ANNOTATION
of Baratov Refat's
PhD thesis on the specialty "6D070600 - Geology and Exploration of Mineral Deposits"
on the topic «Ring structures of Central Kazakhstan and their ore bearing using processed remote sensing (ERS) data»

This thesis is dedicated to one of the most pressing challenge of modern geology – the role of ring structures in the formation of the Earth's crust and the location of deposits of ore minerals.

Assessment of the current state of the scientific or scientific-technical challenge.

The arcuate character of individual morphostructures was noted by pioneers as early as the middle of the 19th century. So, L. Lehmann in 1852 described the arched structure of the Bukantau mountains in Central Asia, and in 1874 A.V. Kaulbars - of Sultanuizdag mountains. However, F. von Richthofen was the first to point out the natural arcuate structure of all mountain-range of the Tien Shan in 1877, which was later reflected in the well-known tectonic maps of Central Asia by É. Argand, D.I. Mushketov, D.V. Nalivkin. Academician E.D. Shlygin drew attention to this phenomenon in his work "On the similarity of the tectonic pattern of the Central Kazakhstan and Yano-Kolyma orogens.

Among the annular morphostructures identified by D.Z. Popova within Central Asia - South Kazakhstan major morphostructure, which covers the area from the South Urals to Altai, from the south of Western Siberia to the South Tien Shan. Its center is located in the hummocks of East Kazakhstan, the southern periphery is expressed in the form of the outer Caledonian Arc (Tien Shan, Karatau, Kokchetau) and the inner Hercynian (Chu-Ili-Tekturmas-Chingiz), which are parts of phase rings. Concentric secondary morphostructures order are superimposed on its southern periphery - South Ural, Aral, Pamir, Barabinsk. They are complicated by higher-order morphostructures.

To all appearance, the first to indicate the presence of rounded structures in Central Asia was V.G. Mukhin (early 30s of the last century). A.S. Adelung (1937, 1939) the first, who drew attention to the formation of a number of dome-shaped structures as a result of the intrusion of magmatic masses. In particular, he pointed to the area of the Angren batholith, which, in his opinion, formed the "largest domal bulging" bordered by a syncline-like depression with "porphyritic-tuffs". V.I. Popov (1955) described the rounded and amygdaloidal growth cores of the continental crust of a concentric structure, considering them to be active magmatic centers of long-term development (Muyunkum, Kuramin, Hisor-Darvoz, Karakum, etc.). K.K. Pyatkov (1976) described in Western Uzbekistan a number of newest structures of the "brachyanticlinal bulging" type, the beginning of the formation of which was attributed to the Miocene.

In Kazakhstan, one of the first to examine in detail the ring structures associated with magmatic complexes was A.V. Avdeev in 1965. The structures described by him in some areas of Eurasia, America and other regions correspond

to plutons, stocks, domes, calderas, etc. The mechanism of formation of these structures involves the ascent of magma (squeezing-out of magmas (mainly acid) by denser rocks), upwarping, formation of dome protrusions, conical and radial faults, and, as a consequence, the collapse over the magma chambers. A.V. Avdeev separated three stages in the development of the Earth's ring structures: Precambrian, Proterozoic-Neogene and Present. He was one of the first to compare terrestrial and lunar ring forms.

With the development of satellite methods of Earth research, the spotlight of researches where isometric objects identified in satellite images. Different researchers name them differently. In addition to “ring structures”, a number of terms are used: ring morphostructures, central type morphostructures (V.V. Soloviev); space geological central type structures (L.F. Volchegursky, V.G. Pronin), isometric structures (D.M. Trofimov), ring or centric space geological objects (I.I.Bashilova, V.A.Bush, etc.), focal structures (I.N. Thomson, M.A. Favorskaya), concenters (O.K. Gintov) and others.

In the earliest works devoted to the ring structures of the Earth, identified in satellite images, ring structures were envisaged as photo anomalies, which were then presumably compared with various geological bodies. In later works, researchers began to more boldly distinguish RSs and confidently identify them with geological objects. As a result, it turned out that RSs are found in various regions of the Earth, sharply differing in geological structure (Bush, 1985, Bryukhanov, 1985, Katz, 1980). Attention was drawn to the fact that the density of the RS manifestation varies widely, depending on the geological structure of a particular region. Indeed, areas of widespread development of volcanic formations or areas of widespread development of metamorphic formations differ by density of RS manifestation and in dimension. New data on the widespread development of RSs on the Earth's surface and the peculiarities of their location clearly show that, along with lineaments, they are an essential tectonic element of the Earth's crust structure. The peculiarities of the location of RSs on the Earth's surface, according to many researchers, are mostly determined by their genotypes. For example, in volcano-plutonic belts, endogenous volcanic, plutonic, volcano-plutonic, volcano-tectonic structures and complex systems of magmatogenic ring structures are most widespread. In areas of widespread development of sedimentary carbonate and terrigenous-carbonate formations, the distribution of karst ring structures can be expected, metamorphogenic and tectonogenic RSs are widely developed. At the same time, cosmogenic structures, being superimposed on any geological basis, can be manifested in any geological province. The foregoing, when interpreting a large number of RSs, admits, among this set, the presence of RSs of various genesis. Given the different internal structure of RS various types, the differentiated study and identification of RS with genotypes known to date is mandatory, regardless of the fact that a number of them are still insufficiently studied.

