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Knowledge transfer inside the regional economic system: the case of eighty years of economic history of the Russian North-East

Introduction

In the last decade there is a reversal of regional studies under the paradigm of the knowledge economy. This process has involved the scientific community of EU countries, USA, Canada, Australia, Japan. Former fundamental concepts of regional development (like industrial complex, labor market, human resources, etc.) have received a knowledge-based interpretation: to what extent do they promote learning and generation of new knowledge? Previous factors of regional development are also beginning to be understood in the context of their ability to be generators, conductors / transfer center of new knowledge.

One can reveal several major themes elaborated inside the topic of knowledge spillover. **First, regional economic growth and knowledge spillover.** In this theme knowledge spillovers are related with increasing returns from the principal regional assets and endogenous economic growth. We can mention at least several authors that work in this area: Grossman Gene, Helpman Elhanan. *Innovation and growth in the global economy.* Cambridge. MA. MIT Press. 1991; Grossman G., Helpman E. 1994. *Endogenous innovation in the theory of growth.* *Journal of Economic Perspectives.* Vol. 8. P. 23-44; Krugman P. 1991. *Increasing returns and economic geography,* *Journal of Political Economy,* Vol. 99. P. 483-499; Lucas R 1988. *On the mechanics of economic development.* *Journal of Monetary Economics.* Vol. 22. P. 3-42.

Second theme can be named as the distribution of economic knowledge in space. Our colleagues trace knowledge flows through the analysis of Internet hyperlinks, co-patent applications, students mobility, research networks etc. In this area we can mention at least several publications: Karlsson C., Manduchi A., 2001. *Knowledge spillovers in a spatial context a critical review and assessment,* in *Knowledge, Complexity and Innovation Systems.* Eds. M. Fisher, J. Frohlich. (Springer, Berlin). P. 101-123; Paci Raffaele, Usai Stefano. *Knowledge flows across European regions.* *Ann Reg Sci* (2009) Vol. 43. P. 669-690; Maggioni Mario A., Uberti Teodora Erika. *Knowledge networks across Europe: which distance matters?* *Ann Reg Sci* (2009) 43:691-720; Fischer M.M., Varga A., 2003, *Spatial knowledge spillovers and university research: evidence from Austria.* *Annals of Regional Science.* Vol. 37. P. 302 – 322; Greunz L, 2003. *Geographically and technologically mediated knowledge spillovers between European regions.* *Annals of Regional Science.* Vol. 37. P. 657- 680.

Third topic can be named as role of proximity factors (geographical, organizational, technological, etc.) in the knowledge flows. Here we can mention several works by European authors: Autant-Bernard C., 2001. *The geography of knowledge spillovers and technological proximity.* *Economics of Innovation and New Technology.* Vol. 10. P. 237-254; Audretsch David B. *Innovation and Spatial Externalities.* *International Regional Science Review* 2003. Vol. 26. № 2. P. 167-174; Breschi Stefano, Lissoni Francesco. 2001. *Localized knowledge spillovers vs. innovative milieux: Knowledge “tacitness” reconsidered.* *Papers in Regional Science.* Vol. 80. P. 255-73; Anselin Luc, Varga Attila, Acs Zoltan. *Local Geographic Spillovers between University Research and High Technology Innovations.* *Journal of Urban Economics.* 1997. Vol. 42. P. 422-448.

Fourth topic is devoted to the innovation flows in space. We can name several articles in this direction: Coe D, Helpman E. 1995, *International R&D spillovers.* *European Economic Review.* Vol. 39. P. 859 – 887; Anselin L., Varga A., Acs Z., 2000, *Geographic and sectoral characteristics of academic knowledge externalities.* *Papers in Regional Science.* Vol. 79. P. 435 – 443; Varga A. 1998. *University research and regional innovation: A spatial econometric analysis of academic technology transfers.* Boston: Kluwer Academic; Varga A, 2000. *Local academic knowledge transfers and the concentration of economic activity.* *Journal of Regional Science.* Vol. 40. P. 289 – 309; Bode E., 2004. *The spatial pattern of localized R&D spillovers: an empirical investigation for Germany.* *Journal of Economic Geography.* Vol. 4. № 1. P. 43 – 64; Varga A., Anselin L., Acs Z., 2005. *Regional innovation in the US over space and time// Spillovers and Innovation: Space, Environment and the Economy.* Eds. G Maier, S Sedlacek (Springer, Vienna). P. 93 – 104; Griliches, Z. 1992. *The search for R&D spill-overs.* *Scandinavian Journal of Economics.* Vol. 94. P. 29-47; Parker D. D. and Zilberman D. *University technology transfers: impacts on local and U.S. economies.* 1993. *Contemporary Policy Issues.* Vol. 11. P.87-99.

Fifth topic is devoted to the inter- and intra-industry knowledge flows, that is MAR-spillovers and Jacobs spillovers. We can mention at least few papers devoted to this topic: Audretsch David B. *Innovation and Spatial Externalities.* *International Regional Science Review* 2003. Vol. 26. № 2. P. 167-174; Los B, 2000. *The empirical performance of a new inter-industry technology spillover measure.* *Technology and Knowledge.* Eds. P. Saviotti, B. Nooteboom (Edward Elgar, Cheltenham, Glos). P. 118 – 151; Roijakkens N,

Hagedoorn J (2006) Inter-firm R&D partnering in pharmaceutical biotechnology since 1975: Trends, patterns, and networks. *Research Policy* 33: 1153–1165

The term ‘MAR-spillovers’ was invented by E. Glaeser (1992). It was coined after three contributions from A. Marshall (1890/1966), K. Arrow (1962) and P. Romer (1986): Marshall, Alfred. 1920. Principles of economics. 8th ed. London: Macmillan; Arrow, K. 1962. Economic welfare and the allocation of resources for invention. In The rate and direction of inventive activity, edited by R. Nelson. Princeton, NJ: Princeton University Press; Romer P. M. 1986. Increasing returns and long-run growth, *Journal of Political Economy*. Vol. 94. P. 1002-1037.

Jacobian spillovers were named by J. Jacobs works on cities where inter-industrial externalities can be seen very clearly: Jacobs, J. 1969. The economy of cities. New York: Random House.

