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Morphological Characteristics and Chemical Composition of Placer Gold from the Kengeveem River Basin and First Data on Associated Platinum-Metal Mineralization (Magadan Oblast)

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Abstract—The paper presents a study of typomorphic characteristics of placer gold from tributaries of the Kengeveem River, Magadan oblast. The placer gold was studied by optical and scanning electron microscopy at the Institute of Volcanology and Seismology, Far Eastern Branch, Russian Academy of Sciences. As a result, the first information on the morphology, internal structure, and chemical composition of placer gold from the southeastern Taigonos Peninsula was obtained. Three mineral types of the gold were determined. The first type is dominant. Its grains are characterized by subore morphology, with weak and medium roundness. Only Au and Ag are present in the composition of native gold, other macrocomponents were not found. The gold fineness is 750–950‰. Some gold grains bear signs of supergene transformation, which is expressed in the development of high-fineness gold rims and intergranular veins. The second type of the gold is represented by well-rounded plates with a fineness of 980–990‰. The third type is loose aggregates of secondary high-grade mustard gold. The obtained data allowed us to determine the different transport distances of native gold and to consider the low-sulfide epithermal Au–Ag mineralization and presumably distal gabbroids as the primary sources of gold.

Keywords: placer gold, typomorphic characteristics, Magadan oblast, Taigonos Peninsula

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INTRODUCTION

The determination of typomorphic characteristics of native gold is of great importance in studying endogenic primary and placer gold deposits. A combination of typomorphic features such as morphology, size, chemical composition, and inner structure serves as heavy tool for reconstructing the origination, transfer, and precipitation of gold under endogenic and exogenic conditions. The largest contribution to the study of typomorphism of native gold was made by the outstanding Soviet mineralogist N.V. Petrovskaya (1973). Her numerous mineralogical and geochemical studies of gold from different deposits were used to develop methodical guides, textbooks, and recommendations for prospecting works (Nikolaeva, 1978, 1985, 1995; Nikolaeva et al., 2003, 2021), which have not lost their relevance and are still applied. At present, the typomorphic characteristics of placer and primary gold are considered in numerous foreign and Russian publications (Bonev et al., 2002; Litvinenko, 2002; Terekhov et al., 2010; Stefanova et al., 2014; Pozdnyakova, 2015; Glukhov et al., 2018; Nikiforova and Kazhenkina, 2018; Nevolko et al., 2019).

Placer deposits are decomposed primary gold deposits. For this reason, the study of typomorphic characteristics of placer gold is of great importance for solving genetic and prospecting problems of endogenic gold mineralization (Nikolaeva, 1978; Nikolaeva et al., 2003; Townley et al., 2003; Nikolaeva and Yablokova, 2007; Pozdnyakova, 2015). This article reports the results of a study of typomorphic features of gold from placers in the left tributaries of the Kengeveem River (Bazovyi, Uglovoi, Kat, and Vitalkin creeks), which runs over the southern Taigonos Peninsula and empties into Penzhina Bay of the Sea of Okhotsk (Fig. 1). Integrated prospecting works performed in 2020 by JSC Taigonos revealed high-grade alluvial gold placers in the studied territory. Heavy concentrate extracted during sampling were given to us for study. The first data on the typomorphic features of placer gold from the Kengeveem River basin were used to discuss the residence time of gold in a placer, transport distance, type of primary source, and, as a result, to predict and search new promising gold placers and primary deposits on the Taigonos Peninsula.

