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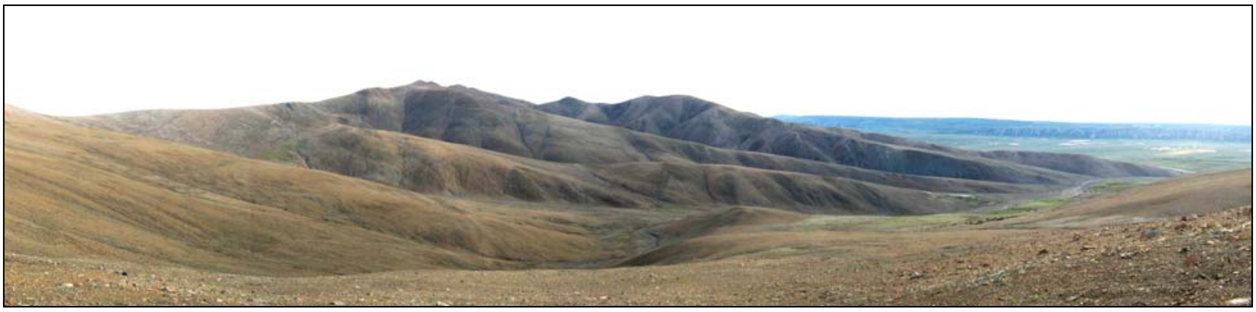
Тезисы
совместного российско-японского рабочего совещания «Офиолиты и связанные с ними комплексы: значение для геодинамических интерпретаций»
15-16 июня 2010 г.

Abstracts of the Russian – Japanese workshop symposium "Ophiolites and related complexes: significance for geodynamic interpretations"
June 15-16, 2010



Совещание проводится в рамках совместного российско-японского проекта (№ 09-05-92103) Российского фонда фундаментальных исследований (РФФИ) и Японского Общества Продвижения науки (JSPS)

The workshop is held within the scope of the joint Russian-Japanese project (No 09-05-92103) of the Russian Foundation for Basic Research and Japanese Society for Promotion of Science

Москва-2010 **Moscow -2010**

PROGRAM - ΠΡΟΓΡΑΜΜΑ

Day 1: June 15, 2010

10-00 – 10-30	**Ishiwatari A.*, Machi S.**, Hayasaka Y.***, Ledneva G.V.****, Sokolov S.D.****, Palandzhyan S.A.****, Bazylev B.A.******* Paleozoic ophiolitic complexes in Northeast Russia: Evidence for opening of the Paleo-Pacific ocean? *(*Tohoku University, Japan; **Kanazawa University, Japan; ***Hiroshima University, Japan; ****Geological Institute RAS, Moscow Russia; *****Vernadsky Institute RAS, Moscow, Russia)*
10-30 – 11-00	**Palandzhyan S.A.** On principles of defining ophiolites *(Geological Institute RAS, Moscow, Russia)*
11-00 – 11-30	**Silantyev S.** Oceanic Core Complex as a key to reconstruction of sequence of magmatic, metamorphic, and hydrothermal events at accretion of the slow spreading ridge lithosphere *(Vernadsky Institute of Russian Academy of Sciences)*
11-30 – 11-45	Coffee-break
11-45 – 12-15	**Sharkov E.V.** What is oceanic spreading in low-spreading ridges? Geological-petrological processes in the axis part of the Mid-Atlantic Ridge: Evidence for the Sierra Leone test area, 5-7^o N *(IGEM RAS, Moscow, Russia)*
12-15 – 12-45	**Savelieva G.N.*, Batanova V.G**, Sobolev A.V**** Uralian ophiolites: diversity of mantle sections and channels of melt transport in the upwelling mantle *(*Geological Institute RAS, Moscow, Russia; **Vernadsky Institute RAS, Moscow, Russia)*
12-45 – 13-15	**Fedotova A.A.*, Khain E.V.*, Razumovsky A.A.*, Remizov D.N.**, Nekrasov G.E.*** The Dzela mafic unit (Polar Urals): the origin and relation to the Voykar-Synya massif **Geological Institute RAS, Moscow, Russia; **Karpinsky Russian Geological Institute, St. Petersburg, Russia)*
	Extended break
14-30 – 15-00	**Khain E.V., Fedotova A.A.** Ophiolites and mafic-ultramafic intrusions of the Central-Asian belt: Polar Urals, Eastern Sayan, Western Mongolia and Northern Baikal regional examples *(Geological Institute RAS, Moscow, Russia)*
15-00 – 15-30	**Zakariadze G.S.*, Korikovsky S.P.**, Solov'eva N.V.*** Problems of origin of the pre-Mesozoic oceanic basins of the Eastern Mediterranean area *(*Vernadsky institute RAS, Moscow, Russia; **IGEM RAS, Moscow, Russia)*
15-30 – 16-00	**Galoyan Gh., Melkonyan R.** Ophiolites of the Lesser Caucasus (Armenia) and their significance for Tethyan geodynamic interpretations *(Institute of Geological Sciences, National Academy of Sciences of Armenia, Yerevan, Republic of Armenia)*
16-00 – 16-15	Coffee-break
16-15 – 16-45	**Luchitskaya M.V.** Plagiogranite complexes of supra-subduction ophiolites (Penzhina region, Kamchatsky Mys peninsula, Taigonos Peninsula) *(Geological Institute RAS, Moscow, Russia)*
16-45 – 17-15	**Ledneva G.V.*, Bazylev B.A.**, Ishiwatari A.***** Lower crustal high-P plutonic complexes of various geodynamic settings: a review of geological and petrological data *(*Geological Institute RAS, Moscow Russia; **Vernadsky Institute RAS, Moscow, Russia; ***Tohoku University, Tohoku, Japan)*
	Discussion

Day 2: June 16, 2010

10-00 – 10-30	**Sokolov S.D.** Geological structures of Chukotka and tectonic position of ophiolites *(Geological Institute RAS, Moscow, Russia)*
10-30 – 11-00	**Hayasaka Y.*, Moiseev A.V.**, Sokolov S.D.**, Ishiwatari A.***, Machi S.****, Ledneva G.V.**, Palandzhyan S.A.**, Bazylev B.A.******* Methodology and philosophy for detrital zircon chronology using EPMA, LA-ICP-MS, and SHRIMP, and outline of results for the Paleozoic to Mesozoic complex in the Ust'-Belaya Range, West Koryak thrust and fold Belt, Far East Russia *(*Hiroshima University, Japan; **Geological Institute RAS; Moscow, Russia; *** Tohoku University, Japan; ****Kanazawa University, Japan; *****Vernadsky Institute RAS, Moscow, Russia)*
11-00 – 11-30	**Chekhov A.D.** Structure and tectonic setting of ophiolite belts of the Koryak Highlands (*North-East Interdisciplinary Science Research Institute FEB RAS, Magadan, Russia*)
11-30 – 12-00	**Bazylev B.A.*, Ledneva G.V.**, Kononkova N.N.*, Ishiwatari A.***** Subduction-reworked subcontinental lithospheric mantle: an example from peridotites and plutonic rocks of the Ust'-Belaya massif (Chukotka) *(*Vernadsky Institute RAS, Moscow, Russia;** Geological Institute RAS, Moscow, Russia; ***Tohoku University, Tohoku, Japan).*
12-00 – 12-15	Coffee-break
12-15 – 12-45	**Machi S.*, Ishiwatari A.**, Hayasaka Y.***, Ledneva G.****, Sokolov S.D.****, Palandzhyan S.A.****, Moiseev A.V.****, Bazylev B.A.*****, Morishita T.*** Serpentinized peridotites from the Ust'-Belaya ophiolite, Far East Russia: serpentinization and metasomatism of the mantle wedge (**Kanazawa University, Kanazawa, Japan; **Tohoku University, Tohoku, Japan; ***Hiroshima University, Hiroshima, Japan; ****Geological Institute RAS, Moscow, Russia; *****Vernadsky Institute, Moscow, Russia)*
12-45 – 13-15	**Moiseev A.V.*, Sokolov S.D.*, Hayasaka Y.**** Middle Mesozoic cherty depositions northern Algansky terrane (Koryak Highlands) (**Geological Institute RAS, Moscow, Russia; **Hiroshima University, Hiroshima, Japan)*
	Discussion

Тезисы не рецензировались, напечатаны в авторской редакции

На титульном листе - *Ультрамафиты массива г. Эльденыр (Чукотка),*
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SUBDUCTION-REWORKED SUBCONTINENTAL LITHOSPHERIC MANTLE: AN EXAMPLE FROM PERIDOTITES AND PLUTONIC ROCKS OF THE UST'-BELAYA MASSIF (CHUKOTKA)

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The Ust'-Belaya ultramafic-mafic massif is located in the mountains of the same name and belongs to the structures of the West Koryak fold system. It is commonly considered as an ophiolite complex of the presumably Paleozoic age. The presented below conclusions are resulted from the 2007-2008 field investigations, petrographic and mineralogical studies of the original rock collection.

Among ultramafic rocks of the Ust'-Belaya massif, we previously distinguished several rock varieties and gave characteristics of their mineralogy (Bazylev et al., 2009). The varieties are spinel lherzolites, spinel harzburgites, dunites, rocks of the layered cumulative suite of dunite – plagioclase peridotite – olivine gabbro – anorthosite, cumulative plagioclase peridotite bearing metamorphic hercynite and plagioclase-free cumulate rocks bearing primary magmatic hercynite. It was inferred that ultramafic rocks are dominated by dunites and spinel harzburgites; some of spinel lherzolites are fertile peridotites alike those of the subcontinental lithospheric mantle, and spinel harzburgites are shown to be originated in a supra-subduction setting. New data on both peridotites and gabbroic rocks allow a better understanding of geologic and geodynamic evolution of the massif formation.

Compositions of primary minerals of spinel peridotites of the Ust'-Belaya massif reflect two distinct episodes of a partial melting of the mantle. Restites produced during one of these episodes are spinel lherzolites, sparsely high-Na clinopyroxene-bearing harzburgites similar to those of "orogenic" lherzolites of within-plate setting. Restites generated during another episode of a partial melting are spinel harzburgites and rare medium-Na clinopyroxene-bearing lherzolites originated in a subduction setting.

The boundary between these two types of restite peridotites is sharp, but it is not tectonic; all findings of lherzolites bearing medium-Na clinopyroxenes are located along this boundary (a possible front of the melting) and, thus, suggest a transitional nature of this rock type. The fertile spinel lherzolites possibly represent the matter whose melting was resulted in producing the spinel harzburgites. A possible mechanism of harzburgite (and some dunite) generation is a lherzolites partial melting induced by reaction of penetrating subduction-derived melts with peridotites.

Compositions of spinels from slightly differentiated dunites and chromitites of the massif suggest that at least four different melts were initial ones for suites of cumulative rocks. Some cumulative rocks were originated in a within-plate setting; others were generated in a subduction setting. Crystallization of both took place at high pressure (9-11 kb as indicated by high Al_2O_3 contents in clinopyroxenes and hornblendes).

The zircon U-Pb ages of two gabbroic rocks of the Ust'-Belay massif (Ledneva et al., in press) along with the geological relationships between rocks suggest that both episodes of the partial melting (in within-plate and subduction settings), which are expressed in restites of the massif, took place in the pre-Cambrian. The gabbroic rocks belong to different series and are significantly different in age, about 800 and 575 Ma.

Thus, the Ust'-Belaya massif represent the deep fragment of the subcontinental mantle that was both partially melted due to penetration of subduction-derived melts and intruded by these melts in the pre-Cambrian time. The latter was resulted in formation of layered ultramafic-mafic and hornblende gabbro bodies. The ultramafic and mafic rocks were not formed in a spreading setting, and they are not genetically related to Devonian N-MORBs and sediments.

