Romanian Reports in Physics, Vol. 68, No. 4, P. 1589–1602, 2016

SEISMOLOGY IN ROMANIAN SCHOOLS: EDUCATION, OUTREACH, MONITORING AND RESEARCH

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Received September 18, 2015

Abstract. The Romanian Educational Seismic Network project is an educational initiative which launches a challenge for the Romanian educational system: how to use seismology in classrooms for raising awareness on earthquake risk as well as a tool for influencing the development of science curriculum. The project is piloted in nine schools. Educational materials were developed comprising theoretical aspects, activities and experiments related to earthquakes and their effects. First Romanian educational seismic network was built and workshops for teachers were organized with the purpose of showing how Earth Science topics can be taught in classrooms based on the concept "learning by doing".

Key words: education, seismology, seismic awareness, science outreach.

1. INTRODUCTION

The Romanian Educational Seismic Network (ROEDUSEIS) project, started in 2012, is the first educational initiative in Romania in the field of seismology involving two research institutes (National Institute for Earth Physics (NIEP) as coordinator, the National Institute for Research and Development in Construction, Urban Planning and Sustainable Spatial Development – URBAN – INCERC, Bucharest branch), one university (The "Babeş-Bolyai" University (BBU) – Faculty of Environmental Sciences and Engineering) and one software development private company (BETA Software). Following similar initiatives already existing in western countries (France and Italy – The Educational Seismology Project [1, 2, 3], UK – School Seismology Project), in USA (IRIS – Seismographs in Schools), in Australia [4], ROEDUSEIS is focused on increasing the level of knowledge of teachers and pupils on earthquake phenomena, earthquake effects, preparedness measures and is also promoting the role of education and schools in disaster risk reduction. The project is developed and implemented in partnership with 9 school units from different Romanian cities

(Brasov, Bucharest, Cluj, Constanta, Focsani, Iasi, Sibiu, Timisoara, Zalau). In each participating school a SEP educational seismometer is installed (Fig. 1).

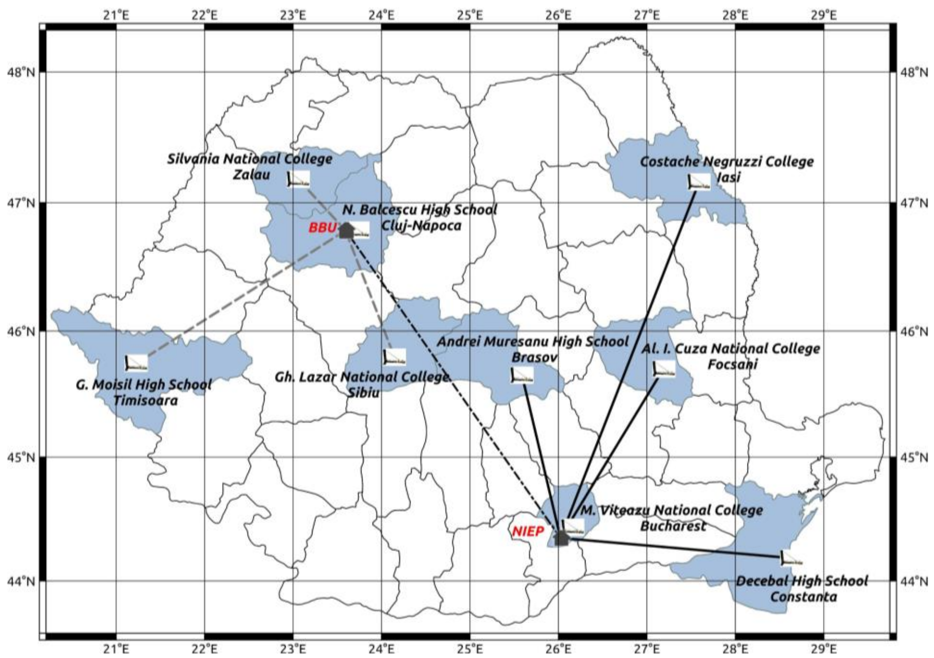

Fig. 1 – ROEDUSEIS Network.

