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Platinum Group Metals and Gold in Supergene Nickel Ores of the Moa and Nikaro Deposits (Cuba)

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Abstract—Contents of PGE and Au in nickel oxide–silicate ores of the Moa and Nikaro deposits, as well as their reworking products in the Moa and Nikaro ore metallurgical plants, have been determined.

STATEMENT OF THE PROBLEM

Supergene nickel deposits undoubtedly belong to promising and unconventional sources of the raw material for platinum group metals (PGM). They accommodate more than 80% of the world reserves of Ni. At present, the share of such deposits in nickel production shows a trend of steady growth. Supergene nickel deposits are mainly confined to laterite sheets on ultramafic massifs of the Earth's present-day tropical belt. Based on such deposits, new metallurgical plants are being constructed and put into operation in New Caledonia, Indonesia, Australia, Brazil, Columbia, Venezuela, and other countries. In Russia, all deposits of this type are located in the Urals. At present, high demand for stainless steel has provoked a drastic rise in the price of nickel in the world market.

Our investigations of nickel ores in the Buruktal, Sakhara, Serov, Ufalei, and Elizaveta deposits of the Ural province demonstrated that contents of PGM, Au, and Ag in them is as much as 0.n g/t. In other words, all these elements and Co are essential associated components of nickel ores (Talovina and Lazarenkov, 2001, 2003). Although these contents are appreciably lower than PGM concentrations in sulfide ores (particularly, ores of Norilsk), our metallurgists have proposed a feasible technology of PGM extraction from supergene ores in the course of nickel production (Krupenko and Astaf'ev, 1993; Greiver *et al.*, 1994; Greiver, 1999). Geologists appreciably lag behind metallurgists in the investigation of PGM in supergene nickel deposits. At the same time, issues of PGM concentrations (particularly, in different types of ores) and calculation of PGM reserves in supergene nickel deposits are an important geological prerogative. From this point of view, analysis of contents of PGE, Au, and Ag in supergene nickel deposits of Cuba is of great industrial interest.

Nickel reserves in the laterite sheet of Cuba amount to 18 Mt (Mikhailov, 2002). In this respect, Cuba holds the first place among world exporters of this metal and surpasses New Caledonia, Indonesia, and Philippines. Cuba also leads wit a Co reserve of 1.4 Mt (Reznik *et al.*, 1995). At the beginning of the 20th century, American companies had expressed industrial interest to Cuban laterites as iron ore deposits. However, high Cr content in the laterites hampered their utilization as iron ore, and their exploitation was terminated at the end of the 1920s. At the beginning of the 1930s, researchers revealed high Ni contents in the Cuban laterites. In 1943, the first nickel plant was constructed based on deposits of the Nikaro district. During the Cuban–Soviet cooperation period, the Cuban laterites were investigated by a large group of Soviet and Cuban geologists (Yu.Yu. Bugel'sky, A.S. Vershinin, I.V. Vitovskaya, I.N. Tikhomirov, A.Ya. Zhidkov, and B.A. Markovskii). Tikhomirov and Zhidkov (VSEGEI, St. Petersburg) initiated the study of PGM concentration in nickel ores of Cuba. The importance of this issue is second only to problems of iron and nickel ores. Since Cuba is among the world's richest regions in reserves of supergene nickel ores, analysis of the content of PGE and Au in supergene nickel deposits of Cuba is of great scientific and industrial interest.

GEOLOGICAL SETTING OF THE MOA AND NIKARO DEPOSITS

The main nickel deposits of Cuba (Pinares-de-Mayari, Nikaro, Moa, Punta-Gordo, and others) are spatially conjugated with the Moa-Baracoa (1500 km^2) and Mayari-Nikaro (650 km^2) mafic–ultramafic massifs. These large massifs have a two-member structure (ultramafic rocks of mantle tectonites at the basement and strongly eroded banded mafic rocks at the top). Cuba occupies a leading position in the American con-

Table 1. Contents of PGE and Au in serpentinized harzburgites and dunites of Cuba, mg/t

No.	*n*	Ru	Rh	Pd	Os	Ir	Pt	PGE	Pt/Pd	(Ru + Os + Ir)/(Pt + Pd)	Au
1	8	–	–	2	–	–	11	–	–	–	33
2	4–11	8.2	2.6	6	3.2	4.8	8.7	33.5	1.5	1.1	–

Note: (1) Moa district (Camariocas, Punta-Gordo, Casimba, and Caledonia deposits (analyses were performed in the laboratory of VSEGEI); (2) average ophiolitic harzburgite (Lazarenkov and Talovina, 2001); (*n*) number of analyses; (–) no data.

