PENZHINA – ANADYR TERRANE, UST – BELAYA SUBTERRANE

MAINITS TERRANE

	A	B	C	D
	LITHOLOGY	THICK-NESS	AGE	MINERAL DEPOSITS
cover complex	Poorly lithified, shallow marine and continental clastic deposits intercalated with subaerial sequences of andesite, dacite, and minor rhyolite, and basaltic andesite (Devyatilova, 1975; Zakharov, 1980)	600 – 1,000 m	Eocene and Oligocene Age based on megafossil assemblages in terrigenous deposits and on five K-Ar whole-rock ages of 44 to 25 Ma for dacite and andesitic dacite (Devyatilova, 1975; Zakharov, 1980)	Clastic rocks of the cover complex served as intermediate traps for gold and platinum group metals (PGM) and subsequently as sources for placer deposits for these metals (Voloshin and others, 1972)
	Lower part: agglomerate and ash-fall tuff, tuffite, and sandstone. Upper part: poorly lithified shallow marine and continental coal-bearing deposits (Zakharov, 1980)	700 m	Late Senonian Maastrichtian ammonites. The upper coal-bearing part of the sequence may be Danian to Paleocene in age on the basis of geological correlations.	
	Sandstone, siltstone, and minor conglomerate, marl, and chert (Zakharov, 1980)	1,100 m	Late Albian to Senonian Age based on megafossil assemblages (Zakharov, 1980; Markov and others, 1982)	
Udachny unit	Sandstone, siltstone, argillite, and minor marl lenses, and olistostromal bodies (Zakharov, 1980; Tilman and others, 1982)	1,000 m	Late Jurassic and Early Cretaceous *Buchia* of Late Jurassic to Valanginian age (Aleksandrov, 1978; Zakharov, 1980)	No deposits known
Otrozhny unit	Sandstone (with clasts of serpentinite, chromian spinel, diabase, and chert), siltstone, conglomerate, and limestone (Aleksandrov, 1978)	300 m	Early Carboniferous Brachiopods, corals, and crinoids (Aleksandrov, 1978; Zakharov, 1980)	Au - Gold-bearing veins in ultramafic rocks and chert-volcanogenic sequence. Associated placer deposits (Voloshin and others, 1972; Aleksandrov, 1978; Zakharov, 1980)
	Calcareous sandstone, limestone, siltstone, chert, and tuff (Aleksandrov, 1978; Zakharov, 1980)	500 m	Middle to Late Devonian Age based on megafossil assemblages (Aleksandrov, 1978)	
	Vesicular basalt, diabase, spilite, and diabase breccia overlain by chert, tuff, and tuffaceous sedimentary rocks (Aleksandrov, 1978; Markov and others, 1982)	700 m	Early Devonian (?) Age based on geologic relationships (Markov and others, 1982)	
	Olivine gabbro, and gabbro (layered and isotropic)	1,000 m 3 km	K-Ar whole rock dates for plagiogranite and related quartz-muscovite veins: 247 Ma (Permian), 218 Ma (Late Triassic), 212 Ma and 204 Ma (Early Jurassic), 192 Ma and 178 Ma (Middle Jurassic) (Aleksandrov, 1978; Zakharov, 1980, Dmitrenko and others, 1990)	
	Peridotite (harzburgite, diopside harzburgite, lherzolite, and dunite)	300 m		
	Mélange with serpentinite matrix. Blocks of gabbro, plagiogranite, diabase, serpentinite, sandstone, and siltstone (Aleksandrov, 1978)	300 m		
Ophiolite complex, Peridotite – Gabbro unit	Olivine gabbro and troctolite, in large part metamorphosed to metagabbro and epidote amphibolite (Silkin and Sterligova, 1973)	1,000 m	Devonian Ar-Ar amphibole ages for metagabbro are 400 Ma and 370 Ma (V.A. Popeko and Paul Layer, unpub. data, 1995)	No deposits known
