

M. K. Bakhteev, O. A. Morozov, and S. R. Tikhomirova

Structure and Age of Serpentinite Melange of the Kamchatskii Mys Peninsula (Eastern Kamchatka)

Inclusions in the serpentinite melange that separates tectonic plates are observed to contain formations of fundamental importance for solving theoretical problems. This paper describes inclusions of Late Miocene (Early Pliocene?) subvolcanic bodies, sedimentary rocks of the Miocene Tyushevskii series, and exotic lumps of aporhyolite and apodacite crystalline schists. The protracted time of formation of melange and the young age of melange-forming movements corresponding to the boundary of the Miocene and Pliocene or Early Pliocene are substantiated. Possible sources of metamorphosed acid magmatic rocks that are supplied during horizontal movements of allochthonous masses and that indicate root zones of tectonic nappes are examined.

The Kamchatskii Mys peninsula has attracted researchers due to its special tectonic position in the frontal juncture zone of the Kuril-Kamchatka and Aleutian island arcs, which are distinguished by the structure of the crust and accretionary basement and by island-arc magmatism. Without data on the peninsula's geology, it is impossible to compile retrospective geodynamic models of the northwestern Pacific. The geological structure of the peninsula was detailed in [2, 3, 5–9]. In 1990 the authors studied the Pikezh dislocation zone (southeastern part of the peninsula) [9] and surroundings; they obtained new data on the composition of inclusions and the age of the serpentinite melange that substantially supplement and alter existing theories.

The siliceous-volcanogenic-terrigenous Afrika series, which consists of the Smaginskii and Pikezh suites, are widespread in the southeastern area of the peninsula. The authors endorse dividing the series into the two suites identified earlier [5, 9], even though this division has been disputed [7, 8]. The Early-Late Cretaceous age of the series, established in [1], is confirmed. Siliceous rocks of the Smaginskii suite (upper subsuite) were found to contain the following Albian–Cenomanian radiolaria: *Pseudodictyomitra* cf. *pseudomacrocephala* (Squinabol), *Thanarla pulchra* (Squinabol), *T.* cf. *veneta* (Squinabol), *Holocryptocanium barbui* Dumitrica, *Alievium* cf. *helenae* Shaaf, *Xitus* cf. *alievi* (Foreman), *Xitus* aff. *spicularius* (Aliev). Late Cretaceous radiolaria found in the Pikezh suite (lower subsuite) include *Alievium* cf. *praegallowayi* Pessagno, *Amphipyndax stocki* (Campbell et Clark) (authors' samples, identification by N. Yu. Bragin, 1991). Less developed are siliceous-terrigenous members of the Tyushevskii series of the Miocene, which have tectonic contacts with the Afrika series.

Cretaceous and Miocene rocks are unconformably covered by terrigenous deposits of the Ol'khovskii and Lakhtakskii sequences of Upper Pliocene–Middle Pleistocene and Quaternary unconsolidated sediments. Intrusive formations are represented by subvolcanic dikes of basic and medium rocks of subalkalic and alkalic series that intrude deposits of the Afrika and Tyushevskii series, are not encountered in the Ol'khovskii sequence, and are dated Late Miocene or Early Pliocene.

The sheet-like nappe structure of the southeastern part of the

peninsula, known since the beginning of the 1980s, is established by many researchers [2, 5–7] and has been confirmed and revised by the authors. On the left bank of the Pereval'naya-1 R. the Afrika series forms a paraautochthon, but to the west, along with the Tyushevskii series, it forms an allochthon that consists of several tectonic plates separated by sheets of serpentinite melange.

The melange matrix consists of serpentinites, in places altered to serpentinite clay. Inclusions in the form of lumps and flattened blocks up to several meters across are represented by diverse formations of different age. Noted earlier among them were rocks widely developed in the southern part of the peninsula: dunites and peridotites, gabbroids and diabases (usually encountered in the Soldatskii and Olenegorskii massifs to the west), siliceous varieties, tuffs, sandstones, tuffogenic sedimentary rocks in the Smaginskii and Pikezh suites, and also exotic lumps of metamorphic rocks [5].

The structure of the melange changes upsection in the allochthon. A typical polymictic melange with inclusions of an ophiolite association, metabasites, and rocks of the Afrika series is observed in the lower serpentinite sheets. The upper sheets contain a more monomictic melange, whose inclusions are dominated by ophiolites and rocks of greenschist and epidote-amphibolite metamorphism facies.

