Rediscovery of the Elements

The Scientific Parson

How Jim and Jenny Marshall rediscovered titanium in Cornwall, England.[1]



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"This summer you want to go where? To Cornwall?" Jenny asked.

"Yes," I said, "land of Sherlock Holmes. The moors and 'Hound of the Baskervilles.'"

"What's in Cornwall?"

"Ancient tin mines. The Romans, when they held Britain as a colony, mined tin here and shipped it back to Italy, to be alloyed with copper to produce bronze. But we're not going to Cornwall for the tin. We're going there for titanium."

"Like titanium white? The pigment used in painting? Didn't that replace poisonous lead paints?"

"Yes, lead carbonate was once used as the white pigment in artists' paints and house paints. No more. But its poisonous nature hasn't been known for only a century. The Romans themselves added 'lead of sugar'—lead acetate—to wine to sweeten it. Some think that's a partial cause for the demise of the Roman civilization."

"So what else is titanium. used for?"

"Titanium is used today in light-weight instruments, tools, and sport gear. Titanium is very common in the eath's crust—ranking the ninth most abundant—even above hydrogen, sulfur, and carbon. But it is not one of the cheapest, because its processing (smelting from its ore) is more difficult than that of copper, for example, which is much less common than titanium. The ancients knew about gold, silver, tin, lead, copper, and mercury, but not titanium which does not occur in the native (elemental) state in nature. It took the expertise of a parson turned chemist, named William Gregor (1761–1817), to extract titanium from a black mineral in 1791 from Cornwall, England."

"Ah, a preacher! Daddy was a preacher."

"Yes, your father was a true Texas polymath! A bronco buster, oilman, ordained preacher, and teacher/principal."

"Yes, I was a 'PK'—'preacher's kid.'

"And long ago, men like your father were common—'scientific preachers.' In the 16th–18th centuries, religion was beginning to view science as a manifestation and a testament of the perfection of God It was natural for preachers to turn to astronomy, geology, botany, physics, or chemistry to praise Him. Gregor was a particularly skilled chemist, and he went about the countryside of his native Cornwall to study rocks and minerals he found in quarries, hills, or scattered about the roads.

"Worshiping God through nature!" Jenny marveled. "Daddy would understand that."

Trip to Cornwall. And so the summer of 1999 we flew to London to search out the historical haunts of Gregor. Our trek took us first to the office of Huntsman Tioxide in Hammersmith, Southwest London, a major producer of titanium. By use of the new medium of the internet, we had arranged to meet with the public relations agent, who showed us

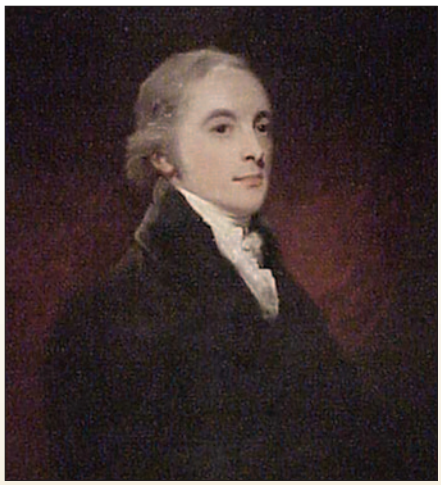


Figure 1. Portrait of William Gregor 1761–1817, the discoverer of titanium), by John Hoppner (1758–1810), who also rendered portraits of Sir Walter Scott and the Duke of Wellington.

the portrait of Gregor (Figure 1). The agent also furnished information about the discovery site of the "black sand" in which titanium was extracted, found by Gregor in a leat (water-wheel trench) near a village named Manaccan in Cornwall. Also with her help we arranged to visit the Camborne School of Mines in Cornwall, and we were promised a guide, Dr. Simon Camm, who would show us where the discovery was made.