Sixth topic is devoted to the knowledge flows and local innovation systems. The idea here is that geographical proximity simplifies interaction between economic actors. This can expedite distribution of innovation in space. Let us mention here several articles: Breschi S., Lissoni F., 2001. Knowledge spillovers and local innovation systems: a critical survey. *Industrial and Corporate Change*. Vol. 10. P. 975 – 1005; Feldman M.P., Florida R., 1994. The geographic sources of innovation: technological infrastructure and product innovation in the United States. *Annals of the Association of American Geographers*. Vol. 84. P. 210 – 229; Audretsch D., Feldman M. (2005) Knowledge spillovers and the geography of innovation. In: Henderson V, Thisse J (eds) *Handbook of urban and regional economics*. Elsevier, Amsterdam; McCann P, Simonen J (2005) Innovation, knowledge spillovers and local labour market. *Papers in Regional Science* 84: 465–485.

Excellent review of the literature devoted to the knowledge spillover agenda can be found in Doring Thomas, Schnellenbach J. 2006. What Do We Know about Geographical Knowledge Spillovers and Regional Growth?: A Survey of the Literature. *Regional Studies*, Vol. 40. №3 (May). P. 375–395.

Gradually the process of "cognitive" interpretation of the previous and contemporary phenomena of regional development will penetrate Russian community of regional scholars. It is therefore very important to start experimental testing of this approach in concrete studies, identifying specific manifestation of the universal laws of the global innovative development in the real world of Russian regions.

In this paper the role of factors of new knowledge in economic history was investigated for the Russian North-East, especially its basic industries - mining and exploration, which form the core of the local economy - that is, a regional mineral complex. Russian Northeast is an isolated industrial area, socio-economic situation in which has been determined by the scale of gold mining for already eighty years.

Sustainable development of extractive industries depends on a set of external (market conditions of raw materials, prices for materials and equipment, transportation costs) and internal factors (qualitative characteristics of the mining deposits, the quality of the mining equipment, ratio between mining and exploration). Considering the importance of all above-mentioned factors on the production of extractive industries, in this paper we have investigated the mechanisms for obtaining information on the mineral resources, knowledge transfer between exploration and mining - topics that have not been studied before.

Patterns of development of the mineral resources sector of the Russian North-East have been studied for decades, but only in the context of productive activity (both quantitative and qualitative characteristics of the volume and growth of reserves, the levels and effectiveness of production, etc.). The process of "communication" between the exploration and mining industry, i.e. mechanism of transmission of knowledge about mineral resources from geologists to miners, never became the object of study. Meanwhile, it is fundamentally important for the stable operation of the regional mineral complex. Such approach has been implemented in this paper.

In this study, we have tried to implement the idea of considering the Russian North-East as industrial district (according to A. Marshall), where knowledge is “in the atmosphere”, i.e. formal and informal knowledge spillovers between exploration and mining industries via different channels have been for decades. These knowledge flows do form the integrity of the industrial district as the place of intensive information exchange between carriers of different knowledge - geologists and miners in the interests of innovation - the discovery and development of new deposits.

The initial hypothesis was that the knowledge-intensive economic activities ("donors of innovation") have different patterns of development in time and location in space than the industry

perceiving innovations from them ("receptors of innovation"). On the basis of our analysis of the 80-year economic history of the Russian North-East - as a laboratory for confirmation of this hypothesis – we have traced patterns of development and spatial distribution of exploration sector (the final product is knowledge about the stocks of mineral resources) and the mining sector (the final product - the volume of extracted minerals).

In the process of testing this hypothesis we have revealed how the scale and the territorial structure of exploration and mining industry have changed, how the processes of concentration and deconcentration in these interrelated forms of economic activity within a regional system have passed for decades, whether these changes were synchronized, or there was a time lag. We have analyzed the main channels of knowledge transfer from exploration industries, generating new knowledge of mineral resources to the mining industry in which it is directly used. In our view, the identification of "a knowledge" patterns and relationships in the development of exploration and mining industries can help to establish how the characteristics of the process of knowledge transfer inside the regional mineral complex affect the efficiency of its operation (the rate of involvement of new facilities, the volume and sustainability of production).

Information base

In analyzing the development of two industries – one generating and one implementing innovations we have studied various factors affecting the production and the location, institutional arrangement of exploration and mining: changes in the federal policy in the sphere of industrial development of the North, mechanisms of information transfer from one branch to another at different periods of the economic history of the development of the region, technical capacity and economic efficiency of geological exploration and mining.

For organizing multi-dimensional data, to identify patterns, visualize the original data and the results we have applied GIS technology: Geographic Information System (GIS) of the evolution in the location of mineral resources sector was built on the basis of the spatial database of the exploration and mining for the 80-year period of economic history. It is structured by the administrative districts of the territory. We have described the formation of GIS in our earlier articles [5, 6, 7]. To fill this database we had to undertake laborious work to collect information in archives, in monographs and articles [1,2,3,4,8,9]. Due to the interdisciplinary nature of research one had to combine the efforts and knowledge of various experts (geologists, economists, economic geographers, historians, and experts in the field of GIS).

To analyze the development of exploration and extraction of gold from placer deposits we have used a geo-database, based on mapping data on the location and the characteristics of 1250 placer deposits containing information about the fields, their size and geological surveys (tab. 1).

Table 1

The structure of the geodatabase for placer gold deposits

Field Name	Field Type	Description
Site	Text	Name of the water course (river)
NameAdm	Text	Administrative district
Guad200	Text	Name of guad scale 1:200000
District	Text	Gold district
DepModel	Text	Genetic type of the placer deposit
Length	Integer	Length of the placer (min, max, average)
Width	Integer	Width of the placer (min, max, average)
Overburden	Integer	Width of the overburden (min, max, average)
PayGravel	Integer	Width of the pay gravel (min, max, average)
Fineness	Integer	Fineness of gold (min, max, average)
GrainSize	Integer	Gold grain size (min, max, average)

Grade	Integer	Gold grade, g/m ³
Roundness	Text	Roundness of gold
Production	Integer	Total production, kg
WashedPayGravel	Integer	Washed pay gravel volume, m ³
WorkExplor	Integer	Data on the period of mining
GeolExplor	Integer	Data on the period of geological exploration
PrimRef	Text	Source of information

Our work was complicated by a number of objective factors. Firstly, the change in administrative division of the North-East: up to 1993 there was a large region of Magadan Oblast, which included the Chukotka Autonomous District; industries of both territories were developed as one economic system. In 1993 Chukotka Autonomous District became a separate entity of the Russian Federation, which has complicated access to information both for earlier periods of development and for the contemporary situation. And we can not limit our work with the study of Magadan region in its present borders due to the fact that information of early periods of development is not always possible to bind to a new administrative division of the Russian North-East.

Secondly, in the considered period, the economic structure of Russia has changed - transition from a planned economy to a market economy has led to a change in the objectives and criteria for the development of the country as a whole and individual sectors and regions. For example, under the plan economy in spite of economic inefficiency numerous deposits of gold, uranium, tin and tungsten were developed because of state urgent necessity like during the Great Patriotic War.

