

The Earthquakes in the area around Adriatic Sea, the causes and measures to reduce their negative consequences

Msc. Lira Musollari
University of Tirana

Abstract

Earthquakes are a shake or movement of Earth that are caused by large splits of the under Earth rocks, under the effect of different forces, in the vast majority of cases it is caused by the movement of tectonic plates of the Earth's lithosphere. The scientific evidence to understand the cause of earthquakes is found in the theory of "The movement of tectonic plates", refined by the known German geophysicist Venger and is presented in his book "The Origin of Continents and Oceans".

The scholars confirm that during their movement, in the meeting lines, tectonic plates create erosion and breakage of great dimension that are accompanied by a large release of energy which is transmitted to the Earth surface through seismic waves causing massive damage. One of these areas is also the region in the both sides of Adriatic that corresponds with the suburb of Adria mini plate.

According to scientists, in the West of Adria plate, passes through Apennine peninsula beginning from Sicilia, Calabria, in the Apennine slopes to Padane lowland, passes in Europe Alps, Dinarid, Albanid to the Greek territory. The Apennine peninsula and especially the central part is continuously struck by earthquakes, because according to researches, Adria plate under the pressure of African plate, is moved towards North and Northeast creating longitudinal cracks that generates strong seismic shaking. This is confirmed from the numerous studies that known personalities of seismology and INGV specialists in Rome have carried.

Another area with high seismic level is Padane lowland, which is also under the effect of Adria plate movement towards Northeast, that causes the closure of Padane lowland. Apennine move towards Southern Alps creating the conditions for earthquakes emerge. The high seismic level is also noticed in the eastern suburb of Adria plate that corresponds with the territories of our country, the Dalmat coast in the North and Helenide in south. According to researchers, in Albanian lands are two longitudinal areas and some cross sections: the longitudinal areas: Janine-Korce-Diber-Peje; Sarande-Vlore-Durres-Shkoder-Ulqin. Whereas the cross sections are the areas: Lushnje-Elbasan-Diber; Vlore-Tepelene-Erseke; Shkoder-Kukes-Prizren.

The precautions to be taken in reducing the negative effects of earthquakes might be classified in three directions:

The assignments of scientific ents;

The assignments of legislative and enforcement state institutions;

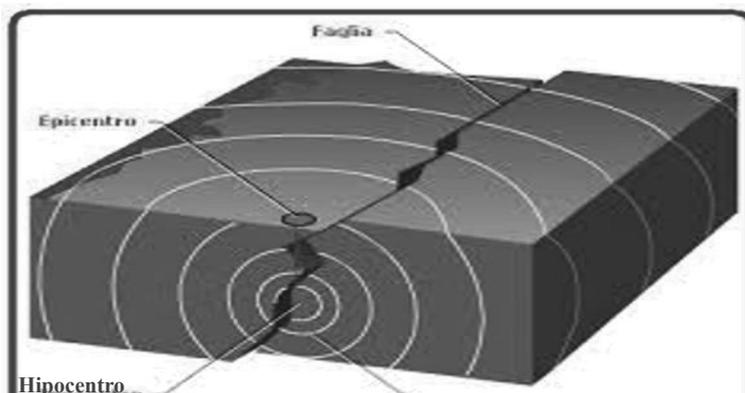
The education of population in how to act during and after an earthquake.

Keywords: the earthquake, the movement of tectonic plates, Adria mini plate, African plate, Eurasian plate, areas with high seismic level.

Introduction

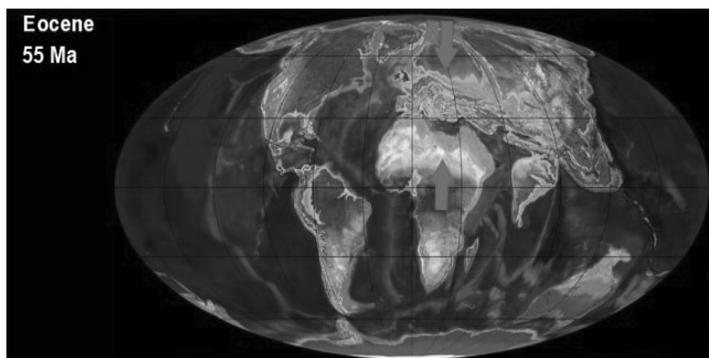
Earthquakes are a shake or movement of Earth that are caused by large splits of the under Earth rocks, under the effect of different forces (Gianotti, 2007). The earthquake

