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USE OF THE LOST SEISMIC INFORMATION ABOUT UPPER PART OF GEOLOGICAL STRUCTURE FOR THE NOT PROSPECTING PURPOSES

Показаны результаты переобработки потерянной в процессе поисков углеводородов сейсмической информации для картирования скоростной характеристики (скорости продольных волн) верхней части геологического разреза для сокращения дорогостоящих инженерно-поисковых работ для промышленного и гражданского строительства и успешного развития точного земледелия на территории нефтегазовых регионов.

Показано результати переобробки втраченої в процесі пошуків вуглеводнів сейсмічної інформації для картування швидкісної характеристики (швидкості поздовжніх хвиль) верхньої частини геологічного розрізу для скорочення дорогих інженерно-пошукових робіт для промислового та цивільного будівництва та успішного розвитку точного землеробства на території нафтогазових регіонів.

The results of reprocessing of the lost (in hydrocarbon prospecting process) seismic information for the mapping of velocity characteristic (velocity of longitudinal waves) of the upper part of geological structure for reduction of expensive engineering-prospecting works for industrial and civil construction and for successful development of precise agriculture on the territory of oil and gas regions is shown.

Introduction

The oil and gas regions of Ukraine and Russia is densely covered with geological-geophysical prospecting, including seismic survey for the hydrocarbon prospecting purposes. This information may be used not only for the geological prospecting purposes, but also for drawing up projects for carrying out engineering-prospecting works for industry and agriculture. It is traditionally considered that the upper part of a geological cross section has no the useful prospecting information and it's only hindrance in seismic data processing and integrated interpretation of geologic and geophysical data. But other opportunities may be realized.

Main objective is reprocessing of the last seismic data of hydrocarbon prospectings for the mapping of velocity characteristic of the upper part of geological structure for reduction of expensive engineering-prospecting works for industrial and civil construction oil and gas regions and for the spatial prognostication of changes of humidity of soil and subsoil layers for implementation of precise agriculture.

Processing of velocity data about the upper part of geological structure

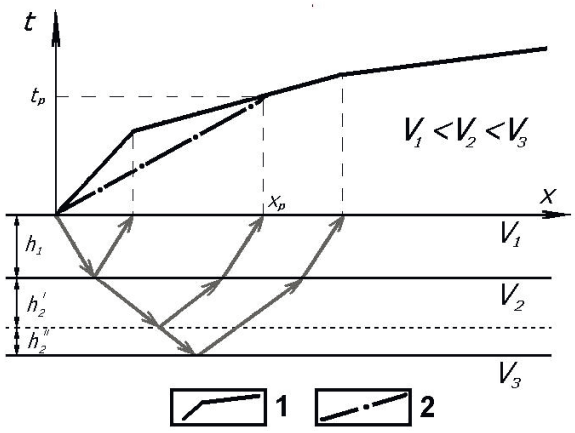


Fig. 1. Refraction travel-time curves of the first wave arrival from model section (1) and conditional layer (2).

This is determination of velocity characteristic of the upper part of a geological cross section for any seismic systems and energy sources (up to depth of tens of meters) without any additional special works in this part of geological section. The process is based on use of estimation of average velocity at the upper part of a geological cross section (up to depth h_1+h_2', see Fig.1). The estimation of average velocity is carried out on times of the first wave arrival from the common range trace section on the distances, commensurable with thickness of the upper part of geological structure. The process uses the times of the first wave arrival of any types of registered waves (refracted, reflected etc.) and does not depend on curvature of borders of the investigated upper part of geological structure. For the mapping the results of calculations of estimated velocity in real points of geophysical surveys are interpolated to a regular grid.

This technology (on the basis of 2D and 3D seismic surveys of method common-depth point – CDP) was successfully applied on territory of North-West Siberia, where the upper part of a geological cross section consists from low-velocity top part of near surface layer and high-velocity upper part of thick permafrost layer (up to depth of 500 meters) with vertical and horizontal "mosaic" structure [1].