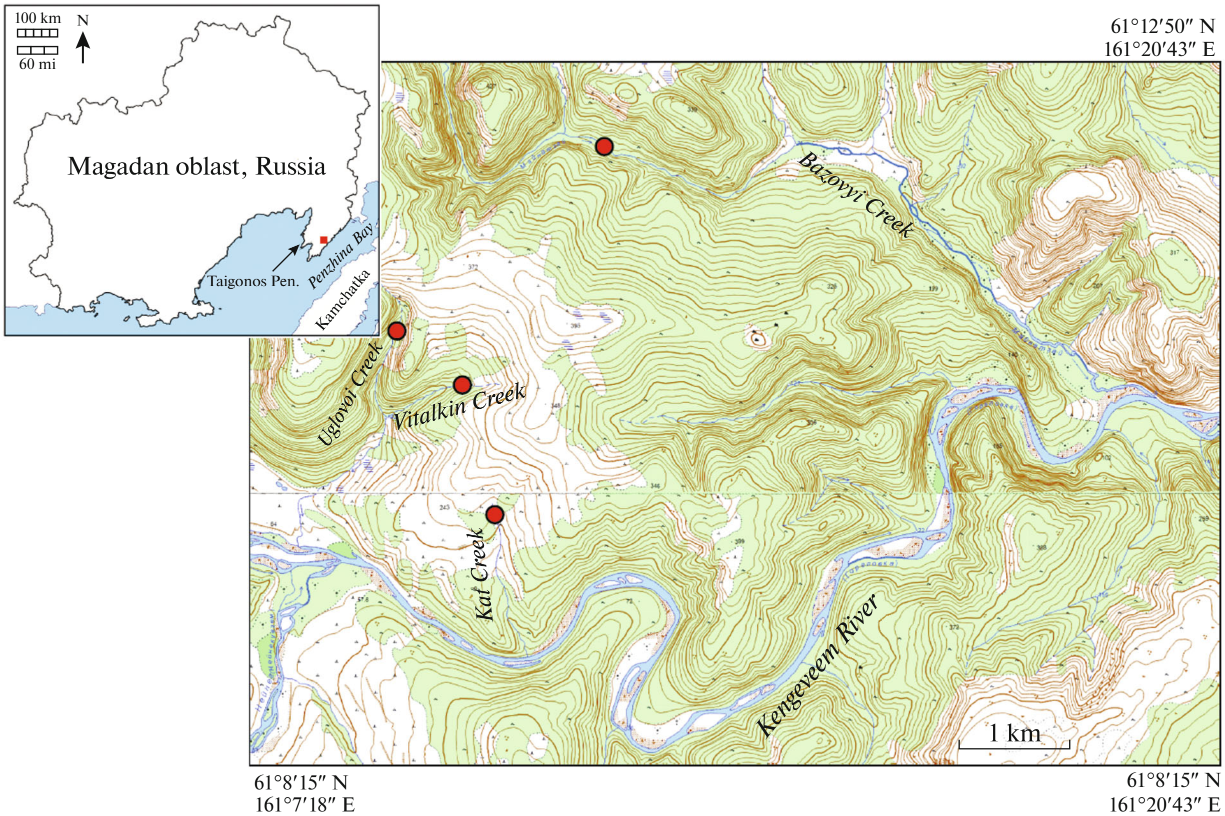

Fig. 1. Sketch map of studied area (sampling locations are marked in red).

GEOLOGY OF THE STUDIED AREA

The Taigonos Peninsula is located in Magadan and Kamchatka oblasts. The sampling area is located in the basin of the Kengeveem River, which runs over the southeastern Taigonos Peninsula and empties in Penzhina Bay of the Sea of Okhotsk (Fig. 1). The placer-forming formations of the Kengeveem River are attributed to the Kengeveem–Yavayam gold placer cluster of the Eastern Taigonos provenance area.

The first data on the gold potential of the Taigonos Peninsula were obtained in 1910–1912 by S.I. Batsevich during prospecting and exploration works for gold-bearing placers of the Gizhiga River (*State*..., 1980). As a result, gold was found in alluvial deposits of the Avekovaya River and its tributaries.

The geological structure of the area is determined by its position within the South Taigonos anticlinorium attributed to the Penzhina–Anadyr fold zone, which extends along the southeastern coast of the Taigonos Peninsula. The anticlinorium is made up of highly deformed Carboniferous, Jurassic, and Cretaceous rocks penetrated by the Early Cretaceous and Late Cretaceous intrusions. They are unconformably overlain by Pliocene–Early Pleistocene and Quaternary rocks (*State*..., 1980; Gorodinsky et al., 2004).

Undivided Lower Carboniferous rocks are represented by metamorphosed sandstones, siltstones, and calcareous pelitic rocks. All these rocks are variably hornfelsed. The Upper Jurassic rocks comprise mudstones, siltstones, black andesitic ash tuffs, volcanomictic sandstones, gravelstones, tuffstones, and tuffaceous gravelstones. The Pliocene–Early Pleistocene Impoveem sequence fills the remained fragments of the peneplained surface. The lower part of the section is made up of poorly compacted conglomerates, sandstones, and sands; and upper part consists of sands with large pebble, as well as boulders of igneous rocks. Undivided Neopleistocene alluvial deposits compose aggradational terraces and cover of mixed terraces. The Neopleistocene alluvial sediments contain pebbles with admixture of sand and clay, pebble and boulders with sand containing lenses of sandy loam and loam. Modern sediments are represented by alluvial, proluviam, eluvial, and talus sediments (*State*..., 1980; Gorodinsky et al., 2004).

The valley and terrace alluvial placers of economic grade were found in the valley of Bazovyi Creek and its tributaries (Fig. 1). The valley of Bazovyi Creek changes from trough shape in the lower reaches to the canyonlike in its upper reaches. The slope angle changes from 30° to 50°. The bottom width varies from 200 to 400 m. The flood plain is no more than 20–60 m. The valley includes two terraces above the floodplain (4–6 and 10–12 m), which have mixed and aggradation character. The majority of alluvial deposits were accumulated in the lower reaches of the creek. In the upper reaches, the thickness of alluvial deposits is insignificant. They contain numerous large boulders and vertical plates of primary rocks (*State*..., 1980; Gorodinsky et al., 2004).

The area of Uglovoi, Kat, and Bazovyi creeks comprises abundant Late Cretaceous intrusive rocks emplaced at the Cretaceous stage of magmatic activity (*State*..., 1980). Most of the massifs are multiple intrusions varying in composition from early diorites to late granodiorites and plagiogranites.

No primary gold deposits, only its occurrences are known on the Taigonos Peninsula. The most significant gold occurrence is located on the right bank of Bazovyi Creek (Fig. 1), 9 km from its mouth. Hydrothermal rocks are represented by monomineralic quartz veins, which were found in the disintegrated blocks or as separate quartz fragments among metamorphic, sedimentary, and volcanosedimentary rocks (Gorodinsky et al., 2004).

METHODS

Gold heavy concentrate was washed in the upper reaches of Vitalkin, Kat, and Bazovyi creeks. Further study of the chemical and mineral composition of gold grains and associated minerals was carried out at the Laboratory of Volcanogenic Ore Formation of the Institute of Volcanology and Seismology, Far Eastern Branch, Russian Academy of Sciences. The typomorphic features of native gold were described in detail in compliance with corresponding methodical guides (Petrovskaya, 1973; Nikolaeva, 1978, 1985, 1995).

To study such typomorphic features as morphology, size, and degree of roundness, the gold grains were initially examined and photographed using a Stereo Discovery.V12 (Carl Zeiss) stereomicroscope. From each sample, we picked ten representative grains of different size and morphology. The selected grains were taped to carbon strip to study the nanorelief of native gold surface in an SE mode on an SEM Tescan Vega 3.

