

# Rediscovery of the Elements:

## Vanadium

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**O**n March 23, 1803, Baron Alexander von Humboldt (1769–1859) landed at Acapulco, Mexico<sup>1</sup> (Figure 1). An independently wealthy explorer and naturalist, Humboldt (Figure 2) made famous world scientific expeditions, notably to the New World and Russia, collecting data and plant specimens to take back to Europe. In Mexico he met Don Fausto Delhuyar (1755–1833), who had set up the mining school in Mexico City, the first scientific institution in Mexico; both Delhuyar and

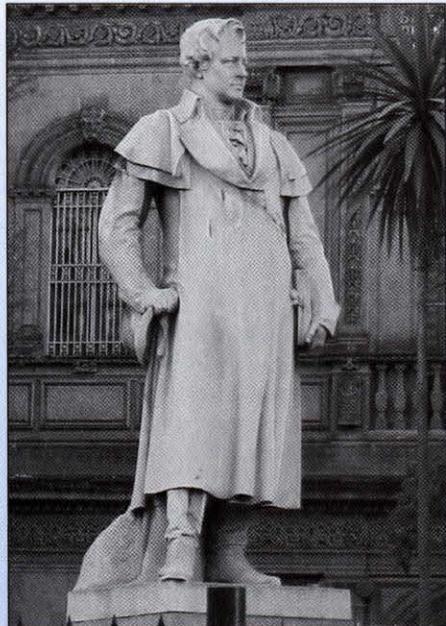


FIGURE 2: This statue of Baron Alexander von Humboldt resides in the Jardín de la Biblioteca Nacional in Mexico City, 90 Republica de Uruguay (SE corner of that street and Isabel la Católica, N 19° 25.82 W 99° 08.22). This statue was donated by Kaiser Wilhelm II in 1910, commemorating Mexico's 100th anniversary of Mexico's declaration of independence. Below the statue is inscribed "Dem Mexikanischen Volke der Deutsche Kaiser" ("To the Mexican people from the German Kaiser").

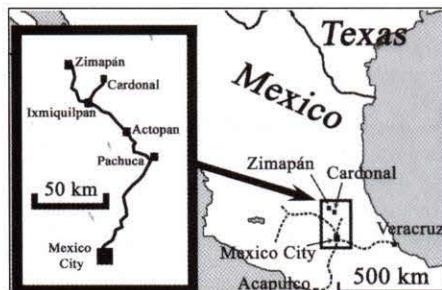


FIGURE 1: Central Mexico. The dotted lines depict the routes traveled by Humboldt, who used Mexico City as his base of operations. Inset: the solid routes show the five-hour drive taken by the authors from Mexico City to Zimapán, the region where plomo pardo (vanadinite) was discovered.

Humboldt had attended the Freiberg Mining Academy in Saxony.<sup>2</sup> Humboldt's Mexican sojourn took a full year; arriving from Guayaquí, Ecuador, he traveled from Acapulco to Mexico City, then as far north as Guanajuato and Real del Monte, and then disembarked from Veracruz for Havana.<sup>1</sup> Using Mexico City as his base of operations (Figure 3), Humboldt gathered enough information for a large 5-volume treatise on Mexico<sup>3</sup> and collected enough specimens for 19 boxes for return to Europe.<sup>4</sup>

Humboldt had particularly looked forward to visiting the mining school in Mexico City because his Freiberg friend and classmate, Don Andrés Manuel del Río (1764–1849) (Figure 4), was now a professor there. Born in Madrid, del Río was a countryman of Don Fausto Delhuyar and had been sent to Mexico City to teach Werner's theory of vein formation. Abraham Gotlob Werner (1750–1817), the famous professor of geology at the Freiberg Mining Academy,<sup>2</sup> was a champion of the Neptunian theory of rock formation.<sup>4</sup> (Note 1)

Two years prior to Humboldt's arrival, del Río thought he had discovered a new element from a newly-discovered mineral from the region of Zimapán, which he called plomo pardo ("brownish-gray lead"). del Río was experienced with the analysis of lead ores, which he had learned from the famous mining school in Schemnitz in Hungary (now Banksá Stiavnica in Slovakia), and he adroitly proceeded with his analysis of plomo pardo.<sup>5</sup> Treating some crushed ore with hot sulfuric acid, he removed



FIGURE 3: The house where Humboldt resided in Mexico City (80 Republica de Uruguay, N 19° 25.80 W 99° 08.12) is only half a block east of the Humboldt statue. A plaque on the wall (not visible in this photo) memorializes the 100th birthday (1869) of Humboldt.