The mapping of velocity characteristic of the upper part of geological structure (on an example of North-West Siberia)

North-West Siberia is one of the most important Russian oil and gas regions. Now Russia satisfies 25 % of world demand for natural gas and 10 % – for oil and the main further prospect is development to commercial level of the production capacity of hydrocarbon deposits of North-West Siberia and Arctic off-shore. By 2020 in Russia the production of natural gas is planned at the level of 750 billions m3, from which 175 billions m^3 will be from new gas region – Yamal peninsula (North-West Siberia). Already about two hundred hydrocarbon deposits are found here. The huge reserves of natural gas (~42415 billions m^3) are concentrated on the territory of North-West Siberia. The development to commercial level of the production capacity of new hydrocarbon deposits of Yamal peninsula is the important step on way to the Russian Arctic off-shore (6,2 millions km^2) with total prospective reserves – 15,25 billions tons of oil and – 84500 billions m^3 of gas.

The large-scale industrial opening up of this region is impossible without construction of new objects for production, processing and transportation of hydrocarbon (not only on West, but also through East Siberia to China, Southern Korea, Japan) and also development of railway, auto and other transport networks. These objects will steadily function only if their foundations will be designed on the depths, where the temperature mode is saved within all year and density does not change. Many accidents and damages took place during last years at North-West Siberia because of unexplored heterogeneity of the upper part of a geological cross section – permafrost layer and first of all because of thawing of this layer under the foundations of different engineering objects. For the estimation of suitability of concrete site of permafrost layer for the construction (structural-tectonic conditions of the site, stable foundation, ability to deformation and

filtration etc.) is possible to use the near surface geophysical information – seismic data about the velocity characteristic of this layer.

The North-West Siberia is densely covered with geological-geophysical prospecting. There are ~16 thousand prospecting wells (total depth ~40 millions meters) and 63 thousand 2D seismic survey profiles (total length ~1,25 millions kilometers) on this territory already. By reprocessing of 2D seismic data for last 15-20 years the map of longitudinal waves velocities at the upper part of geological structure (scale 1:200000) is constructed for the most part of territory of North-West Siberia [1]. Now the map is ready on territory ~37,5 thousand km^2 (Fig.2).

Interpretation of velocity data about the upper part of geological structure with heterogeneous thick permafrost layer

The sites of the increased thickness of a permafrost layer (sites with increased velocity of longitudinal waves) and the sites of its almost complete absence – so-called "the zones of thawing" (sites with the lowered velocity) are well shown on our map of velocity characteristic of the upper part of geological structure. "The zones of thawing" spatially coincide with some meandering rivers (in conditions of North-West Siberian marsh tundra) or with much traffic railways and motorways. The fragment of regional map of velocity of longitudinal waves at the upper part of geological structure along railway line Novy Urengoy – Nadym is illustrated on Fig.3*a* (light points). This line is located on border "zone of thawing" and frost zone. As a result deformations of the railway often take place because of seasonal and century fluctuations of temperatures. On this part of the railway line the constant speed restriction (no more than 20-30 kms/hours) is

