress

- Earthquake epicenters plotted on map of same scale allowed her to see that her rift valley was seismically active.
- The epicenters fell exactly within the rift
- Along with a smattering of drill core data, this told her that what she was seeing was the boundaries of the plates that Alfred Wegener had hypothesized in the early 1900s
- Conclusion: the crust here was young and it was moving!



In a way, Marie's story is like the maps themselves. This map, from 1957, was created with much more scientific rigor, and reveals the extent to which Marie was making arguments about how features on the ocean floor were formed. But it's rarely reproduced, and most Earth scientists have never seen it. Hali Felt's book argues that the reason for this lay in that no one really knew exactly how it was made, and what knowledge Marie had that allowed her to create it.

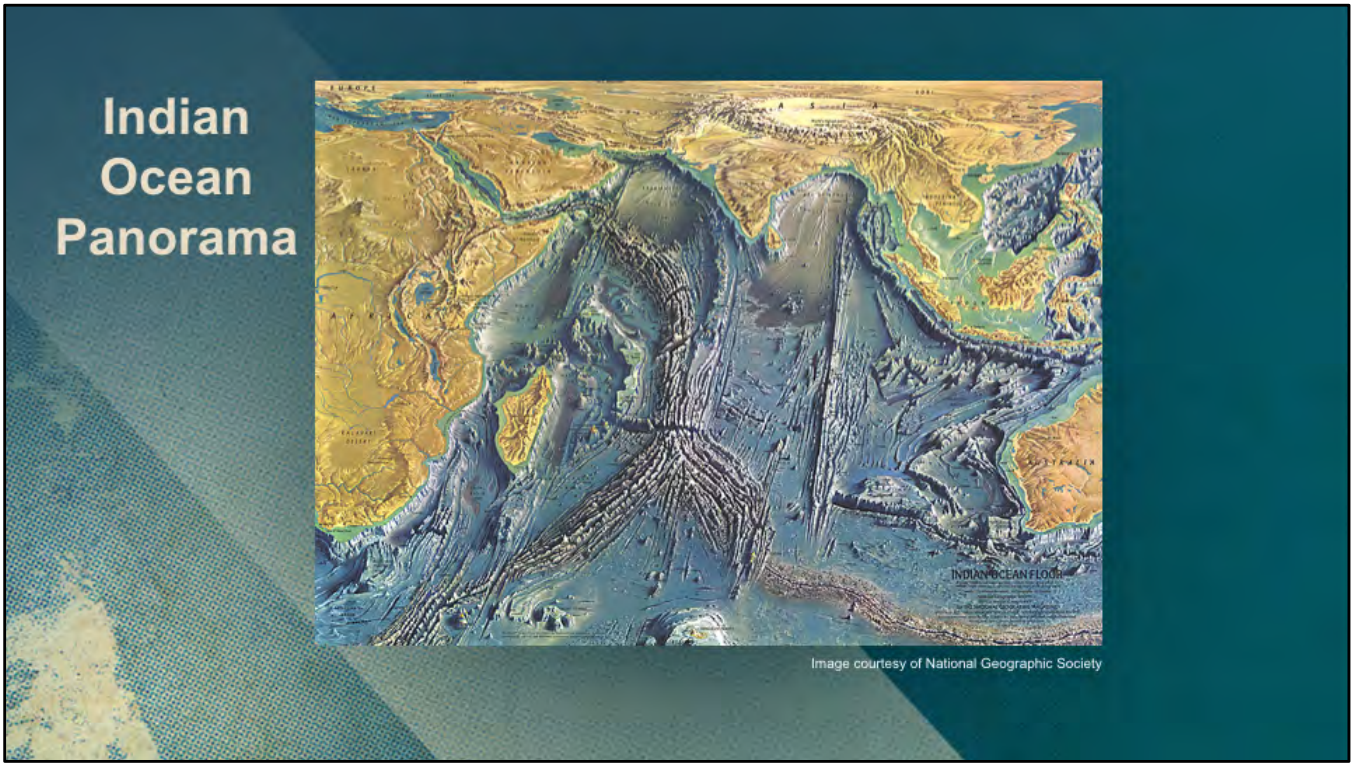


- Milestone's in Tharp's work as compared to the timing of some of the seminal papers in the history of plate tectonics
- She had made some significant discoveries some years before they were described in the literature, literature in which she was not allowed to be named as a co-author, not until 1959, and she was not allowed to go to sea until 1968

