

Particles, fragments, fibers: what IARC missed in its assessment of talc mineralogy. (Authors' reply to Comment on ["The IARC re-classification of talc carcinogenicity: a move in the wrong direction?"])

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Particles, fragments, fibers: what IARC missed in its assessment of talc mineralogy. (Authors' reply to Comment on ["The IARC re-classification of talc carcinogenicity: a move in the wrong direction?"])

ABSTRACT

This short communication is a response to the Letter to the Editor submitted by Alessandro Gualtieri (2026, forthcoming) entitled—Comments on the article “The IARC re-classification of talc carcinogenicity: a move in the wrong direction?” by A.A. Korchevskiy and A.G. Wylie (Crit Rev Toxicol. 55(9):867–889). The response argues that the definitions of the terms “asbestos”, “asbestiform”, and “fibrous” in the IARC Monograph, Volume 136 on talc do not consider recent advances in mineralogical science and may lead to contradictions in interpreting information for toxicological assessment.

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Dear Editor,

With much interest we read the letter from Alessandro Gualtieri (2026) (forthcoming) responding to our paper published in *Critical Reviews in Toxicology* (Korchevskiy and Wylie 2025a). We agree with Dr. Gualtieri that much of our disagreement with the mineralogical analysis of talc deposits published in the IARC Monograph, Volume 136 (IARC 2025) stems from differences in definitions. However, we must reemphasize that in our opinion Dr. Gualtieri employed the definitions of such terms as “asbestos”, “asbestiform”, and “fibrous”, significantly differently not only from scientifically based mineralogical literature, but also from IARC’s own published definitions. We also think it is essential that before a talc deposit is declared possibly or probably contaminated by a carcinogen, there should be direct evidence for it, so as not to misinterpret the mineralogy of talc exposures. For these reasons, we continue to question the reliability of the data in IARC Table 1.1 (IARC 2025).

In Table 1, we listed four definitions of “asbestos” and “asbestiform”. The first was utilized by IARC in the Monograph on Asbestos, Volume 100c (IARC 2012); the second is from our paper (Korchevskiy and Wylie 2025a); the third is from the IARC (2025) talc Monograph; and the fourth is from the Letter to the Editor by Dr. Gualtieri.

Dr. Gualtieri stated that his definition of asbestos is “adopted in IARC Volume 136”. It is obvious, however, that the definitions are different. We could not find any reference in this volume that would replicate Gualtieri’s definition.

At the same time, as it is easy to see, the definitions of asbestos-related terms in our paper are consistent with IARC Monographs on asbestos (IARC 2012). In our version of the definitions (developed and discussed in Chapter 1 of our recent book; Korchevskiy and Wylie 2026), we followed mineralogical terminology by stating that “asbestos” is a commercial term applied to several asbestiform minerals that have been mined and used worldwide for their unique (and rare) properties; “asbestiform” is the specific habit of asbestos characterized by polyfilamentous bundles of very narrow

fibrils. “Asbestiform” is an essential characteristic of asbestos. We agree with IARC (2012) which only assessed asbestos for carcinogenicity. The particles with “non-asbestiform” habit were mentioned as a fully different subtype of elongate structures and “cleavage fragments” as the most wide-spread non-asbestiform type of mineral particle.

However, definitions from both IARC (2025) and the Letter by Dr. Gualtieri seem not to be justified. Without foundation, the “updated” definition of asbestos in IARC talc Monograph (IARC 2025) equates the “fibrous” and “asbestiform” habits of minerals. This position is not supported by regularized mineralogical terminology. “Fibrous” and “asbestiform” are not interchangeable terms. In particular, the National Research Council (NRC 1984) stated that “asbestiform” is a special type of fibrosity and the term fibrous may be applied to asbestiform minerals, but also to others, like pseudomorphic fibrous quartz. As Veblen and Wylie wrote in 1993, asbestiform minerals are fibrous, but not all fibrous minerals are asbestiform (Veblen and Wylie 1993).

Nevertheless, Dr. Gualtieri suggested that “any fibre (not necessarily asbestiform) of one of the 6 asbestos minerals can be classified as ‘asbestos’”, where the term “fibre” refers to particles with length $\geq 5 \mu\text{m}$ and width $< 3 \mu\text{m}$. This statement shows what contradictions can be produced by this new attempt to re-define asbestos. With the approach of Dr. Gualtieri, there is a “non-asbestiform asbestos”, which is nonsensical, deeply confusing, and has no support from mineralogical, epidemiological, or toxicological science.

Remarkably, Dr. Gualtieri suggested in his Letter that “classification of regulated (respirable) carcinogenic fibres is based on their (fibrous) shape and size (particle length $L \geq 5 \mu\text{m}$ long, particle width $W < 3 \mu\text{m}$, and aspect ratio $L:D \geq 3:1$)... and not on whether they are asbestiform”. Dr. Gualtieri referenced here the World Health Organization (WHO) method for determination of airborne fiber number concentration by phase-contrast microscopy from 1997. This method does not distinguish various habits of particles, nor does it detect differences between asbestos and particles from other mineral types (like silicon carbide). WHO (1997)

Table 1. The definitions of the term “asbestos” and “asbestiform” from several sources.