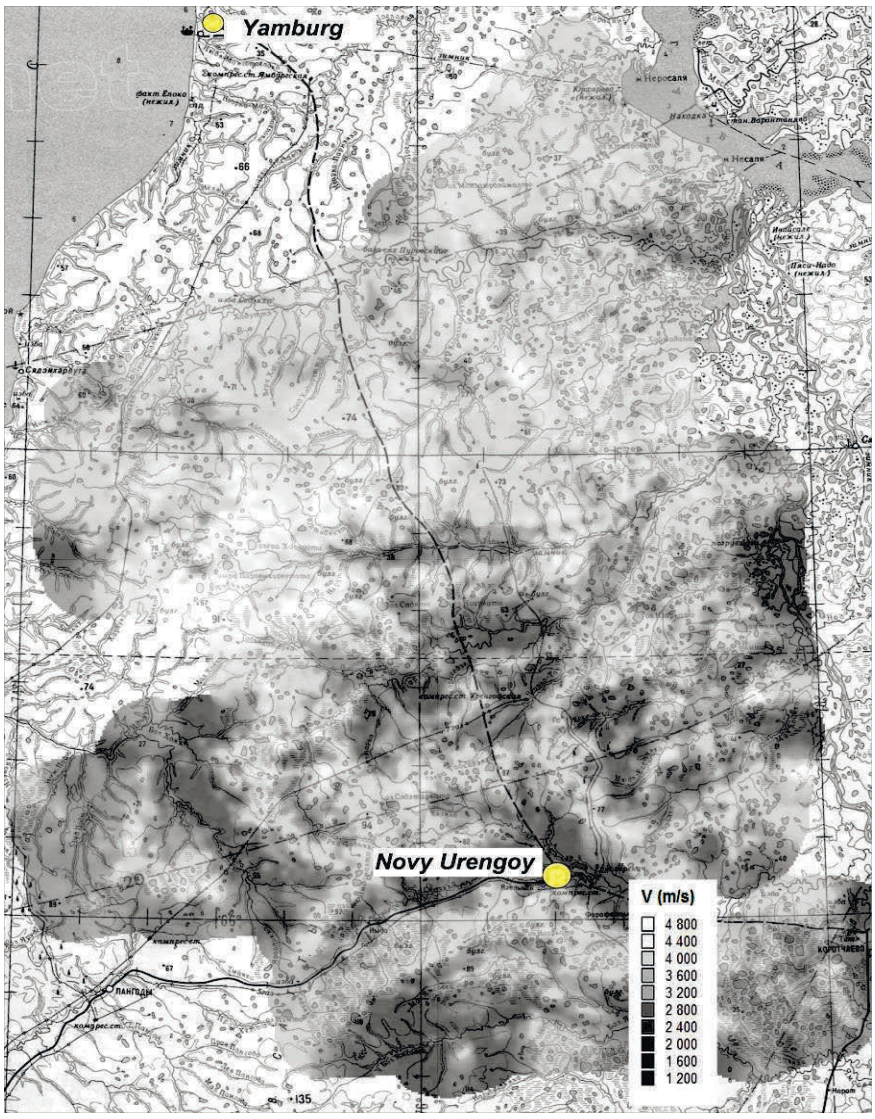
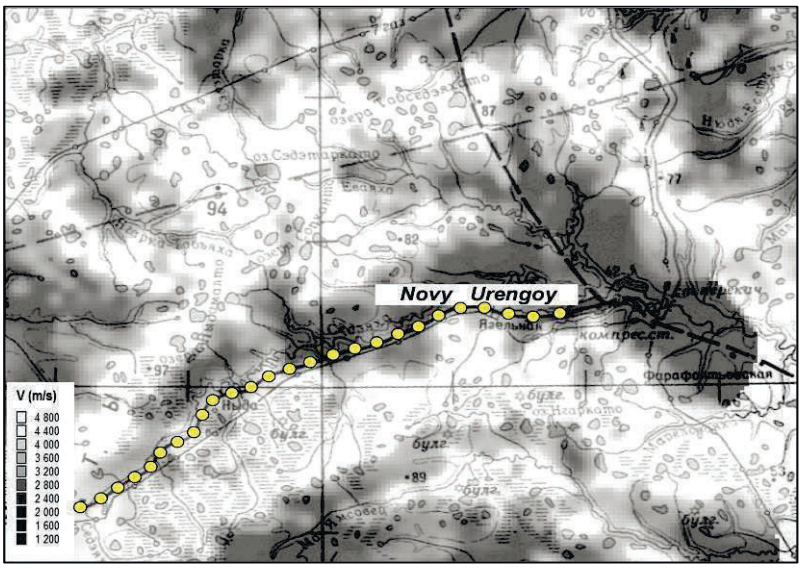


Fig. 2. The territory of North-West Siberia with already of available regional map of velocity of longitudinal waves at the upper part of geological structure

ordered because of possible deformations of the way and wrecks.

