## Impressions of geological features, nature, and life in Kamchatka

# Report on an excursion conducted in August 2014

#### PHILIPP SCHMIDT-THOMÉ AND MICHAEL STAUDT

he southern part of the Kamchatka Peninsula has a very high density of active volcanoes (Fig. 1). We have a long-standing interest in this remarkable place, not only due to its fascinating geology, but also due to its wild nature and interesting historical past. Philipp Schmidt-Thomé conducted a privately organized excursion to Kamchatka in August 2014. The journey had a strong focus on geological features and the nature, but also on socio-economic structure and historical background of the area. This article describes the sites visited during the excursion and puts the trip into a geological and geographical context. Kamchatka is definitely worth visiting for a dedicated geoscientist, and this article hopefully sparks some interest.

During the ten-day trip we hiked on four days, were aboard two helicopter flights and one boat trip, and sojourned at a Pacific beach and in the city of Petropavlovsk.

Hiking up a glacier valley we encountered two roaming bears searching for food – and were luckily able to evade them. During the helicopter excursion to the Kuril Lake at the southern tip of the peninsula we were able to observe dozens of bears fishing salmon (Fig. 2). This trip brought us also to the Ksudach caldera, where we were able to enjoy a bath in a hot spring.

The other helicopter excursion took us to a close flyby of the Karysmky and Maly Semyachik volcanoes. The former experiences daily eruptions, while the crater of the latter bathes in acidic, stunning turquoise water. The excursion included hikes in the "Valley of the Geysers" (Fig. 3), in the enormous Uzon Caldera, and in beautiful alpine meadows, also allowing us to bathe in hot springs and in a cold stream.

The hiking tour to climb the Gorely volcano was challenging due to the visibility at the summit of less than 10 meters. Our stay at the base camp at the foot of the Avachinsky volcano (Fig. 4) was followed by a hike over a basalt extrusion called the Camel. The ascent to the Avachinsky crater also proved difficult due to the weather conditions characterized by a very low visibility.

During a boat trip in the Avacha Bay we could observe several bird species as well as whales. We also saw nuclear submarines waiting for maintenance. The participants of the boat trip were handed fishing rods and we caught some sea perches, out of which a





Figure 1. A Digital Elevation Model (DEM) map of Kamchatka and the main locations discussed in the text. Data source: Jarvis et al. (2008). © M. Staudt and P. Schmidt-Thomé, GTK.

Kuva 1. Kamchatkan korkeusmallikartta (DEM) ja tekstissä käsitellyt kohteet. Aineistolähde: Jarvis *et al.* (2008) © M. Staudt and P. Schmidt-Thomé, GTK.

#### Planning excursions

The long political isolation of Kamchatka and recent engagements in improving the environmental protection of the flora, fauna, and volcanoes make the peninsula a nearly idyllic place – from an eco- (or geo-) tourism point of view. There are vast areas of virtually untouched landscapes and a high abundance of plant and animal species – and volcanoes which dominate the scenery. Kamchatka is on the UNESCO's World heritage list, described as "one of the most outstanding volcanic

traditional Russian fish soup (ukha) was cooked on board.

On the last day we visited a Pacific beach and, as a really nice surprise for us, we were invited by the cook who had accompanied us on so many excursions to prepare Kamchatka crab and "shashlyk" at her "datcha", Russian for summer cottage.



Figure 2. Bears fishing in the Kuril Lake caldera in front of the Ilyinsky volcano. Photo: P. Schmidt-Thomé. Kuva 2. Karhuja kalastamssa Kuril-järven kalderassa. Taustalla Ilinski-tulivuori. Kuva: P. Schmidt-Thomé.



regions in the world" (UNESCO 2015). Currently around 7000 tourists visit Kamchatka annually, most of which are from Russia, followed by Western countries like Japan, Germany, and USA.

Fishing is one of the most important tourist activities. Eco-tourism, e.g., hiking and trekking, is on the increase. Most of the tourists visit during the short summer; winter tourism (e.g. heli-skiing) plays a minor role.

Conducting excursions in Kamchatka is highly weather-dependent, as conditions can change frequently throughout the day. It is highly recommended to get a guide for the excursions and hikes. As an example, several possibilities exist to access the craters and the peaks of the volcanoes, but not all paths lead to the desired destination. Quick changes in the weather and visibility can make orientation challenging. The abundance of bears must also be taken into account: several persons get killed every year. The official local guides are welltrained and have to pass annual examinations.

