g.Fe yr^{-1} in Oceanus Borealis. This quantity of Fe is comparable to the estimated deposition rate (2.25×10^{13} g.Fe yr^{-1}) in a typical Precambrian Fe formation on Earth [10]. The surges of water that periodically inundated the martian northern lowland plains in the past were probably initiated by increased volcanic activity that melted frozen regolith [9]. Such volcanism would also have provided fresh sources of basaltic glass and ferromagnesian silicate minerals that underwent submarine chemical weathering, thereby replenishing the supply of dissolved Fe^{2+} ions to be oxidized near the surface of intermittent martian oceans.

In addition to the circumpolar body of water in the northern hemisphere, other semipermanent locations of deep-water stratification may have provided sites for the deposition of hydrous ferric oxides on Mars. These include numerous impact basins (e.g., Hellas and Argyre) and several closed depressions in the Valles Marineris system [11]. The bright deposits littering the Argyre and Hellas Basins may comprise wind-blown dust derived from desiccated hydrous iron oxide-silica deposits that remained there after water had evaporated from these deep depressions.

Deposition Rates in UV Irradiated Surface Water: As indicated by equations (2) and (3), oxidation of aqueous ferrous iron to hydrous ferric oxides does not require dissolved atmospheric O. Dissolved ferrous iron may also be oxidized photochemically by solar UV radiation. In dilute, near-neutral pH solutions, rates of photo-oxidation of dissolved ferrous iron are increased by the presence of the complex $FeOH^+$ ion, which is sensitive to wavelengths in the 300–400-nm region [4,6]. Calculations of oxidation rates by solar UV have been made for the early Earth. In areas of vigorous upwelling in ocean basins containing 0.5–5.5 ppm total dissolved Fe, photo-oxidation could have precipitated hydrous ferric oxides at rates of $1-2 \times 10^6$ ppm Fe m^{-2} yr^{-1} [4,7,12], allowing for 50% loss of UV radiation through scattering and absorption by clouds and based on the present-day solar flux [4].

On early Mars, similar processes of photo-oxidation of dissolved Fe in surfacewaters could also have occurred, leading to the aqueous deposition of hydrous ferric oxide phases that have now been desiccated to nanophase hematite. However, since Mars is further away from the Sun than Earth, the lower solar UV flux incident on the martian surface would have induced slower deposition rates of the ferric oxides, perhaps smaller than 10^4 ppm Fe m^{-2} yr^{-1}.

Ferric Oxide Deposition on Present-Day Mars: Since frozen regolith currently prevents upwelling of Fe^{2+}-enriched subsurface aquifers, oxidation of aqueous Fe^{2+} by atmospheric O and solar UV radiation cannot occur, so dissolved Fe^{2+} ions may now persist beneath the martian surface. However, sublimation of permafrost and evaporation of daytime equatorial meltwaters exposed to the martian atmosphere would cause localized oxidation of dissolved ferrous iron, hydrolysis of Fe^{3+} ions, and flocculation of colloidal ferric-bearing clay silicate, oxide, and hydroxysulfate assemblages at freshly exposed surfaces on the planet. Such nanophase materials may constitute the particulate matter in local and global dust storms. During eolian transport, any unoxidized ferrous salts liberated from sublimed permafrost would be oxidized completely by exposure to atmospheric O, while desiccation of ferric hydrolysis products to Fe_2O_3 phases would be facilitated. Therefore, most of the nanophase hematite littering the martian surface is the ultimate oxidation product of dissolved Fe^{2+} ions that were derived from chemical weathering of basaltic ferromagnesian silicate minerals.

On the present-day arid martian surface, traces of O, OH, and HO_2 radicals formed by the photolysis of H_2O vapor in the atmosphere may have yielded low concentrations of H peroxide on the martian surface [13]. Experimental studies have demonstrated that rates of oxidation of dissolved Fe^{2+} by H_2O_2 are considerably higher than reactions involving atmospheric O [14,15]. Any Fe-bearing solutions percolating to the surface of Mars or resulting from melting of frost condensates would be immediately oxidized to ferric-bearing assemblages. Thus, thin veneers of ferric oxides may be continuously forming on the outermost arid surface of Mars.

Acknowledgments: Research supported by NASA grant NAGW-2220.

