4. MARS AT THE BELGIAN INSTITUTE FOR SPACE AERONOMY

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ABSTRACT

The Belgian Institute for Space Aeronomy has been interested in the Martian atmosphere since its founding, however it was only at the occasion of the Phobos mission in 1989 that spacecraft results could be studied at the Belgian Institute for Space Aeronomy. A parallel modeling effort emerged at the same time, the first result being the tentative identification of formaldehyde in Martian Phobos results and its examination in terms of theoretical modeling. This success led to the development of the SPICAM instrument for the Mars 94 mission in cooperation between BISA the "Service d' Aéronomie", France and the Institute for Space Research (Russia). The SPICAM instrument will measure solar and stellar occultations during the Mars 94 and the Mars 96 campaigns from the U.V. to the middle infrared. BISA is mainly in charge of the SPICAM solar part and the missions of this instrument will be described in this report.

INTRODUCTION

In 1963, Mars observation had a far lower priority than the observation of the earth upper atmosphere and space environment, however, it was known since the late fifties that Mars had an atmosphere where carbon dioxide was the major constituent. Martian CO had been recently discovered and there were still doubts about the presence of water vapor and molecular oxygen, the composition of the icecaps was not known as well as the reasons for seasonal changes of color and patterns on the Martian disk. Mars at that time was known as an aeronomical object at the institute (Nicolet, 1970), but no studies were initiated due to the urgencies met in the mapping of the earth's "ignorospere" starting at the same time. This orientation was modified on the basis of the numerous atmospheric results of the Martian missions: Mariner 9, Mars 5 and Viking (1 and 2). It was then decided to push for an ESA mission to the Martian atmosphere: the Kepler satellite, which went into Phase A ESA study. The institute proposal would have led to a national Belgian Martian limb sounder for which the main participants would have been BISA and the Liège "Institut d' Astrophysique" together with other Belgian academic institutions. This effort led to several publications in the ESA Leeds proceedings (Muller, 1982, Simon and Brasseur, 1982) and to an orbital study (Vercheval, 1982). Unfortunately, twelve years later, the Kepler project is in a dormant state and ESA will probably begin the studies for a Martian mission from scratch if a new mission were decided. From that time, the Belgian Institute for Space Aeronomy, prepared itself for a Martian mission through theoretical modeling and simulation of instrument results. The modeling effort evolved from a mere adaptation of a simple two dimensional model to a sophisticated one including the surface of the planet and the chemistry of carbon and sulfur (Moreau et al, 1991, 1992). In the meanwhile, studies of the Martian plasmasphere and magnetic field were also proposed (Lemaire and Rycroft, 1982). In parallel, a complete study of the Martian insolation was performed, taking into account not only the Martian orbital elements and oblateness but also the dust storms. (Van Hemelrijck, 1983, 1985, 1987).

Two missions were decided in the 1982 frame in order to explore Mars: one was the NASA Mars observer and the other was the Soviet Phobos mission. Despite the analogies between Kepler and Mars Observer, the American investigators of Mars Observer did not consider the inclusion of European scientists in their teams. On the contrary, the management of the Phobos mission encouraged foreign space agencies to submit proposals. A limb sounder proposed by the French "Service d' Aéronomie du C.N.R.S." and IKI (Moscow) followed very closely the recommendations of the Belgian study (Muller, 1982, Simon and Brasseur, 1982), the Russian part decided then to associate the BISA scientists with the interpretation of the infrared channel of the AUGUSTE instrument.

CONTENT

The main result of this cooperation is the tentative observation of formaldehyde in the Martian atmosphere from the 1989 PHOBO-SAUGUSTE observation of solar occultation (Korablev et al., 1992, 1993). This region had been chosen for the observation of HDO. The results of the observation are compared with a synthetic spectrum computation on figure 1. This computation uses the HITRAN spectral data file (which is the world standard for line parameters). It has been shown (Rodin et al, 1993) that more laboratory and theoretical work was necessary on formaldehyde due to discrepancies between laboratory measurements. The formaldehyde value deduced was then found to be compatible with the model (Moreau et al, 1992), however a lot of theoretical problems remain unsolved, the main one being the absence of methane, which should be more abundant than formaldehyde if the chemistry was limited to the gas phase.

