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The Impact of Regional Geological Factors on Prevalence of Type 2 Diabetes

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Abstract

The inter relation of type 2 diabetes with regional geological conditions in the Republic of Bashkortostan (region in middle part of the Russian Federation) is considered. A broad diversity of geological structures (platform, foredeep, folded region) and rocks (sedimentary, magmatic, metamorphic rocks of different composition, structure and age) on the territory of Bashkortostan determines the diversity of regional characteristics of biosphere microelement profile, thus making this region a unique scientific testing ground for the study of medical and biological role of geological factors. The disease prevalence was evaluated according to the diabetes register for the 2010–2014. Mapping of the diabetes prevalence was made using ArcGIS 10.2 computer program. 45 trace element (Be, Sc, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Br, Rb, Sr, Y, Zr, Nb, Mo, Cd, Sn, I, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, W, Tl, Pb, Bi, Th, U) composition of soils in different areas of the country was analyzed using ICP-MS method (mass spectrometry with inductively coupled plasma) in 1042 soil samples. The consistency of the regional geological conditions with the features of the elemental composition of the region and the diabetes prevalence is established. Three clusters of districts were distinguished within the republic, of which the western one was characterized by higher diabetes prevalence compared to the northern and Uralian clusters. Relatively lower diabetes prevalence within the northern cluster is associated with the presence of limestones, which are characterized by high availability of minerals contained in them and high concentration of calcium and magnium. The Uralian cluster with lower diabetes prevalence is characterized by high concentration of tectonic dislocations increasing mobility of trace elements. The pattern of diabetes prevalence in the area accords with the peculiarities of the distribution of trace elements in the area due to the geological structure. Reduced levels of iron and beryllium revealed by geochemical studies in the western cluster is consistent with the regional geological conditions. Areas with relatively high content of iron and beryllium in the soils are associated with lower prevalence of type 2 diabetes, that suggests possible protective role of these elements.

Keywords: Diabetes; Ecology; Medical geology; Microelements; Environment

Introduction

According to modern views the environment is one of the main factors that determine the health of a person. Therefore the problem of interrelationship between geo-ecology and public health is highly topical. The study of the impacts of geologic materials and processes on animal and human health is a dynamic emerging discipline bringing together the geoscience, biomedical and public health communities to solve a wide range of environmental health problems [1]. Today there are a number of works that reflect medical and biological role of geo-ecological conditions of the residence area [2,3]. Microelement contained in rocks is a mainstream factor of the geological environment, because organisms do not synthesize them. The correlation between trace element status of the area with plants and human body is known [4-7]. New data on the role of trace elements in regulation of carbohydrate metabolism [8-11], accumulated over the past decade, shows feasibility and availability of in-depth interdisciplinary studies of the element status effect of the environment on the diabetes development [12]. The aim of research is to study the influence of geological factors and features of microelement composition of the terrain on the diabetes development.

Epidemiological studies of type 2 diabetes (diabetes) have revealed that most of the disease-affected people live in the United States, Southeast Asia, as well as in Russia, Canada, Brazil, Mexico, Turkey, Iran, and Pakistan. However, diabetes prevalence varies considerably. For example, in the UK about 3% of population are affected by diabetes, while in Mexico-more than 14%, and in Oman-about 30%. Studies have also revealed changes in the diabetes prevalence during migration, indicating the role of the living environment in the spread of the disease. For example, among the Indians who migrated to Singapore, diabetes is 5 times more frequent than with those living in their homeland, and the difference is not explained by nutrition peculiarities and obesity. Type 2 diabetes doesn't seem to affect certain populations of Melanesia, located on the coral islands (limestone massifs of the skeletons of marine organisms) in the Pacific Ocean [13-15].

The 20th century witnessed remarkable discoveries in micro element logy. Initially, metals mined from rocks were considered toxic to humans. Over the last century, information have been accumulated on the important biological role of trace elements in functioning of a living organism. The importance of micronutrient deficiencies in living environment was first proved for goiter. Later, correlation was established between some other trace elements and various diseases: phosphorus-with osteomalacia, selenium-myocardial dystrophy, etc Avtsyn et al. [16,17].

