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The ties that bind: Soil surveyor William Edgar Tharp and oceanographic cartographer Marie Tharp

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ABSTRACT

The link between soil science and geology is personified in the American father and daughter: soil surveyor William Edgar Tharp (1870–1959) and oceanographic cartographer Marie Tharp (1920–2006). From 1904 to 1935, W.E. Tharp mapped soils in 14 states for the US Department of Agriculture, and campaigned during the late 1920s–early 1930s to raise awareness of the high rates of soil erosion from croplands. The lifestyle of the federal soil surveyor in the United States during the early 20th century involved frequent household moves, and it played a formative role in Marie Tharp's childhood. Her path to a career in geology was molded by this family experience, by mentors encountered in the classroom, and by social barriers that faced women scientists of that era.

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1. Introduction

On August 23, 2006, Marie Tharp died at age 86. Together with Bruce Heezen (1924–1977) at Columbia University, she had created the map of the ocean floor that is one of the most widely recognized images in modern earth science, and discovered the Rift Valley of the Mid Atlantic Ridge through analysis of depth soundings. As with most people, the path of her career was not without detours—M. Tharp attended Ohio University and changed her major nearly every semester, looking for "something I was good at, something I could get paid for, and something I really liked". She quickly ruled out two of the typical jobs available to woman—secretary and nurse—noting, "I couldn't type and couldn't stand the sight of blood" (Tharp, 1999). She graduated from Ohio University in 1943 with majors in music and English, and four minors. But the world of mapping of geological features and landscapes was by no means foreign to M. Tharp. She had an early role model in her father, soil surveyor William Edgar Tharp.

Recognition of M. Tharp's accomplishments in cartography and oceanography came late in her career (see paper by Gary North, this issue), but are now well documented (see, for example, Tharp and Frankel, 1986; Doel, 1994; Barton, 2002; Lawrence, 2002, Doel et al., 2006). In contrast, the formal record on W. Tharp is limited. But thanks to M. Tharp's penchant for saving materials in a personal archive, and efforts by her estate, the Library of Congress/Geography and Map Division (LOC/GMD),[1] and the Oral History Project of the Society of Women Geographers,[2] we can reconstruct a picture of the life of one the pioneering soil surveyors in the United States.

The focus of this paper is on a father and daughter—a pair linked by the traditional family bonds, but also by earth systems- and spatial-thinking skills that helped them make important contributions

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[1] Much of the material on W. Tharp's activities outside of his official soil survey duties (see Section 3) comes from material added to the LOC/GMD collection since M. Tharp's death, and has yet to be cataloged.

[2] The chronology and background on W. Tharp in Section 2 comes from M. Tharp's detailed discussions with interviewer Helen Shepherd conducted in 1994 for the Oral History Project of the Society of Women Geographers (Shepherd, 1994); specific page references to this transcribed 434-page record are given in the text for key points, and supplemented by footnotes. M. Tharp was 74 years old at the time of the interview, but her recall of details—such as W. Tharp's starting salary with the Bureau of Soils (US Department of Agriculture, 1904–1935), or the name of her 7th grade teacher and classmate in Florence, Alabama (written communications, Louise Huddleston, Archives/Special Collections, Collier Library, University of North Alabama; 24, 27 July 2009)—check with information gathered from independent sources. M. Tharp had, over the years, compiled several short biographies and chronologies of her own life and that of her family (on file at the LOC/GMD), and had been collecting copies of soil surveys on which her father had worked. This latter effort continued up to her death. I established contact with M. Tharp in November 2005. The letter from her personal assistant (e-mail from Lex Reibestein, 25 November 2005) indicated that "Marie was very fond of her father and I'm sure she would quickly tell you that he was probably the biggest influence on her career and personality." M. Tharp provided a chronology on her father's life and career as a soil surveyor, and we were able to have one round of written questions and answers before her health failed.

in soil science and oceanography.[3] In chronicling the career of W. Tharp, the hope here is to also provide glimpses of progress in soil survey, of emerging issues (such as erosion impacts and loss of soil organic matter) in soil science, and of soil science's evolving links to the geologic community in the United States during the first third of the 20th century.

As a far better known figure, the focus on M. Tharp will be more limited. Her position in American life is unique, both in terms of her scientific contributions and of her position in a profession that was populated overwhelmingly by men. While others have covered her full career and scientific accomplishments, the goal here is to examine her life as the child of a soil surveyor, and her influences and mentoring as a young woman entering the earth sciences in the 1940s. W. Tharp and M. Tharp were colorful individuals; in this paper, focused on W. Tharp, and the companion paper (by Gary North) focused on M. Tharp in this volume, we will show aspects of their lives outside the sphere of the earth sciences that will hopefully reveal them as multidimensional people.

2. William Edgar Tharp (1870–1959): career and public life

W. Tharp was born in La Harpe, Illinois, in 1870. By the following year, his family had moved to west-central Iowa. His father, a shoemaker, bought a farm outside of Stuart, Iowa (just west of Des Moines). W. Tharp attended high school in Stuart for 1 year, and then became a teacher at that same school. This was not a good fit; according to M. Tharp: "... he just hated it. He couldn't stand teaching. He had nightmares of that experience for years afterwards." (Shepherd, 1994, p. 10). W. Tharp then began work at a local plant nursery.

Despite a lack of formal education, W. Tharp clearly took the path of self-education, whether through observation, reflection, reading, discourse, and/or the example of others. Around 1902 he took the test to become a meteorologist with the Weather Bureau, then part of the US Department of Agriculture (USDA). He was unable to identify a "polar band"—cirrus clouds arranged in parallel bands—and failed the exam (Shepherd, 1994, p. 14). A few years later, an opportunity came to take the exam for a position with another branch of USDA—this time as a soil surveyor with the Bureau of Soils (BOS). He passed, and in June 1904, W. Tharp was appointed an Assistant in Soil Management at a salary of $1000 per year (US Department of Agriculture, 1904–1935). That same year, he helped with the Allen County, Kansas soil survey, the first in that state (Drake and Tharp, 1904). This began his on-the-job training and a career as a "field man" (Fig. 1a and b); W. Tharp went on to map soils in 14 states—from New York to Florida, and west to Idaho—and co-authored at least 55 soil survey reports during his 30-year career with USDA (Tharp and Artis, 1921; Holman et al., 1937; Reibestein, 2003).

In 1904, W. Tharp was joining a fledgling scientific agency at a time when the field delineation of soil types was still in its early stages of development. Hugh Hammond Bennett joined BOS a year earlier (Helms, 2008), and around 1907, they mapped together in the area around the town of Easton (Caroline, Queen Anne's and Caroline Counties) on the Eastern Shore of Maryland (Bennett et al., 1926a,b; Holman et al., 1937, p. 303). The BOS (originally the Division of Agricultural Soils) had been established as a subunit of the Weather Bureau, just 10 years earlier. The first soil survey was done in 1898 on the Maryland Eastern Shore (McCracken and Helms, 1994). By the end of 1904, about 230,000 km^2 had been mapped by the BOS (~2.5% of the Nation), and 20 field parties in as many states/territories were carrying the work forward; achieving total national coverage was then estimated to take 18 more years and $6 million (New York Times, 1905). The BOS would grow considerably under the lead of founding chief Milton Whitney; the staff increased from 10 persons in 1895 to 218 in 1927 (Weber, 1928).

From our present-day perspective, a career in science with considerable independence in terms of responsibility and judgment seems remarkable for a person with only one year of high school, even for this era. However, as a point of comparison, it is instructive to note that in 1900, of the approximately 25,000 medical students in the United States, fewer than 15% had more than a high school education (Braverman, 2008). This is not to say that a "field man" without a college degree had unlimited opportunities—a rise to the Inspector level was not likely, and a perceived class distinction between this group and the college-trained surveyors within the BOS is clearly evident in M. Tharp's retelling of W. Tharp's career.

