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Preface to the volume "Improving geophysics for a better future"

This 25th volume collects a selection of papers presented during the 41st annual national conference of the *Gruppo Nazionale di Geofisica della Terra Solida* (GNGTS) and published in the Bulletin of Geophysics and Oceanography [BGO, formerly *Bollettino di Geofisica Teorica ed Applicata* (BGTA)]. Overall, it summarises the papers presented at the conference, with particular focus on the novelties.

The GNGTS was established in 1978 as an offshoot of the Italian National Research Council (CNR) to promote, develop, and coordinate research in the field of solid Earth geophysics. The GNGTS comprised various sections: seismology, geodesy and gravimetry, geothermal research, crustal geophysics, mining and environmental geophysics, near-surface applications, as well as seismic exploration. In the past years, despite its limited budget, the GNGTS funded several research activities and sponsored multi-disciplinary projects, mainly dedicated to the study of the Earth's crust. About 500 researchers refer to the GNGTS and meet every year for a national conference: a point of reference in the life of Italian geophysics. Although the GNGTS institution was closed in December 2000, the GNGTS annual congress, sponsored by the National Institute of Oceanography and Applied Geophysics (OGS), continues to be held and reached its silver anniversary in 2006.

The GNGTS annual conference, a recurring event for more than 40 years now (Table 1), is the spontaneous meeting point for all researchers who work, even in different roles, in geophysics, seismology, geology, and volcanology, as well as all the scientific branches that collaborate to improve our knowledge of the solid Earth. The participation in the GNGTS congresses has always been plentiful with more than 200 scientists, reaching the number of more than 600 in 1994, 2006, 2007, and 2019, when the conference location was Rome (Fig. 1). The COVID-19 pandemic,

Table 1 - Locations of the annual GNGTS national conferences.

Conference	Year(s)	Location	Local organising institution
1-26	1981-2007	Rome	La Sapienza University, Rome
27-28	2008-2009	Trieste	OGS, Trieste
29	2010	Prato	Istituto Geofisico Toscano, Prato
30	2011	Trieste	OGS, Trieste
31	2012	Potenza	Basilicata University, Potenza
32	2013	Trieste	OGS, Trieste
33	2014	Bologna	Emilia Romagna Region, Bologna
34	2015	Trieste	OGS, Trieste
35	2016	Lecce	CNR, Lecce
36	2017	Trieste	OGS, Trieste
37	2018	Bologna	Emilia Romagna Region, Bologna
38	2019	Roma	CNR, Roma
39	2021	In streaming	OGS, Trieste
40	2022	Trieste	OGS, Trieste
41	2023	Bologna	University of Bologna

which started in Italy in February 2020, interrupted the organisation of the 2020 conference but it was decided not to give up on organising the successful yearly event in the future. For this reason, after the break in 2020, the 39th conference was held in streaming mode. Despite the absence of in-person participation, the 39th national congress still proved to be successful, and was, then, repeated and improved by the following edition organised in Trieste (Fig. 1b). The 41st GNGTS conference was held in Bologna from 7 to 9 February 2023.

