VESUVIUS 2000 – forum 2004, September 2-3, 2004, Ercolano (Napoli), Italy

PHYSICAL MODELING OF ERUPTION PROCESSES AND GLOBAL VOLCANIC SIMULATION

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Accurate forecasting of future volcanic events of a volcano requires detailed understanding of its past behavior and extrapolation of this behavior into the future. Geological and geophysical studies are required to understand the origin and composition of deposits, magma and lava flows, presence of aquifers, strength, elasticity and plasticity of magmas, lavas, surrounding rocks and soils, etc. Research in applied mathematics requires the development of physical models at the microscopic and macroscopic levels for the magma, lava, soil, and atmospheric dispersion of erupted materials. The complicated form of the resulting coupled and non-linear differential equations requires efficient numerical methods and computer techniques for solving these equations and visualizing large data sets produced by the simulations. Such an effort was proposed over a decade ago for the purpose of producing a Global Volcanic Simulator for Vesuvius [1,2], with some notable progress already being made in modeling magma chamber dynamics, magma ascent in conduits, and pyroclastic dispersions [3].

A Global Volcanic Simulator should adequately resolve the thermodynamic processes associated with magma mixing, differentiation, and crystallization in the magma chamber, changes in magma chamber geometry with time due to the inflow and outflow of magma and changing stresses of surrounding rocks, magma ascent along the conduit(s) and interaction with conduit's walls, structural response of the volcanic edifice to magma chamber and conduit processes, and distribution of erupted products in the atmosphere and along the slopes of the volcano. A global model should therefore simulate efficiently all relevant physical processes below and above the surface of a volcano for tens of thousands of years (several large-scale volcanic events) and over large spatial domains. Magma chamber modeling should account for several crystallizing phases, crystallization kinetics, and gas exsolution, whereas the conduit modeling should account for crack propagation due to intruding magma, magma-water interaction, magma fragmentation, and erosion of conduit walls. The rock and soil modeling should use deformation maps which characterize the elastic, plastic, and viscoelastic characteristics of rocks at different mechanical, thermal, and chemical states. The pyroclastic dispersion modeling should involve pyroclasts with several granulometric particle classes, mixing of magmatic gases with the atmosphere and interaction with pyroclasts, particle-particle interactions and two-way turbulence coupling between the gas and particulate phases. With a serious support of a scientific effort it is feasible to produce the required physical models and solve the resulting set of mathematical equations through the domain decomposition on parallel or multiprocessor computers [1]. Some multiphase flow models already exist for modeling dense multiphase suspensions [3, 4] while others need to be developed and tested. This practice should involve both verification (solving correctly the mathematical equations) and validation (insuring that the physico-mathematical model represents correctly the reality) because these two distinct procedures are often confused in the scientific literature.

Current modeling capabilities of magma chamber dynamics, magma ascent along conduits, and pyroclastic dispersion in the atmosphere forecast a large-scale eruption of Vesuvius in the near future (within this or the following century), a rapid time for magma ascent from a magma chamber (several days), and a devastation of the surrounding territory in several minutes following the collapse of a volcanic column. The hazard from ash fall and pyroclastic flows produced from column collapses can be mitigated by constructing defensive measures on the slopes of the volcano and by relocating people to safe distances from the cone of the volcano. The determination of such living and working areas around Vesuvius by means of a Global Volcanic Simulator is important for proper urban planning of the territory and forms an integral part of the VESUVIUS 2000 project [5].

References

1. Dobran, F., 1993. **Global Volcanic Simulation of Vesuvius**. Giardini, Pisa.

2. Dobran, F., 1994. Prospects for the global volcanic simulation of Vesuvius. In **Large Explosive Eruptions**, Academia Nazionale dei Lincei, Rome, Vol. 112, 197-209.

3. Dobran, F. **Volcanic Processes: Mechanisms in Material Transport**. Kluwer Academic/Plenum Publishers, 2001.

4. Dobran, F. 1991. **Theory of Structured Multiphase Mixtures**. Springer-Verlag, New York.

5. Dobran, F., 2004. **VESUVIUS 2000**. This volume.