CINDER CONES ON THE EARTH, MOON, MARS, AND VENUS: A COMPUTER MODEL;

J. Dehn, Institut für Mineralogie, Postfach 102148, Ruhr-Universität Bochum, D-4630 Bochum 1, FR Germany and **M.F. Sheridan**, Dept. of Geology, Arizona State University, Tempe Arizona 85287.

The formation of a cinder cone is numerically modeled by consideration of the eruptive environment and physical behavior of the ejected particles. The model consists of two parts: 1) calculation of the ballistic trajectories of the erupted pyroclasts, and 2) determination of the morphology of resultant deposits. The ballistic part of the model was constrained by observations of actual eruptions, field work on cinder cones (in Arizona, Hawaii, Mexico, and West Germany) and published information on basaltic volcanism. Slope stability of the cinder cone was determined using an 'energy line', a maximum energy value defined for each position in the cinder cone, and models of particle movement. These methods were verified by field work and elementary experimentation. A series of time dependent equations model each portion of the eruption, and a cinder cone is created with respect to specified eruptive conditions. Because of the iterative nature of the solution, a microcomputer is used to calculate and graphically display the results of the model.

The modeled eruptions match the appearance of lava fountains and produce the morphology of cinder cones observed in the field. This model supports the conclusion that ejection angle and velocity of erupted particles determine the initial distribution of material and thus, the early morphology of the cone. As the cone grows, external morphology is determined by the angle of repose of the cinders, represented by the coefficient of friction. The occurrence, size, and shape of the central crater is determined by the angle of ejection of pyroclasts, vent geometry, and displacement of erupted material by prevailing winds. The model can be used to generate terrestrial cinder cones or their analogs on other planets using appropriate environmental and eruptive conditions.

Modeling was performed under conditions for the Moon (1), Mars (2), andVenus (3). Though they would certainly differ on other planets, constant ejection angles and velocities were used to isolate and study the effects of gravity, atmospheric density, and viscosity on cinder cone morphology.

(1) As a result of the low gravity and lack of atmosphere, lunar cinder cones are widely dispersed, having diameters approximately 10 times those of terrestrial cinder cones. The erupted material forms a continuous blanket near the vent but becomes discontinuous with distance from the vent. The cinder cones do not achieve heights over a few tens of meters. Morphologically, the lunar cinder cone resembles a shallow impact crater.

(2) Martian cinder cones also have discontinuous and continuous ejecta blankets. They do not have as large a diameter as lunar cones, only 2 to 3 times that of a terrestrial cinder cone. They achieve a greater height than lunar cones, well over 100 meters. Correspondingly, the central craters are deeper and well defined.

(3) Venusian cinder cones are more similar to terrestrial cones. The ballistic limit of the erupted particles is rapidly covered by material tumbling from the flanks of the cinder cone. These cinder cones have a diameter of 1.5 times that of terrestrial cones. The central crater on a venusian cone is half as large as that of a terrestrial cone, making it appear as a nearly perfect cone.

The model demonstrates that particle distribution is the primary control of cinder cone morphology. The particle distribution changes with different gravities and atmospheres and produces different cinder cone forms on different planets.