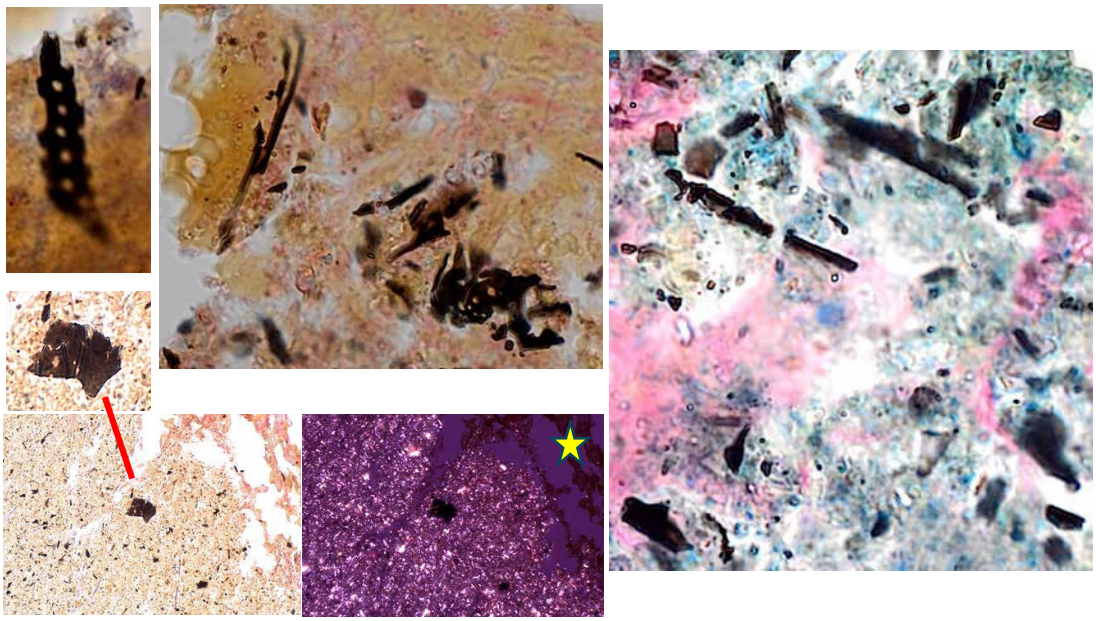
Paleopathology answer for case # 150

**History:** This is a montage of some of the unusual particles found in the tissue sections of the lungs of mummies from the Azapa Valley. (~ 1100 BC t0 1000 AD). What are they? What might they signify?



**Diagnosis:** These particles are best termed as 'vegetative char' particles. They are the remnants of burned plant/wood. Likely these signify inhalational exposure to the smoke from wild fires or anthropogenic burning of woody vegetation. The birefringent particles ([seen in the polarized light microscopy (PLM) image*] are present focally in large numbers and were shown by microanalysis to be mostly aluminum silicate particles, consistent with soil origin (aeolian dust). In our USCAP 2025 Paleopathology Club presentation we reported also that the abundance of these vegetative char particles seemed to relate to the historical age of the mummies over the several centuries span of the lung samples.

## What is Vegetative Char?

- Such particles apparently not previously well documented in lung tissues.
- Mostly described in modern fire investigation sources:

- **Soot:** "black carbon," a fine carbonaceous material produced during incomplete combustion. The distinguishing features of are grape-like clusters or open branch-like structures (aciniform morphology).

