IMPACT ORDER FRAMEWORK FOR SMALL BODY GEOLOGY; Philip J. Stooke, Department of Geography, University of Western Ontario, London, Ontario, Canada N6A 5C2 (e-mail: stooke@sscl.uwo.ca)

INTRODUCTION: Small bodies examined to date exist in varied dynamical environments and have very different mean radii, shapes and apparent ages. To facilitate geological interpretations of individual bodies and comparisons between them, I propose a geological framework which can be applied to asteroids and small satellites. No absolute chronology is involved, but relative ages are implied. Five orders of impact event are described: parent body fragmentation, facet formation, impacts which shake the whole body, small craters and regolith 'gardening' microimpacts. Phobos, Deimos and Gaspra are described in these terms. For Phobos, Order 2 (facet-forming) impacts older than Stickney are found, any or all of which might have initiated groove formation, and Stickney-related features may be extensive enough to form a global time marker for geologic mapping.

IMPACTS: Impacts of each 'order' may occur at any time. Each one totally obliterates everything two orders higher and many features one order higher (some allowance for size in this subdivision of a continuum), and will subdue existing features of the same order within range of its effects. Order 3 and 4 crater densities date the latest large order 2 impact, not the order 1 event.

FIRST ORDER: impacts which fragment a parent body, determining the overall shape (elongation etc.) of each fragment. As debris leaves the demolished parent body, medium-sized fragments may become satellites of larger objects (e.g. Dactyl) or components of a multi-lobate object (e.g. Castalia), and loose debris may be attracted to form an initial, maybe extensive, regolith. Fragments may be fractured.

SECOND ORDER: very large but not disruptive impacts creating a landscape of ridges and facets (craters with diameters near the mean radius of the body). Near-total erasure of pre-existing smaller craters, major rounding of existing topography by shaking, deep fracturing or reactivation of older fractures, some regolith and ejecta lost to space but late low velocity ejecta retained. These impacts largely determine the rotation state of asteroids.

THIRD ORDER: impacts large enough to shake the body significantly, having global effects on regolith but not shape. Crater diameters are 25-50% of mean body radius, larger ones sufficient to reactivate fractures near the crater, soften topography, erase some small craters and cause downslope movement of regolith if feasible. If regolith accumulates in facets, older third-order craters within them may be hidden or subdued.

FOURTH ORDER: small impacts with only local effects. May excavate unweathered material from depth to produce distinct ejecta deposits. Fresh examples date only from the latest large third order crater.

FIFTH ORDER: craters too small to show in typical spacecraft images, but contribute to erosion of existing features and shallow regolith mixing (gardening). May be implicated in 'weathering' effects, e.g. by impact glass generation or volatile loss.

MAPPED BODIES:

PHOBOS - South polar depression and several very subdued facets (now only visible as slight flattenings in the shape model) are order 2. Stickney is a fairly small, late order 2 crater, shaking Phobos enough to subdue older topography but not to erase it globally. Note lower density of Order 3 and 4 craters in the hemisphere centred on Stickney. The Stickney antipodal region has old order 3 craters, so was subdued but is not a spallation scar. Many grooves may date from order 1 or older order 2 (e.g. south polar) impacts but are augmented and/or reactivated by Stickney. Regolith is insufficient to bury most order 3 craters, but they are eroded by order 4 and 5 impacts and subdued progressively by shaking induced by each later order 3 impact. The Stickney-related ejecta deposits, groove creation or rejuvenation, and smoothing by shaking might be sufficient to constitute a global stratigraphic marker and permit subdivision of feature ages.

DEIMOS - Major facets are order 2. Many old order 3 craters are visible on ridge crests, subdued by shaking. Deep regolith (order 2, partly re-accreted from Mars orbit?) in facets probably hides many order 3 craters and possibly grooves. Fresh material, originating either as order 3 or 4 ejecta or as debris eroded by order 5 impacts from exposed order 2 and 3 crater rims, forms bright streamers.

GASPRA - Major facets are order 2 features. Gaspra probably has as many order 3 craters as Deimos, several previously undescribed examples being visible in low resolution images or on the limb. Super-resolution images will be used to augment Gaspra crater interpretations. Grooves were probably formed by the order 2 impacts. Groove sets with differing orientations may have different sources, including Neujmin Regio or the facet opposite it (grooves parallel to intermediate axis) and the 5 km diameter facet at 15° N, 330° (grooves parallel to long axis). Order 3 or late order 2 ejecta is possibly thicker on leading rotation surfaces, but shaken off the highest areas, smoothing topography around 10° N, 350° and 20° N, 60°-130° (note: the boundary between leading and trailing rotational surfaces is <u>normal</u> to facets, not simply at longitudes 90° and 270°).

