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Complex geophysical investigations of the West Timan fault

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In this paper we discuss results of complex geophysical works within the southern and middle segments of the West Timan fault. In the study area, based on the nature of potential fields (magnetic, gravitational), various areas of the West Timan fault were identified: the southern part (Beloborsk block), the central part (Nivshera block), and the northern part (Sindor block). These areas were studied by profile magnetometry on foot and express radon survey. The detailed magnetic survey revealed that the West Timan fault was clearly visible in the gradient sections of the magnetic field, with some degree of conventionality it can be identified within the regional maximum, and it is impossible to trace it in the zone of the regional minimum. Based on the interpretation of seismic data, the location of the West Timan fault has been clarified. The nature of the seismic record does not always allow identifying the exact location of the fold planes, only the difference in the record in individual blocks is clearly noted. The border area sometimes captures 5 km. The express emanation survey showed that the West Timan thrust, in general, was characterized by increased values of radon volumetric activity, where they are further traced to the territory of Timan, while areas of different intensity are distinguished.

Thus, with insufficient seismic knowledge and low differentiation of potential fields, the emanation radon survey can be used as an additional method for identifying and tracing tectonic dislocations. The complex of geophysical studies allowed clarifying the location of the West Timan fault.

Keywords: *West Timan fault, potential fields, seismic profiles, volume radon activity.*

Комплексные геофизические исследования Западно-Тиманского разлома

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На территории южного и среднего сегментов Западно-Тиманского разлома, основываясь на материалах потенциальных полей, выделяются различные области: южная — Белоборский блок, центральная — Нившерский блок, северная — Синдорский блок. Белоборский блок — осевая часть регионального минимума гравитационного поля, осевая часть минимума магнитного поля. Нившерский блок — пограничная область между двумя гравитационными минимумами, осевая часть максимума магнитного поля. Синдорский блок — зона перегиба положительных значений гравитационного поля, градиентная зона между положительными и отрицательными значениями магнитного поля.

Исследования, включающие магниторазведочную и радоновую съемки выполнялись по двенадцати профилям, секущим Западно-Тиманский разлом.

Обобщая детальные магниторазведочные работы, выяснили, что Западно-Тиманский надвиг в магнитном поле проследить четкой зоной невозможно как на градиентных участках поля, так и в пределах региональных максимумов и минимумов. Как правило, ширина градиентной зоны меньше зон максимумов и минимумов. В отдельных случаях можно лишь трассировать разлом по сериям даек основных и ультраосновных пород, которые могут находиться и не во фронтальной зоне разлома.

По результатам экспрессной эманационной съемки отмечается, что южная и центральная части Западно-Тиманского разлома характеризуются повышенными значениями объемной активности радона (ОАР), которые изменяются в интервале 400—2150 Бк/м3, при этом выделяются различные по интенсивности области. Среднее значение ОАР Белоборского блока составляет 670 Бк/м3, Нившерского — 670 Бк/м3, Синдорского — 600 Бк/м3. Средний относительный показатель ОАР Белоборского блока составляет K_Q = 2.0, Нившерского блока — K_Q = 5.4, Синдорского блока — $K_{Q(юг)}$ = 2.0, $K_{Q(север)}$ = 6.0. Почвенный радон распространяется за пределы тектонических нарушений из-за повышенной трещиноватости верхних горизонтов осадочного чехла, в связи с этим ширина аномалии радона всегда превышает ширину самого разлома.

Таким образом, эманационная радоновая съемка может использоваться как дополнительный метод для выявления и трассирования тектонических нарушений. Особое внимание следует обратить на Синдорский блок, где в магнитном поле отмечается резкая градиентная область, на фоне которой выделяется серия даек. Также эта зона характеризуется высоким показателем K_Q.

Ключевые слова: *Западно-Тиманский разлом, потенциальные поля, сейсмические профили, объемная активность радона.*

Introduction

Initially, the faults were identified according to the data of gravimetric and magnetic surveys, and then, by seismic surveys using the methods of deep seismic sounding (DSS), converted waves of earthquakes (ECWM), reflected waves (RW), common depth point (CDP), correlation method of refracted waves (CMRW).

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In situ, their identification was confirmed by geological surveys and drilling. The signs, on which the identification of faults is based, using the analysis of maps of magnetic and gravitational fields, are well known and are widely covered in the literature. In this work, we used results of studying the fault tectonics of the European North-East of Russia [1—3, 5—7, 10, 11, 13, 14, 17, 18, 20, 21, 24, 28, 34—36 and etc.]. Numerous maps and schemes of tectonic zoning of the Timan-Northern Ural region have been built and published on the basis of materials of previous studies. The maps and diagrams of the block structure and fault tectonics of the region constructed by different authors, despite their significant similarity, also have certain differences, sometimes even fundamental ones both in the genesis and in the location of the structures [18]. The purpose of our research was to clarify the location of the West Timan fault and detailing its tectonic activity using available materials and additional studies.

Object of study

Tectonically the territory of the Komi Republic is represented by a node of heteroaged structures of the East European Platform: Volga-Ural anteclise, Mezen syneclise, Timan, Pechora syneclise, Northern Urals. The boundary of the Russian and Pechora plates is the West Timan deep fault. The Timan Ridge is included in the Pechora Plate as its southwestern structural boundary. The main difference between the Russian and Pechora plates is the age of the basement [28].

The West Timan fault was initially identified by a change of magnetic field sign, predominantly positive of the Pre-Timan foredeep of the Russian Plate, to the negative magnetic field of Timan. At the same time, it was noted that within the suture zone, the basement of the Russian Plate sinks under the marginal folded structures, which was expressed by NW oriented wide band anomalies. In other words, we observe an overthrust of the Timan Ridge on the basement of the Russian Plate [6, 9, 25].

The West Timan fault — a boundary structure ("marginal suture" according to [6, 12]) between the epikarelian Russian and epibaikalian Timan-Pechora plates, over 800 km long. It is traced from the Kanin Peninsula of the Pechora Sea to the Northern Urals, where it passes into the overthrust of the Polyudova Ridge, and further to the south, into the system of disjunctives of the West Ural megazone of the Middle Urals. In the extreme northwest of the region, the role of the "marginal suture" passes to the Kola-Kanin fault with a suture with a submeridional closure in this part of the Timan-Pechora plate of the West Timan fault. Stretching northwestward, the fault marks the western boundary of the Timan Ridge [34].

The West Timan fault is a thrust fault, where the basement of the Timan-Pechora plate is thrusted over the basement of the Russian plate. According to seismic data, it has been determined that the suture occurs along a fold-thrust zone confined by the West Timan and Central Timan faults, the distance between which varies widely. It has the greatest width, up to 75—80 km, in the area of Chetlas Kamen. The width of the zone is significantly reduced northwestward and southeastward, to 10—20 km at the Kanin Peninsula and further northwestward, the junction of the Lower and Upper Precambrian complexes has a pattern of a marginal suture [4, 23, 28—30].

