WHEN JULES VERNE BECAME A GEOLOGIST

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Since their publication, the novels of Jules Verne (1828–1905) have gained popularity worldwide and been translated into many languages. Allusions to some of Verne's texts are often found in the introductions of scientific articles or books within the fields of geology, oceanography, or geography. However, prior to becoming a writer of poetry, plays, and adventure novels, the man wrongly coined "the father of science fiction" had studied law. To lend realism to his *Voyages Extraordinaires*, Verne regularly and extensively read scientific, geographical, and technical literature and took copious notes, enabling him to extrapolate the latest discoveries without actually being an "anticipator." Had Verne lived in a later time period, he would certainly have read this issue of *Elements* for ideas to use in his novels. Jules Verne's voyages on land, under the sea, and in the depths of the Earth were an opportunity for the writer to present to his readers what was then known about the history of the Earth, to discuss the formation of coal and similar topics, while developing his favorite geographical themes: islands, caverns, and volcanoes.

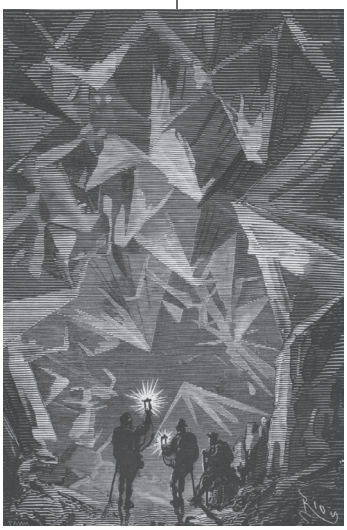

Figure 1 Explorers in Voyage au Centre de la Terre imagine themselves traveling inside a diamond.

Among his many works, *Voyage au Centre de la Terre* (1864; *Journey to the Center of the Earth*) is undoubtedly the most geological. Its hero is Professor Otto Lidenbrock, author of a *Treatise on Transcendental Crystallography*, "a true scientist" who "combined the genius of the geologist with the eye of the mineralogist." Professor Lidenbrock leads his nephew Axel on a journey into the depths of Earth in the footsteps of a medieval alchemist. After entering the bowels of the Earth through the crater of the extinct volcano Sneffels on Iceland, they emerge in Italy with a lava flow from Stromboli...

This expedition is an opportunity (for the scientist character, as well as for the novelist) to educate the reader in the theories of Humphry Davy and, in particular, to detail the various hypotheses that were current at the time about volcanoes and the first ages of the Earth, with the appearance of water, and then life, on our planet (Breyer and Butcher 2003). Thus, Professor Lidenbrock states: "The arrangement of these volcanic soils absolutely supports Davy's theory. We are in the middle of a primordial layer, a layer in which the chemical action of metals, in contact with air and water, ignited; I absolutely reject the system of central heat."

During their underground exploration, something like a course in geology and mineralogy takes place live in front of the travelers (Fig. 1):

> **"As we descended, the succession of layers that make up the primitive terrain became clearer. Geological science regards this primitive terrain as the base of the mineral crust and has recognized that it is composed of three distinct layers, schists, gneisses, and micaschists, resting on that unshakable rock we call granite.**
>
> **Never before had mineralogists met under such marvelous circumstances to study nature in situ. [...]**
>
> **Metallic veins of copper and manganese, with a few traces of platinum and gold, meandered through the shale, colored in beautiful shades of green. [...]**
>
> **The schists were followed by stratiform gneisses, remarkable for the regularity and parallelism of their sheets, then by micaschists arranged in large lamellae, enhanced to the eye by the scintillations of white mica.**
>
> **The light from the lamps, reflected by the small facets of the rock, crossed its fiery jets at every angle, and I imagined I was traveling through a hollow diamond in which the rays broke into a thousand dazzles.**
>
> **Towards six o'clock in the evening, this feast of light diminished perceptibly, almost ceasing; the walls took on a dark, crystallized appearance; the mica mixed more intimately with the feldspar and quartz to form the rock par excellence, the hardest stone of all, the one that, without being crushed by it, supports the four levels of terrain on the globe. We were walled up in the immense prison of granite."**

A later novel published by Verne, *L'Île Mystérieuse* (1874–75; *The Mysterious Island*), includes a surprising and not fully realistic presentation of its geology, especially in such a small area ("the island was about the size of Malta"): "At the sight of those convulsed rocks piled up on the left, a geologist would not have hesitated to ascribe to them a volcanic origin, for they were undoubtedly the product of a plutonic work." But there is also a "black granite" and a mixture of rocks and minerals from different geological eras: "This is iron ore, this is pyrite, this is clay, this is lime, this is coal."

