Shungites and Their Industrial Potential

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Abstract. Shungite rocks are widespread in Zaonezhye, Republic of Karelia, where they constitute dozens of carbonaceous rock deposits of the Paleoproterozoic Onega structure with predicted carbon resources of more 4 billion tons. The lower age boundary is of 2.1 Ga. Shungite rocks belong to carbonaceous rock class. These rocks metamorphosed in greenschist facies of muscovite-chlorite-biotite subfacies are unique natural, noncrystalline, non-graphitized, fullerene-like carbon. They have various structural-mineralogical levels: (a) supramolecular, (b) molecular, (c) electron-energetic, (d) structural-physical and (e) geologic-genetic (parametric). Shungite rocks contain shungite carbon (shungite matter) and a variety minerals, microminerals and nanominerals. The applications of shungite rocks are determined with regard for their natural types. Authors had shown their intergrated application in ore-thermal processes.

Keywords: Shungite rocks · Carbon · Metamorphism · Paleoproterozoic · Application

Shungite rocks, named so after a Karelian town, Shunga, have attracted attention for decades and have no counterparts in the Earth’s geological evolution with respect to the mode of occurrence and tremendous reserves. They are unique from both scientific and practical points of view. Shungite rocks are part of Paleoproterozoic carbonaceous formation in Karelia. They are common in the Trans-Onega area, Russian Karelia, where 25×10¹⁰ tonnes of autochthonous organic matter have been formed over an area of about 9000 km². These complexes constitute dozens of carbonaceous rock deposits in the Paleoproterozoic Onega Structure with forecast carbon reserves of over 4 billion tones and are mainly confined to the rocks of the Ludicovian system with the lower age boundary of 2.1 Ga. The bulk of free carbon (Corg.) is in the Trans-Onega suite of the Ludicovian superhorizon. Phenomenal carbon accumulation in this superhorizon is responsible for the mineralogenic specialization of the rocks of the Trans-Onega suite. Their Corg. concentration varies from less than 1% to 70 wt% in rocks and up to 98 wt% in anthraxolite aggregates. Carbon concentration in the rocks of the Kondopoga suite of the Kalevian superhorizon is not more than a few percent. Thus, the black shale formation of the Onega Structure is formed of the rocks of the Trans-Onega, Suisari and Kondopoga suites. The world’s largest Zazhogino Ore Field, covering an area of 3240 km², with two active quarries, Zazhogino and Maksovo, has been identified and relevant evidence was presented (Table 1).

Metamorphism and metasomatism have contributed markedly to the genetically distinctive shungite rocks. They belong to a metamorphogenetic class of shungite formation. Their industrial properties are controlled by metamorphism and a special

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contribution of K-Na alkaline metasomatism which has affected the formation of the natural types and varieties of shungite and, correspondingly, industrial types and varieties and applications of this unique raw material. On the P-T scheme, showing principal correlations between metamorphic facies and subfacies after S.A. Bushmin and V.A. Glebovitsky, shungite rocks were derived under greenschist-facies, muscovite-chlorite-biotite-subfacies conditions of metamorphism at a temperature of 325–450 °C and a pressure of 2–5 kbar (Bushmin and Glebovitsky 2016).

The mineral form of shungite (shungite matter) is non-graphitizable fullerene-like carbon, which differs from graphite at a supramolecular, atomic and zonal (electron) structure level. The main supramolecular character of shungite is an ability to form spherical structures (empty globules). At an atomic level, in addition to hexagonal rings alone typical of graphite, pentagonal and heptagonal rings, characteristic of fullerene-like structures, are also observed. At a zonal structure level, the energy of collective excitations of valent (external) and framework (internal) π- and σ-electrons decreases relative to graphite, which is typical of fullerenes as well (Kovalevsky et al. 2016). Shungite from some deposits displays diamagnetic properties characteristic of fullerenes. The structure of shungite rocks is similar to that of vitreous-crystalline materials, where highly dispersed crystals are distributed in non-crystalline matrix.

Shungite rocks belong to a class of carbonaceous rocks varying in carbon content and mineral diversity and those are natural carbon-mineral composite materials. They contain shungite (shungite matter) and a variety of micro- and nanominerals. Silicate minerals are highly disperse and are evenly distributed in carbon matrix. Major rock-forming minerals are quartz, mica, albite and pyrite. High secondary and accessory mineral concentrations and a certain spectrum of layered and cluster impurities are observed. Natural types of shungite rocks display several textural and structural varieties and the non-uniform phase composition of carbon and geochemical characteristics.