References: [1] Burns R. G. (1993) *JGR, 98,* 3365–3372. [2] Burns R. G. (1993) *GCA, 57,* in press. [3] Zent A. P. and McKay C. P. (1992) *LPI Tech. Rpt. 92-04,* 41–42. [4] Braterman P. S. and Cairns-Smith A. G. (1987) in *Precambrian Iron-Formations* (P. W. A. Appel and G. I. LaBerge, eds.), 215–242. [5] Cairns-Smith A. G. (1978) *Nature, 276,* 807–808. [6] Braterman P. S. et al. (1983) *Nature, 303,* 163–164. [7] Francois L. M. (1987) *Paleoceanog., 2,* 395–408. [8] McElroy M. B. and Kong T.-Y. (1976) *GRL, 3,* 569–572. [9] Baker V. R. et al. (1991) *Nature, 352,* 589–594; *Nature, 354,* 86–87. [10] Trendall A. F. (1973) *Econ. Geol., 68,* 1023–1034. [11] Spencer J. R. and Fanale F. P. (1990) *JGR, 95,* 14301–14313. [12] Anbar A. D. and Holland H. D. (1992) *GCA, 56,* 2595–2603. [13] Barth C. A. et al. (1992) in *Mars* (H. H. Kieffer et al., eds.), 1054–1089, Univ. of Arizona, Tucson. [14] Millero F. J. and Sotolongo S. (1989) *GCA, 53,* 1867–1873. [15] Millero F. J. et al. (1991) *J. Soln. Chem., 20,* 1079–1091.

N94-33199

59-91 ABS ONLY 8

MARSNET: A EUROPEAN NETWORK OF STATIONS ON THE SURFACE OF MARS. A. F. Chicarro, Space Science Department, ESA/ESTEC, 2200 AG Noordwijk, The Netherlands.

Introduction: Following an ESA preliminary study on the possible areas of European participation in the future international exploration of Mars [1] and an ESA call for ideas of new missions, MARSNET, a network of small surface stations, was selected for further in-depth scientific and technical assessment studies [2] as a potential European contribution to such exploration. Subsequently, the MARSNET phase A studies started in the autumn of 1991. The industrial kickoff took place in early January 1992, following the tender evaluation and the decision to select the Aérospatiale-led consortium including Dornier, Alcatel, Laben, and Etca to perform the industrial studies. The phase A studies ended in early 1993 [3]. However, critical items such as an instrument deployment device continue to be studied in the framework of ESA's Technology Research Program.

The MARSNET mission consists of a network of three semihard landers to be placed on the martian surface, several thousand kilometers apart, thus defining a regional/global seismological and meteorological network in the Tharsis region. The small stations would be targeted for landing at scientifically interesting sites in this region of Mars, which is the most likely area to still show tectonic activity; this will would allow the seismometers to acquire data for the determination of the internal structure of the planet. Landing site geology and geochemistry will also be studied.

Network Concept: Following early global survey missions such as Mariner 9 and Viking, and ongoing orbital and *in situ* missions like Mars Observer and Mars '94, focusing on the atmosphere

TABLE 1. MARSNET scientific payload.

Disciplines	Instruments	Acronyms	Mass
Geophysics of the interior	Seismometer	SEM	2.30
Geology	Panoramic camera	PCS	1.60
	Descent imager	DEI	0.20
	Close-up imager	CUI	0.30
Geochemistry and mineralogy	α-proton X-ray spectrometer	AXS	0.40
	Neutron detector	NED	0.15
Volatile studies	Differential thermal/ evolved gas analyzer	EGA	0.70
Iron studies	Mössbauer spectrometer	MÖS	0.40
Meteorology	Meteorological package	MEP	0.75
Atmospheric structure	Atmospheric structure experiment	ASE	0.30
Exobiology	Solar-UV dosimeter	SUV	0.40
Magnetic properties	Permanent magnet array	PMA	0.07
Instrument Deployment Device	To carry CUI, AXS, NED, EGA, and MÖS	IDD	1.80
Total (kg)			9.37

and surface of Mars, the subsequent natural evolutionary phase of Mars exploration would be to establish a network of small stations on the surface of Mars as an effective precursor to more detailed surface exploration.

The mission and scientific objectives of the network require the placing of a number of stations on the martian surface to perform seismological and meteorological measurements at sites of varied latitudes and altitudes to infer the internal structure of the planet and the atmospheric circulation and weather patterns. These long-term investigations would require an operational lifetime of at least one martian year (687 days). Other important scientific goals would be the morphology and geology of the landing sites, and the chemical and mineralogical analysis of martian volcanic and sedimentary surface rocks and soils, as well as the magnetic properties and volatile content of the surface materials. Also, atmospheric pressure and temperature profiles would be obtained during entry and descent, and surface and descent imagery would allow the correlation of the geological setting of each landing site to orbital imagery. The surface stations would also monitor the amount of solar-UV radiation reaching the martian surface in order to infer the present exobiological conditions on the planet, which may allow or prevent biochemical activity from occurring on the martian surface. The MARSNET mission would therefore contribute to provide a global perspective of Mars with simultaneous seismic and meteorological measurements at each landing site, as well as their chemical and geological characterization.

