

**ROCK GEOCHEMISTRY IN THE
LENINOGORSK AND ZYRYANOVSK VMS
REGIONS (RUDNY ALTAI VMS PROVINCE ,
KAZAKHSTAN)
IMPLICATION FOR ORE GENESIS AND
EXPLORATION**

**I. GOLDBERG, G. ABRAMSON,
V. LOS & V. NAZAROV
IONEX Pty Ltd, AUSTRALIA
AO “KAZZINC”, KAZAKHSTAN**

MAP OF KAZAKHSTAN



RUDNY ALTAI



RUDNY ALTAI VMS PROVINCE

- The Rudny Altai VMS Province extends over 500 km along the north-eastern border of Kazakhstan. The main resources are concentrated in the Leninogorsk and the Zyryanovsk Ore Regions, where they are associated with Devonian volcanogenic-sedimentary rocks. The metal reserves (Zn-Pb-Cu) total approximately 23 million tonnes in the Leninogorsk Region and 20 million tonnes in the Zyryanovsk Region.

NEW EXPLORATION

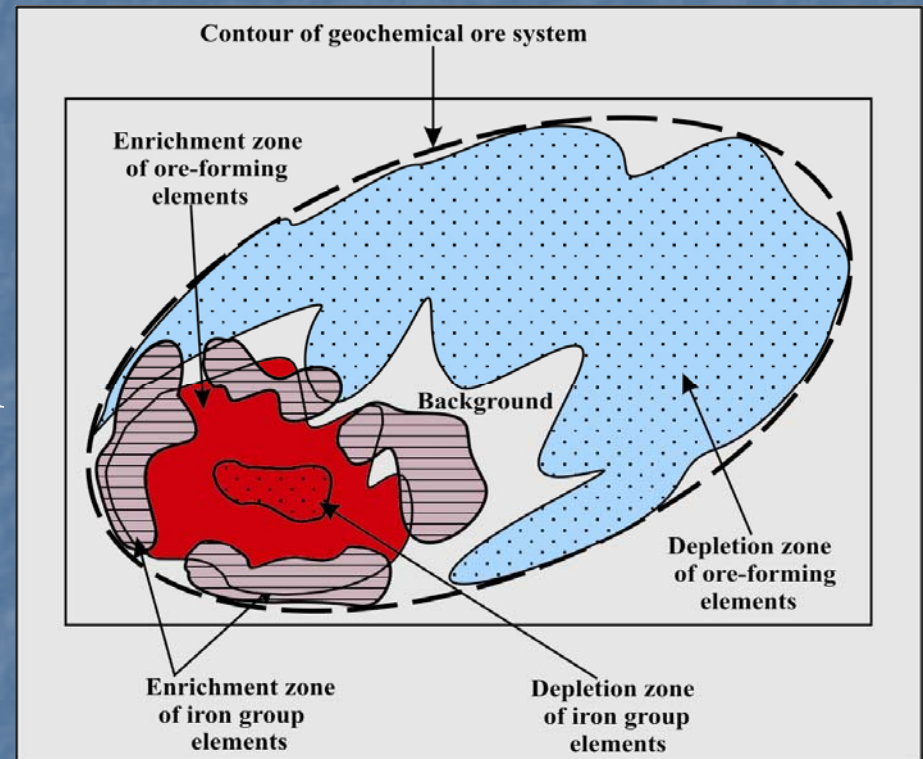
- The known orebodies in the 20,000 km² Leninogorsk and Zyryanovsk Regions now are all but exhausted and there is an urgent need to discover new reserves. To meet this need, the joint stock company “AO Kazzinc” has commenced exploration of the region based on IONEX technology.
- Exploration using IONEX technology involves a sequence of four stages that start with a reconnaissance geochemical survey and continue with progressively more detailed work in selected areas.
- IONEX technology is based on mapping geochemical systems at various scales and identifying the enrichment and depletion zones of ore-forming and associated elements in the systems. (The distribution of enrichment and depletion zones in a geochemical system is referred to as “polar zoning”)

MODEL OF GEOCHEMICAL ORE SYSTEMS

It has been found that geochemical systems in ore bearing areas contain zones where elements are enriched relative to background and zones where they are depleted relative to background and that this so-called “polar zoning” is present in the geochemical systems at all scales. That is to say the geochemical systems are fractal.

□ Exploration using IONEX technology involves mapping geochemical systems of various scales and then identifying:

- polar zoning of the distribution of ore-forming elements
- polar zoning of the distribution of ferrous group elements



SAMPLE COLLECTION

- Samples for the regional reconnaissance stage of exploration in the Leninogorsk and Zyryanovsk Regions were taken using helicopter and ground transport.



SAMPLE COLLECTION

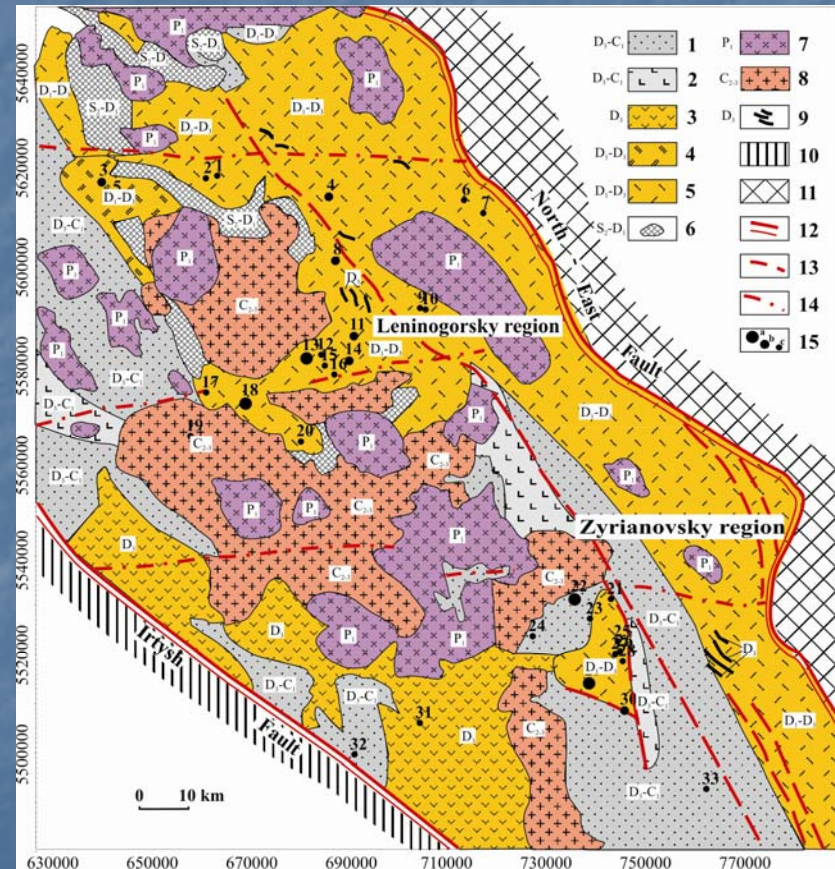
- Samples for the regional reconnaissance stage of exploration in the Leninogorsk and Zyryanovsk Regions on a grid of 5x5 km.
- 30% of the regions was in mines and covered areas and was inaccessible for taking rock samples on a regular grid.
- The weight of each rock sample was $\sim 1\text{kg}$.
- Total number of samples taken – 683.