A train connection out of London took us to Camborne in Cornwall, where our lodging accommodations were graciously set up by the Mining School (Figure 2). We were led into the school museum, where many displays showed the historic tin mining of the area. Tin had been produced in Cornwall since Roman times, when the low draft boats would cruise up the creeks to load up the metal which would be taken back to Italy for use in tools and dining plates. Dr. Camm arrived and introduced him-

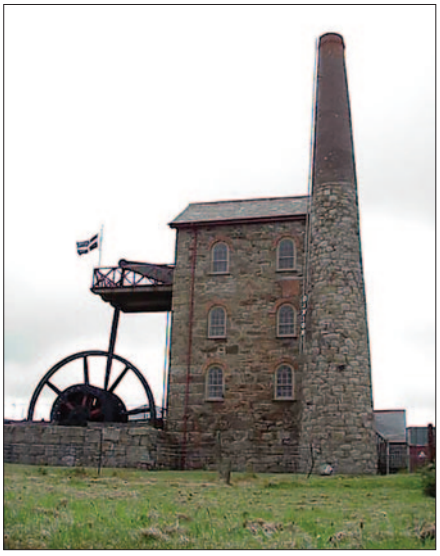


Figure 2. Historic tin mine East Pool Mine (50.171129N 5.126532W near the Camborne School of Mines. The richest ore of tin was cassiterite, SnO_2. This mine dates from the 18th century, furnishing both copper and tin.

self. He was a big, burly jolly man with white hair and mustache. (Figure 3).

Simon was ready to drive us to Manaccan, 20 miles south. "You have your galoshes?" he asked. "We'll be wading through water."

The road was narrow and twisty, wandering through hedges that blocked the view of oncoming traffic. These were the same kind of hedges that Sir Arthur Conan Doyle described in the moors of Devonshire for his Sherlock Holmes story. We passed through villages with strange Cornish names—Gweek, Mawgan, Garras. After one half-hour we broke up on top, to a high plain. A huge green meadow stretched in all directions. "We have arrived at the Lizard Peninsula," said Simon (he pronounced it "Lizz-uhd" without the "r"). "'Lizard has nothing to do with the reptile; it is Cornish



Figure 3. Dr. Simon Camm of the Camborne School of Mines, a world traveler and a jolly guide for our search for titanium.

for 'high court.'" He waved his arm through 180 degrees across the horizon. "This is the Goonhilly plain. Look at the Goonhilly satellite dishes. These received are the first trans-Atlantic television images in 1962." A set of huge dishes, like a row of Dutch windmills broke the horizon, and for good measure, a historic castle was nestled in between two of them.

He stopped the car beside a rock outcropping. It was a huge dark boulder six feet high, encrusted with red and yellow lichens, splotched like a Jackson Pollock painting. We all tumbled out, Jenny with her camera and me with my notepad. "Look at this rock. It's gabbro," Simon said. He scraped off some of the multi-colored lichens to show a coarse-grained balsalt, resembling sandstone, but dark gray in color. "It's part of an ophiolite formation."

Jenny was snapping photos, close-up of the lichens and gray rock. "Ohfy-what?"

"Ophiolite. Part of the Lizard complex. This used to be ocean bottom. This may be the best example of ophiolite in the British Isles. Ophiolite is deep oceanic crust, and sometimes even molten rock below that, the mantle—which has been uplifted to the earth's surface. Quite unusual—usually the mantle stays put, deep down below the surface of the earth."

Simon took out his rock hammer and chiseled out a section. He held up a chunk about the size of silver dollar. "Look at this black vein running through it. This is ilmenite. Iron titanate, $FeTiO_3$." (Figure 4)

"It looks like black marble, that be used for a kitchen counter top," said Jenny.

"Yes," said Simon, this ilmenite would weather away into black sand, and wash downstream—that way," he turned huge frame and



Figure 4. A sample of ilmenite -rich gabbro from the Goonhilly Hills, cut and polished for us by Simon Camm, sent to us later after our return to the U.S. The ilmenite (FeTiO3) is embedded in the gabbro, an igneous rock, similar to basalt, except that it is coarse-grained owing to slow-cooling origin. The ilmenite was leached out over the millennia and washed down to Gillam Creek below, to be discovered by the Parson Gregor.



Figure 5. Jim and Simon panning for ilmenite, using gold pans Simon had used in his prospecting in foreign lands.

pointed to the north. "Down to Gillam Creek, near Menaccan, 2 miles away."

