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IRON AND MANGANESE ORES IN THE GEOLOGICAL HISTORY OF CENTRAL KAZAKHSTAN

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ABSTRACT

The history of iron and manganese accumulation in Kazakhstan has been analysed by identifying ore formations and revealing geological conditions of their generation. A quantitative assessment of the ore contents of the formations identified has been carried out. Epoches of maximum ore accumulation and regimes most favourable for ore genesis have been distinguished.

INTRODUCTION

At present, Central Kazakhstan has become the second manganese ore base in the USSR after the Ukraine (ROZHNOV *et al.*, 1985). 321 deposits and ore manifestations of iron and manganese are discovered on the territory of Central Kazakhstan. Specialised metallogenic works carried out at the mentioned objects and on an entire territory allow us to characterize history of iron and manganese accumulations of the region *(Fig. 1)*. A metallogenic analysis was carried out on the basis of the identification of ore formations, i.e. sets of ore deposits and manifestations common in mineralogical-geochemical composition, geological conditions of origin and age. Paleotectonic constructions were used to characterize geological conditions in terms of the ore formation generation.

ORE FORMATIONS

Studying a process of the iron and manganese accumulation it is only advisable to consider its development in time *(Fig. 1)*.

Pre-Cambrian series different in age contain horizons of iron quartzites. However, all the deposits of commercial value occur only among rocks of the Early Proterozoic Karsakpayskaya series, making up the *Early Karelian regionally-metamorphosed hydrothermal (volcanic) — sedimentary formation of iron quartzites (jaspilitic)*.

After S. B. ROSANOV (1976) and L. I. FILATOVA (1983) Karsakpayskaya series is characterised with a rough rhythm. There are four suites which may be considered

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as microrhythms. Porphyritoids and greenschists make 50% of the section whereas high-iron basalts dominate in composition. The latter is isolated in the lower part of each suite, and its upper parts are formed by phyllite bands with iron quartzite horizons. Nine horizons of iron quartzites have been revealed, part of which is traced in a submeridional direction at a distance of 200 km (the Karsakpayskaya ore zone in *Fig. 1*). Quartzites are mostly of hematite, rarely of magnetite-hematite. Ore varieties transit into ore-free ones, sometimes into graphitite microquartzites. Marble may also occur. Thickness of ore bodies within a deposit drastically changes achieving 25 m depending on the confinement to limbs or curves of folds. A mean iron content in the ore is of 40%, SiO_2 — 35%. The Karsakpayskaya series is considered to be a greenschist basalt-spilitic jaspilite-bearing early geosynclinal early Karelian formation generated within the intracratonal trough.

Non-commercial, though the most ancient manganese ore manifestation is Utegensor in the Chingiz mountains in the East of the region. Quartzites with 2—12% iron content and that of the 29—37% manganese occur in the band of sericitic-quartz microquartzites being in themselves the metamorphosed (greenschist facies) tuffogene siliceous sediments with volcanites of predominantly acid composition referred to the Late Proterozoic Murzhikskaya series.

Three ore formations were generated during the Early Caledonian geosynclinal cycle.

The deposits of the *Early Caledonian iron-manganese hydrothermal (volcanic) — sedimentary formation* are confined to the early geosynclinal Caledonian troughs *(Fig. 2)*. The ore generation is probably connected with processes accompanying volcanism displayed in these troughs against the background of the siliceous-terrigenous sedimentation in 0_{1-2}. Volcanites are represented, predominantly, by homogeneous basalt series of tholeiitic composition. The Kosagalinskaya ore zone deposits are typical ones *(Fig. 1)*. They occur among sandstone suites of the Middle Ordovician, sections of which reveal rare horizons of basalts and siliceous rocks. The latter contains ore bodies 1—32 m thick (6 m in average), the iron content is of 18—42%, that of the manganese is of 0,1—7%. The main ore minerals here are magnetite and hematite. The deposits in terms of size are small ones. Conditions involved into the ore formation generation characterized with a high tectonic activity did not assist in forming large deposits. A quality of ores occurring in zones of the contact with the later granitoid intrusions becomes slightly higher.