ANALYSIS

- The chemical analysis method used was inductively coupled plasma mass spectrometry.
- Samples were analysed for a broad range of elements.
- This presentation provides data for Zn, Pb - the main ore elements in the regions and for Ti – which is the most characteristic siderophile element in the regions.
- The limits of detection were Zn – 5 ppm, Pb – 3 ppm, Ti – 0.05% - each lower than the Clarke value for the rock types present in this regions.
- Quality control was provided by analysis of 30 samples. The random error shows to the good quality of the analyses

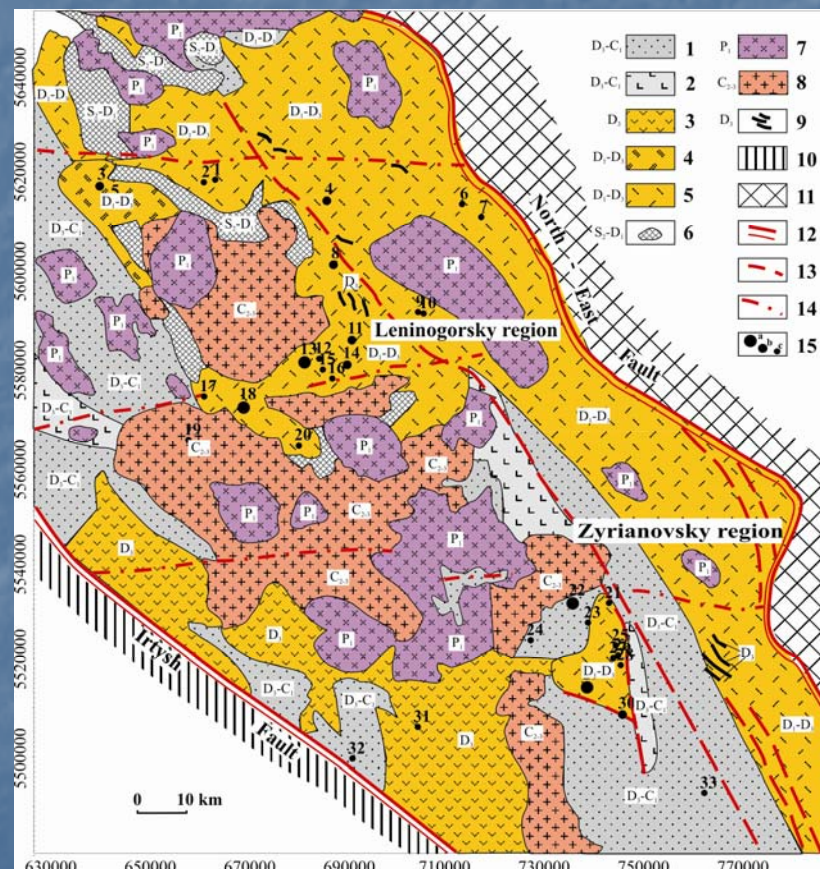
GEOLOGICAL MAP OF LENINOGORSK AND ZYRYANOVSK REGIONS

- The Rudny Altai Province is flanked on its western side by the deeply penetrating Irtysh Shear Zone which separates the Province from the western Kalba Region. On its eastern flank the Rudny Altai Province is bordered by the North-east Shear Zone which separates the Province from the Gorny Altai Region.



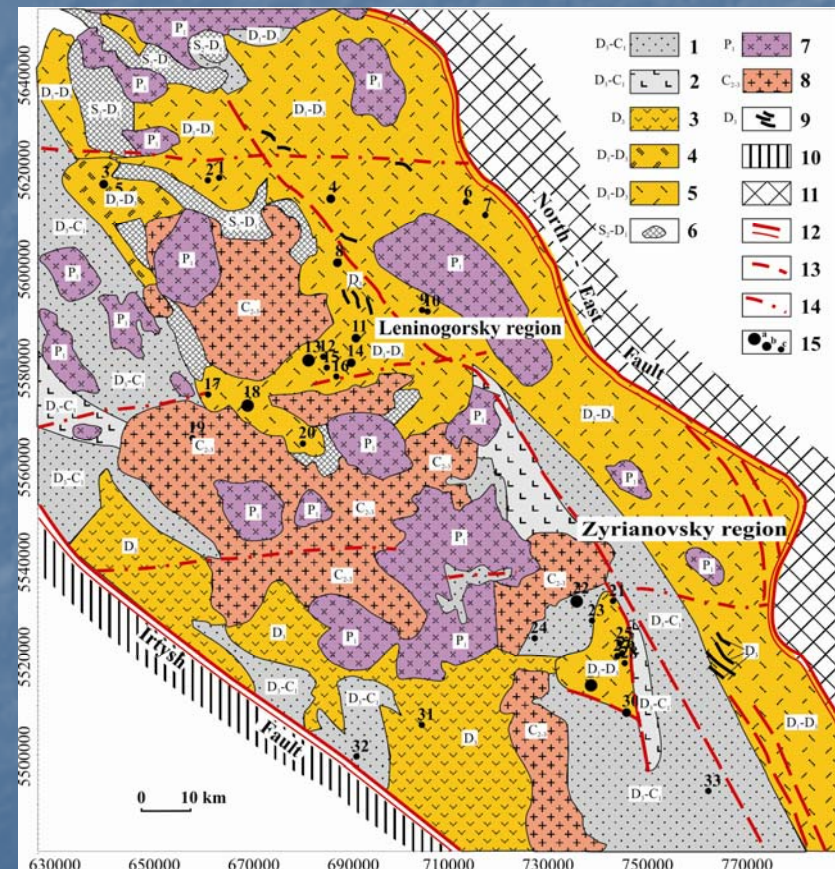
GEOLOGICAL MAP OF THE LENINOGORSK AND ZYRYANOVSK REGIONS

- Seismic data show that the Irtysh Shear Zone extends to a depth of 20 km and that the North-East Shear Zone extends to a depth of about 60 km



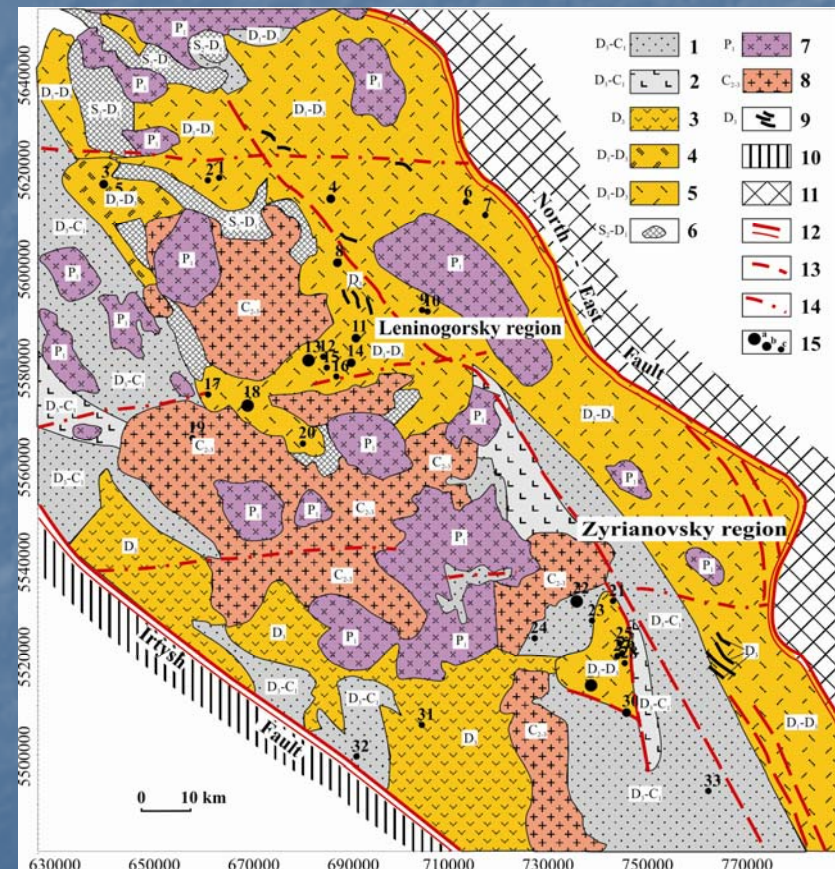
GEOLOGICAL MAP OF LENINOGORSK AND ZYRYANOVSK REGION

- Down to depth of ~10 km the regions have a two-layer structure:
 - a lower (Caledonian, S_2 - D_1) layer – sandstone, phyllites and greenschist.
 - an upper (Hercynian, D_1 - D_3) layer – volcanogenic – sedimentary formations.
- The main VMS mineralization is linked spatially to the Hercynian layer.