Circular morphostructures of meteoric origin found the recognition of researchers only after the discovery in the late 1920s of the 1600-meter Arizona crater in the United States. In subsequent years, several dozen more craters of

cosmogenic origin were described, the sizes of which range from tens to hundreds of meters and very rarely reach tens or hundreds of kilometers. The beginning of substantiating the presence of meteorite structures in the USSR is connected to the works of V.L. Masaitis and his collaborators, who identified and studied the signs of impact metamorphism using the example of the giant Popigai crater.

On the territory of the USSR in the 1970s, 15 reliable and 30 supposed meteorite craters were identified (Masaitis, 1975; Walter, Ryabenko, 1977; Zeilik, 1978, etc.).

Thus, we can assume that the lively discussion of the problem of ring structures that has been taking place in the scientific world in the last 40-50 years, is due, first of all, to the fundamental (as it turns out) role of ring structures in the architecture of the lithosphere not only of the Earth, but also of other planets of the Solar system.

With regard to RSs, there are still a lot of unresolved issues, for example, their genesis and age, the processes of their development in geological space and time, genetic connection with other phenomenal structures of the Earth - lineaments, etc. In this regard, there is no doubt that further comprehensive study of such a specific and widespread geological object, which undoubtedly are the ring structures of the Earth and the Solar system planets, will allow not only to know their nature, but also to deepen our understanding of the mechanism of formation and development of the Earth's crust and associated minerals. The most widespread among RSs on Earth, as studies of recent decades show, are cosmogenic and endogenous structures, the study of which will be mainly devoted to this work.

The most important thing in the problem of RSs is that almost all researchers, who study them, note an undoubted connection with various minerals. Many instances are given where many oil, gas and ore deposits are associated with ring structures. However, despite the seemingly obviousness of the identified controlling role of ring structures; in the location of minerals, this search criterion is still insufficiently utilized in practical geology.

Basis and initial data for the research of the subject. The thesis is an extension of the applicant's scientific research, which was started while studying at the magistracy of KazNTU and continued at the Institute of Geological sciences named after K.I.Satpayev with admission to work there. The basic data for the development of the subject of the thesis are the collected fund and published materials concerning the problem of ring structures, the data of office and field studies when performing a dissertation as a member of the Laboratory of geological and ore formations of grant and contractual projects: 1. "Analysis of the epithermal gold-silver mineralization of Zhongar-Balkhash region and the separation of potentially productive areas for the discovery of large deposits of this type" (2012-2014); 2. "Capability of identifying the large-volume epithermal deposits of gold, silver and copper in the volcano-plutonic belts of the Zhongar-Balkhash fold system" (2019); 3. "Study of the ore content of the ring structures in Central and South Kazakhstan and identification of the most prospect among them for organizing exploration works" (2018-2020).

Justification of the need for the research work.

Against the background of the almost complete depletion of easy-opening deposits in Kazakhstan, as well as throughout the world, since the end of the twentieth century, the scale of mining has increased sharply, which has led to a noticeable lag in the replenishment of mineral resources for many types of minerals compared to their production. In addition to the above, in recent decades in the state of the mineral resource base (MRB) of Kazakhstan, additional negative phenomena have emerged due to the insufficient competitiveness of deposits of a significant group of the most important and traditional minerals for the country - copper, molybdenum, zinc, gold and others.

For evening-out the situation when **production outstrips and exceeds the replenishment by many times**, the need for a sharp increase in prospecting and exploration work is clearly indicated, which in the country has almost been reduced to zero.

Taking into account the above, to solve this problem, it becomes obvious not only the accelerated resumption of explorations, but also an increase in their efficiency by identifying reliable exploration criteria and attracting new modern methods. At the present stage, the solution of exploration issues is impossible without the use of an optimal complex of basic geological and geophysical methods with full involvement of Earth remote sensing data (ERS), computer geo-information systems (GIS). Only a combination of a complex of exploration methods, which makes it possible to effectively use a huge amount of data in exploration operations, can contribute to the successful solution of exploration issues.