A small deposit of Otaydy-Karasu represents the *Early Caledonian titanomagnetite late-magmatic formation.* After E. M. Spiridonov (1979), an ilmenite-titanomagnetite mineralization is confined to most large differential bodies of ultrabasites o

Fig. 1. Iron and manganese deposits in Central Kazakhstan. I — **ore formations:** 1 — oligocene platformal chemogenic-sedimentary oölitic (siderite-leptochlorite-hydrogoethitic); 2 — Late Hercynian skarn-copper-magnetite; 3 — Early Hercynian skarn-magnetite; 4 — Early Hercynian magnetite-titanomagnetite of coastal-marine placers; 5 — Early Hercynian iron-manganese hydrothermal (volcanic)-sedimentary; 6 — Late Caledonian skarn-magnetite; 7 — Early Caledonian skarn-magnetite; 8 — Early Caledonian titanomagnetite late magmatic; 9 — Early Caledonian iron-manganese hydrothermal (volcanic)-sedimentary; 10 — Early Karelian regionally-metamorphosed hydrothermal (volcanic)-sedimentary formation of iron quartzites (jaspilitic). **II — IV — deposits (II—small, III — middle, IV — large). V — age of mineralization. VI — iron and manganese ore zones:** *A* — Atansor-Kuzganskaya, *B* — Karsakpayskaya, *C* — Dzhezdinskaya, *D* — Zhailminskaya, *E* — Kosagalinskaya, *F* — East-Karkaralinskaya. **VII — a boundary of the epipaleozoic platform mantle** spread within Central Kazakhstan. **VIII — a boundary of the area to carry out** specialized metallogenic works.

