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Editorial

40 Years Later: New Perspectives on the 23 November 1980, Ms 6.9, Irpinia-Lucania Earthquake

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After more than forty years since the 1980 Irpinia-Lucania earthquake, with this Special Issue "The 23 November 1980 Irpinia-Lucania, Southern Italy Earthquake: Insights and Reviews 40 Years Later" we revisit this milestone geological and seismological event, bringing together the latest views and news on this earthquake, with the aim of improving the dissemination of wide-ranging information on this remarkable case history.

This earthquake struck Irpinia-Lucania region (Lucania is also called Basilicata; Southern Italy) on 23 November 1980 (Ms 6.9, Io X MCS) [1,2], and it is remembered in Italy not only for being the strongest earthquake recorded in the last 100 years causing devastation of entire regions and severe loss of human life, but also for the destruction of the cultural heritage in the epicentral area.

It was felt throughout Italy, from Sicily in the South, to Emilia Romagna and Liguria in the North (Figure 1) causing damage in over 800 localities spread in the regions of Campania and Basilicata with a total of 75,000 houses destroyed and 275,000 seriously damaged. The number of victims was about 3000, with 10,000 injured people [1–8].

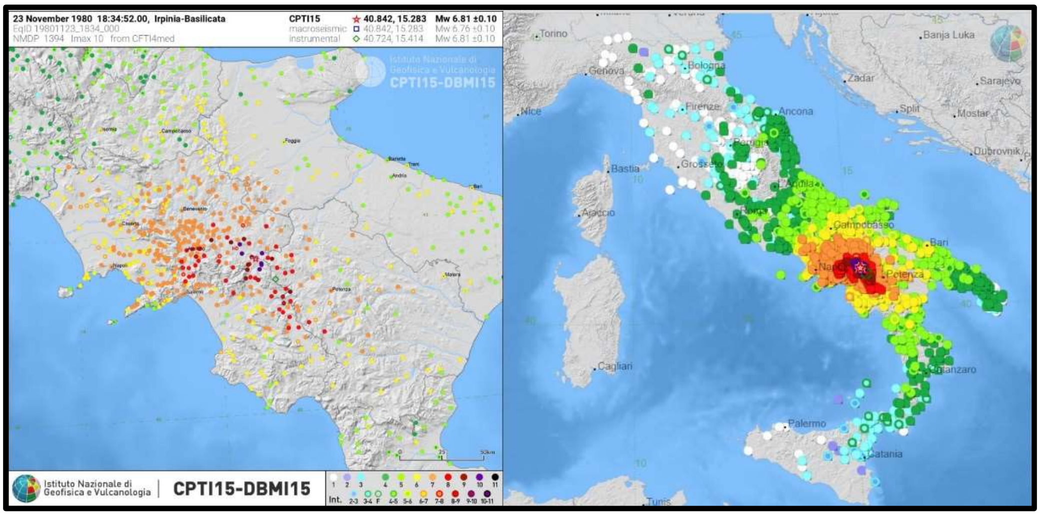

Figure 1. Intensity felt reports of the Irpinia-Basilicata 23 November 1980 earthquake (modified by CPTI15 [2]).

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The earthquake also caused several striking effects on the natural environment, including extensive coseismic surface faulting which is still visible today (Figures 2 and 3), and was mapped in the following years for a total length of about 40 km [9–19].