Scientific and technical level of the paper.

The scientific and technical level of the thesis is determined by the large volume of collected and generalized material on the geology, genesis and ore content of ring structures, the use of modern computer software for processing remote sensing data such as Erdas Imagine and Geomatics, geo-information systems like ArcGIS software and statistical analysis.

Metrological support of the thesis.

In this dissertation work, the main results are obtained on the basis of interpreting materials of Earth remote sensing. The reliability of these results is confirmed by the use of pre-processed and georeferenced Landsat-7 scanner images of and Radarsat-1 radar images provided by Kazgeokosmos JSC and Landsat-8 images provided by Center for Remote Sensing and GIS “Terra” LLP in Almaty. The work also employed the results of laboratory studies of lithogeochemical samples taken in the field 2018-2019 season from ring structures of Shoptybai, Ayuly, Shoimbai, Shyndy, East-Kyzyltas and others. Samples were analyzed in certified laboratories of Help Geo LLP and in the Laboratory of Physical and Chemical Research Methods of the Institute of Geological sciences named after K.I.Satpayev. Most of the samples were analyzed by the "semi-quantitative optical emission spectral analysis" method, the rest of the samples were processed by the "atomic absorption analysis" method for gold.

Relevance. The expansion of space research in the 60-80s, including space remote sensing of the Earth's surface (433), showed the broadest development of ring structures on its surface, ranging in size from tens and hundreds of meters to thousands of kilometers across.

The most important in a practical aspect in the problem of ring structures is the confinement of certain mineral deposits to them, noted by all researchers. Examples, when a spatial connection of oil, gas, and ore deposits (copper-porphyry, gold-silver, rare-metal, etc.) is established with the RS today can be cited in huge quantities. However, despite the seemingly obviousness of the established ore-controlling role of ring structures, this exploration criterion is used insufficiently in practical geology. Considering that at the present stage, when the fund of easy-opening deposits has almost completely dried out, and in order to increase the efficiency of prospecting, it is imperative to attract new modern methods, the need for the full use of Earth remote sensing materials seems to be *extremely relevant.*

The scientific novelty of the study is determined by the fact that, based on the use of Earth remote sensing materials (433) and previously identified characteristic features of ring structures of various genesis, their ranking was carried out for the first time, the most widely developed types of RSs were determined, and the degree of intensity of manifestation of one or another ore mineralization was established in RCs of different genesis, which allows to recommend new directions of prospecting works in the territory of Central Kazakhstan.

The relationship of this work with other researches. The thesis is directly related to the work carried out in the Laboratory of Physical and Chemical Research Methods of the Institute of Geological sciences named after K.I.Satpayev during grant projects: 1. "Analysis of the epithermal gold-silver mineralization of Zhongar-Balkhash region and the separation of potentially productive areas for the discovery of large deposits of this type" (2012-2014); 2. "Capability of identifying the large-volume epithermal deposits of gold, silver and copper in the volcano-plutonic belts of the Zhongar-Balkhash fold system" (2019); 3. "Study of the ore content of the ring structures in Central and South Kazakhstan and identification of the most prospect among them for organizing exploration works" (2018-2020). In the last two projects, the candidate is one of the main performers.

Purpose of the study: based on the analysis of numerous publications on space geology and the geology of ring structures, to reveal the scale of the development of ring morphostructures in the territory of Central Kazakhstan, to determine the ratio of various genetic types of ring structures and to identify their magma and ore-controlling role.

The object of research is the ring structures of Central Kazakhstan and their ore content.

Subject of research: ring structures, the intensity of their manifestation, determination of their genetic types, the relationship of different ore mineralization with RSs of different genesis, identified promising ore-bearing RSs.

Research objectives: 1. Analysis of numerous scientific and technical information on space geology and the geology of the Earth's ring structures. 2. On the basis of the compiled Map of Ring Structures of Central Kazakhstan, scale 1:1000,000, rank them for various genotypes and determine their most dominant types in Central Kazakhstan. 3. To generalize the material on the ore content of Central Kazakhstan and determine its relationship with ring structures and large lineaments. 4. To further study and identify new ore-controlling ring structures of different genesis in Central Kazakhstan and highlight the most promising of them for discovering deposits of one type or another. 5. To develop recommendations regarding the organization of exploration works on the identified promising ore-bearing ring structures.

