IOP Conf. Series: Materials Science and Engineering **365** (2018) 022004 doi:10.1088/1757-899X/365/2/022004

Impact of settlement location conditions on the formation of urban coal mining area borders

Nadezhda Samoylova[1 2] and Yuri Alekseev[2]

[1] Russian Academy of Architecture and Construction Sciences, Bolshaya Dmitrovka, 24, Moscow, 107031, Russia
[2] Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia

E-mail: grado@mgsu.ru

Abstract. The solution of city planning tasks of the significant coal resource potential use and sustainable living environment creation in the coal mining areas with the use of boundaries of urban coal mining areas and interposition of settlements is considered. There are substantiate the possibility of urban planning in specific boundaries distinct from the administrative-territorial division in the proposed structure of the pre-project organization of urban-planning activity. For existing coal mining areas in Russia with the use of GIS technologies, a mapping scheme of the current urban situation of development of coalfields has been drawn up, showing the boundaries of urban coal mining areas, taking into account the population in the settlements, zones of urban settlements impact and their spatial relationship. The types of interposition of settlement impact zones in forming urban coal mining area borders have been developed and their characteristics have been determined. The close relative positions of zones of impact of urban settlements have been established in the major significant urban development areas of coal mining in Russia. The types of interposition of settlement impact zones and their parameters are designed to unify urban development analysis of coal mining areas in terms of special location of settlements and formation of the city planning potential of territories. The acquired results can be used by the federal, regional and municipal authorities while drawing the urban policy and the implementation of major public-private projects.

1. Introduction

In the world practice, urban development of the areas of coal basins is uneven relative to the size of the country, historical development of settlements during the initial development of the territory, time of detection of minerals (coal), commencement of industrial coal mining, mining time and subsequent revitalization of areas disturbed by coal mining activities. The main problem of urban planning of coal mining areas[1] is balanced intensification of urban development of the territories disturbed by coal mining activities on the one hand and the territories of the existing urban development in the settlement groups on the other hand.

[1] The coal mining area is the territory where direct coal mining activities are carried out in the form of: mine preparation works, coal mining, enrichment and processing of coal and its by-products κ land reclamation and associated livelihoods of people, including the use of various material facilities, including residential, socio-cultural and communal, engineering and transport infrastructure [1].

For Russia, this problem is new. It is known that the distribution of coal reserves in the world's largest coal basin is such that Russia has the following basins: Tungusky - 2299 mil.t, Lensky - 1647 mil.t, Kuznetsky - 637 mil.t, Pechora - 265 mil.t, Taimyrsky - 217 mil.t; Germany has: Ruhr Basin - 287 mil.t; the United States have Appalachian - 284 mil.t; the West - 170 mil.t; Ukraine has: Donetsk Basin - 141 mil.t [2]. Only Kuznetsky, Pechora and Eastern part of Donetsk basin in Rostov Oblast are being developed.

In recent decades the global energy interest in coal has been growing, because coal deposits are widely distributed in the world and according to forecasts coal reserves significantly exceed oil reserves Annual Statistical World Energy Review. It seems that the solution of problems of coal mining and production use in view of the global fuel and energy balance in the world and within the country, as well as processing of coal products in coal, chemistry includes the urban planning of coal mining areas. The emergence of 'new players' - the countries which are intensively developing areas of coal production, proven reserves of which are not comparable with the above major coal basins of the world - China, India, Australia, Indonesia[2] - requires rethinking of the used urban planning of coal mining areas in Russia under the changed socio-economic conditions in the light of scientific and practical experience.

In Russia it is necessary to find a science-based modern information-technological method of forming the urban development borders of coal mining areas, which will allow not only to mine coal with due regard to embeddedness in the internal and external markets of consumers/producers of coal and its by-products, but to provide long-term urban development and revitalization of coal production areas, ensuring the area sustainable development and creating the comfortable living environment.

