Features of the distribution of molecular hydrogen in groundwater in various geological and tectonic conditions of Uzbekistan

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Abstract. As a result of generalization and analysis of previously performed work on the determination of hydrogen on the day surface, a picture of the distribution of hydrogen concentration in the aeration zone was obtained. The increased concentration of hydrogen on the day surface and in the aeration zone is associated with the most favourable conditions for the transit of fluids from the folded Palaeozoic basement to the surface cover (upper part of the Earth's crust). These zones are zones of active fluid conductivity, which leads to a high concentration of hydrogen on the day surface. Intense linear anomalies are confined to the zone of intersection of the Tuzkoy-Rometan transverse fault with the Bukhara-Gissar regional fault, with which seismic events are associated (epicentres Gazli earthquakes occurred 08.04.1976, 17.05.1976 and 19.03.1984). Analysis of long-term observations of gas composition on an example of molecular hydrogen in groundwater southwestern part Karzhauntaus fault, covering the territory of Tashkent city and its surroundings, obtained hydrogen concentration distribution pattern area. A different concentration of hydrogen in the fault zone was revealed, associated with the heterogeneity of the geological and structural structure.

1. Introduction

The development of scientific research in the search for earthquake precursors is characterized by the widespread use of various methods. Along with the traditional methods of studying earthquakes (seismological, geophysical, deformation, etc.), a promising hydrogeoseismological method is currently used. This method is based on the study of the regularities of changes in the hydrogeodynamic and hydrogeothermal parameters of groundwater (such as groundwater level, flow rate, pressure, temperature). In addition, this method studies changes in: 1) the content of gases in groundwater (hydrogen, helium, carbon, oxygen, nitrogen, carbon dioxide, etc.); 2) radioactive elements (in particular radon); 3) macrocomponent composition (chlorine, hydrocarbontes, sulfates, sodium, calcium, magnesium, etc.), as well as indicators of pH, Eh and isotopic composition. As studies have shown, these changes occur in periods preceding earthquakes, and their essence and intensity of manifestation are due to the high intensity of geodynamic processes during the preparation of earthquakes. These processes are manifested, in particular, by the formation of cracks and microcracks, a change in pore pressure in a water-saturated medium under the action of elastic stresses. Due to the possibility of
operational tracking of the complex of precursors that supply information from the depths, the hydrogeoseismological method is the most promising at the present stage.

2. Study area

From a scientific point of view, observations of changes in the content of molecular hydrogen on the surface, as a precursor to earthquakes, are of the greatest interest. To study the deep flow of hydrogen along the rupture structures in the Gazli area, one of the subdivisions of the State Committee for Geology carried out measurements of hydrogen on the surface [1]. The measurements obtained differentiated pattern of distribution of hydrogen concentration in the aeration zone, set the hydrogen concentration of 90-64690 c.u. (conventional units). The concentration value at each point is shown in Figure 1.

In the eastern part of Gazli, while hydrogen rheoles have a linear character and a submeridional direction, the hydrogen concentration varies from 1671 to 9000 c.u. In the middle of the east and north portion identified local zones of high hydrogen concentration from 13365, 58520 to 64890 c.u, which is associated with the intersection of a given territory. Sublatitudinal (Bukhara- Gissar, Ashikuduk, North Shorkuduk, Karakyr; Gazli) and meridional (Rometan) fault zones.

![Figure 1. Areoles of areal hydrogen imaging on the Earth's surface in the Gazli region at the intersection of both sublatitudinal (Bukhara-Gissar, Ashikuduk, North Shorkuduk, Karakyr; Gazli) and submeridional (Rometan) zones of the fault (made by RK Umurzakov on the base of materials of Perevozchikov G.V., Borisova B.A., Rogozhin E.A., 1986). 1 – field hydrogen concentration in n10^3 c.u.; 2 – oil and gas deposits; 3 – point observations and the value of the hydrogen concentration in c.u.; regional faults: A-A Bukhara-Gissar, B-B South-Gissar; local faults: 1-1 Ashikuduk, 2-2 North Shorkuduk, 3-3 Karakyr; longitudinal, 4-4 Gazli, transverse faults, 5-5 Tuzkoy, 6-6 Rometan; Epicenters of Gazli earthquakes: Z1 - 19.03.1984, W2 - 17.05.1976, W3 - 08.04.1976.](image)

A local anomalous manifestation of hydrogen (with a concentration of 7560-53550 conventional units), confined to an active tectonic zone, was established near the village of Gazli.
North of Gazli settlement observed two linearly elongated halo hydrogen sublatitudinal: first – with a concentration of 270-900 c.u. (in the zone of Bukhara-Gissar deep fault) which coincides with the South Tien-Shan seismogenic zone confined there to the epicenters of Gazli earthquakes that occurred on 08.04.1976, 05.17.1976 and 03.19.1984. Changes in the conjugate-deformed state of the medium under the action of tectonic forces may lead to a change in migration paths in the deep hydrogen that reflect changes in concentration of H₂ in subsoil gas fault zones. It is possible that an abnormal signal in the dynamics of hydrogen subsurface field indicate intensity deformations arising in the fault.