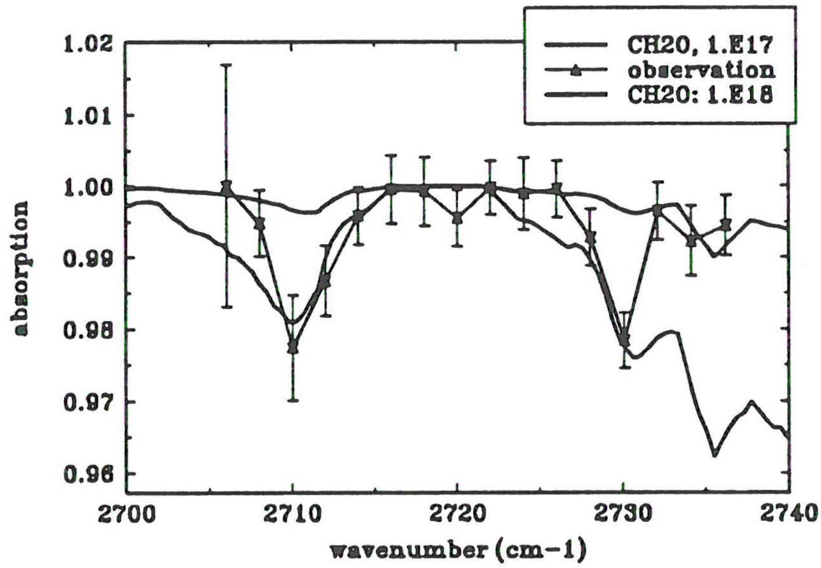

Figure 1: comparison of the observed Martian average spectrum with a Martian simulation using the formaldehyde HITRAN data file.

CURRENT PROJECT: THE SPICAM INSTRUMENT

SPICAM is an optical package designed for the study of the Martian atmospheric physics and composition in a close cooperation between IKI (Moscow), Service d' Aéronomie du CNRS (France) and the Belgian Institute for Space Aeronomy (Brussels). It is composed of a stellar occultation spectrometer and a solar occultation spectrometer. It was designed as a following to the Phobos results. The stellar spectrometer operates in the U.V. and visible regions while the solar instrument is double, one of the spectrometers covers the U.V. and visible while the other covers the middle infrared, this communication deals with the data base needs of the solar instrument. Both solar spectrometers are based on the ORIEL 125 mm monochromator which had to be modified for space operations. The instrument is part of the Mars 96 payload and the observations are scheduled to begin in 97 after insertion in Martian orbit. A simulation of the Martian transmission for an intervals of the first and second order infrared channel are shown on figure 2 and 3.

Table I : instrumental properties of the solar SPICAM package.

INfrared Channel	U.V. - visible channel
1950-3050 3920-5405	200-800 nm
res. : better than 1000	res. : 300
PbSe cooled to 240 K in two linear arrays of 128 pixels.	reticon : 1024 element diode arrays
S/N : 1000 at 5000 cm-1 200 at 2000 cm-1	better than 2000

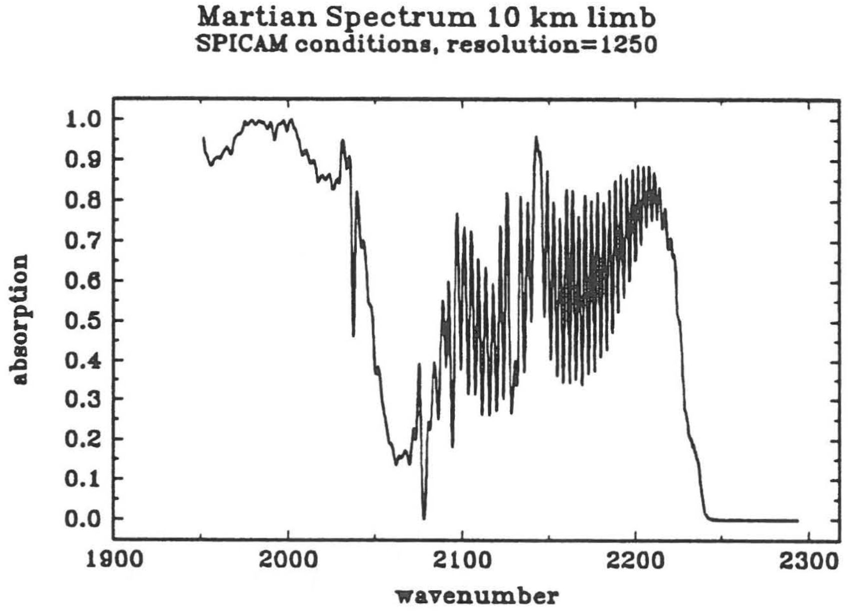

Figure 2: computations of the Martian limb transmission for a tangent altitude of 10 km in the first order of the SPICAM infrared domain.

