

## Geologic Setting

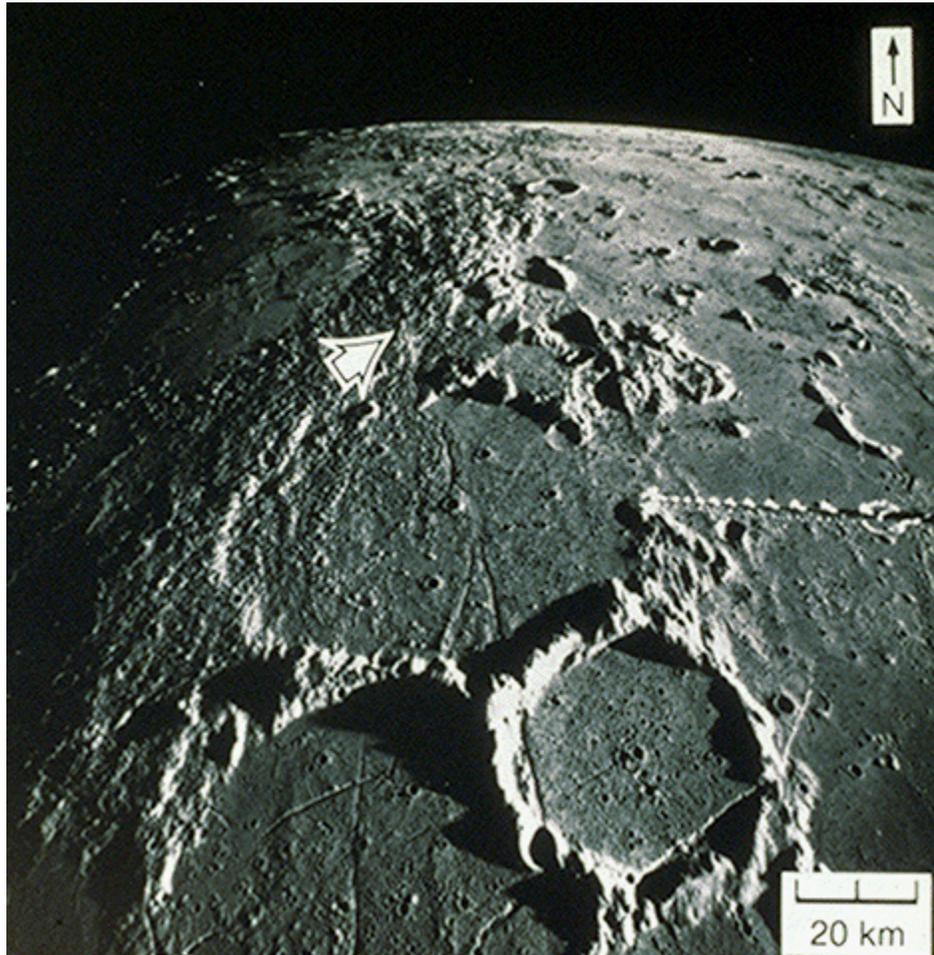
After the successful return of numerous basalt samples from the mare regions by the Apollo 11 and 12 missions, it was desirable to sample a different kind of area. For this reason a major objective of the Apollo 14 mission, was to sample material comprising the Fra Mauro Formation, which had been interpreted as being a portion of the ejecta blanket deposited during the impact-formation of the Imbrium Basin (Gilbert, 1893; Eggleton, 1964; Wilhelms, 1970). This event was believed to predate mare formation, and it was hoped that an age for the Imbrium event could be established through successful return of these samples.

The geological formations in the area of the landing site are shown in figure I. The formations shown on the map are subdivided into four age groups: pre-Imbrium (oldest), Imbrium, Eratosthenian, and Copernican (youngest), in accordance with U.S. Geological Survey usage. Imbrium formations predominate the region of the Apollo 14 landing site. This area is known as the Fra Mauro region, and is a light-colored, topographically high area surrounded by maria.

The Fra Mauro region and the Fra Mauro Formation are named for the crater Fra Mauro, an ancient, eroded, and partially buried crater 70 km south of the landing site. The Fra Mauro Formation is a distinctive ridged and furrowed unit surrounding the Imbrium Basin. This formation had traditionally been interpreted as fragmental ejecta from the Imbrium Basin since the idea was first proposed by G. K. Gilbert in 1893. In recent years, however, this idea has met with some challenge by investigators who point out that much local material excavated by secondary cratering is admixed with the Imbrium Basin material (Morrison and Oberbeck, 1975).