The work was supported by the Russian Foundation for Basic Research (projects No 09-05-92103 and 10-05-00529).

Bazylev B.A., Ledneva G.V., Kononkova N.N., Ishiwatari A., Solov'eva N.B., Fomichev N.N. Typification of peridotites from Ust'-Belaya ultramafic-mafic massif (Chukotka) by mineral compositions: preliminary results // Mafic-ultramafic complexes of folded regions and related deposits. 3-d International conference. Yekaterinburg, Institute of geology and geochemistry, Ural Division Russian Academy of Sciences, 2009. V. 1. P. 73-76.

Ledneva G.V., Bazylev B.A., Lebedev V.V., Kononkova N.N., Ishiwatari A. U-Pb ages of zircons from gabbroic rocks of the Ust'-Belay ultramafic-mafic massif (Chukotka) and their interpretation // Geochemistry International (in press).

ПРЕОБРАЗОВАНИЕ СУБКОНТИНЕНТАЛЬНОЙ ЛИТОСФЕРНОЙ МАНТИИ НАД ЗОНОЙ СУБДУКЦИИ НА ПРИМЕРЕ УСТЬ-БЕЛЬСКОГО МАССИВА (ЧУКОТКА)

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Усть-Бельский ультрамафит-мафитовый массив расположен в одноименных горах и относится к структурам Западно-Корякской складчатой системы. Исследователями массив относился к офиолитам предположительно позднепалеозойского возраста. Представленные ниже выводы основаны на результатах полевого изучения массива в 2007 и 2008гг. и петрографического и минералогического изучения коллекции отобранных образцов.

Ранее (Базылев и др., 2009) среди ультрамафитов Усть-Бельского массива нами были выделены и минералогически охарактеризованы следующие типы пород: шпинелевые лерцолиты; шпинелевые гарцбургиты; дуниты; породы полосчатого комплекса кумулятивных дунитов – плагиоклазовых перидотитов – оливиновых габбро – анортозитов; кумулятивные плагиоклазовые перидотиты с метаморфическим герцинитом; бесплагиоклазовые кумулятивные породы с первичномагматическим герцинитом. Был сделан вывод о преобладании среди ультрамафитов массива дунитов и шпинелевых гарцбургитов, установлено присутствие среди шпинелевых лерцолитов массива фертильных пород, соответствующих перидотитам субконтинентальной литосферной мантии, установлена надсубдукционная обстановка формирования шпинелевых гарцбургитов. Привлечение новых аналитических данных как по перидотитам, так и по габброидам массива позволяет лучше представить геологическую и геодинамическую историю его формирования.

Составы первичных минералов шпинелевых перидотитов Усть-Бельского массива отражают два различных эпизода частичного плавления мантийного материала. Реститами после одного эпизода являются шпинелевые лерцолиты, реже гарцбургиты с высоконатровыми клинопироксенами, аналогичные субконтинентальным «орогенным лерцолитам» и сформированные во внутриплитной обстановке. Реститами после другого эпизода являются шпинелевые гарцбургиты и, вероятно, редкие лерцолиты с умеренно-натровыми клинопироксенами, сформированные в надсубдукционной обстановке.

Между двумя типами реститовых перидотитов в пределах массива прослеживается достаточно четкая граница, которая не является тектонической; все находки лерцолитов с умеренно-Na клинопироксенами приурочены к этой границе, что свидетельствует о переходном характере этих пород (возможно, маркирующих фронт плавления). При этом фертильные шпинелевые лерцолиты массива являются вероятным субстратом, за счет частичного плавления которого формировались шпинелевые гарцбургиты. Вероятным механизмом формирования гарцбургитов (и части дунитов) массива является индуцированное плавление лерцолитов за счет реакции с просачивающимися надсубдукционными расплавами.

Составы шпинелидов в слабодифференцированных дунитах и хромититах массива указывают на существование по крайней мере четырех различных расплавов, родоначальных для серий кумулятивных пород. Часть кумулятивных пород массива формировалась во внутриплитной обстановке, часть – в надсубдукционной; кристаллизация и тех и других происходила при высоком давлении (9-11 кбар, судя по высокому содержанию глинозема в клинопироксенах и роговых обманках).

Данные по изотопному датированию циркона из двух образцов габброидов Усть-Бельского массива (Леднева и др., в печати) в совокупности с геологическими соотношениями пород позволяют отнести оба эпизода частичного плавления, проявленные в реститах массива (во внутриплитной и надсубдукционной обстановках) к докембрийскому времени. При этом габброиды массива, относящиеся к разным сериям, имеют древний и существенно различающийся возраст – около 800 млн.л. и около 575 млн.л.

Таким образом, Усть-Бельский ультрамафит-мафитовый массив представляет собой глубинный фрагмент субконтинентальной литосферной мантии, которая в докембрийское время претерпела как частичное плавление, инициированное просачиванием надсубдукционных расплавов, так и внедрение этих расплавов с формированием расслоенных мафит-ультрамафитовых тел и тел роговообманковых габброидов. Ультраосновные и основные плутонические породы массива не были сформированы в обстановке спрединга и генетически не связаны с девонскими базальтами типа N-MORB и осадками.

Работа выполнена при поддержке Российского Фонда Фундаментальных исследований (проекты № 09-05-92103 и 10-05-00529).

Базылев Б.А., Леднева Г.В., Кононкова Н.Н., Ишиватари А., Соловьева Н.В., Фомичев Н.Н. Типизация перидотитов Усть-Бельского ультрамафит-мафитового массива (Чукотка) по составам минералов: предварительные данные // Ультрабазит-базитовые комплексы складчатых областей и связанные с ними месторождения. Материалы третьей международной конференции. Екатеринбург: Институт геологии и геохимии УрО РАН, 2009. Т. 1. С. 73-76.

Леднева Г.В., Базылев Б.А., Лебедев В.В., Кононкова Н.Н., Ишиватари А. U-Pb возраст цирконов габброидов Усть-Бельского ультрамафит-мафитового массива (Чукотка) и его интерпретация // Геохимия (в печати).

THE STRUCTURE AND TECTONIC NATURE OF OPHIOLITE BELTS OF KORYAK UPLAND

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Ophiolites West- and East-Koryak belts has widely varying ages (from Early Paleozoic to Campanian), different petrological characteristics and distinctive multistage tectonic histories. All specific geological features suggest that these ophiolites probably formed in island arc environments in marginal-sea setting.

Ophiolites belts may have evolved through repeated stages of non-accretion, in which SSZ ophiolites and blueschists formed, and accretion, in which accretionary complexes mainly composed of clastic rocks (with olistostromes) developed. Their present-day structures therefore represented of the multiple nappe piles consistes of many times repeated ophiolite – blueschist associations and accretionary complexes.

The lithosphere of the marginal-sea basins in which generated ophiolites belts was distinguish – with all more oceanical nature eastwards.

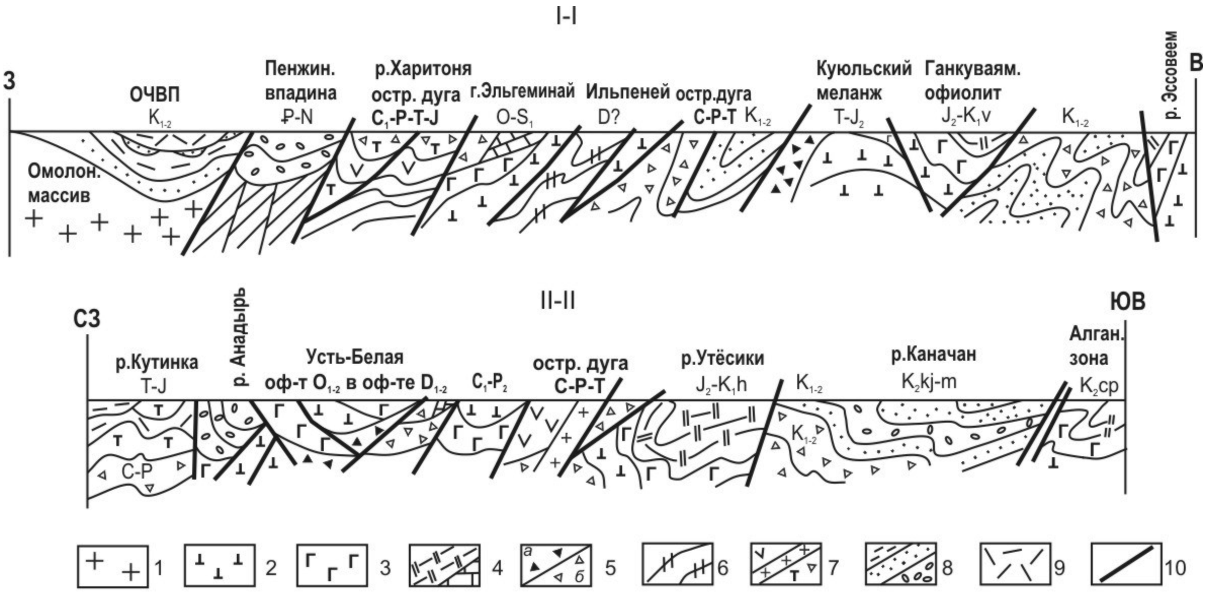

Рис. Схематические разрезы по “пенжинскому” (I-I) и “усть-бельскому” (II-II) пересечениям вкрест Западно-Корякского офиолитового пояса (соответственно “Омолонский массив - Пенжинский кряж - Эссовеем” и “Кутинка - Усть-Белая - Утесики - Алган”). Условные обозначения: 1 - дорифейский фундамент; 2-4 - офиолитовая серия, в том числе ультрабазиты (2), базиты (3) и кремнисто-вулканогенный чехол с известняками (4); 5 - серпентинитовые меланж (а), офиолитокластовые олистостромы (б); 6 - голубосланцевые метаморфические комплексы; 7 - островодужные образования и плагиограниты; 8 - терригенные тонко- и грубообломочные отложения и молассы; 9 - вулканиты Охотско-Чукотского пояса; 10 - разрывные нарушения.

СТРУКТУРА И ТЕКТОНИЧЕСКАЯ ПРИРОДА ОФИОЛИТОВЫХ ПОЯСОВ КОРЯКСКОГО НАГОРЬЯ

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Офиолитовые образования Корякского нагорья полихронны (от Є-О до K_2cp) и полигенны (от разнотипных окраинноморских, иногда до океанических). Входят в состав долгоживущих телескопированных аккреционных систем на континентальных окраинах, образуя два пояса -Западно-Корякский (”бореальный”) и Восточно-Корякский (”тетический”). В палеогеодинамическом отношении отвечают окраинным бассейнам арктической и тихоокеанской тектонической принадлежности.

В двух пересечениях “Омолонский массив - Пенжинский кряж - Эссовеем” и “Кутинка - Усть-Белая -Утёсики - Алган” вкрест простирания Западно-Корякского офиолитового пояса по геологическим данным устанавливается четырехкратное чередование разновозрастных офиолитово-голубосланцевых и флишево-олистостромовых комплексов (соответственно $Є_1$-O_2; D_{2-3}-C_1; P_2(?)-T-J_2; J_{2-3}-K_1g; K_2cp(?) и O_3-S; C_2-P_2; K_1g-al; K_2m) (рисунок). В Восточно-Корякском поясе такой мультиплет трехкратный (D_{2-3}-C-P_2; T_{2-3}-J_2; J_3tt-K_1al; K_2sn и P_2-T_1; J_{2-3}; $K_{1-2}al$-cj; K_2m_2-P).