To study the chemical composition, separate grains of native gold were pressed in an epoxy compound and polished to reach relief-free surface. The optical properties of the gold grains were examined using a Nikon Eclipse LV100 POL microscope equipped with digital camera for photography. The chemical composition of gold was analyzed using an SEM Tescan Vega 3 equipped with EDS Oxford Instruments X-Max 80 mm^2. The operating conditions were as follows: accelerating voltage of 20 kV, beam current of 14 nA, and counting time of 10 s for all elements. Synthetic conventional standards served as references.

RESULTS

The studies made it possible to obtain the first data on the morphology, size, and composition of placer gold from the Kengeveem River. The placer gold was variably subjected to mechanical transformations, which resulted in a change of primary morphology of gold grains and chemical composition.

Vitalkin Creek

Gold of Vitalkin Creek is represented by poorly and moderately rounded grains with sizes no more than 2–3 mm. The gold grains have a bright yellow color. Morphologically, it forms platy crystals bearing slight signs of mechanical deformation (Fig. 2a) and clumpy hemihedral crystals with well pressed margins and tighten branches (Figs. 2b–2d). As well, primary crystallographic outlines are quite well discernible. Numerous voids on the grain surface are filled with iron hydroxides and quartz.

The gold fineness of Vitalkin Creek widely varies from low-fineness 506‰ to high-fineness 944‰ (Fig. 3; Table 1). Some separate gold grains are rimmed by discontinuous corrosional shells of variable intensity (Figs. 4a–4c) and are characterized by the wide development of high-fineness veinlets (Fig. 4d). The thickness of the corrosional shells varies from a few microns to 0.5 cm (Figs. 4a–4c). The high-fineness veinlets within the grains are developed mainly around voids or along fractures. The Au concentrations in the recrystallization zones account for 89–97 wt % (Figs. 4c, 4d, 4f, 4g; Table 2). One of the reasons for the formation of high-fineness gold is related to the chemical interaction of gold grains with solutions migrating in placer (Petrovskaya, 1973; Nikolaeva, 1995). In reflected light, the recrystallization zones are marked by more saturated yellow tint (Figs. 4a, 4e).

Kat Creek

Gold of Kat Creek is represented by intergrowths of imperfect crystals, as well as hemihedral and clumpy segregations (Figs. 2e–2h). The grains are small, usually no more than 1 mm in size. The color is goldish yellow with metallic luster. The degree of roundness varies from poor (Figs. 2e, 2f) to moderate (Figs. 2g, 2h). The gold occurs in intergrowths with quartz and iron oxides.

The placer gold of Kat Creek contains only Au and Ag (Table 1). Based on the histogram of Au distribution in placer gold of Kat Creek (Fig. 3), two gold populations are distinguished: relatively low- to moderate-fineness gold (738–828‰), and sufficiently high-fineness gold (930–945‰). Some grains have high-fineness rims and intergranular veinlets (Fig. 4f). They are well seen both in reflected light and in scanning electron microscope in BSE mode (Figs. 4e). The external recrystallization zones changes from small

