NOA (naturally occurring asbestos) is underrepresented in Southern California hazard maps and can generate airborne asbestos fibers during large seismic events that trigger earthquake-induced landslides

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Introduction

This study focuses on previously undermapped NOA (naturally occurring asbestos) that are an inherent part of Southern California's geology. Specifically, we examined the potential NOA distributions that exist in landslide susceptible regions that can become disturbed due to potential seismic events that can release the NOA fibers into the air.

Asbestos is a commercial term and was previously heavily mined due to its powerful insulating properties. It was later discovered that the fibrous mineral releases toxic fibers into people's lungs, potentially causing a rare lung cancer called Mesothelioma. Most commercial mines ceased production in the US due to its hazardous status.

There are two types of mineral groups that develop asbestos habits, Serpentine (Chrysotile Group), a sheet silicate that forms in fault and shear zones from altered mantle minerals olivine and peridotite. It is brought up to the surface via tectonic forces. Chrysotile forms into hollow tiny tubes as the silicate sheet rolls up due to a molecular misfit(Figure 1). The tiny rolled tubes give chrysotile its iconic curly appearance. Serpentine is also classified as ultramafic meaning that is has a high Fe and Mg content

Most commercial asbestos is from Chrysotile. However, the other five types of NOA are from the Amphibole group and are classified as mafic or intermediate. Amphiboles are a double-chain silicate and exhibit a significantly different chemical structure that is rigid, needle-like in structure(Figure 1). Amphibole NOA are thought to be significantly more hazardous to lung tissue. Crocidolite,a rare and deadly amphibole, has been found to reside in the lung tissue for hundreds of years(Werner et al.,1995). The five amphibole minerals are; riebeckite asbestos(crocidolite), grunerite asbestos(amosite), Anthophyllite asbestos,tremolite asbestos, actinolite asbestos. Most importantly, serpentine groups and amphiboles have markedly different physical properties. Southern California is a heterogeneous geological environment that does create favorable conditions for asbestos but not only Serpentine and ultramafic rocks. “Rock types known to host asbestos include serpentines, altered ultramafic and some mafic rocks, dolomitic marbles and metamorphosed dolostones, metamorphosed iron formations, alkalic intrusions and carbonatites.” (Van Gosen 2007)

This study seeks to create a scaled geological based mineral map that identifies all potential NOA’s in Southern California according to existing occurrences/geological maps and geological reports, as well as newly identified NOA potentials (subject to field evaluation and laboratory testing to confirm presence of NOA.

Figure 1: Asbestiforms: Chrysotile and Amphiboles

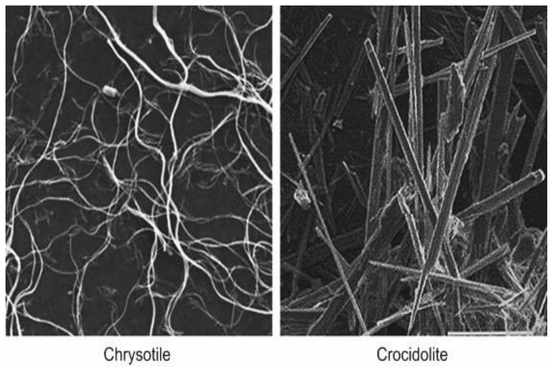


Photo: Denver Microbeam Laboratory

Left: Serpentine group known as “White asbestos” has curly fibers as shown in this micrograph.

Right: Amphibole group includes five types. Shown here is the deadly type called “blue‘ asbestos. Amphibole asbestos is a double chain silicate with rigid, needle-like structure with a large chemical variability.

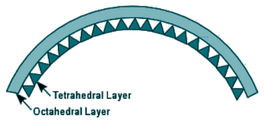
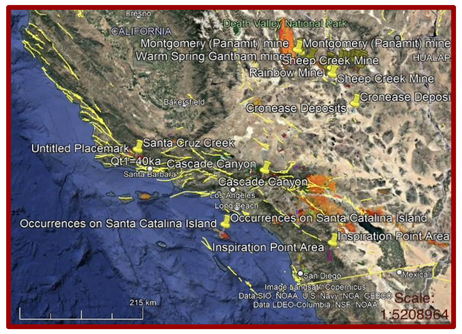


Figure 2: Illustration credit: *Tulane University.* Brucite bond doesn’t fit,so it rolls up into thin flexible, hollow tubes that are curly. All Serpentine asbestos is chrysotile, which is a sheet silicate.

Methodology

- A Google Earth Pro platform was used to map out potential NOA content and construct a mineralogical contacts based on extensive review and research of geological literature alongside with detailed geological maps with accompanied studies of the areas geological histories and settings (Figure 3).
- The information was then transposed and scaled to the 3D terrain and each identified area of potential NOA, based on geological maps and research was mapped out based on the geological setting and rock units identified on the geologic map. Each layer a polygon on a KMZ layer was cataloged and mineralogical contacts were constructed that represent the potential southern California NOA distributions.
- Part of the project’s focus was to find potential NOA rock bearing units areas that were unmapped and to research the geology of the area and to identify earthquake-induced landslide hazards to determine if they intersect with potential NOA hazard maps. Landslide maps were researched at CGS website as well as California’s landslide inventory. The landslide susceptibility maps were located, scaled and transposed onto the Google Earth Pro NOA potential hazard map to evaluate if there is an intersection of potential NOA rock bearing units with landslide susceptible areas that could present coseismic-risk of landslides containing potential NOA particles during a large seismic event.



