MINE SHIFT: EXAMINING GROUND DISPLACEMENT IMPACT ON MINES AROUND THE WORLD

The Landslide at Anargyroi

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The Amyntaiou Lignite Mine

On Saturday 10 June 2017, the villagers of Anargyroi in northern Greece received the unsettling news instructing them to evacuate their homes.

Many believed it was a temporary measure and they would be returning soon. But just 24-hours later, the decision had been made to demolish every single home.

The extraordinary measure was taken after an estimated 80 million cubic meters of earth from the Amyntaiou lignite mine suddenly shifted and thundered three kilometers into the homes of more than 180 people.

Investigations later identified an enormous tectonic fault running parallel to the provincial road through the Anargyroi community, determining it to be the primary cause.

Despite the speed of events, the signs had been there as early as a week before, with many reporting hearing the tremors below their homes.

What they didn't know was movement had started in May, gaining speed from a rate of 200mm per day to 600mm per day.

Amid growing stability concerns, the mine had been shut down however authorities were fully confident collapse was unlikely.

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When it came, though, it proved the final straw for the residents of Anargyroi, who had long persisted with failing roads, shifting walls in their homesand cracks in their foundations caused by decades of local mining activity.

But such was the devastation in June 2017, all that many could do was to recoup what they could of their belongings and move on.

A once 400-strong community, no longer.

For the mine's owner, Public Power Corporation – Greece's largest electric power company - the impact of the landslide was felt both in the short and long term.

Immediate replacement of equipment totalled €30-40 million, while more than 25 million tons of lignite reserves worth approximately €500 million was also lost.

Population: 400
A strong community

Failing Infrastructure
Caused by decades of local mining activity.

Approx €500 million
25 million tons of lignite reserves lost

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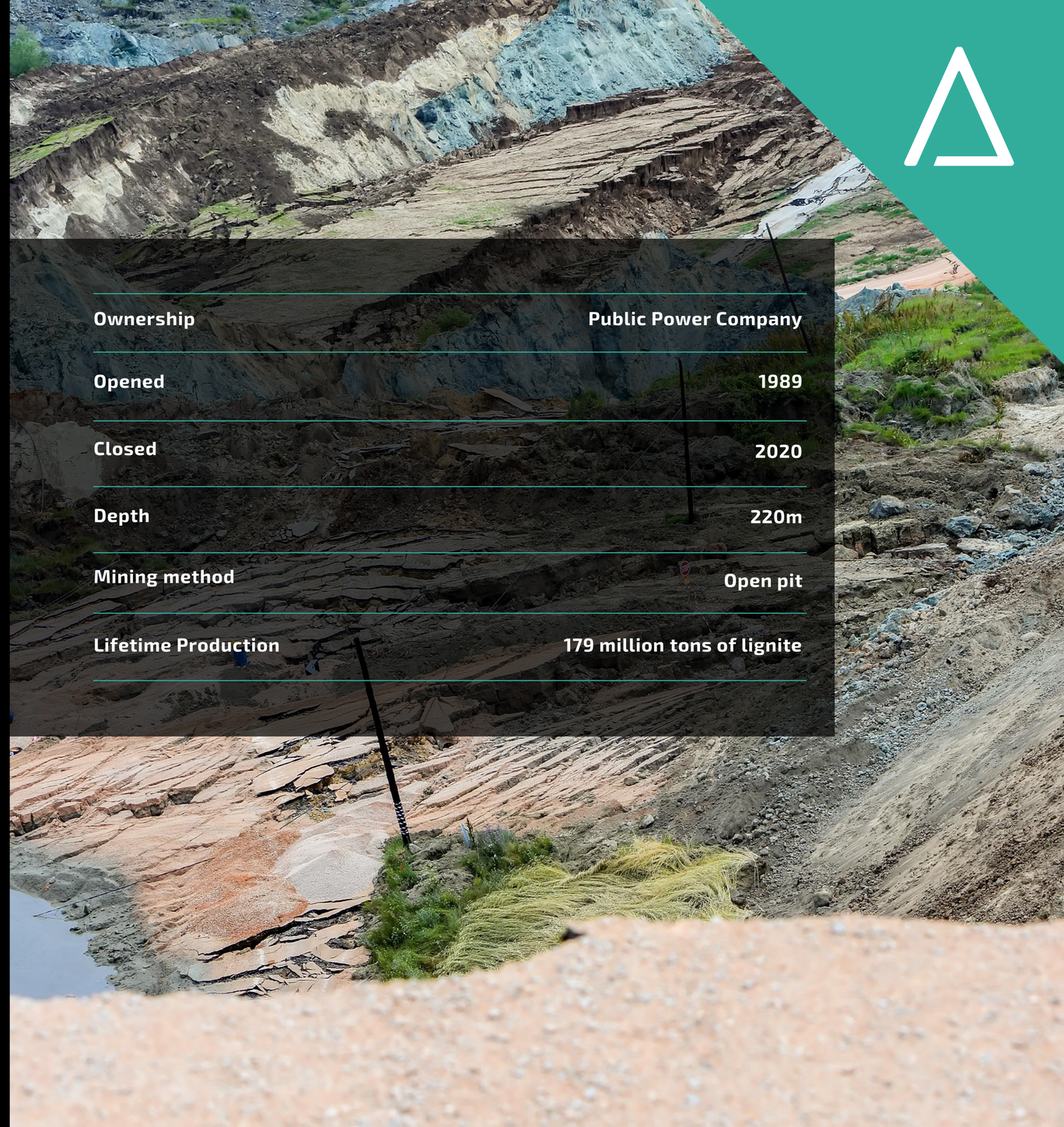
The relocation of the villagers was also required with the costs yet to be disclosed.