FIGURE 4: Don Andrés Manuel del Río's statue now resides in the same building (see Figure 13) where he discovered erythronium (vanadium). The chemical laboratories were located in the area behind the statue, both on the base floor and the mezzanine. Before 1967 this statue was displayed in the Palacio de Minería (see Figure 14).

the lead (by precipitating  $\text{PbSO}_4$ ) to produce a green solution. He treated this green solution with ammonia, which produced white crystals. Acidification of the ammonia solution produced a brown-gray residue, which he dissolved in hot concentrated nitric acid. The nitric acid was



FIGURE 5: Royal Spa Hotel, on the outskirts of Zimapán. Now hanging in the hotel is a poster, constructed by the authors as a gift to the owner, describing the history of mining and the discovery of vanadium in the Zimapán region.

evaporated, and the solution was diluted with water to give a gradually clearing solution. This solution gave yellow precipitates with silver, mercury, and lead nitrates. The borax bead test gave a green color. This behavior was unique in del Río's experience, and he claimed he had discovered a new element, calling it "panchromium," from the varied colors of its derivatives. del Río distributed news of his discovery by publishing a notice in a Spanish journal,<sup>6</sup> and he submitted a complete paper to Jean-Antoine Chaptal, the French chemist who, as Minister of the Interior in France, was instrumental in developing the chemical industry under Napoleon. Unfortunately, this paper was lost in a shipwreck.<sup>4</sup>

When Humboldt visited Mexico the next year, del Río pinned his hopes on Humboldt's conveying news of the discovery to Europe. Humboldt never actually visited the mines of Zimapán: he traveled no further than Actopan, half-way between Pachuca and Ixmiquilpan (Figure 1). However, del Río gave him specimens of his mineral to return to the New World. Humboldt left Veracruz in March 1804. Before

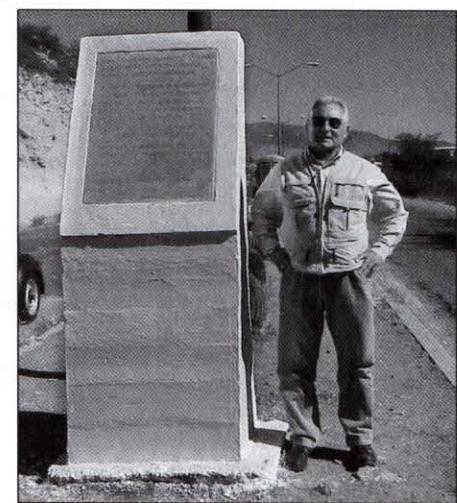


FIGURE 7: Oscar Fernando Nieto de la Mora, the retired Gerente of the Peñoles Mining Company, was the authors' guide in the Zimapán area. Well honored and respected in the Zimapán mining district, Oscar was instrumental in erecting this public plaque in Zimapán ( $N\ 20^{\circ}\ 43.92\ W\ 99^{\circ}\ 22.50$ ) which celebrates the historic contribution of the miners to the culture and the economy of the area.

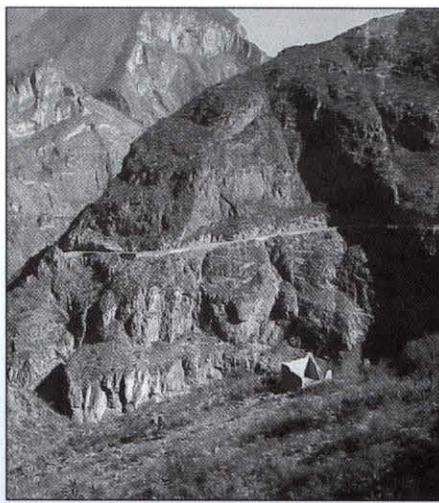


FIGURE 8: Forbidding landscape of the Lomo de Toro Mine ( $N\ 20^{\circ}\ 47.31\ W\ 99^{\circ}\ 26.51$ ), in the Moctezuma River valley. This mine was opened in 1635 and throughout its history has produced zinc, lead, and silver.

returning to Europe, he visited Cuba and the United States. In Havana he concentrated on the sugar industry; in the United States he met with President Thomas Jefferson, who was most curious about the economic and military implications of Mexico, which as a result of the Louisiana Purchase had just become the bordering Southern neighbor of the U.S.