"And that's where Gregor found the black sand, down there," I said.

"Yep. He called it 'black sand which followed the compass,' because it was magnetic."

"But titanium is not magnetic."

"No, but the iron is. Sometimes compounds of iron are magnetic, such as this, or magnetite, Fe_3O_4. You can find magnetite polished into semi-precious stones, perhaps worn as a necklace, in souvenir shops. Other compounds of iron are usually not magnetic, such as ordinary rust, Fe_2O_3."

"Jenny, look," I said, touching this ordinary-looking rock, which to us was precious. "This fills in the gap for element number 22."

Simon looked quizzically, "This rock does?"

"Yes, I said, "our goal—before we finish our long-term Rediscovery project—is to find a sample of every mineral, in which each element was discovered, from the original site."

"That's quite an ambitious project!... Let's drive down to the creek. We'll get you some more 'original material'—the sand that Gregor discovered."

Five minutes later, the road entered a deep ravine, following the creek to the left. Simon found a clearing and parked his car. "Get your galoshes on. We're going wading."

We got out, and Simon opened his boot (British for "automobile trunk") and pulled out a huge pan.

"Going to pan for gold?" I asked, half serious.

Simon grinned. "This indeed is a gold pan, I used it in Africa. But we're going to be panning for black sand!"

We climbed down the mossy bank to the creek below, swirling with algae which waved

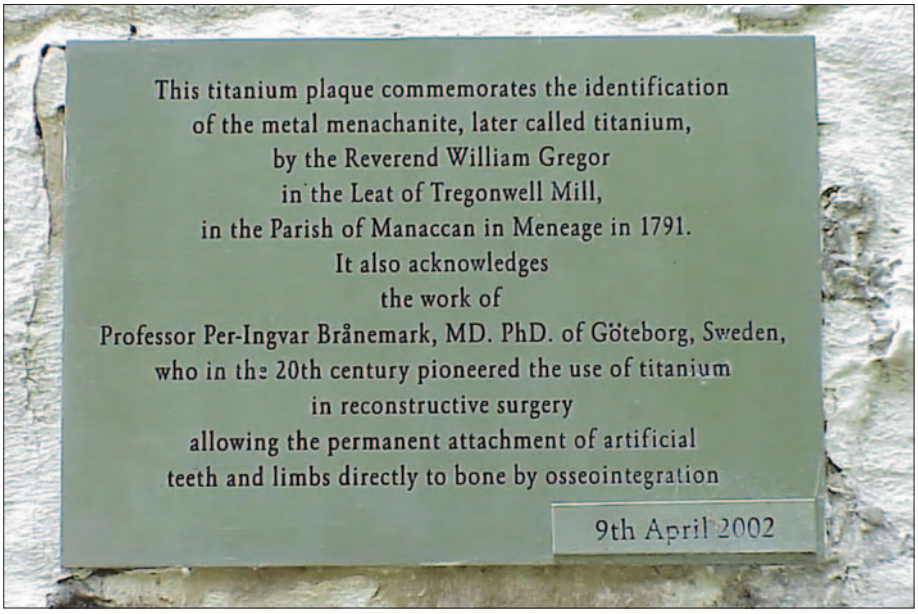


Figure 6. Plaque erected by a joint venture by British and Swedish scientific societies in honor of the discovery of titanium.



Figure 8. Manaccan Church, near Gillam Creek.

in the water like prairie grasses in a storm. He scooped up a shovel full of dirt from the bottom of the creek, plopped in his pan, and swirled slowly and carefully. Jenny and I had done this before, in the mountains mountain streams of Colorado, hunting, unsuccessfully, for tiny flakes of gold. After a moment, a fine black sand settled to the bottom. He continued the process several times and then swished out the top decanter of muddy water, maintaining a black fine residue that resembled gunpowder in the bottom of the pan. (Figure 5).

"Let's try out the magnet!" I said.

Jenny perked up. "Oh! My job!" She dug in her pouch in another pocket and pulled out a gray metallic ingot, the size and shape of a sugar cube.