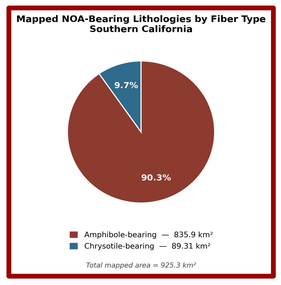


Figure 3: NOA distribution map study area for Southern California, and composition percentage by fiber type.
(Morton & Miller, 2006), (Yerkes & Campbell, 2005)

Results

Potential NOA (naturally occurring asbestos) distribution in the Southern California study area yielded 112 potential NOA rock bearing units based on extensive geological map and geological literature review.The NOA potential sites did include previously known mines that were represented by a coordinate locator marker which was redrawn with the area being mapped with mineralogical contacts that showed the full area extent of the mines. 86 sites out of 112 of the mapped areas showed potential of containing amphibole asbestos. This was measured by the polygonal area that the geological unit was mapped. The smaller percentage was Chrysotile (Serpentine Group) at 7.53% (89.31km^2) and 92.47% (835.9km^2) of potential NOA amphibole asbestos fibers.

Additionally, in the focus areas as well as the general study area, a strong association was found with areas with potential NOA rock-bearing units and the intersection of landslide susceptible regions such as the middle to eastern San Gabriel Mountains that exists on weak rocks, such as Pelona schist, as seen in the focus area NOA map (Figure 4a). Here, the NOA focus map shows large areas of Pelona schist, which contains tremolite, and greenschist amphibolite. Santa Ynez Mountains focus map (Figure 4c) has a 65% landslide susceptibility that intersects with NOA in a large Serpentine unit, which is also weak rock occurring on steep, unstable slopes.

The Chocolate Mountains focus area (Figure 4b) near the Salton Sea showed a lower level of landslide susceptibility vs. the Eastern San Gabriel Mountains, but had potential NOA rock bearing units composed of green schist and mafic intrusive suite. The last focus section is Santa Catalina Island Mountains (figure 4d). Again, the areas with high topography have high potential for landslide susceptibility and have NOA bearing rock units which are serpentine, blueschist, and green schist.

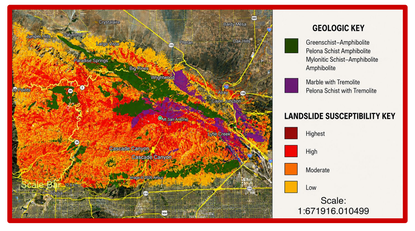


Figure 4a: Mid to Eastern San Gabriel Ranges, including Cajon Pass.
Wills, C.J., Perez, F., and Gutierrez, C., 2011, Susceptibility to deep-seated landslides in California: California Geological Survey Map Sheet 58

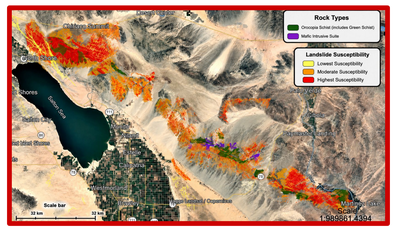


Figure 4b: Chocolate Mountains near Salton Sea
Wills, C.J., Perez, F., and Gutierrez, C., 2011, Susceptibility to deep-seated landslides in California: California Geological Survey Map Sheet 58

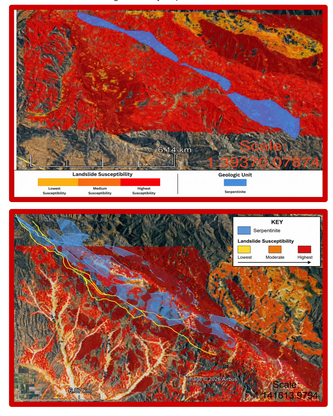


Figure 4c: Santa Ynez Mountains, Santa Barbara
Wills, C.J., Perez, F., and Gutierrez, C., 2011, Susceptibility to deep-seated landslides in California: California Geological Survey Map Sheet 58

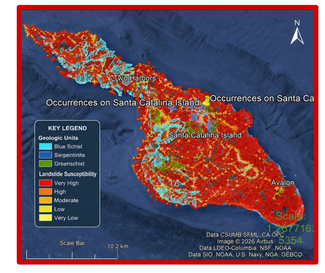


Figure 4d: Catalina Island
Wills, C.J., Perez, F., and Gutierrez, C., 2011, Susceptibility to deep-seated landslides in California: California Geological Survey Map Sheet 58

Conclusion and Future Work

The results of this study tell us that many areas in Southern California have known landslide susceptibility that intersects with rocks containing NOA (Naturally Occurring Asbestos). The study highlights that Southern California’s complex geology has a large area of NOA rocks that have not been previously mapped. This matters because NOA commonly develop near faults and shear zones. If a fault ruptures, it can result in rocks containing NOA to break open and create earthquake dust that contains NOA fibers that become airborne from an earthquake induced landslide.

The results overall in both resolving the research question and also raises more questions because the more NOA mapping leads to the discovery of even more potential NOA rock bearing units.This specifically applies to amphibole asbestos that are yet to be clearly delineated on a published map.

The limitations of the study are places of NOA geological units that exist but have yet to be mapped. The other limitation is that field observation and laboratory confirmation is needed for a definitive result.

This preliminary study demonstrates that Southern California has potential for many previously unmapped NOA rock hosting units that reside in landslide hazard areas. A future study that includes a ground motion model that shows the intersection of the hazardous NOA rock units and the amount of potential hazardous materials that could become airborne from a large seismic event would provide data about potential coseismic risks that involve hazardous NOA fiber becoming airborne in an earthquake plume.

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