73 In 2013 the RAS Institute of Ethnology and Anthropology turned eighty. Its regular, tenth, congress held in Moscow last summer had kudos for the job done.

80 Legend has it that the first Russian czar of the Romanov dynasty, Mikhail Feodorovich, was born in the house of his grandfather, Boyar Nikita Romanovich Zakharyin-Yuriev. This house, one of the oldest in Moscow, is still there.

103 Lying in the coastal area of southern Primorye, or the Maritime Region, is the Far Eastern Natural Sanctuary in care of the Russian Academy of Sciences. Also out there is the Krabbe Peninsula, an open-air mineralogical museum with its old dead volcanoes and deposits of industrial stones.

Karelia's pristine carbon-containing rocks are wonderful natural formations of the Proterozoic age—about two billion years old and having no analogs in the geological history of the earth. Such rocks have a wide range of carboniferous inclusions, rich and lean alike. Shining schungites certainly take pride of place among the minerals of that northern land. These objects command close attention of the home research institution—the Karelian Research Center of the Russian Academy of Sciences.

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"LIVE" STONES OF KRABBE PENINSULA

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Southern Primorye, or the Maritime Region of the Russian Far East, is unique in many ways. A region described with much love by such great travelers and naturalists as Nikolai Przewalski, Yuri and Valery Jankowskis, and by story writer Mikhail Prishvin. Most of this ecosystem is under the Far Eastern Sea and Biosphere Preserve in care of the Russian Academy of Sciences, together with the adjacent Khasan Natural Park. As a major area of international ecology and research tourism it needs special care and attention. Its geological objects (Krabbe and Novgorodsky peninsulas above all) are in fact open-air mineralogical museums with old, now dormant volcanoes that became inactive thirty million years ago. This is a mineral-rich territory with deposits of industrial stones— opal, chalcedony, agate…

These two peninsulas, Krabbe and Novgorodsky, attracted geologists long ago. Back in 1928 Edouard Anert, an eminent explorer of our Far East, described the Tertiary deposits flora there; and in 1945 Georgi Vlasov, another explorer, came up with a detailed map of Cenozoic formations in the Kraskino hollow—he did it during surveys for brown coal deposits in the Khasan district. His research findings still hold today.

The author of the present article also made a close study of volcanic formations there in the nineteen-nineties and later on. Field research data and those on succession of geological events made it possible to identify several foci of eruptions at Kraskino and Zaisanovka, and also on Novgorodsky and Krabbe peninsulas. Basalts and andesites (basic and intermediate rocks composed of plagioclase, olivine, pyroxene and volcanic glass), as it came out, are present in the

Seashore map of southern Primorye where Krabbe Peninsula is situated.

wrecks of strato-volcanoes (stratified cones)*, while rhyolites and dacites (acid, or persilicic rocks made up of quartz, soda-potash feld spar and biotite) are actually extrusive lava structures with pyroclastic (fragmental) deposits most conspicuous on Krabbe Peninsula. The diversity of facies and the petrografy of its volcanic rocks, the good exposure and clear morphology of its geologic bodies as well clearly "readable" profiles in sea bluffs including bedrock shows of zeolites, chalcedonies and quarts—all that makes this object unique.