And also some “the zones of thawing” are the large territories with borders, which do not coincide with the rivers. It may be the display of some tectonic blocks of Earth crust, which have various modern geodynamic characteristics. (The fragment of the map of velocity characteristic of the upper part of geological structure, where territory along the rivers is not “the zone of thawing”, but even frost zone in river-heads is shown on Fig.3*b*.) It is the additional opportunities for mapping of fault-block tectonics of the region and estimation of the appropriate hydrocarbon prospects [2]. The earth's crust (lithosphere) is cut by the systems of subvertical faults having complicated hierarchy, starting with planetary faults and down to faults confining the blocks to several kilometers and even several meters.

a



b

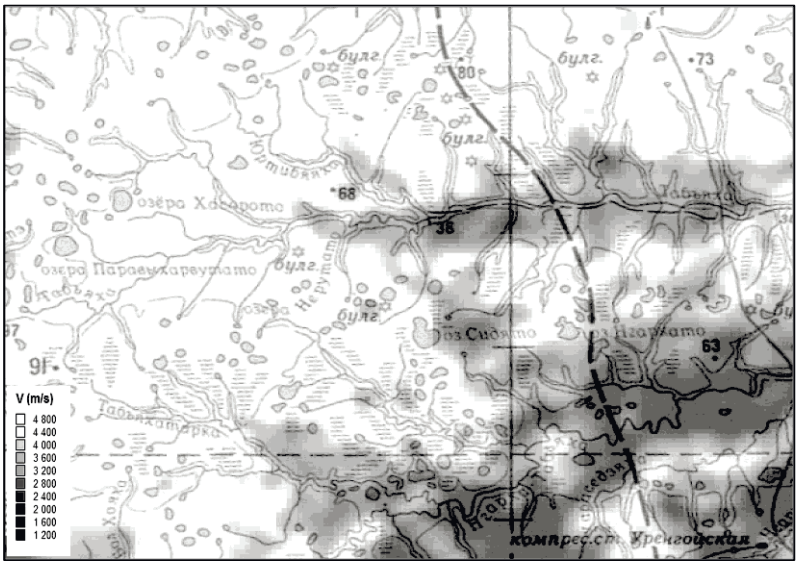


Fig. 3. The fragments of regional map of velocity of longitudinal waves at the upper part of geological structure: along dangerous part of railway line Novy Urengoy – Nadym (*a*) and along the rivers with absence of “the zones of thawing” (*b*).

The intersection of faults of various ranks and directions results in very mixed picture of lithosphere blocks, the horizontal dimensions of which are incomparably small with respect to the vertical ones. The analysis of geomorphological indications of the revealed faults has allowed to determine their fragments, which stirring up at the newest time. The important role of the tectonic information in researches of the top part of a geological section, soil and vegetation is possible to illustrate with results of previous researches. The interrelation of radioactive pollution of the upper part of geological structure, vegetation and agricultural goods, superficial and underground waters with Precambrian bedrock faults on the example of Kirovograd region of Central Ukraine (main center of uranium mining in Ukraine) was earlier shown [3].

The determined velocity characteristic of permafrost layer at the upper part of geological structure also represents potential interest for researches of gas accumulation in this layer. The total prognosis of gas resources in permafrost layer in Russia (for local gas supply in Arctic regions) are ~17000 billions m^3 [4].

The map of velocity characteristic of the upper part of geological structure (based on seismic data densely covering the territory) is easily recalculated to the density (durability/stability) and engineering characteristics. It isn't only significant reduction of expensive engineering-prospecting works for construction of new industrial and civil objects, but also essential increase reliability and completeness of the initial data for drawing up a projects for carrying out these works, and also for prognosis negative ecological influences of the projected objects and organization of system of geoecological monitoring in the natural-technogenous conditions of Arctic North.

The choice of concrete sites (outside of "the zones of thawing") for construction of objects of an industrial infrastructure (objects of support of drilling and preliminary processing of gas, underground gas storehouses, minifactories of the liquefied gas etc.) with social-civil objects is prime modern tasks of industrial opening up of new gas region – Yamal peninsula. However regional seismic data CDP of 2D is not enough for the complete solution of these tasks. And the use for mapping of velocity characteristic of the upper part of a geological cross section of the detailed seismic data CDP of 3D (the network of profiles (300-500)×(400-500) m, nominal overlap 30×-42× for bins 25×25 m) is necessary. The map of velocity characteristic of the upper part of geological structure on a basis of the detailed seismic data CDP of 3D is by much more detailed (Fig.4).

