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沈阳地质矿产研究所所刊

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中亚褶皱带黑龙江地块的 深部构造及矿床

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内容提要 黑龙江地块位于中亚褶皱系东缘, 时, 也隶属于太平洋活动带的一部分, 以强烈的中—新生代岩浆活动及与之相伴的金属成矿作用为特征, 并构成直径1500—2000km的巨大环状岩浆—成矿系。根据侵入岩体的形态、构造和分布特征, 该环状构造可划分为: 燕山、锡霍特—阿林、外兴安岭、贝加尔—蒙古及二连等5个链环段, 它们之间具有对称、对应相似之特点, 同时, 其形成的构造环境亦相似。中—新生代金属成矿作用多出现于环状构造中, 矿石主要集中于环状带中, 54个成矿带中32个(60%), 310个矿床中155个(50%)均分布在环状带中。内生金属成矿作用由西向东呈规律性地年青化。贝加尔—蒙古大链环段以多金属矿化为主, 东西南为铝矿化所代替; 而外兴安岭和燕山链环段则主要发育有金矿化, 并伴随有多金属及钨、铜矿化。

黑龙江地块位于中亚褶皱带东缘, 同时, 也是太平洋活动带东亚环的组成部份。该活动带可以划分出一系列与之相似的构造, 其特点是赋存有大量的中—新生代岩浆作用及伴随的金属成矿作用, 并组成了直径为1500—2000km的巨大椭圆形环状岩浆—成矿系(Н.П. 罗曼诺夫斯基, 1987), 其环状构造常常表现为这些岩体的分布格局(本文作者, 1988)、太平洋西岸的地貌形态(胡佳柯夫等, 1982), 有5级以上地震震中的位置及由全球性重力、地震模型所反映出的深部地幔的非均一性(本文作者, 1989)。

黑龙江岩浆—成矿系统作为一个环状构造是由М.Г. 佐罗托夫在综合分析了地质与地貌特点的基础上于1976年首次提出来的。他将这一系统的离心演化特点与软流层内热点的环形波动作用联系在一起。其后, 这些构造发展的问题; 作者之一(Н.П. 罗曼诺夫斯基), 于1986、1989年从太平洋活动带内生作用的深部释放带、释放中心的角度予以研究过。但是, 有关黑龙江岩浆—成矿的出现, 尤其是深部构造的本质以及其它相似的问题, 仍然存在有争议。除指明的一些特征外, 本文也报导了广为引人注意的关于地球物理场、深部构造和金属矿化形式等特点, 目的在于查明黑龙江环状构造的演化及深部构造与内生成矿作用的关系。

作为岩浆—成矿系之一的黑龙江环状构造, 广泛发育有中—新生代岩浆活动。

侵入体的分布形成了这一椭圆—环状构造的轮廓, 并且主要集中于环形部份(577个岩体, 占68%), 而其外缘和环内中央部分, 岩体数分别为150个和133个, 相应比例分别为17%和15%, 这些由图1统计出的数字基本证实了本区所划定的中—新生代岩浆活动构造呈环形轮廓的正确性。

根据侵入体的形态、构造和分布特点,环状构造可划分出5个链环段即:燕山、锡霍特-阿林、外兴安岭、贝加尔-蒙古和二连,它们具有对称、对应相似的特点:燕山与外兴安岭链环段含有巨大的花岗岩体;锡霍特-阿林与贝加尔-蒙古链环段有密集分布的小岩体;

