“Earthquakes, volcanic eruptions and geodynamic: a “box”and an “idea” for thinking/working”

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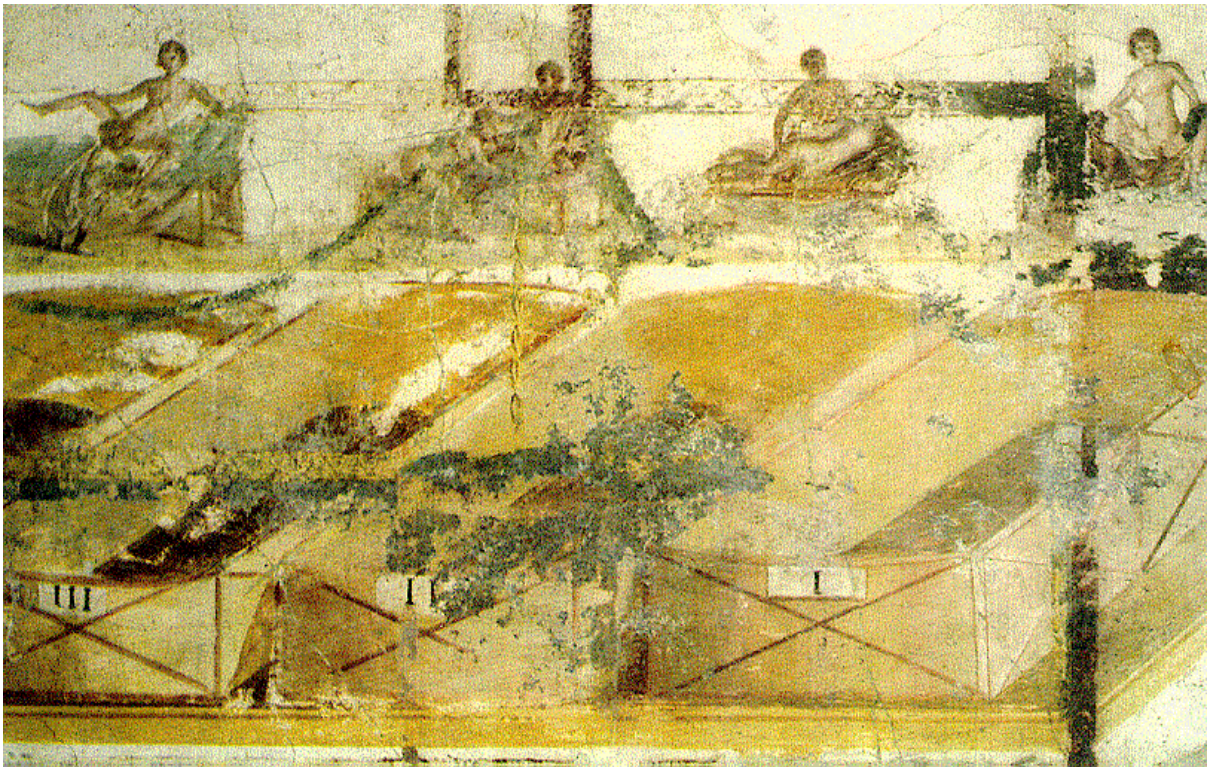


(from **Suburban Thermae [mixed] of Pompei – Apodyterium**);

Box, skull	**scatola cranica**
eros, intelligence	**(intus-lego), intelligenza**

Ideas like ‘men and women together in the hot water’

eros is nude and give the possibility to penetrate and to be fecundated (whatever is the sexual identity) to become pregnant (new life, ideas, etc.).

I received one **idea**; I received a **baby**.

See ***non-bounded energia*** (Breuer-Freud).

to Loredana

Abstract

After reviewing the main results present in the literature on geodynamic toward seismic and volcanic activity and risks, the paper present a causative global model of these phenomena and delineates a model of calculus for earthquakes and volcanic eruptions prediction.

