International Journal of Geology, Earth & Environmental Sciences ISSN: 2277-2081
An Open Access, Online International Journal Available at http://www.cibtech.org/jgee.htm
2025 Vol. 15, pp. 77-83/Begimkulov et al.,
Research Article

ASPECTS OF THE MODEL OF HELIUM MIGRATION IN A LAYERED SYSTEM AT THE TASHKENT GEODYNAMIC LANDFILL

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ABSTRACT
The article is devoted to the study of changes in the concentration of helium in groundwater. A model of helium migration in a layered system is constructed, where it is noted that the formation of helium anomalies is different in areas with a predominant distribution of fractured-vein groundwater and in conditions of storied aquifers. When the concentration of helium in the lower layer is up to 1 ml/l (concentration gradient is 2·10-2 ml/l), anomalies with a helium content of up to 10·10-3 ml/l are formed within blocks where discharge from the underlying horizon is at least 20% of the total flow. In this case, anomalies are recorded only in the lower part of the layer (0.2-0.5 power).

Keywords: *Helium Concentrations, Helium Migration, Fluids, Helium Anomalies, Hydrogeology, Hydrogeoseismology, Intensive Nutrition, Artesian Basin, Hydrogeological Floors*

INTRODUCTION

Currently, there is no reliable model that quantifies the migration of helium in the Earth's crust. In addition, the problems of the formation of the gas composition in groundwater have been and remain relevant. Research on changes in the concentration of helium in groundwater responsible for the formation of anomalies remains an urgent task of hydrogeology and hydrogeoseismology at the present stage. Modern concepts of helium migration are based on its transfer in a dissolved state by a phase carrier – groundwater, and other fluids. In most cases, the convective and often only diffusive mechanism of helium migration in the Earth's crust is considered. However, numerous studies conducted on the territory of the Pritashkent geodynamic polygon have made it possible to establish the existence of contrasting helium anomalies in the Cretaceous sediments, which is confirmed by previous studies (Bulashevich and, Bashorin, 1971); Borodzich *et al.,* 1980; Borodzich *et al.* 1978; Valyaev *et al.*, 1977; Vasilikhin, 1982; Yanitskiy and Pimenov, 1976). The predominance of the convective mechanism over the diffusive one, or a combination of convective and diffusive forms of helium transport, seems more reliable. V.S.Golubev et al. The co-authors (Golubev *et al.,* 1974) carried out work on the analysis of models of helium migration in the lithosphere, however, they were conducted essentially without taking into account the influence of groundwater dynamics, although the authors noted in their conclusions that «... in the conditions of sedimentary strata, the distribution of helium is complicated by a multilayer filtration medium, where the cross-section is influenced by the transverse flow of artesian waters, a change in sorption rock capacity, the presence of hydrocarbons, the difference in the permeability of the layers». In addition, Vsevolozhsky [1983] considers a model of helium migration in various hydrogeological floors and various geofiltration media based on the scheme of hydrodynamic zonation of the basin.

Thus, the purpose of this article is to study the formation of helium anomalies in the presence of a thick cover of sedimentary deposits. To achieve this goal, it is necessary to perform the task of analyzing and generalizing ideas about the migration of helium in the conditions of the natural regime of the aquifer. This condition, in turn, complicates the study of helium migration due to the heterogeneity of the section. A fundamentally high-quality model of the helium distribution in the section in structures such as artesian basins platforms can be considered based on the characteristics of the dynamics of groundwater at different levels of the section and patterns of formation of groundwater flow. As is known, the formation of helium anomalies is significantly different in areas with a predominant distribution of fractured-vein groundwater and in areas where the crystalline basement reaches the daytime surface. Under these conditions, the position of the anomalies will be determined by the presence of deep permeable discontinuities with an open fluid-conducting system, through which upward movement with a high degree of helium saturation is possible and rigid (impermeable) basement rock blocks are characterized by minimal (background) helium concentrations [Zakirov *et al.*, 2018a; Zakirov *et al.*, 2018b; Zakirov, 2015; and Zakirov *et al.*, 2017]. In some conditions, abnormal helium values are observed, confined to the most permeable areas of zones or weakened fault zones. The contrast of helium anomalies is very high and can reach several orders of magnitude at a relatively short distance [Valyaev *et al.*, 1977, Zakirov *et al.*, 2018; Zakirov *et al.*, 2017].