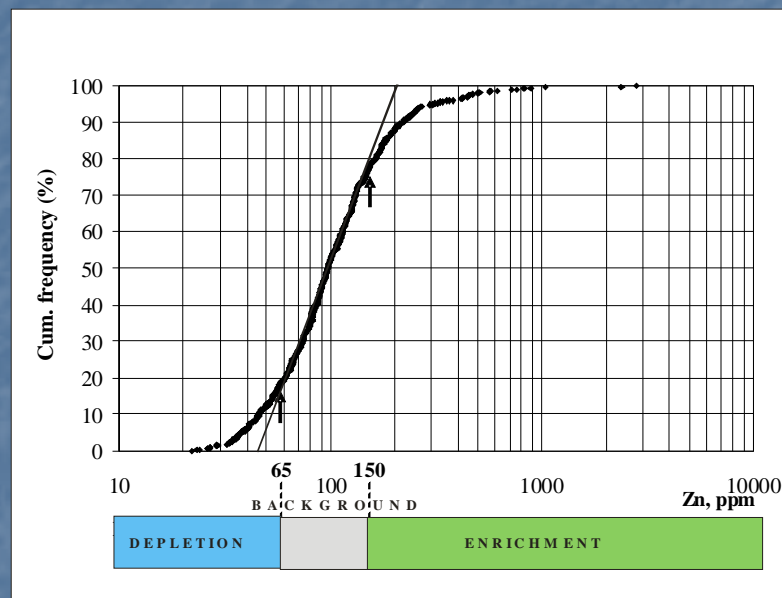
GEOLOGICAL MAP OF LENINOGORSK AND ZYRYANOVSK ORE REGIONS

- The upper layer is exposed mainly in the centre of area where it consists of carbonate and terrigenous deposits (D_3-C_1), of gabbros granodiorites and granites (C_2-C_3), and granites (P_1)
- Granites are exposed over about ~30% the area.



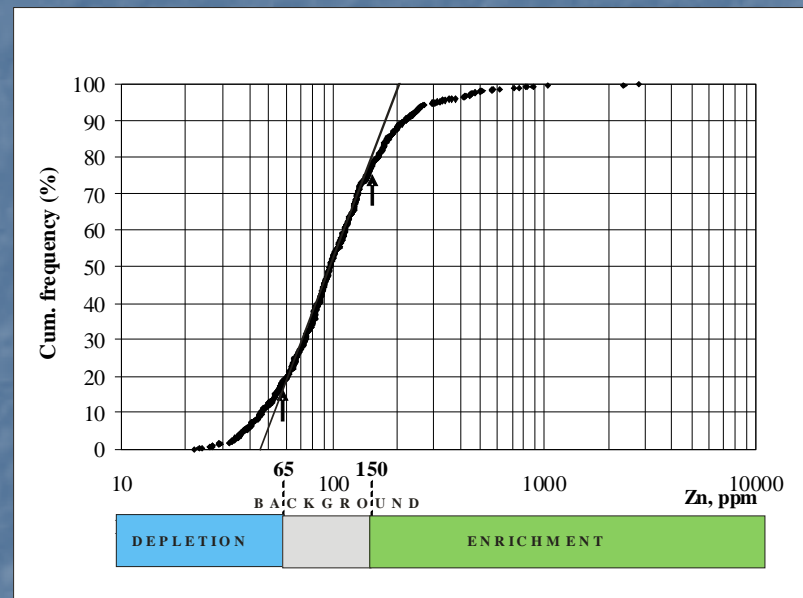
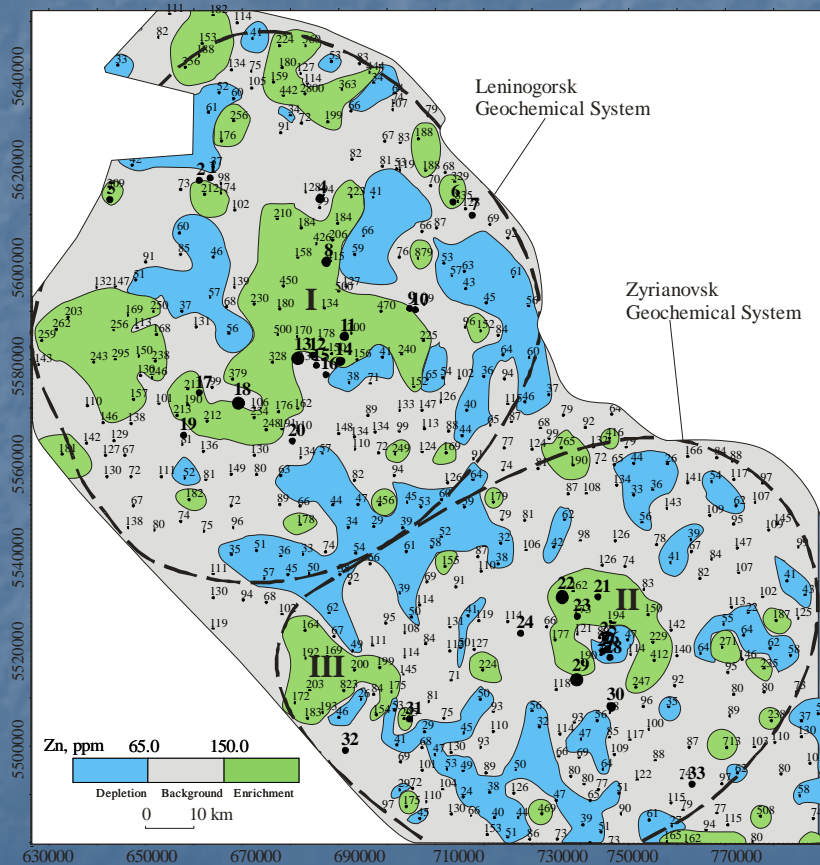
DISTRIBUTION OF ZINC LENINOGORSK AND ZYRYANOVSK REGION

- There are 3 main Zn populations in the Leninogorsk and Zyryanovsk Regions:
 - < 65 ppm – depletion zone
 - 65 – 150 ppm – background and average (101ppm) is very close to Clarke value
 - >150 ppm – enrichment zone



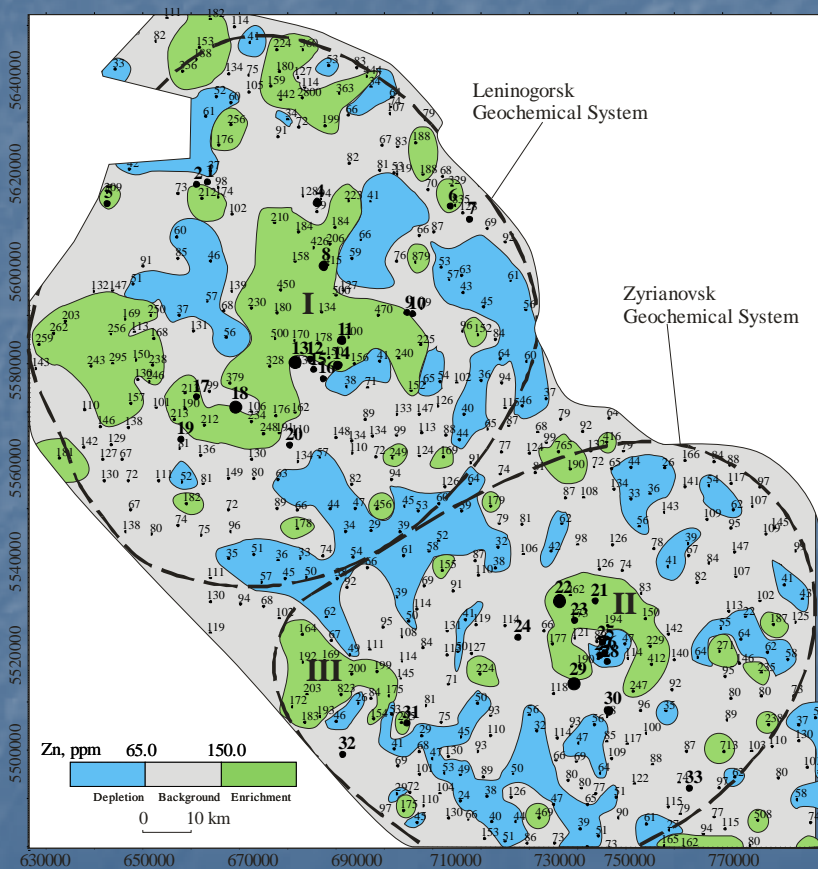
Cumulative distribution plot of Zn in host rock of Leninogorsk and Zyryanovsk Ore Regions

DISTRIBUTION OF ZINC LENINOGORSK AND ZYRYANOVSK REGIONS



Cumulative distribution plot of Zn
in host rock of Leninogorsk and
Zyryanovsk Regions

