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Radu Vacareanu
Constantin Ionescu *Editors*

The 1940 Vrancea Earthquake. Issues, Insights and Lessons Learnt

Proceedings of the Symposium Commemorating 75 Years from November 10, 1940 Vrancea Earthquake

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Preface

The November 10, 1940 Vrancea intermediate-depth earthquake, with a moment magnitude M_W = 7.7, is the strongest seismic event in the past 100 years in Romania and it ranks as the largest intermediate-depth earthquake that occurred in Europe in the twentieth century. This seismic event caused a high death toll (more than 550 people) and more than 1200 casualties, as well as very heavy damage in the epicentral region and hundreds of kilometers away from the epicenter. In Bucharest, the tallest reinforced concrete structure at that time—Carlton building—completely collapsed.

The *National Symposium 75 Years from November 10th 1940 Vrancea Earthquake* took place on November 10, 2015 at the *Technical University of Civil Engineering of Bucharest* (*UTCB*). The symposium aimed at sharing the lessons learnt after 1940 Vrancea earthquake and the research progresses in seismology and earthquake engineering in Romania 75 years after. The event was jointly organized by *UTCB* (through the *Seismic Risk Assessment Research Center*) and *National Institute for Earth Physics* (*INFP*) with the support of *Romanian Association of Civil Engineers* (*AICR*).

The symposium greatly benefited from the comprehensive and professional support of the Scientific and Organizing Committees. The full list of the Committees' members is given in Appendix A.

The symposium's Scientific and Organizing Committees invited specialists from academia, researchers, and practitioners to participate and to contribute with scientific papers to this event. At the time of the symposium, a Book of Abstracts published by CONSPRESS (the publishing house of the Technical University of Civil Engineering of Bucharest) was distributed to the participants. Fifty-two abstracts were received and published. The distribution of the abstracts in between the topics was as follows:

- 11 in Topic 1—Effects and Lessons from November 10th, 1940 Vrancea Earthquake
- 20 in Topic 2—Seismicity of Romania. Seismic Hazard Assessment; Local Soil Conditions Effect

- 12 in Topic 3—Structural Design in Seismic Areas; Performance-Based Design
- 9 in Topic 4—Seismic Evaluation and Rehabilitation. Seismic Risk Assessment.

A very well-balanced distribution of contributions between seismology and earthquake engineering was achieved during the symposium. The detailed program of the symposium is presented in Appendix B.

Because of the harsh times in the fifth decade of the past century, the lessons learnt after 1940 Vrancea earthquake were not extensively and completely shared with the international scientific community and thus, this book is trying to fill a gap in the knowledge acquired after major disasters.

Most of the original relevant literature concerning the 1940 Vrancea earthquake is in Romanian, so it is not available for the international scientific community. Moreover, even though the relevant scientific information in the past 25 years is in English, each journal article considers the November 10, 1940 Vrancea earthquake as a piece in the great puzzle that represents the intermediate-depth seismicity of Vrancea. This book gathers altogether the relevant information about this destructive earthquake in one compelling piece and offers to the international scientific community the opportunity to study in depth one of the most important earthquakes in Europe in the twentieth century. To this aim, the seismic effects of 1940 Vrancea earthquake are revisited with the state-of-the-art knowledge to acquire and share the most important lessons.

The lessons learnt and the current understanding of the 1940 Vrancea earthquake are presented to the reader along with state-of-the-art information on the seismicity of Romania, seismic hazard and risk assessments and seismic evaluation and rehabilitation of buildings and structures. Moreover, a collection of genuine information from Romanian post-disaster reports and textbooks concerning the 1940 Vrancea earthquake, compiled and translated into English, accompanies the book. An English translation of the chronicle of the aftermath of November 10, 1940 disaster is presented in Appendix C.

The most valuable full papers submitted were selected by the international reviewers and members of Scientific Committee and are published in this contributed volume. The book contains the Proceedings of the Symposium Commemorating 75 years from November 10, 1940 Vrancea Earthquake and includes, inter alia, most of the available information on this major seismic event and its consequences. The proceedings are structured in four parts, namely:

1. Effects and Lessons from November 10, 1940 Vrancea Earthquake
2. Seismicity of Romania. Seismic Hazard Assessment; Local Soil Conditions Effect
3. Structural Design in Seismic Areas; Performance-Based Design
4. Seismic Evaluation and Rehabilitation. Seismic Risk Assessment.

The sharing of the 34 chapters in between the parts is as follows: eight in Part I, twelve in Part II, six in Part III, and eight in Part IV. Again, a very good balance between the chapters addressing engineering seismology (Part II) and earthquake

engineering (Parts III and IV) is achieved. Each chapter starts with an overview that provides a summary of the papers included.

Each chapter has benefitted from the professional input and hard work of the following coordinators: Alexandru Aldea and Mircea Radulian (Part I), Mihaela Popa and Florin Pavel (Part II), Viorel Popa (Part III) and Carmen Cioflan and Mihail Iancovici (Part IV). The coordinators liaised with the authors and the reviewers and ensured the scientific quality and relevance of the manuscripts. The full list of the reviewers, to whom we are deeply indebted for their excellent timely work, is given as follows:

- Alexandru Aldea (Technical University of Civil Engineering of Bucharest, Romania)
- Anastasios Anastasiadis (Aristotle University of Thessaloniki, Greece)
- Luminiţa Ardeleanu (National Institute for Earth Physics, Magurele, Romania)
- Andrei Bala (National Institute for Earth Physics, Magurele, Romania)
- Alex Barbat (Universitat Politècnica de Catalunya • BarcelonaTech, Spain)
- Virgil Breabăn ("Ovidius" University of Constanta, Romania)
- Mihai Budescu (Technical University "Gheorghe Asachi" of Iasi, Romania)
- John Douglas (University of Strathclyde, Glasgow, Scotland, United Kingdom)
- Emil-Sever Georgescu (National Institute for Research and Development in Constructions, Urbanism and Sustainable Land Planning URBAN-INCERC, Bucharest, Romania)
- Athanassios Ganas (Institute of Geodynamics, National Observatory of Athens, Greece)
- Daniel Grecea (Politechnica University of Timisoara, Romania)
- Marian Ivan (Faculty of Geology and Geophysics, University of Bucharest, Romania)
- Mihaela Kouteva-Guentcheva (Faculty of Structural Engineering, University of Architecture, Civil Engineering and Geodesy, Sofia, Bulgaria)
- Grzegorz Lizurek (Institute of Geophysics PAS, Warszawa, Poland)
- Eugen Lozincă (Technical University of Civil Engineering of Bucharest, Romania)
- Gheorghe Mărmureanu (National Institute for Earth Physics, Magurele, Romania)
- Öcal Necmioğlu (Department of Geophysics, Boğaziçi University, Istanbul, Turkey)
- Florin Pavel (Technical University of Civil Engineering of Bucharest, Romania)
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- Radu Petrovici (University of Architecture and Urbanism "Ion Mincu", Bucharest, Romania)
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The professional involvement and work of the chapters' coordinators and the constructive suggestions of the reviewers greatly contributed to the quality of the manuscripts.

The editors acknowledge the dutiful and careful checking of all the manuscripts performed, before the final submission to Springer, by our colleagues from Technical University of Civil Engineering of Bucharest (UTCB) and National Institute for Earth Physics (INFP): Carmen Cioflan, Veronica Colibă, Ionuţ Crăciun, Cristi Ghiţă, Cristian Neagu, Florin Pavel, and Dragoş Toma-Dănilă.

A final word of gratitude is conveyed to Dörthe Mennecke-Bühler, Johanna Schwarz, Ashok Arumairaj, Sivajothi Ganesarathinam, and all the editorial staff from Springer International Publishing AG for their professional coordination and support in preparing this contributed volume.

Bucharest
December 2015

Radu Vacareanu
Constantin Ionescu

Contents

Part I Effects and Lessons from November 10th, 1940 Vrancea Earthquake

Overview of Part I 3
Alexandru Aldea and Mircea Radulian

The Strong Romanian Earthquakes of 10.11.1940 and 4.03.1977. Lessons Learned and Forgotten? 19
Andrei Bala and Dragos Toma-Danila

Before and After *November 10*th, *1940* Earthquake 37
Ileana Calotescu, Cristian Neagu and Dan Lungu

The Collapse of Carlton Building in Bucharest at November 10, 1940 Earthquake: An Analysis Based on Recovered Images 57
Emil-Sever Georgescu

Main Characteristics of November 10, 1940 Strong Vrancea Earthquake in Seismological and Physics of Earthquake Terms 73
Gheorghe Marmureanu, Carmen Ortanza Cioflan, Alexandru Marmureanu and Elena Florinela Manea

The 10 November 1940—The First Moment of Truth for Modern Constructions in Romania 85
Radu Petrovici

Macroseismic Effect of the November 10, 1940 Earthquake in the Territory of Moldova, Ukraine and Russia 101
Nila Stepanenco and Vladlen Cardanet

Causes and Effects of the November 10, 1940 Earthquake 113
Ion Vlad

Part II Seismicity of Romania. Seismic Hazard Assessment; Local Soil Conditions Effect

Overview of Part II: Seismicity of Romania. Seismic Hazard Assessment; Local Soil Conditions Effects 131
Mihaela Popa and Florin Pavel

Use of Various Discrimination Techniques to Separate Small Magnitude Events Occurred in the Northern Part of Romania 135
Felix Borleanu, Bogdan Grecu, Mihaela Popa and Mircea Radulian

Prediction of Site Characterization Based on Field Investigations and Empirical Correlations 151
Elena-Andreea Călăraşu, Cristian Arion and Cristian Neagu

Spectral Displacement Demands for Strong Ground Motions Recorded During Vrancea Intermediate-Depth Earthquakes 169
Ionut Craciun, Radu Vacareanu and Florin Pavel

Analysis of the Seismic Activity in the Vrancea Intermediate-Depth Source Region During the Period 2010–2015 189
Andreea Craiu, Mihail Diaconescu, Marius Craiu, Alexandru Marmureanu and Constantin Ionescu

A Contemporary View to the Impact of the Strong Vrancea Earthquakes on Bulgaria 205
Mihaela Kouteva-Guentcheva and Krasimir Boshnakov

Site Dependent Seismic Hazard Assessment for Bucharest Based on Stochastic Simulations 221
Florin Pavel, Daniel Ciuiu and Radu Vacareanu

Scaling Properties for the Vrancea Subcrustal Earthquakes: An Overview 235
Emilia Popescu, Mircea Radulian and Anica Otilia Placinta

The 2013 Earthquake Swarm in the Galati Area: First Results for a Seismotectonic Interpretation 253
Mihaela Popa, Eugen Oros, Corneliu Dinu, Mircea Radulian, Felix Borleanu, Maria Rogozea, Ioan Munteanu and Cristian Neagoe

Comparison of Three Major Historical Earthquakes with Three Recent Earthquakes 267
Maria Rogozea, Mircea Radulian, Mihaela Popa, Daniel Nistor Paulescu, Eugen Oros and Cristian Neagoe

An Attempt to Bridge the Gap Between the Traditional Concept of Seismic Intensity and the Need of Accuracy Required by Engineering Activities 285
Horea Sandi and Ioan Sorin Borcia

Earthquake Precursors Assessment in Vrancea Region Through Satellite and In Situ Monitoring Data 305
Maria Zoran, Dan Savastru and Doru Mateciuc

Part III Structural Design in Seismic Areas; Performance-Based Design

Overview of Part III: Structural Design in Seismic Areas; Performance Based Design 317
Viorel Popa

Influence of the Infill Panels Masonry Type on the Seismic Behaviour of Reinforced Concrete Frame Structures 319
Mircea Bârnaure, Ana Maria Ghiţă and Daniel Nicolae Stoica