Table 2. Contents of PGE and Au in chromitites in ore districts of Cuba, mg/t (Proenza *et al.,* 1999)

No.	Ore district	Number of samples	Ru	Rh	Pd	Os	Ir	Pt	PGE	Pt/Pd	(Ru + Os + Ir)/(Pt + Pd)	Au
1	Moa-Baracoa	16	45.6	3.1	3.8	19.7	8.0	10.3	90.4	2.7	5.4	6.1
2	Sagua de Tanamo	3	60.0	15.8	6.3	43.3	77.3	17.7	220.4	2.8	7.5	1.6
3	Mayari	4	38.5	4.6	4.3	34.3	26.6	7.0	115.3	1.6	8.8	3.2
4	All deposits	13	38.6	6.6	5.5	26.5	30.0	9.8	117.0	1.8	6.5	2.8
5	Average	–	135	12	10	85	104	55	401	5.5	5.0	2.8

Note: (1) Mercedita deposit; (2) Negro Viejo, Rupertina, and Santa Isabel deposits; (3) Casimba and Caledonia deposits; (4) all deposits mentioned in (1–3), as well as Potosi, Cayo Guam and Amores deposits in the Moa-Baracoa district (6 samples); (5) average composition of podiform chromitites in the world (Lazarenkov and Talovina, 2001).

tinent in terms of ultramafic rock area (more than 5000 km^2). These massifs are interpreted as Upper Jurassic–Lower Cretaceous intrusions (Proenza *et al.*, 2001) or products of separate Cretaceous (pre-Maestrichtian) and Late Eocene intrusions (Bugel'sky, 1979). They are mainly composed of serpentinized harzburgites and the subordinate dunites, lherzolites, pyroxenites, gabbroids, and chromitites.

Ultramafic rocks in Cuba are characterized by universal Cr concentration and local copper–nickel sulfide mineralization (pyrrhotite, pentlandite, chalcopyrite, and cubanite). About 300 chromite deposits and occurrences with a total chromite ore reserve of 6.5 Mt are known in Cuba (Proenza *et al.*, 2001). The Moa-Baracoa Massif incorporates more than 100 chromite deposits of low-grade ores with Al_2O_3 > 20 wt % and (Cr + Al) > 60%. The majority of these deposits are small in terms of reserves.

Beginning from the Maestrichtian, ultramafic rocks of Cuba were exhumed and eroded. They were actively destructed in the Paleogene and, particularly, Neogene–Quaternary. This is marked by the formation of areal weathering crusts with very large nickel deposits. At the same time, clayey–silty and chromite-bearing sediments were accumulated in coastal-marine banks. Platinum group minerals could be accumulated together with the clastic chromite in the alluvial lateritic and silty–clayey shelf formations (particularly, in the Nipe Bay).

PLATINUM GROUP ELEMENTS IN BEDROCKS OF THE MOA-BARACOA AND MAYARI-NIKARO MASSIFS

Information on PGE contents in ultramafic rocks (harzburgites, chromitites, and their sulfidized varieties) of the substrate of the Nikaro and Moa deposits can provide insights into the degree of PGE concentration in supergene nickel ores of these deposits.

Data on the content of PGEs in serpentinized harzburgites and dunites of Cuba are virtually absent. Therefore, we use the average ophiolitic harzburgite with the PGE composition relatively close to that of harzburgites in Cuba as the PGE content standard for serpentinized harzburgites of this country (Table 1).