Характером смены эпох офиолитообразования (и тектонической субдукционной эрозии) интервалами накопления аккреционных комплексов и существенно бореальными макрофаунами Западно-Корякский пояс напоминает Алазейско-Олойские и Северо- и Центрально-Аляскинские офиолиты (Ливенгуд, Ангаучам); тогда как присутствием тетической микро- и макрофауны, наряду с ярко выраженным бонинитовым островодужным магматизмом, не оставляет сомнения в Тихоокеанской тектонической принадлежности Восточно-Корякского пояса.

Намечающиеся различия между офиолитовыми поясами обусловлены своеобразием литосферы соответствующих им окраинноморских бассейнов, более океаничной на востоке.

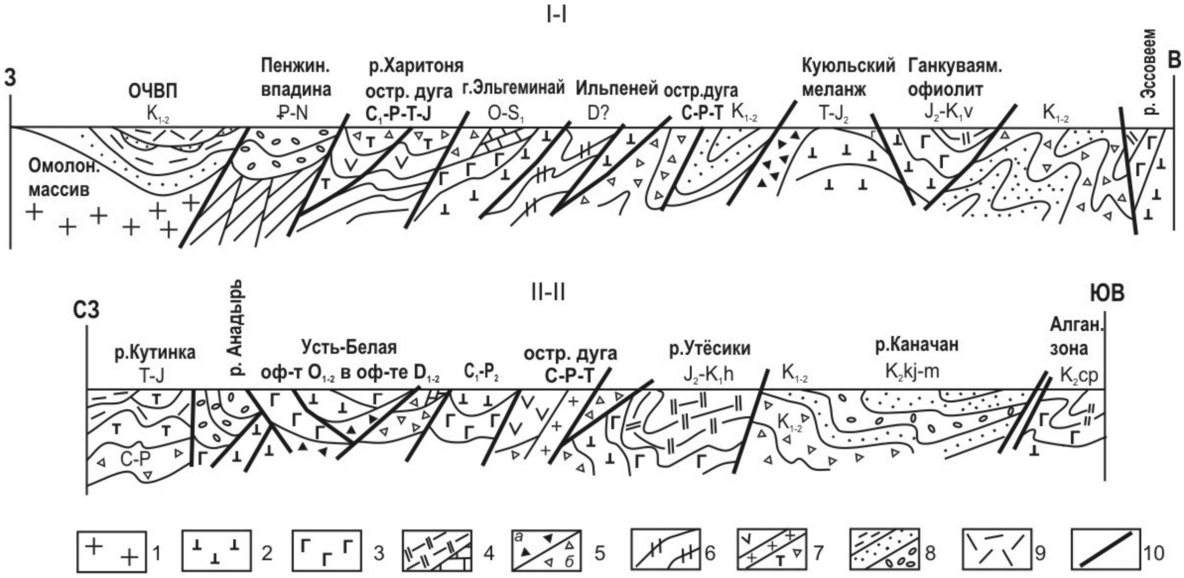

Рис. Схематические разрезы по “пенжинскому” (I-I) и “усть-бельскому” (II-II) пересечениям вкрест Западно-Корякского офиолитового пояса (соответственно “Омолонский массив - Пенжинский кряж - Эссовеем” и “Кутинка - Усть-Белая - Утесики - Алган”). Условные обозначения: 1 - дорифейский фундамент; 2-4 - офиолитовая серия, в том числе ультрабазиты (2), базиты (3) и кремнисто-вулканогенный чехол с известняками (4); 5 - серпентинитовые меланж (а), офиолитокластовые олистостромы (б); 6 - голубосланцевые метаморфические комплексы; 7 - островодужные образования и плагиограниты; 8 - терригенные тонко- и грубообломочные отложения и молассы; 9 - вулканиты Охотско-Чукотского пояса; 10 - разрывные нарушения.

THE DZELA MAFIC UNIT (POLAR URALS): THE ORIGIN AND RELATION TO THE VOYKAR-SYNYA MASSIF

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The Voykar-Synya ultramafic-mafic belt is one of the largest ophiolite complexes of the world. The Khord'us-Dzela (also known as Khulga) zone extends along the western flank of the belt. This zone composed of ultramafic-mafic and garnet bearing mafic rocks; it was described as a unit showing non-ophiolite affinity based mainly on the high (up to 1000 ppm) Sr concentrations [Efimov, Potapova, 1990]. The Neoproterozoic (Vendian)-Cambrian age (578±9 Ma and 501±10) for gabbro from the Dzela complex was obtained by zircon dating [Remizov, Pease, 2004]. The origin of the complex remained controversial, and we therefore studied composition and geochemical affinity of the Dzela unit.

A cross-section in the area of the Khoimadyu river (the left tributary of the Khulga river) was chosen for a field study; 25 samples for geochemical analyses were collected. Three parts of the mafic unit were recognized along the cross-section. SE part composed mainly of coarse-grained websterites, melanocratic gabbro and garnet-bearing gabbroids. The central part of the unit contains garnet-bearing gabbroids more rarely and pass into the NW part composed of leucocratic gabbroids. Garnet bearing gabbros are very rare in the NW part, but garnet veins and large crystals are typical. Magmatic layering was identified in all types of rocks, and overprinting metamorphic fabrics were revealed in the SE part of the cross-section. Secondary minerals are amphibole, epidote, and zoisite. Chondrite-normalized REE patterns for studied samples are flat or slightly fractionated (typical $[La/Lu]_N$ is 1-3, and higher for amphibolised samples). Positive anomaly of Eu is more pronounced for the samples from SE (melanocratic) part. Sr (up to 880 ppm) and Ba concentrations are high and correlate with a magnitude of the Eu anomaly. Negative anomaly of Nb is identified for five the samples (and for other samples the concentrations was close to the detection limit (lower than 1 ppm)).

The Dzela unit in the studied area according data obtained is a layered mafic body with mixed geochemical signature of spreading and suprasubduction settings. The origin of the unit therefore may be related to the back-arc spreading position. The Neoproterozoic (Vendian) age and the suprasubduction origin were identified for the ultramafic part of the Voykar ophiolite complex [Savelieva et al., 2007]. We can conclude that the Dzela mafic and Voykar ultramafic units show corresponding age and origin.

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OPHIOLITES OF THE LESSER CAUCASUS (ARMENIA) AND THEIR SIGNIFICANCE FOR TETHYAN GEODYNAMIC INTERPRETATIONS

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The Lesser Caucasian ophiolites in Armenia represent highly dismembered ophiolite complexes, located along the northern boundary of the South Armenian Block (SAB), which is a continental microplate (detached fragment of the Arabian platform) of Gondwanian origin. These ophiolites are considered to be an eastern extension of the Izmir-Ankara-Erzincan suture of Turkey, where similar lithologies were described and dated to as early as Late Carnian (Tekin et al., 2002).

The plutonic part of the studied Armenian ophiolites (Stepanavan, Sevan and Vedi areas) consists of serpentinites and serpentinized peridotites, minor pyroxenites and gabbros evolving to diorites and plagiogranites, and the volcanic part that includes pillow and/or massive lava flows with compositions varying from basalts to basaltic andesites. Significantly, no developed sheeted dykes have been observed during either our or previous studies. The sedimentary rocks of the ophiolite complexes, interbedded within the lava flows, consist of reddish pelagic fossiliferous limestones and mainly radiolarian cherts.

Petrographic observations, and especially the geochemical analyses (including major, trace and REE, and isotopic Nd, Sr and Pb data) indicate that as a whole, three different types of igneous rocks are present in the Armenian ophiolite complexes: (1) a contaminated MORB series evolving from gabbros to plagiogranites and from basalts to basaltic andesites, exhibiting slight calc-alkaline features (enrichments in LILE; negative anomalies in Nb-Ta and Ti relative to N-MORB); (2) an alkaline (OIB type) series evolving from basanites to trachyandesites, and (3) a calc-alkaline (IAT type) series of basaltic to andesitic rocks, with the island arc affinities.

The studied ophiolite windows, having shown geologically the presence of Lherzolite Ophiolite Type (LOT) sections in several locations, should correlate with each other and be part of a unique obducted nappe. Thus, the presence of relics of MORB-like signatures in the extrusive parts of these ophiolites suggests that the fossil oceanic lithosphere, preserved in this area, developed in an oceanic spreading center, which corresponds to a back-arc basin (Galoyan et al., 2007, 2009; Rolland et al., 2009). New $^{40}Ar/^{39}Ar$ age estimates of ophiolitic amphibole-bearing gabbros, which are in good agreement with the micropaleontological radiolarian datings (Danelian et al., 2008) suggest that the age of oceanic crust formation varies from Early (180Ma; Vedi area) to Middle Jurassic (165Ma; Sevan area). These data are further used to discuss the geodynamic significance of these ophiolites and the history of the northern part of the Neo-Tethys ocean region (Rolland et al., 2009). Therefore, we consider that the Lesser Caucasus ophiolites have been obducted over the SAB in the Early Coniacian, just before the Arabian-Eurasian collision.

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OPHIOLITES OF WEST CHUKOTKA: FRAGMENTS OF A PALEOZOIC – EARLY MESOZOIC CONVERGENT MARGIN

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In west Chukotka two large ophiolite complexes, i.e. the Gromadnen–Vurguveem basic-ultrabasic massif and Aluchin basic-ultrabasic complex, are recognized. These ophiolites are situated at the boundary of two large geological structures, i.e. the South Anyui suture (SAS) and the Alazeya–Oloy folded zone (AOZ). The SAS complexes are represented mainly by volcanic-sedimentary and terrigenous sequences of the Late Jurassic and Early Cretaceous (Seslavinskii, 1979; Natal'in, 1984; etc.). Several interpretations were proposed for the geodynamic nature of the SAS. It was considered as a Late Mesozoic eugeosyncline (Natal'in, 1984) or as a suture zone marking the trace of a Late Mesozoic oceanic basin (the South Anyui Ocean), which separated either the North Asian and North American continents as a bay of the Mesopacific (Zonenshain, 1990; Parfenov, 1984) or the North Asian and hypothetical Hyperborean continents (Seslavinskii, 1979). In the earliest studies (Radzivill, 1975), a rift origin was supposed for the South Anyui Ocean on the basis of the existence of local exposures of Late Paleozoic–Early Mesozoic rocks, which considered as basement inliers among the Late Mesozoic complexes of the SAS. The AOZ represents complex island-arc terrane of middle Paleozoic – Mesozoic ages. Absence of the data about of geological structure and chemistry rocks of ophiolites does not allow us to draw a conclusion about correlation ophiolites with accommodating structures (Sokolov et al., 2002). The new data on these ophiolites are presented in this short report.

In terms of petrography, two groups of rocks can be distinguished in the Gromadnen–Vurguveem peridotite–gabbro massif. The first group includes leucocratic gabbroids (mostly gabbronorites), composing most of the massif and have pre-middle Paleozoic age (320 Ma, Ar-Ar dating) (Bondarenko et al. 2003, Ganelin, Silantyev, 2008) The second group includes olivine-bearing cumulate rocks: olivine gabbros, troctolites, plagioclase-bearing dunites, and amphibolized wehrlites. The major element variations in these rocks suggest their affiliation to low-titanium, low-potassium, and high-alumina plutonic derivatives of island-arc magmatism. According to geochemical characteristics (distribution of REEs and indicator incompatible elements), the gabbroids of the first group are akin to both island-arc tholeiites and boninites. The olivine-bearing rocks of the second groups show the boninitic affinity. Based on these observations, it was concluded that the intrusive complex of the Gromadnen–Vurguveem massif was formed during an early stage of the development of an ensimatic island arc.

