THE SCIENTIFIC DATA THAT LED TO THE OPENING OF THE MINERAL WEALTH OF SIBERIA AND MONGOLIA

(Chemical Composition and Petrographic Features of Mesozoic Granitoid Rocks Located on the Territories of Russia and Mongolia to the East 100°E Meridian)

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CONTENTS

PREFACE

We would like to dedicate this volume as a tribute to all the geologists who studied Asia and to the thousands and thousands of people, and many geologists were amongst them, who in the terrible years of Stalin's terror were forced to sacrifice their health and lives in inconceivable conditions to work for the accumulation of natural resources and to provide the information on geology of North-Eastern Asia (to the East of the 100°E meridian and to North from Amur basin up to the Polar ocean). There were diggers of pits in gold bearing placers of the Kolyma up to imprisoned professors, trying in conditions of concentration camp between the knife of a gangster and the bullet of a sentry, to develop the idea of "highest mineralogy" (Boldyrev, 1944). The territory to the East of the 100°E was ivestigated only after the 1920's. Nothing serious was known about the geology and petrography of rocks, and in particular, of Mesozoic granites (the exsistence of which was rejected in general by such authorities as V.A. Obruchev. This error was especially described in the text book for students by Luchitsky and Kuznetsov, 1930).

The first general information about mineral resourses of the region and only for part of the Amur River basin appeared in 1928 (Annert, 1928). After this, the territory (within Russia and Mongolia) has been studied by three different organizations; The NKVD USSR, The Ministry of Geology of Russian Federation and The Mongolia Expedition of the Academy of Sciences of the USSR with participation of the Mongolian Institution.

Especially tragic was the examination of the territory in the basin of the Kolyma River and to the North and the East of it, which was based on the activities of the NKVD USSR. This tragedy can not be understood if one does not introduce the reader in some special features of the history of Russia after the Bol'shevik's putch of 1917. The Government, which was formed by this putch, was helpless in the organization of an efficient civiilized state. All hopes of this government were restricted to the problem of how to keep its position by gathering and accumulating gold by any means. The main quantity of gold was obtained by directly robbing the population of the state and the Orthodox Church.

All methods were good for robbing the gold including terrible tourchers. It is obvious that during the period 1917-1930, by these means, a tremendous quantity of gold was accumulated, the fate of which is unknown up to now. Some gold was received from the export of agriculture production and timber. About 1930 the efficient agriculture was finally destroyed, in such a way that it is not regenerated even up to now. The resourses of timber were on threshold of existence. The government began to sell pictures from the national treasure "Hermitage", and was only stopped by general irritation. Thus the sources of gold were used up before their disappearing.

Under this situation, it was natural for the government to search for territories with gold deposits. One such territory was the basin of Kolyma River and its vicinities up to the Okhotsk sea and the Chukotka peninsula. In 1928 an expedition was sent to the Kolyma basin and was headed by Yu.A. Bilibin. The expedition proved that this territory was really rich in gold. The areas most rich with gold were the internal regions of the studied terrains which were not populated. Gold was concentrated practically only in fissures. The entire territory was covered with permanently frozen ground, roads were completly absent in the winter, and about half of the year the temperature of the air could be less than 70^{o}C.

Without huge capital investments, which were not available for the government to use, this territory was impossible to develope on the normal basis of organization of a human society.

Stalin solved the problem very simply and efficiently; he rendered all population of the former Russian Empire to the hands of the secret police (NKVD) and organized a special institution, which was known very widely after A.I. Solzhenitzyn, as GULAG. The NKVD could sentence any person, without any fault or reason to imprisonment for decades in concentration camps of GULAG, organized for mining gold, particularly at Kolyma. The sentences could be up to 25 years. This system flourished most during Stalin's life. It enabled the organization of a special department referred to as Dal'stroy for the exploitation of resourses and especially gold in the territory of all North-Eastern Asia from Upper Kolyma River basin and up to the Polar ocean (Nikolaev, 1990).

The following example indicates how geologists could go to Kolyma. The well known Dr. V.O. Vereschagin,who worked in Meritime territory for coal measures and general geology, in 1944, quite surprisingly was appointed as chief geologist of the Krasnoyarsk local Geological Survey. It was several thousand kilometers from Meritime territory. Dr.Vereschagin never worked in Krasnoyarsk territory, and he was very far from being an economic gelogists, most necessary for this territory.

He protested against his appointment, stating that he was not an expert on the geology of Krasnoyarsk territory and that he was not an expert in economic geology. He repeated in many written reports to the Ministry that he could not be appointed on the new post because he was not able to satisfy the necessary requirements. He never received any replies on these reports. In May 1949 he was arrested by NKVD, was judged by a special court of the NKVD and sentenced for 15 years work in Kolyma for the limitation of the copper resourses of the Krasnoyarsk territory. In Kolyma he was put in a concentration camp with criminals. His applications were never accepted and only after Stalin's death in 1953, his sentence was lifted and he was freed. Such sentences as that of Vereschagin, permited the NKVD and in particular Dal'stroy to obtain experts in geology and mining. A great number of them died in Kolyma or in the best case lost their health because the old professors well known as the best experts in their field were sent as prisoners.

In the beginning the Dal'stroy was interested only in gold (and in tin sometime later) but the placers were exhausted rapidly, in the process of placer prospecting, whole regions were lost because there were no geological maps. All trials of Yu. Bilibin to apply the use of geology were neglected for years. As a result, the quantity of gold obtained by slave labor was much smaller than what could be gained under normal conditions. Only in 1939, a main Geological and Mining Service was organized by Dal'stroy. The skilled geologist B.A. Tzaregradsky, one of the pioneers of North-Eastern geology who worked before with Yu.A. Bilibin, was appointed as the head and accepted this appointment. Tzaregradsky organized in Dal'stroy a normal geological survey with a chemical laboratory. His good relations with the imprisoned professors allowed him to use their abilities in this work. Some of the analyses in the TABLES (presented in this volume) were done after Tzaregradsky organization of the geological survey. In the beginning of the 1950's, the Ministry of Geology organized new local geological surveys; The Yakut Geological Survey in Yakutsk and The North-Eastern Geological Survey in Magadan. In 1957 GULAG and Dal'stroy were abolished. All the material provided by Dal'stroy were alloted between Yakut and the North-Eastern Geological Surveys as basis for future archives of these surveys. In the organization of the mentioned geological surveys, the Ministry of Geology of the Russian Federation continued their tradition to have under their own influence very large territories.

The Geological Surveys were responsible for the geological surveying of the territory under the geological jurisdiction of these Surveys. Thus step by step, all the territories to the North from the Amur River and the territories of Yakut and North Eastern Surveys were covered by the geological investigations of the corresponding surveys. The surveys had chemical laboratories, basic facilities for the organization of geological work, archives and so on.

Each geologist who worked under contract with the survey was obliged to deliver to the survey the so called "Report" where he provided all his geological results. These reports were published only if the contract was for a sheet of the State Geological Mapping (usually in a scale of 1:200000). Practically all other materials were never published and reports were considered as secret materials. All reports were kept in archives of the surveys. These archives had no specific installations for the keeping of materials typed on a bad paper with bad ribbons for a long time. Naturally, the typing lost color and these very important "secret" data, for which rather large sums of money were paid by the government (in some cases geologists paid with their health and sometimes with their lives), were stored by the secret service in such conditions that all this precious work was lost.

The author knew about these special types of archives but only in 1965, when he visited all of these archives, was completly puzzled how he could organize a good and expensive service to make these materials useful. It was obvious to him that it was necessary to save this material, in particular the chemical analyses of Mesozoic and partly Paleozoic granitic rocks, which give unique information for large and important parts of granitic belts around Pacific and which could attract the interest of the geological community of the World. It was especially important that all the local surveys worked under the auspices of curators from VSEGEI - the

Geological Institute, which inherited the Russian Geological Survey, which exsisted before 1917. This Survey understood the importance of the chemical investigation of the rocks. It followed the methods of Hillebrandt of the Geological Survey of the USA. All analyses were made under the same conditions by the same instructions, using reagents of good quality.

In 1967 we began to compile the analyses from all the archives of the Geological Surveys located East of the 100^{0}E meridian. Step by step with the help of the Mathematical Department of the Academy of Sciences of the USSR and the Ministry of Geology of the Russian Federation the following steps were taken. We prepared the instructions according to which the analyses should be compiled and we proceeded to work with this material as well as with material which was not considered secret. After the Ministry of Geology of the Russian Federation allowed the surveys with the largest archives to organize special groups which compiled analyses from the reports, estimations of the position of sampled locations by graphic method from maps (usually of a scale 1:200000) were made. These groups were periodically visited by the collaborators of our laboratory. The following regional groups have worked: North-Eastern Geological Survey (M.L. Gel'man), Far-East Side Geological Survey (A.I. Aralina), Maritime Geological Survey (Z.E. Nadezhkina and I.Z. Bur'yanova), Kamchatka Geological Survey (I.S. Guziev), and Yakut Geological Survey (G.G. Naumov). Additional materials from North-Eastern Survey especially for Chukotka Peninsula were compiled in 1990 by the collaborators of our Laboratory (A.F. Ivanova, M.A. Romanova), who were kindly helped by A.P. Kuklin from North-Eastern Survey. All materials for Transbaikal and Near Baikal regions were compiled by I.N. Fomin - the Director of the Transbaikal Research Institute in Chita with the participation of A.L. Alexandrov from the Eastern Siberian Prospecting Geological Institute in Irkutsk. The data for the Buryat Survey were compiled by the collaborators of our laboratory (D.N. Ivanov and Yu.A. Vysotsky), they compiled also data from the Sakhaline Geological Survey, additional material (mainly for the Middle Sakhalin Island region) were kindly sent to us by V.A. Naryzhny.

The authors of the compilation would like to mention the kind and very helpful participation of Prof. S.S. Augustithis in the preperation of this book from its begining.