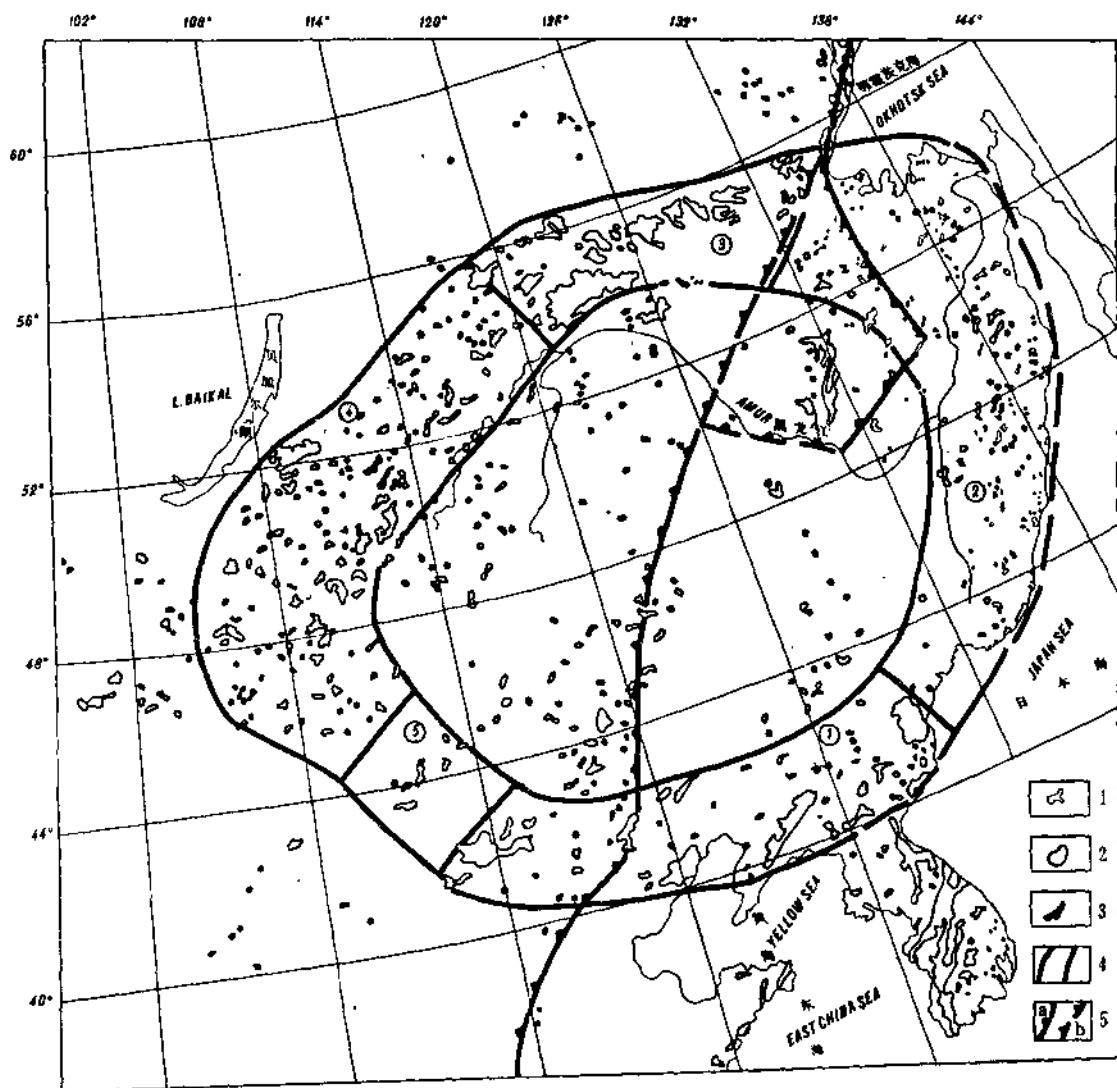


图1 黑龙江巨型环状构造侵入岩分布图

(根据A·II·马尔柯夫斯基)

1972年所编 1:5000000 环状构造侵入岩分布图和中国地质科学院 1975 年编 1:5000000 亚洲地质图)

1—晚古生代—新生代花岗岩; 2—早—中生代花岗岩; 3—中生代基性岩、超基性岩; 4—黑龙江构造—岩浆环状构造的轮廓; ①—燕山链环段, ②—锡霍特—阿林链环段, ③—外兴安岭链环段, ④—贝加尔—蒙古链环段, ⑤—二连链环段; 5—边界深断裂(重力梯度)(a. 已定的, b. 推测的)

而最短的二链连环段则只有稀疏分布的花岗岩体,或者说实际上是环状岩浆—构造带的间断部位。

上述链环段不仅构造—形态特点相似,而且构造环境也相似:燕山和外兴安岭段分布于成分和变质相都相当于太古界变粒岩区,锡霍特—阿林和阿爾泰—蒙古段则相当于古生代—

中生褶皱系。

根据统计, 中—新生代基性岩和超基性岩的分布与花岗岩不同: 在环状构造带中有42个, 占68%, 在其环带之内的中央部分有6个, 占9%, 环状构造之外有18个, 占27%。从古生代和前寒武纪基性岩和超基性岩来考虑, 在黑龙江岩浆—成矿系的中心部位仅是一个低的“背景”(28个占8%), 而环状构造内及其外缘实际上相差无几(分别为160个与155个, 几乎都近于42%)。因此基性岩主要集中出现于时代相对应的构造系统中。

