SOUTHERN NECTARIS FOSSAE: A MICROCOSM OF MARTIAN GEOLOGY.

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Introduction: The proposed Exploration Zone (Figure 1) encompasses an area within 100 km radius of a landing site located at approximately 28.88˚S 300.29˚E, at the southwestern terminus of Nectaris Fossae near Protva Valles [1].

The EZ lies in a geologically complex transition zone between the Late Noachian volcanic units of Thaumasia Planum to the northwest and the Middle to Late Noachian cratered highland units of Noachis Terra to the south and east [2]. The topography of the region is indicative of extensive reworking by tectonism and subsequent incision of valley networks [3]. The EZ also lies in an area that is yet to be explored by landers or rovers [4].

The Southern Nectaris Fossae EZ is ideal in its close proximity to a number of distinct geologic features and sites for potential resource utilization; in addition to Protva Valles and Nectaris Fossae, the science ROIs include a volcanic edifice and an unusual double crater. The extensive fluvial deposits associated with Protva Valles could provide a source of water in the form of hydrated clay minerals. As they are marked in Figure 1, the ROIs are rough outlines; in reality, one would be likely to find a mix of fluvial, volcanic, and impact features throughout the EZ [2].

Landing site: The 25 km^2 landing site is situated at the northern end of a gently rolling floodplain with sparse meter-scale dunes [5] at ~1.8 km altitude [6]. This floodplain would provide ample space for a habitation site, resource utilization and infrastructure development over hundreds of km^2. Much of the EZ lies at elevations greater than 2 km, but grades are generally shallow enough to allow ready access to ROIs from the lower-elevation landing site.

Science ROIs:

ROI 1: Valley networks. Some of the most fascinating geologic features on the Martian surface are those that are thought to have been formed by fluvial processes, particularly within the southern highland regions of the planet [7]. There is general agreement [8-10] on the timing of valley network formation during the Late Noachian into the Early Hesperian, but the mechanism by which they formed is less clear. Some studies based primarily on geomorphology [11-12] indicate evidence of a "wet and warm" early Mars, but related climate modeling exercises [13-14] are generally unable to produce surface temperatures above freezing.

Protva Valles, which have been independently dated to Late Noachian/Early Hesperian age [3], are considerably degraded but would still provide an opportunity to observe the hydrologic and stratigraphic characteristics of Martian valley networks in unprecedented detail; this in turn could revolutionize our understanding of the early Martian climate. Proposals for ROIs throughout Noachis Terra should be seriously considered in order to take advantage of the rich and ancient geologic history of the area.

ROI 2: Double crater. Recent interest in crater interiors has been piqued by the exciting discoveries of the MSL *Curiosity* rover, which has been traversing the basal layers of Aeolis Mons inside Gale crater. Apart from abundant evidence of lacustrine and deltaic sedimentation, the rover has also made significant advances in understanding the character of enhanced levels of atmospheric methane and chlorinated hydrocarbons in soils at the site [15].

While Gale crater is certainly unusual, perhaps unique, in its history as a sedimentary basin, the crater in the ROI may have its own secrets to reveal. Like Gale, its morphology is complex and asymmetrical, although there are no obvious sedimentary landforms at the surface. Instead, the crater appears to have undergone significant reworking by eolian processes and perhaps even ice flows [5], which are known to exist at higher elevations outside polar latitudes [16]. Unlike outcrops that have been exposed to water in the past, ices have the potential to preserve present-day geochemical and biochemical signatures, which should make this and other nearby craters a prime target for exploration within the EZ. The main crater also overprints a second crater of similar size to the east; such an area could exhibit unusual impact structures worthy of additional investigation.

ROI 3: Volcanic edifice. Perhaps the most difficult areas of Mars to access are those with significant outcrops of basaltic igneous suites. The Tharsis volcanic province is inaccessible to human exploration given the present constraints on altitude and would nevertheless be treacherous due to steep, rocky terrain. This ROI features a more manageable volcanic edifice with a maximum elevation of slightly less than 4.3 km (2.5 km higher than the landing site) [6].