DISTRIBUTION OF ZINC LENINOGORSK REGION

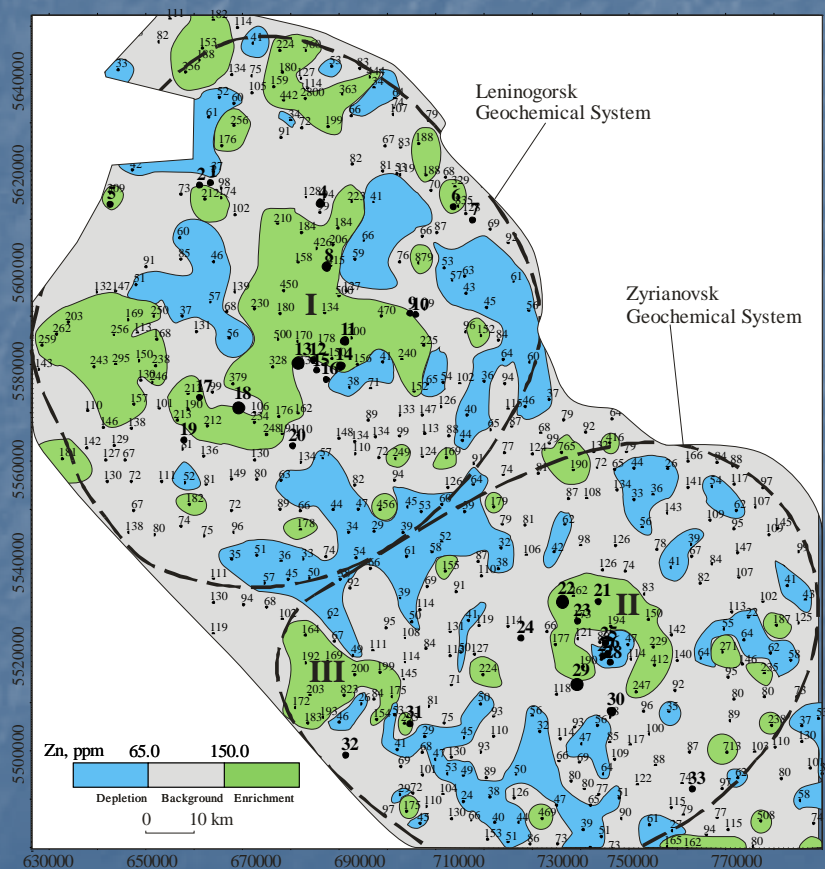


□ In the Leninogorsk Region the enrichment zones cover $\sim 2,450 \text{ km}^2$. Ore deposits are localized mainly along the periphery of enrichment zones.

The depletion zones are located around enrichment zones and cover $\sim 2,400 \text{ km}^2$.

The depletion and enrichment zones could be outlined as a single Leninogorsky geochemical system.

DISTRIBUTION OF ZINC ZYRYANOVSK REGION



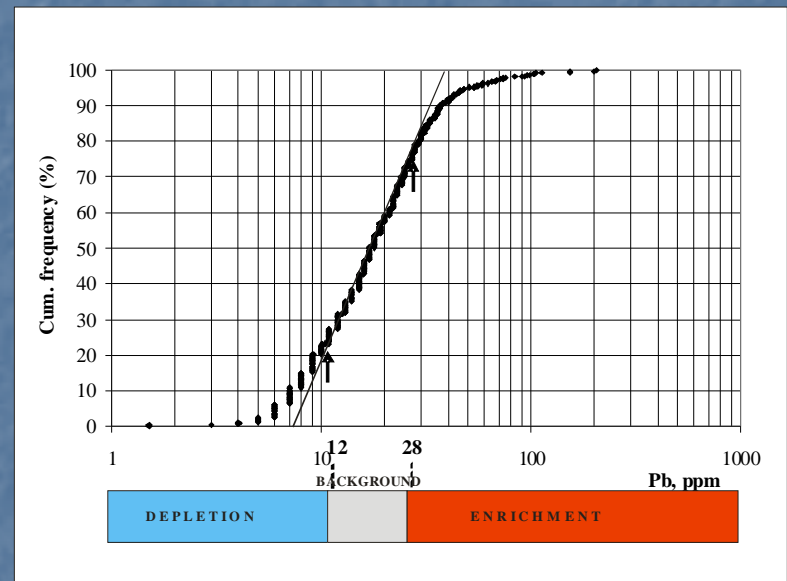
■ In the Zyryanovsk Region (II) the enrichment zone covers $\sim 350 \text{ km}^2$. Ore deposits are localized mainly inside or along the periphery of the enrichment zone.

The depletion zones are located around the enrichment zones and cover $\sim 1,300 \text{ km}^2$.

■ In the west of the Zyryanovsk Region there is the Ormansk Ore Cluster (III). It is outlined as part of the Zyryanovsk geochemical system

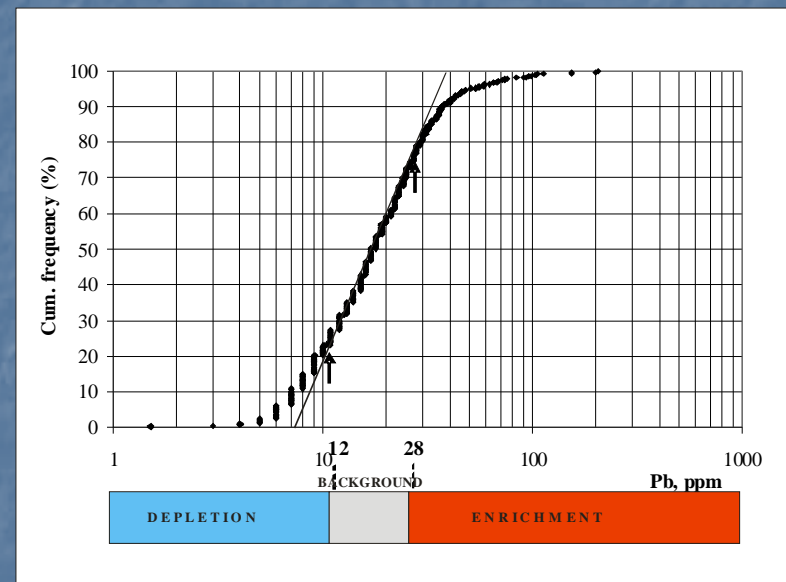
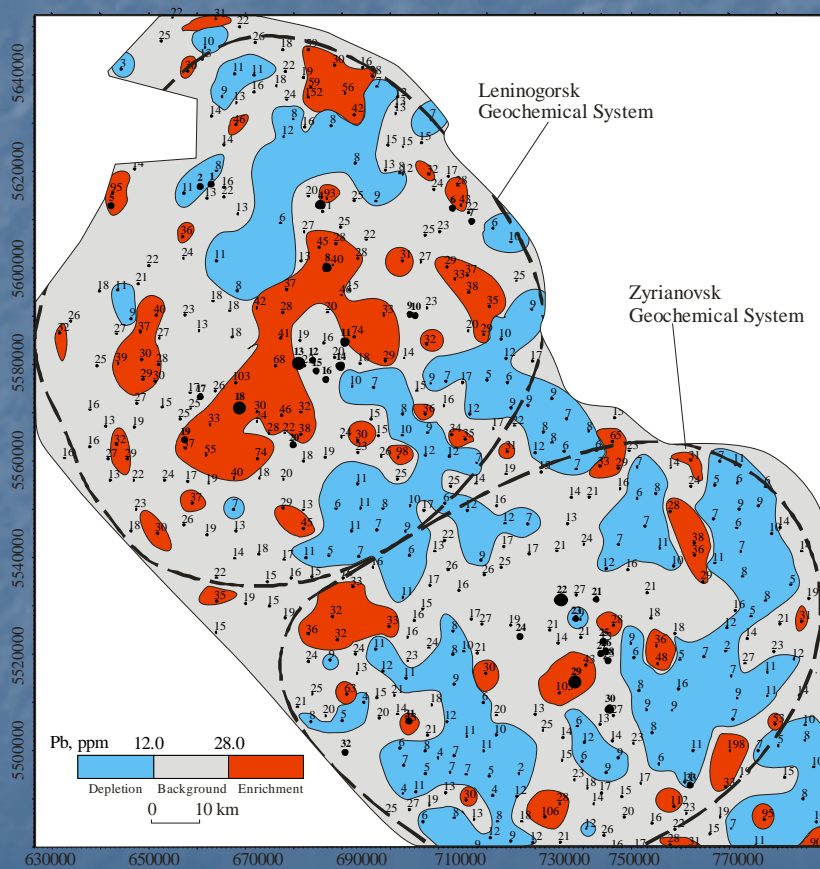
DISTRIBUTION OF LEAD LENINOGORSK AND ZYRYANOVSK REGIONS

