

Prediction of Methane Emission Out of Seams on The Basis of Geodynamic Deposit Zonation

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ABSTRACT. By the results of geodynamic zonation of coal deposits in the south-eastern part of Kuzbass the districts of predominant compression (domes), of extension (subsidence troughs) and of areas separating them are rather confidently delineated. Within them the rock mass is under relatively stabilized state.

The discovered regularity for the zones of dome and subsidence trough has the obvious explanation. As a result of geodynamic peculiarities of relief formation: the horizontal compression is accompanied with "hummocking" of lithosphere blocks with the alternation of the districts of predominant compression or extension.

Localization and characteristics of geodynamic processes on the territory and in the mines of Kuzbass including geodynamic deposit zonation are being done on the basis of geoinformation system (GIS) "Geodynamic phenomena in Kuzbass". Information system of geodynamic phenomena in Kuzbass presents itself an automated system of data base and electronic cards of natural and technogenic phenomena.

I INTRODUCTION

Methane content of coal deposits in Kuzbass grows in conformity to the increase of degree of metamorphism of coals and reaches the maximum in hard coal 10A. This relationship is based on the analysis of the search results for coal deposits and was the basis for the estimation of predictive resources of methane in the Basin and for the choice of more perspective districts within it (Erunakovsky, Tersinsky, Tom-Usinsky, Mrassky). There are some reasons to consider that the output of the operating holes in the designed coal-gas works and the degree of danger of gas-dynamic phenomena in the mines are determined with modern geodynamics-characteristics of spatial strained - deformed state of carbonaceous rock in the rock mass.

2 GEODYNAMIC STRUCTURES OF MINE TAKES OF COLLIERIES AND GAS CONTENT OF A SEAM

By the results of geodynamic zonation of coal deposits in the south - eastern part of Kuzbass the districts of predominant compression (domes), of extension (subsidence troughs) and of the areas separating them are confidently enough contoured. Within these areas the rock is under the relatively stabilized state. The detailed elaboration of

geodynamic reconstructions within mine takes of collieries Alardinskaya, Tomskaya, the Shevyakov showed that maximum gas content and the manifestation of dangerous gasdynamic phenomena as a result are typical to neotectonic domes having been formed under the conditions of horizontal compression of rock mass. The subsidence troughs are characterized with minimum gas content. The example of the geodynamic zonation of "Alardinskaya" mine's field is presented in figure 1.

The exposed relationship for the zones of dome and subsidence troughs has the obvious explanation as a result of geodynamic peculiarities of relief formation: the horizontal dome is accompanied with "hummocking" of the lithosphere blocks with alternation of the districts of predominant compression or extension. The extension along the vertical axis corresponds to the horizontal compression and vice versa. Therefore within the domes there is a possible formation of subhorizontal cavities of exfoliation of coal -bearing deposits in which the concentration of free hydrocarbon gases can be formed. As a result of the predominant compression of coal-bearing rock along the vertical axis subsidence troughs being exposed to natural degasification serve as an additional source "alimentation" with free methane for adjacent domes. One can suppose that natural "pump" which provides the methane migration along the lateralia

