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F. V. Shestakov

"OBIS" LLP, Almaty, Kazakhstan.
E-mail: feoshestacov@yandex.kz

STEAM CONDENSATION IN THE ATMOSPHERIC MOISTURE AND CONDENSATION PROCESSES IN FRACTURED AND KARST RESERVOIR ROCKS

Abstract. This article reviews the main scientific publications on atmospheric moisture condensation and condensation processes in fractured and karst reservoir rocks. Analysis of the results of experiments and observations showed that the recommendation previously proposed by the scientists on not taking into account condensation component in balance calculation, is untenable and it needs to be clarified and finalized. Experiments and regime observations in the Crimea and other parts of the CIS showed that water of condensation of fractured and karst reservoir rocks can be the most important source of fresh water because of its renewability. Therefore, exploration and development of water of condensation in fractured and karst massifs must be considered one of the important tasks, the solution of which will improve the water supply in many regions of Kazakhstan.

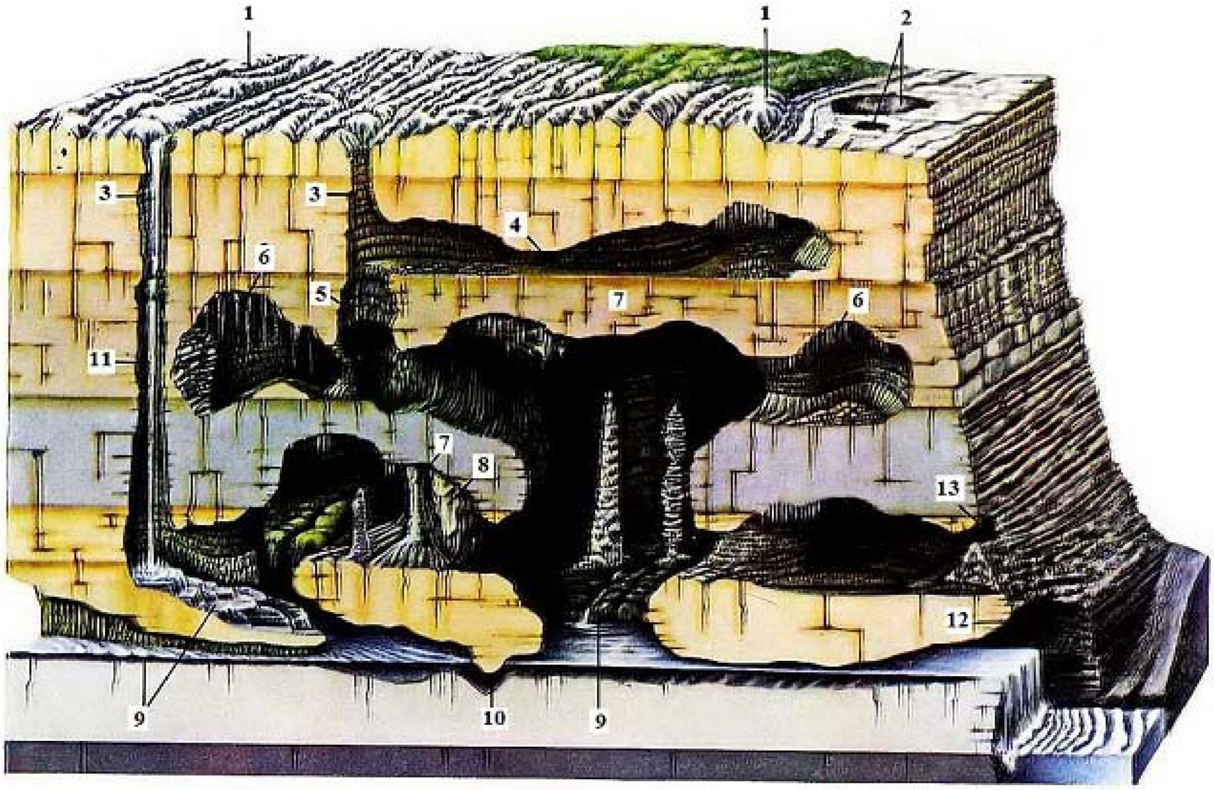
The discovery of the negative impact of water of condensation on the development of karst in frozen rocks makes it possible to solve the ecological problems of these regions in a new way. In the eighties of the last century, after review of the new data on water of condensation in the Institute of Geology of Academy of Sciences of Kazakh SSR, was made a decision to finance the work of this direction; the group of F.V. Shestakov searched for scientific information, created a databank for the steam condensation in fractured and karst reservoir rocks, was made a review with the actual material on steam condensation directly in the Crimea (the Red Cave and other objects). A hydro-speleological group was organized to study water of condensation in the fractured and karst reservoir rocks, which began its work on Uluchur karst plateau in one of the deepest vertical caves of Kazakhstan (260 m deep). The study of the trunk up to eighty meters confirmed the presence of stream water. Although there were no sources of water and even vegetation on the surface of the plateau, streams of water flowed along the trunk, constant drops dripped, the sound of falling water came from the depth of the cave. To conduct research at different altitudes on cliffs were installed devices for measuring humidity, temperature, pressure. Indications from these devices were being taken for a week. However, in connection with the restructuring, the financing of these inte-resting and important works was discontinued.

