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Women at the Dawn of Diamond Discovery in Siberia or how Two Women Discovered the Siberian Diamond Province

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Abstract: Exploration for diamonds in the Soviet Union had started in the 1940s, however not until the beginning of 1950s, the government has acknowledged a strong need of locally mined diamonds to support the industry demand. Multiple expeditions were formed aiming to map vast and remote areas in Siberia, Kola peninsula and Far East. In this article, we describe a story of two heroic women, Larisa Popugaeva and Natalia Sarsadskhih, who implemented a new methodology that eventually lead to the discovery in 1954 of the first diamond deposit in the country – a kimberlite pipe "Zarnitsa". This discovery was made by Larisa Popugaeva, who, in the 1954 field season, conducted the exploration together with a dog Pushok and her technical assistant Fyodor Belikov. Her discovery was stolen by the higher officials from the Amakinskaya expedition, one of the largest diamond exploration organisation in the country. Multiple efforts to restore the justice did not succeed, with

Popugaeva being awarded the title of the "Discoverer" only in 1970, while Sarsadskhih not until 1990. This article provides a detailed description of Larisa's life until the discovery of Zarnitsa, and a few significant events after.

1. Short notes on Larisa's biography. Early years

Larisa Popugaeva (nee Grintsevich) was born on the 3rd of September 1923 in Kaluga, a small town 180 km to the South of Moscow (Treivus, 2009; Yuzmukhametov, 1998). Her mother, Olga (nee Tsvetkova), and father Anatoliy Grintsevich (Fig. 1) were closely involved with the communist party. Her father fought for the Red Army during the revolution, and his entire life was a strong Leninist who believed in people's equality and communist values. Larisa's nickname was Ninel, for inverted "Lenin", and that's how she was called by her family and friends[1].

Larisa's family travelled a lot during her childhood. In 1924 they moved to Tula, while in 1931, Larisa and her mother moved to Leningrad, where Larisa first went to school. In 1936 the family reunited in Odessa, where Larisa's father worked in different positions for the party line.

The life of Larisa's family was typical for any Soviet family of that time, with both parents being great believers in communism, full of enthusiasm to work hard and "build" a new country. However, this positive spirit came to an end in 1938, when a sudden tragedy

[1] Here and below, personal information reported in this article is mostly sourced from interviews of Natalia Popugaeva, Natalia Sarsadskhih and Fyodor Belikov. The interviews were conducted by Rishat Yuzmukhametov.

happened. Like many other innocent people during the years of the 'big terror', when the country lost thousands of its citizens, her father was arrested as an 'enemy of the country' and sentenced to death shortly after his arrest (Silaev, 2007). Unfortunately, the bureaucratic machine of that time made all family members of the political 'criminals' carry the burden of the 'country's enemy' for many years ahead. Since their father's arrest, Larisa and her sister Irina were considered almost second-tier people, being stripped of their rights and opportunities, and being allowed only to take certain jobs. In was not until 1959, 21 years after his death, that Anatoliy was reinstated and his prosecution was deemed "not supported by evidence".

After Anatoliy's arrest, the family returned to Leningrad and settled there. They were very poor and lived in a single bedroom in a dormitory-style block of apartments, sharing kitchen and bathroom facilities with many other families.

Larisa's interest in geology started in school. In year 10 (in USSR's system students completed ten years of education after which they could apply to do a university degree) Larisa took a "geology and mineralogy course" and completed it with excellence. She planned to do a degree in geology. However, her plans were impeded by the start of the Second World War (WWII) in June 1941.

June 22nd 1941, when Germany attacked the USSR, was a 'canonical' date for every Soviet person, when the life of ordinary people underwent dramatic changes. Most men were summoned to the army, while their families were evacuated from European Russia behind the Urals Mountains where they worked in factories supplying the army. In the first years of the war, the Soviet Army was retreating towards Moscow, while Leningrad was sieged for most of the war. Huge losses made it necessary for women also to volunteer to fight, and Larisa was one of them.

Recovering from the events of her life from the start of the war, on the 22nd of June 1941, the family was on a short visit to Moscow, and this is what probably saved them from the gruelling Leningrad siege. A few months later, Larisa's mother and sister were evacuated to Molotov, a small town in the Ural Mountains (now Perm). Larisa joined them in September and being a person who could not be inactive, she immediately applied for a geology degree at the local university (Silaev, 2007). In her diary, on the 23rd of September 1941, Larisa wrote: "… I am very interested in geology and I chose the faculty of geology and soil; however, I had to leave Leningrad urgently…". During the first year of studies, Larisa has also completed a course in nursing and firing a machine gun, and in April 1942, she volunteered in the war. Larisa fought in the 89th Artillery division, whose task was to cover the air space around Moscow (Fig. 2). She received multiple War awards and rank promotions and was demobilised to Leningrad in the rank of sergeant on the 23rd of July 1945, two and a half months after the end of the war. As soon as she returned to Leningrad, Larisa resumed her geological studies in the Leningrad State University (Silaev, 2007).

In their memoirs, many colleagues and friends say that Larisa was very different from the other students. Physically, she was short, wore a plat circled around her head and looked feeble; however, she gave an unforgettable impression of a very cheerful and active person, smiling, positive and full of life. Coming back to academia after years spent in the war, she was noticeably older than her peers; she smoked and looked and acted confidently.