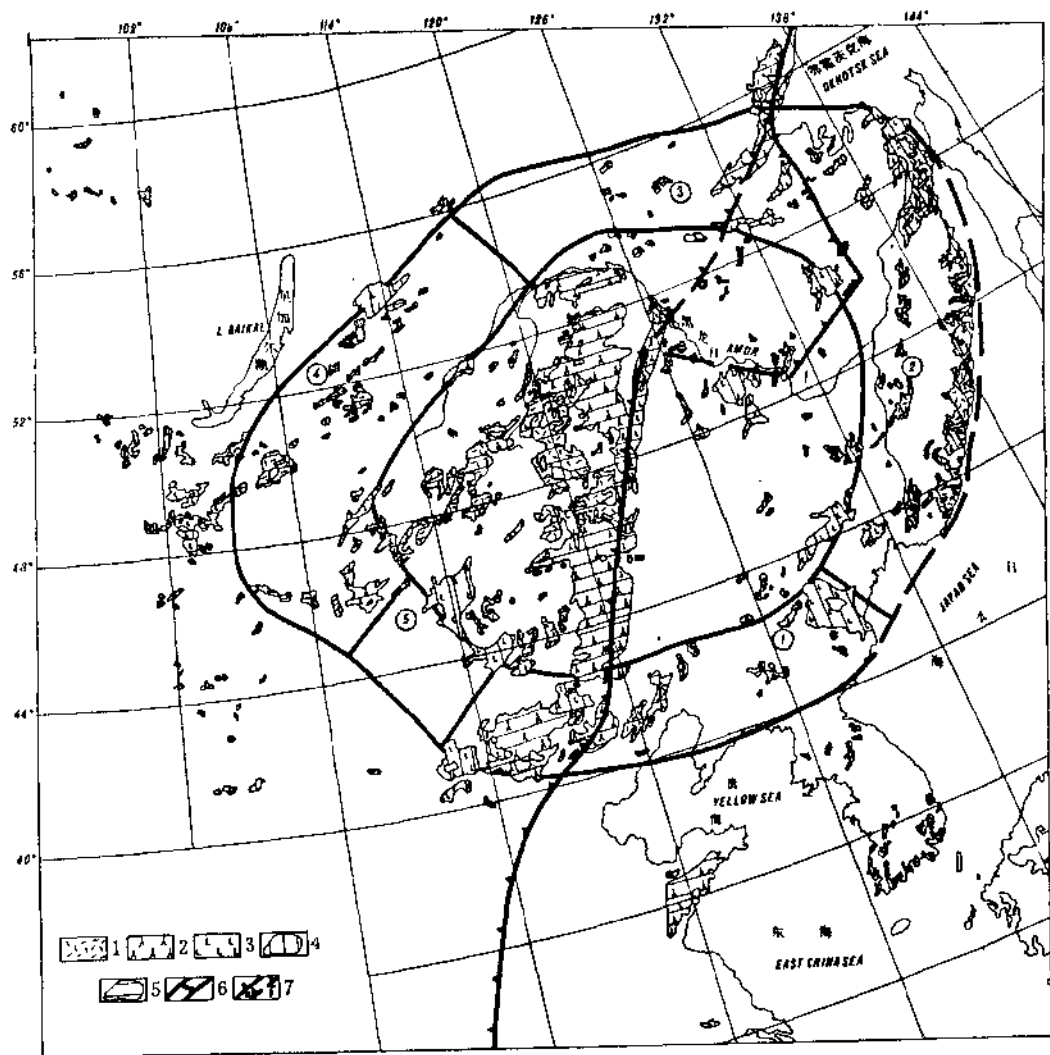


图2 黑龙江巨型环状构造的火山岩分布图

(资料来源同图1)

1—酸性火山岩; 2—复成分混杂火山岩; 3—基性火山岩; 4—晚中生代—新生代火山岩区;

5—早—中生代火山岩区; 6—7—参照图1

与东亚其它类似构造相对比, 黑龙江环形构造发育大量的中—新生代火山岩, 并且几乎所有的火山岩都分布于岩浆—成矿系中, 不论是环本身还是环内(图2)。火山岩与侵入岩的空间分布截然不同, 无论在其边缘或内部(东、西锡霍特—阿林, 大兴安岭或其它地区), 火山岩主要呈北东向的线形带分布。东亚火山岩带的年龄分带性由大陆向海洋逐渐年青, 在黑龙江环形构造带尤其明显: 贝加尔—蒙古的三叠纪—早侏罗世的火山岩为中国东北大兴安岭的晚侏罗世—早白垩世以及锡霍特—阿林的晚白垩世—早第三纪的火山岩所代替。

