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GEOLOGY OF ORE DEPOSITS

The Natalkinskoe Gold Deposit: Formation Conditions Based on Paragenetic Analysis of Dike and Ore Vein Networks

K. Zh. Seminsky[a,*], **J. P. Burzunova**[a], **A. K. Seminsky**[a,**], **G. L. Vursiy**[c], **R. N. Ovsov**[c], **and Academician N. S. Bortnikov**[b]

[a] *Institute of the Earth's Crust, Siberian Branch, Russian Academy of Sciences, Irkutsk, 664033 Russia*

[b] *Institute of Geology of Ore Deposits, Petrography, Mineralogy, and Geochemistry, Russian Academy of Sciences, Moscow, 119017 Russia*

[c] *Management Company Polyus LLC, Moscow, Russia*

**e-mail: seminsky@crust.irk.ru*

***e-mail: aks@crust.irk.ru*

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Abstract—The aim of the research was to reconstruct the structural environment of ore formation for the Natalkinskoe gold deposit (NGD), which is located in the north-east of Russia and contains unique accumulations of precious metal. Based on the paragenetic analysis of fracture networks containing different types of dikes and ore veins with a known age of formation, it was established that the NGD localization is confined to the intersection of two regional fault zones. These are the longitudinal northwestern Tenka zone and the transverse sublatitudinal zone of the hidden basement fault, the kinematics of which at the stage of ore formation corresponded to left- and right-lateral strike-slip faults. It is shown that under conditions of the reconstructed strike-slip regime, the migration of mineralized solutions and ore formation were controlled by sections of the fracture network in the second-order and higher ranked extension regime. The patterns of fracture formation established for the ore stage made it possible to characterize the structural-tectonic conditions of the development of the Natalka mineral-forming system, which can subsequently be used to develop its model.

Keywords: the Natalkinskoe gold deposit, orogenic gold deposits, structural geology, faults, dikes, ore veins, paragenetic analysis, stress state of rocks, stage of ore formation