Two more educational seismometers were installed on two Seismo-Laboratories, one hosted by NIEP and one by BBU where data are stored and shared between network members and also made freely available to the general public via an e-learning platform website (http://www.roeduseis.ro). This network represents a great opportunity for students to use real advanced research instruments and scientific data analysis tools in their everyday school activities and a link to observations of Earth phenomena and Earth science in general.

The project has many educational, scientific and social aims. The most important educational objectives are related to: preparing comprehensive educational materials as resources for training students and teachers in the analysis and interpretation of seismological data, experimentation of new technologies in projecting and implementing didactic activities based on the concept “learning by doing”, professional development and support for teachers and development of science curriculum module. The scientific objective is to introduce in schools the use of scientific instruments like seismographs (SEP seismometer) and experimental methods (seismic data analysis) that are usually restricted to research laboratories. Regarding the social objectives, the project will facilitate the interaction between scientists, teachers and students, thus allowing the students and teachers to be more involved in research activities, on one hand, and the scientists to share their knowledge and to participate in didactic activities, on the other hand. Finally, the project represents an instrument for informing and raising seismic risk awareness, but also for increasing the general interest of students in science.

2. NEEDS ASSESSMENT AND EDUCATIONAL MATERIALS

One of goals of the project was to develop comprehensive educational materials [5]. In order to properly calibrate our products to the needs of beneficiaries (students and teachers) and to identify their opinions before starting the collaboration with the schools, a needs analysis has been carried out between October–December 2012. At the study participated 266 children aged 9–18 years and 75 teachers from 7 counties, who filled in an online questionnaire on the earthquake theme. Results revealed that more than 60% of the pupils participating in the survey know very little or nothing on how to behave in case an earthquake occurs, while 79% declared that they have never participated in any activity on the earthquake theme. The interest of the children in activities on earthquakes theme is very high: 70% of the children declared that they are willing to take part in activities on the earthquake theme if they are to be organized in schools, 95% are interested in learning how a seismograph works and 81% are interested in accessing an online platform offering information on the earthquakes. Children offered suggestions related to the themes they are interested in: the causes of an earthquake, their effects, the impact on buildings, the way to measure them, statistics, sharing experiences with people who faced an earthquake. They also mentioned that it would be important that activities should not offer only theoretical information, but also practical and interactive opportunities (trips, visits to museums, films, projects, practical experiments and group work). The findings on teachers revealed their poor initial training in seismology (the majority of the teachers declared that they have not been trained on the earthquake theme during their career) and their interest in running such activities in schools (80% of the respondents consider that the activities on the earthquake theme are needed in schools). Teachers offered also suggestions on the themes to be addressed with primary, gymnasium and high school children, addressing also the same need as the one expressed by children in relation to the way of organising these activities: in a practical and interactive way, using case studies, simulations, experiments, trips, debates projects and portfolios. In addition, they mentioned the need to have access on guides, technical support and online resource in order to be better prepared for running activities on the earthquake theme. All suggestions have been taken into account and integrated in the development of the educational resources.

The collection of the educational materials for different levels (kindergarten, primary, secondary and high school), entitled "Earthquakes and their effects" (Fig. 2), is organized, except the preschool level, in a guide for teachers accompanied by a booklet for students. The motto of the collection "We learn. We experiment. We protect ourselves" illustrates very well the structure of the educational material which is divided in theoretical chapters followed by sections with activities and experiments adapted to the level of understanding particular to each educational cycle. The collection covers the following topics: i) Defining an earthquake, ii) Why and how the earthquakes occur, iii) Measuring the earthquakes, iv) Earthquakes effects on the natural environment, and v) Earthquakes effects on the built environment, protection and safety measures. The developed materials have important educational character and do not require a high level of scientific knowledge in order to understand the concepts and activities.