DISCUSSION OF THE RESULTS

The distribution of helium in the Pritashkent Artesian basin is mainly related to the structural and tectonic situation, the presence of groundwater, and the permeability of the sedimentary stratum of the vertical geological section.

In accordance with the hydrogeological zoning of the territory of the Republic of Uzbekistan, the eastern – mountain-folded and western – platform regions are distinguished [Golubev *et al.*, 1974, Sultankhodzhaev *et al.*, 1983]. The plain-platform area is characterized by the development of large artesian basins separated by structural uplifts of the Paleozoic basement and accumulating runoff from mountainous areas. It is dominated by pressurized aquifers associated with Cretaceous and Jurassic age sediments. In artesian basins, such properties as water availability, quality, quantity, nature and depth of groundwater circulation are characterized by the hypsometric position of the feeding and unloading areas, as well as the depth of immersion of aquifers. As can be seen from the above, the main hydrogeological features of the territory of the republic are determined by its geological and structural position. This allows us to base the hydrogeological zoning on the geological and structural principle and schematically identify three structural and hydrogeological floors representing large structural and hydrogeological elements of the section, each of which is divided into aquifers and horizons [Tulyaganov, 1971].

The lower structural and hydrogeological floor is associated with rocky, highly metamorphosed and significantly dislocated sedimentary and igneous rocks of the Paleozoic, with which fractured, fractured-vein, and less often fractured-karst waters are associated.

The middle structural and hydrogeological floor is formed by less dislocated and slightly metamorphosed aquifer complexes of the Jurassic, Cretaceous, Paleogene and Neogene. The groundwater associated with them is characterized by slow motion. The mineralization of groundwater varies from fresh in the feeding areas to salty in the central part of the basin. The exception is the aquifer confined to the Cretaceous sediments of the Cenomanian stage.

The upper structural and hydrogeological floor is composed of aquifer complexes of loose-block quaternary sediments characterized by active water exchange. From the point of view of the formation of the helium field, in the lower structural and hydrogeological floor of the basin, where local flows are formed that are closely related to the structural background and fault zones of the basement, the distribution of helium will differ slightly from its distribution in the underlying crystalline rocks. This is especially true in conditions with the spread of fractured water-bearing rocks, where movement is largely carried out through zones of cracks and tectonic disturbances. Thus, the distribution of helium in the groundwater of the lower hydrogeological floor practically corresponds to its distribution in the underlying basement rocks.

From the point of view of groundwater formation in the second floor, the conditions for the distribution of helium in the supply and discharge areas of groundwater will be fundamentally different. Thus, within the first zone (marginal feeding area), the updrafts should be "suppressed" by the prevailing filtration and downward movement of groundwater. Detection of elevated helium concentrations here is unlikely. The second zone (the marginal discharge area) is characterized by a sharp reduction in lateral (reservoir) flow rates with a corresponding increase in water exchange periods. The main type of movement here is the difficult vertical discharge of groundwater into the aquifers of the upper floor of the basin. Based on this, the marginal discharge area should be characterized by an increased value of the helium field density, the value of which in each case will depend on the intensity of vertical discharge of groundwater and the helium saturation of the lower horizons of the section.

1. It follows from this that it is in the upper hydrodynamic zone that the deep helium flow should be dispersed and redistributed in the layered system. Based on the understanding of media, it can be assumed that these processes occur most intensively in areas where the upper part of the section of the zone of intensive water exchange is represented by non-fractured rocks in which there is no movement through zones of permeable discontinuous faults. The study of the patterns of formation of the helium field in the zone of intensive water exchange is considered on the basis of the hydrogeological model of helium migration for the conditions of the upper part of the section of the Tashkent Artesian basin. They have been fairly well studied hydrogeologically (Burak, 1968; Tulyaganov, 1971, Zakirov *et al.*, 2018; Mavlyanov *et al.*, 1973; Polyak *et al.*, 1990; Sultankhodzhaev *et al.* 1983; Yusupov, 2017) and form the basis of the primary material for the model of helium migration under specific conditions (fig.1).

