EXCESS MASS STRESS TECTONICS (EMST) :

AN OUTLINE OF THE HYPOTHESIS

Stavros T. TASSOS

Institute of Geodynamics, National Observatory of Athens,
P.O. Box 200 48,118 10 Athens, Greece

e-mail: tasschec@acropolis.gr

ABSTRACT.

Geodynamic phenomena are attributed to Excess Mass Stress (EMS). The basic idea is that the Earth expands and not due to a heat but to a stress engine. Below the depth of about 100 km in the Earth's interior, electromagnetic and nuclear forces, not heat and gravity, are considered to dominate. Excess Mass (EM) is the product of transformation of cold plasma (electrons, protons and positive ions) into bulk matter, within the outer core, through electromagnetic confinement, resonance, laser clustering, shockwaves, and controlled nuclear fusions.

About $3.6\mathrm{x}10^{51}$ ***nucleons, most of them as*** ^{2}H ***nuclei, a small number of free protons and about*** 10^{53} ***electrons were trapped inside the primordial Earth. The primordial Earth had a diameter about 40% its present size. Up until now about 2/3 of this original number of*** ^{2}H ***nuclei have been transformed into bulk matter in two distinct phases: The first from 4000-200 m.y. a., when a granitic continental type crust, with a thickness of 300-350 km, was formed. In the second phase (200 m.y.a. to present), the Fe-rich oceanic crust and more than 90% of the rigid mantle were formed.***

During orogenic episodes, caused by an intensification of laser clustering, degeneracy pressure is reduced and the Earth tends to contract. The net result of its electrical unbalance is a pulsation of the Earth (expansion-contraction), which is superimposed upon its general expansion due to EM generation and emplacement processes.

Earthquakes are considered to be the result of coalescence of crystal sized solid EM 'wedges'. The diminution of elastic moduli, is associated with positive gravity anomalies, that imply excess mass, and high heat flow. This EM is the cause of seismic Low Velocity Zones (LVZ). The High Velocity Zones (HVZ) are a result of earlier emplaced, cooler and more compacted EM typified by a faster rate of increase of elastic moduli as compared to density.

Excess Mass Stress (E.M.S.) Hypothesis :
An Outline

Why the Earth is not a Heat Engine.

Temperature while it provides an indicator of the ***direction of heat flow***, can not be a measure of the ***total amount and/or nature of Earth's internal energy.*** When two objects are in contact, heat goes from the one at higher temperature to the one at lower temperature, ***regardless of the total amounts of internal energy within each object.*** It is possible therefore that the warmer body has lower internal-total energy and the cooler body, higher total energy. Because of this consideration, it is incorrect to equate ***heat* with *internal energy*.** That assumption is only true in the ideal gas case, where the random free movement of atoms and molecules can occur unrestricted.

Heat, by definition, is the ***kinetic energy of atomic or molecular*** translation*,* ***and/or rotation, and/or vibration.*** In gases and liquids heat is the kinetic energy of randomly and more or less free moving atoms and molecules.In solids the electromagnetic forces hold the entire assembly of atoms and molecules to a definite size and shape, and they only vibrate about fixed locations, instead of moving randomly as with a gas or liquid. If, in high pressure states, the movement of atoms and molecules is limited, the heat energy content will be low and heat transport slower. Thus temperature and heating capacity are low and the internal energy is in the form of electronic-chemical energy, i.e., free electron movement and/or compression of electron shells within the atoms of the solid.It is only when the electro-chemically stored energy is transformed into kinetic energy of atoms (via vibration, and/or rotation, and/or translation) that the heat content increases. Only then, will a solid's internal energy exist as kinetic energy of its atoms and heat and internal energy can be truly considered equivalent. Conditions inside Earth where its internal energy can exist and be released as kinetic energy of its atoms, are only possible at, or very near to its surface, i.e. at lower pressures.

When a crystalline solid melts, the original ***ordered arrangement*** of its ions, atoms or molecules alters to the ***random arrangement*** of molecules in a liquid., and convection occurs. Plate tectonics is theoretically driven by convection, either in Earth's whole mantle, or in the upper 700 km of mantle. Associated with upper mantle convection is the mechanism of negative buoyancy. If negative buoyancy is responsible for subduction, complete decoupling is necessary between the 100 km thick plate and the underlying mantle. In other words the "ridge push - positive buoyancy" and the "trench pull - negative buoyancy" must exceed the friction between the plate and the upper mantle, as well as the strength of the underlying mantle. With a viscosity of the order of 10^{21} poises and an average spreading rate of ~ 6 cm/yr, the strain rate, in a ~1 km thick boundary layer is of the order of $e = 2x10^{-12}$ s^{-1} and the viscous energy dissipation per unit volume is $E = he^2/2 = 2x10^{-4}$ Wm^{-3}. For the decoupling of a world wide ocean layer, of an area of ~5´ 10^{14} m^2 (Earth's surface area) and 100 km thickness, the energy required is of the order of 10^{16}W. That is about three orders of magnitude greater than the ~$3x10^{13}$ W of Earth's heat flow. In other words the thermal energy required to overcome internal friction is two to three orders of magnitude greater than the ~$3x10^{13}$ W available. If such thermal energies were supplied the temperatures at the core - mantle boundary should be from $120,000^0$ C to $1,200,000^0$ C. At such temperatures the whole mantle would be a convecting liquid melt, or actually would burn. But the estimated temperatures, even by plate tectonics advocates, do not exceed $5,000^0$ C.

To add further to the convection explanation's dilemma :

> **a)** penetration of crust into the mantle is only possible if the rigidity, the strength and viscosity of the mantle, is several orders of magnitude less than that estimated for the mantle. Materials with viscosities of the order of 10^{20} poises and higher, can only be treated as a solid. The viscosity of the asthenosphere, even by plate tectonics advocates, is no more than one order of magnitude lower than that of the overlying material. It is like saying that a vertical nail will eventually penetrate into a piece of wood simply because is 2-3% heavier, let alone that such density inversion is wholly imaginary since all available evidence indicates density increases with depth in our Earth.
>
> **b)** Another major failure of the ridge push-trench pull mechanism, presently adapted by the majority of plate tectonics advocates, is the stress field it requires. Compression in ridges, tension within the subducting slab. Exactly the opposite of what is observed.
>
> **c)** But even if we assume that subduction is possible there is an insuperable geometric problem. The combined length of all the trenches is ~30,000 km, about ¼ of the length of all spreading ridges, at 2´ ~60,000 km. Plate tectonics' proposed balance of construction and destruction of oceanic crust is impossible. In order for a crustal construction-destruction balance to be maintained, all of the ocean basins require coequal trench systems at their margins.
>
> **d)** Also, is it not absurd for earthquakes to occur only in the vicinity of hot and more ductile spreading centers, but absent from the cold and more rigid part of the oceanic plate, laying between the ridge and the trench? Could a friction-free sliding of the lithosphere on the underlying mantle occur?