Numerous details about the role of micro and macro elements in functioning of the pancreas have been obtained over the past decades. It was determined that calcium affects activity of the enzymes converting proinsulin into insulin. Insulin granules move to the cell membrane and release insulin into extracellular space with participation of calcium ions in beta cells. Zinc is essential for insulin production by pancreatic beta cells. This element is contained in insulin granules (0.4–0.5%). Iron, copper, magnesium, chromium, vanadium, manganese, nickel and lithium are involved in glucose oxidation, they promote glucose absorption by peripheral tissues, potentiate insulin action [11,18-20] Ametov 2014.

Material and Methods

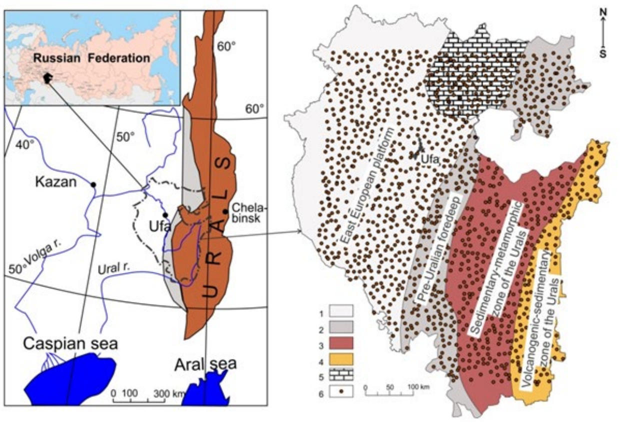

Figure 1: Review and tectonic scheme of the Republic of Bashkortostan.
1-4-structural-formational zones: 1-East European platform; 2-Pre-Ural foredeep; 3- Sedimentary-metamorphic zone of the Urals; 4-Volcanic-sedimentary zone of the Urals; 5-Area of limestone distribution on the Ufimian plateau; 6-Sampling locations.

Study of the interrelation between geological conditions, microelement composition of the area and diabetes prevalence was carried out on the territory of the Republic of Bashkortostan (RB). RB is a region in the middle part of Russia, with the total area of 143,600km2 and population of 4,065,993 people (according to Russian Federation State Statistics Committee, 2010). The western part of RB is situated in the south-eastern part of the East European Platform and the eastern part is in the Ural Mountains (Figure 1). A wide range of geological structures (platform, fore deep, folded region) and rocks (sedimentary, volcanic, igneous, metamorphic rocks of different composition, structure and age), causes variety of microelement profile of the biosphere, allowing to use this region as a unique research ground for studying the biological role of geological factors [21].

Results of studying 1042 soil samples on the content of 45 chemical elements (Be, Sc, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Br, Rb, Sr, Y, Zr, Nb, Mo, Cd, Sn, I, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, W, Tl, Pb, Bi, Th, U) using ICP-MS method (mass spectrometry with inductively coupled plasma) from the report by L Krinochkin and A Shkarin (FSUE "IMGRE") "Geochemical bases of the scale of 1:1000 000 sheet N-40,41,42" were analysed to determine patterns of trace-element distribution in areas with different geological structure [22]. Multi-element analysis was held in the department of research and production of analytical works IMGRE Institute (Moscow). Mass spectrometric analysis was performed in the standard mode on the device Elan 6100 DRC (ELAN 6100 DRC, Software Kit, May 2000, PerkinElver SCIEX instrument). The diabetes prevalence was estimated according to the diabetes register for the 2010–2014. The prevalence of type 2 diabetes was analysed, which represents the basic form of the disease (90%)-more than 80 000 patients with diabetes are registered in RB. In order to mitigate man-made factors, the population of 8 industrial centres of RB was excluded from the statistics. 2,189,026 people-53.83% of the population of the RB including 38,819 patients were used in the statistics.