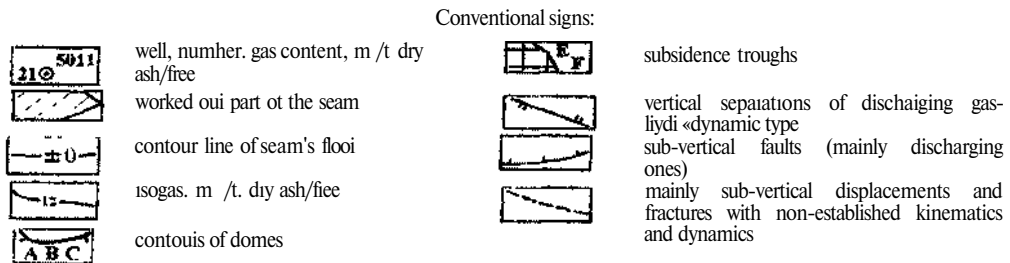
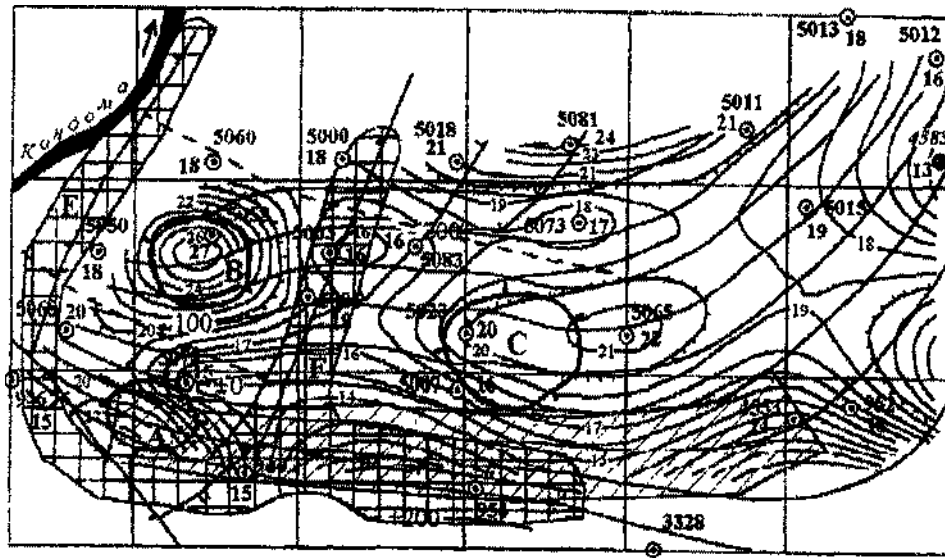


Figure 1 Results of geodynamic zonation of the field of mine "Alardinskaya" (seam 3 - 3').

out of the subsidence troughs into the domes is the creep movements of earth's crust, the phenomena of earth's tides, other seismic and geodynamic phenomena.

The model of the mechanism of dome formation is presented in figure 2, and the calculations made by means of final elements for two-dimensional computer models corroborated the possibility of dome formation and open cavities under them. The upper boundary of gas-bearing domes is from 250 to 300 meters, the depth of the deposits can have several hundred meters of coal-bearing formations. The domes and subsidence troughs are low amplitude neotectonic structures.

The amplitude of the domes (gas reservoirs) in the districts of mine fields of collieries Alardinskaya, Tomskaya, the Shevyakov is from 1,0 to 3.0 m. The amplitudes of the shift of neotectonic upthrow faults into the domes didn't exceed 1,0 - 2,0 cm.

The dynamic activity of these structures was studied with the method of the registration of natural impulse electromagnetic radiation of the rock by

means of VNIMI hardware of type "Impulse". The investigations were carried out with the method of dipole electromagnetic profiling on the surface and under the underground conditions in the workings contouring the longwalls.

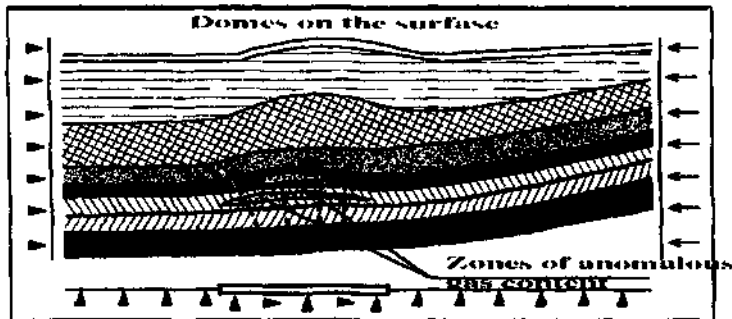
As a result of studies more than 5000 measurements were selected:

- zones of compression (domes) having permeability close to zero;
- inclined upthrow faults, thrusts and underthrusts (mainly filming).

The increase of gas content per 40 - 70 percents is typical for these structures.

The structures with low methane content are:

- zones of extension (subsidence troughs, mines "Alardinskaya", the Shevyakov);
- vertical separations of discharging type (mine "Alardinskaya");
- vertical separations of infiltrated type (mine "Tomskaya");
- subvertical faults (mines Alardinskaya, Tomskaya, the Shevyakov).