**Rediscovering Zimapán.** Two centuries after Humboldt, the authors arrived at Mexico City and drove north to Zimapán (Figure 5), where we stayed at the elegant Royal Spa Hotel (Figure 6). The owner of this hotel, César Sánchez Lozano, was the manager of the M.M.M. [Minera Metalúrgica Miguel] Purísima Company at Lomo de Toro (Figure 6), the main mine of Zimapán. His father Romualdo Sánchez had been owner of the Purísima del Cardonal Mine (Figure 6). The Royal Spa Hotel was a favorite haunt for many of the friends and colleagues in the mining industry who frequently met in fellowship and exchanged stories while dining in the courtyard.

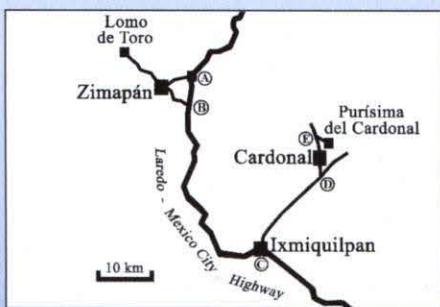


FIGURE 6: The Zimapán mining district. In addition to the Lomo de Toro and Purísima del Cardonal mines, other auxiliary locations are (A) the Royal Spa Hotel ( $N\ 20^{\circ}\ 45.20\ W\ 99^{\circ}\ 19.88$ ); (B) intersection leading from main highway to Zimapán ( $N\ 20^{\circ}\ 42.24\ W\ 99^{\circ}\ 20.13$ ); (C) the intersection in Ixmiquilpan leading north ( $N\ 20^{\circ}\ 28.67\ W\ 99^{\circ}\ 13.29$ ); (D) intersection leading from main road to Cardonal ( $N\ 20^{\circ}\ 35.60\ W\ 99^{\circ}\ 07.24$ ); (E) intersection leading to mine ( $N\ 20^{\circ}\ 37.37\ W\ 99^{\circ}\ 07.24$ ).

We had made contact with the retired manager of the Peñoles Mining Company in Zimapán, Oscar Fernando Nieto de la Mora (Figure 7), who had assembled some friends at the Royal Spa Hotel to share their knowledge with us. There is only one known scientifically documented<sup>4</sup> specific reference<sup>5</sup> to the exact locality where plomo pardo de Zimapán was found: Purísima del Cardonal, 27 km to the southeast of the hotel (Figure 6). However, it was the opinion of several mining colleagues that "la vanadinita" (vanadinite,  $Pb_5(VO_4)_3Cl$ ) had also been observed at the Lomo de Toro mine, 12 km to the northwest (Figure 6). In Humboldt's Essai,<sup>3</sup> "Lomo de Toro" and "Cardonal" (or "Real del Cardonal") are mentioned several times, but "Purísima" is never cited. (Note 2) None of the colleagues had ever seen "la vanadinita"—whatever specimens that existed in del Río's time were long gone as the mine was spent of its main veins of rich ore. That evening in the Royal Spa, plans were made to visit both Lomo de Toro and Purísima—but with no real expectation of finding specimens of "la vanadinita."

Both the Lomo de Toro and Purísima del Cardonal date back for hundreds of years, originally dug by the Spaniards and yielding large amounts of silver and lead. Lomo de Toro (meaning "shoulder of the bull") is spread over an expansive area of rugged terrain (Figure 8). Some galeries are so large in the mine complex that we were able to drive through them in our van. The smelters at the Peñoles Mining Company, in the village proper, date back for centuries (Figure 9). Lomo de Toro was the main economic resource of Zimapán until regrettably it closed on March 1, 2003.