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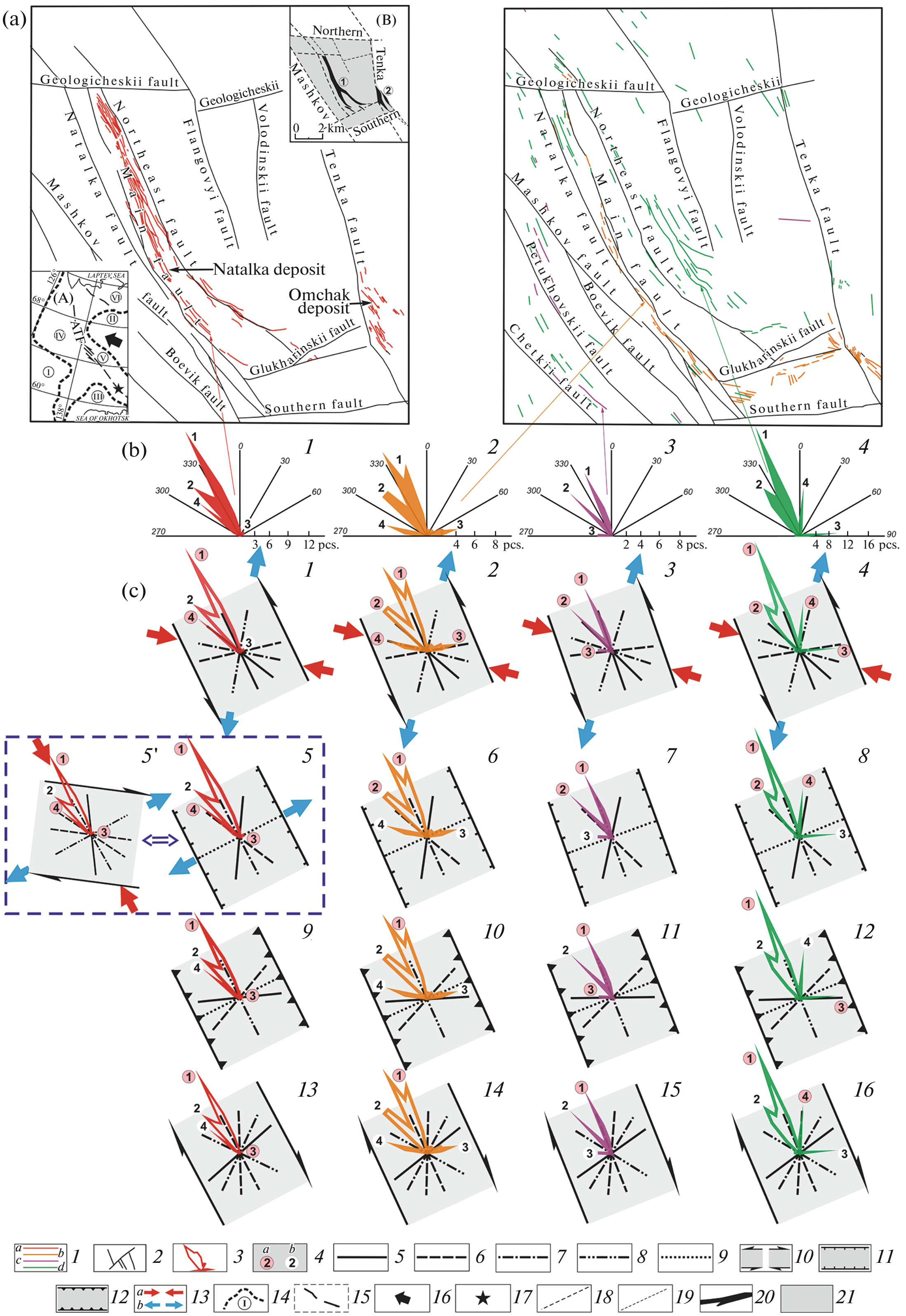
INTRODUCTION

The development of models of ore-forming systems is currently one of the most urgent tasks in ore geology, since its solution allows moving to a fundamentally new level of predictive constructions. One of the key questions is how huge volumes of ore-forming fluids migrate in the Earth's crust, supplying significant quantities of metals to its upper zones. Auriferous veins of orogenic deposits and associated dikes of igneous rocks, located in extension zones related to regional transcrustal zones of normal faults or steep differently oriented strike-slip faults or reverse faults, represent vivid examples of the structure in the network of channels for episodic fluid flow, whose pressure could exceed the lithostatic load. The study of the development of such fault-joint structures is of great interest for clarifying why permeability of rocks that ensure fluid seepage through them and the filling of joints with dikes and ore bodies increases. This work presents the results of solving this problem by the example of Natalka super-large orogenic gold deposit and proposes a preliminary model for the development of its geological structure at the ore-formation stage. This model can be useful for understanding the conditions of ore formation and other orogenic gold deposits.

The Natalkinskoe gold deposit (NGD) is located in northeast Russia (Fig. 1 a-A) and hosts the eponymous deposit with reserves of the gold ≈2000 t at an average content of ≈1.5 g/t [6]. A determining role of fault tectonics in the localization of ore bodies is specified for the Natalkinskoe and the adjacent Omchak deposits, located in the volcanic-sedimentary sequence of Permian (P_2) rocks. Consequently, the further development of an ore-forming system model that led to the formation of unique ore clusters, will require to establish the pattern of structural control of auriferous bodies, which remain contentious on many fundamental issues for the NGD.

