Mineralogical compounds of the composition of the dust aerosol on the period of dust storms in Tajikistan

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Abstract. This contribution presents the composition of the dust aerosol sampled during dust storms in the territory of the weather station Ayvaj, southern Tajikistan, in 2007-2015. High concentrations of the compounds quartz SiO_2 (44.3%), calcite CaCO_3 (17%), potassium mica $\text{KAl}_2[(\text{AlSi}_3\text{O}_{10})(\text{OH},\text{F})_2]$ (12.8%) were found. The statistical characteristics of measured compounds is determined and the correlation coefficients between certain compounds are calculated. A significant correlation is observed between quartz with albite ($r=0.65$), clinocllore with dolomite-2 ($r=0.43$), and quartz with dolomite ($r=0.40$).

1 Introduction

The Republic of Tajikistan is located in the global dust belt, on the way of transportation of dust from sources such as the Sahara, drying Aral Sea Aralkum, Kyzyl-Kum and Kairakum, the Iranian deserts Dashti Kabir and Dashti Lut, the Takla-Makan Desert and Gobi. Dust, rising in these deserts, invades the territory of Tajikistan through its southern and western borders in the form of dust haze (DH) or dust storm (DS) [1-3]. Dust storms, defined by wind velocities exceeding 17 m s^{-1} and visibility under 1000 m, occur with great frequency and magnitude in the world's arid and semiarid regions [5-8]. Desert dust, an estimated 500 Tg y^{-1} worldwide [9], is frequently transported over hundreds of kilometers. The most severe dust storms, which can carry fine particles over thousands of kilometers, originate in such great desert regions as the Sahara and Northwest China [10]. The world's major deserts and the surrounding arid and semi-arid lands, where this dust originates, cover $4.33 \times 10^7 \text{ km}^2$ or 36% of the Earth's landmass [11]. In Asia, spring frontal activities in Northeast and North China are the origin of the widespread transport of particles over northern China [12-13].

The problem of atmospheric pollution remains one of the main problems in the modern world, including in Tajikistan. Pollution of atmospheric air is due to the presence of a wide range of chemical compounds and elements in the composition of aerosol deposition associated with emissions of motor vehicles, thermal power plants, utilities and industrial enterprises. Dust storms (dust haze) are an informative source for research and monitoring of pollution of atmospheric deposition, which is related to the determination of the chemical composition of

these compounds in dust aerosols of both natural and technogenic origin and their quantitative analysis.

The relevance of the studies is related to the need to study the mineralogical composition of the dust aerosol, the dynamics of its change during the invasion of dust storms into the territory of Tajikistan.

2 Methods

Quantitative determination of the content of minerals in the dust aerosol during dust storms was carried out using the Bruker D2 PHASER diffractometer. The D2 PHASER is equipped with an integrated personal computer and a monitor for the analysis of polycrystalline samples. The software DIFFRAC.SUITE allows to quickly and easily take measurements and get experimental results. D2 PHASER is successfully used in the field of powder x-ray diffractometer for laboratory research and quality control, for example, rocks and minerals in Geology, as well as in the cement, mining, chemical and pharmaceutical industries.

The selected dust aerosol samples for the period 2007-2015 as a result of the invasion of dust storms at the weather station Ayvaj in southern Tajikistan were investigated on the D2 PHASER.

3 Results

The average values of the mineral content are shown in Fig. 1. For the period 2007-2015, the average values of the following minerals were determined in the dust aerosol composition: quartz SiO_2 (44.3%), calcite CaCO_3 (17%), potassium mica

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$\text{KAl}_2([\text{AlSi}_3\text{O}_{10}](\text{OH},\text{F})_2$ (12.8%), dolomite-2
 $\text{CaMg}(\text{CO}_3)_2$ (8.3%), dolomite $\text{CaOMgO}_2\text{CO}_2$
 (6.1%), albite $\text{NaAlSi}_3\text{O}_8$ (6.0%) and clinochlore
 $(\text{Mg},\text{Al})_6[\text{Si}_{1-2},\text{Al}_{0.9-1},2\text{O}_{10}](\text{OH})_8$ (4.4%)
 (Fig. 1).

Figure 1. Average values of minerals (%) in the composition of the dust haze over the period 2007-2015.

Figure 2 shows the dynamics of changes in the dust haze, high quartz values are observed in 2013 and 2014, and low values in 2007. Calcite has a maximum in 2007 and a minimum in 2008. Dolomite-2 has a maximum in 2011 and a minimum in 2013. Dolomite has the same values, except for the minimum in 2011. Clinochlore has a maximum in 2007 and 2014 (for the soil), with a minimum in 2013. Potassium mica has a maximum in 2008 and a minimum in 2013. Albite has a maximum in 2008 and 2014 (soil samples only) and a minimum in 2009. The dust aerosol contains higher values of quartz, calcite and potassium mica than their content in the soil of Tajikistan (Tab. 1).

Figure 2. Dynamics of changes in mineral content in the composition of the dust samples over the period 2007-2015.

Table 1 shows the statistical characteristics of mineral compounds of dust. Primary minerals are formed in the deep layers of the planet from molten magma. Secondary minerals arise from primary minerals in surface horizons under the influence of various biological and climatic factors. The following minerals are detected in the dust aerosol samples: quartz, potassium mica, albite and secondary minerals: calcite, dolomite-2, dolomite and clinochlore. The statistical characteristics of measured compounds is determined and the correlation coefficients between certain compounds are calculated. A significant correlation is observed between quartz with albite ($r=0.65$); clinochlor with dolomite-2 ($r=0.43$); quartz with dolomite ($r=0.40$). In conclusion it can be noted, that based on the mineralogical composition of dust aerosol, high values of the content of such minerals as quartz (44.3%), calcite (17%) and potassium mica (12.8%) are established.

Table 1. Average, maximum, and minimum mineral content C in percent, in samples of dust aerosol, σ - root-mean-square deviation, δ - standard error, V - variation data.

Minerals, %	Chemical formula	$\langle C \rangle \pm \delta$	$C_{\max}$	$C_{\min}$	σ	V	$\langle C \rangle / C_{\min}$	$\langle C \rangle / C_{\min}$
Quartz	SiO_2	44.35 ± 0.97	48.1	40.5	42.89	5.36	1.10	1.19
Albite	$\text{NaAlSi}_3\text{O}_8$	6.00 ± 0.09	6.9	5.3	0.54	0.07	1.13	1.30
Calcite	CaCO_3	17.05 ± 0.19	21.2	11.1	3.27	2.13	1.54	1.91
Dolomite	$\text{CaOMgO}_2\text{CO}_2$	6.06 ± 0.09	6.3	4.7	0.53	0.07	1.29	1.34
Dolomite-2	$\text{CaMg}(\text{CO}_3)_2$	8.27 ± 0.14	10.8	6.5	1.13	0.14	1.27	1.66
Potassium mica	$\text{KAl}_2([\text{AlSi}_3\text{O}_{10}](\text{OH},\text{F})_2$	12.82 ± 0.17	16.7	10.2	2.14	0.27	1.26	1.64
Clinochlore	$(\text{Mg},\text{Al})_6[\text{Si}_{1-2},\text{Al}_{0.9-1},2\text{O}_{10}](\text{OH})_8$	4.40 ± 0.07	4.8	3.8	0.32	0.04	1.17	1.26

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