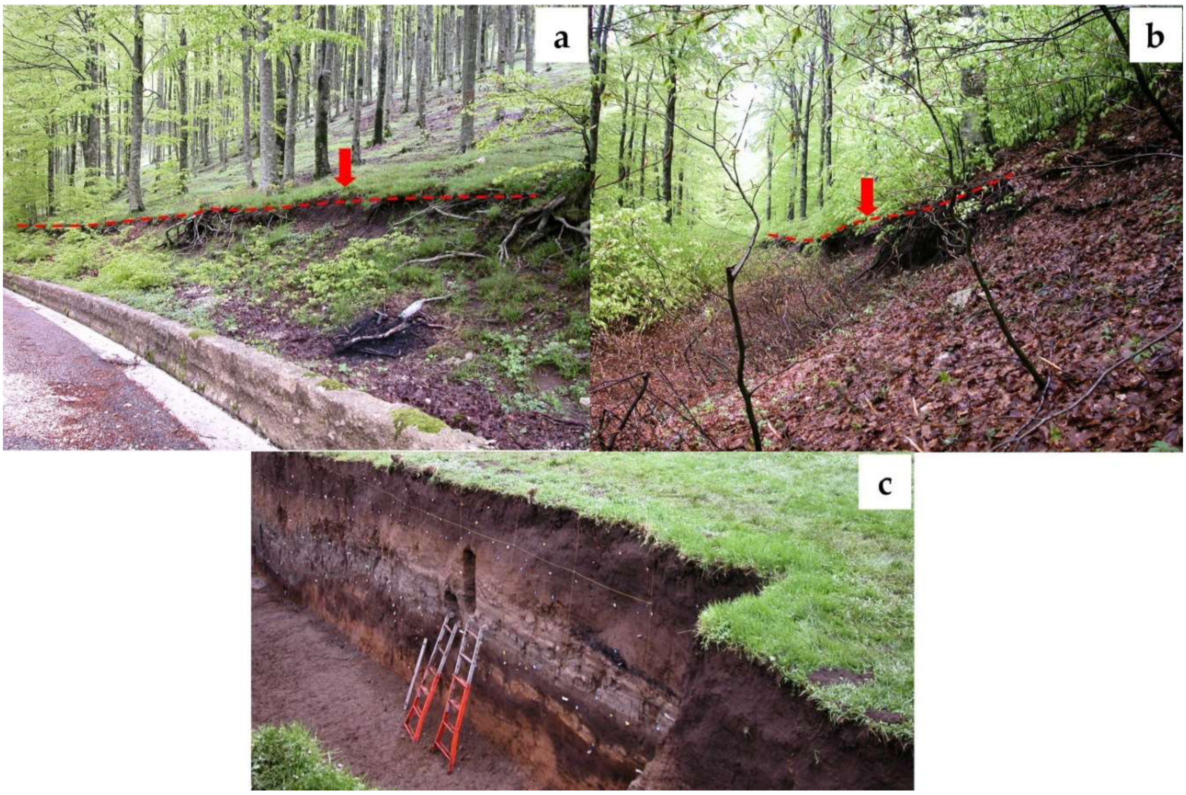

Figure 2. The photos (**a**,**b**), taken in 2004, show the coseismic 1980 fault scarps along M.te Carpineta; the photo (**c**) shows a paleoseismological trench wall along the Piano di Pecore plain (Photos by Rosa Nappi).

Figure 3. The coseismic 1980 fault scarp along M.te Carpineta, 40 years later (Photos by Giuliana Alessio, October 2020).

Moreover, over 200 landslides occurred [20–24]; also, widespread soil fracturing was observed, and minor liquefaction effects [25,26]. Wide changes in water flow rate in some regional karst springs [27,28] were reported. In that extremely dramatic context for Italy, the national scientific community played an important role, through the Geodynamic Finalized Project of the National Research Council ("Progetto Finalizzato Geodinamica", PFG-CNR), that involved in the field many researchers, from different universities and research institutes, contributing to collect instrumental data, macroseismic surveys (Figures 4 and 5), geological fieldwork and mapping (Figures 6 and 7), and seismic engineering analyses, indispensable for the knowledge of the 1980 earthquake and for implementing a proper risk mitigation strategy [1,28–36].


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PROGETTO FINALIZZATO GEODINAMICA

IL TERREMOTO DEL 23-11-1980
RILIEVO MACROSISMICO
STATO DI AVANZAMENTO AL 27-1-1981

CONVEGNO STRAORDINARIO
DEL PROGETTO FINALIZZATO GEODINAMICA

Roma 27-28 Gennaio 1981

Figure 4. First macroseismic study published about two months after the 23 November 1980, earthquake (January 1981), showing preliminary intensity assessment by PFG researchers [29].

In particular, during the emergency activity for urban reconstruction, preliminary seismic microzonation studies were carried out in collaboration with the Tuscany and Emilia-Romagna regions, involving 39 towns in the epicentral area of Campania and Basilicata, with the objective of providing technical maps, on a scale of 1:5000, with indications of areas with different geological characteristics and the most suitable areas for reconstruction [35]. Other two important publications edited by the CNR- PFG in the field of seismology were certainly the Atlas of Isoseismal maps of Italian Earthquakes, and the first modern Italian Seismic Catalogue (Figure 8) [1,36].

