Feature

Geology of the Tour de France: taking a sports audience by surprise

Every year, tens of millions of cycling enthusiasts watch and read about the Tour de France, one of the largest sports events of the year. For hours on end, they wait in anticipation of the climax of the race, and these hours are filled by commentators and journalists with background information about riders, the course, history, cuisine, culture and architecture. Little do they realize that every day the peloton is actually setting out on a beautiful excursion through what is one of the most geologically and geographically diverse regions in the world. The Geo-Sports project provides journalists, readers, and viewers with accessible excursion guides, in written and video format, on websites and social media. In this article, we explain the rationale and background of the project, and we hope you will join us in lifting the veil to expose the beauty of the natural world and its role in our society.

Earth science offers a myriad of fascinating stories about where we came from; where we might be going; what is deep below our feet and high above us in the sky. Earth scientists are generally renowned for talking about these stories to any audience willing to listen. For decades, earth scientists have sent their stories to the public through documentaries, books, newspaper articles, and—following the boom of the last 15 years—through social media. For those who want to find it, there are libraries full of information. However, it is still surprisingly easy for a well-educated and interested individual to remain essentially oblivious to the history or workings of the planet, and its role in providing the resources and land on which society is built. This is worrisome, because Earth science plays an essential role in the drive towards a more sustainable society. It is therefore a challenge for the Earth science community to not only reach audiences who consciously tune in for a geo-story but also to those who do not.

The Geo-Sports project, along with its 'Geology of the Tour de France' flagship, is built around a concept that brings to life the landscapes and subsurface, and their role in society, to an audience who tuned in for a sports event. Every year, tens of millions of viewers tune in for professional cycling races on television. This includes three-week-long tours in France, Spain, and Italy, one-week tours all over the rest of the world from South America to Australia, and Asia to Arabia, as well as one-day classics races in especially Italy and northwest Europe. For hours, fans/viewers watch a slowly unfolding race, in which the action is typically concentrated in the first and last hour. In the meantime, commentators fill the silence/space with background stories on everything that has to do with cycling, cyclists, and the parcours. The 2023 Tour de France included 82 h of live TV coverage for commentators to fill. Organizers offer a 400-page route books with facts about architecture and history, culture, cuisine, and wine, to advertise much more than just a bike race. However, it hardly pays attention to the natural environment and underlying geology, even though many a viewer marvels at the beauty of the landscape.

Much of the geo-stories remained unheard by the Tour de France's international audience. Through a mix of blogs written by an international team of Earth scientists, clips that have been used by Dutch and UK television, and an array of social media channels, the Geo-Sports initiative brings the landscape and the underlying hidden treasures to life for an unsuspecting

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audience, who tuned in to enjoy a sports event. In addition to cycling races (not limited to the Tour de France), we also ventured into the Dakar Rally and the Ocean Race sailing regatta (Fig. 1). In this article, we explain the philosophy that we developed and the communication vehicles that we chose to target our audience(s).

Process, team, content, and use

Our idea of offering geological backgrounds around cycling races was not the first initiative along these lines. French scientists, including Patrick de Wever at the National Museum of Natural History in Paris, and French Geological Survey BRGM have offered explanations of local geology around the Tour de France (in French), and about ten years ago, Italian colleagues developed the GeoloGiro, later the EcoGiro, around the Giro d'Italia. Oblivious to these earlier initiatives, our version of this project started in 2021 with a series of blogs about the Tour de France written by the lead author on a few rainy Covid-lockdown afternoons. These led to positive responses from public and media and were used in the Dutch Tour de France commentary. In the subsequent years, we developed a website—www.geo-sports.org—on which blogs about the geology of Tour de France stages are published, as well as from major cycling classics, world championships, grand tours and one-week tours. Blogs have been written by dozens of invited guest writers from all over the world. Co-author José Been, a cycling journalist and TV commentator with a broad interest but no specialist knowledge of Earth science, joined the team as editor. Among other contributions, she has coached and aided the blog writers to make sure their blogs are accessible to the broad cycling public. In the Tour de France 2024, there are some 60 blogs that cover a wide range of aspects of the Earth sciences and their—for the public often unexpected—role in society (Fig. 2).