The Pt potential of Cuban chromitites has been studied by Proenza *et al.* (1999, 2001). The PGE content in chromitites from ore districts and separate deposits of the Moa-Baracoa and Mayari-Nikaro massifs can be judged from the data in Table 2. We analyzed 16 samples (several kilograms each) of massive chromitite from the Mercedita deposit (Moa-Baracoa ore district). The total REE content in these samples varies from 55 to 166 mg/t (90 mg/t, on average). Similar results were obtained for the Mayari and Sagua de Tanamo ore districts that occupy an intermediate position between the Moa-Baracoa and Mayari ore districts. Data presented in Table 2 suggest the following conclusions:

(1) Podiform chromitites from ore deposits in Cuba are characterized by lower PGE contents relative to average world chromitites (Lazarenkov and Talovina, 2001b) and,

Table 3. Contents of PGM and Au in sulfide-bearing chromitite ores of the Potosi deposit, mg/t (Proenza *et al.,* 2001)

No.	Number of samples	Ru	Rh	Pd	Os	Ir	Pt	PGE	Pt/Pd	$\frac{Ru + Ir + Os}{Pt + Pd}$
1	1	45	3	2	18	15	5	88	2.5	11.1
2	4	26	2	14	14	12	10	78	0.7	2.2
3	1	19	3	23	12	11	15	83	0.7	1.1
4	1	79	22	69	99	57	172	498	2.5	0.98
5	1	234	38	247	188	115	291	1113	1.2	1.0
6	–	422	72	490	356	222	572	2134	1.2	0.95

Note: Note: (1) Chromitites (traces of sulfides); (2) chromitites (sulfides ~1%); (3) brecciated chromitites; (4) chromitites with 30% sulfides; (5) chromitites with 50% sulfides; (6) calculated sulfide fraction (100% sulfides).

in particular, chromitites of the Kempirsai Massif (Kazakhstan).

(2) Like average world chromitites, Cuban podiform chromitites are characterized by the prevalence of (Ru + Os + Ir) over (Pt + Pd), the prevalence of Pt over Pt (Pt/Pd > 1), and the predominance of Ru.

The PGE distribution in sulfidized ultramafic rocks from the substrate of supergene nickel deposits of Cuba can be judged from the data on sulfide mineralization in chromitites from the Potosi deposit in the Moa-Baracoa district (Proenza *et al*., 2001). The sulfide mineralization is confined to narrow (*n*–10*n* cm) chromitite zones at the contact with dikes of pegmatitic olivine norites. Sulfides are represented by pyrrhotite, pentlandite, cubanite, chalcopyrite, and secondary valleriite. The $\delta^{34}S$ value in pyrrhotite (–0.4 to +0.4%) indicates high-temperature contact-metasomatic origin of sulfide mineralization. The Potosi deposit includes the following types of chromitites with different contents of sulfides:

(1) Sulfide-poor chromitites (less than 1% sulfide minerals). They account for more than 80% of all ores in the deposit.

(2) Brecciated ore chromitites (~1% sulfides), in which chromitite fragments are cemented by the pegmatitic olivine norite.

(3) Chromitites enriched in sulfide minerals (10–50% sulfides).

Data on the PGE distribution in chromitites with different contents of sulfides (Table 3) suggest the following conclusions:

(1) Sulfide-poor chromitites (analysis 2) are characterized by a low content of total PGE relative to average podiform chromitites (Lazarenkov and Talovina, 2001b) and the prevalence of rare PGM, i.e., (Ru + Os + Ir) over (Pt + Pd). This is typical of podiform chromitites in the Moa-Baracoa district. Such features are particularly well manifested in sulfide-poor chromitites (analysis 1) with (Ru + Os + Ir)/(Pt + Pd) = 11.

(2) In sulfide-rich chromitites, the Pt content has a positive correlation with the content of sulfide minerals; e.g., the PGE content is 498 mg/t in chromitites with 30% sulfides and as much as 1113 mg/t in chromitites with 50% sulfides. The PGM content is approximately 2 g/t in the pure sulfide fraction (100% sulfides). Quantitative ratios of PGEs in this fraction are shown in Table 3 (analysis 6). The relatively high PGM content in sulfides is mainly related to the input of Pt and Pd (particularly, Pt), because the Pt/Pd value increases from 0.7 to 1.2 and 2.5. The role of rare PGM decreases and the (Ru + Os + Ir)/(Pt + Pd) ratio decreases from 2.2 to 1.0. Thus, sulfides could locally contribute much to Pt concentration in supergene nickel ores of the Moa-Baracoa district.

