Rediscovery of the Elements

A Travelogue of Rediscovery Sites

PART 1

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Empedocles (490–430 BC) had first defined the "elements" as fire, earth, water, and air, an idea later promoted by Aristotle (384–322 BC). Robert Boyle (1627–1691) advanced the modern idea of element by defining it (*The Sceptical Chymist*, 1661) in analytical terms—as a substance that could not be reduced to simpler principles.[1j] Later Antoine-Laurent Lavoisier (1743–1794) in 1789 identified the "true elements."[1f] His list of elements included not only the seven metals (gold, silver, copper, iron, lead, tin, mercury) and two nonmetals (carbon/charcoal and sulfur/brimstone) known to the ancients, but 22 elements discovered since then, which included molybdenum, tungsten, chlorine, hydrogen, nickel, cobalt, bismuth, etc.

In the last half of the second millennium with its technological advances, the search was on for the discovery of new metals/elements. The majority of these discoveries were in Europe. The reason for this was not due to any special concentration of the elements in this continent—other regions, notably Africa and China, were perhaps geologically richer. Recognition of the true elements was due to the European Scientific Revolution and the Age of Enlightenment originating in the 1700s.

Figure 1. Romanian miners and Australian overseer of the Roşia Montană gold project, an attempt to make the mining area economically productive again. The rugged miners were gentlemen, kissing the hand of one of the authors (Jenny) upon greeting her. They also were persuaded to take the authors up to the mining site in their jeep (background) by a bribe of two beers apiece at a local bar in Zlatna, a historic gold-mining town deep in the Transylvania region.

Metallurgists in other regions of the world actually discovered a few elements earlier—such as China's development of an alloy of nickel—but these substances were not recognized as elements until the European development of modern science.

The authors have recounted their "Rediscovery" adventures in *The HEXAGON of Alpha Chi Sigma* during the last 15 years. These travels covered every site where every element has been discovered and involved travel through covering 24 countries of Europe and North America. Most of these trips occurred before the advent of Google Earth and Google

Figure 2. Jenny's favorite picture of the entire "Rediscovery" project. The remoteness and isolation of the Fața Băii area gives one a feeling of connection with the distant past, when tellurium was discovered in 1782.

Maps and involved the personal mapping of the authors using a handheld aviation GPS unit, used by the authors in their flying activities (JLM is an authorized flight instructor). Hence, these discoveries were made by the "archaic" method of studying old maps and

Figure 3. The Manaccan church, of Norman design, was built in the 12th century. The fig tree growing out the side of the church is more than 250 years old. Inside is a display of titanium and a plaque of Gregor. Inside the Lord's Prayer is mounted on the wall, in the original Cornish language (a celtic dialect).

Figure 5. Modern saltworks, "Salins du Midi," ("saltworks of the midday"), near Aigues-Mortes, France. Salt produced here is sold under the name of "La Baleine" ("the whale") and is familiar to connoisseurs of salt throughout Europe and North America. "Aiges-Mortes" is Occitan for "dead water"; Occitan is an ancient Romance language of southern France. Some street signs in old-town Montpellier are written in both French and Occitan.

other historical documents, and by consulting with regional scientists and local denizens. These maps developed by the authors were published along with *The HEXAGON* articles, and have been subsequently used by scientific travelers to the rediscovery sites. For example, Oliver Sacks, author of *Uncle Tungsten*, whose story was told in a recent *HEXAGON* article,[1l] used these in his visit to Sweden.[1g]

Today, after some 100 articles devoted to the "Rediscovery" theme, the stories are deemed complete. In the next few issues of *The HEXAGON*, a review of these travels will be presented. In this Travelogue, a brief description of the original discovery sites will be presented—mostly mines, but sometimes other sources, including estuaries, ponds, or fields.

Tellurium.[1f] This was one of the first elemental sites discovered, at the Faţa Băii Mine in Romania, known originally in Hungarian as the Fascebanyá Mine (N46° 07.85 E23° 08.84). The mine was found with the aid of local miners (Figure 1) in the Transylvania Mountains (Apusenis), the historical source of Bram Stoker's *Dracula* stories. The chemical analysis itself was conducted by Müller von Reichenstein (1740–1825) in Sibiu, Romania. This visit of the authors to the Faţa Băii Mine (Figure 2) marked the beginning of the "Rediscovery" project, and it spurred them to

Figure 4. Dr. Simon Camm (left) of the nearby Cambourne School of Mines (with a history of tin mining) shows to the author (JLM, right) the "black sand," ilmenite, which has been collected by old-fashioned panning. Dr. Camm was an expert in gold prospecting and had traveled all around the world in his studies.

passionately pursue the project, because it proved to them that difficult sites could be discovered upon persistence and continued visits with local citizenry.