Using the blogs as input, and using the same general format, geo-educator, documentary maker and co-author Mark Carpenter joined the team in 2023. With the lead author Douwe van Hinsbergen (Fig. 3), and co-author Marjolein Naudé (Fig. 4), an Utrecht geologist, as presenters, the team began to develop short, 2-min clips about the geology of -Tour de France stages and selected spring classics. Including the 13 clips produced for the Tour de France of 2024, there will be 30 such clips for use

Fig. 1. Different flavours of Geo-Sports: the general initiative, and applications to cycling, rally racing, and sailing.

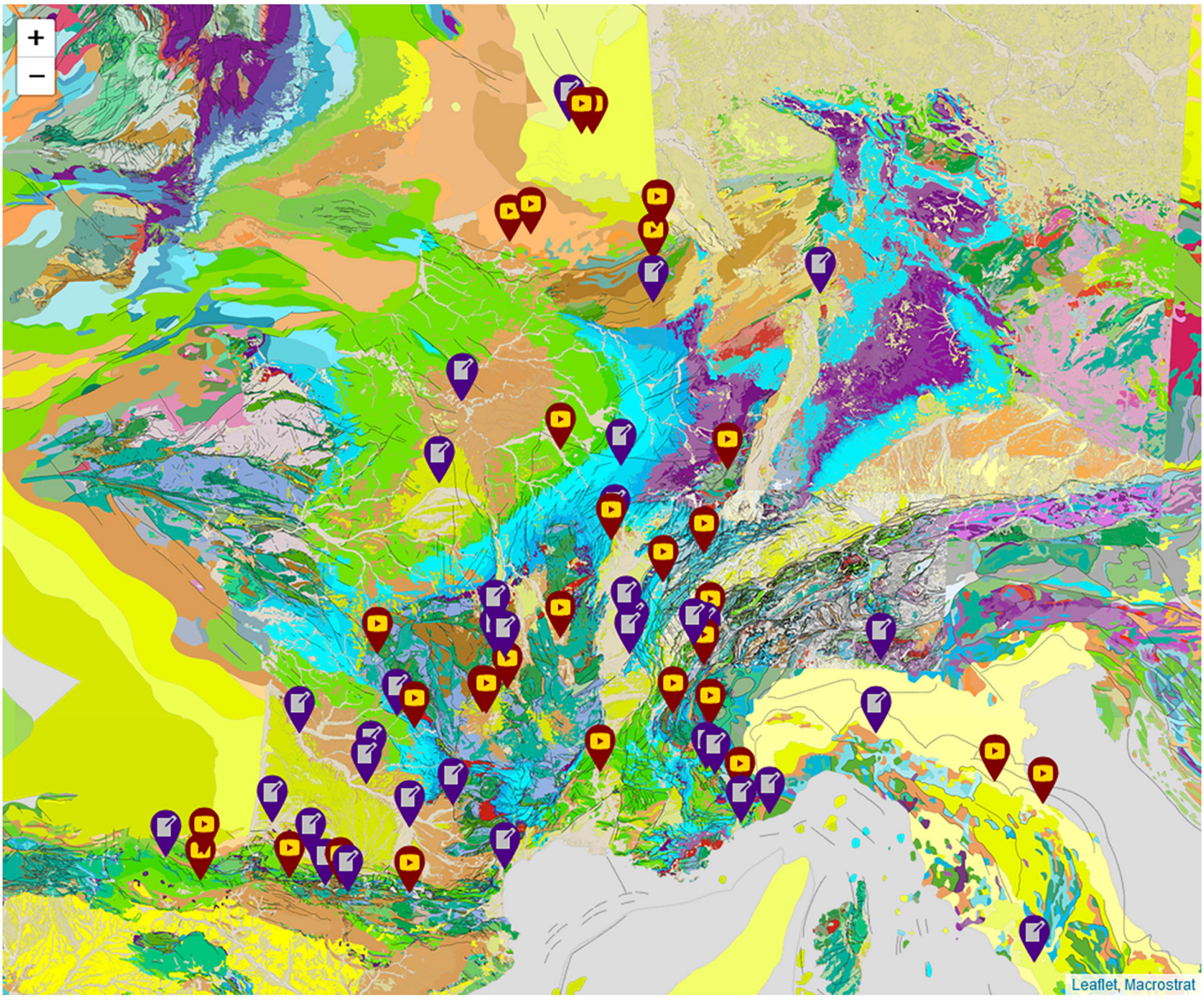

Fig. 2. Locations for which blogs and clips are available on www.Geo-Sports.org as of April 2024, plotted on the geological map of Europe. The Tour de France 2024 will add another 28 blogs and 13 clips.

on TV or social media, that are loosely tied to the blogs.

Finally, all of this content is shared through social media. Particularly through X (formerly Twitter), the team speaks to and interacts with the cycling community, including pro riders, journalists, and general enthusiasts. Besides the more extensive blogs, short anecdotes and explanations are provided for each stage of the Grand Tours, and incidental ones for one-day races or one-week stage races.

Collectively, these communication channels have connected Earth scientists to a community of sports enthusiasts who show a rapidly growing interest. We cherish this connection. It provides a pathway for scientists to reach an unsuspecting audience, and vice versa, it provides this audience with the possibility to direct their questions directly back to the Earth science community who joins them along the road. Because the project's intention is to showcase Earth science, and to connect science to society, each contributing scientist and their host institutions are free, and encouraged, to use their contributions for their own advertisement, at no cost.

Geo-Sports concept and challenges

Sports audiences are large and diverse and therefore an ideal target for science outreach. However, these audiences were brought together by an interest in their sport, which should thus remain the leading theme. The items we bring thus start with the sports event the audience has initially tuned into,

Fig. 3. Presenter Douwe van Hinsbergen in the Pyrenees, explaining which ore deposits are needed to make a racing bike.

casually breaking in by pointing out a geological or geographic feature that the sports fan sees passing on their screen. We try to point out a geological or geographical landmark that would be of interest/that could pique their curiosity. From there, we add an information sidebar into our subject of choice—Earth science—after which we lead the viewer or reader back to the sports event. All of our communication formats use this simple concept. It avoids breaking into a Tour de France stage with a message about a billion-year-old rock that has no connection to cycling, and it also avoids leaving an audience