Most researchers suppose ([8, 4, 18, 5, 19] and many others) that the leading role in the NGD structure is played by the Tenka fault zone, which is located


(a)
Geologicheskii fault
Geologicheskii
Northeast fault
Main fault
Natalka fault
Mashkov fault
Flangovyi fault
Volodinskii fault
Tenka fault
Natalka deposit
Omchak deposit
Glukharinskii fault
Boevik fault
Southern fault
(B)
Northern
Tenka
Mashkov
Southern
0
2 km
(A)
LAPTEV SEA
SEA OF OKHOTSK
126°
68°
60°
138°
ATF
Petukhovskii fault
Chetkii fault
(b)
1
2
3
4
0
30
60
300
330
270
90
3 6 9 12 pcs.
4 6 8 pcs.
2 4 6 8 pcs.
4 8 12 16 pcs.
(c)
5'
5
6
7
8
9
10
11
12
13
14
15
16
a
b
c
d
1
2
3
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on the southeast continuation of the Adycha-Taryn fault, a large ore-controlling disjunctive of the Yana-Kolyma collisional orogenic belt (Fig. 1a-A). It has a northwest orientation concordant with the strike of the region's fold structure, ≈15 km wide, and consists of several relatively large subparallel faults (the Tenka, Main, Northeast, Natalka, etc.) without a clearly expressed master fault plane [18].

Besides, researchers have different opinions on the dynamic settings of the formation of the fault structure in the Natalkinskoe gold deposit, the role of individual systems of tectonic dislocations in ore localization, and their rank subordination. For example, the position of the ore cluster is associated with the curve of the entire Tenka zone or the Tenka fault confined to the Omchak River Valley, where the 2nd order ore-localizing feathering faults are activated [11]. Other researchers assign primary importance to the conditions that appear during the intersection of the equal-rank faults or the fault zones. There are also different opinions on the orientations of the disjunctive structures forming the ore cluster: northwestern and meridional [8]; north-northwestern and latitudinal [7, 12]; northwestern, meridional, and latitudinal [13].

There is almost a full range of opinions on the dynamic settings for the development of the fault network during the ore-forming period: a strike-slip with a NW–SE orientation of the compression axis and a NE–SW orientation of the tension axis [4, 18]; a complex strike-slip with transtension for north-northwest fault zones [19]; tension in the east-northeast direction [10]; compression in the NE–SW direction [8]. Depending on these settings, the assessments of the morphogenetic characteristics of ore-controlling fractures and their networks differ greatly, which is of fundamental importance for predictive constructions.

Despite the different opinions on the nature of structural control of the deposits and ore bodies in the Natalkinskoe gold deposit, its geological structure has been studied sufficiently completely. For example, the Geological-Structural Map of the Natalkinskoe Gold Deposit [3], compiled at the scale of 1 : 10000 by A.I. Kalinin, V.K. Kanishchev, and A.G. Orlov, involving the data collected by the geologists E.P. Mashko, V.D. Volodin, M.P. Krutous, G.I. Kuz'min, A.S. Lavtev, Yu.P. Karelin, and V.P. Petukhov, who studied the ore district for a long time, was often used as a base map for constructing different patterns in the above-cited and other works. In addition to the positions of the fractures, this map presents the networks of dikes of different types (Fig. 1a, right) and large auriferous veins (Fig. 1a, left), whose U–Pb-, ^{40}Ar/^{39}Ar-, Re –Os-isotopic ages are 148 ± 2 Ma and from 136 ± 1 to 132 ± 2 Ma, respectively, according to the subsequent estimates [1]. These data on the spatial position and age of the fractures filled with dikes and auriferous bodies served as a basis for studying the patterns of structure generation at the stage of formation of the Natalka field gold deposits by revealing the paragenetically associated fracture networks.

The main task of the works was to use a paragenetic analysis to the networks of various types of dikes and gold veins in the Natalka field in order to reconstruct the stress state of the rocks at the ore formation stage, to identify the ore-controlling role of individual fracture systems, and to establish the influence of structural-tectonic conditions on the development of the ore-forming system, that led to super-large gold accumulations.

