FIRST MEASUREMENT OF HELIUM ON MARS: IMPLICATIONS FOR THE PROBLEM OF RADIOGENIC GASES ON THE TERRESTRIAL PLANETS; V.A. Krasnopolsky, NASA/Goddard SFC, Code 693, Greenbelt, MD 20771
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108 photons of the Martian He 584 Å airglow detected by the Extreme Ultraviolet Explorer satellite during a two-day exposure (January 22-23, 1993) correspond to the effective disk average intensity of 43±10 Rayleigh. Radiative transfer calculations, using a model atmosphere appropriate to the conditions of the observation and having an exospheric temperature of 210±20 K, result in a He mixing ratio of 1.1±0.4 ppm in the lower atmosphere. Nonthermal escape of helium is due to electron impact ionization and pickup of He^+ by the solar wind, to collisions with hot oxygen atoms, and to charge exchange with molecular species with corresponding column loss rates of 1.4×10^5, 3×10^4, and 7×10^3 cm^{-2} s^{-1}, respectively. The lifetime of helium on Mars is 5×10^4 yr. The He outgassing rate, coupled with the ^{40}Ar atmospheric abundance and with the K:U:Th ratio measured in the surface rocks, is used as input to a simple two-reservoir degassing model which presumes the loss of all argon accumulated in the atmosphere during the first Byr by large-scale impacts. The model results in total planet mass ratios of 10^{-5} g/g for K, 2.3×10^{-9} g/g for U, 8.5×10^{-9} g/g for Th, 4×10^{-10} g/g for He, and 1.5×10^{-9} g/g for ^{40}Ar. The predicted radiogenic heat flux is 2 erg cm^{-2} s^{-1}. Similar modeling for Venus results in total planet mass ratios of 4.7×10^{-5} g/g for K, 6.7×10^{-9} g/g for U, 2.2×10^{-8} g/g for Th, 1.3×10^{-9} g/g for He, 6.7×10^{-9} g/g for ^{40}Ar, and a radiogenic heat flux of 15 erg cm^{-2} s^{-1}. The implications of these results are discussed. The modeling shows that the radioactive elements were not distributed uniformly in the protoplanetary nebula, and their relative abundances differ very much in the terrestrial planets.

Comparison of the Earth, Venus, and Mars

Parameter	Earth	Venus	Mars
U and Th	1	0.3	0.1
K	1	0.17	0.04
Rad. Heat Flux, $erg/cm^2/s$	63	15	2
Surface enrichment	100	100	250
Degassing time, Byr	9	5	5
$k = aR^2/\tau$	1	2	1/2
T(surface, K)	280	730	200