PGM POTENTIAL OF THE MOA AND NIKARO NICKEL DEPOSITS

Reserves of supergene nickel ores in Cuba consist of oxide–ferruginous (ocherous) ores (~65%) and silicate (nontronite–serpentine) ores (~35%). The oxide–ferruginous ores contain 1.3–1.4% Ni and 0.1–0.15% Co, while the silicate ores contain 1.6% Ni and 0.05% Co. The major nickel ore fields of Cuba (Pinares-de-Mayari, Nikaro, and Moa) occupy an area of 50–130 km^2 in the Oriente province. The ore deposits are 1–20 m thick (up to 50 m in some places). The ore fields have a block-type structure. They are exposed at different hypsometric levels (20–850 masl). The largest deposits are located in three districts extended in the latitudinal direction. The westernmost Pinares-de-Mayari ore district incorporates an areal weathering crust. The intermediate Nikaro district includes more than ten deposits. Some of these deposits are already exhausted. The large Marti deposit is currently in operation. Deposits of the Nikaro group belong to the type of areal weathering crusts with intermittent thickness. In the Moa ore district located east of the Nikaro group, linear-areal weathering crusts incorporate orebodies from 7 to 13 m thick. Tectonic fracture zones in this district contain pockets up to 30–50 m deep filled with ore-bearing products of the weathering crust. The Punta-Gordo deposit located east of the Moa deposit is prominent in the Moa ore district. Deposits comparable in size to

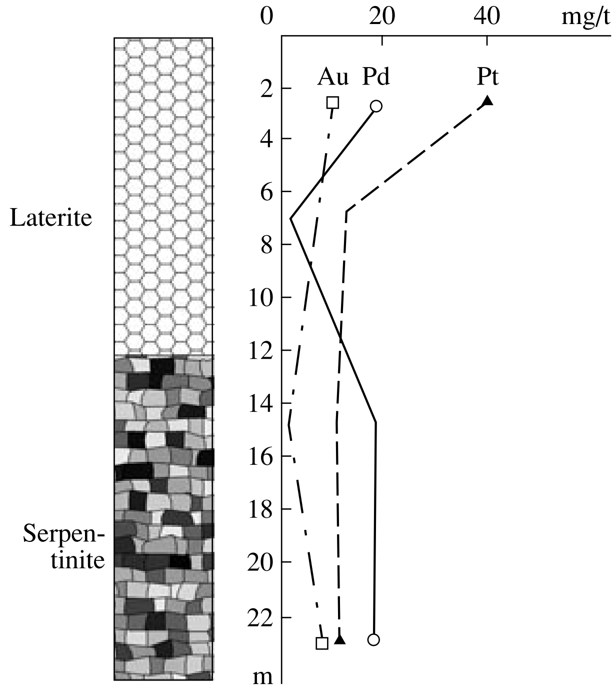

Fig. 1. Distribution of Pt, Pd, and Au in Borehole 65/84, Camariocas deposit, Moa district.

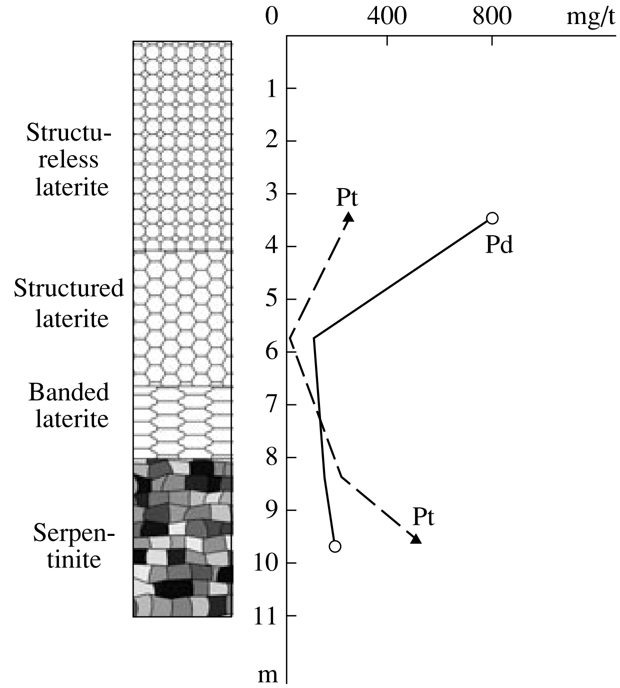

Fig. 2. Distribution of Pt and Pd in Borehole 101/84, Pinares-de-Mayari deposit, Nikaro district.

those described above are so far unknown beyond the Oriente province.