In an iron melt outer core the lowest possible ionization potential is 7.87 eV, that is 1.26´ 10^{-18} Joules. The required temperature for the ionization to occur is of the order of 60,000 Kelvin ($E = 3kT/2$ ® $T=2E/3k$, where k =1.38´ 10^{-23} J/K). For the ionization of hydrogen the required temperature is of the order of 100,000 K. For helium, the inert gas with the highest ionization energy (24.5 eV), the required temperature is of the order of 180,000 K. Even for the ionization of atoms of the alkali metals (Li, Na, K, Rb, Cs), that have the lowest ionization energies of the order of 5 eV, the required temperature is of the order of 40,000 K, well outside reasonable consideration of Earth's interior.

For these and many other reasons, the concept of a heat engine Earth is questioned when it comes to convection cells, and abandoned when it comes to earthquakes, even by the plate tectonics advocates. Bott (1982), mentions: *"...**The most decisive argument against the viability of classical convection mechanism comes from the calculation of the strain energy dissipation within the low viscosity channel ... This seems to be quite unacceptable on thermodynamic grounds, even if the viscosity distribution differs from our assumptions. Thus the answer to the question - are the plates driven by mantle drag? - is probably no**t..."* In another point the same author writes: *"...Stress in the elastic lithosphere may result from change of temperature. For instance, the new elastic part of the lithosphere forms near ocean ridges at a temperature of about $0.5T_m$. The upper part of it cools more rapidly than the lower part, causing tension above and compression below. Under such circumstances, thermal stress may exceed 100 MPa. **There is a lack of evidence for tectonic activity resulting from such stress and it is possible that is relieved by transient creep over a relatively short period of time**..."* Similarly Bolt (1982) is quite clear stating that: *"...A much more efficient way of transporting heat from one place to another is by convection. In this mechanical process a bodily transfer of the heated material from one place to another occurs. It commonly occurs in liquids, through buoyant movements. Thus, in a saucepan of heated soup, the soup at the bottom expands, becomes less dense, and rises, forming an upward current toward the surface. There, cooling takes place into the air and the soup becomes denser and falls under gravity - forming convection cells. **However, if the soup is thick, its viscous properties tend to prevent the upwelling of the buoyant liquid and the decent of the cold. When this happens, the soup may be hotter and hotter at the bottom of the saucepan until steam forms or it burns...For example on field trips geologists and archeologists can point to exposed rocks and ancient monuments that have been deformed by slow flow (but not fractured) under gravitational and tectonic forces**..."*

In other words the question is: if thermal forces can not exceed the static friction (strength) of rocks of the order of ***10^{10} Pa.s***, how can they surpass the more than ***10^{20} Pa.s*** of the mantle's viscosity, in order to accommodate convection and, furthermore, subduction, which requires the penetration of a ~100 km thick slab into the underlying dense and solid mantle? But even if we assume that this happens and the mantle drag moves the plates, how is if that thermal stress does not play any role in earthquake generation, and we have to rely on some (mysterious and unknown) external equivalent of forces, when the spatial distribution of earthquakes is still attributed to the action of thermal convection stress, that supposedly moves the plates? That is to say, that thermal stress is held responsible for the spatial distribution of earthquakes, but it is not compatible with earthquake generation. That defeats logic.

Radioactive decay can by no means provide the heat energy required for convection. Almost all radioactive elements are concentrated in the upper few kilometers of the continental crust, far away from the location where convection supposedly takes place. These concentrations are extremely small, and of the order of 80 ppb. In the Moon, the concentration of radioactive elements is more than three times greater. Following that reasoning radioactive decay causes mantle convection, and the Moon should therefore have a vigorously convecting mantle instead of a non-convecting mantle, as we observe.

Finally, primordial heat can not be the energy source either. That highly speculative hypothesis asserts that gravitational energy, liberated from the sinking of vast drops of iron, were trapped within the core in long-lived radioactive isotopes around 4.6 billion years ago. This is estimated to be about $6x10^{22}$ W (Press and Siever, 1978). With the present rate of heat loss, that amount can only last for about 2 billion years. This is however a very conservative estimate, because the rate of heat loss in the early stages of a heat-engine Earth were certainly much higher. If the heat energy requirements for convection are between one or two orders of magnitude greater, this primordial energy can only last from 200 to 20 million years!

In the outer core, the shockwave pressures of protons traveling with a speed of the order of 10^7 m/sec, are of the order of 10^{30} Pa. At such pressures the mechanical energy is stored in atoms as chemical energy within compressed electron shells. Such a system has low entropy and temperature. The only way for thermally controlled expansion to occur, that is for the chemical energy of atoms to be transformed into heat, is by causing extensive disintegration of the overburden solid mantle that will result to diminution of pressure. Obviously this is not happening.

Only in an ideal gas or liquid, with very low viscosity, all four stages of the heat engine cycle - i.e., thermal expansion, adiabatic expansion, thermal contraction, and adiabatic contraction - can materialize. In very viscous or solid materials, as the interior of the Earth is, the process is not cyclic but unidirectional. That is because the non conservative, time and path dependent force of friction is involved. In thermal convection, the higher the viscosity, the higher the temperature difference required before convection starts, the higher the thickness of the boundary layer, the smaller the Reynolds number, the higher the Rayleigh number, the higher the instability and the time dependence of motion (Acheson I990); that is, the higher the irreversibility of motion.

Seismic attenuation can be the result of ‘cold’ pressure gradient flow. High Q implies either the absence of flow or a very thin flow, ‘invisible’ to seismic waves; that is, material with low viscosity - high Reynolds number (Re>> 1). The low Q could be the result of the combined effect, primarily of bulk flow and secondarily, of temperature that further reduced resistance to ductile strain. The temperature throughout the whole mantle must be well below the melting point, as is implied by the increase with depth of seismic wave velocities and the Q factor. In a heat-engine Earth scenario, the temperature of the mantle is thought to be close to melting point and its Re number very low ($\sim 10^{-19}$) implying a very thick (~75 km) boundary layer (Bott 1982). This, combined with the estimated increase of seismic wave frequency with depth, will resulted in a decrease in Q, that is an increase of seismic wave attenuation.

In a solid Earth scenario however, we don't have to rely on flow to explain attenuation.The elastic properties of the Earth’s interior are better described by the formulas:

$$V_p = \sqrt{\frac{k + \frac{4}{3}\mu}{\rho}}, \quad V_s = \sqrt{\frac{\mu}{\rho}}, \quad \textbf{(1)}$$

> where ***V_p*** and ***V_s*** the velocities of ***P*** and ***S*** waves respectively, ***k***, bulk modulus*, **m***,rigidity modulus, and ***r**,* density.

In that context the High Velocity Zones (HVZ) correspond to areas whereby the elastic moduli increase with increasing density more rapidly than density itself does, while the opposite is happening in the Low Velocity Zones (LVZ), and in the so called asthenosphere. This is not a temperature, but an EMS controlled process. In the areas where EM penetrates causes dislocations, defects, and micro-fracturing and thus reduces the elastic moduli of the surrounding rocks, producing a LVZ. In the areas, free of EMS, where compaction of matter takes place, a HVZ is formed as a result of gravitational sliding of the LVZ upon it. That can explain in a much better way the coexistence of the LVZ with positive gravity anomalies and high heat flow values, indicating a mass surplus injection and increased temperatures as a result of the reduction in pressure as EM rises upward during emplacement.

