5. INTEGRATED EXAMPLES FROM REAL EQs.

Some strong seismic events occurred in the Greek territory, during the period 2003 - 2007 of the operation of the installed, monitoring network, for the registration of the preseismic, electric signals. These EQs provided the raw material to test and validate the methodology, already presented. Depending on the time span of the used data, one monitoring site was used **(VOL)**, two monitoring sites were used **(ATH, PYR)** and only once, just recently after the installation of **(HIO)** monitoring site, three monitoring sites **(PYR, ATH, HIO)** were used.

The examples to be presented refer to the following earthquakes:

Zakynthos, Greece, 04/04/2006, Ms = 5.7 R.

East of Kythira, Greece, 08/01/2006, Ms = 6.9 R.

South of Creta, Greece, 24/11/2003, Ms = 5.1 R.

Lefkada, Greece, 14/8/2003, Ms = 6.4 R.

Skyros, Greece, 26/7/2001, Ms = 6.1 R.

For each earthquake, the following parameters will be presented:

- Time of occurrence vs. daily, tidal, lithospheric oscillation.

- Time of occurrence vs. 14days period, tidal, lithospheric oscillation.

- Calculation of the epicenter, based, on preseismic, electric signals.

- Determination of magnitude.

- Accelerating deformation / quiescence, if any.

5.1. Zakynthos, Greece, 04/04/2006, Ms = 5.7 R.

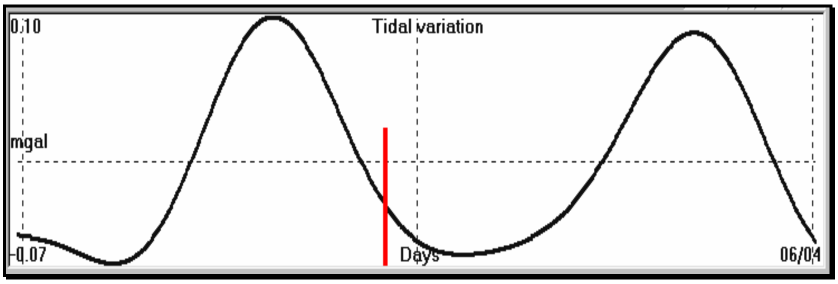

Fig. 5.1.1. Daily, tidal, lithospheric oscillation vs. time of occurrence of the EQ in Zakynthos, Greece, 04/04/2006, Ms = 5.7 R.

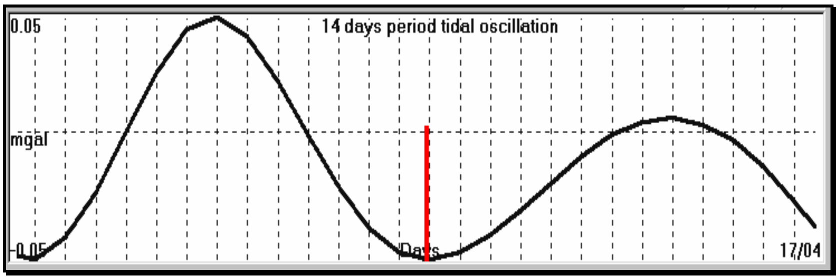

Fig. 5.1.2. 14 days period, lithospheric oscillation vs. time of occurrence of the EQ in Zakynthos, Greece, 04/04/2006, Ms = 5.7 R.

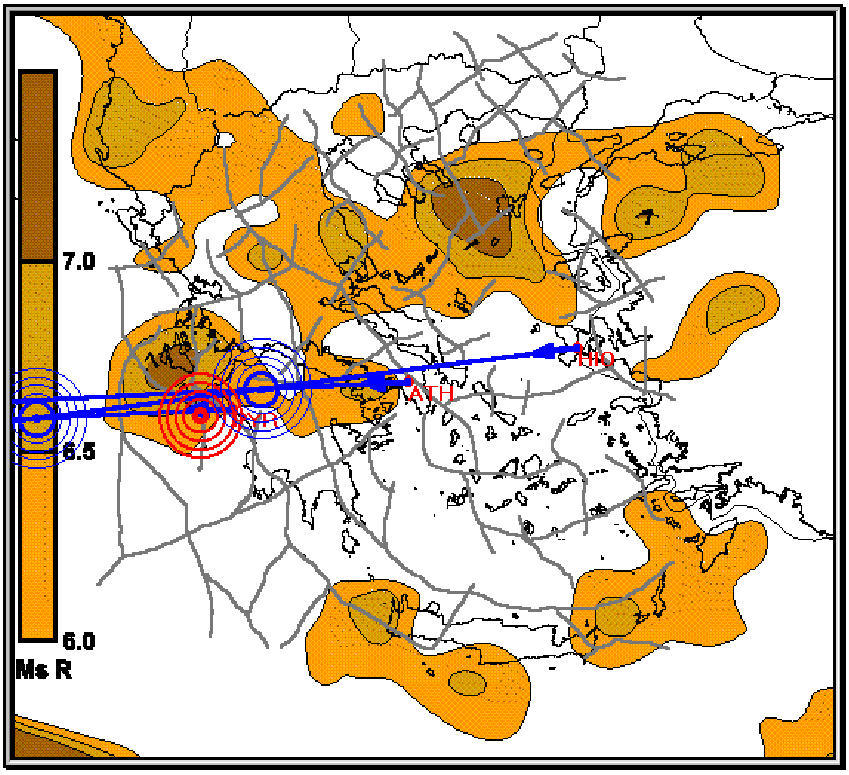

Fig. 5.1.3. Epicenter areas (blue circles) determination by electric precursory signals vs. to epicenter (red circle), determined, by seismological methods for the EQ in Zakynthos, Greece, 04/04/2006, Ms = 5.7 R.

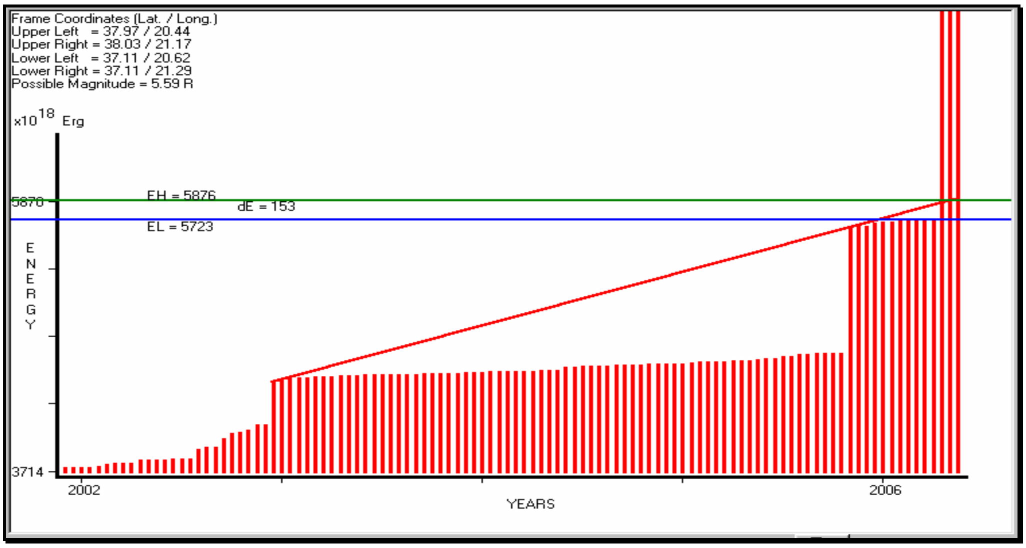

Fig. 5.1.4. Magnitude calculation, as M = 5.59 R, for the EQ in Zakynthos, Greece, 04/04/2006, Ms = 5.7 R.

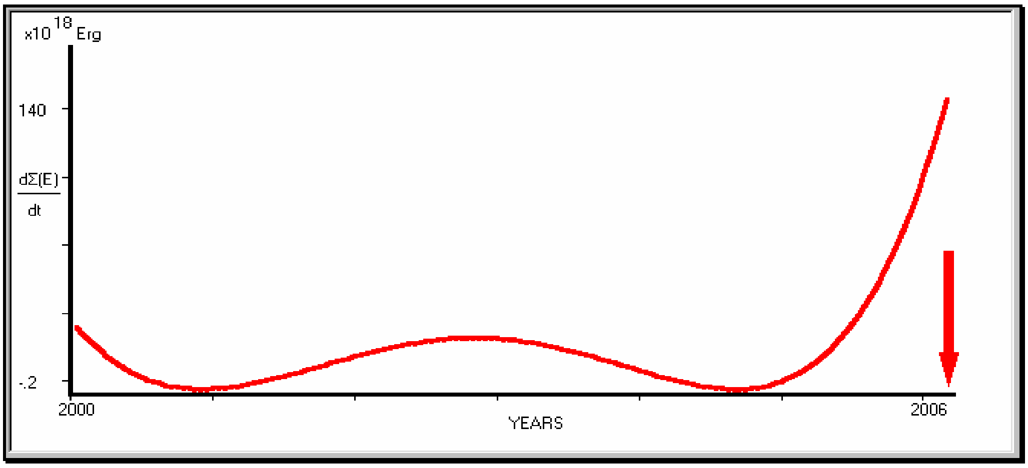

Fig. 5.1.5. Increased accelerated, seismic energy release rate, observed, prior to the EQ in Zakynthos, Greece, 04/04/2006, Ms = 5.7 R.

5.2. East of Kythira, Greece, 08/01/2006, Ms = 6.9 R.

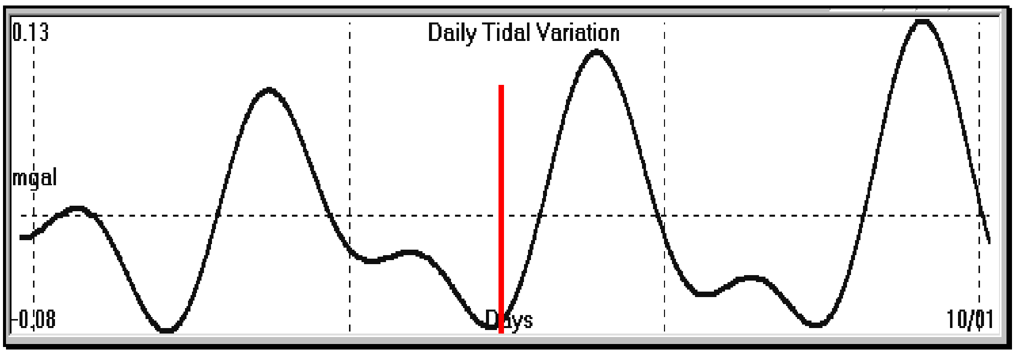

Fig. 5.2.1. Daily, tidal, lithospheric oscillation vs. time of occurrence of the EQ, East of Kythira, Greece, 08/01/2006, Ms = 6.9 R.

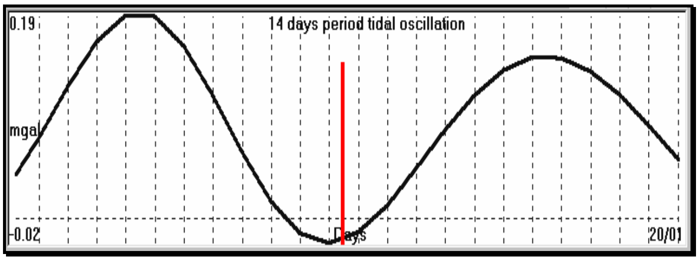

Fig. 5.2.2. 14 days period, lithospheric oscillation vs. time of occurrence of East of the EQ in Kythira, Greece, 08/01/2006, Ms = 6.9 R.