黑龙江环状构造是经过重新整理磁法和重力等物探资料之后确切无疑划出的, 主要表现为局部磁异常轴方向排列和密度的不均一性(图3), 控制环状构造的轮廓。地壳的低密度

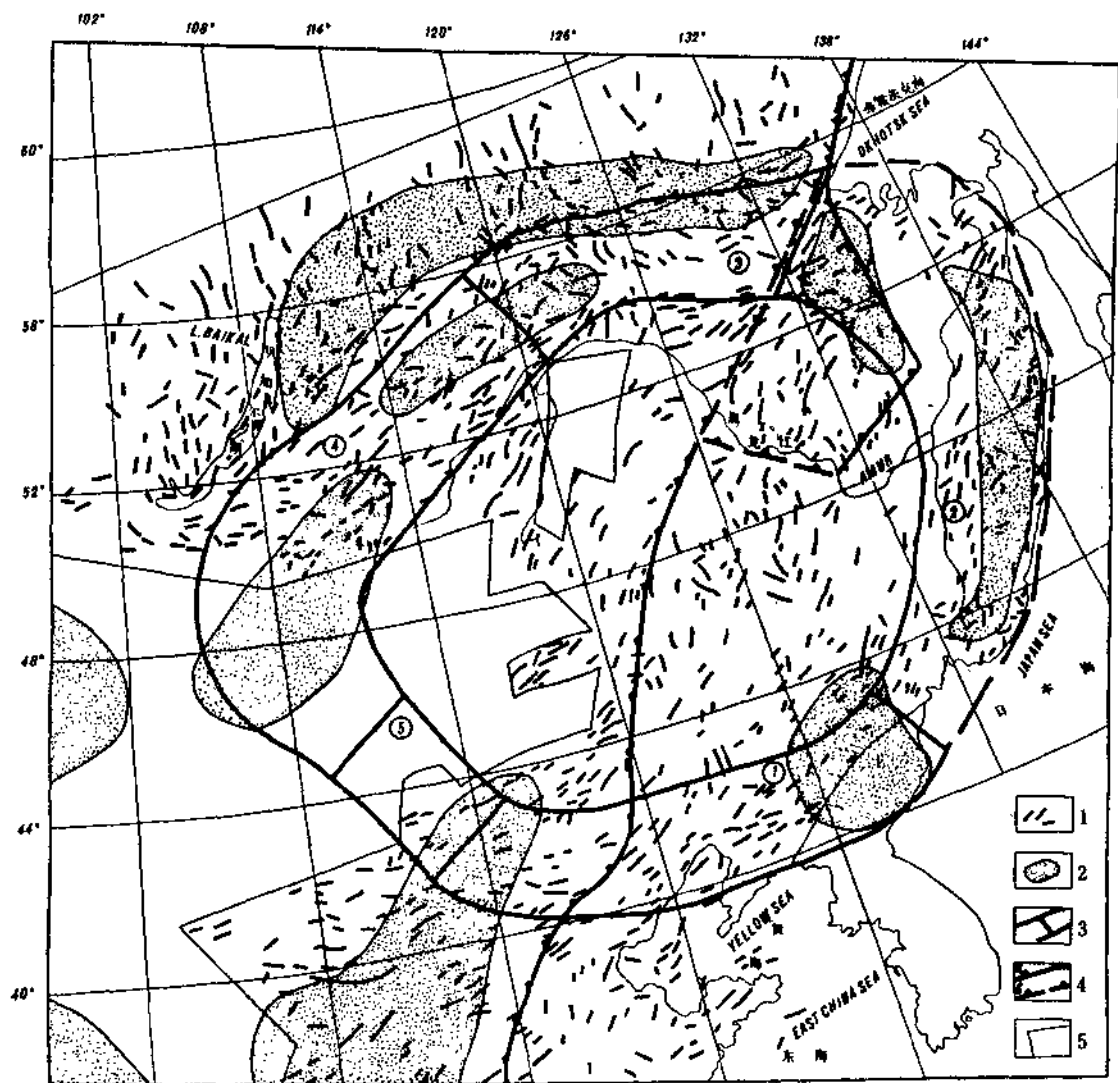


图3. 黑龙江巨型环状构造地球物理要素示意图

(据3·A·玛卡洛夫, 1974; 张文祐, 1986; 冯锐, 1985等)

1—局部区域异常轴; 2—地壳和上地幔低密度集中地段; 3—4—同图1; 5—未经磁法测量的范围

带主要集中于环带或其外缘,环的中心部位实际上没有出现,而且,岩浆—成矿系的基本轮廓与低密度带是吻合的,仅在环状构造面南部(二连链)见有不相一致的现象。

边界深断裂(Ю·Ф·马累谢夫,1987)不仅依靠重力资料而且依据磁异常资料均能显示出来,作者把黑龙江环形构造分成大约相等的两部分,北与鄂霍茨克—楚科奇带相连,在中部与大兴安岭中—新生代火山岩相接。岩浆成矿系的西部与东部之区别在于,前者具有较厚的地壳(王金生等,1982及马杏垣等,1986)岩石圈、低重力值(大地构造动力图,1985)、地震活动少以及时代较老的花岗岩与火山岩,但在地壳基底和岩石圈底而突起处,黑龙江岩