Of the three ways of energy-heat transfer in fluids and solids, that is ***convection, conduction,*** and ***radiation*,** only the last two refer to solids. It is well known that **convection** refers to bulk flow of mass in a fluid produced by gravity acting on density differences produced by unequal temperatures of the convecting material. Convection occurs on a large scale in the atmosphere and oceans. In other words the process is applicable to material with, more or less, free atoms and molecules, which have very low viscosity, i.e., below 1 poise.

On the other hand, in **conduction***,*heat is carried by means of collisions between rapidly moving and rotating molecules in fluids (gases and liquids) at the hotter end of a body of matter and the slower ones at the colder end. In solids it is not translation but the vibration of lattice ions, atoms or molecules, and the movement of free electrons that carry the energy. Conduction is poorest in gases because their molecules are relatively far apart and so interact less frequently than in the case of solids and, to a lesser degree, in liquids. In ***metallic solids*** conduction is mostly done by the movement of their shared free electrons that can move about relatively freely and can travel past many atoms between collisions. The translational movement of the ‘sea’ or ‘bath’ of conduction electrons is considered to be the most effective way of conducting heat, or any kind of energy. In ***nonmetals***, such as most of the minerals of the crust are made of, the outermost electrons are attached tightly and are not readily available to conduct energy by electron movement. ***The ability of free electrons to carry energy without, or with limited impedance, is very important, because this energy transfer is just that, a transfer--it does not result in or convert to a temperature rise.***

Temperature or energy potential increase could increase the kinetic energy of an electron. But for an electron to acquire a velocity of the order of $v = 10^7$ m/sec, the required temperature (T=2,200,000 K) is extremely high, and outside reasonable consideration, (KE=3*k*T/2=mv^2/2, T= mv^2/3*k*, where m = 9.1´ 10^{-31} kg, v =10^7 m/sec, *k*=1.38´ 10^{-23} J/K), while the potential difference is a low V=290 Volt, (KE=W=QV= mv^2/2, V= mv^2/2Q, where Q=1.6´ 10^{-19} C).

Ions cannot move-vibrate freely in a solid. To the degree they can vibrate, the frequency of vibration depends upon the strength of the interatomic forces, whereas the amplitude depends upon the total heat content, that is temperature (Verhoogen et.al., 1970). Nevertheless vibrational conduction is the least efficient way of thermal conduction. At high temperatures the thermal conductivity of many nonmetals increases rapidly with increasing temperature, asT^3, the transfer of heat now being dominated by radiation.

In **radiation** energy is carried by the spontaneous or induced emission of ***electromagnetic waves and/or particles*** from a source. According to Stefan's law, the ***total energy, E,*** emitted in the form of heat radiation per unit time from unit area of a ***black body*** is proportional to the fourth power of its absolute temperature, *E* = s T^4, where s =5.67´ 10^{-5} erg.cm^{-2}.sec^{-1}.K^{-4} = 5.67´ 10^{-5} mW.m^{-2}.K^{-4} is the Stefan-Boltzmann constant of proportionality. At a temperature of 1,000^0 C, the radiation of heat is of the order of 150´ 10^6 mW.m^{-2}. That is, about 2.5´ 10^6 greater than the ~60mW.m^{-2} of the heat flow of the Earth. The temperature that can give the same heat-infrared radiation as that of the observed Earth's heat flow is of the order of ~33 K, that is -240^0 C. In other words the Earth is a very cold body.

Wien's displacement law states that, the wavelength l_m at which most of the energy is radiated is l_m=0.29/T, where T the temperature in Kelvin. At low temperatures the wavelength of this (infrared) radiation is very long, and falls in a part of the spectrum in which most of the solids are nearly opaque; then the radiation emitted by a hotter portion of the body cannot travel very far without being reabsorbed, and the transfer of heat energy is limited. For a temperature T=1400 K, the wavelength of the emitted radiation is, l_m=2´ 10^{-4} cm. The higher the temperature the more energy is emitted in the infrared and visible parts of the spectrum, where many nonmetals, and particularly many silicates, are transparent. The shorter the wavelength the longer the distance a radiation can travel before being reabsorbed, and the rate of energy transfer thus becomes rapid, since the radiation itself travels at the velocity of light in the solid (c / refraction index) and is much greater than the rate of the elastic waves propagation involved in ordinary conduction.

Opacity, a, is the extent to which a medium is opaque, that is, not transparent and does not permit a wave motion, i.e., sound, light, X-rays, etc, to pass. Numerically the reciprocal of the transmittance. If radiation of intensity I_0 is reduced to intensity I_x after traveling a distance x, the ***opacity, a***, is such that I_x=I_0 e^{-ax} where a = *ln* I_0 / x I_x. Opacity is a function of pressure, temperature, and physical state. Large, clear, single crystals are less opaque than aggregates of small grains, in which light is scattered at grain boundaries and at imperfections of any kind within the lattice.

Excluding convection as the means of energy transfer in solids, we have to rely on conduction and radiation. The suggested surplus of 'free' electrons (~10^{53} as compared to ~10^{51} protons) favors conduction through free electron movement, and short-wave high energy electromagnetic radiation, up to the level of the mantle-crust boundary. Above this boundary the dominant nonmetallic composition of the Earth's crust allows mostly radiant conduction of energy, which travels very fast. Only at or very close to the surface, vibrational conduction which involves friction, and consequently the rise of temperature, becomes possible. The fact that heat flow values are about the same in continental and oceanic areas, i.e., ~60 mW.m^{-2}, implies that the energy source is deep seated and, more or less, homogeneously distributed. The other near surface sources of heat are hydrothermal activity and radioactive decay.

It has been found that in modem island arcs the potassium content of andesitic rocks increases as the depth of the Benioff zone increases. Plate tectonic theory explains the increase in K content via subduction and partial melting of basalt due to temperatures increasing with depth (Sawkins et.al., 1978). We attribute it to temperature decrease. About l % K_2O content corresponds to a temperature of ~1000^0 C and to a depth of ~100 km, and the value of ~3% to a temperature of ~800^0 C and to depth of 200-300 km. In other words, the K_2O content of rocks indicates the depth, the composition and the temperature of the mantle below it and not the properties of some down-going slab.

According to Press and Siever (1978) the heat flow in active ocean ridges is ~3 HFU; within geologically young and active areas i.e., the Alpine belt, ~2 HFU, in the ocean basins ~ 1.3 HFU, in geologically old inactive areas ~1 HFU, in the ocean trenches < l HFU. In the Sierra Nevada the heat flow is only ~0.4 HFU. The case of Sierra Nevada is very interesting since it is at the flank of the Yellowstone volcanic hotspot which belongs to the Basin and Range Province, that is associated with a 53 m high, and ~1600 km in diameter geoid anomaly (Hunt et. al 1992).