At last, the compilation ended when we received specimens of Mesozoic granites from the Novosibirsky Islands where they were taken in the process of geological mapping by M.K. Kos'ko from the Institute of Geology of the Arctic (St. Petersburg). Similarly we obtained specimens from the Bear Islands (N. Vorob'ev). The analyses of these specimens were made in our Laboratory.

Thus the granites on Russian territory were compiled from the reports of the former Dal'stroy and the local Geological Surveys of the Ministry of Geology. The TABLES also contain analyses provided by I.N. Fomin from different institutes of Ulan Bator (Mongolia) where they were also included in reports of the collaboration of different Soviet-Mongolian joined organizations. As it is clear from the TABLES, Mongolian granites were investigated only at the Eastern part of the Mongolian territory. As previously mentioned, the Mongolian expedition of the former USSR cAcademy of Sciences worked in Mongolia for decades. Some of these analyses were published in V.I. Kovalenko et al., (1971). These data did not satisfy our requirements and many questions arised from these analyses. This was the reason why published analyses of this expedition were not used by us.

In summary, we can state that for the Russian territory Mesozoic granitoids were analyzed on the basis of the same instructions, in similar organizations and with reagents of the same quality. It is very likely that the analyses from Mongolia were also obtained under the same conditions, because they were made with the participation of the Ministry of Geology of the Russian Federation, which used the instructions and recommendations of VSEGEI.

Allthough VSEGEI itself lost the authority as the Geological Survey of Russia of the 19th Century, nevertheless it continued to have responsible people, in particular, chemists who followed Hillebrandt methods of silicate analyses. Thus at the end of the 1960's all territories to the East of the 100^{o}E meridian were geologically studied on the basis of the single geological tradition. All geological administrations worked on the geological mapping of the territory on the of scale 1:200000 with traditional chemical analyses of igneous rocks and particularly Mesozoic granitoids. The results of this work were described in reports of geologists and were accumulated in the archives of the corresponding local Geological Surveys. Among numerous reports, only the results of 1:200000 mapping were printed systematically by VSEGEI. Other materials were not printed and could be lost. The Laboratory of Mathematical Geology studied this situation and decided to do its best to save these chemical analyses, since this material was unique. General aspects of this work were discussed with Dr. F. Chayes and we also received permission to publish these chemical analyses. The data for volcanic rocks appeared in 1982 as a separate book (Vistelius, Ivanov, Romanova, 1982). After this publication the local Geological Surveys began to permit geologists to publish chemical analyses of rocks with coordinates of the sampled locations.

We began the investigation of Mesozoic granitoids in 1965 and after visiting all the local Geological Surveys to the East of the 100^{0}E we found that in the archives of these administrations there were a lot of reports containing data on the chemical composition of the granites which we were investigting. Chemical analyses of these granites have been done by similar methods and under similar conditions.

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CRUSTAL STRUCTURE OF THE NORTH-EASTERN EURASIA

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Three major types of the crust can be recognized within the area based mainly on seismic data, gravity and magnetic anomalies: continental (C), oceanic (O) and transitional zone continent-ocean (T). The late Mesozoic- Tertiary volcanic belts consist of the Eastern boundary of the Eurasian plate. The transition zone is located to the East of the belts at the Western boundary of the oceanic plate along the deep sea trenches (Figure 1).

The continental zone includes several blocks, which have different compositions.

The Siberian craton is characterized by the most ancient and the most stable crust, usually older than 1.8 Ga. The seismic cross sections of the craton show that the crust thickness is between 33 and 52 km, the Moho velocity is 8.0 - 8.6 km/s (Krulov et al.,1982).

The magnetic fields of the craton display a system of banded anomalies, striking to nearly N-S direction for several hundreds of kilometers. These anomalies are the most intense in the early Precambrian rocks of the Aldan and the Anabar shields. It is very important that the anomalies correspond only to Precambrian, not to the Phanerozoic structures of the Siberian craton, despite the evidence of superimposed Post-precambrian tectono-magmatic processes. The same characteristics of the magnetic fields are observed in the areas of exposed or buried median masses such as the Chukotka (Ch), the Kolyma-Omolon (K-O), Okhotsk (Oh), Bureya-Khankay (B-Kh). Moreover, there are also other magnetic anomalies striking W-E and N-E corresponding to the Mesozoic-Cenozoic tectono-magmatic events. The seismic data shows that the crust thickness of these areas is about 40 km, the Moho velocity is about 8.0 km/s. Thus, the geophysical data demonstrate that the Precambrian rocks are the main constituent of the median masses, and of the basement the Phanerozoic foldbelts and the embedded volcano-sedimentary depressions.

The Sikhote-Alin' geological structure (SA) closely spaced to the Transitional zone (T,Fig.1) is characterized according to geophysical data by a 32 - 36 km thickness crust. The magnetic anomalies correspond to the Mesozoic rocks without having the strikes which are characteristic for the adjacent Precambrian Bureya - Khankay median masses. The same geophysical characteristics are observed into Verkhoyansk foldbelt.

The transition continent - ocean zone is the mosaic of blocks (or Terrains) consisting of continental and oceanic crusts. It had been accreted during the Late Mesozoic - Tertiary movements. The crust thickness of the transition zone is 8 - 40 km, for example, the crust of Western Kamchatka is about 40 km, the crust of Eastern Kamchatka is about 20 km (Anosov et al.,1978).

The magnetic fields of Western Kamchatka correspond to the Precambrian crust, but for the Eastern part they have the characteristics of a new formed arc-related to the suboceanic crust.

The Transbaikalian and the Western part of the Paleozoic Mongolian-Okhotsk foldbelt belong to the zone of the anomalous mantle with low velocities to the depth of about 400 km (Zorin et al., 1982). The area reflects the influence of comparably high heat flow within Central Asia. The magnetic fields of the abundant Paleozoic rocks have no characteristics which are typical for the Precambiran basement of the neighbouring Siberian platform.

The seismic data show that the Moho surface is the reflection of a recent relief. It may be assumed that the lower crust of the area is the product of recent tectonic and endogenous processes.

In particular, it has resulted in the development of the Baikal rift system with corresponding basaltic magmatism. It is established that geodynamic processes of the area were displayed early as the Tethys ocean structures between the Siberian and the North China platforms. It was twice that vast granitoid magmatism took place; first in the Late Paleozoic and later in the Mesozoic time.

Thus, the Transbaikalian and the eastward located part of the Mongolia-Okhotsk foldbelt were considered as a structure with repeated rejuvenation of the crust, which determined the unique chemical characteristics of every granite generation.

Summary:

According to geophysical data the continental part of North- Eastern Eurasia includes the following types of the crust:

- An ancient continental crust of the Siberian craton and other stable masses with or without a platform cover.
- The Phanerozoic crust without Precambrian basement.
- The Phanerozoic crust without Precambrian basement with recently rejuvenation lower crust and with a low velocity mantle beneath.

Each type of crust is characterized by a special chemical composition of the generated granitoids.

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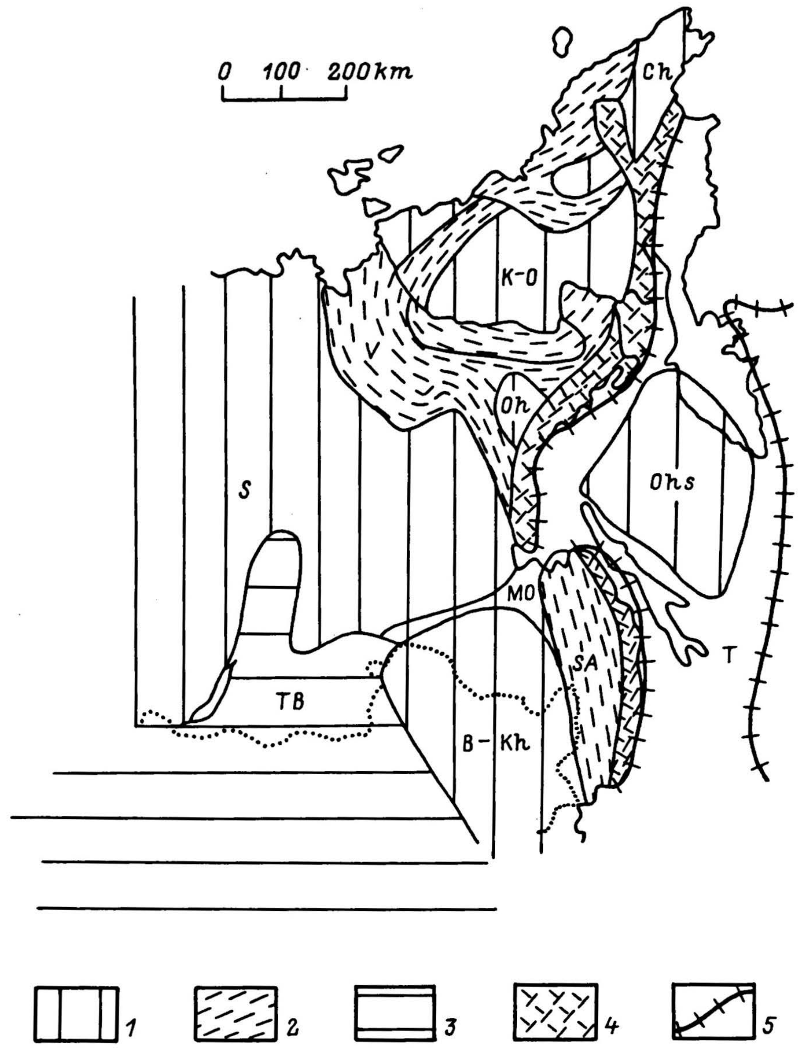

Fig.1. The crust structure of the North-Eastern Eurasia according to geophysical data.

