CHAPTER 2.
MATERIALS AND ANALYTICAL METHODS

Since 1976, I studied PGE mineralogy of the ultramafic massifs in the Russian Far East at the institutes of the Russian Academy of Sciences. These were North East Interdisciplinary Research Institute (NEIRI) in Magadan, Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry (IGEM) in Moscow, and Institute of Precambrian Geology and Geochronology (IPGG) in St.-Petersburg. These studies investigated prospecting mineralogical criteria of the PGE deposits. The mineralogical predictability is based on genetic principle of mineralogy. This principle is based on fundamental law, according to which the processes and mineral-forming medium are recorded in minerals and expressed in mineral constitution, external (morphological) habit, internal (atomistic) pattern and mineral assemblage. The recognized sequence in formation of a PGE deposit in ultramafic rocks is based on the ontogeny of PGM aggregates with silicates, oxides, and sulfides. Mineragenetic analysis of the PGE deposits in the lithosphere showed that relations of mineralogical, geochemical, and genetic types of the PGE deposits are variable in geological time. Therefore, the identification criteria for mineralogical, geochemical, and genetic types of the PGE deposits with placer-forming platinum minerals is an important area of the study.

This study follows conventional mineralogical postulates. Mineral or valuable mineral is a foundation of the geological and ore assemblages. Genetic mineralogy aims to decipher the mineral history, resulting in understanding of formational parameters of geological and ore assemblages. This is important for regional metallogenic and deposit-scale predicting (Ginzburg *et al.*, 1981; Yushkin, 1982). Mineral is *'a material document, which recorded geological history from giant-scale processes to microchanges in environment'* (Lazarenko, 1979) and *'tells its history, i.e., process of formation'* (Grigoriev and Zhabin, 1975). *Ontogeny* of minerals, *'history of mineral individuals and aggregates, process of their formation'*, is a basis for the understanding of mineral genesis (Grigoriev, 1961). Ontogeny studies the processes of nucleation, growth, and destruction of mineral individuals and their structural and time relations in aggregates and combinations of the aggregates (Grigoriev and Zhabin, 1975). Chronological sequence of *'petrified processes'* (Grigoriev and Zhabin, 1975), determined using physicochemical calculations and experimental study of mineral equilibria, results in logically reconstructed genesis of minerals. According to Grigoriev (1961), *genesis of minerals* is *'a combination of the following phenomena: (1) formation of minerals including nucleation, growth, alteration, and collapse; (2) mode of mineral formation, i.e., physicochemical mechanism of genesis, free crystallization, metasomatic replacement, polymorphic transformation, and recrystallization in solid state; and (3) geological (magmatic, hydrothermal, sedimentary) process responsible for mineral formation. It is evident that minerals can be formed via a different mode during each*

2.1. Isoferroplatinum nugget 'Birthday' with Medal and Diploma of Discoverer of Deposits in the USSR.

process, and all listed formation phenomena are inherent in them'. Comprehensive and continuous genetic study of separate mineral objects and comparative historical analysis produce characteristic features of minerals, minerals themselves, and mineral assemblages, from which *typomorphic* (reference) ones as they were understood by Fersman (1960) are identified. Recognition of mineral typomorphism is a foundation of applied mineralogy, as agreed by most mineralogists after Fersman.

During 1979–2017, I explored placer deposits, particularly at the Konder Massif. Since 1979, I participated in prospecting and exploration together with the geologists of the Nelkan Exploration Expedition, part of *Dalgeologia*, Khabarovsk. I was responsible for examination of the PGE mineralogy during feasibility study and reserve estimation of the placer deposits at the Konder and Uorgalan rivers (Order no. 541, 17.12.1984 of the USSR Ministry of Geology). In 1988, the USSR State Reserve Commission (SRC) approved results of these studies. The SRC adopted many elaborated criteria into exploration and exploitation guidelines (Budilin *et al.*, 1992).

Platinum-group minerals, collected from placer and primary prospects at the Konder Massif during these studies, formed the basis for research works. After macro- and microscopic studies, PGM and associated minerals were comprehensively examined at numerous analytical laboratories of the USSR Academy of Sciences, Ministries of Geology and Non-Ferrous Metallurgy of the USSR, Leningrad Mining Institute, and Lomonosov Moscow State University. The laboratory studies included: electron-microprobe analysis of the chemical composition; determination of rare earth elements (*REE*), Zr, Ti, and Cr in clinopyroxenes and amphiboles using secondary ion mass spectrometry (SIMS); X-ray diffraction; crystal morphology; electron microscopy; and H, O, Os, ^{190}Pt-^{4}He, Rb-Sr, and Sm-Nd isotopic composition. Some results are published as figures and tables in this paper.

Here, I present a collection of PGM from placers, cumulative and recrystallized dunite, chromitite, magmatic and metasomatic pyroxenite, and altered dunite. Most studied PGM grains are intergrown with chrome spinel (Spl), magnetite (Mt), olivine (Ol), clinopyroxene (Cpx), amphibole (Am), phlogopite (Phl), biotite (Bt), apatite (Ap), serpentine (Srp), chlorite (Chl), zeolite, and native gold. Cu, Fe, and Ni sulfides are extracted from residue or crushed rock samples. Morphology of some PGM individuals and aggregates has been studied on JEOL JSM-6510LA scanning electron microscope (SEM) at the Institute of Precambrian Geology and Geochronology (analyst O.L. Galankina). Thin polished sections were made for the most representative minerals and ore-bearing rocks. These sections were studied under Opton Zeiss and Micromed Polar 3 optical microscopes equipped with digital cameras. Chemical composition of minerals in thin polished sections was determined on JSM-6510LA SEM equipped with a JED-2200 spectrometer and on JXA-8230 Superprobe electron microprobe. The following standards were used for determination of the PGM composition: isoferroplatinum, tetraferroplatinum, laurite, sperrylite, and clinopyroxene.

As a result of the mineralogical study of PGE from the Konder Massif and placer deposits at the Konder and Uorgalan rivers, mineralogical and geochemical types of PGM were established, and morphological placer-forming platinum mineral groups were identified. Typical individuals, aggregates, their fragments, and grains of placer-forming platinum minerals of the identified morphological types were photographed using Pentax K1 and K3 cameras equipped with lenses for macrography. The author took a class in macrography of rocks and minerals from Mikhail Bogomolov (1936–2018), a well-known geologist and photographer, during joint 1996 works at the Konder Massif in Khabarovsk Krai and Galmoenan Massif in the Koryak Mountains, Russian Far East.