

Post-publication careers: follow-up expeditions reveal avalanches at Dyatlov Pass

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Having shed new light on an old mystery—how nine Russian mountaineers perished in the Urals in 1959—Alexander Puzrin and Johan Gaume got hooked. Three expeditions later it is clear that avalanches are not exceptional at Dyatlov Pass.

Our 2021 study in *Communications Earth & Environment*¹ shows that a snow slab avalanche is a plausible explanation of the 1959 Dyatlov Pass incident. It was published on 28 January 2021—exactly 62 years after a party of Russian mountaineers led by Igor Dyatlov set out on their skiing expedition from the abandoned North-2 mining settlement in Ural mountains, never to be seen again. The mystery had drawn much attention over the years; several investigations in Russia, stretching from 1959 to 2020, were not entirely conclusive.

The media echo to our article motivated us to continue investigating, and brought us in contact with some incredible people: a brilliant Swiss documentary director, a leading snow scientist from the Moscow State University and two heroic mountain guides from the Urals. In the year since publication of our article, we helped them to organize three successful expeditions to the Dyatlov Pass. The direct evidence from the Dyatlov Pass area obtained in those expeditions confirms that the region is avalanche prone and that slopes above the location where Igor Dyatlov and his group pitched their tent are steep enough for avalanches to release. Independent research by Russian snow and climate scientists supported assumptions and the main results of our slab avalanche modeling.

The mystery

The deaths of the mountaineers had variously been attributed to an infrasound-induced panic, animals, attacks by Yetis or local tribesmen, katabatic winds, a snow avalanche, a romantic dispute, KGB/CIA secret activities, ballistic rockets, or nuclear weapons tests. In our study¹, we focused on the plausibility of a snow slab avalanche as the trigger. Using basic physics, we showed that in spite of a lower-than-usual apparent slope angle, scarcity of avalanche signs, uncertainties about the trigger, and unusual injuries of the victims, such an avalanche is indeed a possible explanation. One important ingredient of our proposed mechanism is the progressive wind-blown snow accumulation on the slope above the hikers' tent. Equally significantly, the topography of the slope is irregular, built of 4-to-6 m-high steps: although the average slope inclination (observed when the steps are covered by snow) is indeed too low for an avalanche to release, we assumed (based on the evidence available at that time), that a locally steeper slope above the tent had an inclination of at least 28 degrees. Such a high angle makes a slab avalanche possible, because a buried weak snow layer would follow this steep terrain.

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Fig. 1 Infographics inspired by the Dyatlov Pass Incident and our paper in *Communications Earth & Environment*. The authors are depicted as comic heroes. Courtesy of PICTOLINE: www.pictoline.com.