The Aluchin ophiolite complex includes two massifs, i.e. the Aluchin and Atomanovskiy massifs. The Aluchin massif represents serpentinitic structured mélange. The peculiar feature of the structure is that the east ultramafic section of the ophiolites includes ultramafic tectonite (spinel dunites-harzburgites and little lherzolites), while the west section consists of ultramafic-mafic cumulate rocks. Tectonite harzburgites have $Cr\#_{spl}$ of 0.40-0.65, Fo_{OL} of 90-91.8 and U-shaped REE patterns with total quantity of $(La+Sm+Yb)_n$ = 0.5-0.9 (unpublished data). This demonstrates formation of these rocks in a suprasubduction geodynamical setting.

The Aluchin ultrabasic rocks cut by diabase dykes belonging to two series. One of them is the Atomanovskiy massif diabase bodes. These dykes are dated at 226 Ma (Ar-Ar dating) and exhibit compositional affinity to N-MORB. Diabase dykes belonging to another series are spatially related to the Atomanovskiy massif but they are separated from it and intrude ultrabasic rocks in the north part of the Aluchin massif. These diabases have compositions similar to island-arc basalts. These two different dyke complexes occur in the back-arc geodynamical setting (Ganelin, in press). The data presented above allow us to conclude that complexes of convergent margin of the middle Paleozoic – early Mesozoic ages widely occur in the region.

This work was supported by the Russian Foundation for Basic research (projects No 08-05-00547 and 10-05-00529).

METHODOLOGY AND PHILOSOPHY FOR DETRITAL ZIRCON CHRONOLOGY USING EPMA, LA-ICP-MS, AND SHRIMP, AND OUTLINE OF RESULTS FOR THE PALEOZOIC TO MESOZOIC COMPLEX IN THE UST'-BELAYA RANGE, WEST KORYAK THRUST AND FOLD BELT, FAR EAST RUSSIA

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Zircon chronology for the Paleozoic to Mesozoic complex in the Ust'-Belaya Range, West Koryak thrust and fold Belt, Far East Russia has been done using the EPMA, LA-ICP-MS, and SHRIMP installed at the Department of Earth and Planetary Systems Science, Hiroshima University, Japan. We have to perceive about the properties of those instrumental analyses having advantages and disadvantages of each. The sequential procedure from sample preparation to final data reduction is thought to be absolutely essential especially for detrital zircon chronology.

Sample Preparation: Separation of pure zircon is impossible without manual selection. But arbitrary selection should be avoided due to an adverse influence on the statistics of age population. Grain size separation is also undesirable for the same reason. The immixing of other heavy minerals will not be impeditive for the grains by grains analysis. We prepare the samples in such a way so that they can use in common for EPMA, LA-ICP-MS, and SHRIMP. Separated heavy minerals with concentrated zircon grains are scattered randomly on the glass slide and mounted by epoxy resin and polished as a thin section together with standard zircon.

Instrumental analysis: First, DP polished samples are coated by carbon for EPMA analysis. Though the reliable age data are only-obtained with Uranium-rich parts (> 0.3 wt% UO2) in zircon grains and only 5-10% of zircon grains have such a high-Uranium part, an EPMA analysis provides some useful data for subsequent isotopic dating. One is the zoning pattern on BSE images and the other is the concentration of Hf, Y, Ca and the Th/U ratio, which are reflected by the origin of zircon grains or their secondary alteration. A U-Pb isotope analysis using LA-ICP-MS is a main procedure for detrital zircon chronology. In turn, since the statistic analysis of age population needs a large quantity of age data (> 50 grains). LA-ICP-MS requires only a few minutes per one point dating with sufficient precision less than 5% relative error in 2-sigma levels. However, the spot size is relatively large (30 micron). The SHRIMP analysis serves precise age dating for the youngest grain or those having characteristic ages with 10-25 micron spot size.

Outline of result: The result of zircon chronology is summarized as bellows:

Sample	lithology and geology	age component (Ma)
1) 07-107	gravel, Otrognay ophiolite	539-598, 622, 1000-1500 (?)
2) 07-111/8	conglomerate, Otrognay ophiolite	421-465, 850, 1500-2000 (?)
3) 07-114	sandstone, separate nappe?	119-137, 155, 251
4) 08-KO-75/1	volcanic sandstone, ??	96-120, 150, 400-450, 2000 (?)
5) 07-134	plagiogranite, basement of Mavrinskaya nappe	547 +/- 17
6) 07-142	plagiogranite, basement of Algan Terrane	545 +/- 14
7) 07-168	plagiogranite, Algan Terrane	226 +/- 11
8) 07-192	plagiogranite, Algan Terrane	542 +/- 29

PALEOZOIC OPHIOLITIC COMPLEXES IN NORTHEAST RUSSIA: EVIDENCE FOR OPENING OF THE PALEO-PACIFIC OCEAN?

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In the context of plate tectonics and Wilson cycle, every ocean is born as a result of continental rifting. Geological records of rifting are well preserved in the passive continental margins around the Atlantic and Indian Oceans, but are scarcely preserved around the Pacific Ocean due to subsequent long-term subduction-accretion processes and voluminous active-margin magmatism. For example, ophiolites in the Alps represent an oceanic lithosphere formed directly after continental rifting in early Mesozoic, and are characterized by a mantle section composed of fertile plagioclase lherzolite with some fragments of subcontinental mantle that is extremely fertile spinel lherzolite with spinel-garnet pyroxenite inclusions (Ishiwatari, 1985; EPSL, 76, 93-). The current analogue of such newly formed oceanic lithosphere after continental rifting is found in the Red Sea, where subcontinental spinel lherzolite is exposed in the Zabargad Island. Thus, the presence of extremely fertile, subcontinental spinel lherzolite with garnet-spinel pyroxenite may serve as an evidence for the early oceanic lithosphere formed after continental rifting.

The Koryak Mountains comprise a typical circum-Pacific accretionary orogen with abundant ophiolites that are arranged with downward (oceanward) younging polarity. The Ust'-Balaya ophiolite (Sokolov et al. 2003; GSL Spec. Publ. 218, 619-) and Pekulney garnet metagabbro-ultramafic body (Ishiwatari et al. 2007; Island Arc, 16, 1-) occupy the highest structural position in the nappe pile of the Koryak Mountains, and may represent the oldest (Paleozoic or Late Proterozoic) lithosphere incorporated in this orogen. Although its mantle section pervasively suffered low-grade metamorphism (Machi et al., this workshop), fresh lherzolite and harzburgite of various degrees of depletion occur in places. We find extremely fertile spinel lherzolite bearing clinopyroxene (Mg#90.4) with 7.9 wt.% Al_2O_3 and 1.8 wt.% Na_2O, which is typical for subcontinental lherzolite. The Pekulney garnet metagabbro-ultramafic body may represent a lowermost part (Moho) of the rifted continental crust. Thus, we interpret that these mafic-ultramafic bodies in the northern Koryak Mountains provide first materialistic evidence for continental rifting and early development of oceanic lithosphere at the birth of the Pacific Ocean in this region, although another rifted continental counterpart is not yet identified. However, majority of the depleted Ust'-Belaya mantle peridotite represent newly formed oceanic lithosphere that subsequently experienced the low grade metamorphism in a forearc setting after subduction initiation of the Paleo-Pacific plate. The ophiolitic mafic-ultramafic complexes in the northern Koryak Mountains thus provide important keys to decipher early history of the Pacific Ocean.

OPHIOLITES AND MAFIC-ULTRAMAFIC INTRUSIONS OF THE CENTRAL-ASIAN BELT: POLAR URALS, EASTERN SAYAN, WESTERN MONGOLIA AND NORTHERN BAIKAL REGIONAL EXAMPLES

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Several types of mafic-ultramafic complexes of the different origin were revealed in the geological structure of the studied regions. The Polar Urals ophiolite association is known as one of the largest ophiolite complexes of the world, including mantle tectonites, dunites and harzburgites, layered dunite-pyroxenite-gabbro, gabbro-diabase and dyke complexes. U-Pb zircon dating carried out for plagiogranites occurring in the dyke complex, and the age of 490±5 My was obtained. Deformed and metamorphosed ophiolite complex (1) is intruded by complex (2) formed by large unzoned wherlite-gabbro massifs and extremely fresh gabbro-norites. These massifs are well exposed at the Eastern slope of the Polar Urals. Geochemical features, REE patterns of the typical gabbro from ophiolite and intrusive complexes are similar. Different level of uncompartible elementes was identified in CPx from gabbros of complexes 1 and 2. The CPx of 1 complex are similar to the CPx-s formed in an equilibrium with N-MORB type magmas with suprasubduction affinites. The CPx 2 show extremely low level of trace elements concentrations with positive anomaly of Sr. The second ultramaphic-mafic association was formed 450-400 My ago. There are the third Khord'us-Dzela gabbro-pyroxenite-granulite complex on the western slope of Polar Urals contained two associations probably corresponding with complexes 1 and 2 described above but representing more lower level of the crust at the present day surface.

In the area of the western and northern Mongolia and the Eastern Sayan the Daribi-Shishkhid-Gargan zone have been identified, it was formed by collision and obduction of marginal sea and island arcs complexes (including ophiolites) over microcontinental margins. Features of tectonics may be characterized by examples of the Daribi Range in the Western Mongolia and of the southern area of Eastern Sayan. We can divide allochtonous complexes, including full ophiolite sequence, and granit-gneiss domes in a partially eroded autochthons. Massifs of granitoids and Daribi intrusive gabbro complex occur at the autochtone-allochtonous boundary and inside gneisses. The last are formed of zonal dunite-wherlite and clinopyroxenites and its periphery is composed of hornblend gabbroids and gabbro-diabases. This massifs cut their way through the rocks of autochtone and intrude the lover part of ophiolite sequence. The U-Pb zircon age of ophiolite plagiogranites is 570 Ma and Sm-Nd age of rocks of Daribi intrusive complex approximetely 470 Ma. In the most eroded parts of domes we have found granulites with U-Pb zircon age 490 Ma. The same situation we can observe in the Eastern Sayan. Gabbros of the intrusive complexes typically show high level of the REE and high Ti, Al and Mg contents.

In the North-Baikal area granulite and related mafic and ultramafic complexes are deformed in conjunction with ophiolites.

We suppose that an appearance of the post-obduction mafic-ultramafic complexes of different types is a result of the slab window evolution under the continental margins. The origin of slab windows is a possible sequence of the subduction of spreading ridge or oceanic plateau in both cases resulting in a slab break-off.

LOWER CRUSTAL HIGH-P PLUTONIC COMPLEXES OF VARIOUS GEODYNAMIC SETTINGS: A REVIEW OF GEOLOGICAL AND PETROLOGICAL DATA

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Ultramafic and mafic cumulates, which are resulted from high-pressure crystallization at the lower crust levels, are know in many places. Here we present results of comparative analysis of high-P cumulates from complexes that were recently a focus of detailed petrological investigations. Among the well studied high-pressure arc cumulates are the ultramafic-mafic Pekulney complex in Chukotka, Russian Far East (Pertsev, 1988a, b, c; Zhulanova, Pertsev, 1988; Pertsev, Merkulov, 1992; Nekrasov, Zhuravlov, 2000; Nekrasov, 2002; Bazylev et al., 2007; Ishiwatari et al., 2007; Ledneva et al., 2008, 2009) and the Tonsina massif of the Talkeetna arc in south-central Alaska (DeBari, Coleman, 1989; Kelemen et al., 2003; Greene et al., 2006). The Chilas complex in northern Pakistan is a series of lower crustal intrusions emplaced during the rifting of the Mesozoic Kohistan arc (Burg et al., 1998; Jan et al., 1992; Jagoutz et al., 2006, 2007). High-P cumulates attributed to be originated owing to a continental lithosphere extension are well described in the Ivrea zone (Pin, Sills, 1986; Sinigoi et al., 1994; Hermann et al., 2001; Müntener et al., 2000, 2001), External Ligurides (Maroni, Tribuzio, 1996; Montanini, Tribuzio, 2001) and other domains of Alps (Rebay et al., 2001; Tribuzio et al., 1999).