Despite the fact that the theory of settlement is considered one of the Russia's (Soviet) most fundamentally and comprehensively studied urban planning science; only in the works of Pertsik E N [4], Bocharov Yu P [5] and Glotov G A [6] such theory is considered in relation to the areas of coal mining. In the early 1970s the area of coal mining was for the first time identified as an independent object of urban planning. In particular, three fundamentally possible settlement systems in the coal areas were developed: decentralized, centralized, group.

In the 1970s, a schematic layout of residential development on the coal-bearing area was also developed [4]. Housing construction often began on the grounds that according to preliminary data, were considered carbonless or placed over coals of non-industrial values, and were built up mainly due to the proximity to mines. As a result of subsequent new mining and geological knowledge of the area, such previously built-up territory was expediently studied at the time of coal mining. This approach led to the 'dumping' of minerals in the ground [5], i.e. incomplete development of the existing coal resources located on this site and impossibility to approach coal because of the existing town planning environment in the vicinity of the site.

For a long time, it was considered the undisputed advantage of centralized settlement and consolidation of residential areas in the coal mining zones. Construction on carbonless territories[3] with conditions favorable for planning and civil engineering was supposed to provide the effect of urban planning and economic concentration of life-sustaining facilities, which will not result due to certain circumstances of the economic situation in the 'extinction' of the settlement created in the coal mining area.

However, in modern conditions the speed and types of transport vehicles, as well as coal mining technologies are changing, including the transition from the underground to open pit andnew underground open method of coal mining, including with the increased use of unmanned production

[2] Currently, the Russia takes the sixth place after China, the United States, India, Australia and Indonesia in coal mining. At the same time the explored coal reserves of Russia rank second after the United States: 3rd place is taken by China, 4th is taken by Australia and 5th place is taken by India [3].

[3] 'Carbonless territories in coal regions should be sought with the same persistence as the coal-bearing territories' [7].

technologies. In this context, the expediency of the search in the areas of coal mining for carbonless territories to place a settlement on them by the type of centralized or group resettlement is not clear. Because after exhaustion of coal deposit areas, more and more territories disturbed by coal mining activities, provided with infrastructure in the existing settlement system, are left behind.
This work [5] highlights the stages of development of the largest agglomeration area by the example of Donbass. Foreign and domestic experience shows that a rapid change in the territory functions does not work well for the areas of coal mining, aggregating a number of people in the territory. In England and Germany after the restructuring of the coal industry in the 1950s, the revitalization of the areas disturbed by coal mining activities with the interest of the business and society in the process of formation of high-quality living environment had only been completed by the 2000s. Russia, which has large spaces, has not yet realized the effects of urban planning of coal mining areas.
The start of rethinking of the Soviet urban planning experience in the development of the territory in the coal mining areas is traced in Articles of Alekseev Yu V and Samoylova N A [1], where the concept of 'the urban border of the coal mining area'[4] is introduced; an approach to the formation of such boundaries and the information accounting system and outlined the problematics of communication between representatives of four subjects of urban development (enlarged names of which: 'power', 'business', 'society', 'individuals').

2. Methods

To carry out scientific research mapping, computational, analytical and statistical methods are applied with the use of computer technologies - Geographic Information System - ArcGIS (ArcInfo).
Urban boundaries of coal mining areas ware simulated with the use of GIS. The rank of a settlement is set taking into account the quantity of population in it. It is possible to build a buffer of absorbing settlements that meet certain conditions, such as taking into account the presence of socio-economic gravity (SEG) - **R** of the biggest settlements (or several villages) in the zone, within the are of urban influence - **¼ R**. In ArcGIS, the data on area objects - large coal basins of Russia, were initially tied to the coordinates with the use of a conical projection Lambert, by separate zones of coal mining (Kuzbass, Pecherskiy) - in UTM projection. For some areas of coal mining, urban borders of coal mining areas by the algorithm (stage I) described in the article of Alekseev Yu V and Samoylova N A [1]. Stage I includes mapping by areas SEG of settlements of various ranks separately for each rank of settlements; synthesis of produced schematic maps and subsequent analysis of the types of interposition of zones of settlements of simultaneously several ranks. Data for the study - cartographic material OpenStreetMap. The population rate in settlements as at January 1, 2015. Information GIS Atlas 'Nedra Russia' about the location of coal basins is taken from open sources. Zones of urban development impact of settlements are accepted as ¼ R from the area of SEG of settlement R, table [1, p. 36].