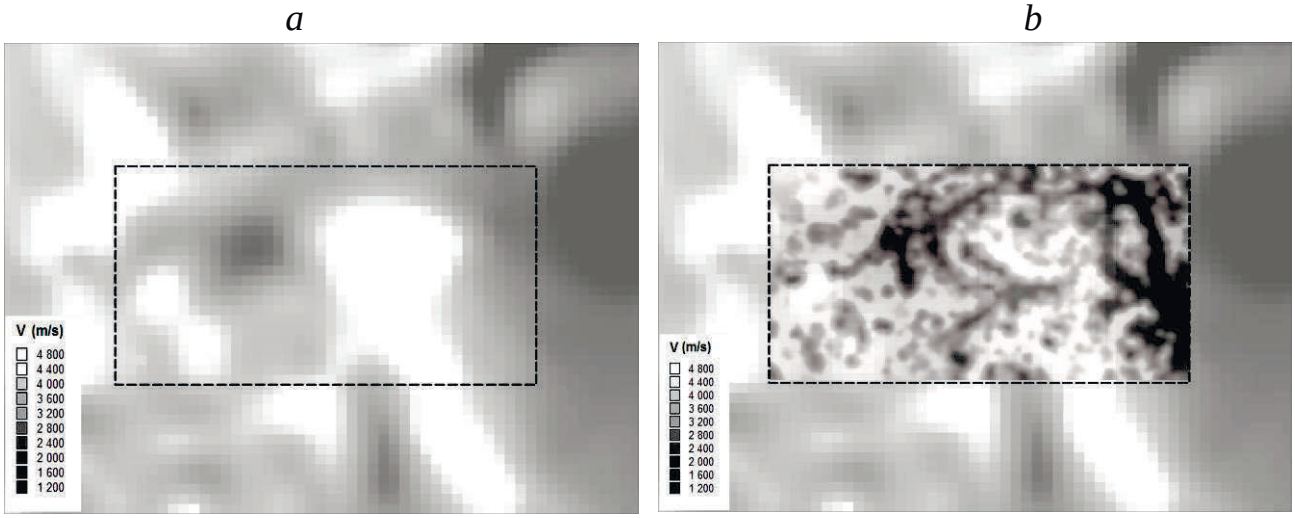


Fig. 4. The fragment of regional map of velocity of longitudinal waves at the upper part of geological structure on the basis of seismic data CDP of 2D (*a*) and the central part – of 3D (*b*).

Such detailed maps already begin to be used for planning lines and stations of railway, motorways and gas pipelines (with compressor stations) outside of “the zones of thawing” or with the minimal crossing with them. Also these detailed maps are used for the choice of concrete places for construction of railway bridges outside of “the zones of thawing” of the river-bed without erection of local dams for

construction of bridge piers (only with drilling of bore holes up to depth 20-40 m in permafrost). It is more economically and also saves ecosystem of the rivers.

The customer of the mapping of velocity characteristic of the upper part of geological structure may be not only regional and local governments, but the oil and gas companies, which earlier ordered seismic researches on own license sites. It's the real opportunity of essential economy in these companies with engineering researches for the subsequent construction of industrial and transport infrastructures. And as a result it is increase of profitability of the hydrocarbons production projects and reduction of the price of oil and gas not only in conditions of North-West Siberia, but also in other regions with Arctic climate, including Alaska (Northern America).

Use of the mapping of velocity characteristic of the upper part of geological structure for development of precise agriculture

The map of velocity characteristic of the upper part of geological structure (based on seismic data densely covering the steppe agricultural territories of Ukraine and Russia) is easily recalculated to the density and humidity. Therefore new perspective way of use of the maps is an agriculture of steppe zones and, first of all, precise agriculture. Here with these maps the research and spatial prognostication of changes of humidity of soil and subsoil layers (both on a horizontal and up to concrete depth) is possible. For these purposes the estimation of average velocity at the upper part of a geological cross section on times of the first wave arrival from the common range trace section on the different fixed distances are used. It allows to research features of a structure of the upper part of geological cross section on concrete depths (really – up to these depths). The comparison and joint research of the appropriate maps of velocity characteristic of the upper part of geological structure enables to define and to predict spatial changes of humidity and to find out its sources (origin): natural (including tectonic) or technogenous – for planning and realization of agricultural activity.