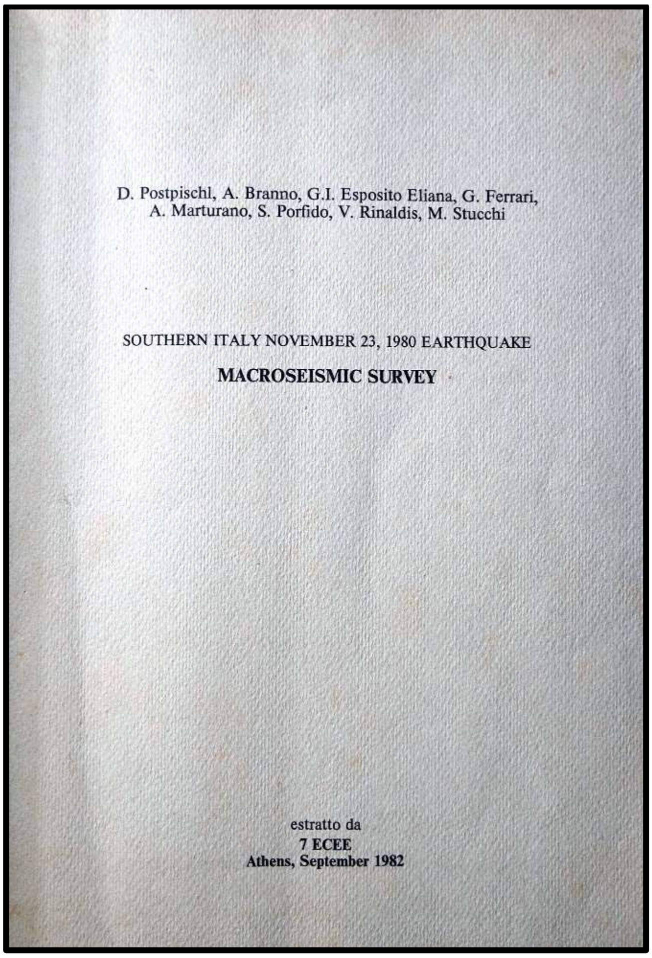

Figure 5. Macroseismic survey of the 23 November 1980 earthquake presented at the 7ECEE conference in Athens in 1982 [3].

The Irpinia-Lucania 1980 earthquake is still considered a crucial seismic event for the study of seismicity in Italy and abroad, and for the development of modern seismology, Quaternary geology and active tectonic studies, also including the emerging methodology of paleoseismology in Europe (Figure 2).

The recognition of the primary surface faulting due to the 1980 seismic event, and of its extent, was not obvious at all, for the limited technological tools, difficult environmental conditions and doubts of the scientific community; it required several months of field work by various researchers, and was firstly properly interpreted in 1984 by Rob Westaway and James Jackson [12] near Piano di Pecore, where a ca. 1 m high fault scarp was observed and mapped [11], then detected in the following months and in the neighbouring areas for over 40 km [12–17].

Paleoseismological studies, based on the excavation of trenches across the coseismic fault scarps detected on the surface, began in Italy only ten years later [15]. Thanks to these studies it has been possible to reconstruct the seismic history of the 1980 seismogenic fault, through the recognition of past earthquakes (historic and prehistoric) detectable by the faulted geological strata and the relative dating.

Forty years after the earthquake and with the introduction of modern scientific knowledge, it becomes important and fundamental to reconsider the many relevant and still open research lines that have been triggered by the Irpinia-Lucania earthquake.