- Signs
- ▲ fixation of vertical displacement
 - ← fixation of horizontal displacement
 - ▭ rigid blocks of substratum basement
 - ▨ zones of anomalous gas content
 - — — displacements or upthow overfaults inside the dome structures

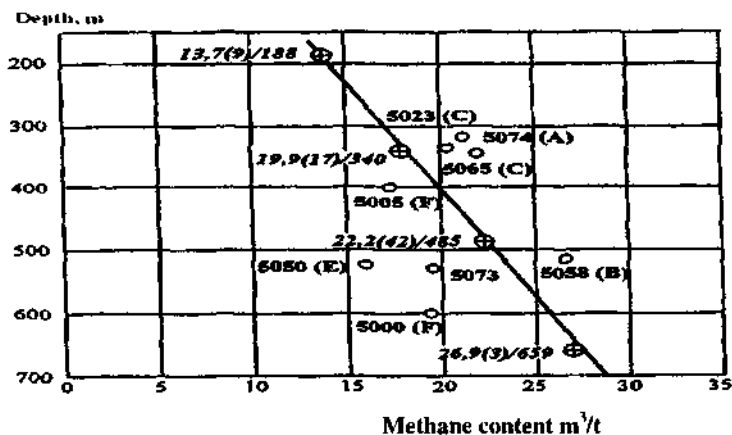
Figure 2 Model of mechanism of loimation of dome (compicssion /ones) and subsidence Houghs (extension zones)

For these structures the decrease of gas content 50 - 70 percents is typical. It is horn expected gas content according to the traditional prospecting estimations (according to the charts "methane" - "the depth of sampling selection")

In Figure 3 the chart of change of the depth of the gas content of seam 3 - 3¹ in mine "Alaidinskaya" in

the district where mining operations are being conducted is presented. In table I there are the data of the sampling of gas content of seam 3 - 3 in the district of the active structures geodynamically pointed out.

It is seen in Figures 1, 3 and Table 1 that between the indicators of gas content and the position of



Signs

○ average methane content (quantity of used samples) average depth of selection

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○ 5000(F)

position of the sample on the chart number of the well and belonging to dome (A B C) or to subsidence trough (E F)

Figure 1 Combined chart of change of the depth of the gas content of coal seams and the position of sampling points on gas of seam 1 - T' (field of mine Alaidinskaya) on domes (holes 5074 5058 5065 5021) on intermediate structures (hole 5071) and on subsidence troughs (holes 5050 5005 5000)

Table I Content of methane in seam 3-3¹ m separate geodynamic structures on the field of mine "Alardinskaya"

№ item	Number of well	Depth of sampling selection, m	Content of methane, mVt
Domes (zones of compression)			
1	5074	300	20,1
2	5058	518	27,4
3	5065	391	21,5
4	5023	368	20,4
Intermediate structures			
5	5073	529	17,3
Subsidence troughs (zones of extension)			
6	5050	508	16,0
7	5005	412	18,0
8	5000	581	17,7

boundaries of the structures being pointed out there is rather a convincing correlation:

- anomalously indicators of gas content corresponds to the zones of compression (domes);
- anomalously value of gas content corresponds to the zones of extension (subsidence troughs).

Dome "A" in fig 1 uncovered with workings is characterized with such intensive absolute and relative gas content (up to 40 m³/t) - that a three - year complex of operations was required to degasificate the district of seam 3 - 3¹ which is prepared for working.

Dome "B" is uncoved with hole 5058. According to the calculated data of the chart in fig. 3 the value of gas content was to be expected within 21 m³/t. The actual data of sampling were 27,4 m³/t.

Dome "C" is uncovered with holes 5023, 5065, sampling selection on gas content gives value 20-22 m³/t, according to the chart in fig.3 the value was to be expected 16 m³/t.

In the zones of extension (subsidence troughs), there is low gas content, so in the extension zone "E" instead of expected gas content 23 m³/t, 16 m³/t was received with actual sampling (hole 5050).

Within the extension zone "F" due to the samplings of holes 5000 and 5005 gas content of the seam was 16 and 18 m³/t instead of 17.7 and 24 m³/t which were expected due to the chart (fig.3).

Thus the results of geodynamic zonation being done by means of methodics of VNIMI allows to determine linear and area structures promoting to preserve and to accumulate the methane in the coal rock mass. i.e. to give the possibility to predict the location of gas reservoirs.