Main directions and results of research

The study of trends and relations between two industries includes three main directions with specific results in each of them.

1. Comparison of trends in the extent of work performed in geological exploration and gold mining industry. The scale of work in the exploration industry were traced by the investments in this sector for the period from 1932 to 2008. To assess the extent of work in gold-mining industry we use the indicator of gold production in the same period. We should mention that, in connection with the previously mentioned reasons, complicating the collection of necessary information, - along with archival data, in case of absence of indicators for individual years, we have used the author's assessment of the values obtained by indirect evaluation which, of course, may differ slightly from the actual.

A comparison of series of selected indicators could reveal that the peaks and troughs in the industries either do not coincide in time, or are in the opposite position. Thus, in the first period (1932-1957 years) the volume of gold production has increased quickly, reaching a peak in 1941, while the maximum amount of investment in the exploration industry was obtained in 1952 - that is, after 10 years. In the next period (1958-1990 years) most of the time (22 years from 32 years) gold mining was increasing, while investment in the exploration industry was falling and vice versa (Fig. 1).

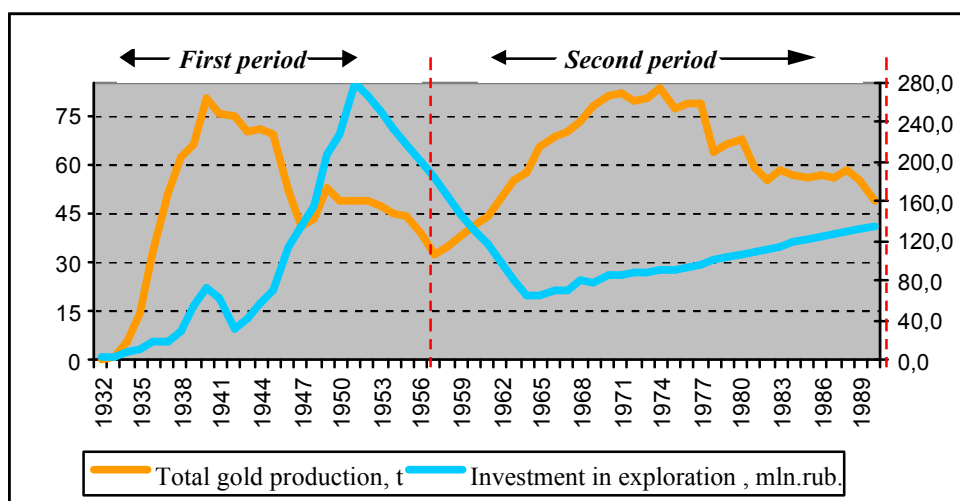


Fig. 1. The dynamics of investment in exploration and gold mining in the Russian North-East

In the third period (1991-2010 years) both industries most of the time had the same growth trend, but the growth of gold mining was essentially higher than a slight upsurge in exploration. Since 2003, both trends go in opposite direction: a rapid decline in gold production and a sharp increase in investment in exploration (Fig. 2).

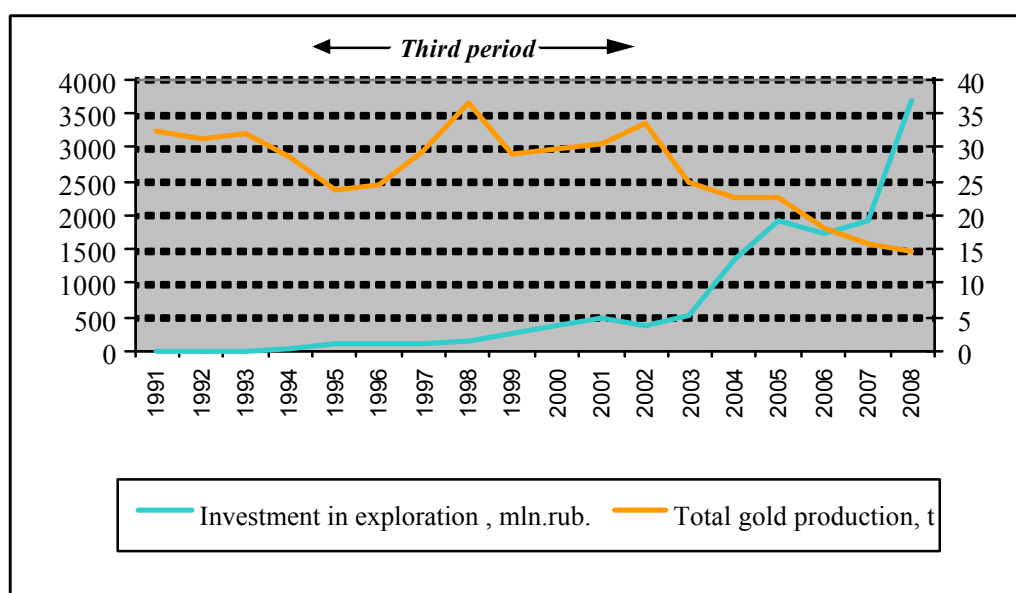


Fig. 2. The dynamics of investment in exploration (in current prices) and gold mining in the Magadan region ¹.

As the rich and easily accessible mining placer deposits had been exploited, geology of the Russian North-East was reinterpreted and the territory was recognized not only as a large alluvial area but also perspective for the detection of ore deposits. This caused a sharp increase in exploration for gold ore: in the period of 1932-1952 years volumes of exploration work for placer deposits had increased in 50 times, and for the ore in the same period in 104 times (Fig. 3).

¹ Because of lack of data from the Chukotka Autonomous District we present data on Magadan Oblast (the volume of gold production in the Magadan Oblast from 1990 to 2008 averaged 77% of the total volume of production in the Russian North-East)