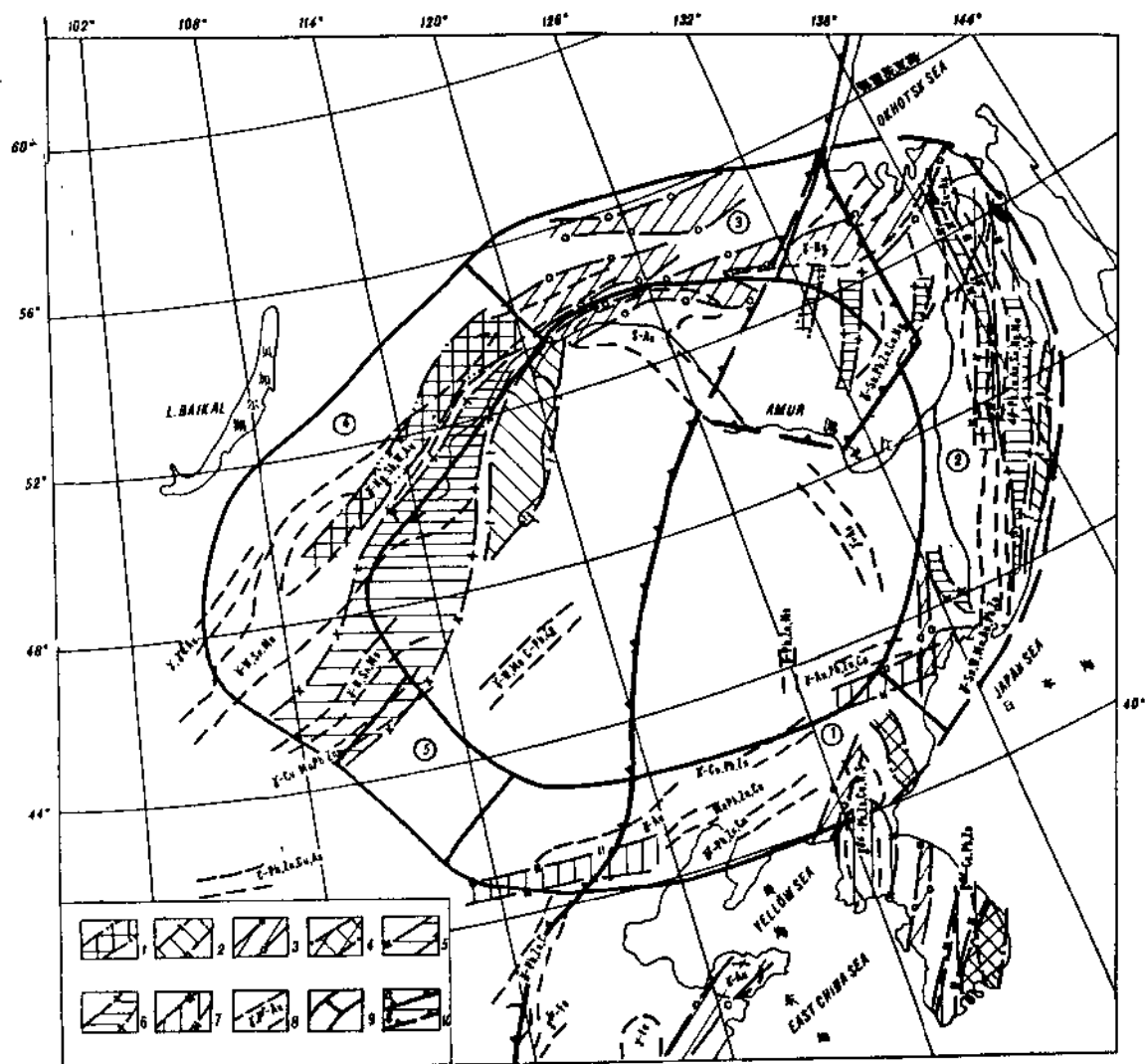


图4 黑龙江巨型环状构造内生成矿带简图

(1—7根据拉德凯维奇1984年,资料,8根据张文祐1986年资料)

1—铜矿带; 2—多金属矿带; 3—金矿带; 4—银矿带; 5—钨矿带; 6—锡矿带; 7—多金属成矿带;
8—内生金属成矿带; 9—10—同图1

浆—成矿系的环形构造表现得不明显。根据这些资料,本区的非均一性具有块体形式,因此,在35—50km的深部,环状构造的特点是见不到的。

根据岩浆岩侵入体分布而确定的环状构造相对链环段的相似性,按照地球物理特征,在锡霍特—阿林和贝加尔—蒙古链环段(年青褶皱系)要比燕山和外兴安岭链环段(前寒武纪活化地块)明显得多。后者之间深部构造的差异取决于边界深断裂对其不均一的影响。

作者早在1988年就分析了东亚中—新生代成矿带的分布特点之后已经指出,大部分成矿带都集中环状构造内。对于黑龙江岩浆—成矿系来说,矿带主要集中于环上,即54个成矿带

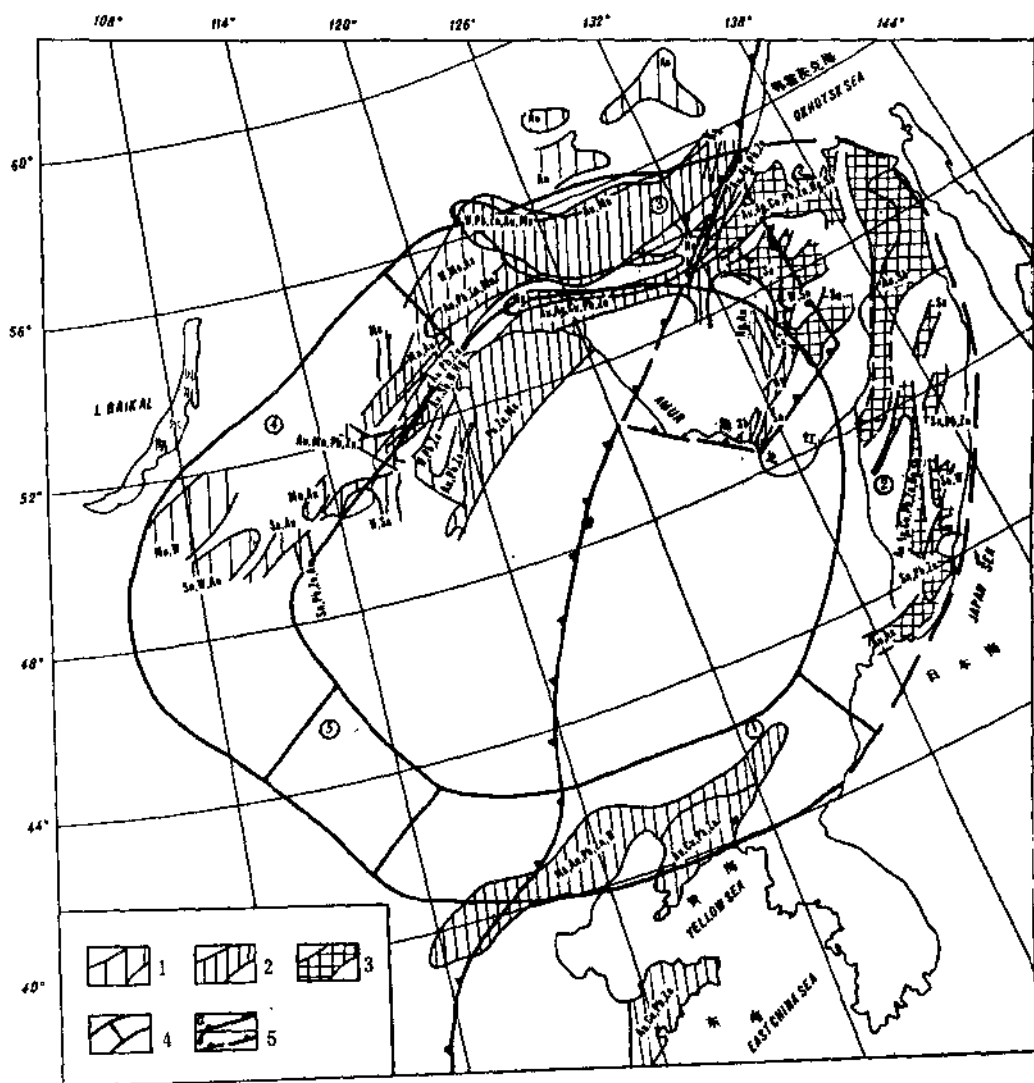


图5 黑龙江环形构造内生金属成矿带时代变迁简图

(根据苏联地质构造第7卷, 1986。郭文魁, 1987等资料)