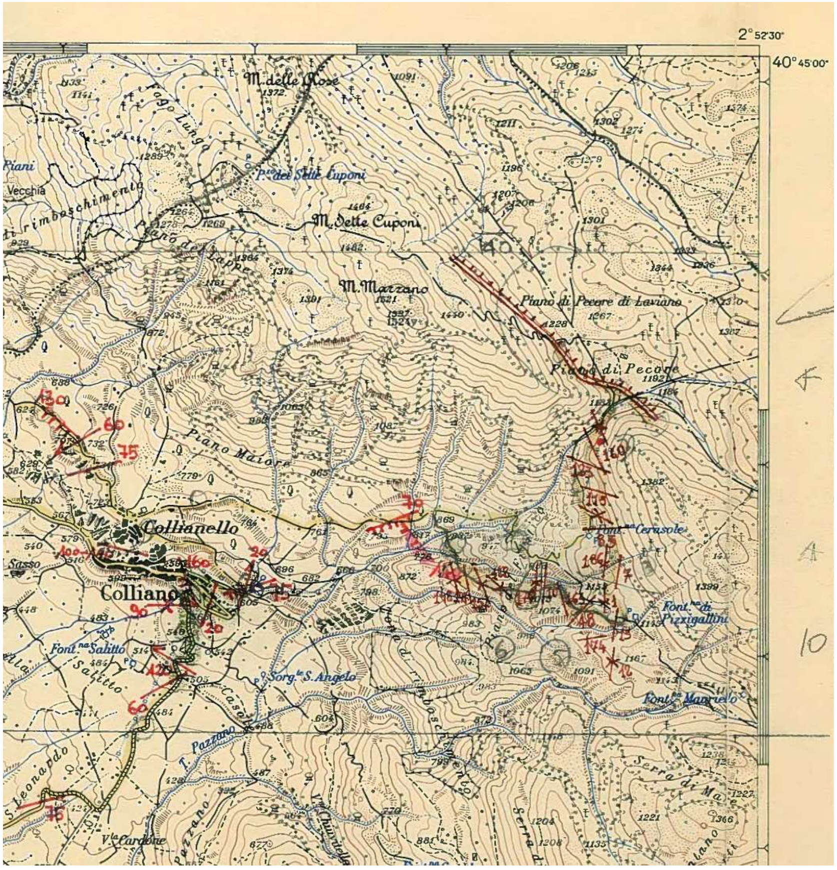

Figure 6. Detail of the original 1:25,000 scale topographical map with the most important geological effects surveyed by Italian geologists immediately after the earthquake of 23 November 1980 (fractures, landslides, faults by Carmignani et al., 1981 [11], see also Supplementary Materials S1) right top corner, trace of the most relevant primary earthquake ruptures located at Piano di Pecore on Monte Marzano (see also Figure 2c; courtesy of Paolo Scandone, PFG).

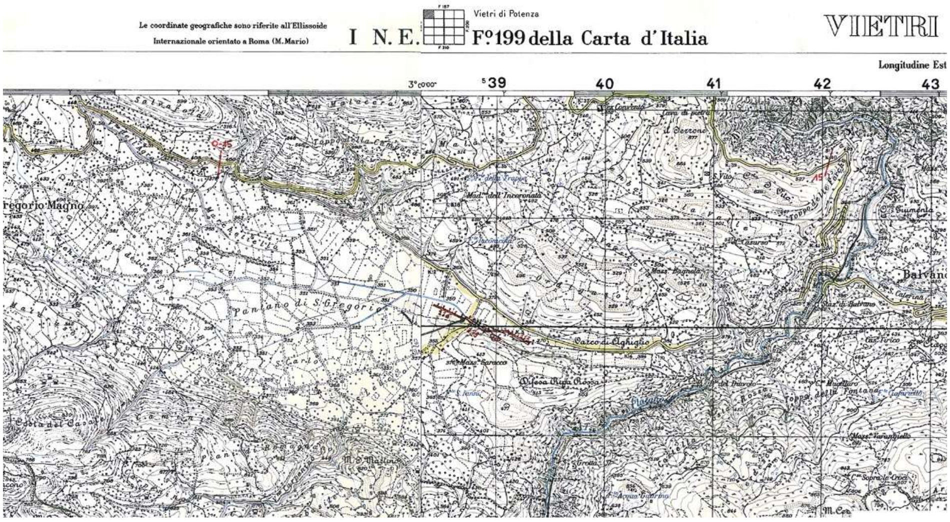

Figure 7. Detail of the original 1:25,000 scale topographical map with the most important geological effects surveyed by Italian geologists immediately after the earthquake of 23 November 1980 (fractures, landslides, faults by Carmignani et al., 1981 [11], see also Supplementary Materials S1); note the trace of the most relevant primary earthquake ruptures located at Pantano di San Gregorio (courtesy of Paolo Scandone, PFG).