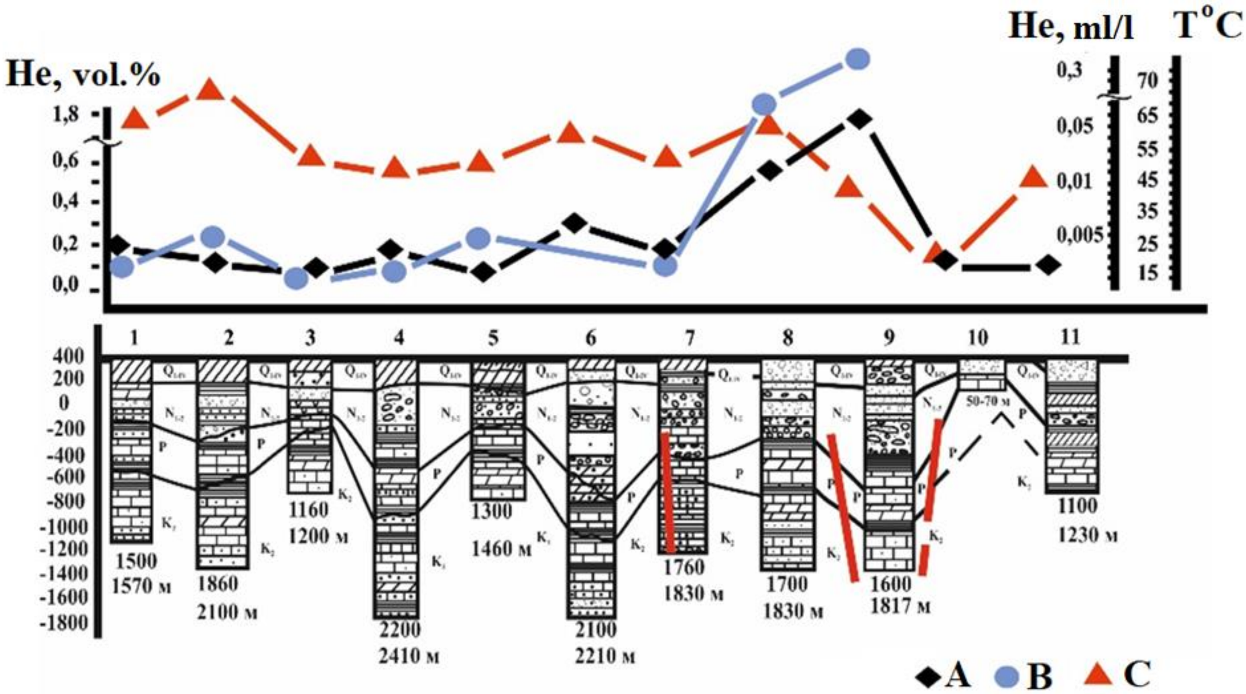

Fig. 1. Change of helium concentration in the direction of san. Yangiyul–san. Chatkal. *A is the concentration of helium, vol.%, B is the concentration of helium, mg/l, C is the temperature; 1 is sle. Yangiyul, 2nd square. Zangi-ota, 3rd sq. Nazarbayev, 4th sq. Textile, 5th floor. Chinabad, 6th sq. Internal combustion Engine (Toshshaharnur), 7 square meters. Semashko, 8 – Institute of Vegetable and Melon Crops (IBC), 9 – sq.m. Ulugbek, 10th sq. Ozodbosh, 11th sq. Chatkal.*

In vertical sections (Fig. 2), compiled from data from deep wells of the Pritashkentsky artesian basin by (Zakirov, 2018; Yusupov *et al.*, 2016) the following hydrogeological units are distinguished from top to bottom: groundwater horizons (depth of 2-5 m); the first dividing layer with a thickness from 30 to 90 m, represented by quaternary sediments distributed within undulating, sloping, flat foothill plains, confined to numerous tributaries of rivers. In addition, gravel-pebble, loess-like sandy loams, and loams of Quaternary sediments composing the vast Pritashkent plain are observed. The surface sediments are characterized by a filtration coefficient from 0.01-22 to 30-50 m/day or more. The water permeability of the sediments of the central parts is extremely negligible: the filtration coefficient of cover loams does not exceed 0.3-0.7 m/day, fine-grained sands - 0.009–0.09 m/day.