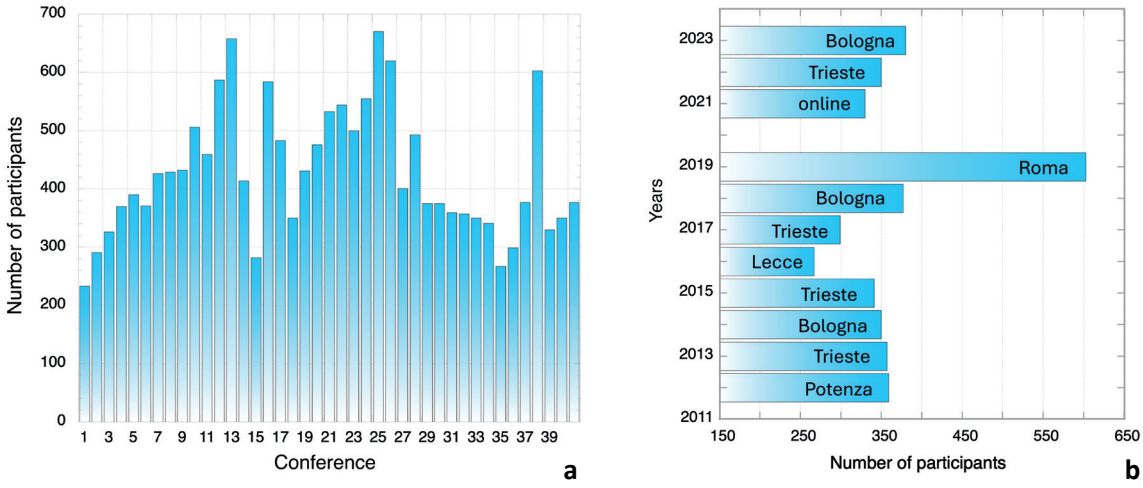

Fig. 1 - Number of participants at the GNGTS conferences: a) from the first to the last (41st) edition; b) in the last editions (2012-2023), with related locations.

The 41st GNGTS conference has brought two important changes. First of all, it was the first time that February was chosen as the conference period. The usual period for the GNGTS congress had always been November, but recently the Researchers' Assembly decided, upon request of the university component of participants, to move the conference to February, during the winter break. In practice, the November dates made it difficult, and for some researchers and university professors impossible, to participate in the conference, given the changes that had occurred in the organisation of the university teaching sessions.

The second innovation, also linked to the choice of the February dates, consisted in the possibility of holding the congress within university structures during the teaching holidays. As a matter of fact, the GNGTS 2023 was held at the Belmeloro campus of the University of Bologna. The venue proved to be excellent, with five rooms available for the conference, two of which were large with more than 200 seats (Figs. 2 and 3). The Belmeloro venue is also close to the historic centre of Bologna, which also facilitated the availability of a sufficient number of hotels to accommodate the participants and an adequate number of local services for the lunch breaks.

Attendance at the conference was also facilitated by the central location of the city of Bologna, a hub for the whole of central and northern Italy. The city is well served by rail, allowing participants from Milan, Florence, Rome and other cities to easily reach the congress.

The total number of participants was 377 (Fig. 1b) and the percentage of women at the conference was 37%.

The 41st conference was characterised by three innovative aspects in the field of logistics.

Firstly, plastic water bottles were not distributed, but, instead, all participants were asked to bring their own in order to reduce environmental impact. The use of paper was kept to a

Fig. 2 - A conference room at the Belmeloro campus of the University of Bologna during the GNGTS congress.

Fig. 3 - Nicola Casagli, OGS president, and Alessandro Rebez, GNGTS president, during the GNGTS Researchers' Assembly.

minimum, and no conference programme was printed but was made available on the GNGTS website, accessible via computer or smartphone. At the end of the congress, all lanyards were collected for future use the next year after being cleaned.

The second innovation was a new, efficient, and modern website where all the information, before and during the conference, was available. The website was also used as a repository for detailed summaries.

The third innovation was the conversion of all official information and summaries into English. This should facilitate the understanding and participation of foreign researchers and students.

The 41st GNGTS conference was organised considering three main topics, each collecting three different subjects, scheduled as nine sessions (Table 2). The first topic referred to basic geodynamics and seismology, the second to risk assessments, and the third to applied geophysics. The number of communications, presented orally or as poster, at the different sessions was in total 242, differing according to the relevance of the subjects treated (Fig. 4): earthquakes and related geology were (as also in the past) largely the theme of most interest with more than 70

notes, the session on preparation and preparedness was the most populated of Topic 2, with more than 40 notes, while near surface geophysics had the largest participation in Topic 3, with more than 20 notes.

Table 2 - Topics of the 41st GNGTS national conference and titles of the sessions.

