

A MODEL OF THE VENUS ATMOSPHERE EVOLUTION ALONG WITH TITANHEMATITE-MAGNETITE-PYRITE BUFFER Zolotov M.Yu., Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Moscow 117975, Russia.

Abstract. A model of Venus atmosphere evolution during and after global resurfacing event as a result of CO₂ planetary outgassing has been designed taking into account temporal changes of volcanism rate as well as buffering of redox potential and sulfur compounds by gas-mineral reactions. The model predicts high atmospheric stability since the resurfacing event and more vivid climatic changes during the event.

Introduction. Concentration of chemically active gases assumed to be controlled by gas-mineral type reactions on the atmosphere-lithosphere interface [e.g. 1,2]. In particular, titanhematite-magnetite-pyrite (Hem-Mt-Py) equilibrium is suggested as current buffer of atmospheric gases in the C-O-S system [3]. Low volcanic activity since global volcanic resurfacing event about 500 Ma ago [4] allows us to expect relative stability of physico-chemical parameters of the atmosphere. Therefore we should expect that atmospheric composition during that epoch was governed by the same mineral buffers as now. While temporal changes of chemically inert components and also CO₂(?) in the atmosphere could be a function of volcanic as well as volcanic-independent planetary outgassing. The purpose of that work is prediction of temperature, pressure, and composition changes of the Venus atmosphere during and after resurfacing event as a result of planetary CO₂ outgassing providing lack of CO₂ chemical interaction with surface materials as well as buffering of redox potential and atmospheric sulfur abundance by the Hem-Mt-Py equilibrium.

Model. A model of physico-chemical evolution of the atmosphere is developed on the basis of advanced GEVA computer program [5]. Atmosphere is suggested as a close gaseous system (H-C-N-O-S) which involves the following gases: CO₂, CO, SO₂, COS, H₂O, H₂S, CH₄, NH₃, N₂, O₂, H₂, and S₂. Besides these gases is in chemical equilibrium on the atmosphere-surface interface (at 6051.4 km). Redox potential and concentration of sulfur-bearing gases are controlled by Hem-Mt-Py buffer at the following activities of solid phases: $a_{\text{Hem}}=0.64$, $a_{\text{Mt}}=0.69$, $a_{\text{Py}}=0.76$ [see 3]. The evolution is modeled from the present time point, which assumed to be characterized by the following parameters: 740 K; 95.6 bar; x_{CO_2} : 0.965; CO: 17 ppm, SO₂: 130 ppm; COS: 30 ppm, H₂O: 4 ppm, H₂S: 0.08 ppm, S₂: 0.1 ppm, $\log(f_{\text{O}_2})$: -21.33. For the each time step the program calculate: 1. Molar ratios and partial pressures of gases for the near-surface atmosphere by chemical equilibrium assessment (Gibbs free energy minimization method); 2. Near-surface temperature by greenhouse effect procedure; 3. Pressure; 4. Redox potential; 5. Sulfur and carbon atmospheric abundance. CO₂ outgassing is assumed as the main factor of atmospheric evolution. CO₂ outgassing rate since the cessation of the resurfacing event is determined by volcanism rate providing 1 wt. % CO₂ solubility in basalts [6]. Therefore outgassing factor $O_f = (\text{mass of outgassed CO}_2)/(\text{mass of lava}) \leq 0.01$. Volcanism rate (V_r) for that temporal interval is used from 0.01 [7] to 0.5 [8,9] km³/year. Taking into account planetary 1 km thick lava layer formed during resurfacing event, V_r value is determined by normal distribution law with dispersion as 10 Ma (Fig. 1a). Assuming possible non-volcanic CO₂ outgassing especially during resurfacing event (outgassing from intrusives; direct mantle outgassing; metamorphic decay of previously formed crustal carbonates), O_f value in the model is used up to 0.3. Used V_r and O_f values result in CO₂ outgassing rate in the following range: 0.28-440 Tmol/year (Fig. 1b). Outgassing of S-, H-bearing gases are not taken into account assuming their buffering by gas-mineral reactions. Solar luminosity, hydrogen and nitrogen masses in the atmosphere are used as constant values.

Brief results. Even providing $V_r=0.5$ km³/year and $O_f=0.01$ since the resurfacing event T-P-chemistry changes were estimated as almost negligible (Fig. 1c-f). During the resurfacing event these changes should be more vivid. But only volcanic CO₂ outgassing ($O_f=0.01$) during the event could not result in great changes. Increasing of atmospheric temperature result in increasing of SO₂ and O₂ partial pressures, which are determined by the Hem-Mt-Py buffer (Fig. 2). Climatic stability since the event provides small changes of SO₂ content and redox potential.

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VENUS ATMOSPHERE EVOLUTION: Zolotov M.Y.