The entire complex of rocks that compose the Timan Ridge is divided by a sharp angular disconformity into two structural stages: the lower one is the Riphean-Vendian, which is a consolidated basement, and the upper one is the Phanerozoic platform nappe, which is composed mainly of Paleozoic deposits from the Silurian (in Northern Timan) to the Upper Permian inclusively. Granitized Archean — Lower Proterozoic crystalline rocks withrelatively unknown composition underlaythe Riphean — Vendian sedimentary-metamorphic formations [7, 28].

The structures of the Timan Ridge are composed of Paleozoic formations up to Upper Permian. The Mesozoic rocks, represented generally by the Lower Triassic and Middle Jurassic rocks, are developed on the slopes of the ridge. In its arched part, there are only remnants of an earlier, probably, continuous cover of the Middle — Upper Jurassic deposits. On a much larger area of Timan, as well as in the Pechora syneclise, Devonian deposits are widespread. They are represented by gravelites, white sandstones with clay members, on which tuffites and basalts occur; basalt nappes are known in the northern Timan. Variegated clays, sands, sandstones, and Devonian marls occur upward the section. Carboniferous deposits are distributed mainly on the eastern slope of the Timan. They include Lower Carboniferous limestone, dolomite, sandstone and sands. The Middle and Upper Carboniferous beds transgressively overlay the Proterozoic deposits of the entire Timan Ridge. Permian and Mesozoic deposits are developed in the margins of the Timan Ridge. Westward of Timan, Permian deposits include limestone, dolomite, clay, sandstone and dolomite, anhydrite, gypsum and rock salt sequences. Eastward Permian deposits are represented by limestone, gypsum, and dolomite, and closer to the Urals — by coal-bearing layers [28] (Fig. 1).

In this paper we consider the southern and middle segments of the West Timan fault (Fig. 2—4). The research has been carried out since 2018 and was accompanied by publications at some stages [33].

Research results and discussion

The research was carried out to clarify the location of the West Timan fault and to assess its activity. We solved the following tasks:

1) qualitative interpretation of magnetic and gravimetric fields and determination of the location of fault zones in the first approximation;

2) study of the geological and geophysical section based on seismic data and specification of the projection of faults and fault zones on the surface;

3) detailed magnetometric cross-strike works;

4) measurement of the volumetric activity of radon, as a factor in the presence of increased fracturing in the section [33].

Traditional geophysical methods (gravimetric, magnetometric, seismic, electrical prospecting) are always used to study the deep structure. The measurement of radon volumetric activity and use of microseismic fields have recently become popular due to their effectiveness [19, 22, 26 and etc.]. This set of geophysical works was previously successfully applied to study the deep structure of the Kirov-Kazhim and Pechora-Kolva aulacogens and Vychegda depression [31—33].

Researches, including magnetic and radon surveys, were carried out on twelve profiles crossing the West Timan fault: "Obdyr", "Sediudor", "Meshchura", "Sindor", "Nivshera", "Troitsk", "Ozyag", "Parma", "Sheryag", "Smolyanka", "Yn", "Beloborsk" (from north to south) (Fig. 2).

Potential fields

Gravity and magnetic surveys on scales of 1:1,000,000 and 1:200,000 cover the entire area of the Timan-Northern Ural region. Based on the performed works, maps of the anomalous magnetic field (isolines and ΔTa graphs) were built and published. The interpretation of magnetic fields resulted in revealing regional regularities in the structure of the sedimentary cover and basement, its material composition, as well as fault tectonics. Maps of the anomalous gravimetric field and its various transformations on a scale of 1:200000 and 1:50000 are widely used to study the basement, its depth, and to identify zones of tectonic faults. The maps and schemes of tectonic zoning were generally constructed on the basis of these materials, further detailing of the maps and schemes was made after seismic works. However, the degree of study by seismic methods of individual structures of the Timan Ridge is very different, and on the whole where the territory has been studied extremely poorly [32, 33].

The gravitational field of the boundary area of two plates is represented in its southeastern part by anomalies

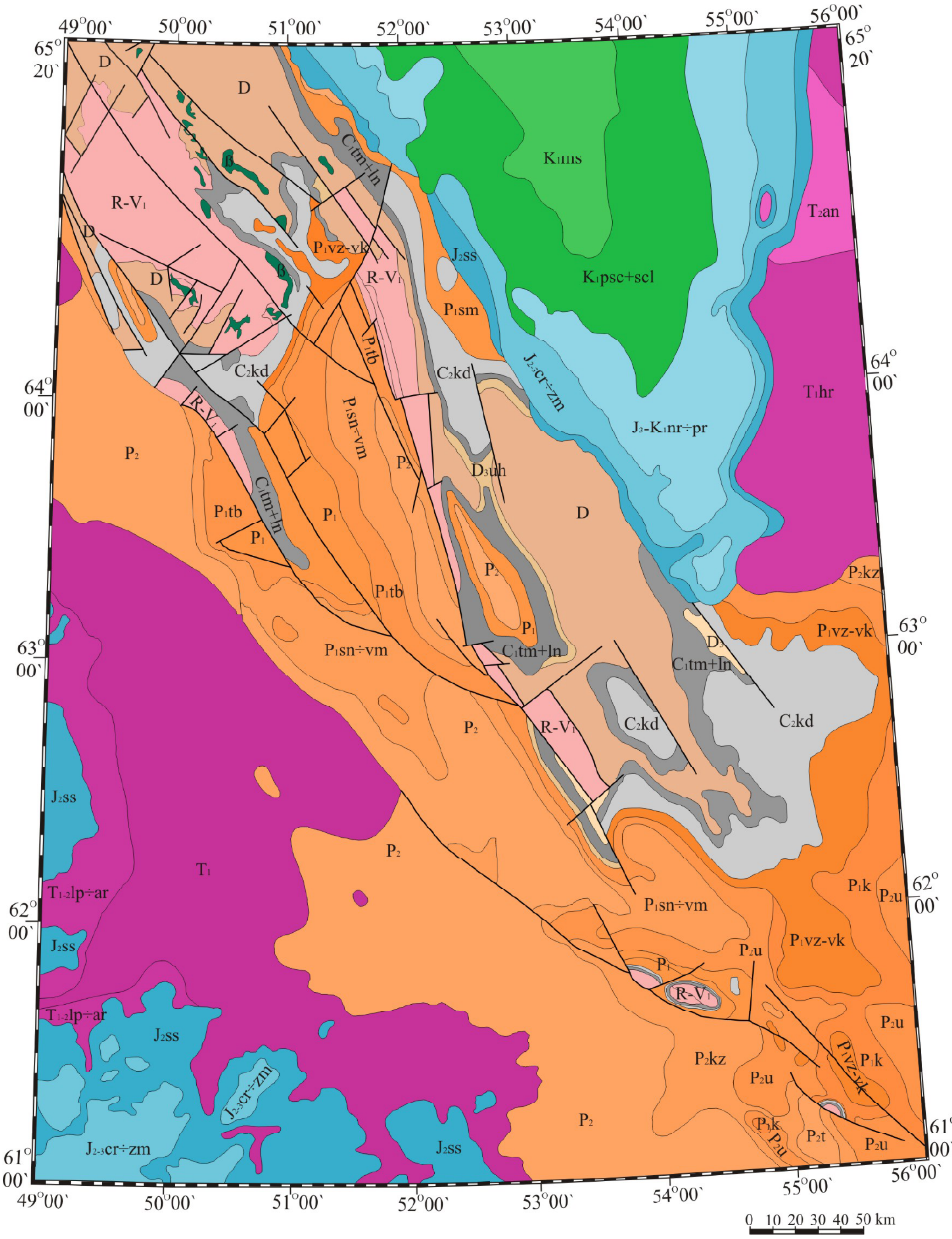


Fig. 1. Geological map of the study area (Atlas of the Komi Republic. Geological structure of the territory. Moscow, 2011. Composed by D. B. Sobolev, N. I. Timonin)