The volcanoes of the Thaumasia region may actually be more useful than Tharsis in revealing the earlier, more dynamic history of Martian volcanism and magmatic evolution [3]. The edifice is likely Noachian in age and represents some of the best-preserved examples of early highland volcanism, including pyroclastic deposits from volatile-rich magmas [3]. Sampling of such primitive crustal material would be invaluable to geochemical studies of Mars, which thus far are based almost completely on a handful of meteorites [17]. With a pristine igneous sample, the entire geologic history of Mars could be rewritten in a stroke with precise radiometric dating and trace element data.

ROI 4: Fossae. The early tectonic history of Mars is also preserved in the fault structures of Nectaris Fossae. The formation of Nectaris Fossae began sometime in the Noachian and may have continued until the Late Hesperian, with evidence of a genetic relationship to Valles Marineris [3]. Faults and rift structures are numerous throughout the Thaumasia region [3], but the structural geology of Mars has remained largely uncharacterized on the local scale due to a general lack of such features at past landing sites [4]. Nectaris Fossae could be used to vastly improve our knowledge of small-scale deformational structures on Mars.

As with Protva Valles, the exploration of Nectaris Fossae would inevitably reveal stratigraphic sections and cross-cutting relationships of Noachian crustal units. The sharper relief of these features suggests that they may also be better preserved, although evidence of subsequent fluvial reworking may also be present [3].

Resource ROI: The primary resource available within the EZ is in the form of hydrated clay minerals, which are likely to be found anywhere within the floodplain of Protva Valles south and west of the landing site; smectites in particular are known to occur elsewhere in the region [18]. In addition, mafic rocks associated with the Thaumasia volcanic sequences could be mined for iron, magnesium, and aluminum if desired.

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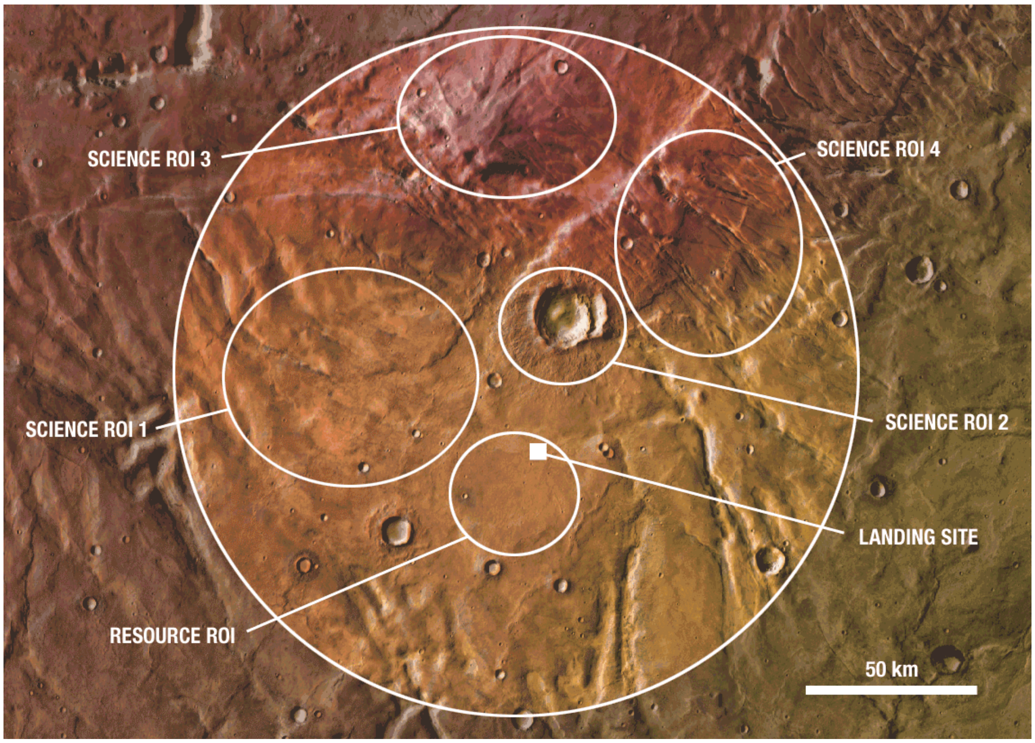

Figure 1. Context image of the Southern Nectaris Fossae EZ [1].