3. Results

Factual data of the interposition of the existing settlements and their zones in coal mining areas is summarized and categorized by type. Three schematic map showing the urban development boundaries of coal mining areas have been drawn, taking into account the population rate in the settlements, SEG zones, zones of impact of urban settlements and their spatial relationships 'figure 1 - 2'. Types of interposition of zones of impact of urban settlements have been detected by materials [1].

[4] Urban development boundaries of the territory are boundaries of the territory within which spatial planning documents are prepared and taken into account [1].

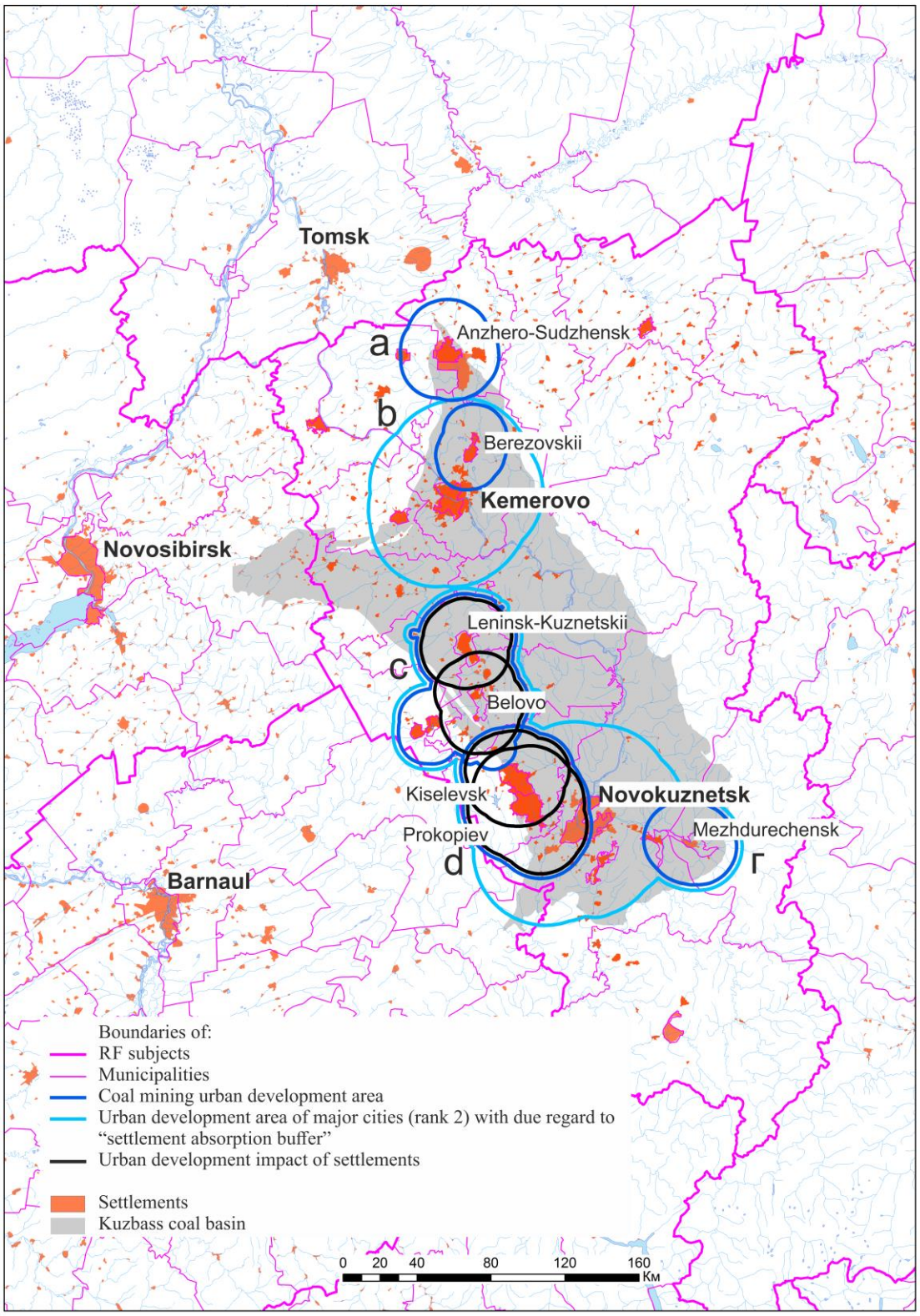


Figure 1. Schematic map showing the first stage of the formation of urban development boundaries of coal mining areas in Kuzbass.