Рис. 1. Геологическая карта района исследований (Атлас Республики Коми. Геологическое строение территории. Москва, 2011 г. Составили: Д. Б. Соболев, Н. И. Тимонин)

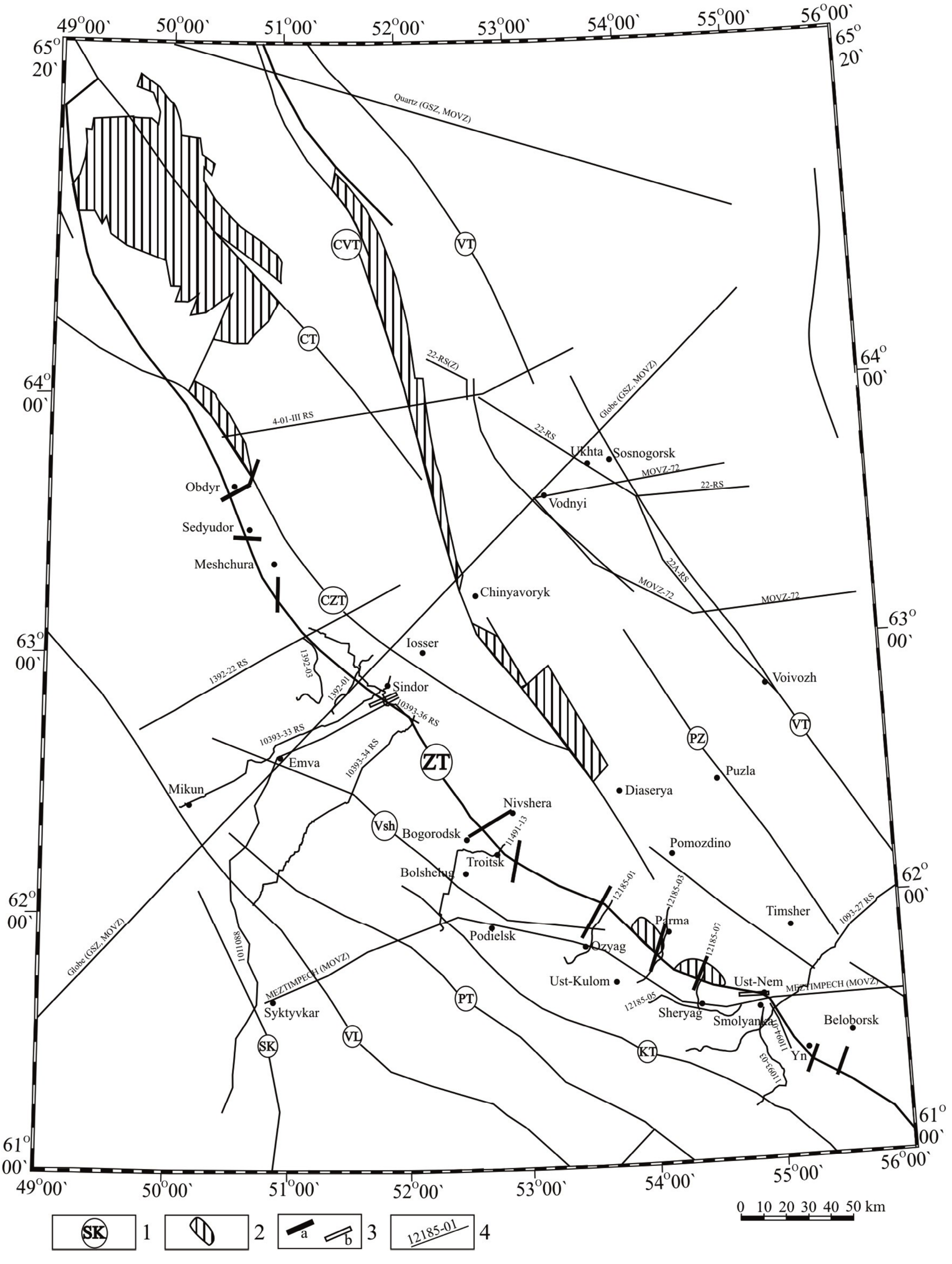


Fig. 2. Fault tectonics and seismic scheme studies of the study area (composed by V. V. Udoratin).

1 — faults: SK — Syktyvkar, VL — Vychegda-Lokchim, PT — Predtimanskiy, KT — Keltmenskiy, VSh — Vishera, ZT — West Timan, CZT — Central West Timan, CVT — Central East Timan, CT — Central Timan, PZ — Puzlinskiy, VT — East Timan; 2 — outcrops of bedrock; 3 — sections of work: "Obdyr", "Sedyudor", "Meshchura", "Sindor", "Nivshera", "Troitsk", "Ozyag", "Parma", "Sheryag", "Smolyanka", "Yn", "Beloborsk" (from north to south), filled rectangle — magnetometric survey and radon works performed, empty rectangle — radon works performed; 4 — seismic profiles

Рис. 2. Схема разломной тектоники и сейсмической изученности района исследований (составил В. В. Удоратин).

1 — разломы: SK — Сыктывкарский, VL — Вычегодско-Локчимский, PT — Притиманский, KT — Кельтменский, VSh — Вишерский, ZT — Западно-Тиманский, CZT — Цетрально-Западно-Тиманский, CVT — Центрально-Восточно-Тиманский, CT — Центрально-Тиманский, PZ — Пузлинский, VT — Восточно-Тиманский; 2 — выходы коренных пород; 3 — участки работ: «Обдыр», «Седъюдор», «Мещура», «Синдор», «Нившера», «Троицк», «Озъяг», «Парма», «Шеръяг», «Смолянка», «Ын», «Белоборск» (с севера на юг), залитый прямоугольник — выполнены магниторазведочные и радоновые работы, пустой прямоугольник — выполнены радоновые работы; 4 — сейсмические профили

