# Towards a comprehensive theory of crystal dissolution

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Tim Drever has moved our field forward with his strong focus on understanding the processes, inorganic and biological, that control the chemistry of surface water and groundwater. With his pioneering work he has often inspired our own research on crystal dissolution kinetics. It is thus an honor for us to participate in this session's tribute to Tim. In our contribution, we will discuss the current progress on how we treat crystal dissolution, both theoretically and with respect to experimental and natural systems. We will advocate an approach that leaves the path of conventional treatment using closed-form equations that we often call "rate laws", and instead moves towards an approach that treats crystal dissolution as a dynamic, many-body problem that must be understood stochastically. This conceptual transformation has significant consequences. As an example, we must rethink the concept of reactive surface area: despite its conceptual utility in philosophical exploration of the so-called surface area problem, it has not proven to be a quantifiable parameter. Practical solutions often do not treat surface area as a function of time and reactivity. A paradigm shift may also be required because of the lack of a single or "true" value for the so-called rate constant. Instead, we must admit the possibility of a range of rates for any given mineral, and that rates exist not as fixed values but simply as probabilities. This insight has significant implication and consequences for our ultimate ability to predict system behavior in diverse fundamental problems ranging from corrosion and nuclear waste sequestration to weathering of rocks and soils, with further implications for water quality and climate change.

# Medical geology: Dust exposure and potential health risks in the Middle East

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In the Middle East, dust & sand storms are a persistent problem and can deliver significant amounts of micro-particulates via inhalation into the mouth, nasal pharynx, & lungs due to the fine size and abundance of these micro-particulates. The chronic and acute health risks of this dust inhalation have not been well studied nor has the dust been effectively characterized as to its chemical composition, mineral content, or microbial flora. Scientific experiments were designed to study the Kuwaiti & Iraqi dust as to its physical, chemical, and biological characteristics for its potential to cause adverse health effects. First, dust samples from different locations were collected & processed & exposure data collected. Initial chemical & physical characterization of each sample including particle size distribution & inorganic analysis was conducted, followed by characterization of biologic flora of the dust, including bacteria, fungi and viruses. Initial data indicates that the mineralized dust is composed of $CaCO_3$ in a coating over a matrix of metallic Si crystals containing a variety of trace metals constituting ~1% of the PM10 by weight. The particles consist of ~1% bioavailable Al and Fe each. Microbial analysis reveals a significant biodiversity of bacterial, fungi, and viruses of which ~30% are known pathogens. The level of total suspended particle mass along with environmental & physiological conditions present constitute an excessive exposure to micro-particulates including PM 2.5 & the potential for long-term adverse health effects. These data suggest that the level of dust exposure coupled with the microbial & metal content could constitute a significant health risk. When taken with other existing work suggest that further research is warranted to provide insight into potential human health risks both acute and chronic.