A Time-Domain Approach for the Performance-Based Analysis of Tall Buildings in Bucharest 333
Mihail Iancovici and George Vezeanu

Unidirectional Cyclic Behavior of Old Masonry Walls in Romania 351
Eugen Lozincă, Viorel Popa, Dragoș Coțofană and Alexandru Basarab Cheșcă

Viscous Damper Distribution Using Genetic Algorithms and Pattern Search Optimization 363
Andrei Pricopie and Alin Costache

Selecting and Scaling Strong Ground Motion Records Based on Conditional Mean Spectra. Case Study for Iasi City in Romania 377
Radu Vacareanu, Mihail Iancovici and Florin Pavel

Part IV Seismic Evaluation and Rehabilitation. Seismic Risk Assessment

Overview of Part IV: Seismic Evaluation and Rehabilitation. Seismic Risk Assessment 395
Carmen Ortanza Cioflan and Mihail Iancovici

Estimation of Damage-Loss from Scenario Earthquake Analogous to November 10, 1940 in Republic of Moldova 399
Vasile Alcaz, Eugen Isicico, Victoria Ghinsari and Sergiu Troian

Some Remarks Regarding Seismic Vulnerability for Orthodox Churches 411
Mihai Budescu, Lucian Soveja and Ioana Olteanu

Seismic Loss Estimates for Scenarios of the 1940 Vrancea Earthquake 425
Carmen Ortanza Cioflan, Dragos Toma-Danila and Elena Florinela Manea

Rapid Earthquake Early Warning (REWS) in Romania: Application in Real Time for Governmental Authority and Critical Infrastructures 441
Constantin Ionescu, Alexandru Marmureanu and Gheorghe Marmureanu

Seismic Assessment and Rehabilitation of Existing Constructions after the 10th November 1940 and 4th March 1977 Earthquakes in Romania 451
Mircea Mironescu, Adrian Mircea Stănescu, Teodor Brotea, Radu Florin Comănescu, Daniel Dumitru Purdea and Mircea V. Stănescu

Analytical Seismic Fragility Functions for Dual RC Structures in Bucharest 463
Paul Olteanu, Veronica Coliba, Radu Vacareanu, Florin Pavel and Daniel Ciuiu

Conceptual Framework for the Seismic Risk Evaluation of Transportation Networks in Romania 481
Dragos Toma-Danila, Iuliana Armas and Carmen Ortanza Cioflan

Appendix A: Members of Scientific and Organizing Committees 497

Appendix B: Program of the *National Symposium 75 Years from November 10th 1940 Vrancea Earthquake* 499

Appendix C: Testimonies on the Aftermath of November 10th 1940 Vrancea Earthquake in the Putna County 503

Part I
Effects and Lessons from November 10th, 1940 Vrancea Earthquake

Overview of Part I

Alexandru Aldea and Mircea Radulian

1 Romania's Seismicity and the November 10th, 1940 Vrancea Intermediate Depth Earthquake

The seismic activity in Romania is dominated by the earthquakes generated at intermediate depths (60–180 km) in the Vrancea region, located at the bend of the South-Eastern Carpathians. This area represents the junction of several tectonic units: East-European Plate to the North and North-East, Scythian Platform to the East, North Dobrogea orogen to the South-East, Moesian Platform to the South and South-West and Carpathian orogen and Transylvanian Basin (Intra-Alpine plate) to the West and North-West. It is a region now in a stage of post-continental collision (Ismail-Zadeh et al. 2012 and herein references).

The seismicity concentrates in a narrow high-velocity lithospheric volume embedded in the upper mantle beneath the South-Eastern Carpathians Arc bend. The rate of seismic moment per volume, $\sim 0.8 \times 10^{19}$ Nm/year, is comparable to southern California (Wenzel et al. 1998) and is in a strong contrast with the low seismicity characterizing the rest of the Carpathians orogeny system. To explain the extreme concentration of the focal volume continuously generating earthquakes in the mantle and its relative isolation (the Vrancea seismogenic zone is one of the few examples of prominent localized intermediate-depth seismicity situated far from active plate boundaries), a complex geodynamics involving manifold processes

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(roll-back, break-off, delamination, gravitational instability, dehydration, thermal shear runaway) is invoked (e.g., Fuchs et al. 1979; Oncescu 1984; Linzer 1996; Girbacea and Frisch 1998; Sperner et al. 2001; Gvirtzman 2002; Cloetingh et al. 2004; Ismail-Zadeh et al. 2005, 2012; Houseman and Gemmer 2007; Lorinczi and Houseman 2009).

The catalogue of Vrancea earthquakes is considered complete for magnitude M_w 6.5 for an interval of six centuries (Oncescu et al. 1999). In average five shocks with magnitude $M_w > 6.5$ are recorded per century. The maximum recorded magnitude is attributed to the event of 1802 ($M_w = 7.9$). In the last century, four shocks with magnitude above 7 were recorded, characterized by large damage over extended and dense-populated areas.

The event produced on 10th November 1940 ($M_w = 7.7$) was the largest instrumentally recorded earthquake recorded in Romania and the fourth of the largest intermediate-depth earthquakes recorded since 1900 until present day. The macroseismic effects were felt over an area of about two million km^2, while the ground motion induced by the seismic waves was recorded at the global scale (as far as Wellington in New Zealand).

A significant increase in the background seismicity preceded by a few months the triggering of the major shock in 1940. As remarkable precursor events we mention the events of 24th June 1940 ($M_w = 5.9$), 22nd October 1940 ($M_w = 6.5$) and 8th November 1940 ($M_w = 5.9$). The aftershock activity was less extensive as compared with aftershock activity for crustal events of similar size (the largest aftershock of M_w 5.9 was produced on 11th November 1940) which is a typical feature for the Vrancea intermediate-depth earthquakes. However, both the pre- and post-shock activities were notably greater than those associated with the subsequent major events of March 1977 ($M_w = 7.4$) and August 1986 ($M_w = 7.1$).