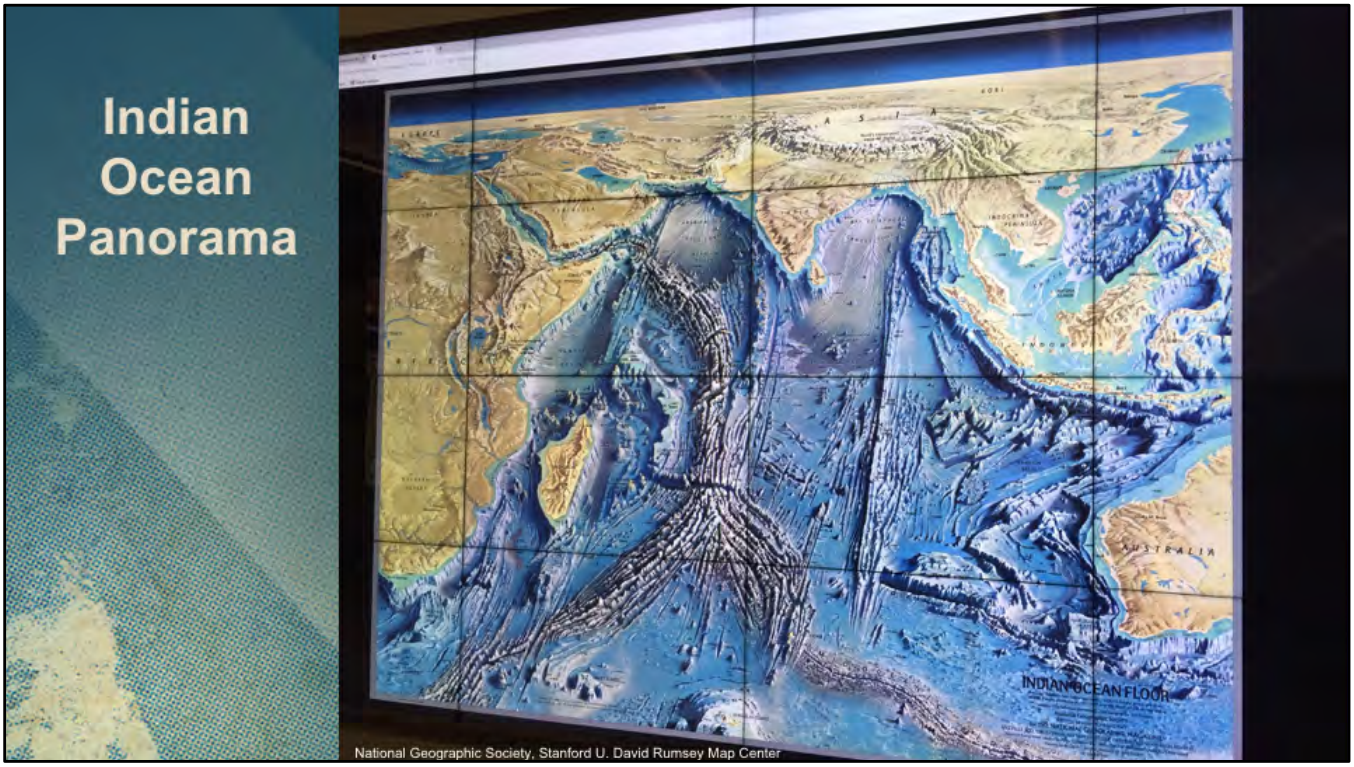
1957 discovery of the rift valley: In the article that accompanied these illustrations, the New York Times said that the Earth was being "pulled apart." As a result, Lamont received letters from members of the public who feared for their safety.