Shungite applications are determined by natural types and varieties of shungite rocks (Kovalevsky et al. 2016). The structure and properties of shungite rocks are

| Table 1. Comparative description of the parameters of major deposits in Zazhogino Ore Field |
|-----------------|-----------------|-----------------|------------------|
| Ore body shape | Size | Maximum thickness | Average free carbon content, % |
| | Length, m | Width, m | |
| **Shunga deposit** | | | |
| Sheet-like | 1400 | 300 | 5.2 | 41 |
| **Maksovo deposit** | | | |
| Sheet-like-cone shaped | 700 | 500 | 120 | 40 |
| **Zazhogino deposit** | | | |
| Sheet-like-cone shaped | 400 | 300 | 60 | 27 |
| **Zalebyazhskoe deposit** | | | |
| Sheet-like | 2000 | 700 | 38 | 35 |

202 V. Kovalevski and V. Shchiptsov
responsible for their application in oxidation-reduction processes: in blast furnace production of foundry (high-silicon) cast iron; in ferroalloy production; in yellow phosphorus production; in carbide and silicon nitride production; as a reinforcing component of groove masses; as a filler of non-stick paints.

The sorptive catalytical and reduction properties of shungite rocks are used: for treatment of high-quality drinking water in flow systems and wells; for removal of many contaminants from urban domestic and industrial sewage; for swimming-pool water treatment; for water treatment at heat power plants; for electrically conductive paint production; for electrically conductive concrete and brick production; for electrically conductive and plastering and masonry solutions; for electrically conductive asphalt production. These materials were used for developing and designing heaters; rooms screening electromagnetic radiation; a method for removal of ice from roads (warm pavements and roads).

Finely ground shungite can be mixed with any binders of organic and inorganic origin and can thus be used as: black pigment for oil and water paints; a filler for polymers materials (polyethylene, polypropylene, fluoroplastic, etc.); substitute for white soot and technical carbon in rubber production.

One essential feature of shungite rocks is that they can be modified with regards for their desirable application. Enrichment of shungite rocks and their division into micro- and nanosized components make a possible to activate shungite carbon and expand the potential applications of shungite rocks in science-intensive technologies, e.g. nanotechnologies.

There is only one geologo-industrial classification of shungite rocks (after Yu. Kalinin) based on industrial types distinguished with respect to their mineralogical composition and corresponding applications. However, the latest results of the large-scale practical application of shungite rocks shows that such a division into industrial types is clearly insufficient. Therefore, division into subtypes or varieties is required.

At the present stage of the study of Karelia’s shungite rocks the goal of research and appraisal is not only to estimate the reserves of potential deposits and to assess the petrographic and structural-chemical characteristics of shungite rocks but to develop criteria and recommendations for the industrial application of rocks from potential deposits in innovative and science-intensive fields (Kalinin and Kovalevski 2013).

For this purpose it is proposed:

1. To re-assess earlier geological, physico-chemical and technological data on known deposits to make up a list of known shungite rocks suitable for particular applications.
2. To reveal promising shungite rock applications (e.g. metallurgy, tyre production, water disposal, the production of composite materials, etc.) and certification requirements to be met by raw material for each application.
3. To specify the critical properties of shungite rocks for each application (e.g. chemical composition, mineralogical composition, the structural parameters of carbon and rocks) and express methods for their analysis.
4. To develop certification requirements for shungite rocks with regard for their applications.
5. To analyze shungite rock samples and cores from each of the bodies and rock exposures and classify all shungite rocks into types and subtypes referenced to a major application, based on the criteria developed.

6. To correlate the geological parameters of the deposits and outcrops with the geochemical and structural-petrological characteristics of shungite rocks to forecast the prospecting of shungite rocks with preset properties for required applications.

A classification of the geologo-industrial types of shungite rocks will be worked out and the most promising shungite rock prospects for each application will be specified, based on the results of prospecting and prospecting-and-appraisal for shungite rocks. The accomplishment of the work planned will result in the efficient investment of the money spent in the cost of future deposits and the updating of innovative approaches to the use of Russia’s unique carbonaceous raw material.

Shungite has unveiled many of his mysteries, has become known all over the world, has attracted the interest of experts by its great potential and yet has remained largely unknown and open to new discoveries.

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References

Bushmin SA, Glebovitsky VA (2016) Scheme of mineral facies of metamorphic rocks and its application to the Fennoscandian Shield with representative sites of orogenic gold mineralization. Trans KRC RAS 3–27

Kalinin Yu, Kovalevski V (2013) Shungite rocks: scientific search horizons. Nauka v Rossii 6:66–72

Kovalevsky V, Shchiptsov V, Sadovnichy R (2016) Unique natural carbon deposits of shungite rocks of Zazhogino ore field, Republic of Karelia, Russia. In: SGEM Conference Proceedings of International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, pp 673–680

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