Isotopic Composition of Underground and Surface Waters at the Uzbekstan Tyubegatan Potassium Salts Deposit

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Abstract

To prevent water inflows in the mine workings, it is important to estimate the genesis of groundwater and its interaction with surface waters and groundwater of other horizons. At the Tubegatan potassium salts deposit (Uzbekistan), these tasks were solved by monitoring the isotopic composition of groundwater and surface water.

In samples of surface groundwater in the deposit area, the content of deuterium and oxygen-18 was studied. Water samples taken in the mines of the deposit have an isotopic composition typical to surface sources.

It been concluded that the identified brine appearance had a direct hydrodynamic connection with the overlying over-salt aquifers through a system of tectonic disturbances. This fact indicates the danger to the functioning of the mine.

Keywords: potassium salt deposit, isotopic composition of waters, genesis.

Introduction

The construction and operation of tunnels, mines, quarries and other mine workings are often complicated by strong and sometimes catastrophic water inflows. The integrated use of traditional hydrogeological, hydrogeochemical, geophysical methods and isotopy of natural indicators allows one successfully solve the problems of safe operation of mining enterprises.

One of the most promising ways for the application of natural isotopes is evaluation of the genesis of groundwater, the conditions of their supply and interaction with surface waters, as well as the interaction of groundwater from various horizons. The solution of these problems is of great practical importance, in particular, in mine hydrogeology in the study of the supply of groundwater involved in mine and quarry water inflows.

The main purpose of monitoring the isotopic composition of groundwater and surface water at the Tubegatan potassium salt deposit in Uzbekistan was to establish a possible hydrodynamic connection of the brines from the brine occurrence in the exploration production of the Dekhkanabad potash plant (DPP) with surface water and determine their genesis.

Methods

To identify patterns of distribution of hydrogen and oxygen stable isotopes on the territory of the Tubegatan field, samples of surface water (6 samples) and mine water (58 samples) were taken.

The analysis of the isotopic composition of water samples was performed on laser analyzer Picarro L1102-i for hydrogen and oxygen content in water using the method of laser infrared spectroscopy. The allowable discrepancy between two parallel measurements for oxygen-18 was 0.1 ‰ and for deuterium - 0.5 ‰.

The isotopic composition of hydrogen and oxygen is expressed in relative values δ^2H and $\delta^{18}O$:

$\delta = [(Rpr/Rstand)-1] \bullet 1000‰$,

were Rpr and Rstand – ratio of 2H/1H or $^{18}O/^{16}O$ in the measured probe and in the standard, which is taken as the average ocean water (SMOW) (Dubinchuk 1988).

The results of the isotopic composition of hydrogen and oxygen in waters were obtained directly as a "δ" value relative to the standard SMOW (Ferronsky 2009), expressed in mg/L.

The Tyubegatan deposit of potassium salts are confined to the deposits of the Upper Jurassic, which form the core of the anticlinal uplift.

The complexity of the geological structure of the area is due to numerous disjunctive disorders, as well as the presence in the section of powerful reservoirs (limestone, sandstone, fractured and cavernous gypsum anhydrides, etc.). These facts determined the water content of some rocks in the sediments of the Upper Jurassic and Lower Cretaceous.

Numerous aquifers do not have a hydraulic connection between them and are separated by layers of impermeable clays and argillites. This is evidenced by the natural outputs of groundwater at various hypsometric heights. When aquifers are immersed on the wings of the anticline to a considerable depth, groundwater becomes pressurized with difficult water exchange conditions.

The regime of groundwater confined to the aquiferous sediments of the Lower Cretaceous and the Kimeridi layer of the Upper Jurassic depends on the amount and time of atmospheric condensation. The groundwater regime in Callovian-Oxford limestone is not related to the climatic conditions in the area of the deposit and is distinguished by its constancy in time (Maltsev 1965).

At the beginning of 2012, during mountain drift at mine workings of the DPP mine, brine manifestation was disclosed with a flow rate of up to 52 l/s. Promptly carried out measures to suppress the brine manifestation led to the minimization of its flow rate, which in November-December 2012 was 0.2 - 0.3 l/s.

The source of the brine manifestation was revealed in the middle part of the right wall of the excavation and lithologically confined to the interlayer of gray sylvinite occurring in the industrial stratum (Fig. 1).

One of the primary tasks in detecting water manifestation in a potash mine is to determine the genesis of brines. This is the main sign by which the degree of danger to the vital activity of the mine is assessed.