Mapping the diabetes prevalence in RB was made using ArcGIS 10.2 computer program. According to diabetes prevalence, areas were classified into 4 groups, applying "natural breaks" classification method. Natural breaks classes are based on natural groupings inherent in the data. Class breaks are identified that best group similar values and that maximize the differences between classes. The features are divided into classes whose boundaries are set where there are relatively big differences in the data values. This classification is based on the Jenks Natural Breaks algorithm. Statistical analysis of the results was performed using Statistica 10 software package, Microsoft Excel 2007. Results were considered valid at $p<0.05$.

Results and Discussion

The average diabetes prevalence was 1773 cases per 100 000 people. Minimum rates were registered in two districts within the Urals-906 and 1036 per 100 000, and the maximum was in the district of western part of RB 2845 per 100 000 people.

The mapping of the diabetes prevalence enabled to mark out 3 clusters – the group of districts with high rates of diabetes in the west (western cluster), as well as the other two groups with relatively low rates in the north (northern cluster) and in the

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zone of the Urals (Uralian claster) (Figure 2). In the western cluster (27 districts with the population of 1,153,523 people) the diabetes prevalence was 1931 per 100 000 people-1.4 (p=0,000071) and 1.7 (p=0,000004) times higher than in the northern and the Uralian clusters, respectively. In the northern cluster (11 districts with the population of 271,921 people) and Uralian (6 districts with a population of 278,992), the diabetes prevalence was registered at 1334 and 1155 per 100 000 people.

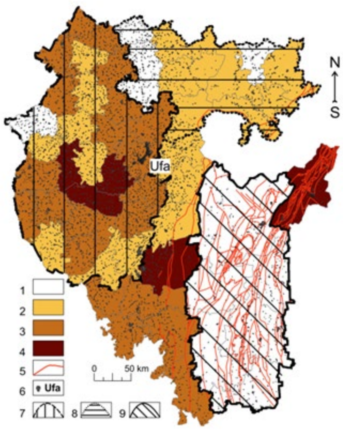

Figure 2: Type 2 diabetes prevalence in the Republic of Bashkortostan.
1- 4-number of cases of type 2 diabetes per 100 000 («natural breaks» classification): 1-905-1277; 2-1278-1745; 3-1746-2213; 4- 2214-2844; 5- Tectonic faults; 6-Settlements; 7- Western cluster; 8- Northern cluster; 9- Uralian cluster.

According to geological structure, the western cluster belongs to the eastern part of the East European platform, the area of the cluster is composed by sedimentary rocks of continental (river) origin. The nothern cluster is situated in the eastern part of the East European platform and in the Pre-Uralian foredeep, the cluster is mostly composed by carbonate rocks of marine origin. The Uralian cluster belongs to the territory of the Ural mountains, composed of sedimentary, metamorphic and volcanogenic rocks of different age and composition, characterized by high concentration of tectonic disturbances.

The diabetes prevalence in the western cluster varies greatly from relatively low-1268, 1378 per 100 000, to high-2845, 2300, 2253 per 100 000. The detected variation of prevalence is also consistent with the peculiarities of the geological structure of the western zone of the RB, where rocks of continental genesis are situated, that causes mosaic distribution of chemical elements according to the relief and paleorelief.

The observed decrease of the diabetes prevalence in the nothern cluster corresponds to widespread carbonate rocks there. It is known, that territory composed by limestones has positive influence on the state of flora and fauna, public health, because of high availability of trace elements containing in carbonates, as well as the high content of calcium and magnesium [23-26]. Furthermore, the north of the RB has a relatively uniform diabetes prevalence in accordance with uniform distribution of trace elements in the area due to the outcrops of rocks of marine origin.

Of particular interest, are the results of research in the mountainous part of the RB, with high concentration of tectonic faults (thrusts, slides etc.) [27]. Excess of the chemical elements in the zones of tectonic activity is associated with the increased risk for developing a number of diseases. Thus, residing in vicinity of the fault increases the risk of cancer and mental diseases [28]. Among the population of the Republic of Lithuania the role of fault zones in developing of coronary heart disease, diabetes, hypertension, diseases of the gastrointestinal tract and kidneys, bladder cancer, genetic disorders was established [29]. However, Uralian cluster was characterized by the lowest diabetes prevalence compared to the northern and western clusters. The data suggest the possibility of a favorable effect of geodynamic active zones on the state of health of the population, perhaps due to the characteristics of the element status [30]. The findings accords with the data on the positive impact of tectonic activity on the human civilization development. Threrefore, most of the places of origin of ancient agriculture in the eastern Mediterranean and the Middle East coincide with zones of active faults, because of their positive role in the formation of rich variety of wild ancestors of cultivated plants [31].