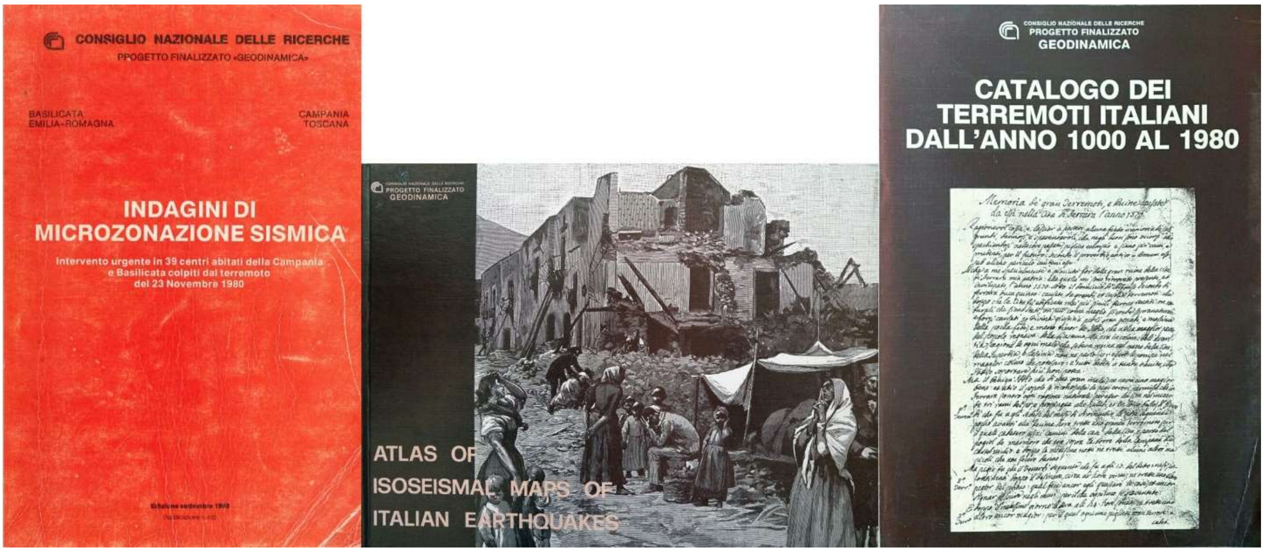

Figure 8. Some of the most important CNR-PFG publications; left, the volume of preliminary seismic microzonation studies for 39 locations severely affected by the 1980 earthquake [35]; center, the atlas collecting the isoseismal maps of the most important Italian earthquakes (1985, [36]); right, the catalogue of Italian earthquake from 1000 to 1980 of the CNR-PFG [37].

The Special Issue "The 23 November 1980 Irpinia-Lucania, Southern Italy Earthquake: Insights and Reviews 40 Years Later" contains 13 articles proposed by 44 researchers with different expertise, with a multidisciplinary approach that highlights the most important aspects of the earthquake from a seismological and geological point of view, without neglecting the reconstruction of cultural heritage, the resilience of the population, and the socioeconomic development of the internal areas of the Southern Apennines after the earthquake. No doubt, lessons learned from the Irpinia-Lucania event are relevant at the local level, for the whole Mediterranean region, and in similar seismotectonic and cultural environments around the world.

The volume is organised in five virtual sections in which the authors deal different features about the 1980 Irpinia earthquake: the historical-scientific framework, the geological and seismotectonic setting, the seismological framework, examples of applied geophysics, post-earthquake and resilience aspects.

The historical-scientific framework is represented by the papers of Lombardi [38] and Gizzi and Potenza [8]. The first paper introduces the "earthquake" topic by highlighting the far-reaching significance of this calamitous event not only in the social history of our country, but also and above all in the context of the various disciplines, from the scientific to the humanistic ones, giving a critical review of the academic debate that still exists today. According to the Author, this socio-historical vision can also support the demand for knowledge and risk mitigation coming from citizens and communities living in seismic areas, focusing on attention to social memory and awareness of seismic risk and natural risks.