The model involves a mechanical schematization of the entire globe, make use of Somigliana's identity and gives results in terms of probabilities given the PDF of mechanical parameters like Lamè'μ on fault planes and viscosity of the magmas.

The results then can be updated with short and long term precursors.

Key words *earthquakes-volcanic eruptions-geodynamics-artificial intelligence-prediction*

Note: a preliminary version of this paper was registered at notaio Francesco fu Cornelio Calliari in Trento Largo Giosuè Carducci 40 (ITALY) dated August 10 1998 Nro di repertorio 25764, Nro di Raccolta 6090.

1. Introduction

It's generally yet accepted the strong relation between global tectonic(s) and all the regional phenomena's as seismicity and volcanism; on the other side big earthquakes recurrence always appears as irregular and they are also observed in the places where for a long time span has been recorded, with disappointment, that is was merely presumed.

Results often verified the intuitive rule that, in the locations where in the past took place relevant seismic events, more the time elapsed from the latest significant event bigger the probability of an event to outcome.

However one can observe also that if it's verifiable the previous assumption, especially on a regional limited scale, the opposite happens on a larger scale; the more correct conclusion that can be drawn is this: the 'seismic gap' and ' anomalous quiescence' concepts has to be reconsidered in a more careful and appropriate way in comparison it has been done till now and with the endeavour of comprehension on an 'enlarged' scale and in a more general contest.

Last but not least very few attention has been paid at the interconnections and space-temporal correlations between seismic and volcanic activities trying to face the 'tectonic flux' problem in global fashion (in spite of the extremely clear correspondence, also not always biunivic, among volcanic eruptions and earthquakes).

In this paper the author try to delineate a causal mechanism connecting global tectonic, seismicity and volcanism, seen as expressions and/or outbursts of the deep earth's movement constrained and/or obstructed in the surface by the plates variously interconnected.

It is also delineated (sketched) finally a conceptual scheme for working and gaining a quantitative evaluation of seismic/volcanic risk on the base of a reliability calculus applied to a mechanic model of the earth.

That last extension reveals necessary for the global congruence (of displacements) retrieval …and potentially is able to pick up the regularity of the global behaviour.

OOOHHH !!!

Recently some interesting (stimulating) papers (contributions) appeared in literature starting to face quantitatively the earthquake triggering' in space.

It's immediately clear that, looking phenomena from this point of view, short term correlation's between seismic and volcanic events, that happen in places some hundreds kilometres apart and on a time span from some days to several years are almost improbable.

In fact the stress change caused by an earthquake overcome a little while the stresses due to tides for a distance almost equal to the prevalent dimension of the generating fault (on this item some discussion with Cinna Lomnitz - UNAM is needed).

Coherently appear improbable at all for example that a correlation exist between big earthquakes near Campi Flegrei (Napoli - Italia) and the bradiseismic phenomena characteristic of that area.

On the other side, when one thinks to earthquakes in connection to evidences or to hypothesis in terms of macro or micro plates and theirs kinematic coherence, very marked regularities appear to the researcher.

For a striking example one can consider the statistical observations of seismic sequences of events along plate borders starting from Azores Island till to Iran and, in conjunction, the sequences of seismic Zones of Mediterranean Area (Hiberic peninsula - North Africa; Calabrian Arc and North Aegean Area, Southern Appennines of Italy and Southern Dynaridis).

On the contrary if one looks to those phenomena from the point of view of the 'engine' such causal interdependence, become possible.

In fact is enough to think to the crust (where the most destructive earthquakes happen) as to the superficial expression of plates from those kinematically droved: on the complex articulation between macro and micro plates the deep motion met boundaries of various origins.

Following the C. Doglioni approach, is fascinating the global coherence following the paramount of plate motions in the contest of the general scheme of the relative motions between mantle against the lithosphere due to the deceleration of earth rotation (Figg. 1 e 2).