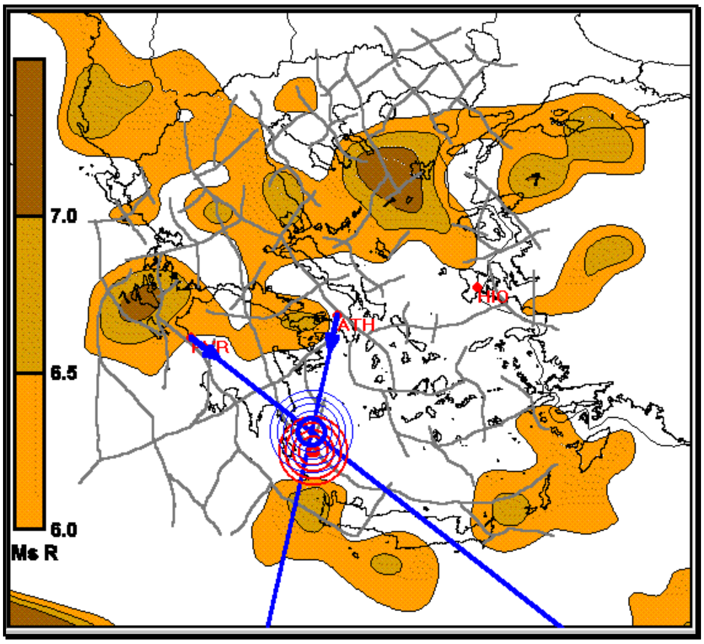

Fig. 5.2.3. Epicenter area (blue circles) determination by electric precursory signals vs. to epicenter (red circles), determined, by seismological methods for the EQ, East of Kythira, Greece, 08/01/2006, Ms = 6.9 R.

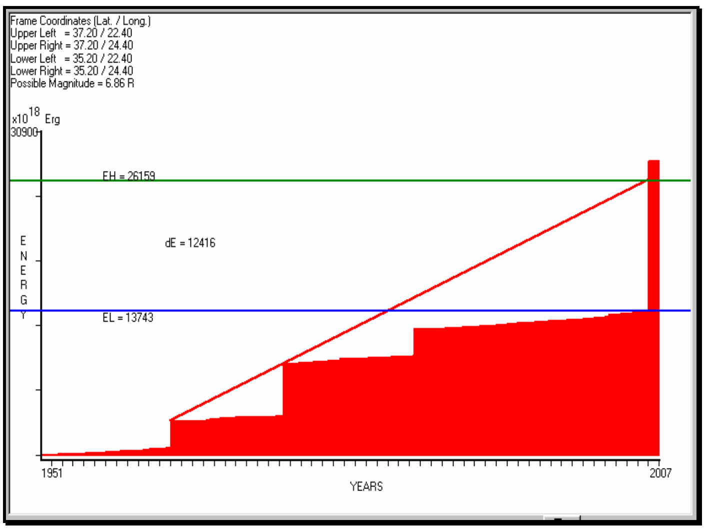

Fig. 5.2.4. Magnitude calculation as M = 6.86R for the EQ, East of Kythira, Greece, 08/01/2006, Ms = 6.9 R.

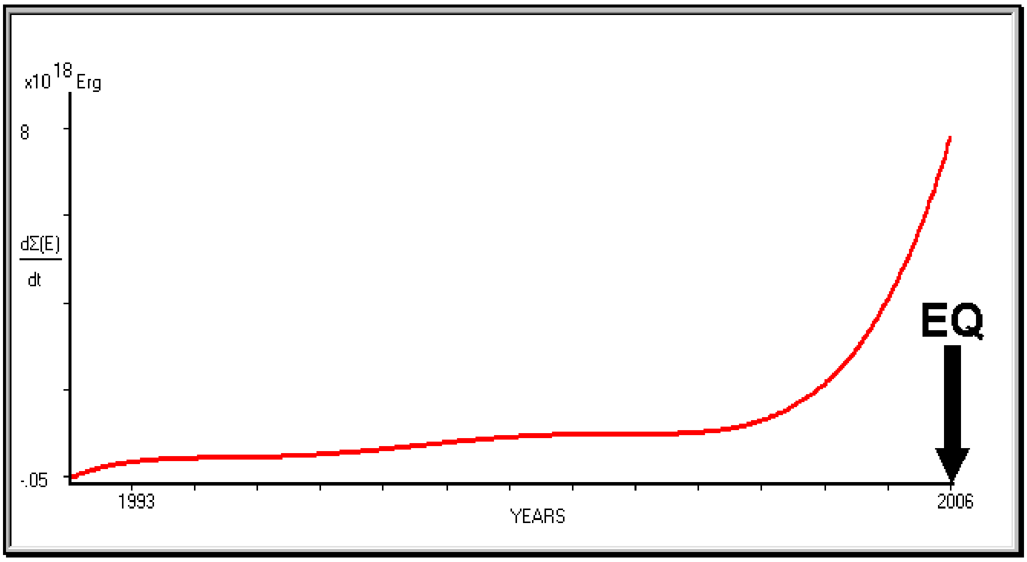

Fig. 5.2.5. Increased, accelerated, seismic energy release rate, observed, prior to the EQ, East of Kythira, Greece, 08/01/2006, Ms = 6.9 R.

5.3. South of Creta, Greece, 24/11/2003, Ms = 5.1 R.

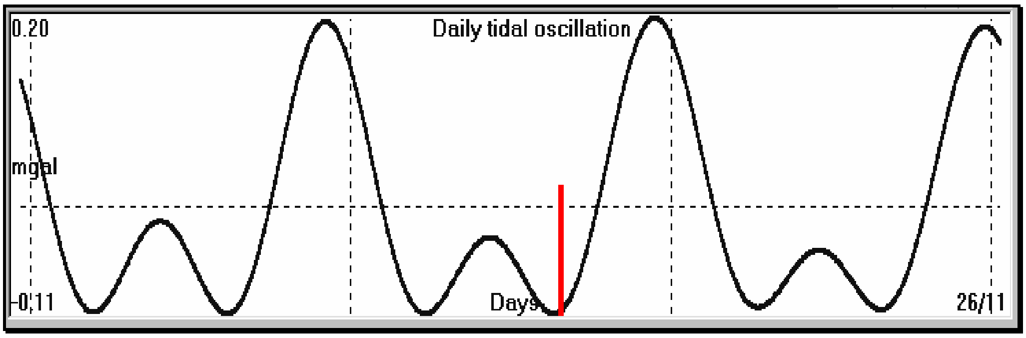

Fig. 5.3.1. Daily, tidal, lithospheric oscillation vs. time of occurrence of the EQ, South of Creta, Greece, 24/11/2003, Ms = 5.1 R.

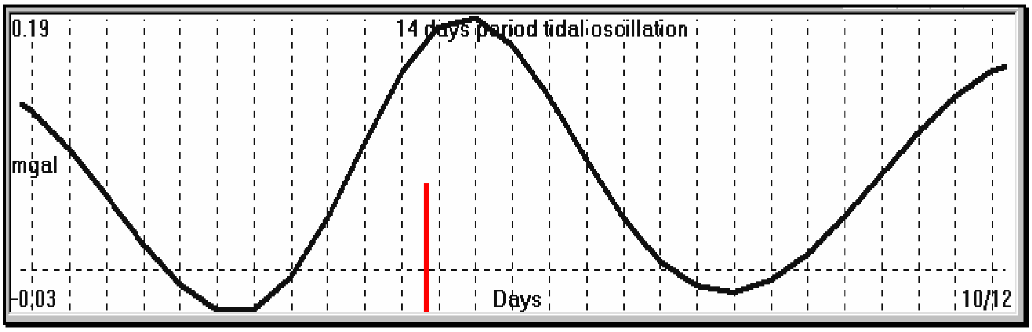

Fig. 5.3.2. 14 days period, lithospheric oscillation vs. time of occurrence of the EQ, South of Creta, Greece, 24/11/2003, Ms = 5.1 R.

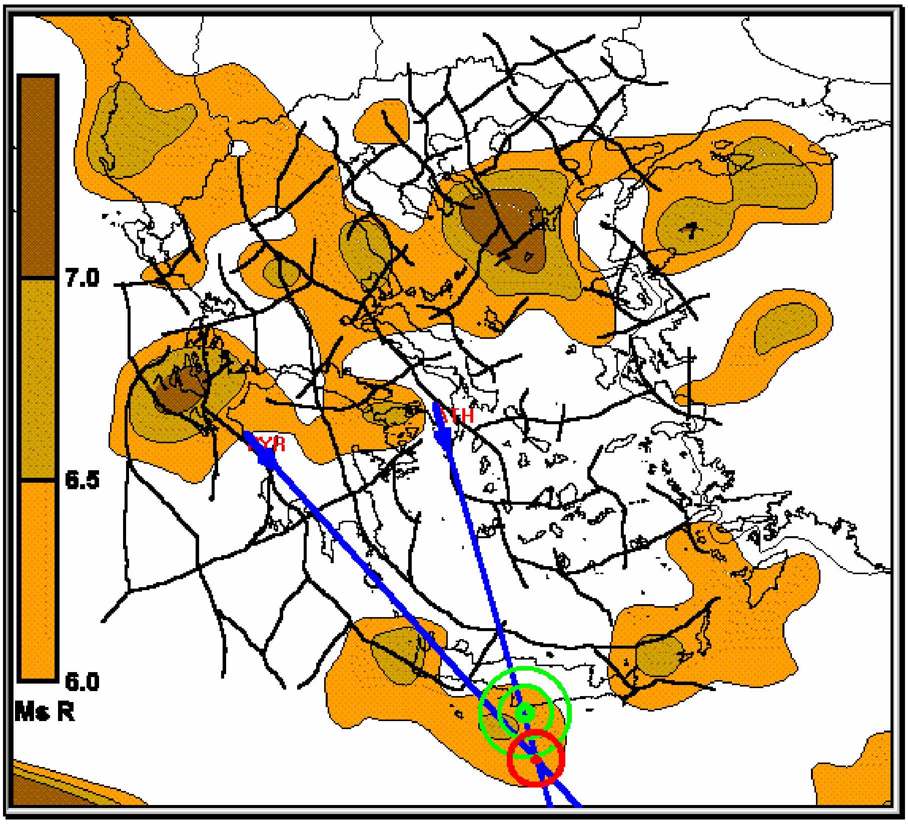

Fig. 5.3.3. Epicenter area (red circle) determination by electric precursory signals vs. to epicenter (green circles), determined, by seismological methods for the EQ, South of Creta, Greece, 24/11/2003, Ms = 5.1 R.

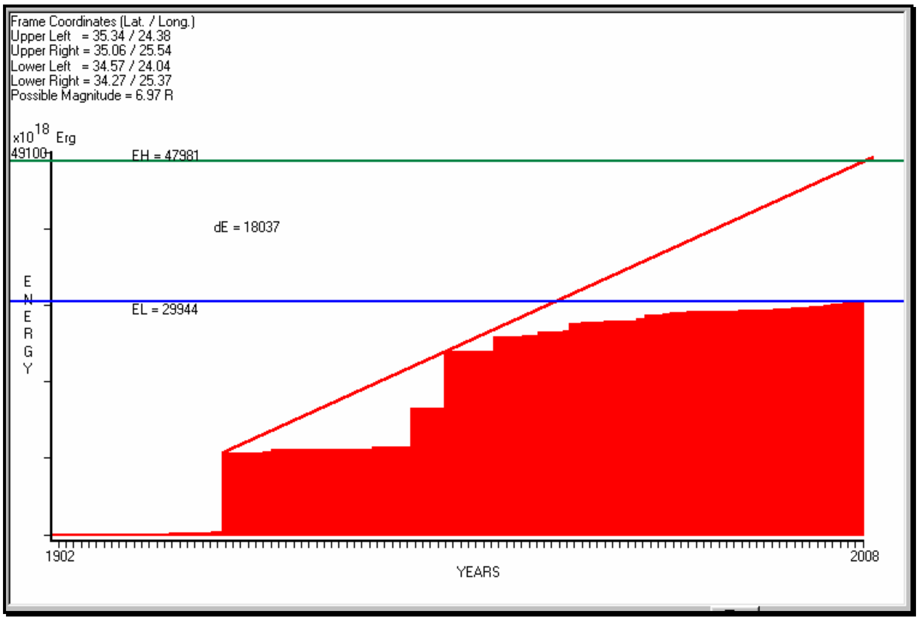

Fig. 5.3.4. Cumulative, seismic energy release indicates that the seismic area (EQ, South of Creta, Greece, 24/11/2003, Ms = 5.1R) was at "lock" conditions and a magnitude M = 6.97R earthquake could occur due to the stored already seismic energy.

