ASBESTOS *SANS* MINERALOGY? A VIEW FROM A DIFFERENT HILLTOP

Gregory Meeker

After reading Professor Mickey Gunter's June Triple Point article, I believe a view from a different hilltop might be in order. For the last ten years, most of my work and research has been on asbestos and the public issues surrounding it. My colleagues at the U.S. Geological Survey and I—professionals in the geology of asbestos; in mineralogy, geochemistry and the health effects of minerals; in microanalysis; and in remote sensing—have provided independent scientific assistance to other federal agencies on issues ranging from the Libby, Montana, asbestos Superfund site to the California "naturally occurring asbestos" (NOA) controversy. Throughout this work, we have emphasized the importance of rigorous geoscience and encouraged the use of correct terminology and nomenclature. From this background I would like to provide additional perspective on a few of the issues Professor Gunter has raised.

Mineralogists have not been out of the loop with regard to asbestos issues and policy. In fact, prominent mineralogists have published in the asbestos literature for decades. Mineralogists, along with toxicologists, epidemiologists, physicians, microscopists, attorneys, lobbyists, regulators, judges, elected officials, and corporations, are all responsible for the progress, or lack thereof, in dealing with the very serious issue of asbestos-related disease. The current state of affairs is a result of give-and-take among competing interests in an arena where all voices have been heard.

Gunter takes exception to a recent legal definition of asbestos; but there is more to that story. For over 70 years, the fibrous amphibole that is a major—not trace—constituent in the Vermiculite Mountain vermiculite deposit near Libby, Montana, was called tremolite, sodium-rich tremolite, or sodic tremolite by everyone including the mineralogists and geologists who studied the deposit. During the 1970s, the names of the regulated asbestos minerals, including tremolite asbestos, were entered into the U.S. Code of Federal Regulations. As recent court proceedings have revealed, company geologists, owners, and operators of the vermiculite mine near Libby understood that the asbestiform amphiboles in the mine fell under those regulations. In 1978 and 1997, committees of the International Mineralogical Association published new recommendations for amphibole nomenclature. Based on this new system of nomenclature, most of the amphibole minerals at the Libby mine were reclassified as winchite. When public and regulatory attention returned to Libby in 1999, mineralogists working on behalf of the company that owned the mine used the changes in nomenclature to claim that the majority of the Libby amphibole had been mistakenly identified as tremolite and therefore was not regulated. A federal judge sided with the defense and, based on a 2003 USGS study of the minerals, ruled that only 6 percent of the Libby asbestos was regulated. This ruling was appealed by federal prosecutors who successfully argued that all of the Libby asbestos still fell under the American Chemical Society's Chemical Abstract Service (CAS Registry) general definition of asbestos: a "grayish, non-combustible material [that] consists primarily of impure magnesium silicates." Contrary to Professor Gunter's assertion, mineralogists were not bystanders in this process. Reports by the Subcommittee on Amphiboles of the IMA Commission on New Minerals and Mineral Names[1,2] changed the classification method for amphiboles perhaps without understanding some of the legal and public health consequences. Mineralogists then struggled to explain to regulators and the public why something that had always been called tremolite was now called winchite. Finally, mineralogists helped to construct the legal arguments as to what should and should not be considered a regulated material.

Whether we appreciate it or not, the mineralogical term "asbestiform" is a fundamental part of the legal definition of "asbestos." The Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration regulate only the asbestiform varieties of tremolite, actinolite, riebeckite, cummingtonite, anthophyllite, and chrysotile. However, "asbestiform" describes a crystal growth habit with unique properties such as flexibility and high tensile strength, properties that have never been directly linked to disease. Therefore, using the term "asbestiform" to differentiate a hazardous from a non-hazardous substance has no foundational basis in the medical sciences. Toxicological evidence comparing human and animal health effects of asbestiform and non-asbestiform minerals is based primarily on particle size and shape and remains controversial[3]. In 1992 OSHA made the decision to not regulate cleavage fragments (mineral particles broken along cleavage planes). This decision appeared to open the door for some mineralogists and others to narrow their definition of "asbestiform," thus calling anything that did not meet this narrow definition unregulated cleavage fragments. During the Libby criminal trial, experts for the defense claimed that fibers of Libby asbestos, clearly of respirable size and with aspect ratios of more than 20:1, were not really asbestos fibers. These experts argued that, because the sides of the fibers were stepped or the cross sections of the fibers were prismatic and not round, the material could not be asbestos. Of course, the real issue lost in these arguments is not what fits someone's mineralogical or commercial definition of asbestos, but what is toxic.