	Northern block: intercalated dunite, harzburgite, cortlandite, pyroxenite, and hornblendite; central block: intercalated dunite, wehrlite, troctolite, and olivine gabbro (Smirnova, 1974; Palandzhyan, unpub. data, 1995)	100 – 1,000 m		Cr - Isolated occurrences of Al-rich massive and disseminated chromitites, which form layers as much as 1.5 m in length and less than 10 cm in thickness (Smirnova, 1974)
	Dunite (in northern block)	100 – 500 m		Cr - About 20 disseminated low-grade chromitite occurrences form a band about 1.5 km in length and as much as 150 m in width (Smirnova, 1974)
	Peridotite (variably serpentinized). Chiefly lherzolite partly altered to amphibolite and antigorite. In northern block also includes harzburgite and diopside harzburgite. Rare tectonic inclusions of mafic metamorphic rocks. Dikes and small stocklike bodies of microgabbro, syenite, albitite, quartz diorite, and olivine gabbro. (Silkin and Sterligova, 1973; Palandzhyan, unpub. data, 1995)	4,000 m 5 – 7 km	K-Ar whole-rock ages for keratophyre, granophyre, and alkaline syenite to microgranite dikes intruded in peridotite in Eldenyr and northern blocks are 118 Ma, 78 Ma, 77 Ma, 58 Ma (Late Cretaceous and Paleocene) (Palandzhyan, unpub. data, 1995)	Au - Ultramafic-hosted gold-bearing quartz veins and associated gold- and PGM-bearing placer deposits lying mainly on serpentinite mélange. The mélange is the probable source of the PGM deposits (Voloshin and others, 1974; Aleksandrov, 1978; Zakharov, 1980; Dmitrenko and others, 1990)
	Mélange with matrix of clay-like serpentinite. Ultramafic blocks (lherzolite, serpentinite, and wehrlite), gabbroic blocks (troctolite, harrisite, olivine gabbro, and metagabbro), and blocks of metabasalt, schist, shale, tuffite, granitoids (muscovite plagiogranite and pegmatite). Metamorphic rocks of greenschist and amphibolite facies. Limestone and sandstone of Devonian age (Aleksandrov, 1978; Palandzhyan, unpub. data, 1995)	300 – 500 m	K-Ar whole-rock ages for plagiogranite, pegmatite, and aplite are 188 Ma, 183 Ma, 172, Ma (Middle Jurassic), and 123 Ma, 108 Ma (Early Cretaceous) (Palandzhyan, unpub. data, 1995)	
Utyosiki unit	A packet of thrusted and imbricated tuffaceous, clastic, and cherty volcanogenic units separated locally by serpentinite and mélange with serpentinite. Units consist of: 1) Tuff and tuffaceous sedimentary rocks of felsic and intermediate composition, keratophyre, sandstone, siltstone, and intrusions of granodiorite, plagiogranite, microgranite, gabbrodiorite, and 2) Schists, tuff, and island arc-type basalt (Zakharov, 1980, Agaltsov, unpub. data, 1995)	1,600 m	Late Paleozoic to Early Cretaceous (Neocomian) Siliceous volcaniclastic rocks presumeably of Late Paleozoic age. They are intruded by microgranite that yield K-Ar whole rock age of 302 and 308 Ma. In the middle part of this tectonic unit a large sheet of sandstone, siltstone, tuff, and marl contains Bathonian *Inoceramus*. Schist, tuff and basalt presumeably are of Late Jurassic to Neocomian age (Aleksandrov, 1978; Zakharov, 1980; Markov and others, 1982)	No deposits known
	Siltstone, argillite, sandstone, schist, chert, and basalt (Zakharov, 1980)	> 2,000 m	Early Cretaceous (Valanginian) *Buchia* of middle to late Valaginian age (Zakharov, 1980)	