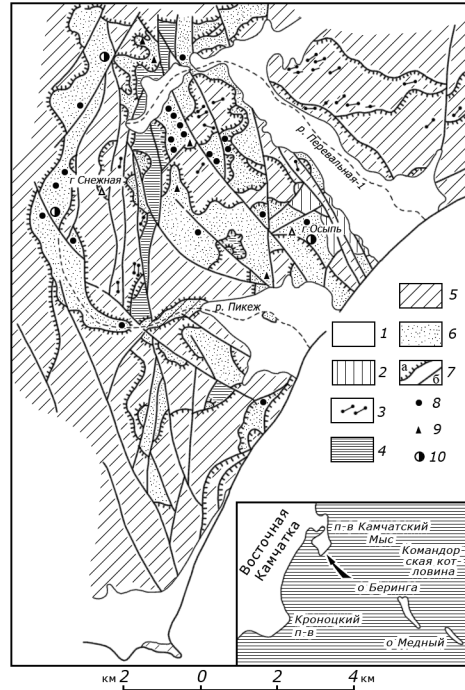
Among inclusions the authors found rocks previously not established but which are fundamentally important for justifying the age of the melange and overthrusting and for determining the root zones of tectonic nappes and amplitudes of horizontal displacements. They include subvolcanic alkalic gabbroids, subalkalic diorite porphyrites, syenite porphyries and trachytes, Miocene terrigenous and tuffogenic sedimentary rocks, and some greenschist varieties.

The subvolcanic inclusions established in serpentinite melange at the source of the Pikezh and Pereval'naya-1 rivers, in their watersheds, in the area of the city of Osyp, and west and northeast of Snezhnaya Mt. (Fig. 1), have typical cigar, egg, and spherical shapes. The length of the cigar-shaped inclusions reaches 10 m, diameter 1.5–3 m; the diameter of the spheres and “eggs” is 1–5 m, occasionally 10–12 m. The inclusions are surrounded by a margin not thicker than 5 cm consisting of peridotites that are serpentinitized and altered to hornfels. Numerous slickensides are observed along their contacts with the serpentinite matrix.

Alkalic gabbroids. Dark green, greenish-gray to black, with massive texture. Main minerals: plagioclase (andesine No. 40–45, in margin areas No. 30–35 (40–45%)); amphibole (barkevikite, in exterior areas of zonal varieties riebeckite (to 40%)); clinopyroxene (augite (10–15%), potassium-sodium feldspar (to 15%)); accessory (biotite, olivine, ore mineral, and apatite). Panidiomorphic-grained structure, fine- to medium-grained, sometimes porphyric, hypidiomorphic-grained. Phenocrysts are formed by amphibole, clinopyroxene, occasionally completely serpentinitized olivine. Small areas of volcanic glass and interstitial segregations are noted. Secondary minerals include chlorite, epidote, zeolites, and calcite. Petrographically the rocks correspond to camptonites.

Fig. 1. Geological map of Pikezh dislocation zone.

1–2) deposits: 1) Quaternary, 2) Upper Pliocene-Middle Pleistocene (Ol'khovskii sequence); 3) Late Miocene (Early Pliocene?) dikes of alkalic gabbroids, subalkalic diorite porphyrites, syenite porphyries, trachytes; 4–5) series: 4) Tyushevskii, Miocene, 5) Afrika, Lower–Upper Cretaceous; 6) serpentinite melange; 7) faults: overthrusts and nappes (a), normal, upthrust, and strike-slip faults (b), 8–10) inclusions in serpentinite melange of: 8) Late Miocene (Early Pliocene) subvolcanic rocks, 9) Miocene terrigenous and argillaceous-siliceous rocks of Tyushevskii series, 10) apophyllite and apodacite albite-chlorite-quartz schists.



Subalkalic diorite porphyrites. Gray, with massive texture. Main minerals include grains and glomeroporphyric growths of conventional hornblende, grains of plagioclase (andesite), xenomorphic crystals of sodium-potassium feldspar, relict grains of augite inside large hornblende segregations, and biotite flakes. Accessory minerals are represented by magnetite and apatite; secondary (calcite, chlorite, indistinguishable products of feldspar decomposition). Porphyric structure with prismatic-grained matrix and subparallel orientation of hornblende phenocrysts. In terms of composition and relative quantity of dark minerals, augite-hornblende and hornblende varieties are identified.