To the structures with increased methane content in coal seams are referred:

- the districts with low level of stress, characterizing the subsidence troughs, in these districts the intensity of radiation "N" was from 0 to 200 imp/min;
- the districts of unstable rock mass state (according to the series of repeated observations).

corresponding to the zones of transition from the domes to subsidence troughs "N" = 200-600 imp/min;

- the districts of anomalously high intensity of impulse electromagnetic radiation ("N" >600 imp/min) corresponding to high level of stress in the rock mass-districts of the domes. In the district of mine "Tomskaya" "N" reached 1000 imp/min;
- the districts of spasmodic changes of radiation level characterizing the boundaries of structures and active fractures.

The checking of the results of geodynamic prediction in reference to the tasks of the estimation of natural seam gas content is carried out over the sampling data at the exploratory drilling and at the gas content data of development workings and worked out faces in mines Alardinskaya, Tomskaya, the Shevyakov.

3 COMPLEX OF MEASURES FOR GEODYNAMIC ZONATION AND PREDICTION OF NATURAL GAS CONTENT

Taking into account all these we consider that before to start the construction of the mine (a block, a flank) geodynamic zonation of deposits must precede the map development of gas content, the planning of degasificated measures

From the example of mine takes of collieries Alardinskaya, Tomskaya, the Shevyakov it is seen that the most dangerous complications of coal mining conditions, being caused with anomalously high seam gas content are connected with neotectonic fractures, with the zones of linear concentration of dynamic stress in rock mass, and also with low amplitude neotectonic fold structures; subsidence troughs and domes. In principle the mentioned neotectonic categories can't be registered with a borehole exploration and are established only by means of geodynamic zonation with the use of special methods of investigation. Such investigations

are: special methods of processing of structural hypsometric surfaces of modern relief, the interpretation of aerial space photographic materials, conjugated analysis of received mapping data with the use of geological and geophysic materials, the calculation of derivative features for final geodynamic map development, carrying out the complex of field geological, geophysic, gas-hydrodynamic observations for the verification of the positions of active fractures and for the delineation of potentially dangerous districts. The mentioned complex of operations under the most responsible situations can be added with volumetric mathematic modelling of strained-deformed state of rock.

The experience of work in geodynamic zonation testifies the necessity of the fulfilment of such zonation with the method of consistent detailization of the scales: a coal basin, a coal district, a coal deposit, a mine take of the colliery. Some individual methods of geodynamic zonation are effective and at more detailed forecast can be used for panels and their separate parts. Acceptable results of the detailed forecast can be received at the additional certification of the predictive constructions by means of VNIMI seismoacoustic hardwares on the surface and in the development workings contouring the panel.

At the map development of gas content and planning of degasificated measures and also at the organizing of methane mining in the coal deposits it's necessary to count up the results of the geodynamic zonation. The first and the main measure in this direction is to organize the work in geodynamic mapping of Kuzbass territory, which is still in the very initial stage. Less then 10 - 12 % of coal deposits are covered with the survey, the scale is 1 : 25000, with the technological scales, accepted for the underground operations (1 : 5000) is much less.

4 INFORMATION SYSTEM OF GEODYNAMIC PHENOMENA IN KUZBASS

One of the first measures in the information systematization of geodynamic zonation in Kuzbass is the creation of information systems of geodynamic phenomena.

Information system of geodynamic phenomena in Kuzbass is a final part of the monitoring system of geodynamic phenomena on the area and of geomechanic (including geodynamic) manifestations in the mines of Kuznetsk Basin. The monitoring system being worked out is a complex system of the regulated observations, the estimation and the prediction of the mining, physico-technical phenomena including geomechanic and geodynamic ones.

The information system of geodynamic phenomena in Kuznetsk Basin presents an automated information system of electronic cards and data base of various geodynamic phenomena, which take place on the area and in the mines of Kuznetsk Basin.

Electronic cards being used in the system are based on the digital electronic geographical map of Kuznetsk Basin. The digital electronic geographical card is developed from the geographical map the scale of which is 1:500 000 and contains geographical system of coordinates (from 52 to 57 degrees of North longitude and from 84 to 90 degrees of East longitude), the biggest town and populated areas of Kemerovskaya region;

- water basin of river Tom with tributaries;
 - coal industrial districts and coal reserves of Kuznetsk Basin;
- " functioning and closed coal mines and opencasts of Kuzbass;

Information system of geodynamic phenomena in Kuznetsk Basin consists of three blocks, which are realized with data base of given phenomena and electronic cards:

Block 1. «Geodynamic zonation of Kuznetsk Basin area».