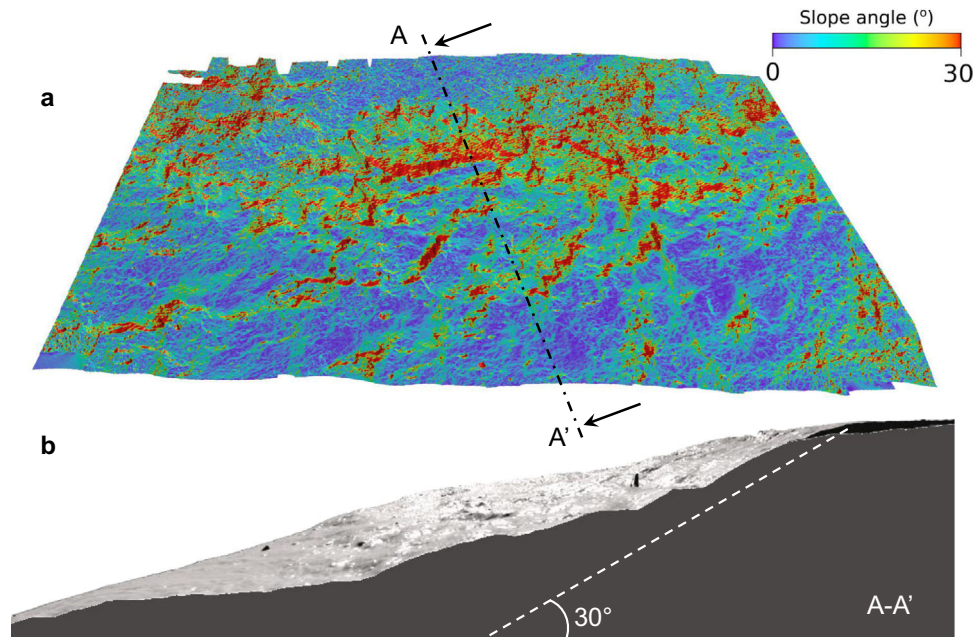


Fig. 2 Local topography. **a** Digital Elevation Model (DEM) showing the local slope angle. The DEM was obtained based on a drone photogrammetry analysis (summer 2021 survey) and has a resolution of 9 cm. **b** A–A' section showing that although the average slope angle is around 20°, locally steeper steps have indeed an inclination exceeding 30° (given as an indicator by white dashed line).

The media response

The Nature press office and video team put together a press release and video, and disseminated them to journalists just before publication of the paper. The media response was overwhelming. During the first month, each of us was giving two to three interviews every day. This was not easy for our young families: because of pandemic restrictions, all the interviews took place in the home office. At least our children were partially compensated, when Latin American graphic design company PICTOLINE was inspired by an article covering our work in the National Geographic², and turned their fathers into comic heroes (Fig. 1).

The media reporting outside Russia was in general very favorable. Within Russia it was mixed, however. Whereas the popular science publications were supportive³, some tabloids were rather negative. Perhaps this is not surprising. Mysteries are more attractive while unsolved, or at least not solved with such a boring scientific explanation. However, as so often, it was the negative responses that turned out to be the most useful ones.

Follow-up work

The main objections to our conclusion of a snow avalanche were: (i) there was no snow cover on the slope, (ii) there was no wind that night, (iii) there is no significant snow transfer by wind in that area, (iv) the slope is flat (no steps), and (v) snow avalanches never happen in this area. This was worrying.

Fortunately, we found the names of two prominent Russian scientists, who had helped the local prosecutor after the Dyatlov Group criminal case was reopened in 2019. Professor Victor Popovnin at the Moscow State University, a leading snow avalanche researcher in Russia, confirmed that the assumptions on the snow properties that we used in our models are consistent with his measurements during a winter expedition to Dyatlov Pass in 2019. The second scientist, Professor Galina Pigol'tsina at the Voeikov Main Geophysical Observatory in St Petersburg, reports⁴ that during the night of the incident, 1st–2nd of February 1959, the snow cover above the tent exceeded 150 cm, consistent with our assumptions. Moreover, the snow transfer by

wind during winter in this area can reach 600–1000 m³/m, which would completely cover local topographic features such as the steps. Astonishingly, her best estimate of the wind velocity above the tent was 9 to 12 m/s, right in the range required to explain the observed delay in the slab avalanche release in our model.

Into the mountains

The question of irregular topography, however, remained open. Luckily, Radiotelevisione Svizzera (RSI) decided to produce a documentary “The Dyatlov Mystery” focusing on our work. We helped them to organize two expeditions to Dyatlov Pass, one during the winter in March 2021 another at the end of summer in September 2021. Because of the snow cover, the winter expedition could not help us much with the terrain topography, but proved valuable later. The summer expedition, however, was equipped with a drone that allowed us to produce a high-resolution three-dimensional digital model of the terrain in the vicinity of the possible tent locations (Fig. 2). Clearly, the steps have inclinations exceeding 28 degrees, and many slopes are even steeper than 30 degrees. What's more, these slopes are not just local, they are continuous: no matter where you pitch your tent you are likely to be below one of them.

Finally, we had to investigate the objection that this area is not susceptible to avalanche hazard. In the Russian Federation Natural Hazards Handbook⁵ of 1997, the area of Dyatlov Pass is characterized as the avalanche risk zone of Category II, defined as at least one avalanche per kilometer every 10 years. January is flagged as the most dangerous month. However, the resolution of the hazard map was extremely low, allowing the critics to claim that the Category II risk refers to western slopes of the mountain chain and not to the eastern ones, where the Dyatlov group's tent was found.