1965 J Tuzo Wilson introduced transform faults as a 3rd type of plate boundary

1967 Jason Morgan's talk at AGU proposing (published as a full paper in JGR in 1968) on a spherical geometry framework for continental drift, extending Wilson's 1965 transform fault concept to a spherical surface was later published in 1968 in JGR



Series of maps in the National Geographic Magazine

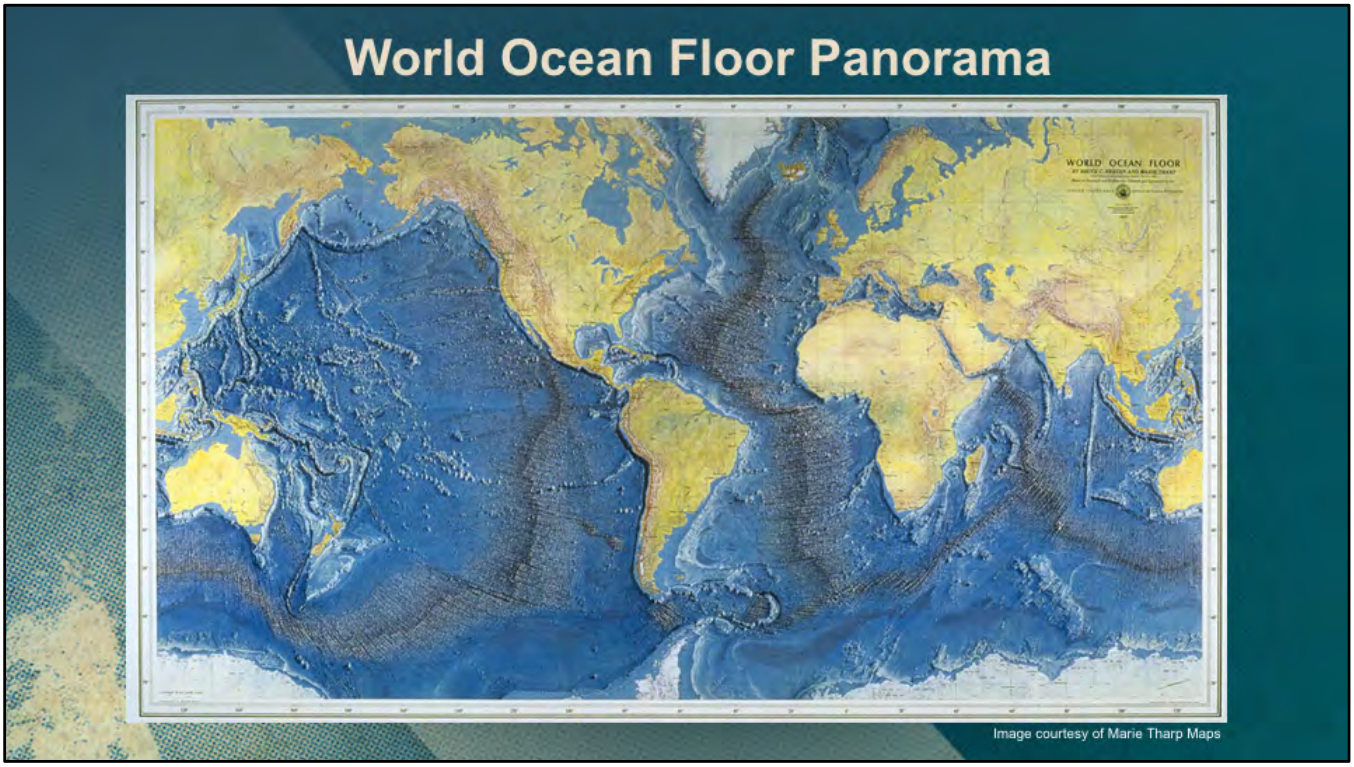


Really comes to life on the wall-sized hyperscreen of the David Rumsey Map Center at Stanford University
https://library.stanford.edu/collections/david-rumsey-map-collection