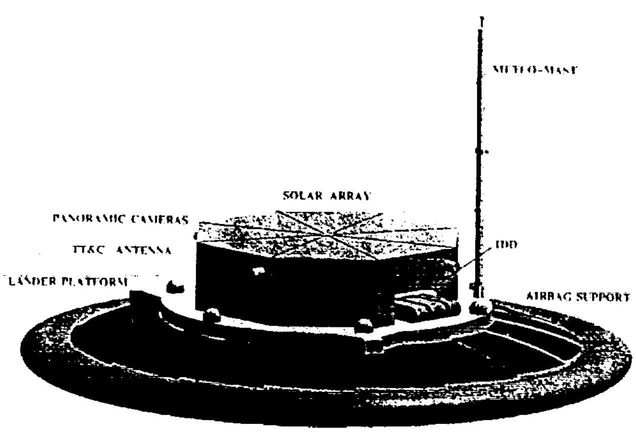

Fig. 1. MARSNET lander configuration on the martian surface showing the IDD.

Model Payload: Table 1 indicates the <10-kg model payload for each MARSNET surface station. A specific Instrument Deployment Device (IDD) will be needed in order to place the sensors of a number of instruments in contact with the martian rocks and soil. The IDD (Fig. 1) is a self-propelled mobile platform carrying sensors and electronics of the AXS, CUI, NED, MÖS, and EGA instruments. The length of each IDD element is 30 cm. A number of meteorological sensors will be placed on an 80-cm boom on top of the station. Each lander carries an identical scientific payload to obtain coherent measurements and to reduce costs.

A typical model payload to be carried onboard the surface stations that is compatible with the above-mentioned scientific objectives has been elaborated upon. It focuses on seismology, geochemistry, geology, and atmospheric physics. An outstanding feature of the model payload is manifested in its conformance with system mass constraints by utilizing state-of-the-art designs in terms of low mass, low power consumption, and a high level of integration.

Landing Sites: A number of baseline network landing sites are being considered. Each target site must be as homogeneous as possible within the 100-km × 20-km landing incertitude ellipse. However, sites of varied geology, chemical composition, and latitudes (within the Tharsis region) are necessary in order to satisfy the scientific requirements of geophysics, geochemistry, geology, and meteorology. Mission analysis constraints limit the number of potential areas of interest. The regions of Tempe Terra, Candor Chasma, and Daedalia Planum have been proposed.

A set of three landing sites (with an average separation of 3500 km) that would satisfy the scientific and technical requirements has been selected as a possible baseline network configuration. Therefore, MARSNET would provide a global scientific perspective of Mars and would also constitute part of a major international robotic precursor mission to future Mars sample return and manned exploration missions.

Lander Design: Each semihard lander would be carried onboard its own 2-m-diameter aeroshell and deployed at 10–15 km altitude for landing at about 25 m/s. Each lander (Fig. 1) would be approximately 1.2 m in diameter and 30 cm in height (excluding booms) and 67 kg in weight, including a scientific payload of about 10 kg. The surface stations would be powered by solar-cell arrays and batteries. Both communications via a relay orbiter at Mars and direct-to-Earth communications as backup are being studied for the landers. A scientific data rate of at least 2 Mb/day/station is expected.

Numerous design trade-offs have been performed, compatible with a design strategy aimed at a low-mass, low-power-consumption, maximum-inheritance, and low-cost approach. Resultant design characteristics reflected in the reference MARSNET probe/lander design are typically photovoltaic primary energy source (solar arrays), minimum booms/mechanisms, S-band communications, passive descent subsystem (no active guidance or control), and landing system based on air vessels (no active propulsion). Further in-depth studies and critical analyses on such potentially critical areas as the descent and landing systems would consolidate and validate work already performed in supporting technology and the MARSNET phase A study. The feasibility of the concept has been adequately demonstrated to the present level, but further studies should be performed in the relevant critical technological areas.

Mission Scenario: The delivery of the three ESA MARSNET semihard landers could be performed by moderate- to high-performance expendable launch vehicles, such as Delta-II, Ariane-4, and Proton. The phase A study evaluated the two major mission scenarios for the transfer, delivery to Mars, and targeting of nominally three and possibly four probe/landers, which would then enter the martian atmosphere, descend, and land on the surface. Surface operations, during which a number of challenging and significant scientific investigations would be performed, is planned for a nominal duration of one martian year. The two major mission design scenarios are both based on a Delta-II 7925 expendable launch vehicle, but either could be performed with a similar class of expendable launch vehicle.

The MARSNET reference baseline mission design was that of the multiprobe carrier scenario, in which all landers are accommodated on one common cruise spacecraft (Mariner Mark-II class). The three entry modules could be launched toward Mars in appropriate reference launch windows (2001, 2003) and subsequent launch opportunities. The carrier spacecraft would then deliver and target the stations for atmospheric entry. The descent in the martian atmosphere would last for about 10 min. The distribution of the three MARSNET stations would take place from an approach hyperbola. The MARSNET probe/landers are targeted and separated sequentially during the Mars approach phase. All targeting maneuvers are performed by the cruise spacecraft. After separation, the entry probes containing the landers are passive with respect to communications until after landing.