It should be noted that in one eastern Uralian district the diabetes prevalence is relatively high-2509 per 100 000. However, higher prevalence of most of disiases including diabetes in this district comparing to other districts of RB is explained by negative impact of mining and processing plant (the second largest zinc concentrate producer in Russia), where 50 times exceeding of maximum permissible concentration of zinc, lead-20 times, cadmium and copper-10 times have been established within 46km zone [32]. Comparative analysis of 45 chemical elements in 3 clusters was implemented to identify patterns of trace elements distribution in the region. Assessment of 45 elements in 472 samples of the western cluster, 224 samples of the nothern cluster and 346 samples of the Uralian cluster revealed reduction of iron and beryllium in the western cluster compared to the nothern and Uralian ones. Thus, in the western cluster average content of iron and beryllium in the samples amounts to 2563.8 and 0.346mg/kg, while in the nothern cluster 5176.9 and 0.631mg/kg (with p=0.0148 and p=0.0001, respectively), and in the Uralian cluster 4444.9 and 0.571mg/kg (with p=0.000144 and p=0.0001, respectively).

Iron being one of the most common chemical elements (about 5% of the mass of the Earth's crust, the 4th place after oxygen, silicon and aluminum) is one of the most biologically significat elements. Iron is the most common and essential trace element in the human body (the total number of about

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5g), it is involved in the operation of more than 70 enzymes. Unlike iron, beryllium belongs to the rare elements (2.6x10-4% of the mass of the crust) and its biological role requires clarification. Revealed regularities of iron contents in soils correspond to geological structure of the area. Rocks of river origin of the western cluster were formed during erosion of the Urals by fresh waters, resulting in leaching of soluble chemicals. Due to the contact of chemical elements in rocks with oxygen in shallow waters, elements with variable valence were oxidized to form more stable compounds. Thus, iron is oxidised from divalent to trivalent, the salts of which are less soluble. As it is known, plants assimilate iron from the divalent form. Preferential content of ferric compounds in rocks of river origin causes their red color, due to which they are called red bed. The western cluster is mostly composed by red beds. The highest level of iron in the soils of the northern part of the RB is also logical from the geological point of view. In contrast to the western cluster, the northern cluster is characterized by the egress of carbonate rocks of marine origin. Carbonate deposits are known to be easily leached by water, which provides high availability of contained trace elements, among which the most common is the divalent iron.

Higher amount of iron in the Uralian zone accords with significant concentration of tectonic dislocations here and magmatic rocks. According to the thrust-nappe theory [33], marginal zones of tectonic plates are characterised by destruction of rocks, increasing the mobility of the elements in the rocks. In addition, due to horizontal movements of the lithosphere metal-rich heavy (ultramafic) rocks of the oceanic crust, intrusive rocks with high concentration of trace elements are uplifted to the surface, volcanic activity is also connected with horisontal movements of the litosphere [24,34]. Destruction and weathering of minerals increase chemical elements content in the environment. The uplift of deep rocks to the Earth's surface under the influence of tectonic movements is, apparently, the most important mechanism for the formation of the element status of the biosphere. Availability of the heavy trace elements would be impossible without such mechanism, because heavy minerals would be buried under the thick layer of lighter minerals for over millions of years.

Mobility increase of chemical elements in the areas of fault tectonics is ascertained by many authors. Research in the Urals has discovered a large number of geochemical anomalies (Pb, Zn, Cd, Be, P et al.), connected to the geodynamic activity areas [35]. Thrust zones are characterized by increased mobility of water, trace elements and other radionuclides. Increased radon concentration in soil gas around local disjunctive tectonic zonez in Krakow area is established [36].