The educational materials intend also to contribute to an overall improvement in science literacy. This is a sensitive issue mentioned in Institute of Education Sciences latest national report on the Romanian preuniversity education system [6]: Romania ranks at 2012 PISA evaluation amongst the last EU countries in the area of scientific competencies: 37.3% of students recorded poor results in science, while the EU average is 16.6% and the 2020 target is 15%. The report calls for urgent efforts in order to improve the quality of education in the following years – which our educational materials intended in respect with science education at preuniversity education.

Another aspects targeted by our educational materials are appreciation for the relevance of scientific research to society and attraction of the best and brightest young students into careers in science. First steps in these directions have been accomplished through participation in national educational contests with reports on seismology theme (*e.g.* the Contest of Creativity in Physics and Technology "Stefan Procopiu"). In the same time, the educational materials represent for teachers a starting point for publication of articles in school magazines [7].

Fig. 2 – Educational materials developed in the framework of the project.

Another group of actions were aimed to promoting the initiative in participating schools and organizing training workshops for teachers. The consortium made visits to all the nine schools participating in the project. Throughout these visits the project and the collection of educational materials developed to be used in school classes were presented to interested teachers and school boards. In the same time one SEP educational seismometer was installed in each school. Every seismic station from each participating school contains the educational seismometer and one desktop PC with jAmaseis package software installed for data acquisition [8]. Presently the recorded waveforms are available to the schools that are part of the project and are stored locally.

3. TRAINING WORKSHOPS FOR TEACHERS

Teachers are key players in project implementation. This requires dedicated support actions for their professional development in the field of Earth science in general and seismology in particular. Yearly workshops have been organized, where all the teachers from the schools participating in ROEDUSEIS-NET project (mainly science and geography teachers) were invited to participate. Workshop themes as *Teaching Earth Science in High School* or *Seismology in Schools. Activities and teaching modules for teachers involved in ROEDUSEIS network* have been approached. The leading goal of the workshops was to show how Earth Science topics can be learned in schools, in other ways than the traditional ones, as they were more focused on activities and experiments related to seismology. The training workshops mainly targeted secondary and high school teachers of sciences or geosciences who are interested in finding out how to use seismology in their own classrooms as a "hook" to get students interested in a wide range of science topics and as a socially relevant context for understanding how the work of scientists impacts everyday live. Simple earthquake related activities have been presented, such as recording, analysing, locating and measuring (magnitude estimation) an earthquake, as well as the way this information can be related to the subject of their discipline.

A special module of the workshops was intended in identifying the specific ways of applying in schools, at all educational levels, of the didactic activities based on the educational resources developed during ROEDUSEIS project. Two options have been considered: conducting certain activities in the context of different compulsory disciplines (*e.g*. geography, physics) and the possibility to introduce seismology in the curriculum an optional discipline. Together with teachers an optional curriculum was developed for all the pre-university educational levels.

An important part of the workshops was the feedback and the evaluation sessions, aiming to identify strong and weak points of the initiative that could be used to properly plan and correct future actions. Having in mind that one the final results of the project is to deliver best practices in initiating and implementing such activities, these groups of actions are crucial.

4. E-LEARNING PLATFORM

One of the main deliverables of the project is the E-Learning platform (http://www.roeduseis.ro). Besides basic information about the project (objectives, partners, participating schools, activities and results), the virtual space contains dedicated modules for free access to developed educational materials, online tools to visualize recorded seismic data and basic data analysis, as well as integrated communication tool for interaction between the members of the consortium, educational network participants and the general public. A special section is dedicated to sharing materials obtained within project school activities (photos, videos and text) between e-platform users. The concept of this e-platform, as well as targeted group beneficiaries, is detailed in Fig. 3.