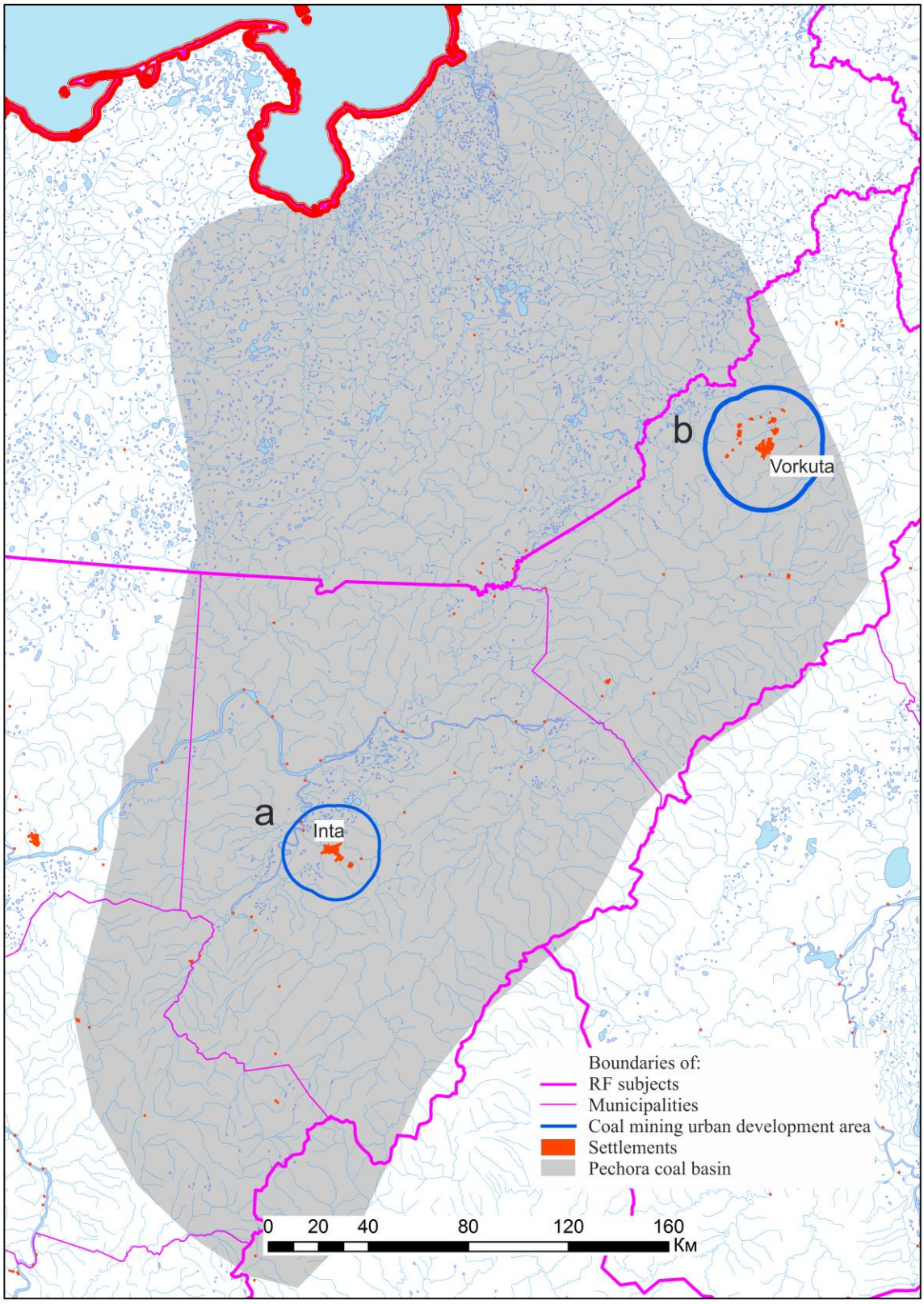


Figure 2. Schematic map showing the first stage of the formation of urban development boundaries of coal mining areas in the Pechora coal basin.

Settlements in the coal mining areas have or do not have a common crossing zone. Given the tightness of interposition of the common crossing area, 5 subtypes are marked (2a, 2b, 2c, 2d and 2e in the table 1).

The developed parameters for all types and subtypes of areas are applicable to SEG areas and areas of urban development impact of settlements. For two or more settlements of the same or similar ranks, complex multicore urban boundaries have been modeled. There are urban development areas of coal mining in the composition of the boundaries for the various purposes of urban planning at the local, regional, national and transnational levels.

The analysis of base maps was executed with the mapping of urban border area of coal mining in next Russian coal basins: Kuzbass, Pechersky. For settlement groups located in coal mining areas, the collocation of the urban development zones has the closest collocation types 2e and 2d of (table 1). So in the coal basins recorded the following urban development situation for settlements, namely Type 2 prevails, for example: subtype 2d for settlements of the same 4 rank - Kiselevsk and Prokopyevsk, the same 5 ranks Leninsk-Kuznetsk and Belovo (Kuzbass, Kemerovo region).

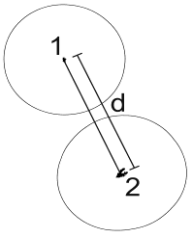
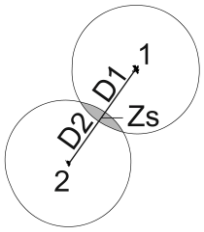
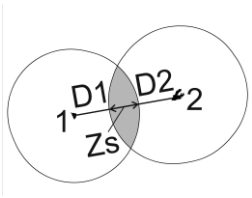
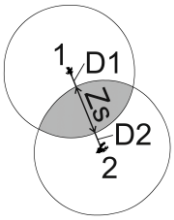
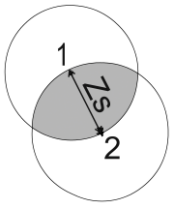
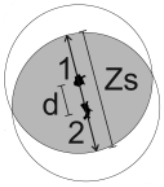
At the same time, the fact of location of the urban development area of the coal mining area in the zone of urban development impact of settlements higher in rank is taken into account, including those not meeting the following condition: the most pronounced feature of areas within the zone of urban development impact - coal mining (Condition 1).