GEOLOGICAL SETTING

The map [3] used for the paragenetic analysis (Fig. 1a-B) shows that the large longitudinal faults of the Tenka zone were taken as the boundaries of the Natalka ore field (the Tenka fault, in the east; the Mashkov fault, in the west), as well as the transverse sublatitudinal faults: the Northern, in the north and

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Fig. 1. Results of paragenetic analysis of the network of the dikes and the ore veins in the Natalkinskoe gold deposit. (a) The network of the ore veins (Fig. 1a, left) and the different-type dikes (Fig. 1a, right) in the diagram of the ore field faults according to the map [3]. Inset A: position of the study area in the location map. Inset B: scheme of the main faults of the ore field according to the inset in the map [3]. (b) The rose diagrams of the strikes of (*1*) the ore veins and (*2–4*) the dikes of (*2*) type 1 (felsites), (*3*) type 2 (quartz-albite porphyries, quartz porphyries, granite-porphyries, and granodiorite-porphyries), (*4*) type 3 (microdiorites, diorite-porphyrites, spessartites, and dolerites) according to the classification [3]. (c) The variants of superimposition of the rose diagrams of the ore veins or the different-type dikes with standard parageneses of 2nd-order fractures in (*1–4*) left-lateral strike-slip, (*5–8*) normal fault, (*9–12*) reverse fault, or (*13–16*) right-lateral strike-slip zones (red and blue arrows mark the position of subhorizontal compression and tension axes in the final solutions of the paragenetic analysis). *1*, Position of (*a*) the ore veins and the dikes of (*b*) type 1, (*c*) type 2, and (*d*) type 3 in the scheme; *2*, main faults of the ore field after [3]; *3*, rose diagram of the strikes of the ore veins or the dikes; *4*, fault directions (a) coinciding or (b) not coinciding with the fracture systems of standard paragenesis; *5–9*, (*5*) left-lateral strike-slip, (*6*) right-lateral strike-slip, (*7*) normal fault, (*8*) reverse fault, and (*9*) transformational 2nd-order fractures in standard parageneses; *10–12*, zones of (*10*) left- and right-lateral strike-slips, (*11*) normal fault, and (*12*) reverse fault (thrust) of the 1st-order for standard parageneses; *13*, orientation of subhorizontal (*a*) compression and (*b*) tension axes, shown only for the solutions of the paragenetic analysis; *14–15*, (*14*) boundaries, including (*15*) fault-type, of main tectonic units: I, Siberian platform; II, Kolyma-Omolon superterrane; III, Okhotsk terrane; IV, Verkhoyansk fold-and-thrust belt; V, Yana-Kolyma orogenic belt; VI, Arctic-Chukotka orogen; ATF, Adycha-Taryn fault (strike-slip for the stage of deposit formation); *16*, direction of movement of the Kolyma-Omolon superterrane during collision (WNW is for the stage of deposit formation); *17*, position of the Natalka ore field (out of scale); *18–19*, (*18*) main and (*19*) other faults of the ore field; *20*, areas of localization of industrial gold mineralization (1, Natalka deposit; 2, Omchak deposit); *21*, area of the ore field. Purple dashed lines represent equivalent (<=>) solutions of the paragenetic analysis that explain the origin of the ore vein network under normal fault movements in the northwest zone (c-5) and under right-lateral strike-slip movements in the sublatitudinal zone (c-5').

the Southern, in the south. The Natalka and Omchak deposits are controlled by the NGD fault structure and are located, respectively, in its central and southeastern parts. The main auriferous zone of the Natalka deposit represents a network of veins of gold-arsenopyrite-ankerite-sericite-albite-quartz composition, which in the northwest occupies almost the entire area between the Main and Northeast faults (Fig. 1a, left). In the southeast, they form relatively narrow zones controlled by the fault planes of the mentioned fractures. The auriferous veins of the Omchak deposit are confined to the eastern wing of the Tenka fault, deviating at this segment noticeably to the southeast and forming a clearly visible curve. Ore deposition occurred in feathering faults, mostly NW trending.