"What kind of magnet is that?" Asked Simon

"Neodymium-boron-iron."

Simon nodded appreciatively. He knew that this was the most powerful permanent magnet material available (today, nickel-plated magnets may be purchased, far superior to the usual refrigerator magnets; they will hold up many times their weight).

Jenny passed the magnet over the bottom of the pan. The black sand was immediately picked up. Carefully, we separated the black sand, bit by bit, and deposited in a glass vial (which Jenny pit in another pouch).

"It's not as magnetic as iron filings," I observed "But it definitely 'follows the compass.'"

Jenny was beaming. "And now we have titanium covered!"



Figure 7. This is an artist's impression of Tregonwell Mill at the time of Gregor's discovery (Lt. Commander John Whale, 2001). It was used to grind corn, as were several other mills along Gillan Creek. The surrounding hills are cleared of trees, in contrast to the wooded appearance today; otherwise, the overall scene is much the same today. Courtesy, John Whale.

We wandered around the creek for about an hour. Simon was explaining what the original system was: a water wheel turning by a narrow channel—called a "leat"—with flowing water from Gillam Creek. The waterwheel was an "overshoot," meaning the water fed from the top, rather than from the bottom. The mill was used to grind corn. Gregor supposedly found his "black sand" in the leat, just below the water wheel. He bagged a handful to take with him back to his home laboratory, and found a new substance, which was called "menachinite," then later formally baptized with the name titanium by arguably the famous analytical chemist at the time, Heinrich Martin Klaproth of Berlin.

Beside the creek was a historic millhouse, a two-story white-washed brick building with a slate roof dating from the 1600s. A sign in front

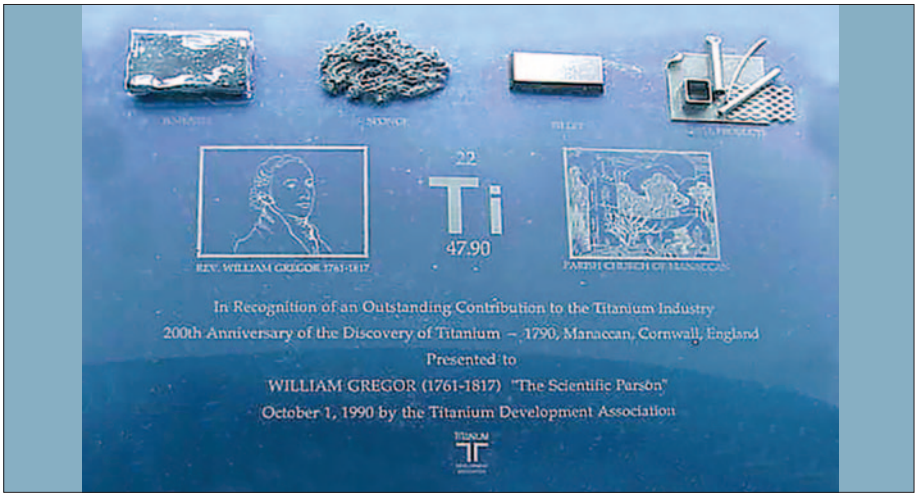


Figure 9. In the back of the church on a table was this plaque commemorating the discovery of titanium by Gregor. At the top of the plaque were samples of titanium in various stamped, crystalline, and ingot forms; as well as an engraving of Gregor's portrait and the scene of the Manaccan Church.

advertised, "Tregonwell Mill. Eggs for sale. Range chickens." On the side of the building a plaque had been erected. "It was placed here last year," said Simon. (Figure 6). "There was a special ceremony with several dignitaries from Sweden and the British Royal Society of Medicine."

Meanwhile, Jenny, noticed a lad with manure-encrusted boots, tight breeches and an open white blouse, who had been leaning against the adjacent building, curiously watching us.

Jenny said, "I'll go meet him. He may tell us something. Looks like he's in charge of the place."