The occurrence of the major earthquake of 10th November 1940 marked a turning point in the research of the seismic phenomenon in the SE Carpathians Arc bend. Through the magnitude of the effects, widely felt, and the multitude of instrumental data which at that time was a unique worldwide database, the earthquake was an event truly revealing in many ways. At the same time, it raised a lot of questions and controversies as concerns the seismological and geotectonical interpretation of the earthquake phenomenon.

2 November 10th, 1940 Earthquake: Victims and Damage

> "The November 10th, 1940 earthquake sprinkled ruins all over Romania and threw mourning over the people" (Romanian Academy of Sciences 1941)

2.1 Earthquake Victims

The first official data concerning the victims was issued on November 11th: The Communicate of Ministerial Council indicated in Romania 267 deaths and 476 injured (as counted until the evening of November 10th).

The Romanian telegraphic information society Rador informed the world about the earthquake in the morning of November 10th, indicating an unidentified number of victims. Rador disseminated the official ministerial data from November 11th on November 12th to London, Rome, Budapest, Athens, Belgrade, Berlin, Moscow, Ankara, Sofia, Berne, Madrid, Clermont-Ferrand (Agerpres 2015).

Around the world journals, magazines and TV news were informing about the Romanian earthquake effects.

In France for example:

- on November 12th, L'Ouest-Éclair newspaper (1940) indicates over 500 deaths in Bucharest, 30 deaths and 100 injured in Galati in Romania, injured people in Sofia (Bulgaria), several dozens of deaths and hundreds of injured in Hungary and Transylvania;
- on November 14th, La Vendée Républicaine newspaper (1940) indicates 500 deaths in Bucharest, 30 deaths and 100 injured in Galati in Romania, and injured people in Sofia (Bulgaria);
- on November 30th, L'Illustration magazine (1940) gives the official Romanian data and also indicates victims details in Galati (45 deaths and 35 injured) and in Focsani (30 deaths and 60 injured) in Romania and mentions injured people in Bulgaria;
- on December 11th, l'INA (1940) TV news indicates hundreds of deaths and injured.

In United States:

- on November 23rd, in Nature journal Tillotson (1940) indicates "More than 150 are known to have been killed in Bucharest alone […] Panciu is said to have been completely destroyed and there are 23 dead and 71 seriously injured […] At Jassy, 4 were killed and 6 gravely injured […] Galati […] the casualties were reported as 36 killed and a 130 injured." He estimates "casualties throughout the country as 400 killed and 800 severely injured". Tillotson also mentions about 15 persons injured at Rutschuk in Bulgaria;
- on November 25th, Time magazine writes "In Bucharest 98 bodies had been taken from the stony ruins of the elegant Carlton apartments. The national toll rose to 357 dead, thousands injured."

In Germany on November 28th, Die Deutsche Wochenschau TV news (1940) indicates almost 300 deaths and over 400 injured in Romania.

In UK on January 9th, British Pathé TV news (1941) talks about 300 deaths in the collapse of one tall building in Bucharest.

In all reports, a special attention was paid to the collapse of Carlton building in central Bucharest, a modern tall reinforced concrete frame structure that buried in its ruins over a hundred persons, Fig. 1.