1-3 - Types of continental crust:

1 - ancient continental crust:

(S) - the Siberian craton, exposed and geophysically established median masses, (K-O) - Kolyma-Omolon, (B-Kh)- Bureya-Khankay, (Oh)- Okhotsk,(Ch)- Chukotka, (Ohs)- Okhotsk sea;

2 - Phanerosoic crust without Precambrian basement: (V)- Verkhoyansk fold belt, (SA)- Sikhote-Alin' structures;

3 - Phanerosoic crust without Precambrian basement having recent lower crust and low-velocity mantle: (TB)- Transbaikalian structures, (MO)- Mongolia-Okhotsk foldbelt;

4 - Marginal volcanic belts;

5 - The boundary between different blocks of continental crust and oceanic crust; (T)- Transition zone between continent-ocean.

MESOZOIC GRANITOIDS OF THE NORTH-EASTERN EURASIA
(essays on geology)

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A description is given for the following regions: the North- Eastern (NE), the Far-Eastern (FE), and the Transbaikalian (TB). The location of these regions are shown on Fig.1.

The North-Eastern region covers the territory of the Sakha-Yakut Republic, the Magadan district (including the Chukotka) and the Kamchatka peninsula.

The Far-Eastern region covers the Khabarovsk district, the Meritime territory (including the Sikhote-Alin' system), the Sakhalin and Kuril islands.

The Transbaikalian region includes the Buryat Republic, the Chita district and the Eastern part of the Mongolia.

The stable platforms and the median masses as well as mobile belts are shown in the paper by Shustova, (in this volume).

The Precambrian-Lower Paleozoic crystalline complexes compose the basement of the median masses and the separate uplifted blocks. The Paleozoic is represented mainly by carbonate sediments and by a volcanic-sedimentary complex. The Middle Carboniferous and the Triassic are terrigeneous. The Jurassic sediments indicate admixture of volcanogenic material. The sediments of the geosynclinal complex (C-J) are known as the Verkhoyansk complex. It covers an extensive part of the NE region, and has a thickness of up to 18000 m (Vasil'kovsky,1981). The Okhotsk-Chukotka volcanic belt (OCVB) is a transcontinental belt forming a border on the continent. Within the Koryak block are outcrops accreted of allochthonous material represented by the melange of ocean-continental core type (Sokolov,1992). The Transbaikalian region is located between the Siberian platform and the Northern blocks of the China platform. The Mesozoic granitic rocks have a specific chemical composition. The granitic belts of Sikhote-Alin' region are pressed together on the continent and the ocean terrains, the granitic massifs are mainly formed by multiphase intrusions. Several belts of Mesozoic granitic rocks are known within the regions. The main features of geology of these rocks are discussed as follows:

THE NORTH-EASTERN REGION

This extensive region occupies the large part of the NE Eurasia continent. The long belts of Mesozoic granitoids are known to occur there (Tectonic of the Yakutia, 1975; Sobolev,1989; and Zonenshain et al. ,1989).

The Northern belt of granitic rocks

This is referred as tin-bearing predominantly with cassiterite-sulfides mineralization. The chemical composition of rocks approximately to that of quartz diorite and tonalite. Interformational intrusions extended along the Northern boundary of the Kolyma mass where there are terrigeneous Mesozoic deposits. They are predominantly multiphase and bedded. The central type of intrusions are from Middle Jurassic to Lower Cretaceous and are spread throughout the Western part of this belt between Proterozoic block and Triassic terrigeneous deposits. Quartz diorites and tonalites have, as a rule, porphyritic textures.

The Main (Kolyma) belt of Mesozoic granitoids

The belt extends NW to 1500 km with a width of 150-250 km. The area is located to the South-West of the Kolyma mass along the Verkhoyansk megasynclinorium, within this area are riftogenic troughs, deep faults, terrigeneous and volcano-sedimentary complexes (C-J) which have up to 10 km thickness and are folded in the NW direction.

The complex was transcected by numerous multiphase granitoid intrusions. The ore-bearing granitoid zone extends up to 1100 km with a width of up to 60 km (Shkodzinsky et al.,1992) and is known as "the Main Belt". Among the massifs to be mentioned are the following:

The Chibagalakh massif (p. 1058) having the size of 210 x 10-45 km, is within NW part of the belt and is elongated near a deep fault that has divided terrigeneous Mesozoic and carbonate Paleozoic formations. Granodiorites are composed of 29% plagioclase, 28% K-Feldspar, 33% quartz, 5% biotite, and accessoric minerals (monazite, apatite, zirkon).

The Khatynnakh massif (p. 2921) is located SE of the Chibagalakh massif mentioned and has the same extention with a size of 16 x 5-6 km. Intrusions cut shales and sandstones of T-J. The early phase is a porphyritic diorites-monzonites with 40-50% Pl, 25-35% K-feldspar, 5-8% Q, 5-10% Hb, and accessories: sphene, orthite, apatite and zircon. The main phase (60% of the area of the massif) is composed by biotite granites, the breccia-like rocks have xenoliths of the host rocks. The age of the intrusion was Lower Cretaceous.

The Lower Cretaceous intrusions almost all are intermediate in composition. In the NW part of the Main belt there are uplifts and dome structures are formed.

The Kerekh massif (pp. 1561, 1727) is placed within Kular anticlinorium. It transverses folded terrigeneous host rocks, and is formed by porphyry granites with quartz-tourmaline veins. The late phase rocks are subalkaline in composition.

The Arga-Ynnykh-Khaya (p. 1701) is a complex volcanic-dome formed by adamellites-tonalites - porphyry granodiorites - white (lithium-fluorine) granites (Romanova,1987). For the white granites Li-minerals: lepidolite, ambligonite (up 8%), topaz, and black cassiterite (up to 1.7%) are typical. The age of dome varies from 122 to 51 Ma, but it is considered as the Upper Cretaceous.

The South-Western branch of the Main belt

This is traced along "transformed" fault and gravitational scarp. The typical intrusions are as follows (from NW to the SE):
The Upper-Allakh (p. 3313), Upper-Emkyrchan (p. 2495), Tarbaganakh (p. 4340), Taryn (p. 3611) and Upper-Khandyga (p. 4179). The area of these massifs is 700-800 km^2. They cut Upper Triassic terrigeneous formations, vary in composition from diorites, tonalites, granodiorites to subalkaline granites and syenites. These Lower to Upper Cretaceous intrusions (ring-structure with shutter-cone segments and with sharp contacts to the Jurassic sediments) formed the Taryn-Elgino Au-bearing zone.

The South-Eastern branch of the Main belt

This is located between the Kolyma median mass, Prikolymsk depression and the deep faults (at South). These thrustfolded dislocations and the Precambrian basements are covered by Triassic (sandstones, shales, tuffaceous rocks), Jurassic (graywackes, sandstouns, argillites) and Upper Jurassic-Lower Cretaceous (marine-continental) formations. The granitic massifs with a predominance of potassic leuco-granites bear a variety of minerals (cassiterite-quartz, cassiterite-silicate and cassiterite-sulfide) types.

The Left-Omsukchan massif is located in a deep depression. Medium-grained biotite granites compose nearly 80% of the area. Fine-grained porphyritic granites containing fluorite and cassiterite, are rich in potassium (Na_2O - 0.75%, K_2O - 6.13%).

The Seymchan massifs are within a zone of abyssal faulting near the Okhotsk median mass. The intrusions are elongated latitudinally; the Southern contact "dips" at an angle of 60-80^0, the Northern contact dips gently. The rock is composed of plagioclase, microcline, quartz, biotite, diopside, hornblende and apatite. The intrusion was Late Cretaceous. The rocks are recognized as a standard type (Vistelius et al., this volume). Here Au-Sn and Sn-W mineralization is connected with Late Jurassic-Early Cretaceous intrusions.

The Anyuy granitoids belt

Near the Northeastern boundary of the Omolon median mass and NW riftogenic fault structure is located the complex of Mesozoic granitoids of the Anyuy belt . The Lys'in massif (p.4329, 4394), being typical and is composed of quartz diorite - monzodiorites - granosyenites - granites - micropegmatites. Hornblende-pyroxenic varieties are more basic, have garnet, ilmenite, magnetite. Micropegmatites are rich in apatite and fluorite. The intrusion was Upper Cretaceous.

The Vukney massif (p. 4659) on the NE part of the zone is complex consisting of quartz diorites (plagioclase up to 73%, diopside and bronzite up to 11%, hornblende, biotite and quartz) to monzonites; with accessory minerals (sphene, magnetite, apatite) up to 2%. The monzonites are enriced with Na_2O (4.68%) and K_2O (2.36%). The intrusion was Early Cretaceous in age.

The Chukotka Mesozoic granitoids belt

The Anyuy uplift to NE-E extends in the Chukotka belt. The folded structures with a chain of granitic massifs are distinguished as stanferrous - rare metallogenic province. The typical intrusions are the following:

The Pevek intrusions which formed a NE-oriented chain of massifs. The host sandy-argillaceous formations (T) surrounding the granitic massifs have changed to cordierite-tourmaline hornfelses rocks. The massifs consist of potassic adamellites, biotite granites and fine-grained tourmaline granites. The intrusions were Late Cretaceous.

Within the Eastern part of Central Chukotka the granitic massifs vary in composition from monzodiorites to biotite granites and potassic leucogranites. The ages are from 120 to 65 Ma and they are accepted as Cretaceous.

Along the Eastern margin of the Chukotka peninsula the following intrusions are studied (from North to South):

The Dezhnev massif (p. 1668), is 125 km^2 in area and transects the Archey (metamorphic rocks) and the Lower Carboniferous (carbonate - terrigeneous) complexes. The core of the massif consists of subalkaline granites with TiO_2 up to 5%. The rocks of the massif are predominantly quartz syenites and syenodiorites. These rocks contain a number of alkaline gabbro xenoliths. The intrusion was Late Cretaceous.

The Providensky massif (pp. 629, 2389, 4429), is 800 km^2 in area, and varies in composition from monzodiorites-granodiorites to tourmaline leucogranites. It cuts Precambrian crystalline rocks (on the North) and carbonaceous-terrigeneous formations (on the South). The intrusion was Early Cretaceous.