The pattern of BOS soil survey work was to map in the northern states in the summer and the southern states in the winter. The surveys were often done in cooperation with soil surveyors employed by the state. W. Tharp worked on 14 county surveys in Indiana during his career (Holman et al., 1937). Although some of his early work in Indiana was done in cooperation with the Indiana Agricultural Experiment Station (e.g., Neill and Tharp, 1906), during the period 1911–1916, the Indiana Department of Geology (which later became the Indiana Geological Survey) was the prime cooperating agency for the USDA soil surveyors such as Tharp (Indiana Department of Geology and Natural Resources, 1912–1917). This policy was begun under the tenure of State Geologist Willis Stanley Blatchley, who was, by training, an entomologist. The policy was apparently not without its foes, as this 1913 defensive stance of his successor, State Geologist Edward Barrett suggests:

> "The major portion of the State Geologist's time during the field season of 1912 was taken up in the investigations of the Soils of the State.
> He believes that a survey of the Soils of the State is a proper function of the Department of Geology. He has never been able to see why an investigation and discussion of the geological formation known as Soil is not as important as the next formation below it, whatever that formation may be."
> (Indiana Department of Geology and Natural Resources, 1913, p. 7)

While some early soil surveys were done in cooperation with state geological surveys in Maryland and Washington (Lapham, 1949), as well as Indiana, the trend was clearly towards partnering with the land grant university and its Agricultural Experiment Station. This was true in the case of the later soil surveys in Indiana counties done by W. Tharp, and remains the basis of the National Cooperative Soil Survey (http://soils.usda.gov/partnerships/ncss/; accessed 22.03.10) to the present day.

Soil surveyors made base maps by using a plane table,[4] alidade and compass when USGS base maps were not available. Construction

[3] Genetic influences appear to be important contributors to individual differences in spatial abilities (Thompson et al., 1991). The influences of genetic factors and early experiences are combined when one considers if such abilities run in families. Whether or not spatial ability tends to be a family trait remains a topic of research interest within the psychological sciences.

[4] Use of aerial photos as a base for mapping soils, rather than the old planimetric method, began with the Jennings County, Indiana soil survey of 1932 (Kunkel et al., 1940). By 1935, the practice was the standard in the United States (McCracken and Helms, 1994). This period encompasses the later part of W. Tharp's career. Airphoto usage does not appear to have occurred in any of his later surveys. There is, for example, no mention of it in the 1933 Steuben County, Indiana soil survey (Smith et al., 1940) where both W. Tharp and airphoto pioneer Tom M. Bushnell of Purdue University's Department of Agronomy were participants. (*Note*: There were considerable gaps between when a soil survey was done and when it was published, particularly during the Depression years.)

of these base maps typically took about half of the time in the field, and diverted resources from the primary task of the soil surveyor—to examine, identify and delineate soils (Lee, 1984, p. 116; Gardner, 1957, p. 51). In remarks on field problems in Indiana delivered at the 1926 annual meeting of the American Soil Survey Association (ASSA), W. Tharp wryly noted: "Our labors resulted in a better base map than the County will ever have unless a mineral boom strikes it and the US Geological Survey gets interested." (Tharp, 1926).

Transportation in the field gradually shifted from horse- or mule-drawn buggies to gasoline-powered vehicles. W. Tharp got his first BOS truck in 1922 while mapping in George County, Mississippi (Reibestein, 2003). Specially adapted speedometers/odometers, designed to measure short distances, were used to measure traverses along roads. Much attention was devoted to details such as tire inflation that might affect such distance measurements (Bushnell, 1921; Schoenmann, 1921; Machlis and Pierre, 1922).[5] Time in the field was arduous and sometimes hazardous, due to encounters with dogs, bulls, wild boars, snakes, bees, moonshiners, hunters, and irate landowners (Gardner, 1957; Lee, 1984). But fieldwork also afforded the opportunity to collect arrowheads and animal skulls—two of W. Tharp's hobbies. It was a hard life—physically challenging and tough on family life—and turnover among the ranks of the field men was high. H.H. Krusekopf, Professor of Soils at the University of Missouri noted in a 1921 address to the ASSA:

> "The nature of the field work is so rigorous that it appeals primarily to young men, and few reach middle age before having abandoned soil surveying for less strenuous or more remunerative labors."
>
> (Krusekopf, 1922, p. 14)

W. Tharp's 30 years in the field and retirement at age 65 is remarkable in terms of endurance alone.

Soil surveyors typically looked at the "3 foot section" by auger. However occasionally monoliths—intact, vertical sections of soil collected in a frame from the wall of a dug-pit, or a stream bank or road cut—were collected for further study of the nature and properties of the soil profile. W. Tharp served on the ASSA's Committee on Soil Sampling, which helped pioneer methods for monolith collection—investigating techniques to preserve and display features such as concretions, surface coatings on structures, and the colors of both the faces and interiors of structures. Monoliths collected in the mid-1920s were taken to a depth of 42 in. This was increased in the late-1920s to 50 in., the new limit set by the longer running boards of the cars used in field work (American Soil Survey Association, 1929). Monoliths remain an important research and teaching tool in soil science (see, for example, http://www.albany.edu/faculty/alapenis/research.htm; accessed 22.03.10).

After many years of mapping, Tharp was keenly aware of "bald spots" on hilltops and the problems of sheet erosion on tilled land. He told a 1927 audience at the University of Mississippi:

> "My boyhood home was on the rolling uplands of the southwestern part of Iowa. The changes that have taken place there within 40 years come to me with something of a shock; there are few gullies, but the deep humus-filled prairie soil which masked the yellow subsoil even on the steeper slopes, has become so thin on hundreds of hillsides, that the clay and stones are much in evidence, where we hardly suspected their existence. The little prairie streams with their deep clear pools, have become transient courses for storm waters, and the old swimming holes of the creeks and small rivers have largely disappeared."
>
> (Tharp, 1933, p. 2)

In the 1930 Calhoun County, Iowa soil survey W. Tharp and co-workers T.H. Benton and W.J. Leighty of the Iowa Agricultural Experiment Station would elegantly detail (with soil loss measurement data; probably by means of stakes) the soil- and water-quality impacts associated with cultivation, noting both bulk erosion and oxidative losses of soil organic matter from friable surface materials under corn (Tharp et al., 1930).[6]

W. Tharp was active in the American Soil Survey Workers Association [name shortened to American Soil Survey Association (ASSA) in 1923], and along with 25 other soil scientists, including Emil Truog and Curtis Marbut, attended its first meeting at the Geology Building of the University of Chicago in 1920 (American

[5] Odometer usage apparently predated the use of cars and trucks in the field. Lapham (1949, p. 13; ca. 1900) and Lee (1984, pp. 118–119; ca. 1918) describe the use of an odometer-equipped buggy in soil surveys.

[6] W. Tharp's reasoning on the role of soils in provision of ecosystem services, and on the storage and loss of soil organic matter, reflects an early variant on earth system thinking before that was the norm:"

The most evident soil changes that have occurred during the cultural period are those caused by erosion. On the steep phase of Clarion loam much of the originally thin surface loam has been removed, in many places exposing the light-colored subsoil. In most places the loss is not of serious consequence because the friable subsurface material allows satisfactory tillage, and clovers and bluegrass thrive on account of the abundance of lime. Of greater consequence, although very generally overlooked, are the slow erosional changes in progress on the moderately rolling areas of Clarion loam. On the sides of prominent knolls and on all the stronger inclines elsewhere there has been much removal of topsoil since the land was brought into tillage. This loss occurs chiefly as little mid-row washes when the ground is in use for corn. One instance was studied in some detail, and the following observations were made.

Early in July 1929, the total rainfall during several successive days was 1.4 in. None of this precipitation was torrential, much of it came rather slowly, and the cornfields were in excellent condition to absorb it. Careful observations on the Clarion loam a few miles northeast of Rockwell City showed that the equivalent of one-tenth inch of soil had been washed off slopes having an inclination ranging from 2° to 5°. Much of this material was deposited along the foot of the slopes or on the adjoining Webster soils, but a large part was carried into the local streams.