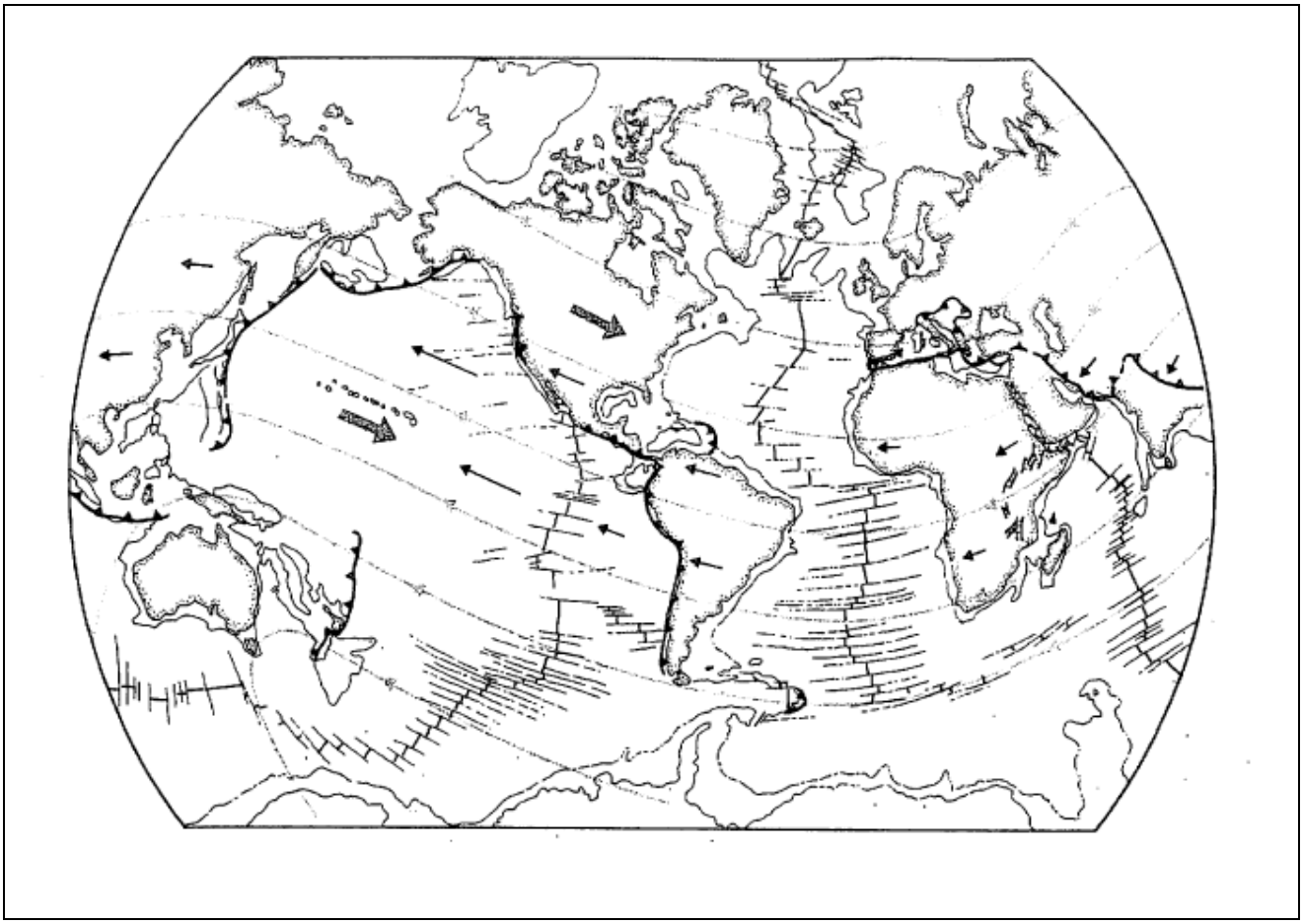


Fig. 1. Plates and mantle movements according to C. Doglioni

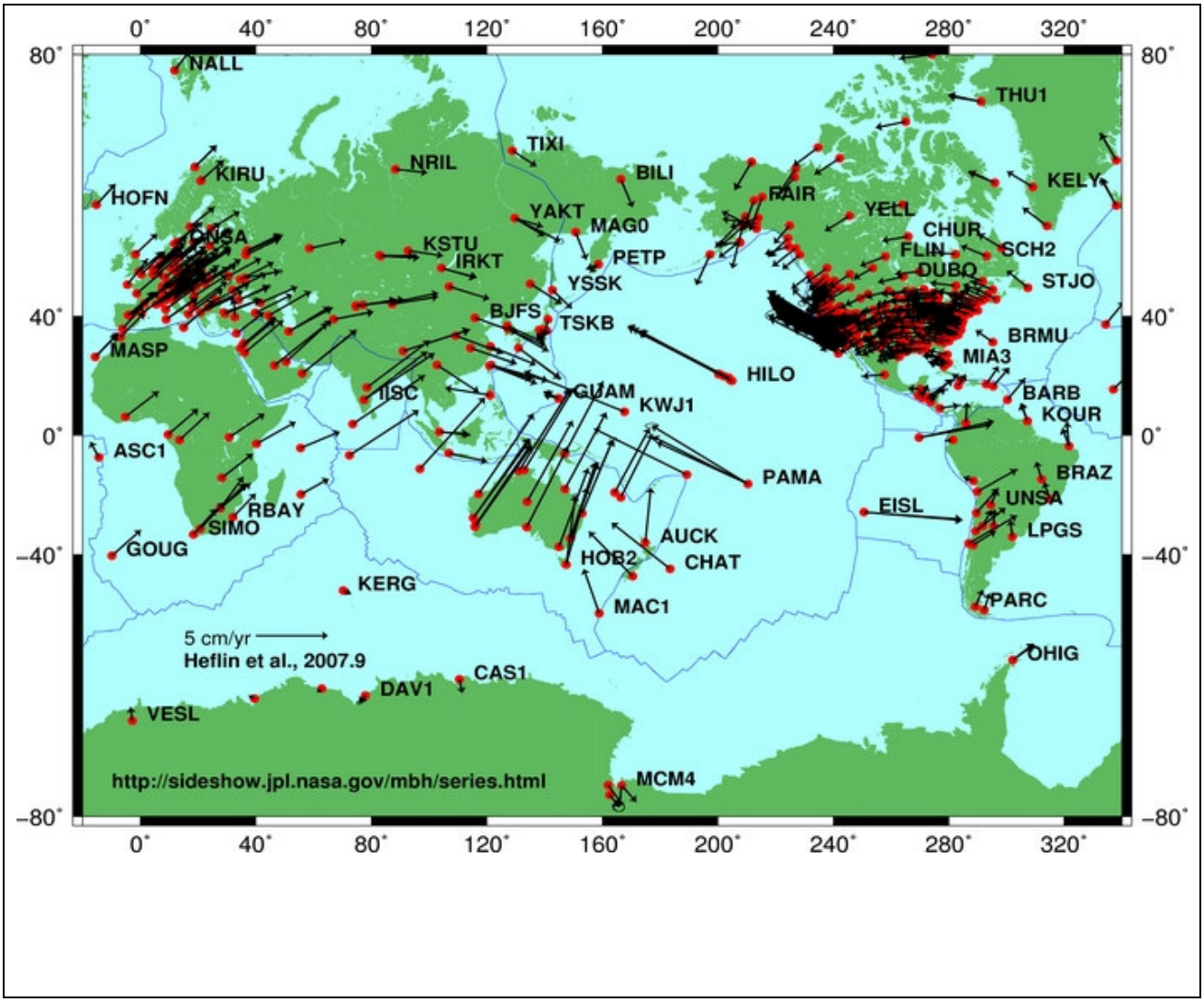


Fig. 2. Plate motion based on Global Positioning System (GPS) satellite data from NASA JPL

On the other side it is possible to calculate displacements and relative velocities of plate margins with geological and geodetic techniques with the requested precision and coherence.