Methodological base of research. The main methods of the designed research are: interpretation of ERS data, geological mapping, paleovolcanic reconstructions, geochemical methods, metallogenic analysis, nearest neighbor method. A number of these methods, in turn, are complex.

Concepts for defense of thesis:

1. The wide distribution of ring structures on Earth, like on all the planets of the Solar system, indisputably proven by ERS materials in recent 40-50 years is also typical for Central Kazakhstan;

2. For the first time, the ranking of the ring structures of Central Kazakhstan by genesis showed that the dominant among them are magmatogenic (endogenous) and cosmogenic ring structures located unevenly in the studied region;

3. For Central Kazakhstan, a clear confinement of most of the ore mineralization to ring structures was revealed;

4. The identified regularities of the confinement of ore content to the ring structures of the structural-formational zones of Central Kazakhstan showed that the most ore content is characterized by the RSs of the SPZ of various VPB, in which significant industrial prospects can be assumed for volcanogenic epithermal Au-Ag, Cu-porphyry and rare-metal mineralization. It is in the ring structures of the highest priority in terms of prospects, with the indicated intensive mineralization, that we should expect the discovery of new porphyry-type deposits. Ring structures of this geological and industrial type, recommended for exploration and appraisal works, include: Bolshoi Konyrat, Kyzyltas, East Kyzyltas, Symbyl, Shoimbai, Shoptybay.

The practical significance of the study is that ring structures can be effectively utilized as a reliable exploration criterion for many volcanogenic deposits (copper-porphyry, gold-silver, rare metal, etc.), and the identification of the nature of ore-bearing ring structures, taking into account the differences in their internal structure, in many respects determines the correctness of the strategy of prospecting and exploration works.

Publications and approbation of the work. Based on the results of research work, 12 scientific articles were prepared and published, including 3 papers in publications included in the Clarivate Analytics database, Scopus and having a non-zero impact factor and 4 articles in scientific publications recommended by the Quality Assurance Committee in education and science of

MES RK. Many aspects of the work were reported and discussed in the form of oral reports at international, republican and university scientific conferences: in Russia - III and V international scientific conferences "Correlation of Altaids and Uralids: Magmatism, Metamorphism, Stratigraphy, Geochronology, Geodynamics and Metallogenic Forecasting", Novosibirsk, in 2016 and 2020; in Bulgaria - "17th International multidisciplinary scientific geoconference SGEM 2017, Science and Technologies in Geology, Exploration and Mining", Albena, 2017; in Uzbekistan - International conference "Science and Practice Integration as the Mechanism of Effective Development of Geological Industry of the Republic of Uzbekistan", Tashkent, 2018; in Kazakhstan - at the Institute of Geological sciences named after K.I.Satpayev at the international conferences "Satpayev Readings" and "Bekzhanov Readings" in 2017 and 2019.

The structure and scope of the thesis.

The dissertation is presented on 136 - pages of a computer typesetting and consists of Introduction, five Chapters, Conclusion and a List of References, including 153 titles. The thesis is illustrated with 51 Figures, 5 Tables.

The Introduction reveals the relevance of research, specifies issues related to the topic under study. Objectives, tasks and research methods are set, scientific novelty and practical significance of the work are shown.

The Chapter I describes the main stages in the development of Earth remote sensing (ERS), a review and analysis of genetic types of ring structures, a variety of methods for their study and their ore content on the cases of domestic and foreign ore fields.

The main types of ERS materials and their areas of application are described. It is noted that today ERS materials are widely used in mining, oil and gas and other industries; however, their use is not yet part of the overall workflow of all enterprises, largely due to the limited understanding of their capabilities, and the complexity of processing and utilizing such data.

A review of the history of studying ring structures and the analysis of genetic types of ring structures is made. Thus, according to numerous publications (Borisov O.M., Glukh A.K., Katz Ya.G., Bryukhanov V.N., Bush V.A., Zeilik B.S. and others), ring structures are distinguished by their genesis into six independent tectonic forms: magmatogenic, cosmogenic, nuclear, metamorphogenic, tectonogenic, exogenous.

The most important in a practical aspect in the problem of ring structures is the confinement to them of certain mineral deposits, as noted by all researchers. The Chapter I ends with typical examples of foreign and domestic ore fields located in spatial connection with ring structures.

The Chapter II is devoted to the method of ERS data interpreting and revealing the size of manifestation of RSs in Central Kazakhstan. According to many researchers (Borisov O.M., Katz Ya.G., Bryukhanov V.N., Zeilik B.S., Korchuganova N.I., Nurkhodzhaev A.K., Lillesand T.M., Kiefer, R.W., etc.) there are two main methods of ERS materials interpreting - visual and automated. The features of these methods are described in detail.