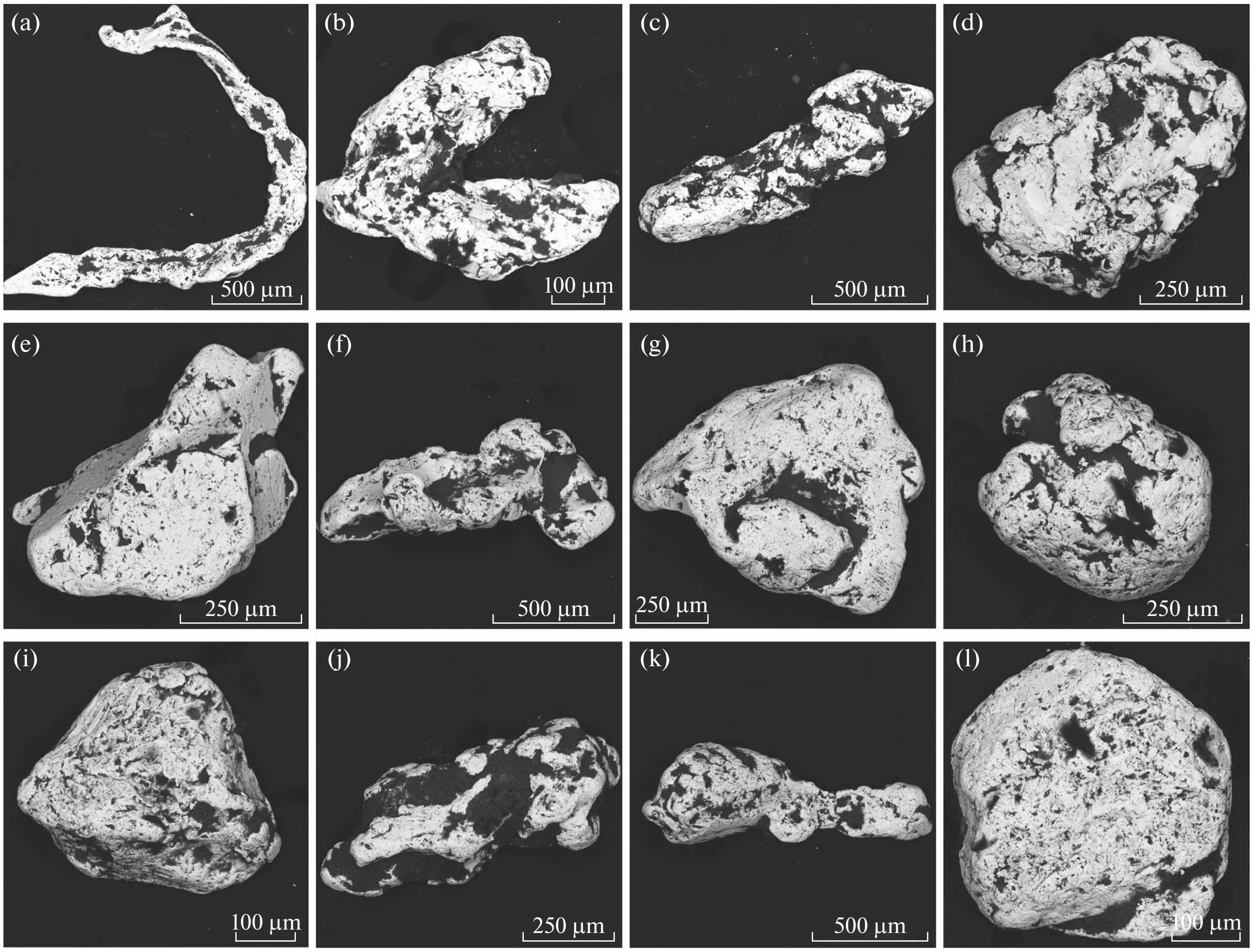

Fig. 2. Microphotographs of native gold from Kengeveem River, illustrating grain morphologies and roundness: (a–d) poorly to moderately rounded ribbonlike (a), hemihedral (b, c), and clumpy grains with iron oxide-filled voids from Vitalkin Creek; (e–h) weakly to moderately rounded gold, hemihedral (e, f) and clumpy (g, h) morphologies in tight intergrowths with iron oxides, Kat Creek; (i–l) semi- to moderately rounded gold grains with preserved primary hemihedral and clumpy morphologies, Uglovoi Creek.

rims to sufficiently deep embayments in the grain (Fig. 4g). The Au concentrations in such zones reach 91.2 wt % up to practically pure (100 wt %) gold (Figs. 4f, 4g, Table 2). The relict gold has the low-fineness composition. The Au concentrations are 79–82 wt % (Figs. 4f, 4g). Single gold grains have a heterogenous inner structure. The primary monogranular gold with a fineness of approximately 790–800‰ contains nearly equant inclusions of high-fineness gold (980‰) (Fig. 4h). Such structures could be related to the initial disintegration arising at hydrothermal metamorphism (Nikolaeva et al., 2003; Nikolaeva and Yablokova, 2007; Nikiforova and Kazhenkina, 2018).

Uglovoi Creek

Gold concentrates of Uglovoi Creek are represented by grains of native gold from 1 to 3 mm in size (on average, approximately 1–2 mm). The grains frequently have equant or extended morphology (Figs. 2i–2k) and bright yellow color. Imprints of vein quartz are preserved on the surface of some grains (Fig. 4l).

Chemically, the gold is homogenous with high fineness. The Au content changes from 84.4 to 95.0 wt % (Table 1). Most of analyzed analytical points fall in a quite narrow range from 85 to 95 wt % Au (Fig. 3a). A distinctive feature of gold of Uglovoi Creek is the constant chemical composition and the absence of recrystallization zones.

Bazovyi Creek

It was found that heavy concentrate samples of Bazovyi Creek contain grains of native platinum, native gold, iron sulfides, Ti-magnetite, native iron, quartz, amethyst-like quartz, and garnet (spessartine–almandine).

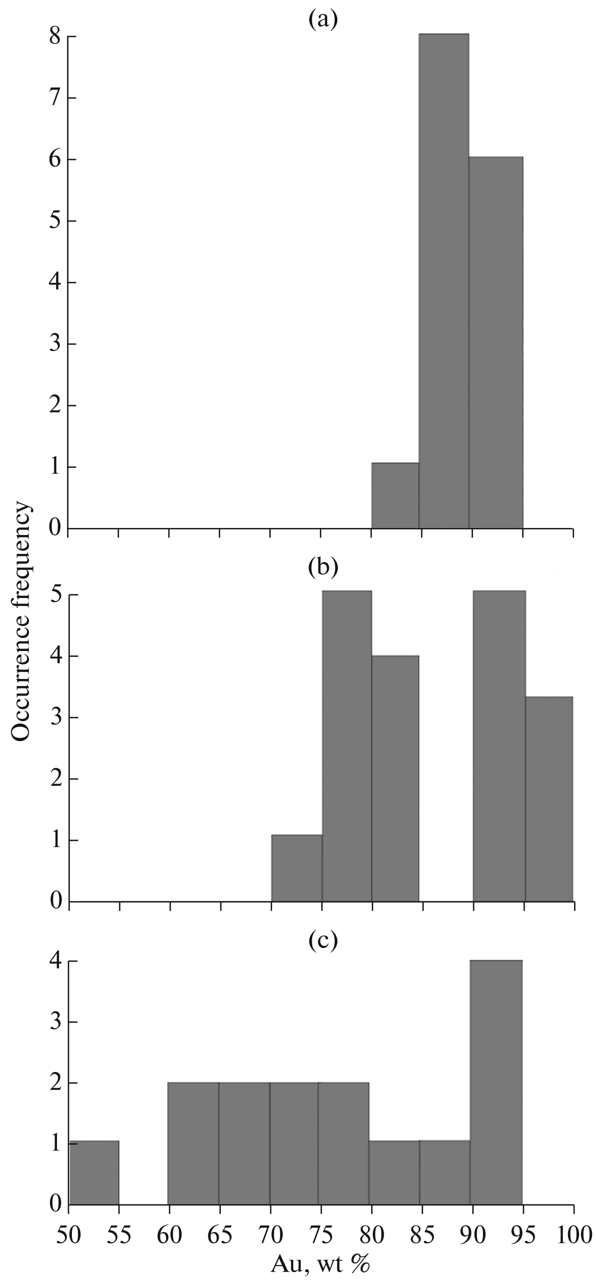

Fig. 3. Histograms of Au concentrations in gold placers from Uglovoi (a), Kat (b), and Vitalkin (c) creeks.