The aquifer complex of Neogene sediments (N) (fig. 1,2) is represented by a stratum of continental, mainly red-colored, marl and siltstone clays, siltstones, marls and subordinate sandstones, sands and conglomerates. They are characterized by facies variability and inconstancy of the lithological composition. Aquifers of sands, sandstones, gravellites, and conglomerates often wedge out. The territory of the Hungry Steppe is dominated by clays and siltstones, accounting for 80% of the section. Their power reaches 220 m. Sands, sandstones, and conglomerates are of subordinate importance. Neogene freshwater with a dense residue of up to 0.5 g/l is widely developed in the Chirchik-Akhangaran basin and the Hungry Steppe. This phenomenon suggests that these waters are sedimentary and their formation occurred due to the infiltration of flood waters in place, simultaneously with the formation of horizons of sand and pebbles, and not due to inflows from the feeding area. Such conditions could have developed in the presence of very small slopes – on the order of 0.0001-0.0002, which ensured a wide overflow of flood waters from the Akhangaran, Chirchik, Amu Darya and Syr Darya rivers.

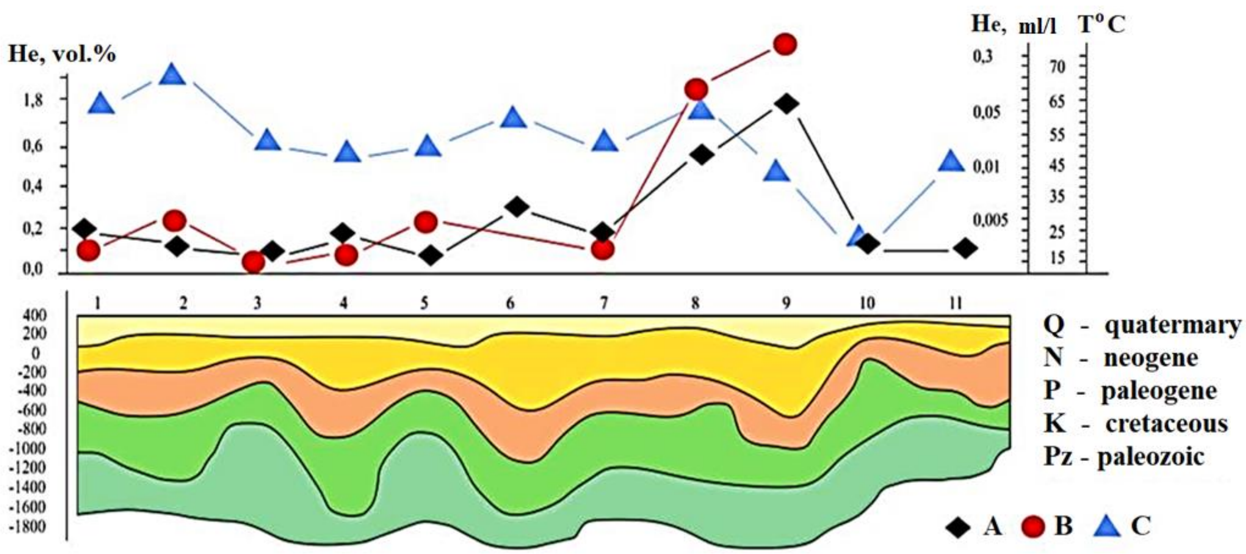

Fig. 2. Diagram of the geological basis of the helium migration model: A –concentration of helium, vol.%; B – temperature; C – concentration of helium, ml/l.