The comparative analysis of data available on subduction- and extension-related high-P cumulates allows the following inferences.

The arc crust sections including high-P cumulates normally occur in composite terranes formed with arc and oceanic deposits. Extension-related high-P complexes (mainly mafic rocks) are often related to ophiolite sections and mélanges and/or blocks of continental lithosphere. In both settings, high-P cumulates are parts of thicker heterogeneous lower crustal sections also including middle crust plutonic and metamorphic rocks.

A modal composition of high-P cumulates varies and is controlled by an initial melt composition and conditions of crystallization. In general, the ultramafic cumulates are much more widespread in a subduction setting. High-P cumulates in extension environments are dominated by mafics, while ultramafic rocks occur as spare layers in gabbroic sections or pipes cutting gabbroic rocks. At the last setting, ultramafic cumulates are located probably within the mantle rock sequence where they are represented often by veins of ceylonite websterites and garnet-ceylonite websterites.

High-P cumulates originated in subduction and arc rifting settings are abundant in hornblende and poor in orthopyroxene indicating high water contents in crystallizing melts. Extension-related high-P cumulates are abundant in orthopyroxene, while hornblende occur in accessory amounts. The common feature of high-P cumulates from both settings is a predominance of high-Al minerals, e.g. Al-spinel (hercynite), high-Al clinopyroxenes and hornblendes. However, these phases are different in composition. Clinopyroxenes and hornblendes are low in TiO_2 and Na_2O in arc cumulates; while they are rich in these components in extension cumulates. It is also notable that initial melts (arc picrite, boninite, high-Al island-arc tholeiites) resulted in crystallization of arc cumulates were in equilibrium with mantle peridotites, while those (mainly contaminated tholeiites) of cumulates originated in arc rifted setting were not.

This work was supported by the Russian Foundation for Basic Research (projects No 09-05-92103 and 10-05-00529).

PLAGIOGRANITE COMPLEXES OF SUPRA-SUBDUCTION OPHIOLITES (PENZHINA REGION, KAMCHATSKY MYS PENINSULA, TAIGONOS PENINSULA)

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Data on structural position, composition peculiarities and petrogenesis of plagiogranite complexes from examples of Mesozoic supra-subduction ophiolites of Penzhina region, Kamchatsky Mys Peninsula, Taigonos Peninsula are discussed.

In the Penzhina region Kuyul ophiolite terrane is disrupted into a serpentinite mélange. In the most complete ophiolite fragment of the Gankuvayam slice the following sequence is reconstructed: 1) harzburgite and serpentinite after dunite; 2) a gabbro-troctolite-wehrlite complex; 3) plagiogranite; 4) a dyke complex, differentiated from basaltic to dacitic; and 5) a pillow lava complex, from basalt to dacite [1]. The age of ophiolite is estimated on the basis of J_2b-J_3^1 radiolarians in cherts within basalts [2] and J_3 U-Pb SHRIMP zircon data from plagiogranites [3]. The Gankuvayam ophiolite has been interpreted to originate from suprasubduction setting [4]. Plagiogranites form a separate slice between the upper massive gabbro and sheeted dyke complex. In upper part of the plagiogranite slice there are fragments of dykes. On the Ab-An-Or diagram, the felsic rocks plot with tonalites and trondhjemites. Their low-K contents place them with oceanic plagiogranites. On Harker diagrams, plagiogranites, intermediate to felsic dykes, and gabbros from the upper part of gabbroic section form a fractionation trend. REE patterns of plagiogranites are slightly enriched in light rare-earth elements, with an almost horizontal high rare-earth element portion and a negative Eu anomaly. The similarity of these rocks to those of the Semail ophiolite is observed. The similarity of REE patterns for plagiogranites, dacites, andesites, and basalts from the sheeted dyke complex suggests that these rocks are cogenetic. Plagiogranites plot in the field of lavas and plutonic rocks of subduction zones on (Nb/Zr)n vs Zr and in the ORG field on Pearce et al.diagrams. Plagiogranites have low $^{87}Sr/^{86}Sr$=0,7036-07046 and ^{18}O =+8,3‰, indicating their parental magmas have mantle origin. The plagiogranites may have formed by fractional crystallization of a basic magma combined with filter-pressing mechanism. They are believed to have formed in the upper part of the ophiolite crustal section above a subduction zone.

Mz ophiolites are well exposed along the SE coast of Taigonos Peninsula within the accretionary pile exposed at Cape Povorotny (Beregovoi terrane). Plagiogranites form veins in gabbro-diabase from blocks in the Main Mélange unit and fall in the fields of trondhjemites and tonalites on Ab-An-Or diagram. The plagiogranites and tonalites are low-Al, -K rocks, have low K/Rb and relatively high Y. Rb and Zr contents of the plagiogranites are similar to those of the average tonalites of Mid-Atlantic Ridge at 2–3°N. REE patterns of the plagiogranites are slightly LREE enriched and show distinct negative Eu anomalies. The increase of total REE content from gabbro-diabase to plagiogranite and the similarity of their REE patterns suggest that these rocks are cogenetic. Comparison between the Cape Povorotny plagiogranites and those from Bay of Islands ophiolites, Newfoundland, shows that both have negative Ta and Ti anomalies indicative of SSZ origin. REE patterns of plagiogranites and trondhjemites from the Maqsad ophiolite, Oman, considered by [5] to have formed at a mid-ocean ridge, differ from those of Cape Povorotny plagiogranites. The latter may have originated through anatexis of a gabbroic parent or as interstitial melt crystallized during mafic magma fractionation. The similarity of REE patterns for the gabbro-diabase and plagiogranite supports the latter interpretation. Negative Ta, Nb, Ti anomalies in the plagiogranites point to their origin in a SSZ setting.

The Kamchatsky Mys Peninsula is a composite terrane, accreted at the Kamchatka Peninsula in Cz time.It has composite fold-and-thrust structure, incorporating volcanic, terrigenous, and volcaniclastic rocks of K and Pg_{1-2} ages and tectonic slices of serpentinite mélange, gabbro, and ultramafic rocks. Plagiogranites belong to K_2 complex, composed of highly depleted peridotite, gabbro, associated with island arc tholeiite, boninite, and high-Al tholeiitic basalt of SSZ origin [6]. They form a network of veins and dike-shaped bodies, which intrude gabbros and enclose its xenoliths. U–Pb SHRIMP datings of plagiogranites are 74.7±1.8

m.a.[7]. The felsic rocks plot with trondhjemites on the Ab–An–Or diagram. ORG-normalized patterns of plagiogranites are characterized by low LILE, approximately on the hypothetic ORG level, and are depleted in respect of HFSE, distinct Ta, Nb, Zr minimum are fixed. Rb vs Y+Nb covariations refer plagiogranites to volcanic arc granites. These features indicate that plagiogranites originated in SSZ origin. Plagiogranites are characterized by non-fractionated REE patterns with low REE totals at nearly 10 chondrite norms that are slightly higher than in gabboids. Geochemical modeling shows that they may be formed as a result of 70–80% fractional crystallization of gabbroic liquid.

Conclusions. Plagiogranites of considered SSZ ophiolites are associated with upper gabbro-sheeted dyke complexes boundary or form network of veins in gabbro-diabases. Plagiogranites from different regions have some varieties in geochemical features, but all of them have Ta, Nb, Ti negative anomalies, LILe enrichment and HFSE depletion typical for SSZ magmatites. Volume of plagiogranites in ophiolite sections less than 10%, data on REE and geochemical modelling allow to suppose that petrogenesis of plagiogranites likely related to fractional crystallization of gabbroid liquid.

The work was supported by the RFBR projects № 07-05-00255, 10-05-00191.

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SERPENTINIZED PERIDOTITE FROM THE UST'-BELAYA OPHIOLITE, FAR EAST RUSSIA: SERPENTINIZATION AND METASOMATISM OF THE MANTLE WEDGE

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Ust'-Belaya ophiolite is exposed in the 80 km x 40 km area on the south of Ust'-Belaya (N65 30', E173 17'), Far East Russia (Sokolov et al., 2003 Geol. Soc. London, Spec. Publ. 218, 619-664). The associated limestone suggests Devonian or older age of this ophiolite. Here we report the petrographical features and mineral chemistry of the peridotite from Ust'-Belaya ophiolite and discuss about their metamorphism and metasomatism.

Mantle section of the Ust'-Belaya ophiolite is composed of fertile lherzolite to moderately depleted harzburgite. Those peridotites are characterized by significant hydration and low grade metamorphism, which causes formation of secondary olivine, secondary cpx, amphibole, chlorite, antigorite, and opaque minerals. They are divided into three major types on the basis of the mineral assemblage; (1) olivine + amphibole + chlorite +/- talc, with or without relict minerals, (2) olivine + antigorite + amphibole + chlorite and (3) olivine + antigorite + chlorite +/- secondary clinopyroxene. In some of antigorite-bearing peridotites, olivine shows an apparent "cleavage". Basically secondary olivine occurs along with antigorite replacing primary olivine or amphibole replacing primary pyroxene. Such petrographical features resemble those of the antigorite-bearing serpentinite from Mariana forearc (Ohara & Ishii, 1998 Island Arc 7, 541-558; Murata et al., 2009 Geosphere 5, 90-104).

Amphiboles show different compositional trend corresponding to the mineral assemblage. Amphiboles in mineral assemblage (1) are calcic amphiboles, showing a pargasite/edenite-tremolite trend. On the other hand, amphiboles in mineral assemblage (2) show a richterite-tremolite trend with some pargasites.

Pargasite/edenite in the mineral assemblage (1) and richterite in the mineral assemblage (2) may be formed at relatively high temperature and low temperature, respectively. Several amphiboles in the mineral assemblage (2) shows zoning composed of pargasitic core, tremolitic mantle and rihiteritic rim. This zoning indicates a multiple-stage addition of Na2O by fluid.

Relict minerals of Ust'-Belaya peridotite do not resemble those of common forearc peridotite (Parkinson & Pearce, 1998 J. Petrol., 1577-1618) in terms of their degree of partial melting, suggested from Cr# in spinel. On the other hand, they are similar to forearc peridotite in terms of their low equilibrium temperature suggested from Mg# in spinel and pervasive low-grade metamorphism as described above.

Ust'-Belaya peridotite may represent a fragment of the Early Paleozoic forearc mantle wedge, which has been effectively cooled and metasomatized by H2O-rich fluids released from the subducting slab, but their protoliths may include fragments of subcontinental mantle that are not reported from forearc peridotites (Ishiwatari et al., this workshop).

MIDDLE MESOZOIC CHERTY DEPOSITIONS NORTHERN ALGANSKY TERRANE (KORYAK HIGHLANDS)

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Algansky terrane is distinguished in northern Koryak fold system [3]. The most widespread depositions are volcanic-siliceous-terrigenous rocks of Middle Jurassic - Early Cretaceous age [1, 4]. It is significant system of sheet. Zones of thrusts associated with serpentinites and serpentinite melange, which spatially associated with chert-basalt association Algansky terrane [2]. We can not exclude that this can be the fragments of ophiolites [2].

In this paper highlights the results of study of the chemical of cherty and cherty -clayey rocks Middle Mesozoic's outcrops Algansky terrane. Outcrops were studied during the joint Russian-Japanese field work along Pereval'nay and middle course Anadyr rivers. The cherty depositions are involved in the structure of several rocks associations - *cherty-volcanic, volcanogenic - cherty -terrigenous, cherty -terrigenous.* Geochemical characterization indicates the existence of two extreme types. One is radiolarites. Geochemical composition indicates that the accumulation of these rocks took place away from sources of allothigenous material, with a marked influence hydrogenous and hydrothermal vents. These flints are involved in the structure of *cherty -volcanic, volcanogenic - cherty - terrigenous* associations.