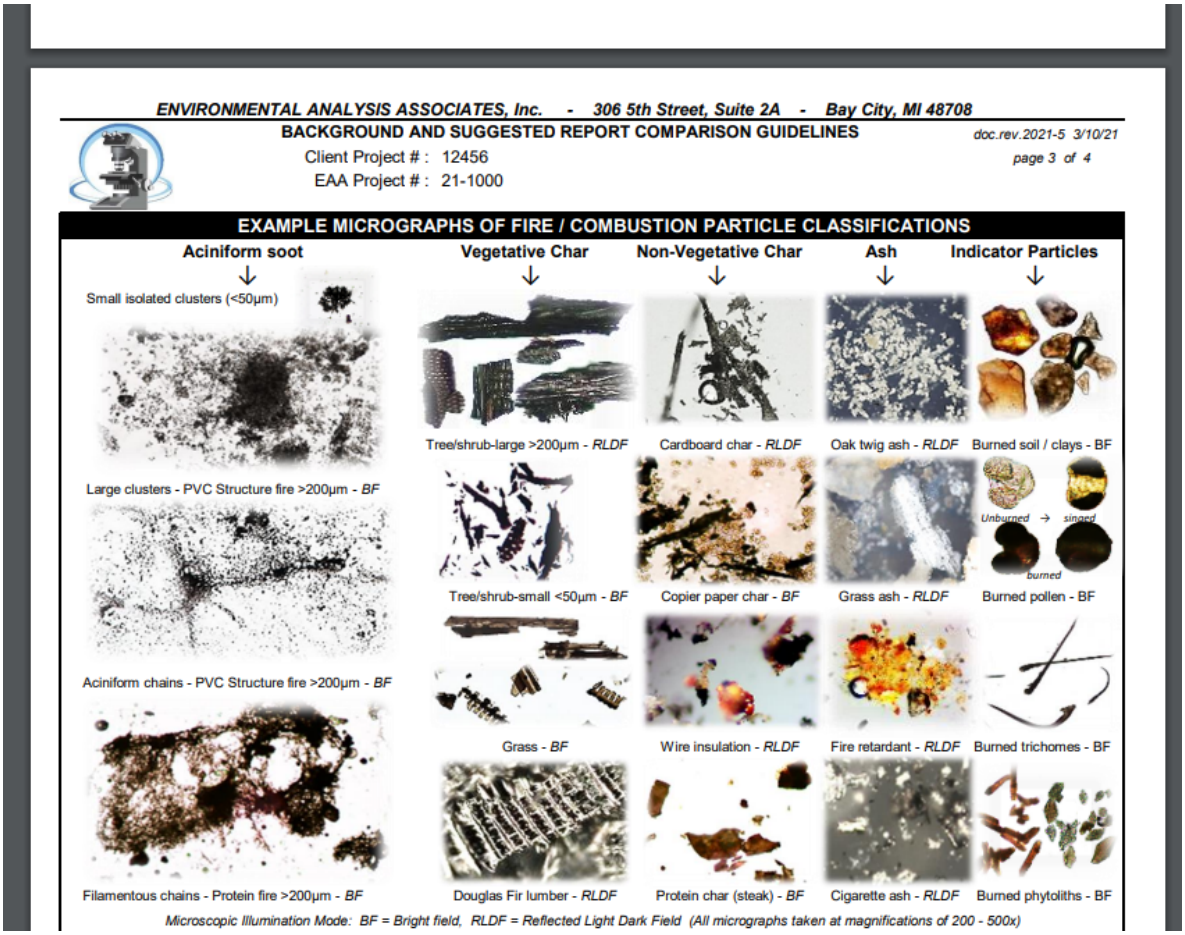
- **Vegetative char:** large, irregular, mostly carbonaceous fragments of burned vegetation from leaves, twigs, and bark, chaff, wood, brush.

- **Ash:** decarbonized residue of cellulose material -- typically soluble mineral salts, carbonates, oxides, insoluble plant phytoliths, and noncombustible compounds.

=> "Anthracotic": a term commonly used non-specifically to describe any black pigment (although it does have a definition referring to coal source)

Although many reports in pathology, anthropology and archeology mention ‘soot’ or ‘charcoal’ or ‘anthracotic pigment’, as far as the author can determine, such particles have not previously been documented with photomicrographic illustrations in lung tissue sections. Since these particles in the lungs are ‘respirable’, they are all aerodynamically small enough to have been inhaled [less than 5 micrometers aerodynamic diameter; many less than a few micrometers diameter] and it is possible that some previous published reports did not use high enough magnification to document such particles adequately.