IARC (2012)	Korchevskiy and Wylie (2025a)	IARC (2025)	Gualtieri (2026) (forthcoming)
The terms ‘asbestos’ or ‘asbestiform minerals’ refer only to those silicate minerals that occur in polyfilamentous bundles, and that are composed of extremely flexible fibres with a relatively small diameter and a large length. These fibre bundles have splaying ends, and the fibres are easily separated from one another.* Asbestos minerals with crystals that grow in two or three dimensions and that cleave into fragments, rather than breaking into fibrils, are classified as silicate minerals with a ‘non-asbestiform’ habit. These minerals may have the same chemical formula as the ‘asbestiform’ variety.†	Asbestos is a commercial term defining six minerals: chrysotile, grunerite (amosite), tremolite, anthophyllite, riebeckite (crocidolite), and actinolite in their asbestiform habit of formation. The term asbestiform refers to a naturally occurring, polyfilamentous growth habit of minerals in which fibers are formed of parallel fibrils (single crystals) in bundles that can be separated into smaller fibers and fibrils with hand pressure. Asbestiform minerals are flexible in hand samples and fibers have higher tensile strength than other habits of the same mineral.	Here, we define “asbestos” as a generic term applied to the (fibrous) asbestiform variety of serpentine (chrysotile) and the (fibrous) asbestiform variety of amphibole group minerals (anthophyllite, amosite (cummingtonite-grunerite), tremolite, actinolite, and crocidolite (riebeckite)), which have been exploited, prospected, described in the literature, traded, and sold commercially for their unique physical properties that result from the fibril width of $\leq 0.5 \mu\text{m}$.	[F]ibre ... of the 6 asbestos minerals [having] a length $\geq 5 \mu\text{m}$ and a width $< 3 \mu\text{m}$... [is] classified as “asbestos.” Any fibre (not necessarily asbestiform) of one of the 6 asbestos minerals can be classified as “asbestos”. For example, a tremolite particle showing elongate(d) “fibrous” shape with length greater than $5 \mu\text{m}$ and width smaller than $3 \mu\text{m}$ can be classified as “asbestos”.

*USGS (2001) and HSE (2005).

†NIOSH (2008).

clearly acknowledged that the method, intended for counting fibers, “does not differentiate between fiber types”. Based on the scope of application, the method would count “all natural and synthetic fibres, including the asbestos varieties, other naturally occurring mineral fibres and man-made mineral fibres”. In addition, WHO indicated that “[u]se of this method has other limitations when applied to samples containing ‘platy’ (flat) or acicular (needle-shaped) particles and consequently should not be implemented without a full understanding of the workplace atmosphere”. It is clear that WHO does not equate all fibers with length $L \geq 5 \mu\text{m}$ long, width $W < 3 \mu\text{m}$, and aspect ratio $L:D \geq 3:1$ to the “asbestos variety”. In the referenced method, WHO also did not define the counted fibers as “regulated”, nor as “respirable”, nor as “carcinogenic”. It is important to understand that not every particle with length $L \geq 5 \mu\text{m}$ long, width $W < 3 \mu\text{m}$, and aspect ratio $L:D \geq 3:1$ will be respirable. For example, using the estimates from Brown et al. (2013), according to the size distribution from our dimensional database described elsewhere (see Wylie and Korchevskiy 2023; Korchevskiy and Wylie 2025c), and assuming the Timbrell formula for aerodynamic diameter of elongate particles (Timbrell 1965), we can demonstrate that among asbestiform fibers with length $L \geq 5 \mu\text{m}$ long, width $W < 3 \mu\text{m}$, and aspect ratio $L:D \geq 3:1$, about 47% can be estimated as respirable, vs. just 7.5% for a non-asbestiform variety of particles (100% nose breathing is assumed). The long-term deposition fraction of particles will be even lower than the respirable fraction, and the difference between asbestiform and non-asbestiform habit will be even more pronounced (Korchevskiy et al. 2025).

In his Letter, Dr. Gualtieri used a specific image of an elongate particle, apparently from Giacobbe et al. (2021) (quoted by Gualtieri as Giacobbe et al. 2020), that “was retained for ca. 40 years in the lungs of a subject diagnosed with malignant mesothelioma”. Dr. Gualtieri claims that this particle would not fit our definition of “asbestiform” (nor apparently the definition from IARC 2012 either). We do not understand why this particle would not be classified as asbestiform. Although we did not find this image in the

quoted paper by Giacobbe et al., it is possible to approximate its size as about $22 \mu\text{m}$ in length and less than $0.4 \mu\text{m}$ in width from the photo in Dr. Gualtieri’s Letter. The method published by our group, for example, would definitely characterize this particle as asbestiform (Wylie et al. 2022). In our dimensional database, among 20,817 elongate particles from the datasets of non-asbestiform riebeckite, only three have length $\geq 22 \mu\text{m}$ and width $\leq 0.4 \mu\text{m}$; they comprise just 0.01%, probably a statistical artifact (while more than 3% of crocidolite fibers have these characteristics).