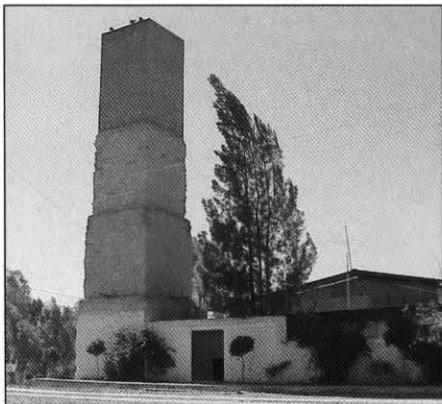


FIGURE 9: The old smelters of Peñoles Mining Company ( $N 20^{\circ} 43.91' W 99^{\circ} 22.92'$ ) date back to the time of del Río, 200 years ago. In this area, ruins still remain of "horno castellano" (Castilian furnaces) that were used nearly 500 years ago.

Purísima del Cardonal (meaning "purest [Virgin Mary] of the cactus region") does not lie in such forbidding geography (Figure 10). This mine is on an accessible hillside north of the village of Cardonal (Figure 11). Key information regarding the history of the region was gained from Father Hubert Dephoff of the local Catholic mission. Father Dephoff could point straight to the mine, directly across the road 700 meters away. He told us that the Spaniards arrived in 1541 and established the mine three years later, which yielded zinc and lead until finally closing in 1950. It was easy for us to scramble up the hillside, noting ancient ruins, which we were told were old smelters and mining huts. We were able to walk into the entrance of the mine, observing interesting minerals—but even with close scrutiny, no minerals resembling plomo pardo could be found, as was foretold at the Royal Spa. (Note 3)

**Visiting Mexico City.** In the historical section of Ciudad México (Figure 12), the building where del Río did his analytical work on plomo pardo still exists, the Royal Seminary of Mining (Figure 13). This was the "first scientific house of science in Mexico" and was the pride of Mexican



FIGURE 11: The Cardonal region was named for the cactus ("Cardon," foreground) prevalent in this area. The village of Cardonal is in the background.

men of learning.<sup>7</sup> This building housed the mining school until 1812, when it was moved to la Palacio de Minería ("Mining Palace," Figure 14). Both buildings are now used by the Engineering School. During our visit to Mexico City, there was an exposition (February–June, 2003) in the library of la Palacio de Minería celebrating the 200th anniversary of Humboldt's visit to Mexico. Exhibits included books, maps, and charts developed from Humboldt's visit; posters and official documents; and scientific equipment donated by Humboldt to Mexico City's mining school.

One of the posters in the exposition included a photograph of the original sample of plomo pardo, now on exhibit at the Berlin Museum of Natural History. This was the sample to which del Río had attached so many hopes, that Humboldt would present to the Institut de France to validate del Río's claim to the discovery of an element. Surely with the weight of the highly respected Humboldt, del Río's claim would command the full and expert attention of the leading chemical experts of Paris, and Europe would recognize the New World as a developing cultural region where significant research and discoveries could be made!

But it was not to be—del Río's specimens were not taken seriously and received only superficial examination, and his claim was doomed to rejection. It took 30 years for him to get even partial credit for the discovery,<sup>8</sup> but by then his claim to naming the element was lost. Only recently has he been given full credit.<sup>4,9</sup> In the next issue of *THE HEXAGON*, we shall travel to Europe and continue this tale of vanadium, which will lead us to the Parisian École des mines, a magnetic mountain in Sweden, a monastery in the Pyrenees, a mining school in Slovakia, and a college in Manchester, England.

## Acknowledgments

Special gratitude is extended to Oscar Fernando Nieto de la Mora, who was Gerente de Unidad Minera, Peñoles Mining Company, Zimapán, Hidalgo, Mexico; Oscar guided the authors on the tours of the Zimapán area and supplied them with important information regarding mining in the Zimapán region and history of the original Real Seminario de Minería in Mexico City (including a rare copy of reference 7). Accompanying Oscar and the authors were two other individuals of Zimapán who were instrumental in locating important sites: Alejandro Contreras, Compañía Fresnillo S.A. de C.V. Unidad El Monte (who furnished the rugged van useful in the mountainous terrain); and Rubén Covarubias, Covamin, S.A. de C.V. Particularly instrumental in locating the Purísima del Cardonal Mine was Father Hubert Dephoff, priest of the Cardonal Catholic Municipality and head of the mission there. Additional information on the history of the



FIGURE 10: Purísima del Cardonal Mine ( $N 20^{\circ} 37.16' W 99^{\circ} 06.76'$ ), view from the German Catholic mission. The mine is in the upper right portion of the photograph.