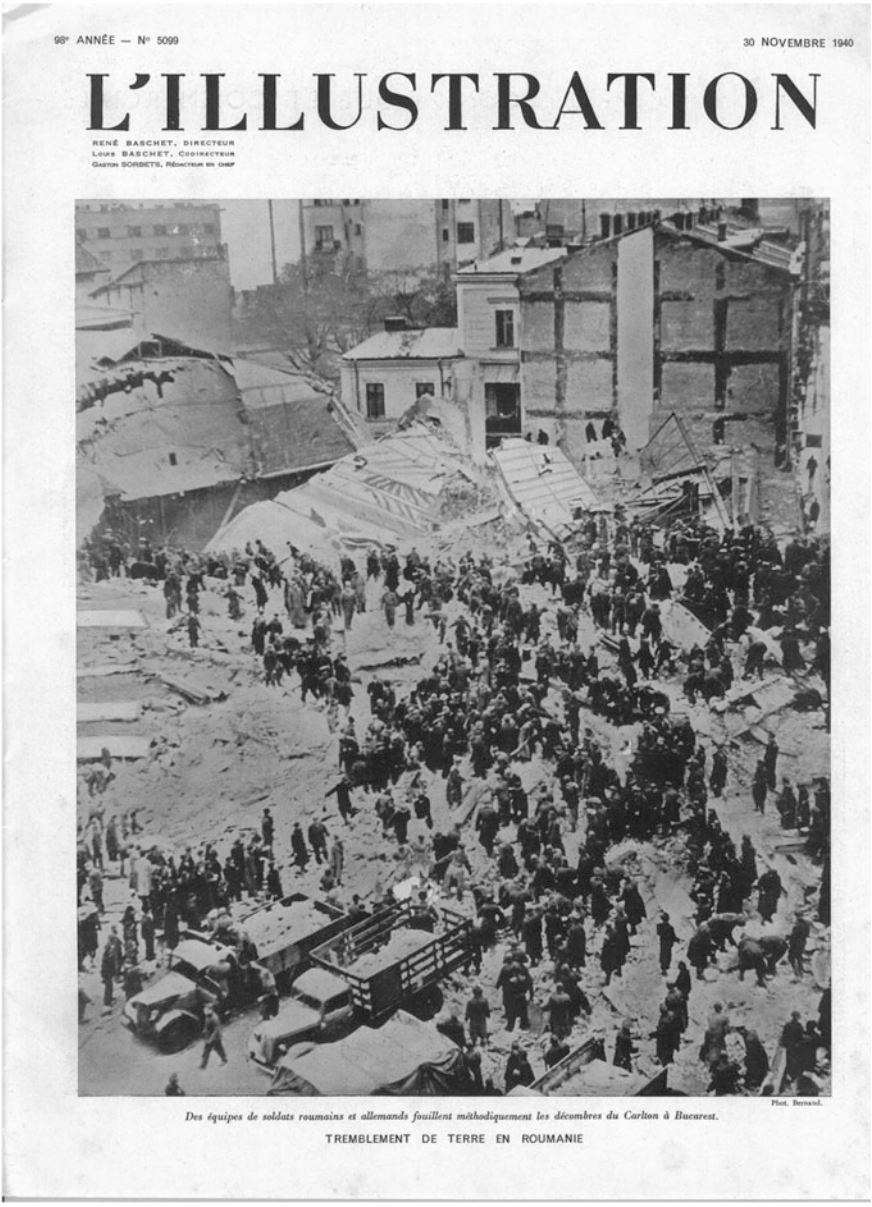

Fig. 1 Collapse of Carlton building in Bucharest—Romania during the November 10th, 1940 Vrancea earthquake (L'Illustration 1940)

Carlton collapse is described in the paper of Georgescu (present Chapter). The search and rescue operation involved not only Romanian fire fighters, military and citizens, but also German soldiers and Italian volunteers, Fig. 2 (La Tribuna Illustrata 1940).

Fig. 2 Search and rescue operations after the collapse of Carlton building in Bucharest—Romania during the November 10th, 1940 Vrancea earthquake (La Tribuna Illustrata 1940)

Due to the war period, the precise number of victims of the November 10th, 1940 Vrancea earthquake was not estimated and there were no final official data. The same is valid also for the neighbouring countries Bulgaria, Hungary and Ukraine and territories Transylvania, Bessarabia and Northern Bukovina that were under Hungarian and Soviet Union occupation.

As above presented, there were injured persons in Bulgaria, deaths and injured in Hungary.

For Bessarabia (Moldavian SSR) Stepanenco and Cardanet (present Chapter) indicate that "there were 17 people killed and died of severe wounds, 66 seriously injured, 546 lightly wounded people". However, another study indicated over 78 deaths and approximately 1000 injured (Drumea 2000).

In their study of 2012, Georgescu and Pomonis gathered data from different sources and indicate a total death toll of 593 and 1271 injured for the Romanian territories.

Other studies are indicating larger numbers of deaths: 980 (EM-DAT: The OFDA/CRED International Disaster Database), 1000 (Gutenberg and Richter 1954; Tazieff 1962, USGS), >1000 (Beles and Ifrim 1962; Coburn and Spence 1992).

With a total number of deaths over 600 and probably reaching 1000 and with over 1000 injured persons in Romania, Hungary, Moldavian SSR and Bulgaria, the November 10th, 1940 Vrancea earthquakes produced a strong public impact around the world and ranked in the top 10 of the deadliest European earthquakes of 20th century.

2.2 *Earthquake Damage*

The Communicate of Ministerial Council of November 11th, 1940 indicated substantial damage in Bucharest where 183 buildings were heavily damaged and had to be evacuated and other 402 buildings suffered lower damages. The collapse of Carlton building is also presented. The Communicate mentions heavy damage in the cities of Galati, Focsani and on Prahova river valley, and slight damage in another 19 cities.

Unfortunately, the damage proved to be much higher.

Popescu (1941) presents a map with an estimation of the macroseismic area of the earthquake, concluding that it over passed 2 million km^2: "The shaking was felt toward east in all the south-western Soviet Union (Odessa, Charkow, Kiew, Moscow—where it even produced slight damages). Toward north, it reached Leningrad; toward west it was felt beyond Tissa river and toward south-west and south if was felt in Yugoslavia, all Bulgaria up to Istanbul." Popescu also estimated the maximum seismic intensity of X (on Mercalli-Cancani-Sieberg international scale) and indicated that the region with intensities equal or higher to VIII reached 80,000 km^2.

Demetrescu (1941) built a seismic intensity map (shown in Bala and Toma-Danila, present Chapter) using data from Romania and Bulgaria and estimated an MSC intensity of X in at least 5 locations. The northern part of Bulgaria was in intensity VII area while almost all the rest of the country (except the far south) in V and VI.

Radulescu (1941) presented a description of the severe damage accompanied by photos in several cities from the epicentral region (Panciu, Barlad, Focsani, etc.) and in Bucharest for which he drew up a first seismic damage microzonation map indicating that building damage was spread all across the city. He also presented several examples of induced hazard (liquefaction, landslides, ground cracking in river meadows, etc.).

Several seismic intensity maps were drawn by researchers and institutions in the years after the earthquake (some of them shown in the papers from this Chapter), and data from the strong earthquake of November 10th, 1940 was the basis of the maps from the 1941 and 1945 Romanian seismic design regulations and in the national macroseismic zonation map from 1952.

In the recent years, a significant effort was made for the reevaluation of the seismic intensities.

Pantea and Constantin (2011) made a "reinterpretation of over 4500 macroseismic questionnaires, as well as the critical and serious research of the expertise reports, monographies, photos, scientific papers published both inside and outside the country". They produce for Romania's territory a map in terms of MSK-64 (Medvedev, Sponheur, Karnik) seismic intensities, Fig. 3.

Konrod et al. (2013) integrated transnational macroseismic data for the strongest earthquakes of Vrancea (Romania), including the 1940 event, using up-to-date procedures for producing isoseismals. The macroseismic map, Fig. 4, confirms the NE-SW directivity of the earthquake effects and a large area with seismic intensity equal and higher to IX.

Building damage was widely described in the press of the time, in Romania and abroad.

In France for example:

- on November 12th, L'Ouest-Éclair newspaper (1940) indicates that all buildings in Bucharest suffered, and that damage was reported in Bulgaria, Hungary and Transylvania;
- on November 30th, L'Illustration magazine (1940) indicates extensive damage in the cities of Bucharest, Ploiesti, Galati, Focsani, Targoviste, Mizil, Iasi, Campina, together with suggestive images (Fig. 5);
- on December 11th, l'INA TV news talk about thousands of buildings destroyed.