Quite remarkable, however, is the term “killer fiber” that Dr. Gualtieri applies to the particle from the microphotograph. There is no toxicological context that would allow application of this wording to a single fiber. As all of us, hopefully, learned long ago, it is the dose of asbestos that can produce a carcinogenic effect; it is a distribution of chemical and morphological characteristics of fibers in lungs that causes toxicity; and labeling the individual elongate particle as a “killer” after 40 years of exposure is not scientifically sound.

It is important for health risk assessment that the habit of elongate particles is an essential quality controlling their behavior during and after inhalation and associated toxic effects. This fact has been published widely, including Mossman (2008), Gamble and Gibbs (2008), Wylie et al. (2022), Wylie and Korchevskiy (2023), Korchevskiy and Wylie (2025b, 2025c), and others. In 2025, the National Institute for Public Health and the Environment of the Netherlands (RIVM 2026) reviewed the available information on the toxicity of ultrafine asbestos fibers (with diameter $\leq 0.2 \mu\text{m}$) and concluded that, with all possible limitations, the findings point to width as a primary driver of mesothelioma risk and fiber widths $\leq 0.15 \mu\text{m}$ having the strongest predictive power for mesothelioma potency of asbestiform amphibole. (Fibers longer than $5 \mu\text{m}$ are assumed in this statement). It is well known that the ultrafine category of asbestos fibers is extremely rare among non-asbestiform amphibole populations (about 0.02% of all non-asbestiform riebeckite fibers longer than $5 \mu\text{m}$ vs. about 31% for asbestiform crocidolite).

As we can see, in its mineralogical assessment of talc, IARC did not attempt to characterize the morphology of the minerals listed under the label of “Occurrence of asbestos” (Table 1.1, Monograph, Volume 136) (IARC 2025). In this table, as we learned from the Letter by Dr. Gualtieri, IARC utilized the controversial definition of asbestos that apparently includes all morphologies of amphiboles, contrary even to IARC’s own definitions as found in IARC (2012) and IARC (2025). Using this misconception, so-called “asbestos” can be found everywhere on earth in abundance and in all sorts of environments, while in reality true asbestos and asbestiform fibers are relatively rare and confined to specific geologic settings (Ross et al. 2008).

In addition, the Letter by Dr. Gualtieri explained that “the references reported for each site in Table 1.1 are not intended to prove the presence of asbestos but simply to give a reference to the geology and mineralogy of the site”. This means that there is no verified source for the data in the column labeled “Asbestos Occurrence” in Table 1.1. It also means that one of the most essential questions of Volume 136 (“is pure talc associated with specific effects or are observed effects the result of associated minerals?”) was answered without verifiable data that the Working Group (or the readers) could assess. Without references, there is no transparent weight-of-evidence analysis (that would require all the references to be announced, as was done for the toxicological part of the Monograph).

From this standpoint, we can see that “specific comments” to our assessment of Table 1.1, provided by Dr. Gualtieri, do not change our conclusion.

First, it was our understanding that the entries in Table 1.1 were there to help understand if a talc deposit might contain asbestos. However, it appears from the discussion on the top of page 6 in the letter by Gualtieri that this warning could be applied when there was the possibility of cross contamination from nearby locations with reported asbestos. This position is not clarified in the Monograph in any way. It also adds to the confusion about what an “Asbestos Occurrence” actually is.

On page 6 of the Letter, Dr. Gualtieri seems to suggest that we do not accept “an association of talc and serpentine minerals, including chrysotile”. He provides four examples for this association. On the contrary, we also know many examples of reports of chrysotile associated with talc. However, only one example in the letter by Dr. Gualtieri applies to a talc prospect. Salem et al. (2025) describes a prospect or mine that was not included in Table 1.1. Here, chrysotile is reported from the chlorite margin of a blackwall-type talc deposit in Egypt. This is the only report of its kind in the literature, and if substantiated, it may suggest a new potential type of association of chlorite-chrysotile in blackwall metamorphic zones around serpentine masses. Without further confirmation, this example would remain an outlier from everything we know about chrysotile and talc.

There are three sets of numbered comments in Korchevskiy and Wylie (2025a) which were used as examples (not a complete listing) illustrating our disagreements on (I) the content of asbestos and asbestiform amphibole fibers, (II) the content of all types of elongate minerals, and (III) the

content of chrysotile found under the column headed “Occurrence of Asbestos”. In the first set of comments, amphiboles may be present in the ore, but documentation for asbestos is lacking. In the second group, documentation is lacking for the presence of amphibole in any habit in the talc ore, although the minerals could be present “in the area”, and the third examines the idea that chrysotile contamination of talc is common.