The positive free-air gravity anomaly indicates the presence of excess mass and uplift of the north-western USA. Heat flow is high in places where recently rising EM is very close to the surface i.e., Old Faithful. Geologically young EM is not present under the Sierra Nevada, and because of this, the observed heat flow is low. Thick old crust and/or low concentrations of radioactive materials and water can result to even lower heat flows. Within the Atlantic, Pacific, and Indian Oceans, it has been found that the heat flow of a lithospheric slab ~100 km thick, reaches the average value of ~l.5 HFU in ~50 m.y., at a distance ~200 km from the oceanic ridge (Anderson et.al. 1977, Parsons and Sclater 1977, Press and Siever 1978; Bott l982). About one third of the heat flow in oceanic ridges is attributed to hydrothermal activity, and therefore the heat flow which can be attributed to radiant conduction is ~2.0 HFU. In ocean basins, the average value is ~1.0 HFU. That value corresponds to a distance from the ridge of ~200km, and a depth of ~100 km and an age of ~50 m.y. The 2:1 ratio between the horizontal and vertical axis is the result of gravitational sliding of the upper most mantle. We argue that the source of this heat is the movement of conduction electrons, short wave electromagnetic radiation, and stored chemical energy from the Earth's interior. The ratio of, 1 HFU to 1000^{O}C, to 200 km distance from the spreading ridge, to 100 km depth, to 50 m.y. age, is the proposed rule.

Table 1. Mean Heat Flow values, due to radiant conduction of heat, as a function of Temperature, Distance from ridge, Depth below ridge, and Age of oceanic crust. For these computations the following formulae have been used:

***a)* Heat Flow - Temperature,**

$HFU_q = (1100^0C)(e^{1/q\ a})$, q= temperature,^{0}C, a =- 0.000144.

***b)* Heat Flow - Distance from ridge,**

$HFU_d = (2.0HFU)(e^{db})$, d= distance, km b = - 0.00347.

***c)* Temperature - Depth below ridge,**

$T_D = (1100^0C)(e^{Dc})$, T = temperature, ^{0}C, D = depth, km, c =- 0.00103.

***d)* Heat Flow - Age from ridge,**

$HFU_A = (2.0\ HFU)(e^{Ad})$, A = age, m.y. ago, d =- 0.0139.

HFU *m* cal/cm^2/sec	Temperature ^{o}C	Distance from Ridge km	Depth below Ridge km	Age m.y. ago
2.0	1100	0	0	0
1.5	1053	83	44	21
1.0	**992**	**200**	**100**	**50**
0.5	902	400	193	100
10^{-1}	746	863	377	216
10^{-2}	598	1527	592	381
10^{-3}	499	2190	1350	1001
10^{-28}	97	18780	2358	4688

Table 1, and Fig. 1 show our proposal for the relationship between heat flow values, temperature, distance from the ocean ridge, depth below the ridge, and age of oceanic crust. The implication here is that, in the crust, heat conduction is mainly radiant, since at temperatures above 750 K the contribution of vibration to thermal conductivity gradually diminishes (Bott, 1982). Wavelengths that correspond to heat radiation are at the infrared part of the spectrum, from 10^{-6} m to 10^{-3} m. We propose that such wavelengths are attainable only in the upper 100 km or so of the Earth's interior. Below this depth, due to pressure induced denser packing, vibrational conduction of energy is not possible. Low temperature and fine grained solid mantle is opaque to long wavelength (infrared) radiation. The ability of atoms to vibrate ranges from suppressed to non-existent, and at the absence of other heat sources, i.e., radioactive elements or promordial heat, resulting temperatures will be low. Energy transportation occurs via free electron movement and short wavelength radiation emission, absorption and re-emission at longer wavelengths as excess mass approaches the surface, within a solid, non-convecting Earth interior.

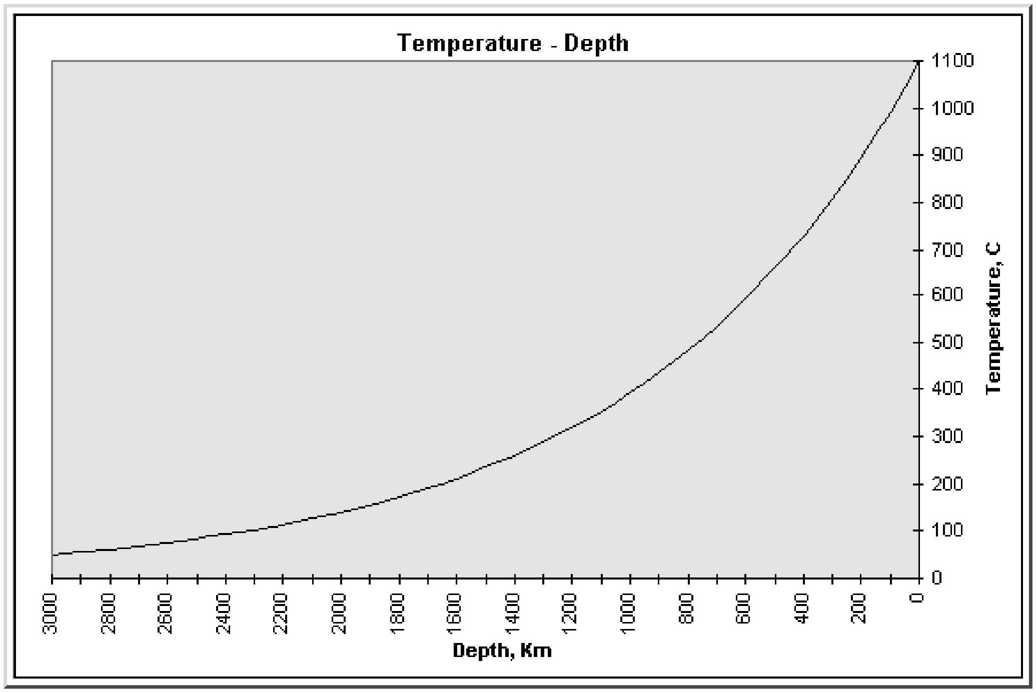

Fig. 1. Temperature-depth relationship in the EMS model.

As we go back in time, due to the lack of iron and also due to lower temperatures, the composition of the surface rocks should be more felsic. This seems to be the case since in the old cratons the rocks are granitic in composition. Considering that felsic magmas solidify at ~ 600^0 C, and according to our estimate, Earth's near surface temperature 1 b.y. a. was ~500^0 C, and taking into account expansion's decompressional effects, the current temperature of the mantle-core boundary should be well below 500^0 C. It may be close to the estimated accretion temperature of ~400 K (Bott 1982), which is about the same as our prediction of ~100^0 C. If this is happening, crystalline ferromagnetic minerals, if present, will be strongly magnetized since their Curie temperature is between 500^0 and 700^0 C.

It is estimated that 30-40% of the continental heat flow is due to radioactive decay, while in oceanic areas this is less than 7% (Bott 1982). If that estimate is correct, the average heat flow in continental areas should not be lower than 0.5 - 0.6 HFU, no matter how old the crust is. Of course local variations in the concentration of radioactive elements can increase or decrease this heat flow. Similarly, but mainly due to hydrothermal activity, heat flow is maintained well above zero in oceanic areas.