At the same time, the fact of finding a urban planning area of coal mining in the zone of urban development influence of a settlement of a higher rank is taken into account, including the Condition: "the most pronounced function of the territories within the zone of urban development influence is the extraction of a natural mineral", for example, coal, or not satisfied the specified Condition.

- Urban development area of coal mining in the zone of urban development impact of one settlement, including Anzhero-Sudzhensk (Kuzbass, Kemerovo Oblast) - ‘figure 1 (a)’. This is Type 1:
- Urban development area of coal mining in the zone of urban development impact of several settlements, one of which has the highest rank - Vorkuta (60 thousand people - rank 5) and settlement Vorgashor (rank 7), Severnyi (rank 8) and Zapoliarnyi (rank 10) (Pechora, Komi Republic) - ‘figure 2 (b)’. This is Type 2, there are no subtypes for the same rank settlements;
- Urban development area of coal mining in the SEG zone of settlements of higher rank (not meeting condition 1), including Berezovsky (rank 6) in the SEG zone of Kemerovo City (rank 2) (Kuzbass, Kemerovo Oblast) - ‘figure 1 (c)’. This is also Type 2, there are no subtypes for the same rank settlements; Including Leninsk-Kuznetsky and Belovo (rank 5) and surrounding settlements of lower rank in the SEG zone of settlements: Kemerovo and Novokuznetsk (rank 2) (Kuzbass, Kemerovo Oblast) - ‘figure 1 (c)’. There is subtype 2e for settlements of the same rank - Leninsk-Kuznetsky and Belovo, which is located within subtype 2d for settlements of the same rank - Kemerovo and Novokuznetsk; In the SEG zone of settlements of higher rank (not meeting condition 1), for example Novokuznetsk (Kuzbass, Kemerovo Oblast), there can be different types of urban development areas of coal mining formed taking into account condition 1: in the SEG zone of one settlement, including Mezhdurechensk, rank 5 ‘figure 1 (d)’or several settlements: Prokopyevsk, rank 4, and Kiselevsk, rank 5 ‘figure 1 (e)’.