As a general guideline, it is recommended to make an excursion plan with an agency that is familiar with the local conditions. August is probably the best month for hiking and trekking in Kamchatka, as by then the snow has melted on most paths and nearly all points of interest are accessible. Furthermore, a relatively stable high-pressure zone and thus relatively sunny conditions can be expected in the late summer. Several easily accessible volcanoes are located close to Petropavlovsk, and can be reached and hiked as day trips, i.e., Avachinsky, Gorely, and Mutnovsky (Fig. 5). No special equipment is needed for these day hikes, besides the obvious such as hiking boots, water-proof and warm clothing, a hat and gloves. Typically the guide is accompanied by a driver and/or a cook. Food packages, water, and other necessities are carried along and prepared during the day. There are also longer



Figure 3. The Valley of the Geysers. Photo: P. Schmidt-Thomé.

Kuva 3. "The Valley of the Geysers", kuumien lähteiden laakso. Kuva: P. Schmidt-Thomé.

overnight hiking excursions, where the participants sleep in tents and the guides are accompanied by porters that carry food and water. In cases where the excursions are up to several weeks, helicopters carry food and water to predefined points of access.

Due to the challenging infrastructure, there are several options for helicopter excursions that allow visiting more remote areas. Helicopter trips usually last for one day and include several scenic stops. Food and water, as well as English-speaking guides, are normally provided. Even though helicopter flights are not cheap, the experience is certainly worth every penny. The helicopters do not have pressurized cabins and fly at an altitude of approximately 1300 meters. Since several volcanoes are taller than that, the helicopters often fly low over passes and in between volcanoes. The helicopter flights can be reserved in advance but are paid only on the day of the flight, because cancellation due to weather conditions is not untypical. Therefore the trip schedule should allow for certain flexibility, and planning for extra days of stay is advisable.

#### Geography and geology

Kamchatka is located in the Russian Far East and comprises an area of 472,000 km<sup>2</sup>, stretching over 1200 km. The peninsula is sparsely populated with approximately 320,000 inhabitants. The entire peninsula has a road network of 741 km, of which 200 km are paved. The main road connects Petropavlovsk through the central valley to the port of Ust-Kamchatsk. There is no road connection to northern Kamchatka or to the Russian mainland, making the peninsula accessible only by sea or air. Settlements in northern Kamchatka can be reached in winter via

ice roads on frozen rivers, or by a dog sledge. For example, coal supply from local mines for settlements in northern and central Kamchatka is only possible via winter roads. The inadequacy, or absence, of road maintenance makes travelling time-consuming and challenging. Many places are not connected by roads, and dry river valleys, or simply "general directions" are used as routes. Many roads are not maintained even though they are under heavy use by mining and energy industries. Often the average driving speed remains lower than 30 km/h.

The southern half of the peninsula is located over a tectonically very active zone where the Pacific plate is subducted under the Eurasian plate (Fig. 1) at an average speed of 8 mm/year. Volcanic cones from the Hawaii hot spot (the Hawaiian–Emperor seamount chain) reach Kamchatka, and the oldest > 81million-years-old cones have already been subducted. The melting of the subducted plate leads to the appearance of the typically associated stratovolcanoes, but shield volcanoes are also found. Some stratovolcanoes have the so-called Somma-Vesuvius form, i.e., with a new cone formed within the crater of an older eruption. The most prominent example of this is the Avachinsky volcano.

Approximately 300 volcanoes are located in the southern half of the peninsula, 30 of which are considered as active. Twenty-nine of the active volcanoes are located on a stretch of approximately 500 km on the eastern coast, the Sredinny range, which has the highest density of volcanoes on the Eurasian continent and among the highest worldwide. The Sredinny range is separated by a central depression valley from the western, or Vostochny, range, which only hosts one active volcano. Some of the volcanoes, e.g., the previously mentioned Karysmsky, have daily eruptions.

The recent history includes outstanding volcanic events. In March 1907, one of the most important volcanic events of the last century took place when the explosion of the Ksudach volcano (Fig. 6) ejected around 3 km<sup>3</sup> of tephra and ash, equivalent to a *volcanic* 

explosivity index (VEI) of 5. The VEI was introduced to provide a relative measure of the explosiveness of volcanic eruptions for historical events and ranges from 0 to 8 (Newhall and Self 1982). The VEI describes the amount of ejected volcanic material, eruption cloud height, and the duration of the eruption. The scale is logarithmic for VEI > 2, so that a one-unit increase in VEI indicates an eruption 10 times more powerful. Famous examples of VEI = 5 eruptions are the Vesuvius AD 79 and Mount St. Helens 1980 eruptions. The Ksudach eruption had considerable climatic effects with a record low spring and summer temperatures in USA (Nechayev 2008). Other well-known eruptions in Kamchatka are the Sarychev eruption in June 2009 (VEI = 4) were the ash clouds interfered with Northern Pacific air traffic. Other larger, recent eruptions in Kamchatka were Bezymianny in 1956 (VEI = 5) and Shiveluch in 1964 (VEI > 4) (Bourgeois



Figure 4. Koryaksky (left) and Avachinsky (right) volcanoes. Photo: P. Schmidt-Thomé. Kuva 4. Tulivuoret Koriakski (vasemmalla) ja Avatšinski (oikealla). Kuva: P. Schmidt-Thomé.