The Yaayakan massif (p. 4594) occurs within a deep fault zone separating the Eskimossky median mass from the Mesozoic folded belt. The massif is composed of quartz diorites close to porphyritic rocks with zonal plagioclases (50-60%), potassium feldspar, quartz (up to 30%), hornblende (up to 15%), apatite (up to 1.7%), titanite. This sample comprising the standard rock (Vistelius et al., this volume). The intrusion was Early cretaceous.

The Mesozoic granitoids within the Okhotsk-Chukotka volcanic belt (OCVB)

The Penzhin part of the OCVB is on the boundary of the Omolon median mass and a long depression. The following massifs are typical and follow a NE to SW direction.

The massif (p. 4607) is a multiphase intrusion from gabbro, diorite, monzonite to syenite and granite. The host molasse complex (Late Jurassic) has a 6 km thickness. The intrusion was Upper Cretaceous.

The Aptian-Albian sodic diorite-monzonites small intrusions extends along 160^{o}-$163^{o}30'$ East longitude. They are located directly within the riftogenic structure, rich in TiO_2(1.21%) with dissiminated sulfide mineralization. As a whole the Penzhin part of the OCVB has zonal granitoids of the stable composition representing the intrusion of magmas from sufficiently great depths at the boundary of the continent to the ocean.

The Okhotsk part of the OCVB

The sampled Mesozoic granitoids are the following:

The volcano-intrusive massifs are located in Permo-Triassic complexes, marine terrigeneous (J) and Lower Cretaceous - Paleogenic volcano-sedimentary complexes.

The massif (p. 4283) consisting of subalkaline sodic granites and plagiogranites, and both are Lower Cretaceous in age.

The Upper-Yam subvolcano (p. 500) is located on the boundary with the uplift, it is composed of subvolkanic hornblende granites of Late Cretaceous age.

The Big Nayachan massif occurs within a deep fault zone. About half of the area is composed of potassic leucogranites Late Cretaceous in age. So, this part of the OCVB is composed of intrusions of comperatively basic and sodic granitoids along deep fault-zones.

The Kuyul massif (p. 4468) is located on the East coast of the Penzhin gulf. It consists of gneissoid, granodiorotes rather sodic - Na_2O (7.09%), K_2O (0.38%).

The Koryak ridge massifs are represented by micropegmatitic Na - alkaline plagiogranites (Na_2O 4.53%0, K_2O 0.35%). The intrusions were Lower

Cretaceous in age.

The Latter Mesozoic-Paleogene quartz diorites are spread between the West-Kamchatka system and East-Kamchatka zone. The rocks are near in composition to monzonite-diorites with high sodium content.

THE FAR-EASTERN REGION

This region includes diverse tectonic structures: the Stanovoy block, the Bureya median mass, the Khankay block, the folded belt of the Eastern part of the Mongolo-Okhotsk belt and the Sikhote-Alin' belt.

The Mesozoic granitoids within this region are grouped into the following magmatic belts: the Olekma-Stanovoy, the North-Bureya the Khingan- Okhotsk and the Sikhote-Alin' complex belts.

The Olekma-Stanovoy belt of Mesozoic granitoids is a continuation of the North-Transbaikalian belt. Here, on the boundary between Precambrian blocks and marine terrigeneous Mesozoic formations occur a series of large massifs varying in compositions from diorites, monzodiorites to plagiogranites with marked sodiun alkalinity and sometimes increased content of MnO (up to 2%). Typical intrusions are presented in the massif (p. 4059) and also in the massif (p. 2574). They were Lower Cretaceous in age.

The North-Bureya magmatic belt is a part of the Amur-Okhotsk system. It is restricted between the Stanovoy and Gondzhinsk blocks. The central part of a trench is indicated by a series of oval domes divided by depressions with thick Triassic-Jurassic terrigeneous formations. Sodium-alkaline ferrodiorites are located in the northern margin of the belt. The banded massifs are composed of plagiogranites and granodiorites. The intrusions were from Early Cretaceous to Paleogenic age.

The Khingan-Okhotsk magmatic belt extends meridionally from the Amur-Okhotsk trench to the Eastern margin of the Bureya mass. Many abyssal intrusions are within this belt. Banded interformational massifs occur on the boundaries between Proterozoic blocks and the siliceous terrigeneous Paleozoic formations. The massif (p. 3746), for example, is a complex intrusion of diorites-monzodiorites-granodiorites, Upper Cretaceous in age.

The Dusse-Alin' massif (p. 3624) is also a complex intrusion of gabbro-diorites-quartz diorites, monzo-diorites, with a predominance of sodium alkalinity, but with potassium alkalinity in the later rocks. Rare-metal mineralization is connected with quartz veins and greisen zones. The intrusions were Upper Cretaceous, the leucogranites were Paleogenic in age.

The Magloy massif (p. 4627) is a multiphase dome, which vary in composition from gabbro-diorites-granodiorites to granites. The rocks are mainly K-alkaline, the intrusion was Late Cretaceous.

The Sikhote-Alin' magmatic belt extends in the North-East direction for more than 1200 km with a width of up to 600 km. It includes three main structural elements: the Main anticlinorium, the Main synclinorium and Pribrezhny (Inshore) anticlinorium. Each structural element has specific complexes of Mesozoic granitic rocks.

The Main anticlinorium is separated from Bureya belts by a zone of faults and a wide depression. The Eastern boundary with the Main synclinorium is defined by abyssal faults. The Upper Paleozoic marine terrigeneous formations are exposed in the core of Main anticlinorium. Triassic-Lower Cretaceous gravels have NE trending folds. The zone of gravitational scarps marks the Western transition from the depression to the Sikhote-Alin' system. Here volcanic domes with alkaline granites are located. Late Jurassic granites and monzogranites are accompanied by Mo, Nb, and Ta mineralization. The system of gravity minimum on the boundary with the Khankay mass is followed by a number of complex granites-leucogranites, alaskites with Li-Ta mineralization.

The Main synclinorium of the Sikhote-Alin' belt separates the Main anticlinorium from Pribrezhny anticlinorium. The Cretaceous sandy-shaly deposits are deformed into NE-oriented folds. The Mesozoic granites are spread approximately parallel to the shore line. Thus, the intrusions of basic granitoids with a composition corresponding to quartz diorites and tonalites are located along the Main structure of Sikhote-Alin belt. The massifs Plotnikovsky (p. 4656) and Ternisty (p. 4608) were accepted as "standard" diorites in composition. The rocks are usually fine-grained, porphyritic with zoned plagioclases, pyroxene, hornblende. The massifs transect the Hauterivian-Albian flysch-like formations. They are Upper

Cretaceous in age.

There is the belt of multiphase intrusions with comparably low-silica (SiO_2 <68.28%), sodium alcalinity and high degree of oxidation (Fe_2O_3 >1.88%). The Lower-Amur complex of intrusions is exposed on the left bank of Lowermost Amur River. The typical massifs are the following: the Sergo-Mikhaylovsky (p. 3581), the Dalzhin (p. 4070), and the Did-Biran (p. 3476). Au-sulfides mineralization is known for some of them. The intrusions were Upper Cretaceous-Lower Paleogenic in age.

The multiphase dome structures are spread at the Northern part of the Main synclinorium. The early phases are gabbro-granodiorites, followed by monzogranites and granites, the latest include granite porphiries with granophyric groundmass. The host rocks are Upper Jurassic-Lower Cretaceous flysch-like formations cross cut by deep faults. Here are the known Sn-mineralized zones. The typical massif (p. 4523) is of Lower to Upper Paleogenic age.

The Kyambizin massif (p. 4416) is more ferriferous with alkalinity varying from sodic to potassic. It is composed by basic granodiorites and miaroltic tourmaline bearing granites.

As a whole, the granitoids of the Eastern belt of the Main Sikhote-Alin' synclinorium are identical in chemical composition to sodium grano-diorites of the Anadyr-Penzhin belt of the North- Eastern region, but they were the later (Aptian in age). The granitoids of the Main Sikhote-Alin' synclinorium are Upper Cretaceous to Lower Paleogenic in age.

Further to the East within the Southern part of the Main Synclinorium, more alkaline porphyritic biotite granites of Late Cretaceous age are abundant.

The Prybrezhny (Inshore) anticlinorium (up to 30 km) is a volcano-plutonic complex in composition (from gabbro to leuco- and plagiogranites) which are located within the Inshore belt. These dome structures occur along the junction of Mesosoic structures with marginal dip to the Japan-depression. The host rocks were Hauterivian-Albian terrigenous formations. As typical volcano-plutonic are the following:

The Samargin massif (p. 3832) with sufficiently high sodic composition is accompanied by ring zones of Sn-Mo mineralizations.

The Mutukhinsky massif (a dome approximately 150 km) is composed of gabbro in the core and micropegmatitic syeno-diorites in the marginal ring-zones. The rocks are Na-K in alkalinity. Both massifs are Upper Cretaceous-Middle Paleogenic in age.

The Dagdy-Japan massif (p. 4159) is located to the South. The composition of the rocks is close to "tonalite" by Daly (1933).

The Dal'negorsky block is located further to the South. The multiphase intrusions are characterized by compositions ranging from gabbro and diabases with Na-alkalinity, to Na-K granodiorites and granites. It is intruded into thick reef limestones. As a result at the contacts, complex polymetallic and molybdenium ores are formed. The subvolcanic granite-porphyries are accompanied by Sn- mineralization.

The Upper Cretaceous formations of the South part of Prybrezhny anticlinorium is transected by large massifs. The Vladimirsky massif (p. 3708) is 60 x 3-5 km in size elongated along the shoreline of the Japan Sea , the contacts dip at high angles. The intrusion is composed by granodioretes and granites with abundance of basic xenoliths. The massif is Late Cretaceous-Paleogenic in age.