The study of steam condensation of and condensation processes in fractured and karst reservoir rocks is particularly important for the karst areas of Kazakhstan (Uluchur, Susingen plateau, etc.), where the condensation component of water resources (according to preliminary data of the Institute of Geology of Academy of Sciences of Kazakh SSR) may have a major role.

Keywords: atmospheric moisture condensation and condensation processes, karst, condensation sources, balance formula of Dublyansky, the role of condensation water in the formation of karst cavities, atmospheric moisture condensation - the most important renewable resource of fresh water, condensation of water vapor in frozen rocks, condensation water - renewable resource of fresh water, steam condensation in fractured and karst frozen rocks.

According to the geological postulates of F.P. Savarensky, under the Karst (from Karst (German), after the name of Krasus limestone plateau in Slovenia) - the phenomena associated with the activity of groundwater, expressed in the desalination of soluble rocks (limestones, dolomites, gypsum) and formation of voids (canals, caves) in rocks, often accompanied by failures and subsidence of the back and the formation of funnels, lakes and other depressions on the surface of the Earth" [1].

Karst is characterized by a complex of surface (funnels, karrens, gutters, hollows, caverns, etc.) and underground (karst caves, galleries, cavities, lines) forms of relief. Intermediates between surface and subterranean forms are shallow (up to 20 m) karst wells, natural tunnels, mines or dips. Karst funnels or other elements of surface karst, through which surface waters leave the karst system, are called ponors.



Scheme of karst processes in the mountain massif [2]:
1 - carrens; 2 - funnels; 3 - natural mines and wells; 4 - cave gallery; 5 - vertical cave cavity; 6 - stalactites; 7 - stalagmites and stalagnate (filamentary column); 8 - filigree draperies; 9 - underground watercourses; 10 - siphon; 11 - underground waterfall; 12 - mainsail with a karst source of Fontaine de Vaucluse type; 13 - entrance to the cave system.

Fissured and fissured-karst rocks are widespread everywhere and often occupy huge spaces. The waters confined to them are very diverse, which is closely related to the conditions of their formation and the time of their contact with the water-bearing rocks.

Karst waters are underground waters forming, lying or moving in cracks and karst rocks, formed with the inevitable participation of dissolution processes.

Usually, leaving in karstic cavities, water accumulates deep under the ground. Very often it serves as a source of water supply.

For example, the water supply of Crimea resort is almost entirely dependent on karst water.

Finally, without karst, there would not have been many mineral springs of Czechoslovakia, Hungary, the USA and our "Borjomi, Narzan and Essentuki".

For the development of karst is not enough only soluble rock and water. If it is dense, without cracks, limestone or even gypsum is poured by water, it can stand for hundreds of years, turn into a saturated solution, but will not create karst forms. For the growth of funnels and caves, it is necessary that the rock has pores or cracks along which water would carry away the dissolution products. Passing through the cracks, the water not only dissolves, but also erodes the rock, accelerating the growth of cracks and voids, preparing conditions for failures and extensive underground passages.

Industrial enterprises of Kazakhstan, the Urals, most of Leningrad and many other cities use karst waters. However, wherever cooking and other salts are being quarreled, the water is unsuitable for either technique or for everyday life. So, in Western Yakutia, artesian water is not water, but brine.

