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GEODYNAMIC TYPES OF THE PYROPHYLLITE DEPOSITS

Пирофиллитовое сырье относится к сравнительно редким видам нерудных полезных ископаемых. По геологической позиции и условиям образования месторождения подразделены на 5 типов. Первые два связаны с гидротермально измененными породами в вулканогенных толщах кислого и среднего составов. К третьему типу относятся месторождения метаморфогенно-метасоматического генезиса. Проявления четвертого типа приурочены к низко- и среднетемпературным стадиям образования гидротермальных жил среди вулканических и метаморфических толщ. Пятый тип - это пирофиллитсодержащие коры выветривания по метаморфическим толщам и метасоматитам. Условия образования и размещения месторождений пирофиллитового сырья в складчатых поясах определяются геодинамической обстановкой формирования.

Pyrophyllite is a comparatively rare economic mineral. Basic consumers of raw pyrophyllite are ceramic and fire-resistant industries. It is also used for manufacture of fillers for paper, cardboard, rubbers, plastic, insecticides, technical ceramics, and in the electro technical industry. Monomineral pyrophyllite is used in high-pressure apparatus to manufacture synthetic diamonds and also as a material for stone culling (agalmatolite). Zaykov et al. [1988] proposed typification of the deposits. We adopt the scheme and relate it to a modern geodynamic scheme (table).

Deposits in metasomatic rocks of intra-continental and marginal-continental volcanic zones (Type I). Host rocks of this type deposit are typically calc-alkaline andesitic to rhyolitic lavas, which are enriched in potassium or sodium and potassium. The pyrophyllite deposits are associated with volcanogenic metasomatic rocks of the "secondary quartzites - pyrophyllites" series, and they are commonly found in ancient rifling zones on platforms and on active continental margins. Pyrophyllite deposits on Precambrian platforms are found in Ukraine, Sweden, South Africa, USA, Canada and Brazil. In contrast, pyrophyllite deposits in Middle Asia, Kazakhstan and Australia are distributed in Paleozoic active continental margins. Pyrophyllite deposits occur at Mesozoic-Cenozoic active continental margins in USA, Canada, Morocco, China, New Zealand, Korea, Japan, Vietnam, Georgia and Azerbaijan.

Pyrophyllite deposits in metasomatic rocks in island arcs and Paleozoic and Cenozoic marginal seas (Type II). In folded Paleozoic island-arc system there are pyrophyllite deposits, which occur in bimodal volcanogenic series. This type of deposit is widespread in the Ural folded Paleozoic island-arc system, where pyrophyllite-bearing metasomatic rocks of sericite-quatrz formations accompany massive sulfide mineralization [Udachin, Zaykov, I994]. Pyrophyllite mineralizalion in folded structures of Cenozoic age is known in "green tuff" region of Japan, the Bolnis area of Southeast Georgia and the Panagursko zone in Bulgaria.

Pyrophyllite deposits in metamorphosed terrigenous-argillaceous strata of Paleozoic and Mesozoic age, containing pyroclastic material and coals seams (Type III). Pyrophyllite deposits in Paleozoic beds in passive continental margins and interior seas and coal-bearing depressions occur in

Table

Types of pyrophyllite deposits [Sinyakovskaya et al., 2005]