Similar results of heavy rainfall were observed in many places during the summer. Most of the erosion occurred in cornfields, commonly as small transient gullies a few inches deep and wide. They were obliterated by the next cultivation of the corn or largely disappeared during dry weather. Some soil washing takes place after fall plowing and occasionally in the early spring in oat fields, but in the aggregate these losses seem slight compared with the more frequent losses in the cornfields ...

Broadly considered, the return of organic matter to the soil under present conditions is meager in amount and irregular in distribution. The oat stubble, if no clover has been sown, is in most places a thin cover, incapable of adding very much humus. Although an occasional heavy crop of clover or of weeds is plowed under, the usual practices in haymaking and grazing do not leave much of the plant growth above ground to be thus utilized. Since 90% of the cornstalks remain in the fields, the contribution of organic matter from this source is doubtless greater than that direct from the oat stubble ...

To what extent the precultural store of organic matter has been reduced by erosion, oxidation, and removal in crops can not be stated with any pretensions to accuracy. That it has suffered much diminution seems beyond doubt, especially where erosive losses are apparent. Tillage operations and the deeper aeration induced by artificial drainage stimulate oxidation, but the total return of vegetal residues, as previously stated, seems very meager. Any marked reduction of organic matter in [such] a heavy soil as Webster silty clay loam seriously impairs the physical properties. Fortunately the Webster soils of this region still contain so much of this valuable constituent that their injury from this cause seems quite remote, but the Clarion soils present, in numerous places, evidences of diminished organic matter reserves. This is also true of the coarser-textured phases of the Sioux and Dickinson soils.

The suspended material in the streams is so dark colored and seems so easily transported as to indicate the inclusion of much material of organic origin. In the extensive improvements of the drainage ways little consideration has been given to the possible retention of any of the sediments on the lowlands. Some deposition occurs on the Wabash silty clay loam areas, and in low places on Cass fine sandy loam, but elsewhere nearly all the material that reaches the larger ditches and the small creeks is discharged into the main streams. Their summer flow, even at low stages, is murky and at flood height becomes very dark colored."

(Tharp et al., 1930, pp. 22–24)

Soil Survey Workers Association, 1920).[7,8] He published a series of short papers in the ASSA Bulletin (the predecessor of the Soil Science Society of America Journal) dealing with description of soils in the field, and mapping techniques (Miller et al., 1931; Tharp, 1922–1924, 1926, 1935). He served for several years (1930–1931; along with H.H. Bennett) on the ASSA Committee on Cultural Changes in Soils. Around this time he was mapping in Monroe County, Iowa; in this 1931-committee report, he again spoke out on the perils of unchecked soil erosion, describing its impact on the friable Shelby and Lindley loams of this rolling terrain:

> "Occasional abandoned fields with many deep V-shaped gullies are seen, but all these conspicuous examples of erosion are of minor importance compared with the thousands of acres that have suffered sheet erosion to such an extent that tillage qualities, moisture properties, and humus content have been greatly changed."
>
> (W.E. Tharp, in Miller et al., 1931, p. 83)

He also served on the regional committee for the Alabama and Mississippi segment of the 1927 transcontinental field trip that followed the First International Congress of Soil Science held in Washington, DC.

W. Tharp saw a need for improved integration of results from the laboratory analysis of soil samples collected during the survey with the field observations:

> "The submission of isolated samples of soil for laboratory examination, or the statement of [*a*] certain problem to some one not acquainted with local conditions does not, as a rule, lead to very satisfactory results. Instead, let the soil specialist [*the bacteriologist, physicist, mineralogist and chemist*] come afield with us, let him stay long enough and travel miles engugh [*sic*] to acquire something of our view point of soils and soil-making processes and also gain some first-hand field impressions of the local problems. Then what contribution he may add should be a valuable contribution to the description to the [*soil*] type in question and give an authoritative value to the reports, which is now often lacking .... Perhaps all these references to the soil specialists coming into the field is a pipe dream or came to us from a broad-casting station on a pure fiction wave length, but never-the-less, we think there is some merit in them."
>
> (Tharp, 1926, p. 50)

Tharp's early experience in soil survey impressed upon him the need for an extension component in order to get the information gathered into the hands of farmers. He was proactive within the BOS in publishing on the agricultural potential and pitfalls for people contemplating the purchase of previously logged pinelands in the South (Tharp, 1911). He saw the parallels between the loess soils of the Mississippi River bluffs of western Mississippi and the loess soils of the Northern states, and campaigned vigorously within the BOS for a publication to encourage farmers from the formerly forested areas of Indiana, Ohio, and Kentucky to consider livestock production on these Mississippi soils (personal communication, Douglas Helms, US Department of Agriculture, Natural Resources Conservation Service). He saw the soil survey maps and reports as having prime public usefulness in matters of land value, and urged that delineations related to agricultural potential of the land be considered when mapping soils (Tharp, 1922).

In 1932–1933, W. Tharp mapped soils in Logan County, Ohio (Fig. 2), and in 1935 retired from USDA. The family moved from Washington, DC to Bellefontaine, Ohio where they had lived during the Logan Co. survey. They soon purchased a farm just outside the city limits. Marie would now spend three uninterrupted years at Bellefontaine High School, solidifying her self image as a mid-westerner (Doel, 1994, p. 15).

Marie's mother (Bertha Tharp) died in Bellefontaine in 1936 (Fig. 3). W. Tharp died in Bellefontaine on January 30, 1959, but lived to see the publication of the Heezen and Tharp physiographic map of the North Atlantic seafloor in 1957. The farm site is now occupied by the present Bellefontaine High School and a city recreation area (Blue Jacket Park); the Tharp farmhouse was renovated and now serves as the offices of the Bellefontaine City Schools Board of Education (written communication, Fred Boring, Principal, 6 August 2008).

3. William Edgar Tharp: the private life

From the W. Tharp papers archived by M. Tharp and now being processed at the LOC/GMD, we can see aspects of his farm practices and ideas for innovations (such as a 1949 letter to The International Harvester Company suggesting the development of implements to enable the cultivation of farmland bordering fences), his spiritual life, and his hobbies. He was a man who loved to write; both during his soil survey career (and the frequent relocation of the Tharp household around the eastern and central states), and in retirement, he would send letters to the editor, short articles, and poems to the local newspaper. His clipping file was voluminous, and the range of topics wide, including: restoring soil fertility, wildlife movies, and historical preservation of World War II-era building chimneys on the Washington, DC Mall. He also wrote poems; the rhyming patterns were simple, but again it is the selection and range of topics that grabs your attention—from one about the end of wartime gas rationing stamps [titled "Good-Bye Gas Stamps" and written in 1945 on a New York Times (a favorite newspaper of the family since their time in Cooperstown, New York, just prior to W. Tharp's retirement; Shepherd, 1994, p. 90) envelope filled with coupons], to one written in 1947 about his prize Jersey cow ("Gold Bond Betty"), to one about unsuccessful 1928 Democratic Party candidate Al Smith. In her Society of Women Geographers oral history interview, Marie Tharp recalled how her father supported his election (Shepherd, 1994, p. 46); in the files, we find a copy of " Goodbye, dear Al" written on the back of a BOS form for recording daily mapping activity (Fig. 4a and b). He did not limit sending his poems to small town newspapers, and in the files, we see polite rejection letters (1952) from *Science* and *National Geographic* magazines (for a poem "The Ice Age").