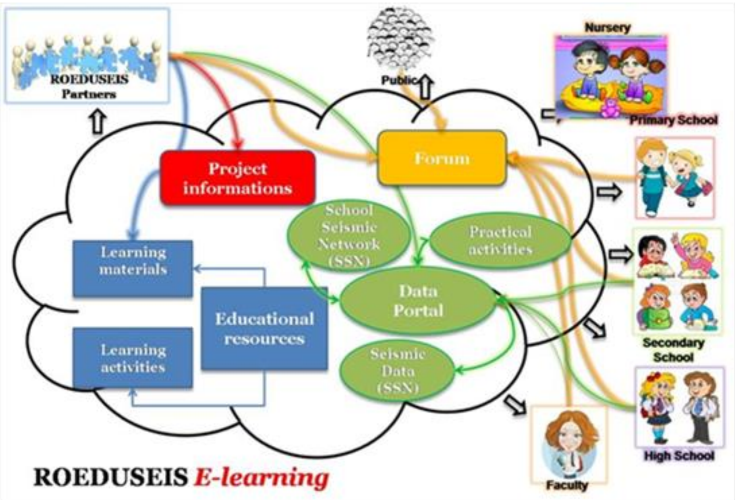

Fig. 3 – Concept and target beneficiaries of ROEDUSEIS e-learning platform.

A dedicated section of the platform displays real-time information about recent earthquakes occurred in Romania and neighboring countries to help teachers and students identify more easily and precisely an earthquake recorded by their school seismometer. A quest could start from this point forward for both students and teachers. If an earthquake is recorded at least by three school seismographs, the teachers could guide students to locate the seismic event using the educational software jAmaseis (Fig. 4).

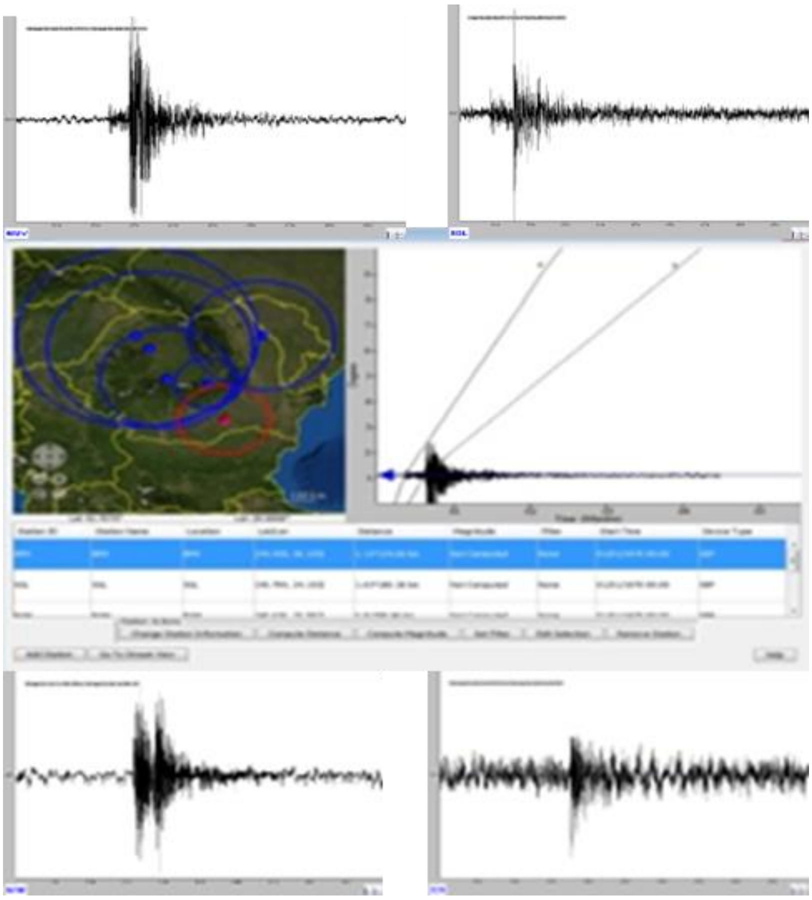

Fig. 4 – Earthquake location using jAmaseis software and data recorded by school seismographs.