Another type of cherty reflects the growing role allothigenous input, the main role in which plays the volcanic rocks of basic and intermediate composition. It indicates the proximity of the source, which is highly explosive rate than likely was the island-raising. These flints are involved in the structure of *volcanic - cherty -terrigenous, cherty -terrigenous* associations.

Thus, within the studied outcrops Algansky terrane occur different facies deposition. Cherty accumulations from the pelagic zones of the ocean to cherty with characteristics of the marginal zones of the ocean, with a significant influence of island arc materials. For further interpretation of the geodynamic conditions of selected associations need to understand they are tectonically combined various parts of a single stratigraphic sequence, or synchronous depositions, which require clarification of their age.

This work was supported by RFBR (projects No 09-05-92103, 08-05-00547, 09-05-00438) and Scientific School 7091.2010.5

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СРЕДНЕМЕЗОЗОЙСКИЕ КРЕМНИСТЫЕ ПОРОДЫ СЕВЕРНОЙ ЧАСТИ АЛГАНСКОГО ТЕРРЕЙНА (КОРЯКСКОЕ НАГОРЬЕ)

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Алганский террейн выделяется на севере Корякской складчатой системы [3]. Наибольшим распространением пользуются вулканогенно-кремнисто-терригенные отложения среднеюрского - раннемелового возраста [1, 4]. Характерна система чешуй, к зонам надвигов приурочены серпентиниты и серпентинитовым меланжи, пространственно связанные с кремнисто-базальтовой ассоциацией [2]. Нельзя исключать, что это фрагменты офиолитовой ассоциации [2].

В данной работе освещены результаты изучения вещественного строения кремнистых и кремнисто-глинистых пород Алганского террейна. Разрезы были изучены в ходе совместных Российско-Японских полевых работ, вдоль бортов р. Перевальная и среднего течения р. Анадырь. Кремнистые породы участвуют в строении нескольких породных ассоциаций – *кремнисто-вулканогенной, вулканогенно – кремнисто-терригенной, кремнисто-терригенной.* Геохимическая характеристика, указывает на существование двух крайних типов. Одни представлены радиоляритами. Геохимический состав указывает, что накопление таких пород происходило в отдалении от источников сноса аллотигенного материала, при заметном влиянии гидрогенного и гидротермального источника. Такие кремни участвуют в строении *кремнисто-вулканогенной,* ассоциациях.

Другой тип кремней отражает возрастание роли аллотигенной примеси, основную роль в которой играет вулканические породы основного и среднего состава. Что указывает на близость источника, обладающего высокой эксплозивным коэффициентом, чем скорее всего являлась островодужное поднятие. Такие кремни участвуют в строении *вулканогенно – кремнисто-терригенной, кремнисто-терригенной* ассоциациях.

Таким образом, в пределах изученных обнажениях Алганского террейна встречаются разнофациальные образования, в строении которых участвуют кремнистые породы, накопление которых происходило от пелагических зон океана до окраинных зон океана, со значительным валянием островодужного материала. Для дальнейшей интерпретации геодинамических условий образования выделенных ассоциаций, требуется понять, являются они тектонически совмещенными различными частями единого стратиграфического разреза, или синхронными разнофациальными образованиями, для чего требуется выяснения их возраста.

Работа выполнена при поддержке проектов РФФИ (№ 09-05-92103, 08-05-00547, 09-05-00438) и Ведущей научной школы (7091.2010.5)

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ON PRINCIPLES OF DEFINING OPHIOLITES

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The Symposium conveners proposed to consider possibilities of solving the so-called Hamlet question: ophiolites or not ophiolites, on the basis of petrological criteria (probably, data of geochemical, isotopic inclusive, investigations, and their interpretation involving physical-chemical petrology) of identification of the ophiolite fragments, separating into "true" and "non-true" ophiolites. However, distinguishing ophiolites seems possible only using the formulation elaborated by the scientific community. At present, the majority of researchers studying ophiolites use the definition offered by the 1972 Penrose Conference, which is based on simple geological and petrographic data obtained in the course of field studies of ultramafic, mafic, subvolcanic and volcanic formations. Over the past 40 years, a great diversity of ophiolitic rock and mineral compositions were revealed (geochemical and isotopic characteristics inclusive), spatial and temporal relations of restites, cumulates, eumagmatites forming ophiolites; "Penrose" and "Hess" edge type ophiolites were identified (massifs of intermediate structure are also in abundance). This diversity is mainly caused by such factors as spreading rate and, depending on its variations, differencies in petrogenetic processes in the mantle crust column. However, definition of ophiolites and development of their types are still based on geological and petrographic data, quite sufficient for solving the problem under consideration.

The other approach to the origin and emplacement of ophiolites, formulated by E. Moores in 1982, is based on their emplacement setting, the reconstruction of which needs further research (also geological-petrographic) along with associated metamorphic rocks, tectono-gravitational mixtites, and mélanges. This is first of all necessary for identifying ophiolites of the Cordilleran type, which are commonly tectonically dismembered into plates and slices, which sometimes consist of one rock complex among those forming the ophiolite sequence; these ophiolitic fragments are most frequently incorporated into ancient accretion prisms, subduction zones, and fore-arc tectonic complexes.

Geochemical characteristics are decisive for interpreting the geodynamic settings of the formation of mantle and crustal ophiolite complexes. However, "anomalous" geochemical indices can not serve as criteria of "non-ophiolite" nature of rock associations. For instance, the presence in the mantle sequence of the Ust-Belaya terrane (West Koryak foldbelt) of fertile lherzolite, which by mineral composition and geochemical features are similar to subcontinental peridotites ("intraplate" geochemical type), is not at all in contradiction to their relevance to ophiolites; the latter is clearly confirmed by existence of a horizon of gabbroid rocks here, by association with tectonic plate of similar in the upper age boundary mafics and pillow basalts of the MORB type. The same is true of the composition of certain lherzolites from ophiolites of the Northern Apennines and Timor. This composition of lherzolites suggests that the formation of oceanic lithosphere occurs on subcontinental protolith of the mantle basement during the emplacement and development of the ensialic basin. Another example: the presence in the section of a volcanic complex instead of MORB- and IAT-type basalts, (or along with them) of rocks of calc-alkaline petrochemical series, specified from andesite--basalts through andesites to dacites and sodium rhyolites (for instance, in the Canyon-Mountain massifs in Oregon, Tamvatney in the Koryak Upland, Shishkhid in Northern Mongolia) is not a reason to deny that these sequences and associated mantle peridotite, gabbroid, and diabase belong to ophiolites. This composition of volcanics of the ophiolite association suggests that the formation of oceanic lithosphere occurred in different tectonic zones of the island arc assembly, most likely, in intra-arc basins.

К ВОПРОСУ О ПРИНЦИПАХ ОПРЕДЕЛЕНИЯ ОФИОЛИТОВ

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Конвинеры симпозиума предложили обсудить возможность решения гамлетовского вопроса "…ophiolite or not ophiolite…" на основании петрологических (по-видимому, имеются в виду данные геохимических, в т.ч. изотопных, исследований, интерпретация их с позиций физико-химической петрологии) критериев идентификации фрагментов рассматриваемой ассоциации, с разделением офиолитов на «правильные» и «неправильные» (not true ophiolites). Однако представляется, что выделение офиолитов возможно лишь на основании выработанной научным сообществом формулировки. В настоящее время подавляющее большинство исследователей офиолитов принимает определение, предложенное в 1972 году Пенроузской конференцией, в основе которого лежат простые геологические и петрографические данные, полученные при полевом изучении ассоциации ультрамафитов, мафитов, гипабиссальных и вулканических образований. За прошедшие почти 40 лет выявилось большое разнообразие составов пород и минералов (в том числе геохимических и изотопных характеристик), взаимоотношений в пространстве и во времени реститов, кумулятов, эвмагматитов, слагающих офиолиты; были выделены офиолиты «Пенроузского» и «Хессовского» крайних типов (многочислены и промежуточные по строению массивы). Это разнообразие в значительной степени контролируется такими факторами, как скорость спрединга и обусловленные её вариациями различия процессов петрогенезиса в мантийно-коровой колонне. Тем не менее основой для определения и типизации офиолитов остаются геолого-петрографические данные, вполне достаточные для решения рассматриваемого вопроса.

Другой подход к разделению офиолитов, сформулированный Э. Мурзом в 1982 году, базируется на обстановке их внедрения (emplacement), реконструкция которой требует изучения (опять-таки геолого-петрографического) также и ассоциирующих метаморфических пород, тектоно-гравитационных микститов, меланжей. Оно необходимо в первую очередь для идентификации офиолитов Кордильерского типа, обычно тектонически расчленённых на пластины и чешуи, сложенные иногда лишь одним из образующих ассоциацию комплексов пород; эти фрагменты офиолитов чаще всего инкорпорированы в древние аккреционные призмы, субдукционные комплексы, тектонические комплексы преддужья.

Геохимические характеристики имеют решающее значение для интерпретации геодинамических обстановок формирования мантийных и коровых комплексов офиолитов. При этом, однако, «аномальные» геохимические показатели не могут быть критериями «неофиолитовой» природы тех или иных комплексов пород. Так, например, присутствие в мантийном комплексе Усть-Бельского террейна (Западно-Корякская складчатая область) фертильных лерцолитов, по составу минералов и геохимическим особенностям близких к субконтинентальным перидотитам («внутриплитный» геохимический тип), вовсе не противоречит их принадлежности к офиолитам, однозначно вытекающей из наличия здесь горизонта габброидных пород, из ассоциации с тектонической пластиной близких по верхней возрастной границе мафитов и подушечных базальтов MORB-типа. То же относится к составу некоторых лерцолитов из офиолитов Северных Апеннин, Тимора. Такой состав лерцолитов может свидетельствовать о формировании океанической литосферы на субконтинентальном протолите мантийного фундамента при заложении и развитии энсиалического бассейна. Другой пример: присутствие в разрезе вулканического комплекса вместо базальтов MORB-, IAT-типов (или наряду с ними) пород известково-щелочной петрохимической сериальности, дифференцированных от андезито-базальтов через андезиты к дацитам и натриевым риолитам (например, в массивах Каньон-Маунтин в Орегоне, Тамватней в Корякском нагорье, Шишхид в Северной Монголии), не является основанием для отрицания принадлежности этих толщ и ассоциирующих мантийных перидотитов, габброидов, диабазов к офиолитам. Такой состав вулканитов офиолитовой ассоциации отражает формирование литосферы океанического типа в тех или иных тектонических зонах островодужного ансамбля, скорее всего во внутридуговых бассейнах.

URALIAN OPHIOLITES: DIVERSITY OF MANTLE SECTIONS AND CHANNELS OF MELT TRANSPORT IN THE UPWELLING MANTLE

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Structure and composition of the Uralian ophiolites reflect a large spectrum of dynamic conditions of their creation and various generation setting. Large well-preserved ophiolites are opportune for recognizing geodynamic environment of their formation: mid-ocean ridge, intra-continenal rift zone, or suprasubduction spreading zone (SSZ) with resultant lherzolite- or harzburgite ophiolite type (LOT and HOT). On the southern Urals, HOT-type ophiolites were formed in course of the *Lower-Middle Ordovician* oceanic spreading. Mafic intrusions within harzburgites originated at the time intraoceanic shearing *(O_3-S_1)*. Ophiolites of the Tagil-Magnitogorsk zone suggest the intracontinental rifting (LOT) and SSZ (HOT) environment. Rifting of the East European margin and spreading in back-arc basin progressed in the *Ordovician*; the *Early Devonian* magmatism is imprinted onto these ophiolites.