In the thesis, to identify ring structures and lineaments, a visual method of interpreting was used and interpretation of ERS materials was carried out in three stages:

- Selection of satellite images and their preliminary processing;
- Visual interpretation with the selection of ring and linear structures;
- Digitization of interpreted materials in the ArcGIS software and creation of the database of ring structures in Central Kazakhstan.

Visual interpretation was carried out in insets of satellite images, 1:500,000, corresponding to specific nomenclature sheets. During interpreting, isometric, oval, arcuate, semi-circular structures sized from 500 meters to 50 kilometers and more were distinguished. Linear structures of different sizes were distinguished. Some of the lineaments and ring structures correspond to faults on the geological map, most have been interpreted for the first time.

The digitization of the results of visual interpretation was carried out in the ArcGIS software manually without using tracing methods from bit-mapping graphics. When interpreting, a Table of attributes was compiled in which the number of the structure was reflected, for known RSs - the name, parameters, ore content, if any, and its quantity. The attribute Table can be extended with the emergence of new data in the analysis of geological and geophysical materials.

To identify the frequency of occurrence or the intensity of distribution of ring structures, they were counted on interpreted plates of satellite images of the investigated territory. At the same time, three groups of ring structures were distinguished in terms of dimension: the first group - large ring structures with a diameter of 30-50 and >50 km, the second - medium-sized 10-29 km, and the third - small ring structures with a diameter of 0.5-10 km. The results of these calculations are shown in Table 1.

Further, the candidate, together with his colleagues, made an attempt to preliminary rank the ring structures by their genesis. It is known that all types of RSs are characterized by various geological, morphological, petrographic-mineralogical, geophysical features, which are the basis for their ranking. Taking into account these signs, the ranking of the interpreted RSs by genesis was carried out by means of a joint analysis compiled by the dissertation candidate "Map of ring structures of Central Kazakhstan", scale 1:1000 000, with all 1:500 000 scaled geological maps of the Central Kazakhstan series (L.F. Dumler, I.V. Orlov, V.F. Bespalov, 1981) and their explanatory notes. Also following materials were used:

- "Layout of the Intrusive Massifs of Central Kazakhstan" scale 1:2,000,000, V.I. Serykh (1985-1995);
- "Cosmogeological Map of Kazakhstan" scale 1:1 000 000 B.S. Zeilik (2008);
- "Layout of the Late Paleozoic Magmatogenic Ring Structures in Central Kazakhstan" scale 1:500,000 E.Yu. Seitmuratova (2004);

Table 1 – Frequency of occurrence of various sized ring structures (RSs) in Central Kazakhstan

Sketching board No.	Number of RSs by dimension			Total number of RSs
	large 30-50 km and >50	medium 8-29 km	small 0.5-8 km	
N-42-V	1	15	247	263
N-42-G	2	29	112	143
N-43-V	4	20	74	98
M-42-A	8	45	271	324
M-42-B	2	58	250	310
M-42-V	0	97	224	321
M-42-G	3	69	46	118
M-43-A	7	66	54	127
M-43-B	6	37	46	89
M-43-V	10	89	102	201
M-43-G	5	78	119	202
L-42-A	3	45	20	68
L-42-B	8	41	36	85
L-43-A	4	31	145	180
L-43-B	11	15	82	108
L-44-A	5	31	69	105
Total	**79**	**776**	**1897**	**2742**

When ranking, the main criterion was the material composition of the rocks that compose one or another ring structure. As a result of the analysis of the "Map of Ring Structures of Central Kazakhstan", for the first time, taking into account the structural features of the RSs of different genesis, the ranking of the interpreted ring structures by genesis was made and Table 2 was compiled.

Table 2 – The results of ranking the ring structures of Central Kazakhstan by genetic characteristics [the number of reliable meteorite structures is indicated in square brackets]

item	Sketching board No.	Magmatogenic (endogenous) RSs	Cosmogenic RSs	RSs of unknown nature	Total number of RSs
1	L-44-A	77	3 [1]	26	106
2	L-43-B	79	4	25	108
3	L-43-A	137	12 [1]	31	180
4	L-42-B	57	1	27	85
5	L-42-A	11	[1]	56	68
6	M-42-V	31		230	261
7	M-42-G	69	1	48	118
8	M-43-V	156	2	43	201
9	M-43-G	171	8	23	202
10	M-43-B	62	1	26	89
11	M-43-A	71		56	127
12	M-42-B	47	2 [1]	261	310
13	M-42-A	50		184	324
14	N-42-V	48	2 [1]	219	269
15	N-42-G	96	2	44	143
16	N-43-V	44	1	53	98
	Total	1206	39	1352	2689