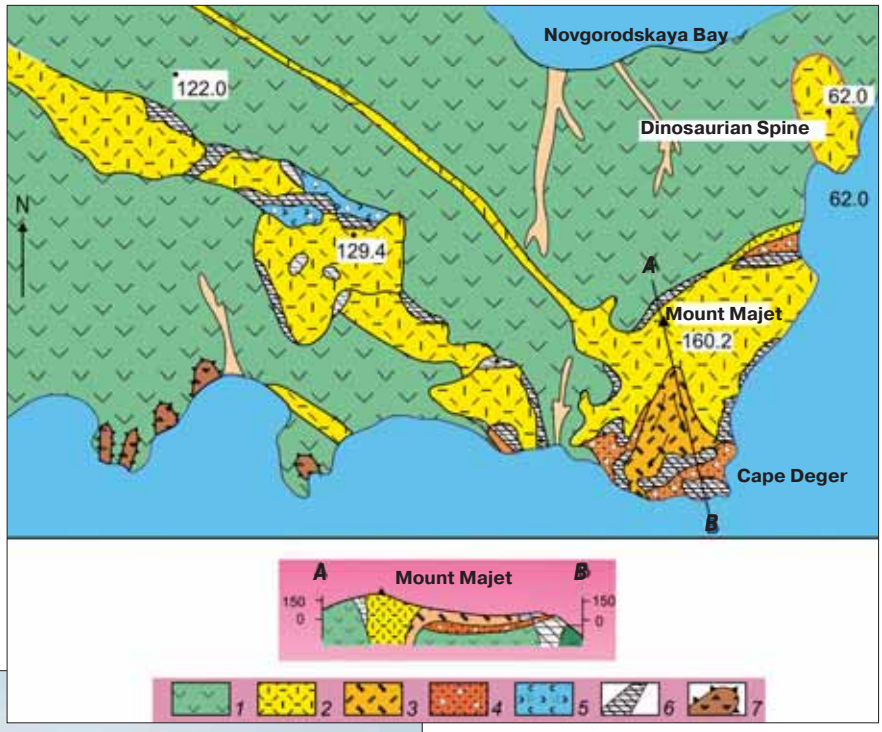
Manifestations of volcanicity, a characteristic and important geological process, are of immense significance in earth crust formations. Each land surface on our planet—be it a continental or an oceanic trough, a folded region or a plateau—could not be formed without lava flows. Dr. Yevgeny Markhinin, a lead volcanologist, describes fiery lava and what goes with it—incandescent ashes, scoria (slag) and scorching clouds—as a "live stone". "A volcano is like man—it is born, it lives through its young, mature and old age, and dies when its vital sustenance, the magma, ceases to support life in it."—"The 'soul' leaves its body in little clouds of bluish gas rising from lava streams or lava domes. Thereupon the lava turns into ordinary stone." Thus volcanites turn dead. Stone dead. Such rocks on Krabbe Peninsula can tell a remarkable lot about the birth and life of once raging volcanoes. Their eruptions, according to geochronological datings, occurred in the Late Eocene, that is 38-32 mln years ago.

This peninsula is just a bit over ten kilometers long, and no more than five kilometers wide. A narrow isthmus, about five hundred meters wide (an ancient spit), links it with the mainland. Minonosok Bay cuts deep into the central part of the isthmus; this bay, along with the neighboring Bay Kreiserok, is within the sea preserve. The western part of the peninsula ends with the steep Cape Astafyev plunging into the sea. A gently sloping range in the middle of the peninsula is crowned by several summits. The tallest, Mount Novgorodskaya, is almost 180 m above sea level. Looking at the peninsula from the isthmus or the nearest point, the top of a small volcano (Dinosaurian Spine), we clearly see the step-like relief features of its slopes. The gentle lateral ridges merge into ranges inclined toward the open Gulf Posiet. In Novgorodskaya Bay they form steep ledges on the seaside. This is what we call a *cuesta*, the Spanish word for a mountain slope, or scarp. As a rule it is confined to sedimental rock strata, or occasionally to volcanic rock of heterogeneous structure.

About a kilometer away from Cape Astafyev lies a long Nazimov (Churkhado) spit stretching for more than four kilometers. Towering above its northwestern tip is a scenic andesite cliff. Lying in between two spits is an unnamed islet, a relic of andesite lavas. Northward is a small peninsula, Novgorodsky, where back in 1859 Russian seafaring explorers discovered the first deposit of lignite, or brown coal (today the site of the community of Posiet).

All these coastal landscapes of Krabbe Peninsula are the living pages of the stone chronicles of bygone volcanic events, a major object of sight-seeing and scientific tourism. This peninsula was named in 1863 for Vice-Admiral Nikolai Krabbe (1814-1876) by an expedition led by Colonel Vassily Babkin that, aboard the training corvette *Kalevala*, were making hydrographic studies. Vice-Admiral Krabbe had sailed on board naval ships in the Black, Caspian and White

* Volcanoes composed of continually interbedding loose deposits and continual lava streams.—*Ed.*



Outline of a schematic geological map of the southeastern part of the Krabbe Peninsula: 1—andesites; 2—rhyolite extrusive bodies; 3—lava stream of rhyolites from Mount Majet volcano; 4—tuffs and rhyolite xenotuffs; 5—glassy rhyolite tuffs; 6—volcanic glass (perlites); 7—explosive bodies and volcanic neck breccia of andesites.

Cuesta relief of Krabbe Peninsula ridges. *Photo, Ye. Kravtsova*

Seas. In 1860 he became a top officer of the Admiralty. Although he did not see service in the Far East, he helped Nikolai Muraviev-Amersky, East Siberia Governor-General, in building up the local flotilla and in sea explorations.