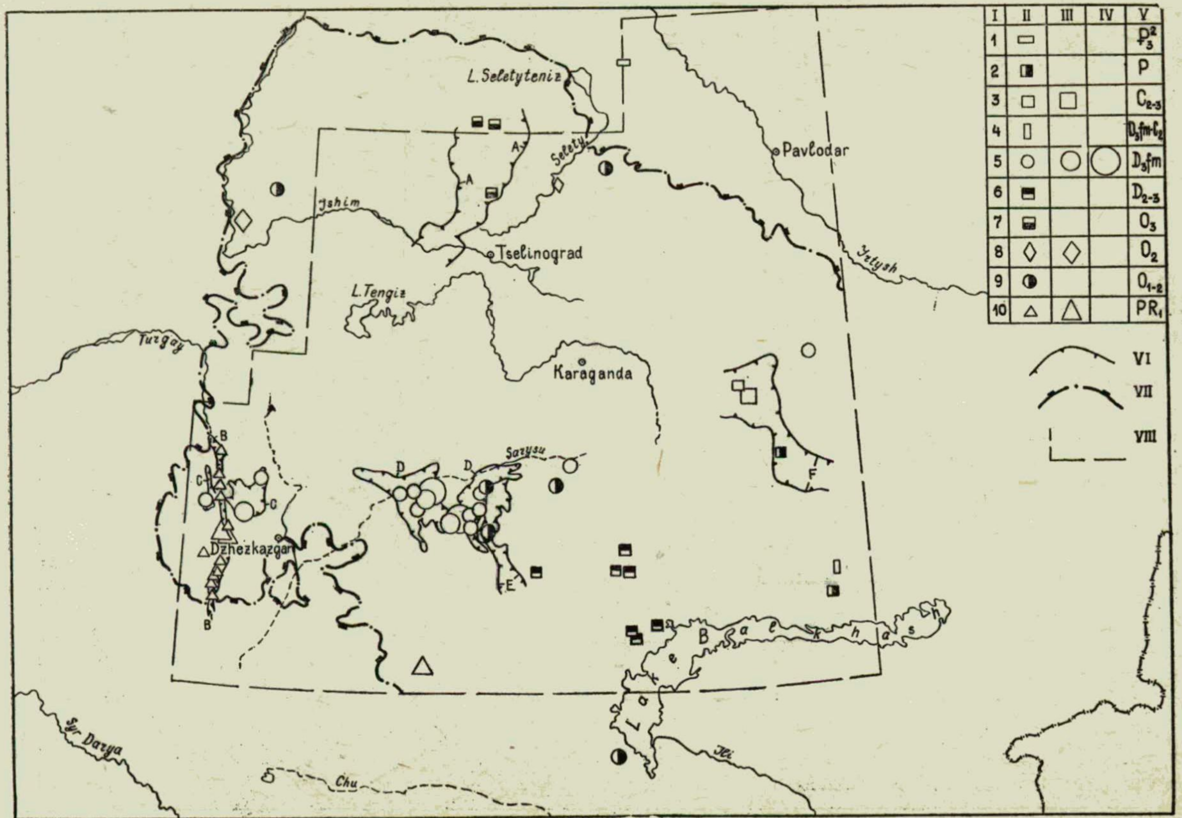

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Fig. 1

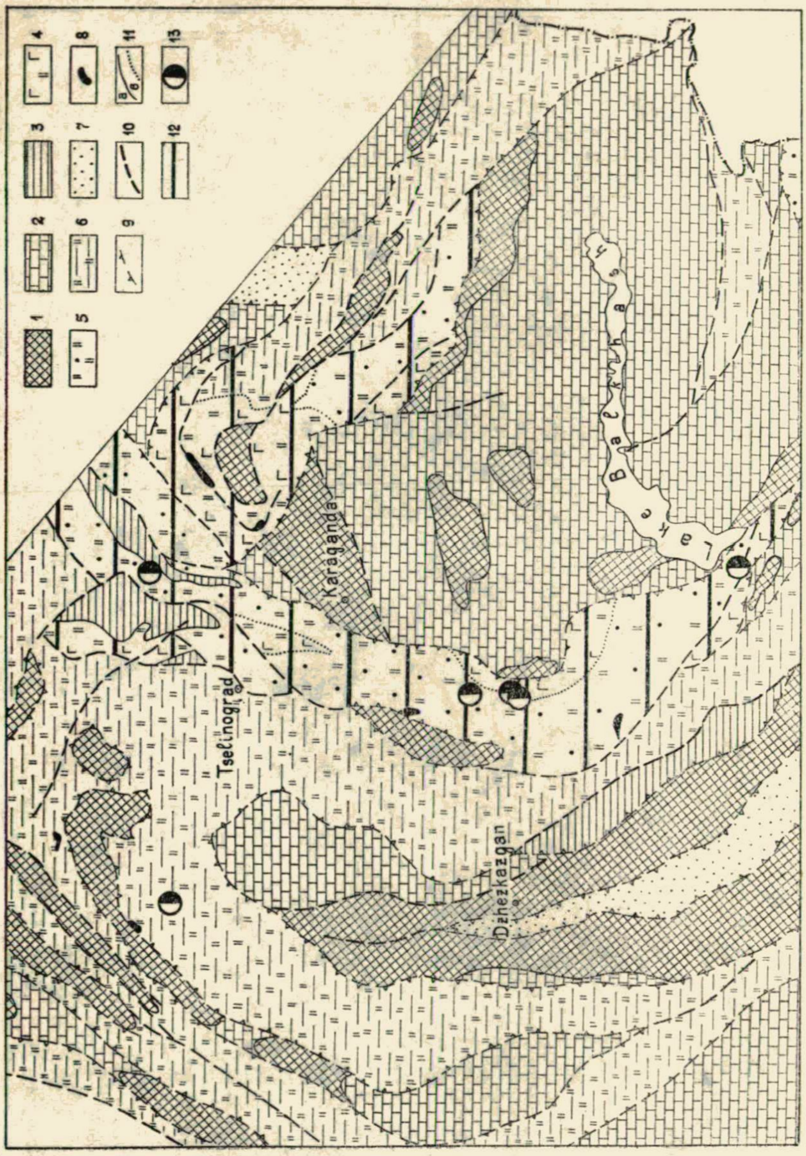
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Fig. 2

the phase II of intrusion (clinopyroxenites are often olivine one) of the Middle Ordovician intrusive complex. The latter being comagmatic to high aluminium basalts of Sagskaya series (O_2) formed under conditions of a mature geosynclinal regime is represented with small stock and funnel-shaped massifs. The iron content in ores is of 12—19% (up to 37% by section), TiO_2 — of 0,5—3% (up to 7%).

The Early Caledonian skarn-magnetite formation was generated on the verge of the geosynclinal stage proper and is associated with intrusions of granodiorites forming within the Taconic folding phase (O_3). Deposits are confined to contacts of diorites and granodiorites with volcanogenic sedimentary rocks of the Sagskaya series (O_2) and groupped into Atansor-Kuzganskaya ore zone *(Fig. 1)*. By composition of metasomatites, these deposits are of calc-skarn, small in size; ores are of magnetite with the mean iron content of 45%.

The Late Caledonian skarn-magnetite formation is typical for a region of the Telbessian-Middle Devonian folding occurrence and is associated with Devonian granitoid massifs widely spread over that region. Two subformations have been identified: calc-skarn and magnesian-skarn. A small deposit of Bapy refers to the second subformation, lizardite-magnetite ores of which have been probably formed under metasomatosis of dolomite.