The South Maritime block is due to Mesozoic granitoid magmatism which is specific in this structure. The block with Archean rocks is uplifted (the Khankay massif) and is surrounded by a deep troughs and depression. The sublatitudial deep fault (along 43-44^{0} N.L.) separates the South block from the Central Sikhote-Alin' structures. This deep fault was followed by a series of alkaline intrusions (the Suyfu zone).

The Sheningous massif (p. 247) is located in the Western part of the block. It is composed by K-Na hornblende granites.

The Vangous massif (p. 412) has a composition of slight potassic alkaline.

The Lampakhez massif (p. 242) is on the boundary of the Archean complexes to Mesozoic rocks. The granites have K-Na alkalinity with a predominance of sodium. The chemical composition of these intrusions is analogous to the alkaline granites of the Transbaikalian complex or to the complex granites of the South margin of the Okhotsk mass (North-Eastern region).

The massifs of the Main zone are composed by ultrabasic rocks in the core and syenites in the margins with a predominance of sodic alkaline massifs which are Jurassic in age.

The Plotnikovsky massif (p. 4656) is composed of biotite-hornblende quartz diorites with low-alkalinity (Na_2O-2.66%, K_2O-1.64%), and is Late Cretaceous in age.

The Valentinovsky massif (p. 1245) is composed of dark granodiorites in the central part and of K-Na leucogranites in the marginal parts.

The South Maritime block is referred to as an accreted structure. The chemical composition of granitoids is close to the chemical composition of rocks of the accretion zone near the Stanovoy complex.

THE TRANSBAIKALIAN REGION

The internal sublatitudinally extended zone between the Siberian platform and Northern marginal blocks of the North China platform is considered usually as a "stress field" area.

The Precambrian basement, as it is inferred on the basis of geophysical data, is plunged in great depths or is reworked extensively by subsequent Phanerozoic processes (L. E. Shustova, this volume). The lineal-extended chains of gneiss-granitogneiss domes are separated by troughs occupied by Upper Triassic graywackes and volcano-terrigenous formations of the Jurassic and Lower Cretaceous to a thickness of 4-km.

The Mesozoic magmatism of the area was intense and depended on the proximaty and its relation to the Siberian platform or to the separate continental crust blocks in the South part of the mobile area.

The Northern zone of Mesozoic granitoids is controlled by the deep transcontinental fault which separate it from the Siberian platform. Along the North deep fault multi-phase K-rich intrusions are exposed of which the Sakun massif (p. 3340) is typical. Along the deep fault zone alkaline granites are widespread while in the South of the fault zone Na-rich granites predominate. Thus, the stock near Sobachkin brook (p. 4574) and the Tungirikan stock (p. 4485) contain Na_2O 4.45% and 4.70%; K_2O 2.20% and 2.70% respectively. These Triassic-Jurassic intrusions are close in composition to monzodiorites despite of their original classification as diorites.

The Western zone of Mesozoic granitoids is followed along the South-Eastern boundary of the Vitim median mass and the adjacent volcano-terrigenous depression. The axis of the depression extends along the

Selenga River and the Uda River valleys. The granites have different composition across theses structures and their boundaries.

The Yakhakta massif (p.147) within the median mass, consists of ultra-acid potassic granites (2.88% Na_2O, 5.41% K_2O). The massif (p. 1357) on the boundary between the depression and the median mass is composed of alkaline miaroltic granites and granosyenites. Both massifs are Triassic in age.

Within the depression are commonly the intrusions of alkaline granites like the Etytey massif (p. 4255) where more early Triassic alkaline granites are rich in fluorine (0.71%) and late Jurassic bodies (p. 291) which are referred to as morion-granites.

Further to the South the belt of alkaline granites is bending to the West and has a sublatitudal extention between Khamar-Daban and Dzhida ridges. The Lower-Middle Jurassic Totkhotoy massif (p. 233) consists of granites rich in phosphorous and fluorine and is typical of the region.

The South boundary of the Transbaikalian arch-block mobile area is situated along the transcontinental Mongol-Amur deep fault which is dividing the Southern platform from the Northern geosyncline blocks. The system of grabben synclines extends from the Kerulen River basin (Mongolia) to the North-Western margin of the Bureya median mass. The grabens are filled by terrigenous and volcano-terrigenous formations.

The Mesozoic granitoids of then Southern boundary have more mafic compositions. It is possible to recognize proceeeding from SW to NE the following typical intrusions:

The Tsagan-Chulutin massif (p. 4056) is composed of quartz diorites Lower-Middle Jurassic in age. They are of the same age as the rocks of the Kyrin complex (p. 4101). The intrusions were transecting Carboniferous-Triassic terrigenous rocks and have been enriched in lithium and boron. Also within this zone at the cross-cutting boundary faults between the Aginsk and Daur structures (usually referred to as the Sn-bearing fields) occurs the Sokhonda sub-volcanic complex (p. 1713) with a predominance of porphyritic granodiorites and late bodies of alaskites which are enriched in Li, Be, and ore sulfides. It is Upper Triassic in age.

In the South part of the Daur structure the North-Eastern oriented chain of stocks is observed. They are Triassic in age and have compositions close to granodiorites.

The regional fault system separates the Khantey-Daur arch (1000x400km) from the Prekurelen uplift of Mongolia.In this area the Shara-khanda intrusions of porphyritic granites, Late Triassic in age, can be mentioned as being typical.

Further to the Transbaikalian in the North-Eastern margin of the Khantey uplift, a number of Middle Jurassic tin-bearing granites are present. The Modoto complex is mentioned as being typical (p. 1165) and consists of subalkaline potassic- and fluorine-rich leucogranites.

Within NE Mongolia potassic leucogranites of Middle-Late Jurassic age are sampled.

They transverse the Jurassic terrigenous and the volcano-terrigenous formations of the Choybolsan depression. Close to Russian-Mongolian border in the Onon deep fault zone, the Khalzan massif is exposed (p. 3852) and it is an interformational body elongated along the Onon River valley. The Paleozoic terrigenous rocks around this Late Jurassic massif were tranformed into migmatites and gneisses. The main phase of the intrusion consists of porphyritic granodiorites with several pegmatite bodies and fine-grained granite dykes cutting them.

Another interformational body is the Borschevochny plutonic body (120 x 20 km) occuring in the Preshilkinsky uplift, between deep faults. The complex intrusion varies in composition from porphyritic Hb-Bi granites to leucogranites with gneissoid facies in the endocontacts. This Plutonic body is Late Jurassic in age and belongs to gneiss-granite dome structures.

The Aginsk structure occupies the territory between the Borschevochny and Nerchinsk ridges, where terrigenous Permo-Triassic sediments gently cover folded sedimentary and metamorphic complexes of the Paleozoic with up to 12-14 km thickness. This thick cover is transversed only by small granitic bodies preferably potassic and ultra-acidic in composition. In the central part of the structure the intrusions are slightly larger in size up to 8 km (along their Long axis). The Khangilay massif and some of the smaller intrusions are accompanied by rare-metal quartz veins. The age of the intrusions varies from 159 to 112 Ma.

The territory of the mobile area between the North zone of predominantly sodic granitoids and the South zone which is indicated by outcrops of low-alkaline granites (the Argun' median mass) is occupied by strong and multiple deformed Riphean-Lower Carboniferous rocks, covered by a variety of terrigenous and volcano-terrigenous alluvials, lake and marine sediments of the Permian-Jurassic age. The intensive pre-Permian deformations - multiple isoclinal folding and foliation accompanied by thrust-imbrication led to the formation of the observed structure of the mobile area, as the system of close NE-extending isoclinal folds with short NW bends, were cut by deep faults sub-parallel to the main NE-oriented structures. The Mesozoic magmatism is manifested intensively and is complex. The composite multiple intrusions often form the watershed chains. The observed sequence of the intrusion events are as a rule standard (homodromic), for each plutonic complex show the sequence gabbro, diorites, Na diorites to Na granodiorites, calc-alkaline granites, subalkaline granites and often alkaline granites. As examples can be mentioned the following massifs:

The Bom-Gorkhon (p. 1414) - the stock-like bodies of 1-2 km extend along deep fault. The range of composition is: monzodiorites - Bi - granite - fine-grained potassic granophyric granite - alkaline granite. These Lower-Middle Jurassic stocks transverse Paleozoic metamorphic and granite rocks.

The Kontalak volcano-plutonic body is located in an arch uplift of the Stanovoy ridge. The composition of the rocks varies from tonalite to porphyritic granites rich in lithium and phosphorous (p. 770). There are several bodies of amazonitic granites as the zones of explosive breccias and tourmaline-rich hornfelses is approached in the exocontacts. The age of the rocks differs from Triassic up to Upper Jurassic. The complex intrusions, where each sample has it's individual unique composition form a whole set of massifs with compositions showing all transitional varieties from granodiorites to quartz monzonite and calc-alkaline granites according to Daly (1933). As a whole in the studied Mesozoic granitoids there is observed a direct transition from basic granitoids to acidic and alkaline granites with increased volatile contents.

Thus, the Transbaikalian arch-block mobile area is sub-divided in three belts: 1) The North belt ajoining the South margin of the Siberian platform with predominance of more basic sodium-rich granitoids referred to as the Goldbearing Ore Belt; 2) The South-Eastern belt adjacent to the Amur-Bureya blocks, with mafic granitoids and potassic-rich granites, with polymetallic ore mineralization, and 3) The Central Transbaikalian belt occupied by subalkaline and alkaline granites both Na- and K-rich and is known as Sn-W Ore Belt. The Aginsk zone is distinguished by ultra-acidic granites with marked enrichment of rare-earth elements.