The second paper by Gizzi and Potenza [8] can be rightly considered a milestone on the topic because it analyses about 640 papers with a tailored methodological approach, international and national (Italian) studies initiated and advanced since the earthquake occurred. They built and analyzed statistically two bibliographic databanks regarding the earthquake studies: (a) the international version of Irpinia Bibliographic database (IR_BASE_ENG), selecting and standardizing the pertinent scientific documents extracted from Scopus, Web of Science, and other databases and (b) the national version of the database (IR_BASE_IT) using the Google Scholar search engine to search for the most relevant papers in Italian. The review provides a rich and useful bibliography (123 papers) that includes studies on seismic source, environmental effects, seismic damage, seismic microzonation, disaster response and recovery, disaster epidemiology, ground motion estimates, and other research. The results of their research confirm that the 1980 Irpinia-Lucania earthquake was a significant occasion for the scientific community to expand the knowledge on the seismic phenomena, as well as to learn lessons in view of setting up preventive actions to mitigate the seismic risk.

The section about geological and seismotectonic setting includes papers by Ascione et al. [39], Matano et al. [19], and Galli [18]. Three papers that provide a broad overview of new insights not only into the detailed geology and geomorphology of the area but also into the seismotectonic interpretation and post seismic deformation of the epicentral area through different methodologies: the analysis of PS-InSAR data, new stratigraphic, petrographic, structural data, paleoseismological and archaeoseismological evidence. In detail, Ascione et al. [39], analyzed eighteen years of PS-InSAR data after the earthquake, showing that in the past decades soil deformation has affected the 1980 earthquake epicentral area. The analysis showed that cumulative deformation is consistent with coseismic deformation inferred from both seismological data (rupture mechanisms of the three main shocks which occurred in a 40 s timespan), levelling data and coseismic surface faulting. It is also consistent with evidence of Late Quaternary active faults at the surface. The Authors identify continuing uplift of the footwall and subsidence of the hanging wall blocks of the two major faults activated by the 23 November earthquake; they also show that the region in the mid part between the main seismic structures is currently affected by slow uplift. Moreover, the results of PS-InSAR data show that postseismic deformation is still occurring 30 years after the earthquake.

Matano et al. [19] collected geological data from the studies for the excavation works of the Pavoncelli bis hydraulic tunnel, developing between Caposele and Conza della Campania, highly damaged during the 1980 earthquake and described the geology of the epicentral area of the 1980 earthquake with new stratigraphic, petrographic and structural data. Through a multi-disciplinary and updated datasets the Authors have achieved (1) new insights on the tectono-stratigraphic evolution and stratigraphic architecture of the southern Apennines foreland and basin system, as well as on the structural and stratigraphic relations of Apennines tectonic units (2) the timing of their kinematic evolution, (3) a better understanding of the relationships between internal and external basin units within the Apennine thrust belt and its tectonic evolution.

Galli [18] in his paper deals with both paleoseismological clues from the Monte Marzano Fault System (the structure responsible for the catastrophic, Ms 6.9, 1980 earthquake) and archaeoseismological evidence of settlements founded in its surroundings, in order to cast light on two poorly known earthquakes that occurred at the onset and at the end of the first millennium CE, likely in 62 and in 989 CE. The Author tried to demonstrate that both earthquakes should share the same seismogenic structure and the same power as the 1980 seismic event.

With regard to the seismological section, the papers presented by Festa et al. [40] and Piombino et al. [41] starting from the 1980 event, give precise information on the current seismicity. Festa et al. [40], provided detailed location and characterization of events of the 3–7 July 2020 Irpinia sequence (southern Italy) that occurred at the northern tip of the main segment that ruptured during the 1980 Irpinia earthquake. Using an autocorrelation technique, they detected more than 340 events within the sequence, with local magnitude ranging between 0.5 and 3.0. The Authors provided double difference locations, source parameter estimation, and focal mechanisms determination for the best quality events and found that the sequence ruptured an asperity with a size of about 800 m, along a fault structure having a strike compatible with one of the main segments of the 1980 Irpinia earthquake fault system, and a dip of 50–55 at depth of 10.5–12 km and 60–65 at shallower depths (7.5–9 km).