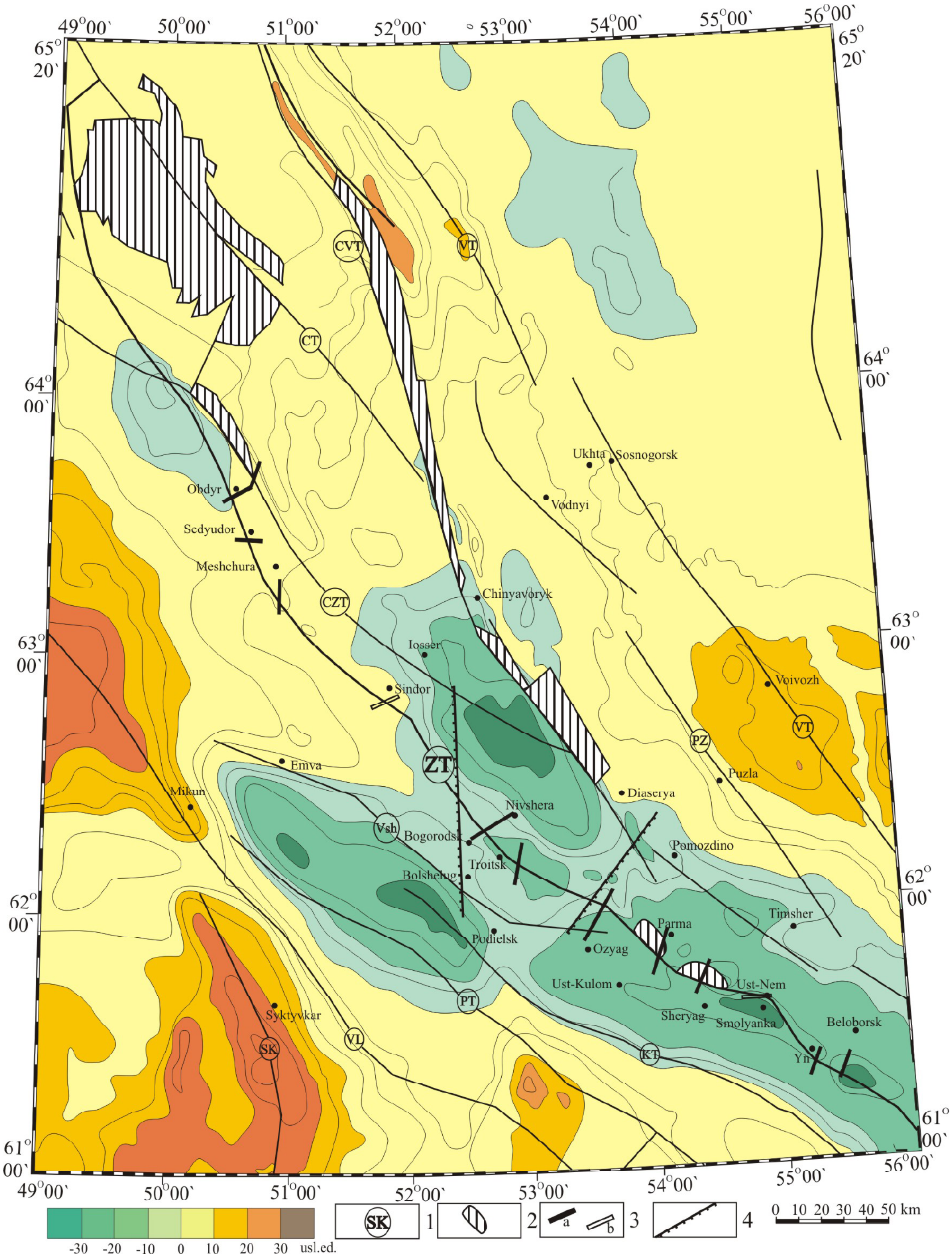


Fig. 3. Fragment of the gravity field map of the study area [16]:

1—3 — see Fig. 2; 4 — block boundaries

Рис. 3. Фрагмент карты гравиметрического поля района исследований [16]:

1—3 — усл. обозн. см. на рис. 2; 4 — границы блоков

of NW-strike minima, and in the northeastern part — by an extended gradient step indicating transition to positive anomalies also of NW strike. In the study area, outlining of the fault in the south passes through the zone of the regional gravity Timan minimum with size of 200 by 100 km, the western part of which corresponds to the southeast of the Vychegda depression, and the eastern part corresponds to the southern end of the Timan Ridge (Fig. 3). Further, this minimum breaks up into two minima close in size (150 by 70 km), where the western one corresponds to the northwestern part of the Vychegda depression, and the eastern one corresponds to the part of the southern Timan. The West Timan Fault runs along their section. Further northwestward, the fault is traced through the zone of positive values and the axial part of the next minimum, 90 by 50 km in size. The width of the axial part of the described minima is about 15–20 km, which indicates a very approximate fault tracing [33].

In the magnetic field, the West Timan fault is reflected along its entire length by a gradient of ΔTa values, which fixes the transition from the Timan regional minimum on the territory of the Timan Ridge and the