is an unforeseen natural phenomenon caused in most cases by the movement of tectonic plates of the Earth's lithosphere. They are created by a powerful and immediate energy release during the present breakages in the Earth's crust. Due to the constant movement of the tectonic plates, very large amounts of energy are constantly accumulated in large rock masses on both sides of the breakages and when the accumulated energy reaches its peak, it is transmitted in the form of an immediate move. The released energy is dissipated in the form of seismic waves through the rocks to the surface of the earth causing shaking that we call earthquakes.



The scientific basis for understanding the causes of earthquakes and high degree of seismicity of geographic areas around the Adriatic Sea is found in the theory of the "The movement of Tectonic Plates" of the well-known German geophysicist, A.Vegener stated in his book "The Origin of Continents and Oceans" at the beginning of the last century. Today his work constitutes the basic scientific theory for the recognition of a series of phenomena that occur in depth and on the surface of the earth, including the main causes of earthquakes.

The theory of the tectonic movement of lithosphere plates, gives us the opportunity to recognize not only the geological origin of our lands which were born on the plate "Adria", an extension of the African plate, but also a series of other phenomena such as the process of orogenesis of Alps and Apennines, the numerous earthquakes in

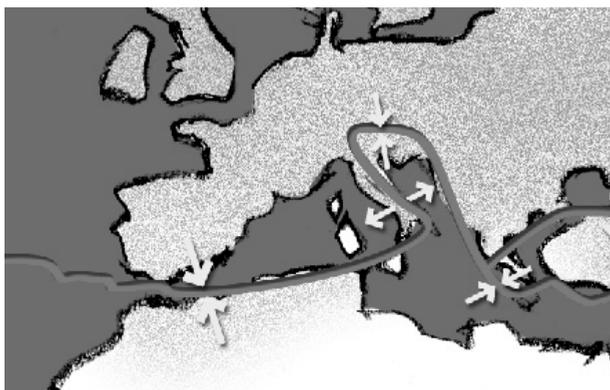


the area etc. The "Adria" plate that was located in the shallow ocean of Tetis, between the African and Eurasian plate, being pressed constantly from the movement of the African plate to the north, crashed with the Eurasian plate.

Given the enormous consequences that are evident on the surface of the earth, the phenomenon of the Tectonic Plates collision has become the subject of many studies and intensive surveys by the scientific research centers. The studies confirm that the Tectonic Plates meeting line during their convergent, divergent or parallel movement leads to weakening, corrosion and breaking of their edges. These fractures of enormous size also affect other breaks of the inner layers of the rocks and are transmitted to the surface of the earth through seismic waves. In this way the contact line of the tectonic plates turns into the main area where earthquakes arise. Based on this, scientists have identified and "inventory" today all areas with seismic hazard extended mainly around the perimeter of tectonic plates. One of these areas is the space on both sides of the Adriatic, which includes the Apennine and the Balkan Peninsula and corresponds to the periphery of the miniplate "Adria".

The Earthquakes in the West of the "Adria" plate, on the Apennine Peninsula

From studies conducted by scientific research centers turns out that during the last millennium, of 1300 earthquakes that have struck the Mediterranean area about 500 were just on the Apennine peninsula many of which have been devastating. This has made the Apennine area become the subject of intensive studies to determine the causes of these earthquakes and also defining areas with higher seismic hazard to avoid their negative effects. Nowadays is scientifically confirmed that the high seismic level on the Apennine peninsula is created due to the movement of the Adria plate towards the European plate that is put under pressure from the African one. The miniplate "Adria", as the elongation of African plate passes in the area of Sicily, Calabria, on the slopes of the Apennines to the Padane lowland and continues in the direction of the Alps of Europe, includes the Dinaric Alps, the territories of our country to the Greek territory. In this way it is driven in the Eurasian plate between the Apennine and Balkan Peninsula, under the constant pressure of the African plate.