In 1940th, the mineralogy degree at the Leningrad State University was very strong. Lecturers and professors were some of the best specialists in the country. Professor A.A. Kukharenko introduced to the students the method of panning for heavy concentrate, which was later used by Larisa during diamond exploration. Obtaining the degree was not easy; between September and June students learned theory in specialised topics:

mineralogy, crystallography, geochemistry, petrology and others, while in summer they spent months of field training being enrolled in geological expeditions. Many areas of the USSR, particularly remote, did not have detailed maps, therefore, there was no time to spend on dedicated student field training courses and geology students were sent to help professional expeditions (Kostitsyn, 2016).

On the 28th of May 1950, Larisa has completed her 5-year honours degree as a "geologist" specialised in "geochemistry" (Kostitsyn, 2016). She was ready to start her new life.

2. VSEGEI and Diamonds

Another peculiar procedure in the Soviet Union concerned the distribution of jobs. The jobs were provided to specialists after their graduation. Specialists had very limited options to choose their job location, and many young people had to travel far from their homes to different regions of the country to obtain a job. Larisa was luckily (or given the later events of her life, perhaps, unluckily) offered a mineralogist position at the All-Russia Geological Institute (VSEGEI). VSEGEI was a research institute and was subdivided into multiple expeditions working on mapping, prospecting and exploration in different regions of the country. Larisa was attached to Tungussko-Lenskaya expedition lead by a very experienced field geologist A.A. Krasnov. Among other goals, this expedition's objective was to conduct diamond exploration and prospecting in a large area in Eastern Siberia (Fig. 3).

2.1. Diamonds in the USSR

Before delving into the details of Larisa's work at VSEGEI, we need to take a step back and to elaborate on why having a local supply of diamonds was such a vital necessity for the USSR economy.

Diamonds were extensively used in the Russian Empire industry since 19th century. With large industrial growth in the 1920s and 30s, there was also a strong demand for diamonds in the Soviet Union, however, not supported by findings of diamond deposits. Episodic diamond exploration expeditions took place since the early 1920s and targeted areas in the Urals and Eastern Sayan Mountains, but it was only in 1938 that diamonds became a strategic resource prioritised by the government. They were used in drilling, radioelectric industry, tool production, optics and many other industries. Before 1938, USSR imported diamonds for more than two mln rubles a year, and that only covered about 50% of the needs. Before WWII, USSR consumed roughly 23 thousand carats a year, a number similar to the US yearly consumption in 1926 (Yuzmukhametov, 2013).

The first long-lasting government expedition for diamond exploration was formed in 1940 and it targeted the Ural Mountains. It consisted of geologists from Leningrad and Moscow and during the period between 1940-1946 was the only organisation responsible for diamond exploration in the USSR. It is important to note that at that time diamond exploration was a rather difficult task.

The main rock hosting diamonds is kimberlite, erupted as a volcano and forming an explosive crater or a diatreme. Therefore, kimberlite locations are usually referred to as kimberlite pipes. These are some of the deepest originating volcanoes found on Earth. The stability field of diamond (as opposed to its lower-pressure variety graphite) starts at around 120-150 km depths, meaning that kimberlite magmas have to travel to the surface from those depths (Yaxley et al., 2019). These are very unusual rocks, bound to stable and

137 geologically rigid regions of the Earth called cratons. The first discovery of diamonds was
138 made in South Africa in Kaapvaal craton, later kimberlite pipes were found in Zimbabwe
139 craton, west African craton and other locations. Up to date, kimberlites are found in most
140 cratons on Earth, including Antartica (Yaxley et al., 2013). There are several cratons on the
141 territory of the former Soviet Union, with the largest one being the Siberian Craton.
142 Kimberlites were first found in South Africa at the end of the 19th century, kimberlite
143 exploration tools were slowly being developed (Williams, 1902), however, none of the
144 methods were familiar to the Soviet geologists. Furthermore, the political tension between
145 the USSR and the Western block did not permit any communication or collaboration with
146 the geologist abroad. This resulted in a complete lack of any knowledge of how and where
147 to conduct a diamond search. Additionally, there was also a strong lack of knowledge about
148 diamond formation and relation to any rocks.
149 The process of diamond discovery in the USSR is significantly more complicated than for any
150 other mineral resources. As stated above, the entire exploration was purely based on the
151 local experience that was not enough for creating a comprehensive methodology.
152 Some astonishing details about that time could be found in the memoirs of a famous Soviet
153 and later Russian geologist Viktor Masaitis (2004), who worked in the diamond field and
154 lived in Leningrad (Saint Petersburg) until his death in 2019[2]: *"Newly arrived exploration*
155 *geologists did not receive any instructions that considering the experience from South Africa,*
156 *could have significantly helped their work. They did not have any rock samples. If most other*
157 *ores could be taken into their hands and studied mineralogically and petrographically, or*
158 *could be found in multiple geological and mineralogical museums, the situation with*

[2] Here in below, in relation to the quoted text. The text was translated in the closest possible way, however, in some instances may not be an exact translation in order to preserve the alleged meaning in Russian.

kimberlites was completely different. The vast majority of field geologists never saw diamonds, let alone kimberlites. (…)

One should not forget that search for diamonds was a "secret" job, and should have been kept concealed from "enemy". This aura of secrecy significantly hurdled the exchange of any information, especially at that stage when there was initially very little information about the distribution and formation of diamonds. Most of geological and topographical maps and books on diamonds and their mining were "classified". Every room where geologists who were allowed to use this information were admitted, had a special person, usually very poorly educated, who vigilantly checked everything around them and reported to the government officials. The word "kimberlite", obviously, nobody said aloud, let alone the word "diamond".

