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No. 98 SULPHUR COMPOUNDS IN THE ATMOSPHERE OF VENUS
II: UPPER LIMITS FOR THE ABUNDANCE OF COS AND H₂S

Carbonyl sulfide + hydrogen sulfide

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ABSTRACT

Laboratory spectra of small amounts of carbonyl sulfide and hydrogen sulfide are discussed relative to their abundance in the Venus atmosphere. The upper limits to the mixing ratios relative to a two-way transmission in the Venus atmosphere, 4 km-atm. of CO₂ are: COS < 10⁻⁶, and H₂S < 2 × 10⁻⁴.

1. Introduction

This paper presents results of attempts to estimate the upper limits of the abundances of carbonyl sulfide (COS) and hydrogen sulfide (H₂S) in the Venus atmosphere using new spectroscopic data. Such limits are especially relevant to the Venus problem because of the computer models of chemical and thermodynamic equilibria in planetary atmospheres (Lewis 1968, and Lippincott *et al.* 1967) that are now available. The sulfur gases also relate directly to the current level of volcanic activity on Venus.

2. Carbonyl Sulfide

Tracings of the near-infrared spectrum of COS were published by Kuiper and Cruikshank (1964). The strongest band in the region 0.9–2.6 μ is centered at 2.44 μ. New tracings of this and adjacent bands with resolution (λ/Δλ) 7000 are shown in Figure 1 for different amounts of the gas from 4.7 mm-atm to 50 mm-atm, all at 705 mm Hg pressure and room temperature. No COS is detected in the Venus atmosphere where the laboratory spectra are compared with the Venus tracings of Kuiper (1962), Moroz (1964), and Cruikshank and Forbes (1967). The latter are more difficult to compare because the heavy telluric water-vapor absorption bands are only reduced. An upper limit of COS relative to two-way trans-

mission in the Venus atmosphere may be established on the basis of this comparison. For 4 km-atm CO₂ in the Venus atmosphere two-way transmission, this corresponds to an upper limit to the mixing ratio of 10⁻⁶.

3. Hydrogen Sulfide

The test for H₂S is less sensitive than for COS because of contamination of the Venus spectrum by many bands of CO₂. The ultraviolet electronic bands occur as a broad continuum from 1900–2700 Å (Herzberg 1966, p. 489) and are therefore unsuitable for our purpose. A strong vibrational band at 1.58 μ lies on a branch of the 301 band of C¹³O₂ (1.5714 μ) which is very strong in the Venus spectrum. The 101 band of H₂S at 1.94 μ is similarly blended with CO₂ in the atmospheres of the earth and Venus, and with telluric H₂O. A rough upper limit of 1 m-atm for H₂S can be established, however, using Kuiper's spectra and those of Moroz (1964) with the H₂S spectra of Cruikshank (1967). Relative to 4 km-atm CO₂ in the Venus atmosphere, this corresponds to an upper limit in the mixing ratio of 2 × 10⁻⁴.

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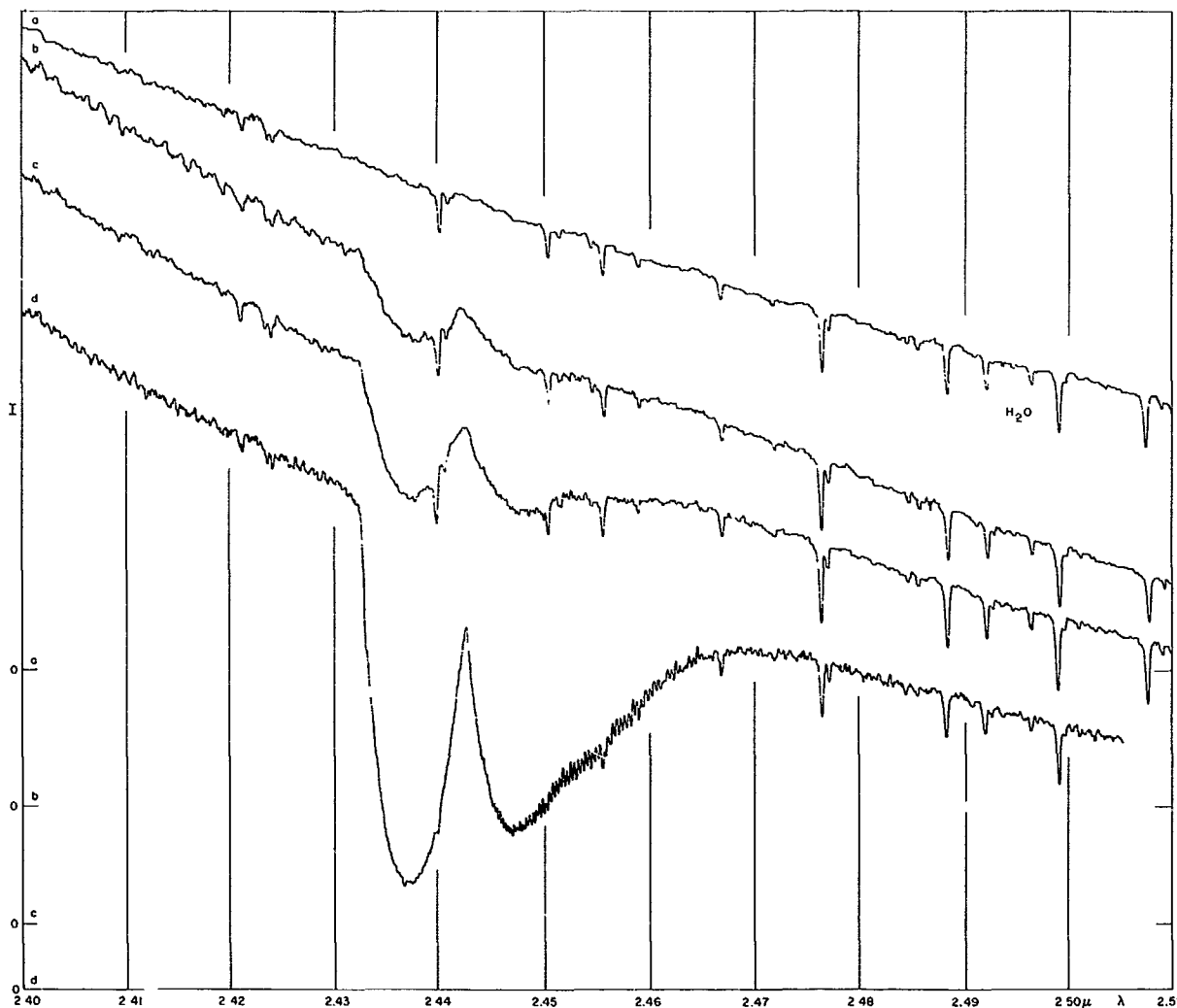


Fig. 1 A portion of the infrared spectrum of COS showing the development of the band with various amounts of gas. (a) Blank run with no COS but 4.36 m laboratory air in optical path, including spectrometer, (b) same air path with 4.7 mm COS at $p = 1$ atm, (c) air path with 7.1 mm COS at $p = 1$ atm, (d) air path with 50 mm COS at $p = 1$ atm. B-spectrometer slit 0.05 mm, detector width 0.05 mm.

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