The alternative was that of the single-probe carrier scenario, in which each lander is carried to Mars by a separate cruise module. Separation of the different cruise spacecraft modules from their launch accomodation structure will be at the time of separation from the launcher upper stage. After completion of the interplanetary cruise an unguided ballistic entry into the martian atmosphere from an hyperbolic approach has been chosen as the preferred solution for the final delivery of the landers. Each lander is contained in a blunt nosed sphere-cone aeroshell and thus uses passive aerobraking techniques with rigid decelerators to effect entry. During descent, further deceleration is achieved through the use of a two-parachute descent system, which stabilizes the descent module during the different phases and reduces the impact velocities to the design range catered for in the MARSNET design.

International Cooperation: NASA is also actively studying a network mission to Mars called MESUR (Mars Environmental SURvey). An existing understanding of future cooperation between the two agencies could develop into a joint ESA/NASA global Mars Network Mission, where ESA could provide, nominally, three surface stations (MARSNET) and NASA a number of additional ones (MESUR), therefore complementing each other in terms of scientific investigations and landing sites. A joint collaborative global Mars Network Mission is ideally suited to an appropriate division of effort and sharing of scientific return between the partners in the collaboration. Such a mission offers potentially high benefits to both the European and U.S. scientific communities.

Conclusions: The scientific exploration of Mars will give us new insights into the physical and chemical processes that took place in the primordial solar nebula, since the chemical composition of a planet depends on its location in the nebula during condensation. Most importantly, however, the study of Mars will deepen our understanding of the evolution of planets, including the Earth. Comparative planetology will thus provide significant clues for assessing current environmental challenges facing our planet.

References: [1] Chicarro A. F. et al. (1989) *Mission to Mars: Report of the Mars Exploration Study Team,* ESA SP-1117, 140. [2] Chicarro A. F. et al. (1991) *MARSNET: Report on the Assessment Phase Study,* ESA SCI(91)6, 103. [3] Chicarro A. F. et al. (1993) *MARSNET: Report on the Phase-A Study, European Space Agency,* ESA SCI(93)2, 119.

N94-33200

510-91 ABS. ONLY

MARS ATMOSPHERIC DUST PROPERTIES: A SYNTHESIS OF MARINER 9, VIKING, AND PHOBOS OBSERVATIONS. R. T. Clancy[1], S. W. Lee[1], and G. R. Gladstone[2], [1]Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder CO 80309, USA, [2]Southwest Research Institute, P.O. Drawer 28510, 6220 Culebra, San Antonio TX 78228, USA.

The longstanding model of Mars atmospheric dust, as derived by Toon et al. [1] on the basis of Mariner 9 IRIS observations and by Pollack et al. [2] on the basis of Viking lander observations, is characterized by a montmorillonite-like composition and a cross-section weighted mean radius of 2.5 μm (mode radius = 0.4 μm). The basis for this model was an analysis of Mariner 9 IRIS infrared (IR) spectra (5–50 μm) of the 1971 global dust storm, performed by Toon et al. [1]. Subsequently, Pollack et al. [2] analyzed Viking lander observations of visible (0.4–0.9 μm) sky brightness and transmission during the 1977 global dust storms. These observations were intrepreted as confirmation of the Toon et al. model of Mars atmospheric dust, with two important modifications. A nonspherical shape of the dust particles and an additional visible/ultraviolet absorbing component of dust were required to match these Viking lander observations. Pollack et al. suggested that a several percent component of magnetite in the Mars atmospheric dust could provide the observed visible absorption by the dust, since montmorillonite does not absorb visible or ultraviolet light efficiently.

Since these key studies, a number of important measurements ranging from analysis of Viking 9-μm dust opacities [3] to Phobos near-IR extinction observations of Mars dust have been obtained. Zurek [5] pointed out that the visible-to-IR dust opacity ratio obtained from the Viking studies (~2) was not consistent with the ratio predicted by the standard dust model of [1] (~1). Clancy and Lee [6] analyzed Viking IRTM emission-phase-function (EPF) sequences, which suggested smaller absorption (visible single scattering albedo near 0.92 vs. a value of 0.86 from Pollack et al.) and larger backscattering (single scattering assymetry parameter of 0.55 vs. the 0.79 from Pollack et al.) for Mars atmospheric dust. Phobos solar occultation measurements of dust extinction at wavelengths of 0.75–3.15 μm indicated particle sizes closer to 1 μm at 20 km altitude [4]. Most recently, Clark [7] interpreted groundbased near-IR spectra of Mars surface reflectance to place a very low limit (<1%) on the amount of montmorillonite-like clay materials.