Finally, consider the asbestos ban that passed in the Senate of the 110th Congress but died in the House without leaving committee. Several of my USGS colleagues and I were asked to provide technical assistance to both the House and Senate committees working on the bills. Neither bill banned all mineral particles greater than 3:1 in aspect ratio, as Gunter implies. In fact, the only change to minerals regulated in either bill was to add "amphibole asbestos" to the existing list of six asbestos minerals. Nor was the definition of "asbestiform" changed in either bill from what it has been for decades. What the Senate bill did provide was funding for extensive research to investigate the toxicity of elongate mineral particles, with the idea of improving our understanding of the roles morphology and other physical and chemical properties of minerals play in asbestos disease. All stakeholders should enthusiastically welcome such research.

The examples above demonstrate some of the complexities of how multiple, and often opposing, interests have shaped the asbestos landscape, and some of the roles played by mineralogists in the process. The simple fact that asbestos is a natural Earth material does not mean that we as mineralogists own the issues and get to drive the boat. Terminology in the asbestos community serves many purposes and needs. For example, the term "elongate mineral particle" serves to describe a wide variety of minerals that are included in the research agenda of the National Institute for Occupational Safety and Health. The term was never intended as a substitute for more specific mineralogical terminology and was not intended for regulatory language. As mineralogists and geologists, we must understand that exposure to airborne asbestos is primarily an occupational, environmental, and public health issue. The job of Earth scientists is not to decide what is toxic; our job is to assist the health community and regulators by carefully describing the physical and chemical properties of natural materials, understanding their occurrence, and providing scientifically rigorous terminology when needed. If, in this multidisciplinary process, terms appear that we would not normally use, such as "naturally occurring asbestos," we should be somewhat tolerant and understand that we are all trying to reach the same goal: preventing unnecessary future suffering and death from asbestos-related disease.

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Mickey Gunter's response on page 270

[1] Leake BE (1978) Canadian Mineralogist 16: 501-520

[2] Leake BE et al. (1997) Canadian Mineralogist 35: 219-246

[3] www.cdc.gov/niosh/docket/pdfs/NIOSH-099b/099B-040109AsbestosNAReviewDoc.pdf

2009 AGU VGP FELLOWS

Congratulations to the 2009 Fellows of the American Geophysical Union (Volcanology, Geochemistry, and Petrology Division):

JAY D. BASS

For his pioneering work using Brillouin spectroscopy to study the elasticity of Earth materials and applying these data to understand the internal structure of Earth

IAN H. CAMPBELL

For his seminal insights into mantle plumes, the dynamics of layered igneous intrusions, the genesis of platinum and related ores, and the development of continental crust

KATHARINE V. CASHMAN

For developing tools to quantitatively characterize volcanic rock textures and for using textural measurements to elucidate the dynamics of magma transport and eruption

DONALD B. DINGWELL

For research leading to a thorough and deep appreciation of the physics and chemistry of magma rheology and volcanic eruptions, thereby replacing an empirical approach to these processes

STEVEN L. GOLDSTEIN

For seminal studies using radiogenic isotopes in sediments and igneous rocks to trace the evolution of the Earth's crust and mantle as well as paleo-ocean circulation

KEY HIROSE

For his groundbreaking contributions to our understanding of the Earth's lowermost mantle and for the discovery of the post-perovskite phase transition

JONATHAN P. PATCHETT

For his pioneering work in the application of Hf isotope geochemistry to the geosciences and for contributions to our understanding of the origin and growth of continental crust

FREDERICK J. RYERSON

For his contributions to our understanding of transport processes in minerals, magmas, and crustal rocks at all scales

RICHARD J. WALKER

For developing the Re–Os isotope system into a useful tool and applying it to achieve fundamental discoveries in a wide range of topics in the Earth and planetary sciences

EMU RESEARCH EXCELLENCE MEDAL TO ANDERS MEIBOM

The European Mineralogical Union Research Excellence Medal is awarded annually to young scientists who have made significant contributions to research and are active in strengthening European scientific links. The EMU medallist committee has awarded the 2008 silver medal to Anders Meibom. Born in 1969, he obtained a PhD in physics at the University of Odense in 1997 and then held a postdoctoral position at the Institute for Geophysics and Planetology at the University of Hawai'i. Since 2005, he has been a member of the team at the Laboratoire de Minéralogie et Cosmochimie at the Museum National d'Histoire Naturelle in Paris.

