Introduction: The operational paradigm for the current search for life (past or present) on Mars is to follow the water [1]. Add to this—sites such as caves, lava tunnels, or natural grottos that provide shelter from an inhospitable atmospheric environment. Terrestrial alcoves associated with spring sapping and plunge-pool development furnish analogs for Martian alcoves and grottos that might serve as protected sites that could have harbored early life forms on Mars.

Terrestrial Alcoves: Alcoves—arched recesses in steep escarpments—are found in a variety of terrestrial environments. Examples include spring-sapping alcoves in Cliff House Sandstone of Mesa Verde [2]; deeply entrenched, theater-headed valleys in Navajo Sandstone [3]; plunge pool alcoves in limestone such as Alcove Springs of northeastern Kansas [4]; and grottos in basalt of Hawaii and the Snake River [5].

Terrestrial alcoves are associated with cliff-forming, permeable rock layers underlain by more easily erodible materials or permeable soluble rock underlain by impermeable shale. Undercutting and removal of soluble or friable rock by groundwater sapping or plunge pool development leads to spalling of the overlying rock to form an arched alcove. This process is effective in both arid and humid environments. Grottos are found at the heads of canyons and in major bends in steep-sided sapping channels [2]. The recessed shelf with an overhanging rock-roof provides a shelter in which biota are protected from the harsher aspects of the environment. Water percolating through the overhanging roof provides nourishment for natural hanging gardens. In the southwest United States alcoves are common sites of early pueblo development. Springs at the rear of the alcove provide water for colonizing biota.

Potential on Mars: Requirements for terrestrial-like alcoves on Mars include steep escarpment; layered permeable and impermeable materials, and groundwater discharge. Stratified materials and water-rich environment of the past provides ample opportunity for alcove development on Mars. Theater-headed valleys on Mars such as Nanedi Vallis [6, 7], Kasei Valles, Nirgal Vallis and Bahram Vallis [8] are cut into resistant rock—presumed to be lavas—underlain by softer rock. Whether carved exclusively by spring-sapping [3] or a combination of sapping and overland flow [9], it is apparent that discharge in the channels was sufficiently large to remove debris as the channels eroded headward [7, 9]. Formation of overhanging rock shelters in sapping channels; fretted channels; canyons; and in crater walls is highly probable (Fig. 1).

Search for Life: The past existence of an ocean, lakes, streams, and springs [10] offer the possibility that life could develop on Mars. The natural shielding provided by ocean waters, caves, lava tunnels [11], or alcoves increases the possibility of survival of early biota by providing a water-rich environment, protected from harsh radiation and severe dust storms. Further, such natural shelters might provide a potential basecamp for long term exploration.

Figure 1. Channel near Olympus Mons exhibiting multiple layered materials, steep slopes, and many potential sites of alcove development, (NASA HiRise image 033685).