What Is The Answer To The Universe, Life, And Everything Else?

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"The Answer to the Great Question... Of Life, the Universe and Everything...

Is... Forty-two," said Deep Thought, with infinite majesty and calm…

"I checked it very thoroughly," said the computer, "and that quite definitely is the answer."

— Douglas Adams, *The Hitchhiker's Guide to the Galaxy*

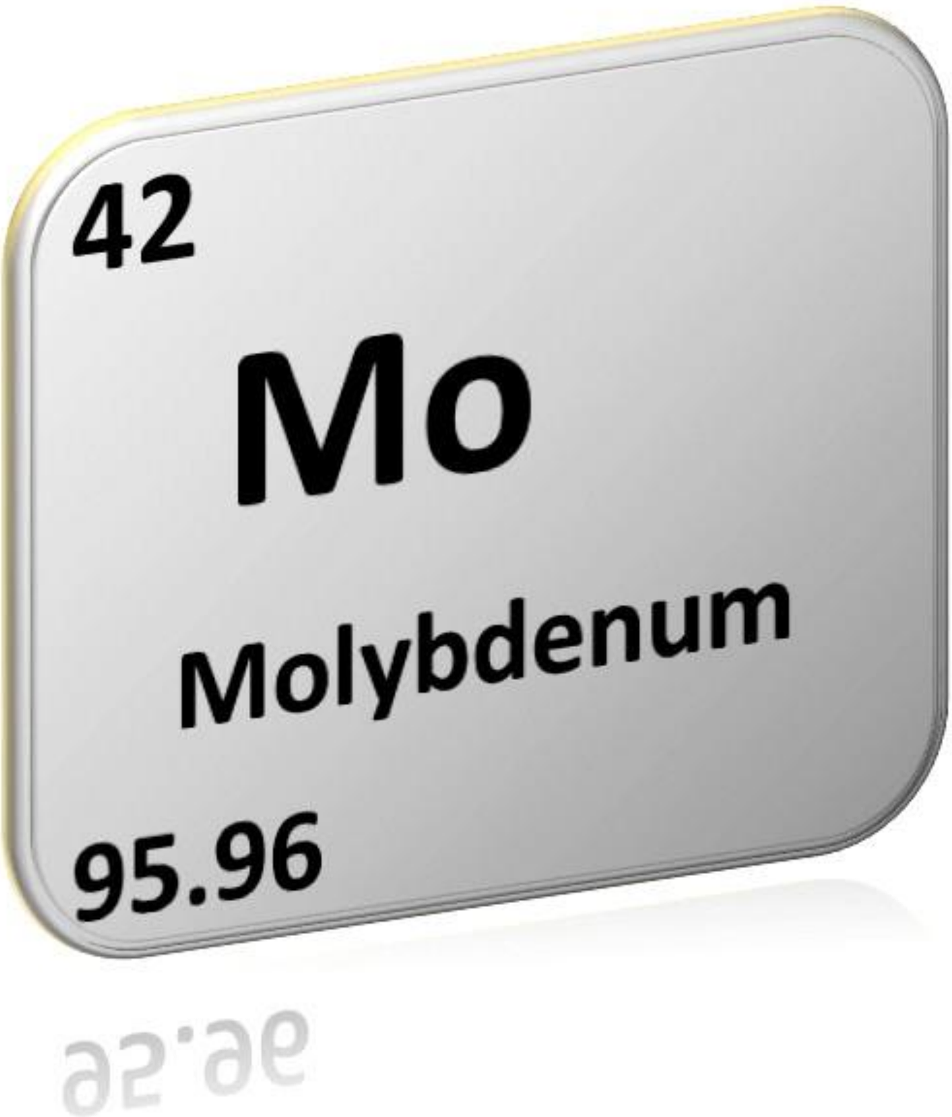
A question that you ask yourself may be and you may have already had the answer in an algorithmic course at university! Isn't it *Loic & Julien*?

"What is the answer to the universe, life, and everything else?
To answer you I call the function that has answer to everything »

https://www.youtube.com/watch?v=VO0OqsH0M3U&list=PLdi5YpL19uBDkRVGWMeZ0ZhtUQKOW-hUZ&index=20

"And the answer is 42!"
42 like molybdenum for a geochemist like me!