Piombino et al. [41] merged historical records of seismicity with new satellite techniques to allow for the precise determination of ground movements, and then derived physical dimensions, such as strain rate. In this way, the Authors verified that in Irpinia, the occurrence of new strong shocks forty years after the 1980 event (one of the strongest known seismic events in the district) with Mw 6.8 is still a realistic possibility. They hypothesized that the reason for this is due to the fact that, since 1990, only areas characterized by high rates of deformation have hosted significant earthquakes, also confirmed by analyzing the historical catalog of events with seismic completeness for magnitude M 6 over the last four centuries. Moreover, they show that strong seismic events with magnitude M 6 generally occurred at a relatively short time distance between one another, with a period of 200 years without strong earthquakes between the years 1732 and 1930.

Nardone et al. [42], Forcellini [43] and Mina and Forcellini [44] provide a useful overview of applied geophysics investigating some specific cases, both real and theoretical on the seismic assessment, the site effects, the soil–structure interactions, the response of the cultural heritage, applying various numerical simulations. Nardone et al. [42], analyze the ground response in the Avellino town (Campania, Southern Italy) and its correlation with the effects caused by the 23 November 1980 Irpinia earthquake on the historical buildings with the aim to get some clues about the earthquake damage and the cause-effect relationship. They use the seismic hazard disaggregation for estimating the ground motion response for Avellino, where strong motion recordings are not available. For assessing the seismic ground motion, the authors use borehole data to build the lithological model. The results indicate that the complex subsoil layers influence the ground motion, particularly in the lowest period (0.1–0.5 s). Moreover, the comparison with the observed damage of the selected historical buildings and the maximum acceleration expected indicates that the damage distribution cannot be explained by the surface geology effects alone.

Forcellini [43] deals with the role of the water level, closely related to changes in the degree of soil saturation, in the assessment of seismic vulnerability for the 1980 Irpinia–Basilicata earthquake, performing several 3D numerical finite element modeling in order to consider the effects of soil–structure interaction (SSI) on a representative benchmark structure. The results show the importance of considering the water level for buildings on shallow foundations in terms of settlements, base shear forces and floor displacements.

Mina and Forcellini [44] present a systematic study of the effects caused by the strong earthquake that struck southern Italy on 23 November 1980 (Ms = 6.9) and affected the Campania and Basilicata regions. In detail the Authors study the response site effects by considering several soil free-field conditions and the assessment of the role of the soil–structure interaction (SSI) on a representative benchmark structure through the numerical simulations performed with the advanced platform Open Sees, which can consider non-linear models for both the structure and the soil. The results show the importance of considering the SSI in the seismic assessment of soil amplifications and its consequences on the structural performance.

Last, but certainly not least, are the papers in the section relating generically to post-earthquake, but including papers on seismic risk and resilience of heavily earthquake-damaged villages. The paper of Wyss and Rosset [45], using the computer code QLARM, calculates the number of dead and injured in near-real time taking into account data from the 1980 earthquake. The results show that the number of casualties and injuries in large and major earthquakes in Italy can be estimated correctly within less than an hour by using QLARM, very important for definition of the seismic risk and for the civil protection actions to be prepared.

The paper by Moscaritolo [46] approaches the post-1980 earthquake reconstruction problem as a complex social process in which cultural backgrounds, expectations, and ideas of the future come into play, without neglecting geological, historical, legislative, economic, and political factors. Combining oral historical sources and archival records, the article shows the paths taken by two small towns among the most affected by the 1980 earthquake.

The last paper by Porfido et al. [7], aims to present, through a photographic reportage, the current state of rebuilding of the most devastated villages by the 1980 earthquake. Forty years after the seismic event, the photographs show villages almost completely rebuilt with modern techniques where reinforced concrete prevails. Only in few instances, the reconstruction was carried out trying to recover the pre-existing building heritage, without changing the original urban planning, or modifying it. Even more than this, documenting the rebuilding process in a large epicentral area reveals the human legacy to the natural landscape, and our ability, or failure, to properly interpret the environmental fate of a site.

This volume, far from being exhaustive, is nevertheless intended to be an important point of reference for the new generations, who will be able to have a historical as well as a multidisciplinary vision a seismic event that some of the researchers involved in the drafting of the volume have experienced personally [7,47–55]. An event that, due to its catastrophic consequences, not only modified and conditioned the lives of many people, but whose effects are still felt today.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/geosciences12040173/s1, File S1: Supplementary_material_Editorial_Porfido et al_2022.

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