Krabbe, once a tilting peninsula formed as a result of the strato-volcano's collapse, now rises over younger tectonic basins (Expedizia and Novgorodskaya Bays, the Gulf of Posiet); it is similar to Samoshir Island in Indonesia so far as its formative conditions are concerned. That island came into being around 73 thous. years ago after a disastrous eruption causing global climate changes. Some archeologists and anthropologists maintain that was the cause of a dramatic cut in the *Homo sapiens* populations on earth. The floor of Samoshira and Krabbe alike exhibits denuded ancient rocks of the volcano's base.

The relic of the maritime strato-volcano still keeps a large number of volcanic necks and pipes as well as extrusive domes (dome-shaped) volcanoes, the eruption centers of smaller (daughter) volcanoes disgorging lava flows of rhyolites and volcanic glass. The largest

Dinosaurian Spine volcano, a natural monument.

Extrusion rock dissected by numerous fissures and cavities made by outflows of acid magma.
Photo, Ye. Kravtsova

Steeply deposited rhyolite tuffs uplifted with the extrusion of volcanic glass. The rocks contain volcanic fragments together the detritus of the base (xenolites) cemented by ashy material.

Diverse sculptural figures and arches on Krabbe are of volcanic glass.

Explosive breccias are composed of fragments of gray andesites and oxidized cementing material of the same composition.

structure of this kind, Mount Majet, rises 160 m above sea level. A mountain two kilometers northwest, 129.4 m tall, is also an independent extrusive dome. Owing to erosion processes, such smaller volcanoes stand out in the peninsula's relief and form characteristic geomorphological forms (lava streams, domes, dykes*); in coastal outcroppings one can discern their structure in vertical sections (elevations). Plutonic rocks are in the form of eruptive breccia, pyroclastic deposits (volcanic tuffs) and lavas—in chemical compositions these are basalts, andesites and rhyolites.

Tuffisites are among the most interesting types of component rock on Krabbe peninsula. Looking like ordinary tuffs, these rocks are deposited in fissures, not on the volcano's slopes, and are a channel for the intrusive magma suspension (similar to kimberlites) composed of dacites and rhyolites. Magma eruptions were accompanied by discharges of fluidal rhyolites and water-containing volcanic glass (perlites); cooling, such flows caused a segregation of geothermal solutions. The circulation of silica-rich suspensions initiated a secondary hydration (water saturation) of amorphous volcanic glass with zeolite group* minerals. Filling in fissures and cavities in rock, they had silica precipitating in various modifications—opal, chalcedony and quartz.

Krabbe Peninsula volcanism reflecting a succession of global geologic events taking place during the Cenozoic (an era in the geological history of the earth still on) on the boundary of the Asian continent and the Pacific concurs with the initial stage in the formation of the Sea of Japan basin. Such basins (grabens), or pull-apart basins, as geologists call them, are essentially riftogenic (linearly deformed). The deep faults confining them may reach down to the magma zone. Therefore, going under, they are filled quickly with a volcanogenic molassa containing detrital rocks, basalt, andesite and rhyolite lavas, and pyroclastic sheets; during volcanic dormancies they are filled with volcanogenic-sedimental and terrigenic (formed from erosion products) coal-bearing deposits.

* Dyke—a hardened, tabular mass of igneous rock that has been forced into a fissure while in a melted state.—*Ed.*

* Zeolite, any of a number of hydrous silicates of aluminum, sodium or calcium found in the cavities of igneous rocks. A natural mineral capable of absorbing and retaining particles of different substances.—*Ed.*

The rhododendron plant (Rhododendron schlippenbachii Maxim.) growing only on the edge of the seashore bluff southernmost.

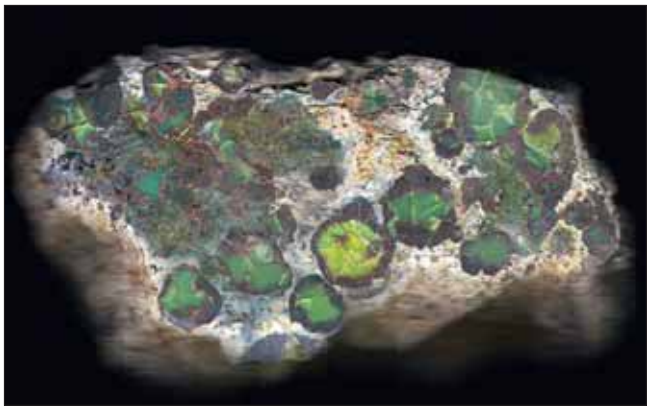
Volcanic glasses trimming the 129.4-high dome hold stone bubbles (lithophysae) comprising particolored opal aggregates.