An added value and the main scientific objective of the project is to create school based earthquakes waveforms database, which can be integrated with national and similar international databases (*e.g*. Incorporated Research Institutions for Seismology (IRIS), British Geological Survey (BGS)). Rather than being a new tool for formal education that can be used in the classroom, ROEDUSEIS e-platform should be considered as a modern method for teaching and learning that integrates and completes the work in classroom.

5. SEISMO LABORATORY – AN INTERACTIVE PLACE FOR STUDENTS AND TEACHERS

Dedicated facilities, in the shape of interactive seismological labs have been created within the project and are hosted, operated and maintained by partner institutions: one seismo lab at NIEP, one at INCERC and one at UBB. The demonstrative platforms intend to be centers for information and education on earthquakes and seismic risk. Within the laboratory, three types of activities are conducted for teachers, students and general public: i) activities for all school levels regarding information on earthquakes and increasing the awareness to seismic risk, ii) meetings and trainings for teachers, and iii) organization of small conferences and events for the general public.

The Romanian education system includes, starting with 2010–2011 school year [9] one week of non-formal education, when students learn things in different way than in the traditional class hours. The event called “School in another way: Knowing more, being better!” is organized every year during spring. This represents a great opportunity for students to visit and intensively use the seismo laboratories. During their visits, the students learnt about earthquakes, where and why do they occur, how can they be recorded, located and measured. Also, they learnt about the seismic regions in the world and in Romania and their main characteristics. The earthquake effects on buildings were exemplified using shake tables and the students found out that the buildings behave differently during an earthquake, depending on the type of the earthquake: surface earthquakes having higher frequencies affects mainly small buildings, while intermediate-depth earthquakes (like those in Vrancea area) with longer periods affects taller buildings. The presentations were adapted for each educational level of the visiting group, from kindergarten up to high school. In the same time, the seismo laboratories represent a meeting place where teachers and general public can discuss with experts on seismology, organize and prepare visits and work on programs of teaching activities.

6. HANDS-ON ACTIVITIES AND ACTIVITIES BASED ON SEISMOLOGICAL DATA

The ROEDUSEIS project promotes and fosters the concepts “inquiry based science” and “learning by doing” used more and more in teaching physics [10]. From kindergarten to high school, students are encouraged to ‘manipulate’ easily accessible things around them in order to understand the earthquake phenomenon and earthquake effects on natural and built environments, as well as to ‘handle’ and build scientific instruments, such as seismographs.

6.1. KINDERGARTEN HANDS-ON ACTIVITIES

The process of learning in kindergarten is supported by games. At preschool level, the child is taught to use nearby familiar objects in order to perform specific exploration activities, such as simulating and recording an earthquake [11]. To reach the desired success, the kindergarten teacher has to explain first to children the basic information related to planet Earth, how and why earthquakes occur, how they can affect our life and what we can do to protect ourselves during an earthquake. The booklet developed within the project for pre-school level represents the theoretical support based on which the teacher realizes the activities in the classroom. To accomplish the proposed themes, the teacher has to imagine different games that attracts the children and strengthens the concepts learned. For example, in Fig. 5 (on the left) is shown a model with buildings built on a line (*i.e.* fault). The model was made by the kindergarten children and was used by teacher to illustrate what happens during a small, moderate or strong earthquake generated by the movement of two tables (which simulate the movement on the fault) on which the model was put on. The children built seismographs using a pen and a roll of paper and captured the movement during the provoked earthquake (Fig. 5 – on the right).

At preschool age, the knowledge acquired through hands-on activities remain fresh in the child's memory for a longer period, thus it can be used and easily improved in the future.

Fig. 5 – Buildings and seismograph made by kindergarten children.

6.2. HIGH SCHOOL HANDS-ON ACTIVITY

Below is described an example of activity designed for high school class which is intended to explain the earthquake phenomenon and the travel of seismic waves through the Earth:

1) **Necessary materials**: brick, small ball, sandpaper, bungee cord, tape, writing desk and slinky.