Syenite porphyries. Gray, massive, sometimes amygdaloidal, with porphyric structure. Phenocrysts are composed of plates and glomeroporphyric growths of potassic-sodic feldspar, idiomorphic grains of augite, zonal hornblende with opacite margins. The ground mass is micrograiny and consists of grains of potassic-sodic feldspar, plagioclase (andesite No. 40–46), quartz (not more than 5%), and ore mineral. The quartz content often rises to 15%, which allows the quartz variety to be identified. Secondary minerals include chlorite, calcite, epidote, and politic aggregate after feldspar. Rare amygdules are filled with chlorite and epidote.

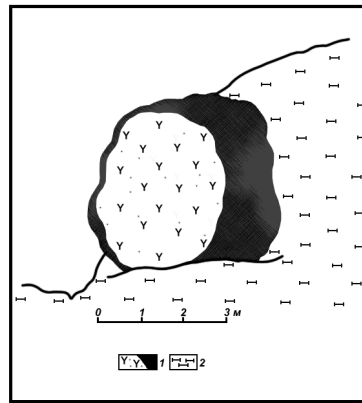
Trachytes. Gray, porous, with porphyric structure. Phenocrysts (to 30–35% of the rock volume) are represented by augite and hornblende, often forming glomeroporphyric growths. The ground mass consists of microliths of potassic-sodic feldspar and a subordinate number of grains of plagioclase, accessory minerals, apatite, and magnetite. Of the secondary minerals epidote and fine-flake chlorite are widely developed. The structure of the ground mass is trachytic.

All the described petrographic types in inclusions of the melange are identical to rocks of dikes in a belt that ran across the peninsula west

of the city of Afrika. Individual dikes of the same rocks are noted in the region of the city of Snezhnaya, where they are controlled by submeridional faults. Cutting relationships with rocks of the Tyushevskii series and the absence of bodies of the dike complex among younger deposits establish the Late Miocene (or Early Pliocene) age of the subvolcanic formations and consequently of the inclusions. Initially subvolcanic rocks of the inclusions are represented not only by the dikes involved in melange formation, but also, judging by the shape of the fragments, tube-shaped bodies (Fig. 2) that transect the melanocratic ophiolitic basement.

Fig. 2. Inclusion of tube-shaped body of syenite porphyries in serpentinite matrix.

Right bank of Pereval'naya-1 R., upper course. 1) syenite porphyries with margin of serpentinites altered to hornfels; 2) tectonized serpentinites.



Miocene terrigenous and tuffogenic sedimentary rocks in serpentinite melange inclusions are encountered in the upper course of the Pereval'naya-1 R., along the left and right tributaries, and also in the lower and upper courses of the Spotykach stream, where they comprise individual lumps and flattened blocks up to 200 m long. Fragments of the stratigraphic profile, which consists of lower coarse detrital and upper argillaceous-siliceous members, are preserved in the coarsest inclusions.

The coarse detrital member is represented by interlayered boulder-pebble and gravel conglomerates and by poorly sorted greywacke and inequigranular lace spar greywacke sandstones. Rock fragments are dominated by flints, jaspers, basalts, and biotitic sandstones of the Afrika series, as well as andesites, dacites and their tuffs, aleurolites, and argillaceous-siliceous varieties. Mineral fragments include albite, andesite, brown and green biotite, quartz, occasionally hornblende and titanium augite. The cement in the sandstones is carbonate, less often argillaceous-siliceous, joint and pore-filling, sometimes basal.

The argillaceous-siliceous member is composed of opoka-like argillaceous-siliceous rocks with streaks of tuff aleurolites. The argillaceous-siliceous rocks consist of a hydromica opal matrix which contains fossil diatom algae, radiolaria, and to a lesser extent spicules of sponges and foraminifers, replaced by opal, chalcedony, and occasionally quartz. Present in the terrigenous admixture (8–15% of the rock volume) are andesite No. 40–45, quartz, clinopyroxene, biotite, rarely hornblende, fragments of volcanic glass, silicites, sandstones, and medium extrusives. The fragments are angular, often similar in shape to pyroclastic particles.

The texture is aleuritic biogenic collomorphic. Transitions to radiolarian arenaceous aleurolites with basal argillaceous siliceous cement are observed. The structure is often microlens-like and lamellar due to small lenses of aleuritic material, pelitic material, and carbonized plant detritus.

Tuff aleurolites possess a similar mineral composition, but are distinguished by the sharp predominance of acicular mineral fragments, primarily plagioclase, and by a spotty texture due to uneven redistribution of siliceous material in the basal hydromica opal cementing matrix.