*et al.* 2012). Very recently in 2012 and 2013, Tolbachik, one of the most active Kamchatka volcanoes, erupted for about 13 months.

An interesting discussion sparked during the excursion over the Avachinsky volcano. According to several geology books this volcano belongs to the so-called "Somma-Vesuvius" type. This discussion might be continued here, as in fact, in geological literature, the Avachinsky volcano is often referred to as a typical example of a "Somma volcano" (Rast 1987, pp. 61–62, Schmincke 2004), which is typically a stratovolcano that grows a new cone within the remains of an older exploded or collapsed cone. Indeed, if one were to extend the outer flanks of the Avachinsky volcano upwards, following its original shape, one would notice that it would be as high as the neighbouring Koryaksky volcano (Fig. 4). Nevertheless, the question that might be posed is whether it is worthwhile to call the Somma-Vesuvius phenomena a volcano "type". Without doubt the Avachinsky is an active strato-, or composite volcano, with the special characteristic of the active cone being embedded into the remains of the ancient crater. One might term this phenomenon a volcano "type" but on the other hand the "typology" is mainly based on shape, not on chemical composition. Since the Avachinsky volcano remains to be a genuine stratovolcano we argue that the phenomena of a new cone within an exploded, eroded, or collapsed crater does not necessarily change



*Figure 5. Petropavlovsk, with Avachinsky volcano in the background. Photo: P. Schmidt-Thomé.* Kuva 5. Avatšinkin tulivuori, etualalla Petropavlovsk. Kuva: P. Schmidt-Thomé.

the volcano type itself, and therefore this phenomenon might also be described as a mere geomorphological feature instead of an own volcano type.

Due to its location in an active subduction zone, the region has a very high seismicity. The largest historical earthquake in the region took place in 1952 with an  $M_w9$  (Moment Magnitude 9) event, with its epicenter between the northern Kuriles and southern Kamchatka. This event also triggered a trans-Pacific tsunami (Bourgeois *et al.* 2012). In the continental zones of Kamchatka, high activities were recorded for the years 1963–1964, 1983, and 1996. The highest activity was experienced in January 1996 when two volcanoes, the Karymskii and the Akademii Nauk erupted simultaneously, and a large  $M_w7$  earthquake occurred (Levina *et al.* 2013).

The common perception has been that the Pacific plate is subducted under the Eurasian plate south of Kamchatka. However, recent research has showed that the tectonic setting might be more complex. An additional small plate, the Okhotsk Plate, located west of Kamchatka, was already proposed in the 1980s and later described by Bird (2003). There is also evidence of a Bering block, which is located east of Kamchatka. According to a new study the Bering block slowly rotates clockwise as a result of a terrane accretion in southern Alaska. Interestingly, the motion of this Bering block is much slower in respect to the North American plate (Mackey *et al.* 2015).

#### Climate and vegetation

The latitude of Kamchatka is comparable to that of the British Isles but due to the absence of a warm current such as the Gulf Stream, the winters are long and bitter. The Pacific Ocean inflicts a humid climate (ca. 1100 mm/ year of precipitation) with abundant masses of snow: 8 meters of snow annually is not a

rare phenomenon, and 4 meters is considered normal. In many places the snow does not melt over the summer, and some routes are not passable due to the snow even by four-wheel drive cars until July or August. While the coastal climate is rather mild and the temperatures range annually from +20 to -15 °C, the valleys experience strong temperature extremes over the year with a range from +40 to -30 °C at sea level, and with respective elevation-dependent variations. Even though Kamchatka belongs to Siberia, it is climatically isolated and can as a result be divided into its own sub-ecoregions, e.g., the meadows represent specific tundra types and the forests a peculiar taiga type. The last glaciation led to the vanishing of the previously abundant coniferous forests. Today, these forests are represented by one small coniferous forest island in central Kamchatka. Erman's birches (Betula ermanii) and Dahurian larches (Larix gmelinii) dominate the landscape in open forests with abundant meadows. These trees grow very slow and do not develop straight trunks due to the heavy snow cover. They are mainly used as fire wood. Cedars are found on mountainous slopes, and the tree line lies at approximately 800 meters above sea level (WWF - World Wide Fund For Nature 2015).