2) **Procedure**:

a) Students learn that an earthquake is the shaking of the ground caused by a sudden release of energy in the Earth's crust. It appears at the contact of two tectonic units separated by a "line" named fault.

b) Earthquake simulation in class: the brick represents one side of a horizontal fault while the other side is the flat from writing desk. One side of the "fault" is covered with sandpaper and fixed with tape to create surfaces with higher friction. The grains of sandpaper grit are the contact points that act as asperities on the fault. Attached to the brick is a short bungee cord. The bungee cord stores elastic strain energy in the system much as crustal rocks do to accommodate plate motion. The brick is hold with one hand and with other hand the bungee cord is tensioned. The small ball is put in front of the brick. When the brick is released it will move forward and hit the ball which represents the seismic waves (Fig. 6).

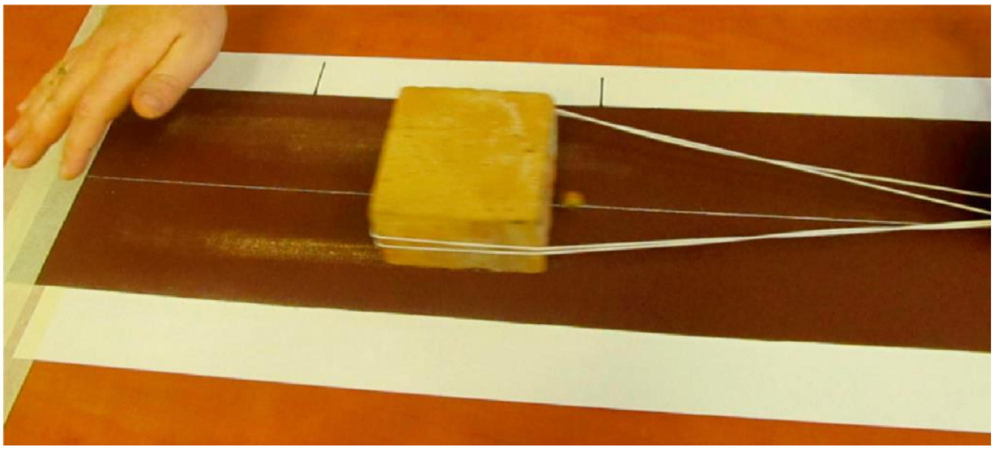

Fig. 6 – Earthquake simulation in classroom.

c) After the earthquake is produced the seismic waves are travelling through the earth. There are basically two types of waves: body waves (travel through the earth's interior) and crustal waves (travel along earth's surface). Most important are body waves represented by:

– **P waves** travel fastest, at speeds between 4–8 km/s (**P**RIMARY); can pass through both solids and liquids;

– **S waves** (transversal propagation) travel more slowly, usually at 2.5–4 km/s (**S**ECONDARY); cannot move through liquids.

The P and S waves have distinctive particle motions (Figs. 7a, b) and travel at different speeds. P and S waves can be demonstrated effectively with a slinky. Note that the motion of each coil is either compressional or extensional. The movement is longitudinal to the direction of propagation for the P wave (Fig. 7a) or transversal on it, for the S wave.

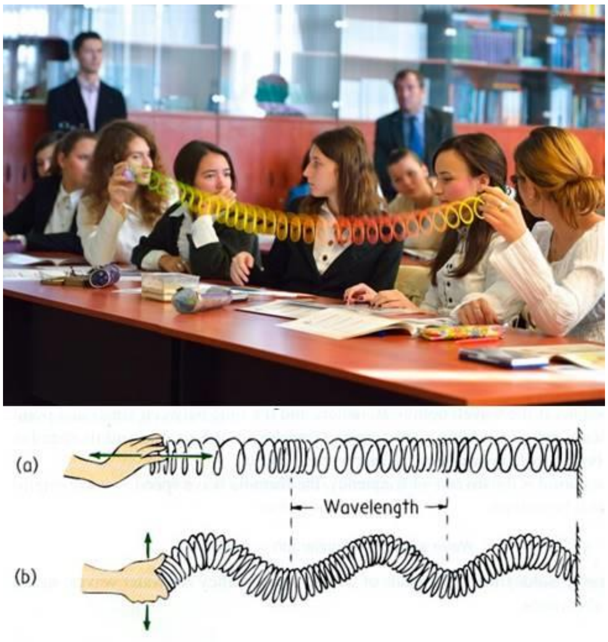

Fig. 7 – Students use a slinky to model earthquake waves, a, b.
Schematic representation of seismic wave propagation using the slinky model.