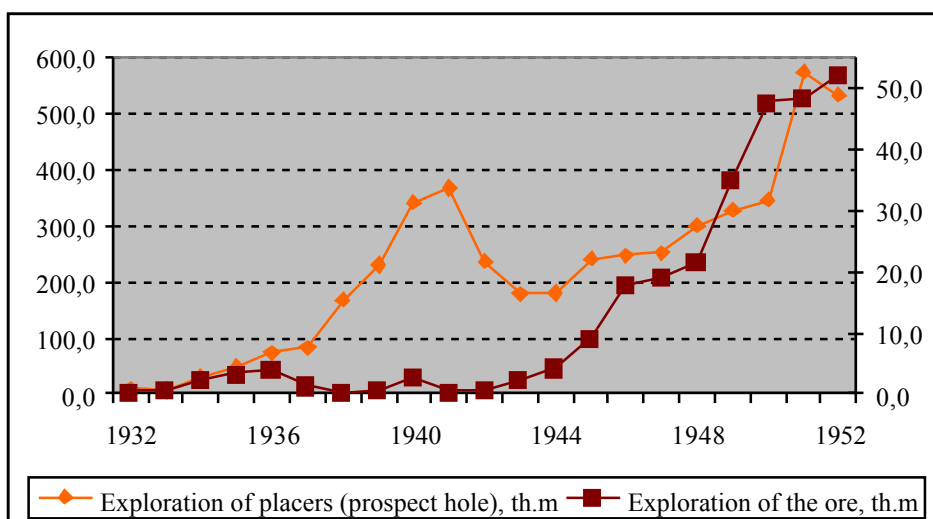


Fig.3. Ratio of exploration for ore and placer gold

Later, from 1975 to 1990 proportion of financial resources allocated to exploration work on ore deposits ranged from 31 to 38%. However, despite the fact that the extraction of gold ore had begun in small amounts in 1942 (less than 1 t), massive increase in the proportion of ore deposits occurred only in the 1990-s with the beginning of exploitation of the unique Kubaka deposit. This fact can be commented as follows: as the extraction of gold from ore deposits is technically more difficult and more costly, in all provinces of the world placer gold deposits are exploited the first and only after their depletion and after the emergence of the necessary equipment and technologies production of gold from the ore deposits starts

One can draw the following conclusions. Initially there is an accumulation of information on holdings and location of deposits, this time accompanied by increased investment in the exploration industry. During the period of early development of the territory peak of production is ahead of peak of investments in exploration. It is very “cheap” to discover the deposit at the early stage of development.

However, rich and easily accessible placer deposits were exhausted. Gold production began to fall. To continue sustainable gold production one need to increase exploration activities. Because of this gold production and exploration trends are going in the different directions.

In other words, depletion of the mineral reserves makes it necessary to increase the scope of exploration activity, and preparation of mineral reserves over time leads to an increase in production.

In 1990-s decline in exploration was due to the hard period of adjustment from a plan to market economy, to the financial crisis in Russia, and the dismissal of the state from conducting exploration. The last can be seen as a decrease in the proportion of state-owned funds to finance the preparation of inventories (Fig. 4). Production in these years was provided by the reserves prepared in the Soviet period.

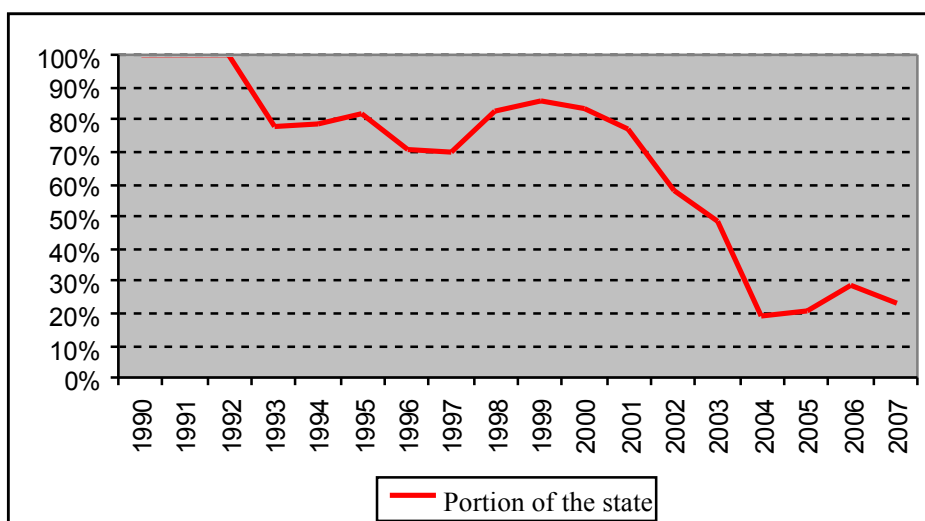


Fig.4. Change in portion of public investment in the financing of the exploration activity

Only the threat of large-scale decline in gold production led to the beginning of the growth of investment in the preparation of reserves, mainly by the private companies.

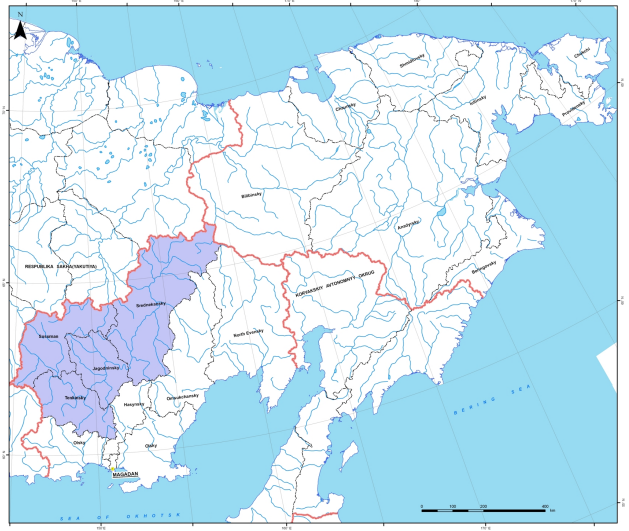
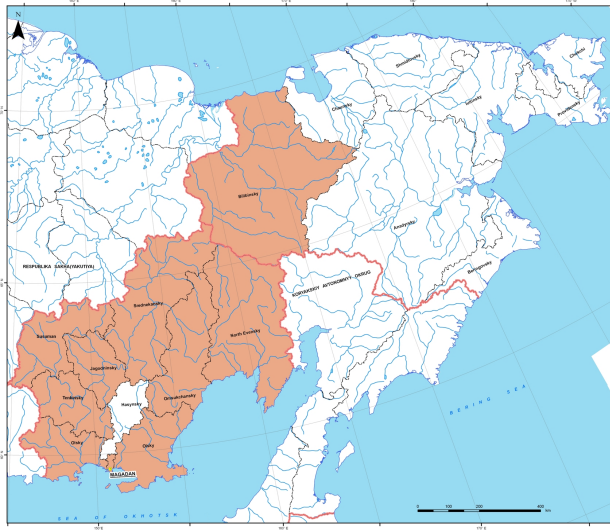
2. Analysis of location patterns and intensity of work. Difference in the development of knowledge-intensive business service – that is exploration, and mining industry where this knowledge can be applicable can be examined on the case of their location patterns in the same time period. In the first period for the exploration industry it is typical to expand its activity at the territory (tab. 2). That is quite natural - first it is necessary to get information about possible future sites, and only after a certain period it is possible to develop it. Geographic distribution of both industries is presented in Fig. 5.