In UK on January 9th, British Pathé TV news (1941) indicate that about 13,000 km^2 of the Kingdom of Romania were transformed into ruins and that the effects were similar to those of a war.

In United States:

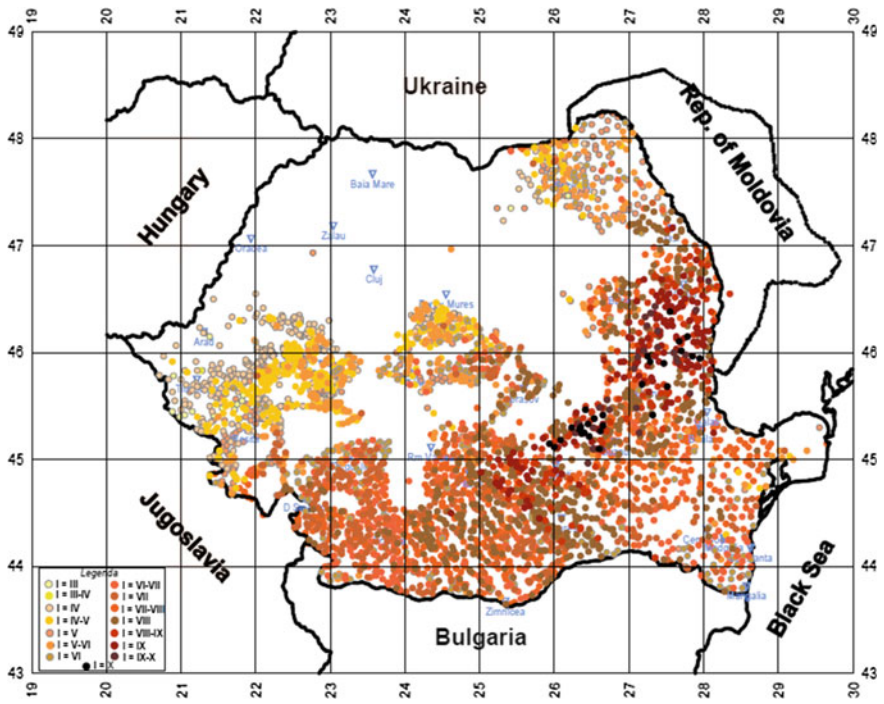

Fig. 3 Reevaluated macroseismic map of November 10, 1940 earthquake (Pantea and Constantin 2011)

- on November 13th, Eleanor Roosevelt (1940) noted: "In Romania, the earthquake seems to have accomplished in a few short hours what all the aviators of Great Britain have tried unsuccessfully to do for weeks—fires are raging, oil wells are destroyed […]."
- on November 23rd, in Nature journal Tillotson (1940) summarises the most important damages in Bucharest and mentions that "among other buildings 200 were destroyed and 400 damaged" and "More than a 1000 badly damaged houses have had to be evacuated in Bucharest, and there is scarcely a house not affected in some way"; he also presents data concerning the damage in other cities: "At Focsani […] 70 % of the houses in the centre of the town are said to be razed and hundreds of people rendered homeless. […] At Giurgiu […] 65 % of the houses are reported destroyed. […] At Buzau […] hundreds of buildings have been destroyed and many people killed. […] Panciu is said to have been completely destroyed […]. Galati […] suffered severely. The cathedral and St. Helen's church were destroyed, scores of houses severely damaged […]"; he also presents information about damage in Bulgaria: "At Rutschuk, just on the Bulgarian side of the frontier, 10 houses were damaged […]".

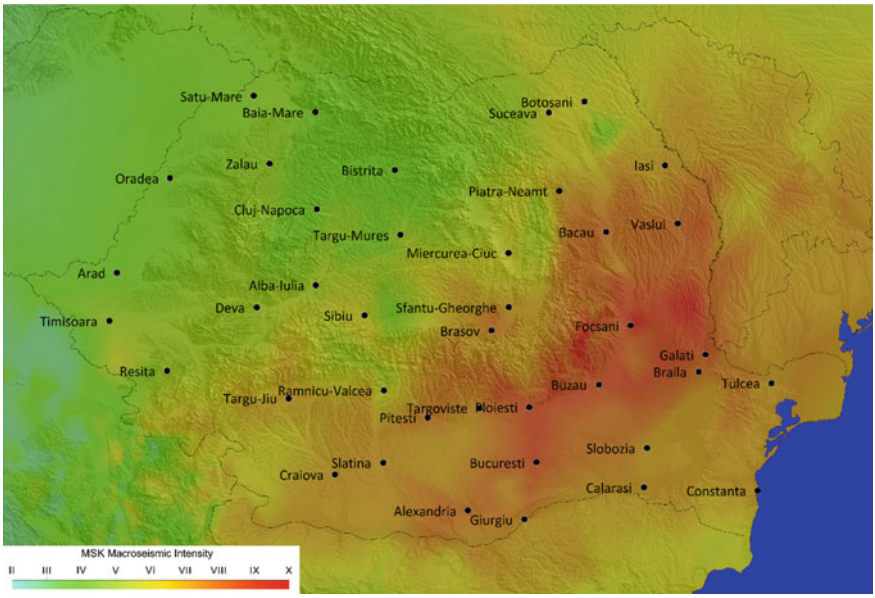

Fig. 4 Macroseismic map of November 10, 1940 earthquake (macroseismic intensities data from Konrod et al. 2013)