An excellent chart showing these type of particles and comparison with other kinds of wild fire particles, including ‘soot’ and ‘ash’ is copied here.



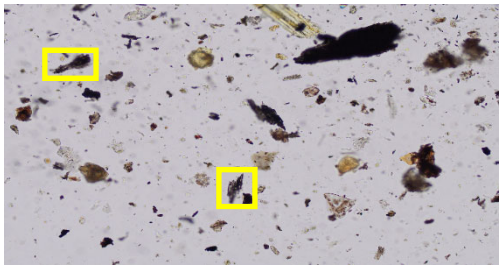

Russ Crutcher, an expert in microscopic particle identification since the 1970s, has published over 100 papers on the Analysis of Environmental Particles using light microscopy. For interesting posts, see:

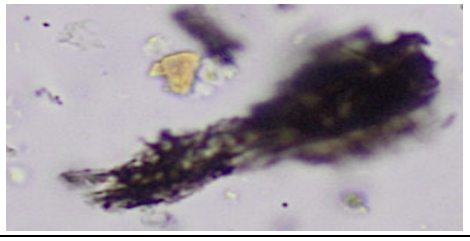
https://www.microlabnw.com/articles/soot-char-and-ash-damage

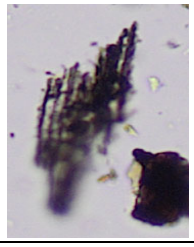
https://www.microlabnw.com/articles/wildfire-smoke-soot-damage

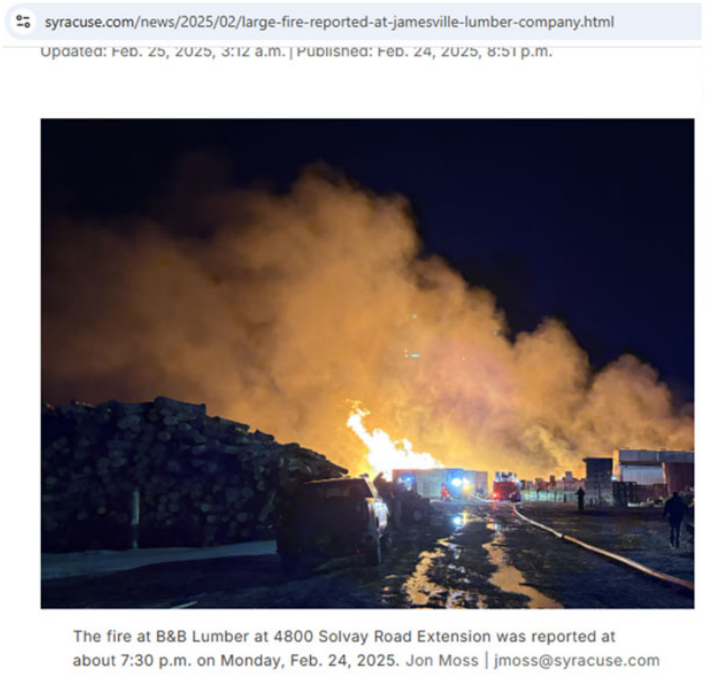
https://www.youtube.com/watch?v=4TaA2f6pZls

For comparison with these particles found in the mummies' lungs, we examined particles from settled dust from the early 2025 Pacific Palisades wildfires in California and from a wood pallet fire recently in Syracuse, NY. These showed presence of similar vegetative char particles.

