SUB-KILOMETER LUNAR CRATERS: ORIGINS, AGES, PROCESSES OF
DEGRADATION, AND IMPLICATIONS FOR MARE BASALT PETROGENESIS. Clark R.
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The size distributions of sub-kilometer lunar craters generally have
been interpreted during the past decade to be the product of impact cratering
and gardening in the regolith. One important application of this
interpretation has been the assignment of relative ages to lunar mare units
using a crater morphological parameter called D_L (1). Correlations of such
D_L ages with mare basalt compositions inferred from spectrophotometry have
been used as constraints for petrogenetic and thermal models for the
evolution of mare basalt source regions with time. Such interpretations
based on D_L ages would be wrong, however, if many sub-km lunar craters were
of endogenic rather than impact origin, as has been proposed by a minority
of workers (2-7).

Motivated by this important problem in basaltic volcanism, we embarked
on a new project to study small crater populations in several carefully
selected lunar mare regions, representative of both red and blue basalt types
with both "young" and "old" D_L ages. The methodology employed is the same
as applied to a variety of other lunar regions by Chapman et al (4).
Craters of diameter 20m to 2km were counted and classified into 4 morpho-
cological classes. In order to correct for systematic classification and
measurement biases between the present study and earlier ones (4 and 7),
regions common to three earlier studies were also measured again.

The new crater size distributions show many of the same anomalous
features previously reported that have seemed incompatible with a simple
model of impact cratering and equilibrium degradation and obliteration by
the cratering process. In particular our "young blue" units show an excess
of -100m diameter (largely degraded) craters compared with both the "old
red" and "old blue" provinces studied; the excesses approach factors of 2
to 5 respectively and violate our intuitive expectation that younger units
should always have the same number or fewer craters than older units. Most
of the regions we have measured share most of the characteristics previously
ascribed to the "Imbrium" or "Alphonsus" population types described by
Chapman et al (4) (called Types I and III by Schultz et al 7).

Preliminary examination of our size-frequency plots show few cases
where even small segments of the distributions approach the -2 cumulative
distribution slope characteristic of classical equilibrium. There are
numerous bumps and dips in the distributions that do not always seem to be
compatible with the two-layer differential erosion process described by
Schultz et al (7). But an elaboration of that model permits us to explain
most of the major features of these distributions without requiring an
ad hoc endogenic component to the population. Schultz et al pointed out
that differential erosion and degradation of larger craters formed in bed-
rock and smaller craters formed wholly in regolith would yield offset
equilibrium populations approximately as observed. We point out that, in
addition, differences in energy/diameter scaling relations in the regolith
and bedrock substantially modify the production function (see Fig. 9 left
in Ref. 4), which is manifested in the equilibrium population of craters
in a manner not envisioned by Schultz et al. Together, the two scaling
effects produce a complicated pattern of frequency relations for craters
of different morphological classes (and for all classes together) similar
to those observed. In particular, our two-layer impact model yields the
steep distribution slope observed for some populations at sizes ~300m,
ascribed by Schultz et al. to a superposed population of non-impact craters.

Included in our interpretation are expectations that craters with
dimensions comparable to the regolith depth may be formed with initially
"degraded" morphology. Furthermore, we expect the equilibrium percentages
of craters in the several classes (and the percentage of geometric satu-
ration for total craters) to vary with size due to different degradation
processes that operate at different scales. Preliminary examination sug-
gests our data are compatible with these expectations.

While we believe our results diminish the requirements for a substi-
tutional endogenic crater population, there remain some puzzling features of
our data and other previously published distributions. In addition, we
believe that it remains difficult to understand the preservation of the
small primary flow features (ring moats, etc.) described by Schultz et al
(6) if crater degradation is proceeding at the rates implied by our present
model. And there is clear evidence that endogenic craters do, in fact,
exist in at least some lunar localities (e.g. those craters arranged in
chains).

But on balance we believe that the case for predominant impact crater-
ing as the origin of the small lunar crater populations is strengthened by
these considerations. In view of these results, we believe it likely that
a crater morphological parameter such as $D_L$ may reflect relative ages of
lunar provinces and thus ultimately be useful for establishing the
chronology of basalt emplacement. On the other hand, it remains to be
evaluated to what degree modifications of the application of the $D_L$
criterion will be required to take account of the more complicated, target-
dependent cratering and erosive processes implied by our interpretation
and the associated work of Schultz, Greeley, and Gault.

(2) Kuiper, G.P., Strom, R.G., LePoole, R.S. (1966) Ranger 8 and 9 Part 2,
75, 1445-1446. (5) Fielder, G., Fryer, R.J., Titulaer, C., Herring, A.K.,
Conf. 7th, 985-1003. (7) Schultz, P.H., Greeley, R., and Gault, D.E.