Le placche tettoniche nel Bacino del Mediterraneo

Throughout this geological scenario the Apennine peninsula has the bad luck to be on the area of the movement of the African plate to the Eurasian. Apennines, the vertebral column of the Italian peninsula lie on the dividing boundaries of the miniplate "Adria" with the European plate. Exactly over this dividing line that starts from Sicilia, Calabria and traverses the whole central part of the Apennine peninsula, including the Umbrian, Marche, Lazio and Tuscany boundaries a series of cracks are being provoked that are expanding and constitute the origin of earthquakes that this area generates. Scientists claim that this makes the Apennine ridge come expanding and the Adriatic Sea come closing. Prof. Carlo Meletti, scientific researcher at INGV in Rome, in an interview to the newspaper "Messaggero" one day after the earthquake of August 24, 2012, says: "The gap involved here is of a distal type, so that one part of the Apennines moves towards the Adriatic, while another part is left behind, how to draw the both sides of a sheet until you tear it off. In this way the Apennines are expanding"¹. As well Prof. Stefano Salvi of INGV in Rome on the occasion of the earthquake of August 24, 2016, in a communication with the newspaper "La Stampa" said: "... The Italian peninsula compressed between the African and the Eurasian plates move towards the Balkans with a greater speed in the southern regions ... while the Tyrrhenian coast remains largely stable and the Adriatic along with the Apennine Mountains continues to move towards the former Yugoslavia with at least 5 m every 1000 years"². The phenomenon of the expansion of the Apennine base is also confirmed by the GPS system data that have been processed by the INGV in Rome. Prof. Carlo Melletti of INGV in an interview to the journalist Ana Lisa Bonfranceschi (La Stampa) on August 24, 2016 said: "In its GPS data results that the speed of the mountain chain movement (Apennine) in these areas is very high"³. Prof. Tertulliani in a communication with the newspaper "La Stampa", on October 1, 2016 states that: "Italy is located in an area where occur even fractures with crashes of crossed forces which extend the Tyrrhenian Sea and narrow the Adriatic"⁴. All this geological scenario explains the large number of earthquakes which strike continually the central part of the Apennine peninsula starting from Sicilia, Calabria, Campania, Lazio, Umbria, Marche, Tuscany to Emilia.

It should be emphasized that this area has been struck not only by numerous earthquakes but also with very powerful and with serious consequences ones. To better understand this it is enough to take into the consideration only the period 1899-1999, a 100 year period during which over 20 earthquakes with a magnitude of 5 to 7 degrees on the Richternga scale have been identified from which: 11 earthquake with a magnitude 5.0-5.9 of the Richter scale, 7 earthquakes with magnitude 6.0-6.9 and 2 earthquakes with a magnitude above 7.0 degrees on the Richter scale⁵.

Thus it is one earthquake in every five years, except to a very large number of earthquakes of lesser power. There are some of these earthquakes that have left very serious consequences in people's lives and property damage such as: the earthquake that struck Calabria on June 07, 1905 with 557 dead, Mesine's earthquake on December

¹ Prof. Carlo Meletti, interview to the newspaper "Messaggero" August 24, 2012.

² Prof. Stefano Salvi, in a communication with the newspaper "La Stampa".

³ Prof. Carlo Meletti, interview to the newspaper "La Stampa", August 24, 2016.

⁴ Porf. Tertulliani, interview to the newspaper "La Stampa", October 1, 2016.

⁵ The History of Earthquakes in Italy, INGV, Rome.

28, 1908 with over 100,000 dead, the Abruco-Avecano earthquake on January 31, 1915 more than 30,000 dead etc. In addition to these powerful earthquakes which have caused considerable damage and many other less powerful, in this area are registered thousands of other earthquakes that although not felt by the population, show the unstable situation in the area. According to prof. Alessandro Amato of INGV in the first half of August 2016 (which preceded the August 24 earthquake) 581 earthquakes were registered, with an average of 39 earthquakes per day and from these seven are with a magnitude of 3 or more: two in Friuli, one in Molise, one in Calabria and three in Tiren. It should be emphasized that the next months are characterized with the same seismic intensity⁶.