The summary section of nickel ore deposits in Cuba (Bugel'sky, 1979; Vershinin, 1993) is composed of the following units (from bottom to top): disintegrated serpentinites–leached serpentinites–nontronite zone–structured ochers–laterites–structureless ochers.

Lithological units make up various combinations in different ore fields. The Moa and Punta-Gordo deposits are dominated by the incomplete (serpentine–ocher–laterite) profile without the nontronite zone, while the Pinares-de-Mayari deposit incorporates the complete (serpentine–nontronite–ocher–laterite) profile. Bugel'sky (1979) suggested that lithological difference between the two types of supergene nickel deposits in Cuba is related to geomorphological and climatic factors that controlled the process of crust formation. The incomplete (serpentine–ocher–laterite) profile is formed in low (plateau-shaped and intensely dissected) mountains with humid climate (precipitation no more than 2000 mm/cm^2/yr), while the complete profile is formed in lower planes with precipitation up to 1600–1800 mm/cm^2 /yr.

The behavior of PGE and Au in borehole cores from deposits in Cuba is shown in Figs. 1 and 2. Data on PGM and Au contents in oxide–ferruginous ochers and leached serpentinites of the Nikaro and Moa deposits are given in Tables 4–6. Data on the PGE content in the oxide–ferruginous ochers are more complete, while data on the leached serpentinites are rather fragmentary. Although the analyses were performed in different laboratories, the results obtained are quite comparable in terms of values that make it possible to identify the following general trend of Pt potential of nickel ore deposits in Cuba:

(1) The total PGE content is approximately 0.2 g/t in the major (oxide–ferruginous) type of nickel ores in Cuba.

Table 4. Contents of PGE and Au in nickel ores of the Pinares-de-Mayari deposit in the Nikaro ore field, mg/t

No.	Sampling zone	Number of samples	Ru	Rh	Pd	Ir	Pt	PGE	Pd/Pt	$\frac{Ru + Ir}{Pt + Pd}$	Au
1	Oxide-ferruginous ochers	2	30	17	135	20	20	222	6.8	0.2	–
2	Oxide-ferruginous ochers	7	–	–	166	–	81	247	2.0	–	35
3	Leached serpentinites	1	–	–	60	–	10	70	6.0	–	–
	Average for zones	10	–	–	150	–	50	200	3.0	–	

Note: (1, 3) Analyzed in laboratory of IGEM (Moscow); (2) Analyzed in laboratory of VSEGEI (St. Petersburg); (–) no data.

Table 5. Contents of PGE and Au in nickel ores of the Punta-Gordo and Camariocas deposits in the Moa ore field, mg/t

No.	Sampling zone	Number of samples	Pd	Pt	PGE	Pd/Pt	Au
1	Oxide-ferruginous ochers	8–1	127	15	141	8.5	24
2	Leached serpentinites	2	20	<20	20	>1	5

Note: Analyses were performed in laboratories of VSEGEI.

The PGE assemblage is dominated by Pd (Pd/Pt > 2). The share of rare PGM (Ru + Ir + Rh) is relatively low, and the (Ru + Ir)/(Pt + Pd) ratio is also low. These data should be considered tentative ones for the time being, because they do not take into consideration PGM-rich sectors confined to structural traps (pockets) with Mn-rich units and other geochemical barriers.

(2) The (Pt + Pd) data on serpentinite ores in the leached serpentinites show that the serpentinite ores are probably depleted in PGM (relative to the oxide–ferruginous ores) in both the Pinares-de-Mayari and Camariocas deposits.

(3) Comparison of average compositions of oxide–ferruginous ore (Pinares-de-Mayari deposit) and harzburgite substrate indicates that the oxide–ferruginous unit of the Pinares-de-Mayari deposit is characterized by the following values of accumulation coefficient (K_a): total PGM 6.6, Pd 22.5, Rh 6.5, Ir 4.2, Ru 3.7, and Pt 2.3. Comparison of the succession of PGM concentrations is rather interesting: Pt > Ru > Pd > Ir > Os > Rh in the substrate and Pd > Ru > (Ir > Pt) > Rh in oxide–ferruginous ochers of the Pinares-de-Mayari deposit.