GEOCHEMISTRY OF MAFIC, ULTRAMAFIC, AND ASSOCIATED ROCKS

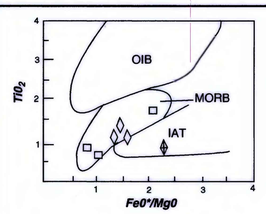

Fig. 1 TiO_2 versus FeO^*/MgO variation diagram for mafic volcanics and dikes. OIB – ocean island basalts: MORB – mid - oceanic ridge basalts: IAT – island - arc tholeiites. Fields of different-type basalts from Glassley, 1974.

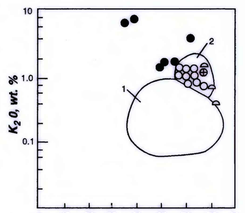

Fig. 2. K_2O versus SiO_2 diagram for granitoids, after Coleman, 1977. 1 – oceanic plagiogranite: 2 – continental trondhjemite.

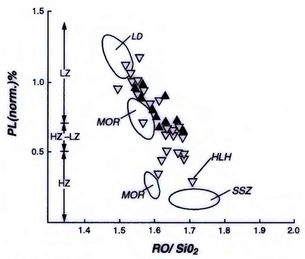

Fig. 3. Normative plagioclase versus RO/SiO_2 variation diagram for tectonized peridotite, after Palandzhyan,1992. Fields of average data for diverse types of mantle peridotite; LD – less depleted sub – continental and sub – oceanic; MOR – mid-oceanic ridge; SSZ – supra-subduction zone. Discrimination of HZ – harzburgite, HZ–LZ – harzburgite–lherzolite, or diopside harzburgite – and LZ – lherzolite, after Dmitrenko and others, 1990. HLH – high level harzburgite, near amphibole cumulate sequence in northern block.

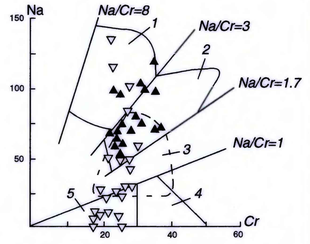

Fig. 4. Na versus Cr in clinopyroxene variation diagram for tectonized peridotite (in parts per mille for 6 oxygen), after Kornprobat and others, 1981, revised by Palandzhyan, 1992. Groups of mantle peridotite according to tectonic setting of their formation: 1 – sub-continental. 2 – abyssal near passive margins, 3 – very low spreading ridges, (dashed lines), 4 – low and fast spreading ridges, 5 – regions of upper mantle with superimpoused hydrous partial melting (supra–subduction zone and/or intraplate hot-spots area).

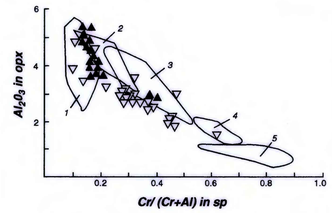

Fig. 5. Al_2O_3, in orthopyroxene (opx) versus Cr /(Cr+Al), spinel (sp) variation diagram, after Bonatti and Michael, 1989, revised by Palandzhyan, 1992. Groups of tectonized peridotite according to tectonic setting of their location: 1 – sub-continental, 2 – passive margins, 3 – mid-oceanic ridges, 4 – west-Pacific island arcs inner slope of trench, 5 – very depleated harzburgite of the west Pacific Mesozoic fore-arc fragments in Mainits Zone of Koryak Highland, and in Papua, New Guinea.

Diagram Symbols

- Basalt and spilite (middle Paleozoic)
- Micrograbbo (dikes in northern block cumulate ultramafics).
- Diabase dike in Otrozhny unit.
- Plagiogranite in Otrozhny unit
- Blocks of plagiogranite included in basement mélange of peridotite - grabbo unit.
- Quartz keratophyre, in Utyosiki unit.
- Granitoids, and alkaline syenite of Late Cretaceous and Paleocene age.
- Peridotites of northern block (Ust–Belaya massif)
- Peridotites of Eldenyr massif