- There are 3 main Pb populations in the Leninogorsk and Zyryanovsk Regions :
 - < 12 ppm – depletion zone
 - 12 – 28 ppm – background and average (19.2ppm) is very close to Clarke value
 - >28 ppm – enrichment zone



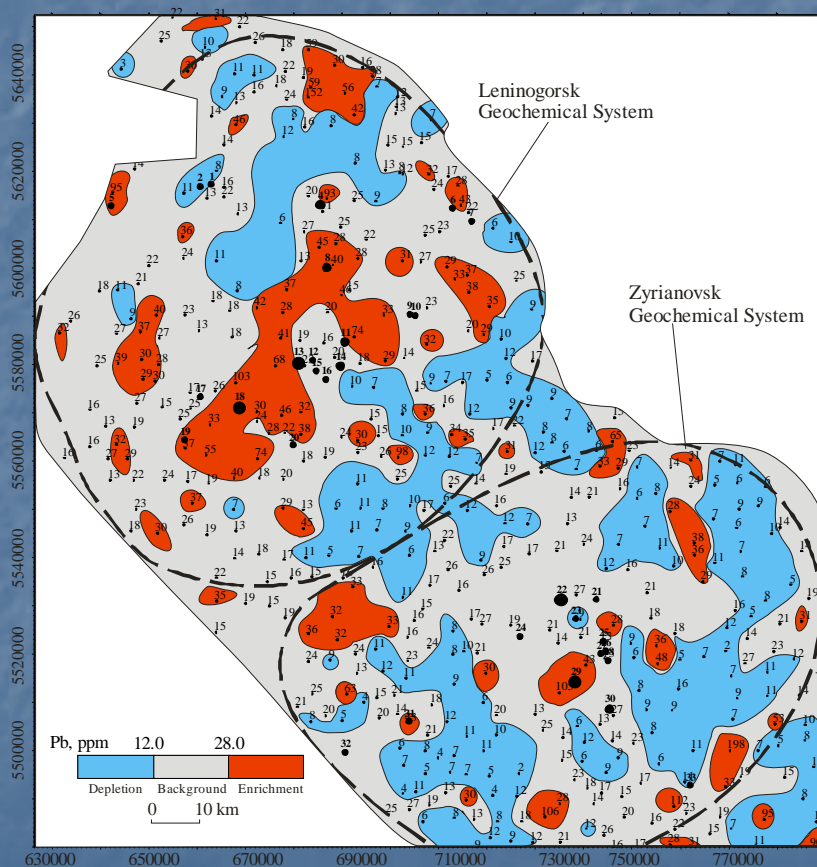
Cumulative distribution plot of Pb in host rock of Leninogorsk and Zyryanovsk ore regions

DISTRIBUTION OF LEAD LENINOGORSK AND ZYRYANOVSK REGIONS



Cumulative distribution plot of Pb in rocks of the Leninogorsk and Zyryanovsk Regions

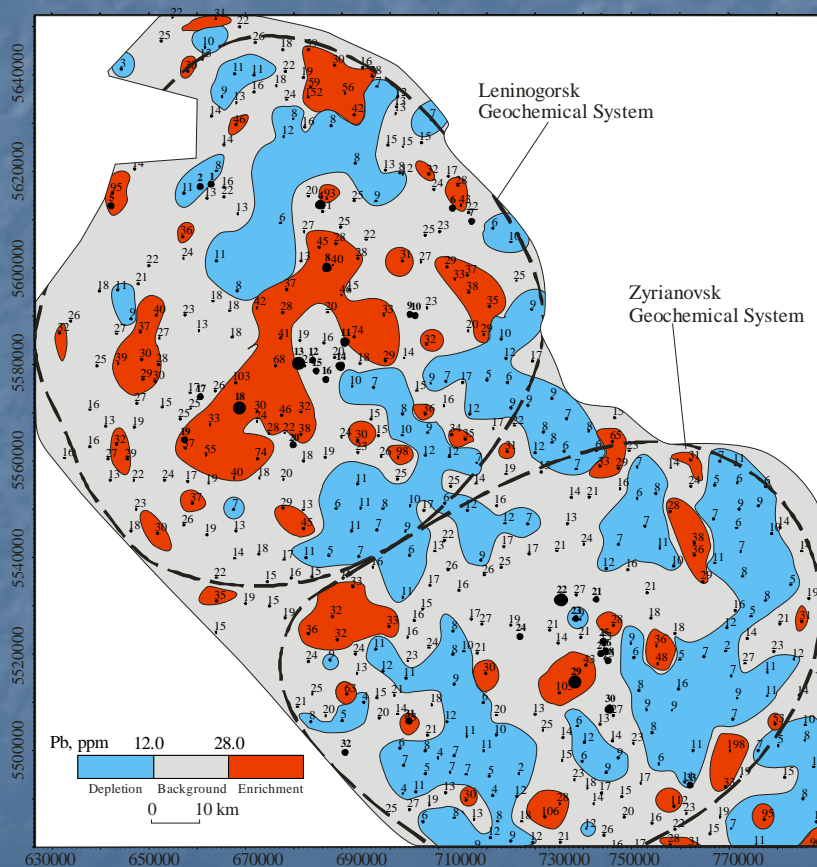
DISTRIBUTION OF LEAD LENINOGORSK REGION



■ In Leninogorsky Region enrichment zones cover $\sim 1,700$ km². Ore deposits are localized inside or along the periphery of enrichment zones.

The depletion zones are located around enrichment zones and cover $\sim 2,400$ km².

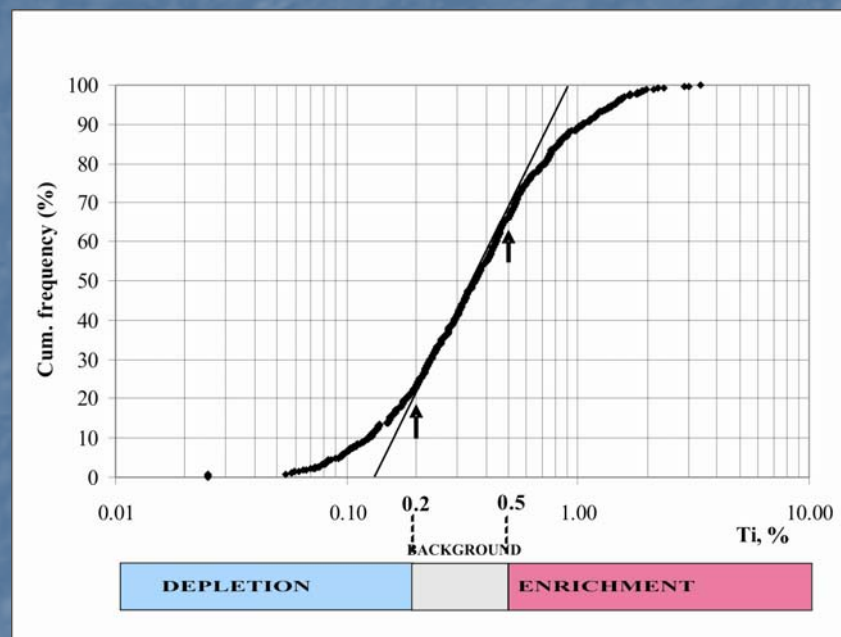
DISTRIBUTION OF LEAD ZYRYANOVSK REGION



■ In Zyryanovsk Region enrichment zones cover $\sim 550 \text{ km}^2$. Ore deposits are localized inside or along the periphery of enrichment zones. The depletion zones are located around enrichment zones and cover $\sim 2,400 \text{ km}^2$. There is the enrichment zone called the Ormansk Ore Cluster (III) in western part of the Zyryanovsk Region