Native gold is represented by grains of different shape and size. Heavy concentrates contain both well rounded platy grains with coarsely shagreen surface and weakly rounded clumpy and hemihedral gold grains (Figs. 5a–5d). Well-rounded gold grains are flattened to thin plates. The margins of the gold grains are stamped, while surface is fractured (Figs. 5a, 5b). The platy gold is ~5–6 mm in size. Gold grains of subore appearance with crumbled round margins and tighten offsets have small sizes (2–3 mm) and moderate rounding (Figs. 5c, 5d), and are intergrown with gangue minerals. Based on the composition, all gold is high-fineness (980–990‰). No elements were detected except for Au and Ag (Table 1).

Supergene gold. Supergene gold was found in the Bazovyi Creek placer. Secondary gold differs from primary gold in structure. It forms loose aggregates with highly fractured surface (Figs. 5e, 5f). The secondary gold has a high fineness of 980–990‰.

Table 1. Chemical composition of gold of placers of Vitalkin, Kat, Uglovoi, and Bazovyi creeks, wt %

Creek	Analysis no.	Ag	Au	Total
Vitalkin	36	49.39	50.61	100.00
Vitalkin	27	33.91	66.96	100.87
Vitalkin	13	29.08	70.92	100.00
Vitalkin	2	14.55	85.45	100.00
Vitalkin	41	8.95	91.18	100.13
Vitalkin	31	5.45	93.77	99.23
Kat	30	23.32	78.09	101.41
Kat	42	7.02	93.68	100.70
Kat	46	5.5	94.75	100.25
Kat	73	20.84	76.57	97.40
Kat	82	20.32	80.17	100.49
Kat	114	18.57	80.99	99.55
Uglovoi	36	12.75	87.39	100.14
Uglovoi	84	11.61	88.63	100.24
Uglovoi	7	11.47	88.65	100.12
Uglovoi	56	9.2	90.56	99.76
Uglovoi	108	5.46	94.03	99.49
Uglovoi	27	5.78	94.59	100.37
Bazovyi	3	1.16	98.63	99.79
Bazovyi	14	0.86	98.39	99.25
Bazovyi	39	2.35	97.23	99.58
Bazovyi	42	0.93	99.55	100.48
Bazovyi	87	1.47	97.80	99.27

Platinum is represented by well-rounded grains with sizes up to 1–2 mm (Figs. 5i, 5j). SEM study of the grains showed that the native platinum is attributed to solid solution corresponding in composition to Pt_3Fe, which according to classification of (Cabri and Feather, 1975) is attributed to isoferoplatinum (Table 3). Pt–Fe alloys frequently contain Pt–Sb–Pd–Rh inclusion.

Pyrite is present as individual cubic crystals and their spherical intergrowths (Figs. 5m, 5n). Based on the chemical composition, two varieties are distinguished: stoichiometric and arsenic-bearing pyrite with As up to 1.3 wt % (Fig. 5n).

Native iron with an Fe content of 100.16–100.45 wt % forms complex aggregates with small spherical inclusions of iron oxides (Fig. 5p). The iron oxides (Fe 68–74 wt %) occur as inclusions in native iron and as individual spheres (Fig. 5o).

DISCUSSION

Placer gold from Vitalkin, Kat, and Uglovoi creeks have some similar typomorphic features. According to the classifications (Petrovskaya, 1973; Nikolaeva et al., 2003), the gold is attributed to the visible class of moderate–large size. Gold from the studied placers is practically identical in the degree of roundness (Table 4). Gold grains are moderately flattened and have moderate roundness expressed in an insignificant change of shape, crumpling of margins, and tightening of offsets (Fig. 2). Distinctive features are the chemical composition and inner structure. Heavy concentrate from Bazovyi Creek is characterized by the qualitatively different indicator features.

Degree of Abrasion and Roundness as Indicators of Transport Distance

Important indicators of the transport distance of placer gold are the flatness (abrasion) index and degree of roundness (Petrovskaya, 1973; Knight et al., 1999). Knight et al. (1999) present convincing evidence for a positive correlation of the flatness index and roundness of gold grains with transport distance. According to their data, the most intense flatness index of gold crystals up to lump-shaped segregations begins from a distance of over 5 km from the primary source. The gold grains acquire a round morphology directly near outcrops of primary bodies, approximately within 3 km (Knight et al., 1999). It is believed that only well-rounded gold grains are subjected to flattening (Petrovskaya, 1973). Thus, the flatness index and degree of roundness of gold are indicative of the transport distance.

The placer gold of Vitalkin, Kat, and Uglovoi creeks is characterized by weakly to moderate roundness and uneven roundness of offsets (Fig. 2). The presence of gold grains with rounded angular offsets and diverse subore morphology can be used as criterion of primary source proximity and insignificant transport of placer material.