The Early Hercynian iron-manganese hydrothermal (volcanic)—sedimentary formation is the most important for Central Kazakhstan. All the known manganese and main iron deposits formed in the Famennian and occurring, basically, among Famennian sediments appertain to the mentioned formation.

Main deposits are concentrated in Zhailminskaya ore zone *(Fig. 1)* (Atasuysky region). The largest deposit — Western Karazhal is confined to the southern part of the zone. It is represented with beds of hematite, magnetite and manganese (braunite-hausmannite) ores occurring in the band of knot-bedded red-coloured limestones of the Upper Famennian substage. The mean content of components in corresponding ores is of Fe — 50%, Mn — 20%. The majority of deposits in the northern part of the zone are complex. They contain iron-manganese and barite-polymetallic ores. By this sign, they are identified as deposits of Atasuysky type (ROZHNOV, 1967). A most large manganese deposit among them is Ushkatyn III, ores of which are also conifined to red-coloured limestones of the Upper Famennian.

The majority of the Zhailminskaya zon edeposits occur within siliceous-carbonate rocks and are singled out into a separate subformation (Karazhalsky type). Deposits confined to terrigenous rocks (Dzhezdinsky type) appertain to another subformation. They are typical for Dzhezdinskaya ore zone *(Fig. 1)*, and occur in the conglomerate-sandstone Uytasskaya suite of the Lower Famennian manifesting the beginning of the Famennian transgression. Their size is not large.

Fig. 2. Paleotectonic scheme of the Early-Middle Ordovician of Central Kazakhstan (after ZAITSEV *et al.*, 1987) and iron-manganese deposits of the given age. 1—2 — residual median massifs (1 — erosion areas, 2 — covered by a mantle of limestone, terrigenous, siliceous-terrigenous and volcanic formations); 3 — new geoanticlinal uplifts (erosion areas); 4—5 — troughs with eugeosynclinal development regime (4 — filled with basalt, andezite-basalt and jasper-basaltic formations; 5 — terrigenous-siliceous formation); 6 — troughs with chemi-eugeosynclinal development regime, filled with siliceous-terrigenous, volcanic-siliceous-terrigenous, carbonate formation; 7 — troughs with inverse development regime filled with terrigenous, carbonate-terrigenous flyschoid formations; 8 — massifs of hyperbasits; 9 — boundaries of median massifs; 10 — regional faults; 11 — geological boundaries (a) and facial boundaries (b); 12 — regions of the highest tectonic activity; 13 — iron-manganese deposits

Famennian weakly differential subalkaline olivine basalts are locally revealed in almost all the ore fields of the formation. Established in time and space, the proximity of processes involved into the basalt magmatism, potassic metasomatism and ore formation constitutes a united hydrothermal-magmatic system (VEIMARN *et al.*, 1981).

A paletotectonic analysis *(Fig. 3)* showed that the majority of deposits in the formation is confined to a latitudinally oriented paleotrough which had occupied a cross-cutting position relative to earlier existed structures, and had a heterogeneous basement (VEIMARN *et al.*, 1986). The tectonic regime within its limits is a geosynclinal activisation (regeneration of geosynclinal conditions) after a preceding orogenic stage in the development. The comparison of the trough with modern rifting zones is quite possible. Most large deposits were forming under conditions of the sea-floor stagnant depressions where a siliceous-coaly-clay-carbonate flyschoid formation under a regime of the miogeosynclinal activization had accumulated. Iron-manganese deposits of commercial value in quazi-platform regions and Hercynides which did not experience previous Caledonian folding and characterized by an early geosynclinal and mature geosynclinal tectonic regime are not fixed.

The Early Hercynian formation of coastal-marine placers is represented by titanomagnetite sandstones. Ultrabasic rocks eroded on adjacent uplifts constitute a principal source of ore minerals. Poor ores prevail.

The Early Hercynian (C_{2-3}) skarn-magnetite and Late Hercynian (P) skarn copper-magnetite ore formations are associated with widespread orogenic magmatism of corresponding time. Deposits of these formations are groupped into Eastern-Karkaralinskaya iron zone *(Fig. 1)* ("Geology and metallogeny...", 1971). The location of the zone is determined by an intersection of the edge part in Dzhungaro-Balkhashskaya geosyncline with deep fault. A most significant deposit here is Kentobe, rich massive magnetite ores of which contain 62% of iron.

Thick crusts of weathering formed during the Mesozoic-Cenozoic in Central Kazakhstan have been, mainly, eroded later. Most probably, the latter served as a source of metals for *Oligocene platformal chemogenic-sedimentary oölitic (siderite-leptochlorite-hydrogoethitic) formation,* commercial deposits of which within Central Kazakhstan have not been singled out.