What we do know is that, in total, according to PPC's GENOP union president Giorgos Adamidis, the total damage, including the end of operation of the Amyntaio power unit, was expected to exceed €1.5 billion.

Whether it was the human cost, the community cost, business or reputational cost, the impact of the landslide has been enormous.

So, could InSAR have helped? See what our team found out.

Ownership	**Public Power Company**
Opened	**1989**
Closed	**2020**
Depth	**220m**
Mining method	**Open pit**
Lifetime Production	**179 million tons of lignite**



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CATALYST Analysis:

Unlike previous mines we've analysed in this series, the catastrophe at the Amyntaiou lignite mine was a sudden, substantial and devastating shift in the earth beneath the site.

This is in contrast to the longer-term, more incremental effects of ground deformation at sites such as Jaegersfontein.

As a result, the focus of our analysis has been less on leveraging InSAR as an 'always on' monitoring solution, continually tracking tiny changes at the site and instead considered how it can be used to understand risks prior to failure events.

For instance, we work with businesses every day to provide informed insight for investment and acquisition due diligence, as well unearthing significant historical or environmental issues and progressions over time to support more informed decision making and mitigation strategies.

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CATALYST Analysis:

To show it in action, our team used historical satellite imagery of the Amyntaiou area dating back six months before the landslide and combined it with CATALYST InSAR analysis to determine displacement levels across the site. Interestingly, just as the local community had reported, movements were detectable even then.

In fig.1 there's clear evidence of both horizontal (purple) and vertical (red) cumulative displacement visible at both the south westerly and north easterly areas of the mine, which we tracked from 1 January 2017 to 6 March 2017.

The individual displacements recorded may only mm-level movements but are considered 'extreme' due to the size and speed of change. The areas of 'normal' movement have been filtered out of these views to highlight the areas of most concern.