Gold from the Bazovyi Creek placer shows a practically perfect to moderate degree of roundness (Figs. 5a, 5d). The perfectly rounded gold grains with flat shapes indicate its long-term evolution in placer and significant transport from the primary source (Figs. 5a, 5b). Gold of "ore appearance" from the Bazovyi Creek placer (Figs. 5c, 5d) has much in common with placer gold from Vitalkin, Kat, and Uglovoi creeks (Fig. 2). The grain morphologies are similar, while the degree of distortion is insignificant, which suggests a short residence time of gold in exogenic conditions and the proximal source.

Chemical Composition of Gold and High-Fineness Shells

Placer gold of Vitalkin and Kat creeks experienced electrochemical corrosion and volume process of silver diffusion, which are expressed in the formation of high-fineness rims of different thickness and intergranular veinlets (Fig. 4). Such transformations are typical of gold from supergene zone and could be intensified in placers. The degree of supergene trans-

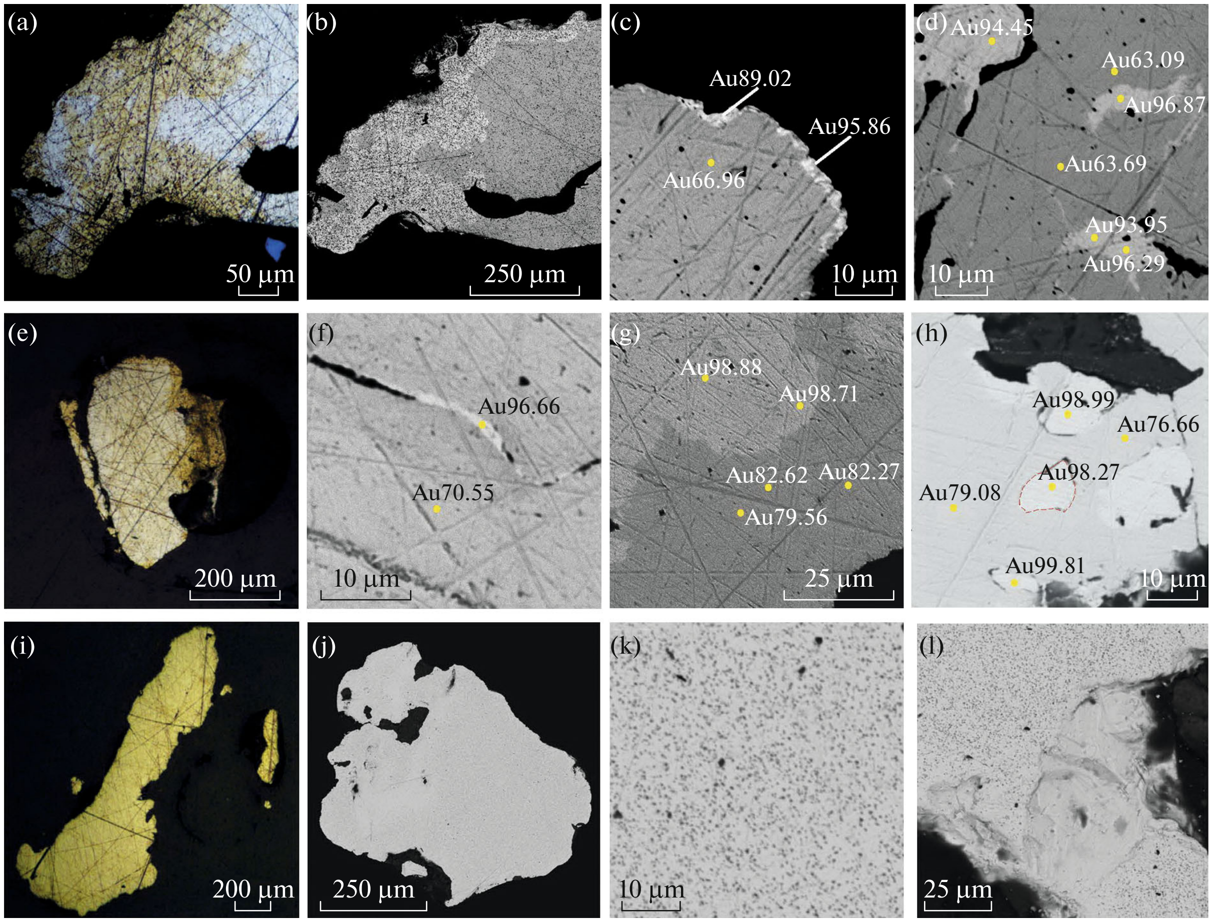

Fig. 4. Characteristics of internal structure of native gold from Vitalkin (a–d), Kat (e–h), and Uglovoi creeks (i–l). Photos (a, e, i) were taken by optical microscope in reflected light; other photos are BSE images taken by scanning electron microscope. (a–c) Intense (a, b) and poorly (c) developed corrosional shell in native gold of Vitalkin Creek; (d) intergranular veins in native gold, Vitalkin creek; (e) high-fineness rim in native gold under reflected light, Kat creek; (f–j) high-fineness vein and corrosion rim in placer gold from Kat Creek; (h) inclusions of high-fineness native gold in placer gold from Kat creek; (i–j) homogeneous internal structure of placer gold from Uglovoi Creek (Au = 87–90 wt %); (k) porosity in gold, Uglovoi Creek; (l) preserved imprint of vein mineral in placer gold, Uglovoi creek.

formations in the placer gold of Vitalkin and Kat creeks is insignificant and likely was caused by weathering of primary ores.