Over the following five years, the political situation was not getting better. If during WWII Great Britain, in the form of military aid, sold to the USSR approximately 2800 carats of technical diamonds (charging 2 carats per 1 pound sterling), with the beginning of the "cold war" this aid was not any longer available (Yuzmukhametov, 2013). The only remaining way of obtaining diamonds was to pay the market price, which was too financially gruelling for the country devastated by WWII. As a result, in 1946 the former head of the Urals diamond expedition M.F. Shestopalov wrote a letter to Stalin, outlining three key goals for the diamond industry:

1) In short terms to seize import of diamonds into the USSR
2) Create a Diamond Trust and expand exploration to multiple areas within the USSR
3) To target every area of the country where diamonds were previously found.

Less than a month later, Stalin invited Shestopalov to the Kremlin and approved his proposal (Yuzmukhametov, 2013). Diamond exploration works were expanded to the following

183 regions of the country: Yenisey River, East Sayan mountains, the Angara and Podkamennaya
184 Tunguska Rivers and Kola Peninsula. Additionally, some work was planned in the Far East, in
185 the Eastern and Western Siberia, in Kazakhstan, North Caucuses and Tajikistan.
186 By the beginning of 1950s alluvial diamonds were found within a large area in Siberia
187 between rivers Yenisey and Lena, and a range of Moscow and Leningrad research institutes
188 were given a task to expand the diamond exploration in that region. This coincided with the
189 new embargo that in 1950 the USA set on diamond trading with all countries of the Socialist
190 block, leaving USSR nothing else but pushing the exploration forward at the fastest rate.
191
192 *2.2. Larisa Popugaeva meets Natalia Sarsadskhih*
193
194 In February 1950, the Central expedition based in VSEGEI, Leningrad, established a branch
195 aimed to create a "heavy fraction map of Siberian platform". Natalia Sarsadskih (Fig. 4), an
196 experienced geologist was appointed as the head of this branch (Melua, 2003;
197 Yuzmukhametov, 1998). Natalia's task was to investigate the heavy fraction of the
198 basement rocks in the Siberian platform and to link it to the alluvial minerals. Additionally,
199 the goal was to locate mineral-indicators of diamonds in the potential alluvial diamond
200 deposits. The scale of the map was supposed to be 1:500000, which was an enormous task
201 for an area of almost 1500 km in length (Sarsadskhih, 1997; Sarsadskhih, 2004).
202 An interesting observation concerning the Soviet women, Natalia was married to a famous
203 geologist Alexander Kucharenko, yet, kept her maiden name, which was, perhaps, unusual,
204 but not rare.
205

In the summer of the same year, Larisa was working in the Lower Tunguska region in Krasnov's expedition. This is how she first met Natalia Sarsadskih, who spent some of the time in the same expedition.

In April 1951 Larisa changed her job and also started working in the VSEGEI branch of the Central expedition. The main reason for this move is still unknown, however, it was likely due to the pressure created by her status of a daughter of the "country's enemy", that disabled her to work on certain jobs, in particular, those that had "classified" information. This year she travelled to the Polar Urals on a task unrelated to diamond exploration (Kostitsyn, 2016).

In spring 1952, Larisa and her future husband Viktor Popugaev moved in together, and in September Larisa gave birth to daughter Natalia. Larisa called her after her dear friend Natalia Sarsadskih. On the same day, on the 27th of September 1952 Larisa and Viktor got officially married and Larisa changed her family name from Grintsevich to Popugaeva. This marriage was not the most successful as her husband used to drink excessively. Later, he also changed his career to academia and worked as a lecturer in an engineering institute of Leningrad. Viktor outlived Larisa by 17 years.

From memoirs of Larisa's daughter Natalia: *"The entire history of the discovery of Zarnitsa I learned only after my mother's death. She used to repeat the same phrase: "don't be afraid of your enemies, in the worst case, they can kill you. Don't be afraid of your friends – in the worst case they can betray you. Be afraid of those indifferent. They do not kill and do not betray, but from their quiet consent there happen betrayals and murders". For me, the main mother's qualities were emotionality and honesty. She really loved children and animals. During my mother's short live she helped a lot of people. I was always amazed by how fully*

she dedicated herself to work. Nothing could stop her – neither her husband, not her daughter…"

2.2. 1953 field season and Larisa's first diamond-exploration expedition

In spring 1953, Natalia Sarsadskih received a letter from Larisa requesting to join her on the field trip to Yakutia. Natalia has agreed to include Larisa into her expedition and since the 1st of April 1954, the two women started working together. For the following year and a half, Larisa and Natalia became the closest friends going through the tough field work conditions in Siberia together.

As mentioned earlier, Natalia addressed diamond exploration from the mineralogical side; her main goal was to find a mineralogical exploration tool, in particular, mineral-indicators of diamondiferous rocks. Thorough study of previous findings made her believe that previous conclusions about mineral indicators were inaccurate, therefore, the entire 1953 field season was aimed at a new search. For this purpose she chose upper Markha river, not a random location, given that in the lower Markha river the diamonds have already been found.

Getting to the location was not a trivial task. The first leg of a journey was to fly to Yakutsk, a major city and a capital of Yakutia (Sakha Republic) (Fig. 4), then a local flight to a small town of Olenek, located on Olenek river (Fig. 4), and from there 250 km of a journey through taiga, heading south towards river Daldyn, a tributary of Markha, using the local deers to carry the food and supplies. The actual work was supposed to be carried along the

two rivers – Daldyn and Markha (Fig. 4), collecting the river sediment and panning it for the heavy fraction.

