However, the nature of the atmosphere, the surface inventory of volatiles, and surface conditions between large impact events are all unknown.

2.4 The Noachian era

If the above chronology is correct, the Noachian era extends from approximately 4.1–3.7 Gyr ago, roughly coincident with the upper Hadean on Earth. Its most distinguishing features compared with later times are high rates of cratering, erosion, and valley formation, the accumulation of most of Tharsis, and surface conditions that enabled the widespread production of weathering products such as phyllosilicates. This is the era for which we have the best evidence for widespread water erosion. The density of visible craters larger than 100 km in diameter in Noachian terrains is roughly 2×10^{-6} km^{-2} (Strom et al., 1992), or 300 such-sized craters planet-wide, implying that one 100 km diameter crater formed every million years. The impacts would have ballistically distributed ejecta around the planet, caused hydrothermal activity around the impact sites, comminuted surface materials thereby enabling them to be moved by wind and water, and brecciated the near-surface materials thereby increasing their porosity, and so affecting groundwater movement and storage. Noachian craters with diameters between 500 and 1000 km would have deposited roughly 300 m of ejecta planet-wide (Segura et al., 2002). Hellas alone would have deposited 500 m. The coarser fraction from all these impacts would have formed bedded deposits with thicknesses depending on the size of the impact events and their proximity to the resulting craters. The fate of the finer ejecta was likely more complicated. Large areas of the Noachian terrain have an etched appearance (Greeley and Guest, 1987; Malin and Edgett, 2001; Scott and Tanaka 1986) as though parts of the surface had been formerly covered with easily erodible, horizontally layered deposits that had been partly removed by the wind. Fine-grained impact ejecta are likely a significant component of these deposits, along with volcanic ash, as well as the products of weathering and erosion as discussed below. Correlations between gravity and topography suggest that the densely cratered terrain of the southern highlands has surface densities of 2500–3000 kg m^{-3} (McGovern et al., 2004), significantly lower than the density of the Tharsis volcanics and Martian meteorites (3100–3300 kg m^{-3}), and consistent with a crust that has been modified by impacts, erosion, and sedimentation.

While volcanism likely occurred almost everywhere, Tharsis was particularly active, resulting in a volcanic pile roughly 5000 km across and 9 km high by the end of the Noachian (Phillips et al., 2001). Large impact basins and the northern basin may also contain significant amounts of Noachian volcanic fill that is buried by younger deposits. Almost everywhere else, the rates of volcanic resurfacing were low compared with the impact rate so that what is preserved in the morphology is an impact-cratered surface on which almost all traces of Noachian volcanic morphology have been destroyed. Despite the scarcity of geomorphic evidence for volcanism, most of the materials exposed in the cratered uplands are probably primarily volcanic rocks or volcanic rocks reworked by impacts. They are mainly basalts rich in low calcium pyroxene, with variable amounts of olivine (Bibring et al., 2006; Poulet et al.,