Most of the studied gold grains show the high-fineness composition, but the placers of Vitalkin and Kat creeks, in addition, contain gold of low and moderate fineness (Fig. 3). Differences in the fineness of residual gold could indicate the age, type, and depth of eroded source areas (Petrovskaya, 1973). The only common feature of all studied placer gold is the absence of other trace elements except for silver, which indirectly confirms their derivation from a common primary source. Thus, the placers of Vitalkin, Kat, and Uglovoi creeks were likely formed from a common genetic source. The presence of low and moderate-fineness gold in the placers could be related to the depth of eroded primary bodies.

The Bazovyi Creek placer contains two gold varieties: primary and secondary mustard. The primary gold has fineness close to that of Uglovoi Creek placer gold: 900–950‰ (Fig. 3), which could serve as an additional sign of a common primary source.

Inferred Genetic Sources

Primary gold deposits in the southern Taigonos peninsula were not found. The disintegrated blocks of quartz veins in the wall of Bazovyi Creek and zone of hydrothermally altered rocks are observed in the Kengeveem River valley (Fig. 1).

Subore morphology and the moderate degree of roundness of gold grains of the Vitalkin, Kat, and Uglovoi placers indicate short-term transport in the placer bed and an insignificant distance from the primary source. Using the criteria of (Knight et al., 1999), we can suggest that the distance to primary sources is no less than 5 km. The presence of high-fineness rims and intergranular veinlets in gold of

Table 2. Chemical composition of relic gold and recrystallization zones in gold of alluvial deposits from Vitalkin and Kat creeks, wt %

Creek	Grain no.	Unaltered gold			Corrosional shell		
		Au	Ag	total	Au	Ag	total
Vitalkin	4	65.91	30.25	96.16	97.71	2.21	99.91
Vitalkin	5	66.96	33.91	100.87	95.86	4.33	100.18
Vitalkin	7	50.61	49.39	100.00	95.25	4.91	100.16
Vitalkin	7	64.99	33.78	98.77	96.87	2.82	99.69
Vitalkin	9	71.26	28.74	100.00	96.96	3.43	100.38
Vitalkin	9	70.92	29.08	100.00	95.69	4.31	100.00
Vitalkin	9	83.50	17.36	100.85	96.62	3.38	100.00
Kat	12	78.09	23.32	101.41	96.08	2.56	98.64
Kat	18	73.03	25.80	98.84	96.66	4.65	101.31
Kat	19	76.57	20.84	97.40	99.04	1.81	100.86
Kat	20	80.17	20.32	100.49	97.16	2.18	99.34
Kat	22	79.56	18.26	97.81	98.71	1.53	100.25
Kat	22	80.99	18.57	99.55	97.54	2.95	100.50
Kat	23	84.18	17.48	101.66	97.88	1.61	99.49

Table 3. Chemical composition of platinum-group minerals from gold-bearing placer of Bazovyi Creek, wt %

Ordinal no.	Analysis no.	Rh	Pt	Pd	Fe	Sb	Total
1	9	0.00	90.7	0.00	9.15	0.00	99.85
2	17	0.00	90.88	0.00	8.84	0.00	99.72
3	20	0.00	90.22	0.00	9.24	0.00	99.46
4	53	0.00	90.76	0.00	9.23	0.00	99.99
5	54	0.00	91.26	0.00	9.08	0.00	100.34
6	24	7.06	46.13	10.71	0.47	36.04	100.42
7	35	6.52	50.23	10.14	1.18	34.3	102.37

Analyses 1–5, isoferroplatinum; analyses 6–7, inclusions in Pt–Fe alloy.

Vitalkin and Kat creeks indicates that the gold was derived from the supergene zone. The placer gold of Uglovoi Creek shows no signs of supergene alteration. Based on this, we can conclude that their source was destroyed primary gold–quartz ores.

The simple chemical composition of placer gold of the Kengeveem River and the absence of trace elements make it similar to gold of epithermal gold–silver deposits of Kamchatka (Andreeva and Kudaeva, 2013; Okrugin et al., 2014; Skilskaia et al., 2015; Okrugin and Skilskaia, 2020). Thus, a possible source of placer gold could be the low-sulfide quartz veins.

The placer gold of Bazovyi Creek has qualitatively distinctive mineralogical-geochemical features. Based on the morphology, degree of roundness, and flatness index, two types of gold were distinguished: well-rounded flattened gold grains and grains with preserved signs of primary crystalline structure (Figs. 5a–5d). In addition, the presence of supergene gold in heavy concentrates indicates gold supply from oxidized ores. Thus, three independent primary sources can be established for the placer gold of the Bazovyi Creek. As well, the moderately rounded gold of subore appearance (Figs. 5c, 5d) based on typomorphic features is similar to gold from placers of Vitalkin, Kat,