In retirement, he continued spreading scientific knowledge with talks on local geology and soils to Rotary Clubs and the like and he was active in acquiring the skulls of small and large mammals. Whether this was a hobby or a business is not clear, but he would follow all possible leads in a quest to have his collection include whatever species were available in North America. Hence,

[7] One sees W.E. Tharp's name written "W.E. Thorp" on this attendee list and on some later ASSA committee lists (e.g., 1930; where W. Tharp served with H.H. Bennett on the Cultural Changes in Soils Committee; American Soil Survey Association, 1930), typographical errors undoubtedly related to people confusing W. Tharp with James Thorp, who began as a soil surveyor with BOS in 1921 and was on loan to the National Geological Survey of China from 1933 to 1936, training the Chinese in soil survey methods (Holliday, 2006). Thorp and Tharp served together on the Soil Geography Committee of ASSA in 1933–1934 (American Soil Survey Association, 1934). The two apparently remained at least casual friends into W. Tharp's retirement years; in the W. Tharp correspondence files (that were saved by M. Tharp) is a typed 1954 Christmas letter from James Thorp (then a professor at Earlham College) and his wife to W. Tharp. In the letter, Mrs. Thorp tells about her husband's Fulbright fellowship in Australia and notes: "He stopped for 10 days in Rome where he enjoyed the hospitality of Dr. and Mrs. J. Losing Buck." This was agricultural economist John Lossing Buck who James Thorp got to know during their time together in China. The Mrs. Buck referred to in the letter was his second wife. His first wife was writer Pearl Buck; they divorced in 1935.

[8] In 1936, the year following W. Tharp's retirement, the ASSA merged with the Soils section of the American Society of Agronomy to form the Soil Science Society of America (Larson, 1994).

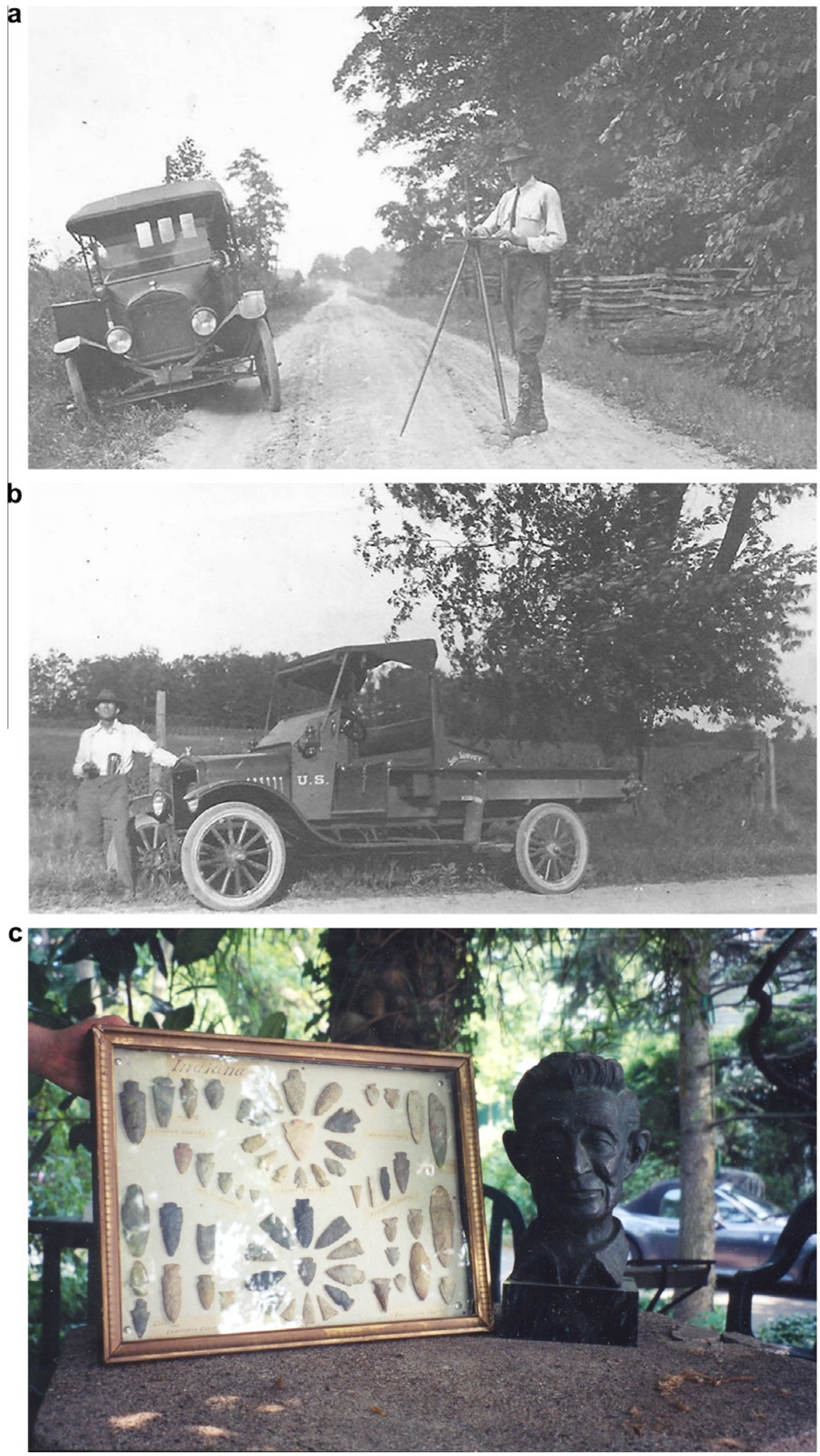


Fig. 1. (a and b) Two photographs of soil surveyor W.E. Tharp in the field (dates and locations unknown). (c) No close up views of W.E. Tharp are available, but Marie Tharp noted that he looked like American humorist Will Rodgers. Marie studied art in the evening in New York City and sculpted this bust of him. The arrowheads in the case were among the many he collected while mapping. Photographs courtesy of the Marie Tharp estate.

we see letters to chinchilla farms, meat packers, game and fisheries agencies, and taxidermists in search of skulls. In 1952, he wrote to famed Canadian novelist Farley Mowat in search of reindeer and musk ox skulls. W. Tharp was also interested in arrowheads and ancient civilizations; we see letters (1946–1947) from anthropologist Loren Eiseley in response to queries from W. Tharp about

