A Travelogue of Rediscovery Sites

Part 4



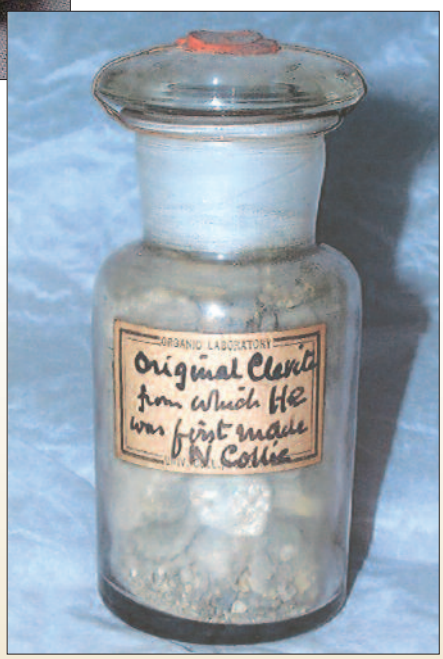
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This is a continuation of a review of "Rediscovery" episodes, initiated in the Spring 2017 issue of The HEXAGON. *This series includes the visits to mine sites taken by Jim and Jenny Marshall over the ten-year period of 1999–2008 in their successful search for the actual original source for the elements. The present issue is devoted to Northern Europe: Norway, Finland, and Scotland.*

Helium.[1a] Helium was first identified spectroscopically in 1868, by two independent astronomers, at opposite ends of the earth. On August 18, 1868, Pierre Jules César Janssen (1824–1907), a French astronomer, traveled to India to view the total solar eclipse of August 18, 1868. He visited the home of a French merchant in Guntur (~ N16° 17.5 E80° 27.3) whose upper level was protected from the wind by "bamboo screens and mats." In the spectrum of the corona he observed new lines of an element never seen before—principally, a strong yellow line that appeared identical to sodium's yellow line except that it was a *singlet*, whereas sodium's was a *doublet*. Simultaneously, Sir Norman Lockyer (1836–1920), who founded in 1869 the famous and classical British science journal *Nature*, observed the same lines from his home observatory in Hamstead (north of London, N 51° 32.59 W00° 10.73).



LEFT: Figure 1. Sample of Norwegian Cleveite, a rare-earth form of uraninite (pitchblende), with the general formula RE-UO_2, where "RE" = rare earths comprising up to 10 percent of the metal content. Helium has accumulated over millions of years from the radioactive decay of uranium and has been trapped in the mineral matrix. Personal collection, J. Marshall.



RIGHT: Figure 2. The actual sample of cleveite analyzed by Ramsay which produced the first identified terrestrial helium. The helium was collected and verified by the superior spectroscopic instrumentation of William Crookes (1832–1919) in his home laboratory at Kensington Park Gardens in London (N51° 30.69 W00° 12.16), who had identified thallium by its spectroscopic green signature.[1m] This sample of cleveite is housed in the present Ingold (Chemical) Laboratories of University College, London (20 Gordon Street—N51° 31.52 W0° 07.95—100 meters northeast of the old chemistry building). Photo, courtesy of J. Norman Collie and Alwyn Davies, Chemistry Department, University College (London).

The *terrestrial* discovery of helium was not made until three decades later by Sir William Ramsay (1852–1916), the discoverer of the inert gases, in 1895.[1b] (His chemical laboratory building was at the University College, London, now the present Slade Hall, Art Building (N51° 31.50 W00° 08.03).) He degassed a sample of cleveite (a variety of rare earth-uranium ore) and observed the same yellow lines as Lockyer and Janssen (Figure 1). The actual original sample of Ramsay's cleveite has recently been discovered in the storage area of University College (London) and is on display at the Ingold Chemical Laboratory of that university (Figure 2). A claim for co-discovery was made by Per Teodore Cleve (1840–1905) of the University of Uppsala, Sweden, shortly after Ramsay's claim (he did his work at the "Philologicum," a building at the University of Uppsala, Sweden, N59° 51.24 E17° 37.69).

The source of Ramsay's cleveite was "Karlshus, Norway." This small village is



Figure 3. View of 70-kilometer train ride from Oslo to Karlshus. This scenic journey takes one by the Oslofjorden ("Oslo fjord"), which connects Oslo to the North Sea.



Figure 4. The Halvorsrød Mine at Karlshus, Norway (N59° 21.57 E10° 51.88), the source of Ramsay's cleveite, was opened in 1884 and closed during the period 1910–1920. The main production was feldspar and quartz used in porcelain and glass production. A few remnants of the building stone remain, exhibiting occasional inclusions of interesting minerals, but no sign of cleveite remains. This archival photograph was made available courtesy of Øivind Thoresen.