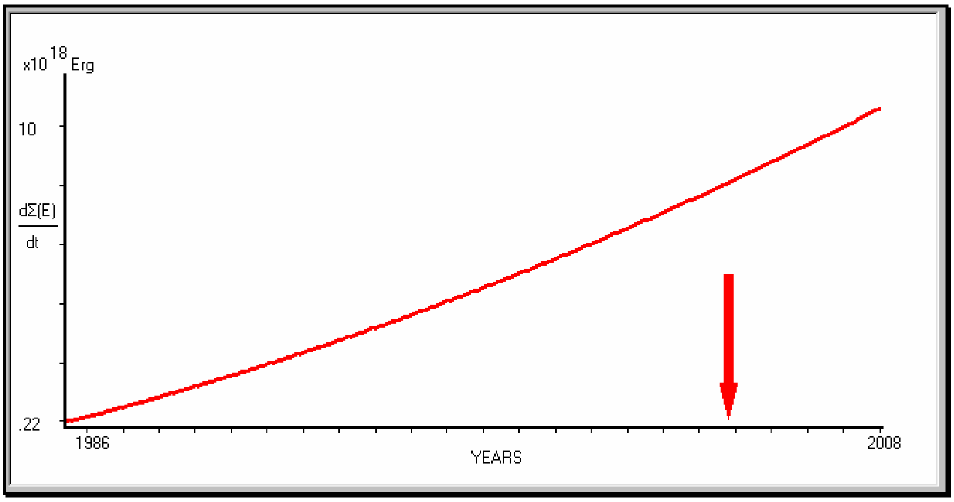

Fig. 5.3.5. No significant, seismic, energy release rate increase is observed, since 1986 for the regional area South of Creta, Greece, EQ, 24/11/2003, Ms = 5.1 R.

5.4. Lefkada, Greece, 14/8/2003, Ms = 6.4 R.

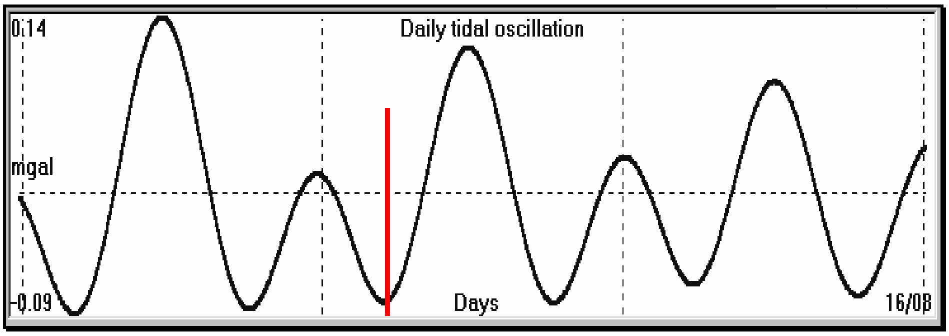

Fig. 5.4.1. Daily, tidal, lithospheric oscillation vs. time of occurrence of the EQ in Lefkada, Greece, 14/8/2003, Ms = 6.4 R.

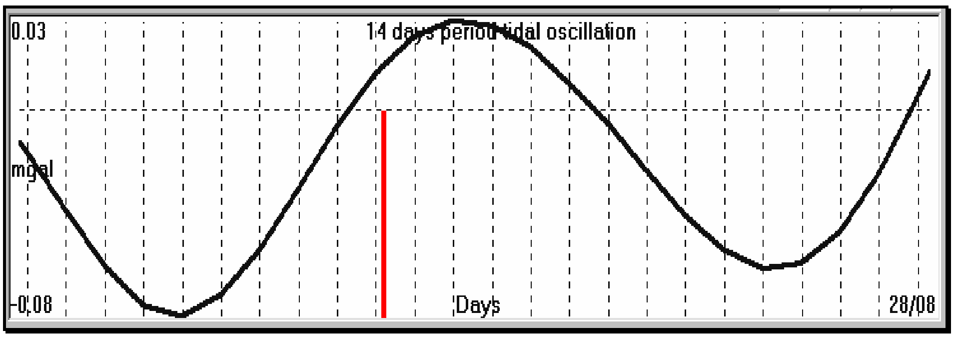

Fig. 5.4.2. 14 days period, lithospheric, oscillation vs. time of occurrence of the EQ in Lefkada, Greece, 14/8/2003, Ms = 6.4 R.

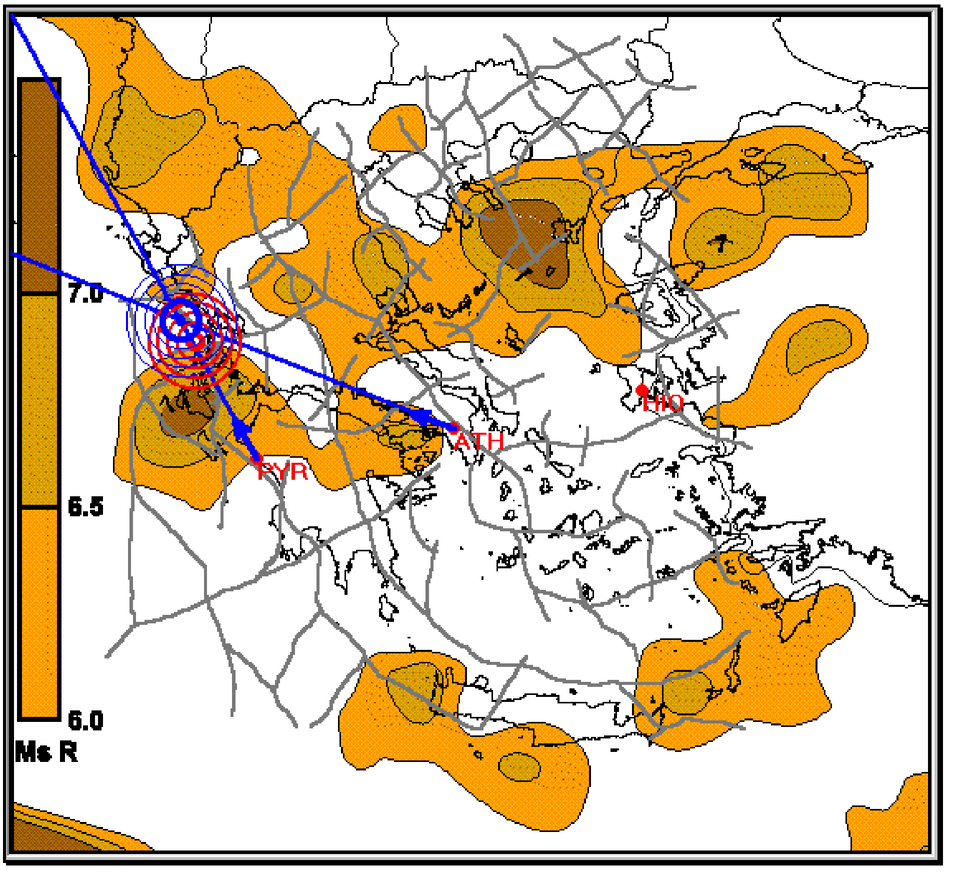

Fig. 5.4.3. Epicenter area (blue circles) determination by electric, precursory signals vs. to epicenter (red circles), determined, by seismological methods for the EQ in Lefkada, Greece, 14/8/2003, Ms = 6.4 R.

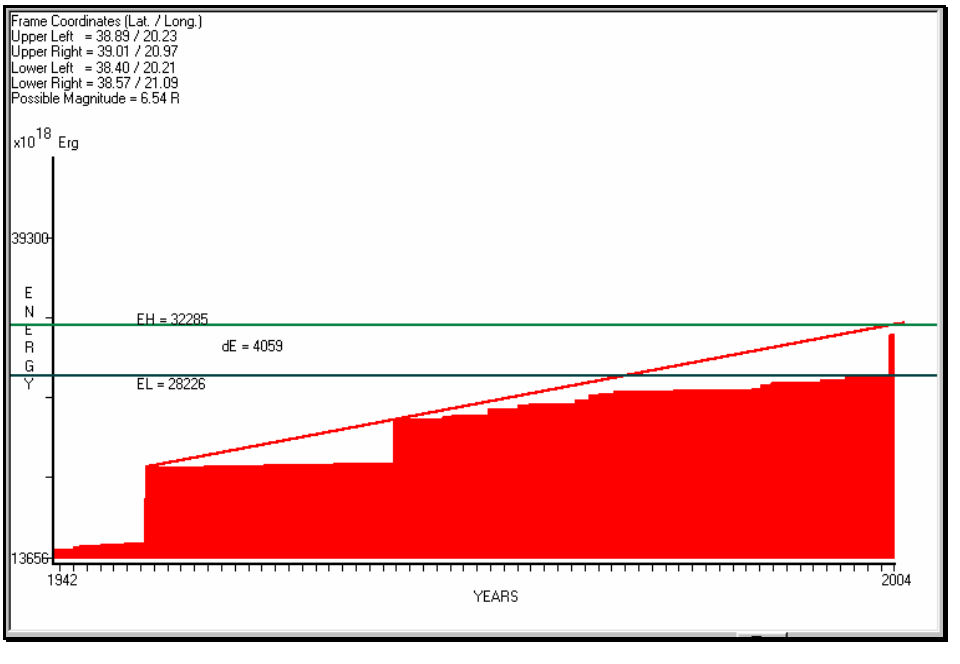

Fig. 5.4.4. Magnitude calculation as M = 6.54R for the EQ in Lefkada, Greece, 14/8/2003, Ms = 6.4 R.

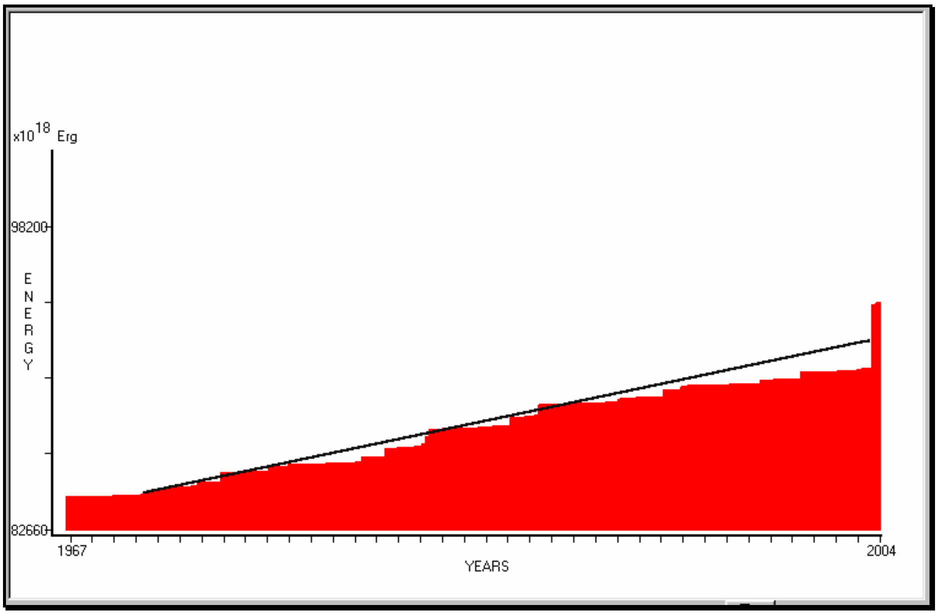

Fig. 5.4.5. Seismic "quiescence" is observed for almost nine (9) years before the EQ in Lefkada, Greece, 14/8/2003, Ms = 6.4 R.