ORE CONTENT OF FORMATIONS

A quantitative assessment of the ore contents of formations identified as performed allowing for forecasting data is presented in a relative scale in *Fig. 4*. As, only a modern structure of the region was analysed, ore contents of formations character-

Fig. 3. The paleotectonic scheme of the Famennian in the Central Kazakhstan. 1 — erosion areas; geological formations and associations: 2 — salt-bearing; 3 — terrigenous, red, continental; 4 — carbonaceous-gypsiferous-terrigenous lagoon type; 5 — carbonaceous (prevailingly dolomitic) marine; 6 — limestone marine; 7 — calciferrous-terrigenous coastal-marine; 8 — terrigenous carbonaceous marine; 9 — red knot-bedded limestones forming upper parts of the sections in a number of structures; 10 — clay-siliceous-carbonaceous flyschoid; 11 — aleurite-clay; 12 — terrigenous marine; 13 — carbonaceous-tuffaceous-terrigenous-flyschoid; 14 — tuffaceous-terrigenous; 15 — terrigenous-siliceous; 16 — porphyric dacite-liparite; 17 — consedimentation faults; 18 — younger faults; 19 — the boundaries of the Kazakhstan-Tien Shan epi-Caledonian median massif; 20 — the boundaries of the areas which had experienced the pre-Famennian folding; 21 — isopachytes; 22 — manifestations of basaltic volcanism; 23 — iron-manganese deposits