In southern Primorye the Kraskino hollow is like that, stretching northwest for 50 km, and 3 to 12 km wide. Its southwestern edge is limited by a system of steep faults. The bottom lies as deep as 900 meters. Playing the main part in its tectonic record were sinistral (left-handed) displacements responsible for the present intermixture of displaced blocks in what was once a solid volcanic structure building up the peninsulas Novgorodsky and Krabbe.

The Sea of Japan was non-existent in the Eocene, and the present-day islands there were part of the continental margin. The Kraskino hollow lay at a considerable distance from the coast, with volcanism manifesting itself in its southeast. In the region of the communities of Kraskino, Posiet and on Krabbe Peninsula there are several centers of eruptions of basalt-andesite and dacite-rhyolite lavas making up the ruins of strato-volcanoes. Geologists assume that powerful eruptions of acid magmas gave rise to a large caldera (bowl), now the site of Bay Reid Pallada. The Sea of Japan came into being in the Miocene, or 22-15 mln years ago. The subsequent tectonic events broke in full the once solid volcanic massif into upstanding and sinking blocks. The sea level rise in the post-glacial period of the Holocene (12-10 thous. years ago) led to the formation of the shallow bays Novgorodskaya and Expedizia, of the deep-water Gulf of Posiet, and of the present-day relief of the seashore on the site of subsidences. The Krabbe Peninsula is the largest relic of the vanishing volcano whose rocks still keep the record of the formative history of the entire Kraskino hollow.

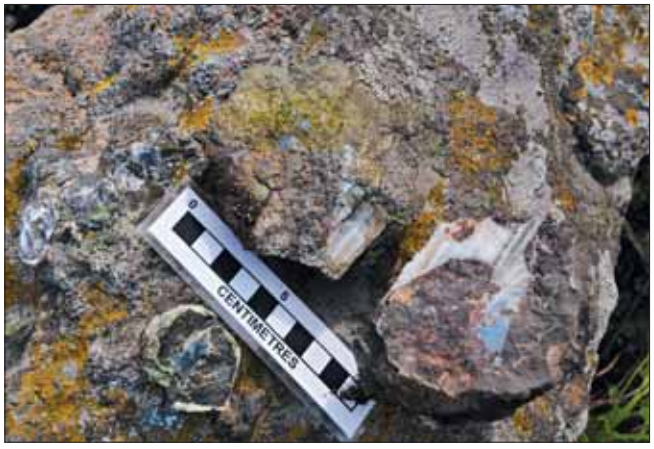
The initial stage of volcanicity witnessed basalt lava flows onto old (Paleozoic) rocks on the basin's bottom. This is clearly seen on Krabbe's northeastern slopes overlooking Novgorodskaya bay where basalts overlap the foundation of the volcanic structure and make up the base of the strato-volcano's cone. Subsequently viscous andesite lavas started pouring out onto the slopes, they alternated with pyroclastic rocks, the products of explosions. Extrusive domes were formed at the final stage. Remarkably, Kamchatka lying faraway from these parts has look-alike volcanoes of the Krabbe kind, the active fire-spitting giants Shiveluch and Bezymyanny.

The basalt-andesite volcanism was then followed by eruptions of persilic (acid) magmatic melts ending in the formation of yet another group of volcanoes. This process was accompanied by discharges of an immense amount of pyroclastic cinerous-pumiceous products. Their horizons intercalated with sedimental carbonif-



***Lithophysa* stone bubbles built of agate also occur on the peninsula.**
Photo, Ye. Kravtsova

Cross cut of opal.



erous rocks. These strata contain numerous imprints of plants and aquatic animals (*Trichoptera* larvae's lorica, fish skeletons). For instance, found in the Kraskino quarry not far from the community of the same name (a quarry well known to paleobotanists) were floriferous deposits making it possible to restore ground plant species growing there in the Oligocene. This profile is now a model one for the plant kingdom on the southern districts of the Far East in those days.