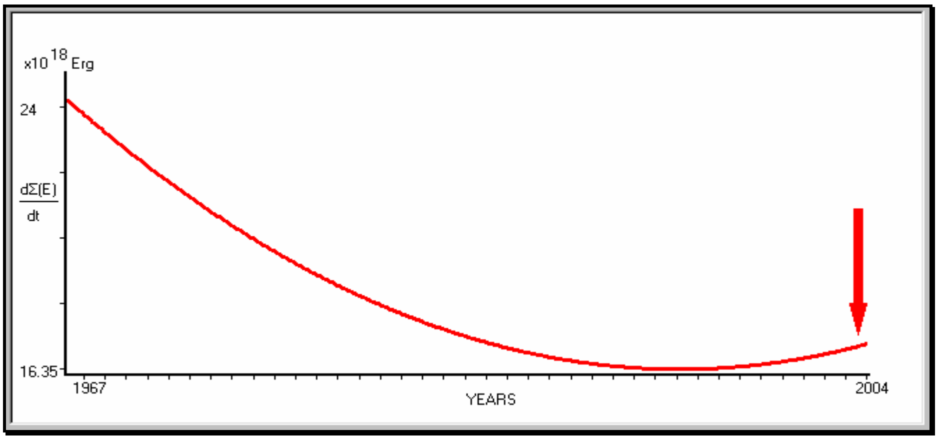

Fig. 5.4.6. De-accelerating, seismic energy release rate, observed, for the EQ in Lefkada, Greece, 14/8/2003, Ms = 6.4 R.

5.5. Skyros, Greece, 26/7/2001, Ms = 6.1 R.

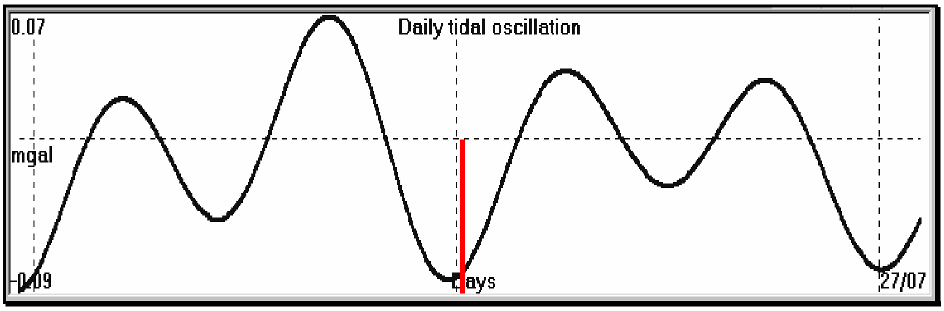

Fig. 5.5.1. Daily, tidal, lithospheric oscillation vs. time of occurrence of the EQ in Skyros, Greece, 26/7/2001, Ms = 6.1 R.

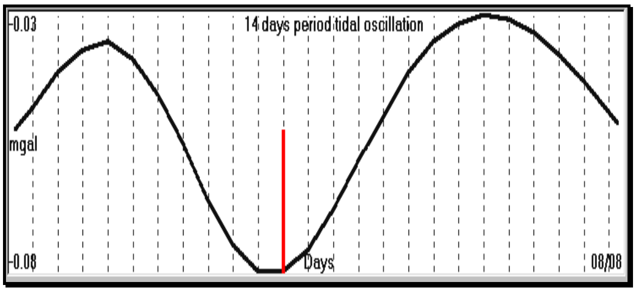

Fig. 5.5.2. 14 days period, lithospheric oscillation vs. time of occurrence of the EQ in Skyros, Greece, 26/7/2001, Ms = 6.1 R.

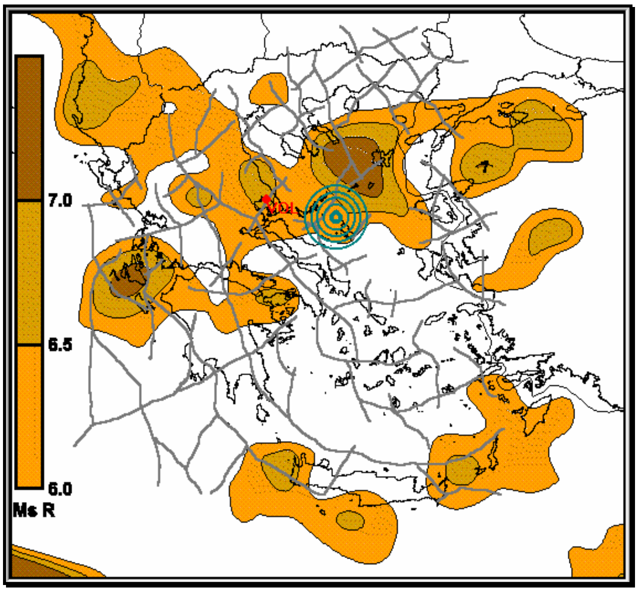

Fig. 5.5.3. Foreshock location (green circles, 21st July 2001, M = 5.1R) that preceded the main, seismic event of the EQ in Skyros, Greece, 26/7/2001, Ms = 6.1 R.

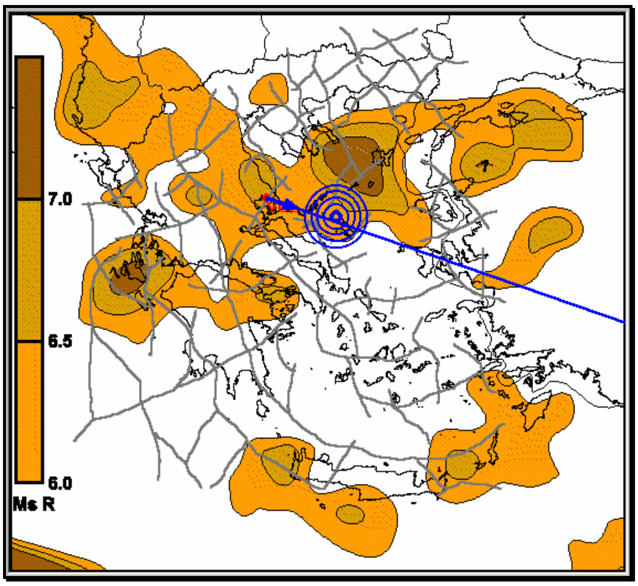

Fig. 5.5.4. Azimuthal direction of the Earth's electric field intensity vector, determined, for **VOL** monitoring site, in relation to the location of the EQ in Skyros, Greece, 26/7/2001, Ms = 6.1 R.

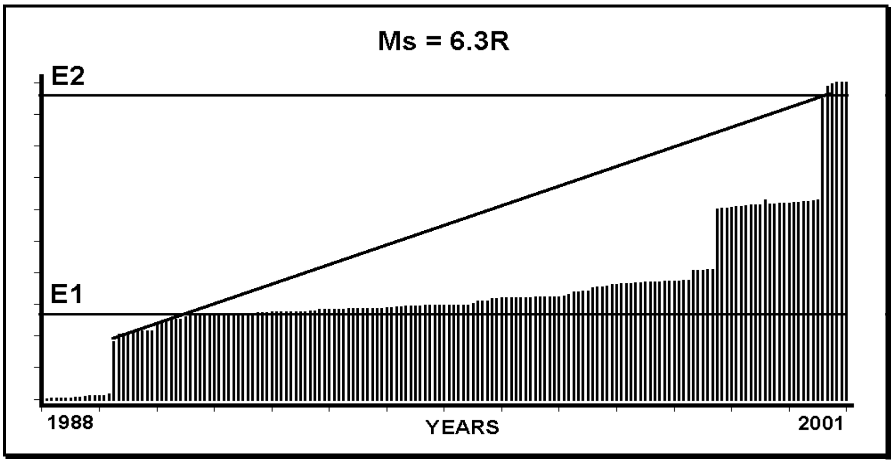

Fig. 5.5.5. Magnitude determination for the EQ in Skyros, Greece, 26/7/2001, Ms = 6.1 R, when a longer “lock” period is considered.

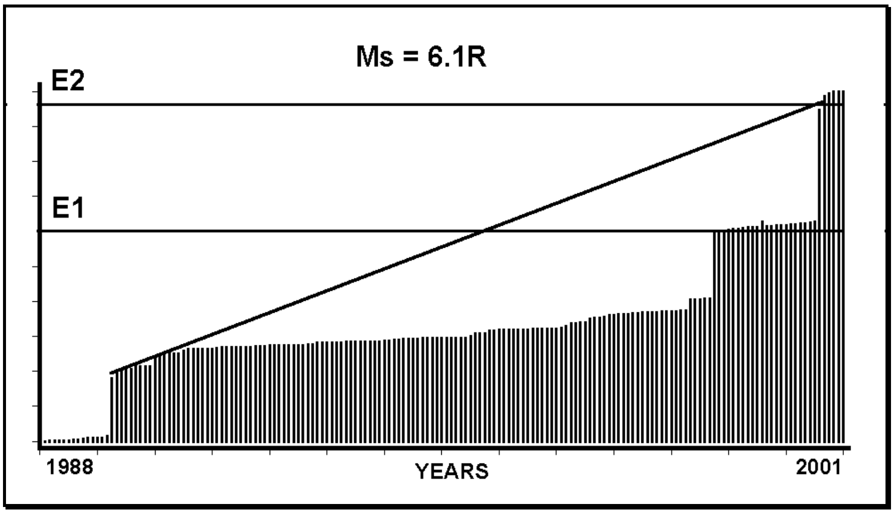

Fig. 5.5.6. Magnitude determination for the EQ in Skyros, Greece, 26/7/2001, Ms = 6.1 R for the last “lock” period.

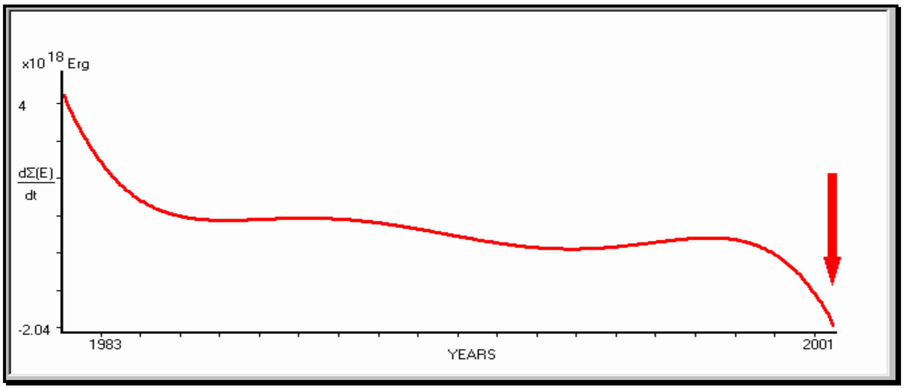

Fig. 5.5.7. De-accelerating, seismic energy release rate (seismic "quiescence"), observed, for about two years before the occurrence of the EQ in Skyros, Greece, 26/7/2001, Ms = 6.1 R.

In all the presented examples, the cumulative, seismic energy release was calculated by taking under consideration a seismogenic area that is closely related to the major, lithospheric, tectonic features which are present in the vicinity of the determined, epicentral area. The latter is in compliance to the postulated "Lithospheric Seismic Energy Flow Model", introduced, in section (2.5.1).

6. IMPLEMENTATION OF THE METHOD.

The theoretical part of the methodology has already been presented. Moreover, examples of analyzed, real seismic events have been presented, too. An overall flow-chart that shows how all these topics, already dealt with, are integrated in an actually working procedure will be shown in this part of the presentation.

In the following figure (6.1) are given the various steps (numbered accordingly) which are followed in order to have a successful short-term earthquake prediction.