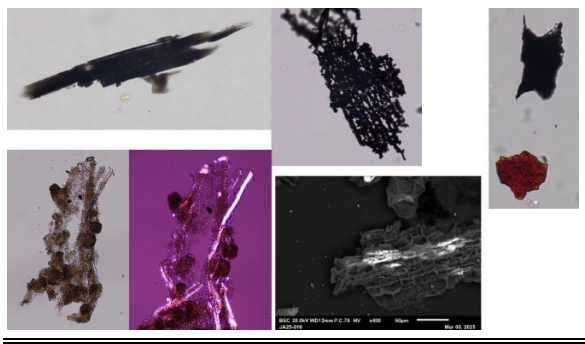








Settled dust from the February 2025 wood pallet fire in Syracuse, NY



The black particles reported in the Egyptian mummies by Montgomerie (2012) and those reported in so-called Hut Lung (now called **Domestically Acquired Particulate Lung Disease (DAPLD)** ) appear to be more soot-like particles. No particles resembling the vegetative char particles were documented. To date, we have been unable to find previous reported documentation of such vegetative ash particles in human or animal lung tissues.

The structural and elemental composition of inhaled particles in ancient Egyptian mummified lungs. R.D. Montgomerie. PhD thesis. Univ. of Manchester, UK. 2012

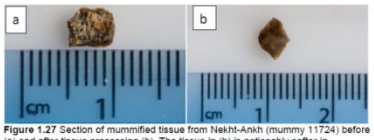


Figure 1.27 Section of mummified tissue from Nekht-Ankh (mummy 11724) before (a) and after tissue processing (b). The tissue in (b) is noticeably softer in appearance.

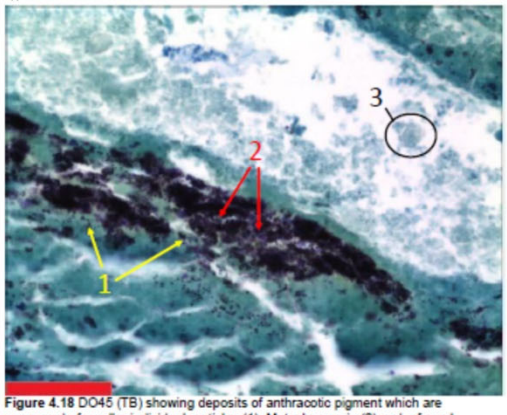
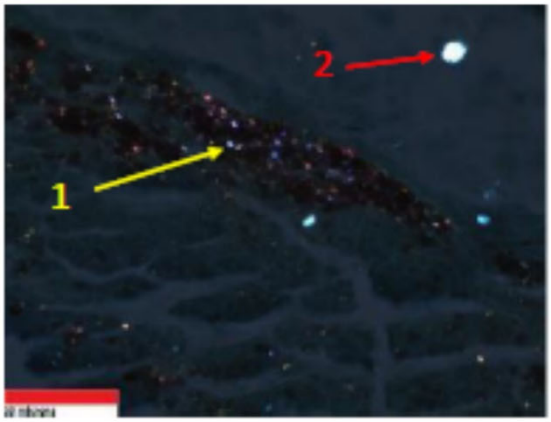


**Figure 4.18** DO45 (TB) showing deposits of anthracotic pigment which are composed of smaller individual particles (1). Metachromasia (2) and a fungal spore (3) can also be seen. Scale bar = 50 microns.

**Figure 4.19** DO45 (TB, polarised) showing inorganic particles (1) and a fungal body (2). Scale bar = 50 microns




Hut Lung (Mukhopadhyay et al ***CHEST 2013; 144 ( 1 ): 323 – 327.. [BAL and transbronchial biopsy]***