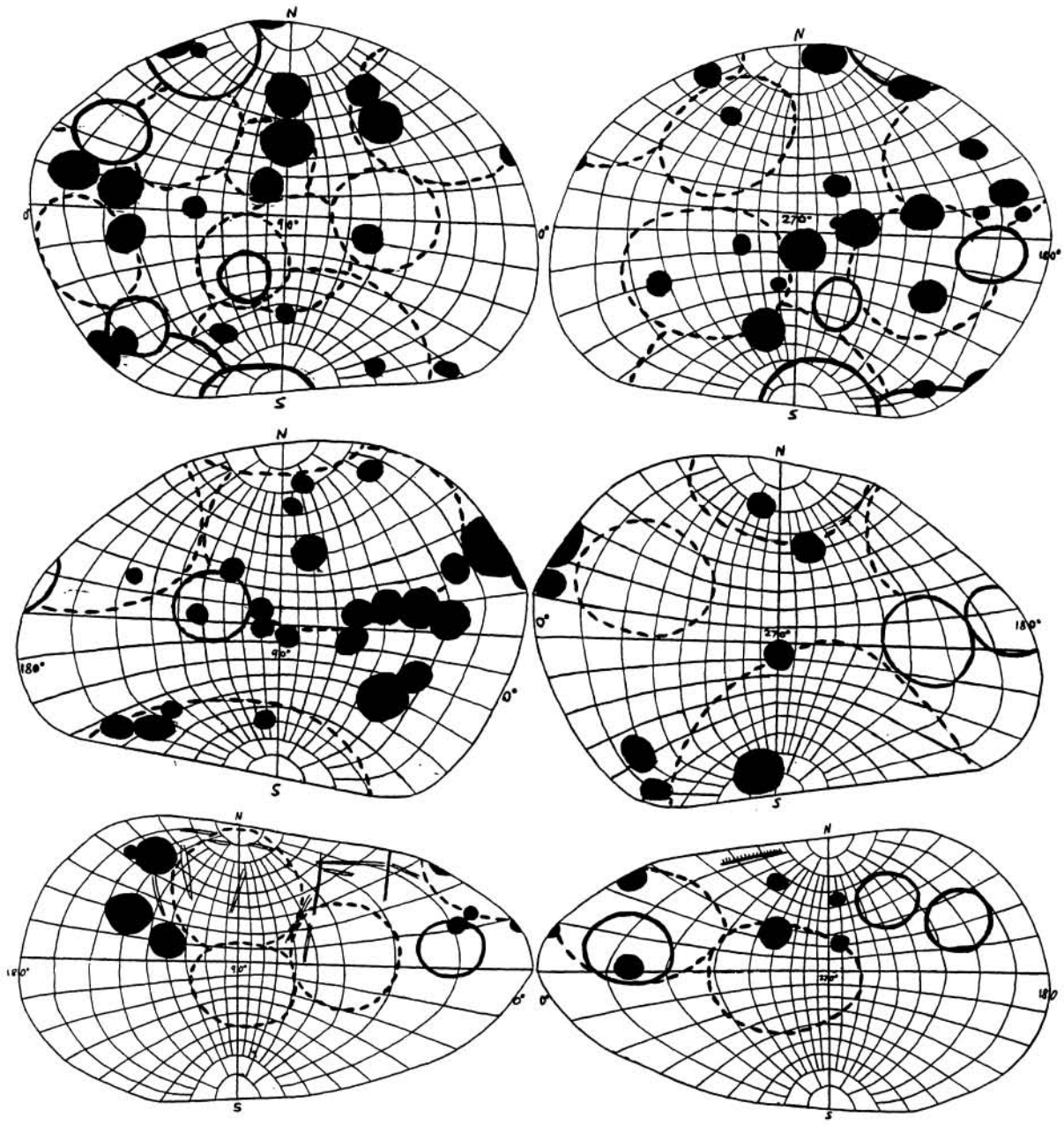

Figure 1. Top to bottom: Phobos, Deimos, Gaspra. Morphographic Conformal projections, not to same scale (and note scale increases towards edges of all maps, as in all conformal projections). Maps show tentative global classification of facet and crater orders (not ages) (based on preliminary mapping only. This work is still in progress.) Dashed lines: Order 2 facets; solid loops: Order 3 (body-shaking) craters; solid circles: Order 4 craters (local effects only). Gaspra only: double lines: grooves; line with ticks: scarp, ticks downslope.