It seems that iron production is associated with orogenic episodes. A possible explanation is that during these periods the 8.8 MeV threshold is surpassed. There are at least two distinct periods of iron production. The first, that started ~3.5 b.y.a, culminating at ~2.5 b.y.a. then ended at ~1.5 b.y.a., and is associated with global Banded Iron Formation (BIF) production. The second is associated with the Alpine orogenesis, that is the relatively recent 200 m.y. of Earth's history when most of the mantle and oceanic crust were fabricated and emplaced due to an increasing rate of matter transformation. Massive iron production appears to be implicated in this transformation process.

At the early stages of the Earth's history the solid overburden was very thin and iron was not abundant. The surface rocks that could form at that time were felsic in composition, and with low melting temperatures. Later, as the iron content and the temperature of rocks in contact with the surface granitic rocks increased, melting and metamorphism commenced. This resulted in the formation of greenstone belts which resemble the composition of rocks found in modern island arc systems. In both cases, the properties of the surface rocks are a result of, and reflect the properties of the mantle below them. That implies a lack of decoupling of the overlying layers of rock.

Excess Mass (EM) and Transformation of Matter

It is proposed that EM is added concentrically at the core-mantle interface and ascends to the surface through zones of weakness within the mantle. At the beginning of this process, the ascending EM produces doming then rifting and formation of an oceanic ridge, and eventually, an ocean basin if the cycle progresses sufficiently. Each cycle is an orogenic episode and is associated with direct manifestations of EM, i.e., granites, andesites and basalts-ophiolites. Likewise, metamorphic and sedimentary rocks can be considered as indirect, and near surface products of earlier orogenic EM emplacement events in the mantle and the crust.

Fault plane solutions of earthquakes at mid-ocean ridges, within island arcs, and orogenic belts, inherently imply global extension. This is expressed in the central zone by doming, rifting, crustal thinning and basinal subsidence, through mechanisms of normal faulting, development of a horst and/or graben patterns and finally, in uplift through passive folding. At the flanks of the passive folding core-zone, the ductile deformation changes into flexural-slip folding and brittle deformation and low angle thrust faulting (Stauder 1968, Kanamori 1977, Burchfiel et.al. 1982). The structure and the deformation mode of the central zone, (i.e., extension and normal faulting), and of the marginal zones, (i.e., compression and thrust faulting), is more or less common within all deformation belts, i.e., western North and South America, the Indonesian arc, the Alpine-Himalayan mountain belt, the Pyrenees etc., and this is associated with positive free-air gravity anomalies. This is indicative of non-horizontal and non-collisional, but of vertical and accretionary characteristics of these orogenic crustal deformation belts.

The vertical deposition of EM piles in a ‘fan’ like maner, around the extensional ridges, produces gravitational compression at the oceanic-continental crust boundary. The center of rotation of the ‘fan’ is at the mantle-core boundary interface. The greater the width of the ‘fan’, the greater the vertical component of compression. When that component reaches a critical angle, probably between 15^{o} and 30^{o}, a Benioff fracture zone begins to form. This is probably the reason for the presence of Benioff zones around the Pacific and for their absence within the Atlantic basin. Gravity is the minimum principal stress and the faulting produced is reverse. Once such through-mantle zone of weakness are formed, EM will tend to rise through it toward the surface. In this case, oblique faulting, where none of the principal stresses are vertical, is superimposed upon the reverse faulting. This seems to be the case, particularly for depths between 100 and 700 km where the dip of the zone is up to 75^{0} (Isacks et.al. 1968, Sawkins et.al. 1978).

The ~1500 km wide and ~5000 km long belts of positive free-air gravity anomalies (in Burchfiel et.al. 1982) imply the presence of EM above Earth’s high seismicity Benioff zones. The strong relationship of volcanoes, earthquakes, and positive gravity anomalies has been noted by prominent scientists. Gutenberg in 1951, writes :***" There is a strong correlation between lines of active volcanoes, lines of earthquakes originating at a depth of 80 to 150 km, and positive gravity anomalies (mass surplus within the uppermost 60 to 80 km), as well as a correlation between recently extinct volcanoes and lines of earthquakes originating at depths between 150 and 250 km..."***