Fig.1 Horizontal Movement - 6 March 2017

Fig.1 Vertical Movement - 6th March 2017

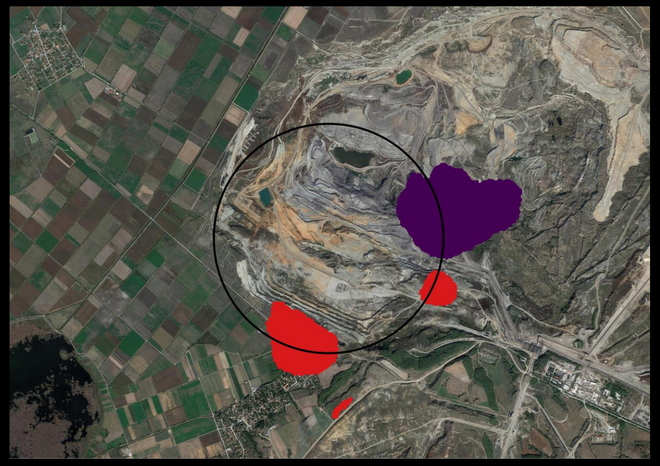


Fig.1 – Combined View - 6th March 2017

CATALYST Analysis:

From this point onwards, the speed of cumulative displacement only increased and, at times, at an alarming rate.

This is what it looked like five weeks later, with increased east to west movements in the north section section of the mine as well as growing vertical movements (movements towards the centre of the earth) in the south west area.

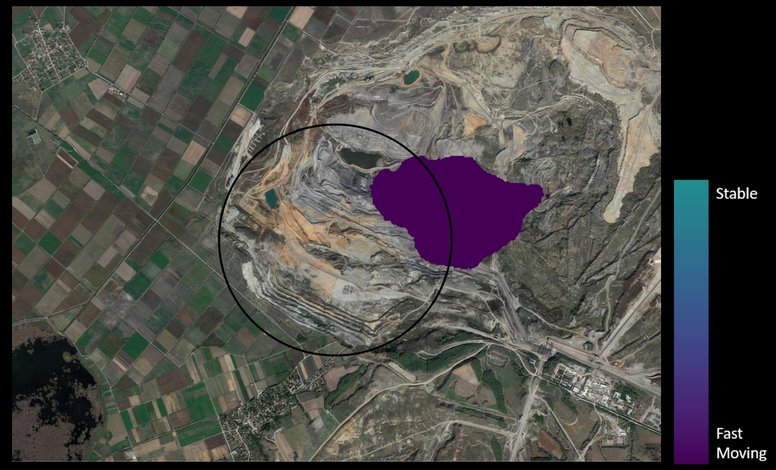


Fig.2 Horizontal Movement - 11th April 2017

Fig.2 Vertical Movement - 11th April 2017

Fig.2 Combined View- 11th April 2017

CATALYST Analysis:

Just weeks out from the event, it's clear how much the rate of displacement increased with each day, with both areas of the mine experiencing significant and sustained movement.

