

Mathematical Modeling of Processes Beneath the Volcano

J. Nicholls, Department of Geology and Geophysics, University of Calgary

Volcanoes can be beautiful or ugly, depending on how close you are when they erupt. The processes that cause eruptions operate beneath the surface of planets, out of direct observation. Inferences about the processes that control the size and intensity of eruptions follow from applications of physical chemistry and Newtonian mechanics. The processes that happen in magmas, which are the partly molten bodies that give rise to volcanic rocks, have to be inferred from observations made after magmas have crystallized and been exposed at the surface. The final stages of crystallization of lava flows on the surface are frequently associated with eruptions too violent and dangerous to observe directly, although there are exceptions, such as Hawaii. Magmatic processes usually produce a suite of rock types that have different chemical, mineralogical, and textural properties, which contrast with the more uniform features of the original magmas. From the different chemical, mineralogical, and textural features of the rock types, as well as the field relations, petrologists infer the processes that caused these differences. Inferences come from a sequence of methods that start with characterization of the rock suite followed by inferences from methods that relate the characters of the various rock types that comprise the rock suite. Inferences generated at this stage are ultimately based on conservation of matter. The next stages of interpretation are based on conservation of energy, thermodynamics and kinetics. Methods, which are based on fundamental conservation principles, often give more than they receive: only a small number of chemical and mineralogical features define the mass and energy balances. The remaining chemical and mineralogical data, which are not required to define the mass and energy balances, are independent of the inferences. From the inferences, mathematical models are constructed to provide calculated values that can be compared with the independent data.