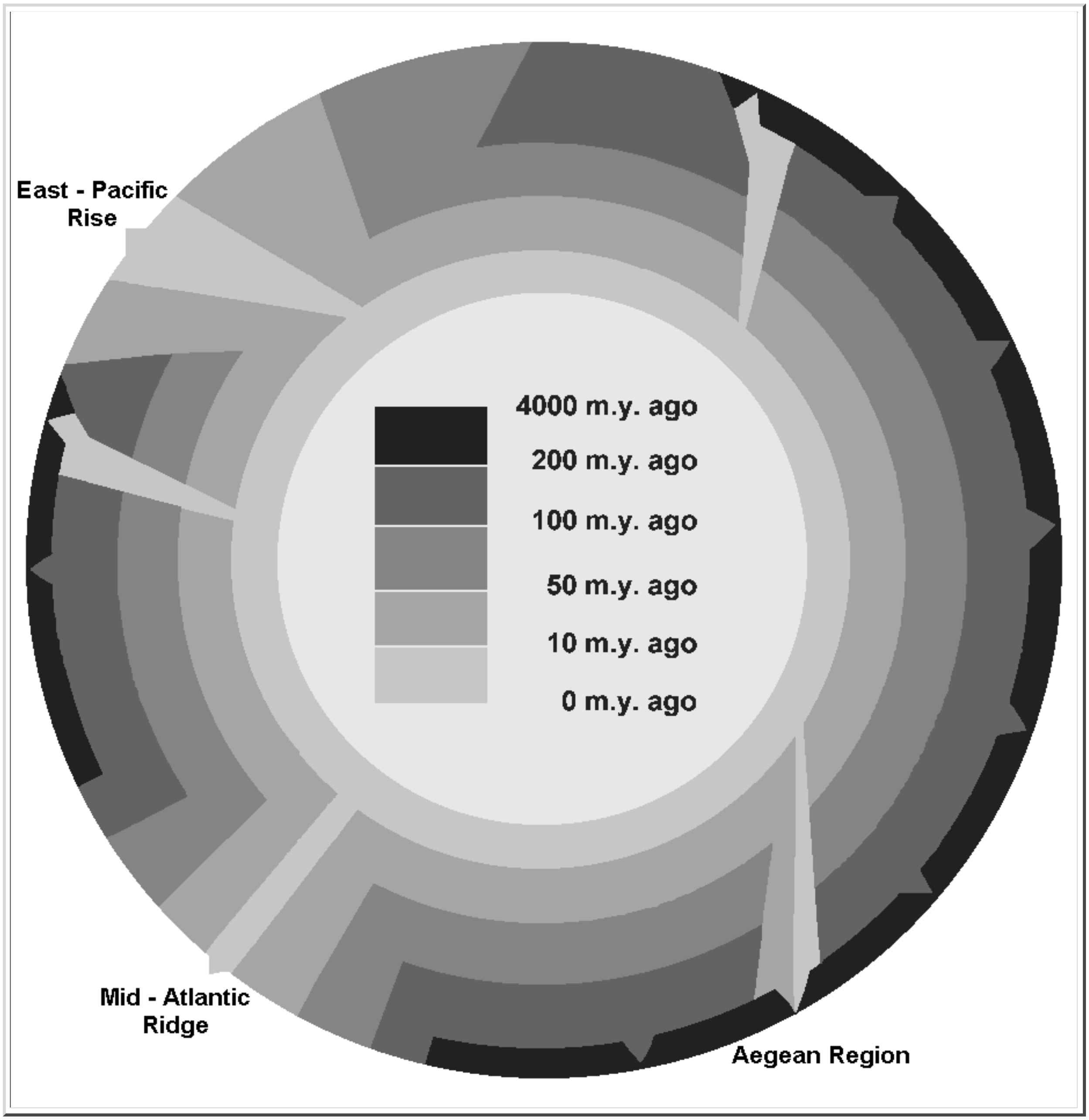

Fig.2. Idealized representation of concentric and vertical addition of Excess Mass (EM). (Drawing by Eleni Zarogianni, and redrawing by David Ford)

Fig.2 is the interpretation of paleomagnetic data without subduction. Magnetic anomalies are thought to represent columns of EM extending down toward their mantle-core boundary origin. In an equatorial (30^{o}N to 30^{o}S) cross section, ~ 60% of its length is occupied by continental crust with rocks from 0 to ~4 b.y. old, that become more felsic as we go back through geological time. The other 40% is occupied by oceanic crust, mafic in composition, and less than 200 m.y. old. The ~24,000 kms of continental crust shown corresponds to a ~3800 km global radius after the necessary convexity adjustment is made, when post Mesozoic to present lithospere is removed. The resulting radius appears to be the case prior to 200 m.y. ago. As Earth expansion proceeded, a considerable convexity reduction occurred as global radius increased. Convexity reduction takes place without long lasting residual doming at the surface if the base of a ~350 km thick crust-like shell is extended during expansion, thus creating zones of mantle weakness and the mantle's viscosity ($\sim10^{22}$ poises), rigidity (10^{11} dyn/cm^{2}) and relaxation time ($\sim10^{11}$sec or ~3000 years) enables this convexity reductions to proceed as Earth radius increases.

Considering that the total length of spreading ridges is about 60,000 km (one and a half great circles), the orientation of the ridges is more or less normal to the equator, and that the average spreading (total) rate is about 11 cm/yr, the corresponding circumference increase is about (11 x 3/2 =) 16.5 cm/yr. When these values are applied they indicate a global rate of radius increase of ~2.6 cm/yr. This rate is in excellent agreement with the rate of 2.8 ± 0.8 cm/yr measured by NASA with the use of satellites and with several other calculations, i.e., 2.6 (Parkinson, in Carey 1988), 2.4 (Ciechanowicz and Koziar 1993, Blinov 1983) and 2.1 cm/yr (Maxlow 1999, personal communication).

The core of the Earth is considered as an electrically unbalanced real gas of particles subject to the exclusion principle. The number of its electrons (~10^{53}) is thought to be around two orders of magnitude greater than the number of protons (~3.6´ 10^{51}) in the core. Excess Mass (EM), is bulk matter which is a product of transformation of simpler and smaller structural units into bigger and more complex ones through a process of controlled nuclear fusions. Hydrogen nuclei, due to electromagnetic confinement, tunnel, resonate and condense into a coherent, friction free, and therefore 'cold' super-conducting state. They then fuse with other ^{2}H nuclei to produce helium (^{4}He) and other larger nuclei. For every 4 nucleons that combine to form a helium nucleus, 2 protons are recycled (Fishbane et.al. I993). Without a source of re-supply, fusioning will reduce to zero as ^{2}H units and electrons are exhausted.

Protons traveling with a speed of the order of 3x10^{7} m/sec, produce shockwave pressures of the order 10^{30} Pa. This pressure energy is more than enough for fusioning to take place since the pressure required for this is only of the order of 10^{26} Pa. If we take into consideration that the confining pressure at the mantle-core boundary is of the order of 10^{11} Pa, it is clear that the driving force of EM is many orders of magnitude greater than the force available from gravity.

In the outer core, the number of electrons is assumed to be ~10^{53}, as compared to the ~3.6´ 10^{51} nucleons. This imbalance in favour of electrons, is reflected in the magnetic properties of the Earth. The Earth has a magnetic field with a surface flux density of about 0.5 Gauss. We know that the ultimate cause of magnetism is the existence of unpaired, or of pairs of unit spin electrons. Therefore the existence of pairs of high energy, unit spin, free electrons can produce strong magnetic fields. Other planets in our vicinity (Moon, Mars, Mercury), have very weak, and only remnant magnetism, or no observed magnetism at all. This is a indication that a present: a) their core is not electromagnetically active, b) no unpaired or pairs of unit spin electrons are present.

On the other hand, the fact that the Earth appears to be a weak magnet does not necessarily mean that the magnetic field is weak within Earth's interior. It may be very strong, but if almost equal magnetic moments lie in more or less opposite directions, the macroscopic magnetic moment of that material will be close to zero. Examples of such ferrimagnetic and antiferromagnetic materials are the iron oxides magnetite ($Fe_{3}0_{4}$) and hematite ($Fe_{2}0_{3}$) respectively (Grant and West 1965).

The present estimated average density of the core ~11 gr/cm^{3} (Bolt 1982), is deduced with a high degree of confidence. This density corresponds to a total of ~1.1x10^{51} nucleons and up to ~10^{53} electrons. All electrons, and more than 90% of nucleons, are thought to be in the outer core, while within the inner core, about 0.6x l0^{50} protons are present. Considering that the density of solid hydrogen is ~6.7 gr/cm^{3} and of solid helium is ~13.4 gr/cm^{3}, and that the average density of the outer core is ~10.8 gr/cm^{3}, the present distribution of nucleons and electrons in the outer core could be: ~0.3x 10^{50} present as free protons, ~5x l0^{50} present as hydrogen, ~5x10^{50} present in the form of helium, and ~10^{53} electrons. The ~3.6x10^{51} nucleons were trapped within the primordial core which had an estimated radius of ~3170 km and corresponding density of ~45gr/cm^{3}. For that number of nucleons, the number of electrons present could be as high as 10^{53} with a total influence on density about 2%.

The presence of condensed ^{4}He atoms-bosons into a coherent, friction free, 'cold' state is the best explanation for the lack of transmission of S waves and for the extremely low attenuation of P waves in the outer core. The lack of transmission of S waves, implies fluid, and the extremely low P wave dumping, represented by a ***Q factor*** of the order of 10,000 (Table 3), implies a superfluid, that is a friction free fluid. If the material was an iron melt, it's temperature would have to be above it's melting point; but then, due to bulk flow effects, observed attenuation should to be very high --not to mention the problems an iron melt raises with regard to Curie point temperature and geomagnetism. This, friction free ***fluid helium*** along with its dielectric property, can explain ***magnetic reversals.*** These properties of seismic waves, are strong evidence for the presence of large amounts of the superfluid helium within the outer core.