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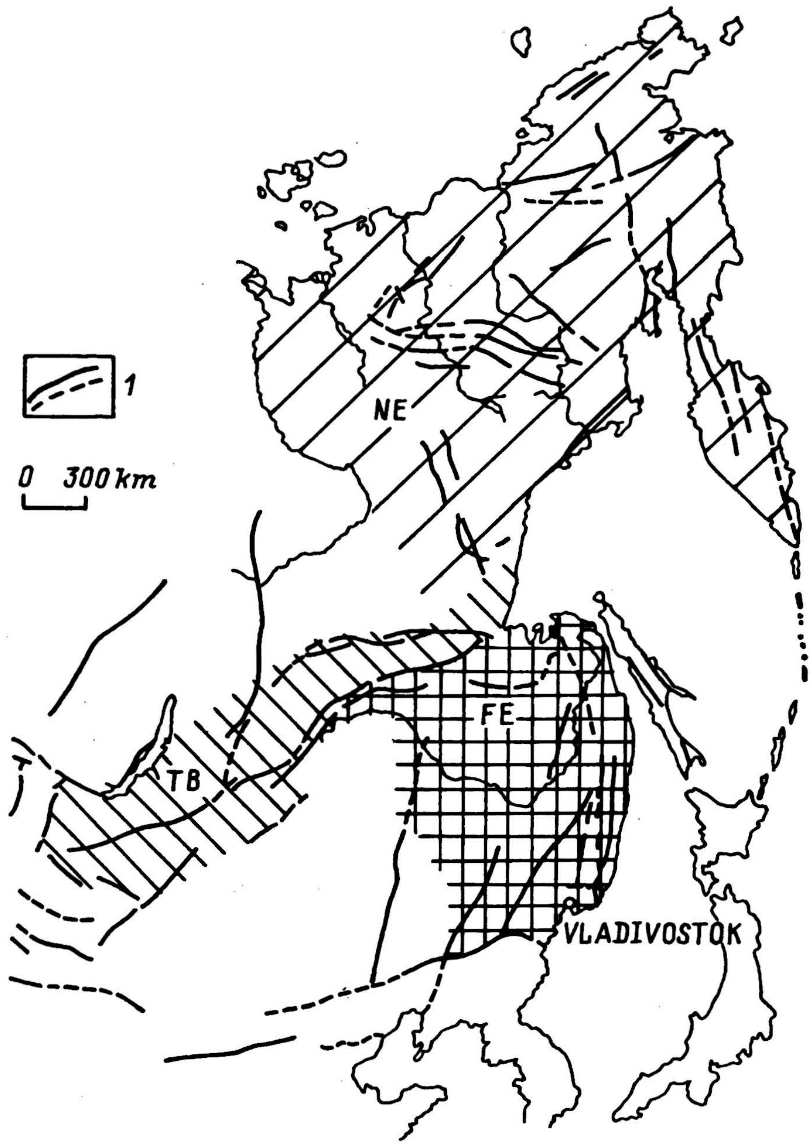

Fig.1. Location of investigated regions of the territory of North-Eastern Eurasia: NE - North-Eastern Region, FE - Far-Eastern Region, TB - Transbaikalian Region.

1 - main deep fault (from geological map of Eurasia, scale 1:5000000, published in Russia, edited by Yanshin, 1966).

CHEMICAL ANALYSES AS THE BASIS FOR REGIONAL GEOLOGICAL INVESTIGATIONS

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The sampling net of the granitoids in the external part of Eurasia was as uniform as the available mapping of rocks permitted. The area distribution of 4659 analyzed specimems to the East of the 100^{o}E meridian is shown in Fig.1.(p 39). In order not to represent each sample by a single point, the sampled territory was divided into trapeziums corresponding to the used catrographic projection with 5^{o} of latitude and longitude. There is a number of specimens within each trapezium. If the specimen (by coordinates) fell at the border of two trapeziums, it was divided between these. Therefore in some cases the shown quantity of specimens is not the whole.

If only one specimen was in a trapezium, its position was pointed on the drawing with a corresponding number (for example, point with the number 1894 at the Kamchatka).

Besides the territory of Russia, the sampling covers the territory of Mongolia. Large numbers of trapeziums at NE of Mongolia (130,5; 150) were formed at the expense of territories of the Chita district which are into trapeziums. One specimen (N 676) was sampled at the China territory.

A lot of the qualitative chemical analyses that represent Mesozoic granitoid magmatism and cover the great territory make it possible to solve global (regional) problems.

Results of similar investigations using simultaneously all major rock-forming oxides has been published from 1970 to the present (Vistelius, 1977, 1982, 1985; Vistelius et al., 1969, 1974, 1980, 1983; and Romanova, 1991). In the latest publications, a quantilic expression of the chemical compositon of rocks was used.

The common one-dimentional distributions of concentrations of major rock- forming oxides in Mesozoic granitoids are characterized by various types of hystogrammes (Fig. 2). As shown, it indicates a considerable degree of differences in the contents of oxides in rock-forming minerals and in the percentage of the analytical data (Vistelius, 1991). These features resulted in the loss of uniformaty of the oxides with predominant small contents (MgO, CaO, FeO, TiO_2) in the attempt of making a comparison and correlation particularly if the rock composition is represented as a point in a multidimentional space (in particual, for the problem of classification, see Romanova, this volume).

The quantilic presentation of oxide concentrations convertes marginal distributions of separate components into uniform distribtions. All oxides became equivalent for maintaining uniformity.

In a given example, the content of each oxide for the 4659 specimens of the Mesozoic granitoids of the North-Eastern Eurasia was divided by quantiles into 7 parts. Each part was coded (referred) by a number from 1 to 7. The final presentation of the division of the oxide concentrations and the corresponding quantilic codes are as follows:

Quantilic code	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O
1	<64.45	0.12	12.86	0.32	0.96	0.21	0.58	2.90	2.80
2	<67.39	0.20	13.58	0.56	1.37	0.38	0.93	3.23	3.46
3	<69.88	0.27	14.23	0.77	1.78	0.58	1.40	3.47	3.92
4	<71.90	0.36	14.83	1.00	2.22	0.90	2.03	3.73	4.30
5	<73.56	0.47	15.52	1.34	2.80	1.37	2.86	4.02	4.61
6	<75.15	0.63	16.39	1.88	3.68	2.12	3.98	4.42	5.00
7	>=75.15	0.63	16.39	1.88	3.68	2.12	3.98	4.42	5.00

Thus, each specimen was characterized by nine quantilic codes ranging from 1 to 7. Most basic granitoids (diorites) had the code set (177 777 771), leucocratic potassic granites could be with the represented code set (721 312 127), and so on.

In this example the quantilic expression of a rock's chemical composition was used for controlling the relation between Mesozoic granitic magmatism and peculiarities of the Earth crust in North-Eastern Eurasia.

The polynominal trend-surface of 4-order as the function of a distance (d) between chemical composition of a specimen and chemical composition of a standard rock (in the quantilic codes) from geographic coordinates was calculated. A choice of polynominal order as well as a form of approximation function was discussed more then once (see above cited publications). The distance was counted as Euclidian for all 9 oxides, that is

$$d = \sqrt{(SiO_2 - SiO_2^{(s)})^2 + \ldots + (K_2O - K_2O^{(s)})^2}$$

where (s) represents oxides of a standard rock with a code set (177 777 711) which corresponds to diorite in our particular case.

The pattern of isolines of the trend-surface (Fig. 3) corresponds to the arragement of major tectonic elements of the area. The basicity of Mesozoic granitoids decreases towards the ancient stable blocks and increases to the regions without Precambrian basement (for example, with oceanic type of crust). The rocks most different from basic granitoids near the Pacific are concentrated into the boundaries of the stable blocks. The median masses as well as the plates influence the composition of the granitoids.

At the extreme North-East (Chukotka region) the composition of granitoids changes and becomes the same as the rocks in the boundaries of the stable blocks (i.e. they become more acid). It means that at the East of the Chukotka Sea and the Bofort Sea, a large consolidated mass exists under the water. It is important for predicting the existance of ore and oil deposits at the shelf of the Extreme North-East part of Asia.

The decrease of the basicity of granitoids in the case of these masses is observed also in the Transbaicalian region. In the region located between the Siberian and the Chinese plates, it should be noted, the composition of rocks changes.

The established features of the behavior of the composition of Mesozoic granitoids at the North-East of Eurasia suggests influences of the basement (types of Earth crust) and of the stable blocks (plates, median masses) on the Mesozoic magmatism. The generation of granitic melts in Mesozoic took place, as a rule, in structures surrounding these blocks, and the melt composition depended on the proximity to them. The different types of the crust resulted in the regional trend of increase of the melt basicity to the Pacific.