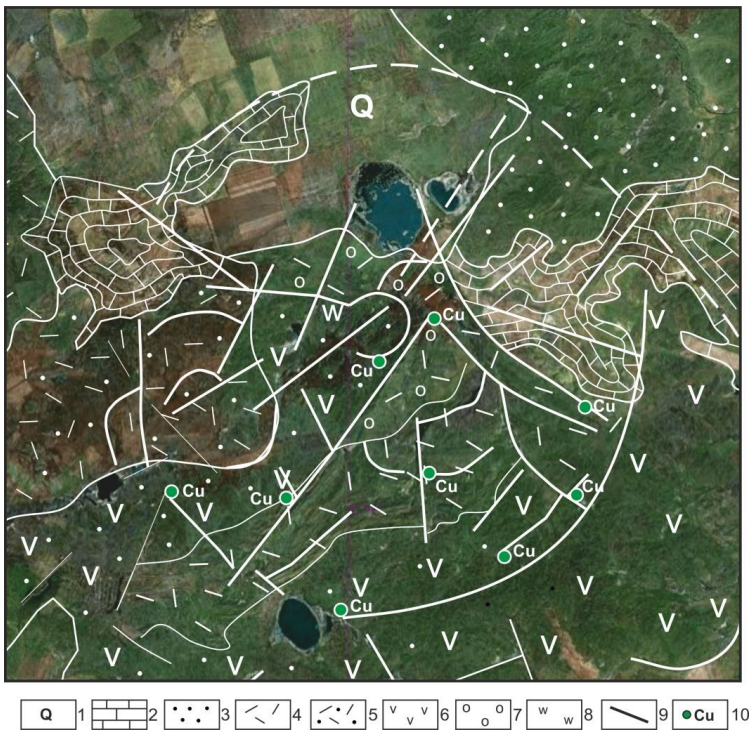
The Chapter III describes the features of the geological structure of typical endogenous and cosmogenic RSs in Central Kazakhstan. A table of typical magmatogenic ring structures of Central Kazakhstan (table 3) was compiled based on the materials of predecessors, and detailed descriptions of the geological structure of known magmatogenic Ulken-Karakuu, Kyzyladyr and cosmogenic ring structures, such as Shunak, Akshoky and Arganaty.

Table 3 – Magmatogenic RSs of Central Kazakhstan

item	RS	Type	Dimensions, km	Age	Sheet	Author, Source
1	2	3	4	5	6	7
1	Zhanatau	VTS	5x5	P_2-P_3	M-43-115-127	Tashchinina M.V., Donskikh V.V.
2	Arkharly	VTS		C_2-P_3	M-43	
3	Kyzyladyr	VPS	20x20	C_1-P_3	L-43-19	Shcherbakova, M.N., 1967
4	Maitas	VPS	17x16	C_2-P_3	L-43-7	
5	Bektau Ata	VPS	37x30	P_2-T_1	L-43-18	
6	Kotan Emel	VPS	30x25	C_1-P_3	L-43-VI	
7	Kargaly	Caldera	42x30	C_1-P_2	M-43-137	Sharpenok, L.N.,1964
8	Kyzylarai	Caldera	35x28	C_1-T_1	M-43-127	Шарпенок, Л.Н.,1964
9	Burguly	Caldera	35x50	C_1-P_2	M-43-XXV-XXVI	Kurchavov A.M., 1984
10	Ulken Karakuu	Caldera	15x17	C_1-P_2	M-43-103-115	Malakhov, 1964
11	Chubaraygyr	VTS				Kopteva, 1974
12	Tas-Kyzyls	VTS				Trifonov, 1967
13	Ushkayin	VPS				Kopteva, 1974
14	Dzhangeldy	VTS	20x17	C_2-P_2	L-43-29	Seytmuratova E.Yu. et al., 2000
15	Besikzhal	VTS	13x12	C_2-P_2	L-43-41	Seitmuratova E.Yu. et al., 2000
16	Kokdombak	VPS	28x17	C_2-P_2	L-43-29-41	Seytmuratova E.Yu. et al., 2000
17	Arkharly	VTS	-	C_1-P_2	L-43-11	Zeilik, 1968
18	Kyzyltas	VPS of long-term development	20x18	C_2-P_3	M-43-138	Zeilik, 1961
19	Mikhneevich Volcano	VS	7x7	C_1-C_2	M-43-138	Zeilik, 1961
20	Zhalpak-Adyr	Domical	28 км	O		Avdeyev, 1965
21	Zerendy	Precambrian dome	90 км	O_3		Avdeyev, 1965
22	Borovskaya	Domical	17x23	D_1	N-42-XXIX	Koptev-Dvornikov, 1953
23	Zhaman Koytas	Domical				Avdeyev, 1965
24	Araul	Caldera		S-D		Avdeyev, 1965
25	East Konyrat	Domical	15x13	P_1	L-43-31	