The novel *Les Indes-Noires* (1877; *The Underground City*) focuses on the technology of coal seam exploration and exploitation; in particular, its chapter III, devoted to the underground of Great Britain, describes in detail the origin of coal formation:

> **"The geological edifice in the bowels of the globe is presented in this order: the primitive layer, surmounted by the filling layer, composed of the primary terrains, then the secondary terrains, whose coal deposits occupy the lower stage, then the tertiary terrains, and above, the terrain of ancient and modern alluvium.**
>
> **At that time, the waters, which had no bed to hold them back, and which condensed all over the globe, rushed down and stripped the barely formed rocks of what they needed to form shale, sandstone, and limestone. They reached the peat bogs and deposited the elements of these layers, which then overlay the coal fields. Over time – periods of millions of years – these soils hardened and layered, enclosing the entire mass of peat forests under a thick carapace of conglomerates, shales, compact or crumbly sandstones, gravel and pebbles.**
>
> **What was happening in this gigantic crucible, where plant matter accumulated at different depths? A real chemical process, a kind of distillation. All the carbon contained in these plants was agglomerated and, little by little, coal was formed under the double influence of the enormous pressure and the high temperature provided by the internal fires that were then so close.**
>
> **Thus, in this slow but irresistible reaction, one kingdom replaced the other. The vegetable was transformed into the mineral.**
>
> **[...] In the lowest layers of the coalfield we find anthracite, which, being almost entirely free of volatile matter, contains the greatest amount of carbon. In the highest layers, on the other hand, we find lignite and fossil wood, substances in which the amount of carbon is infinitely less. Between these two layers, depending on the degree of pressure they have undergone, we find veins of graphite and fat or lean coals."**

Throughout this novel, we also see descriptions of mining techniques in deep galleries and surface equipment. Production and consumption figures are given, and the characters worry about the overconsumption of coal linked to the development of the steam engine and its uses. The fear of the resource running out is clearly expressed in a dialogue between young Harry and engineer Starr:

> **"– [...] it's a pity that the whole globe wasn't made of coal! It would have taken millions of years!**
>
> **– No doubt, Harry, but you have to admit that nature had the foresight to form our spheroid mainly of sandstone, limestone, granite, which fire cannot consume!**
>
> **– Are you saying, Mr. Starr, that man would have burned his globe in the end?**
>
> **– Yes, all of it, my boy, the engineer replied. The Earth would have been burned to a crisp in the furnaces of locomotives, steamers, and gas works, and that's how our world would have ended one fine day!**
>
> **– You don't have to worry about that anymore, Mr. Starr. But then again, the coal mines will probably run out faster than the statistics show!**

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– It will happen, Harry, [...] I'm well aware, the engineer added, that neither hydraulics nor electricity have had their last word, and that these two forces will one day be used to a greater extent. But no matter! Coal is very practical and easily adapted to the various needs of industry! Unfortunately, humans can't produce it at will! While the outer forests are constantly growing back under the influence of heat and water, the inner forests are not reproducing, and the globe will never find itself in the right conditions to replant them!"

Similar reflections can be found in *Voyage au Centre de la Terre* ("Thus were formed these immense layers of coal which, however, excessive consumption will have to exhaust in less than three centuries if the industrial peoples are not careful") and in *L'Île Mystérieuse*:

"[...] This whole industrial and commercial movement, which you predict will go on steadily, isn't it in danger of being completely stopped sooner or later?

– Stopped! And by what?

– By the lack of coal, which can rightly be called the most precious of all minerals!"

But fortunately, Jules Verne had an alternative solution, outlined in a further discussion between the characters of *L'Île Mystérieuse*: "When the coal deposits are exhausted, we will heat and be heated with water. Water is the coal of the future." In fact, it is explained that it will be:

"water broken down into its constituent elements, [...] and broken down, no doubt, by electricity, which will then have become a powerful and manageable force, for all great discoveries, by some inexplicable law, seem to coincide and complete at the same moment. [...] Water will one day be used as a fuel, and the hydrogen and oxygen of which it is composed, used separately or simultaneously, will provide an inexhaustible source of heat and light of an intensity that coal could never have."

However, this approach requires a high consumption of electricity, which we can imagine to be what powers Captain Nemo's submarine Nautilus, enabling him to travel in *Vingt Mille Lieues Sous les Mers* (1869–1870; *Twenty Thousand Leagues Under the Sea*) and which is mysteriously presented as "not everyone's"!