Table 2

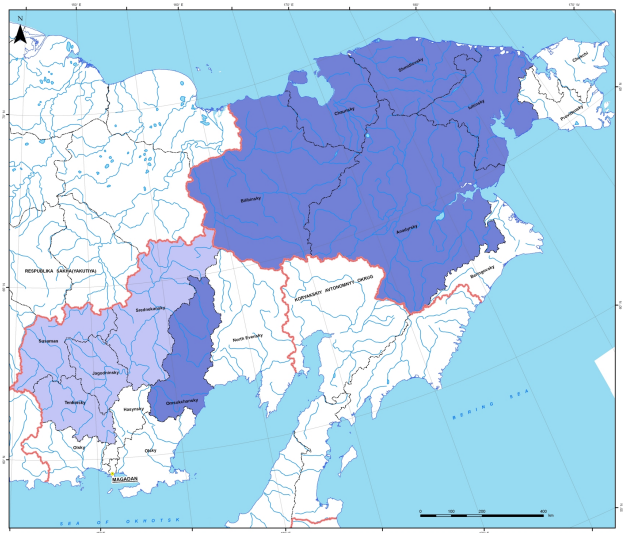
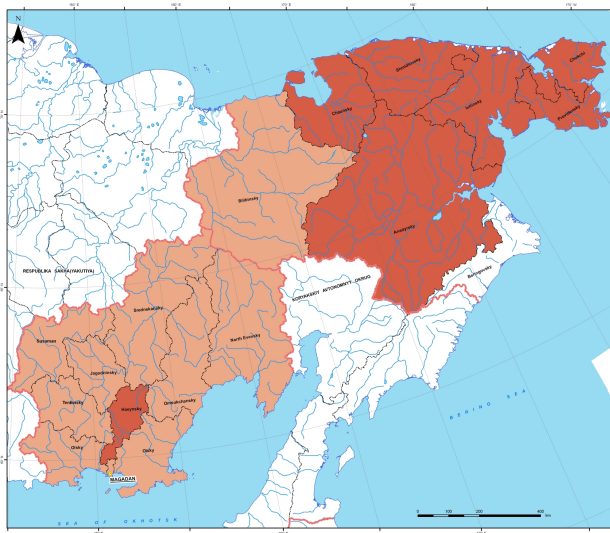
Areas of geological and mining activity

Period	Gold exploration, districts	Gold production, districts
1 (1932-1957 гг.)	Srednekan, Yagodninsky, North-Even, Tenkinsky, Susumansky, Ola, Omsukchan, Bilibinskiy.	Srednekan, Yagodninskiy, Susuman, Tenkinskiy.
2 (1958-1990 гг.)	Khasyn, Providenskiy, Chukotka, Schmidt	Bilibinskiy, Chaunskii, Iultinsky, Anadyr, Schmidt, Omsukchan.
3 (1991-2010 гг.)	All of the above areas	North-Even

a



b



C

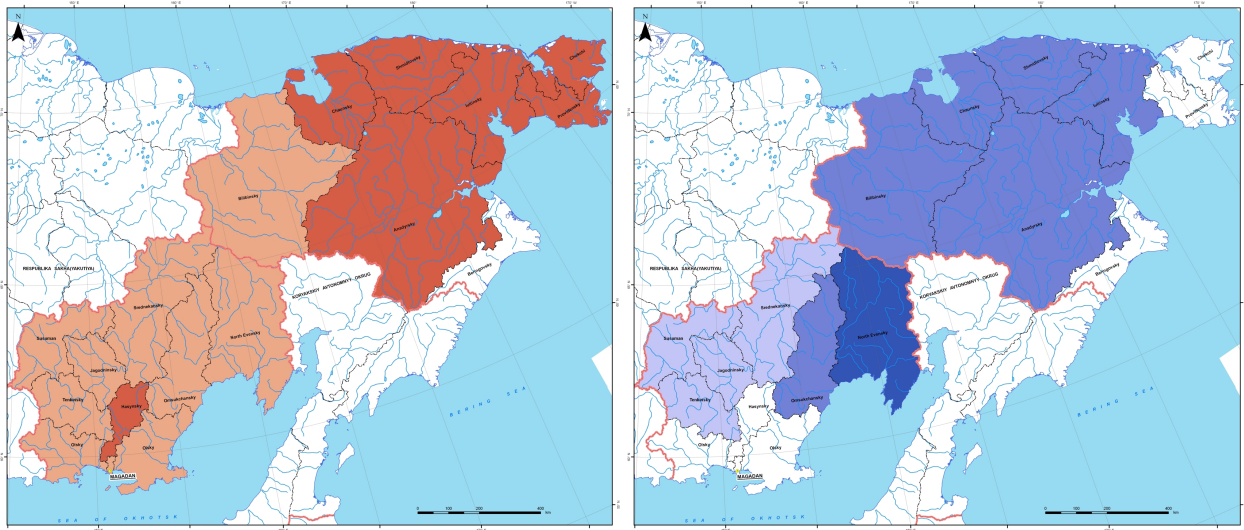
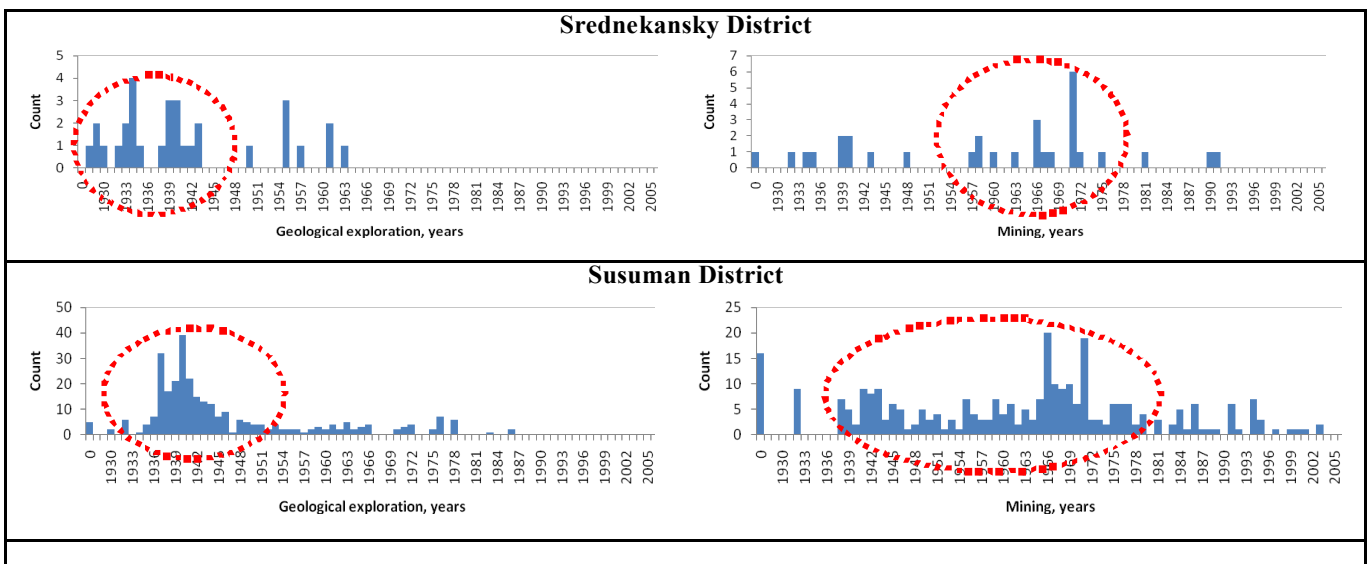