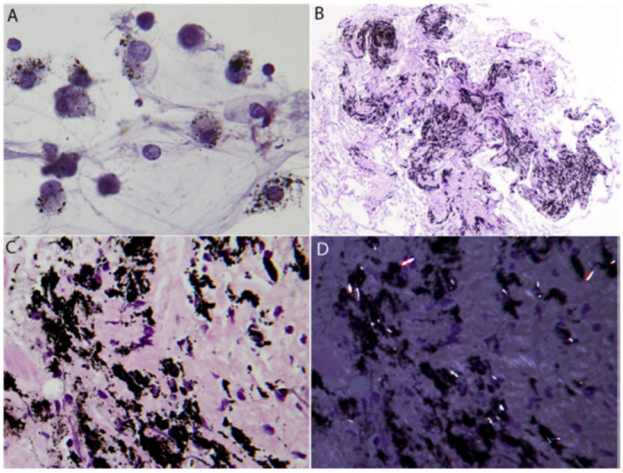


Figure 3. A, BAL cytology showing several macrophages filled with coarse black dust (Papanicolaou stain, x 400). B, Transbronchial biopsy, low magnification (Papanicolaou stain, x 40). There is heavy deposition of black pigment within the pulmonary interstitium, including alveolar septa and peribronchial interstitium. There is mild interstitial fibrosis. This is, therefore, a mixed-dust fibrotic lesion. Similar lesions without significant fibrosis (macules) were also present. The combination of mixed-dust fibrosis lesions and macules is typical of mixed-dust pneumoconiosis. C, Dust-filled macrophages in transbronchial biopsy, high magnification (Papanicolaou stain, 3 400). D, Same area as C, viewed under polarized light, showing that although the black dust is not birefringent, small numbers of other particles are weakly birefringent (silica) or strongly birefringent (silicates).

An environmental history revealed that while residing in Bhutan she cooked daily in a small (3 3 2 ft) windowless room in a bamboo hut. She used an open mud stove fueled by fi rewood (a biomass fuel) for at least 5 h daily since age 15 years. She continued this practice in Nepal using charcoal (another biomass fuel) and also used a stone grinder to grind rice, buckwheat, and maize.

**SUMMARY:**

- The novel observation of vegetative char particles in the mummies' lungs – and the seeming relationship to historical age -- raises challenging anthropological questions about cultural practices
  - We are unaware of symptoms of course, but evidence of infections (e.g., pneumonia) has been reported as possibly related to/exacerbated by dust inhalation
  - Possible (not exhaustive) influences on 'char' accumulation: cooking practices, ventilation, agricultural practices, cultural rituals, wildfires, climate change
- These findings from ancient people have relevance to current concerns about health effects of exposures to smoke from indoor (e.g., cooking) and outdoor (e.g., wildfires) sources

Pathologists and other microscopists should be encouraged to look at and report the details of the particulate materials found in the samples they examine.

Further reading if interested:

The following references relate to the other dusts found in the lungs of the mummies, and some of the literature related to human and animal pneumoconiosis from soil-related silicate exposures.

Also a reference on the likely diets of dwellers in the Azapa Valley, related to differences in largely marine based diets near the ocean and more agricultural-based diets in inland regions (where the mummies we studied lived).

Simple Siliceous Pneumoconiosis in Negev Bedouins. Bar-Ziv, J and Goldberg GM. Arch Environ Health; 29:121, 1974.

Schoning P, Abraham JL, Burnett BR. Silicate and Metal Dust in lungs of Greyhounds. Am J Vet Res 57:1006-1009, 1996.

In addition to the dust in the lungs matching in composition the dust of the racing tracks, the amount of dust increased with the age of the dogs.

Schoning et al 1996 [2]

Dogs had high concentrations of aluminum silicates, increasing in age. Low percentages of silica were found. The composition of the lung dust matched the composition of the dirt tracks on which the dogs raced.

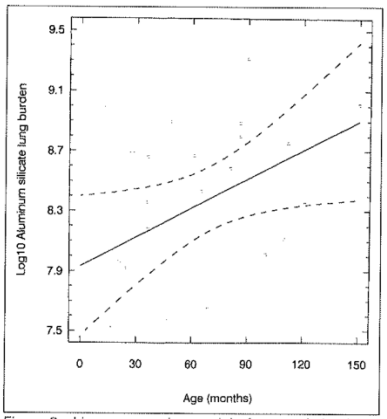



Figure 3—Linear regression model of age and aluminum silicates on logarithmic scale for 20 Greyhounds ($P < 0.035$, $r = 0.47$). Dotted lines = 95% confidence limits.