EMU's President Roberta Oberti awarding the EMU Research Excellence Medal to Anders Meibom

Ander's main interest is cosmochemistry. He is involved in a number of international projects and networks aimed at investigating the anatomy of primitive solar system materials, including early isotopic fingerprints. Anders takes part in interdisciplinary research merging biology, geochemistry, and mineralogy to better understand biomineralization and past climate change. Expeditions to recover meteorites have taken him around the world, from Greenland to Antarctica. The remarkable results from his work are related to the understanding of extraterrestrial materials and the early Earth. He is also interested in modelling thermodynamic and kinetic processes. He has published more than 70 papers in international peer-review journals and more than 100 abstracts from national and international meetings and conferences.

Anders Meibom is an excellent lecturer and a very enthusiastic and generous collaborator. He is regularly invited to give talks at international meetings and universities worldwide. He is currently an associate editor of *Geochimica et Cosmochimica Acta* and serves on the committee of the Meteoritical Society. For the relevance and international dimension of his work, Anders Meibom is a highly deserving recipient of the EMU Research Excellence Medal for 2008. His talk "NanoSIMS on Carbonates: From the Solar Nebula to the Modern Coral Reef" was given during the 2009 EGU meeting.

ASBESTOS *SANS* MINERALOGY? A VIEW FROM A DIFFERENT HILLTOP – *Mickey Gunter's response*

Greg Meeker's response (page 269, this issue) to my article "Asbestos *Sans* Mineralogy" (*Elements* 5: 141) provides much needed insight into ongoing asbestos issues (i.e. the unintended consequences of changes in mineral nomenclature). My intention in writing the article was to point out what I think should shock any mineralogist: mainly, a "new legal definition of asbestos" that did not include the word mineral, and the misuse of mineralogical nomenclature.

I stated that the vermiculite ore at Libby contains "trace" amounts of amphibole; Greg states that the Libby deposit contains "major" amounts of "fibrous amphiboles." Greg has defined "trace" as less than 5% and "major" as greater than 25% (Meeker et al. 2003), and he showed that samples the USGS collected at the mine all contained amphiboles as a major component; but these samples were collected in amphibole-rich areas, not in vermiculite ore. From our work (Gunter et al. 2007), we showed that the amphibole content of products produced from the ore was less than 1%, and we also showed that only a portion of the amphiboles is asbestiform. Our unpublished results indicate that tailings contain around 5% amphiboles. We know that many amphiboles in Libby soils did not originate from the vermiculite mine (Gunter and Sanchez 2009). This case points out the need for thorough, unbiased characterization of minerals by professional mineralogists.

I stated that the Ban Asbestos bills would define asbestos as having an aspect ratio of 3:1 or greater. As might be guessed, there is more to this story. If you read these bills (House bill: www.govtrack.us/congress/billtext.xpd?bill=h110-6903; Senate bill: www.govtrack.us/congress/billtext.xpd?bill=s110-742), you will see they refer to other documents to define asbestos, and if you track through all of them you end up with the definition being chrysotile, crocidolite, amosite, and the asbestiform habit of of the minerals actinolite, anthophyllite, and tremolite. From Greg's point of view, the "door was opened" to

Cont'd on page 329

Société Française de Minéralogie et de Cristallographie

www.sfmc-fr.org

SFMC AND GFA AT THE XIV INTERNATIONAL CLAY CONFERENCE

Many members of the SFMC and the Groupe Français des Argiles (GFA) attended the 14th AIPEA meeting, the largest ever held, in Castellaneta Marina (Italy), in a beautiful and peaceful Aleppo pinewood and close to Unesco world heritage sites. In this exquisite sunny environment, delegates had the opportunity over a full week (14–20 June) to participate in exciting scientific exchanges (1028 contributions from 50 countries) and to experience the wines, cooking, villages, dances and tarantellas typical of the region. For the success of the conference highlighting the vitality of the clay community, Professor Saverio Fiore (CNR, Tito Scalo) and his efficient and welcoming team are warmly thanked. For more meeting information and photographic reports, visit www.14icc.org/index.html and see meeting report on next page.