The electronic cards of this block show the locality of tectonic fractures, the boundaries of the blocks and the zones of various geodynamic activity in Kuzbass. In Figure 4 is given the model of the map of geodynamically active zones in Kuzbass.

Block 2. «Great geodynamic natural and technogenic phenomena on the area of Kuznetsk Basin» includes the data base of phenomena:

- «historical» earthquakes from 1734 to 1943 years;
- modern earthquakes from 1943 to 2000 and 2001 years;
- industrial explosions, mining tectonic rock bumps and sudden coal-and-gas outbursts.

Kuzbass is a modern seismoactive region, where about 20 big earthquakes with amplitude of 3.6 - 6.5 took place during the last 200 years, and annually hundreds of earthquakes with less amplitude are fixed; the most part of them presents itself technogenic seismic events connected with active exploitation of Kuzbass bowels. The considerable increase of quantity of technogenic phenomena is registered during the last decade.

Great geodynamic phenomena are determined with event time, a co-coordinate and phenomena power. On the basis of data base the electronic cards of geodynamic phenomena are built and the estimation of phenomena is made. The construction of the electronic cards is being made with the

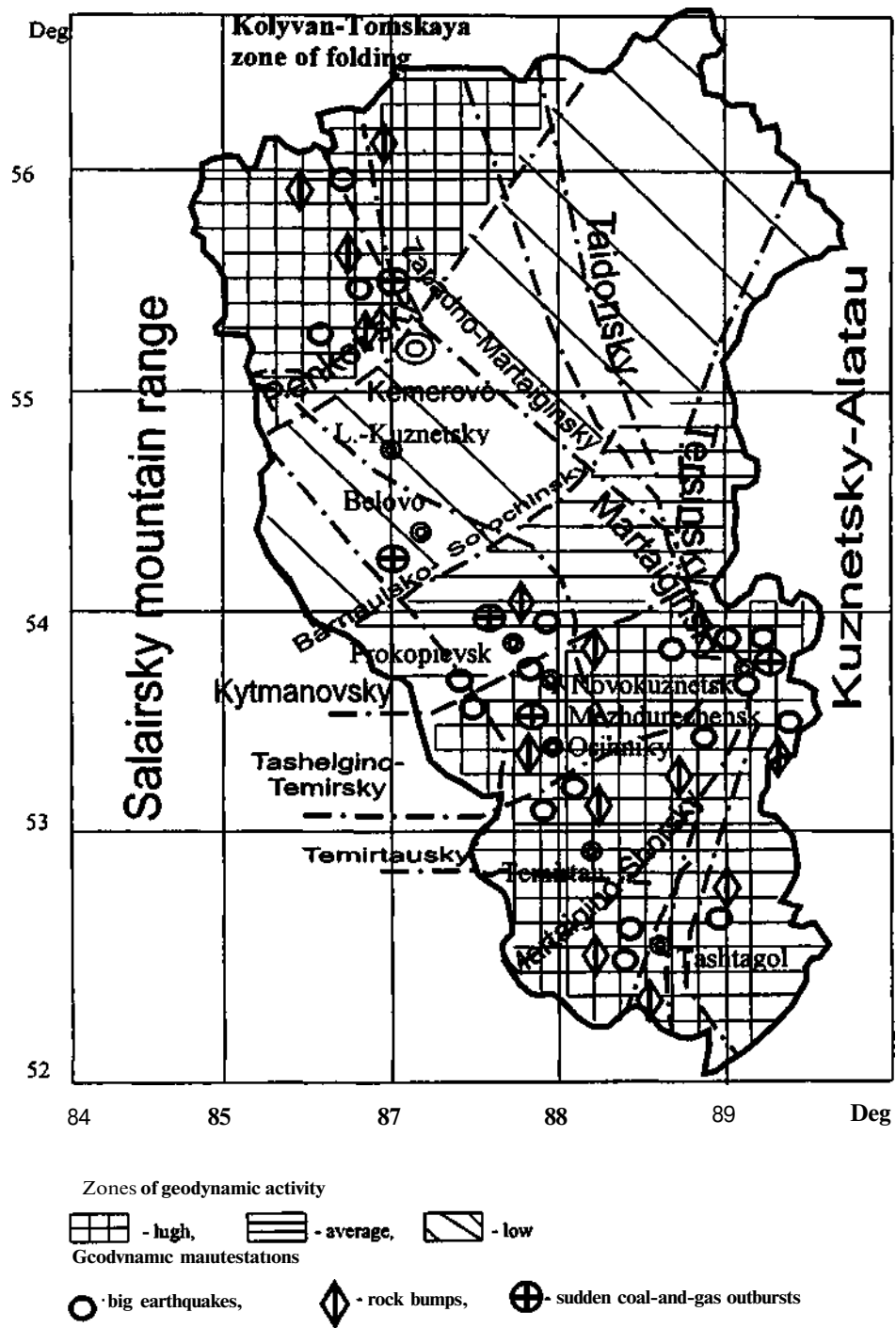


Figure 4 Map of geodynamic activity of Kuzbass

Taking into account the big historical earthquakes, the biggest part of Kuzbass area up to 2000 year related to the hexagonal zone of tremor according to the map of the seismic zonation. Since 1898 the big earthquakes (as seen in Figure 4.) are registered in the locality of Novokuznetsk. Here the biggest natural Kuznetsk earthquakes in Kuzbass took place (1898, 1903, 1966 years) and also recent Prokopyevsk and Mezhdurechensk earthquakes (1995 and 1998 years) a monoseismic reply for the nature of which isn't received yet. By the present time on Kuzbass area 853 natural earthquakes have been registered, energetic class "K" from 7 to 15.

Block 3. "Rock bumps in the mines of Kuznetsk Basin."

The block contains the data base of rock bumps, which have taken place in the mines of Kuzbass since the moments of their origin. On every rock bump is given the information about the association, the mine, the time and the place where the bump has taken place, about the depth, the seam's data, the characteristic of adjoining rock, the position of mining operations at the moment of the bump, about the phenomena preceding the bump, about mining operations at the moment of the bump, about the characteristic of the bump manifestation, about the fulfilment of the measures warning rock bumps. The information about the rock bump from the data base can be presented graphically in terms of schemes of mining operations and sketches of actual sight of bump manifestations in workings.