Titanium.[1b] "The Scientific Parson," William Gregor (1761–1817), discovered titanium in 1792 in "the black sand that follows the compass" (i.e., is magnetic). Gregor preached at Manaccan, Cornwall, England (Figure 3). The "black sand" is known today as ilmenite, $FeTiO_3$. The "black sand" was collected from Gilly Creek, just down the road from the church (Figure 4) on the estate of Tregonwell Mill N50° (04.83 W05° 07.64). Gregor had first noticed this black material, collecting as a black sediment, in the leat (artificial canal) leading up to a watermill in the Gilly Valley. The analysis itself was prepared by Gregor at his parents' home at Trewarthenick, Cornwall, England.

Bromine.[1c] This element was discovered by "salt mining," i.e., collection of salt for commerce from ocean evaporites. The salt was prepared by damming the ocean water in the spring, evaporating over the summer, and collection in the fall (Figure 5). Bromine was discovered by Antoine-Jérôme Balard (1802–1876), who observed that chlorine reacted with brines to produce a brown substance, which could be distilled to prepare pure liquid bromine. The saltworks (N43° 22.80 E03° 37.58) were located at Les Anciens Salins ("ancient saltworks"), near Sète, 20 kilometers southwest of Montpellier, France. The analysis and preparation of bromine was performed at the old École de pharmacie in central Montpellier, France. A modern exhibit presenting the original apparatus and methods of Balard is found at the new École de pharmacie in northern Montpellier.

Figure 7. Fragments of "phosphoro di bologna" found by the authors on the Monte Paderno hillside.

Figure 6. (right) Holding up shards of bologna stones, barium sulfate, which were commonly strewn on Monte Paderno, part of the Apennines, geologic backbone of Italy. The Apennines have been described as a "mound of breccia [broken fragments of rocks cemented together]," generated when the African plate smashed into Europe 20 million years ago.

Figure 8. The island of Løvøya in Langesundfjord, 2 kilometers east of Brevik, Norway, where Esmark was pastor. Many islands in this fjord are rich in the rare earth elements, and one in particular—Låven, a tiny island (30 x 30 meters) located at N58 59.73 E09 49.05—is a protected geological sanctuary; the mineral mosandrite (a lanthanum mineral) was discovered here.

Barium.[1e] Nuggets of "phosphoro di bologna" ("glowing rocks of Bologna") were originally collected in the early 1600s by Vincenzo Casciarolo from Monte Paderno (N44º 26.73 E11º 18.81), located 4 kilometers southwest of Bologna, Italy (Figures 6,7). These "bologna stones" were actually barium sulfate. Barium was first identified by Carl Wilhelm Scheele (1742–1786) in 1774 by his differentiating it from calcium, in Köping, Sweden.[1g]

Thorium.[1d] One day in 1829 Hans Morten Thrane Esmark (1801–1882), a Norwegian pastor of Brevik, Norway, was hunting ducks for his family's dinner plate in the ocean waters harboring his home. He rowed his boat past a small island (N59º 03.45 E09º 44.08) named Løvøya (Figure 8). In a huge boulder projecting into the water, he spotted shiny black crystals (Figure 9). These crystals were analyzed by the famous Swedish chemist Jöns Jakob Berzelius (1779–1848)[1h] in Stockholm who determined it to be the silicate of a new element. Berzelius named the new mineral thorite, and the new element, thorium.

Figure 9. Jenny poses beside the famous rock where thorite was discovered. All specimens of thorite were removed in the rush of the 1800s to provide refractive materials for lanterns. The black crystals seen in this figure are minerals composed of silicates and oxides of iron, zirconium, and molybdenum.

Uranium.[1i] In 1789, Martin Heinrich Klaproth (1743–1817) discovered uranium in ore taken from the Georg Wagsfort Mine (N50º 25.98 E12º 43.77) in Johanngeorgenstadt, Germany (Figure 10). This mine was originally a silver mine, dating from 1670 (Figures 11, 12). Klaproth was the best analytical chemist of his time; "Klaproth. . . utterly altered the face of mineralogy. When he began his labours, chemists were not acquainted with the true composition of a single mineral."[2] Klaproth performed his research at his apothecary in Berlin, Germany.