The SSZ ophiolites of the Polar Urals suggest interaction between mantle peridotite and percolating melt with formation of dunites and chromitites at 585,3 Ma; harzburgites are much older - 1,9 Ga. Magmatic events in the mantle are correlative with the Vendian rifting of the East European continental margin. The pre-Paleozoic oceanic complexes were reworked during the *Early Ordovician* SSZ and *Early Devonian* convergence environment. As a result, rocks complexes of different age are now members of integral ophiolite association. The allochthon sole is composed of garnet amphibolites, blue and lawsonite schists; olivine-antigorite rocks occur as tectonic slices in harzburgites. Age range of metamorphic events is 375–330 Ma. Transition from eclogite–amphibolite to glaucophane (high-P and low-T) metamorphism typical of ophiolite-associated metamorphics in the Urals could be related to subduction/obduction events by collision between island arc and continent.

Srtuctural position of channels of melt transport through mantle is illustrated on example of LOT and HOT types of the Uralian ophiolites. Replaceve dunite bodies considering as markers of melt migration was formed in the following positions: (a) due to stress-driven melt segregation along the margin of peridotite body during the accretion of the upwelling mantle to lithosphere (well expressed in LOT-type and vague- in HOT), and (b) due to focused melt migration along network of weakened zones with high permeability (only HOT). These zones were formed as a result of high stress concentration and their abrupt relaxation in flow-fold hinges (the central part of only harzburgite mantle sequence). It is supposed, that last stage of the creation of mantle HOT section took place under subduction environment. Dunite channels within harzburgite were formed under large intervals of the depth and time.

КАНАЛЫ ТРАНСПОРТИРОВКИ РАСПЛАВОВ В ПОДНИМАЮЩЕЙСЯ МАНТИИ: СВИДЕТЕЛЬСТВА В УРАЛЬСКИХ ОФИОЛИТАХ

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Структура и состав уральских офиолитов отражают широкий спектр условий их образования в различных геодинамических обстановках. Крупные хорошо сохранившиеся офиолитовые разрезы позволяют распознать такие обстановки их формирования как срединно-океанические хребты, рифтогенные бассейны и надсубдукционные спрединговые зоны (SSZ), с лерцолитовым или гарцбургитовым типом разреза (LOT или HOT). На южном Урале существенно гарцбургитовые массивы формировались в ходе океанического спрединга в нижнем-среднем ордовике. Дифференцированные мафитовые дайки интрудировали мантийный разрез в ходе внутриокеанических деформаций в позднеордовикское-силурийское время. Лерцолитовые массивы (LOT) соотнесены с внутри континентальным рифтингом, а гарцбургитовые массивы (HOT) Тагило-Магнитогорской зоны – с обстановкой SSZ. Рифтинг Восточно-Европейской окраины и спрединг задуговых бассейнов проходил в ордовикское время; раннедевонские дайки секут офиолиты. В офиолитах Полярного Урала есть свидетельства взаимодействия между мантийными перидотитами и проходящими сквозь них расплавами, что выразилось в образовании дунитов и хромититов с возрастом 585,3 млн лет; гарцбургиты имеют возраст около 1,9 млрд.лет.

Магматические события в мантии коррелируются с ведским рифтингом Восточно-Европейской континентальной окраины. Предположено, что допалеозойская океаническая кора была переработана в обстановке SSZ в раннеордовикское, а затем – в раннедевонское время в обстановке конвергенции. Как результат, породы единого офиолитового разреза имеют различный возраст. Подошва офиолитового аллохтона сложена гранатовыми амфиболитами, глаукофановыми и лавсонитовыми сланцами; оливин-антигоритовые породы образуют тектонические пластины в гарцбургитах. Возраст метаморфизма составляет 375-330 млн. лет.

Распределение, количество и форма дунитовых тел как маркеров транспортировки расплава сквозь перидотиты отражают два главных пути формирования каналов в мантии. Первый – миграция, сегрегация и транспорт расплава к краям блока-домена мантийных пород, аккретирующихся к относительно холодной литосфере. Этот путь особенно четко проявлен в лерцолитовых массивах, образованных в рифтах (и зонах центрального спрединга) и также фиксируется в гарцбургитовых массивах, образованных в надсубдукционной обстановке. Второй путь - транспортировка расплавов сквозь весь мантийный разрез по системе пересекающихся жил, субвертикальных каналов вне пространственной связи с краями аккретирующегося тела, - проявлен исключительно в существенно гарцбургитовых массивах, образованных в обстановке надсубдукционного спрединга. Подъем этих расплавов происходил в ходе деформаций, завершавших этап пластического течения мантийных реститов. Предполагается, что формирование каналов, маркированных дунитами краевых зон (первый путь) происходит на меньших глубинах и при более низких температурах относительно формирования каналов в центральной части разреза, маркированных системой дунитовых жил и тел (второй путь). В мантийных реститах, поднимающихся при надсубдукционном спрединге, вероятно присутствие дунитовых каналов, образованных не только в широком диапазоне глубин, но и в разные геологические эпохи и, возможно, в разных геодинамических обстановках.

Работа выполнена при финансовой поддержке гранта РФФИ № 08-05-00151

WHAT IS OCEANIC SPREADING IN LOW-SPREADING RIDGES? GEOLOGICAL-PETROLOGICAL PROCESSES IN THE AXIS PART OF THE MID-ATLANTIC RIDGE: EVIDENCE FOR THE SIERRA LEONE TEST AREA, 5-7^{O} N

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Sierra Leone test area was studied during Cruise 10 of R/V "Akademik Ioffe" (2001-2002) and Cruise 22 of R/V "Professor Logachev" (2003). The region is located at southern continuation of the Central Atlantic oceanic core complex (OCC), where gabbros and mantle peridotites expose on seafloor, and where existence of fresh basalts limited. Our complex geological, petrological, geochemical and isotopic-geochemical investigations showed that development of geological processes here rather differ from canonical model of spreading zone.

Formation of oceanic crust here occurred at three independent episodes of activity: (1) effusions of fresh basalts MORB type, which were undergone by crystallizing differentiation in transitional magma chambers; (2) more ancient altered primitive gabbros, derived from the MORB source; and (3) also altered differentiated ferrogabbroids with high contents of Fe-Ti oxides, which crystallized from melts of siliceous Fe-Ti-oxide series; origin of such melts was probably linked with melting of hydrated oceanic lithosphere under influence of mantle plumes.

Our data consider that geochemical and Sr-Nd isotopic variations in fresh basalts within relatively small (less than 2^{o} in meridional direction) Sierra Leone test area are comparable with the variations along a 15-20 times longer MAR segment and could be caused by heterogeneous source of basaltic melts. The points order along line of mixing of two finite members: depleted mantle material and geochemical enriched plume material.

Judging on seismic tomography data (Anderson et al., 1992; Ritsema, Allen, 2003) asthenosheric beneath MAR is lens-like body about 200-300 km thick. It suggests that this lens has constantly fed by material of fresh mantle plumes which fulfil force convection of the asthenospheric matter. The most powerful and stable from them realized in form of large centers of within-plate activity (Iceland, Azors, Tristan, etc. islands); about less significant plumes we can judge on appearance of melts of the siliceous Fe-Ti-oxide series. Due to such feeding, asthenospheric lens gradually enlarge both crosswise and along ridge, promote to spreading and propagation of the ridge.

Our U-Pb dating by SHRIMP-II zircon, separated from gabbroids, display two groups of grains: (1) young (0.7-2.3 Ma) magmatic zircon, and (2) ancient (xenogenic) – from 87 to 3117 Ma. It is important that many samples contain zircons of both groups, which evidently were contained in the same portions of the basaltic melt. Their origin could be related to the partial capture of materials of different ages from the "graveyard" of slabs in lithospheric mantle beneath the asthenosperic lens by mantle plume, ascended from the core-mantle boundary.

I suggest that appearance of spreading zone is linked with melting of the upper part of the asthenospheric lens due to adiabatic decompression because essential (11-12%) lowering of density of material in melting zone. As a result, ridge-like uplift has occurred in axial part of the MAR with appearance of numerous low-angle extensional structures (detachment faults) accompanied by gravitational sliding of a previously formed oceanic crust. This lead to moving out of typical for OCC deep-seated plutonic rocks: high-depleted mantle peridotites and lower crustal gabbroids. Due to accumulation of relatively light restites at the upper part of the melting zone, melting process periodically ceased and recommenced only after decreasing of pressure from partial removing of crust and pressing-out plastic asthenospheric material to axis of ridge due to increasing of pressure on lateral part of the lens. Renewal of melting can be explained also arriving of new mantle plume, resulted in appearance of siliceous Fe-Ti-oxide series magmas. According to our data, both mechanisms of melting were involved in formation of the upper oceanic lithosphere of the low-spreading ridges.

OCEANIC CORE COMPLEX AS A KEY TO RECONSTRUCTION OF SEQUENCE OF MAGMATIC, METAMORPHIC, AND HYDROTHERMAL EVENTS AT ACCRETION OF THE SLOW SPREADING RIDGE LITHOSPHERE

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The composition of the lithosphere generated in slow- and ultraslow-spreading mid-oceanic ridges testifies that the geodynamic regime responsible for the development of these planetary-scale structures is very specific, as is manifested in the physicochemical parameters of the magmatic, metamorphic, and hydrothermal processes that form rock complexes in these structures and the parameters of related hydrothermal manifestations over vast areas of the oceanic basement in the basins of the Atlantic, Indian, and Arctic oceans. The goal of this study was to reconstruct the main stages of the magmatic, metamorphic and hydrothermal evolution of the oceanic core complexes (OCC) situated in the crest zone of different MAR areas (12^o-16^{o}N, 30^{o}N, 37^{o}N). All active hydrothermal systems discovered so far in the Hess crust of Atlantic ocean are hosted in serpentinites composing OCC. Large peridotite massifs in which active hydrothermal fields were discovered in the Atlantic ocean are exposed at the seafloor surface in MAR segments that show indications of faulting related to detachment faults. These tectonic features are typical of all known hydrothermal fields at MAR related to serpentinites: Ashadze, Logachev, Lost City, and Rainbow. Summarizing all results obtained by this study, the following sequence of magmatic, metamorphic and hydrothermal events can be deduced for the formation of the typical OCC of the slow-spreading ridges: (1) Trapping of basaltic melts in shallow mantle below MAR crest zone; formation of gabbroic lenses and dikelets; existence of large magma chamber located in the shallow mantle and functioning for a considerable time under steady-state conditions. (2) Migration of the parental magmatic melt of the gabbroi’s into the base of the oceanic crust and its interaction with the hosted mantle peridotites, which resulted in the formation of troctolites and plagioclase peridotites. (3) Formation of trondhjemite veins and dikes in the plutonic complex; recrystallization of gabbros and serpentinites during trondhjemitic melt formation; development of enriched isotopic and geochemical signatures in the peridotite–gabbro assemblage owing to the influence of the trondhjemite injections. (4) Emplacement of dolerite dikes. (5) Metamorphism of the upper epidote-amphibolite facies with the participation of fluid of marine origin. (6) Rapid exhumation of the plutonic complex to the seafloor surface accompanied under greenschist-facies conditions. Seawater-derived fluids driving hydrothermal anatexis of the lower oceanic crust could be responsible for trondhjemite formation. Judging by U-Pb dating and Lu-Hf isotopic analyses of 140 zircon grains recovered from samples of gabbro’s and trondhjemites dredged in MAR crest zone at 6°N and 13°N, last stage of formation of OCC here was finished up to 0.82-0.96 Ma (Kostitsyn et al., 2009). Geodynamic model for the development of serpentinite hosted hydrothermal systems proposed in (Silantyev et al., 2009) takes into account the principal phases of the compositional and tectonic evolution of OCC. According to this model, low-density serpentinite material formed at crustal depths of about 3.5–4.5 km has an excess volume compared to the pristine unaltered peridotites, and this results in the uplift of this material to upper crustal levels. This process is associated with faulting of the rigid and cold lithosphere of slow-spreading ridges. The detachment fault arrays produced thereby drain lower crustal magmatic chambers and trigger the emplacement of shallow-depth gabbro intrusions. As a result, conditions favorable for the “startup” of a hydrothermal circulation system are created in the serpentinite slab brought to the seafloor surface.

