Part V

Extraterrestrial Volcanism

Haraldur Sigurdsson

Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, USA

In the Space Age we have discovered that volcanoes occur on most of the rocky bodies of our Solar System, and future explorations of other worlds will without doubt reveal volcanism as an important feature of planetary evolution in the universe as a whole. The evidence for volcanism on other bodies of the Solar System is reviewed in the five following chapters in Part V of the second edition of the Encyclopedia of Volcanoes, Extraterrestrial Volcanism. Although just beginning, the exploration of extraterrestrial volcanoes has revealed some amazing surprises, as described in this part of the volume.

We begin with the Chapter 39, studying the volcanism of our nearest neighbor. When Apollo 11 landed on the Moon in 1969, it touched down on the surface of a basaltic lava flow. Ever since Galileo aimed his telescope at the Moon in 1610, we have wondered about the origin of its numerous and large craters. The lunar craters, however, turned out to be of impact origin, whereas the dark plains, which are clearly visible with the naked eye from Earth and were termed maria by Galileo, turned out to be made up of great floods of basaltic lavas. Studies of the rocks returned back to Earth laboratories have shown that the Moon has been extinct for over one billion years—a consequence of the small diameter of this rapidly cooling planetary body.

In contrast to our volcanically “dead” Moon, the Jovian satellite Io has a continuous display of spectacular eruptions, as described in the Chapter 43. It is in fact the only body outside the Earth known to have large-scale active volcanism today. Io is indeed a strange and colorful world, with a surface decorated with a wonderful mosaic of yellows, oranges, and reds and sulfurous volcanic plumes that rise over 300 km above its surface. We are accustomed to thinking of volcanic energy as largely derived from primordial heat in the planet, but Io’s energy source is different. The intense and continuous volcanism of Io is due to heat from great tidal stresses generated by its giant neighbor Jupiter.

Venus—our nearest planetary neighbor—has volcanic features that are in several respects similar to the activity on Earth, as described in the Chapter 42. While there is no evidence of Earth-style plate tectonics on the Moon, Io, or Mars, or currently on Venus, there is indication that global-scale processes may have been operating there, causing geologically recent global resurfacing, reflected in its extensive volcanic plains. Large central volcanoes dot the surface, but Venus also possesses enigmatic coronae, enormous circular structures that are several hundred kilometers in diameter and found nowhere else in our Solar System.

The Chapter 41 answers the question: how did a planet one-half the size of Earth generate volcanoes that are several times larger than the largest volcanoes on Earth? Mars has widespread volcanic plains, like the Moon, but the characteristic Martian volcanic features are huge central volcanoes that dwarf any terrestrial volcanoes. These immense lava shields are the result of hotspot activity, and the largest is Olympus Mons, 25 km high, 600 km diameter. Is the size of these volcanoes a reflection of a much thicker lithosphere and the absence of plate tectonics?

Volcanism on Mercury is a new chapter in this volume, reflecting the great discoveries made on this planet in recent years, primarily due to the MESSENGER spacecraft mission. These results show that indeed volcanism has been important in shaping the Mercury’s surface. There has been extensive flooding of the surface by lava flows to form regional smooth plains.

In the farthest reaches of our Solar System, on the moons of Uranus, Saturn, and Jupiter, a unique form of volcanism occurs, in which geyser-like plumes of nitrogen and water-rich “magmas” are ejected from volcano-like structures. The final chapter of this section, Cryovolcanism in the Outer Solar System, discusses this distinctive form of volcanism. Most of the moons around Jupiter, Uranus, and

Neptune are made up of water ice and other volatiles. From time to time, heat generated within these satellites churns up a slush of ice and volatiles that are erupted at the surface, forming volcano-like manifestations of “dirty ices” mixed with ammonia, silicates, and other impurities. The discovery of nitrogen-rich and geyser-like plumes on Triton, Neptune’s distant moon, by Voyager 2 in 1989 and, more recently, the discovery of the Enceladus plume by the Cassini spacecraft, shows that this type of volcanism occurs today.