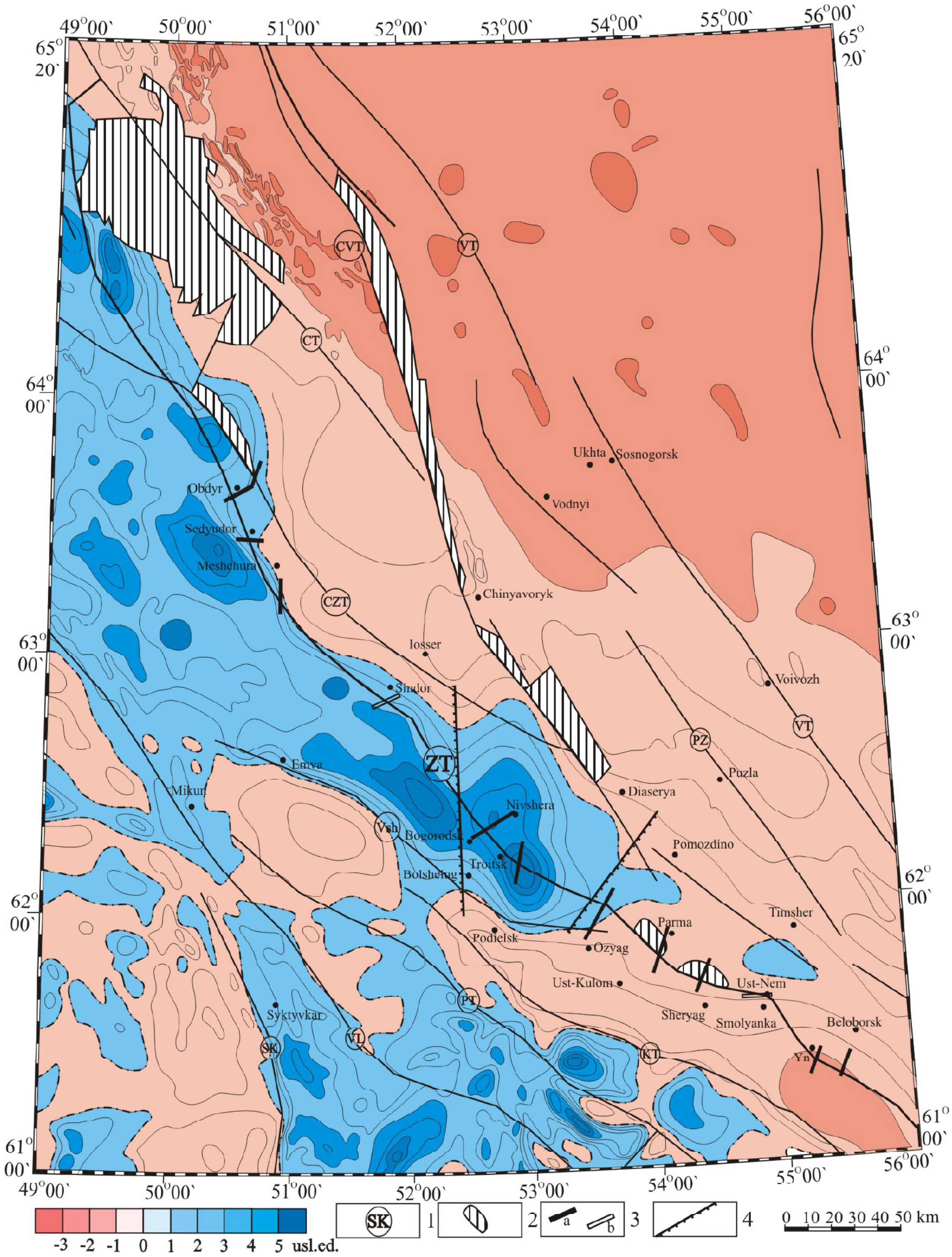


Fig. 4. Fragment of the anomalous magnetic field map of the study area [15]:

1—3 — see Fig. 2; 4 — block boundaries

Рис. 4. Фрагмент карты аномального магнитного поля района исследований [15]:

1—3 — усл. обозн. см. на рис. 2; 4 — границы блоков

Pechora syneclise to the band of regional maxima of the Pre-Timan structures — the Safonov and Vychegda depressions. The anomalies of this band are generally NW oriented, but in some areas they have a sublatitudinal strike caused by a stepped “angular” form of an orthogonal combination of faults of the general NW “Timan” and a less pronounced NE direction in the suture zone of the Russian and Timan-Pechora plates. Apparently, it can consist of en echelon segments with a single displacement plane with depth. The width of this “suture” reaches 10—12 km considering the steps of the gravitational and magnetic fields [33, 34].

However, the confinement of the West Timan Fault to the gradient zone described above is very conditional (Fig. 4). The southern segment of the fault is practically not expressed in the magnetic field, being in the region of the regional minimum, covering the south of the Timan and the southeastern part of the Vychegda depression. Further, the West Timan fault is traced along the axial part of the Nivshera maximum, with a size of 75 by 30 km, and only further north west ward the fault can be somewhere related to the gradient zone and to the axial parts of the maxima. This nature of the physical fields indicates the complex structure of the thrust zone with heterogeneous internal content [33].

In the study area, based on the materials of potential fields, we distinguish various areas of the West Timan fault: the southern part (Beloborsk block), the central part (Nivshera block), and the northern part (Sindor block). Beloborsk block: axial part of the regional minimum of the gravitational field, axial part of the minimum of the magnetic field. Nivshera block: boundary area between two gravitational minima, axial part of the magnetic field maximum. Sindor block: inflection zone of positive values of the gravitational field, gradient zone between positive and negative values of the magnetic field (Fig. 3, 4) [33].

Seismic research

The seismic study of the territory under consideration is insignificant, and the quality of the material does not always allow confident conclusions. We have studied all possible materials of seismic studies, the results of the interpretation of which served as the basis for constructing a scheme of fault tectonics. It was the CDP seismic survey data that allowed confidently interpreting the West Timan deep fault as an overthrust, while DSS [8] and ECWM data [4, 29, 30] allowed tracing it to depths of 20—35 km or more [33].

On the geological and geophysical sections along the seismic profiles 10393–33 PC, 10393–34 PC, 1392–22PC and 11093–27PC, the first, second and thirdones crossing the Middle Timan, respectively, and the fourth ones–the South Timan, the fault is presented in the form of an overthrust from "beam" of the fold planes, emanating from one deep focus, where 2—3 planes are noted, and diverge as a "fan" to the surface, reaching there already 7—9 planes and a width of 10—15 km [34]. The vertical displacement of the Upper Riphean rocks of the northeastern shoulder of the fault in some of its areas (the Vadyavozh disjunctive anticline of the Dzhedzhim-Parma swell) relative to the age analogs of the southwestern foot shoulder can reach 4 km, and in others, 2.8 km (Obdyr structure). On the northwestern flank, the fault amplitude decreases to 1—2 km. In the sedimentary cover, it thins out to the first hundreds and even several tens of meters. On the southwestern foot shoulder of the West Timan Fault, Paleozoic-Riphean deposits are uplifted to the fault planes, and older Lower Proterozoic and Archean complexes sink under the thrust [34].

As can be seen on the seismic scheme, the number of profiles crossing the West Timan fault is insignificant (Fig. 2). The profiles under study, if possible, were selected