Figure 5. The variety of zircon ($ZrSiO_4$) that contains a substantial portion of hafnium is called "alvite," with a formula of ($(Zr,Hf)SiO_4$) which does not form the typical beautiful crystals of pure $ZrSiO_4$. This sample of alvite comes from the Kragerø Mine in Norway and contains 10 percent of hafnium. Personal collection, J. Marshall.



Figure 6. The Tangen Mine is found on this hillside of the Kammerfosselva river on the eastern side of Norway, 2 kilometers west of Kragerø, about 120 kilometers southwest of Oslo.

reached by train south of Oslo (Figure 3). Although there are several potential mine sites for the "Karlshus cleveite," it is believed by mineralogists that most certainly the source was the most prolific producer of feldspar and quartz in the area, the Halvorsrød Mine, which was locally known simply as the "Karlshus Mine." This mine was located 1½ km north of the present railway station, now filled in and closed, but located at a site now neighboring a local community center (Figure 4).

Hafnium. The discovery of this element was particularly elusive, because of its chemical similarity with zirconium. Hafnium would coexist with zirconium, but would be masked by the more plentiful element (the terrestrial crustal abundances of zirconium and hafnium are 165 ppm and 4 ppm, respectively).[1c] Zirconium naturally occurs in minerals such as zircon, $ZrSiO_4$. Cubic zirconia (ZnO_2) has a hardness and appearance like diamond, for which it is a common more inexpensive alternative in the jewelry business. The reason hafnium is so similar to zirconium, both in the fourth column of the Periodic Table, is because of the "lanthanide contraction," which causes the relative sizes of the atoms hafnium and zirconium to be virtually identical. Thus, they form the same crystal lattices and admixture randomly. (The lanthanide contraction is the decrease in atomic size as one proceeds in the Periodic Table from zirconium (at. no. 40) to hafnium (at. no. 72), passing through the lanthanides or rare earths (at. no. 57–71).)

Earlier chemists guessed that the chemical properties of element 72 would be similar to those of the lanthanides, but two scientists in Copenhagen, Denmark, György de Hevesy (1885–1966) and Dirk Coster (1889–1950), suspected the true behavior of element 72. They analyzed samples of zircon from the Geologic Museum in Copenhagen (Figure 5) and were able to discover an analytical method to separate zirconium and hafnium: potassium hexafluorohafnate (K_2HfF_6) is more soluble than potassium hexafluorozirconate (K_2ZrF_6), and repeated recrystallizations slowly led to an enrichment of the hafnium compound in the soluble portion. The discovery of hafnium was announced in 1923.

The source of the zircon (alvite) that Hevesy and Coster analyzed was the Tangen Mine in Kragerø, Norway (Figures 6, 7). This mine is a preCambrian pegmatite formation, furnishing a great deal of feldspar and quartz for the porcelain industry. A careful search through the talus allowed us to find a sample of the desired mineral (Figure 5).

An exhibit in the City Museum of Copenhagen includes a plaque celebrating the fact that the element has been named for the Latin name of the city (Figure 8).

Tantalum. This element was found in 1802 by Anders Ekeberg (1767–1813) in the general mineral tantalite.[1d,e] Ekeberg studied two different tantalites from two different sites—the Ytterby Mine, in Sweden (yttrotantalite, $YTaO_4$)[1f] and Skogsböle, Finland (ferrotantalite, $FeTa_2O_6$ and manganotantalite, $MnTa_2O_6$).[1d] The Skogsböle site was described by the miner-

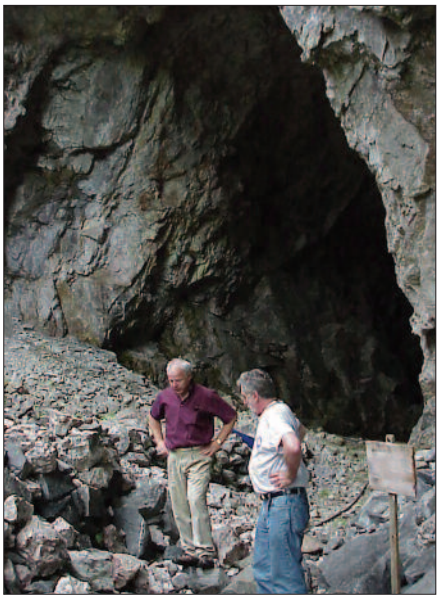


Figure 7. Tangen Mine, Norway (N58° 52.29 E09° 21.24). Jim Marshall (right) and host Alf Olaf Larsen (left) scrambling through the entrance of this historic mine which furnished the hafnium-bearing alvite analyzed by Hevesy and Coster. Larsen is arguably the most knowledgeable mineralogist in Norway.



