Introduction to Photogeologic Mapping

More than three decades of planetary exploration show that the surfaces of the solid planets and satellites have been subjected to the same geologic processes: **volcanism, tectonism, erosion**, and **impact cratering.** The relative importance of each process differs from planet to planet, depending upon the local environment. For example, a planet not having running water, such as the Moon, will experience erosion of a different style and intensity in contrast to a planet having abundant running water such as Earth.

Prior to the space program, the importance of impact cratering as a geologic process was not fully appreciated. It is now known that all of the planets were subjected to intense impact cratering in the early history of the solar system. Indeed, most of the craters on the Moon are of impact origin. On some planets, such as the Moon and Mercury, evidence of the impact process is preserved; on other planets, such as Earth, impact cratering is less evident. On the Moon, craters range in size from tiny micro craters of sub-millimeter size to the giant impact basins such as the 1300 km-diameter Imbrium basin.

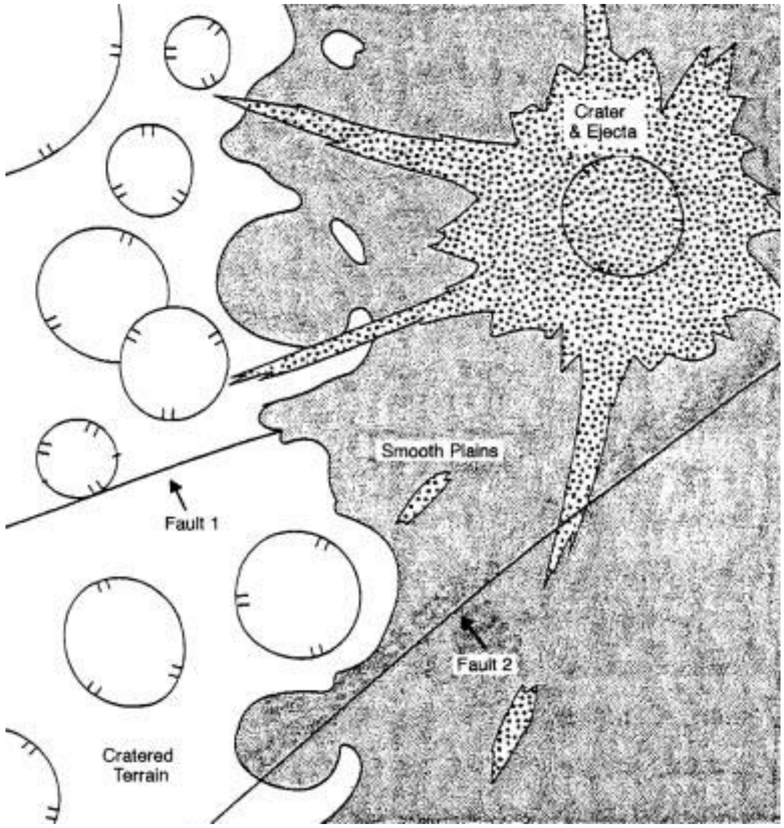
A geologic map is a graphic portrayal of the distribution and sequence of rock types, structural features such as folds and faults, and other geologic information. Such a map allows geologists to represent observations in a form that can be understood by others and links the observations made at different localities into a unified form. In many respects, a geologic map is like a graph to a physicist; it allows one to understand many observations in a comprehensive form.

The **unit** is the basic component of geologic maps. By definition, it is a three-dimensional body of rock of essentially uniform composition formed during some specified interval of time and that is large enough to be shown on a conventional map. Thus, the making of geologic maps involves subdividing surface and near-surface rocks into different units according to their type and age. On Earth, geologic mapping involves a combination of field work, laboratory studies, and analyses of aerial photographs. In planetary geology, geologic mapping is done primarily by remote sensing methods—commonly interpretation of photographs. Field work is rather costly and not always possible. Mapping units are identified on photographs from **morphology** (the shape of the landforms), **albedo** characteristics (the range of "tone" from light to dark), color, state of surface preservation (degree of erosion), and other properties. Remote sensing of chemical compositions permits refinements of photogeologic units. Once units are identified, interpretations of how the unit was formed are made. In planetary geologic mapping the observation and interpretation parts of a unit description are separated (see figure on next page).

After identifying the units and interpreting their mode of formation, the next task in preparing a photogeologic map is to determine the stratigraphic (age) relation among all the units. Stratigraphic relations are determined using: (a) the **Principle of Superposition,** (b) the law of cross-cutting relations, (c) embayment, and (d) impact crater distributions. The Principle of Superposition states that rock units are laid down one on top of the other, with the oldest (first formed) on the bottom and the youngest on the top. The law of cross-cutting relations states that for a rock unit to be modified (impacted, faulted, eroded, etc.) it must first exist as a unit. In other words, for a rock unit that is faulted, the rock is older than the faulting event. Embayment states that a unit "flooding into" (embaying) another unit must be younger. On planetary surfaces, impact crater frequency is also used in determining stratigraphic relations. In general, older units show more craters, larger craters, and more degraded (eroded) craters than younger units.

Once the stratigraphic relations have been determined, the units are listed on the map in order from oldest (at the bottom) to youngest (at the top). This is called the **stratigraphic column.** The final task, and the primary objective in preparing the photogeologic map, is to derive a general geologic history of the region being mapped. The geologic history synthesizes, in written format, the events that formed the surface seen in the photo -- including interpretation of the processes in the formation of rock units and events that have modified the units -- and is presented in chronological order from oldest to youngest.

The figure at right shows a sample geologic map. The unit descriptions and stratigraphic column are shown below. The relative ages were determined in the following manner: The cratered terrain has more (and larger) craters than the smooth plains unit -- indicating that the cratered terrain unit is older. In addition, fault 1 cuts across the cratered terrain, but does not continue across the smooth plains. Faulting occurred after the formation of the cratered terrain and prior to the formation of the smooth plains -- indicating that the smooth plains unit is younger than the cratered terrain and fault 1. The crater and its ejecta unit occurs on top of the smooth plains unit, and thus is younger. Finally, fault 2 cuts across all the units, including the crater and its ejecta unit, and is thus the youngest event in the region. The geologic history that could be derived from this map would be similar to the following:



"This region was cratered and then faulted by tectonic activity. After the tectonic activity, a plains unit was emplaced. Cratering continued after the emplacement of the smooth plains unit, as seen by the craters superposed on the smooth plains and the large, young crater mapped as its own unit. Finally, there has been a continuation (or reactivation) of tectonic activity, indicated by the major fault which postdates the young crater."

Stratographic Column

	Geologic Unit	Structural Event
		Fault 2
Youngest ↑	Crater and Ejecta	
	Smooth Plains	
		Fault 1
Oldest	Crater Terrain	

Unit Descriptions

Unit Name	Observation	Interpretation
Crater and Ejecta	Rough, blocky surface, high albedo, surrounds and includes crater	Crater and ejecta formed by impact
Smooth Plains	Smooth plains, few craters, low albedo, lobate(rounded) margins	Volcanic flow
Crater terrain	Rugged, heavily cratered plains, high albedo	Old unit, possible of volcanic origin, has had extensive cratering