Inclusions of terrigenous and argillaceous-siliceous rocks correspond to deposits of the Tyushevskii series, which comprise one of the tectonic sheets in the Pikezh dislocation zone, whose Early and Middle Miocene age is established by bivalve fossils. The argillaceous-siliceous member is analogous to the middle part of the Middle Miocene Talovskii suite on the Kronotskii isthmus. Apodacitic and aporhyolitic albite-chlorite-quartz schists were first discovered among inclusions of metamorphic rocks represented by greenschists and amphibolites.

Apodacitic albite-chlorite-quartz schists, encountered in inclusions of melange in the form of isolated lumps (5–10 m across) at the headwaters of the Pereval'naya-1 and Pikezh rivers are represented by light greenish-gray and light bluish-gray rocks of puckered texture and blastoporphyric structure. Blastoporphyric segregations, which comprise 10–25% of the rock volume, are composed of quartz and albite and have irregular outlines due to intergrowth of matrix minerals along the edges. The segregations often lose their initial shape and acquire oval outlines, elongated in the form of lenses in the direction of the schistosity. The matrix consists of an aggregate of irregular albite and quartz grains, between which chlorite flakes, actinolite needles, and fine-grained accumulations of titanite and epidote are distributed. The structure of the matrix is microlepidogranoblastic. The lenslike structure is due in places to small lenses of an aggregate of quartz, albite, and sometimes potassic-sodic feldspar and reflects relict lens-shaped fluidization.

Judging by the chemical composition (64.40% SiO₂, 0.55% TiO₂, 14.44% Al₂O₃, 5.71% Fe₂O₃, 2.84% FeO, 0.47% MnO, 3.60% MgO, 2.29% CaO, 8.07% Na₂O, 0.24% K₂O, and <1.0% P₂O₅; average of two analyses), the original composition of the schists corresponds to high-alumina dacites of the normal series.

Discovered in the region of the city of Osyp are inclusions of aporhyolitic albite-chlorite-quartz schists (5–6 m across), distinguished from apodacitic schists by a smaller amount (5–10%) of blastoporphyric quartz and albite segregations and a significantly greater quartz content in the lepidogranoblastic and granoblastic matrix. The chemical composition (76.98% SiO₂, 0.3% TiO₂, 13.03% Al₂O₃, 2.8% Fe₂O₃, 1.45% FeO, 0.17% MnO, 0.68% MgO, 2.04% CaO, 4.4% Na₂O, 0.28% K₂O, and <1.0% P₂O₅) corresponds to very high-alumina rhyolites of the potassic-sodic series of the normal series.

Conclusion

The melange formed over a long period. Its generation, linked to the beginning of overthrusting of allochthonous sheets, occurs at the end of

the Cretaceous, as evidenced by the weaker dislocation of thick Cenozoic sequences in the northern part of the peninsula than of Cretaceous deposits in the south [5]. The concluding stage of melange formation is linked to horizontal movements at the Miocene–Pliocene boundary or in the Early Pliocene, which is indicated by the involvement of deposits of the Tyushevskii series and Late Miocene (Early Pliocene) subvolcanic bodies in melange formation.

Finds of metamorphic inclusions, including apodacitic and aporhyolitic schists, bring into sharp focus the question of the roots of tectonic nappes. According to some theories, the Olenegorskii and Soldatskii massifs, which are a relative [относительным] autochthon, are located in the root zone of the nappes of the Pikezh zone. The amplitude of horizontal dislocations is 7–10 km [5]. There is no explanation for the appearance of metamorphic formations in the melange. Other researchers believe [7] that the Olenegorskii and Soldatskii massifs are found in allochthonous bedding, and the nappes of the Pikezh zone within the peninsula are rootless. In this case the territories west of the Kamchatskii Mys peninsula on a line connecting the Ganal'skii and Khavyvenskii projections of the metamorphic basement could have served as the “birthplace” of the nappes. Specifically within these territories rocks analogous to inclusions of serpentinite melange are encountered in the metamorphite profiles [4].