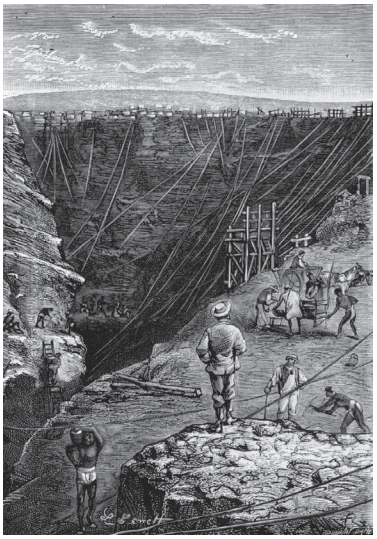

Figure 2 Diamond mining in South Africa (from *L'Étoile du Sud*).

Figure 3 By the Lidenbrock sea (from *Voyage au Centre de la Terre*).

The artificial synthesis of diamonds was attempted in his own successful way by Cyprien Méré, a young French geologist working in the diamond fields of South Africa. In *L'Étoile du Sud* (1884; *The Southern Star*), a novel that is less well known than the others mentioned above, Verne presents an original theory of diamond formation from solutions based on an analogy with solfataras:

"Who knows, Cyprien thought, if diamond deposits are not true carbon-ataras? Since a mixture of hydrogen and carbon necessarily arrives there with the water and the alluvial deposits in the form of marsh gas, why shouldn't it be the oxidation of the hydrogen, combined with the partial oxidation of the carbon, which would cause the crystallization of the excess carbon?"

and elsewhere he added:

"The only explanation that satisfies me, if not completely, at least to some extent, is that of the transport of the elements of the gemstone by the water and the subsequent formation of the crystal in situ."

His "theory of adamantine formations" was confirmed when he entered a "marvelous grotto," an "immense crypt" containing "diamonds, rubies, and sapphires" naturally formed by crystallization.

Several times in the novel, the nature of diamonds is discussed ("Diamonds [...] are simply pure carbon. It is a fragment of crystallized coal, nothing more.") and its extraction in volcanic chimneys (Fig. 2), as well as the cutting techniques that make it shine: "Its transparency, its brilliance when it has been cut in such a way as to refract the light, the very difficulty of this cut and, finally, its extreme hardness make it a really very interesting body for the scientist and, I would add, very useful for industry."

After the discovery and characterization of a hydrous ringwoodite present as an inclusion in a diamond from the deep mantle, Nestola and Smyth (2016) noted that if the water found in this ringwoodite is representative of this region of the Earth's mantle, "it would constitute about 2.5 times the total water of all oceans around the world, and this could have a strong impact on global Earth's water cycle", in line with previous estimates by Keppler (2014). Thus, as quoted by these researchers, the existence of a subterranean ocean discovered by the heroes of *Voyage au Centre de la Terre* (Fig. 3) would not be totally impossible—except that it would involve OH groups and not H_2O molecules! The Earth's deep water cycle and hydrogen storage over geologic time are discussed throughout this issue of *Elements*.

In recognition of Verne's popular promotion of geological and mineral sciences with the general public, the name *Verneite* was recently given to a new mineral found in fumaroles of both the ancient volcano Hekla (Iceland) and of Vesuvius (Italy) (Balić-Žunić et al. 2018), i.e., close to the places where the *Voyage au Centre de la Terre* novel begins and ends: A fine accolade for the author of numerous geological novels! Several other novels by Jules Verne, not mentioned here, evoke remarkable geological formations, mining operations, the origin of these minerals, and more. Interested readers are referred to Bollinger (2022) for more information on Jules Verne's geology compared with today's knowledge.

Notes

1. The English translation of the quotes from the novels was done by the author.
2. The illustrations in this article are engravings in the original editions published by Hetzel (Paris), taken from the "Project Jules Verne Illustrations" (collection B. Krauth) www.jules-verne-club.de.

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ABOUT THE AUTHOR

Jean-Claude Bollinger taught environmental chemistry at the Faculty of Sciences, University of Limoges (France), where he is now a professor emeritus. Since his retirement in 2010, he has continued his scientific research, mainly in the field of liquid/solid adsorption modeling and thermodynamics. He is also interested in the interactions between science (especially chemistry and geology) and popular literature, in particular the novels of Jules Verne read through the eyes of present-day science (articles mainly published in French).