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Presentation of the Dana Medal of the Mineralogical Society of America for 2016 to Sumit Chakraborty

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Sumit Chakraborty has been chosen to receive the 2016 Dana Medal of the MSA primarily for his outstanding contributions in two frontier areas of petrology, namely the Diffusion Kinetics in natural systems and the Petrological Geodynamics of the Himalayas.

Sumit's contributions in the field of diffusion kinetics of minerals, which has now emerged as a major research area in Earth and planetary sciences, spans a wide range of technical developments in theory and experiments, coupled with first-hand field studies, and innovative applications to retrieve timescales of metamorphic, magmatic, and planetary processes. In this area, Sumit's main focus has been garnet and olivine (and its high-pressure polymorphs), but the domain has now expanded to include spinel, plagioclase, pyroxene, etc.

Sumit's papers on the complex problem of multicomponent diffusion in metapelitic garnet have greatly influenced petrologists to measure and model compositional zoning in garnet to retrieve timescales of metamorphic processes. Because of its importance in the understanding of mantle and planetary processes, diffusion properties of olivine, especially those for Fe and Mg, have been studied extensively over the past 40 years or so, but with conflicting results. However, Sumit and his group have provided us with the most complete and definitive set of diffusion data of different species in olivine (Fe, Mg, Mn, Ni, Ca, Li), and theoretical formulations and algorithms that now permit, along with his works on diffusion kinetics of pyroxene, plagioclase, and spinel, retrieval of tightly constrained timescales of various petrological processes.

Sumit has also carried out detailed studies of the fundamental aspects of point defects and how these relate to diffusion properties, and diffusion mechanisms. This has led to a mechanistic understanding of the incorporation of such dilute species as hydrogen that has a strong effect on the rheological and transport properties of olivine. Sumit has also shown the existence of a new diffusion mechanism that dominates the low-temperature diffusion properties in transition metal bearing phases, and it is of fundamental importance in the interpretation and extrapolation of diffusion data.

For a long time, people working on the geodynamics of the mantle have been suffering from the lack of a better constraint on the mantle viscosity as function of depth than is possible from analysis of the post-glacial rebound. The problem still persists, but Sumit and his group showed that the creep behavior of the most abundant upper mantle mineral, olivine and its polymorphs, is controlled by the diffusion of Si and is also affected by water fugacity. This has opened up a potentially direct route to the determination of mantle viscosity as a function of P, T, f_{H_2O}, and mineralogical properties.

In collaboration with his research group, Sumit has carried out a highly innovative set of studies on the residence timescales of melts and mixing processes in magma chambers from modeling compositional zoning in plagioclase and olivine in the ejected materials. The temporal resolution (decadal) of these studies far surpasses that of any geochronological method. This has been possible only through the acquisition of robust experimental data, coupled thermodynamic and diffusion kinetic analyses, as well as the development of sophisticated modeling protocol incorporating full consideration of anisotropic diffusion in olivine. The approach that Sumit and his group developed also led to an understanding of the plumbing system, magma mixing, and transport beneath Mt. Etna, thus providing important clues regarding the potential triggering mechanism for volcanic eruptions. Sumit and his group have also provided important insights about how cooling process of young oceanic crust, determined on the basis of diffusion kinetic analysis, can power the formation of megaplumes in ocean water, and the dominant heat transport mechanism during cooling of oceanic crust around mid-ocean ridges.

Sumit is one of a limited number of scientists to have studied multicomponent diffusion in silicate melts. He has clarified how uphill diffusion (diffusion of a component against its own concentration or chemical potential gradient) can take place in a melt, how to deduce diffusion paths in a melt that provides information about stoichiometry and rates of homogeneous reactions, which are responsible for mass transport, and several other aspects of diffusion in silicate melts including its relationship to properties such as glass transition and relaxation behavior, melt structure, etc.

Along with these activities, Sumit began a program of intensely field-based study about ten years ago to resolve the long-standing problem of the inverted metamorphic sequence (IMS) in the Himalayas and related magmatic activities. He led an international group of scientists with diverse expertise in a very coordinated way and came up with a series of papers that, as a whole, constitute a very comprehensive and insightful analysis of the problem of IMS. Sumit and coworkers also addressed the problem of nucleation kinetics and disequilibrium melting in the Himalayas, on the basis of numerical modeling of melting and mineral diffusion kinetics, thus providing important insights on the nature and time scale of the processes that led to the observed geochemical characteristics of the partial melts.

Sumit is one of a small number of people in our community who have worked on both kinetic and thermodynamic problems. The power of this coupled approach is reflected in some of the pioneering studies discussed above. In collaboration with Ralf

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Dohmen, it has also enabled Sumit to elucidate the role of dry vapor phase in the transport of components during planetary and terrestrial processes, and the mechanism and kinetics of element and isotopic exchange between adjacent phases in the presence of a fluid phase that are of fundamental importance in the fields of geothermometry, geochronology, and geospeedometry.

Prior to coming to the U.S.A. with a prestigious fellowship at the University of Arizona, Sumit was a recipient of the Jawaharlal Nehru fellowship (named after the first prime minister of India) that was awarded to only 10 students from all disciplines on the basis of a nationwide competitive examination. This impressive record was matched by a performance in the Ph.D. comprehensive examination that his committee members talked about for many years since. The oral examination, which typically drags on to the maximum official limit of three hours, was terminated just after the official requirement of minimum one hour, and without giving me a chance to ask any question since, to quote one of the committee members, "for one hour the committee could not come up with a single question that the candidate was not able to answer." I wish I had a chance!

Sumit has always been a night owl. Once he moved on to complete research after finishing his course works and comprehensive examination, Sumit's "day" would typically start sometime in the afternoon and continue past midnight, often with dinner in an all-night Mexican restaurant in the campus that folded business after Sumit graduated. And often he would drop by in my office in the late afternoon, when I was pretty much worn out, to discuss something that he had been working on, and this discussion would then continue for hours.

So, it is with a sense of great personal satisfaction that I introduce Sumit Chakraborty as the recipient of the 2016 Dana Medal of the Mineralogical Society of America that is intended to recognize a mid-career scientist for "sustained outstanding contributions through original research in mineralogical sciences."