1—中侏罗世—早白垩世金属成矿带; 2—晚侏罗世—晚白垩世金属成矿带; 3—晚白垩世金属成矿带;

4—5—图例同图1

内的32个(占60%), 310个矿床中的155个(占50%)都分布在这个范围内,这个数字由拉德凯维奇1984年编的小比例尺内生成矿图和1970年编制的矿产图中统计的,在其核部和外缘中,内生成矿带分别为18%和22%,矿床分别为29%和21%(图4)。由此来看,黑龙江环形构造花岗岩侵入体最为集中的环带上,分布有3倍于区域上的矿化带和2倍的矿床。

在岩浆一成矿系的西南部,没有形成内生成矿元素封闭的岩浆环状构造,呈北东向,少数近东西向。在二连链环段成矿作用缺失。因此,黑龙江岩浆矿床系统呈现马蹄状而非闭合环形。

总的看来,环状构造各链段的内生成矿专属性特点具有各对应链环段矿化的相似性,但是它们的变换程度是不相同的。在这方面,锡霍特—阿林与贝加尔—蒙古对应链段的相似性比外兴安岭和燕山组成的对应链段高得多。在锡霍特—阿林和贝加尔—蒙古链环段都发育一套特点十分相似的多金属成矿带(Sn、W、多金属等)。两者不同的是,由贝加尔—蒙古链环段向东南而逐渐接近于岩浆一成矿系的核部,多金属成矿带为广泛发育的钼矿化代替。对于外兴安岭和燕山链段来说,主要发育有金矿化,并伴随有多金属矿化。除此之外,外兴安岭段发育有钼矿化,而燕山链段则发育有铜矿化。

在早中生代—新生代范围内广泛发育的内生金属成矿带的特点是根据“苏联地质构造和矿床分布规律”第7.8卷资料加以研究的。根据这些资料可以指出,在其链环部分,内生金属由西向东有规律地年青化(图5)。而且,在贝加尔—蒙古链环段,成矿带绝大多数为中侏罗世—早白垩世。这种成矿时代明显的变化,尤其是在边界深断裂的不同地段见到。

结 论

1. 位于太平洋活动带内亚洲部份的黑龙江巨型环状构造,形态上明显地反映了中—新生代岩浆岩区和内生金属成矿区。这个环形构造是由一系列地表和地壳上部标志所确定。实际上并不超过30—150 km。

2. 在巨型环状构造范围内,其地质—地球物理特征,包括岩浆岩的成分、时代内生金属成矿作用的时期,地壳和岩石圈的厚度等从西向东都在发生着变化。这种变化在边界深断裂的两侧十分明显,而边界深断裂则是在太平洋的作用下,亚洲大陆深部改造作用的活动带。

3. 黑龙江岩浆一成矿作的环形部份,具有明显的线形分带迭加特征和成对对称构造特点。

4. 环形构造要素与大陆、海洋过渡带锋面的联结,导致了复杂的混合构造,并可证明黑龙江环状构造的空间继承性和时间的多旋回性。此种巨型构造乃是超区域性的中—新生代岩浆成矿系统。

(母瑞身、朱志明译,段瑞焱校)

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DEEP STRUCTURE AND ORES OF THE AMUR GEOBLOCK IN THE CENTRAL ASIAN FOLD BELT

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Summary

The Amur geoblock occupies the eastern marginal part of the Central Asian fold belt and simultaneously is the element of the East Asia link of the Pacific mobile belt (PMB). The spatial coincidence of areals of high concentration of the Mesozoic-Cenozoic magmatism and its metallogeny are typical of them. They form the largest (1500-2000km in diameter) oval ring magmatic-ore systems (MOS) (Romanovsky, 1987). The most clearly the ring contour of these megastructures is reflected on the map of the distribution of intrusive bodies (Malyshev Romanovsky, 1988), in the scheme of the geomorphostructures of the Pacific ocean western margin (Khudyakov et al. 1982). Their settings are emphasized by the distribution of earthquake epicentres with magnitude more than 5 and by deep mantle heterogeneities on global gravitational and seismographic models (Maslov, Romanovsky, 1989).

The Amur MOS as a ring structure was described first by M.G. Zolotov (Zolotov, 1976) on the basis of geological-geomorphic signs which connected the centrifugal character of its evolution with the action of circle wave processes from hot points in the asthenosphere. Later this question was considered by Romanovsky (Romanovsky, 1985, 1987) from the point of view of the connection of these megastructures with zones and centres of deep release of endogenic processes in PMB. Nevertheless, the problem of existence and deep tectonic nature of the Amur MOS and other such structures remains disputable. In this paper, besides above mentioned signs, there was used information geophysical fields, deep structure and metallogenic peculiarities with the aim of investigating the connections of endogenic mineralization manifestations with the deep structure and evolution of the Amur megastructure.