The third aquifer [8] consists of: -an aquifer of Middle Eocene sediments distributed in the Chirchik River basin and the northern part of the Hungry Steppe, and characterized by the development of calcareous sandstones and limestones in the upper part, and quartz sands and sandstones in the lower part of the section. Their capacity ranges from 10-12 m within the city of Tashkent, up to 98 m in the area of villages. May morning. They are weakly permeable and are characterized by low well productivity. Filtration coefficient from 0.06 to 6 m/day; - an aquifer of Lower Eocene sediments, common only in the Akhangaran valley, represented by quartz sands with a thickness of 34 to 67 m. In the rest of the basin, it is represented by green clays and siltstones up to 48 m thick; -the Eocene water-resistant horizon, represented by mottled (red, green, gray, lilac) clays, siltstones with subordinate interlayers of marls, sandstones and polymorphic limestones of the Danish stage, and in areas where deposits of the Danish There are no tiers, the limestones of the Bukhara and green clays of the Suzak layers. The total capacity is up to 100 m.

The aquifer complex [8,19,21] of Cretaceous sediments is represented by the Senonsky, Senomansky, and

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water-bearing horizons of the Lower Turonian. The latter is represented by green and pink clays (up to 80 m thick), which is a regional water barrier separating the Senomana and Senon Turona aquifers. They are widespread in the northwestern part of the basin, occupying the valley of the Chirchik River and the lower reaches of the Akhangaran River. On the left bank of the Syrdarya River, in the Hungry Steppe, Cretaceous deposits wedge out along the foot of the Chatkal Range, on the denudated surface of Paleozoic rocks. On the territory of the village of Kaplanbek, the Cenomanian lies at a depth of 813 m and up to 2080 m in Tashkent. The deepest occurrence is assumed to be in the axial part of the Chirchik depression of S. A. Yassaviy, where only Neogene deposits have been uncovered to a depth of 2200 m. The water-bearing sediments are conglomerates, coarse-grained gravel, sandstones based on calcareous cement, red-colored siltstones, dark brown and purple-red clays, and sometimes lenses of sandy limestones. The flow rate of wells ranges from 5 to 30 liters/sec at decreases from 5 to 170 m. The specific flow rates range from 0.03 to 1.0 liters/sec, which indicates a relatively low water availability of the complex. The low yield of water-bearing rocks (50-60 km2) and loess-loamy cover on them allows us to consider these areas as the main feeding area for Cenomanian aquifers. In addition, fractured waters of the underlying Paleozoic rocks are partly the main source of nutrition for these horizons.

Below lies an aquifer complex of Jurassic sediments. They are represented by continental sediments, which are divided into two formations: the upper kaolin and the lower coal-bearing. Information on water availability is available only in the area of the Akhangaran coal deposit, north of Tashkent at the Poltoratskaya structure (at a depth of 1,180 m). The flow rate of self-draining water at an excess pressure of 5.2 m (above the ground) is 0.0007 l/sec, the rock filtration coefficient is 0.28–0.3 m/day. The groundwater of the Paleozoic fractured zone was exposed by a narrow strip of Devonian limestones of the Havatag structure of the southern part of the basin at a depth of two wells 131-1321 and 1183-1384 m (fractured, thermal waters were exposed). The Paleozoic forms the bed of the basin and is represented by Upper Paleozoic effusive rocks. In this regard, the study of the solar potential of the aquifers of the Republic of Uzbekistan is carried out in a test mode. The study of the solar velocity of all horizons has not been carried out under real conditions, therefore, the formulation of tasks is of a test nature and contains some assumptions. The main task is to study the distribution of helium from the Cenomanian aquifer complex at a known concentration.

The solution of the problem is based on the application of the theory of mass transfer in hydrogeological calculations. The issues of using the theory of mass and heat transfer to study the processes of groundwater pollution, underground burial of industrial waste were considered by K.E. Pisheva [1972], the formulation of a test problem for studying the formation of a chemical flow of groundwater was carried out by S.S.Yuupov and Zakirov with co-authors [2015, 2018, 2017] Sultankhodzhaev *et al.*, [1983].