Quantitative palinspastic reconstruction are also available or possible.

Where reliable seismic catalogues exists (in terms of moment tensor) it's possible to perform additive analysis of seismic events and compare the results with the measures of the previous sentence.

It's very encouraging to verify both the coherence of principal axis of deformations directions with geometry's kinematics and both the relative constancy of global displacement percentage 'justified' by displacements inferable from seismic events.

Really this is very reasonable: the mantle flux that moves the plates, in some sense leaned on his upper part, is constrained from the plates themselves in such a way that they can be thought as kinematically constraining.

The mantle flux, capable of building up mountain chains, can't be stopped and express itself in surface both in continuous relative motions between plates, both in plums and hot spots, both in concentrated episodes as the earthquakes and the volcanic eruptions.

A volcanic eruption indicate in fact, that a sub-ducted plate is moving and that an act of motion manifest himself throwing (out, away) material. If the mantle advance in a given sector will try to recall a coherent motion in the neighbouring sectors and if it will find plates that, variously interconnected in the surface, obstruct his motion then the stress grows in those plates and particularly along the margins.

That is why it seems reasonable to hypothise that after volcanic activities cycle will follow a seismic one an so on and so forth.

The spatial-temporal correlation between the cycles of events can strongly variate in consequence of the past geological history and of the outcoming geometry of macro and micro-plates.

Theoretically is however completely reasonable to expect distances of the order of tens to hundreds of kilometres and from several till to tens of years.

Such values are in fact in connection to the plates spatial dimensions and to the times owed to the information's that a relevant act of motion, happened in a given sector, will propagate, induce deformations into the mantle and reach the others sectors where such deformation is hindered from friction on the boundaries that on turn will affect the friction on the faults that limits and connects the blocks.

Here is formulated the hypothesis that the plates 'game' around, when there isn't kinematically the possibility of the act of motion - earthquake (see for example 1908 Calabro-Messinian earthquake and its precursors spanning several years) in a given portion candidate to the coming out of the event then will happen as spatial jump: the mantle can't be stopped and moves the plates.

Plates themselves can only try to counteract (the) mantle motion (or to accommodate it with a-seismic slipping) either with earthquakes, volcanic eruptions or trying to decrease the stress moving the neighbouring plates.

This last contingency is, in my opinion, to be connected to the statistical observation that in specific zones more the time lasting from the past more relevant seismic event and more the decreasing probability of its repeating, after that the mean return period has been reached.

2. Calculation model

The calculation model here presented is proposed thought to be applied as 'matrioske': conceptually is thinkable and adaptable at different scales but operationally has to be applied with meshes densing, using the preceding mesh results as constraints the next step of calculus.

The geological studies are now able to provide accurate palinspastic reconstruction's of plates motion also at regional scales kinematically fixing the relative motions description.

Forgetting at the first step earthquakes and volcanic eruptions one can realistically set up a 3D global calculation at given displacement (that one obtainable from the aforementioned studies) making a crude 'discretization' of the globe.

It will be the more and more rare reaching earth's centre; toward the external surface the mesh will dense and consist in 'blocks' and tectonic discontinuities.

Given a first calculus enough satisfying from the kinematic point of view, one can obtain (read), in the points where the displacements has been applied, the final forces (constraining reactions) obtained: that is forces that applied on the un-deformed model give the final configuration from which we started.

The degree of kinematic constraint that the various blocks exert among themselves can bear to stresses concentrations that can vary either with relative gradual steps or show more or minus evident (astonishing) 'jumps'.

In this phase of the calculations the big discontinuity surfaces will be modelled with the possibility of mutual sliding (to model the different geotectonic scenarios).