0023-6837/79/4005-0576$02.00/0
LABORATORY INVESTIGATION

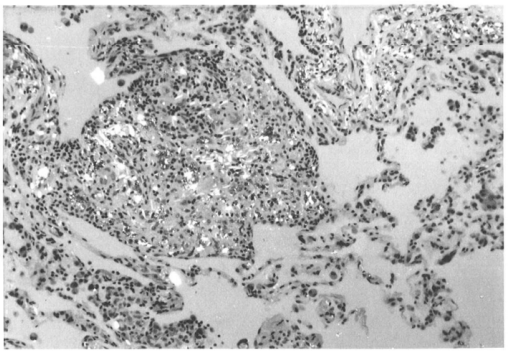
Vol. 40, No. 5, p. 576, 1979
Printed in U.S.A.

# Silicate Pneumoconiosis of Farm Workers

R. P. SHERWIN, M.D., M. L. BARMAN, M.D., AND J. L. ABRAHAM, M.D.



FIG. 3. Autopsy section of lung (patient 4). Characteristic nodular lesion is shown in the *central portion* of the field. The nodule is primarily a loose, fibroreticular thickening of the interstices and is associated with birefringent crystals and a prominent lymphocytic infiltrate. Alveolar walls immediately adjacent to the nodular lesion show little or no fibrous thickening, but there is a prominent lymphocytic infiltration. Birefringence of the elastica of a small arterial branch is present (*right upper quadrant*). ×140.



---

- 3.1. **Archaic period** -- Chinchorro populations were almost completely reliant upon the marine environment for subsistence
- The first evidence for human settlement of the Arica region is between 9400-8200 BCE
- By 5000 BCE these coastal populations developed extraordinary funerary practices including artificial mummification that lasted until ca. 1500-1000 BCE; the end of the Chinchorro cultural tradition and also the transition towards food production in the coastal valleys of the Arica region
- **3.2. Formative period [~900 BCE- 600 CE] {~2400 BP to 1250 BP}**
- The first farmers of the inland Azapa Valley sites have generally been associated with the Alto Ramírez cultural Phase, which according to Rivera (1994, 1975) corresponds with a migration from the complex Formative centres of the highlands,

Marine resource reliance in the human populations of the Atacama Desert, northern Chile -- A view from prehistory. Charlotte L. King [a, *], Andrew R. Millard [b], Darren R. Grocke [c], Vivien G. Standen [d], Bernardo T. Arriaza [e], Sian E. Halcrow [a] Quaternary Science Reviews 182 (2018) 163-174

A b s t r a c t

The Atacama Desert is one of the most inhospitable terrestrial environments on Earth, yet the upwelling of the Humboldt Current off the coast has resulted in the presence of a rich marine biota. It is this marine environment which first enabled the human settlement of the northern Atacama Desert, and continues to form the basis of regional economies today. In this paper we explore how the desert has shaped human dietary choices throughout prehistory, using carbon and nitrogen isotope analysis of human bone collagen (n = 80) to reconstruct the diets of the inhabitants of the Arica region of the northern Atacama. This area is one of the driest parts of the desert, but has been generally understudied in terms of dietary adaptation. Statistical analysis using FRUITS has allowed deconvolution of isotopic signals to create dietary reconstructions and highlight the continued importance of marine resources throughout the archaeological sequence. Location also appears to have played a role in dietary choices, with inland sites having 10-20% less calories from marine foods than coastal sites. We also highlight evidence for the increasing importance of maize consumption, coinciding with contact with highland polities. In all periods apart from the earliest Archaic, however, there is significant variability between individuals in terms of dietary resource use. We conclude that marine resource use, and broad-spectrum economies persisted throughout prehistory. We interpret these results as reflecting a deliberate choice to retain dietary diversity as a buffer against resource instability.

Submitted by: Jerrold L. Abraham, MD, and Judith Crawford, CIH, PhD, SUNY Upstate Medical University, Syracuse, NY, USA. abrahamj@upstate.edu