Figure 8. Plaque in the Bymuseum ("City Museum," Vesterbrogade 59, N55° 40.33 E12° 33.20) of Copenhagen, Denmark. The Danish inscription says: "Hafnium, element number 72. Discovered 1922 in Copenhagen." The name "hafnium" is taken from the Latin "Hafnia," medieval name for Copenhagen.



Figure 9. The Kimito Church (Kemiö Kirkko, N60° 10.14 E22° 44.72) in southeast Finland. This is one of the oldest stone churches in Finland, dating from the 14th century. This church is of scientific interest; it was referenced by Nils Gustaf Nordenskiöld (1792–1866), the mineralogist who first described tantalite in his publication of 1821, to locate the Skogsböle mine, the original source of tantalum ore. Courtesy, Creative Commons, Taneli Mielikäinen.



Figure 10. View of the Baltic Sea, as seen by Nordenskiöld, from the Skogsböle Mine area (N60° 8.59 E22° 36.00). (The Finnish word for the Baltic Sea is "Itämeri.") The original area was a rich source of tin; now it is only used to mine feldspar for the porcelain and construction industry. The original outcrop has been stripped bare of tantalite specimens and is overgrown with vegetation.



Figure 11. The Knaben Mine area of Norway (N58° 39.55 E7° 04.41), a rich source of molybdenum. This was the prime source of the molybdenite (MoS_2) processed by the Noddacks to produce their "1st gram of rhenium."

alogist Nils Gustaf Nordenskiöld (1792–1866) in his publication of 1821 as "¾ mile from the Kimito church" in "view of the Baltic Sea" in southern archipelago of Finland (Figure 9). The authors were initially puzzled by the described location of the church, because there has never been a church in the vicinity. However, it was eventually realized that Nordenskiöld was referring to *Swedish* miles, which were intended to measure the walking distance of a man in one day—measuring in modern units as 10.7 kilometers! The view toward the Baltic Sea and the mine could then be located (Figure 10). The mine area is a feldspar quarry, now totally stripped of any tantalite specimens. Nils Nordenskiöld belonged to a long line of well-known explorers and scientists—his son, Adolf Erik Nordenskiöld (1832–1901), was a famous Arctic explorer who discovered the Northeast Passage. Adolf also was the major biographer of Carl Wilhelm Scheele (1742–1786), the famous Swedish chemist who discovered oxygen, tungsten, barium, molybdenum, and chlorine.[1g]

Rhenium.[1h] This was the last element discovered in naturally occurring terrestrial minerals (exception: francium was discovered in uranium ores in 1939, but with a half-life of 20 minutes was never collected in quantity). Rhenium was originally detected by X-ray analysis in 1925 in columbite and platinum ores by marriage team of Walter Noddack (1893–1960) and Ida Noddack neé Tacke (1896–1978). The isolation of the "1st gram of rhenium" was done in 1929 by processing large quantities of Scandinavian ores, principally from molybdenite (MoS_2). Their work was done at the Physikalisch-Technische Reichsanstalt in Berlin (Abbestraße 2-12, N52° 30.98 E13°



Figure 12. The matrix is so rich with molybdenite that it appears as heavy splotches of solder.



Figure 13. Welcome to Argyllshire! — the far northwest county of Scotland, home of the village of Strontian.



Figure 14. The brooding, surrealistic landscape of this remote region of Scotland is the site of the original lead mine of Strontian, from which the element strontium was discovered. In this scene, the peculiar geological feature is caused by ancient volcanic extrusions of white granite. This area dates from the Devonian era, about 400 million years ago.



Figure 15. Discovery! The seam of strontianite ($SrCO_3$) can be seen in the open pit mine of Strontian (N56° 44.03 W05° 32.84). The lead of the Strontian mines appeared in the form of galena, PbS, appearing as steel-blue metallic-appearing cubic crystals embedded in quartz.





Figure 16. ABOVE LEFT: Galena (lead sulfide) was the main product of the Strontian mines. The gray cubes are typical crystals of this mineral. ABOVE RIGHT: A byproduct of the mines: alkaline earth (barium, strontium, calcium) minerals. The greenish color toward the bottom is indicative of strontium which has been "chromatographed" or separated out in secondary hydrothermal processes many millions of years ago.

19.26; name changed to Physikalisch-Technische Bundesanstalt, "Physics-Technical Federal Institute," in 1945). One of the richest sites is Knaben, Norway (Figure 11). Here on the talus slopes one can find large splotches of molybdenite on the matrix of preCambrian granitic gneiss (Figure 12).