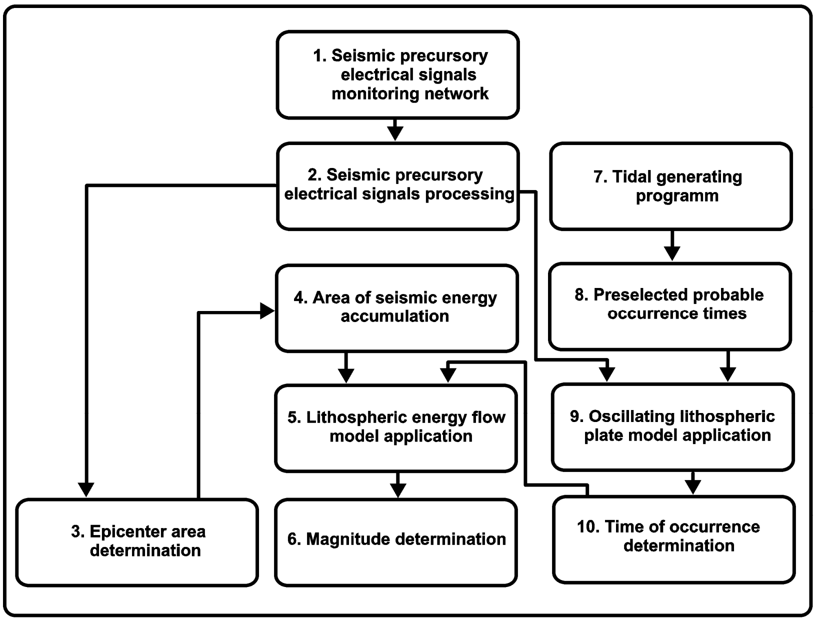

Fig. 6.1. Flow-chart, indicating the different, interrelated steps, to be followed, for a successful, short-term earthquake prediction.

The specific flow-chart has two distinct inputs. The first one (step 1) is the monitoring of the Earth's electric field, while the second one (step 7) is the generation of the theoretical, tidal, lithospheric oscillations.

The most probable occurrence times, for a future strong earthquake, are selected, from data which are generated from step (7), at step (8).

From step (1), the seismic precursory electrical signals are processed at step (2) and these signals are correlated at step (9) with the results of step (8). The output of this operation, is the time of occurrence of the future earthquake (step 10), through the use of the oscillating, plate lithospheric model.

From step (2), the epicentral area of the future earthquake is determined at step (3). As an immediate result of this calculation, there is the possibility to calculate the corresponding, cumulative energy which is stored in the regional seismic area as a function of time (step 4) using as input, the past, seismic history of the regional, epicenter area which has already been calculated.

Furthermore, the time of occurrence is already known from step (10) and therefore, the lithospheric, seismic energy flow model can be applied at step (5), using as inputs the output of step (10) and step (4). Consequently, the magnitude (step 6) of the future strong earthquake can be calculated.

In the already followed procedure, just two data inputs were used; namely the seismic, electric, precursory signals and the specific times when max - min oscillating, lithospheric stress-load is achieved.

In conclusion, the three parameters (time, location, magnitude), needed for a successful earthquake prediction, may be determined, following the algorithm, presented, in figure (6.1).

7. OVERALL CONCLUSIONS.

The study of strong earthquakes is not the same, as it could be, when studying other physical phenomena. Actually, if a seismological experiment is conducted in real time, it is not guaranteed that within the time span of the experiment some strong earthquakes will take place, serving thus the purpose of this research. On the other hand, it is completely different to fracture rock specimens, under laboratory conditions, from studying an earthquake under natural conditions. The character of the rare occurrence of strong earthquakes poses a real problem to the study of their prediction.

As a first approach, the chaotic, in time, behavior of their occurrence led the researchers to apply statistical methods. Some "return times" of occurrence, at specific, seismogenic areas, were found through the used, statistical methodologies. This was especially facilitated, where long seismic history was recorded in the past, thus enabling statistical methods to be applied.

Consequently, seismological research, aiming into earthquake prediction, developed with, mainly, statistical methods (and use of earthquake catalogs) in countries with low seismicity, while in other highly seismogenic countries the earthquake prediction topic was additionally dealt with other methodologies, too.

An important parameter, generally, in any “in situ" earthquake prediction research project, is the country, where this project will be performed. It is evident, that not all countries are suitable for such research activities. What is actually required is a high, seismicity country, which will provide in a reasonable time span (as long as the research project lasts) the adequate, seismic events, so that any postulated theoretical scheme can be successfully tested.

Greece, a country with large seismicity, due to its location on a major, seismic belt, is the country where this research took place. This facilitated, a lot, the development of the methodology, already presented, by providing strong enough, seismic events data in a rather short period of time.

In the course of the development of the earthquake prediction methodology, the basic principles, as in any research field, were followed. In brief, these are as follows:

- Observations of some physical parameters are made in nature.
- A theoretical model is postulated, which justifies the generation of the observations.
- Following the theoretical model, theoretical observations are made.
- Comparison is made between the theoretical and the real observations in nature.

In case, a satisfactory agreement is found between the theoretical observations and the real ones, then the model is adopted as a valid one that represents what actually happens in nature, regarding this physical phenomenon. In a different case, the postulated model is disregarded and a new one is being searched.

A problem the seismologists, who study the topic of earthquake prediction, face is that there is no physical model mechanism that accounts for the generation of the earthquakes. Consequently, there is no way to analyze the problem, in physical, mathematical terms, and hence, to devise a corresponding earthquake, prediction scheme. On the other hand, the earthquake prediction problem is referred as a multidisciplinary one, quite often. Actually, what is suggested by the term "multidisciplinary" is that geologists propose geological methods to be involved, geochemists suggest geochemistry, engineering geologists suggest rock mechanics, geophysicists suggest geophysical methods and so on.

In the course of the presentation of the methodology for earthquake prediction based on electrical signals, recorded, on ground surface, three different physical models were postulated. The first one is the oscillating, lithospheric plate, due to Moon - Sun interaction, which generates the tidal waves. The second one is the homogeneous ground Earth. This facilitates the epicentral area determination. The third one is the lithospheric, seismic energy flow model, which facilitates the magnitude calculation. Instead of one physical model, required, as a prerequisite, three different models were combined in order to provide an acceptable solution for all predictive earthquake parameters (time, location, magnitude).

Consequently, the term "multidisciplinary" is defined now, in the field of Physics, as stress-strain maxima of a seismogenic area, due to lithospheric oscillation, seismic energy release through an "open lithospheric physical system" and homogeneous, electrical properties of Earth, due to long wavelengths of the used electrical signals.

The corresponding theory, which was used for each model, was presented, following basic principles of Physics and Geophysical theories. Each model was tested against actual observations that comply with the theoretical ones. Therefore, the postulated models represent, to a very large degree, the seismological reality of an under study seismogenic region.

Largely innovative ideas were introduced, in order to overcome the various difficulties that were met in the course towards earthquake prediction. The most severe problem, met, is the noise contamination of the preseismic signals. This was treated with the newly, introduced, "noise injection" technique.

Moreover, the presence of various, different, electrical signal-generating mechanisms in the focal area was treated by the adoption of the "apparent point current source". The term "apparent" is quite often used in Applied Geophysical methods. Finally, the energy conservation law of Physics was introduced for the analytical calculation of the magnitude of a future earthquake.

The three prognostic (location, time, magnitude) parameters of a future strong earthquake were calculated analytically, using the latter three physical models. Following the basic principle of scientific research, these methodologies were validated by real strong earthquake data. Consequently, the proposed methodology that complies with the seismological observations made by seismological methods is a valid one. In contrast to statistical methodologies, it is a, more or less, deterministic methodology, which is characterized as "short-term prediction" or even more as “immediate prediction”, since the time window which is achieved by this methodology, is of the order of hours - days.

As a by-product of the method which is followed for the determination of the “magnitude” parameter of an earthquake, are the compiled "Seismic, Potential Maps". These maps can be considered as prognostic tools for an intermediate-term prediction.

The obvious question is: are all strong earthquakes predictable? The answer is no!! Actually, predictable are the earthquakes that are capable to generate electrical signals and consequently, the presented methodology can be applied to. These earthquakes are the ones, which occur in the crystalline part (crust) of the lithosphere. The main idea is that, preseismic electrical signals are generated, due to crystalline deformation, by any valid strain inducing physical mechanism. The earthquakes, located, in the part of the Earth’s outer-shell, where plasticity exists (upper mantle, lower lithosphere), are not capable to produce preseismic, electrical signals. Therefore, in this case this methodology cannot be used.

It is anticipated that, this methodology can be improved further more. A topic that should be studied in detail is the application of a weighting factor in the calculated azimuths, according to the used signal amplitude. In the present methodology, the real azimuthal direction is determined as the average value of all individual azimuths, calculated from all data points, regardless of the corresponding signal amplitude. Instead, a threshold was selected, so that the preseismic signal would be kept above a certain level from ambient noise.

Another topic that is very interesting and should be addressed to is the preseismic signals azimuthal directions, in relation to the regional - local stress field, observed, at each seismogenic area.

As far as it concerns the practical application of the methodology, a wide, monitoring network is required, in order to cover, in an even density, a largely, extended, seismogenic country.

In the particular case of the Balkan Peninsula which presents high seismicity, is required a network which will cover up the neighboring countries of Greece (Albania, FYROM, Bulgaria, and Turkey).

Finally, it must be understood that this presentation does not exclude the existence (in the future) of any other methodologies, with even better accuracy than the one, which has been achieved with the present work. I hope that some other eager and younger researcher will either improve it or invent a better one, in the near future.

What is only required, is to believe that a problem shouldn't be considered unsolvable, just because it was not solved for a long period of time, in the past.

8. OTHER SEISMOLOGICAL TOPICS. THE AEGEAN MICRO – PLATE ROTATION.

The kinematics of the Aegean micro-plate is studied in relation to the forces acting upon it, through the African and Anatolian plates' motion. The net result of these forces is a counter clockwise (CCW) rotational motion of the Aegean micro-plate, combined with a SW drifting component, as far as it concerns the internal Hellenides, while a clockwise (CW) rotation is considered applicable to minor tectonic blocks for the external Hellenides.

The postulated, physical-mechanical model, justifies the presence of different morpho-logical, tectonic, volcanic, seismological and geophysical (paleomagnetic) features which have already been observed and studied by many researchers.

Moreover, the kinematics rotational, postulated model, through its tectonic implications, justifies the location and presence of the already known geothermal fields, mineralization deposition, at various sites and concentration of radioactive elements at places.

Finally, the rotational velocity of the Aegean micro-plate is determined by taking into account the observed plate deformation velocity and its recorded seismicity.

8.1 Introduction.

The plate tectonics theory, which was developed on early sixties, was validated and adopted by the majority of the scientific community. The majority of the geological phenomena, which were observed on the surface of the Earth, are due to tectonic plates, relative to each other, movement, caused by the heat convection currents which are located underneath. Due to this heat convection mechanism, the Earth's lithosphere has been divided into a few major plates, as shown in the following figure (8.1.1).

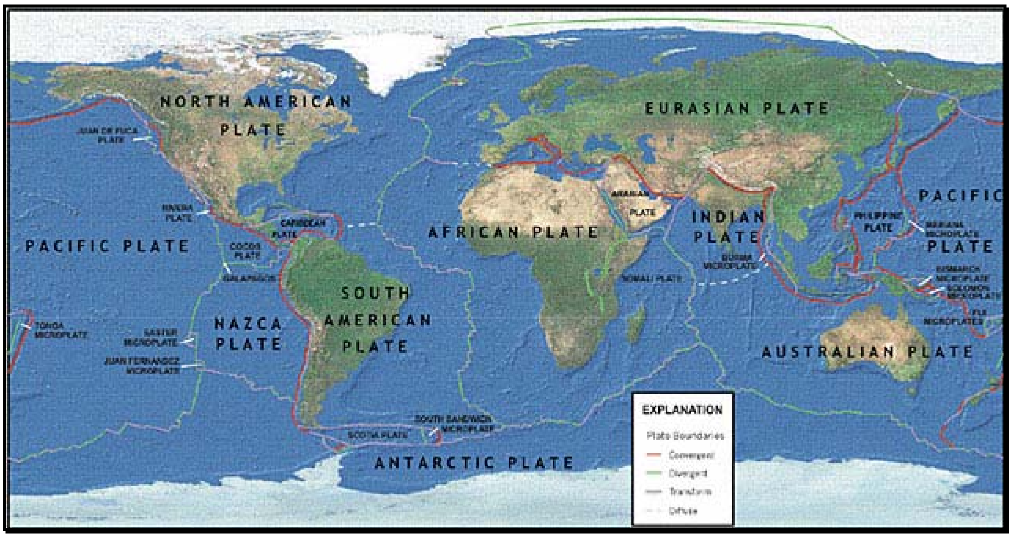

Fig. 8.1.1. The major, lithospheric plates of the Earth (after USGS).