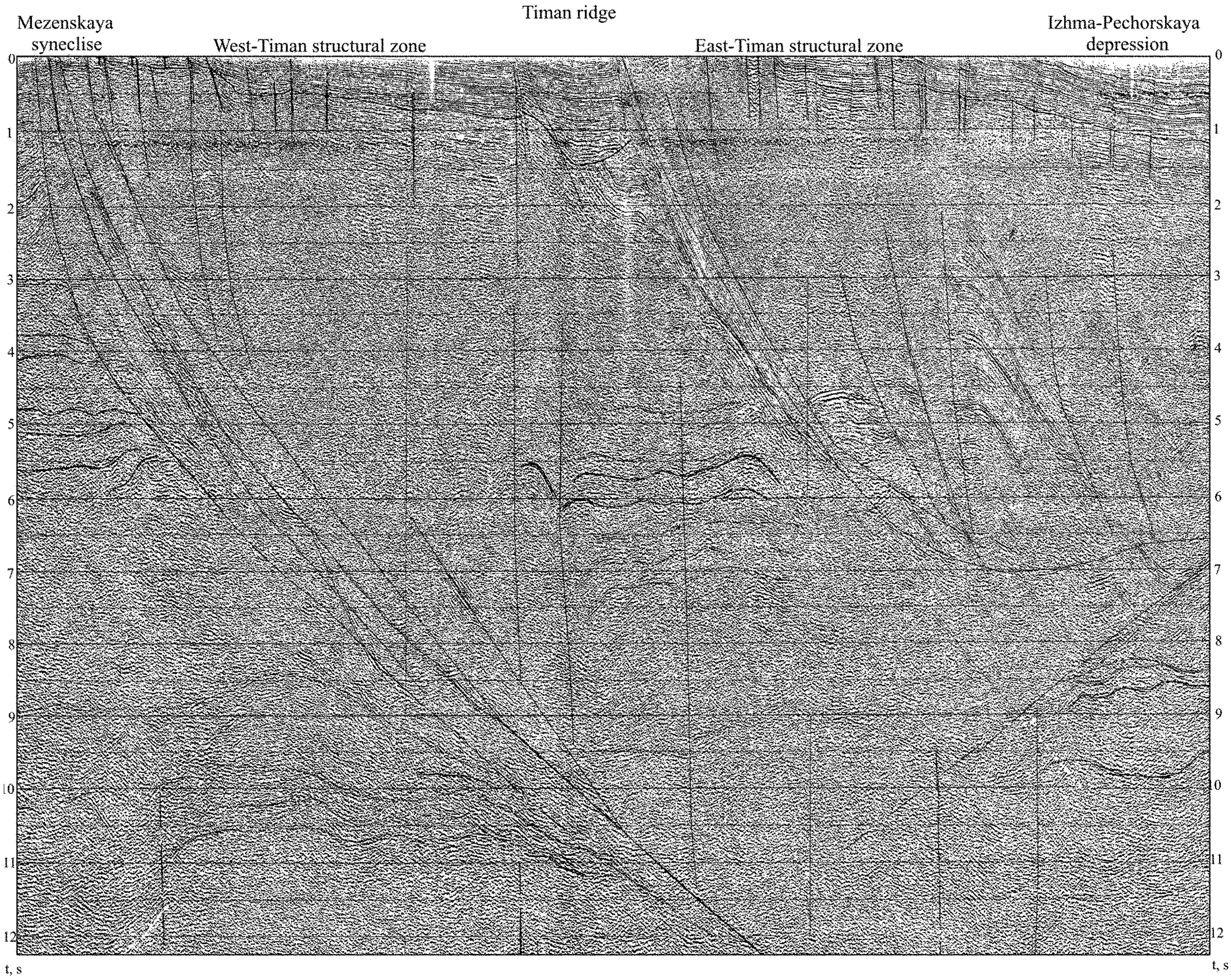


Fig. 5. Fragment of the temporary seismic section along the profile 4-01-III-RS across the West Timan fault [34]

Рис. 5. Фрагмент временного сейсмического разреза по профилю 4-01-III-PC через Западно-Тиманский разлом [34] along the line of seismic profiles, or near them. In some areas, our studies took place far enough from the seismic profiles.

In the Sindor block, not far from the work area, regional seismic profiles 10393-34 RS and 10393-33 RS, 4-01-III-RS were completed. In the Nivshera block, seismic profile 11491–13 is the closest to the "Nivshera" and "Troitsk" profiles. In the Beloborsk block near the village of Smolyanka seismic profiles 12185–05 and 11093–27 RS intersect the Smolyanka profile, 11093–03 and 11094–01 pass next to it; "Sheryag" and "Parma" — correspond to seismic profiles 12185–07 and 12185–03; profile "Ozyag" coincides with a fragment of seismic profile 12185–01. Fault tracing is not in doubt according to seismic data, although the nature of the seismic record does not always allow identifying the exact location of the fault planes, only the difference in the record is clearly notedin some blocks. The boundary area sometimes covers 5 km (Fig. 5).

Profile magnetometric studies

For almost 400 km, within the blocks we have identified, in their various sections, we have worked out the magnetic prospecting profiles "Obdyr", "Sedudor", "Meshchura", "Nivshera", "Troitsk", "Ozyag", "Parma", Sheryag", "Yn", "Beloborsk". The distance between the profiles was determined by the accessibility to the sites and ranged from 20 to 65 km (Fig. 2—4).

Magnetometric studies were carried out with MINIMAG pedestrian devices, which are designed to measure the modulus of the geomagnetic field. The limit of the main systematic error of the magnetometer when measuring the magnetic induction does not exceed ±2 nT. The step between the observation points was 50 m. The length of the profiles ranged from 10 to 23 km. Simultaneously with ordinary observations, variations of the magnetic field were taken. The magnetometric station was installed in a quiet magnetic field and recorded variations with an interval of 1 minute. Topographic referencing was performed using a GPS Garmin 62S, the referencing accuracy at full visibility of the horizon reaches 3 m. The referencing was performed in 100 m increments. Time referencing between magnetometers was performed using a GPS Garmin 62S, referencing accuracy was ±1 second. All profiles started from the Vychegda trough [33].

The task of the research was to study in detail the anomalous magnetic field within the fault. The research results are shown in Figure 6.

The Sindor block of the West Timan fault is represented by the "Obdyr", "Sedyudor", and "Meshchura" profiles (Fig. 4). The "Obdyr" profile, 23 km long, crosses the West Timan and Central West Timan faults. The profile passes through a quiet positive magnetic field (Fig. 4, 6, A). The West Timan fault is not distinguished on the ΔT plot, while the Central West Timan fault corresponds to a sharp stepwise drop in the magnetic field PN360–PN370 (Fig. 6, A). On the "Sedyudor" profile, passing through the gradient zone, the West Timan fault is not traced in the magnetic field by any clear area (Fig. 6, B). On the "Meshchura" profile, the West Timan fault is distinguished by a confidently sharp drop in the magnetic field, which is against the background of the general gradient PN15–PN55 (Fig. 6, C). We carried out detailed work in this area, the results of which made it clear that a series of local dikes can be traced here, located in the Timan thrust zone.

Within the Nivshera block of the West Timan fault, the "Nivshera" and "Troitsk" profiles were mined (Fig. 4). According to the "Nivschera" profile, on the plot of the positive gradient magnetic field in the fault zone, its slight drop PN100–PN140 is traced (Fig. 6, D). On the "Troitsky" profile in the region of PN30–PN70, magnetic field fluctuations are observed, which can be associated with dikes located in the fault zone (Fig. 6, E). A magnetic anomaly is traced at the end of the profile (PN195–PN205).

The "Ozyag", "Parma", "Sheryag", "Yn", and "Beloborsk" profiles pass along the Beloborsky block of the West Timan fault (Fig. 4). On the graphs of anomalous magnetic fields, the West Timan fault is not reflected (Fig. 6, W, Z, I, L, M). Attention should be paid to the "Sheryag" profile, where jumps of the anomalous magnetic field (PN170–PN230) are noted after the frontal fault zone (Fig. 6, I). In the ΔT plot along the "Beloborsk" profile in the area of PN100–PN120, already within the Timan thrust zone, an anomaly associated with a mafic rock dike was traced (Fig. 6, M).

Detailed magnetic surveys have shown that it is impossible to clearly trace the West Timan Fault in a magnetic field, both in the gradient areas of the field and within the regional maxima and minima. It can be only noted that the width of the gradient zone is generally less than the zones of maxima and minima. In some cases, it can only be traced along a series of dikes of basic and ultrabasic rocks, but they may not be in the frontal fault zone [33].

