**Significance of Maars on Mars: Terrestrial Analogs to Martian Monogenic Volcanism.**
R. A. De Hon, Department of Geography, Texas State University, San Marcus, Texas, 78666, dehon@txstate.edu

**Introduction.** Improved resolution of the Martian surface provides improved images of volcanic features at scales comparable to terrestrial imaging (1, 2). Studies of terrestrial monogenic volcanic fields in arid regions on Earth provide insights into the significance of cinder cones, maars, and pseudo-craters in interpreting Martian ground-water or permafrost environment and subjacent geology.

**Attributes of maars and cinder cones.** Terrestrial monogenic volcanic fields are typically composed of an assortment of eruptive landforms ranging from pseudocraters, minor rimless depressions, cinder cones and associated lava flows (3). Maar-type craters are common features in many volcanic fields. They range from a few hundred meters to a few kilometers in diameter. Preservation of the original vent morphology is a function of surface processes of degradation which are largely related to the climate and age of the feature as well as a function of continuing eruptions at the vent (Fig. 1). Maars are often restricted to the edges of volcanic fields because they are buried by more abundant tephras and lavas where eruptions are concentrated.

Maars are generally attributed to pheatomagmatic eruptions in which a rising magma encounters groundwater (4, 5). The initial eruption creates a cone-shaped crater surrounded by a low, raised ring of vent-opening-breccia. If no further gas venting occurs the initial small crater may be modified by slumping of the walls to widen the initial crater and reduce the overall relief. Continued eruption may proceed as renewed gas-venting laden with accidental ejecta; cinder or scoraceous cinder material derived from the rising magma. Eventually lava may reach the surface. The initial crater may be modified by renewed explosive eruption resulting in a crater-in-crater form; less explosive venting building on the initial rim deposits; cinder eruptions building intercrater cones; or lava eruptions filling the crater. Still further eruptions may completely engulf the earlier formed crater as the cinder cone grows to completely engulf the maar.

Vent opening breccias contains blocks and smaller fragments of lithics entrained in the gases rising to the surface. This material provides a unique sampling of material traversed by the gases on their way to the surface (6). Although most maar eruptive material is made up of accidentals, some maars and their underlying diatremes and breccia pipes contain material derived from the mantle. Prolonged venting is accompanied by slumping of the walls of the initial narrow crater and re-entrainment of slumped materials into the escaping gases. Material erupted during this phase tends to be shallow materials immediately beneath the surface that slumps into the actively outgasing vent. This material is commonly deposited by as base surges flowing away from the vent, and is preserved as trough, crossed-beds radial to the vent (7). Before maar-volcanism was completely understood, these epiclastic deposits were sometimes mistaken as fluvial in origin. Base surge cross-bedding and graded bedding from air fall mimic fluvial deposition. Clues to the volcanic origin include such things as flow direction indicators in bedded tuffs, bomb sag structures, and accretionary lapilli.

**Significance.** Pseudocraters attest to a water- or ice-saturated surface over which the lava flows are moving (8). Maar-type craters are common products of an initial eruptive phase that may be followed by more voluminous phases as cinder or lava eruptions. Maar craters are evidence of a water or ice saturated zone in the subsurface. Rim deposits of maars and tuff rings preserve earliest, pyroclastic base-surge and fall-materials representing the initial vent-opening breccia. These breccias include a mixture of mantle xenoliths, lithic ash, and tuff breccia composed of fragments of subcrater lithology traversed by the initial venting of gases from the underlying magma. Vent-opening breccias may be present as basal layers of many cinder cones. Cinder cones on Mars provide evidence of magma water interaction. Cinder cone fields on Mars provide fertile ground for sampling sites of underlying lithologies.