The earthquake of August 24, 2016 that struck the central area of the Apennine peninsula, included the provinces of Riet, Perugia, Ascoli-Piceno, Aquila and Teramo here municipalities closer to the epicenter and had the most damage are: Amatrice, Akumoli and Arkuata del Tronto. The feature of this earthquake is the small depth of the hypocentre, about 7 km and therefore caused considerable damage. This earthquake, as many other earthquakes in this region, was being followed by multiple shaking after the main strike. The seismic network of INGV in Italy has recorded more than 3200 earthquakes of various sizes from August 24 to 31, 2016.

Another high seismic area on the Apennine peninsula where a complicated geological process takes place directly related to the movements of "Adria" plate is the Padan Lowland.

The Padan Lowland makes up the separating boundary between the Apennines and the Alps, thus divides the north of the Apennine mountains from the south of the Alps of Europe. Influenced by the movement of African plate Towards the Eurasian plate, the Apennines move to the Alps leading to the closure of the Padan Lowland. According to the studies conducted, in depth of the Padan Lowland the lower layers of the Apennines have already joined the Alps of Europe and are gradually moving towards the closure of the Lowland. This makes this area also a different space with high seismic level. In a study prepared by INGV specialists in Rome and published in the magazine "Pure and Applied Geophysics", "Blind Gaps" are analyzed and classified in the depth of The Padan Lowland summarizing all the experience gained with the studies that have been conducted after the Emilian earthquake on May 2012. In this material is emphasized that: "The Padan Lowland represents a geological feature because the sediments that cover this area keep hidden one *thrust*, or an invers gap between the southern Alpine in the north and the northern Apennines in the south. In fact these two ranges, that we see separated, in the exposed part, in their depths covered by sediments have nearly come to meet"⁷. This approach of these ranges is the result of the oppression that African plate has on Adrian pushing it towards the European plate. The study highlights that "The approach of the Alps with the Apennines, in north-south direction, thus as result of this is the narrowing of the Padan Lowland, is still in action". This shrinking of the Padan Lowland, in depth, below marine sediments, at the meeting point among the

⁶ Prof. Alessandro Amato interview to the newspaper "La Stampa", September 30, 2016.

⁷ P.Vanoli, P.Burrasco e G.Valese, "The sismotectonic of the Po Plain: tectonic diversity in a blind faulting domain", 2014 published in "Pure and Applied Geophysics" magazine.

depths of the Alps and the Apennines generates compressive energy. That makes us understand that below the sediment of the Padan Lowland are active tectonic layers capable of generating earthquakes. Such a fact is confirmed not only from scientific measurements and observations by the specialists with technical tools, but also from actual facts, from earthquakes that have historically struck this area. So there is the earthquake that struck Ferrara in 1570, the one that struck Argenta in 1624, the many earthquakes that struck Bologna in 1929, all with a magnitude of 5.5 to 6. Finally in 2012, "the burial" gap is also being activated in the depths of the northern Apennines with the earthquake of Emilia which is very similar to the earthquake of Emilia in 1570. The most powerful earthquake that has occurred in the Padan area is that of January 3, 1117 that struck Verona and the areas that lie to its south, with a magnitude of 6.7 causing great damage to the lives of people and their properties.

As a conclusion we can say that, just as it has been, even in the future it is quite possible that the Apennine peninsula, continue to be hit by earthquakes of different sizes without excluding earthquakes of severe strength which can cause significant damage. This is due to its position on the Mediterranean geological scene, where it is in pressure, on the way of moving of the African plate to the Eurasian one. This will definitely lead to continuous tectonic fractures causing shaking that will leave consequences on the surface of the earth especially in the central part of the Apennines.

Earthquakes on the east side of "Adria" plate

While in the western part of Adria plate lies the Apennine peninsula, in its eastern part lies the Balkan Peninsula where are also the Albanian territories. Actual data on seismic strikes of these areas during the early geological periods are missing, however, studying the relief of these areas we find the signs of old tectonic fractures, such as horse, graben, marine terraces etc. which speak about the geological dynamics of these areas. In the earliest geological periods and especially during the last millenniums there are also data on damage to our inhabited centers caused from earthquakes. Thus, today is accepted that "One of the causes of the destruction of Apollonia, has been because of the earthquakes that struck this ancient city in the III or II century BC. Also Durres was struck by the earthquake in 177 BC, in 57 or 58 AD, in 334, 506 and 1273 even in 1926. The earthquake of 1273 has caused 25000 victims, destroying the city totally".