The thickness of the Fra Mauro Formation is not known, and estimates vary by an order of magnitude. Offield (1970) estimates the thickness to be between 100 and 200 meters based on its relation to the local topography, while Kovach (1971) finds it to be only 20 - 70 meters thick, using results from the active seismic experiment by the Apollo 14 astronauts. It is seen to cover 26,000 km<sup>2</sup> in the region of the landing site, feathering to a thin edge in the vicinity of the (crater Bonpland approximately 150 km to the south. A northwest-trending ridge, radial to the Imbrium Basin lies about 600 meters east of the smooth terrain of the landing site. At the crest of this ridge is Cone Crater, a relatively young crater 340 meters deep. Here, it becomes important to know the thickness of the Fra Mauro Formation, for some of the material collected at station C<sub>1</sub> (figure 2) is interpreted to be Cone Crater ejecta. The question is whether this material is from the Fra Mauro Formation, or from the underlying material. The relief of the ridge is 90 meters. If Cone Crater is only 70 - 80 meters deep, chances are the ejecta represents Fra Mauro material.

The Cone Crater event has been dated by Turner et al. (1971). They show that the surface of the Cone Crater ejecta blanket has been in place for only 26-40 million years. The Imbrian event has been dated as being between 3.75 billion years (Sutter et al., 1971), and 3.94 billion years old (Nyquist et al., 1972). On the basis of terrestrial crater analogs, Gault et al. (1968) suggest that ejecta closest to the rim of Cone Crater must be derived from the greatest depths, and that a mixture of ejecta from different depths occurs in rays extending outward from the crater. Doublet and Triplet craters are situated between the landing site and Cone Crater, and may have penetrated into Fra Mauro material. Samples from Station G and G<sub>1</sub>, as well as from the Comprehensive sample, may be representative of ejecta from these events (Table 1, figure 2). More detailed information is available in a recent discussion by Hawke and Head (1977), in summaries by the Imbrium Consortium (1976), and Swann et al. (1972, 1977).



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[http://www.lpi.usra.edu/expmoon/Apollo14/A14\\_LandingSite\\_views.html](http://www.lpi.usra.edu/expmoon/Apollo14/A14_LandingSite_views.html)

Figure 1a

Fra. Mauro Region

Note: The arrow points to the Apollo 14 landing site.

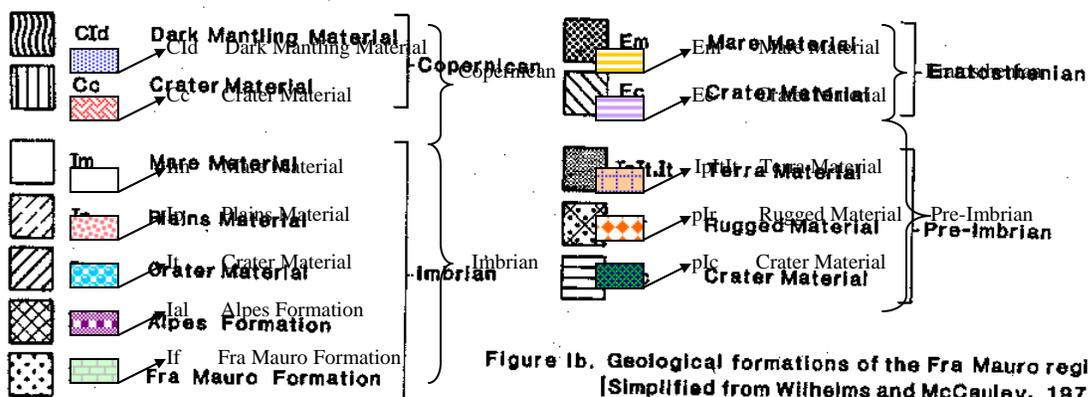
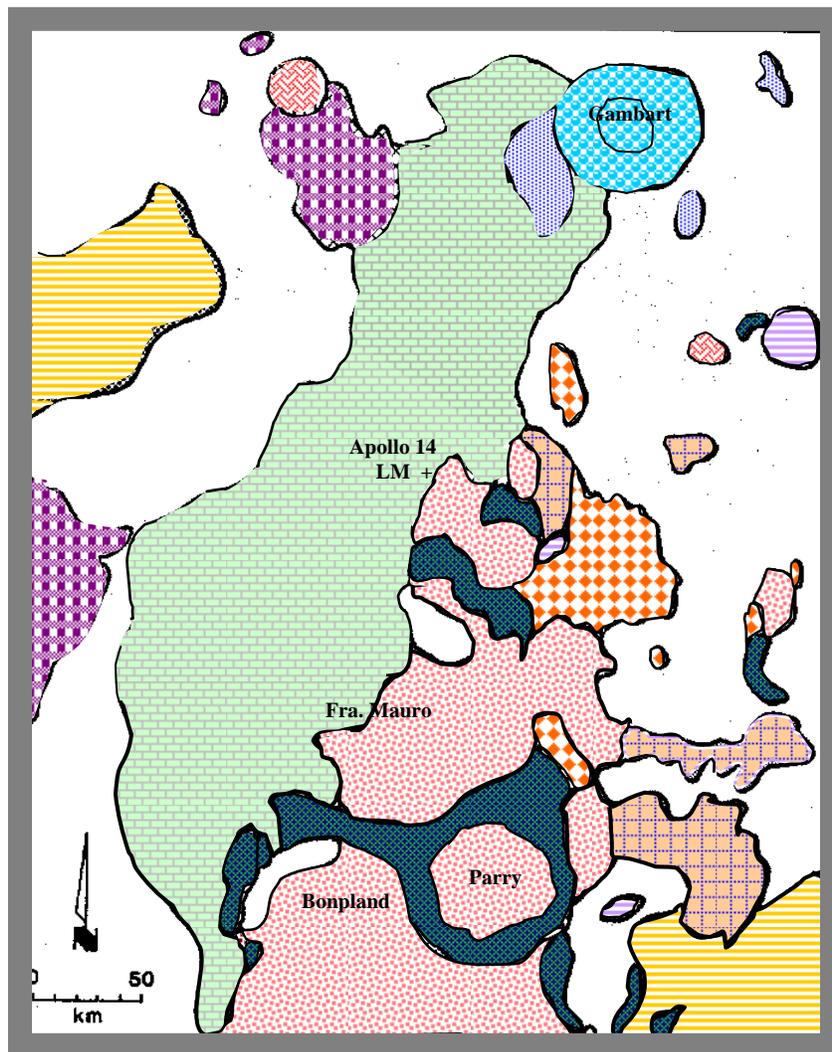