26	Karkaral	Domical PS				Avdeyev, 1965
27	Ortau	Domical PS	14x14		M-43-XXXI	Avdeyev, 1965
28	Sarytau	Domical PS				Avdeyev, 1965
29	Shaltas	Domical PS				Avdeyev, 1965
30	Kyzyltau	Domical PS				Avdeyev, 1965
31	Kent	Domical PS	19x20	C_3	M-43-XXVIII	Kopteva, 1974
32	Kuvskaya	Domical PS	13x14	P_2	M-43-XXIII	Kopteva, 1974
33	Zhaman Karabas	Complex structure VTS	20x17	D_1-D_2	M-43-121-122	-
34	Zhanet	Complex structure VTS	19x16	C_1-P_2	L-43-17	-
35	Naizakara I	Ring Structures System	20x22	C_2-P_2	L-43-6	-
36	Bayan Aul	Domical	20x36	Pz_3	M-43-X	Monich, 1957
37	Temirshi	Domical	19x16			
38	Akbastau Kushmurun	Complex structure VTS	35x40	O_3	M-44-XXXI	Kaipov, 1970

The Chapter IV describes the characteristics of ore-bearing ring structures of different genesis in Central Kazakhstan. The geological features of the previously distinguished predecessors of ore-bearing ring structures are described: Konyrat, Akbastau-Kosmurun, Kargaly, Bainazar. The confinement of some known deposits and ore occurrences to ring structures, such as the Big Konyrat ring structure with a group of rare-metal deposits, the Symbyl gold volcano-caldera, the Maykain group of polymetallic deposits, has been identified. It also shows the geological characteristics of the first identified ore-bearing ring structures of Shoimbay, Shoptybay, on which field work was carried out along with mapping the structure and taking ligeochemical samples. Thus, the results of laboratory studies of 40 samples of the Shoimbay site characterize the unusual anomalous geochemical composition of the rocks. Thus, the Co content is 110 times higher than the clarke, the Ag content is 60 times higher than the clarke. The concentration coefficient for Pb (5.0) and Sb (3.75) is slightly higher than the clarke. There is a high copper content in the Shoptybay ring structure (Fig. 1), there are 10 points of copper mineralization. The results of laboratory studies of samples taken from these mineralization points showed increased contents of copper and silver - Cu about 1%, Ag about 30-50 g/t.



1 - undissected Quaternary sediments, 2 - Lower Carboniferous carbonate deposits, 3 - Middle-Upper Devonian terrigenous deposits, 4 - Lower-Middle Devonian felsic volcanics, 5 - predominantly felsic tuffs, 6 - Lower Devonian intermediate volcanics, 7 - silicification, 8 - secondary quartzites, 9 - faultings, 10 - points of copper mineralization

Figure 1 - Scheme of the geological structure of the Shoptybai ring structure in the Bing image

The Chapter V provides statistical data on the ore content of ring structures in Central Kazakhstan. An analysis of the mineralization types that are in spatial connection with the interpreted ring structures, as well as a scientifically grounded assessment of the industrial prospects of the structural-formational zones (SFZ) of Central Kazakhstan from the standpoint of the identified ring structures is given. Based on the statistical analysis of the manifestations of different types of ore content in the SFZ of Central Kazakhstan, the metallogenic trend was specified for the previously identified and determined for the newly identified RSs.

Brief conclusions based on the results of dissertation research

This work is focused on the further development of a highly interesting direction in geology - the study of ring structures, the wide distribution of which on the surfaces of all planets of the Solar system became evident in the very first years of space surveys. However, with all the relevance of the use of Earth remote sensing (ERS) materials in geology, work in this direction was and is being carried out unreasonably little, especially in Kazakhstan. In light of the above, this study is characterized by elements of novelty and innovativeness. As a result of the study, the following results were obtained:

- An assessment of the state of knowledge of ring structures (RS) is given on the basis of published and stock materials on the geology and metallogeny of RS, given in the List of references (there are total 154 titles in the work).

- Interpretation of Earth remote sensing data was carried out according to generally accepted methods on the territory of 17 sketching boards at a scale of 1:500,000

- Based on the materials of predecessors, the method of interpreting, the method of studying ring structures is systematized, and the features of the geological structure of typical ring structures of Central Kazakhstan are described.