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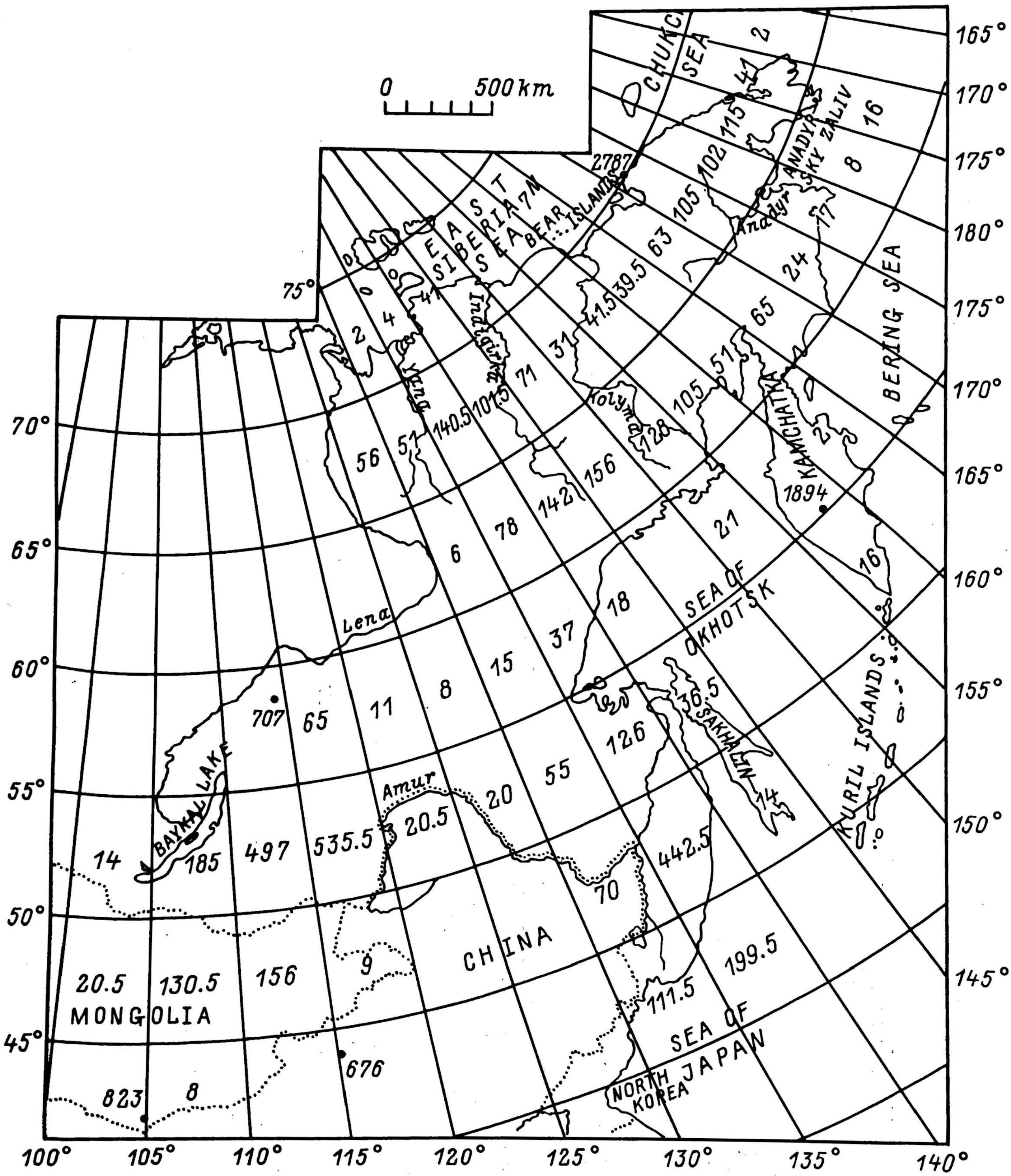

Fig. 1. Distribution of sampled points on the territory of North-Eastern Eurasia (explanation in the text).

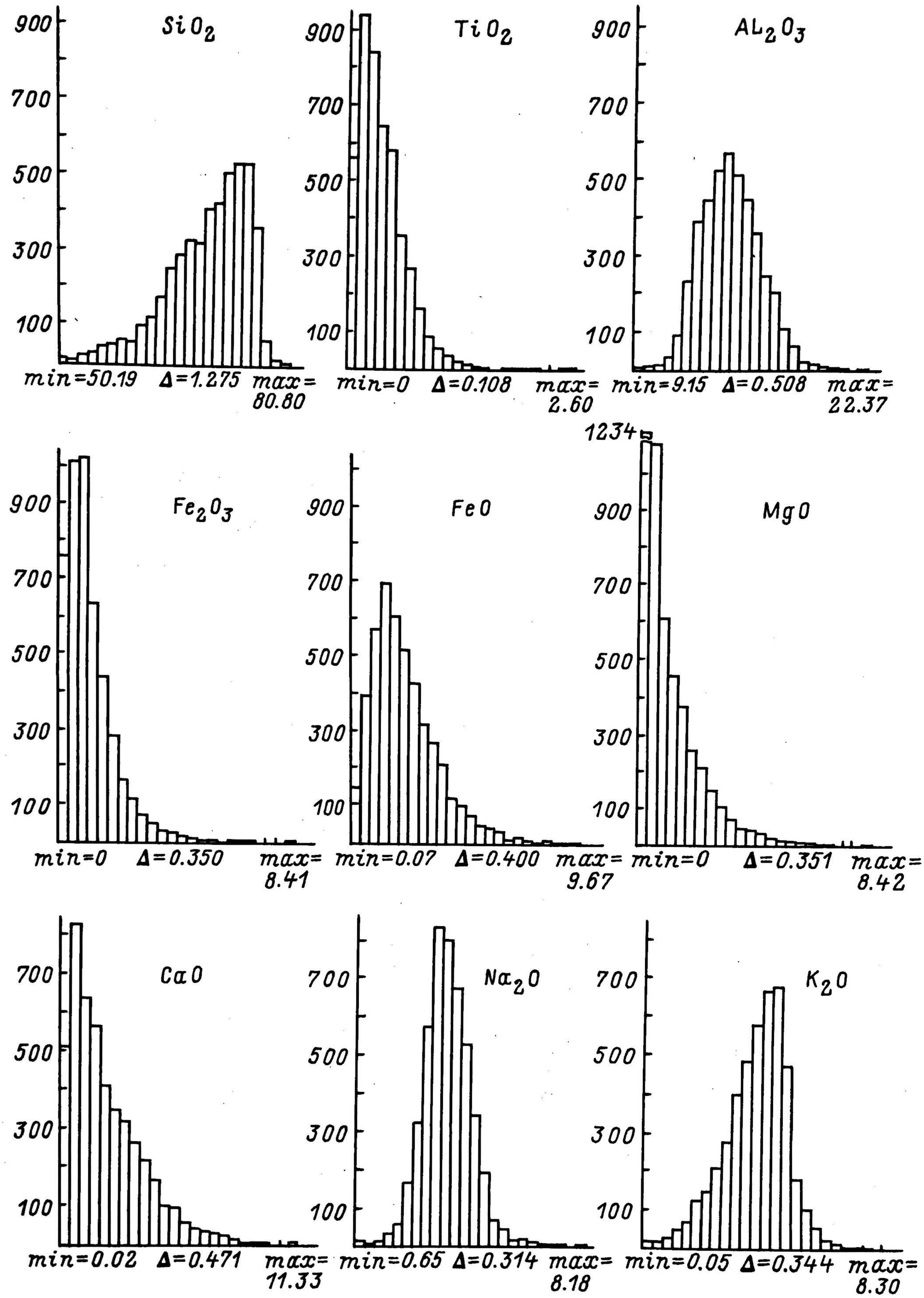

Fig. 2. Distribution hystogramms of 4659 chemical compositions (in percentages) of granitoids of North-Eastern Eurasia.

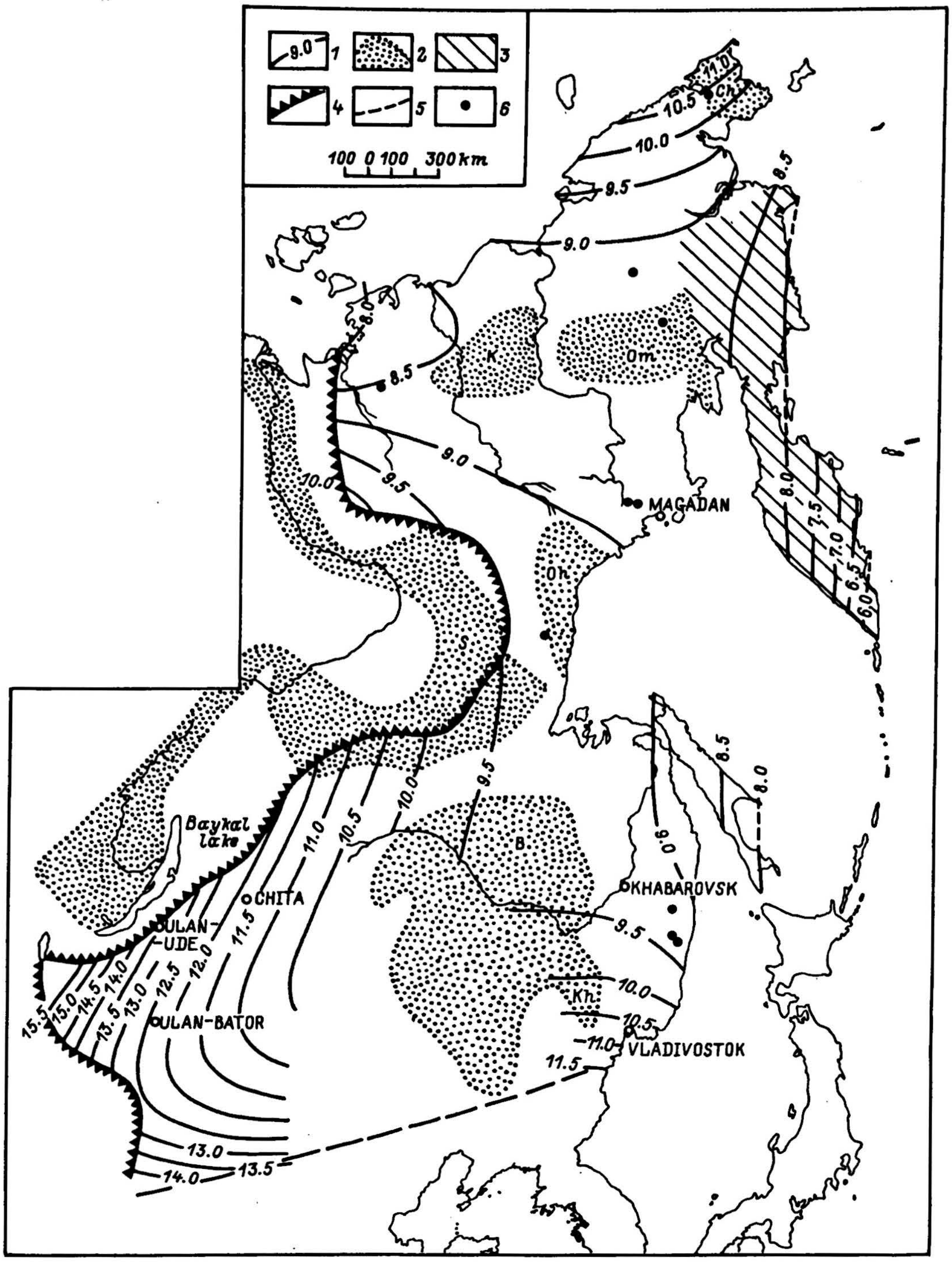

Fig.3. Relations between tectonic structure of North-Eastern Eurasia and chemical composition of Mesozoic granitoids:

1 - isolines of the compositional trend-surface approximating Euclidian distance of sample points from standard rock;

2 - stable elements of structure: (S)-Siberian platform, (K)-Kolyma, (Om)-Omolon, (Oh)-Okhotsk, (B)-Bureya median masses;

3 - Nippon geosyncline;

4 - Western border of Mesozoic intrusions;

5 - Northern tectonic border of China platform;

6 - position of samples accepted as standard rocks.