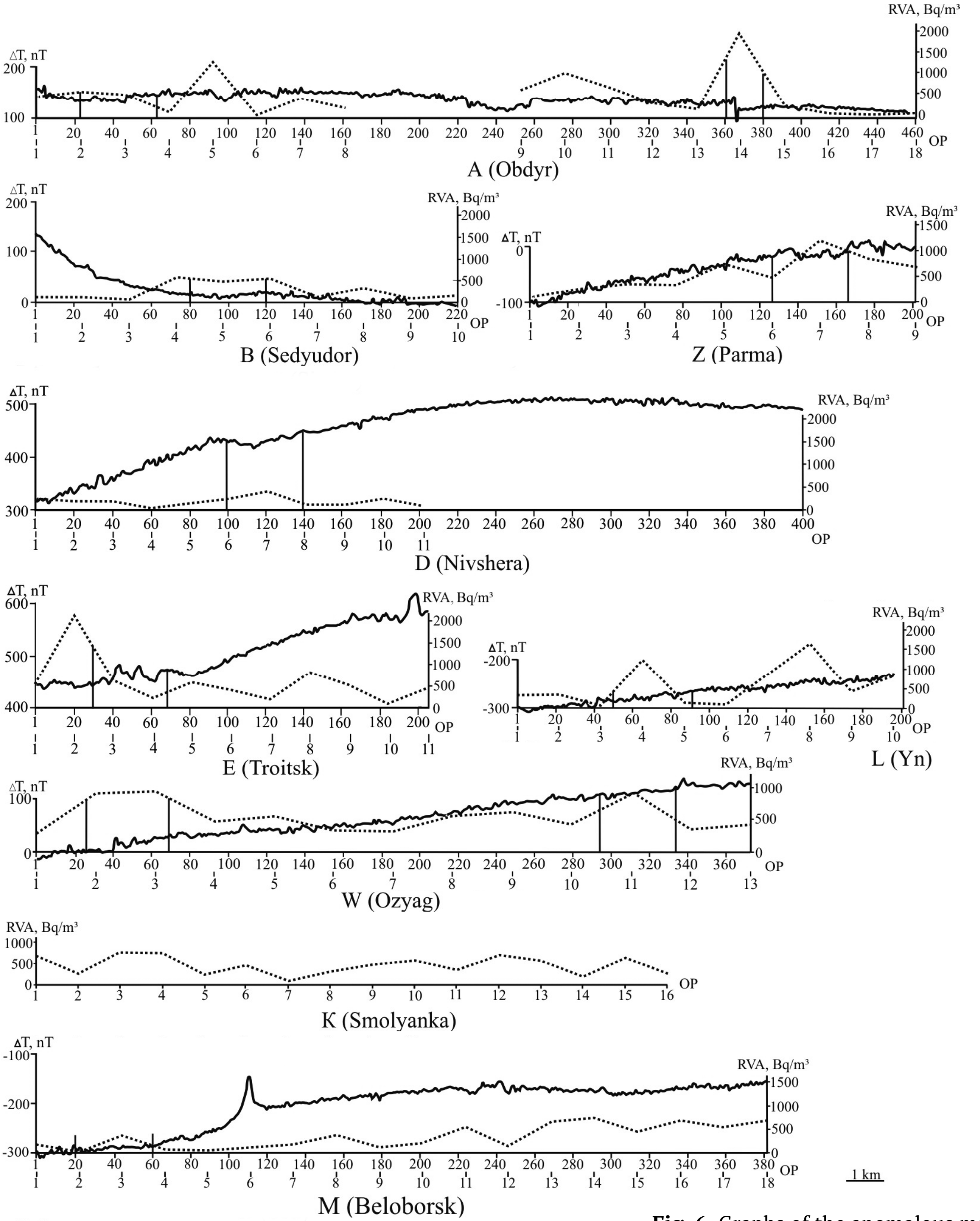
Radon monitoring

Emanation survey is one of the available, express, and cost-effective methods to identify and trace fault zones within platform areas, where faults are covered by a thick nappe [26, 31, 32].

Radon is generated through uranium-238 decay chain producing several isotopes with a long half-life (uranium-234, thorium-230, radium-226) usually found in granitic, igneous, sedimentary, metamorphic rocks, so radon is produced by almost all types of rocks and soils at different depths [37]. In addition, radon-222 is characterized by the longest half-life relative to other isotopes (thoron, actinon), which makes it an optimal indicator for detecting and tracing tectonic faults.

Express radon survey in the West Timan fault was carried out on twelve profiles (Fig. 2—4), which are combined with magnetometricsurvey. A portable radiometer RRA-01M was used to measure the volumetric activity of radon (RVA) in the soil air. At each observation point, a well was drilled with a depth of 50 cm and a diameter of 10 cm. The measurements were express and began immediately after drilling the well. Before each measurement, the system was pumped with ambient air for 4 minutes. The time for sampling soil air with a pump was 4 minutes and 20 minutes for the natural measurement of RVA. A flask with $CaCl_2$ silica gel was used to dry the soil air. Atmospheric pressure, humidity, temperature, and gamma radiation readings were recorded simultaneously with RVA measurements [33].

For a qualitative assessment of RVA, we drew a middle line on the profile graph. For a quantitative assessment, we used the relative indicator of the volumetric activity



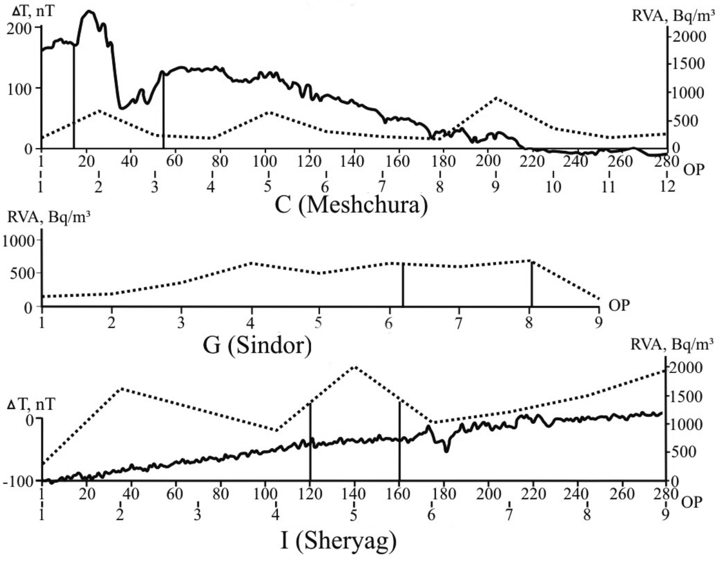


Fig. 6. Graphs of the anomalous magnetic field and the volume radonactivityalong the profile line: A — "Obdyr", B — "Sedyudor", C — "Meshchura", G — "Sindor", D — "Nivshera", E — "Troitsk", W — "Ozyag", Z — "Parma", I — "Sheryag", K — "Smolyanka", L — "Yn", M — "Beloborsk". Continuous line — graph of anomalous magnetic field, scale on the left; dashed line — graph of volume radonactivity, scale on the right; vertical lines — fault zone

Рис. 6. Графики аномального магнитного поля и объемной активности радона вдоль линии профилей: A — «Обдыр», B — «Седъюдор», C — «Мещура», G — «Синдор», D — «Нившера», E — «Троицк», W — «Озъяг», Z — «Парма», I — «Шеръяг», K — «Смолянка», L — «Ын», M — «Белоборск»». Сплошная линия — график аномального магнитного поля, шкала слева; пунктирная линия — график объемной активности радона, шкала справа; вертикальные линии — зона разлома of radon $K_Q = Q_{max}/Q_{min}$, где Q_{max} — the intensity of the near-fault anomaly, Q_{min} is the minimum value of Q directly outside ($Q_{min} = Q_{min1} + Q_{min2})/2$. According to the value of K_Q, discontinuities of ultra-high ($K_Q > 10$), high ($10 \geqslant K_Q > 5$), increased ($5 \geqslant K_Q > 3$), medium ($3 \geqslant K_Q > 2$), low ($K_Q \leqslant 2$) radon activity are distinguished [27].

