MARE BASIN FILLING: LABORATORY SIMULATIONS. **R. Greeley** and **M. Womer**, Department of Geology, Arizona State University, Tempe, Arizona 85281.

Despite more than a decade of intensive study, many fundamental questions regarding the style(s) of volcanism and mechanics of lava emplacement remain unanswered for mare lava flows. Although data on the composition of the flows obtained from returned samples place constraints on some of the characteristics of eruption, factors such as rates of effusion and size, shape and location of vents remain mostly unknown. However, some of these factors can be assessed through photogeological interpretation, because the morphology of pristine volcanic landforms is a function partly of the style of volcanism involved in their formation. Laboratory experiments have demonstrated (1) to be a useful means for determining the effect on morphology in varying eruptive parameters. The design of models for use in laboratory simulation requires geometric, kinematic and dynamic similarity between prototype and model (2). According to the *Buckingham Pi Theorum*, $S = N - B$, where S is the number of dimensionless parameters required to define a system, N is the number of variables in the system, and B is the number of basic dimensions in which the variables are measured (3). The variables in a single phase (liquid) system are: fluid density (ρ), gravitational acceleration (g), fluid velocity (V), characteristic horizontal length (L), characteristic vertical length (H), all other horizontal lengths (l), all other vertical lengths (h), viscosity (u), Bingham Fluid yield stress (Ty), surface tension (σ), specific heat (Cp), thermal conductivity (k), temperature (T), temperature difference (ΔT), heat transfer coefficient (h_c), heat of fusion (Qf), pressure (p), and time (t). These variables have the dimensions of mass, length, time and temperature. The following 14 dimensionless parameters are therefore derived: horizontal geometric scaling (1/L), vertical geometric scaling (h/H), Reynolds number (VL/γ) where $\gamma = u/\rho$, Froude number (V^2/Lg), Weber number ($\rho V^2 L/\sigma$), Peclet number ($\rho CpVL/k$), Prandtl number ($\rho\gamma Cp/k$), Grashof number ($g\Delta TL^3/T\gamma^2$), effective Reynolds number ($1/(\upsilon/LVO + (Ty/(\rho VL\partial V/\partial\gamma))$), fusion number (QF/CpT), temperature ratio (ΔT/T), and dimensionless time (t^2g/L) (gravity based). For a model to satisfy similitude requirements each of these Pi terms for both systems must be equal, respectively. Average values for the above variables are listed in Table 1. A comparison of model and prototype Pi terms is given in Table 2 when Carbowax 4000 is used as modelling material. Note that the Weber number indicates greater relative surface tension effects in the model and the Prandtl number indicates greater convective heat loss in the model. Other parameters match moderately well. Based on this system, a series of simple experiments was run to assess the best means for modelling lavas (3).

To simulate lava emplacement in impact basins a 3 m square topographic model of an idealized pre-mare lunar impact basin was constructed. To satisfy modelling constraints of the Carbowax, the model was constructed with a 5X vertical exaggeration. The basin was scaled to the approximate diameter of the basin Schrodinger (~300 km) and consists of inner basin, inner ring, outer basin, outer ring and extra-basin topography. Data for generation of the model were derived from limb profiles across Orientale basin (4). Design of the experimental apparatus allows precise control of both extrusion rate and temperature (and therefore viscosity) of the Carbowax. In addition, from one to seven vents of either circular or fissure type may be used, and the entire model may be tilted up to 5° in any direction. Scaled thicknesses of the model flows average approximately 40 m. Two preliminary runs were conducted at scaled viscosity of 2.5×10^6 poise and scaled extrusion rate of ~40,000 m^3 sec^{-1} from a single circular vent 500 m in diameter. Both runs resulted in complex, channel flow formation. Infilling was restricted largely to the inner basin, individual flows seldom retaining sufficient mobility to fill the outer basin. Early flow profiles (<20 years, scaled duration) exhibit very low gradients, typically less than 7 m/km from vent to flow margin, the result of ponding against the inner wall of the first ring. Later profiles become

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increasingly shield-like as some material flows into the outer basins. A third preliminary run, conducted with scaled values of ~2.0 x 10^6 poise and 430,000 m^3 sec^{-1} from a central vent yielded strongly contrasting results. Material was emplaced as a single cooling unit, gradually filling the inner basin, then flowing outward into the outer basin. Relief on the flow was essentially zero, and filling of the outer basin much more complete. Transition from sheet flow to channel flow occurred at approximately the inner ring, with filling of the outer basin episodic. The result is a complex accumulation of flow units averaging 20 to 50 m thick in the outer basin.

In conclusion, these preliminary runs exhibit substantial differences in morphology due to extrusion rate, and display many features seen in both lunar and terrestrial basic lavas. Future runs with a variety of vent configurations are expected to yield insight into the mechanisms and parameters of mare emplacement.