This study was supported by the Russian Foundation for Basic Research, grant № 09-05-00008.

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GEOLOGICAL STRUCTURES OF CHUKOTKA AND TECTONIC POSITION OF OPHIOLITES

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The Chukotka Peninsula represents the collage of geological structures of the Arctic and Pacific continental margins. These structures belong to four tectonic units. The South Anyui Suture and Chukotka (Anyui – Chukotka or Novosibirsk-Chukotka) fold belt are the parts of the Arctic Ocean margin, while the West Koryak and Anadyr-Koryak fold belts are the fragments of the Pacific Ocean margin.

The Arctic margin has been originated from the collision of the North America and Siberia continents that was resulted in a closure of the proto-Arctic Ocean and formation of the South Anyui Suture. The Pacific margin has been formed owing to accretion of various oceanic terranes to the continent.

Ophiolites of Chukotka have different tectonic positions, ages and geodynamic settings of their formation. The large Aluchin and Vurguveem massifs along with small allochthonous slices of ultrabasic rocks, gabbro, basalts and cherts spatially relate to the South Anyui Suture. The Aluchin and Vurguveem massifs are the Paleozoic and late Triassic in age, and they were originated in a suprasubduction setting [2]. The ages of small slices, which are mainly located in the Polyarny segment, are unknown. Amphibolites and green schists associated with these slices are dated at 256-229 and 125 Ma, respectively.

The South Anyui suture was thought to have a continuation in the Vel'may terrane, which is composed of ultrabasic and gabbroic rocks. But during the 2009-year joint Russian-Japanese expedition it was found that ultrabasic-basic complexes of various compositions and possibly various geodynamic affinities are juxtaposed in this terrane.

Ophiolites of the Ust'-Belaya terrane are a part of the accretionary structure of the late Cretaceous Pacific margin of the Asian continent. They are allochthonous and are thrust over Jurassic-Cretaceous volcanic-chert-terrigenous complexes and serpentine mélanges of the Algan terrane. The Ust'-Belaya terrane incorporates several tectonic nappes, which are composed of ophiolitic assemblages, terrigenous and tuff-terrigenous rocks of the middle Jurassic and late Jurassic – Valanginian ages [4, 5]. The Otrozhnaya nappe includes ophiolites (ultrabasic and gabbroic rocks, diabases and basalts) that underlie cherts, sandstones, conglomerates, tuffs and limestones of the middle-late Devonian and early Carboniferous ages. The Ust'-Belaya massif (the Tolovka nappe) is composed of lherzolites, harzburgites, gabbroic rocks and locally serpentine mélanges. U-Pb zircon ages of 799±15 Ma (gabbro) and 575±10 Ma (diorite) are indicative of several episodes of magmatic activities [3]. The ultramafic-mafic massif represents relatively deep sections of the subcontinental lithospheric mantle modified by intensive partial melting induced by percolation of subduction-derived melts of various compositions [1].

This work was supported by the Russian Foundation for Basic research (project No 09-05-92103) and Scientific School NSH-7091.2010.5.

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СТРУКТУРЫ ЧУКОТКИ И ТЕКТОНИЧЕСКАЯ ПОЗИЦИЯ ОФИОЛИТОВ

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Чукотский полуостров включает структуры арктической и тихоокеанской континентальных окраин. Они входят в состав четырех крупных тектонических элементов. Южно-Анюйская сутура и Чукотский (Анюйско-Чукотский, Новосибирско-Чукотский) складчатый пояс принадлежат Арктической окраине, а Западно-Корякский и Анадырско-Корякский складчатые пояса - Тихоокеанской окраине.

Арктическая окраина сформировалась в процессе коллизии Северо-Американского и Сибирского континентов, что привело к закрытию Прото-Арктического океана и образованию Южно-Анюйской сутуры. Тихоокеанская окраина была сформирована в процессе аккреции со стороны океана разнообразных террейнов.

Офиолиты Чукотки различаются по своему тектоническому положению, возрасту и геодинамическим обстановкам их формирования. С Южно-Анюйской сутурой пространственно связаны крупные Алучинский, Вургувеемский массивы и небольшие аллохтонные тела ультрабазитов, габбро, базальтов и кремней. Алучинский и Вургувеемский офиолиты имеют палеозойский и позднетриасовый возраст и образовались в надсубдукционной обстановке [2]. Возраст небольших тел, локализованных, главным образом, в Полярнинском сегменте неустановлен. Связанные с ними тела амфиболитов и зеленых сланцев имеют соответственно 256-229 и 125 млн. лет.

Продолжением Южно-Анюйской сутуры принято считать Вельмайский террейн, включающий ультрабазиты и габброиды. Однако, в результате полевых работ российско-японской экспедиции в 2009 г., (грант 09-05-92103) выяснилось, что в составе террейна объединялись различные по составу и геодинамическому происхождению ультрабазит-габбровые комплексы.

Офиолиты Усть-Бельского террейна входят в состав аккреционной структуры раннемеловой тихоокеанской континентальной окраины Азиатского континента. Они находятся в аллохтонном залегании и надвинуты на юрско-меловые вулканогенно-кремнисто-терригенные комплексы и серпентинитовые меланжи Алганского террейна. Усть-Бельский террейн состоит из нескольких тектонических пластин, сложенных офиолитами, терригенными и туфо-терригенными породами средней юры и верхней юры-валанжина [4, 5]. Отрожненская пластина сложена офиолитами (ультрабазиты, габброиды, диабазы, базальты), которые перекрываются кремнистыми породами, песчаниками, конгломератами, туфами и известняками среднего-верхнего девона и нижнего карбона. Усть-Бельский массив (Таловская пластина) состоит из лерцолитов, гарцбургитов и габброидов с зонами серпентинитового меланжа. U-Pb возраста цирконов 799±15 (габбро) и 575±10 (диорит) млн. лет указывают на несколько этапов магматической активности [3]. Ультрамафит-мафитовый массив представляет собой относительно глубинные части субконтинентальной литосферной мантии, претерпевшей интенсивное частичное плавление в результате взаимодействия с различными по составу надсубдукционными расплавами [1].

Работа выполнена при поддержке РФФИ (проект № 09-05-92103)и Ведущей научной школы НШ-7091.2010.5

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PROBLEMS OF ORIGIN OF THE PRE-MESOZOIC OCEANIC BASINS OF THE EASTERN MEDITERRANEAN AREA

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Paleozoic oceanic complexes of the transition area from European Platform to Eastern Mediterranean Hercynides exemplified by the Balkan-Carpathian ophiolite belt and paleooceanic zones of the crystalline basement of the Great Caucasus are described.

Brief characteristics of the Tracian-Transcaucasian terrane, situated to the south is also given.

1. The Balkan-Carpathian ophiolite (BCO) belt, framing from south the Moesian Platform, extends over 250 km from NW to SE. The ophiolite sequences of the belt were considered as fault-block remnants of a single Late Precambrian-Earliest Cambrian (563$\pm$5Ma) ophiolite thrust sheet formed in a mid-ocean ridge setting and possibly representing a crustal fragment of large oceanic basin. It is assumed, that BCO is a part of extended South European paleooceanic suture continued on southeast in Pontides and further in the Arabian-Nubian Shield, representing a trace of proto-Tethys closed in early Paleozoic in relation with Cadomian orogeny (Haydoutov, Yanev, 1997; Savov et al. 2001). A complex petrological, geochemical and geochronological investigation of representative samples of gabbros and associated diabase dike body, sampled in eastern part of Deli Jovan massive (BCO, Eastern Serbia) has been carried out. All studied gabbros represent high-alumina (19-24.5 % Al_2O_3) gabbro-troctolites and correspond to Ol_{82-89}+Cpx_{79-87}+Pl_{77-91} cumulates originated from shallow level ($\leq$ 1kb) crystallization of low-K (< 0.3 % K_2O) tholeiitic basaltic melt (T= 1050-1160^{o}C). Dike body corresponds to fine-grained, Cpx-Pl microphyric, high-magnesian tholeiitic gabbro-diabase. Multielement pattern and characteristic trace-element ratios of the series [$(La/Sm)_n$=0.18-1.31; $(La/Yb)_n$== 0.22-1.35; Th/La= 0.073-0.19; Zr/Y=1.60-2.39; etc.] fit well a MORB type setting. All geochronological data carried out for fresh Deli Jovan gabbros showed narrow Late Silurian-Early Devonian interval: a) Sm-Nd mineral isochron age of 406$\pm$24 Ma, MSWD=0.71, $^{143}Nd/^{144}Nd_{init}$=0.512547$\pm$0.000044; WR εNd_T=8.32$\pm$0.39; $87Sr/^{86}Sr_{init}$= 0.702592$\pm$0.000160; b) U-Pb SHRIMP zircon age 405.0$\pm$2.6 Ma, MSWD= 0.36. Nd and Sr isotopic ratios evidently indicate that the studied basic series are related to strongly depleted mantle source. Two of five samples of studied gabbros have shown clear overprint of the prograde regional metamorphism of upper part of greenschist facies at T ~ 400-450^{o}C (as. Actinolite $\pm$ hornblend + chlorite + epodote + plagioclase). Accordingly, the BCO reveals a complex geological history, along with Late Proterozoic complexes Paleozoic (Late Silurian-Early Devonian) fragments of paleooceanic lithosphere are also obviously presented here.

2. The Crystalline Core and Front Range zones of the Great Caucasus Hercynides framing south the Scythian platform (southernmost part of the European Platform), include paleooceanic thrust sheets of Paleozoic age (490-420 Ma; Adamia et al. 1990, 2004, Somin et al. 2006, 2008). Two types of series were identified. *The first* low-silica (SiO2=43,94-48,10%), high-titanium (TiO2=2,–3,03%, high phosphorus P_2O_5 = 0.22-0.88%) tholeiitic basalts of T-MORB type [(La/Sm)n=2,98±0,57; (La/Yb)n=5,72+2,05; (Tb/Yb)n=1,42±0,62; (Yb)n=13,15±4,73 and (Yb)MORB=0,97±0,35]. And *the second* of supra-subduction type corresponding to comparatively high-silica (SiO2=47.54-53.94%), low-titanium (TiO2=0,46-1,09%), low-potassium tholeiitic, basalts and associated basaltic andesites and andesites. Basalts of the latter series show an exclusively low total (51±31 ppm) and clearly fractionated REE pattern (La/Sm)n=0.77-2.40; (La/Yb)n=0.72-3.38. HREE is somewhat lower compared to the average N-type MORB [(Tb/Yb)n=1,04±0,34, (Yb)n=9,97±3,44, (Yb)morb=0,62±0,28)].

3. Despite of the revealed essential heterogeneity of composition of the compared oceanic complexes, we suggest that the Paleozoic oceanic suture of the Balkan-South Carpathian ophiolite segment probably extends eastwards to the Paleozoic ophiolite zones of the Great Caucasus. To the south from this extended Paleozoic suture zone an extensive peri-Gondwanan Thracian-Transcaucasian terrane is located (Rhrodope, Serbo-Macedonian and Transcaucasian massifs) pre-Hercynian crystalline basement of which show clear record of Cadomian orogenic events (Zakariadze et al. 1998; 2007; Carrigan et al. 2005; Kounov et al. 2006).