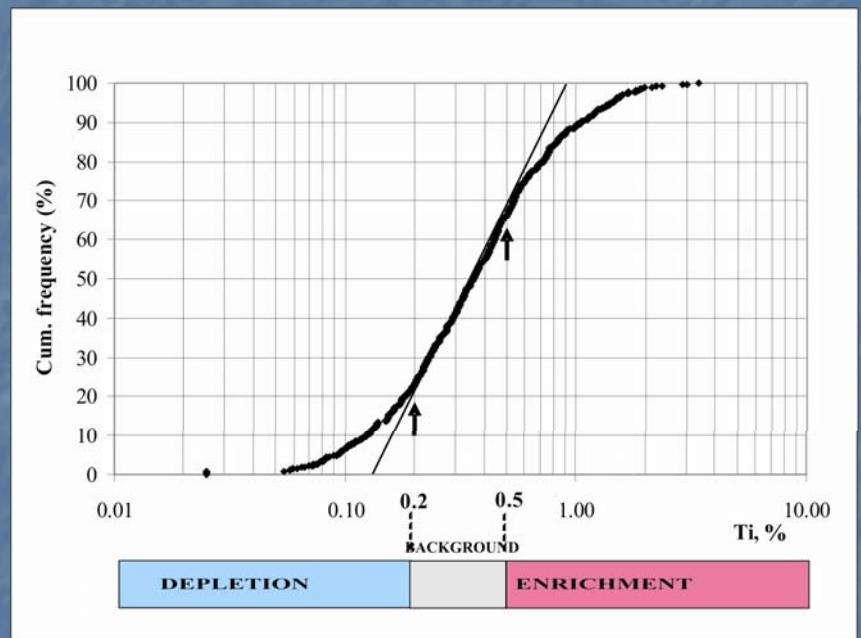
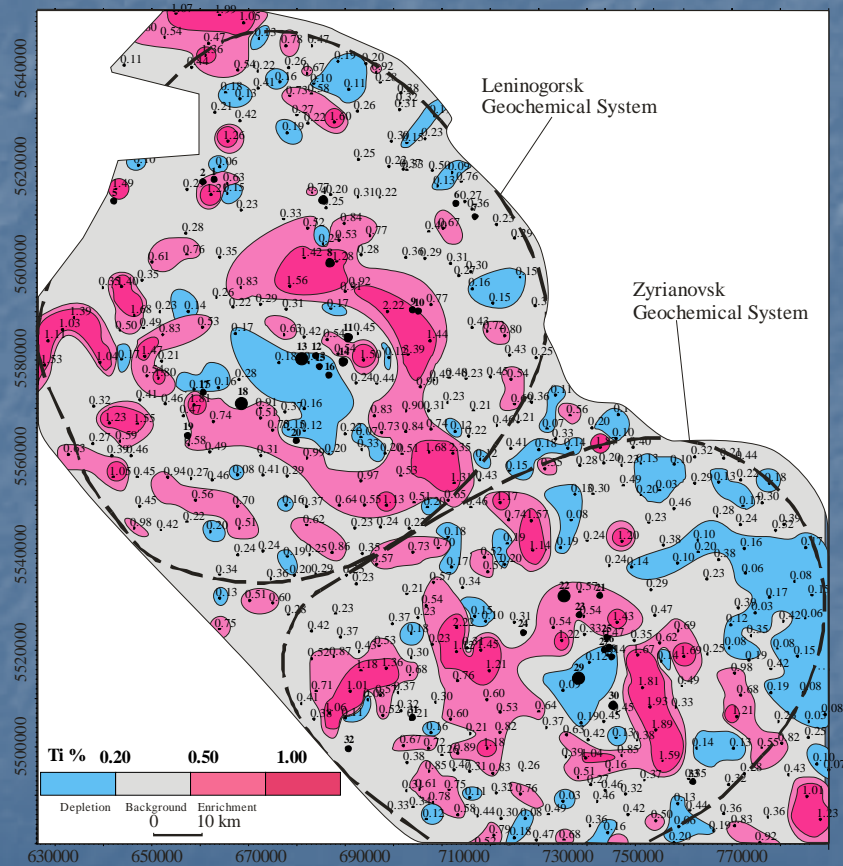
DISTRIBUTION OF TITANIUM LENINOGORSK AND ZYRYANOVSK REGIONS

- There are 3 main Ti population of the Leninogorsk and Zyryanovsk Regions:
 - < 0.2 % – depletion zone
 - $0.2 - 0.5$ % – background and average (0.33%)
 - >0.5 % – enrichment zone



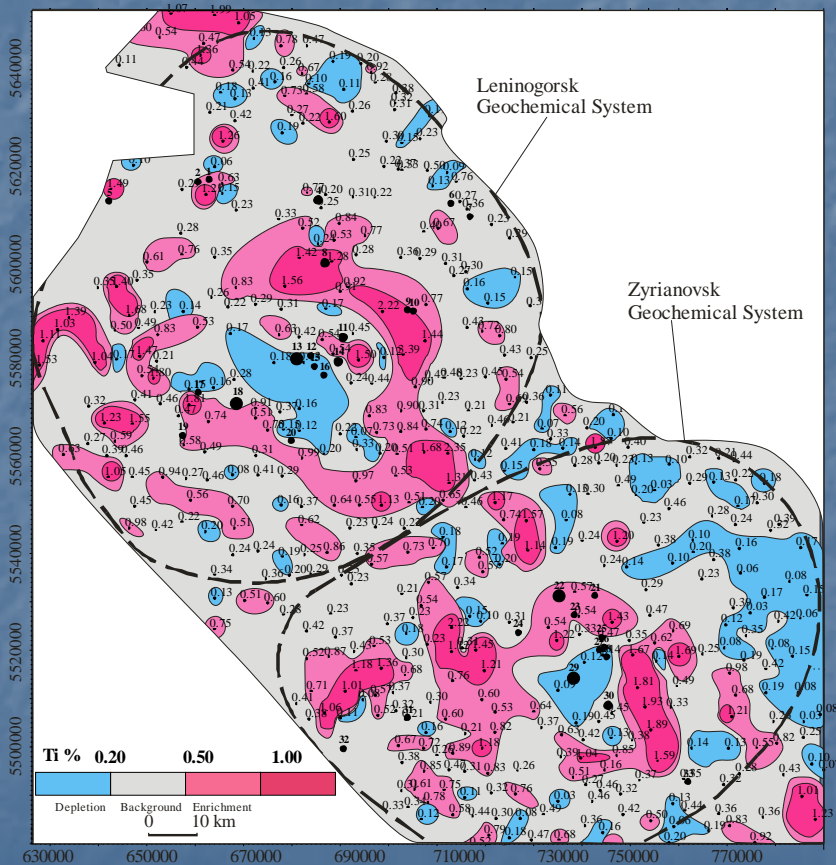
Cumulative distribution plot of Ti
in host rock of Leninogorsk and
Zyryanovsk ore regions

DISTRIBUTION OF TITANIUM LENINOGORSK AND ZYRYANOVSK REGIONS



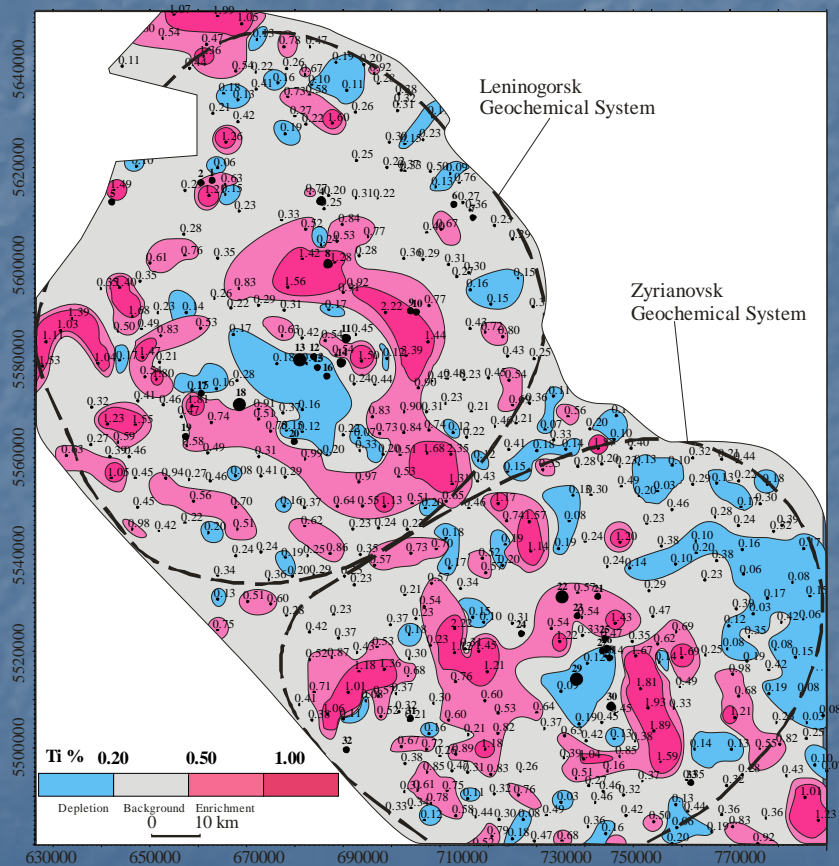
Cumulative distribution plot of Ti
in host rock of Leninogorsk and
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DISTRIBUTION OF TITANIUM LENINOGORSK REGION



- In Leninogorsk Region the main Ti enrichment zone forms a horseshoe-shaped anomaly around the Zn and Pb enrichment zones. The width of this Ti anomaly is 5-15km and its diameter is ~60 km. At its centre there is a depletion zone. The majority of deposits are inside this zone or in its periphery.