Conclusion

A broad diversity of geological structures, such as platform, foredeep, folded region and different rock types as sedimentary, magmatic, metamorphic on the investigated territory make this region a unique scientific testing ground for the study of medical and biological role of geological factors. Analysed 45 trace element (Be, Sc, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Br, Rb, Sr, Y, Zr, Nb, Mo, Cd, Sn, I, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, W, Tl, Pb, Bi, Th, U) composition in soils showed the consistency of the regional geological conditions with the features of the elemental composition of the region and the diabetes prevalence. Reducing the type 2 diabetes prevalence is associated with the zone of carbonate rocks, characterized by high availability of minerals contained in them. The relatively low prevalence of type 2 diabetes is observed within the Southern Urals, where high concentration of tectonic

faults, magmatic and metamorphic rocks tend to raise the concentration of trace elements in the soils.

The observed beneficial effect of higher concentration of iron and beryllium in the soil on the diabetes prevalence suggests possible protective role of these elements in this desease and shows the necessity of more detailed research into the role of these elements in the regulation of carbohydrate metabolism. The results of investigation suggest that the orientation of the biological impact of near-fault zones depends on the complex range of factors - the structure and composition of the rocks, their density, permeability, etc., which determine the elementary status of the area. Enriching the soil by chemical elements in the fault zones may produce positive impact on the biosphere, while a pronounced excess causes adverse effects.

References

1. Bunnell JE, Finkelman RB, Centeno JA, Selinus O (2007) Medical Geology: a globally emerging discipline. Geologica Acta: an international earth science journal. 5(3): 273-281.
2. Komatina M (2004) Medical geology: effects of geological environments on human health. Elsevier 2: 488.
3. Centeno JA, Finkelman RB, Fuge R, Lindh U, Smedley P, et al. (2013) Essentials of medical geology. In: Selinus O (ed.), Earth Sciences & Geography Geology. Springer publishing, New York, USA, p. 820.
4. Alloway B (2005) Bioavailability of elements in soil. Essentials of Medical Geology, pp. 347-372.
5. Rikhvanov L (2006) Environmental and geochemical characteristics of natural environments of the Tomsk region and prevalence. Tomsk: TPU (In Russian), p. 216.
6. Rikhvanov L, Baranovskaya N, Sudyko A (2013) Chemical elements in the human body as the basis for the implementation of medical geology ideas. Gorniy journal 3: 37-42.
7. Farkhutdinova LM, Speranski VV, Gilmanov AJ (2006) Trace elements in hair of patients with goiter. Clinical diagnostics 8: 19-21.
8. Aggett P (1985) Physiology and metabolism of essential trace elements: An outline. Clin Endocrinol Metab 14(3): 513-543.
9. Avcyn A, Zhavoronkov A, Rish M, Strochkova L (1991) Microelementoses of a human. Moscow: Mir, Russia, p. 495.
10. Pittas AG, Harris SS, Stark PC, Dawson-Hughes B (2007) The effects of calcium and vitamin D supplementation on blood glucose and markers of inflammation in nondiabetic adults. Diabetes care 30(4): 980-986.

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11. Lindh Ulf (2013) Biological functions of the elements. In: Olle Selinus (Ed.), Essentials of Medical Geology. (1st edn), Springer, Netherlands, pp. 129-177.

12. Farhutdinova LM, Bayburina GG, Farkhutdinov IM (2010) Diabetes: challenges, achievements and prospects. Bulletin of the Academy of Sciences of the Republic of Bashkortostan 15(3): 32-39.

13. Cowie CC, Rust KF, Byrd-Holt DD, Eberhardt MS, Flegal KM, et al. (2006) Prevalence of diabetes and impaired fasting glucose in adults in the US population: National Health and Nutrition Examination Survey 1999-2002. Diabetes Care 29(6): 1263-1268.