And here the story takes an almost mysterious turn. In October 2021, we were contacted by a Russian mountain guide, Dmitriy Borisov, who had photographed on 29th of March 2021 a peculiar feature on the western slope of a nearby mountain (Fig. 3a, b), about 3 km away from the tent location. It looked like a local depression in the slope with probable avalanche traces. But we were concerned that it could also be a shadow from a cloud. Then



Fig. 3 Avalanches near Dyatlov Pass. **a** Location of the area where avalanches were observed. Source: Google Earth © 2021 Maxar technologies Landsat/Copernicus. **b** Picture taken by Dmitriy Borisov on the 29th of March 2021 from the Dyatlov Pass. The zone highlighted in red is located ~3 km away from the tent. **c** Picture extracted from a video taken by Matteo Born (RSI movie director), the day later, i.e., 30th March 2021. **d** Picture of a crown tensile fracture on the left side of this slope taken by Dmitriy Borisov on 29th January 2022. **e** Picture of a small slab avalanche in the middle of the slope by Dmitriy Borisov on the same day (29th January 2022).

the RSI film director Matteo Born went through the footage he took for the documentary during his own winter expedition and accidentally discovered the same features only in a higher resolution (Fig. 3c and Supplementary Movie 1)—taken during the following day, on the 30th of March! It is highly unlikely that a cloud would stay in the same place for close to 24 h. Although it is difficult to confirm the type of snow slope instability based on this picture's resolution, the dark shaded zone below the ridge could be a tensile crown fracture resulting from one or several slab avalanches. A dozen international avalanche scientists or practitioners whom we talked to suggested that these could be classified either as a snow cornice, cornice falls or small wind slab avalanches.

The avalanches

The uncertainty was, however, so unsettling that we decided to organize the third expedition, this time to study the particular

area in Fig. 3b, c. On the 28th of January 2022, exactly 63 years after the Dyatlov group was seen alive for the last time, two professional mountain guides from Ekaterinburg, Oleg Demyanenko and Dmitriy Borisov, left for the Dyatlov Pass on two snowmobiles. The initially favorable weather conditions quickly deteriorated, with wind and temperatures becoming similar to those on the night of the 1959 tragedy. Several times, the 300 kg snowmobiles and their drivers were overturned by wind gusts. Visibility became extremely poor. And then, when after a few failed attempts the two mountain guides approached their destination, the visibility briefly improved and revealed traces of two snow slab avalanches (Fig. 3d, e and Supplementary Movie 2).

Contrary to multiple claims that snow avalanches have never been observed around this area, in two subsequent winter expeditions within the year since publication of our article, we can report several documented slab avalanches in an eastern slope <3 km away from the Dyatlov group tent. And while some

doubts remain for the March 2021 instability type in Fig. 3b, c, the outcome of the January 2022 expedition is clear: the traces of two new snow slab avalanches were observed for weather conditions apparently similar to those on the night of the Dyatlov incident, during the same time of the year. The first slab avalanche (Fig. 3d) is located on the left side of the slope, and has a crown thickness of about 1 m. The second one (Fig. 3e and Supplementary Movie 2), which was observed in the middle of the slope, appeared to have a smaller crown thickness, close to the one predicted in our model¹. It slid along a smooth weak interface with an older compacted snow and was very likely triggered by a local cornice fall. Oleg and Dmitriy report that this second avalanche was practically invisible after less than an hour, as it was covered by the wind-transported snow. They estimate that the avalanche released less than an hour before their arrival. No wonder then that the Dyatlov rescue team could not find signs of an avalanche 3 weeks after the incident. This also explains why no avalanches have been observed there before: in such severe weather conditions the Pass cannot be easily accessed by hikers, while traces of small slab avalanches disappear within few hours.

No final word

Some of the conditions leading to the avalanches observed on 29th January 2022 were very similar to those experienced by the Dyatlov group: eastern slope aspect, date in the year, low temperatures, strong winds and large amounts of wind-transported snow. Other conditions were different: the slab was softer, the slope was steeper, it was not undercut from below and the trigger was probably different, too. Nevertheless, the area is clearly avalanche prone, and the avalanche danger on the night of February 1st, 1959 was real.

Time and again, we were asked whether our article brings to an end our work on the case. We always responded that, although the case itself remains open, our part is closed: we did not want to spend the rest of our lives trying to solve the Dyatlov Pass mystery. One year later, we are no longer so sure. If someone asks, we will refrain from an answer.

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Author contributions

A.M.P. conceived the idea of the article, co-organized expeditions and co-wrote the paper. J.G. co-organized expeditions and co-wrote the paper.

Competing interests

The authors declare no competing interests.

Additional information

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