SOURCES OF SHAPE VARIATION IN LUNAR IMPACT CRATERS--
FOURIER SHAPE ANALYSIS. D.T. Eppler, NORDA, NSTL Station, MS
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R-mode factor analysis of the first ten harmonic
amplitudes that describe the shape of 716 large (diameter >15
km) nearside lunar craters (1) shows that two factors describe
84.3% of the total shape variance observed within the sample.
Factor I accounts for 68.2% of the observed shape variance and
describes moderate-scale roughness (harmonics 7, 8, 9, 10).
Factor II accounts for 16.1% of the observed crater shape
variance and describes crater polygonality and elongation
(harmonics 2, 3, 4, 6). Analysis of the 716 lunar craters
sampled permits the following conclusions to be drawn regarding
sources of shape variability described by the first two
factors:
1. Factor I harmonics measure transient shape features
that reflect surficial lunar processes of degradation and
aging.
2. Low-order harmonics measured by factor II primarily
reflect variables that affect the crater forming process.
Polygonal shape features that factor II harmonics describe
are not transient but persist for the life of the crater. The
dominant contributor to factor II variation is geologic
structural variation in impacted material.
3. Craters in grooved terrane that postdate grooving
(and thus were not modified directly by ejecta scour) are more
circular than craters in the same area that formed prior to
scouring. Shape differences between these groups exist in
harmonics 6, 8, 9, and 10, or at a scale described principally
by factor I.
4. The range of shape variability among craters that are
located in regions modified by Imbrium and Orientale ejecta
scour is the same as that characteristic of craters in
unscoured nearside regions. This might indicate that the shape
of most old, nearside craters shows the effect of ejecta
emplaced by basin-forming events that pre-date the Imbrium
event.
5. Degradational processes act to increase crater
irregularity with increasing age. The effect is more
pronounced for moderate-scale shape irregularities (factor I
harmonics) than for polygonal shape components (factor II
harmonics). Thus, fundamental, large-scale characteristics of
crater shape are likely to persist through time in a relatively
unchanged, undegraded state.
6. Young craters typically are more circular than old
craters. However, our data do not suggest that the observed
age-shape relation is indicative of post-impact crustal
deformation as other workers suggest (2-5). Craters that are
distinctly elongate fail to cluster within well-defined areas
as would be expected if lunar tectonism was a contributing
cause of elongation. Observed deviations of crater outlines
from circularity are predominantly polygonal, not elongate. Although crater elongation does appear to be related to geologic structural patterns in lunar crust, observed relationships between structure and elongation can be explained by mechanisms other than post-impact deformation.

7. Flooding of crater cavities by upwelling magma makes slight modifications to crater outlines. Minor shape changes occur in the third and tenth harmonics.

8. Shape irregularity that results from oblique impact is expressed principally as slightly inflated amplitude values of the second harmonic. Between 6.7% and 25% of all lunar craters are assumed to be so affected.

9. Geologic structural relationships in lunar crust (faults, fractures, joints) are a principal source of crater polygonality. The imprint of geologic structure is placed on crater shape according to two independent mechanisms: A) during formation of the transient crater cavity, excavation occurs preferentially in directions parallel to trends of structural weakness; B) in the course of modifications that occur to the crater cavity, walls fail and slumps develop along trends of structural weakness.

10. Shape features related to topography and to adjacent and overlapping impacts, although undeniably present in craters sampled, do not occur consistently in the same harmonic. They contribute to noise in the shape spectrum.

11. The permanence of polygonal shape features that reflect structural variables suggests that the shape of old craters is indicative of structural patterns present in early lunar crust. That is, old craters could carry vestiges of lunar features effaced long ago by younger impacts. The shape of younger craters would reflect remnants of these same old patterns, if they persist, as well as younger features imposed by more recent events. Polygonal aspects of crater shape, when evaluated in this light, could define past episodes in the structural evolution of cratered surfaces.

Abundant information regarding impact processes of crater formation and ongoing surficial processes of crater modification is stored in the shape of impact craters. Much of this information is carried in discrete, non-random elements of shape. Fourier shape analysis is a powerful tool with which to define these elements quantitatively and to extract information they contain. The fact that the shape imprint of geologic structure can be so described by a single variable (factor II) is of singular importance. It permits structural information contained in shape to be isolated from a field of conflicting variables and used with more conventional tools to define events in the evolution of lunar and planetary surfaces.