The expedition started in late June, when both Larisa and Natalia flew to Olenek, and they only reached Daldyn by mid-August.

In 2007 Larisa's daughter Natalia found her mother's diary from this trip and below, we will list some of the entries. The entries between July and mid-August were made during a 250 km hike between Olenek and river Daldyn.

26.07.53 – we sleep in tents, laying on the ground everything we can because only 10 cm below the moss is permafrost or permanent ice. It is very cold at night, while during the day it is unbearably hot. Along the route, we see the same limestones, there are a lot of trap fragments[3]. Our caravan consists of 43 deers, out of these, five sled deers called "uchugs" are assigned to our expedition. I have a lucky one: ugly, with small horns, but a very frisky one. At first, I was not getting along with it, but now I have got comfortable, and feet are not getting too tired. It is the first time in 7 years of my work that I have a deer to ride during a field trip

In her memoirs, Natalia Sarsadskhih wrote:

"Larisa and I at times allowed ourselves to ride deers. However, this "rest" was very doubtful; we were not told how to ride a deer. Once, when stopped at an outcrop, I unleashed a deer and wanted to climb on it from a stump. That didn't go well, it kicked me from the saddle and ran after the rest of the deer herd. I suddenly felt a sharp pain in my lower back, and barely crawled back to the base. That frightened me a lot because I was not alone, together with me travelled my not yet born daughter. I was afraid for her".

[3] Larisa refers to the trap basalts that cover the area

Natalia's statement shows how strong these women were and how much hardship they had to go through doing their job. Pregnancy was not an excuse to take a 3-month long trip to gruelling conditions in Siberia: to be bitten by midges and mosquitos, to starve, to pan buckets of sediment in a freezing cold water, to set up tents in snow not having proper clothes and boots.

The 250 km journey between Olenek and Daldyn river was exhausting. Continuing Larisa's diary:

1.08.53. We are trying to get close to river Siligir[4], hoping for better hunt and fishing, because now we do not have many supplies left and the food is vanishing very fast.

11.08.53. The time flies so fast, and we are still far away from work. The deers are lost. Hunters search for their deers, while the latter are running in a search for mushrooms. Today we ate three ducks. But in general – it's a dense and lifeless taiga. I feel fearful and pity.

15.08.53 We haven't moved from this spot for three days. Terrible, and everything is futile. We are missing 19 deers. We are consuming the groceries, while the work isn't being done. I really want to go home. We still have 60 km to Daldyn. Yesterday we searched for deers, walked about 10 km and found only three of them. It is cold, and it rains all the time.

26.08.53. We finally got to Daldyn. It's beautiful here. Taiga is dressing into its autumn decor. The grass is dark-red. We have panned some sediment.

30.08.53. In the morning I planned to go into a 4-day long route without the sacks, only with a tent. Grrrrr.. I can only imagine.. The weather is terrible. It does not stop snowing.

[4] Siligir is a tributary of Olenek River, see Figure 4.

05.09.53. Nothing has changed; we sifted about 100 buckets of sediment. It is cold, but it's tolerable.

14.09.53. I am in a tent. The boots are torn in pieces. Outside of the tent the snow is up to the knee. It looks nice and soft, but if you step into it, it's grrrrr, cold. Today we'll have to walk another 20-25 km through the snow, but this is not the worst. There's barely any food left. It's been three days already that we didn't have any bread. We're using flower to make soup. But it's all right, we'll cope! I really hope that our today's hunt will be successful.

20.09.53. It's frosty, the river has frozen near the banks up to 15 meters, and we have another 900 km to raft. There is no more food left, only a few cans of preserves and some salt. In 8 days my daughter is turning one – such a big girl, so pity that I am not at home. How is my family going to celebrate this day?

After reaching Daldyn, Larisa and Natalia split into two groups; Natalia went on a route along river Sytykan, that flows parallel to Daldyn, while Larisa and her assistant Fyodor Belikov were rafting along Daldyn.

While working in Daldyn river, Larisa and Fyodor panned about three cubic meters of sand. This is 300 10-liter buckets. Even if the sand is clean and does not contain any mud, this job would take about 150 hours of work (Kostitsyn, 2016).

Having regrouped, the geologists stopped in a village called Shelogontsy, 130 km to the south from Daldyn's estuary. By that time, the village was abandoned and hosted only a geological base. Later in 1975 during an interview, Larisa confessed that they arrived at Shelogontsy so hungry that she stole a loaf of bread from one of the local geologists. Together with Fyodor they immediately ate it. The geologists at Shelogontsy had photoluminescence equipment. Larisa investigated the heavy fraction sifted at Daldyn river and found a small diamond crystal. They were delighted. Natalia remembered that she and

Larisa were dancing out of happiness when they discovered this diamond. One of their dreams had come true. They found a diamond!

From Shelogontsy, they flew to Nuyrba, a town that hosted the headquarters of the Amakinskaya expedition, the main diamond exploration party in the USSR (Yuzmukhametov, 2010). Given a degree of rivalry between the expeditions located in different cities, the relationship between Leningrad and Nuyrba geologists were relatively cold. Therefore, the geologists tended not to share any information about their exploration routes and discoveries. As this field work was led by Natalia, she was very vigilant and experienced, minimising communication with the Amakinskaya group. Next year Larisa will make a mistake of being much more open, and that made her pay a high price.