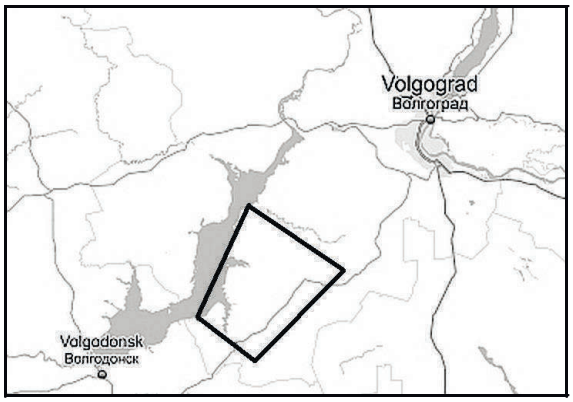


Fig. 5. The site of researches of velocity characteristic of the upper part of a geological cross section at the central part of the Volgograd region.

Mapping and interpretation of velocity characteristic of the upper part of a geological cross section may be shown on an example of the central part of Volgograd region (Fig.5) – one of the agricultural leaders of Russia [5]. The soil-climatic conditions and large sizes of farmland the Volgograd region (total area of the land – 8,8 millions hectares, including – 5,9 millions hectares of ploughed field) allow actively to develop here powerful agriculture. High potential for the further increase (annually on 5% till 2025) of agricultural production takes place here. But the region is located in a zone of risky agriculture because of a droughty climate. And one of the most critical factors, which constrain development of an agriculture in this region, is a small area of irrigation (only 2,5% of farmland). The significant development of irrigation systems is necessary.

The sites with the increased humidity are displayed on the map by anomalies of increased velocity of longitudinal waves at the upper part of a geological cross section. As a rule it is lowered sites of rivers valleys. Towns and villages (with traditional problems of technogenous raising of underground waters level) increase intensity and area of these anomalies (Fig.6). Higher and more dry sites (on a natural status) are displayed on the map by anomalies of the lowered velocity of longitudinal waves at the upper part of a geological cross section. The new sites of abnormal humidity of technogenous origin are well shown on this background by changes of the velocity characteristic of the upper part of a geological cross section. The zones **A** of lowered velocity on height slope (Fig.6) are sites of draining influence of main irrigation channel.