Topic 1 - SEISMICITY, VOLCANOES, DATA AND MODELS		
Session 1.1	Recent advances in the study of earthquakes, seismogenic structures and capable faults	Convenors: Paolo Galli, Claudia Piromallo, Luisa Valoroso
Session 1.2	Volcanoes and geothermal fields	Convenors: Anna Maria Marotta, Carla Braitenberg, Barbara Orecchio
Session 1.3	Physical models for the solid Earth and integration between modelling and data of different nature	Convenors: Daniela Di Bucci, Dario Albarello, Bruno Pace
Topic 2 - DISASTER RISK ANALYSIS AND REDUCTION		
Session 2.1	Towards new approaches to estimate earthquake and tsunami hazard: data and procedures	Convenors: Daniela Di Bucci, Dario Albarello, Bruno Pace
Session 2.2	Science and technology to support earthquake prevention and preparedness	Convenors: Mauro Dolce, Francesca Pacor, Maria Polese
Session 2.3	Risk communication	Convenors: Serena Tagliacozzo, Valentina Rizzoli
Topic 3 - APPLICATIONS: ENERGY, ENVIRONMENT, TECHNOLOGIES		
Session 3.1	Energy transition and resources	Convenors: Michela Giustiniani, Paolo Mazzucchelli, Vincenzo Lipari
Session 3.2	Near surface geophysics	Convenors: Emanuele Forte, Michele Cercato, Cesare Comina
Session 3.3	Theoretical and methodological development in geophysics	Convenors: Andrea Tognarelli, Nicola Bienati, Gianluca Gola

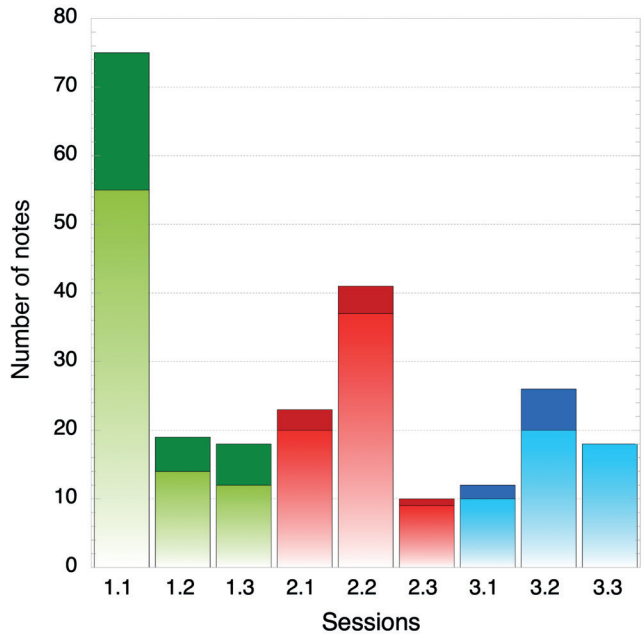

Fig. 4 – Number of notes of the 41st GNGTS conference in the different sessions. The main topics and session titles are listed in Table 2. The darker part of the bars indicates the number of posters.

Peer-reviewed proceedings of the national conferences have been published in special volumes and on CD-ROMs, mainly in Italian, since 1997. These documents are also available at the GNGTS website: https://gngts.ogs.it. Since the year 2000, with the exceptions of years from 2012 to 2015, when the volumes of the proceedings of the congress were printed, it was decided to publish selected papers from the GNGTS conferences in an international geophysical journal (the BGTA, now BGO) also in order to achieve a broader dissemination of the GNGTS activities for an international audience.

Over the years, multidisciplinary and single-theme volumes have been issued (Table 3). The multidisciplinary volumes, which make up most of the published volumes, generally presented one paper from each of the sessions of the GNGTS conference. In this case, all three broad themes, i.e. geodynamics, seismic characterisation of the territory, and applied geophysics, have been documented by a set of papers. Conversely, the five thematic issues published to this day, presented papers from a single GNGTS session that was of particular interest in the year of presentation. In this way, one BGTA volume was dedicated to the 2009 L'Aquila earthquake (Amato *et al.*, 2011), another to the GNGTS session concerning earthquake forecasting and hazard assessment (Albarello and Meletti, 2012), a third to the international session on the seismic hazard of the critical facilities (Grimaz and Slejko, 2014), a fourth referred to the session about science, technology, and communication to support seismic prevention (Dolce and Martelli, 2019), and a fifth focused on energy, related risks, and cascade effects (Martelli and Masi, 2021). A summary of the GNGTS structure and activities is described in a recent paper by Slejko (2020).