That was like her; she could talk to anybody, make friends with everybody. In a jiffy she was chatting away with the young man. I drifted over, to hear him saying, "It looked much different then. See those hills up there, stretching up towards Goonhilly? Today it's full of trees, but in the days of Gregor, they weren't there. They were plowed for growing wheat. Horses could do the job. Today they use tractors, but they would tilt over, can't plow. So they quit growing wheat. The trees grew back." (Figure 7)

Simon said, "let's go up to the church." It was about ¼ mile up the hill. Built of stone, it dated from the 12th century. As all churches of the era, it was Norman. A fig tree, 250 years old, grew out of the side of the church. (Figure 8).

Jenny was always somber when entering a church. Beautiful stain-glass windows graced the walls that faced the sun. On another wall was a picture frame of what looked like the text of a poem. Its title was "Pader Agan Arluth."

"What's this?" she asked.

Simon answered, "The Lord's Prayer. In Cornish."

"How beautiful!" she said. She touched the frame gently. She tenderly traced the Cornish words with her fingertips: "*Agan Tas-ny, us yn nef, Benygys re bo dha Hanow, Re dheffo dha wiacor, Dha voth re bo gwres, y'n nor kepar hag y'n nef; Ro gaf dhyn agan camwyth, Kepar del avennyny dhe'n re-na us ow camwul er agan pyn-ny; Ha na wra agan gorra yn temptasyon, Mess delyrf ny dworth drok. Rag dhyso-jy an walscor, ha'n gallos, ha'n gordhyans Bys vyken ha bynary. Amen*"

Jenny whispered, "God exists everywhere, doesn't He." She turned to me. "I love it here!"

Simon said, "Come over here, I have something to show you." In a corner was a plaque commemorating Gregor's discovery. (Figure 9). After a moment, he said, "Hungry and thirsty? Let's go visit a local inn."

A couple of miles away, we stopped at the Gweek Inn, a thatched-roof pub (Figure 10). "This used to be a harbor in Roman days, where the Roman boats would dock," Simon told us. As usual for Great Britain, the pub was family oriented and offered delicious fish and chips, as well as the local brew.

"We are so grateful of all you have done for us today," I said. "I wish there was something I could do."

Simon shifted his weighty frame toward me and said, "There is. See that Levi jacket you have on?"

"This thing? Yes, I have worn it many times out West, hiked the Grand Canyon in it, worn it in Texas to keep off both the dust and the rain."

"You don't use an umbrella in Texas?" Simon raised his bushy eyebrows and mustache simultaneously.

"Hardly. This denim keeps off a brief shower. It doesn't rain all day in Texas."

"Well. I could use one of these. I travel to many countries. Egypt. Pakistan. I would like to get one. It's what I need for the sand and wind. Just like Texas."



Figure 10. The New Pub in Gweek, Cornwall. Thatched-roof houses are common in this part of Cornwall.

I took off the jacket. "See if it fits?"

Jenny said, "Oh, Jimmy, he's two sizes bigger than you!"

"Then I'll send you one!" I promised. I turned to Jenny, "Could you take his measurements?"

"Stand up and turn around," she commanded. She measured his broad shoulders with her tiny palms, then said, "You're just like Daddy. Okay, I've got it. You're the size of the pony I once had!"

We spent another hour nursing bitters and lagers, talking about geology and mineralogy, what the landscape looked like some 400 million years ago when the Lizard Peninsula was deep down, literally miles below, touching the mantle of our planet—and how the gabbro and ilmenite were formed in the molten magmas. . . . accompanied by not only tin lodes, but also gold deposits, allowing some lucky Cornish prospectors to gain fortunes, while others went broke. . . .

Two weeks later, when we arrived in Texas, Jenny and I visited the Western Store in Denton, Texas, and bought an XL Denim jacket, and mailed it to Simon at Cambourne. And in our Living Periodic Table shelf, under element 22, we proudly display a bottle of "the black sand that follows the compass" that we collected from a Gillam Creek, as well as the specimen of ilmenite-infused gabbro Simon mailed to us. (Figure 4). ⬡

References

1. More technical details regarding Gregor, titanium, and the authors' visit to Manaccan are available in J. L. and V. R. Marshall, *The Hexagon of Alpha Chi Sigma*, **2001**, *92(1)* 4–5.