Until recently, it was believed that in the formation and feeding of fissured-karst waters, mainly infiltration waters [3] take part, and the possibility of their condensation feeding in balance calculations was not taken into account.

It has now become clear that the accumulation of empirical material has led researchers to critically reconsider their attitude to the old paradigm. It turned out that the solid of the Earth is corroded not only by rainwater and running water penetrating deep into it, but also by the so-called condensation moisture. In underground voids, this moisture is rapidly saturated with carbon dioxide and becomes even more active solvent of carbonate rocks than water seeping from above; there is reason to believe that condensation moisture is ten times more active. But in fact, perhaps, in all over the world you will not find a cave, where there would be no condensation moisture. For example, T.I. Ustinova painstakingly calculated that in the summer in the cave cavities of the Crimea for each cubic meter of emptiness there is at least half a liter of condensation water. Subsequent researchers have proved that this figure can be significantly increased.

It all began with a thorough study of the agrophysicist A.F. Lebedev, who found that "pumping" through the pores and cracks in the rocks of a large amount of air is not necessary for condensation. Water vapor moves independently from areas with large to regions with a smaller partial pressure of water vapor and air temperature. From this it follows that in a warm period condensation is theoretically possible in fractured rocks and karstic cavities, and in cold period - evaporation (figure 1) [4].

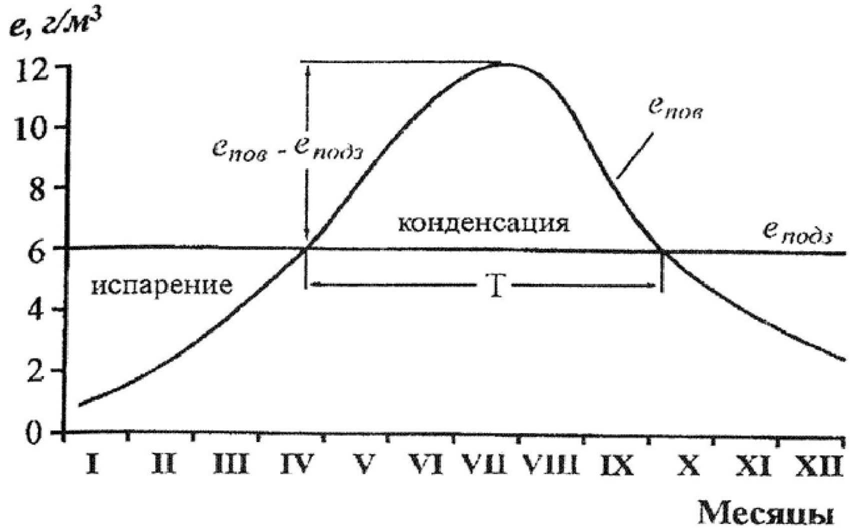


Рисунок 1 – Ход абсолютной влажности (мм рт. ст.) на поверхности ($e_{пов}$) и под землей, в нейтральной зоне карстовых полостей ($e_{подз}$). Т – продолжительность конденсации, сут; ($e_{пов}$ – $e_{подз}$) – градиент абсолютной влажности воздуха, мм рт. ст.

Figure 1 – Line of absolute humidity (mm of mercury) on the surface (e_{surf}) and underwater, in neutral zone of caverns (e_{undgr}). T – condensation duration, days (e_{surf} – e_{undgr}) – absolute air humidity, mm of mercury

For the period from 1869 to 1987 about 1000 scientific articles have been published on the problem of condensation of atmospheric moisture [5]. To date the number of publications has increased significantly.

10% of the researchers consider that condensation of atmospheric moisture under the ground is impossible, 30% believe that the condensation of the warm period is compensated by the evaporation of the cold period and its role in the water balance is negligible, 50% assigns some role to it in the water balance, but abstains from quantitative estimates and only 10% recognize its significant hydrogeological significance.

In modern reference and methodological literature it is noted that *"in connection with the complexity and laboriousness of quantitative determination of condensation in balance studies, it is not yet expedient to take it into account"* [6, p.120]; *"due to practical difficulties of definition, condensation is conditionally taken into account along with precipitation and evaporation"* [7, p. 89] and others.