The present volume consists of nine of the 242 papers presented, orally or as posters, during the 41st GNGTS national conference. The topics treated in this volume include almost all the subjects of the congress and cover several themes of solid Earth geophysics, such as seismology, exploration geophysics, and engineering seismology. These topics present specific studies conducted in the Italian territory that also give important insights into the subsurface geological/geophysical structure and on the role of surficial geology in seismic risk assessment.

Volcanic regions can be characterised by different unrest phenomena and secondary volcanism. In the case of the Campi Flegrei caldera, recent literature suggests that thermo-poro-elastic (TPE) inclusion models are suitable to describe both the observed deformation and seismicity that often accompany its unrest episodes. In the first paper of this volume, Benussi *et al*. (2024) demonstrate how to estimate the minimum number of elements to represent both displacement and stress fields caused by cylindrical TPE inclusions with an arbitrary aspect-ratio (thickness over radius).

In the second papers of this volume, seismic signals generated by mud volcanoes are used by Brindisi *et al*. (2024) to monitor gas emission. To this end, a seismic array of vertical geophones and three-directional velocimeters have been deployed close to major emission cones in the Nirano mud volcano area, in the northern Apennines. A detailed analysis of the resulting time series has been performed both in time and spectral domains, revealing the existence of three distinct kinds of signals: background noise, paroxysmal phases (drumbeats), and regular sequences of identical pulses (drumrolls). These seismic signals could be related to the mechanical interaction of shallow solid conduits with a two-phase (mud and gas) slug flow from depth, which is characterised by irregularly spaced long bubbles (drumbeats), alternated with trains of small bubbles (drumrolls).

The paper by Caracciolo (2024) is divided into two parts: the first presents a summary of the history of macroseismic collection data in Italy, from an initial experience in the mid-19th century, to the beginning of the use of macroseismic postcards and their evolution in the first decades of the 20th century; the second part analyses a number of specific aspects of the content of

Table 3 - The special issues of the BGTA dedicated to selected papers from the GNGTS conferences.

No.	Conference- year	Editor(s) (year)	Title	BGTA vol./issue
1	19-2000	Slejko (2002a)	Advances in solid Earth geophysics	43/1-2
2	20-2001	Slejko (2002b)	More about solid Earth geophysics	43/3-4
3	21-2002	Marcellini *et al.* (2004)	More about regional and local seismic hazard in Italy	45/4
4	22-2003	Slejko and Rebez (2005)	A step forward in solid Earth geophysics	46/2-3
5	23-2004	Slejko and Rebez (2006)	New insights into solid Earth geophysics	47/1-2
6	24-2005	Slejko (2007)	Solid Earth geophysics: a bit of this and a bit of that	48/2
7	25-2006	Slejko (2008)	Carlo Morelli's mission and passion: geophysics	49/2
8	26-2007	Slejko (2009)	Pieces of geophysics	50/2
9	27-2008	Slejko (2010)	Novelties in geophysics	51/2-3
10	28-2009	Albarello and Slejko (2011a)	Geophysical research in Italy	52/2
11	28–2009	Amato *et al.* (2011)	The 2009 L'Aquila earthquake: geophysical insights from the 28th GNGTS Congress	52/3
12	28-2009	Albarello and Slejko (2011b)	Geophysics for prospecting, monitoring, and hazard assessment	52/4
13	28-2009	Albarello and Meletti (2012)	Earthquake forecasting and hazard assessment	53/1
14	29-2010	Cardarelli and Slejko (2012)	A little bit of Geophysics	53/3
15	29-2010	Rossi and Slejko (2012)	The Earth, its phenomena, and some related methods	53/4
16	30-2011	Grimaz and Slejko (2014)	Geophysics and critical facilities	55/1
17	35-2016	Persico and Slejko (2017)	Recent multi-topic geophysical investigations	58/4
18	36-2017	Dolce and Martelli (2019)	Science, technology and communication to support seismic prevention	60/2
19	36-2017	Rossi and Slejko (2020)	Geophysical solutions in environmental and natural hazard fields	61/1
20	37-2018	Volpi and Slejko (2020)	Geophysical approaches for subsurface investigation: Italian case studies	61/3
21	37/38- 2018/2019	Martelli and Masi (2021)	Energy, related risks and cascade effects	62/2
22	38-2019	Rebez and Slejko (2021)	One small step to further our knowledge of the solid Earth	62/4
23	39-2021	Rebez and Slejko (2022)	Italian geophysics today	63/4
24	40-2022	Rebez and Slejko (2023)	Exploring the solid Earth: novel geophysics and seismology	64/4

macroseismic postcards. Both the historical and analytical parts of the paper, aim to improve the comprehension of the sources and, consequently, the knowledge on Italian seismicity.