In the block, there is data base of mines and coal seams liability to rock bumps, it is made on the ground of «The catalogue of coal seams liability to rock bumps of Kuznetsk Basin» (St. Petersburg, 1996). The data base contains the information about the mine's name, the seam's name and its index, the mining operation depth having been reached, the minimum depth from which the seam is related to threatened and dangerous one being liable to rock-bumps. In all the mines of Kuzbass there are 266 seams and seam districts liable to rock bumps.

The block includes data base of geodynamic states of unworked coal in the mines of Kuznetsk Basin. It is made by the mine geophysical measurements of rock mass state under various mining - geological conditions and by the mining situation of panels of Kuzbass mines which have been carried out by Kemerovo Representation of VNIMI. Geophysical

measurements characterize the level of rock - bump hazard and allow to determine the zones of the coal seam liable to rock-bumps. The disturbance level of rock mass is determined with a sounding of rock mass in the locality of development faces.

The analysis of the technological parameters of the operations on the methane extraction out of the coal seams showed the priority of geodynamic processes at the formation of methane reservoirs on the coal seams. This circumstance motivates the applicability of the morphometry and other methods of computing of remote sounding for their discovery.

Detailed elaboration of geodynamic reconstructions within mine allows to determine the maximum gas content and as a result possible manifestations of dangerous geodynamic phenomenon. On the basis of geodynamic zonation in the mines it is possible to predict the methane anomalies in the coal area.

5 CONCLUSION

The work experience in geodynamic zonation shows the necessity of their fulfilment with the method of successive detailed elaboration of the scales: a coal basin, a coal district, a coal deposit, a mine take. Some individual methods of geodynamic zonation are considered to be effective at more detailed prediction in the districts of the panels and their separate parts. Acceptable results of the detailed prediction can be received at additional predicted buildings by means of seismoacoustic appliances on the surface and in the development workings of the panel.

At the building of gas content maps and at the planning of degasification measures and also at the organization of methane extraction out of coal deposits the registration of geodynamic zonation results is necessary. The first and the main measure in this direction is the organization of the work in geodynamic mapping of the area.

The developed geoinformation system (GIS) "Geodynamic phenomena in Kuzbass" consists of blocks of electronic cards of geodynamic phenomena and geodynamic zonation of Kuznetsk Basin area, of catalogues of rock bumps, of mines and coal seams liable to rock-bumps, of in-situ data and pictures of geodynamic rock mass state in the mines.