(4) On the whole, PGE patterns are similar in the average oxide–ferruginous ore from the Pinares-de-Mayari deposit, on the one hand, and analogous ores from the Buruktal and Sakhara deposits in the Urals, on the other hand. Relative to the Buruktal deposit that was also formed after ophiolitic harzburgites, the Pinares-de-Mayari deposit is characterized by higher contents of total PGE and a more prominent Pd specialization. Relative to the Sakhara deposit, however, oxide–ferruginous ores of the Pinares-de-Mayari deposit are depleted in the total PGE and they are specialized in Pt rather than Pd. These differences are related to the following fact. Country rocks of the Sakhara deposit are composed of dunites in the Sakhara Massif of the Uralian Platinum Belt. The dunites are more enriched in PGE relative to ophiolitic harzburgites. Moreover, they show a prominent Pt specialization. In other words, oxide–ferruginous ores of the Sakhara deposit bear distinct signs of PGM specialization of the substrate.

In addition to PGE contents in supergene nickel ores, the PGE contents in their metallurgical processing products are also of great interest. In Cuba, nickel is produced in the Nikaro and Moa ore dressing plants. In the Nikaro Plant, oxide–ferruginous and serpentinite ore mixture (2 : 1) is processed and nickel is produced as "Sinter" with 95% Ni. Based on the processing of oxide–ferruginous ores with 1.3–1.4 wt % Ni and 0.13–0.14% Co, the Moa Plant produces sulfide concentrate with 55% Ni and 5% Co (Reznik *et al.*, 1995).

In the process of Ni extraction in the Nikaro and Moa plants, PGMs are lost in tailings, sulfide concentrates, and end nickel products. For example, the Nikaro "Sinter" contains 0.13 g/t Pd, 0.03 g/t Pt, and 0.009 g/t Au. Average contents of PGM and Au in the Nikaro tailings are as follows (mg/t): Pd 12, Pt 10, and Au 10. Contents of PGM and Au in sulfide concentrates from the Nikaro and Moa plants are reflected in Table 7. Although data on PGE contents in sulfide concentrates obtained in different laboratories demonstrate certain discrepancy (Table 7), one can make the following conclusions:

(1) Contents of PGE in the sulfide concentrate are sufficiently high (2–6 g/t) for their commercial extraction.

(2) The (Pt + Pd) content is obviously higher than the sum of rare PGM (Ru + Ir + Rh), and the (Pt + Pd)/(Ru + Ir + Rh) ratio is approximately 5.

(3) Based on data of the Gipronikel Institute, Pd dominates over Pt in sulfide concentrate of the Nikaro Plant (Pd/Pt = 1.6); i.e., the PGM specialization of the concentrate, probably, inherits the PGE specialization of oxide–ferruginous ores of the Nikaro deposit.

The Cuban nickel concentrate was exported to Russia since 1961 and to Canada since 1991. The total Ni production in Cuba is 40 kt/yr (Mikhailov, 2002). Platinum group metals are not extracted in the metallurgical

Table 6. Average contents of PGE and Au (mg/t) in oxide-ferruginous ores of Cuba, New Caledonia (Ahmad and Morris, 1978), and the Urals (Talovina and Lazarenkov, 2001, 2003)

Deposit, area	Ru	Rh	Pd	Os	Ir	Pt	PGE	Pt/Pd	Au
Pinares-de-Mayari, Nikaro	30	17	135	–	20	20	222	0.15	35
Southern sector, Du Sud Massif	–	–	71	–	6.2	141	218.2	2	34
Buruktal, the Urals	33	5	33	14	14	31	130	0.9	64
Sakhara, the Urals	80	18	75	18	<10	244	469	3.3	50

Note: (–) No data.