SFMC and GFA participants at the XIV International Clay Conference
Photo credit J. Brendlé

MEETINGS ANNOUNCEMENTS

LE VERRE, les enjeux de la recherche

The "Days of the Glass Science and Technologies Union" event will be held at the Polytech'Orléans, at the University of Orléans (France), on 5–6 November 2009. The event is jointly organized by René Vacher (LCVN, Montpellier), Pernette Barlier (Corning, Avon), Daniel R. Neuville (IPG, Paris), Patrick Echegut (CEMHTI, Orléans) and Dominique Massiot (CEMHTI, Orléans), and will be held under the auspices of the CNRS and of several glass industry companies.

Three posters sessions and ten keynote lectures will cover a wide range of topics, including Silicate melts simulation (W. Kob, LCVN, Montpellier); Exotic glasses (J. Lucas, Rennes); Glasses for fibers and amplifiers (E. Burov, Draka); Vitroceramics (M. Comte, Corning); Physics of glasses and liquids (P. Richet, IPG Paris); SiO_2 and B_2O_3: Peculiar glasses (A. Takada, Asahi Glass Company); Technologies and inventions (H. Arribart, Saint-Gobain); Nuclear wastes, success and challenges (A. Ledieu, CEA); Heavy metals and release in glass containers: A statistical survey 1974–2008 (N. Favaro, Stazione Sperimentale del Vetro); and Sub-nanometric scale of glass structure: Topologic or chemical disorder (D. Massiot, Orléans).

For information, contact Daniel Neuville (neuville@ipgp.jussieu.fr) or visit **http://verre2009.cnrs-orleans.fr/**.

Cont'd from page 270

ASBESTOS *SANS* MINERALOGY? A VIEW FROM A DIFFERENT HILLTOP – *Mickey Gunter's response*

narrow the definition of asbestiform when the Occupational Safety and Health Administration (OSHA) did not regulate cleavage fragments. From my point of view, the "door was closed" on using a broader definition. Even though I am very aware the term "elongated mineral particle" is not the new definition for asbestos, it is my opinion that we are headed in that direction. Greg also commented on the use, during the Libby trial, of methods other than aspect ratio to determine if a particle really is a fiber and not an elongated crystal fragment. Strohmeier et al. (2007) discussed established criteria for distinguishing a fiber from a fragment of amphibole, and one criterion to indicate the particle is a single crystal fragment is stepped sides. So, in the end, we always seem to fall back on aspect ratio to distinguish fibers from fragments of amphiboles.

One of our most important concerns should be with human exposure to potentially harmful materials. The refereed literature indicates exposure to non-asbestiform amphiboles is less harmful than to asbestiform amphiboles. In fact, this is why OSHA regulates only asbestiform amphiboles. Gunter et al. (2007) reviewed the literature in this field, and interested readers should refer to three recent articles published by other authors in the *Journal of Regulatory Toxicology and Pharmacology* (2008, volume 52, pp S154-S186, S187-S199, S200-S203), which come to similar conclusions.

Greg and I disagree on many things—from the recent legal definition of asbestos to the amount of "tolerance" we should have for the misuse of mineralogical nomenclature. I remain steadfast in not accepting the phrase "naturally occurring asbestos," which appears to be derived from the popular media. Regardless, I hope Greg and others interested in these issues will attend and contribute to our upcoming symposium "Asbestos Issues: Past, Present, and Future" at the combined Northeast/Southeast sectional GSA meeting in Baltimore (March, 2010). I, for one, would like to get off the "hilltop" and enjoy a more harmonious life down in the valley.

Gunter ME, Sanchez MS (2009) Amphibole forensics: Using the composition of amphiboles to determine their source, the Libby, Montana example. American Mineralogist 94: 837-840

Gunter ME, Belluso E, Mottana A (2007) Amphiboles: Environmental and health concerns. In: Hawthorne FC, Oberti R, Della Ventura G, Mottana A (eds) Amphiboles: Crystal Chemistry, Occurrences, and Health Concerns. Reviews in Mineralogy & Geochemistry 67, Mineralogical Society of America, Chantilly, VA, pp 453-516

Meeker GP, Bern AM, Brownfield IK, Lowers HA, Sutley SJ, Hoefen TM, Vance JS (2003) The composition and morphology of amphibole from the Rainy Creek Complex, near Libby, Montana. American Mineralogist 88: 1955-1969

Strohmeier BR, Bunker KL, Harris KE, Hoch R, Lee RJ (2007) Complementary TEM and FESEM characterization of amphibole particles in mixed mineral dust from Libby, Montana, U.S.A. The Microscope 55: 173-188