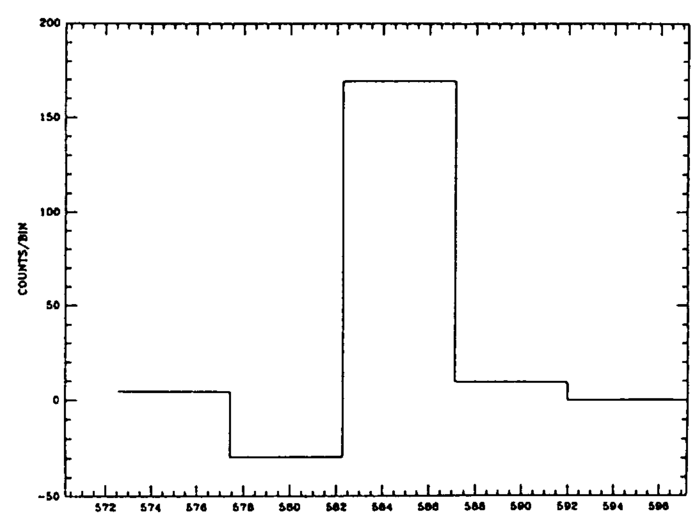

Fig. 1. Spectrum of Mars in vicinity of the He 584.3 Å line

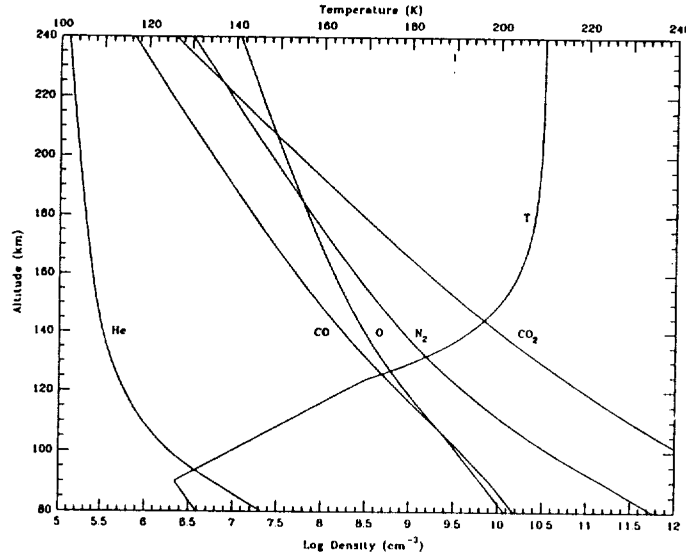

Fig. 2. The Mars model atmosphere appropriate to the conditions of the EUVE observation

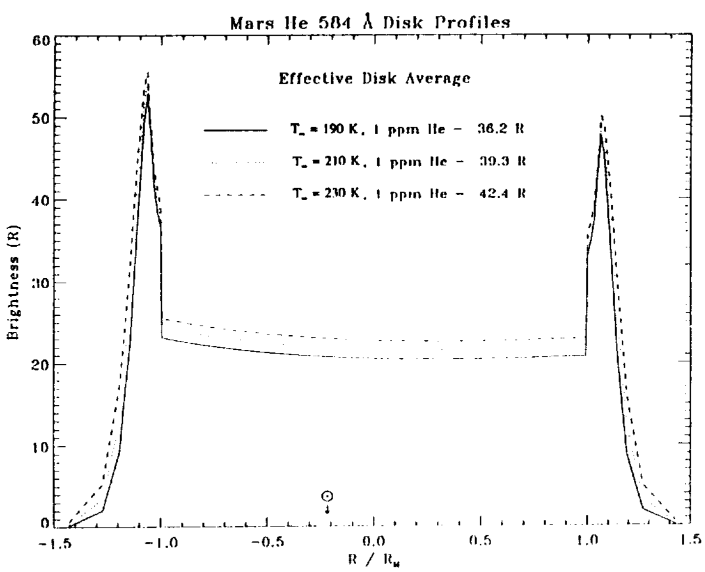

Fig. 3. The calculated He 584 Å brightness profiles across the mid-section of Mars for three models of the atmosphere with T_∞ = 190 K, 210 K, and 230 K

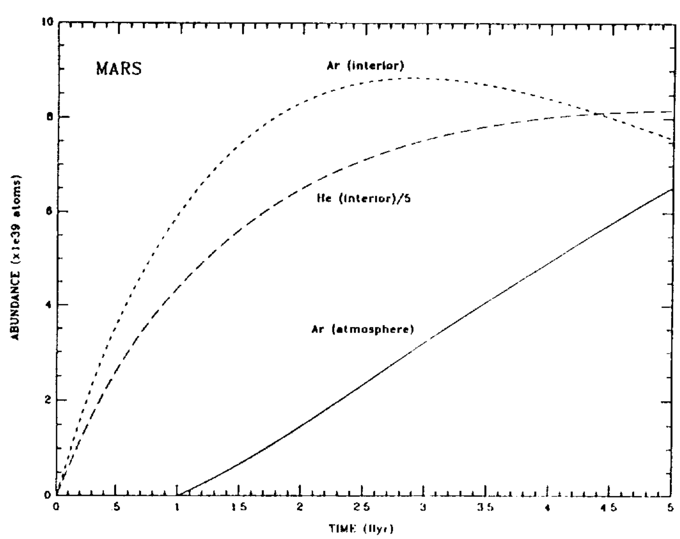

Fig. 4. Abundances of ^{4}He in the interior and ^{40}Ar in the atmosphere and the interior of Mars during its history