By measuring the length of arcs of observed magnetic anomalies at the periods of, 0 -10 - 50 -100 - 200 m.y.a., we can estimate the paleo-circumference, and from this value, the radius, the paleo-volume, the paleo-density, and paleo-mass at 10, 50,100 and 200 m.y.ago. Table 2 and Fig. 3 show the radius, the volume, the density, and the mass of the Earth for the last 200 m.y. The annual rate at which EM is being added today, can be calculated if we consider a spherical shell, ~2.6 cm thick, and a wedge of mass 60,000 km long and 11 cm wide, extending down to the core mantle boundary. That is ~ 6.45x10^{16}

kg/yr, or ~3.86x 10^{43} nucleons per year. This value is of the same order, but more than two times larger, than the 2.82x10^{16} kg/yr estimated by Ciechanowicz and Koziar (1994).

Table 2. Estimated Radius, Volume, average Density, Excess Mass, and Excess Mass Rate as a function of Time. The Radius and the Excess Mass (E.M.) of the Earth are calculated according to the formulae :

Radius :

$R_t = R_1 + R_2 e^{rt}$ $dR/dt = rR_2e^{rt}$, R_1=3170 km, R_2=3200 km, r = - 0.0081 m.y.$^{-1}$

E.M (10-200 m.y.a):

$E.M_t = M_{mantle}e^{mt}$, M_{mantle}=4.08´ 10^{24}kg, m =- 0.0158 m.y.$^{-1}$, $d(E.M.)/dt = mM_{mantle} e^{mt}$

	Radius		**Volume**			**Density**			**Mass**			
Time m.y. ago	R km	R rate cm/yr	Earth	Mantle ´10^{19} m^3	Core	Earth	Mantle	Core	Earth	Mantle **E.M.** ´10^{24} kg	Core	**E.M. Rate ´10^{16} kg/yr**
0	**6370**	2.60	108.3	**90.6**	17.7	5.5	**4.5**	10.7	5.98	**4.08**	1.90	**6.45**
10	**6121**	2.39	96.0	**78.3**	17.7	6.2	**4.4**	14.1	5.98	**3.48**	2.50	**5.50**
50	**5304**	1.73	62.5	**44.8**	17.7	9.6	**4.1**	23.3	5.98	**1.85**	4.13	**2.93**
100	**4594**	1.14	40.6	**22.9**	17.7	14.7	**3.7**	29.0	5.98	**0.84**	5.14	**1.33**
200	**3803**	0.50	23.0	**5.3**	17.7	26.0	**3.2**	32.8	5.98	**0.17**	5.81	**0.02**
500	**3226**	0.05	14.0	**0.7**	13.3	42.7	**2.8**	44.8	5.98	**0.02**	5.96	**0.00+**

.

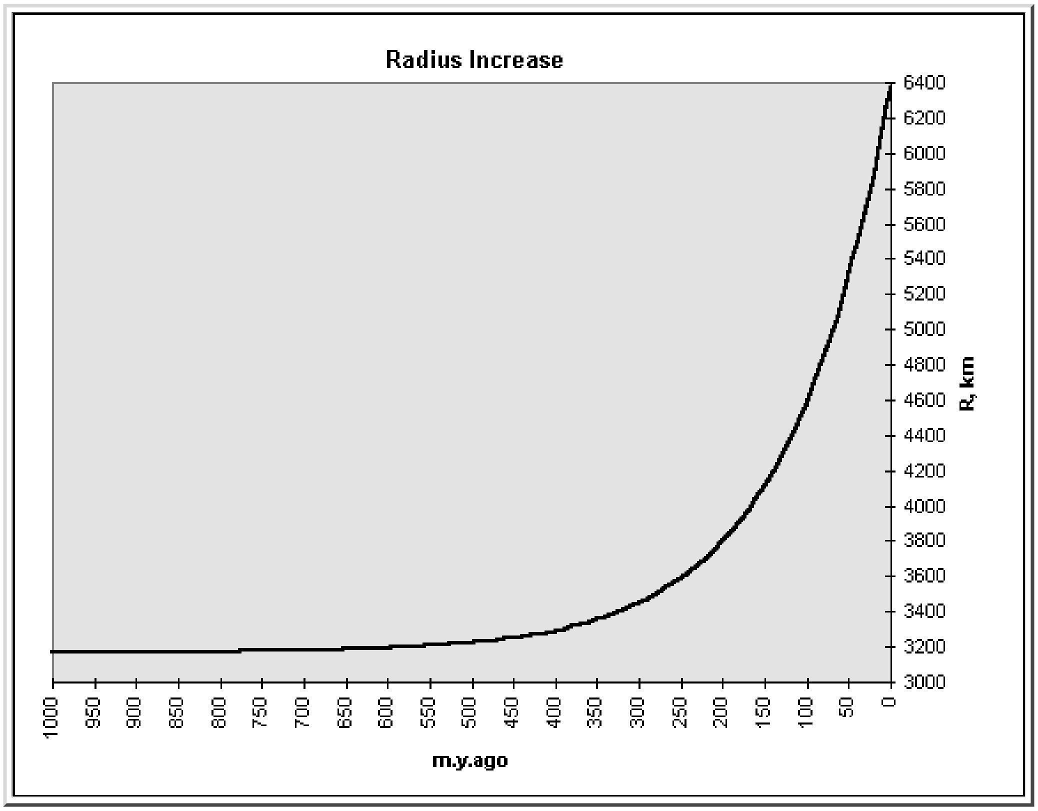

Fig. 3. Proposed Earth radius increase with time.

Two phases in the process of EM generation can be distinguished. The first was extremely slow and lasted from ~4000 m.y. ago to ~200 m.y. ago. During that period, only a small fraction, less than 3%, of the available plasma in the core, was transformed into bulk matter. Its main characteristic is the low nuclear binding energy and/or the large size of atoms. Except for the BIF, the rocks that were formed during this earlier EM production phase, and make up the old cratons of Earth, are poor in iron, and rich in ^{23}Na, ^{39}K and ^{40}Ca atoms, the ionic radii of which are l, 1.4 and l Å, respectively. Felsic rocks of that age-phase also cover most of the surface of the Moon, Mars and Mercury.