- The main results of the study should include the compiled "Map of ring structures of Central Kazakhstan" at a scale of 1:500,000, on which 2686 RSs of various dimensions and nature were identified. The presence of such a large number of RSs indicates the intense fragmentation of the lithosphere and their autonomous development, caused by processes in the mantle and meteorite strikes from space. Areas of the lithosphere with a wide manifestation of RSs are zones of increased permeability for a more intense course of mass-thermal processes and the formation of ore objects.

- As a result of the analysis of the intensity of the RSs, the ratio of the ring structures in terms of dimension was revealed sheet by sheet and by the SPZ. An extremely uneven manifestation of the RSs is registered, which largely depends on the material composition of the rocks participating in the geological structure of a particular area of the Earth's crust. The identified RSs are clearly ranked by dimension into 3 classes: large with a diameter of 30 and >50 km, medium 10-29 km and small with a diameter of 0.5 <10 km. Prevailing are small RSs, which stand out in the amount of 1897 in the investigated area of Central Kazakhstan. While there are 1077 RSs of medium size, and only 197 large ones.

- According to a huge number of publications, RSs are divided into 6 types according to genesis: magmatogenic, cosmogenic, nuclear, metamorphogenic, tectonogenic, exogenous. All these types of RSs occur in the study area. On the basis of the compiled Map of Ring Structures of Central Kazakhstan, for the first time, they were ranked by genotypes, the dominant types were determined and the Table, presented in the Chapter II, was compiled. Thus, of the 2689 ring structures decoded in the study area, 1206 are attributed to the group of magmatogenic, which are fragmentary or completely represented by magmatic formations and are distributed mainly in the volcano-plutonic belts of the Devonian, Carboniferous-Permian Balkhash-Ili and Carboniferous Tasty-Kusak-Kotyrasan-AltynEmel VPB, as well as in the North-West sector of the island-arc Bozshakol-Shyngys-Tarbagatai folded system. Most - 1352 interpreted ring structures belong to the group of unknown genesis. Such structures were mainly observed in poorly exposed areas and in areas with outcrops of sedimentary and metamorphic deposits. Also, according to the "Catalog of Impact Structures of the Earth" A.V. Mikheeva, 39 impact structures are registered on the territory of the studied sheets, of which 5 are attributed to the group of reliable RSs, the remaining 34 - to the group of probable and estimated ones.

- A database of ring structures in the ArcGIS Database has been compiled, which includes the RSs identified earlier by the predecessors and newly identified during interpretation. The database is represented by a Table of attributes, reflecting the number of the structure, for known RSs - name, parameters, genetic

type, ore content, if any, and its quantity. The attribute Table can be extended with the advent of new data in the analysis of geological and geophysical materials. The database can be easily integrated with other Geographic Information Systems and exported to MS Access.

- Based on the statistical analysis of the manifestations of different types of ore content in the SFZ of Central Kazakhstan, the metallogenic trend was specified for the previously identified and determined for the newly identified RSs.

- Reliable basic material on the ore content of the investigated area, highlighted in Chapter V, made it possible to compile a very informative Table 5.2, which shows the manifestation intensity of ore mineralization in the SFZ of Central Kazakhstan and its amount in spatial relation to the RSs. Analysis of the Table showed a direct dependence of the concentration of ore-bearing RSs on the composition of the rock complexes composing one or another SFZ and, accordingly, on the conditions of their formation. Also, according to the data in the Table, the predominance of one or another type of mineralization in the SPZ is established, in connection with which their previously identified metallogenic trend is confirmed or clarified.

- According to the data in the Table, the polymetallic trend of most of the SPZ of Central Kazakhstan is clearly indicated, and in this regard, the confinement to the same ring structure of manifestations of different mineralization.

- The analysis of the types of mineralization showed the predominant development in the SFZ of Central Kazakhstan of copper-porphyry, copper-porphyry with gold and gold-silver mineralization.

- The performed statistical analysis of the spatial relationship of mineralization with RSs shows their high role in ore localization, which allows to recommend them as an effective exploratory criterion, therefore, despite significant differences in the geological structure of the studied region, the presence and number of ore-bearing ring structures allows to rank the studied areas into different groups according to the degree of prospects.

- As a result, Big Konyrat, Kyzyltas, East-Kyzyltas, Symbyl, Shoimbai, Shoptybai RSs with copper and gold-silver specialization were recommended as promising for further prospecting and exploratory evaluation works.

The results obtained sufficiently indicate that additional study of ring structures at a new level using modern ERS methods seems to be a promising and fruitful direction of searches.