The Natalka ore field is surrounded by intrusive plutonic bodies and hosts only dikes of a similar pre-ore age of formation [1]. The thicknesses of certain dikes can reach 15–25 m with a length of 2 km and greater. According to [3], they are divided into three main types by composition: 1, felsites; 2, quartz-albite porphyries, quartz porphyries, granite-porphyries, and granodiorite-porphyries; 3, microdiorites, diorite-porphyrites, spessartites, and dolerites. The difference in composition and a degree of abundance in the ore field territory (Fig. 1a, right) served as the reason to perform their separate paragenetic analysis, providing the results in a uniform form (Fig. 1c).

METHODS

Since the Tenka fault zone is the dike- and ore-controlling structure in the territory of the Natalka field, this type of analysis should be based on a set of fracture systems (paragenesis) forming in the zone of shear stresses. In the absence of information on the dips of fractures, such parageneses are successfully used to reconstruct strike-slip situations with an element of additional compression or tension [16]. The variant of paragenetic analysis used rose diagrams of the strikes of natural faults in comparison with standard templates of 2nd-order fracture systems [15], which may take place in strike-slip, normal and reverse fault zones during their development from the origination of advanced faults to the formation of the master fault plane, the 1st-order fracture. In Fig. 1c, the components of the standard parageneses are marked by conventional symbols: Nos. 5–9, for 2nd-order fractures and Nos. 10–12, for 1st-order fault zones. Satisfactory coincidence of natural and standard fracture networks provides the solution on the kinematics of movements in the 1st-order fault zone (normal fault, reverse fault, right- or left-lateral srtike-slip fault) and the dynamic setting (the stress field) in which they occurred: tension, compression, or srtike-slip fault with particular orientations of the axes of the principal normal stresses.

RESULTS

The rose diagrams (Fig. 1b–2-4) show that the networks of all types of dikes are characterized by similarity of the systems. It is determined by the existence of three directions dominated by the north-northwestern (system 1). Slightly inferior is the northwestern system (2) with a substantially lower representative sublatitudinal system (3). In addition, dikes of the first (Fig. 1b–2) and third (Fig. 1b–4) types form additional systems, west-northwestern (4) and submeridional (4), respectively, which are equally abundant as the sublatitudinal system.

In the paragenetic analysis, the templates of the left-lateral strike-slip zone (Fig. 1c–2-4), the normal fault zone (Fig. 1c–6-8), the reverse fault zone (Fig. 1c–10-12), and the right-lateral strike-slip zone (Fig. 1c–14-16) were oriented in accordance with the position of system 1, which reflects the orientation of the Tenka fault zone within the ore field. It is evident that a similar set of systems predetermined the result of the paragenetic analysis, presented in the first line of Fig. 1c–2-4. The combination of three systems typical of all dike types is explained by the existence of a strike-slip setting with a west-northwest orientation of the compression axis and a north-northeast orientation of the tension axis. In this stress state, the first and second systems are left-lateral strike-slips, while the sublatitudinal system is represented by right-lateral strike-slips. The additional systems in the dikes of the first and third types are associated with normal faults and reverse faults, respectively.

In addition to spatial localization (Fig. 1a, left), the auriferous veins in the Natalka and Omchak deposits are ranked in terms of spatial orientation, judging from the rose diagram (Fig. 1b–1). Individual bodies are east-west trending (system 3), while their overwhelming majority are northwest oriented (systems 1, 2, 4). An independent system (4) is formed by the fractures, corresponding to a separate ray in the rose diagram (Fig. 1b–1) and to the position in the southeastern part of the Natalka deposit and in the northeastern part of the Omchak deposits (Fig. 1a, left).