We could retain correct the modelling if we will find adequately modelled relative displacements and if stress patterns, along discontinuity surfaces, will be in accordance with regional data of geological/seismological origin.

At this point giving realistic values to the mechanical parameters of the discontinuity elements and having assumed one or more fracture criteria (earthquake and/or fusion/extrusion - volcanoes) we will try to reproduce the succession of catastrophic events that have characterised the span time under examination.

Under this light earthquakes, volcanic eruptions and related phenomena (like for example bradisism) are time-space concentrated events belonging to the earth's motion history, understood as spatio-temporal plates evolution.

For example the relative motion of a sub-ducted slab can give vent in repeated volcanic eruption until the crust's blocks involved can slide and/or a-seismically deformate; when either geometrically and/or for stress pattern increasing on discontinuity elements an instability situation will begin; the seismic act of motion probability will enormously increase and a seismic cycle will begin ending the volcanic one and vice-versa.

Of course mixed solutions are possible and historically observed (see for example the earthquakes and volcanic eruptions in the area from Vesuvius to Etna included described in the examples section).

At this point are of maximum utility the spatial-temporal correlations between the main events of seismic (bradi and /or taki), volcanic and geometric parameters to find out on scales of time and space either restricted or enlarged and that for the aforementioned multiple interaction possibility.

For the geometric parameters is striking the incredible and wonderful correlation (correspondence) between 3D curvature of plates contact surfaces and the layout of volcanic buildings.

With all generality it's thinkable of writing an equation of global conservation of deformation energy due to plates motion, to the work done to overcome frictions in the considered arc of time added to that of seismic moments and to the energy set free (spent) in the volcanic eruptions (for example as for as concern earthquakes using the stress glut formalism and seismic efficiency concept).

It's obvious to take into account a calibration phase (first trial and error and then, if possible, at least squares on the free parameters of materials constitutive laws).

Where historical catalogues of events are available and basic geological research are enough developed is thinkable the semi-deterministic simulation of deformative history.

A positive interaction with archaeological data and hypothesis has to be looked for.

After all when this phase will be positively concluded one could perform a reliability calculus in which, for example, will be random variable the parameter μ on fault planes and the limit equation be that of fracture on one or more fault planes.

3. Examples

It's clear that an example strictu sensu can't be produced cheaply.

As a contra-example one could look at the plots in Fig.3 following the technique of Meyer, Olsson and Kulhánek (1985) and make terrific prediction for Sicily (ITALY).
And here I would thank Paolo Federici of RSE for continuous helping in data collections and processing.

At a first glance one can see that big volcanic eruptions alternate to severe earthquakes sequences and viceversa; also a strong non-linear correlation (spatio-temporal) exist between the two activities.

The seismic activities (check moment tensor solution of last cycles) is in optimum accordance with structural macrogeology (from Pangea to now…).Some intresting confirmations to the model come from the pioneristic work of Maria Serafina Barbano (Catania – ITALY) and wonderfull comment of Claudio Margottini (ENEA Rome - unpubblished and personell communication) on Sicily channel.

On the other hand, at this moment Etna activity is slowly reaching 0 after periods (1983-2004 , 2005-2007) of strong vitality.

The question that arises is:

- *how reliable is the implicit prediction that can follow?*

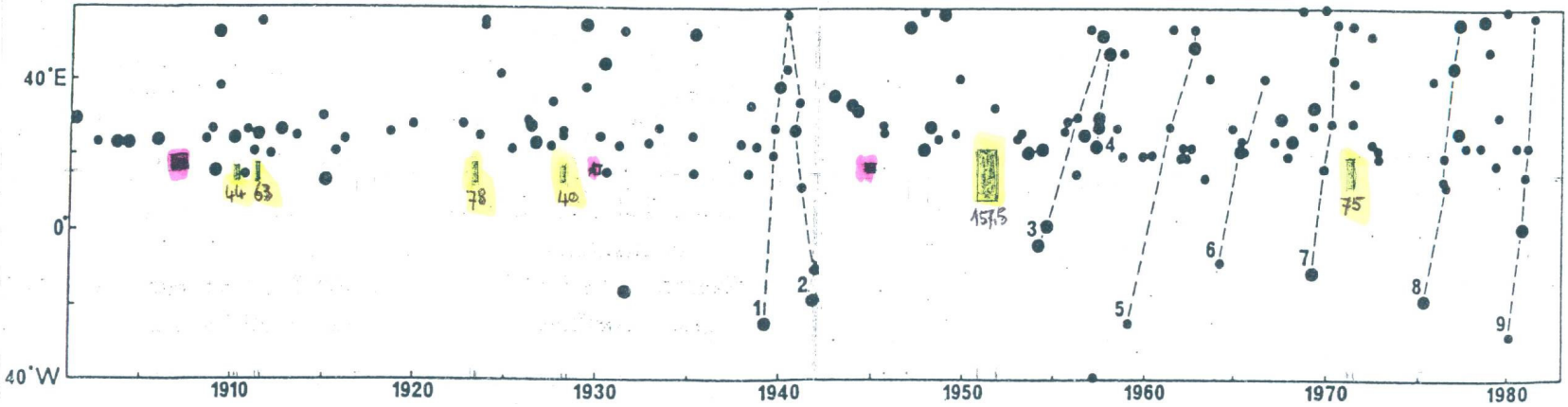
On the other side is quite comfortable remember that Etna erupted widely in time and space (broadly) in 1669 and that the violent earthquake that struck Iblei area timed 1693, giving the past (1990÷2005) Etna's activity.

To answer quantitatively the calculation here suggested is needed but if similar plots are generated for homogeneous geological areas (for all the world) and looked contemporary in space and time... (make classical [and non] model identification).

<u>PLEASE DO IT AS SOON AS POSSIBLE</u>

Following another approach (artificial intelligence, neuronal networks etc.) one can get, maybe, approximate solutions ridiculous cheap.

-Pay attention not to identify a local minimum;
-Use foreword of the model forgetting, e.g., 100 years of recent measurements;
-Perturbation of 'geological borders' for testing the inner stability, etc., etc., etc…


Vesuvius
Etna
40°E
0°
40°W
1910
1920
1930
1940
1950
1960
1970
1980
44
63
78
40
157,5
75
1
2
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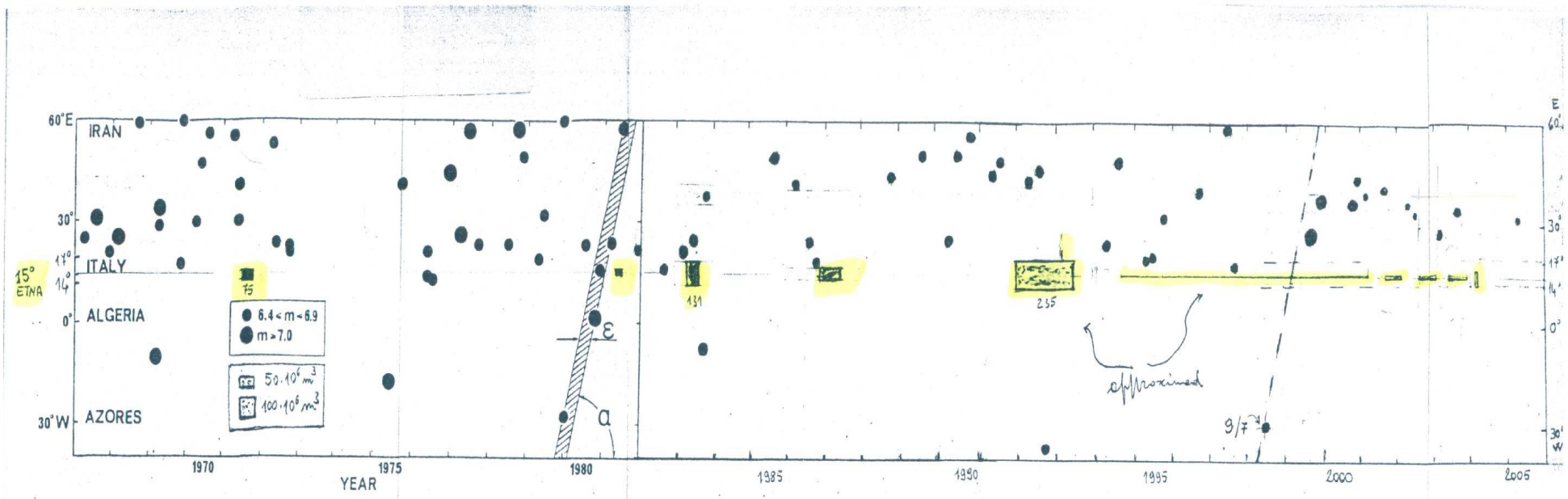