On the other hand, when geomechanically stresses are growing up during preparation of strong earthquakes, migration of fluids in the zones of deep faults along planes schistose rocks, may also result in the increase of fluid mass transfer from depths and pulsed release of hydrogen in the atmosphere – a sphere in areas of active faults; the second – with a concentration 540-1800 c.u., which is observed in the zone Ashikuduk and North Shorkuduk faults.

The western part of research area, hydrogen areoles have a polygonal form, elongated from north to south and its concentration varies from 315 to 7560 c.u. which is associated with the intersection of sublatitudinal (Bukhara-Gissar, Ashikuduk, North Shorkuduk, Karakyr; Gazli) and meridional (Tuzkoy) fracture zones.

3. Distribution of molecular hydrogen (H₂).

In groundwater of the Pskem-Tashkent seismogenic zone, the content of molecular hydrogen is measured in hundredths fractions of a percent. Based on the available geological, tectonic, hydrogeological and hydrogeochemical data [2, 3], a map of the distribution of average annual values of molecular hydrogen (H₂n x 10⁻⁴) (Figure 2) was compiled and the following blocks, bounded by tectonic faults, characterized by different values molecular hydrogen:
1) Eastern block: well. Chernyaevka, Schroeder, Ulugbek, Chinabad – from 0.0016 to 0.0078 vol.%,
2) Western block: well. IBK, Fozilova, Tashminvody, Keles – from 0.0005 to 0.0135 vol. %,
3) Southern block: well. Tekstil, Bii, Botanika, Pobedy, DVS – from 0.0007% to 0.0012 vol. %.

![Figure 2](image-url)  
Figure 2. Map of the distribution of average long-term values of molecular hydrogen in groundwater of the Tashkent geodynamic test site: a – line of tectonic faults, b – isolines of molecular hydrogen in vol.%, c – the value of molecular hydrogen, d – observation points and their numbers: 2 – Victory
In the eastern part of Tashkent, areoles of molecular hydrogen have a submeridional direction along the Karzhantau fault, the concentration of which varies from 0.0016 vol.% (Schroeder) to 0.0078 vol.% (Chernyaevka), to a submeridional fault crossing the Karzhantau regional fault, limited from the western part of the study area. Groundwater on the territory of the Institute. Schroeder at a depth of 1240-2340m. Cretaceous age, in the thickness of interbedded sandstones, gravelstones, shales and clays, hydrocarbonate-sodium chloride waters with a salinity of 0.6-0.7 g/l were exposed.

In the western part of the study area, a local anomalous manifestation of hydrogen in the submeridional direction was established along the continuation of the Karzhantau fault, the concentration of which varies from 0.0005 vol.% (Keles) to 0.0135 vol.% (Fozilova), confined to the tectonic zone. Lower Cretaceous groundwaters exposed at the Fozilova well in the interval of 2241-2293 m. in sandstones with fragments of effusive rocks. Water with a mineralization of 15.7 g/l, the chemical composition is sodium chloride and hydrocarbonate-sulphate-sodium (Keles).

In the southern part of the study area, the shape of hydrogen halos becomes linear, elongated from northeast to southwest, and its concentration varies from 0.0007 vol. % (BII) to 0.0012 vol.% (Textile), along the right bank of the river Chirchik to the southern border of the Karzhantau fault (Figure 2). Underground waters of chalk deposits at depths of 1700-2210m have a mineralization from 0.59 to 1.5 g/l, the chemical composition of hydrocarbonate-sodium and with chloride water (Textile, Botanika).

As a result of generalization and analysis of previously performed work on the determination of hydrogen on the surface, a picture of the distribution of hydrogen concentration in the aeration zone was obtained. The increased concentration of hydrogen on the surface and in the aeration zone is associated with the most favorable conditions for the transit of fluids from the folded Paleozoic basement to the surface cover (upper part of the Earth's crust). These zones are zones of active fluid conductivity, which leads to a high concentration of hydrogen on the surface.

4. Conclusions

Thus, the following conclusions can be drawn from the material presented:
- areal anomalies of hydrogen content is caused by complex nodes of intersection of faults of different directions. Intensive linear anomalies are confined to the zone of intersection Tuzkoy-Rometanskogo cross fault with the Bukhara-Gissar regional faults, which is associated with seismic events (epicenters of Gazli earthquakes);
- the increased concentration of hydrogen on the surface and in the aeration zone is associated with the most favorable conditions for the transit of fluids from the folded Paleozoic basement to the surface cover (upper part of the Earth's crust). These zones are zones of active fluid conductivity, which leads to a high concentration of hydrogen on the surface;
- observation of changes in hydrogen concentration can be used for monitoring, as a harbinger of earthquakes, as well as for detecting seismically active faults;
- hydrogen concentration in tectonic blocks associated with non-identical geological structures and lithological features of water-bearing rocks - vary from 0.0005 to 0.0135 vol.% (Figure 2);
- the high concentration of hydrogen in groundwater in some areas is explained by the presence of zones of active fluid conductivity, i.e., uncovered (crushed) zones through which hydrogen freely reaches the upper layers of the hydrosphere.

5. References

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