On their way to Leningrad, Natalia and Larisa stopped for a few days in Irkutsk. There Larisa met with Natalia Kind and Ekaterina Elagina – these two women were future discoverers of the second largest diamond mine in the USSR – kimberlite pipe Mir. They become very close friends with whom Larisa kept close contact for the rest of her life.

The 1953 field season was over, and it brought one diamond.

2.3. 1954 field season. Leading the exploration

As stated earlier, one of the main difficulties in the exploration work was the lack of any exploration methods that target diamonds. While in South Africa it has long been known that chromium-rich purple pyrope garnets were the key indicator minerals, in the Soviet Union, this mineral was largely overlooked. This was not entirely due to the lack of evidence or knowledge, but partially due to the fear of taking any responsibility and propose something new, especially based on the experience of western geologists. As an example, in

1938, A.P. Burov, who was a leading diamond exploration geologist in the USSR between 1937 and 1956 prepared a report in which he stated that *"the most typical minerals that accompany diamonds are olivine, ilmenite, chromite, pyrope, phlogopite, perovskite and diopside"*. All these minerals are typical for kimberlites and if this report had been published, it would have substantially helped the future exploration. However, Burov decided not to expose it and the report was only found in 1992 in archives. Historians hypothesised that the reason of why this report was never published was that earlier in 1937, two experienced diamond exploration geologists who proposed to link parental diamondiferous rocks in the USSR to the similar rocks reported by South Africans, were arrested. Back in those times, it took as little as someone's minor complaint to be arrested and prosecuted.

Coming back to Natalia and Larisa's expedition, in the heavy fraction they found both ilmenite and pyrope, however pyrope was not a commonly well-known mineral, and although determined as garnet, it only reminded the geologists of the so-called "bohemian garnets", found in Bohemian massif in Czechoslovakia. The only samples of African kimberlite-derived pyropes were kept in the Department of Mineralogy of the Leningrad State University. These samples derived from Jagersfontein kimberlite pipe and were bought by the Russian empire in 1912. Alexander Kucharenko, Natalia's husband, had access to those pyropes, however, as a rule in their family, they decided not to bring work home, therefore, Alexander was not familiar with Natalia's projects. Surprisingly, it was Larisa who addressed Alexander to compare minerals found in Daldyn River with the pyropes from Jagersfontein mine. They were identical.

Later Natalia Sarsadskhih wrote in her memoirs: “I only learnt about pyropes from Alexander when he came home from work. That evening Larisa visited us. Our second dream came true – we found mineral-indicators of diamonds, and consequently, now we have an exact area where to search for kimberlites. We have excellent results! The task for our 1953 is fully accomplished! There is no end to my and Larisa’s joy!”

This discovery has set the goals for the 1954 expedition. Geologists had to return to the area and pan the heavy fraction along Daldyn River basin. The rationale was the following: the number of minerals, ilmenites and pyropes in the heavy fraction will depend on the proximity to the ore body. Pyropes are more resistant to transportation that ilmenites, and additionally, being red, or purple, they are easier to notice. Therefore, Natalia called this “pyrope mapping”, or a “red guiding thread” which was supposed to lead to the diamond ore body.

The “panning of heavy mineral concentrate” revolutionised the diamond exploration in the USSR. Importantly, it was incredibly cheap and mainly required labour.

In February 1954, Natalia gave birth to a daughter, Lena, which made it impossible for her to travel to Daldyn. Natalia hoped to ask Larisa to do this work, but Larisa suddenly refused. Later, Natalia wrote that Larisa was very distressed, she apologised for not being able to go, visited Natalia at home and cried. Natalia tried to convince Larisa that they should finish the work that they started, while Larisa was saying that she would not cope alone. It was only later that Natalia found out the two main reasons for her refusal, Larisa applied to do a PhD in Leningrad Mining Institute, but more importantly, she was pregnant with her second child, and she never dared to tell anyone. Therefore, being torn between her life, family and work, she was stressed and upset. Eventually, Larisa’s hardworking and heroic nature took

over; she consciously decided to lose the baby and started getting ready for her Siberian trip (Kostitsyn, 2016).

Another problem arose from the bureaucracy. The abovementioned head of the Central expedition, Burov, refused to financially cover the trip because the Daldyn location was not in the plan for exploration works in 1954 (Elagina, 2003). Larisa managed to find money only for two members of the expedition – herself and her loyal assistant and a good friend Fyodor Belikov, who did the field work with her during the previous year. But even that money did not come from one source. Larisa had to be partially funded by the rival Amakinskaya expedition, while the head of Tungussko-Lenskaya expedition, Ivan Krasnov, covered Fyodor's subsistence and travel (Sarsadskhih, 1990; Sarsadskhih, 1997; Sarsadskhih, 2004). These details to the story are important because it was this connection with the Amakinskaya expedition that later allowed the head geologists of this organisation to assign Larisa's discovery to themselves.

Larisa left for the field at the end of June 1954, accompanied by Fyodor and her husband, who was worried about Larisa and preferred to travel with her (Kostitsyn, 2016). However, according to Larisa, her husband was more of a burden, therefore, she asked him not to continue the trip and to return home. In Nyurba geologists collected all the necessary "equipment" for the trip: bucket, shovel, pickaxe, a tray to pan the heavy fraction and a magnifying glass. They also picked a homeless dog Pushok, whom Larisa managed to take on the plane to Daldyn, making this dog a witness to the first kimberlite discovery in Siberia (fig 5). The field work lasted until September 1954 (Fig. 6a)

While staying in Nyurba and waiting for the plane to Daldyn, Larisa did not make a secret of the previous season of work. She told her peer geologists from Amakinskaya expedition about Daldyn, diamond and pyropes (Treivus, 2014). Many of her friends called her naïve,

however, is it really naïve to trust your colleagues and to share your achievements with the others?