Kinematics studies of the plates, all over the world, have provided details for the direction of movement of each plate. The latter is presented in the following figure (8.1.2).

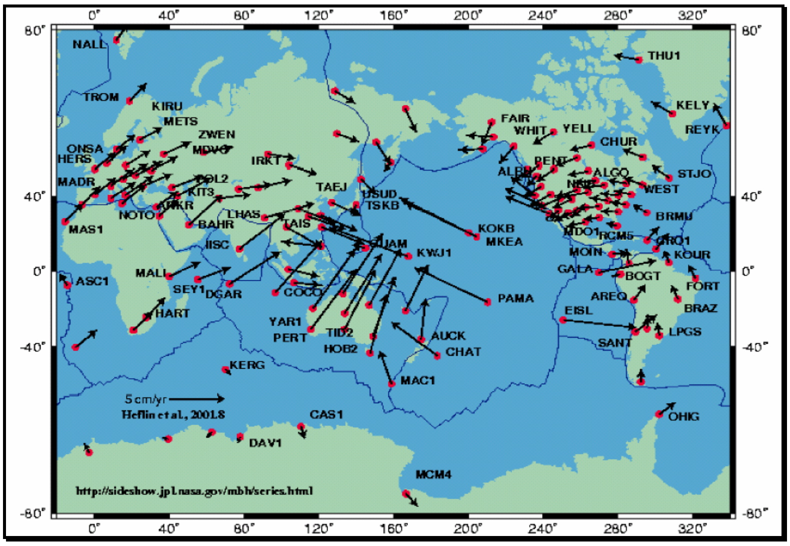

Fig. 8.1.2. World plate kinematics is presented (Heflin et al. 2001, JPL, NASA).

The Greek territory forms part of a major, seismic belt that starts at the Indian Ocean and extends up to the Atlantic Ocean and is bounded by the African, the Eurasian and the Anatolian plates. Due to the collision of these three plates, at the Greek area, the majority of the seismic activity of the eastern Mediterranean area occurs in the Greek territory (Jackson and McKenzie, 1988).

The earthquakes that occur in Greece are caused by stress release which was accumulated from the local lithospheric plates motion (Cox, 1973). The focal mechanisms, of the triggered earthquakes, depend on the temporary stress conditions of each focal area (compressional - extensional stress field), and therefore, normal faulting, strike slip faulting, over thrust faulting or / and mixed type, can be the fault plane solution of each, triggered earthquake.

The Greek territory is compressed from west by the Adriatic plate, from south by the African plate, while from east it is compressed by the Anatolian plate. The combined effect of these compressing forces is that the Greek territory drifts towards southwest (McKenzie 1972, 1978, Papazachos et al. 1989).

In the following figure (8.1.3) are shown the lithospheric plates that occupy the Greek regional area (McKenzie, 1972). The arrows indicate the corresponding motion of each micro-plate.

The Greek area consists of two micro-plates, the North Aegean plate and the South Aegean plate. The North Anatolian Fault separates these two plates.

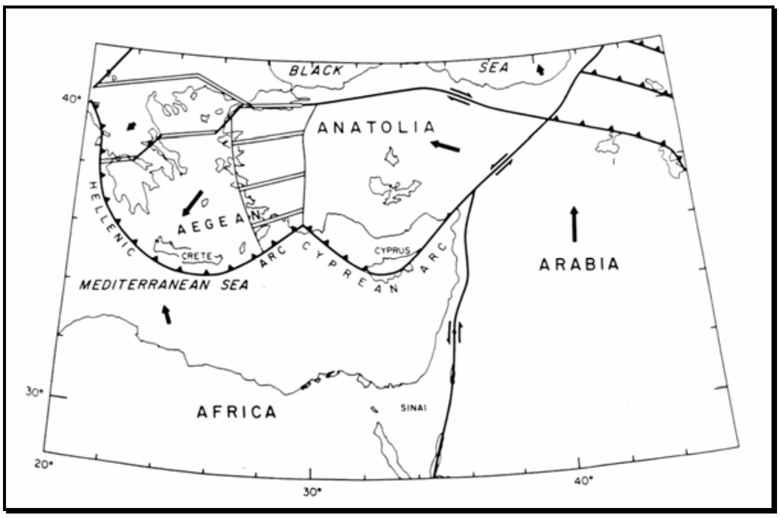

Fig. 8.1.3. Relative motion of Greek micro-plates presented, by McKenzie (1972).

A detailed study of the movement of the same area was presented by McClusky et al. (2000). The GPS technique was applied and the results are presented, assuming Eurasia fixed (fig. 8.1.4) and Anatolia fixed (fig. 8.1.5).

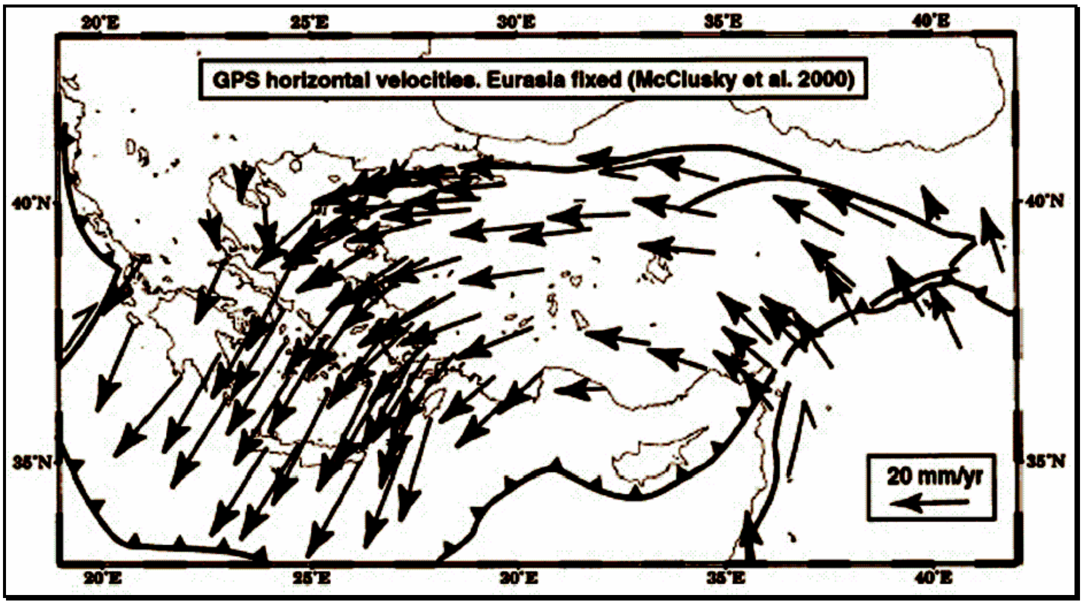

Fig. 8.1.4. GPS horizontal observed velocities. Eurasia fixed (McClusky et al. 2000).

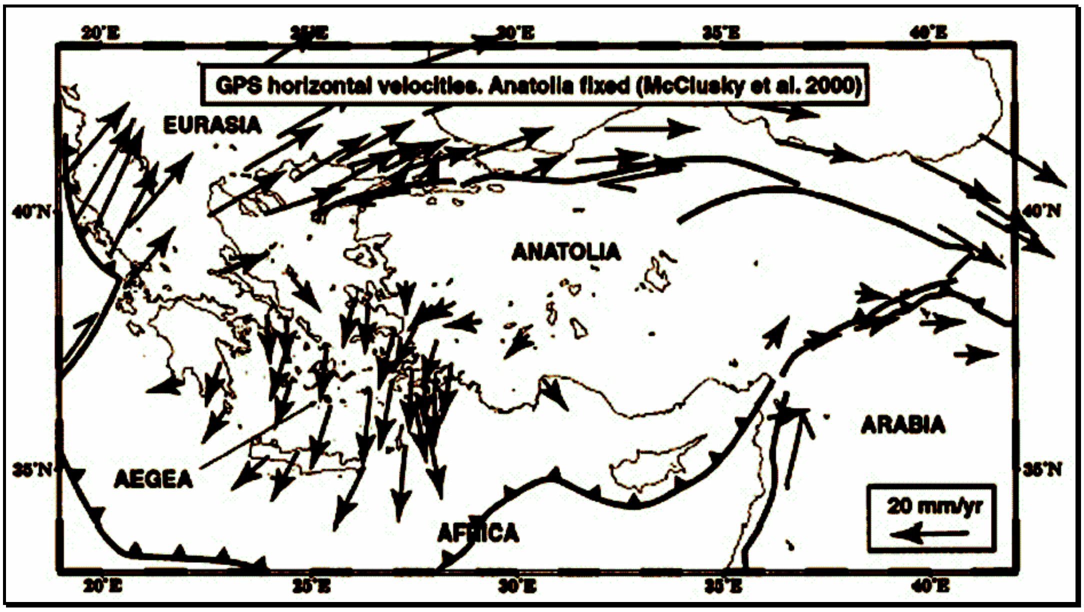

Fig. 8.1.5. GPS horizontal observed velocities. Anatolia fixed (McClusky et al. 2000).

Detailed information and different geodynamic mechanisms that apply on the Aegean - Anatolia area were presented by Doglioni et al. (2002). The key element of this model is that the Aegean - Anatolian plates are subjected to extension and therefore, the observed horizontal velocities, increase towards the southwest direction.

In the same study (Doglioni et al., 2002), the main directions and tectonic meaning of Miocene-Quaternary faults in western Anatolia and Aegean, due to the southwest extension, were calculated and are presented in the following figure (8.1.6), while a pictorial presentation of the Aegean - Anatolian extension is presented in figure (8.1.7).

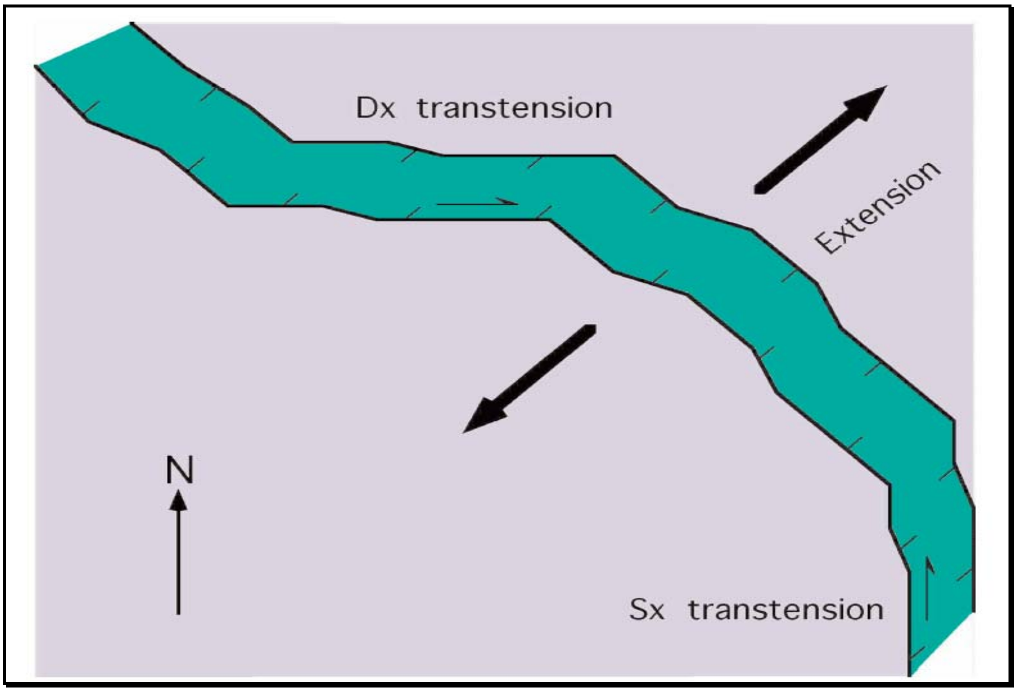

Fig. 8.1.6. Main directions and tectonic meaning of Miocene-Quaternary faults determined in western Anatolia and Aegean (Doglioni et al., 2002).

