Ozone in Martian atmosphere from the 1.27 µm O2 emission: OMEGA Mars Express measurements

L.V. Zasova, *Spase Research Institute , Moscow, Russia- IFSI INAF, Rome, Italy(zasova@irn.iki.rssi.ru)*, **F. Altieri, Grassi D., G. Bellucci, V. Formisano, N. Ignatiev,** *Instituto dell Fizica Spacio Interplanetario,Rome, Italy,* **J-P. Bibring,** *Institut d'Astrophisique Spatiale, Orsay, France,* **P. Drossart, T.Encrenaz, T. Fouchet** *,LESIA, Observatoire de Paris, France* **and the OMEGA team**

Introduction:

Ozone in the Martian atmosphere was discovered by Mariner-9 in the UV spectral range. In Martian atmosphere, as in the Earth one, the strong O2 emission on the day side is produced as a result of photolysis of O_3: 90 % of ozone molecules produce oxygen at $a^1\Delta_g$ state. There are two ways of de-exitation of the O2: by the emission (97% of emission in 1.27 µm band and the rest in 1.58 µm) or by collisions with the CO2 molecules. Krasnopolsky (1997) found that the best way to observe high altitude ozone is by measuring the O2 day glow. The dayglow is quenched by CO2 below 20 km.

Observations.

OMEGA is the imaging spectrometer on Mars Express. For each pixel of the OMEGA image acquires the spectrum in 352 contiguous channels covering the range 0.35 to 5.1 µm. The spectral sampling is 0.007 mµ, 0.014 µm, and 0.020 µm, and in the spectral channels from 0.35 to 1.0 µm, 1.0 to 2.5 µm, and 2.5 to 5.1 µm, respectively (Bibring et at., 2004). Field of view of OMEGA at limb observations is from 1 to 9 km, depending on the position of the spacecraft on orbit. However, spectral resolution is pretty low and the band remains not resolved.

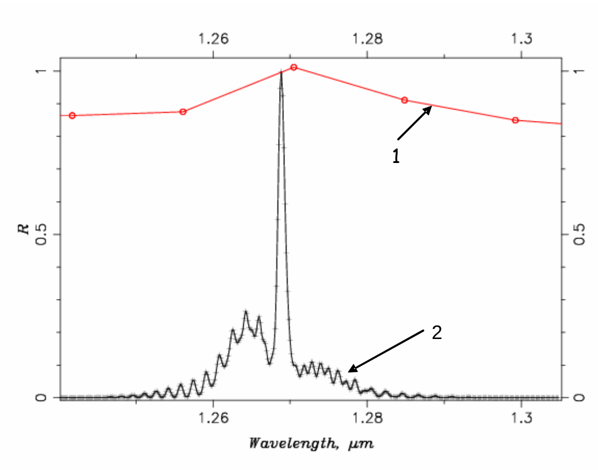

Fig.1. The 1.27 µm O2 emission in OMEGA IR channel (each channel is marked – red line) and synthetic spectrum of emission, calculated by M. Lopez Valverde with spectral resolution of 1.6 cm-1.
(or 3 Å)

To estimate an apparent abundance of ozone we should know the absolute intensity of the O2 emission in the 1.27 µm band. A spectrum of OMEGA in the range of O2 emission together with synthetic spectrum, calculated with spectral resolution of PFS is shown in Fig.1 . For a spectral resolution of 0.014µm about 98% of the O2 emission is contained in 'one spectral channel" 1.271 and continuum may be taken at 1.256 and 1.285 µm (Fig.1). To obtain the absolute intensity of the O2 emission we also include into consideration the other possible spectral features in that spectral range: the main of them is the solar Fraunghofer line at 1.283 µm, however it influences mainly the continuum. The transmittance of the CO2 in Martian atmosphere is very close to 1 and equal to 0.9983, 0.9994 and 0.997 at 1,256, 1.271 and 1.285 µm respectively, and may be taken into account.

We show here some results to demonstrate the ability to obtain the vertical profiles of ozone from the OMEGA limb data.

To obtain the apparent abundance of O3 we use the method , described by Novak et al. (2002).

O3 photolysis

This process is described by equation:

$$\alpha [O3] = \tau^{-1}[O2(a^1\Delta_g)] + k[CO_2]\,[O2(a^1\Delta_g)] \quad (1)$$

Square brackets mean the abundance of gases. According to paper Nair et al. 1994, α = 0.0015 – 0.0022 s^{-1}, τ = 3800 s. Parameter *k* defines a level below which the quenching becomes important. Neglecting the second term we obtain an apparent abundance of ozone or high altitude ozone.
Vertical profile of O3 may (N_{O3} (h))be retrieved from the limb profile of the O2 emission (eq.2). This work is in progress now.

$$4\pi I = const\int_0^\infty N_{o3}(h)\cdot\exp(-\tau_a(l))/(1+k\tau N_{CO2}(h))\cdot dl \quad (2)$$

Here *h* is the vertical coordinate, *l* is the slant distance, and τa is the aerosol opacity, *I* is absolute O2 emission. At first step we neglected of the aerosol opacity.