In contrast to these two fracture directions considered, the separation of the main north-northwest system into two rays (1 and 2) for the Natalka deposit is determined by the tracking of ore-localizing fractures, curved in plan, by auriferous bodies. The latter fractures deviate from the north-northwest orientation dominating in the center of the ore field to the southeast in the south or to the northwest in the north, which makes the Tenka zone to have a Z-shape, recognized in the earlier studies [4]. This conclusion was confirmed by the results of the paragenetic analysis (Fig. 1c–1, 1c–5, 1c–9, 1c–13), which do not explain the appearance of ray 2 in any of the four variants, when the standard templates are oriented in accordance with the trend of the Tenka fault zone (system 1).

In this situation, the tension setting in the NE–SW direction should be taken as the main solution of the paragenetic analysis (Fig. 1c–5), when the fractures of a normal fault type were the most favorable for ore deposition, forming systems 1 and 2 of similar orientation due to curving. In addition, the ores filled left-lateral strike-slips in system 4, as well as transformational faults in system 3, which have a dual (shear-extension) nature due to the transverse orientation in the tension zone [15]. At the same time, we cannot completely exclude the existence of a second solution of the paragenetic analysis, the strike-slip setting (Fig. 1c–1), which was previously reconstructed for all three types of dikes (Fig. 1c–2-4). As in the main solution, the corresponding template explains the origin of the identified systems, except for the sublatitudinal ray 3, which was formed by the minimum number of gold veins.

DISCUSSION

Thus, it was established that the fracture network formed in the Tenka fault zone during left-lateral strike-slip displacements of the wings became the chanels for the intrusion of all types of dikes (Fig. 1 c–2-4). In contrast, the auriferous veins used it only partially (Fig. 1c–1), since the main ore-hosting role was played by the fractures formed in the tension setting that was transverse to the faults of the Tenka direction. In the opinions of the researchers who associate the mineralization with the Tenka fault zone, most auriferous bodies are localized both in fractures of left-lateral strike-slip paragenesis [18, 19] and in the systems of faults forming in the tension setting [10].

The results of the paragenetic analysis of dike and auriferous vein networks, as well as the different views of our predecessors on the parageneses of ore-stage fractures can be consistently combined in the model of the Natalka field, whose structure is determined by the nodal intersection of the regional fault zones. The first one is the Tenka fault zone, and the second is the transverse fault zone of the sublatitudinal strike, as it was previously suggested by some researchers [7, 4, 12]. It can be called Inyakan-Kolyma, since this is the name of the extended fault identified in the earlier research [7, 4]. One of its fragments in the study area is the Severnyi fault (Fig. 1a–B). However, judging by the sizes of the curves in the fractures of the Tenka direction (Fig. 1a, right) and the sublatitudinal boundaries of the Natalka ore field (Fig. 1a–B), the width of the study zone is several kilometers. In addition to the Severnyi fault, it includes the Yuzhnyi, Glukharinskii, Geologicheskii faults, as well as smaller sublatitudinal faults shown on the NGD geological-structural map at the scale of 1 : 10000 [3] and thickening in the central part of the study area. Taking into account the absence of a master fault plane near the surface, this disjunctive structure can be associated with hidden basement faults, whose intersection with large longitudinal fractures controls the localization of the ore fields in many activated areas [14, 12].

Considering the known shapes taken by the fractures during rock displacement in the shear zone, the faults of the Tenka direction bent due to right-lateral movements in the Inyakan-Kolyma sublatitudinal zone. In this case, the main solution for the ore vein network about the paragenetic analysis on the tension in the NE–SW direction can be made as a second-order setting, in which normal faulting occurs along the fractures of the Tenka direction (systems 1 and 2) under overall right-lateral strike-slip in the zone of the hidden transverse basement fault (Fig. 1c–5').

First-order solutions on left-lateral movements along the longitudinal Tenka fault and right-lateral displacements in the zone of the Inyakan-Kolyma hidden transverse basement fault indicate their conjugation. Thus, at the tectogenesis stage considered, the nodal junction developed in one strike-slip dynamic setting, with generalized orientation of subhorizontal axes of compression and tension, respectively, in the northwest and northeast directions. The movement to the west-northwest of the Kolyma-Omolon superterrane at the stage of its oblique collision with the Siberian craton should be considered as the most probable cause of occurrence of this setting [17, 20, 9, 2] (Fig. 1a–A). At the same time, the different age of the dikes and the veins with different parageneses of the fractures into which they intruded suggests two stages in the development of the fault node controlling the Natalka ore field.