Already in the field, Larisa wrote a short poem that tells about women-geologists in the field:

I live in a tent as a man,
I wear men’s boots
Lumps of mud get stuck to them
Creating circles in water

I touch a quiet rock
When taiga is humming in rain
And geologists say that this rock
Is the same rock as in my chest

As a pine in the wind,
I succumb to tension
It is difficult for me
To be such as a man

I would really want
Even for a moment
To fall into your arms
And to be weak again.

This season's field work was not the same as in the previous one. From time to time, Larisa and Fyodor had unexpected visitors from the Amakinskaya expedition (Fig. 6b) (Treivus, 2014). Higher authorities explained that by the fact that Larisa needs help, however, nobody doubted that geologists in Nyurba realised how close Larisa was to discovery. The head of Amakinskaya expedition A. Bondarenko could not allow a "stranger" from Leningrad to take the glory of discovery, therefore, he sent his people to check on her and to follow her routes along the river.

Once, when after another long route Larisa saw four more tents in her camp; herself and Fyodor collected their tents and went a different way, she could not tolerate an increasing number of guests.

This field season was somewhat better than the previous one in respect to the supplies. In her letter to mother, Larisa wrote that the entire summer they had meat, because Fyodor hunted two deers (Treivus, 2014).

Larisa and Fyodor crossed Daldyn and went towards a creek called Dyakha (Fig. 7). It should be noted that in her work Larisa did not have any mercy of herself. She went into the taiga without sleeping bags, far from their tents, frequently spent nights just sitting under the sky. Her hands were scratched and knees were full of lashes because she searched for pyropes sitting on her knees. Along Dyakha Larisa and Fyodor found a lot of ilmenites. Larisa made a correct conclusion that the parental rocks should be somewhere in the watershed of these two rivers – Daldyn and Dyakha.

From Fyodor Belikov's memoirs: *"We climbed to the top of the hill. Larisa immediately found an ilmenite there. Ah, what was next. We started to search the moss, even forgot to smoke. There were a lot of ilmenites there, and Larisa said: "What a mysterious place! Let's go down towards the river, rest, and return here in the morning". The next day we spent on this hill,*

while during the following day we went towards a small valley with short and rare larches. By lunchtime, it started raining. We had a piece of tarpaulin and used it as a cover. To warm up, I decided to lit a fire and heat up a large stone, so that it would act as an oven. I lit a fire and invited Nelya[5] to stay next to this stone below the tarpaulin. She sat down and suddenly jumped, picking up a magnifying glass: "Look, Fedyunya![6] Blue mud, and full in pyropes".

This was the first kimberlite pipe found in Siberia. Larisa and Fyodor took samples and erected a post, under the post they left a note stating that here they found a very rich pyrope-ilmenite and possibly a diamond deposit.

The pipe was called by a geologist M. Gnevushev – "Zarnitsa", which means a distant, sudden and ephemeral flash in the sky, a gleam of a distant thunderstorm. Larisa Popugaeva herself was as a "zarnitsa", a "gleam" in the diamond history of the USSR. Larisa wanted to call the pipe "pipe of Shestopalov" commemorating the name of the chief of the Central expedition, who died in 1954.

3. "*Had I known what would happen, I would have never wanted to discover Zarnitsa".*

It was the end of 1954 and time to return to Leningrad. Larisa and Fyodor took 60 kg of the heavy mineral concentrate, carrying them in rucksacks, and specimen of the found rock. Larisa could not contain her feelings: "*Flowers and champagne are waiting for me!*".

On their way back they stopped in a little town Yaralin, from where the plane was supposed to take them to Nuyrba. According to local geologists, Larisa was impatient to check that the

[5] Here and below, Nelya is a shortened diminutive version of Ninel, Larisa's nickname given to her by her father. In fact, Nelya is a version of a different Russian name Nelly, yet, Larisa seemed to have adopted this short name among her friends and colleagues.

[6] Fedyunya is a diminutive form of Fyodor, usually used for children or very close friends.

heavy mineral concentrate collected near Dyakha contained diamonds. Therefore, she went directly to Yaralin, where the plane could collect her faster than in Shelogontsi, the place where she and Natalia stopped in 1953 (Kostitsyn, 2016).

In Yaralin they found one diamond in the heavy concentrate, which confirmed that the found ilmenite-pyrope deposit was diamond-bearing. Yaralin was also considered fatal for the future of Larisa and her work. Nobody knows what happened and what plans Larisa had, but knowing that she discovered a diamond-bearing location, most likely a diamond deposit, she did not contact Natalia and did not send her a rock sample. In fact, Larisa spent more than two months in the taiga and never sent a single message to Natalia, who was desperately waiting for the news.

Later Natalia wrote that it was from another geologist who incidentally was in Leningrad that she found out about Larisa's discovery. Natalia was shocked and devastated by the fact that her best friend had never got in touch with her and the only hand specimen she had, was transported to Leningrad by a distant person. "*How could Larisa share this specimen with him and not with me?*" – wrote Natalia.

By the time Larisa arrived at headquarters of Amakinskaya expedition Nyurba, the decision had already been made. The superiors decided to force Larisa to quit her job for the Central expedition in Leningrad and to sign up as an employee of the Amakinskaya expedition. That would allow them to claim the discovery and to keep Natalia and Leningrad's expedition away.