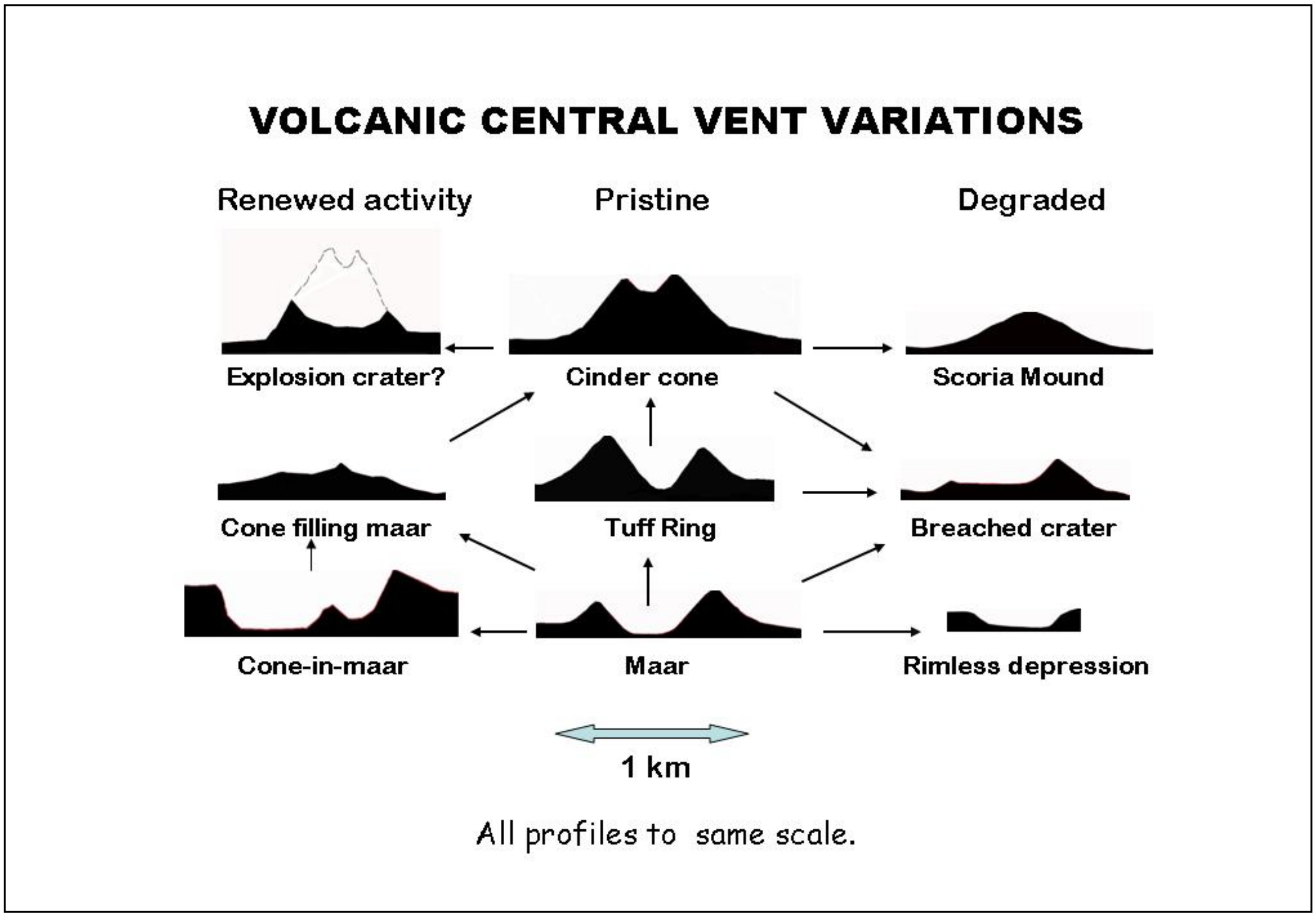


**Fig.1.** Progression of landforms in monogenic volcanic fields as a result of renewed volcanic activity or modification by erosion.

**References.** [1] Borz, P. and E. Hauber (2011) LPSC 42, Abs 1379. [2] Lanz J. And others. (2010) *JGR*, *115*, E12019, doi:10.1029/2010JE003578. [3] C.A. Wood and J. Kienle (1992) *Volcanoes of North America; United States and Canada.* Cambidge University Press, 354p. [4] Lorenz, V., 1973, Bulletin Volcanologique, v. 37, p. 183-204. [5] Ort, M.,and others (1998) in *Geologic excursions in northern and central Arizona*: Flagstaff, Northern Arizona University, p. 35-58. [6] Semken, S. (2003) New Mexico Soc, Guidebook, 54th Field Conf. 133-138. [7] Fisher, R.V. (1966) Amer. J. Sci. 264, 287-298. [8] Fagents S.A. (2007) in *Geology of Mars* Cambridge University Press, 151-177.