Atlantic Ocean Panorama

June 1968 issue
of *National Geographic*

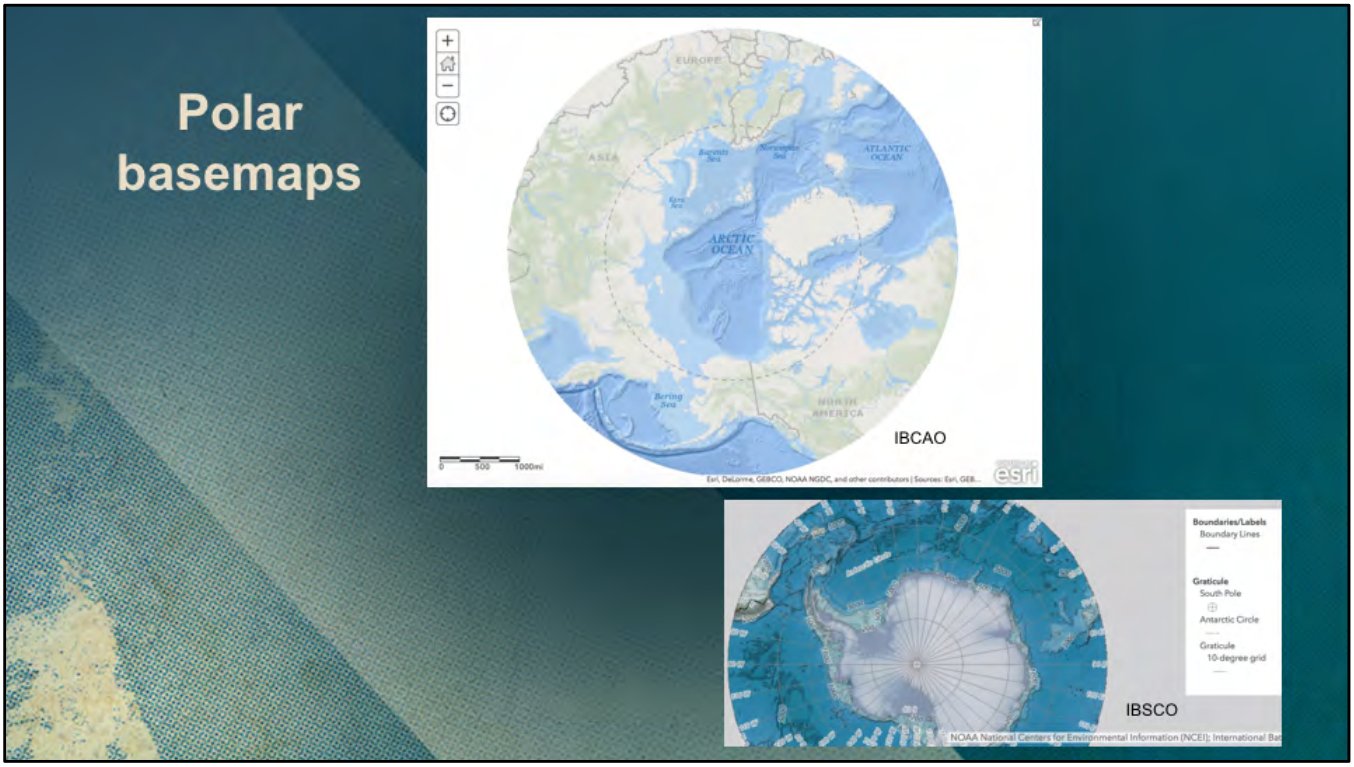
Image courtesy of Marie Tharp Maps



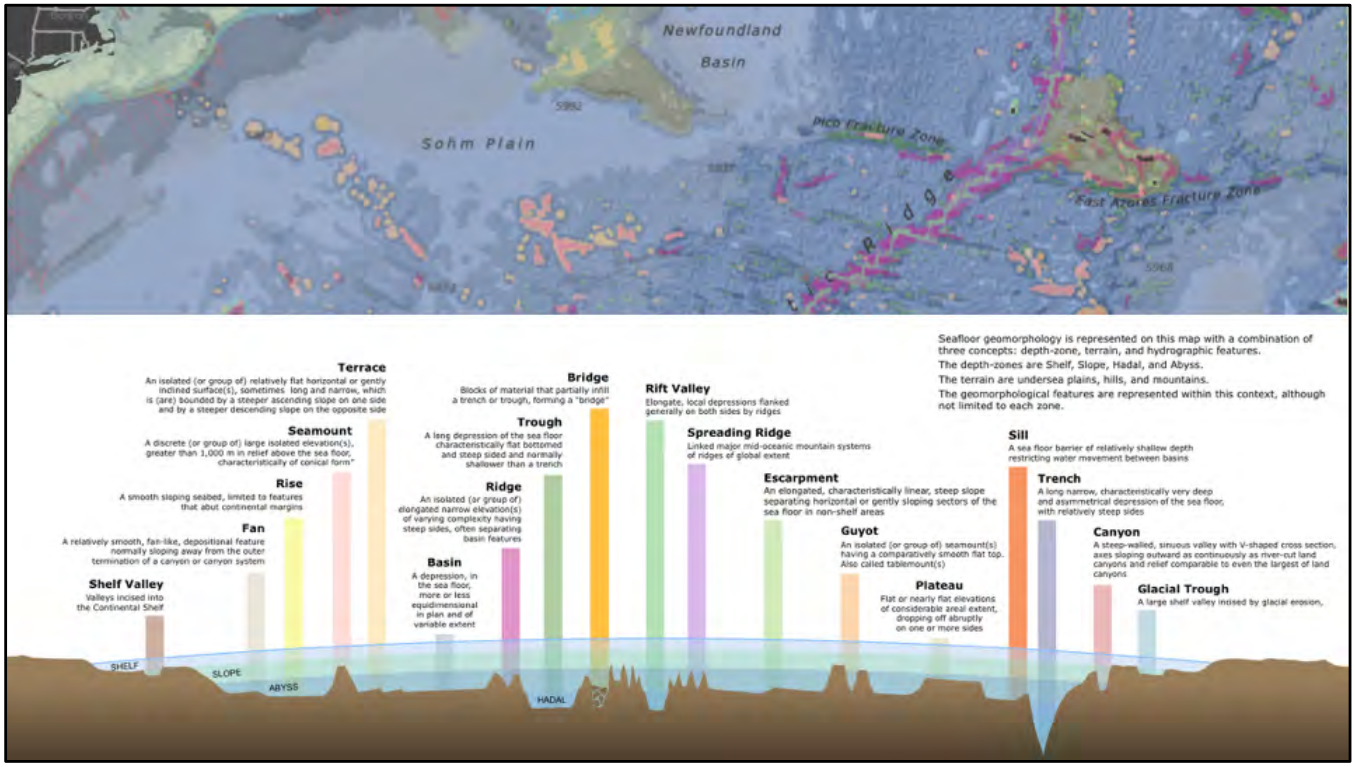
And again the iconic 1977 World Ocean Floor Panorama

MODERN LEGACY OF MARIE THARP is seen in efforts such as our ongoing Ocean Basemap at Esri. It was not only inspired by Marie, the inventor of marine cartography, but resulted in many *years* of cartographic design work in terms of the choice of **colors, color saturation and shading**; label placement, angle, and legibility; the chosen hierarchy of the information on the basemap, the coordinate systems, etc. …
Access the Esri Ocean Basemap within the ArcGIS Living Atlas of the World,