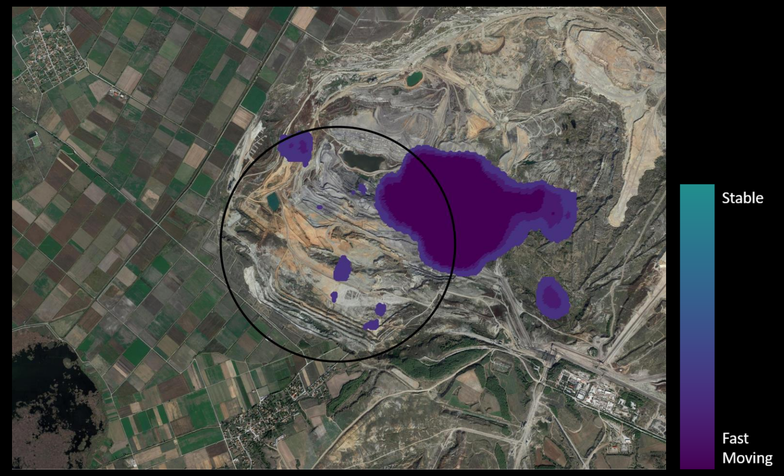


Fig.3 Horizontal Movement - 29th May 2017

Fig.3 Vertical Movement - 29th May 2017

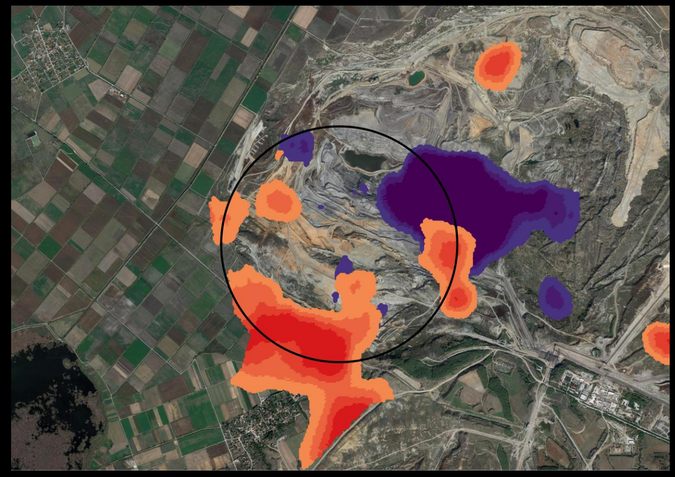


Fig.3 Combined View - 29th May 2017

CATALYST Analysis:

By the date and time of the landslide – 10th June 2017 – it's evident how the level of both the vertical and horizontal has reached significant levels across both the north-east to south-west areas, ultimately leading to the catastrophic shift in earth that eventually crashed through the Anargyroi community.

Each of these moments show the precision monitoring capabilities of CATALYST InSAR in detecting significant historical displacement trends over the course of a sustained build up; in this instance, six months.