References

1. N. Yu. Bragin, V. P. Zinkevich, O. V. Lyashenko, et al., “Middle Cretaceous (Aptian-Turonian) Deposits in the Tectonic Structure of Eastern Kamchatka,” *Essays on the Geology of the Eastern USSR [Ocherki po geologii Vostoka SSSR]*. Moscow, Nauka, 1986.
2. V. P. Zinkevich, A. D. Kazimirov, A. A. Peive, et al., “New Data on the Tectonic Structure of the Kamchatskii Mys Peninsula (Eastern Kamchatka),” *Dokl. AN SSR*, Vol. 285, No. 4, 1985.
3. M. S. Markov, V. A. Seliverstov, M. Yu. Khotin, et al., “Juncture of the Structures of Eastern Kamchatka and the Aleutian Island Arc,” *Geotektonika*, No. 5, 1969.
4. M. N. Shapiro, V. A. Yermakov, A. Ye. Shantser, et al., *Essays on the Tectonic Development of Kamchatka [Ocherki tektonicheskogo razvitiya Kamchatki]*. Moscow, Nauka, 1987.
5. A. A. Belov, V. S. Burtman, V. P. Zinkevich, et al., *Tectonic Stratification of the Lithosphere and Regional Geological Studies [Tektonicheskaya rassloennost' litosfery i regional'nye geologicheskie issledovaniya]*. Moscow, Nauka, 1990.
6. A. V. Fedorchuk, “Tectonic and Magmatic Evolution of the Area of Juncture of the Kuril-Kamchatka and Aleutian Island Arcs,” *Izv. vuzov. Geol. i razv.*, No. 2, 1990.
7. A. V. Fedorchuk, “Polygenetic Ophiolites of the Kamchatskii Mys Peninsula,” *Izv. AN SSSR. Ser. geol.*, No. 2, 1991.

8. A. V. Fedorchuk, V. S. Vishnevskaya, I. N. Izvekov, et al., "New Data on the Structure and Age of Siliceous Volcanogenic Rocks of the Kamchatskii Mys Peninsula (Eastern Kamchatka)," *Izv. vuzov, Geol. i razv.*, No. 11, 1989.
9. M. Yu. Khotin, *Extrusive Tuff Siliceous Formation of the Kamchatskii Mys Peninsula [Effuzivno-tufovo-kremnistaya formatsiya poluostrova Kamchatskii Mys]*. Moscow, Nauka, 1976.

Moscow State Geological
Research Academy

МИНИСТЕРСТВО НАУКИ, ВЫСШЕЙ ШКОЛЫ
И ТЕХНИЧЕСКОЙ ПОЛИТИКИ РОССИЙСКОЙ ФЕДЕРАЦИИ
КОМИТЕТ ПО ВЫСШЕЙ ШКОЛЕ

ИЗВЕСТИЯ
ВЫСШИХ УЧЕБНЫХ ЗАВЕДЕНИЙ

ГЕОЛОГИЯ И РАЗВЕДКА

НАУЧНО-МЕТОДИЧЕСКИЙ ЖУРНАЛ

№ 3

МАЙ—ИЮНЬ

ИЗДАЕТСЯ С ЯНВАРЯ 1958 г.

Выходит 6 раз в год

МОСКВА — 1993

Редакционная коллегия

Чл.-корр. РАН Ю. М. Арский, В. Е. Бойцов, А. М. Гальперин, Л. Г. Грабчак (главный редактор), Д. С. Даев, М. Н. Денисов, Е. И. Зальцман (отв. секретарь), А. Г. Калинин, В. Я. Колесник, В. И. Комащенко, Л. Л. Ляхов, Б. П. Макаров, чл.-корр. РАН А. А. Маракушев, Ю. Б. Марин, В. А. Мейер, В. М. Моралев, чл.-корр. РАН И. Я. Некрасов, Ю. Б. Осипов, Б. С. Панов, В. П. Петров, В. Г. Румынин, Ж. В. Семинский, А. К. Соколовский (зам. главного редактора), С. В. Тихомиров (зам. главного редактора), М. В. Толкачев, Н. Н. Трофимов, Г. Б. Удинцев, акад. РАН В. Е. Хаин, В. М. Цейслер (зам. главного редактора), В. М. Швец.

Сдано в набор 24.12.92. Подписано в печать 26.04.93. Формат 70×108^{1/16}.
Бумага офсетная. Гарнитура литературная. Печать высокая. Усл. печ. л. 12,6.
Усл. кр.-отт. 13,0. Уч.-изд. л. 13,9. Тираж 790 экз. Заказ № 296.

Адрес редакции: Москва, 117873, ул. Миклухо-Макляя, 23, МГГА, тел. 433-61-66.
АО «Чергановская типография» Мосгорпечать
133545, Москва, Варшавское шоссе, д. 129а.

© Изв. вузов. Геология и разведка, 1993