Discovery and ramifications of Magnéli phase generation and release from industrial coal burning

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Coal has been used by humans for thousands of years to produce energy through its combustion. According to the International Energy Agency, roughly 30% of the world's overall energy needs come from coal. It is used to produce approximately 40% of the world's electricity, more than any other energy source, and 70% of the world's steel. Its use for these purposes has continually increased over the last 150 years. Considering global reserves and demand in developing counties, especially India, coal will likely be a significant player in the world's energy portfolio well into the future.

We have recently discovered that TiO_2 minerals naturally present in coal quickly convert to titania suboxides, specifically Magnéli phases (Ti_xO_{2x-1} with $4 \leq x \leq 9$) during the coal's heating/burning in coal-fired power plants. As a coal ash component, these Magnéli phases are subject to widespread distribution, likely globally. This family of previously overlooked, incidental submicron- down to nano-materials, is distributed via airborne and waterborne processes. We propose that Magnéli phases can be used as a tracer in the environment to indicate/map the distribution of solid state emissions from coal-burning industrial processes. In its first toxicity testing, our team has shown that nanoscale Magnéli phases have potential toxicity pathways that are not photoactive like TiO_2 phases, but instead may be biologically active without photostimulation. Our findings strongly suggest that these unusual, widespread materials should be thoroughly tested for their toxicity in soils, sediments, and animals, and particularly in the human lung.

In this talk, we will describe in detail how we recognized and categorized these incidental Magnéli phases, our crystallographic analyses of the various suboxide varieties encountered, our syntheses of these phases which strongly supports our hypothesis that these materials are generated during coal combustion, why Magnéli phases are highly reliable tracers for determining coal ash distributions via aeolian or riverine processes in the environment, and finally a first look at its toxicity using the well-established zebrafish (*Danio* rerio) embryo model.