

IMPROVE

European Training Network



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IMPROVE
Innovative Multi-disciplinary
European Research
training network on VolcanoEs

IMPROVE - Final Conference

Rome, July 2025

IMPROVE: Four Years of Discovery, Growth, and Impact

Last August (2025) the IMPROVE project celebrated the successful conclusion of four years filled with curiosity, exploration, and scientific breakthroughs. Fifteen passionate early-career researchers completed their 36-month fellowships: four have already triumphantly defended their PhDs, while the others are on the verge of achieving this milestone in the coming months.

IMPROVE has already sparked the creation of around 15 influential scientific papers, with many more on the way. A collaborative and stimulating environment was created within the project. At the heart of the project was immersive training: fellows dived into network schools addressed to provide them with background knowledge and understanding, specialised short courses focussing on high level training on selected topics relevant for the fellows' research, digital learning modules in the form of webinars accessible through the IMPROVE channels, large-scale field campaigns that brought the fellows into real action on active volcanoes, a hands-on science-industry workshop exploring the potential for improved relationships, and the lively final IMPROVE conference

where the fellows presented and discussed their individual and team achievements. These activities also welcomed many external students, cultivating a growing, vibrant community of young volcanologists across Europe.

Thanks to the active collaboration with SMEs, fellows gained invaluable exposure to real-world industry challenges and explored a spectrum of career paths. Today, every IMPROVE researcher has either secured, is about to start, or is negotiating exciting new positions with leading institutions and organisations. We are proud and confident that many of them will emerge as the next generation of pioneering European scientists in Solid Earth sciences and volcanology.

Paolo Papale and Raffaella Pignolo

SUMMARY

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The IMPROVE Final Conference



The IMPROVE Final Conference took place on July 16–17, 2025, at the INGV headquarters in Rome. The event brought together all IMPROVE Early-Stage Researchers (ESR), many of their supervisors, external guests, and INGV staff who joined the sessions, fostering a fruitful scientific debate and constructive exchange of ideas.

The INGV President Fabio Florindo opened the meeting with a welcome to all participants, highlighting the importance of IMPROVE in building and strengthening a European network of volcano researchers, while providing advanced training and research opportunities. Additional relevant invitees included Carmela (Lilli) Freda, Executive Director of EPOS-ERIC, the European Solid Earth research infrastructure and an external partner of IMPROVE; Francesca Bianco and Claudio Chiarabba, Directors of INGV's Volcanoes and Earthquake Departments; Stefano Branca, Director of the Mount Etna Observatory; and Björn Þór Guðmundsson, CEO of the KMT-NPO (Krafla Magma Testbed Non-Profit Organization).

The meeting focused on the two IMPROVE target volcanoes: Krafla (Iceland) on day one and Mount Etna (Italy) on day two. The ESRs took center stage at the meeting, enjoying maximum visibility. Each day included only two short 15-minute introductory talks by senior academics and two presentations by industrial partners at the end of the day. The rest of the program featured ESR-led presentations and discussions, with ESRs also acting as section chairs.

Taking advantage of the INGV venue, each after-lunch session began with a short guided tour of key facilities. On the first day, Jacopo Taddeucci, IMPROVE supervisor led a visit to the High Pressure–High Temperature laboratories. On the second day, Lucia Margheriti, Director of the INGV National Earthquake Observatory, guided the participants through the National Seismic Control Room, which operates 24 hours a day, 7 days a week.

Major Outcomes from Day One: Research on Krafla Volcano

The first day focused on Krafla volcano, where nine ESRs presented their research on the underground caldera structure, its thermal and mechanical behavior over time, and the evolution of shallow magma—one presentation also covered the nearby Þeistareykir geothermal area. Overall, the results significantly advance our understanding of the volcanic system and its shallow magma bodies. Despite the challenges posed by the highly heterogeneous caldera structure, combining multiple approaches and inversion techniques has successfully revealed magma batches within the first few kilometers below the surface. Furthermore, advanced modeling of Krafla's cooling and

crystallizing magma shows that solidification can take much longer than previously estimated with simpler models. This helps explain a long-standing puzzle about the longevity and emplacement of shallow magma encountered by drilling at just 2.1 km depth. Additional results from the nine ESRs have greatly improved our understanding of Krafla's underground system, knowledge that is fully shared with the industrial partner Landsvirkjun, which operates the Krafla geothermal power plant, for strategic planning. A late-afternoon presentation by Landsvirkjun highlighted the benefits of academia-industry collaboration, showcasing the work

done at Krafla and the Krafla Magma Testbed initiative, while also discussing challenges and opportunities for even more fruitful cooperation in the future.

Major Outcomes from Day Two: Research on Mount Etna

The second day focused on Mount Etna, where six ESRs presented a wide range of approaches and results. Their work explored the volcano's deformation, from long-term ground changes to short-term volcanic tremors, shallow degassing, and links with seismo-acoustic signals, as well as analogue and numerical studies of structural deformation associated with magmatic movements. Overall, the results confirm that intermediate-frequency ground displacements, from minutes to a day, carry valuable information about magma movements at depth, a region that has been little studied so far. High-frequency seismic signals, unrelated to typical rock fracturing, appear linked to shallow degassing and the volcano's structural response. Meanwhile, ultra-long-period signals, observed in continuous ground tilt measurements, match patterns from numerical simulations, offering new perspectives for studying deep magma dynamics and improving early warning systems.

In a late-afternoon session, the industrial partner West Systems presented a new gas-steam measurement instrument developed within IMPROVE. Designed jointly by INGV and West Systems, with the participation of Landsvirkjun, the instrument can be used for both field measurements and geothermal wellhead monitoring. After further lab tests, it will be deployed at Krafla in 2026, showcasing the benefits of close academia-industry collaboration.



Keep on Learning with IMPROVE

The IMPROVE Digital Training Modules are online and ready to support your learning journey. Designed to cover a broad range of topics, these video lessons provide accessible and valuable resources for students and researchers.

The training content spans a wide spectrum of themes, from technical skills to scientific communication:

- Analogue Modelling in Volcanology
- Geothermal Environments
- Hydrothermal Systems
- How to Change the Cold-Head of a Superconducting Gravimeter?

- How to Write Your First Paper and Get It Published
- Machine Learning Basics
- Mixture Thermodynamics
- Science Communication
- Volcano Geodesy

The modules are freely available on the IMPROVE website and on the IMPROVE YouTube channel (<https://www.youtube.com/channel/UCkylt5mH7MWx7Uk2ToqNMBw>).

Farewell note

After four years and 98 deliverables, IMPROVE has come to its conclusion. It has been a remarkable journey, full of challenges but even more rewarding moments. I am proud to have served this outstanding research and training consortium, and I am deeply grateful to all PIs, Supervisors, and Participants who made IMPROVE possible and successful.

A special thanks goes to the administrative, technical and management team in Pisa – Patrizia Pantani, Pamela Gaini, Massimiliano Cascone, Alessandro Casagli – under the expert coordination of Project Manager Raffaella Pignolo, whose support was invaluable. I am also grateful to Alessandro Fornaciai, and to the many colleagues who contributed with administrative, scientific, and field support.

Above all, this project was for the fifteen young researchers recruited and trained under IMPROVE. They are the future, and on behalf of the whole consortium, I wish them the very best for their careers and personal lives.

Paolo Papale
Coordinator