Strontium.[1i] This element was found in strontianite (strontium carbonate, $SrCO_3$) in the far reaches of northwestern Scotland (Figure 13). The original source of this mineral was the lead mine at Strontian, a remote region in Northwest Scotland (Figures 14–16). This was a lead mine which produced the material for lead shot for the war industry. The miners were historically French prisoners, taken during the French-British Wars of the 1700s.

The first samples of strontium salts were used in the St. Thomas Hospital in Southwark, London, reported in 1790 (Figure 17, on page 44). This historically bawdy area of London was used by Charles Dickens as the source of much of his somber tales. A physician, Adair Crawford (1748–1795), prescribed the salts and described them as an effective "evacuant, deobstruent, and tonic" and was an interesting substitute for the usual "muriated barytes" (barium chlorides).

The characterization of strontium was made with the help of William Cruickshank ?–1811), the elaboratory chemist at the Woolwich Arsenal (Figure 18). Cruickshank was the scientist who in 1801 discovered that the "heavy inflammable air" of Joseph Priestley (1733–1804)—which Priestley considered the same as a form of hydrogen—was actually an oxide of carbon: it was carbon monoxide. Cruickshank's discovery and analysis was initially perplexing to the followers of Lavoisier, who thought "inflammable air" (hydrogen) always came from water. However, Cruikshank's analysis led to the sophisticated concept of compounds that dispelled Priestley's argument for "phlogiston."

The name "strontium" was given to the element by Thomas Charles Hope (1766–1844) of the University of Edinburgh (historic site: N55° 56.85 W03° 11.17) [j,k] who was the first to clearly differentiate the element from barium; he prepared pure strontium hydroxide in 1794 and wrote a full characterization of the element in 1798. Hope was reputed to be the "most popular lecturer in Edinburgh"; Charles Darwin when he attended the University of Edinburgh said all the lectures at the University of Edinburgh were "intolerably dull" except for those by Hope.

(continued on page 44)

Next: Travels to Western Europe!



Figure 17. This site in Southwark (southeast London), now used for a sidewalk market, stands before a wall which is the only portion of the historic St. Thomas Hospital remaining today (Bourough High Street, N51° 30.31 W0° 05.36). This hospital is where Adair Crawford administered strontium salts to his patients, the first known use of this element. The St. Thomas Hospital, named after St. Thomas Becket and offering a refuge for the sick and homeless, dates back over 800 years and was frequently used as a gathering place for the people passing through on their pilgrimage to Canterbury to honor Becket. On the wall above the vendor is a plaque (see inset) commemorating the history of the site, which includes the first published English Bible, in 1537.



Figure 18. This was the teaching school (Royal Military Academy) of the Woolwich Arsenal, 11 kilometers east of London on the Thames River (N51° 29.64 E00° 04.18). In this academy Cruickshank characterized strontium, as well as being the first to correctly identify carbon monoxide as an oxide of carbon instead of merely "heavy inflammable air." Woolwich (pronounced "Wool-ich") has a long history, beginning with ship building under Henry VIII (1491–1547) and later military industrial expansion to include many military factories (Royal Ordnance Factories). At one of these factories in 1854, Frederick Abel invented cordite, a form of smokeless propellant to replace gunpowder.

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1. J. L. and V. R. Marshall, *The HEXAGON of Alpha Chi Sigma*, (a) **2012**, *103(2)*, 20–24; (b) **2012**, *103(3)*, 36–41; (c) **2011**, *102(3)*, 36–41; (d) **2013**, *104(2)*, 20–24; (e) **2013**,*104(3)*, 46–51; (f) **2008**, *99(1)*, 8–11; (g) **2005**, *96(1)*, 8–13; (h) **2013**, *104(4)*, 84–89; (i) **2002**, *93(3)*, 42–47; (j) **2014**, *105(3)*, 4–8; (k) **2015**, *106(2)*, 24–29; (m) **2011**, *102(4)*, 62–27.

The 2nd edition of the Marshalls'"Rediscovery of the Elements"is now available! This edition has the complete series of the "Rediscovery" articles published in *The HEXAGON* since 2000—55 total, as well as a memoriam to Jenny Marshall, who passed away in 2014. There are additional discovery sites included, as well as new biographies and expanded text tables, and an update of all the elements through the recently named oganesson, element 118. This edition, after a total review, has several errors (maps, typos, dates, links, etc) corrected. The 2nd edition is available to the public on the UNT website. At present it can be found at:

http://www.chem.unt.edu/~jimm/REDISCOVERY 7-09-2018/