Group 1. No documentation of asbestos or asbestiform amphibole in talc ore. As described earlier, in all the examples listed below, we do not agree that all forms of tremolite meeting the Gualtieri definition are asbestos.

1. *Afghanistan, Nangarhar Province.* The references do not support the presence of asbestiform tremolite in talc ore.
2. *Brazil, Bahia District.* The references do not support the presence of asbestiform actinolite or asbestiform tremolite in talc ore. A new reference was introduced in Dr. Gualtieri’s response, dos Santos and de Menezes Leal (2022), which stated that “[t]hey [tremolite/actinolite] occur as fibrous crystals”. The source also reports that tremolite/actinolite are in “lozenge form”. Furthermore, the new reference does not substantiate the presence of asbestiform actinolite or tremolite in talc ore. Instead, dos Santos and de Menezes Leal discuss the geology of the meta-mafic and meta-ultramafic rocks of the Greenstone belt Guajeru area. The paper does not describe talc mines or talc ore. If talc is mined from the meta-ultramafic rocks described in this reference, they are minor talc occurrences in this large district (Carvalho 2000; Gondim and Jiang 2004).
3. *Canada, Madoc, Ontario.* The IARC reference, Sabina (1987), uses the term asbestos in other entries, for example, the Denholme Mine (39), but refers to tremolite as prismatic to fibrous. Other descriptions of the Madoc deposit (Minnes 1984; LeBaron and van Haaften 1989) do not call the tremolite asbestiform; Minnes refers to it as prismatic. LeBaron and van Haaften (1989), in their extensive description of the carbonate-hosted talc deposits in Ontario, do not report any evidence of a fiber-forming event, or do they report amphibole asbestos from Madoc.
4. *India Rajasthan.* Dr. Gualtieri suggested that Shekhawat et al. (2010) reported that tremolite asbestos occurs in the geographic area and is accompanied by talc. Shekhawat et al. stated that “Economically significant occurrences of ultramafic rocks form a part of the pre-Aravalli Bhilwara Supergroup, and Aravalli and Delhi Supergroups in the state of Rajasthan. These ultramafic rocks host workable deposits of talc, amphibole asbestos and serpentinite (used extensively as decorative stone)”. Furthermore, they include the following geographic distinction, “The ultramafic rocks exposed about 55 km south-west of Udaipur form two long narrow belts spaced nearly 3 to 4 km apart and are designated as Jharol West and East ultramafic belts. The western ultramafic belt hosts world’s largest deposit of anthophyllite asbestos while, the eastern belt is characterised by having workable deposits of talc”. With respect to tremolite-

asbestos, the sources are described as independent bodies with different geologic histories. “Tremolite asbestos deposits are also characterized by the lithological zoning (Figure 3(C,D)) which differs from that observed at talcose bodies in having an additional acicular actinolite–chlorite zone and by the absence of phlogopite zone. These lithological zones are important guides to prospectors in predicting either talc or tremolite mineralisation”. The references do not support tremolite-asbestos occurring in talc ore.

5. *Korea, Dongyang Chunju*. Dr. Gualtieri points to Figure 1 in Dongbok et al. (2004) because it “clearly shows that the tremolite is fibrous-asbestiform”. It is clear that the figure is labeled tremolite but evidence for asbestiform tremolite is not convincing, although we only had a photocopy of the image to examine, and Dr. Gualtieri did not provide the criteria he applied to the image to come to his conclusion. Park et al. (1995) describe, rather unclearly, the tremolite as “long prismatic crystal bundles and columnar to fibrous”. This description is consistent with the tremolite-talc intergrowths from this mine (and in tremolitic talc generally) described by Ahn et al. (2000), which occur along parting(defect) planes in tremolite. Weaknesses parallel to cleavage (0 1 1) as well as parting ($\{100\},\{010\}$) enhance elongation and development of smaller crystallites of tremolite. A careful review of the dimensions of the tremolite from this location would be informative about this habit. Without this analysis, however, the statement that tremolite in Korean talc is asbestiform could not be substantiated.
6. *Norway, Altermark, Rana*. Dr. Gualtieri explains that he relied on a report by Wergeland et al. (2017), and that their study was undertaken because of a report by the Norwegian National Institute of Occupation Health (NIOH) of the presence of “fibrous (asbestiform) fibers”. However, Wergeland et al. (1990) in their first study of talc workers from this location did not find anthophyllite or tremolite and specifically noticed that their analysis showed no increased lung cancer mortality for populations exposed to talc *not containing asbestiform fibers* and not exposed to other occupational carcinogens. Furthermore, Wergeland et al. (2017) state that the results of their study demonstrated that “Repeated exposure measurements after 1981 showed only trace amounts of fibrous tremolite and anthophyllite”. They do not refer to these trace particles as asbestos or asbestiform. We are not aware of any other data that would confirm a contamination of talc from this location by definitely asbestiform elongate particles.
7. *USA, Georgia, Chatsworth District, Murray County*. Dr. Gualtieri asserts that the report by Furcron et al. (1947) of chrysotile (asbestos) and the amphiboles actinolite and anthophyllite in the ore deposit is justification for stating that tremolite and anthophyllite asbestos are present in this talc district. A discussion of the Furcron et al. report of chrysotile (found below under group 3 number 7) confirms that chrysotile does not occur in talc ore. With respect to the contention that there is actinolite-asbestos and anthophyllite-asbestos in

