Presentation of the Dana Medal of the Mineralogical Society of America for 2019 to Matthew J. Kohn

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If there's one word that describes Matt Kohn's career, it's eclectic. What is perhaps most astounding is that Matt's contributions have not been in a single, narrow field, but in two distinct fields that, at least at first glance, are not even that closely related. While Matt is a metamorphic petrologist par excellence making significant contributions to the fields of geothermobarometry, metamorphic phase equilibria, metamorphic fluid flow, monazite geochronology, argon geochronology, and metamorphic *P-T-t* studies and their tectonic implications, he has also pioneered the use of stable isotopes to unravel vertebrate paleodietary patterns and paleoclimate.

Matt's ability to "think deeply" about petrologic and tectonic problems is truly exceptional. On a number of topics where, after reading the literature, Matt has concluded that "this doesn't make sense," and then goes on to develop some fundamental new insights into the issue. Of course, Matt's perspicacity could sometimes be downright annoying. I have many memories of Matt coming to my office with a "simple" question about a paper he had just read and I got used to the realization that a question from Matt usually required hours of pondering (on my part) and usually led to new insights and sometimes even a publication!

An early example that I worked on with Matt is his contribution to error propagation in thermobarometry (Kohn and Spear 1991a, 1991b). This was primarily Matt's intuition and insights and provides the definitive baseline for uncertainty estimation in crustal *P–T* conditions. A recent favorite is Kohn et al. (2016) "Implications of near-rim compositional zoning in rutile for geothermometry, geospeedometry, and trace element equilibration." The take-away message of this paper is that one should not attempt interpretation of trace element thermometric results (specifically Zr in rutile) unless one has a thorough knowledge of the boundary conditions imposed by the phase assemblage on diffusive processes during cooling—and those grain boundaries may become locked up, unable to provide the trace element of interest to the target mineral. This highly insightful paper resolves the recent debate about the closure temperature of Zr in rutile thermometry: namely, that the diffusivities are reasonably accurate, but the rutile grain boundaries become locked up in dry rocks, prohibiting diffusive resetting. This study will have a major impact on our understanding of the *P-T* conditions of UHT metamorphism, where trace-element thermometers are being used to constrain extreme crustal temperatures.

Another particularly evocative direction of Matt's current research is the search for "ground truth" about the thermal structure of subduction zones. His recent paper with Sarah Penniston-Dorland and Craig Manning (Penniston-Dorland et al. 2015) highlights the discrepancies between the *P-T* records preserved in blueschists and those retrieved from thermal models. That the thermal models predict conditions not observed in the rocks suggests that there are important tectono-thermal considerations in subduction zones that we do not yet fully understand.

Matt has also played a key role in the development of two relatively new tools for petrologic analysis of metamorphic rocks: (1) accessory monazite thermochronometry and "Thermoba-Raman-try." Unlike zircon, whose value lies in its persistence through numerous cycles of weathering, diagenesis, metamorphism, and anataxis, monazite is not so robust and is absent in mature sediments such as pelites. Given its high concentrations of U and Th and relatively low Pb diffusivity, monazite constitutes a unique prograde geochronometer allowing access to a heretofore inaccessible region of an orogen's *P-T-t* path. Matt demonstrated that the trace amounts of phosphorus in common silicate minerals are sufficient to yield prograde monazite in pelites without P-rich precursor phases (Kohn 2004). He has recently completed a similar investigation on zircon formation metabasalts and pelites (Kohn et al. 2015). Matt also developed petrogenetic guidelines for interpreting Th and Y zoning (e.g., Kohn and Malloy 2004; Kohn et al. 2005; Corrie and Kohn 2008), and applied them to Himalayan monazite. His group has pioneered the use of trace element thermometers (Zr-in-titanite, Zr-in-rutile, and Ti-in- zircon) in conjunction with in situ U-Pb dating (e.g., Kohn and Corrie 2011; Kohn and Northrup 2009; Wolfowicz et al. 2015) to unravel tectonic events.

Matt's approach to issues in vertebrate paleontology, paleoecology, and paleoclimate are neatly described in a perspective article he published in *Science* in 1999, "You are what you eat?" that describes how the isotopic composition of vertebrate bones and teeth reflect the isotopic composition of various edible components of their habitat, i.e., their ecosystem. Applications to fossil evidence have implications for paleoecology that, in turn, reflect the influence of paleoclimate. That climate can be influenced by tectonics makes the connection between fossil tooth enamel and mountain building! Many of the insights in this perspective were derived from his very successful, generalized model that predicts the oxygen isotopic composition of animal body water and phosphate as a function of diet and physiological adaptation (Kohn 1996). In another foundational

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contribution, Matt developed a laser probe fluorination method enabling the analysis of herbivore tooth enamel, demonstrating that their compositions were broadly consistent with habitat and diet, providing support for the applications to fossil teeth (Kohn et al. 1996, 1999). This was subsequently exploited in an investigation that combined oxygen isotopic data from fossil bivalves and teeth and demonstrated that relative homogeneity of surface water in Himalayan foreland from 10.7 Ma to the present. This result implies that the Tibetan plateau had reached an elevation sufficient to support an Asian Monsoon prior to this time (Dettman et al. 2001). As such, Matt's work in metamorphic petrology and paleoclimate have come together through their mutual implications on tectonics.

As a metamorphic petrologist, Matt continues to be a leader, applying phase equilibria, stable isotope and trace-element geochemistry, and geochronology to *P-T-t* analysis and tectonics. That Matt has achieved similar eminence in vertebrate paleontology, paleoecology, and paleoclimate took many of us by surprise and attests to his broad scientific curiosity as well as his intellectual flexibility and rigor. With this broad range of exciting and fundamental applications, all traceable to the foundations of crystal chemistry and mineralogy, Matt is an exemplar of modern mineralogy and truly deserving of the recognition that comes with the Dana Medal.