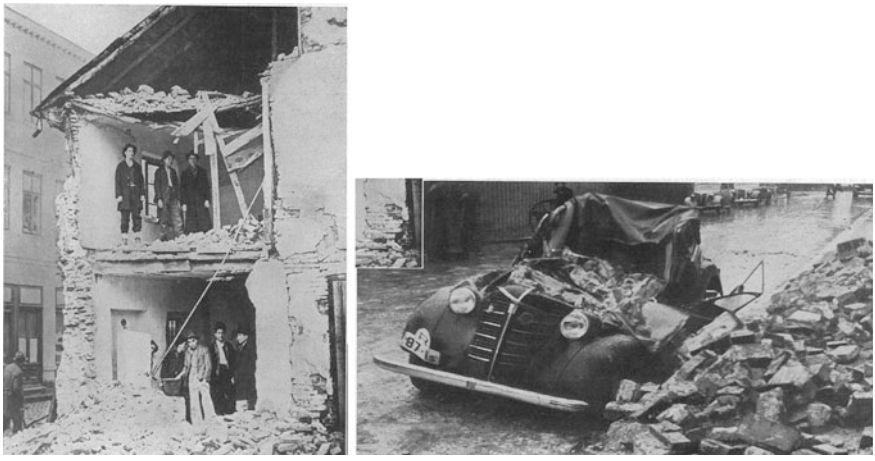

Fig. 5 1940 earthquake damage in Romania (L'Illustration 1940)

In Romania all national, regional and local papers reported about the earthquake effects for several days. Several scientific papers were published in Romania and abroad in 1940 and 1941, most of them referenced in the papers from this Chapter.

Two of the most important scientific papers, considered by many as the starting point of earthquake engineering in Romania, were published by Beles (1941a, b), one in French and one, extended, in Romanian. Beles, a professor at the Polytechnic School of Bucharest, at the Civil Engineering Faculty, described and analysed in detail the building damage and suggested repairing and retrofitting solutions. Several aspects from his impressive work are found in this Chapter's papers.

Over Romania, extensive damage occurred to most of the important buildings like city-halls, prefectures, schools, hospitals, railway stations, etc., in general masonry buildings. In Bucharest, damage also occurred to many reinforced-concrete structures that were built in between the wars. Elements concerning the building stock prior to the earthquake are given in some of the papers from this Chapter. Impressive images were published over time in different papers and there is a continuous effort of retrieving such useful historical information (for example Agerpres, 2014, website).

The paper of Calotescu et al. (present Chapter) shows severe damage in Kishinev.

Another category of damaged constructions, whose destructions had a powerful social impact inluded churches and monasteries. All around the country many religious buildings suffered complete collapse or severe damage. The paper Marmureanu et al. (present Chapter) covers a number of damaged churches and the seismic intensity evaluation at those locations.

Antonescu (1942) was concerned with new design solutions for new churches. He mentioned that predictions about earthquake strength were over passed and that a high destructive force was noticed in areas where nobody expected. Churches that stood up against earthquakes with little damage for many centuries were now destroyed of severely damaged. He indicates that prior to the earthquakes several churches were strengthened by inserting a reinforced concrete skeleton and that these churches had a good behaviour during the 1940 earthquake, and he recommended the reinforced concrete structures with in filled masonry as a possible solution for new churches.

A special damage case was the city of Panciu. All news, national and international attracted the public attention toward the city of Panciu, located in the epicentral area, and national and international aid was directed to support Panciu inhabitants. Images and TV news showed King Michael of Romania visiting the city soon after the earthquake. Capatana (1941), the mayor of the city at that time, presented an overwhelming picture of the disaster: "the only town in Romania that was 99 % destroyed, from 371 masonry houses only 5 stood up, together with 57 adobe or wooden houses at city borders." Capatana also mentions about 42 dead persons and 76 injured from which several died later. The almost entire ruin of the city, Fig. 6, induced a special reaction from Romanian state who issued a Law (1942) for the city reconstruction.

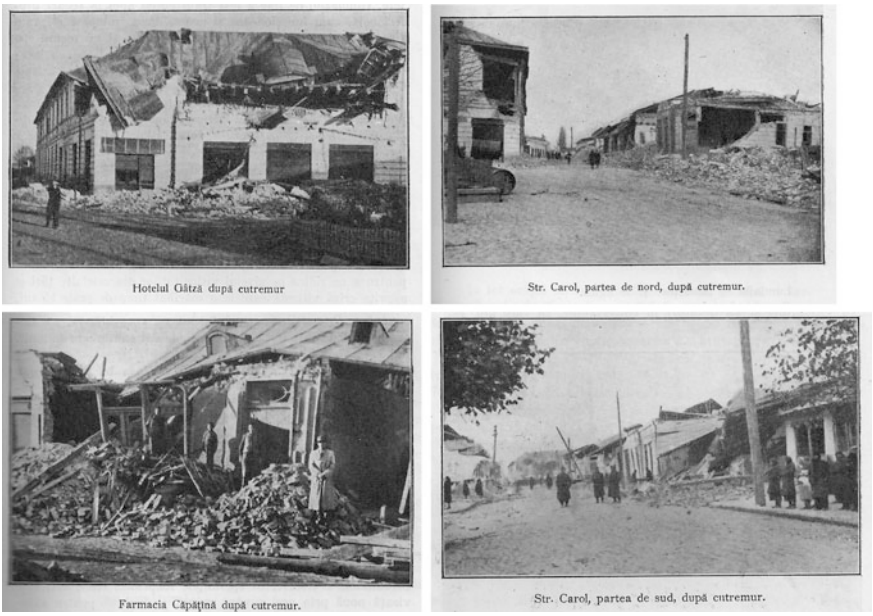

Fig. 6 1940 earthquake damage in Panciu, Romania (Capatana, 1941): Hotel Gatza (*upper left*), Capatana Pharmacy (*upper right*) Carol Street (northern part *lower left* and southern part *lower right*)

3 November 10th, 1940 Earthquake: Concluding Remarks

> "Altogether, the shock constituted one of the great earthquakes of the world" (Tillotson 1940)

The Chapter devoted to the effects and lessons from November 10th, 1940 Vrancea earthquake groups seven papers dealing with earthquake characteristics, seismic intensities, victims and building damage, earthquake engineering and seismology and building design before and after the earthquake. In the annex of the overview a brief description of the papers is given.

The wide macroseismic area and the large destruction area of the 1940 earthquake, as well as of other strong Vrancea earthquakes (1802, 1977, 1986, 1990, 2004) are a direct effect of the intermediate depth at which these earthquakes occur.

