plains of Gusev and the Pathfinder landing site are many orders of magnitude below the lowest rates (10^4–10^5 nm year^{-1}) for the Earth. However, despite the extremely low average rates, extensive post-Noachian erosion has occurred locally, causing some post-Noachian units, such as the Medusae Fossae Formation and the polar layered deposits, to be deeply eroded. The higher rates appear to occur mainly as a result of local events such as floods, or where rock properties are such that wind and sublimation are effective removal agents. In addition, steep slopes, particularly in midlatitude craters, are commonly gullied (see Section 2.6).

The widespread detection from orbit of olivine (Putzig et al., 2005) on post-Noachian surfaces indicates persistently low weathering rates throughout much of Mars' history (Hoefen et al., 2003), olivine being a mineral particularly susceptible to breakdown under moist conditions. Low weathering rates are also implied by alteration of the basalts in Gusev. The basaltic flows on the floor of Gusev crater have a crater retention age of 3.6 Gyr (Greeley et al., 2005) and although individual boulders analyzed by the Spirit rover cannot be dated they are likely also to be billions of years old. The rocks have a thin alteration rind in which S, Cl, and Br are enhanced, but the primary minerals olivine, plagioclase, and magnetite are retained. Chemical patterns in the soils indicate migration of soluble elements, thereby implicating liquid water. However, the alteration rinds and soil patterns are likely to be mainly the result of interactions at low water/rock ratios such as that might result at low rates from acid clouds or local melting of frost under present or higher obliquity conditions (Haskin et al., 2005).

2.5.5 Sulfates

Abundant sulfates have been observed in the soils at all the landing sites so far visited; many of the rocks in the Columbia Hills have been pervasively altered by sulfate-rich fluids. Sulfates are a major component of the sediments at Meridiani, and thick sulfate deposits have been detected from orbit at several locations mainly in the western hemisphere, but also around the north pole. The sulfate-rich deposits sampled by Opportunity in Meridiani are part of a unit roughly 600 km across and several hundred meters thick, which overlies typical Noachian cratered terrain. It appears etched in orbital images (Arvidson et al., 2003). The Mars Exploration Rover (MER) science team interprets the composition of the deposits analyzed by the rovers as the result of a mixture of roughly equal parts of a sulfate end member and altered basalt that has been depleted of roughly 50% of its original Fe, Mg, and Ca. Jarosite, the only sulfate mineral detected by the rovers, has the same sulfur content as the hypothesized sulfate end member. Kieserite has been detected elsewhere in the etched unit by CRISM (Wiseman et al., 2007) as have phyllosilicates (Poulet et al., 2008). The MER science team interprets the section at Meridiani to result largely from eolian deposition of sand-sized grains of the two end members to form dunes and sand sheets. Sedimentary structures indicative of aqueous deposition in the upper part of the section in Endurance crater suggest ephemeral, inter-dune playas, which are interpreted as acid because jarosite precipitates under very acid conditions. Mineral casts and incrustations together with variations in Cl and Br in the section probably result from groundwater oscillations (McLennan et al., 2005).