Based on the presented results of the paragenetic analysis of the networks of different types of the dikes and the ore veins, mapped by our predecessors for the Natalkinskoe gold deposit at the scale of 1 : 10000, we infer about the development conditions of the ore-forming system that created the deposit, resulting from the faulting patterns established for the ore stage.

This system that formed a super-large orogenic gold deposit functioned in the geodynamic setting of collision between the Siberian craton and the Kolyma-Omolon superterrane (Late Jurassic–Early Cretaceous), which was reflected for the volcanogenic-sedimentary sequence of the study region in the form of a strike-slip stress state with generalized orientation of the NW–SE compression axis and the NE–SW tension axis.

The Tenka fault, the southeastern segment of the Adycha-Taryn zone of multiple activation and probably of mantle origin, is the structure controlling the emplacement of the magma- and ore-forming system [18, 12]. In the dynamic setting under study, northwest movements in the Tenka zone were left-lateral strike-slips and caused upward migrations of magmatic melts of mixed composition, followed by the formation of different-type and possibly a granitoid intrusive dikes in the NGD, which is expected to occur at depth according to the geophysical and other indirect data [5].

The transition from the pre- to ore stage of dike emplacement occurred during the Valanginian, when the area of ore-bearing fluid formation, controlled at a depth by the Tenka left-lateral strike-slip fault, faulted due to the activation of the sublatitudinal conjugate zone of the hidden basement fault in a right-lateral strike-slip setting. The large area of nodal intersection of these 1st-order fault zones determines the spatial boundaries of the ore-forming system and, as a consequence, the structural position of the Natalka ore field.

The conditions of tension that appeared at certain sections of the fault node are the key factor that ensured the intense rise of metal-bearing fluids and probably the formation of super-large ore clusters. For the Natalka deposit, they formed in the wings attributed to the Tenka zone of the Main and Northeast faults of the 2nd order, the movements along which in the zone of dynamic influence of the transverse right-lateral strike-slip acquired a normal fault character, and for the Omchak deposit, at the section of increased rock permeability at the curve of the Tenka fault, caused by its junction with the Glukharinskii fault and the smaller sublatitudinal fractures.

The decompression regime, related to the setting change from strike-slip to tension for the ore-controlling faults, intensified as the metal-bearing solutions migrated upward due to the decreasing lithostatic pressure. At the formation depths of the deposits, this probably led to phase separation of fluid [5], intense release of the gaseous component, and ore emplacement in the wings of the ore-conducting faults. Under the dynamic impact of the fluid with the pressure exceeding the lithostatic load, not only active faults of the 3rd and higher orders were opened, but also some joints of early structure formation stages (e.g., the stage of NE–SW horizontal compression [17, 2, 20]). The proposed mechanism of ore deposition caused the diversity in morphology and dimensions of vein-shaped and stockwork bodies that is typical of the NGD [4, 8].

CONCLUSIONS

In general, the Natalka ore-forming system developed in a structural-tectonic setting that is typical of super-large gold deposits and is characterized by the crust thickened during the collisional processes, by control of the magma- and ore-forming focus in the deep-seated longitudinal Tenka zone, its development in the strike-slip setting with the formation of a network of different-type dikes, followed by its activation at the intersection with the transverse zone of the hidden basement fault, which caused intense upward migration of the ore-bearing fluid through the permeable zones of normal faults (the Natalka deposit) or at the curves of strike-slip faults (the Omchak deposit) with the subsequent ore deposition in different-rank feathering faults and joints. These settings agree with the ideas about numerous sources of the fluid that formed the NGD [5], among which the magmatogenic source is the dominant, and the solutions of metamorphogenic and probably meteoric origin play a subordinate role.