The Amur megastructure is more than other MOS saturated with Mesozoic-Cenozoic magmatic rocks. Granitoid intrusives form oval-ring figure of this megastructure and concentrate mostly (577 bodies or 68%) in its ring (outer) part, on the contrary, within and outside the megastructure the number of them is not more than 150 bodies (17%) and 133 (15%) accordingly from all bodies on the map (fig.1). These data quantitatively confirm the rightness of singling out contours of the Mesozoic-Cenozoic ring magmatic structure at the modern erosional level as 4 times exceeding background.

The ring zone according to morphology and structural peculiarities of granitoid bodies and mode of their distribution may be divided into 5 links or

segments: Yinshan, Sikhote - Alin, Stanovoy, Baikalo-Mongolian, Erlian. The segments situated at the opposite sides are similar according to the above mentioned signs: Yinshan and Stanovoy (large separated granitoid bodies), Sikhote-Alin and Baikalo-Mongolian (thick impregnated small bodies). The Erlian segment (the shortest link) is less saturated with granitoids. The break off of the ring magmatic structure is assumed here.

The segments, close in their structural-morphological characteristics, have a similar tectonic position. The Yinshan and Stanovoy segments are situated within the outcrops of the Archaean granulite rocks similar in composition and metamorphic facies. The Sikhote-Alin and Baikalo-Mongolian links correspond to paleozoic-Mesozoic fold systems.

The distribution of Mesozoic-Cenozoic basites and ultrabasites differs from that of granitoids: in the ring part-42 bodies (68%), within the megastructure -6(9%), outside-17(27%). Including paleozoic and Precambrian intrusions, this distribution is the following: within-28 bodies(8%), in the ring part and outside accordingly 160 and 155 bodies, that is, 42% for each. The localization of basite bodies is mainly observed in tectonic systems of the same age.

The Amur megastructure is more saturated with Mesozoic-Cenozoic volcanites in comparison with similar structures of East Asia. Almost all volcanites are situated within the Amur MOS contour (fig. 2). The mode of spatial arrangement of volcanite bodies sharply differs from peculiarities of the intrusive bodies distribution. volcanites usually form mainly NE linear belts which are situated both on the margin and in the centre of the megastructure (Eastern and Western Sikhote-Alin, Daninggan et al). Age zoning of the arrangement of the East Asia volcanic belts (rejuvenation from continent to ocean) distinctly manifests itself in the Amur megastructure. The Triassic-Early Jurassic volcanic belt in Zabaikalie and Mongolia is changed by Dahinggan Late Jurassic-Early Cretaceous volcanites in North-East China and Late Cretaceous-Paleogene volcanites in the Sikhote-Alin.

In geophysical fields the Amur megastructure is singled out for certain only after evaluation of measured magnetometric and gravitational data (transformation and modeling). Its ring structure is emphasized by peculiarities of distribution of local magnetic anomalies axes. It mainly conforms to megastructure's elements. Ring structure is reflected in the arrangement of density heterogeneities (fig. 3). Low density zones of the earth crust are mainly localized in the ring (outer) part of the megastructure and outside its contour, but they are absent in its core. Low density zones mainly conform to MOS elements and only in the south-western part of the megastructure (Erlian segment) there is a discordant character of their joint.

The Boundary deep fault (Malyshev, 1987) is clearly reflected according to

not only gravitational but magnetic data as well. It divides the Amur megas-structure in two nearly equal parts and coincides with the Okhotsk-Chukotka (in the north) and Dahinggan (in the centre) Mesozoic-Cenozoic volcanic belts. The western part of MOS differs from the eastern one by the thickened earth crust (Wang Qianshen et al., 1982) and lithosphere (Ma Xingyuan, 1986), low gravitational field (Geodynamic map, 1985), low seismicity, and more ancient age of Mesozoic granitoid bodies and volcanites. But in the relief of the crust and lithosphere soles the ring structure of the Amur MOS is reflected poorly. From these data there is only the heterogeneity of the block type corresponding to this place. So the ring character of the megastructure at the depth of 35-150 km is not established.

The likeness of the opposite segments of ring parts of the megastructure established by the distribution of intrusive magmatism, is preserved in geo-physical signs more for the Sikhote-Alin and Baikalo-Mongolian links (young fold systems) than for the Yinshan and Stanovoy ones (activated precambrian blocks). Differences between latter links in deep structure peculiarities are aggravated by unequal action of the Boundary deep fault.

The analysis of peculiarities of Mesozoic-Cenozoic metallogenic zones arrangement which has been done earlier (Malyshev, Romanovsky, 1988), showed that the majority of zones concentrate in contours of oval-ring megastructures. In the Amur MOS these zones are mainly localized in contours of the ring part of the megastructure where concentrate 32 from 54 or 60% of metallogenic zones and 155 from 310 or 50% of endogenic ore deposits shown on small-scale metallogenic (Radkevich, 1984; Guo, 1982) and mineral resources (Map of Economic, 1970) maps. In the core and outside MOS the number of deposits is 18 and 22% for zones and 29 and 21% for deposits (fig. 1). So there are 3 times exceeding backgrounds for zones and 2 times for deposits in the ring part of the Amur megastructure where granitoid bodies mostly concentrate.

In the south-western part of MOS there is no closing of metallogenic elements. They are of the NE seldom sublatitude direction. In the Erlian link closing is absent. So the Amur MOS is not of a ring but rather horseshoe form.