Other earthquakes during the last millennium we can mention the Butrint earthquake of 1153 and that of Kruja in 1617. On October 17, 1851, a powerful earthquake struck Berat, where 400 soldiers were killed in the city's castle. "The earthquake series in the city of Shkodra during the 19th century began with that of 1815 and is followed by the earthquake of 1837 and 1852, which according to Prof.Sulstarova was as strong as that of 1905".

Over the last century our country has been struck by a series of earthquakes and the most powerful is considered the one of June 1, 1905 in the city of Shkodra with a very tragic balance, that of Peshkopi on August 24, 1924, which left 44 dead, 119 injured

and destroyed nearly 80% of the houses. The same situation was almost repeated on 30 November 1967 when the earthquake struck the districts of Dibra and Librazhd by killing 12 people, wounding 174 and destroying 177 villages. This earthquake created a landfall of about 10 km and a vertical landslide up to 50 cm. During 1944-'89, our country was struck by 17 earthquakes which had caused damage, on the average such an earthquake every two years".

Not only in the territories of our country, but also across the Dalmatian coast, the eastern periphery of "Adria" plate has been in the same situation. Old documents speak about a powerful earthquake which struck the Roman city of Cask in 361 that has completely destroyed the city and island of Pag in Croatia. In 515 another powerful earthquake destroyed the city of Skopje. This city was destroyed by the earthquake in 1555 and for the third time in 1963, when 100 people were killed and about 3,000 were injured. In 1969 it was destroyed by a powerful Banjaluka earthquake, while other earthquakes struck the town of Vrana near Belgrade, in 1418 and the catastrophic earthquake that struck Dubrovnik in 1667 destroying the city and killing about 5,000 people. Historically, the cities of Dubrovnik, Zadar, Split, Ljubljana etc. have been hit several times.

Causes of earthquakes in the Balkans and especially in Albanian territories are primarily related to the movement of African plate to the Eurasian one and the "Adria" miniplate as part of the African plate. The Mediterranean area, which also includes the territories of our country and the Balkans, are areas once covered by the Tetis ocean and today make up the meeting line of African and Eurasian plates in the Mediterranean Sea-Black Sea-Caspian Sea direction and goes to the east. This movement has not only led to the tectonic rise of the area, but has also created tectonic fractures of underground rocks generating earthquakes in continuity. According to seismologists, our country is covered by two longitudinal seismic zones and then there are some transverse fractures that complement the scenario of geological breaks. Longitudinal breaks are in lines:

- Ionian-Adriatic seismic area extending north-south along the Saranda, Vlora, Durrës, Lezha, Shkodra, Ulcinj;
- Longitudinal seismic areas in the Korca, Ohrid, Diber, Peja,
- In addition to these two longitudinal areas parallel to the edges of Adria plate that move below the Eurasian, there are also some tectonic transverse areas:
 - Lushnjë-Elbasan-Dibër;
 - Vlorë-Tepelenë-Ersekë;
 - Shkodër-Kukës-Prizren.

The seismic area that is quite active recently is that Vlore-Tepelena-Ersekë. In the period August 6-9, 2006, 161 seismic strokes were recorded in this area. This line is classified as the area with the most regular periodic shakings. According to specialists in this problematic line powerful earthquakes are registered once every 30 years, the last of them was registered in Nivica village in 1968. We also mention that on November 20, 1920, an earthquake with magnitude 8 struck Tepelena causing 36 victims and 102 injured, destroyed 2500 homes and left over 15,000 people homeless. Ten years later in Vlore and Tepelena another earthquak caused 30 dead and 100 injured. According to specialists, dozens of other earthquakes have been recorded

over these years, but the shakings have been light and have not caused any damage and victims.

The Balkans and especially the Albanian territories in the future are likely to continue to be seismic areas because they are areas under the influence of the movement of the "Adria" plate to the Eurasian as well as the ever closer approach of the African plate to the Eurasian one, but also because these spaces are characterized by relatively new and easily breakable rocks.

Measures to avoid the negative consequences of earthquakes

Just like volcanoes, geysers etc also the earthquakes are natural phenomena that occur in accordance with the laws of nature. They stand for normal developments in the life processes of geological development of the earth. In this way we can say that earthquakes are not a fatality. It is important that we recognize and respect the laws of their normal development.