It should be noted that the measurements on the profiles or their parts were carried out several times (in different years), the average values are given in the paper.

In the Sindor block, located in the north of the work area, radon surveys were carried out along four profiles: "Obdyr", "Sedyudor", "Meshchura" and "Sindor" (Fig. 2).

18 measurements were made along the Obdyr profile. The data range is from 70 to 2074 Bq/m^3. In the western part of the profile, there is a maximum of RVA plot with a value of 1386 Bq/m^3, 2 km east of the supposed location of the fault. In the eastern part, there is also RVA maximum with a value of 2074 Bq/m^3, which corresponds on the ground to the Central West Timan Fault (K_Q = 5.7) (Fig. 6, A).

10 measurements were carried out along the "Sedyudor" profile. The range of RVA values is 70—580 Bq/m^3. The zone of the West Timan fault corresponds to increased RVA values of 480—580 Bq/m^3, (K_Q = 6.3) (Fig. 6, B).

12 observation points were worked out along the "Meshchura" profile. RSA values are in the range of 157—914 Bq/m^3. The fault zone corresponds to the first maximum of RVA values with a value of 559 Bq/m^3, (K_Q = 2.6). Further along the profile, two more maxima are observed, which are already in the Timan thrust zone (Fig. 6, C).

On the "Sindor" profile, against the background of the average line of RVA plot of 245 Bq/m^3, a wide maximum of RVA with values of 500—700 Bq/m^3, K_Q = 1.4 is clearly distinguished, in the eastern part corresponding to the West Timan fault (Fig. 6, G).

In the Nivshera block, which corresponds to the central segment of the fault in the study area, two profiles were worked out, with 11 observation points each.

In the northern part of the block along the "Nivshera" profile, the average line of RVA graph is 180 Bq/m^3, the fault corresponds to RVA peak with a maximum value along the profile of 407 Bq/m^3, K_Q = 2 (Fig. 6, D).

Along the line of the "Troitsk" profile, against the background of rather high values along the middle line of RVA of 600 Bq/m^3, a peak of radon activity with a value of 2144 Bq/m^3 is distinguished, located near the fault zone (Fig. 6, E).

In the Beloborsk block, radon surveys were carried out along six profiles.

The "Ozyag" profile crosses two faults — the Vishera, located within the Vychegda depression, and the West Timan. Both dislocations are clearly manifested in the radon field as increased values with an average line on the RVA graph of 400 Bq/m^3 and maximum values of 949 and 925 Bq/m^3, respectively ($K_{Q(VSH)}$ = 2.6, $K_{Q(WT)}$ = 2.5). In the area between the faults, there is an area with reduced values of radon concentration (Fig. 6, W).

Within the "Parma" profile, the fault is fixed along the middle line of the RVA plot of 500 Bq/m^3 with a maximum value of 1177 Bq/m^3, K_Q=2.6. To the left of the main peak corresponding to the fault, there is another area of increased RVA values 1.5—2 km wide (Fig. 6, Z).

On the "Sheryag" profile, 9 observation points were worked out, the RVA chart is very similar in shape to the Parma profile chart, with RVA maximum of 2010 Bq/m^3 (K_Q=2.1) in the fault zone and a previous increase in RVA values (Fig. 6, I).

On the graph, which corresponds to the "Smolyanka" profile, there is a chaotic change in the concentration of radon in the soil air, where the values vary from 75 to 763 Bq/m^3. This is explained by the fact that most of the profile runs along the fault zone. For this reason, the specification of the location of West-Timan fault turned out to be difficult in this area (Fig. 6, K).

The RVA plot along the "Yn" profile line is characterized by two RVA maxima with values of 1217 and 1590 Bq/m^3, the first of which corresponds to the fault zone, the second is already in the Timan thrust zone (Fig. 6, L). Here the largest value of K_Q = 14.4 is observed.

According to the "Beloborsk" profile in the radon field, the boundary between the Vychegda depression, which is characterized by RVA values reaching only 150 Bq/m^3, and Timan, where differences in radon activity are observed in the range of 380—745 Bq/m^3, K_Q = 2.8 (Fig. 6, M).

Based on the analysis of the express emanation survey data, the following conclusions were obtained:

1. The southern and central parts of the West Timan fault are generally characterized by increased RVA values within 400—2150 Bq/m^3. The RVA plots clearly show an increase in values from the Timan troughs to the Timan thrust, where the radon volumetric activity remains stably high.

2. RVA values for the Sindor block are 70—2074 Bq/m^3, average RVA values are 600 Bq/m^3; Nivshera block — 46—2144 Bq/m^3, average — 670 Bq/m^3; Beloborsk block — 23—2010 Bq/m^3, average — 670 Bq/m^3. The average relative indicator of the volumetric activity of radon in the Beloborsk block is K_Q = 2.0, in the Nivshera block — K_Q = 5.4, in the Sindor block — $K_{Q(south)}$ = 2.0, $K_{Q(north)}$ = 6.0.

3. Considering sections along separate profiles, without being tied to blocks, three areas of increased values are distinguished — 1-Obdyr; 2-Troitsk, Ozyag, Parma, Sheryag; 3-Yn.

4. Soil radon spread beyond the boundaries of tectonic faults due to increased fracturing of the upper horizons of the sedimentary cover; therefore, the width of the radon anomaly always exceeds the width of the fault itself.

Thus, with insufficient seismic knowledge and low differentiation of potential fields, emanation radon survey can be used as an additional method for identifying and tracing tectonic faults.

Conclusion

To solve the tasks, we used a set of standard geophysical surveys, involving detailed magnetic surveys, and also express radon measurements.

Interpretation of these potential fields allowed identifying blocks of different nature of the fields: Beloborsk, Nivshera and Sindor, and the analysis of seismic data — a fault zone with a relatively small error.

Detailed magnetic surveys have shown that it is impossible to trace the West Timan Fault in a magnetic field, both in the gradient areas of the field and within the regional maxima and minima. It can be only noted that the width of the gradient zone is generally less than the zones of maxima and minima. In some cases, it can only be traced along a series of dikes of basic and ultrabasic rocks, but they may not be located in the frontal fault zone.

Express emanation survey showed that the West Timan thrust, in general, is characterized by increased values of radon volumetric activity, where they are further traced to the territory of Timan, while areas of different intensity are distinguished. The survey results allow applying this method as an addition to a set of standard methods for identifying and tracing faults, as well as to judge their activity, and even more in the case of insufficient seismic knowledge and low differentiation of potential fields.

Particular attention should be paid to the Sindor block, where a sharp gradient region is noted in the magnetic field, against which a series of dikes stand out. Also, this zone is characterized by a high K_Q.

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