FIGURE 12. The Historic District of Mexico City includes (A) Real Seminario de Minería, where vanadium was discovered by del Río; (B) Palacio de Minería, the second mining school; (C) the Humboldt statue; (D) the house where Humboldt stayed. Other locations of cultural interest to the tourist are (E) the Cathedral, (F) Zócalo (where public Tenochtitlan dances are performed); (G) Palacio de Bellas Artes; (H) the National Palace; (I) the Alameda Central Park.

Cardonal region was gained from Dr. Verónica Kugel of the Colegio Alemán Alexander von Humboldt en la Ciudad de México, who has extensively studied the history of the Otomí Indians there. Finally, enlightening discussions with Dr. Lyman Caswell, Professor Emeritus of Texas Woman's University, Denton TX, who has thoroughly studied the available scientific literature on del Río, are gratefully acknowledged, as well as heavy dependence on his review article.<sup>4</sup>

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(continued on page 65)

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Figure 13. "The first scientific house in Mexico," El Real Seminario de Minería (the Royal Seminary of Mining) stands at 90 República de Guatemala, Mexico City (N 19° 26.06 W 99° 07.70). The "SEFI" banners announce a meeting of Sociedad de Exalumnos de la Facultad de Ingeniería (Society of Alumni of the Faculty of Engineering). Vanadium was discovered in the chemical laboratories located in a 16x16 meter area in the northeast corner of the building (inside the door and diagonally to the right).

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### Notes.

NOTE 1. Humboldt found ample evidence in Mexico for the *Plutonian* origin of minerals. Today geologists recognize both the *Neptunian* (aqueous) and the *Plutonian* (volcanic) mechanisms.

NOTE 2. Humboldt in his *Essai* refers to Lomo de Toro and Real de Cardonal as producers of lead, and he mentions "Zimapán" as a producer of silver. These mines have produced much argentiferous galena (silver-bearing PbS). Although the Lomo de Toro is a specific mine, the Real de Cardonal is a general area, and "Zimapán" is a extensive region which encompasses some 15,000 square kilometers. The boundaries of his defined Zimapán are not exact, since he was the first person determining the longitudes (as part of his scientific researches), which were approximate. The reader of his *Essai* will find his placement of longitudes confusing until it is recognized that he used l'Observatoire de Paris as the zero meridian. Humboldt never mentioned the *plomo pardo* in his *Essai*. References elsewhere state that *plomo pardo* was found in "Cardonal" without a specific mine defined.<sup>10</sup>

NOTE 3. Although no vanadinite can be found in Zimapán, it can be presently found at San Carlos Mine, Chihuahua, 1000 kilometers northwest. A colored photograph of this Mexican vanadinite, as well as of Moroccan specimens, can be found in J. L. and V. L. Marshall, *Walking Tour of the Elements*, 2002, CD-ROM. ☐

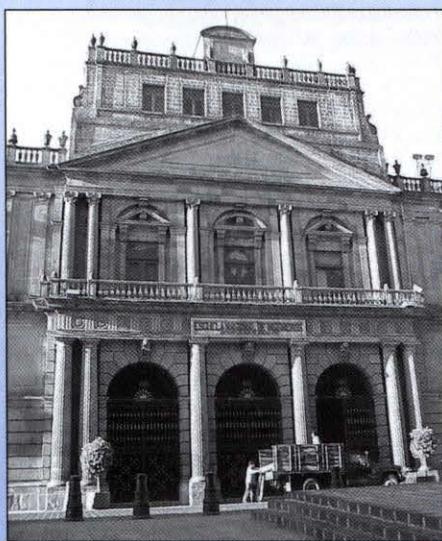


Figure 14. La Palacio de Minería (5 Tacuba, N 19° 26.17 W 99° 08.39) is 1.2 km west of the original mining seminary. The names of del Río and Delhuyar are inscribed at the top of the gates. Today this building houses the "Escuela Nacional de Ingenieros" (National School of Engineers).