Metallongenic specialization of megastructure segments emphasizes likeness of opposite pairs of links but transformation of signs for these pairs is different. The likeness of the Sikhote-Alin and Baikalo-Mongolia segment is higher than that of the Stanovoy and Yinshan ones. In the first case a set of profiling metallongenic zones (Sn, W, Pb-Zn) and their arrangement are similar. Distinctions are in the drift of metallongenic zones of the Baikalo-Mongolia

segment into the core of MOS and in the manifestation of Mo-mineralization. For the Stanovoy and Yinshan segments the common sign is wide distribution of Au-mineralization with polymetallic ores. Besides, in the Stanovoy segment there is Mo-mineralization, but in the Yinshan one there is Cu-mineralization.

Peculiarities of spatial distribution of metallogenic zones from Early Mesozoic to Cenozoic were considered from the data of "Geological structure and Economic Minerals of the USSR" (V.8, 1984; V.7, 1986) and Guo et al (1982, 1987). From these data rejuvenation of endogenic metallogeny age is established in the ring part of the megastructure from the west to the east (fig. 5). In the Baikalo-Mongolia segment there are mainly Middle Jurassic-Early Cretaceous zones, in the Stanovoy segment-Late Jurassic-Late Cretaceous zones, in the Sikhote-Alin segment mostly Late Cretaceous zones. A sharp change of ore age is observed on both sides of the Boundary deep fault.

The conclusions may be drawn as follows.

1. The Amur megastructure of the Asian part of PMB is a good morphological manifestation region of Mesozoic-Cenozoic magmatism with accompanying metallogeny. On the basis of some signs on the earth surface and in the upper part of the crust there is established its ring structure which is not translated to the depth of 30-150km.

2. In this megastructure there is distinguished a change of geological-geophysical characteristics from the west to the east: composition and age of magmatism, age of endogenic metallogeny, thickness of the crust and lithosphere. This change is the sharpest one on both sides of the Boundary fault-supposed geophysical limination of the most active deep transformation of Asia under the influence of the Pacific ocean.

3. The ring part of the Amur MOS has a distinct (on the basis of many signs) pair-symmetric segment structure with elements of superpositional linear zoning.

4. combination of stable relict elements of ring structure with front changes specific for the Transitional Zones from continent to ocean, results in a complex heterogeneous structure and indicative of inherited in space and polycyclic in time evolution of the Amur megastructure which is the superregional magmatogenic-ore Mesozoic-Cenozoic system.

环太平洋带中国大陆增生、构造演化 和成矿作用基本特点的初步总结

王五力

内容提要 本文从几个方面初步总结了环太平洋带中国东部的基本特点: 1. 中国及邻区环太平洋带的划分; 2. 大陆增生和构造演化; 3. 构造岩浆带及成矿作用; 4. 与东太平洋大陆边缘的对比。重点分析了众多地体和地块在大陆增生、构造演化、岩浆成矿作用和碰撞挤压、位移和裂解方面的特点以及与整个环太平洋带的共同发展规律。

一、中国及邻区环太平洋带的划分

环太平洋带中国大陆及邻区, 以郯庐-敦密-跃进山断裂带为界, 可以划分出内带和外带(图1)。内带恰是环太平洋带的主要区域。在内带中连同整个环太平洋带考虑, 又可分为内大带和外大带。内大带一直沿近代的地槽和岛弧延伸, 其成矿作用主要属于第三纪和中生代晚期, 局部较早。一些现代火山活动区, 成矿年代甚至延到现代, 以伴有Cu和Au的一些安山岩和闪长岩为特征。超基性和基性岩带沿着伴生有Cr、Ni等矿床的深大断裂延伸, 除表明其边缘与地幔接近外, 目前已证实由一系列构造-地层地体所组成, 并进一步分离成岛弧。这些岛弧由厚层硅铝质地壳所组成(花岗岩和酸性火山岩), 具有与硅铝亲合的成矿作用(锡、钨、钼)。在中国及邻区, 主要有日本秩父、那丹哈达-西锡霍特阿林-日本美浓、东锡霍特阿林-东北日本、北上山、台湾、菲律宾等地体和联合地体。外大带位于亚洲和美洲两侧很不相同的大陆架及其外侧的地体和地块范围内。在中国主要有延吉、辽东-狼林、鲁东-京几、沃川、南朝鲜(庆尚)、宁芜-南黄海、华南等地块。

环太平洋外带的西界在大兴安岭和华北、扬子板块西缘。区内基本上是布列亚-佳木斯、张广才岭-小兴安岭地块、华北、扬子板块和西伯利亚板块东南缘的林西、北兴安地块等相互拼合、位移和裂解活动区, 也是造山带花岗岩和裂解带火山岩的主要分布区, 在晚中生代至新生代则是松辽、华北等强烈拉伸能源盆地生成区。其中的成矿作用, 大多与块体的拼合和裂解所产生的若干重要构造岩浆带有关。

任纪舜^[1,2]在黄汲清^[3]划分的中国滨太平洋构造域的基础上将东缘岛弧带归入环太平洋带。这一划分与王鸿祯等^[4]的观点相似, 但后者将中国东部分别归为北亚、亚洲中轴、南亚构造域的亚构造域。张秋生^[5]认为环太平洋带在中生代时可达贝加尔湖, 新生代时可到松辽、华北、湘东地区。上述分歧意见基于对东亚大陆边缘的性质认识不同, 如王鸿祯等认为在(J-K₁)时期东北环太平洋带属被动大陆边缘, 该时期中国东部的构造岩浆活动主要受南