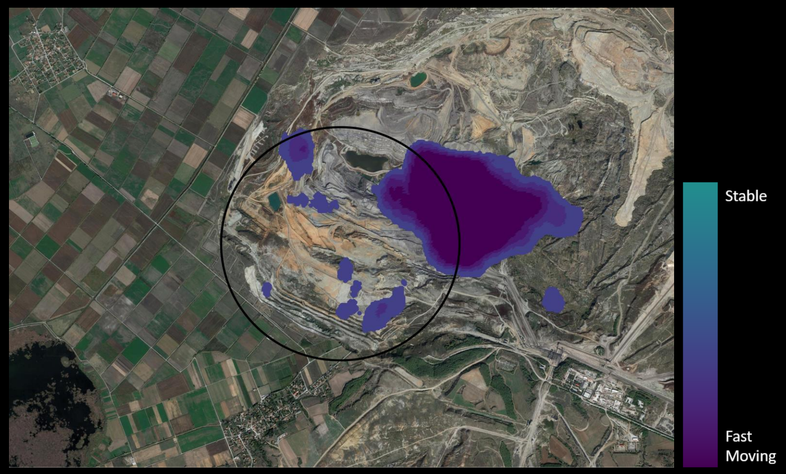


Fig.4 Horizontal Movement - 10th June 2017

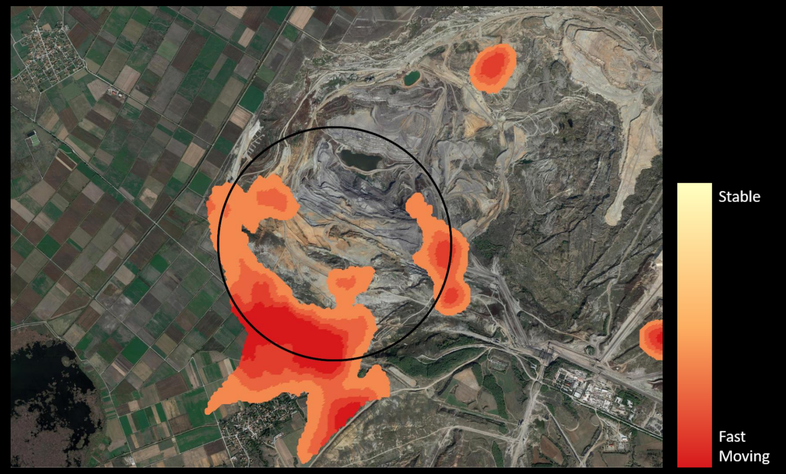


Fig.4 Vertical Movement - 10th June 2017

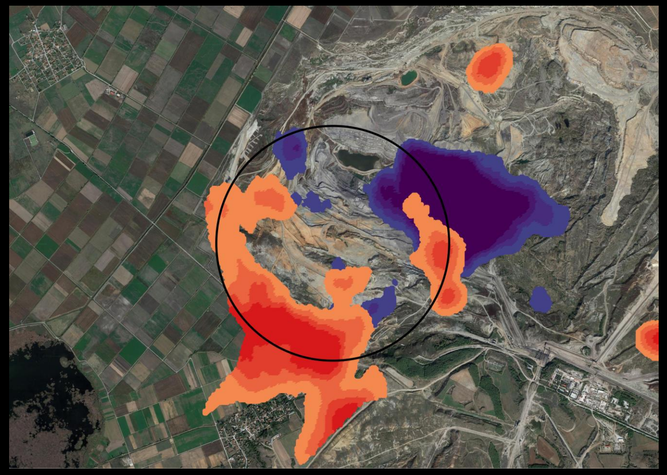


Fig.4 Combined View - 10th June 2017

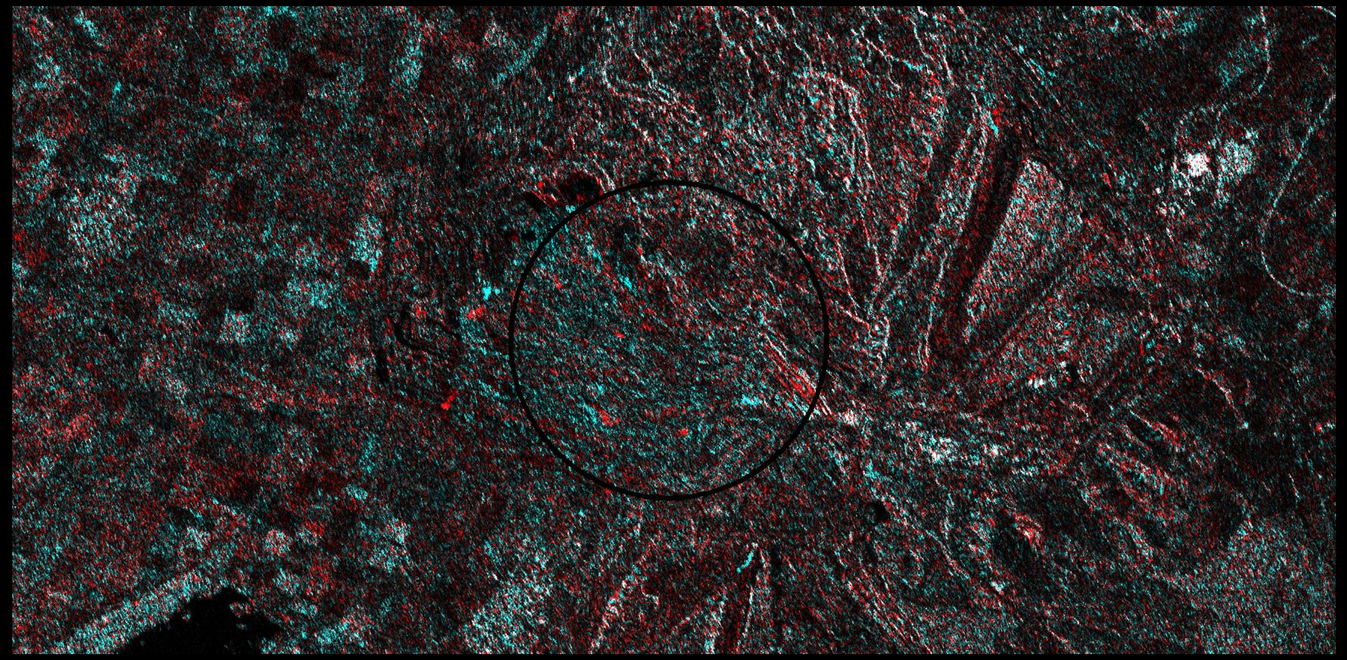
CATALYST Analysis:

As an early warning system, CATALYST InSAR is hugely effective in several ways. Understanding risks prior to failure events means stronger mitigation strategies and more robust emergency response protocols.