The events happened in Nyurba during the following few months, although constrained quite well, do not depict the exact detail of the situation. It is well-known that Larisa was threatened, blackmailed and not allowed to fly back to Leningrad. She could only travel back

to her family after she signed all the papers assigning the discovery to the Amakinskaya expedition.

A fellow female geologist from this expedition Natalia Kind wrote: "*In Nyurba they drove Nelya to hysteria*". A large report issued immediately after the field work and sent to the top officials stated that Amakinskaya expedition had discovered two diamondiferous fields in the region. In the meanwhile in Lenindgrad, Natalia Sarsadskih was not aware of the events occurring in Nuyrba. Only later in October she received a telegram congratulating her on the great achievements of her group. Larisa never wrote to her. Natalia was absolutely sure that it was due to Larisa's vanity, pride and desire to be the only discoverer, she did not want to communicate with Natalia any more.

From memoirs of Ekaterina Elagina: "*Being a difficult, stressful condition, Popugaeva was so frightened that she was afraid to talk to anyone. (…) The officials lost their patience and promised her that she would never see her daughter or husband again, and will share her father's destiny*" (Elagina, 1999; Elagina, 2003).

Ultimately, Larisa gave up and signed the documents transferring her to Amakinskaya expedition. This gave the priority of the first kimberlite pipe discovery to an organisation that did not have any rights to claim it. Moreover, the geologists from Amakinskaya expedition have removed the post set by Larisa and Fyodor and announced that the location was incorrect, moving it 200-300m to the side.

4. Burden of being the first

Sarsadskhih never forgave Larisa for changing affiliation. This event haunted her for her entire life, poisoning her relationship with her colleagues and making her change the job and leave the diamond exploration field.

Many people later stated that although Larisa behaved disrespectfully, she was manipulated, forced and ultimately threatened. This was not a willing choice and she certainly was not driven by a desire to have all the glory to herself. In 1954 Larisa was a 31-year old young professional who conducted her first independent field work. Defending herself in front of much older, more experienced and forceful superiors was not easy. During the following years, Larisa tried to reconcile with Natalia and to reestablish the justice. She talked to people, wrote letters to the higher officials and tried to publicise Natalia's achievement.

To slightly smoothen the conflict, in 1955 Natalia and Larisa received an official gratitude and award of one-month payment for conducting exploration work in 1953-1954 seasons. Fyodor Belikov also received a gratitude and two-months' salary (because his salary was substantially lower than the lead geologists of the trip).

In April 1957, six leading male geologists of Amakinskaya expedition received one of the most prestigious Soviet award – Lenin Prize. However, both Larisa (although acknowledged as a discoverer), and Natalia were left aside (Yuzmukhametov, 1998; Yuzmukhametov, 2004).

In the summer of 1955, using Larisa's and Natalia's panning method and data, three other kimberlite pipes were discovered in the region: Udachnaya, Mir and Sytykanskaya. Both women were never acknowledged of these discoveries.

Later in 1957 Larisa wrote a letter to Nikita Khruschev, the leader of the USSR, requesting to investigate the events of 1954. The reply was disappointing, the government committee did not find any law infringements and hence the reason to revert the prize awardees.

Yet, during the next round of government awards, Larisa was granted with the Order of Lenin, the highest civilian award by the Soviet Union, and Natalia received The Order of the

Great Banner of Labour, an award given for services to the country and society. None of the women were recognised to be the discoverers of diamonds in Siberia.

In 1970 Larisa finally received a status of the Discoverer of a mineral deposit. On the 16th of April 1970, she was granted a diploma "For discovery of diamond deposit kimberlite pipe Zarnitsa in Yakutskaya ASSR".

Only some 35 years later, in 1990, Sarsadskih received the same status. Also, a large diamond found in Yakutia diamond province was called in honour of Natalia.

The price of this discovery ended up being enormous. Larisa and Natalia could not continue in the diamond exploration field and, importantly, lost each other as friends. The bright flashing light of "Zarnitsa" had separated them forever.

In 1970s the news of Larisa's discovery and her name were widespread all over the world. Only in 1973 her name was mentioned in more than 100 Soviet and international publications, there were radio and TV programs dedicated to her. Larisa did not like being a celebrity. She rejected a proposal of a Moscow sculptor Vera Isaeva to erect her monument. In her letter to Isaeva, Larisa wrote: "*Yes, I happened together with Fyodor Belikov to discover the first diamond deposit in the USSR. (…) However, the subsequent events, linked to this discovery, brought into my life such a huge amount of dirt, careerism, lies and distorted facts that I cannot speak about this topic without bitterness and deep insult. Don't misunderstand me, for God's sake, Vera Vasilyevna. You will find many objects, who would like to capture their faces and bodies. Bless them. They, perhaps, should be carolled and sculpted. But this is not for me*".

In VSEGEI Larisa was treated as a traitor, and eventually was compelled to quit that job. In 1960 Larisa started her work in the Central Research Laboratory of Gemstones and Semiprecious stones. She became the head of the group that consisted only of two people,

including herself. She turned 37 that year, and her life was not easy. Her family included her elderly mum, young sister, husband and an 8-year old daughter. All of them lived in two rooms in a shared communal flat that overall had six rooms. At around that time, Larisa ran into a friend, who later described that meeting: "*Larisa was dressed very poorly, one could notice that her life was difficult*".