Of great interest, geologically, is the volcano dubbed Dinosaurian Spine, a keen rocky projection rising above sea level to 62 meters and stretching from the southeast to the northwest, kind of guarding the entrance to the peninsula from the isthmus. Visible in the tall walls of seashore exposures facing the bay Reid Pallada are bedrock volcanic zones of Mount Majet. Most different rocks occur out there—xenotuffs, rhyolite fluidal lavas, extrusive bodies of volcanic glass with lithophysae (stone bubbles) of opal, chalcedonies and quartz, and enclosed giant blocks of xenoliths; likewise present there are what is called tuffisites, a spectacular group of plutonic rocks. This term, tuffosite, was coined in 1941 by Hans Kloos, a German geologist, for detrital (clastic) rocks building volcanic necks and embedded in the form of veins, dykes and sills (stratal formations). Lately there has been a growing interest in these rocks due to their uncommon composition and genesis. In 2000 two geologists working in the Urals, Irina Golubeva and Lev Makhlaev, proposed to single them out into an independent classification taxon.

The tuffisite outflows on Krabbe Peninsula form striking relief features, the volcanogenic cuestas responsible for the inimitable mountain-steppe landscape of the dividing ridge. Usually it is typical of regions built by sedimental rocks of heterogeneous composition. We can see landscapes like that in the Crimea. In the Maritime Region (Primorye) they are confined to volcanic rocks well resistant to weathering, such as andesite lavas alternating with looser interstratal tuffisites of rhyolite composition that form 3 to 25 m arched bodies in a stretch of 5 to 7 kilometers. Their ground surface exposures lie in the basement of cuesta ledges. Tuffisites are remarkable for their intricate structure. Their central zones are built predominantly of rhyolites and their intermediate zones, of peculiar tuff gritstones and conglomerates. And their marginal zones include explosive breccias branching out in veins and thread veinlets filled with the finest bright green material, the emulsified magmatic suspended matter.

Xenotuffs, the pyroclastic rocks, are remarkable both in origin and in composition. These are products of gas-explosive eruptions of the rhyolite volcano, Mount Majet, embedded at its base. These are intrusive (granites, diorites, gabbro) and metamorphic (crystalline schists, gneisses) rocks of Rifeian (1,570-600 mln years) and Paleozoic (570-230 mln years) age. Clearly seen in coastal denudations is the layered tuff structure. Each layer is a product of still another eruption; deposits of detritus on the volcano's slope are cemented by primary magmatic material, composed of rhyolite ashes. Interacting with water solutions, volcanic glass was substituted by secondary minerals—zeolite, opal and hydromica.

Well-polished pebbles of rhyolites and other ornamental stones dominate the Bay of Fluidal Waters not far the Cape of Deger.

Volcanic glass (foreground) spatially associated with Alnidal rhyolites (background) forming zones of chilling in extrusive bodies.

Krabbe is rich in deposits of ornamental chromatic stones, such as agates, chalcedonies, opals, fluidal-striated lavas and chlorous tuffs as well as red jasper-like rocks. On Cape Deger, near the 129.4 m eminence, we come across lithophysae stone bubbles 10 to 15 cm across having semitransparent opal of yellow-green color; rhyolites also occur out there. The latter are of fine fluidal structure noted for alternating gray and brown-greenish streaks; they are good as industrial stones. Also attractive are ornamental silicified ashy tuffs containing fairly large (1-2, 3-4 cm across) lentiform fragments of modified volcanic glass, pistachio green in color, standing out against the lilac-brown background. Strolling about the pebbly beaches of Cape Deger, you can collect a good many colored and industrial stones. It will be a rich collection, sure.

This peninsula has quite a lot to offer to people of the wanderlust kind, ecotourists and researchers alike. Owing to the great variety of plutonic rock types and their good exposure, it is excellent field practice for would-be geologists and geographers, biologists and ecologists enrolled at Far Eastern Federal University.* Data obtained in explorations of Krabbe's natural objects are presented in film slides and in an exposition prepared for the Museum of Geology and Mineralogy run by the Far Eastern Institute of Geology. Our collection features rock types, maps, space photos as well as photographs of landscape monuments and other illustrative materials making it possible to visualize what the "outgoing volcanoes of Krabbe Peninsula are like"—the guideline of the exposition.

* *See*: V. Solyanik, "Golden Fund" of Geological Science of Primorski Krai", *Science in Russia*, No. 5, 2013.—*Ed.*

Illustrations supplied by the author