Figure 2

Portion (1967–81) of the longitude–time plot of large earthquakes in the western segment of the Alpide belt used in this study. The hatched area represents a particular position, corresponding to the 1980–81 sequence, of the tilting window with $\varepsilon = 0.3$ yr and $\tan \alpha = 50°/\text{yr}$.

$m_b \geq 6$ NEIS (FREGONESE R, 2005)

http://www.neic.cr.usgs.gov/neis/epic/epic.html

following MEYER, OLSSON and KULHÁNEK 1984/85
PAGEOPH, Vol. 122 (1984/85) pag. 837

Fig.3

4. Conclusions

At that point the old question will rise: what to do?

First of all look, via satellites, the impinging earthquake and it's radiation pattern and then learn to 'dance' with earthquakes and 'run away' with volcanic eruptions (and if there are some *buffone* and *menestrello* that make fun and play around, why not?).

That is: in the most dangerous area and following due priorities and in a global convenience scenario provide and /or integrate the bearing capacity of structures (humans included of course) in order to being able to face successfully the cimento to witch they will be called.

It's near obviously that an efficient civil defence policy will be able to mitigate the potential injury to human lives: it's well known really that die as many people under ruins for not tempestive intervention as those that directly loose their lives at 'catastrophic' event happening.

5. Post Scriptum

The presented technique may be view also like a 'GEA transform (or of Fregonese) and/ a 'GENERALIZED REPRESENTATION THEORY'.

It seems to me that, at heuristic level, this paper/theory/box can also be inserted on the trace of what M. J. Sewell proposed in[i] 'Degenerate Duality, Catastrophes and Saddle Functionals' University of Reading Department of Mathematics, 11 April 1977 published by Ossolineum Publishing House of the Polish Academy of Sciences, Warsaw, Poland.

APPENDIX I

Earthquakes, Volcanic Events and Geodinamics

user manual (scheme)

GEOFEM(Ismes) from 2D (present) to 3D;

- also vertical sections representations + contours;
- NIKE3D o FAULT (P.Bird) or, best over all **FEMLAB3**;
- (results and models from **B.Romanovicsz** and **C.Doglioni** using **costitutive law of T.Hueckel, Peano and Pellegrini).**

FAULTID

from macrosismic data (*Shebalin and Bottari method)* and geology and exploration geophisics;

Auto-cross **CORRELATIONS**

PIERS (Parallel Integrated Environment for the Reliability of Structures of existing industrial plants – **Ismes/CILEA** Milano)

Temporal series analysis of earthquakes and volcanic eruption (following Meyer, Olsson and Kulhanek, 1985) for all the world, previous identification of macrozones homogeneous from the point of view of geology and tectonic

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All the wonderful works of Adam Dzievonski and Barbara Romanovics.