the talc ore, Dr. Gualtieri introduces an additional reference (Hopkins 1914, 85–86) on which he relies for the “presence of asbestiform minerals including actinolite known since 1944 for the Chatsworth talc deposits”. These pages are in the chapter entitled “The Asbestos Deposits of Georgia”. Hopkins describes multiple occurrences of amphibole asbestos throughout a broad geographic area mostly outside Murray County (Hopkins Figure 1, 14) where asbestiform members of the tremolite–actinolite series occur as veins along well-defined fractures in and adjacent to mafic and ultramafic rocks and mass fiber deposits of anthophyllite-asbestos are found within these same rocks. The single reference linking talc to actinolite asbestos is in the table entitled “Analyses of Asbestiform Amphiboles” on page 86. Sample 10 is from the Cohutta Talc Company. On page 211, Hopkins clarifies that the fibrous actinolite is from the Cohutta talc Company *property*, not specifically the mine, but he does describe it as asbestiform. He does find actinolite in some talc particles which he refers to as needles (210), not asbestiform fibers. Hopkins (1914) never mentions anthophyllite in Murray County talc. There is no literature support for identifying anthophyllite-asbestos as present in the Chatsworth talc district.

Group II. Our concern was lack of documentation of amphibole in any habit in talc ore.

1. *Allamoore talc district*. Dr. Gualtieri brings additional references to support the presence of amphiboles in the talc from the Allamoore talc district. First, Greene (1995) is quoted as identifying magnesite and tremolite, some of the latter asbestiform as locally present within the district. These are likely located near diabase dikes. More detail is provided by Rohrbacher (1973) and Wylie and Huggins (1980) who identify a potassian winchite-asbestos that occurs in several places in the District. The occurrence could have been referred to as soda tremolite or richterite earlier as IMA nomenclature of amphiboles of winchite composition has changed over time (Wylie and Verkouteren 2000). In this district, amphibole asbestos deposits are associated with mafic dikes and are not spatially related to the talc mines (Edwards 1984; Van Gosen et al. 2004); some of the asbestos occurrences were prospected before their hazards were fully recognized (Rohrbacher 1973). Dr. Gualtieri provides no additional justification for including tremolite as present in the talc ore. Talc ores from the Allamoore District are black. They contain abundant organic matter and other features characteristic of sediments such as bedding and desiccation cracks (Edwards 1984) and like the deposits from Jiangxi Province China, are probably chemical sediments (Li et al. 2016; Zheng et al. 2024). Van Gosen et al. (2004) state that “[a] review of published descriptions of about 360 talc deposits in the US reveals that a consistent relationship occurs between the primary talc forming geologic environment and the amphibole content of the talc deposit. That is, talc deposits formed by hydrothermal processes – meteoric or basin brine fluids