The urban development boundaries of Russian coal mining areas formed and reflected on the schematic map are the result of the first stage of pre-project urban planning of coal mining areas and the basis for subsequent implementation of analytical and research activities of a city planner. Urban planning must be carried out within the formed urban development boundaries of coal mining areas, taking into account the differentiated composition of the coal-bearing areas, types and number of the disturbed territory (territory being disturbed) as a result of coal mining and transport accessibility of settlements from places of coal mining activities. The use of the established types of interposition of the SEG zones and areas of urban development impact of settlements unifies the analysis of urban development in the coal mining areas in terms of spatial distribution of settlements and urban areas potential formation and can be applied for all countries.

Table 1. Types of interposition of the zones of urban development impact of settlements

Type 1: no common intersection zone:	
	d > (R1 + R2) – the distance between the 1st and 2nd settlements (classified in the same rank according to table [1, p. 36] is greater than the sum of the lengths of the radii (R) of their zones set for urban planning with due regard to their ranks.
Type 2: there is a common intersection zone, wherein the subtypes are determined by the following parameters (note to table 1):	
	**Type 2a**: d > Zs – the distance between the 1st and 2nd settlements (classified in the same rank in accordance with table [1, p. 36]) is more than the length of the common intersection zone of these settlements (Zs), Zs ~ 1/10 R - the length of the common intersection zone of settlements of the same rank (Zs) is about 1/10 of the radius (R) of the zone, taking into account their rank in accordance with table [1, p. 36], D1 = D2 - the distance from the 1st settlement to the common intersection zone (Zs) is equal to the distance from the 2nd settlement to the common intersection zone (Zs);
	**Type 2b**: d > Zs – the distance between the 1st and 2nd settlements (classified in the same rank in accordance with table [1, p. 36]) is more than the length of the common intersection zone of these settlements (Zs), 1/4 R < Zs < 1/2 R - the common intersection zone of the 1st and 2nd settlements (Zs) is located within the length of the distance from 1/4 to 1/2 the radius (R) of the zones, taking into account the rank of settlements in accordance with the table [1, p. 36], D1 = D2 - the distance from the 1st settlement to the common intersection zone (Zs) is equal to the distance from the 2nd settlement to the common intersection zone (Zs);
	**Type 2**c: d > Zs – the distance between the 1st and 2nd settlements (classified in the same rank in accordance with table [1, p. 36] is more than the length of the common intersection zone of these settlements (Zs), Zs ~ 1/2 R - the length of the the common intersection zone of settlements of the same rank (Zs) is about 1/2 of the radius (R) of the zone, taking into account their rank in accordance with table [1, p. 36], D1 = D2 - the distance from the 1st settlement to the common intersection zone (Zs) is less than the distance from the 2nd settlement to the common intersection zone (Zs);
	**Type 2d**: d > Zs – the distance between the 1st and 2nd settlements (classified in the same rank in accordance with table [1, p. 36]) is equal to the length of the common intersection zone of these settlements (Zs), Zs = R - the length of the common intersection zone of settlements of the same rank (Zs) is equal to the radius (R) of the zone, taking into account the settlement rank in accordance with table [1, p. 36], D1 = 0 D2 = 0 - the distance from the 1st settlement to the common intersection zone (Zs) is equal to zero; the distance from the 2nd settlement to the common intersection zone (Zs) s equal to zero;
	**Type 2e**: d > Zs – the distance between the 1st and 2nd settlements (classified in the same rank in accordance with table [1, p. 36]) is less than the length of the common intersection zone of these settlements (Zs), Zs = R - the length of the common intersection zone of settlements of the same rank (Zs) is more than the length of the radius (R) of the zone, taking into account the settlement rank in accordance with table [1, p. 36], D1 = 0 D2 = 0 - the distance from the 1st settlement to the common intersection zone (Zs) is equal to zero; the distance from the 2nd settlement to the common intersection zone (Zs) s equal to zero.