The helium migration model is performed in two stages: 1) construction of a hydrodynamic grid of the Cenomanian aquifer; 2) study of the distribution of helium concentration in it.

To study the flow balance of the Cenomanian aquifer and build its hydrodynamic grid, the entire horizon is divided into 4 zones with boundaries passing through feeding areas (watersheds) and discharge zones (divided relief, sections of river valleys). The zones are divided into 19 blocks, characterized by relatively homogeneous filtration properties. The division into blocks was carried out in such a way that the center of the blocks coincides with the centers of the exploration wells from which the filtration properties of the rocks were determined. The balance of water flows to each block is represented as the sum of inflows and outflows from neighboring blocks.

The first two blocks of the first zone (the feeding area) are characterized by the predominance of downward discharge from the upper aquifer complex, and there is no influx of helium into the reservoir in this area. In the third block (transit zone), the amount of supply from below from the Paleozoic horizon is 0.6% of the total supply, and there is also no helium supply to the reservoir. In the fourth block, the amount of power from below increases to 8%, while anomalies with a helium content begin to form in the bottom layer. 0,0-4,0·10-3 ml/l, which is 0.2-0.4% of the helium concentration in the Paleozoic horizon. Groundwater is discharged within the fifth block, the amount of supply from below increases to 17% of the total flow rate, and the helium content in the bottom of the horizon increases to 10·10-2 ml/l (1%) of the concentration in the Upper Cretaceous horizonThe anomaly forms within the entire thickness of the layer.

In the second zone, the power supply from below ranges from 12 to 22% of the total power supply of each of the three units. In this area, a helium anomaly of up to 10·10-3 ml/l is formed within 0.5 of the aquifer capacity.

In the third zone, the inflow from below in each of the blocks, starting from the supply area, is 28, 22, 20 and 24%, respectively, while within 0.6-0.8% of the reservoir capacity, a "stretched" zone with a helium content of 2.0·10-3 to 10·10-3 ml/l is formed. In the discharge area (the 5th block of the third zone and the first block of the 4th zone), anomalies cover the entire reservoir capacity. The fourth is characterized by significant changes in the concentration of helium in the Cenomanian aquifer. Thus, in areas where the amount of supply from below reaches 90% of the total supply (block 6), an anomaly forms within the entire reservoir capacity with a helium content from 2.0·10-3 to 2.2·10-2 ml/l. In areas where a significant proportion of the total balance is supplied from above (up to 90%), the helium anomaly practically does not form (2nd, 4th blocks) of the fourth zone. The site under consideration represents the area of regional groundwater discharge of the 2nd hydrogeological floor and is characterized by significant heterogeneity of the helium field with its variation within the reservoir from 2.0·10-3 to 2.2·10-2 ml/l.

Conclusions. The analysis and generalization of literary sources have established the prevalence of helium gas, which has characteristic peculiar physico-geochemical properties on Earth. Based on the results of the generalization of regime observations over a period of more than 40 years, a relationship has been established with the theory of helium velocity and the manifestation of helium anomalies in the aquifers of the Pritashkentsky Artesian basin.

Migration routes in the Earth's crust and the facts of the manifestation of high-contrast helium anomalies in the sedimentary rocks have been established.

A model of helium migration in a layered system is constructed, where it is noted that the formation of helium anomalies is different in areas with a predominant distribution of fractured-vein groundwater and in conditions of storied aquifers.

The formation of helium anomalies was revealed in the layered section under the conditions of the natural regime of groundwater in the absence of permeable zones of tectonic disturbances. According to the compiled model of helium migration, the intensity is determined by the amount of upward pressure filtration through weakly permeable layers (overflow). When the concentration of helium in the lower layer is up to 1 ml/l (concentration gradient 2·10-2 ml/l), anomalies with a helium content of up to 10·10-3 ml/l are formed within blocks where discharge from the underlying horizon is at least 20% of the total flow. In this case, anomalies are recorded only in the lower part of the layer (0.2-0.5 power). In areas of intensive groundwater supply from the upper horizons (up to 90% or more of the total flow), helium anomalies are practically absent.

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