Type, geodynamic situation	Ore-hosted formation age	Lode structure and parameters (thickness, m)	Mineralogy of raw material	Examples
I. Metasomatic rocks in intra-continental and continental margin volcanic zones	Trachyandesitic, trachyrhyolitic in Precambrian platforms	Linear zones, lens (n • 10) along faults at contacts with plutons; layers (n • 1) in tuffaceous-sedimentary packets	Pyrophyllite, pyrophyllite-quartz, sericite- pyrophyllite	East-Europe platform; North-American platform; South-American platform; African platform
	Dacite-rhyolite, rhyolite at Paleozoic continental margins	Lenses, strips (n • 10), bodies of irregular form in secondary quartzite massifs and in faults	Pyrophyllite, diaspore and kaolinite- pyrophyllite, chlorite- pyrophyllite	Ural-Mongolian belt; East-Australian belt, East-Atlantic belt
	Andesite-dacite-rhyolite in Mesozoic-Cenozoic continental margins	Bodies of stratal and lens-shaped form (n • 10), irregular form (30-60x300-800), steeply-dipping zones in tectonic dislocations (n • 10)	Quartz-pyrophyllite, diaspore- pyrophyllite, pyrophyllite, kaolinite- pyrophyllite, sericite- pyrophyllite	West-Pacific belt; East-Pacific belt, Mediterranean belt
I. Metasomatic rocks in island arcs and marginal seas	Massive sulphide-bearing rhyolite-basalt in Paleozoic continental margin	Strips (n • 10) extent up to 1500 m on strike of massive sulfide-bearing zones	Quartz-pyrophyllite, pyrophyllite-quartz, sericite- pyrophyllite-quartz, diaspore- pyrophyllite, pyrophyllite	Ural-Mongolian belt
	"Green tuffs" in Mesozoic island arcs	Irregular in form (l00-300 x 300-600), steeply-dipping zones along contact with plutons	Pyrophyllite- kaolinite- sericite-chlorite, pyrophyllite- quartz-sericite- diaspore-alunite	West-Pacific belt
III. Metamorphosed terrigenous- clay formations of platforms and folded belts	Terrigenous-clay in Paleozoic and Mesozoic passive continental margins, internal seas and coal hollows	Strata and intercalations (interlayers, interbeds) (10) among metamorphosed terrigenous and clay strata	Quartz-chlorite- pyrophyllite- sericite, kaolinite- pyrophyllite-illite, kaolinite- pyrophyllite	East-Europe platform; South-American platform, East-Australian belt, East-Pacific belt
IV. Hydrothermal veins in metasomatites in platforms and folded belts	Quartz veins in Precambrian granitoids and Paleozoic metamorphic rocks	Zones (0.01-1) parallel to contacts of veins	Pyrophyllite, muscovite-pyrophyllite, diaspore- pyrophyllite, kaolinite- pyrophyllite- muscovite	Indian platform; Ural-Mongolian belt
V. Weathering crusts metamorphites and metasomatites in folded belts	Weathering crusts in slates formed by metasomatism of Paleozoic and Mesozoic rocks	Linear weathering crusts (l5-20), extent n • 100	Illite-montmorillonite-pyrophyllite, kaolinite- pyrophyllite	East-Pacific belt; Ural-Mongolian belt

Germany, Argentina and Spain. Mesozoic terrigenous-argillaceous strata with pyrophyllite are known in Australia and the Carpathians.

Pyrophyllite occurrences in quartz veins in hydrothermal systems (Type IV). Pyrophyllite deposits in India at the margins of large vertical quartz bodies (so-called "quartz reefs") are connected with a Precambrian granitoid complex. In Russia pyrophyllite connected with hydrothermal veins is found in Paleozoic metamorphic rocks. Pyrophyllite was identified as a mineral species in gold-quartz veins at Berezovsk (the Urals, in 1929).

Weathering crust containing pyrophyllite mineralization on the metamorphic and metasomatic rocks (Type V). Pyrophyllitic clays in weathering crusts formed by metasomatism of Paleozoic and Mesozoic rocks are found in the USA, Spain, Ural and Altai.

Analysis of formation conditions of raw pyrophyllite deposits shows that the geodynamic situation is a determining factor. Geodynamics influences composition of magma at depth of magmatic centers, character of volcanic structures, and their position in continental and oceanic crust, and in sea basins. These factors influence the composition of hydrothermal solutions, their dynamics, and the character of metasomatic reactions. At cessation of' volcanism, geodynamic situations govern the character of subsequent tectonic dislocations and fabrics, which then control the distribution of ore bodies.

The work is supported by the Russian Federal Program of Ministry of Science and Education (no. 14.740.11.1048).

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TIMING AND SOURCE OF METALS OF URALS VHMS DEPOSITS: BIOSTRATIGRAPHY VERSUS RADIOGENIC ISOTOPES

Формирование южно-уральских колчеданных месторождений считается связанным с внутриокеанической стадией развития Магнитогорской островной дуги [Herrington et al., 2001] в силуре-среднем девоне (444–385 Ma). В статье приводятся данные определения абсолютного возраста по соотношению Re-Os сульфидной минерализации колчеданных месторождений Яман-Касы и Куль-Юрт-Тау, которые сходны и составляют 362±9 Ma и 363±1 Ma. Эти данные согласуются с полученным ранее аналогичным методом абсолютным возрастом месторождений Дергамыш и Александринка. Верхнедевонский возраст несколько более поздний, чем возраст коллизии «Магнитогорская дуга – континент Лавруссия» [Brown et al., 2011]. Участие субдуцированного континента и/или осадков подтверждается также результатами изучения изотопного состава свинца 14-ти колчеданных месторождений Урала. Содержание древнего свинца понижается от преддуговой обстановки к дуговой и стремится к нулю на фронте субдукции. Повторяющийся «молодой» Re-Os возраст совместно с данными изотопии свинца позволяет предположить, что «закрытие» Re-Os радиогенных событий на Южном Урале произошло не позднее, чем в верхнем девоне (~360 Ma), несколько позже начала коллизии «Магнитогорская дуга – континент Лавруссия».

The tectonic setting and sampling

In the Southern Urals, the intra-oceanic subduction has triggered the volcanism leading to the Magnitogorsk island arc development starting from the Early Devonian time ~400 Ma ago (Fig. 1). The timing of collision of this volcanic arc with adjacent Laurussia continent was established at 380–372 Ma