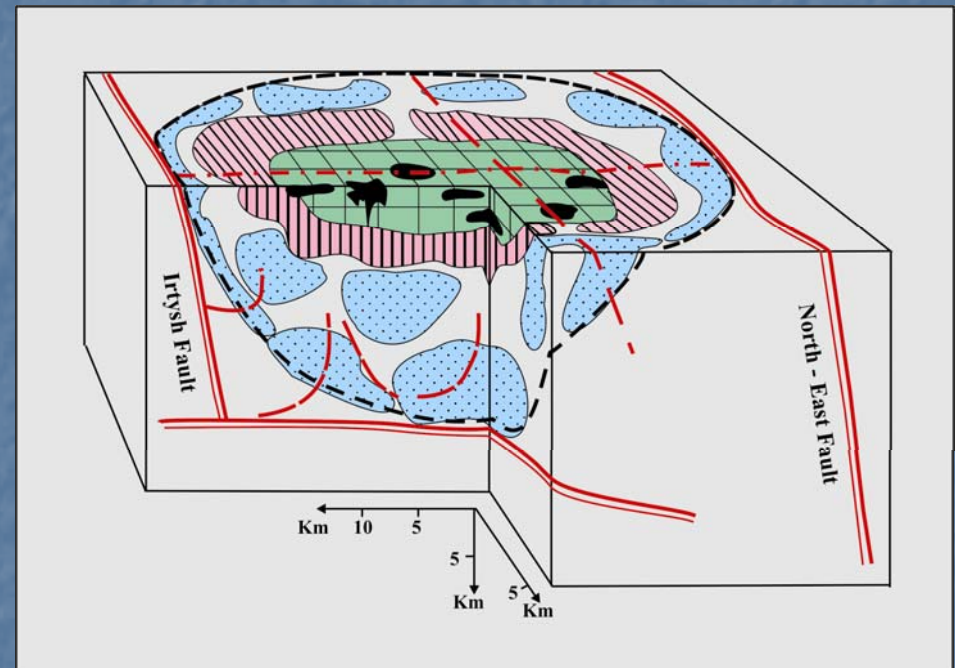
DISTRIBUTION OF TITANIUM ZYRYANOVSK REGION



- In the Zyryanovsk region the main Ti enrichment zone forms a ring-shaped anomaly around the Zn and Pb enrichment zones. The width of this anomaly is 5-10km and its diameter is ~50 km. At its centre there is a Ti depletion zone. The majority of deposits are inside this Ti enrichment zone or in its periphery.

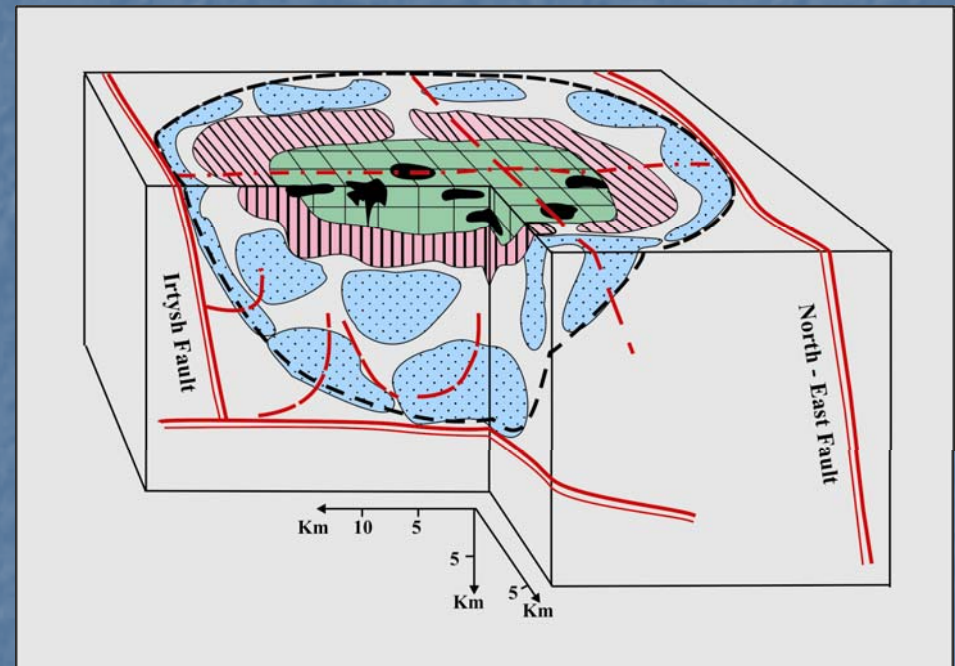
MODEL OF GEOCHEMICAL SYSTEM OF THE LENINIGORSK REGION

❑ The geochemical ore system of this region is characterized by polar zoning in distribution of ore-forming elements (Zn, Pb) and siderophile elements (Ti).



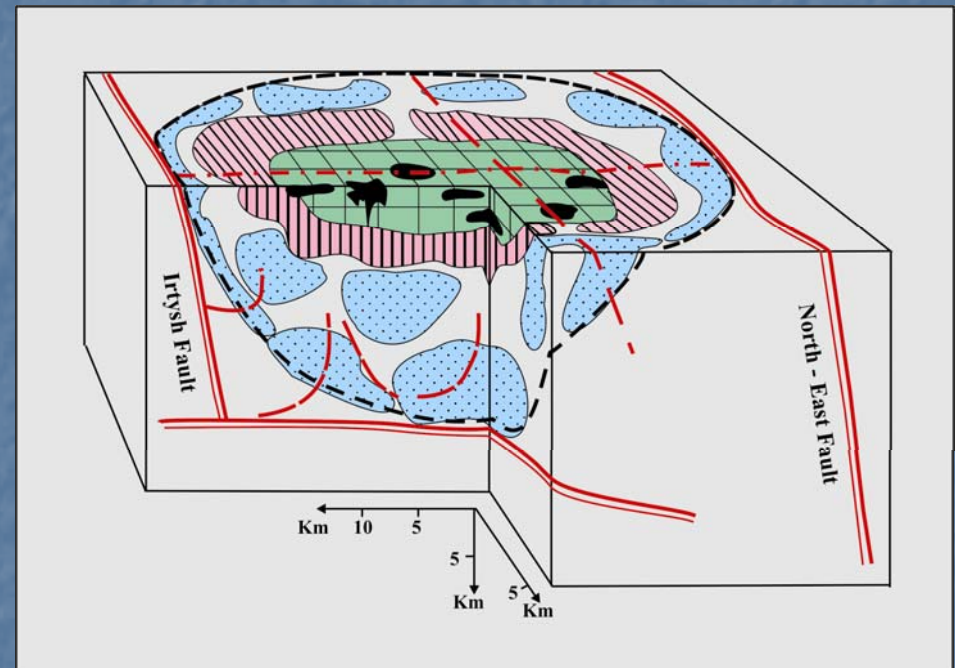
MODEL OF GEOCHEMICAL SYSTEM OF THE LENINIGORSK REGION

❑ The ore deposits are localized in enrichment zones of Zn, which are surrounded by an enrichment zone of Ti. All of them are surrounded by depletion zone of Zn



MODEL OF GEOCHEMICAL SYSTEM OF THE LENINOGORSK REGION

- ❑ Diameter of this system is ~100 km and the depth could be less then 20 km.