Limb observations:

From the limb observations we can retrieve the vertical profile of O2 emission and consequently the vertical profile of ozone distribution. In this abstract we show the preliminary results related to the abundance of ozone along the line of sight and consequently its vertical profile.-

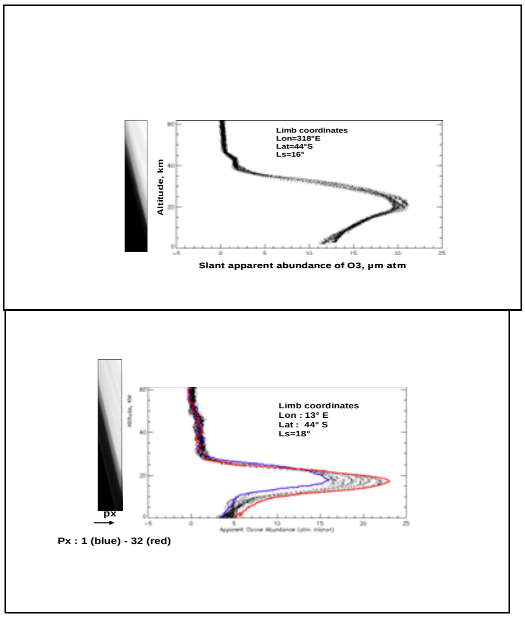

Fig. 2. Profile of apparent O3 abundance above Argire (top) and Nochias (bottom), LT=10.8h.

In Fig.2 two examples of vertical profiles of ozone column density along the line sight is shown. If we assume that a layer at 20 km may be a result of quenching effect below 20 km, we try to estimate the quenching parameter *k*. This value was estimate as very low, $k < 2 \times 10^{-20}$ cm3 s-1 (DeMore et al. 1997). With this value of *k* both terms in Eq.1 should give the equal input at about 30 km .

We can estimate *k* assuming that both de-exitation effects, emission and collision play equal role at 20 km (Fig.2). From simultaneous observation by PFS we retrieve the T(P) profile and the CO_2 number density profile. For the number density [CO2] = 3.8e+16 cm-3 at 20 km we obtain k = 0.7e-20 cm3 molecule-1 s-1, which is three times lower than the upper limit.

We made deconvolution of measured profile on the limb of O2 [cm-2] emission to obtain its vertical profile (over altitude) [cm-3]. Three vertical profiles of ozone concentration in Argire are shown in Fig. 3 for different value of *k* : 0 – without quenching effect, *k* = 0.7e-20 cm3 s-1 (from OMEGA profiles) and upper limit value.

An error may be of factor of 2 just because of uncertainty of *k*. Aerosol is not taken into account at this step. It may correct the profile of ozone below 10 km.

Ozone concentration from the model of Clancy and Nair (1996) at Ls=60°: 35 km – 2.e9cm-3, 20 km - 3.e9cm-3, 10 km – 1.e9 cm-3 and near surface – 2.e9 cm-3. Green curve in Fig. 3, obtained with *k* = 0.7e-20 cm3 s-1 roughly corresponds to the model.

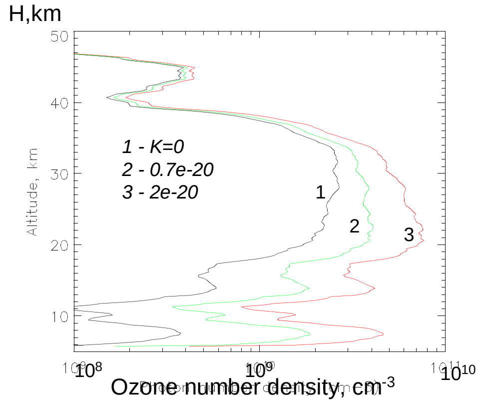

Fig.3. Vertical profile of ozone above Argire. It was obtained from Eq.1 (no aerosol is taken into account): φ= -44° N, λ= 318° E., Ls=16°, Lt=10.8h.

Acknowledgements

We acknowledge the Russian Foundation of Basic Research for financial support, grant RFFI 04-02-16856a.

References

Bibring, J-P. et al., 2005. Mars Surface Diversity as Revealed by the OMEGA/Mars Express Observations. Science, 307, 1577-1582

Clancy, R.T., Nair, H., 1996. Annual (perihelion–aphelion) cycles in the photochemical behavior of the global Mars atmosphere. J. Geophys. Res. 101, 12785–12790.

DeMore,W. B., S. P. Sander, D. M. Golden, R. F. Hampson, M. J. Kurylo, C. J.Howard, A. R. Ravishankara, C. E. Kolb, and M. J. Molina 1997. *ChemicalKinetics and Photochemical Data for Use in Stratospheric Modeling*. JetPropulsion Laboratory, Pasadena.

Krasnopolsky V., 2003. Mapping of Mars O2 1.27 μm dayglow at four seasonal points. Icarus 165 (2003) 315–325

Krasnopolsky, V.A., 1997. Photochemical mapping of Mars. J. Geophys. Res. 102, 13313–13320.

Nair, H., M. Allen, A. Anbar, Y. Yung, and R. T. Clancy 1994. A photochemical model of the martian atmosphere. *Icarus* **111**, 124–150.

Novak, R., Mumma, M.J., DiSanti, M., Dello Russo, N., Magee-Sauer, K.,2002. Mapping of ozone and water in the atmosphere of Mars near the 1997 aphelion. Icarus 158, 14–23.