It supports clearer, more informed due diligence for businesses seeking to acquire or invest in major sites around the world by offering a chance to uncover potential liabilities.

When events like the one at the Amyntaiou lignite mine occur, it can be used to quickly assess impact, aid faster initial response and support teams to understand the scale and extent of what has happened, in turn supporting crisis communication and public relations approaches to minimise reputational impact, both in the short and long term.

We can do that by using an RGB composite image and analysing backscatter – the electromagnetic energy reflected by terrain or particles in the atmosphere.



In fig. 5, the backscatter is identified by the blue and red markers. Red denotes materials or structures that are no longer present, while the blue markers reflect new material.

The value of this analysis

The intent of our analysis and indeed of earth observation in general, is to highlight how sensitivity to ground changes – long and short term - can be used as an early warning indicator of areas that require more monitoring.

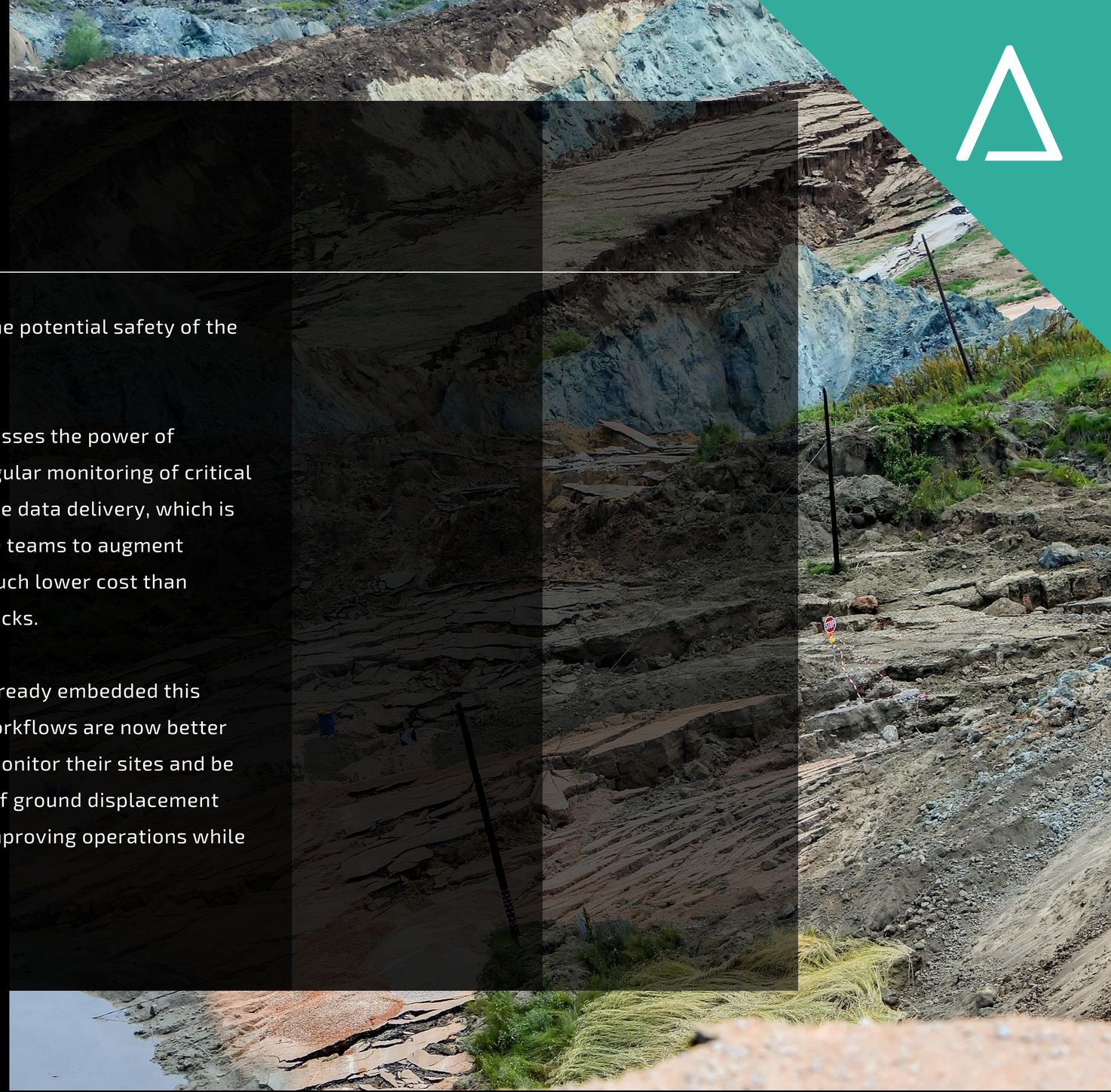
Satellite-based change analysis coupled with in situ ground monitoring equipment and surveying can be used as an effective risk reduction solution.