Fig. 4. Presenter Marjolein Naudé in the Champagne region, explaining how sea level change was a necessary ingredient for the formation of gravel roads.

somewhere in the Cretaceous in a herd of ferocious dinosaurs, 70 million years away from the bike race they tuned into.

Each tweet, blog, or clip attempts at explaining one 'fun fact' about Earth history, geology, or its use in society and everyday life, that may not be widely known to the viewer. But what is a fun fact for a geologist does not always translate well to a non-specialist viewer whose sports-experience we are breaking into. Where scientific colleagues are typically eager for a detailed and full account of the underlying data and principles, and students have paid for their lectures and are expected to be able to remember the contents of a lecture, a sports audience has neither characteristic when it comes to Earth science. Our challenge is to keep the content interesting enough for a two-minute attention span for a viewer, and 5–10 min for a reader. So, we should not only simplify but also keep the content exciting and interesting. And Earth's processes offer a further challenge: they often occur at a wide range of scales. The viewer may see one mountain clearly enough, but what about a mountain range or an entire lithospheric plate? Or a microscopic organism? To make matters worse, there are temporal issues as well. Some features stopped forming in the past and even those still active today operate so slowly that they're barely noticeable on a human timescale. Luckily, we geologists have options. Samples to reveal the deep, hands and sleeves to model plate movement, and when the going gets tough, we can call in the big guns, CGI, allowing us to split continents, kill dinosaurs, raise sea levels, and bring the hidden Earth to life.

For us as makers, this is the interesting challenge that we enjoy the most, and where we see the highest impact of the project. And as a cycling commentator, José Been has the insight about which facts could easily be shared in race commentary and which not. These are shared in a commentary book for TV commentators. In communicating, we always presume no prior knowledge of our viewers and explain in the simplest way possible. The blogs give some more insight and deepen the knowledge for those interested. It is a two-tiered approach to get the public drawn into Earth sciences and be tempted to learn more. After all, a central aim of science is to trigger interest and change the thinking of the audience based on the latest state of knowledge and understanding.