NEXT: The "Rediscovery" Travelogue continues with radium in the next issue of *The HEXAGON*. And at a future date, a new series will be presented, a personal story how it emotionally felt to be the team of Jim and Jenny in their Chemical Journey.

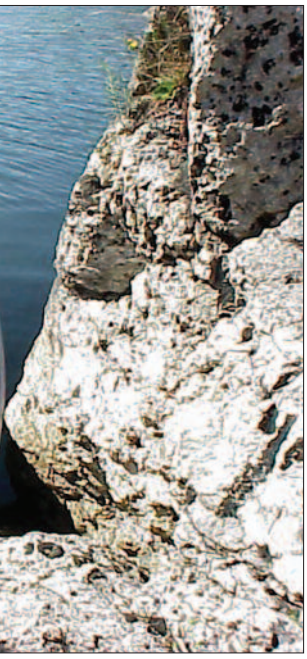

Figure 11. (left) A local denizen explains to the authors how the mine was exploited by the Soviets after World War II as a source of uranium for their atomic weapons program. Tons of uranium ore were shipped back to Russia after World War II during the days of the DDR (Communist East Germany). The mine is behind the sign to the left. In their "Rediscovery" travels, the authors found local citizenry to always be a rich source of incidental information not available in the classical scientific literature.

Figure 10. (right) The Georg Wagsfort Fundgrube (Mine) is located within walking distance of the Czech border, where a busy "border town" offers souvenirs for German tourists. The mine is now bricked up.

References

1. J. L. and V. R. Marshall, *The HEXAGON of Alpha Chi Sigma*, (a) **2000**, *91(3)*, 43–45; (b) **2001**, *92(1)*, 4–5; (c) **2001**, *92(3)*, 36–39; (d) **2001**, *92(4)*, 70–73; (e) **2002**, *93(2)*, 24–26; (f) **2005**, *96(1)*, 4–7; (g) **2005**, *96(1)*, 8–13; (h) **2007**, *98(4)*, 70–76; (i) **2008**, *99(2)*, 20–24; (j) **2013**, *104(1)*, 4–6; (k) **2016**, *107(2)*, 20–25; (l) **2016**, *107(3)*, 36–40.
2. T. Thomson, *The History of Chemistry*, **1975**, Vol. II, 1–25, reprint of 1830–1831 edition, H. Colburn and R. Bentley, London. 191–211.

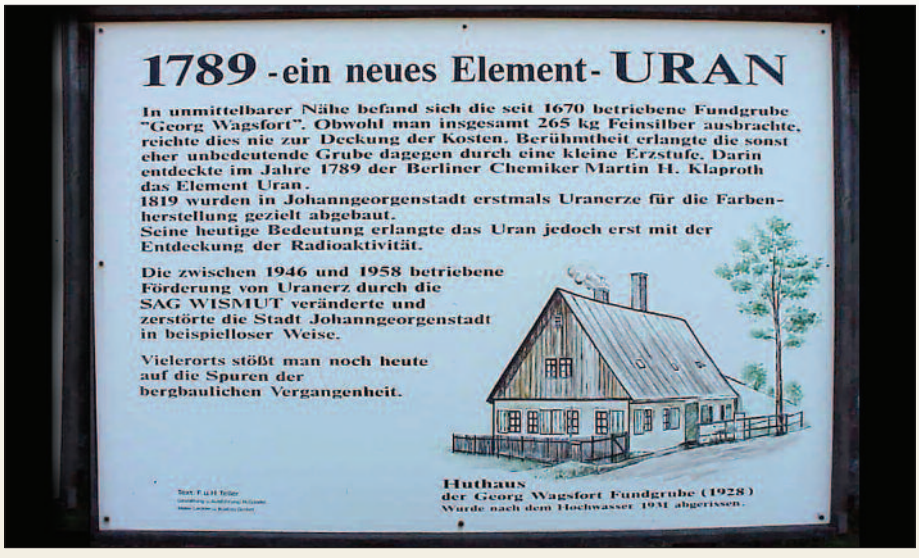

Figure 12. (right) The sign reads "1789—a new element—uranium" and explains the full history of the mine. In 1819, uranium was produced for the color of its compounds, used in the manufacture of yellow glasses and porcelain. But a more important use was realized for uranium after radioactivity was discovered by Henri Becquerel (1852–1908) in Paris, France, in 1896. The "Huthaus" at the lower right was a classic example of the mining office so common in German silver mining.