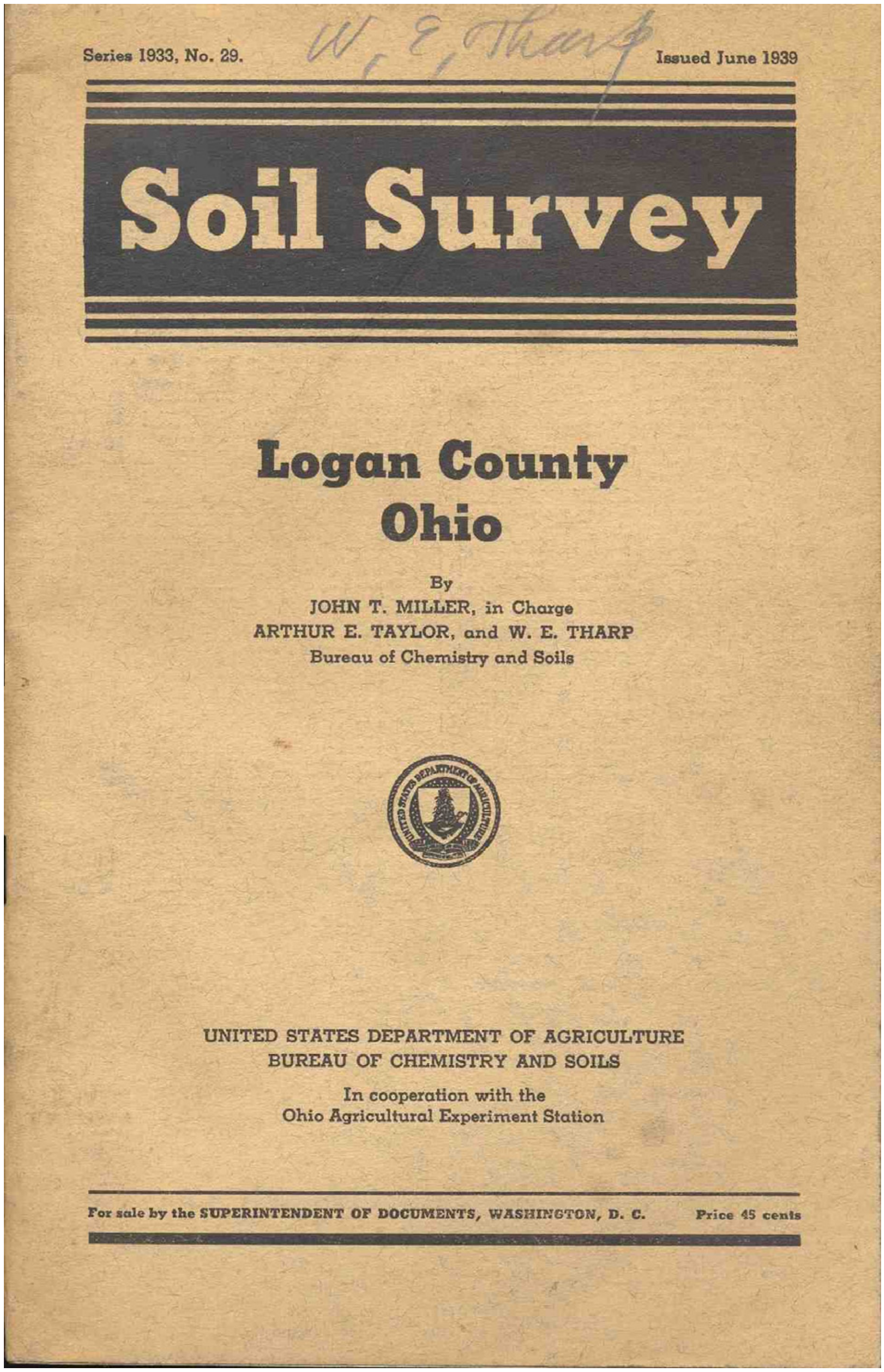


Fig. 2. W.E. Tharp's personal copy (see his handwritten name; upper center) of the published Logan County, Ohio soil survey, on which he worked. Logan County later became his home, from the time of his retirement from the Bureau of Soils until his death (1935–1959). Material courtesy of the Marie Tharp estate.

Eiseley's research on the fossil human skulls from South Africa, and (1951) soliciting his views on eugenics.

4. Marie Tharp (1920–2006): the path to a career in oceanography

Marie Tharp was born in Ypsilanti, Michigan in the summer of 1920. Her mother was a college graduate and taught German and Latin in high school prior to her marriage to W. Tharp (Tharp, undated(a)). The BOS surveyors mapped in the northern states in the summer-fall months, and the southern states in the winter–spring months. They also spent the winter–spring of every fourth year in Washington, DC to help with report publication. For their families, this meant an always-moving-on lifestyle; M. Tharp described her family as close-knit "perennial gypsies" (Shepherd, 1994, p. 112), and estimated that she had attended 18 schools by the time she graduated from high school (Tharp, undated(a)). These included

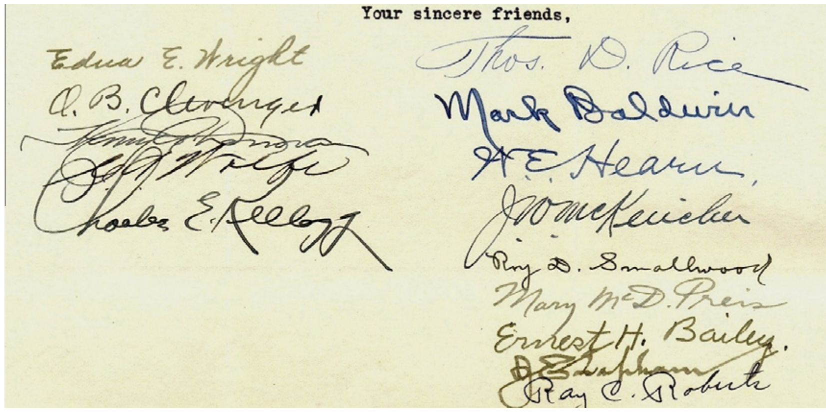
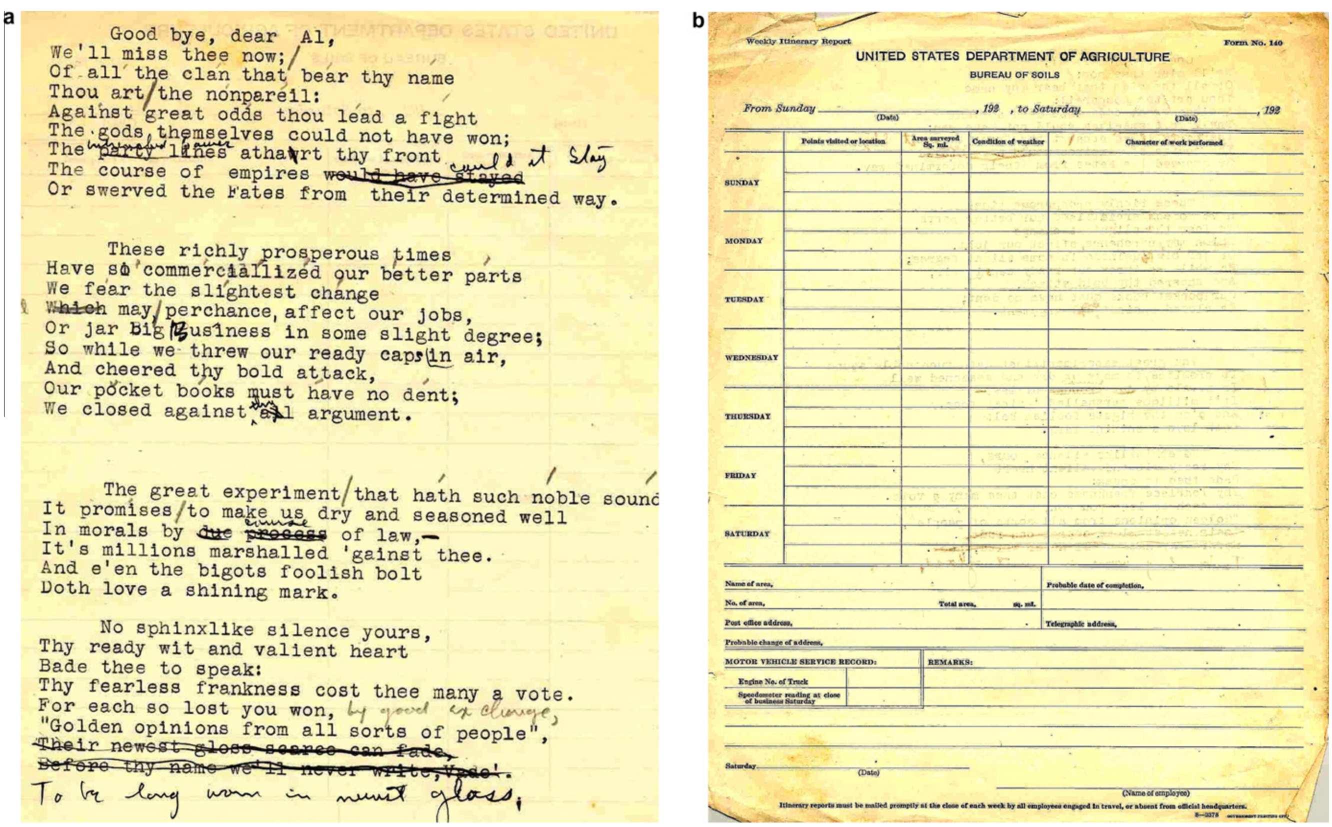


Fig. 3. Signatures on 21 September 1936 condolence letter sent from the Bureau of Soils in Washington, DC following the death of Bertha Tharp. One sees the signatures of prominent figures in the early soil survey community in the United States here, including Charles E. Kellogg, Thomas D. Rice, Mark Baldwin, and Williamson E. Hearn. Material courtesy of the Marie Tharp estate.



a

Good bye, dear Al,
We'll miss thee now;
Of all the clan that bear thy name
Thou art the nonpareil:
Against great odds thou lead a fight
The gods themselves could not have won;
The ~~party~~ lines athawrt thy front could it stay
The course of empires ~~would have stayed~~
Or swerved the Fates from their determined way.