In 1970 Larisa had finally completed her PhD degree, started in 1950s. Her thesis was dedicated to diamonds and diamond exploration in Yakutia. She was not the only one whose work on diamond exploration in Siberia was not rewarded, and not the only one who had to stop working in this field. Larisa had two closest female friends, both from the "diamond exploration times" in Siberia – Natalia Kind and Ekaterina Elagina. Both lived in Moscow and Larisa frequently visited them.

Stressful events and difficult life did not go unnoticed. Larisa developed hypertension. In 1971 she was first admitted to hospital and stayed there for four months. Her friends noticed that after that event she could not work as hard as usual.

In 1974 Larisa's family was offered a 3-bedroom flat – a luxury for those times, perhaps, triggered by her award.

Later in 1974, she was admitted to the hospital again, with the diagnosis of aortic valve sclerosis. She was suffering from headaches for a long time, as well as had severe pain in her neck, thinking that was a consequence of carrying very heavy backpacks in fieldtrips. Doctors forbade her to smoke that she never adhered to.

Larisa's last visit to Moscow was in September 1977, two weeks after her 54th birthday. She had a work-related trip, but as usual, she stayed at her friend Natalia Kind's flat. Her husband and daughter waited for her on the platform when she returned to Leningrad by train. She went straight to work, and on her way home from work decided to buy a few

600 groceries. She never got home. Larisa died instantly on the street from aortic aneurysm. She
601 was buried in Leningrad (Fig. 8).
602 Natalia Sarsadskih lived in Leningrad (later Saint-Petersburg) for the rest of her life and died
603 in 2013 aged 97.
604 Fyodor Belikov never travelled to Yakutia again until 1985, when he was invited to star in a
605 documentary film – "Yuakutian Diamonds". He lived his entire live with his wife in a shared
606 communal flat on Vasilyevskiy island in Leningrad. His "house mate" was an aggressive
607 alcoholic, while Fyodor worked as a driver of a waste disposal truck. The last "celebration"
608 in Fyodor's life occurred in summer 1994, when he was invited to celebrate 40 years since
609 the discovery of Zarnitsa. He died in the beginning of 1995.

610 ## 5. Legacy and life after life

611 The story of Larisa's life and diamond discovery was largely publicised. There were multiple
612 authors, both geologists and historians working on the topic, recovering letters and notes
613 from archives. A few films and both fiction and documentary were released in the last 20
614 years.
615 Exploration for diamonds in the fields is still continuing and multiple kimberlite pipes were
616 found in the area by multiple expeditions and parties since Zarnitsa discovery
617 (Yuzmukhametov, 2006; Yuzmukhametov, 2010).
618 The first monument to Larisa was erected at the beginning of the 1990s in the town Mirniy,
619 build around the kimberlite pipe Mir.
620 In spring 2006 at VSEGEI that exists until now, was a large celebration of Natalia Sarsadskikh
621 90th birthday. Natalia raised her glass and drank to Nelya Grintsevich, the name she used to
622 call Larisa.

In 2007 a school in a small town of Udachny in Yakutia was named in honour of Larisa. In 2011 in the museum of the state Saint-Petersburg university was created a fund of Larisa Popugaeva – the most famous graduate of this university during the last 100 years.

Acknowledgements and brief notes from authors

This article is a combined work by a geologist, whose scientific interests are closely related to diamonds and kimberlites, and a historian, who published more than 30 books and articles in Russian on diamond discovery in Siberia. Despite being well-publicised in the Russian literature, to authors' knowledge there are no articles dedicated to the discovery of Siberian kimberlite field in English. One of the goals of this study is to uncover this story to English-speaking readers. Another goal is to commemorate and acknowledge a great input of women into such a difficult profession as geology in Soviet Union.

The story of "Zarnitsa" has already been told by many authors. There are excellent books by Kostitsin, Treibus, Masaitis, Sarsadskhih, Elagina, Silaev and others. The authors apologise if any of the publications are missed from the reference list.

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682 62.

683 Figure captions

684 Fig. 1. Olga Grintsevich (a) and Anatoliy Popugaev (b), Larisa’s parents.

685 Fig. 2. Larisa Grintsevich (a) after graduating from school, June, 1941 (from Kostitsyn, 2016).
686 (b) In the army, December 1942 (from personal archives of Natalia Popugaeva)

687 Fig. 3. Region of Tungussko-Lenskaya expedition mapping area.

688 Fig. 4. (a) Natalia Sarsadskhih, 1953 (from Kostitsyn, 2016). (b) Natalia Sarsadskhih (right)
689 and Larisa Popugaeva (left) with geologists from Yakuatian meteorolical station om

690 Shelogontsy, 1953. At the front – larisa's favourite dog called Verniy ("fathful" in Russian)
691 (photo from Treivus (2014).
692 Fig.5. Part of Eastern Siberia with the area where the diamond exploration was conducted
693 (see text for description). With stars are shown some of the largest kimberlite pipes of the
694 area. Kimberlite pipes are shown in stars with Zarnitsa (1) as a red star. 2 – Udachnaya, 3 –
695 Sytykanskaya, 4 – Yubileynaya, 5 – Aikhal, 6 – Druzhba, 7 – Internatsionalnaya, 8 – Mir,
696 Fig.6. 1954 field season. (a) Larisa in the field – September 1954. (b) Larisa, Fyodor and
697 Pushok in the field during the visit of the authorities from Amakinskaya expedition. August
698 1954.
699 Fig.7. A sketch of the main geological routes Popugaeva took in 1954 along the river Daldyn.
700 Adopted from Treivus et al., (2014)
701 Fig. 8. Larisa Popugaeva's grave in Saint Petersburg (from Kostitsyn, 2016).
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