#### History and economy

Only about 10,000 of the original indigenous population remain in Kamchatka. Since the discovery of Kamchatka by Russians and the incorporation of it into the empire in the 17<sup>th</sup> century the indigenous population has strongly declined. Following several foreign explorations and increasing Russian settlements, Kamchatka experienced a strong inflow of hunters that nearly caused the extinction of sables, foxes, sea lions, and many other animals. The devastation was so extensive that the first areas to protect local species were established in the 1930s. In the 18th century Vitus Bering discovered the Avacha Bay and founded the city of Petropavlovsk, which is named after his two ships, St. Peter and St. Paul. Avacha Bay is a perfect natural port: it is 24 km long, separated from the Pacific Ocean by a 3-km-wide passage, and has an average depth of 25 meters. The narrow passage to the ocean protects the harbor city from surges and tsunamis, and enables easy defense against intruders. Petropavlovsk is the administrative center of the Kamchatka Krai, a federal entity of Russia, and has less than 180,000 inhabitants, i.e., more than half of the entire population of Kamchatka (Nechayev 2003).

Kamchatka was an off-limit zone for military reasons for 60 years (until 1991), including citizens of the Soviet Union. The Soviet army used Avacha Bay as an important harbor for nuclear submarines (Nato code name "Wasp nest"). Kamchatka also hosted important air fleets and other key military equipment and installations. The entrance to Avacha Bay from the Pacific is approximately 6 meters deep and was shut off by an iron fence during the Soviet time. Each entering ship was searched. Today the town of Vilyuchinsk in Avacha Bay is the most important submarine harbor of Russia's Pacific fleet, and remains off-limits for non-military staff. The importance of the military is still visible today while the most important economic sectors are fishery and forestry. Raw materials and coal are mined to some extent, as are minerals. Oil and gas reservoirs are being discovered but not yet substantially exploited. There are some ship vards for maintenance (Kamchatskyi Krai).

#### Figure 6. Ksudach crater. Photo: P. Schmidt-Thomé.

Kuva 6. Ksudatšin kraateri. Kuva: Photo: P. Schmidt-Thomé.





While Kamchatka would have a strong potential for geothermal energy, there is only one such plant, located south of Petropavlovsk. Otherwise, energy is produced from mainly imported coal or gas. Over 50 % of the food consumed in Kamchatka is imported although agriculture would likely be possible, especially in the central valley in the vicinity of Petropavlovsk. Agriculture was more extensive in the soviet times, and greenhouses were heated by geothermal energy, but this activity has declined since 1991. The dependence on imported food makes life in Kamchatka rather expensive in comparison to other Russian cities.

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### Tiivistelmä

Vaikutelmia geologisista piirteistä, luonnosta ja elämästä Kamtšatkalla

#### Raportti elokuussa 2014 tehdyltä ekskursiolta

Kamtšatkan niemimaan eteläisessä osassa on runsaasti aktiivisia tulivuoria (kuva 1), ja olemme olleet pitkään kiinnostuneita tästä huomionarvoisesta alueesta, sen geologiasta, luonnosta ja mielenkiintoisesta historiasta. Tässä artikkelissa kuvailemme geoturistin silmin kohteita, joissa Philipp Schmidt-Thóme vieraili elokuussa 2014 tekemänsä ekskursion aikana.

Matkan aikana patikoimme, teimme helikopterilentoja ja laivamatkan sekä vierailimme Tyynenmeren rannalla ja Petropavlovskin kaupungissa. Ensimmäinen helikopteriekskursio suuntautui Kuril-järvelle, missä kymmenet karhut kalastivat lohta (kuva 2) ja Ksudatšin kalderalle, missä nautimme kylvystä kuumassa lähteessä. Toisella helikopterimatkalla lensimme säännöllisesti purkautuvan Karimskin ja happamasta turkoosista vedestään tunnetun Mali Semjatšikin tulivuorten läheisyydessä. Kävimme myös vaeltamassa kuumien lähteiden laaksossa ("Valley of the Geysers", kuva 3), jättiläismäisessä Uzonin kalderassa ja kauniilla alppiniityillä sekä uimme kuumissa lähteissä ja kylmässä vuoristopurossa.