These richly prosperous times
Have so commercialized our better parts
We fear the slightest change
~~Which~~ may perchance, affect our jobs,
Or jar big Business in some slight degree;
So while we threw our ready caps in air,
And cheered thy bold attack,
Our pocket books must have no dent;
We closed against all argument.

The great experiment that hath such noble sound
It promises to make us dry and seasoned well
In morals by ~~due process~~ of law,—
It's millions marshalled 'gainst thee.
And e'en the bigots foolish bolt
Doth love a shining mark.

No sphinxlike silence yours,
Thy ready wit and valient heart
Bade thee to speak:
Thy fearless frankness cost thee many a vote.
For each so lost you won, by good ex change,
"Golden opinions from all sorts of people",
~~Their newest gloss scarce can fade,~~
~~Before thy name we'll never write, fade'.~~
To be long worn in newest gloss,

b

Weekly Itinerary Report — Form No. 140
UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF SOILS
From Sunday ______ (Date), 192 , to Saturday ______ (Date), 192

	Points visited or location	Area surveyed Sq. mi.	Condition of weather	Character of work performed
SUNDAY				
MONDAY				
TUESDAY				
WEDNESDAY				
THURSDAY				
FRIDAY				
SATURDAY				

Name of area, Probable date of completion,
No. of area, Total area, sq. mi.
Post office address, Telegraphic address,
Probable change of address,
MOTOR VEHICLE SERVICE RECORD: REMARKS:
Engine No. of Truck
Speedometer reading at close of business Saturday
Saturday (Date)
(Name of employee)
Itinerary reports must be mailed promptly at the close of each week by all employees engaged in travel, or absent from official headquarters.

Fig. 4. (a) Poem ("Good bye, dear Al") written by W.E. Tharp in 1928 following the defeat of Democratic Party Presidential candidate Alfred E. Smith by Herbert Hoover. Material courtesy of the Marie Tharp estate. (b) Reverse side shows the Bureau of Soils mapping progress form on which the poem was written. Per Marie Tharp, it was written while her father was mapping soils in South Carolina (Shepherd, 1994, p. 46). Material courtesy of the Marie Tharp estate.

1st grade in Peru, Indiana [the winter headquarters for several circuses] (1926), 5th grade in Selma, Alabama (1929–1930), and 9th grade in Cooperstown (New York) High School (1933–1934). The Clark Gymnasium in Cooperstown, where M. Tharp took swimming lessons, later became part of the adjacent Baseball Hall of Fame (Tharp, undated(a); written communication from James L. Gates, Library Director, National Baseball Hall of Fame and Museum, Cooperstown, New York, 23 September 2009). Marie would tag-along with "Papa" in the field on Saturdays (Fig. 5) (Shepherd, 1994, pp. 44, 117). These informal field trips with her father, and other weekend field trips with a science club during 7th grade in Florence, Alabama, sparked her early interest in science. It is interesting to note that for this school year (1931–1932), she attended a school (Kilby Training School) run by the state teacher training college. Florence State Teachers College (now the University of Northern Alabama) was one of the nation's first coeducational (1874)

Fig. 5. Marie Tharp as a young woman using a plane table, alidade and compass, as she accompanied her father in his soil mapping activities (date and location unknown). Photograph courtesy of the Lamont-Doherty Earth Observatory.

Fig. 6. Clarence Lorenzo Dow (1895–1955), professor of geology and geography at Ohio University, and an early mentor to Marie Tharp. Seen here (in pith helmet) with a group of students (date and location unknown). Dow Lake near the Athens, Ohio campus is named for him (Chapman, 2009). Photograph courtesy of John E. Dolan, School of Electrical Engineering and Computer Science, Ohio University, and the Estate of Elizabeth Dow Dolan.

colleges, and she had the rare opportunity to spend a full school year here.

The nomadic lifestyle had some unique benefits. For example, M. Tharp, in later life (Tharp, 1999), commented on the variety of landscapes she had seen by the time she finished high school. Born in Michigan, she got to see the ocean near Pascagoula, Mississippi when she was a preschooler (Shepherd, 1994, p. 33) [probably while W. Tharp worked on the Soil Survey of George County, Mississippi (Tharp and Lowe, 1925)]. In addition, the BOS field men had an every fourth year rotation to Washington, DC, and this enabled M. Tharp to see the inaugurations of Herbert Hoover (1929) and Franklin Roosevelt (1933) (Shepherd, 1994, p. 161).

After high school (see end of Section 2), M. Tharp attended the Ohio University (OU) and graduated in 1943 with a B.A. and majors in English and music. Late in her time at OU, she took classes in physical and historical geology, and came under the mentorship of Professor Clarence Lorenzo Dow (1895–1955; Ohio Academy of Sciences, 1956) (Fig. 6). He encouraged her to apply for a wartime

program at the University of Michigan to train petroleum geologists. There were ten women and one man in the program headed by Professor Kenneth Landes. M. Tharp was the only graduate student in the group, and she earned her M.A. degree in Geology with a 1944 thesis on subsurface studies of the Detroit River series (Shepherd, 1994, pp. 257–258; Tharp, 1944).[9,10,11]

After graduation, she worked as a junior geologist for Stanolind Oil and Gas Company in Tulsa, Oklahoma, and took night classes in mathematics at the University of Tulsa, obtaining an additional bachelors degree in 1948. That same year, she moved to New York City and got a job as a mathematician with Maurice Ewing at Columbia University's Geophysical laboratory. In 1949, with the founding of the Lamont Geological Observatory (now the Lamont-Doherty Earth Observatory), she moved to the newly opened research facility and worked there until her retirement in 1983 (Fig. 7a) (Tharp, undated(b); Doel, 1994; Fox, 2006).

5. Lessons from history: opportunities lost and opportunities found

In 2006, a committee of the Board of Earth Science and Resources of the National Academy of Sciences/National Research Council (NRC) published a study on learning to think spatially:

> "Spatial thinking is based on a constructive amalgam of three elements: concepts of space, tools of representation, and processes of reasoning. It depends on understanding the meaning of space and using the properties of space as a vehicle for structuring problems, for finding answers, and for expressing solutions. By visualizing relationships within spatial structures, we can perceive, remember, and analyze the static and, via transformations, the dynamic properties of objects and the relationships between objects. We can use representations in a variety of modes and media (graphic [text, image, and video], tactile, auditory, and kinesthetic) to describe, explain, and communicate about the structure, operation, and function of those objects and their relationships."
>
> (National Research Council, 2006, p. 3)

Clearly soil mapping requires this kind of thinking. Using the examination of widely separated auger hole samples and a feel for landscape features, the soil surveyor must extrapolate to find areas of commonality and areas of difference to be delineated by mapped boundaries between soil units (see Fig. 8).