We attempt to take the unexpected angle in the story. For instance, in a blog about the geology of Paris-Roubaix, the spring monument under the nickname 'The Hell of the North' that is famous for its bumpy cobbled roads (Fig. 5), Utrecht Quaternary geologist Kim Cohen immediately takes the reader away from those cobbles, because they're imported from Belgium. The story he focuses on, is why the cobbles are there in the first place, and why the riders of the race often finish completely covered in dust or mud; namely, northern France is part of the loess belt that formed in the ice ages.

In the clip that we based on this blog we ran into the problem that it is hard to show a geological feature that can link directly to the ice ages. Therefore, we explained that the red bricks that are widely used for building material in the region are made from loess—a point explained several years ago in a Tour de France blog by Patrick de Wever. The clip then used the bricks to link to the Quaternary ice age history and its role in modern agriculture, and ends noting that 'the Hell of the North froze over'. Similarly, in the Tour of 2023, we used the impact breccias in the wall of the castle of Rochechouart to explain the story of a meteorite impact in central France in the late Triassic, the relics of which cannot be directly seen from the flat landscape. This way, we enjoy trying to lift the veil on the stories hidden in the landscape, and use it to explain lighter and more serious stories that vary from the mining and role of critical metals in society to the geological backgrounds of wine making, from

the causes of sea level change to the impact that wiped out the dinosaurs, from how orogenesis relates to subduction to the presence of dinosaur tracks along the race, and even to how a volcanic eruption in Indonesia eventually led to the invention of the bicycle by a German farmer.

One key element of the communication is that we try to explain Earth science subjects that have become politicized, particularly climate change and sea level rise, but without invoking a political discussion. We therefore have no activist agenda. Using the direct interaction through social media as a feedback mechanism, we pushed one item in the Tour de France 2023 slightly too far, which resulted in negative responses by some members of the audience. It was a clip about the retreating glaciers of the Alps. We explained how those glaciers act as water towers, regulating the hydrology of a vast area of lowlands, and that the retreat of the glaciers as a result of rising temperatures will affect a large population and region. The item ended with a negative tone: the glaciers are like cyclists who did not eat enough before the final climb, and those rarely win. This item led to several annoyed responses that noted that one cannot even watch a cycling race without being confronted with items on climate change. While we scientifically stand with the story told, the lesson learned is that our audience tunes in to sports programs for entertainment. To blend into the program effectively, we best bring our messages, including those that may include societal problems, in a lighthearted fashion.

For the Tour de France of 2024, we made an item to explain the geological causes of sea level change on long timescales—mostly plate tectonic activity and global temperature—where we explain what would be needed to raise sea level 200 m to reach marine deposits of the Mesozoic situated along a particular stage course. There, we notice that just melting all land ice will not do the trick, as that would only drown France until Paris. What will be needed is an increase in plate tectonic activity (causing a younging of average ocean floor age), which is not going to happen any time soon. We attempted to deliver a message that may be perceived as alarmist in a casual way, and we look forward to seeing whether this succeeded.

Geology of the (Tour de) France

The geology of France (Fig. 2) lends itself to explain a wide range of Earth scientific subjects. At first order, France consists of three types of geological provinces: sedimentary basins are home to the sprinters; crystalline massifs are the favourite territory of the puncheurs (those who specialize in rolling terrain with short but steep climbs; and young orogens are the territory of the climbers). We used this subdivision to make a first link between cycling and geology, but the connection is of course the topography that comes with these regions. As an ITV presenter in 2023 put it: 'this year we're doing something a little different, we're bringing you the geology under and beside the course. Not only is it beautiful to look at but also it sometimes affects the very outcome of the race'.

Fig. 5. Cycling world champion Mathieu van der Poel on his way to victory on the cobbles of the regions around Roubaix, northern France, April 2024.