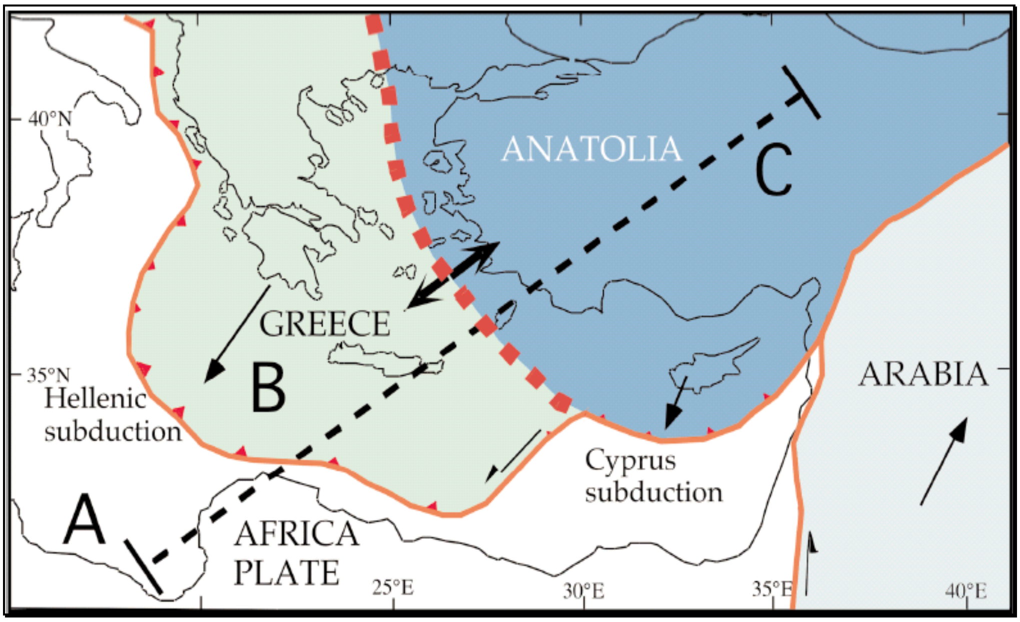

Fig. 8.1.7. Aegean - Anatolian extension. Greece (B) overrides the African plate (A) faster than Cyprus and Anatolia (C) (Doglioni et al., 2002).

A different point of view, concerning the tectonics of the Aegean plate, was presented by Rotstein (1985). The key element of this model is the concept of "side arc collision".

The term is used to describe the interaction of subducted, oceanic lithosphere with continental lithosphere in a subduction arc, where oblique subduction occurs. In the Hellenic arc "side arc collision" is proposed for the Northeast corner near Rhodes. The latter is presented in the following figure (8.1.8).

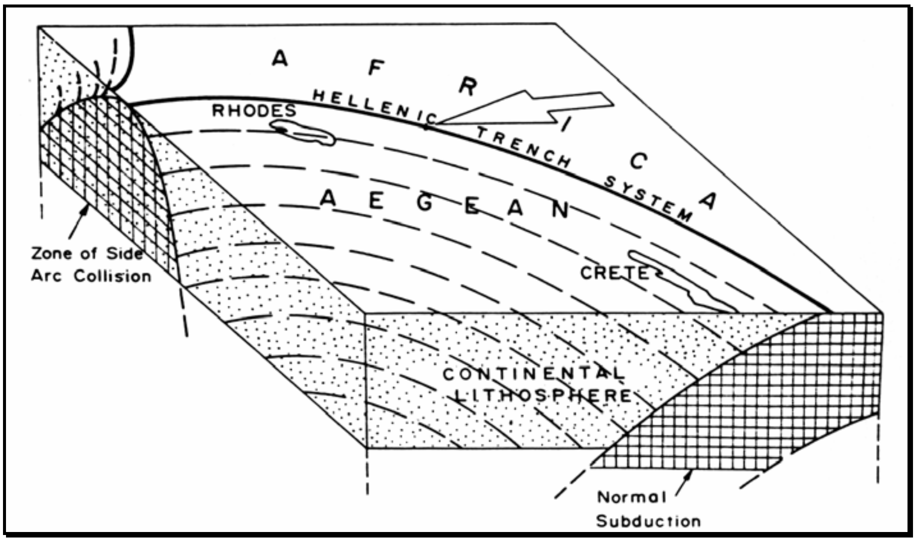

Fig. 8.1.8. Subduction, in the eastern part of the Hellenic arc that shows the zone of oceanic-continental interaction (side arc collision) is presented in a simplified sketch. The arrow indicates relative plate motion across the subduction arc (Rotstein, 1985).

The southern part of the Aegean plate, particularly the region of Crete, was studied by onshore-offshore wide-aperture seismics (Bohnhoff et al. 2001). The depth of investigation reached the crust - mantle boundary. The crust of the region of Crete was identified to be continental, with maximum thickness of 32.5Km below northern Central Crete, thinning towards the North and South to 15 and 17Km.

A generalized map of the main, tectonic elements of the south Aegean region is presented in the following figure (8.1.9).

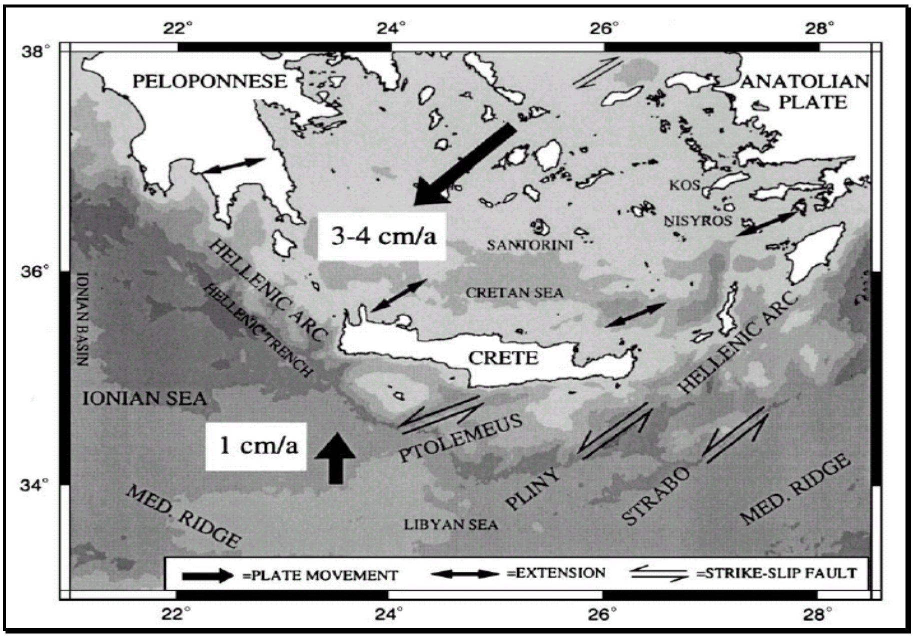

Fig. 8.1.9. The main, tectonic elements of the south Aegean region are presented in a generalized map. The gray shades indicate 1000m steps in water bathymetry (Bohnhoff et al., 2001).

The detailed study of the drift velocity of the Aegean micro-plates (De Bremaecker et al. 1982) indicated that the southern Aegean part drifts faster than the northern one. This is presented in the following fig. (8.1.10).

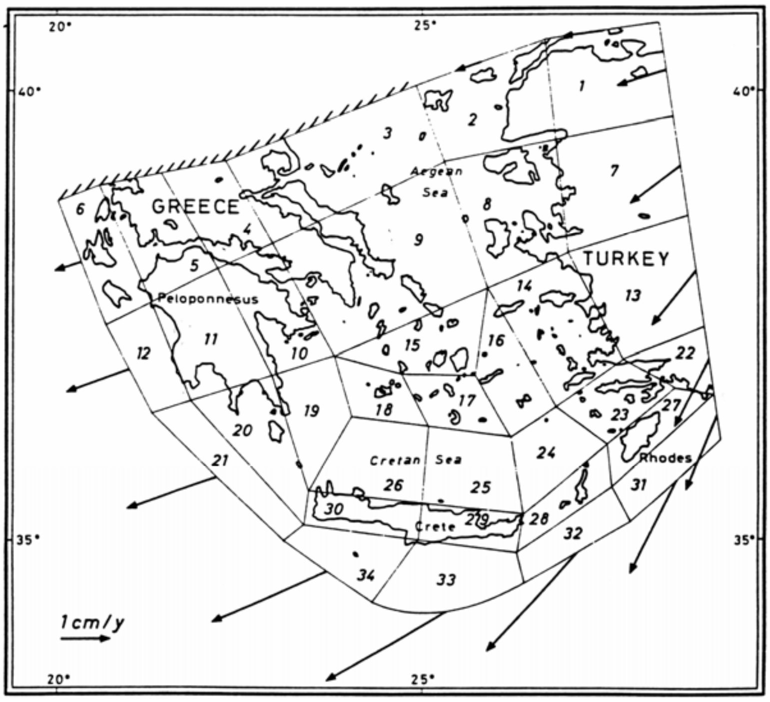

Fig. 8.1.10. Drift velocity finite element model for the Aegean area, after De Bremaecker et al. (1982).

Papazachos et al. (1996) have adopted a different approach for the kinematics of the Aegean micro-plates. The deformation velocity of the regional seismic sources was estimated and presented, in a map form, in the following fig. (8.1.11).

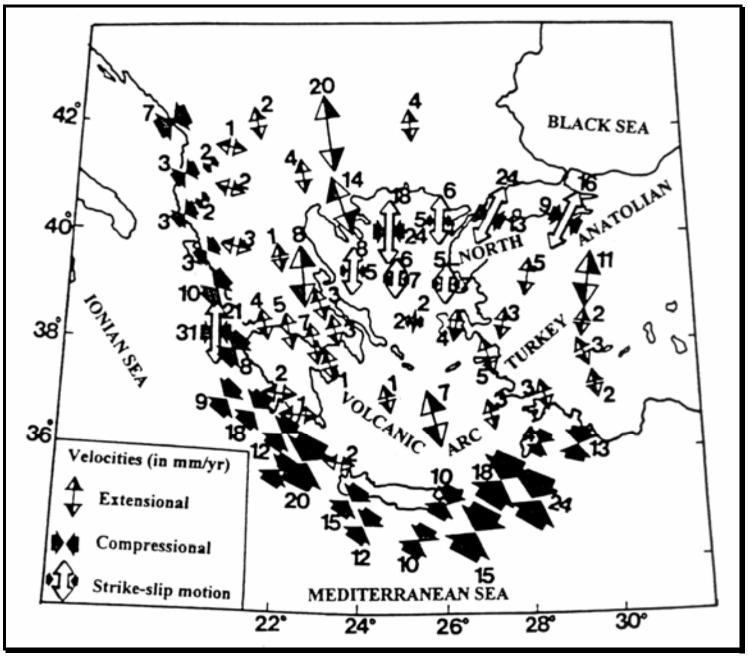

Fig. 8.1.11. Greek seismic sources deformation velocities, after Papazachos et al. (1996).

