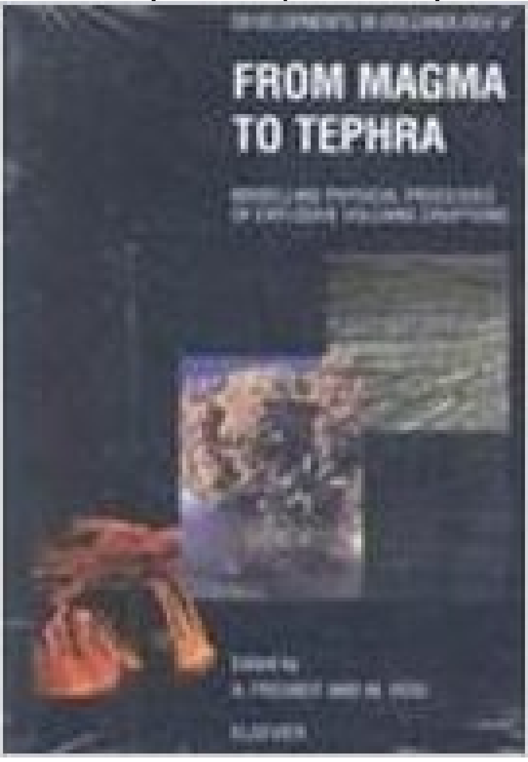
From Magma to Tephra: Modelling Physical Processes of Explosive Volcanic Eruptions (Developments in Volcanology)



Hot magma rising through the Earths crust releases gases that expand and may come into contact with external water that vaporizes. The magma is then fragmented into an accelerating gas-particle/droplet mixture that is shot into the atmosphere, possibly in an overpressured state, where it may buoyantly rise up into the stratosphere as an ash plume, partially or totally collapse back to the surface, or rapidly expand sideways, or undergo a combination of these processes. Tephra is then deposited on the Earths surface by pyroclastic fall, flow or surge, or some hybrid mechanism. The combination of processes that operate from the degassing of magma to the emplacement of tephra makes an explosive volcanic eruption, and the physical characterization of these processes is the scope of this book.In this book we summarize the insights into key aspects of explosive volcanic eruptions gained from physical modelling to date.The seven chapters are arranged in an order reflecting the sequence from processes acting within the volcanicconduit through dynamics of eruption and transport through the atmosphere to mechanisms of emplacement on the Earths surface.Chapter 1 reviews the progress made in understanding how magma vesiculates and fragments, considering results obtained by experiment, theory, and analysis of the vesicle-texture of pumice. Magmatic fragmentation is discussed in terms of brittle failure as tensile strength is exceeded by internal and/or external stresses. The explosive fragmentation of hot magma upon contact to external water is experimentally shown in Chapter 2, emphasizing the need for water-entrapment configurations to cause explosive interaction during which extremely high stresses fracture melt in a brittle fashion. The motion through the conduit of vesiculating magma below the fragmentation level, and of the gas-particle/droplet mixture above fragmentation is investigated in Chapter 3. Pressure evolution along the conduit and exit velocity at the vent are shown tovary with initial magma chamber pressure, magma composition, and composition of the mixed H2O+CO2 volatile phase. Chapter 4 then reviews the processes that control the dynamic evolution of eruption columns during rise into the stratosphere or collapse to form pyroclastic flows, considering supersonic dynamics, influence of the atmosphere, and time-dependent unsteadiness effects. Transport and fallout of pyroclasts from eruption columns with or without cross-wind are the topic ofChapter 5, showing how deposit characteristics can be used to estimate eruption parameters such as discharge rate and column height. The generation, transport and emplacement of pyroclastic flows is discussed in Chapter 6, reviewing the presently much debated transport concepts ranging from grain flow through fluidized flow to suspension currents,and elaborating the suspension-current model thought to be applicable to widespread ignimbrites. Finally, Chapter 7 summarizes observations from nuclear explosions and characteristics of pyroclastic surge deposits as a basis to then theoretically analyze the compressible two-phase flow of both dry and wet pyroclastic surges.

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