Vaellus Gorelyn tulivuorelle ja Avatšinskin kraateriin olivat haastavia huonon näkyvyyden vuoksi. Leirimme oli Avatšinskin tulivuoren juuressa, mistä vaelsimme vielä basalttiekstruusiolle nimeltään Camel. Avatšanlahdelle suuntautuneella laivamatkalla havaitsimme useita lintulajeja ja valaita. Näimme myös sukellusveneitä odottamassa huoltoa ja kalastimme meriahvenia, joista valmistettiin venäläistä kalakeittoa (ukha). Viimeisenä päivänä kävimme Tyynenmeren rannalla ja valmistimme Kamtšatkan rapuja ja saslikia kokkimme datšalla eli kesämökillä.

Kamtšatkan pitkäaikainen poliittinen eristyneisyys ja viimeaikaiset luonnonsuojelulliset ponnistelut ovat luoneet eko- (tai geo-) turistin näkökulmasta lähes idyllisen kohteen. Kamtšatka, "yksi maailman merkittävimmistä tuliperäisistä alueista", on UNESCOn maailmanperintökohde. Retkeily Kamtšatkalla on hyvin sääriippuvaista: on suositeltavaa varata lisäpäiviä matka-aikatauluun ja palkata mukaan koulutettu paikallinen opas. Päiväretkiä varten Petropavlovskin lähellä on monta helposti saavutettavaa tulivuorta (kuva 5); pidemmille retkille mukaan tulee oppaan lisäksi usein kokki ja jopa kantajia, jotka huolehtivat ruokahuollosta. Helikopterilla pääsee kohteisiin, jotka eivät puutteellisen infrastruktuurin vuoksi ole muuten saavutettavissa.

Venäjän kaukoidässä sijaitseva yli 1200 km

pitkä Kamtšatkan niemimaa on harvaan asuttu: väestön suuruus on noin 320 000 ja tieverkoston pituus 741 km. Tievhtevttä mantereelle ei ole vaan niemimaalle pääsee ainoastaan meriteitse tai lentäen. Niemimaan eteläinen osa on tektonisesti erittäin aktiivinen, alitvöntövvöhvkkeessä sijaitseva alue (kuva 1). Tyypillisesti vuoret ovat kerrostulivuoria, myös Somma-Vesuvius -tyypin vuoria kuten Avatšinski (kuvat 4 ja 5), mutta kilpitulivuoriakin esiintyy. Lähihistoriasta tunnetaan useita purkauksia: esim. Ksudatšin maaliskuussa 1907 tapahtunut purkaus vaikutti maailmanlaajuisesti ilmastoon ja ilmatilaan. Viimeisin huomattava tapahtuma oli Tolbatšikin 13 kuukautta kestänyt purkaus vuosina 2012–2013. Myös seismisyysaste on Kamtšatkalla korkea: tunnetuin historiallinen maanjäristys, magnitudiltaan 9, tapahtui vuonna 1952 ja aiheutti laajan tsunamin Tyynellämerellä.

Kamtšatkalla talvet ovat pitkiä ja purevan kylmiä. Tyynenmeren vaikutuksesta ilmasto on kostea ja talvisin saadaan jopa kahdeksan metriä lunta. Lämpötila vaihtelee rannikolla kesän +20 °C:sta talven –15 °C:een; laaksoissa ja vuoristossa vaihtelu on vielä suurempaa. Kamtšatkan tundra- ja taigaekosysteemeissä tavataan esim. kaukoidässä tyypillistä kivikoivua (*Betula ermanii*), dahurianlehtikuusta (*Larix* gmelinii) ja setripuuta.

Kamtšatkan asukkaista noin 10 000 on alkuperäiskansaa. Niemimaa liitettiin Venäjän keisarikuntaan 1600-luvulla ja ulkopuolelta tulleet metsästäjät ajoivat monet lajit sukupuuton partaalle. Vitus Bering perusti nykyisen pääkaupungin, Petropavlovskin, 1700-luvulla löydettyään suojaisan Avatšanlahden. Kamtšatka oli vuoteen 1991 saakka sotilaallisista syistä myös Neuvostoliiton kansalaisilta suljettu alue, ja Avatšanlahdella sijaitseva Viljutšinskin kaupunki toimii edelleen Venäjän Tyynenmeren laivaston satamana. Tärkeimpiä elinkeinoja ovat kalastus ja metsätalous; kaivannaisista Kamtšatkalla hyödynnetään kivihiiltä, joitain raaka-aineita ja mineraaleja. Öljyja kaasuvaroja ei ole vielä hyödynnetty huomattavasti. Geotermistä energiaa tuotetaan tällä hetkellä vain yhdessä laitoksessa Petropavlovskissa, vaikka sen kehittämiselle olisi runsaasti potentiaalia. Maataloustuotanto on vähäistä, ja tuonnin varassa oleva ruoka onkin Kamtšatkalla selvästi muuta Venäjää kalliimpaa.

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