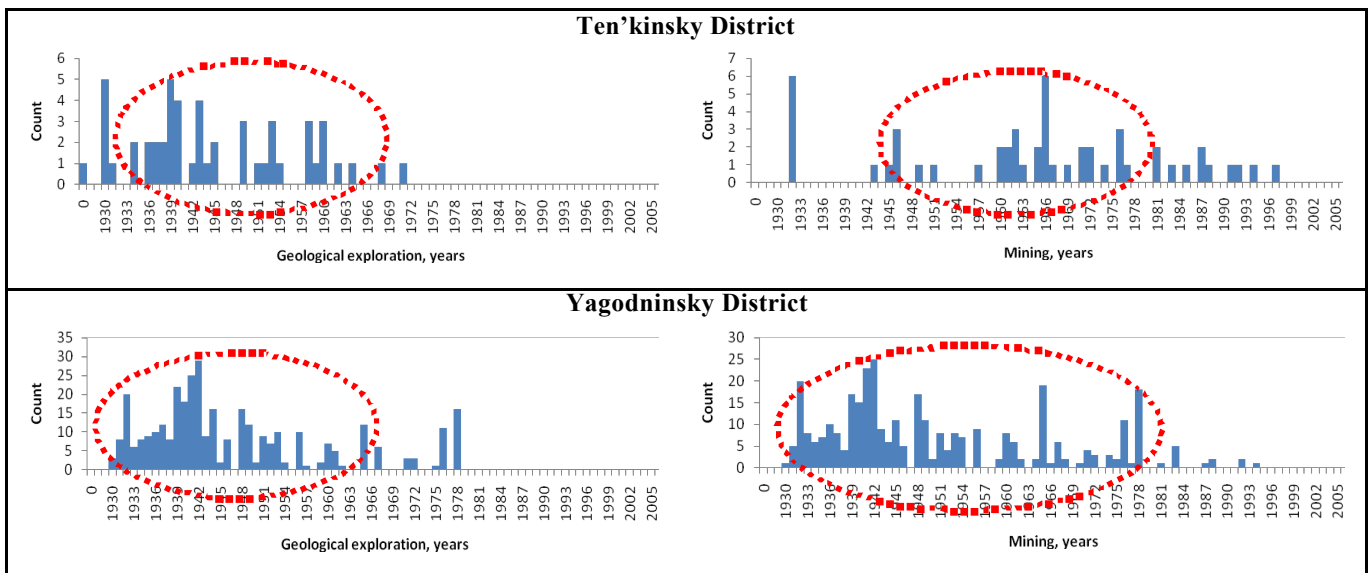
Fig. 5. The intensity of exploration and mining of placer gold districts in Magadan region. Periods of development: *a* – 1932-1957 гг., *b* – 1958-1990 гг., *c* – 1991-1995 гг.
Note. Red color presents exploration activity, blue – mining activity, a darker shade shows areas of later development.

What is the time-lag of one branch from another? To answer this question it is important to evaluate the intensity of their activities. This was done using a sample (database) of 747 placer deposits characterized by the presence of the necessary data. According to the histograms shown below (tab. 3) describing the number of placer deposits involved in geological exploration and mining in each year, it is obvious that it is more expedient to count in the study of location the intensity of exploration and mining activity.

Table 3

Comparison of the intensity of exploration and mining of placer gold districts in Magadan region





3. Changes in the organizational structure of industries and their mechanisms of communication in different periods of the economic history of the North-East.

The first period (1932-1957). Till 1957 geological service and gold production were in the same structure - Trust Dalstroy (the same territorial structure), which facilitated the rapid transfer of new knowledge from exploration to mining.

However, it should be noted that this period was characterized by government regulation in all spheres of economic activity of Dalstroy: main trends and rates of exploration and mining activities in Kolyma and Chukotka regions were determined by decisions of the CC CPSU (B), CNS / USSR, but in concrete forms – in the orders of NKVD / MVD of the USSR. For example, in SNK Decision of 29 July 1936, Dalstroy was urged to cover by geological survey the whole district of Kolyma, a part of the basin Indigirka by 1940. In 1939, Dalstroy had received Chaunskii and Chukotka regions, and in 1940 - the basin of the Anadyr river. In 1941, mining enterprises had begun development of tin deposits in the basin of the Jana River in the Yakut ASSR and on the Okhotsk coast from the Penzhina Bay to Okhotsk. The final zone of the Dalstroy activity was installed on January 29th, 1951. Since 1932 the area of industrial development had increased from 450 km² to 3 million km², which is 1 / 7 of the USSR territory.

During this period, prior attention was given to exploration. Geological forecasts had determined the scope of construction and specialization of industrial facilities, the transport scheme of roads and location of the productive forces of the North-East of the USSR.

In the process of exploration in 1930-1940 it was concluded that gold reserves in the basin of the Kolyma and Indigirka rivers occupied one of the first places in the world that was equal to 20% of the world's known reserves. Information exchange between exploration and mining companies depended on concrete conditions.

Scientific conferences, which did not have regular status, convened mainly in the periods of changes in government industrial policy. The problem of intensification of exploration work in the Kolyma and Chukotka, was proclaimed on the geological meeting of Dalstroy on December 9th, 1944.

In the first phase (1930-1940) as a rule, the development of new areas has been rapid. Lack of roads, housing, etc. were not considered a serious obstacle to the rapid development of new facilities. For example, Omchakskiy Valley was exploited only from the autumn of 1941, but already in 1942, it had produced 21,9 tonnes of gold. Gold mining, construction and organization of the mines, road construction - all was at the same time. Rapid transfer of new knowledge from the exploration to the production was simplified by two conditions – the existence of both branches in one enterprise - the trust "Dalstroy" and the development of the richest and the most accessible placer deposits.