Figure 1b. Geological formations of the Fra Mauro region. [Simplified from Wilhelms and McCauley, 1971, after Marvin, 1976]

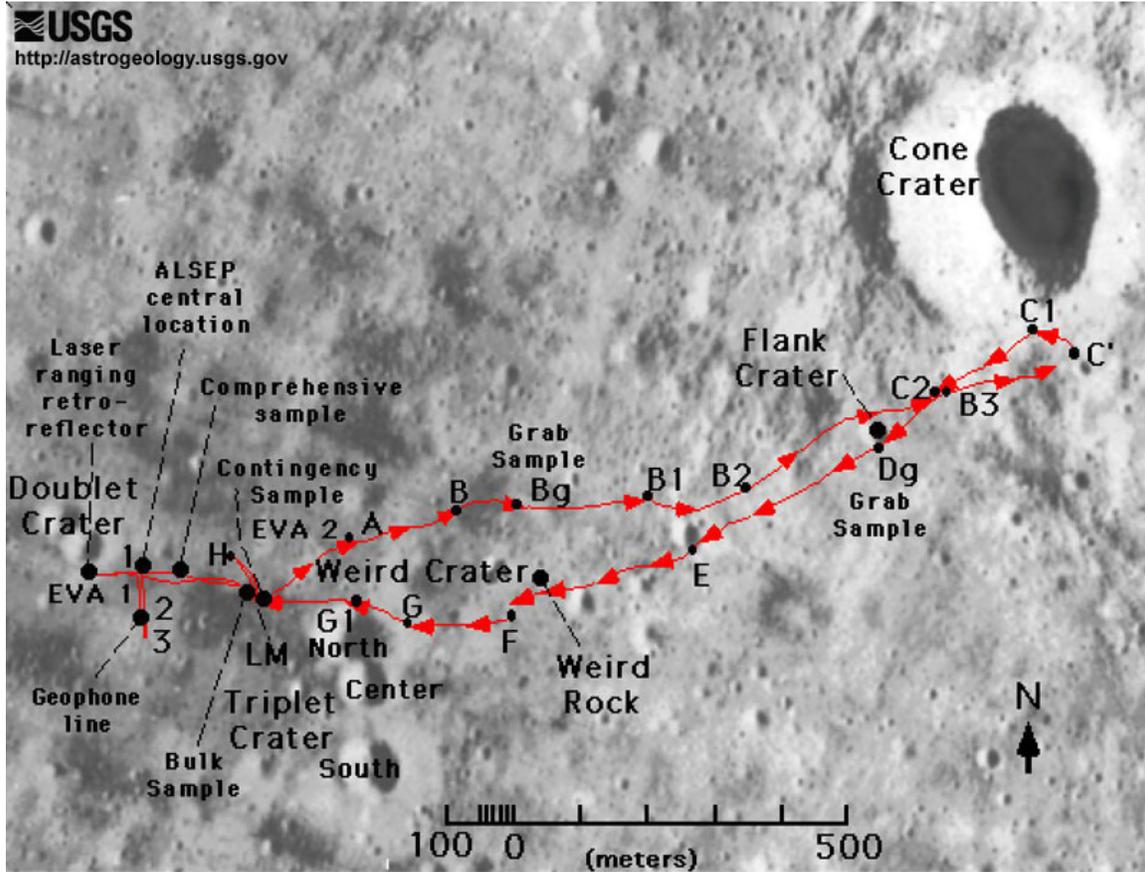
Image created by L. Carrillo.

