result of their formation after the core dynamo terminated (e.g., Schubert et al., 2000; Solomon et al., 2005; Hood et al., 2010), a "late scenario" is possible. In this case, the timing of the core dynamo is not bounded except by the lack of a global magnetic field from a dynamo today.

2. Hellas is plausibly younger than 4.09 ± 0.03 Gyr on the basis of its non-magnetization and ALH84001's magnetic signature. On its face, this is consistent with crater model ages of 4.02–4.04 Gyr (though the systematic calibration is far more uncertain than this range suggests). This upper bound on the absolute age of Hellas goes away if the core dynamo terminated before ALH84001 (the 'early scenario') or if the new ALH84001 age (Lapen et al., 2010) is too young and it is actually older (as originally thought). Unless one of the hypothesized reasons requiring a 'late scenario' is correct, the relative age sequence where the magnetic dynamo terminated before Hellas remains.
3. Large basins like Hellas, Isidis, and Argyre pre-date the end of valley network formation, and hence the magnetic field likely does so as well. The gap between the termination of the magnetic field and the formation of the Late Noachian to Early Hesperian valleys could be appreciable, depending on the absolute length of the Noachian; current impact models would suggest a period of 0.3–0.5 Gyr between the Hellas impact and end of widespread valley formation. Neither the loss of the magnetic field, nor a decline in the rate of volcanism or the impact rate, connects in a one-to-one manner with the decline in valley network formation.
4. Similarly, formation of much of the phyllosilicate record that indicates that pervasive aqueous alteration on Mars is difficult to connect temporally to the period of valley network formation; many of the alteration products that are observed are likely to be older than at least the last period of widespread valley formation.
5. Portions of Tharsis are magnetized (Johnson and Phillips, 2005), suggesting that Tharsis construction began in the Early-to-Mid Noachian or before. This is consistent with ancient tectonic activity in parts of Tharsis (e.g., Plescia and Saunders, 1982) and with the observation that the bulk of the Tharsis load was in place before valley network formation (Phillips et al., 2001). A secular change in the Mars environment linked to Tharsis formation cannot be connected in a one-to-one manner with observations of the shift in the nature of aqueous alteration environment.

A few other implications from these timing constraints are apparent. As has been discussed before (Fassett and Head, 2008b; Hynek et al., 2010), the obvious large basins (>∼500–600 km) on Mars appear too old to be the direct cause of valley formation, in contrast to the original scenario described by Segura et al. (2002), where >100 km impactors lead to surface warming and valley formation. If the impact hypothesis described by Segura et al. (2002) is to work, smaller impactors are more likely to be the cause of valley networks (see also Toon et al., 2010). Timing constraints alone allow for this possibility, although whether it is possible to reconcile the observed erosion with the erosion that impacts might produce still seems uncertain.

Second, these results suggest that *if* the magnetic field of Mars was necessary for protecting life at surface of Mars, valley sediments and even phyllosilicates that date to the Late Noachian or Early Hesperian such as those in Holden, Eberswalde, or Jezero craters may have been formed in conditions that had already become less than favorable for life. Even though such sedimentary sites provide invaluable information about surface hydrology and have the advantage of clear stratigraphic context, their deposition in the Late Noachian or Early Hesperian may have occurred on a surface subject to a radiation environment that was similar to that of Mars today. If the presence of the magnetic field was a necessary requirement for habitability, and exploring habitable conditions is the goal, this would imply that locations with more ancient materials may give us the best hope for detecting traces of life from early Mars.

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