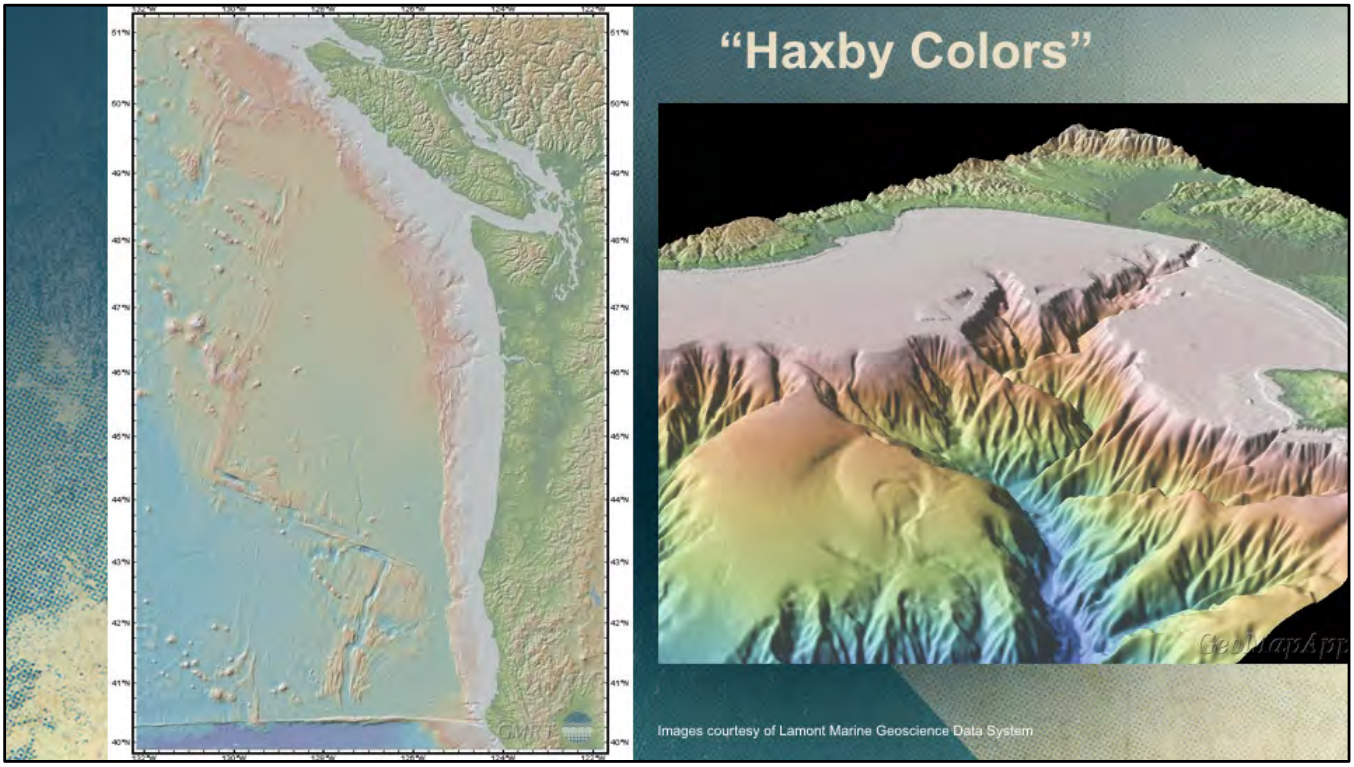
Here bathymetry exists as a **web service**, upon which you can interactively overlay any number of points, lines, polygons, rasters, any other LAYERS of your choice, such as this simulation by UH-Manoa of the estimated 1.5 million TONS of debris headed to the US and Canadian west coast from the **2011** Tohoku-Oki earthquake and tsunami.