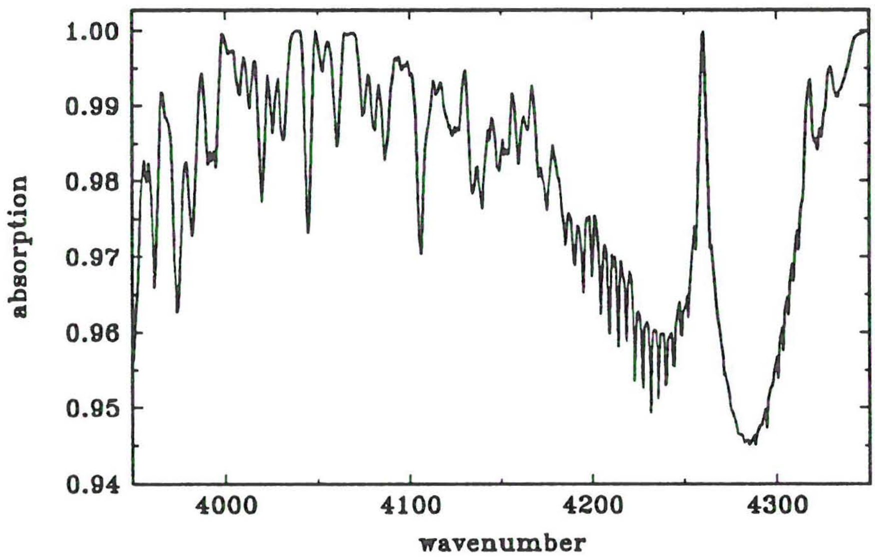

Figure 3: computations of the Martian limb transmission for a tangent altitude of 10 km in the second order of the SPICAM infrared domain. Carbon monoxide and dioxide, water vapor and formaldehyde are included, aerosols have not been included and the instrumental response is approached by a triangular function.

SCIENTIFIC OBJECTIVE 1 : MARTIAN MOLECULES

The U.V. visible part of the experiment will be essentially dedicated to the observation of the spatial and temporal evolution of the concentration of ozone and aerosols in the atmosphere while the infrared part has been conceived to realize a mapping of carbon dioxide, water vapor, and carbon monoxide atmospheric distributions. Though ozone is a trace constituent in the Martian atmosphere, analysis of its spatial distribution is meaningful for a good understanding of Martian aeronomy. Ozone was previously detected in high latitudes regions by both Mariner 9 and Mars 5 spacecraft but is not yet detected in equatorial areas. Though CO and water vapor have been intensively observed during the last three decades, spatial distribution of these constituents in the Martian atmosphere remains a major scientific problem. Observations made during Phobos mission apparently shown a higher abundance for water and lower abundance for carbon monoxide over the volcanic Tharsis region leading to a renewal of interest in possible current Martian volcanic activity. Analysis of carbon monoxide variation of concentration in the Martian atmosphere is an essential scientific problem to solve in the frame of the study of the Martian atmospheric stability. Organic molecules, in particular formaldehyde and methane, are also among the SPICAM scientific objectives.

SCIENTIFIC OBJECTIVE 2 : MARTIAN AEROSOLS

The Martian aerosol population is represented by two main groups: the mineral dust and the ice or two-layer (dust core and ice cover) particles. Water ice is known to represent the dominant type of condensate layers, the solid CO_2, however is also possible at high altitudes. Mineral dust forms the so-called permanent haze of Mars in the lowest 20 km, where the dust is rather well mixed with gas. The wavelength dependence of the dust complex refraction index is in quantitative agreement with the silicate mineral that contains a small amount of ferric oxides. Infrared spectra show also the signatures of clay minerals (montmolillonites) (Rodin et al, 1993).

ACKNOWLEDGMENTS

The SPICAM programme is financed by the Space Agencies of the participating countries, in particular the Belgian science policy office and the Russian Academy of Sciences. Other Martian researches have been funded through the Belgian National Science Foundation and through the own subsidy of the Belgian Institute for Space Aeronomy.

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