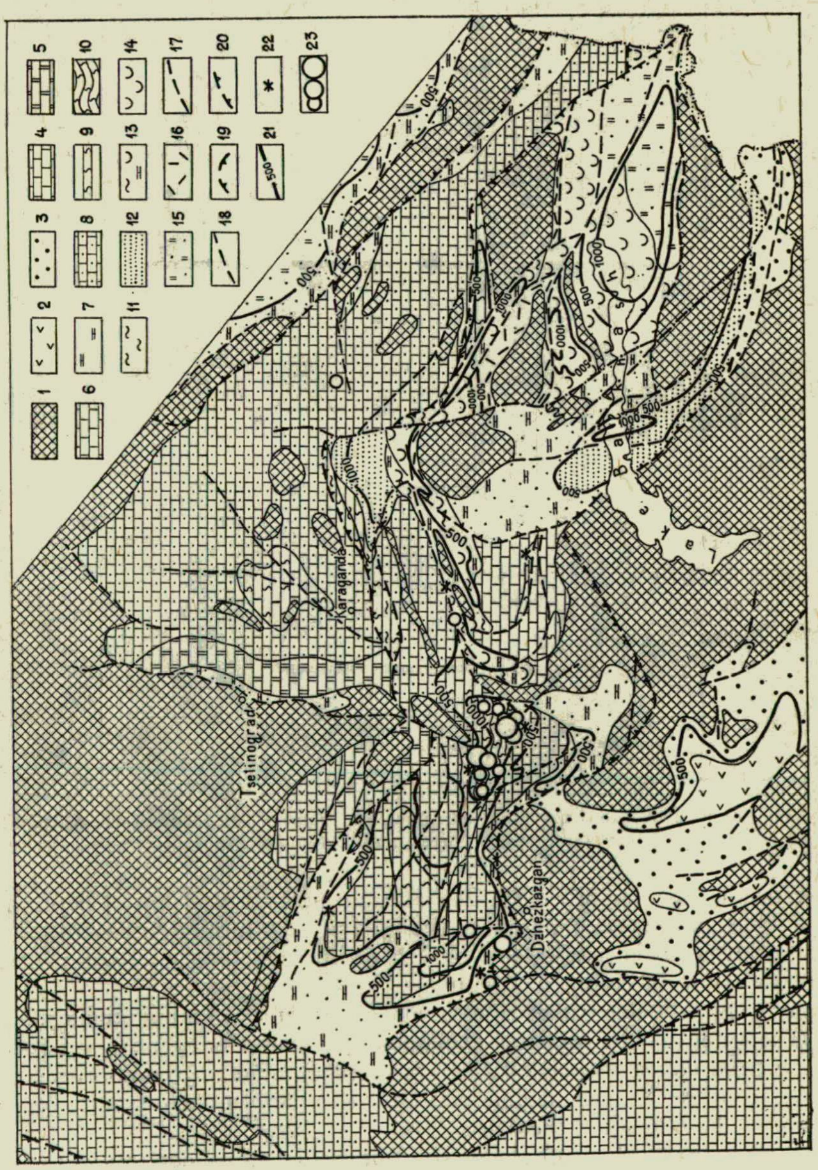

Fig. 3

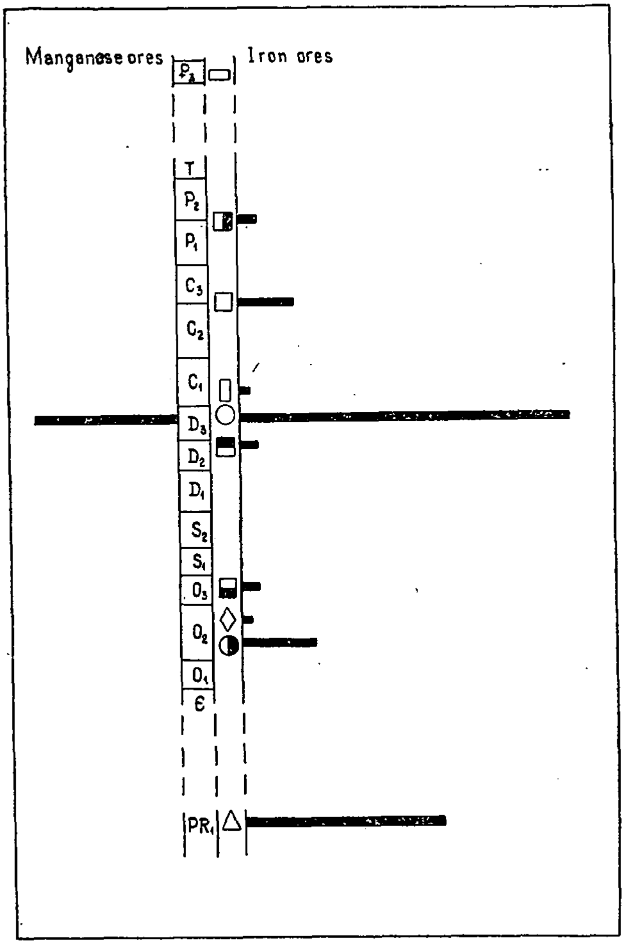

Fig. 4. Ore content of iron and manganese formations. Signs of ore formations located along the stratigraphic scale correspond to signs in *Fig. 1.*

ize an erosional section of Central Kazakhstan up to 0,5—1 km of depth and not absolute scales of ore accumulation in the time of each formation generation.

Following a given assessment, only hydrothermal (volcanic)-sedimentary and skarn deposits are of commercial value.

Skarn-magnetite deposits various in age contain ores of a high quality but small in size. The latter may be probably explained by a character of magmatic rocks with which the deposits are associated. They are predominantly granodiorite complexes derivative from the granite magma as opposed to gabbro-plagiogranite ore-bearing intrusions of the Urals and the Turgai.

The generation of hydrothermal (volcanic)-sedimentary deposits in the geological history of the region took place three times. In the Early Proterozoic a considerable number of ores, though, of low quality has been formed. Geological conditions typical for early geosynclinal troughs of the Early-Middle Ordovician were not favourable for ore concentration. Small in size, iron-manganese deposits, rarely the manganese ones have generated. Similar deposits are typical for the Urals geosyncline. The Famennian is the time of all the commercial manganese concentrations along with most large ones of the iron ore in Central Kazakhstan being formed.

A study of the changes in the endogenic tectonic regimes both in time and space within Central Kazakhstan show that the miogeosynclinal activization regime (regeneration of geosynclinal conditions, rifting) for areas which experienced a considerable previous consolidation of the earth crust is most favourable for iron-manganese accumulation.

The interrelationship between iron and iron-manganese ore zones of various age is most peculiar. With a general latitudinal orientation of the expansion range of the Early Hercynian hydrothermal (volcanic)-sedimentary iron-manganese formation, a most important in the region, its main ore zones are conjugated in space with more ancient ones *(Fig. 1)*.

CONCLUSIONS

Metallogenic analysis of Kazakhstan territory showed that virtually all the commercial manganese deposits are of Famennian age and appertain to the Early Hercynian hydrothermal (volcanic)-sedimentary iron-manganese formation. Studies on geological settings of the deposit formation have allowed us to identify epochs and tectonic regimes most favourable for ore concentration ensuring a substantial approach to prospecting, evaluating and predicting mineralization. Comparison with other regions serves to prove the relationships established, to a certain degree, to be of a common nature.

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