Mars Time and Martian Environments: Changing Habitability through Time and Prospects for Ancient Mars Biosignatures. B. L. Ehlmann[1,2] [1]CDivision of Geological & Planetary Sciences, California Institute of Technology, Pasadena, CA 91125 (ehlmann@caltech.edu) for first author, [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109

Recent data permit refinement of relative Martian chronology (Fig. 1, after [1]). An important observation for habitability made by [1,2] is that while it is commonly assumed there was some period of time in Mars history when all conditions favorable to habitability "existed simultaneously (active magnetic field, valley formation, erosion and transport, aqueous alteration, etc.)….a variety of observations constraining the timing of these processes suggests that it may not be the most probable scenario" [2]. Rather, the magnetic field likely had significantly weakened well before the Hellas impact, which defines the base of the Noachian. Approximately 90% of the atmosphere of Mars was lost early, indicated by isotopic signatures of noble gases in Martian meteorites [e.g., 3]. In contrast, under the standard model for stellar evolution, the luminosity of the sun was greater later in history. The record of early Martian fluvial processes is most obviously preserved 3.5 Ga.

The presence of a magnetic field and thicker atmosphere would provide enhanced shielding from radiation. Yet, only three of the sites under consideration offer the potential of sampling rocks preserved from this time period, the enigmatic "deep phyllosilicates" in the lowermost strata at Nili Fossae, NE Syrtis, and Mawrth Vallis, which have been variously ascribed surface and subsurface origins. Landing sites with surface morphology preserving fluvial-deltaic systems occurred much later in time: Jezero (mid- to late-Noachian), Holden and Eberswalde (early-Hesperian), and Melas basin (late-Hesperian). The terrestrial fossil record begins around 3.5 Ga. The first fossils are found entombed in chemically precipitated sediments, indicated by macro- and micro-morphology, isotopic signatures, and sub-mm scale chemistry and mineralogy [4]. Indeed, though modern terrestrial fluvial systems concentrate organic matter for preservation: "Regions dominated by siliciclastic sedimentation are typically not prime localities in the search for Archean fossil life due to a very low level of in situ mineral formation and a generally poor preservation potential for biomass" [1]. Rather, silica, carbonate, and other minerals that entomb biochemistry over geologic time are favored for the preservation of Earth life, circa 3.5 Ga. We have little insight on mechanisms preserving earlier life, though look to the Archean record and modern chemolithotrophic biosphere for clues. The most crucial processes in Mars planetary evolution were (1) magnetic field evolution, (2) the rate and timing of atmospheric loss, (3) the timing and effects of the late heavy bombardment (if such a "spike" in fact occurred), and (4) the climate of the surface during the bulk of aqueous mineral formation. These all drive selection of a landing site that permits interrogation of Mars' earliest epochs.

References: [1] Ehlmann et al., 2011, *Nature*, 479 [2] Fassett & Head, 2011, *Icarus*, 211, [3] Jakosky and Jones, 1997, *Rev, Geophys*., 35, [4] Sunmons & Hallman, 2014, *Treatise on Geochemistry 2nd Edition*

Figure 1. Revised timeline of Mars history [1] including key processes in planetary evolution and the age of rocks available for interrogation at each landing site.