Note to table 1. Additional variations may be separated for each of these subtypes, if necessary.

Urban planning of areas with the use of the proposed analysis of interposition of urban development zones of settlements in the formation of urban development boundaries of coal mining areas contributes to the sustainable development of the territory in terms of integrated planning within the established borders of disturbed territories for the period of coal mining and advanced planning after the completion of coal extraction. The quantitative value of the radius of the zone of urban development impact of settlements equal to the distance in kilometers in a straight line from the perimeter of the settlement, after additional in-kind and (or) simulated studies, can be specified for the coal mining areas. However, currently there are no restrictions for use of table 1 for the formation of the currently existing or planned urban development boundaries of coal mining areas, including suggesting various options for the urban development of settlements, i.e an increase or decrease in the number of people in the settlement - a change of the rank and its zone of impact, respectively. It is advisable to check these types of interposition of settlement zones in application to other areas unrelated to the coal-mining types and, if necessary, to supplement variations in each of these subtypes of type 2 in table 1.

4. Conclusions

The proposedanalysis of interposition of zones of urban development impact of settlements in the formation of urban coal mining area borders is in line with modern scientific research ‘for the symbiosis of urban development and the preservation’ of the territory, for the convergence of forms of economic and urban clusters and the use of GIS technologies in urban development. It aims at studying an urban planning project for the integrated solutions of spatial problems in the coal mining regions, both for urban planners, professionals and the interested public community of residents. Active participation of such community, taking into account modern information and communication capacities, is constantly increasing. Knowledge of the type of the zone of urban development impact of settlements and identification of the urban development area of coal mining is the beginning of urban planning and forecasting of development of changes in the coal mining region, which will require processing of significant volumes of information generated within the urban development boundaries of the coal mining area. Application of research results is possible in projects (programs) or departmental target programs using project management mechanisms.

References

[1] Alekseev Ju V and Samoylova N A 2015 Podhod k organizacii gradostroitel'nogo planirovanija i formirovaniju granicy gradostroitel'nogo ugledobyvajushhego areala [Approach to urban planning of the coal basin]. *Architecture and Construction of Russia*, no **8**, pp. 30-39
[2] Voronina N V 2008 Sovremennye tendencii razvitija mirovogo rynka uglja [Modern trends in the global coal market development]. *Russian Foreign Economic Journal*, no **2**, pp. 36-52
[3] Annual Statistical World Energy Review [Electronic resource] // BP: [web-site] [2016] URL: www.bp.com (reference date: 01.06.2016)
[4] Percik E N 1999 Goroda mira. Geografija mirovoj urbanizacii [Cities of the world. World urbanization geography]. Moscow: International Relations (in Russian)
[5] Bocharov Ju P, Ljubovnyj V Ja and Sheverdjaeva N N 1980 Gorod i proizvodstvo [City and manufacturing]. Moscow: Strojizdat (in Russian)
[6] Glotov G A and Percik E N 1972 Budushhee gorodov Kuzbassa. Problemy gradostroitel'stva i rajonnoj planirovki [Future of the cities of Kuzbass. The problems of urban development and regional planning]. Kemerovo (in Russian)
[7] Kabakova S I 1973 Gradostroitel'naja ocenka territorij gorodov [Urban planning evaluation of territories of cities]. Moscow: Strojizdat (in Russian)