Molybdenum, of symbol Mo and atomic number 42 is an element of the periodic table that has unique properties that make it the answer to many questions in the sciences of life and earth and in industry!



In the field of geoscience, the redox sensitivity of Mo makes it particularly useful for answering questions about environmental redox conditions. In particular, it is used as a paleoredox proxy for ocean circulation for more than 30 years.

In the field of life sciences, Mo is a catalyst for many reactions. One of the rare species to fix nitrogen is the bacterium *Azobacter vinelandii* which uses an enzyme called nitrogenase. During the fixation process, the nitrogenase needs iron as well as other elements that catalyze the reaction, such as Mo. Molybdenum is also at the heart of the enzymes of nitrate reduction, which are essential for nitrates assimilation and dissimilar reduction. Therefore, Mo is at the center of the biogeochemical cycle of nitrogen. This biological role combines with its geochemical behavior to be at the heart of the processes responsible for the coevolution of life and the environment.

In industry, Mo is used in various ways as a catalyst, pigment, steel additive and lubricant.

Most of these uses are found in different types of steel, to improve physical properties such as hardness and temperature resistance, as well as chemical properties, including corrosion resistance. More than 230,000 tons are used each year, mainly in China. The porphyritic molybdenum and copper-molybdenum deposits are the most important sources of molybdenite, Mo ore.

Isotopic geochemists have been attracted to Mo because of its biogeochemical and economic importance, and its seven stable isotopes, all of which are relatively abundant (10-25%) and cover a relatively wide mass width. This isotopic tool, which has developed since the 1990s, made it possible to study whether the composition of Mo isotopes varied significantly and whether the fractionation of Mo isotopes could provide new answers to other questions, in particular to the appearance of life on Earth and its first oxidizing events.

It is within this framework that I have been able to work with colleagues from the University of Bern in Switzerland on the impact of the alteration of igneous rocks on the isotopic composition of Mo in streams of the Massif Central.

River waters have shown to be systematically enriched in the heavy Mo isotopes when compared to average crustal rocks (with Mo isotopic compositions, $\delta^{98/95}Mo$, of around 0‰). The cause for heavy riverine $\delta^{98/95}Mo$ signatures is thus argue against weathering of crustal rocks. Incongruent dissolution of primary bedrock is an important process by which the anomalous Mo signatures of the river dissolved load are produced. The effect of igneous crustal rock weathering on the aquatic $\delta^{98/95}Mo$ signal is investigated by comparing stream water and bedrock Mo isotope data to results of bulk rock leach experiments.

We have studied stream water and bedrock (orthogneiss, granite, basalt), as well as soil and vegetation samples in a small catchment in the Massif Central (France). Streams are isotopically heavier (0.5-1.1‰) than the average crustal rocks. This is in agreement with experimental results from leaching of basalt bedrock (0.6-1.0‰) that allow us identify a predominance of basalt weathering over the stream water Mo geochemistry. Other processes (i.e. soil formation, secondary mineral precipitation and surface processes) are subordinate in this catchment. Molybdenum fractionation during basalt incongruent dissolution can explain these isotopically heavy aquatic Mo signatures, especially considering that basalt sample reflects a value typical for crustal magmatic rocks (ca. 0.1‰). Mass balance calculations allow us to identify the rare, but in part highly Mo-enriched sulfide melt, coexisting with the basaltic magma, as a principal Mo source for the leach solutions. Heavier $\delta^{98/95}Mo$ signature is observed for the magmatic sulfides compared to the coexisting silicate melt. It suggests a huge Mo isotope fractionation potential at magmatic temperatures. Incongruent crustal bedrock weathering may consequently cause a preferential release of heavy Mo isotopes. However, this is greatly dependent on the minerals from primary bedrock.

This work was published in the journal Geochimica and Cosmochimica Acta a few years ago.

Voegelin, A.R., Nagler, T.F., Pettke, T., Neubert, N., Steinmann, M., Pourret, O. and Villa, I.M. (2012) The impact of igneous bedrock weathering on the Mo isotopic composition of stream waters: Natural samples and laboratory experiments. Geochim. Cosmochim. Acta 86, 150-165.

https://www.sciencedirect.com/science/article/pii/S0016703712001275