One cannot help but to speculate that Marie Tharp's childhood exposure to her father's mapping activities helped to develop her own sense of spatial thinking. And a keen sense it was—one that the NRC committee chose to single out for special attention:

> "The expert's visualization of the parts of a structure that cannot be seen is guided by more than simple mechanical interpolation between observable sections or profiles. The physical oceanographer's visualization is, for example, shaped by physics that decrees that lower-density water masses overlie higher-density water masses... The field geologist's visualization is shaped by the understanding that marine sedimentation processes tend to produce layers roughly horizontal and roughly uniform in thickness before deformation. Marie Tharp's case .... is interesting because neither she nor anyone else knew any details about the tectonic and volcanic processes that form the seafloor geomorphology; yet her maps in areas of sparse data (the Southern Oceans, for example) are far better than would have been possible by interpolating from data alone. In these examples, the physical oceanographer and the field geologist are guided by knowledge of the processes that shaped the unseen parts of the puzzle, but in Tharp's case she seems to have developed a spatial intuition or feel for the nature of the seafloor before the formative processes were understood."
>
> (National Research Council, 2006, pp. 76–77)

M. Tharp apparently never considered following in her father's footsteps with a career in soil survey.[12] Opportunities for women during his tenure with the BOS were very limited. For a glimpse of the status of women in soil science around the time W. Tharp joined

[9] Marie Tharp's master's thesis looked at the stratigraphy and structure of the Detroit River Group, a sequence of dolomite, anhydrite, halite, limestone and sandstone of Devonian age. The oil and gas potential of these rocks of the Michigan Basin were the drivers for this investigation. The text is brief—just seven pages, but the project involved synthesis of a large data set. Her work included construction of stratigraphic cross sections and structural contour maps based upon the examination of drill cuttings from about 50 wells scattered across the southern peninsula of Michigan, as well as additional samples and drillers logs. Her focus was on the thickness of halite units in the sequence (Tharp, 1944, p. 1), information of importance in discerning the depositional history of the basin. In later life, Tharp described the thesis work as "very routine" (Shepherd, 1994, p. 287). Nevertheless, it formed a significant part of the summary report on the Detroit River Group in the Michigan Basin that Kenneth Landes produced for the US Geological Survey (Landes, 1951; see Footnote 10 for details), and Tharp's thesis is cited therein.

[10] The thesis copy on deposit at the Shapiro Science Library of the University of Michigan (http://mirlyn.lib.umich.edu/Record/003918381; accessed 18.03.10), the only library in the WorldCat catalog that owns this title, is missing the four figures that originally accompanied the text. A reconstructed "tentative list of illustrations," compiled by an unknown person (personal communication, 18 March 2010, Lori Tschirhart, Associate Librarian, Shapiro Science Library), accompanies this copy. Tharp's Figs. 1 and 2 (cross section of wells showing lithology of the Detroit River Series) likely formed the basis of Fig. 3 in Landes (1951); a few wells may have been added to the data set [56 wells are included in the Landes; Tharp thesis (p. 1) indicates "approximately 50 wells"]. Tharp's Fig. 3 (salt isopach map of the Detroit River Series) formed the basis of Landes (1951) Fig. 5 [the text here (p. 7, indicates modified from Tharp (1944)]. Tharp's Fig. 4 (structure contour map on top of the Detroit Series) seems to be Landes (1951) Fig. 11, although the caption here (structure contour map of Southern Peninsula of Michigan contoured on base of Lucas formation) is a bit ambiguous; the Lucas formation is the uppermost unit in the Detroit River Series.

The thesis is dated 13 November 1944 and the Master of Arts in Geology was granted in February 1945.

[11] Along with M. Tharp, the wartime University of Michigan (UM) petroleum geology (PG) program under Kenneth Landes trained a number of other pioneering woman geologists, including:

Helen L. Foster (born 1919) who received a PhD in geology (1946) at UM under structural geologist Armand J. Eardley, and then had a long research career at the US Geological Survey (USGS) in the Military Geology Branch (including mapping in the Pacific islands formerly occupied by Japanese forces) and Alaskan Geology Branch (American Men and Women of Science, 1999, p. 1383);

Helen Martin (1889–1973), a research geologist with the Michigan Geological Survey, and in retirement a prominent conservation educator (http://hall.michiganwomenshalloffame.org/; accessed 22.03.10); and

Lois J. Campbell (1923–2004) who went onto a PhD in Pleistocene geology at Ohio State University in 1954, and then a career on the geology faculty at the University of Kentucky (http://www.uky.edu/AS/Geology/dept/ees_newsletter2007.pdf; accessed 22.03.10) (Shepherd, 1994, p. 270; Foster, 1995).

While not part of the UM-PG cohort, Annabel B(rown) Olson (1922–1992) and M. Tharp became friends at the UM field station (Camp Davis, near Jackson Hole, Wyoming) while Brown, a student at the University of Chicago, did geologic mapping with Armand J. Eardley, the director of Camp Davis. She went onto a career at the USGS that included work in photogeologic mapping of the Moon and Mars (Robertson, 1992; Wilhelms, 1993). The women in this unique group referred to themselves as the "Petroleum Geology Girls" or "Petroleum Girls" (Tharp, 1995; http://www.uky.edu/AS/Geology/dept/ees_newsletter2007.pdf).

[12] Commenting in later life on the influence of her father's work on her career path, Marie Tharp (1999) would say "... I had seen a lot of different landscapes. I guess I had map-making in my blood, though I hadn't planned to follow in my father's footsteps." I had pursued this same question in my correspondence with M. Tharp (see Footnote 2). My 27 December 2005 question "*Did M. Tharp ever consider a career in soil science, and did W. Tharp influence her choice to pursue other avenues in the earth sciences?*" did not get answered at that point; but Reibestein (20 January 2006) wrote "*No, M. Tharp never considered a career in soil science, nor did W. Tharp influence her choice to pursue other earth sciences. (She will go into this in more detail later).*" Unfortunately, her death on 23 August 2006, precluded further details.