STABLE CHEMICAL COMPOSITION CLASSES OF MESOZOIC GRANITOIDS, THEIR DISTRIBUTION PER REGIONS OF THE NORTH-EASTERN EURASIA

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All the chemical compositions of analysed rocks were represented by coded sets as the quantilic expression for concentrations of each oxide (see Vistelius et al., this volume). Three (1, 2 and 3) codes were used for the presentation of analyses, because the concentrations of oxides were divided into three equiprobability parts (Tabl. 1).

The frequency distributions of analyses when the concentration axis is divided into three parts give many classes of analyses' groups (Tabl. 2), some of them have more than hundred of observations. The study of the petrographical composition of the rocks in the cells with a fixed number of analyses (N) being more than 10, then the follwoing classes of granitic rocks are registred (see Table 3).

I. Basic granitoids with three big classes of a stable compositions.
II. Acidic granites with four classes of a stable composition.

The distribution of stable rock classes in the regions of North-Eastern Eurasia shows the following:

Type I - Basic granitoids

1. Class of quartz diorites, the cells are (133..3 311) the most stable class of basic granitoids. The rocks belong to small intrusions homogeneous in composition and textures. They occur in the North-Eastern region (NE) and the Far-Eastern region (FE), near deep faults, with dominance of plagioclase over potassium feldspar, pyroxene concentration reaches up to 20%, hornblende concentrations are greater than biotite, magnetite is up to 2%.

2. Tonalites class, or monzo-diorites, the cells are (133..3 321) and

belongs to diapiric stretch ring structures, near gravitational grabens and deep faults, and with a dominance of porphyritic plagioclase over potassium feldspar, and with hornblende over biotite, pyroxene, magnetite, garnet, tourmaline. They occur in the NE and FE regions, near outcrops of quartz diorite intrusions.

3. Sodic quartz diorites class, the cells are (133..3 331), and the rocks (syenodiorites) belong to subvolcanic dome-intrusions along deep faults near depression zones, sometimes they are explosion breccias rich in TiO_2, occuring mainly in the Transbaikalian region, in the East part of the Omolon belt of the NE region.

Type II - Acidic granites

1. The potassium granites class are leucocratic alaskitic rocks, the cells are (311..1 113), with a dominance of potassium feldspar over plagioclase (feldspar up to 74%), biotite (up to 3-5%), frequently with granophyric textures, and belong to batholithic intrusions. They are distributed in all regions, some less in the Far-Eastern. Intrusions are concentrated to the border uplifts.

2. The K-Na subalkaline granite class, the cells are (311..1 123), with a dominance of potassium over sodic, and with porphyritic granophyric texture, they belong to multiphase dome intrusions, with topaz, tourmaline, and cassiterite. They are located within the Main granitic belt (which follow NW in direction) of the NE region, in the central part of the TB belt, in the Chukotka and the Sikhote-Alin' sinclynorium.

The rock classes of (1) and (2) have Sn, W, Mo mineralization.

3. The alkaline granites class, the cells are (311..1 133). These granites have K-Na alkalinity, belong to a subvolcanic dome, in a central ring of massifs, with aegirine, alkaline amphiboles and have Mo-Cu mineralization.

4. The sodic granites class, the cells are (311..1 132), with a dominance of Na over K, and are coarse porphyritic granites to granite porphyry, with alkaline amphibole; the monazite belongs to subvolcano-dome massifs.

The alkaline granites and sodic subalkaline granites are typical in the Transbaikalian region (Table 3). They are displaced by troughs and depressions, and often are contiguous to the border of stable blocks and depression, (with F, Bi, TR mineralization).

Granitoids of different types of intermediate composition between the basic and acidic type are characterized by a single sample in each compositional cell. This concerns the problem of the relations of rock composition and regional and local geologic structures of the area sampled.

Summary:

*The recognizing of stable compositions of different oxides in granitic rocks permits to identify a relative sufficient number of rock types (classes).

**The existence of two major type rocks appears to give a number of oxide combinations, using (9) mine rock-forming oxides only.

***Seven stable classes were registered, using quantilic values for oxide concentrations. Each class belongs to certain regions and have specific mineralizations.

Table 1
Quantilic division in 3 parts for rock-forming oxides (percentages) of Mesozoic granitoids of North-Eastern Eurasia

Quattilic code	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O
1	<68.32	0.22	13.80	0.63	1.50	0.44	1.07	3.32	3.64
2	<73.06	0.43	15.27	1.20	2.59	1.20	2.56	3.91	4.51
3	>=73.06	0.43	15.27	1.20	2.59	1.20	2.56	3.91	4.51

Table 2

Frequency distributions of cell numbers (n) with fixed number of analyses in the cell (N>10) for the case of division in 3 quantilic parts

n	1	1	1	1	1	1	1	1	1	2	2	1	1	1
N	144	105	87	61	58	47	44	43	42	41	39	35	32	31
n	1	1	1	1	2	2	2	1	2	3	5	6	2	10
N	30	27	26	25	23	20	19	18	16	15	14	13	12	11

Table 3

Distribution of stable classes of the chemical composition of Mesozoic Granitoids per regions of North-Eastern Eurasia (in parenthesis quantilic codes)

Basic granitoids: SiO_2<68.28%, K_2O<3.65%

Regions of area sampled	Na_2O<3.31% Quartz diorites (133..3 331)	Na_2O<3.91% Monzo-diories, tonaltes (133..3 321)	Na_2O>3.91% Na-quartz diorites (133..3 331)
North-Eastern	147	126	52
Far-Eastern	114	57	42
Transbaicalian	15	18	45

Acidic granites: SiO_2 >= 73.05%, K_2O >= 4.51%

	Alaskites (311..1 113)	Subalkaly granites (311..1 123)	Alkaly granites (311..1 133)	Sodic granites (311..1 132)
North-Eastern	55	43	21	8
Far-Eastern	38	38	14	14
Transbaicalian	56	50	52	90

TABLES OF CHEMICAL COMPOSITION OF MESOZOIC GRANITOIDS OF NORTH-EASTERN EURASIA

Comments to TABLES

The 4659 chemical analyses (wet method) of Mesozoic granitoids were obtained mainly from archives of the local Geological Surveys of the former USSR. The teams in these Surveys compiled the analytical data and submitted them to the Laboratory of Mathematical Geology for further checking or rejecting them. A part of the analyses was compiled by the collaborators of the Laboratory. Some analyses were made by chemists of the Laboratory on the material of specimens kindly provided by other geologists or collected by collaborators of the Laboratory (see PREFACE).

Each analysis was accepted originally as suitable if it was ploted on the geographic map (with conventional coordinates), had a petrographic description of the rock (as a rule) and the sum of all components was from 99 to 101%.

In the Laboratory of Mathematical Geology each analysis was more thoroughly controlled. The scheme of such checking is cited in Vistelius, Ivanov, Romanova, 1980; (see this volume). So, analyses without any general oxides (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O, K_2O) were rejected. The dash means that the value of oxide was less than 0.01%. If the value of loss on ignition (L.i.) exeeded 2% such analysis was also rejected. The sum of each analysis was checked once more, and if the sum of all oxides did not equal one or more than 0.2% then such an analysis was rejected.

If the values of MgO, Fe_2O_3 or FeO were very small (0.01% or traces) but the modal composition of analyzed rock demonstrated the presence of real contents of biotite, hornblende and so on, then such an analysis was rejected. Similar was the case for CaO and plagioclase. The absence of loss on ignition and the presence in quantities the color minerals was not sufficient for the keeping of the analysis.

The presentation of the checked analyses in TABLES (20 analyses and corresponding descriptions on each page) is as follows.

All analyses were listed to comply with a decreasing content of SiO_2. If SiO_2 contents were equal, the listing of similar analyses was based on the increased content of MgO. The listed analyses were numbered from 1 to 4659.

Each analysis was presented so as hygroscopic water (h_s) did not enter into the total sum. If the h_s entered in the sum of the analysis originally, the h_s-value was distributed between oxides proportionally with their contents.

There is also the column "oth." (others) in the list of analyses. "oth." includes contents of H_2O^+, CO_2, SO_3, Cl, F, etc. entered in the sum, but not accounted in the loss on ignition. The case of the "oth." was considered in the description of the analysis. If these contents did not enter in the sum, they were cited in the description as "det." (determined), and it is supposed that they enter as a rule in the loss on ignition. The description of the analysis is as follows:

-order number;
-geographic coordinates of the sample point (in parenthesis);
-rock name;
-whole-rock age;
-massif name (if it was cited in original report);
-analyst name (if it was cited);
-interpretation of "oth." and "det.";
-author and year of the original report (in parenthesis).

In some descriptions (in particular, for specimems from Mongolia) the year of the original report is not cited - it was absent in the received materials.

Following signs are used in the descriptions:

-Px - pyroxene,
-Amf - amphibole,
-Hb - hornblende,
-Bt - biotite,
-Mu - muscovite.

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