The main sedimentary basins are the Paris Basin in the north, the Aquitaine Basin in the south, and the Rhone and Bresse grabens in the east. These are low-lying, flat areas with topographies not exceeding 200 m, which form the catchment regions of the major rivers of the Garonne, the Seine, the Loire, and the Rhône. We used Tour de France stages through these regions to explain general basin geology, sea level change, palaeontology, seismic imaging, rift tectonics, subsidence processes, coal geology, the history and effects of the Messinian Salinity Crisis, ice ages and loess belts, geomorphology, and wine geology.

What we dubbed the 'crystalline massifs'—notably the Armorican Massif, the Central Massif, and the Vosges—are regions that expose the remains of the Variscan orogen. These are regions that were uplifted in or after the Mesozoic and now form erosional windows below the Mesozoic sedimentary cover. Because these rocks were typically deeply exhumed, mostly in the final stages of the Variscan orogeny, they are crystalline. Because they are durable, they make for rugged topography: 'the terrain of the puncheurs'. The causes for uplift vary—and are in some cases debated in the literature—but topography varies from hundreds of metres in the Armorican Massif of Bretagne, to ~1500 m in the Central Massif and the Vosges. In addition, the heart of the Central Massif is home to

France's youngest volcanoes, of Neogene to Quaternary age, that make for more serious climbing, notably the Puy de Dôme and the Cantal, Europe's largest, and once highest volcano. Processes that we explained in these crystalline massifs vary from geochronology to subduction zone metamorphism, the role of rift flank uplift, granites and magma chamber processes, plume-related uplift, monogenetic volcanism, the formation of kaolinite and its role in lithium mining, and to explain the paradox that the topographically lowest regions typically expose the highest, youngest geology, and that the higher a ride climbs, the deeper and older the geology gets (with as the main exception: volcanoes). During last year's Tour de France Femmes, a groundbreaking event in women's sports, we heralded the female pioneers in Earth science such as Yvonne Brière who recognized eclogite as a metamorphic rock (and was mocked for it).

Finally, the Pyrenees and Alps form the young accretionary orogens of France and are home to the climbers. Every year the spectacular high passes bring the peloton over the deformed and thrusted equivalents of all of the above, and in addition show mantle rocks and oceanic rocks from the hyperextended and oceanic basins that once separated Eurasia from Iberia (in the Pyrenees) and Adria (in the Alps). Moreover, the Tour de France has ventured into Spain and Italy in 2023 and 2024, respectively, which gave the opportunity to explain some of the geology and history of Iberia and Adria as well. We used the young orogens to explain plate tectonic processes—both rifting and ocean basin formation as well as subduction, metamorphism, nappe stacking and folding—by showing how a slicer deforms the top of a block of cheese; exhumation, subducted slabs, and palaeogeography, but also glacier and landslide dynamics in relation to climate change, and the causes and effects of catastrophic floods such as storm Alex in 2020.

Combined, the geology of France provides a wonderful and comprehensive overview of geology and physical geography, and the pro-cycling tours such as the Tour de France provide the earth scientist with hours-long excursions through all those wonders, and an audience who are interested—to a limited extent—in backgrounds behind and below the race. This is not limited to France of course, and there are now also 'X' accounts and websites about the Geology of the Tour of Britain, and for cycling races in Norway, Ireland, and Germany. Keep them coming!

Geo-Sports classroom: future plans

The blogs and clips that were developed for the Geo-Sports project are made to be accessible for a wide audience and may thus provide interesting material for secondary school teaching. The short format clips are well suited to engage students and provide a hook bringing students into projects that range from process and landform geology to exploring bigger ideas in Earth science such as 'change over time' or 'natural hazards'. The project's next step will be to align the content around core areas of several national curricula. The clips are obviously directly applicable for geography classes, but for the broader sciences—physics, chemistry, and biology—there may be an opportunity to use the Geo-sports content within cross-curricular projects. And to make the content as widely available as possible, the web content is (auto-)translated into nine languages—English, French, German, Italian, Spanish, Danish, Norwegian, Slovenian, and Dutch—and other languages can easily be added. Colleagues and teachers who are interested in thinking along are welcome to contact the team!

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Suggestions for further reading

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