REFERENCES

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TABLE 1

	Lunar Lava*	Terrestrial Basic Lava**	Carbowax 4000***
L	1000 cm	2500 cm	.25 cm
Vmin	50 cm sec^{-1}	10 cm sec^{-1}	.3 cm sec^{-1}
Vmax	400 cm sec^{-1}	400 cm sec^{-1}	.3 cm sec^{-1}
ρ	3.0 g cm^{-3}	2.0 g cm^{-3}	1.07 g cm^{-3}
Cp	.2128 cal g^{-1} °c^{-1}	.20 cal g^{-1} °c^{-1}	0.55 cal g^{-1} °c^{-1}
k	1.5 x 10^{-3} cal cm^{-1} sec^{-1} °c^{-1}	7.0 x 10^{-3} cal cm^{-1} sec^{-1} °c^{-1}	0.8 x 10^{-3} cal cm^{-1} sec^{-1} °c^{-1}
QF	~100 cal g^{-1}	~200 cal g^{-1}	43 cal g^{-1}
σ	300 d cm^{-1}	300 d cm^{-1}	65 d cm^{-1}
γ	50 to 1000 poise	~1000 poise	~1 poise
l	1000 m	1000 m	1 cm
H	5000 m	5000 m	5 cm
h	10 m	25 m	0.05 cm
g	167 cm sec^{-2}	980 cm sec^{-2}	980 cm sec^{-2}
T	1473 °K	1473 °K	373 °K
ΔT	1200 °K	1200 °K	100 °K
t	–	–	–
h_c	–	–	–
P	0	1 atmos.	1 atmos.
Ty	~1.0 x 10^3 N m^{-2}	~1.0 x 10^4 N m^{-2}	–

*Values as given by 3, 4, 5, 6, 7, 8, 10

**Values as given by 2, 11, 12, 13

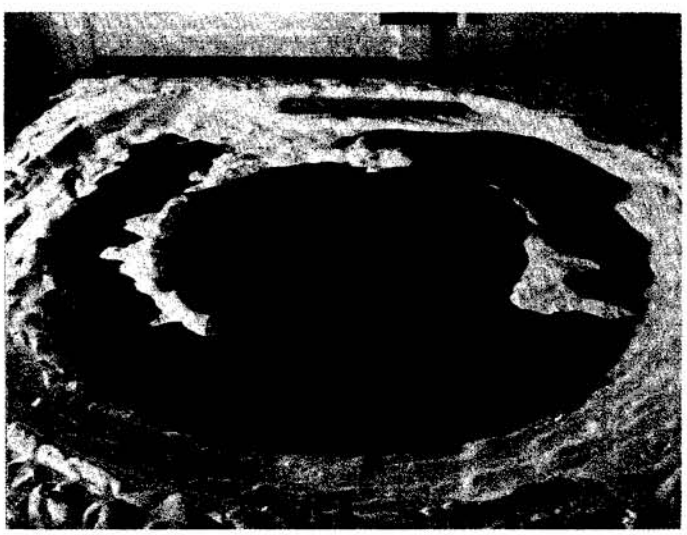
***Values as given by 2, 14

TABLE 2

	Lunar Flows	Terrestrial Basic Flows	Carbowax 4000*
Width Ratio (l/L)	0.20	0.20	0.20
Depth Ratio (h/H)	0.002	0.005	0.01
Reynolds Number (VL^*/γ)	5×10^1 to 8×10^3	2.5×10^1 to 1×10^3	7×10^{-2}
Froude Number (V^2/L^*g)	1.5×10^{-2} to 9.9×10^{-1}	4.1×10^{-5} to 6.5×10^{-2}	4×10^{-3}
Weber Number ($\rho V^2 L^*/\sigma$)	2.5×10^4 to 1.6×10^6	1.7×10^3 to 2.7×10^6	4×10^{-4}
Nusselt Number ($h_c L^*/k$)	$6.7 \times 10^5 (h_c)$	$3.6 \times 10^5 (h_c)$	$6 \times 10^3 (h_c)$
Prandtl Number ($\rho\gamma Cp/k$)	2.1×10^4 to 4.3×10^5	5.7×10^4	7×10^2
Eckert Number (V^2/CpT)	8×10^{-4} to 5.1×10^{-2}	3.2×10^{-5} to 5.4×10^{-2}	3×10^{-7}
Fusion Number (QF/CpT)	0.3	0.7	0.2
Temperature Difference ($\Delta T/T$)	0.8	0.8	0.2
Grashof Number ($g\Delta TL^{*3}/T\gamma^2$)	5.4×10^7 to 1.4×10^5	1.2×10^7	4.1×10^2
Peclet Number ($\rho CpVL^*/k$)	2.1×10^7 to 1.7×10^8	1.4×10^6 to 5.7×10^7	5.5×10^1
Dimensionless Time ($t^2 g/L^*$)	$1.7 \times 10^{-1} (t^2)$	$9.8 \times 10^{-1} (t^2)$	(t^2) 3.9×10^3

*Carbowax 4000 values calculated assuming 5X vertical exaggeration on test model.

**Effective Reynolds number not evaluated.



Oblique view of lunar basin model and Carbowax 4000 simulated lava flow.