The main character of this map is the large deformation values which are observed at the southern Aegean plate, where large compressional forces control the stress field, while at the northern Aegean micro-plate are observed smaller values of deformation velocity, along with extensional forces.

Apart from the previous studies, other researchers have studied the regional Aegean area and Eastern Mediterranean, too. Hatzidimitriou et al. (1985) studied the seismic parameter (b) in relation to the geological zoning of the Greek territory, Papazachos et al., (1986) studied the seismotectonic properties of the same area, Papadopoulos (1989), Liakopoulou et al. (1991) presented the main seismotectonic features of the Hellenic Arc and the Aegean Sea, while Hanus and Vanek (1993) presented a different zoning for the seismically active areas of the Greek territory.

In contrast to the mainly seismological methods which were used for the previous studies of the Greek area, Thanassoulas (1998) used gravity data in order to delineate the narrow, seismically active zones, where strong (Ms>6R) earthquakes occur.

In this study, that concerns the plate kinematics of the Greek territory, an entirely different approach, is adopted and a completely different, physical - mechanical model, is postulated. This model complies, quite well, with other geotectonic observations, presented, to date and moreover it explains some of them, which had not been very clear or well justified, yet.

8.2. The theoretical model.

The theoretical model which is postulated for the Aegean Sea, basically, consists of two mechanical sub-models. The first one is the rotational sub-model. In this sub-model the basic adopted, driving mechanism, is a rotational moment. The second one is the thrust model. The thrust mechanism is adopted and considered to be applicable at the center of the stress-subjected area.

These two mechanisms are presented in detail as follows:

8.2.a. The rotational moment model.

Let us consider a pair of forces F1 and F2 which act simultaneously in opposite direction, upon a solid object and at different positions upon it (fig. 8.2.a.1). The result of this force scheme is the development of a rotational moment (P) that tends to rotate the solid body as the circular vector indicates, in figure (8.2.a.3).

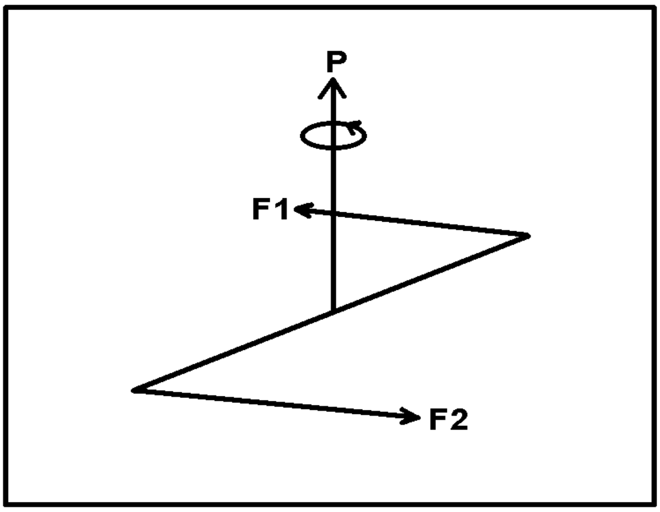

Fig. 8.2.a.1. Rotational moment vector (P), developed, by a pair of forces F1, F2 that act in opposite direction.

A more complicated case evolves, when more than a pair of forces acts upon the same object. This is demonstrated in the following figure (8.2.a.2).

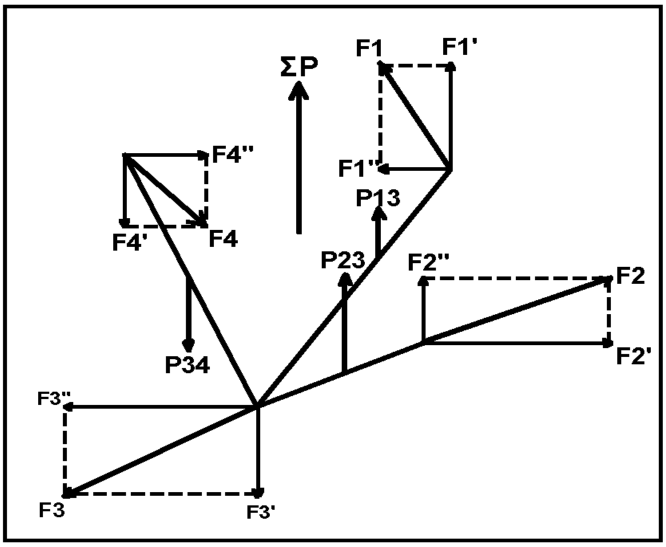

Fig. 8.2.a.2. Synthesis of total rotational moment vector ΣP as a result from different forces F1, 2, 3, 4 in effect, that give rise to moment vectors P13, P23, P34.

The forces F1, 2, 3, 4, randomly oriented in space, can be analyzed into orthogonal components, so that finally pairs of forces, which can be utilized, develop rotational moment vectors, P13, P34, P23 of the same or opposite direction. These moment vectors can be summed up in to a total rotational moment vector ΣP that characterizes the solid object.

Next, we consider a highly viscous media, where a specified, circled area is affected by the forces F1, 2, 3. The total rotational moment, which is developed, following the previous mechanism, forces the central part of it to rotate, as the thick arrow indicates.

Fig. 8.2.a.3. The rotational, mechanical model that is generated by the application of forces F1, 2, 3 on the inner part of the host material (stable area) is schematically presented.

As a result, of the rotational action, three areas can be distinguished. Generally, the first one is the stable area, where the effect of the applied forces F1, 2, 3 is null. The second one is the rotating area, where the rotating effect has its maximum value. In between these two, a third area exists, where rather rotation diminishes, in magnitude, towards the stable area or increases towards the central (rotating) area. This is called the transition zone.

Furthermore, in the brittle transition zone, the following mechanism can take place. Smaller media blocks are forced to follow a clockwise rotational movement so that there is mechanical motion compatibility between i.e. inner counterclockwise rotational motion and the outer, stable area. This is schematically presented in the following figure (8.2.a.4).

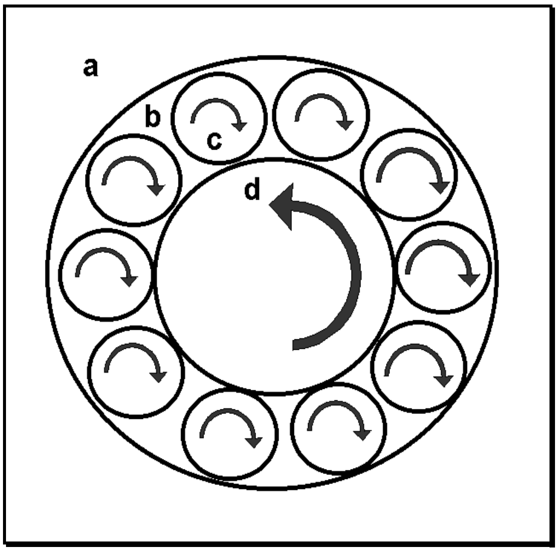

Fig. 8.2.a.4. Schematic presentation of the resulting, relative, rotational movement of the distinct sub-areas of the previous, mechanical model, (a) stable area, (b) transition zone, (c) clockwise **(CW)** rotating block, (d) counter-clockwise **(CCW)** rotating plate.

8.2.b. The thrust model.

Next case is the thrust model. Let us consider a media where an interface **(B-B)** exists and **(A-A)** is its upper surface. If forces **(1)** and **(2)** compress both sides in opposite direction, the net effect is either an upward or downward movement of each side, depending on the magnitude of the two forces. This is demonstrated in the following figure **(8.2.b.1)**.

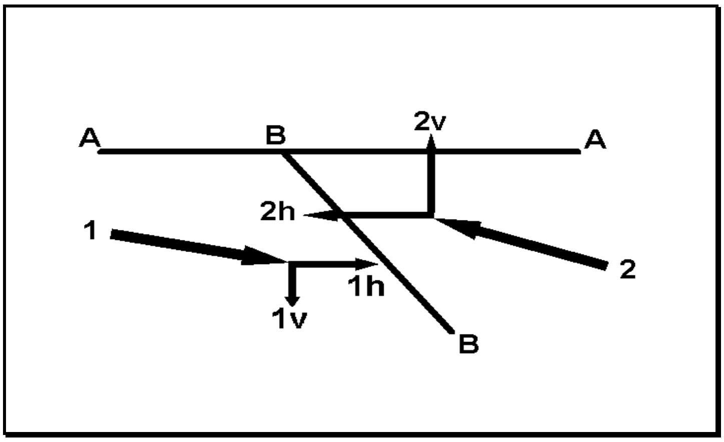

Fig. 8.2.b.1. Schematic presentation of forces **(1, 2)** applied, on movable media, separated by an interface, where sliding takes place. Symbols V and h denote the vertical and horizontal components of the forces **1, 2**.

As long as the interface B-B is laterally extended, then fracturing lineaments, on the surface of the media, can be observed parallel to the trace of the interface B-B and the media surface.

Suppose now, that the previous thrust mechanism is applicable only to a narrow, restricted area of the media. In this case, the following fracturing pattern is generated on the surface of the media, due to mainly extensional, mechanical reasons. This is schematically presented in the following figure (8.2.b.2).

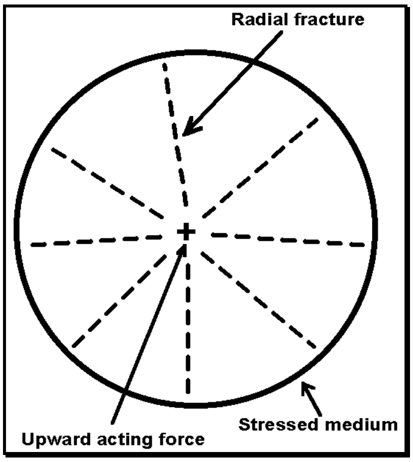

Fig. 8.2.b.2. Radial fracture zones are shown developed, by an upward stress field, applied, to the center of the medium.

These two mechanical models, the rotational model and the thrust one, are applicable, as it will be demonstrated, in the following presentation, both of them on the Aegean micro-plate. Moreover, these two models interpret many geotectonic observations made to date.

8.3. Forces applied to the Aegean micro-plate.

The Aegean micro-plates, as a result of the geotectonic studies, available to date, are affected by three main forces. The Anatolian (Turkish) plate (TPF) through its southwest applied movement is the first one. This force (TFP) pushes the Aegean micro-plates towards southwest against and on top of the African plate. The African plate subducts the Aegean micro-plates and therefore, applies the second, northeast force AFPF to them. This force (AFPF), partly, opposes the southwest movement of the Aegean micro-plates, while, more or less, the Adriatic plate force (APF) which exhibits the same behavior is the third one. This schematic mechanism is shown in the following figure (8.3.1).

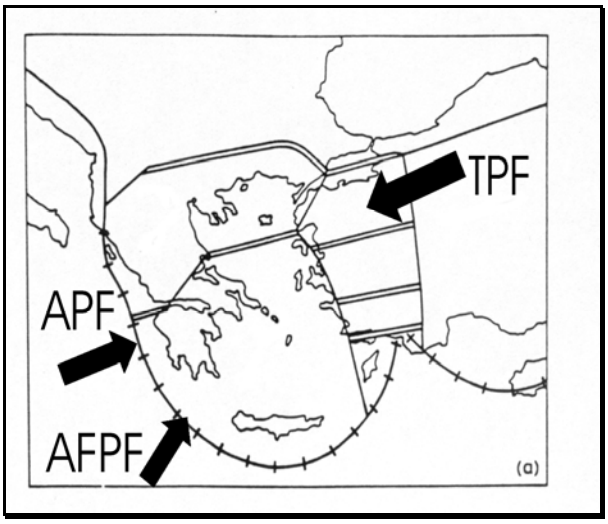

Fig. 8.3.1. Schematic presentation of the forces, applied, to the Aegean micro-plates, due to the Adriatic (APF), African (AFPF) and Anatolian (TPF) plate movements.