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Final Technical Report

Planetary Geology, Stellar Evolution and Galactic Cosmology

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I. Planetary Geology (Dr. Ronald Greeley)

Most of the lunar mare surfaces and parts of the martian surface appear to be covered with basaltic lava flows and show other signs of volcanic activity. By learning the identifying characteristics and mode of origin of terrestrial basalt structures, we can better interpret and understand similar features on planetary basalt flows. Toward this end, field studies of selected basalt flows in the western United States are in progress.

The Snake River Plain, Idaho, is a geologically young basalt-filled depression about 250 miles long x 65 miles wide. It has a wide variety of structural features that are well preserved and which may be directly analogous to planetary structures. These include double craters, collapse craters, lava channels, channel-vent structures, and partly collapsed lava tubes. Photogeologic maps are prepared of selected regions of the Plain. During the field season, specific structures are examined on the ground to determine their mode of origin and large-scale geomorphology. This information is currently being used to interpret Apollo 15 pictures of mare surface features and will serve as reference data for the interpretation and geological mapping of Mars from Mariner 9 photographs.

Parts of the Snake River Plain are covered, or partly covered, with sand dunes. Mariner 9 has shown that eolian processes play an important role in modifying the martian surface. Therefore the Plain, being an eolian-modified basaltic terrain, is an appropriate area for comparative studies of Mars. These studies were initiated last summer in cooperation with the University of New York at Buffalo, Geology Department.

Similar, but more restricted, studies of basalt flows have been completed or are in progress. Studies of basalt lava tubes in Washington, Oregon, Hawaii, and Northern California were initiated for comparisions with lunar sinuous rilles. All areas except California are completed and regional geologic reports are in print or press. Data from these studies has been and is being used to interpret lunar rilles and it is likely that the information will be applicable to some martian rilles.

Results of these field studies have been presented to the Apollo 15 and 16 crews prior to their missions as briefings on possible analogs to lunar mare surface features. In addition to lunar and planetary applications, these studies are of interest to other federal and state agencies from a safety and recreational standpoint. Most lava tubes studied are on National Forest lands and the U.S. Forest Service has been greatly interested in our work. They are currently using our geologic reports for road construction and in their interpretive natural history programs. Similarly, the Bureau of Land Management in Idaho is interested in our studies. Bruneau Sand Dunes State Park, Idaho, has requested geologic data and photographs for their museum.

References in Lunar and Planetary Geology for 1971-1972

Terrestrial Analog Studies

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Geology of selected lava tubes in Bend area, Oregon. Ore. Dept. Geol. and Min. Resources, Bull. 71, 47 p.

Phreatic explosion in a lava tube (abs.) Trans. Amer. Geophy. Union, v. 52, p. 433; with J. Hyde.

Seismic wave velocity patterns in some basaltic lava flows. Jour. Geophy. Research, v. 76, p 5765-5769; with J. Rinehart

Note on the occurrence of dribblet spires in the Snake River Plain, Idaho. Northwest Science, v. 54, p. 145-148.

Hambone, California and its magnificent lava tubes (abs.) Geol. Soc. Amer, abstracts, v. 3, p. 128; with R. Baer.

Analog Studies Applied to Lunar-Planetary Problems

Bruneau Sand Dune Field, Idaho and its possible implications in Martian geology (abs.), Trans. Amer, Geophy. Union, v. 52, p. 860 with D. Koscielniak and D. Hodge.

Endogenetic craters interpreted from crater counts on the inner wall of Copernicus. Science, v. 171. p. 477-479; with D. Gault.

Origin of Lunar Hadley Rille (abs.), Trans. Amer. Geophys. Union, v. 52, p. 274.

Lunar Hadley Rille: considerations of its origin. Science, v. 172, p. 722-725

Lava tubes and channels in the lunar Marius Hills, (in press, The Moon; also, NASA TM X62013).

II. Early Phases of Stellar Evolution (Dr. Peter Bodenheimer; work done in collaboration with Dr. David Black)

This project involves the calculation of the hydrodynamic collapse of a protostellar cloud with the view of examining the effects of angular momentum on the collapse and of determining possible models for the "solar" nebulae which are associated with the formation and early evolutionary phases of stars. Comparison of theoretical results with observations of infrared objects suspected to be in the protostellar phase is a further aim of the program.

The main effort has been directed toward development of a two dimensional (axially symmetric) computer code to calculate hydrodynamic flow coupled with radiative energy transport. The method is similar to the explicit hydrodynamic code with a moving Eulerian grid developed by Leblanc and Wilson at Livermore; however the program has been developed from scratch and adapted to the particular problem at hand. A critical and difficult part of the work is the calculation of the gravitational potential in a non-spherical system. An efficient and accurate method based on fast-Fourier-transform techniques has been developed and tested with the aid of Demos Karazis at Ames; this technique has not previously been applied to problems in stellar hydrodynamics. Another aspect of the problem that has required considerable attention and experimentation is the proper specification of the surface boundary condition.

Rough estimates of the effects of rotation on a collapsing cloud have shown that the critical parameter in the theory is the total angular momentum. Calculations employing a range of values are planned; the initial work is being done with a total angular momentum consistent with that in a main-sequence binary system of the same total mass, taken in this case to be 2 solar masses. The cloud becomes unstable to collapse when its density is approximately 10^{-17} - 10^{-18} g cm^{-3}, but under the assumed conditions rotational effects do not become significant until the central density has reached 10^{-8} g cm^{-3}. The early part of the collapse has therefore been calculated using an independent spherically symmetric computer code. This calculation serves to provide the initial conditions for the subsequent collapse with rotation. The spherical calculations are also being used as a check on the accuracy of the two-dimensional code; the first tests show good agreement.

III. Galactic Cosmology (Dr. William A. Barker)

There is a symmetry between matter and anti-matter as observed in particle accelerators. Does this symmetry exist in the universe as a whole? What role does anti-matter play in astrophysics and cosmology? In an effort to respond to these questions, we have concentrated attention on the atom positronium, a hydrogen like atom consisting of an electron and a positron. The Paschen alpha (3.74 micron) and Balmer alpha (1.31 micron) lines are among a number of transitions for which the earth's atmosphere is transparent. We believe they are the most favorable for observations by ground based astronomy and that the center of the galaxy should be examined for these particular wave lengths.

Details of this study are presented in the University of Santa Clara Physics Department Technical Report entitled "A theoretical study of discrete infrared radiation from the atom positronium for which the earth's atmosphere is transparent", dated May 1972.