The Apollo 14 Lunar Module (LM) landed in the Fra Mauro region of the moon on February 5, 1971, at latitude 3° 40' 24" S, longitude 17° 27' 55" W. The landing site is located 1,230 km south of the center of the Imbrium Basin and 550 km south of the southern rim crest of the basin (Swann et al., 1977). Figure 2 shows a map of the traverses taken during the Apollo 14 mission.

Three photogeologic map units were traversed during the two EVA's:

- 1) a smooth terrain unit on which the LM landed,
- 2) a cratered ridge of the Fra Mauro Formation which has slope angles of 10°-15, and
- 3) the blocky rim deposit of Cone Crater, densely strewn with blocky ejecta 1-15 meters in size.

The smooth unit was originally thought to be either highlands volcanic material or a smooth facies of the Fra Mauro Formation that had been ponded in low areas between ridges (Eggleton and Offield, 1970). A primary objective of the mission was to sample the Fra Mauro Formation. Other objectives were the sampling of Cone Crater ejecta and the sampling of the smooth terrain around the LM. During the first EVA, the astronauts set up the Apollo lunar surface experiment package (ALSEP), collected the Contingency, Comprehensive, and Bulk Samples, and two "football size" rocks (FSR) (Table 2). On the second EVA, they traveled to the rim of Cone Crater, taking cores and grab samples enroute. During their return to the LM, more grab samples, cores, and trench samples were collected (Table 2, figure 2).



Approximate Coordinates of LM:  
 3.675°S Latitude, 17.467°W Longitude

Figure 2. Showing LM location and area traversed by astronauts during EVAs.

*The map was prepared as part of a project by a United States Geological Survey (USGS) team under funding from the USGS Technology Transfer Program and NASA's Planetary Geology and Geophysics Program.*

Image acquired and transferred to document by L. Carrillo on 1/03.

Table 1  
Sample Locations (Swann et al., 1977)

<u>SAMPLE NUMBER</u>	<u>TRAVERSE STATION</u>
14001 to 14012	Contingency sample, EVA 1
14041 to 14046	A
14047 and 14048	B
14049 and 14050	Bg
14051 and 14052	C'
14053 and 14054	C2
14055 to 14062	E
14063 to 14065	Cl
14066 and 14067	F
14068 to 14072	C'
14073 to 14081	G
14082 to 14084	Cl
14140 to 14144	C'
14145 to 14156	G
14160 to 14163	Bulk Sample
14165 to 14189	Comprehensive Sample, EVA 1
14190 to 14204	Unknown, Residue in weigh bag 1031, EVA 2
14210 and 14211	A
14220, 14230, 14240	G
14250 to 14289	Comprehensive sample, EVA 1
14290 to 14297	H (?) Residue in weigh bag 1038, EVA 2
14301	G1
14302	EVA I, part of 14305 FSR
14303	EVA I, part of 14304 FSR
14304	EVA I, FSR
14305	EVA I, FSR
14306	G
14307	G
14308	Dg part of 14311
14309	EVA 2, unknown station
14310	G
14311	Dg
14312	H
14313	G1
14314 to 14320	H
14321	Cl
14411	A, core bit
14414	G, core bit
14421	Comprehensive Sample
14222 – 14453	Bulk Sample

Table 2

TRAVERSE STATION LOCATIONS AND  
 DESCRIPTIONS  
 {Swann et al., 1977)

STATION EVA 1	LOCATION BETWEEN LM AND ALSEP	DESCRIPTION SMOOTH UNIT
A	150 m NW of LM and 90 m N of North Triplet Crater	Fine grained friable breccia
B	330 m NE of LM and 65 m NNW of rim of Weird Crater	Fine grained clastics
C'	1.28-1.29 km ENE of LM and approximately 95-100 m SE of rim of Cone Crater	Fine grained polymict breccia (Cone Crater ejecta)
C1	1.24-1.25 km ENE of LM and 17-30 m SE of Cone Crater rim	White Rock area, breccia
G1	150 m E of LM on north rim crest of North Triplet Crater	Coherent clastic breccia
G	230 m ESE of LM and 50 m E of 50 m E of North Triplet rim	Coherent clastic breccia crest
H	Turtle Rock area, North Boulder Field 70-80 m NW of LM	Coherent clastic breccia