6.3. ACTIVITIES BASED ON SEISMOLOGICAL DATA

One of the goals of the project was to facilitate the access of the students and teachers to scientific instruments and experimental methods that are usually restricted to research laboratories in order to become familiar with the use of such instruments and the steps that are followed in any research study: recording, visualizing, processing and analyzing the data and finally, obtaining the results. This was achieved through the educational seismic network which allows to record local, regional and teleseismic earthquakes with the seismometers installed in the schools participating in the project, the e-platform which permits the access to the data recorded in each school as well as to the data recorded by NIEP's seismic stations made freely available on the platform and with the help of the researchers involved in the project.

The educational activities based on the seismological data are focused mainly on a more advanced processing of seismic signals that can be easily understood by students, especially from high schools and faculties: reading the P and S-wave arrivals, computing the epicentral distance (distance between the epicenter of an earthquake and the recording station) based on the arrival time differences of P and S-waves, locating an earthquake using the triangulation method, filtering of seismograms. These activities are based on two applications: jAmaseis – an educational program that allows viewing waveforms and locating earthquakes recorded by SEP educational seismometers and SeisGram [12] – a Java program widely used in seismological research, but also adapted for the use in schools and colleges that enables interactive visualization and analysis of earthquake seismograms recorded at any seismic station, either educational or professional.

Figure 8 shows an example of an interactive determination of the epicentral distance of a Vrancea earthquake using a waveform recording, the difference between the arrivals of the P and S-waves and SeisGram software. Students have the possibility to change some parameters (*e.g.* depth of the earthquake, the velocity of the P and S-waves in the crust, the depth to Moho discontinuity, etc.) in order to understand how these parameters can influence the arrival times of seismic waves.

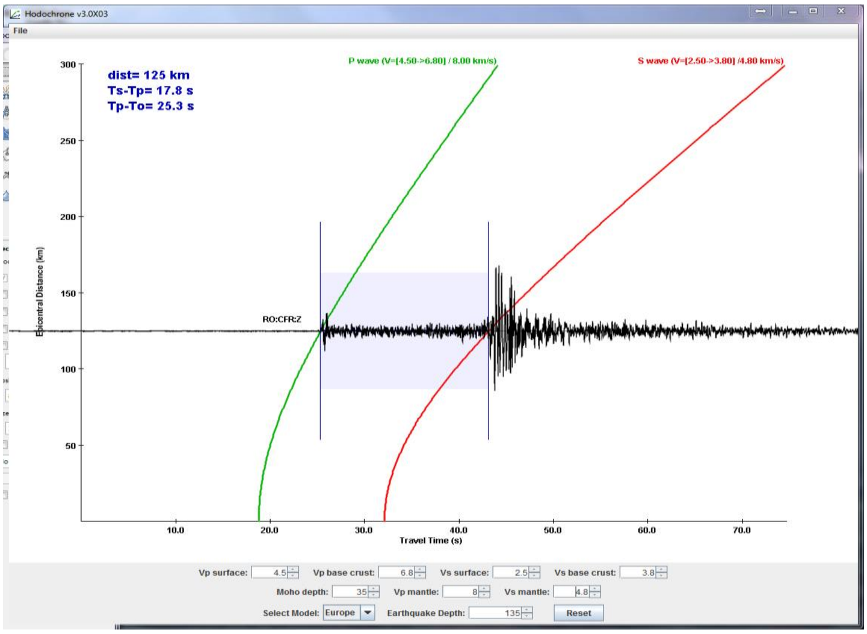

Fig. 8 – Example of epicentral distance computation using the graph of travel time difference between P and S-wave.