- heated by buried magma bodies – consistently lack amphiboles as accessory minerals”. Talc deposits of this type that Van Gosen et al. include in this group are the Allamoore Talc District, Talc City, CA, Yellowstone Mine Montana, Alabama, California, New Mexico, Nevada, and Washington. Our understanding of the geology of the major talc mines of China in Guangxi, and eastern Liaoning Province and the black talc mines in Jiangxi would also place them in this group.
2. *China, Guangxi Province.* Dr. Gualtieri relies on Schober (1998) to conclude that tremolite asbestos is possible at Guangxi. However, Schober’s remarks apply to three provinces in China, not just Guangxi. While there may be tremolite in Shandong, for example, that does not mean that it is present in an entirely different geologic environment at Guangxi. A study of Guangxi talc by Cai et al. (2015) shows that the formation of talc took place at fairly low temperatures, much lower than the 400 °C Van Gosen et al. (2004, 927) postulate as necessary for the formation of tremolite. There is no evidence presented to support the conclusion that there is tremolite in any form at Guangxi.
 3. *China, Liaoning Province.* As stated above, Schober’s statement does not specify that tremolite in any form occurs in talc from Liaoning, China, nor does the reference given for this deposit, Misch et al. (2018). By being “set in this environment”, Schober is referring to dolomite hosted ore deposits generally. Eastern Liaoning Province contains dolomite hosted magnesite, serpentine jade, tremolite, and talc mines. Others who have studied this deposit do not support the presence of tremolite in talc ore. For example, Misch (2012) reports no amphibole in the major talc producing areas of Liaoning Province but mentions its potential in other economically unimportant mines. Misch et al. (2018) report tremolite only from a magnesite mine. Congxi et al. (2003), a reference not provided by IARC or Dr. Gualtieri, report that a trace amount of tremolite has been found from the province but where in the Province this occurred was not specified.
 4. *Italy, Sa Matta, Sardinia.* The presence of nonasbestiform tremolite in the gangue (waste) country rock, not included in talc mine products and not even uncovered until recently (Fiori and Grillo 2002), should not qualify deposits as possibly containing asbestos. There is no evidence to support contamination by gangue rock in Sardinia.
 5. *USA California, Inyo (County) Northern Panamint Range.* The District name listed by IARC in Table 1.1 is consistent with the talc district nomenclature of Greene (1995). As we commented in our paper, Greene does not discuss tremolite in this district. Greene does discuss tremolite in a different district that he calls the Southern Death Valley-Kingston Range District, including Silver Lake to Yucca Grove, Inyo and San Bernardino Counties. This more southern district contains some of the Panamint Range, but it is a different district with different geological controls, being directly related to diabase sills (Greene 1995).
 6. *USA, Montana, Dillon-Ennis District, Yellowstone (mine).* Since other mines from the Dillon-Ennis District have separate entries on the IARC chart, it seemed logical to assume the descriptions here were related to the Yellowstone mine, an important source of talc. In his response, Dr. Gualtieri asserts that any mention of an amphibole anywhere whether asbestiform or not, in this case, in the “whole Yellowstone area”, justifies a warning about asbestos. How close does it have to be to a talc mine to receive this designation is not clear nor specified by Dr. Gualtieri. Nonetheless, tremolite has not been documented from the ores from this district. Buzon and Gunter (2017) state that the tremolite nearby and the talc deposits formed under different geological conditions and they do not occur together in the ore. Dr. Gualtieri’s implication that a mining company would not provide representative ore samples is in our view inappropriate and unnecessary.
 7. *USA, Montana, Dillon Ennis District, Willow Creek, and Beaverhead mines.* Berg (1979) reports tremolite from one location on Ruby Peak. It was not identified from the Willow Creek or Beaverhead mines but only from a talc or chlorite location. It is hard to see how a single reported occurrence of nonasbestiform tremolite, perhaps only from a chlorite location, makes asbestos possible in multiple talc mines from which it has never been reported. The most recent work on this district by Van Gosen et al. (2004) and Buzon and Gunter (2017) specifically states that tremolite is absent.
 8. *Finland, Polvijarvi, Sotkamo, and Vuonos mines.* It seems from Dr. Gualtieri’s response that just being part of a large group of rocks, the Outokumpu assemblage, means that talc ore would “probably” contain tremolite-asbestos. The Outokumpu assemblage, according to Kuuttila (2022), is “carbonate, skarn, quartz rock and serpentinite”. Scarn occurs as selvages around serpentinite bodies. One might expect them to be found around Blackwall type talc ores. In a discussion of the mineralogy of talc from the Lahnaslampi soapstone (talc) deposit, tremolite is not mentioned by Isokanges (1978), and Kuronen and Tuokko (1997) report tremolite in their description of the Horsmanaho talc mine only in the skarn (waste rock).
- Group III.* Suggestions that chrysotile can be present in the talc from each of the following talc mining districts.
1. *Brazil, Bahia district.* There are two districts in Bahai, and these occur in four different geological terranes. Only in those associated with one of these terrains, Archean granulite basement, do Gondim and Jiang (2004) implicate the presence of chrysotile. Carvalho (2000) points out that there is in fact a single deposit associated with vermiculite where chrysotile has been identified, but he does not confirm that it is in talc ore, not the vermiculite. In this region there are 40 vermiculite mines and only four talc mines. This is slim evidence on which to warn that talc from anywhere in the Bahia District is probably contaminated with chrysotile.

2. *Brazil, Parana district, Ponta Gross, and Castro Mine.* We do not deny the presence of serpentine but do not accept that as sufficient evidence that chrysotile is “probably” present in the talc ore. Dr. Gualtieri provides a quote in Portuguese from Saunite et al. (2011), on which Dr. Gualtieri justifies chrysotile’s presence, which is given below in full (Google Translate used):

Thermal metamorphism related to the diabase dike swarm of the Ponta Grossa Arch generated irregular bands of very fine grain size, black, brown, and green in color, containing serpentine in the metadolomites. Metadolomite megaxenolites in thick dikes contain chrysotile, partly pseudomorphic over olivine, and brucite veins. No talc was observed in the metamorphic aureoles of these dikes, which truncate talc schist bands. The thickness of these aureoles is typically on the order of millimeters to centimeters, indicating limited fluid percolation. However, in the vicinity of more powerful dikes, the metadolomite recrystallized at distances of up to several meters from the contact, in the form of white dolomitic and calcitic marble.