As a result, in the first period placer deposits were quickly converted into gold, the maximum number of placer deposits was involved in the year of exploration - that is, simultaneously. That means a rapid transfer of knowledge from exploration into mining (Fig. 6).

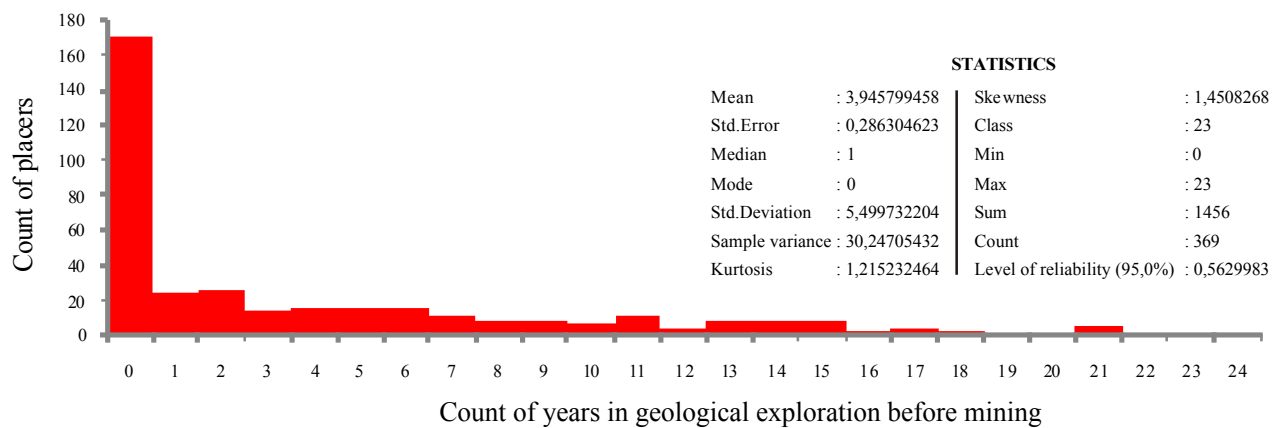


Fig. 6. The number of placer deposits, involved in processing during the years 1932-1957.

More than 160 deposits in the first period were developed in the beginning year of exploration; 20 or more at the first or the second year after they started. Because the median is 1 year, it is obvious that half of the placer deposits were developed at the year of exploration; 20+ in one or two years after the beginning year of exploration. The rest half was developed at intervals from 2 to 23 years from the year of exploration.

In the early 1950's in connection with the crisis in the growth of gold reserves, geological survey had been concentrated within the Kolyma gold-bearing zones in the Upper Kolyma, the Central Kolyma.

Thus, in the first period, despite the active exchange of information between the geologists and miners at the district level, decision-making occurred at the state level in the form of target figures of the state plan of gold mining.

The second period (1958-1990). The second period of exploration and mining was characterized by their structural reorganization on the sector principle and the dramatic expansion of the area of geological activity. Applied geological survey of the first period was supplemented with basic research of the geological structure of the North-East. After 1957 geological service was separated from the mining as Severovostokgeologiya (SVGU) and Severovostokzoloto (SVZ).

The main task of SVGU (organized in 1957) was the exploration for placer and ore gold deposits, the revision of old mining areas, development of geological investigations on the shelf of Arctic seas. With the organization of SVGU (then SVTGU and SVPGO) a clear system of communication between the two branches was established through the State Reserves Committee (GKZ) and Territorial Reserves Committee (TKZ) with the approval of the Ministry of Geology of the USSR. Issues of exploration in a given area were solved by the scientific and technical councils (NTS), by the expeditions (district level), then the NTS SVTGU (regional level), after this geological work was defended in the Ministry of Geology of the RSFSR (national level) and approved in Ministry of Geology of the USSR (All-Union level). At the same time for a faster settlement of the replenishment of raw materials between mining enterprises Mintsvetmet USSR and geological services of Mingeo RSFSR there was developed mechanism of transfer of reserves by acts involving subsequent approval in TKZ (GKZ). In some cases small placer deposits were developed without any further protection in the TKZ, because they were worked out in a single season. Close cooperation between mining and exploration companies at the district level allowed to exchange information on a daily basis about deposits with industrial reserves.

Exploration and mining organizations of the Russian North-East functioned in the framework of administrative system of management, which was based on the monopoly of state ownership in mineral resources, a centralized system of planning, pricing, financial and material distribution. Intersectoral, departmental interaction between geological surveys and mining enterprises was a complex system of approvals at various levels - district, regional, republican, All-Union.

The transition from territorial to branch management scheme, along with positive had negative consequences. Striving to fulfill the established plans for growth in gold reserves geological services overestimated reserves that led to the crisis in gold production.

The key links in information exchange in this period were republic and annual district (Pevek, Anadyr, Egvekinot, Susuman), inter-regional and regional scientific conferences. For instance, the main directions of development of geology and mining in Magadan Oblast for 1960-s were approved at the First Regional Scientific Conference held September 10-15, 1959 in Magadan. It was attended by leading scientists of the USSR, Central, Siberian and Far Eastern organizations.

Thus, despite the fact that the process of communication between the sectors has been active both at the district and at the regional level, decision-making system on the development of exploration and mining industry had a number of levels - the highest, departmental, regional, what significantly complicated the formal transfer of this knowledge (and reserves) in the mining industry.

Therefore, in the second period (Fig. 7) deposits were developed, exploration for which were undertaken in the earlier period from 0 to 56 years ago; for the majority, exploration held 22 years ago (modal value 22 years). The period within which the development of half of placer deposits was realized had increased significantly - from 1 to 24 years. This indicates that the communication process has been more difficult - industries were in different departments, so the information from exploration enterprises reaches the consumer - the mining industry for a longer period.