7. CONCLUSIONS

Even if the project is still in the implementation phase, the obtained results already proved that ROEDUSEIS is an efficient instrument for informing and creating awareness about seismic risk. This is due to two main components, educational – reflected by the direct involvement of the schools and social – approached by information diffusions towards the large public.

The main achievements can be synthesized as follows:

– developing, testing and implementation of ROEDUSEIS technologies (hardware and software) as learning tools about earth sciences;
– training and teachers personal development on the use of seismic station, analysis and data interpretation;
– elaboration of educational materials that also improve science literacy and students interest in science career;
– developing and testing new didactic modules with teachers involved in the project;
– developing an online educational earthquake database and specific e-tools for data access and sharing;
– design, realization and opening of 3 seismo laboratories with the fundamental aim to involve citizens in the experimentation of the social and educational activities, based on innovative methodologies and on the use of new technologies, with the aim to propagate the knowledge about earthquake phenomenon and seismic risk.

All the teachers involved in the project believe that seismic risk education can add a significant content to learning activities in schools. As future work, the project will aim to propose a national seismology interdisciplinary curriculum, at school choice, based on the educational materials developed and teachers/students feedback.

Acknowledgements. This work was done in the framework of ROEDUSEIS project, nr.220/2012 supported by UEFISCDI, program Partnership 2012. Also, we want to thank all the teachers involved in this project for their work at class.

REFERENCES

1. Berenguer JL, Courboulex F, Tocheport A, Bouin MP, *Tuned in to the Earth … from the school EduSismo: the French educational seismological network*, Bulletin de la Societe Geologique de France **184**, 183–187 (2013).
2. Courboulex, F., Berenguer JL, Tocheport A, Bouin MP, Calais E, Esnault Y, Larroque C., Nolet G, Virieux J, *Sismos à l'Ecole: A worldwide network of real-time seismometers in schools*, Seismological Research Letters **83**, *5*, 870–873 (2012).
3. Zollo A, Bobbio A, Berenguer JL, Courboulex F, Denton P, Festa G, Sauron A, Solarino S, Haslinger F, Giardini D, *Workshop and laboratory-based approaches, The European experience of educational seismology*, in: Vincent C. H. (ed.), *Geoscience Research and Outreach. Schools and Public Engagement*. *Series: Innovations in Science Education and Technology*, Springer, 2014, p. 340.
4. Balfour NJ, Salmon M, Sambridge M, *The Australian Seismometers in Schools Network: Education, Outreach, Research, and Monitoring*, Seismological Research Letters **85**, *5*, 1063–1068 (2014).
5. Zaharia B, Tataru D, Borleanu F, Bican-Brisan N, Georgescu ES, *Despre cutremure si efectele lor*, CD PRESS, Bucharest, 2013.

6. *Analiza sistemului de învăţământ preuniversitar din România din perspectiva unor indicatori statistici. Politici educaţionale bazate pe date*. Available at http://www.ise.ro/wp-content/uploads/2015/03/PUBLICATIE-Sistemul-de-invatamant-2014.pdf.
7. Chivarean D, Spiridon N, *Seismicitatea Romaniei*, CROMATIC Magazine **2**, http://www.revista-cromatic.ro/revista2.html#1 (2014).
8. http://www.iris.edu/hq/programs/education_and_outreach/software/jamaseis
9. Ordinul 4292/2011 privind structura anului şcolar 2011–2012.
10. Sporea D, Sporea A, Iacob C, *Inquiry-Based Science education in Dimensional Measurement Teaching*, Romanian Reports in Physics **67**, *3*, 1206–1217 (2015).
11. Sporea A, Sporea D, *Romanian teachers perception on inquiry-based teaching*, Romanian Reports in Physics **66**, *4*, 1253–1268 (2014).
12. http://alomax.free.fr/seisgram/SeisGram2K.html.