14. Suntsov YI, Maslova OV (2011) Epidemiology of diabetes. In: Dedov II, Shestakova MV (Eds.), Proc Diabetes: diagnosis, treatment, prevention under. Moscow: Medical News Agency, Russia, pp. 124-158.

15. (2014) IDF Diabetes Atlas. (6th edn).

16. Kowalski VV (1982) Geochemical environment and life. Moscow: Nauka, Russia, p. 78.

17. Kudrin AV, Gromova OA. Trace elements in immunology and oncology. Moscow: GEOTAR–Media, Russia, p. 543.

18. Jansen J, Karges W, Rink L (2009) Zinc and diabetes--clinical links and molecular mechanisms. J Nutr Biochem 20(6): 399-417.

19. Wiernsperger N, Rapin J (2010) Trace elements in glucometabolic disorders: an update. Diabetol Metab Syndr 2: 70.

20. Terekhina EA (2012) The impact of heavy metals, localized in the arable soils of the administrative districts of the Ulyanovsk region, on the diabetes mellitus in the local population. Scientific results of the year: achievements, projects, hypotheses 2: 23-25.

21. Farkhutdinov IM, Farkhutdinova LM (2016) Regional geological factors and diabetes Bulletin of the Tomsk Polytechnic University. Geo Assets Engineering 327(3): 38-46.

22. Krinochkin L, Shkarin A (2011) Geochemical bases of the scale of 1: 1000 000 sheet N–40,41,42, P–45,52,55,57, O–38,55,56. Moscow: Rosgeolfond, Russia.

23. Shvarts A (1996) Environmental Hydrogeology. Publishing house of the St. Petersburg State University, Russia, p. 60.

24. Farkhutdinov IM, Ismagilov RA, Farkhutdinov AM, Farkhutdinova (LM 2017) Murat Kamaletdinov and the struggle for acceptance of the thrust-nappe theory. Earth Sciences History 36(1): 101-115.

25. Rapant S, Cvečková V, Dietzová Z, Fajčíková K, Hiller E, et al. (2013) The potential impact of geological environment on health status of residents of the Slovak Republic. Environ Geochem Health 36(3): 543-561.

26. Chiu HF, Chang CC, Chen CC, Yang CY (2011) Calcium and magnesium in drinking water and risk of death from kidney cancer. J Toxicol Environ Health A 74(1): 62-70

27. Kamaletdinov MA (1962) About klippes of the Middle Urals. Doklady of the USSR Academy of Sciences 146(5): 1160-1163.

28. Galjautdinova SI, Belan LN, Gumerova RB (2012) About the effect of biological discomfort zones on human. Bulletin of Bashkir University 17(3): 1403-1406.

29. Pronin A, Wolfson I, Oderova A (2010) Fluid activity of land and environment, biogeochemical province, geopathic zones, geo-ecology of human. Medical Geology: Status and Prospects pp. 24-37.

30. Farkhutdinov IM, Farkhutdinova LM (2016) Geo-environmental aspects of the problem of type 2 diabetes. Herald of the Academy of sciences of the Republic of Bashkortostan 21(1): 38-45.

31. Trifonov V, Karakhanian A (2004) Active faulting and human environment. Tectonophysics 380(3-4): 287-294.

32. Teregulova Z (2009) Features of environmental pollution and the prevalence of the population in the mining region of the Republic of Bashkortostan. Medical Journal of Bashkortostan 4(6): 20-25.

33. Kamaletdinov MA (2001) The modern thrust-nappe theory. Geologichesky Sbornik 2: 29-37.

34. Ismagilov RA, Farkhutdinov IM, Farkhutdinov AM, Farkhutdinova LM (2015) The thrust-nappe theory 50th anniversary. Priroda 12: 50-59.

35. Kopylov IS (2014) Geoecological role of geodynamic active zones. Mezhdunarodnyj zhurnal prikladnyh i fundamental'nyh issledovanij 7: 67-71.

36. Swakoń J, Kozak K, Paszkowski M, Gradziński R, Łoskiewicz J, et al. (2005) Radon concentration in soil gas around local disjunctive tectonic zones in the Krakow area. J Environ Radioact 78(2): 137-149.

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