Table 7. Contents of PGM and Au in sulfide concentrates from the Nikaro and Moa ore dressing plants, g/t

No.	Number of samples	Ru	Rh	Pd	Ir	Pt	PGE	Au	Pd/Pt	$\frac{Pt + Pd}{Ru + Ir + Rh}$
1	8	0.210	0.090	1.26	0.11	0.78	2.45	0.35	1.6	5.0
2	8	–	–	1.94	–	3.93	5.87	–	0.5	–
3	1	–		4.5	–	1.7	6.2	1.0	2.6	–
4	3	–	–	3.36	–	2.87	6.23	0.56	1.2	–

Note: (1–3) Nikaro Plant: (1) laboratory of the Gipronikel Institute, (2) laboratory of the Leningrad Mining Institute, (3) laboratory of the Mekhanobr Institute; (4) Moa Plant, laboratory of the Leningrad Mining Institute; (–) no data.

process. Our estimates show that if the average PGM content is 0.2 g/t, the tentative amount of PGM that can be extracted from the concentrates is as much as 800 kg/yr.

DISCUSSION

Comparison of cobalt–nickel deposits in Cuba with their counterparts in both the Urals and New Caledonia is of great interest. Deposits in these regions demonstrate several common features: affinity to young island arcs, harzburgitic substrate, and similar periods of laterite formation with analogous humid climate and alternation of dry and rainy seasons. Both these regions are located at an approximately similar distance from the equator. They are leaders in the world with respect to reserves of supergene nickel and cobalt ores. Moreover, total contents of PGM and Au are similar in oxide–ferruginous ores of Cuba and New Caledonia (Table 6).

Nickel deposits were discovered in New Caledonia as early as 1864. Therefore, they have been efficiently investigated over a long time. Although nickel deposits in Cuba and New Caledonia demonstrate several similarities, they are also characterized by significant distinctions. In particular, the ultramafic substrate is exposed over a large area in New Caledonia; e.g., the Du Sud Massif alone occupies an area of 4950 km^2. According to Vershinin (1993), deposits in New Caledonia are distinguished from their counterparts in Cuba by anomalously high Ni contents in the leached serpentinites, lesser Ni contents in the ocherous ores, and high Co content in the section. The Co concentration is reflected in the development of an essential (with respect to PGM potential) ore-controlling "transitional Co–Mn horizon" in the lateritic profile of New Caledonia (Llorca, 1993).

According to (Augé *et al.*, 1995), the most spectacular feature of the lateritic profile of the Du Sud Massif (New Caledonia) is as follows: the Pirogue sector includes a 1-m-thick PGM horizon with an average Pt content of 0.5 g/t (maximum 2 g/t). Like at the Sakhara deposit in the Urals, the Pirogue sector was locally enriched in Pt owing the involvement of Pt-rich chromitites of bedrocks, suggesting an essential role of substrate in the PGM specialization of laterites. Chromite deposits are abundant in harzburgites of the substrate in Cuba. Therefore, prospecting for Pt-rich areas that are similar to the Pirogue sector is a sufficiently tempting issue for Cuba. Accumulation of PGE in the so-called "pockets" (structural depressions and traps related to tectonic deformation zones) remains a debatable issue in both Cuba and New Caledonia. It is well known that such areas in New Caledonia show high concentrations of Co and associated Pt. It is also worth mentioning that the lithological profile of New Caledonia differs from the profile in Cuba by the virtual absence of the nontronite zone. This zone is developed in a different geomorphological setting with a lesser amount of atmospheric precipitation (Bugel'sky, 1979). In other words, geochemical distinctions of lateritic crusts in New Caledonia and Cuba could be related to different rates of the lateritic profile formation.

CONCLUSIONS

(1) Concentration of PGM (mainly, Pd) in oxide–ferruginous ores of the Moa and Nikaro deposits is approximately 0.2 g/t.

(2) Substrate for the formation of supergene nickel deposits in the Moa and Nikaro deposits is represented by the PGE-depleted mantle-derived serpentinized harzburgites and serpentinites of the Moa-Baracoa and Mayari-Nikaro massifs. They are locally enriched in chromitites and sulfide dissemination.

(3) Chromitites of the substrate are usually enriched in PGEs than the harzburgites. However, the chromitites are depleted in these elements relative to average podiform chromitites of the world.

(4) In areas characterized by the development of sulfide dissemination in country rocks of the substrate, the Pt content shows a positive correlation with the amount of sulfides.

(5) Contents of PGM and Au in the dressing product (sulfide concentrate of the Moa and Nikaro plants) are as much as 2.8–7.2 g/t.

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