The observations of Saunite et al. (2011) do not support the likelihood of chrysotile in talc ore, since chrysotile is restricted to inclusions (metaxenolites) within dikes, where olivine was altered to serpentine. Talc was not observed around these dikes.

3. *China Liaoning Province.* Liaoning Province’s major talc deposits are in the east where they occur in dolomite. Where there are deposits of chrysotile asbestos they occur in serpentine. There may be some small talc deposits formed from altered serpentine, but these are of little economic importance. Liaoning Province covers 150,000 km² and it is not reasonable to use such a large geographic area as a basis for serpentine or amphibole affecting talc ore within it.

A “mining district” generally refers to a set of mines that share geological similarities and target the same minerals. It seems unwise to lump together deposits from two distinctly different geologic environments (carbonate hosted and serpentine hosted) when considering “occurrences of asbestos” as Dr. Gualtieri appears to propose for Liaoning. Minerals from the same district often share properties that relate to the potential carcinogenicity of their dusts but by artificially extending district boundaries to include dusts with different characteristics, we degrade the data and lose information about the characteristics of exposures and signals of asbestiform fiber can be suppressed.

4. *India Rajasthan.* In response to our comments, Dr. Gualtieri introduces a new reference by Hrishikesh and Rajawat (2020), who mapped remotely and reported talc in fractures in serpentines. We did not find a discussion of chrysotile association with talc; however, Figure 6 from this paper shows that talc and chrysotile mine locations do not overlap.
5. *Italy, Valmalenco.* The formation of serpentine and chrysotile, and the formation of talc ore from the large-scale alteration of serpentine, are two distinct geological processes. Just because serpentine occurs in the same large geographical region as a talc mine or that small amounts of talc can be found in a serpentinite body

does not mean chrysotile will contaminate talc ore. Figure 1 in Cavallo (2020) shows that the talc mines are a kilometer or more from any asbestos mine. Further, despite the presence of chrysotile in the serpentinite quarries, Cavallo and Petriglieri (2020) report that “The commercial finished rock products (both ‘massive’ and schistose serpentinite) (Table 2) can be considered virtually asbestos free (in almost all cases no detectable asbestiform fibers). In contrast, it is not clear why talc ore with no reported chrysotile component should ‘probably’ contain chrysotile, as Table 1.1 asserts for this district”.

6. *Sweden, Handöl Köli, Asån.* It appears that Dr. Gualtieri considers that a listing in Mindat.org from a single location justifies a warning that ore from this area probably contains chrysotile. According to Mindat, the single sample came from the entrance to a soapstone mine and from scrap rocks. The entry does not say it is from talc ore. It is listed as Handol, Are, Jamtland County, Sweden. Chrysotile is one of 16 minerals occurring within 20 km of this location. Based on the trace element studies of Bergman (1993), this talc deposit was formed from the alteration of a serpentinite and as we have said in our paper, chrysotile would not be preferentially preserved during the process of talc ore formation. Figure 3(d) in Pereira et al. (2025) relied upon by Dr. Gualtieri, shows “talc overprinting chrysotile fibers”. Talc is preferentially replacing chrysotile while leaving the more massive serpentine unaltered as would be expected given its high surface area and chemical stability.
7. *USA, Georgia, Chatsworth district, Murray County.* The conclusion that the talc deposits from the Chatsworth district contain chrysotile rests on Furcron et al. (1947) and Hopkins (1914). Both report serpentine as a common component of the ore. Both refer to chrysotile in the Cohutta Mine. On page 40, Furcron et al. state “Relatively small amounts of two varieties of fibrous serpentine have been identified, chrysotile composed of delicate flexible fibers that have a silky luster *is found in thin seams in massive serpentine*. Picrolite, columnar to fibrous serpentine having a splintery fracture *occurs associated with dolomite in the Cohutta Mine* (italics ours)”. Picrolite is nonasbestiform. It may be composed of antigorite, but some samples have shown a small amount of lizardite and chrysotile by XRD. The ability to identify the serpentine components of this picrolite by XRD was not available to Hopkins (1914) or Furcron et al. (1947) because it was Whittaker and Zussman (1956) who provided the criteria necessary for identification of the polymorphs by XRD. A single report of picrolite in dolomite or chrysotile in massive serpentinite does not justify a sweeping conclusion that talc from this district contains chrysotile asbestos.
8. *USA, Maryland, Piedmont Belt.* Large serpentinite masses are exposed in Maryland, some of which contain very small amounts of chrysotile. Smaller serpentinite bodies have been transformed almost entirely to talc, forming many small talc prospects and mines throughout the piedmont. Where talc has replaced serpentine, there is

no evidence that chrysotile could be preferentially preserved.