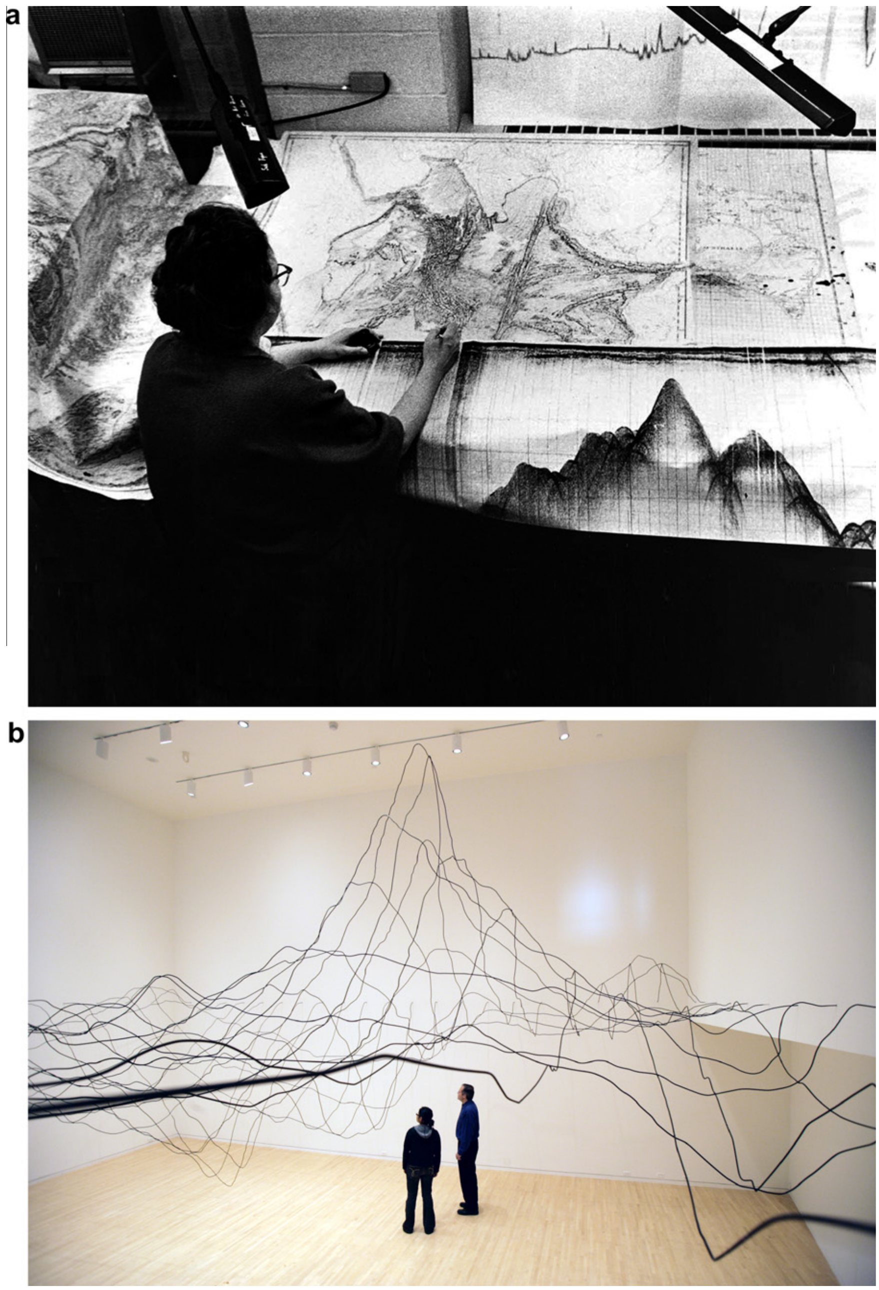


Fig. 7. (a) Marie Tharp working on a topographic map of the ocean floor at Columbia University in the 1960s. Photograph courtesy of the Lamont-Doherty Earth Observatory. (b) Maya Lin's *Water Line*, a floating wire-frame topographic drawing representing the South Atlantic sea floor around Bouvet Island. Maya Lin, Water Line, 2006, aluminum tubing and paint, 19′ × 30′ × 34′9″ (579.1 cm × 914.4 cm × 1059.2 cm), Photo by: Colleen Chartier, © Maya Lin Studio, Inc., courtesy PaceWildenstein, New York.

the BOS, we can look at the case of Julia Pearce. She was hired, upon graduation in 1901 with a degree in agriculture from the University of California at Berkeley, on the orders of Secretary of Agriculture James Wilson, and posted to a position with a survey team in the Central Valley of California. Macy Lapham, the BOS party chief, did not allow her to work in the field, and instead, assigned her to copying maps (Lapham, 1949). After a short time at that task, she was transferred to laboratory duties in Washington, DC, where she worked with Lyman Briggs and helped to develop the centrifugal method for particle size analysis of soils (Briggs et al., 1904; Landa and Nimmo, 2003). In a similar manner, Marie Tharp was excluded from research at sea until the mid-1960s (Barton, 2002).

Progress for women in science in the United States was slow during the years when W. Tharp worked for BOS. However, World War II provided a significant, if sometimes temporary, boost to opportunities for women in science in the United States (Rossiter, 1995); this was particularly true in cartography (Monk, 2004). Things would change more slowly in soil science (Levin, 2002). For example, a 1943 announcement (*Civilian War Service Opportunities for College and University Students*) for federal positions as a junior soil conservationist noted "Women have not held many positions of this type"; higher-level agricultural specialist positions, it told potential applicants "These positions will be filled primarily by men." (Rossiter, 1995; pp. 14, 393). Amongst 96 science subfields studied by the National Science Foundation, the percentage of women employed full time in soil science for the period 1956–1958 ranked 94 at 0.11%. This represented just one woman in the sampling; only radiological & health engineering and nuclear

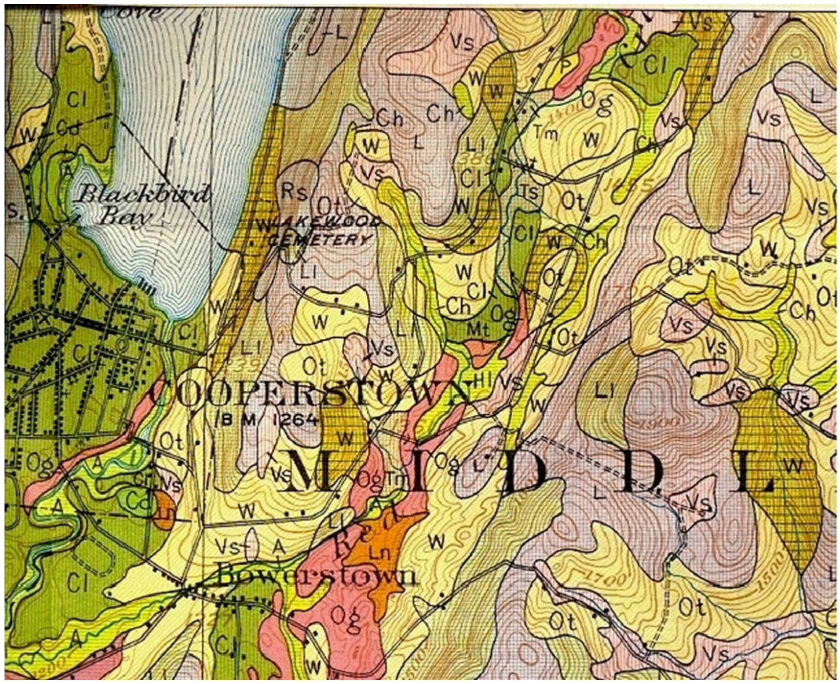


Fig. 8. The complex spatial relationships inherent in soil mapping are exemplified in this portion of the 1: 62,500 scale map that was part of the first USDA soil survey of Ostego County, New York (Tharp et al., 1940); it shows the mapped soil units, as well as the city of Cooperstown and the southern tip of Ostego Lake. W.E. Tharp served as the chief of the Ostego Co. soil survey party, one of his final field assignments prior to his 1935 retirement (Shepherd, 1994, pp. 166–180). The last glacial advance in the county occurred just south of Cooperstown, making this an area of transition in soil parent materials. Rock fragments in the glacial till made augering difficult (personal communication, 9 March 2010, Ed Stein, USDA soil survey project leader for the 1985–1990 Ostego County soil survey).

engineering ranked lower, with no woman in the survey sample for those specialties (Rossiter, 1995; Table 5.3).

The status of women in soil science in the United States has improved greatly, and in 2004 about 40% of graduate students enrolled in soil science programs in the United States and Canada were women (Hartemink et al., 2008). There are surely lessons of opportunities lost and opportunities found, and of the valuable role of science role models and mentorship—by her father, by her science teachers at the Kilby School, and by people like Clarence Lorenzo Dow and Kenneth Landes—that can be discerned from tracing the early career of Marie Tharp.

6. Conclusion

In October 2008, the Soil Science Society of America held its first joint meeting with the Geological Society of America. The careers of William Edgar Tharp and his daughter Marie Tharp exemplify that nexus of the two fields on a truly personal level. A home where education was a priority, and a father whose profession provided a role model in science in general, and mapmaking in particular, were likely strong influences in Marie's life.[13] Indeed, mentorship and a broadly inclusive environment are now recognized as key components of programs to promote diversity in the workforce. In globe- and map-form, in countless classrooms and textbooks, the Heezen–Tharp physiographic charts of the oceans have become iconic images in the earth sciences. These images have spread beyond the realm of the earth sciences—see, for example, Maya Lin's *Water Line* (Fig. 7b), a floating wire-frame topographic drawing representing the South Atlantic sea floor around Bouvet Island (Andrews and Beardsley, 2006; http://www.contemporarystl.org/maya_lin.php; accessed 22.03.10). Today Marie Tharp is also remembered in a way that reflects both her life story and her scientific accomplishments—the Marie Tharp Visiting Fellowship program was begun in 2004 at Columbia University's Earth Institute, to support emerging and established women scientists, as part of a National Science Foundation funded effort to cultivate an environment that attracts, fosters and promotes women leaders in science and engineering (http://earth.columbia.edu/advance/mt_fellowship.html; accessed 22.03.10).

[13] The literature on paternal influences on early women in science and similar examples of father–daughter pairings appear to be limited. Among these examples in America are 18th century botanist Cadwallader Colden and his daughter, botanist Jane Colden (Gronim, 2007), and 19th century plant pathologist Nathan Augustus Blanchard and his daughter, geneticist Frieda Cobb Blanchard (McGrath, 2000).

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