The presented patterns were established based on the analysis of the networks of the dikes and the auriferous veins in the NGD, as well as a priori information about their isotopic age. This indicates the effective use of the variant of paragenetic analysis, which can be recommended at the preliminary stage of research into the patterns of structural control of ore deposits, when a priori data on an ore body and fracture network are available to specialists. The obtained results should be verified using complete field data on the spatial position and forms of occurrence of different-ranked fracture structures and ore bodies. Eventually, this will help develop the final model for the formation of the structure of the Natalkinskoe gold deposit, as a basis for predicting hidden mineralization and new deposits within its area.

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CONFLICT OF INTEREST

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

REFERENCES

1. V. V. Akinin, A. V. Alshevsky, G. O. Polzunenkov, S. A. Sergeev, and V. A. Sidorov, Russ. J. Pac. Geol. **17** (6), 570–586 (2023).
2. N. S. Bortnikov, G. N. Gamyanin, O. V. Vikent'eva, V. Yu. Prokof'ev, and A. V. Prokop'ev, Geol. Ore Deposits **52** (5), 339–373 (2010).
3. A. I. Kalinin, V. K. Kanishchev, and A. G. Orlov, *The 1 : 10 000 Geological-Structural Map of Natalkinskoe Ore Field* (Central Research Institute of Geological Prospecting for Base and Precious Metals, Moscow, 1991).
4. V. I. Goncharov, S. V. Voroshin, and A. A. Sidorov, *Natalkinskoe Gold Ore Field* (North-Eastern Integrated Res. Inst., Magadan, 2002) [in Russian].
5. N. A. Goryachev, O. V. Vikent'eva, N. S. Bortnikov, et al., Geol. Ore Deposits **50** (5), 362–391 (2008).
6. S. A. Grigorov, Rudy Met., No. 3, 44–48 (2006).

7. A. M. Zhirnov, Izv. Akad. Nauk SSSR, Ser. Geol., No. 3, 98–111 (1984).
8. A. I. Kalinin, V. K. Kanishchev, A. G. Orlov, and V. V. Gashtol'd, Kolyma, No. 10–11, 10–14 (1992).
9. A. A. Konstantinovsky, Geotectonics **41** (5), 337–355 (2007).
10. M. F. Kornilov, N. I. Mishin, and A. L. Panfilov, Nedropol'zovanie – XXI Vek, No. 3, 60–62 (2007).
11. S. V. Mezhov, Kolymsk. Vesti, No. 9, 8–17 (2000).
12. E. M. Nekrasov, Izv. Vyssh. Uchebn. Zaved., Geol. Razvedka, No. 6, 33–43 (2019).
13. V. P. Pluteshko, S. V. Yablokova, and V. M. Yanovskii, in *Ore Field Geology of the USSR East* (Central Research Institute of Geological Prospecting for Base and Precious Metals, Moscow, 1988), pp. 126–140 [in Russian].
14. E. A. Radkevich, I. N. Tomson, and N. V. Gorlov, Sov. Geol., No. 58, 170–185 (1956).
15. K. Zh. Seminskii, Geodynam. Tectonophys. **5** (2), 445–467 (2014).
16. L. A. Sim, Izv. Vyssh. Uchebn. Zaved., Geol. Razvedka, No. 10, 3–22 (1991).
17. *Sakha Republic (Yakutia): Tectonics, Geodynamics and Metallogeny* (Nauka/Interperiodika, Moscow, 2001) [in Russian].
18. V. G. Shakhtyrov, Estestv. Tekh. Nauki, No. 6, 313–319 (2009).
19. Yu. P. Yushmanov, Reg. Probl. **23** (1), 6–12 (2020).
20. R. J. Goldfarb, R. D. Taylor, G. S. Collins, N. A. Goryachev, and O. F. Orlandini, Gondwana Res. **25** (1), 48–102 (2014).

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