… the coordinate system, including for polar regions especially, the proper stereographic projections. And all this is in addition to the incorporation of authoritative data from the community, including of course the GEBCO, IBCAO, IBSCO, NOAA, USGS, and others. Access the Arctic Ocean Basemap **https://arcg.is/1TjCem** The Antarctic basemap is still in development



Also, this world seafloor GEOMORPHOLOGY web service, inspired by Tharp, and based on Peter Harris et al., original work at Geosciences Australia, transferred to GRID-Arendal and originally published in Marine Geology, 2014, Harris, P. T., M. Macmillan-Lawler, J. Rupp, and E. K. Baker (2014), Geomorphology of the oceans, *Marine Geology*, *352*, 4-24.
Access this in the ArcGIS Living Atlas of the World at **https://arcg.is/0iWP9W** including full descriptive metadata



Lamont has also given us the legacy of Bill Haxby and the famed "Haxby colors" that generations of us have used within Generic Mapping Tools (GMT), and as featured in Bill's GeoMapApp from Lamont, the Global Multi-Resolution Topography (GMRT) Synthesis, the Marine Geoscience Data System (MGDS) and more shepherded by Suzanne Carbotte, Vicki Ferrini, and other great colleagues

https://blogs.ei.columbia.edu/2016/01/07/the-floor-of-the-ocean-comes-into-better-focus/

Another important part of Marie Tharp's legacy has been in helping our community to dispel the public's notion of the ocean floor as infamously depicted in this New Yorker cartoon.

While in Washington, DC I would also encourage you to visit the Heezen and Tharp Map and Papers Collection, Library of Congress, Geography and Map Division Reading Room, James Madison Bldg of the Library of Congress Complex, 101 Independence Ave SE, Washington, DC 20540
https://www.loc.gov/item/2006629258/
Includes that famous globe from the 1959 picture!

“Not too many people can say this about their lives: The whole world was spread out before me (or at least, the 70 percent of it covered by oceans). I had a blank canvas to fill with extraordinary possibilities, a fascinating jigsaw puzzle to piece together: mapping the world’s vast hidden seafloor. It was a once-in-a-lifetime—a once-in-the-history-of-the-world—opportunity for anyone, but especially for a woman in the 1940s. The nature of the times, the state of the science, and events large and small, logical and illogical, combined to make it all happen.”

-- Marie Tharp, 1999

WHOI Mary Sears Women Pioneer in Oceanography

Library of Congress

For the best in further reading: Felt, H. (2012), *Soundings: The Story of the Remarkable Woman Who Mapped the Ocean Floor*, 352 pp., Henry Holt and Co., New York.

See also:

- Wright, D. J. (2014), Review of *Soundings: The Story of the Remarkable Woman Who Mapped the Ocean Floor* by Hali Felt, *Geographical Review*, *104*(1), 115-117, doi:10.1111/j.1931-0846.2014.12010.x; http://dusk.geo.orst.edu/soundings_tharp_djw.pdf.
- New York Times review of *Soundings* by Michael Washburn: https://www.nytimes.com/2013/01/27/books/review/soundings-about-marie-tharp-by-hali-felt.html
- Doel, R. E., T. J. Levin, and M. K. Marker (2006), Extending modern cartography to the ocean depths: military patronage, Cold War priorities, and the Heezen-Tharp mapping project, 1952-1959, *Journal of Historical Geography*, *32*, 605-626.
- Landa, E. R. (2010), The ties that bind: Soil surveyor William Edgar Tharp and oceanographic cartographer Marie Tharp, *Physics and Chemistry of the Earth*, *35*(15-18), 868–880, doi:http://dx.doi.org/10.1016/j.pce.2010.06.003.
- North, G. W. (2010), Marie Tharp: The lady who showed us the ocean floors, *Physics and Chemistry of the Earth*, *35*(15-18), 881-886, doi:http://dx.doi.org/10.1016/j.pce.2010.05.007.
- Wolfe, C. (2012), Depth charge, *Nature*, *487*, 167.

National Geographic Animation, How One Brilliant Woman Mapped the Ocean Floor's Secrets, https://www.youtube.com/watch?v=vE2FK0B7gPo