MASS BALANCE CALCULATION OF Zn LENINOGORSK REGION

Zones	Zn average ppm	Zn Enrich,loss ppm	R/1km ² Mt	S Km ²	H Km	V Km ³	R Mt
Enrichment zone	291	190	0.475	2430	2	4806	2300
Background	101						
Depletion zone	48	53	0.132	2384	20	15893	2100

■ From this data it can be seen that:

- The deficit of Zn in depletion zones closely corresponds to the quantity of this metal in the enrichment zones. The total mass of redistributed Zn is ~2000 million tons

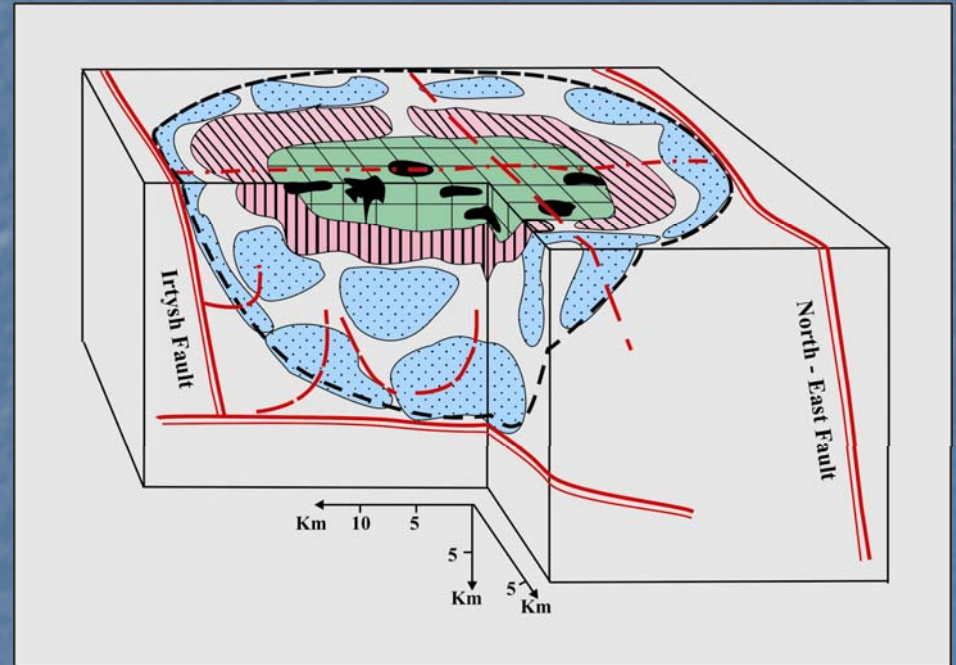
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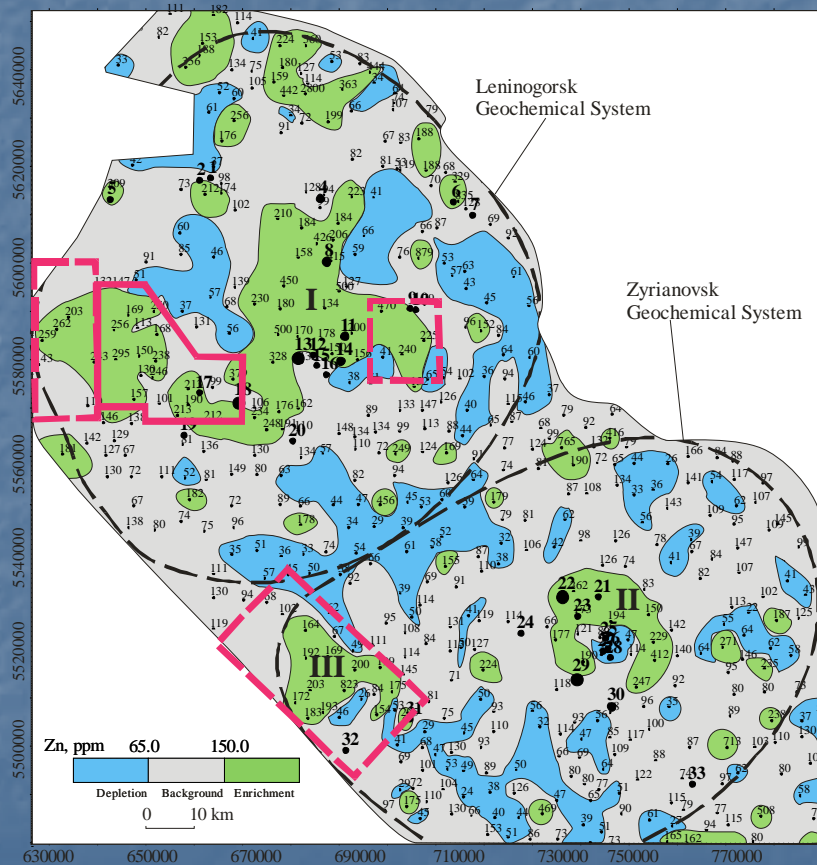
- From this data it can be seen that:
 - The reserves of Zn in all deposits of ore region (23Mt) are two orders less then a quantity of Zn in the enrichment zones (2300 Mt)

MODEL OF GEOCHEMICAL SYSTEMS IN THE LENINOGORSK AND ZYRYANOVSK ORE REGION

- ❑ The areas of depletion and precipitation are linked by transition zones.
- ❑ The depletion zones should be seen as areas of ore element mobilisation.
- ❑ The combination of depletion-transition-precipitation zones can be called as ore-forming systems.

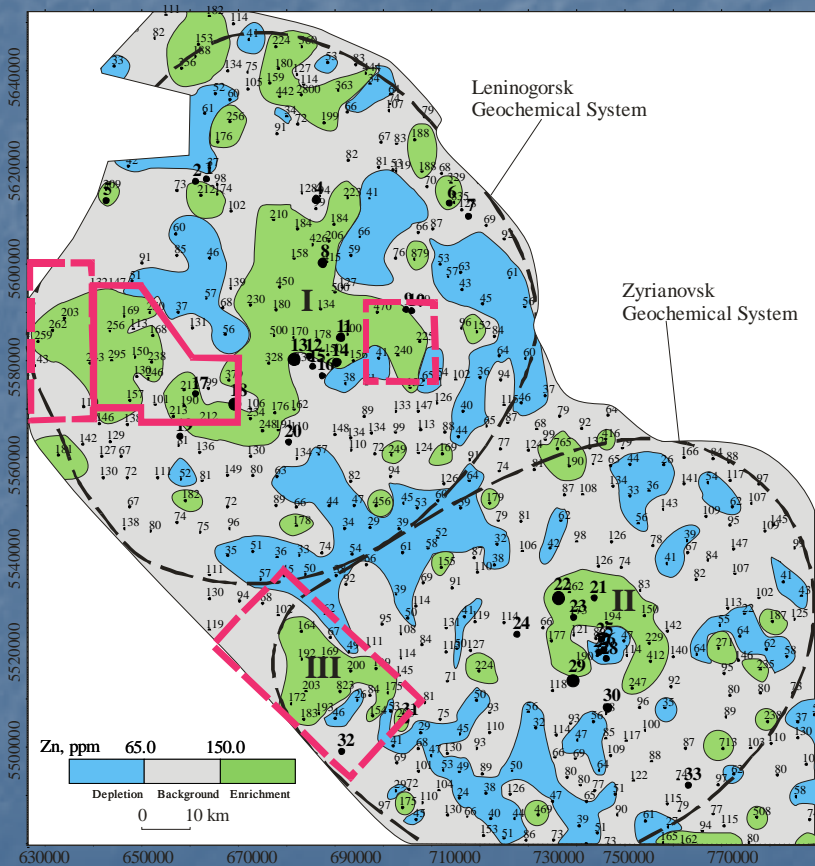


PROSPECTIVE AREAS FOR EXPLORATION IN STAGE II



- The stage I work has made it possible to identify the nuclei within the geochemical systems.
- The size of the depletion zones associated with the systems' nuclei has helped determine the potential and the priority of areas for the next stage of exploration.

PROSPECTIVE AREAS FOR EXPLORATION IN STAGE II



- As a result of the first stage of work on the 20 000 km² area, the area for follow up exploration has been reduced by 80% and the most promising areas singled out.
- Currently detailed exploration is being carried out in the most promising areas.