From the studies conducted science has been able to determine the fundamental features of earthquakes: they are unpredictable, develop in a very short period of time that is measured in seconds and usually occur in the same areas.

Despite the efforts that have been made, science has not been able to predict the moment of the earthquake collapse yet and knowing that it takes place in a very short period of time, we have many difficulties in avoiding or reducing the damage that may arise. In this regard, the third feature is helpful to us, the fact that earthquakes usually strike the same areas.

The theory of tectonic plates movement is an extraordinary contribution in recognition of areas with seismic hazard. Studies have shed light on the causes of earthquakes and consequently areas where they are repeated in time. Nowadays based on these data there are prepared maps of areas with seismic hazard, areas that match the periphery of the tectonic plates of the Earth's lithosphere. By recognizing these areas, measures are taken to organize life and human activity in these areas, or near, taking into account seismic hazard. If today earthquakes continue to cause major damage to the lives and wealth of citizens this is due to the negligence of people and institutions that do not respect the laws of nature related to earthquakes. So for instance in Italy, after the considerable earthquake damages of August 24, 2016, specialists and researchers of INGV Rome have given the alarm for disrespect of rules on organizing life in areas which are already known for the high seismic hazards. Prof. Massimo Cocco, a specialist at this scientific institution says: "The last earthquake (August 24) has occurred in a known area that is at the highest level of risk. All new constructions must be made with anti-seismic criteria, but the problem is that in those areas the constructions are without any anti-seismic criteria", while prof. A.Tertullianii INGV says: "It is unusual that houses continue to be destroyed, although the risk of the area is known". Many other seismic science authorities in Italy have stated the same thing, findings that apply to all other countries where seismic zones are identified.

These problems are noticed even in our country. So the scholar and specialist of seismology, S.Koçiu referring to the construction and expansion of the cities of our country, make numerous remarks about disrespect of anti-seismic rules The

measures to be taken to respond to the difficult situations that come as result of seismic movements can be in three directions:

- The assignments of seismic scientific institutions;
- The assignments of legislative and enforcement state institutions;
- The Education of the population on lifestyle and behavior before, during and after an earthquake.

Scientific research institutions have the duty to study the history of seismic movements in

the area they cover and identify areas where the earthquakes are repeated. They should also do the geological study, the layers of rocks, their types and resistance to fractures. In this way, the seismic risk of the relevant area is determined by compiling the respective map.

The data and conclusions of scientific institutions should be carefully analyzed by the legislative and enforcement state institutions in order to legally discipline the way of life organization and activities in these areas, especially in terms of settlements, industrial buildings, infrastructure, ports and airports which should be avoided in areas with high risk and should be build in accordance to anti-seismic criteria in the least risky areas.

To reduce the negative effects of earthquakes should also be done the education of people when they are still in school. The educational work also includes the way people act when the earthquake strikes, thus during the seismic movements and after them. This is very important because these moments are shocking to residents as they need to maintain calmness and performing punctual actions to avoid as much as possible the negative effects of seismic shock. It is also important the behavior after the earthquake collapse, as there are moments when the collapse of the buildings continues, there may be after seismic shock, there may be water bursts, fire, gas explosions, etc.⁸

References

- Bosellino, A. (2001). "Storia geologica d'Italia".
- Gianotti, A. & Modelli, A. (2007). "Earth Science".
- Muço, B. (2001). "Earthquakes, Underground Demons".
- Sulstarova, (E. (2013). "Albania, here are the most endangered areas from the earthquakes"
- Sulstarova, E. & Kociu, S. (2014). "The catalog of earthquakes in Albania".
- Vanoli, P. & Burrato, P. & Valense, G. (2001). "The sismotectonic of the Po Plain: diversity in a blind faulting demoin", 2014.
- Vegener, A. (2011). "Origin of continents and oceans".
- Interviews given to Italian press after the earthquake on 24th August 2016 in Italy from known researches of INGV, Rome: Prof.A.Tertulliani, Prof.Carlo Meletti, prof.S.Ardito, Prof. A.Amato, Prof.M.Cocco.

⁸ Betim Muço, Earthquakes, Underground Demons.