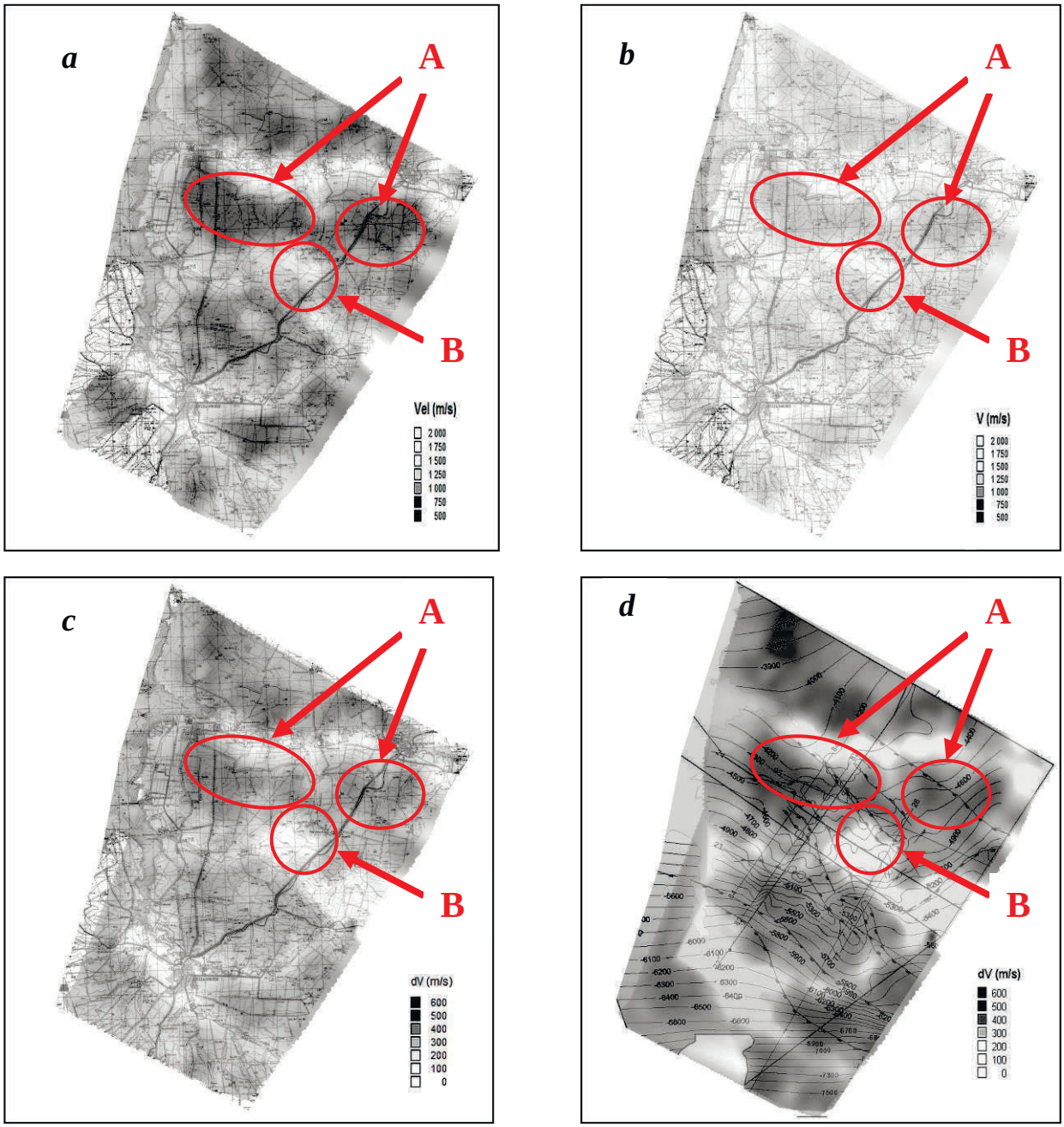


Fig. 6. The fragments of map of velocity of longitudinal waves at the upper part of geological structure up to depth ~10-15 m (*a*), ~40-45 m (*b*), in an interval of depths from 10-15 m till 40-45 m (*c*), the same with basic structurally-tectonic features (*d*).

The contrast of these anomalies decreases with increase of depth of research (Fig.6,*a*,*b*) because their sources is very close to a surface. Also it is illustrated on Fig.6,*c* by significant anomalies of a difference of velocity on small and large depths. And the zone B at the upper part of height is characterized of the increased velocity (and accordingly – increased humidity) because of a site on the tectonic block limited to northwest faults (Fig.6,*d*). Here difference of velocities on small and large depths (as well as for abnormal sites of valleys of the rivers along the basic fragments of faults) changes a little.

Conclusions

The upper part of geological structure is not only complication at processing the geophysical information, but also it's the source of useful near surface geophysical information for drawing up projects of construction of objects of industrial, transport and social infrastructures, effective development of an agriculture and first of all precise agriculture.

On a basis of reprocessing of past seismic data we constructed the maps of longitudinal waves velocity at the upper part of geological structure for the territory of most part of North-West Siberia, where the increased velocity show the sites of increased thickness of permafrost layer and the lowered velocity – so-called "the zones of thawing". The maps are the real opportunity to reduce expensive engineering-prospecting works for industrial and civil construction on areas of hydrocarbon deposits of North-West Siberia and they may be used for the prognosis of ecological influences of projected industrial and transport objects.

Also we constructed the same maps of longitudinal waves velocity at the upper part of geological structure of farmland. These maps may be used for the spatial prognostication of changes of humidity of soil and subsoil layers. And they are real preconditions for successful development of precise agriculture and the opportunity to pay back the appropriate expenses in short terms.

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