Vrancea earthquakes are not Romanian earthquakes, but European earthquakes being felt in several countries (Romania, Bulgaria, Republic of Moldova, Ukraine, Russia, Greece, Turkey, Hungary, Yugoslavia, etc.) and producing victims and damage on a wide area beyond Romania's borders.

The large magnitude (M_W = 7.7), the huge macroseismic field with seismic intensities reaching X and with a large area with intensities equal or higher to IX, the relatively large number of victims, altogether rank the November 10th, Vrancea intermediate depth earthquake as one of the major European earthquakes.

Appendix: Summary of the Papers in this Chapter

The paper by Marmureanu et al. introduces a brief presentation of the seismicity of Vrancea source before the November 10th, 1940 earthquake. An important part of the paper is devoted to the description (data selected from various sources) of the earthquake effects in Romania, focusing on several cities which experienced extensive damage (Barlad, Ploiesti, Bucharest, Targoviste, Buzau). The paper ends by presenting data on earthquake damage of a number of churches and monasteries in Romania, the authors estimating MSK seismic intensity values at the sites of damaged religious buildings.

The paper of Calotescu et al. begins with the presentation of the evolution of seismic design of buildings in Romania with emphasis on Bucharest, "Europe's capital of earthquakes" (The Guardian, March 25th 2014, online edition). Following 1940 Vrancea earthquake, new seismic design regulations (1941, 1945) were prepared (but not enforced) and macroseismic hazard maps were documented. In the paper the most representative macroseismic maps available to the authors compared and discussed. Seismological data available before and after the Nov. 10th, 1940 event and data related to the damage produced by historic strong Vrancea earthquakes (1802, 1838, 1940) are presented and discussed.

The paper of Georgescu focuses on the complete collapse during the November 10th, 1940 earthquake of Carlton building in Bucharest. With about 45 m height, the modern Carlton building was one of the symbols of the capital city Bucharest and was a representative work of avant-garde architecture. Located in the city center, the building had a reinforced concrete frame structure with in filled masonry walls. Using an extensive bibliographic documentation (from Romania, Germany, Belgium and France), the paper describes the possible collapse mechanism and the Search and Rescue operations.

The paper of Petrovici begins with a historical overview on the seismicity and on the reinforced concrete design and construction in Romania. The paper continues with the presentation of the main aspects of architectural and structural building design in Romania prior to the 1940 earthquake and ends with a critical analysis of the main post-earthquake lessons from Beles (1941a, b), with elements concerning the 1977 earthquake effects and with a warning for the potential damage during a future strong earthquake.

The paper of Bala and Toma-Danila is structured in two main parts: one devoted to the seismological aspects of the November 10th, 1940 earthquake and its effects in Romania (with special emphasis on the paper of Beles (1941a, b), on the conclusions and recommendations that were made) and other devoted to the seismological aspects of the March 4th, 1977 earthquake and its effects in Romania. The authors underline the link between the 1977 collapses and the damages from 1940, in Bucharest and the lessons to be considered for preventing future earthquake effects.

The paper of Vlad discusses the seismic event of November 10th, 1940 in the light of "seismic islands", situated far away from the vicinity of the located

epicentre of the earthquake. In this respect, the most representative example is that of Bucharest, located nearly 160 km from the epicentre, and where the macroseismic intensity was set to IX, according to the seismic intensity scale of G. Mercalli and processed by A. Sieberg. The paper focuses on the relevant issues regarding the design and construction practices of the building categories that were severely damaged by the destructive 1940 Vrancea earthquake.

In the paper of Stepanenco and Cardanet the available macroseismic data to the northeast of the epicentre of November 10th 1940 Vrancea earthquake are analyzed. As a result of the previously-mentioned analysis and through the generalization of macroseismic information contained in the relevant literature, a new table with intensity values for the territory of Moldova, Ukraine and Russia was developed, and the isoseismal map of this earthquake are re-drawn. The macroseismic effects for the Eastern Europe of the Vrancea earthquakes of January 23, 1838, March 4, 1977, August 30, 1986 and May 30, 1990 are compared and discussed.

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The Strong Romanian Earthquakes of 10.11.1940 and 4.03.1977. Lessons Learned and Forgotten?

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Abstract Bucharest is among the European capitals most vulnerable to earthquakes. Although located at a relatively large epicentral distance (about 140–160 km) from Vrancea area, Bucharest has suffered much destruction and loss of life during great Vrancea earthquakes. In the last century, November 10th, 1940 earthquake (Mw = 7.7) caused the completely collapse of Carlton building located in the central city area, killing over 300 people, and many other high buildings were affected in capital city as in other cities closer to the epicenter. More than 1000 people were killed in a matter of minutes in all Romania during the earthquake, while city of Panciu was destroyed in 90–95 % proportion. This was the moment when the first alarm signal regarding the introducing of mandatory regulations in the seismic design of buildings came out. However, the recommendations made by the specialists were largely ignored by the authorities of the time, so that the next major earthquake of March 4, 1977 (Mw = 7.4) caused the biggest recorded disaster in the history of Bucharest The earthquake of 1977 caused only in Bucharest the collapse of 32 buildings, 8–12 floors high, while about 150 old buildings, with 4–6 floors were badly damaged. Most of the collapsed buildings were built between the 1920 and 1940, they did not benefit of the anti-seismic design. In the case of Bucharest the buildings have been previously damaged in the 1940 earthquake and during the bombardments in the World War II. Over 1500 people died and about 7500 were wounded, most of them in Bucharest City. The total cost of the damage amounted to more than 2 billion dollars, two thirds being related to the capital city only. The aim of the paper is to present aspects related to the consequences of the Vrancea 1940 and 1977 earthquakes, highlighting the differences between the two catastrophic events and their consequences. Therefore everything learned from the past should not be forgotten in order to insure that the next catastrophic event will find a better prepared society.

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