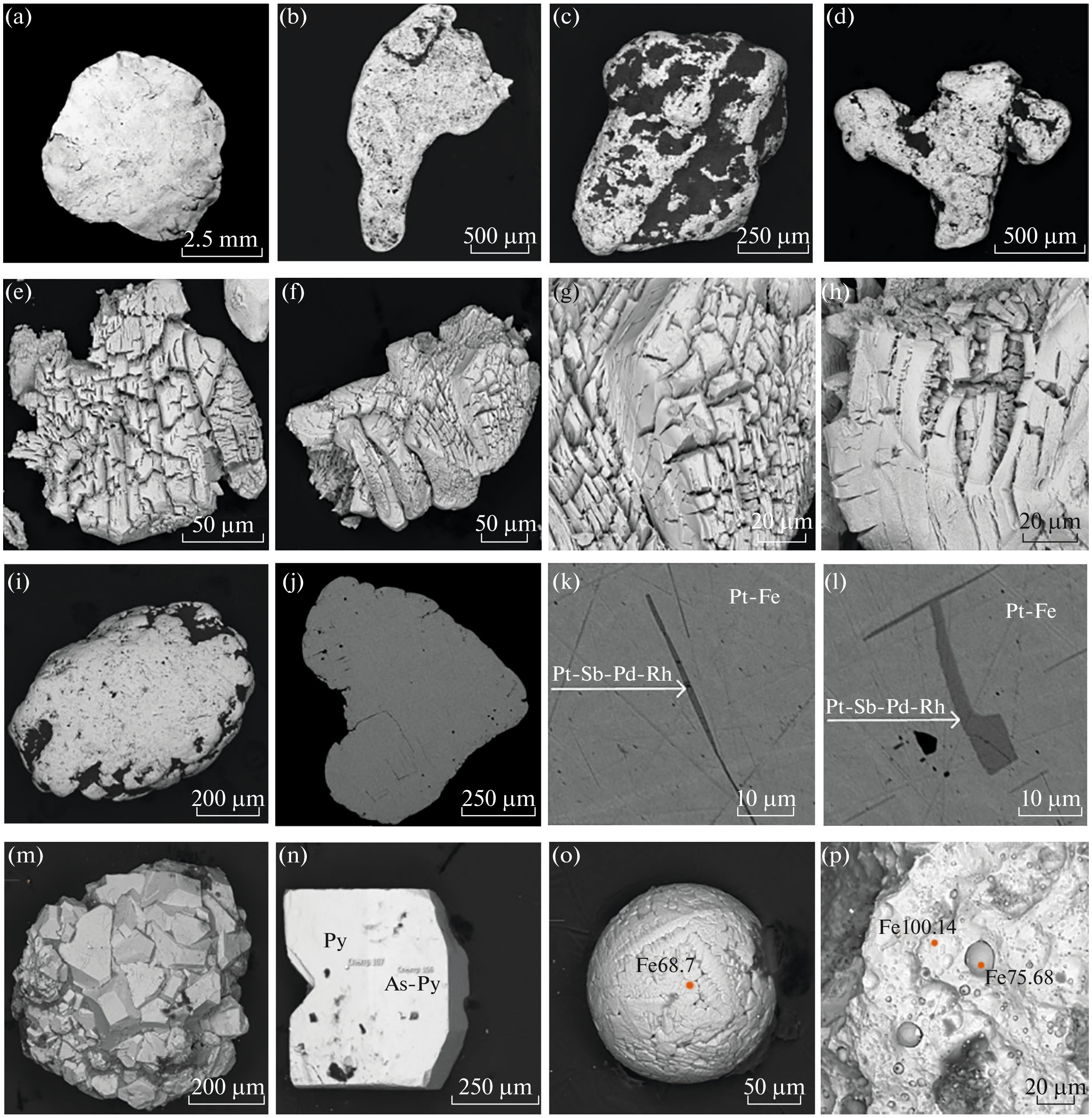

Fig. 5. BSE images of native gold and associated minerals from placer deposit of Bazovyi Creek. (a–b) Well-rounded lamellar gold grains with rough shagreen surface; (c–d) medium-rounded gold intergrown with quartz (black); (e–f) supergene (mustard) gold; (g–h) details of structure of mustard gold surface; (i–j) grains of native isoferroplatinum; (k–l) inclusions of Pt-Sb-Pd-Rh (dark gray) composition in isoferroplatinum; (m) spherical intergrowth of hypidiomorphic pyrite crystals; (n) fragment of surface; (o) spherical iron oxide grain; (p) inclusion of Fe_2O_3 (gray) in native iron.

and Uglovoi creeks and could have been derived from the same genetic source. Such source could be monomineralic quartz veins localized in the right bank of the Bazovyi Creek (Fig. 1). Flattened gold grains with the high degree of roundness were formed from a distal source supposedly related to gabbroids.

The genetic source of platinum in the Bazovyi Creek placer and its relationship with gold remain unknown.

CONCLUSIONS

Gold from placers of the Kengeveem River of the Taigonos Peninsula is represented by the following varieties: well-rounded high-fineness platy grains; moderately rounded hemihedral clumpy monograins with a wide fineness range; grains with a heterogenous internal structure (high-fineness shells, intergranular veinlets, and heterogenous patchy structure), and supergene secondary gold. All gold has a simple chem-

Table 4. Typomorphic characteristics of alluvial gold from Kengeveem River

Creek	Degree of roundness	Flatness index	Fineness, ‰	Thickness of high-fineness rims, mm	Associated minerals	Inferred transport distance	Inferred primary source
Vitalkin	Weak to moderate	Weak	506–944	Up to 5 mm	Not found	No less than 5 km	Low-sulfide gold–quartz ores
Kat	Weak to moderate	Weak	738–945	Up to 5 mm	Not found	No less than 5 km	Low-sulfide gold–quartz ores
Uglovoi	Weak	Weak	840–950	Not found	Not found	No less than 5 km	Low-sulfide gold–quartz ores
Bazovyi	Weak to strong	Weak to strong	980–990	Not found	Platinum, pyrite, Ti-magnetite, native iron	More than 5 km	Low-sulfide gold–quartz ores

ical composition, with silver as the only admixture. High-fineness gold predominates.

Given these facts, we can conclude that the placer gold of the Kengeveem River Basin was supplied from different genetic sources: low-sulfide quartz veins similar to the epithermal deposits of Kamchatka, the supergene zone, and an unestablished distal source.

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CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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