MARS HISTORY DERIVED FROM THE MINERALOGICAL DATA OF OMEGA/MEX ACQUIRED DURING THE FIRST MARTIAN YEAR OF OPERATION. J-P. Bibring[1], Y. Langevin[1], F. Poulet[1], B. Gondet[1], A. Gendrin[2], J. Mustard[2], N. Mangold[3], R. Arvidson[4], and the OMEGA Science team, [1]IAS, Université Paris-Sud, 91405 Orsay, France, [2]Brown University, Providence, USA, [3]IDES, Orsay, France, [4]Washington University, Saint-Louis, USA, bibring@ias.u-psud.fr.

Introduction: The pionneering Mariner and Viking optical mappings have revealed that Mars underwent an intense and active evolution, with tectonic, volcanic, water-driven and erosion processes that left record in a variety of surface structures. At the same time, they showed that Mars did not suffered a global surface reset, as it preserved areas dating from the early heavy bombardment. Major questions however remained unanswered, in particular with respect to the past climate: did Mars ever hosted Earth-like environmental conditions enabling liquid water to remain persistent? Is Mars a potential candidate for astrobiological search? The MGS/TES thermal infrared mapping has shown that Mars must have been cold and dry over most of its history (1). However, a few locations were identified as rich in grey hematite (2), suggesting they have been subjected to sustained aqueous processing. Here we present an updated view derived from the global mineralogical mapping acquired by the OMEGA instrument on board the Mars Express mission, during its first and nominal Martian year of operation.

Dataset: OMEGA has covered most of the planet in a global mode at 2 to 5 km spatial sampling (from altitudes 1500 to 4000 km), and some 5% of the surface in high resolution mode (down to 300 meters footprint), acquired close to the orbit periapsis. For each resolved pixel, OMEGA acquires the spectrum in 352 contiguous spectral channels from 0.35 to 5.1 µm.

Results: In addition to the monitoring of the evolution of polar ices and frosts (3,4,5,6), OMEGA has identified several classes of mafic minerals (7,8,9,10) and alteration products. The Noachian crust is enriched in low Ca pyroxene, with espect to more recent lava flows in which high Ca pyroxene dominates. Olivine-rich areas are detected in localized spots, mostly within crater floors, rims and ejecta. Large areas however, including the extended northern plains, do not exhibit mafic features: they have been subjected to an alteration process which modified their surface composition. In terms of surface coverage, most of the resulting minerals are ferric oxides, that OMEGA has shown to be not hydrated: water did not play a major role in giving Mars its red color. In addition, OMEGA has detected two classes of hydrated minerals, in localized areas: phyllosilicates and sulfates. Phyllosilicates are found in very ancient terrains, exposed by either impact or erosion (7,11,12). A variety of phyllosilicates have been detected, including Mg and/or Fe rich ones, such as nontronite, the formation of which requires alkaline conditions. Mg and Ca sulfates have been mapped, with different hydration level, in three types of sites (7, 13,14,15,16): deposits in Valles Marineris, extended areas in Terra Meridiani and dunes within the northern polar cap.

Derived History: the mineralogical detections summarized above can serve to describe the Mars evolution in three main eras:

a) The Mars early times, dominated by the heavy bombardment, hosted conditions during which liquid water was abundant enough to enable large structures of phyllosilicates to form. Given the classes of clays OMEGA detected, alkaline conditions were likely dominating. These clays could either result from surface alteration of the mafic crust in a wet climate, or subsurface processing, involving either hydrothermal activity or cooling of a water-rich mantle.

b) The second era started when, after some hundreds of millions years, the increase of internal activity resulted in large scale surface tectonic and volcanic processes. The massive outgassing of sulfur-rich compounds, rapidly oxidized by the solar flux in a tenuous atmosphere, led to an essentially acidic environment. Triggered by the tectonic activity, violent discharges produced giant outflows and intense erosion, and raised the ground water table up to the surface in a variety of sites. This multiple supply of surface water resulted in the formation of sulfates. Sulfate formation does not require liquid water to be stable or persistent at the surface: in fact, no hydrated sediments are detected by OMEGA in the channel floors or in their openings, but rather on the eroded flanks, as in the Marwth Vallis area. When sulfates formed, Mars atmosphere could already have become very tenuous. The rapid cooling of the central core and the related drop of the magnetic shield against the solar wind might have triggered an efficient atmospheric escape, precluding a sustained green house effect.

c) The third era started when the conditions of sulfate formation faded away, in a dry and cold global climate that has lasted untill now, except for transient and localized episodes that eventually occurred. During this phase, the alteration has been essentially restricted to the very shallow surface, at a very slow rate, mostly driven by interaction with atmospheric peroxides, forming ferric anhydrated oxides, including magnetic nanophases.

In such a climatic evolution, conditions more favourable to harbour life would have existed in the first era, characterized by the formation of phyllosilicates. Consequently, it is suggested that the search for astrobiological targets of interest focus on these clay-rich areas, within which clay-rich samples may still host bio-signatures: the future MSL, ExoMars then MSR rovers might wish to select, collect and analyse such samples with prime priority.

References: [1] Christensen P.R. et al. (2001), *JGR 106*, 23823-23871. [2] Christensen P.R. et al. (2001), *JGR 106*, 23873-23885. [3] Bibring J-P. et al. (2004), *Nature 428*, 627-631. [4] Langevin Y. et al. (2005), *Science 307*, 1581-1584. [5] Langevin et al., this conference. [6] Vincendon M. et al., this conference. [7] Bibring J-P. et al. (2005) *Science 307*, 1576-1581. [8] Mustard J. et al. (2005), *Science 307*, 1594-1597. [9] Mustard J. et al., this conference [10] Gendrin A. et al., this conference. [11] Poulet F. et al. (2005), *Nature 438*, 623-627. [12] Poulet F. et al., this conference. . [13] Gendrin A. et al. (2005) *Science 307*, 1587-1591. [14] Langevin Y. et al. (2005) *Science 307*, 1584-1586. [15] Arvidson R. et al. (2005) *Science 307*, 1591-1594. [16] Gendrin A. et al., this conference.