REGIONAL SETTING AND GEOLOGY

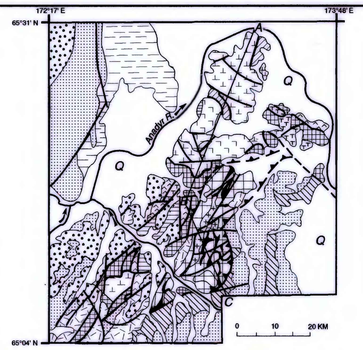

Fig. 8. Geologic map of the Ust - Belaya subterrane

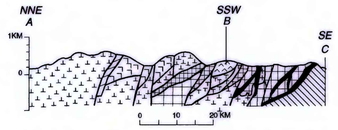

Fig. 9. Cross section of geologic map of the Ust - Belaya subterrane

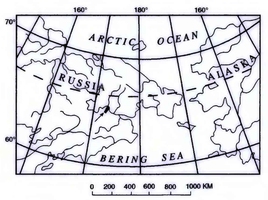

Fig. 6 Location of the Ust–Belaya subterrane

EXPLANATION

Overlapping molasse deposits (late Mesozoic to Cenozoic)

- Q Alluvial deposits (Quaternary)
- Volcanic deposits (late Eocene to Oligocene)
- Sedimentary deposits (late Eocene)
- Sedimentary deposits (late Albian to Senonian)

Mainits terrane (Valanginian)

- Chert, shale, and volcanic rock

Penzhina – Anadyr terrane

Main River subterrane (Triassic, Jurassic)

- Sedimentary rocks

Ust - Belaya subterrane

Udachny unit (Late Jurassic to Early Cretaceous)

- Sedimentary rocks

Otrozhny unit (middle Paleozoic)

- Sedimentary and volcanic rocks
- Ultramafic and gabbroic rocks

Peridotite – Gabbro unit

- Ultramafic rocks
- Mafic rocks
- Serpentinite
- Mélange

Utyosiki unit (late Paleozoic to Early Cretaceous)

- Package of tectonic slices and blocks of tuffaceous, and sedimentary rocks
- Granitoids
- Serpentinite
- Thrust faults
- Strike – slip faults

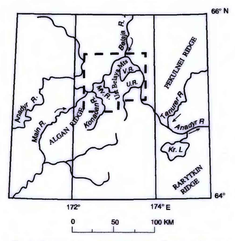

Fig. 7 Geographic position of the Ust–Belaya subterrane geologic map (dashed line).
Mv. R. – Mavrina River: U.R. – Utyosiki River: V.R. – Vetvistaya River: Kr.L. – Krasnoje Lake.

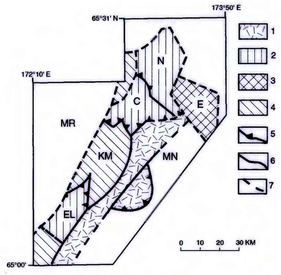

Fig. 10. Main tectonic blocks of the Ust-Belaya subterrane ophiolite.
Names of blocks: N – northern, C – central, KM – Konachan-Mavrina, EL – Eldenyr, E – eastern, MR – Main River subterrane, MN – Mainits terrane,
Ust-Belaya subterrane tectonic units: 1 – Utyosiki, 2 – Peridotite – Gabbro, 3 – Otrozhny, 4 – Udachny.
Faults: 5 – thrust, 8 – strike-slip. 7 – concealed boundary.

EXPLANATION

Sedimentary and metamorphic rocks

- Argillite, shale
- Siltstone
- Sandstone
- Conglomerate
- Limestone, marl
- Chert
- Greenschist

Igneous rock

- Tuff, and tuffaceous rock
- Dacite, andesitic dacite keratophyre
- Basalt, spilite
- Diabase
- Microgabbro
- Gabbro pegmatite
- Isotropic gabbro
- Layered gabbro
- Dunite
- Intercalated dunite, wehrlite, cortlandite, and pyroxenite
- Lherzolite, and harzburgite
- Serpentinite
- Tectonic mélange

Faults

- Thrust and strike-slip fault bounding the lithotectonic units
- Same, within the lithotectonic units

This report is preliminary and has not been reviewed for conformity with U.S. Geological editorial standards or with the North American Stratigraphic Code. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government

OPHIOLITIC COMPLEXES AND ASSOCIATED ROCKS IN UST – BELAYA MOUNTAINS AND ALGAN RIDGE, RUSSIAN FAR EAST

compiled by
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1996