The infrastructure sector is paying increasing attention to sustainability. In particular, certain events have proven how preventive local interventions can save both user lives and the same infrastructures, thus highlighting the importance of maintenance. The ineffectiveness of concrete repairs is one of the main issues in civil engineering. The study by Borghese *et al*. (2024) investigates a potential strategy to improve the sustainability of infrastructure restoration solutions by a simplified examination of CO_2 emissions, intervention costs, social factors, structural performances, and other factors considered relevant for this research.

As safety and resilience of learning facilities are critical issues in disaster-prone areas, the study by Grimaz and Malisan (2024) presents the SPRINT-Lab researchers at the University of Udine, under the UNESCO umbrella, finalised to the development of the Visual Inspections for defining Safety Upgrading Strategies (VISUS) methodology. VISUS consists of visual inspections of school facilities, with the aim of providing decision-makers with evidence-based recommendations for upgrading safety and resilience in learning environments. The Grimaz and Malisan (2024) paper summarises the key features of the VISUS methodology and illustrates the progression of its application in the last decade, achieved through its implementation in pilot projects promoted by the UNESCO Unit on Disaster Risk Reduction.

Considering that non-destructive monitoring methods are crucial for the management and maintenance of assets, which include reinforced concrete (RC) structures, and that steel reinforcing bar (rebar) corrosion is one of the main causes of deterioration of engineered reinforced structures as it decreases their strength and serviceability, Fornasari *et al*. (2024), in their study here reported, use non-destructive geophysical techniques to detect and monitor rebar corrosion phenomena. To achieve this, several laboratory tests were performed on RC samples partially immersed in a water solution containing 5% of sodium chloride.

The seventh paper of the present volume is authored by Gutgesell and Forte (2024) and reanalyses and reinterprets the GPR data set collected in 2018 on the Von Postbreen polythermal glacier, in the Tempelfjorden region of the Svalbard Islands. Different ground penetrating radar attributes were exploited as tools for the detection of peculiar patterns and inapparent glaciological facies in typical reflection amplitude data. Spectral attributes, such as dominant frequency, instantaneous phase and sweetness, were specifically calculated. In addition, some texture attributes, like chaos and entropy, were integrated with the previous ones, so as to enable the detection of a peculiar anomalous zone, related to local temperature variations.

Distributed Acoustic Sensing (DAS) technology repurposes fibre optic cables into seismic arrays, offering unprecedented dense strain/strain-rate measurements. To understand some particular features of the DAS technology (such as signal axial polarisation, coupling inhomogeneities or sensitivity to site conditions) that can affect seismic phase amplitudes and their coherence, potentially reducing the number of useful measurement points, the study by Bozzi *et al*. (2024) analyses 'real data' from various seismic events recorded by shallow-horizontal DAS deployments. The results suggest the importance of avoiding 'blind' usage of shallow-horizontal DAS arrays and emphasise the need for case-dependent data selection/weighting procedures.

Imaging of the first metres of the subsurface with seismic methods constitutes a key challenge for several applications. In this context, the analysis of Rayleigh waves can reveal information about the S-wave velocity structure in the first metres of the subsurface. A full-waveform inversion of surface waves has been implemented, offering the possibility to exploit the complete information content of the recorded seismograms. The last paper of this volume, authored by Berti *et al*. (2024), presents a gradient-based Markov chain Monte Carlo elastic full-waveform inversion method, where posterior sampling is accelerated by compressing data and model spaces through the discrete cosine transform, and, also, by defining a proposal that is a local, Gaussian approximation of the target posterior probability density.

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