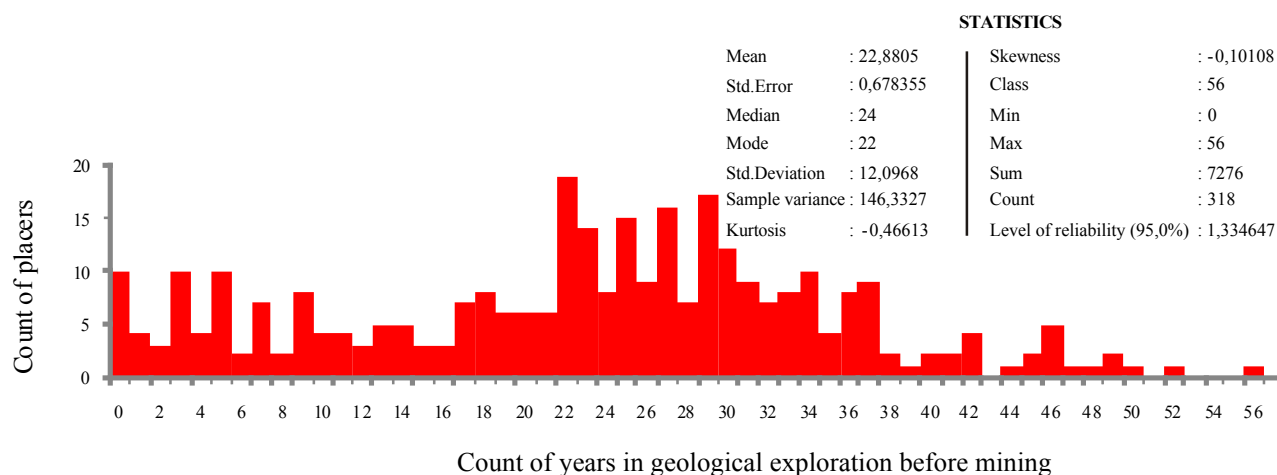


Fig. 7. The number of place deposits, involved in processing during the period 1958-1990.

The third period (1991-2010). In the new socio-political situation, Russian economy was in deep crisis. And the mining industry of Magadan region was not exception. At the result of the several federal laws including the privatization of property, de-monopolization and others gold mining and exploration enterprises have changed the owner, often with serious violations of the rules. The monopoly of the "Severovostokzoloto" in gold production and "Sevvostgeologiya" in exploration has been eliminated. At the result of reforms, dozens of small and medium enterprises are involved in gold mining activity.

In 1990-s transfer of information from exploration industry to the mining industry had come through a system of licensing. At first there was a system of "two keys," under which a license to the majority of deposits had been issued by a regional representative of the Ministry of Geology of Russia (later the Ministry of Natural Resources) and a representative of regional government. Then, in the process of transformation of legislation, the licensing authority had been transferred to the federal level, which complicated the process of transferring information on mineral reserves, making it longer - from 2-month period of obtaining licenses by the mining companies has to 2-3 year period. Before 2008 licenses were issued for a nominal fee, now license fees have increased approximately 30 times. Thus, the communication process between exploration and mining is very complicated and inefficient now, which negatively affects the development of both sectors.

In the third period (Fig.8) placer deposits were exploited, on which the period from the beginning of exploration activity before production was in the range of 13 to 61 years; the greatest number of deposits with the period of 16 years. If we compare time from exploration to the development for the placer gold deposits on the second and third period, we can reveal that it has increased from 24 to 39 years. This result can be explained not only by the fact that in the early years of mining development these placer deposits were unprofitable or were in inaccessible areas, but also because the process of communication between exploration and mining in the last period is very complicated.

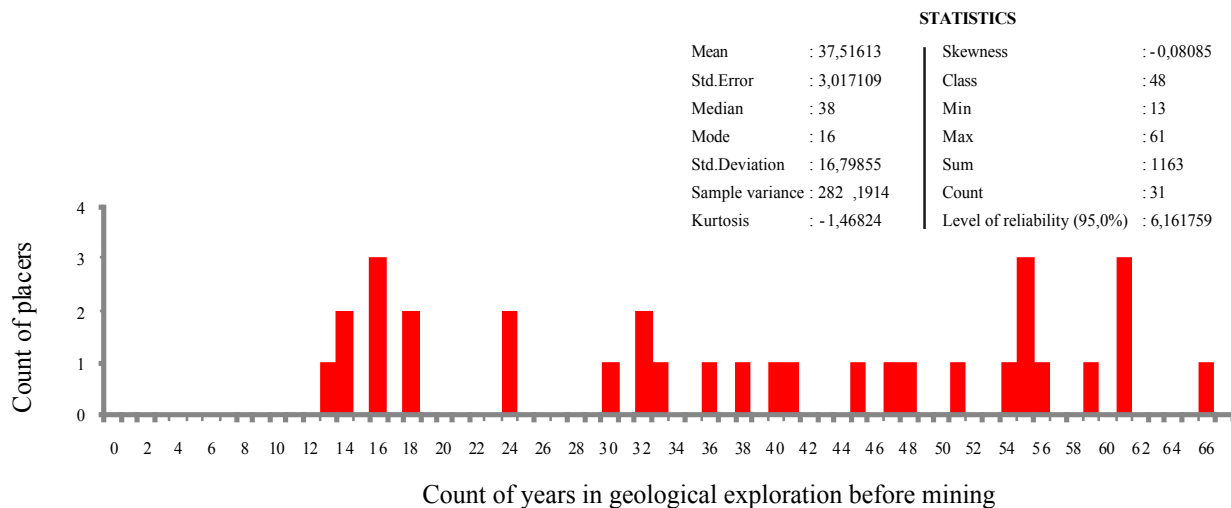


Fig. 8. The number of placer deposits involved in production during the years 1991-2010.

It is typical to study knowledge transfer in manufacturing and in knowledge intensive business services. But it is important not only for the development of high-technology branches of the economy. For instance, mining development is impossible without knowledge transfer from geological exploration. Geological survey can be understood as the special service which deals with risk, discovery, knowledge. Interaction between exploration and mining can be understood as the relations between knowledge-intensive business service and manufacturing, or Universities and commercial firms (and licenses for the mining development can be understood as specific patents). In this paper we have examined the process of interaction between exploration and mining on the local and regional level of the Russian North-East for the case of gold mining during the last 80 years.

It is interesting to mention that during different periods of economic history location behavior of the exploration and mining was not constant. During the early period of breakthrough in new knowledge on the territory and its mining reserves intense knowledge transfer between geologists and miners was typical. Geological service and mining industry was inside one organization. Because of these intensive knowledge spillovers united localized complexes or clusters of geological and mining enterprises were the reality. New knowledge determined the necessity to synchronize territorial structure of the exploration and mining activity. Mining industry

firms was inclined to co-locate with the source of new geological knowledge that was - to the places of exploration activity. This was the period of increasing returns from new geological knowledge.

After this period when the process of exploration was routinized, geological survey centralized, and mining industry, on the other hand, decentralized. Knowledge transfer from exploration to the mining became more formalized and more distant. This was the period of decreasing returns from new geological knowledge.

After new geological breakthrough the first period can be repeated. Again territorial structures of the exploration and mining industries will be inclined to synchronize, mining and geological enterprises will tend to co-locate and form localized clusters of combined activity.

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