In mining, postsedimentation, condensation and backfilling brines can be developed, which differ in chemical composition and numerical characteristics of the values of ionic ratios of chemical elements.

The chemical composition of all three types of brines is substantially affected by the material composition of the rocks with which they are associated.

Also, the brines contained in the lower part of the section of the super-salt rock can penetrate into the underground mine workings. Mining brine shows that have a

Figure 1 *The brine in the operational development in the direction of the panel number 2.*

hydraulic connection with supersalt waters, for a certain period from the moment of the start of entering the mine workings will practically not differ from the post-sedimentary brines. The dynamics of changes in their chemical composition will depend on the dynamics of water inflows and the volume of accumulated brines.

The complex method for determining the genesis of miner brines, which includes standard chemical analysis and additional determination of the isotopic composition of hydrogen and oxygen of various types of waters of the studied territory, is effective. This leads to a reliable establishment of their relationship with brines.

To identify patterns of distribution of stable isotopes of hydrogen and oxygen on the territory of the Tubegatan field from May 2013 to June 2014, samples of surface water (6 samples) and mine water (58 samples) were taken.

The isotopic composition of hydrogen and oxygen in groundwater and surface waters has no substantial distinctions. Thus, it is not possible to establish isotope ratios for different aquifers. Fig. 2 shows the actual data for the investigated area.

According to the regime observations carried out by the geological service of the DPP, the chemical composition of brines is sodium chloride (unlike the chloride-magnesium composition of brines found in the overlying sediments of surface salt). Substantial changes in the salt composition during the observation period are not found. The contents of easily soluble salts of $CaCl_2$, $MgCl_2$ vary from 3 to 4 g/L ($CaCl_2$) and from 8 to 9 g/L ($MgCl_2$). Constancy of the ratios of (KCl) x 10^4 and NaCl is also noted. In addition, there are minor fluctuations in the amount of salts in the range of 330-370 g/L. The presence of dissolved hydrogen sulfide in groundwater has not been established, the chemical composition is relatively stable and there are no substantial changes.

As a result of the fulfilled work, the intervals of distribution of the deuterium and oxygen-18 contents in natural waters on the territory of the Tyubegatan potassium salt deposit and the conditions for the formation of groundwater (Blinov 2015) were revealed.

Conclusions

Water samples taken from the brine occurrence in the mining site of the DPP, represent the brine formed as a result of the penetration of atmospheric precipitation through the thickness of salt rocks. This conclusion was made because the samples have an isotopic content characteristic to the surface sources.

The detected brine appearance has a direct hydrodynamic connection with the aquifers lying in the suprasalt interval of the section through the system of tectonic disturbances that cut through the strata of rocks overlying the studied industrial formation.

This fact testifies to the threat of safe operation of the mine. The method of comparing the isotopic composition of groundwater and surface water is effective

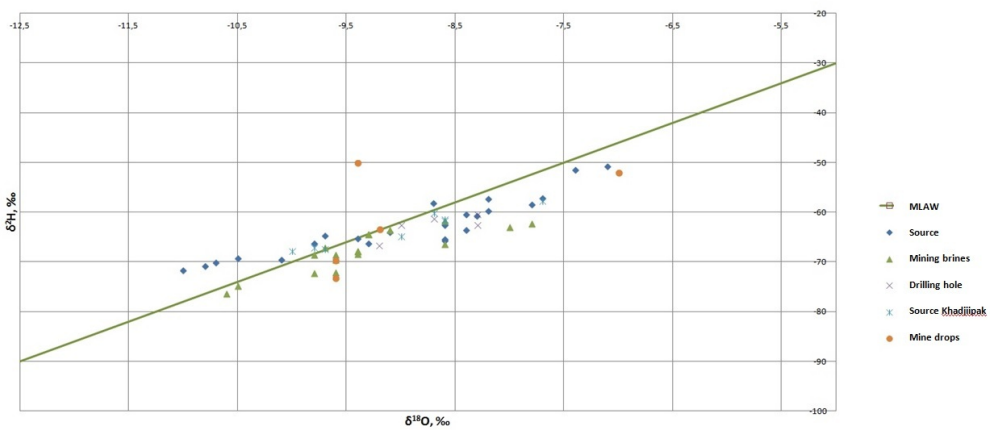

Figure 2 The ratio of stable isotopes δ18O and δD in selected samples.

for predicting catastrophic water inflows in underground mine workings.

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