9. *USA, New York, Gouverneur*. Dr. Gualtieri calls upon a new reference, Dement and Zumwalde (1976), who report trace amounts of chrysotile in two of seven samples that they analyzed from this district. During the 1970s, chrysotile could be found in the air of every major city where it was tested. At the University of Maryland, we found chrysotile in road dust in Prince George's and Montgomery Counties in every sample we took. We do not accept this single report as grounds for claiming talc from this District can contain chrysotile although it does contain antigorite/lizardite as a major component. This deposit has been extensively studied over many years, and with the exception of Dement and Zumwalde (1976), chrysotile has not been reported from this talc ore body. It is, however, the type locality for a complex multi-silicate asbestiform fiber referred to as a "transitional fiber" or "fibrous talc" (as defined by Stemple and Brindley 1960). The IARC monograph on talc (IARC 2025) specifically stated that fibrous talc is not asbestos.
10. *USA, New York, Lewis County Natural Bridge*. Dr. Gualtieri states that "contrary to what Korchevskiy and Wylie (2025a) stated, Engel (1949) does cite fibrous serpentine (chrysotile) in Table 1 page. 347". Unfortunately, Engel (1949) does not have a page 347, and Table 1 lists 7 analyses of talc, and none of serpentine, so we cannot comment on this source. Chrysotile is not mentioned in the Engel chapter. Again, relying on a single entry in mindat.org is questionable as proof of a district characteristic.
11. *USA, Texas, Llano District*. Barnes (1946) and Barnes et al. (1950) report chrysotile in the Coal Creek serpentinite, while the soapstone occurrences are in two bands on either side of a long serpentine body in the Big Branch Area. There is no report of chrysotile in or near talc ore in the Big Branch Area.
12. *USA, Vermont (Blackwall) talc*. While Dr. Gualtieri appears to rely on a Letter to the Editor by Egilman et al. (2020), we do not accept this as a reliable source because it reports unverifiable data from litigation and the response of the authors to this letter (Fordyce et al. 2020) was not included by IARC. Of most concern to us, however, are Dr. Gualtieri's comments about Gunter et al. (2018). Dr. Gualtieri states that Figure 17(b) on page 22 of this article "shows the picture of an evident chrysotile bundle for the talc ore sample (1)(TEM data in Figure 17(b), page 22)". The three authors of this paper, all university professors in the United States, label this figure as "bright-field images of talc particles showing two different morphologies". Chrysotile is not identified in the photomicrograph by the experienced scientists, skilled in TEM, who took the images. Dr. Gualtieri's "reinterpretation" of this image is unjustified.

In general, there is clear evidence that some talc ore deposits contain amphibole asbestos, e.g. Dadeville, Alabama, Gouverneur District, New York, Soapstone Ridge, Georgia,

and Death Valley, California (as described by Van Gosen et al. 2004). The report of Salem et al. (2025) shows that a small amount of chrysotile might be found in the chlorite zone of Blackwall talc deposits. However, the IARC document makes these untypical occurrences seem common, which the evidence does not support.

In conclusion, we strongly believe that the mineralogical analysis in IARC Volume 136 has significant methodological deficiencies. It is obvious that full and detailed mineralogical characterization of the deposits is needed, to inform possible future toxicological studies. We hope that toxicologists and mineralogists will be able to work together, to come up with better identification of hazards and assessment of risks for minerals.

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Declaration of interest

Andrey Korchevskiy is a co-owner and salaried employee of Chemistry & Industrial Hygiene, Inc. (Lakewood, CO). Since 2023, Ann Wylie has served as a part time Senior Scientific Adviser for Chemistry & Industrial Hygiene, Inc. in the role of mineralogy consultant. She is also a Professor Emerita of University of Maryland. She has never received compensation for writing papers or giving professional presentations. Both authors participated in litigation related to asbestos and talc as experts and/or consultants. Chemistry & Industrial Hygiene, Inc. is involved in a research project on toxicological characterization and human health risk assessment for potential associated minerals in the cosmetic grade talc deposits, supported by Johnson & Johnson. Both authors serve as members of the Scientific Advisory Board (SAB) of the National Sand, Stone, and Gravel Association (NSSGA). NSSGA sponsored the creation of a database for dimensional characteristics of various elongate mineral particles. Chemistry & Industrial Hygiene, Inc. has NSSGA as a client for various other consulting projects. None of them included compensation for any part of this paper. In general, no time for writing this letter was billed to any clients of the authors. No copies of the letter were provided to any clients of the authors prior to publication. No feedback or comments were received from any party outside of the authorship team during the letter preparation. The paper reflects only opinions of the authors and not the organizations that they represent. Debbie Vaughan performed only administrative tasks and helped to organize references in this paper. She performs different tasks as a researcher for projects with various clients of C&IH, but she has never communicated any information about this paper to any of the clients. No funding was received by the authors for the preparation and writing of this paper, or for the study of the IARC timeline and classification methodology included in the paper. At the same time, Chemistry & Industrial Hygiene, Inc. is involved in a research project on toxicological characterization and human health risk assessment for potential associated minerals in the cosmetic grade talc deposits that is supported by Johnson & Johnson. Specifically, no funding from this project was received or used by the authors to prepare or write this paper.

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