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60 Fifth Avenue  
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March 11, 2016

Re: 9 Deadliest Rocks and Minerals on Earth by Trevor Nace, Forbes Magazine, February 14, 2015

To the Editor,

Trevor Nace's article states that "You have likely heard of the mineral asbestos...." There is no mineral known as asbestos: it is a commercial term applied to a group of six fibrous minerals. Each of the six types of asbestos does have a mineral name - anthophyllite, actinolite, chrysotile, grunerite (known commercially as amosite), riebeckite (known commercially as crocidolite) and tremolite. Five of these minerals can form without the distinguishing character of asbestos - polyfilamentous fiber bundles. To denote one of these five minerals as asbestos, the mineral name should be followed by asbestos, e.g., tremolite asbestos.

The example that Nace presents as the "mineral asbestos" has an elemental composition consistent with chrysotile, one of the six minerals known commercially as asbestos. However, the photomicrograph in the article does not have the most common macroscopic morphology of chrysotile that it grows naturally as cross fibers. In other words, the chrysotile fibers grow in perpendicularly across the millimeter-sized seams found in serpentinite rock. The image shown in Nace's article is not a cross fiber. The appearance is inconsistent with the normal appearance of chrysotile ore.

Chrysotile is one of a group of minerals known as serpentines, while all the other commercial types of asbestos are amphiboles. These five amphiboles have similar crystal structures but differ markedly in elemental composition while the serpentine minerals have markedly different structures but similar elemental compositions.

In the 20th century the commercial asbestos market was dominated by four types of asbestos – amosite, anthophyllite, chrysotile and crocidolite. In the 21st century the only type of asbestos that remains in commercial use is chrysotile, with production in excess of 2 million tons per year. The potency for chrysotile to cause the increased lung cancer and mesothelioma risk Nace mentions is markedly lower than amosite or crocidolite. The use of the term asbestos in the Forbes article does not inform readers about the current situation regarding the commercial use of chrysotile.

Nace's premise that his list comprises the nine deadliest rocks and minerals known leaves the reader with a false impression of their toxicological potential. For example, copper is often described as "essential" as all living things require it. Copper sulfate is given as an example of one of the deadliest minerals. On the contrary, copper sulfate, used as an antibacterial agent, has kept many people alive. The search for antibacterial agents is as old as man and historically the use of copper sulfate as such an agent goes back to the very beginning of medicine. The first scalpels used in early anatomy studies and surgeries were made of copper. Many chemists have used copper sulfate to prevent the development of bacteria in standing water in the laboratory without experiencing any toxicological effects. However, if you dissolve large amounts of copper sulfate in water and drink it you will indeed suffer toxic effects. The same is true of all substances, including essential nutrients. All rocks and minerals have the potential to be deadly if ground to fine powder and inhaled, or dissolved in water and ingested, or

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simply by coming into forcible physical contact with humans and animals. Toxicity depends upon exposure of biota to toxic components of the rocks and minerals, something that is relatively rare in the absence of human intervention by ill-considered mining and exploitation converting rocks and minerals into toxic derivatives.

Thus, we should recognize that deadliness of rocks and minerals, like war, is conferred by the deadliness of the human species, which humorously calls itself *Homo sapiens*, the wise man.

Cordially,

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