Significant structural failures, breaches or collapses can occur suddenly and they can have both catastrophic human and economic impact.

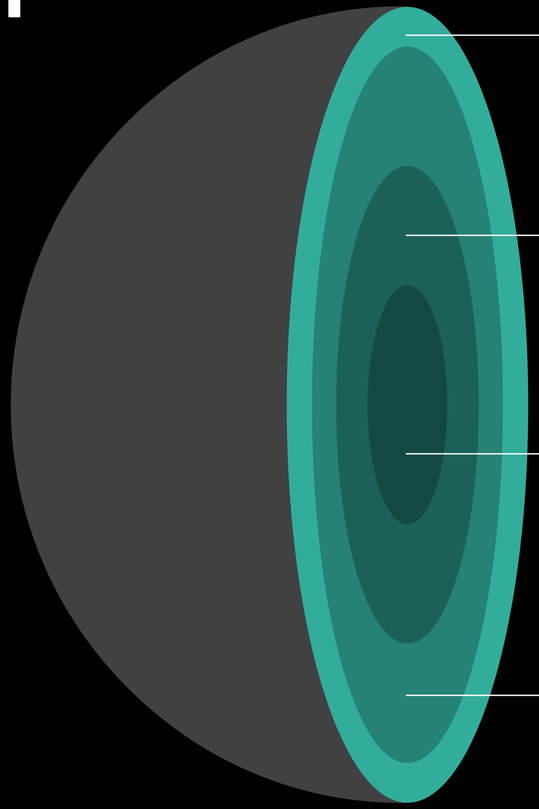
Traditional monitoring, maintenance and risk mitigation strategies play a key role in preventing them, but they have their limitations, including operational costs and the potential safety of the maintenance teams.

Earth observation harnesses the power of satellites to conduct regular monitoring of critical sites, with near-real time data delivery, which is perfect for maintenance teams to augment existing strategies at much lower cost than intermittent manual checks.

Businesses who have already embedded this technology into their workflows are now better equipped than ever to monitor their sites and be alerted to the dangers of ground displacement keeping people safer, improving operations while reducing costs.



Discover what CATALYST can do for you



Earth observation and ground displacement technology is no longer a tool for the specialists.

Thanks to our cloud-based innovations, CATALYST solutions are available to all businesses, teamsand decision makers.

Integrated seamlessly into your workflows without the need for technology upgrades, they can have an immediate transformative impact on your strategies and outcomes.

Discover what they can do for you.
Get in touch with our team today.

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