During the second phase that started ~200 m.y. a. and continues today, another 65% of plasma-particles have been transformed into EM. The high energies and high pressures of this phase, are responsible for the high nuclear binding energies and/or the small size of atoms, i.e., iron (8.8 MeV / nucleon - the highest binding energy, 0.6-0.7 Å radius). In this framework, the main criterion for the participation of an atom in a mineral structure is not its weight, but its size. Of course, it also depends on the relative availability and the chemical affinity of the atoms. For example, oxygen, although large in size (its ionic radius is ~1.4 Å) occupies about 90% of the volume of the Earth and is more abundant in the crust, thus the greater concentration of Si in crustal rocks. The greater the overburden weight, the closer the atomic packing, and the smaller atoms must be to participate in highly ordered, though small in size, crystal structures. Large atoms, regardless of their weight, are preferentially expelled to the surface region (as per standard Substitutional-Solid-Solution geochemical principles). This is probably why large heavy atoms of ^{238}U and ^{232}Th are concentrated in the uppermost continental crust and are practically absent in oceanic crust. At present, surface rocks will tend to be felsic because of size constraints, and mafic because of temperature constraints. Thus, most granitic batholiths should not be the result of metamorphism, but from direct crystallization of large atoms at greater depth but also lower temperatures (i.e. with increasing depth, temperature does not increase, it decreases).

The degeneracy pressure, of the ~10^{53} free electrons, is of the order of 10^{17} Pa, while the gravitational pressure of the ~3.6x $l0^{51}$ nucleons present is of the order 10^{12} Pa. In the primordial Earth, the degeneracy pressure was about five orders of magnitude greater and laser formation was limited. Because of this the primordial Earth 'blew-up', from the ~3200 km radius to ~3500 km radius. When ~200 m.y. a. the solid overburden reached a thickness of ~320 km, a considerable reduction of the degeneracy pressure occurred due to the intensification of resonance and laser clustering, and a balance between these two pressures occurred. If the number of electrons relative to the number of nucleons exceeds a certain threshold value, the laser clustering can not reduce the degeneracy pressure to sufficient degree to make it equal to gravitational pressure. The result would have produced explosive rupture of a primordial felsic crust into pieces that travel away as meteorite and asteroid sized objects.

If this sort of electrical imbalance is the universal rule, it means that the universe is locally inhomogeneous and anisotropic, and its average isotropy and homogeneity is a result of its vastness, and not of its long term degradation. In that context, the temperature increase with time is indicative of the general energy flow increase with time, that results in the upgrading process of matter transformation. Also the red-shift could be an indication of just a stage in the evolution of a planetary body and not a result of the Doppler effect (see also Arp 1994).

During orogenic episodes, the degeneracy pressure could be reduced to values smaller than the gravitational pressure, due to intensification of laser clustering. The result will be contraction of the core and compression at the surface of the Earth. During inter-orogenic periods, laser clustering is decreased and the degeneracy pressure will tend to reach its original value. The net result will be expansion of the core and tension at the surface.

If this is happening, the Earth is expanding, as a result of EM generation and it is also pulsating as a result of the alternating imbalance between degeneracy and gravitational pressure. One might suppose that at inter-orogenic periods, superimposed upon the Earth's general expansion due to EM generation, is an additional expansion due to degeneracy pressure, in which case the global surface stress field would be strongly tensional. On the contrary, during orogenic episodes the normally extensional field is hampered by compressional processes. What stage is the Earth at within this cycle now? We are most likely in a quieter expansion phase between the more active orogenic pulses.

To summarize the present mass of the Earth is $6x10^{24}$ kg and corresponds to ~$3.6x10^{51}$ nucleons, which were trapped about 4.6 billion years ago in the primordial core. Since then, the volume of the whole Earth has increased by more than eight times. The volume of its core has increased by about 33%, and around 2/3 of its particles have been transformed into bulk matter. This process is in conformity with the conservation of mass, in agreement with Gottfried (1990) and Hunt et. al. (1992). l would not be surprised though, if other processes or mechanisms are discovered involving the fabrication of 'new matter' (Tassos 1994, 1997).

Excess Mass Stress (EMS) and Earthquakes

The mechanism of generation of surface and deep earthquakes is the same. Ricther, 1958 states, ***"...Compression and dilatation in the P phase show a quadrantal distribution in azimuth irreconcilable with an explosive source, but easily explained in terms of shearing fracture*** (S.T. Note: i.e., an implosive source)***...All evidence indicates that deep - focus earthquakes originate in a process involving shear and elastic rebound and of the same nature as that causing shallow shocks. The problem of plastic flow at great depth then must be faced; the apparent contradiction is resolved by appealing to a time parameter. Slowly accumulating strains will be relieved by flow before they can arrive at fracture, but rapidly accumulating strains may progress until fracture is reached. The behavior may be compared with that of wax, which flows gradually under pressure or even under its own weight but fractures sharply if struck with a hammer..."***

Earthquakes are a mechanical phenomenon. In the EMS model the lever is the 'pile' of EM originating at the core-mantle boundary, and motive energy other than thermal, i.e., shockwaves caused by laser clustering that takes place in the outer core, does the mechanical work. The High Velocity Zones (HVZ) correspond to areas whereby the rigidity and the bulk modulus increase with increasing density more rapidly than the density itself does (see eq.1), while the opposite is happening in the Low Velocity Zones (LVZ), and in the so called asthenosphere. This isn't a temperature but an EMS controlled process. In the volumes where EM penetrates, it causes microfracturing and thus reduces the elastic moduli of the surrounding rock which results in a LVZ. Also, close to the surface, the increased easiness of flow caused by increased ductility, which is attributed to temperature increase, enhances seismic wave attenuation. When the effect of compaction exceeds that of density, a HVZ is formed, i.e., as the result of gravitational sliding of LVZ material over it at shallower depths, or of high confining pressures at greater depths. This approach can explain in a much better way the coexistence of LVZ with positive gravity anomalies, indicative of mass surplus below the surface. On the other hand, the implosive stress can not be heat and gravity controlled, since thermo-gravitational forces can only cause slow flow, i.e., creep, but no sudden movements producing brittle fracture.

Defects, as shown in Fig. 4a, due to lattice imperfections in the structure of crystalline solids can offer the channels where EM ascends. As a matter of fact, the first dislocations can be attributed to the action of EMS. Closer to surface the thin width, crystal sized ($\sim 10^{-6}$ m) EM 'wedges', cause ***cataclastic*** micro-cracks and thus weaken, by decreasing the rigidity and the bulk modulus, the strength of the surrounding rocks. Juvenile water, by filling micro-cracks can act the same manner. When these EM 'wedges' coalesce earthquakes are produced. It is possible that the coalescence is done massively and in one big 'wave', therefore few, or absence of preshocks, or gradually in smaller 'waves', with a lot of preshocks. The conventional explanation for the generation of earthquakes is the inhomogeneity of stress distribution, due to the existence of asperities-barriers along an old fault, and of strain hardening of an elastic medium.

The ***elastic rebound hypothesis*** requires the generation of discontinuity surfaces, i.e., faults, that move relative to each other during an earthquake and after the earthquake the surfaces come together again. It does not answer the question; what real forces could cause the internal fracturing? It assumes an ***equivalent system of external forces,*** which can cause the internal fracturing of the elastic medium. The best equivalent of external forces that could have this effect, and generate the shear strain is ***a double pair of torques.*** The values of the twisting moment of the forces that could cause an earthquake are of the order of 10^{30} dyn.cm for very strong earthquakes (M~9), about 10^{12} dyn.cm for small earthquakes, and just 10^{5} dyn.cm for micro-fracturing in laboratory experiments (Papazachos 1990).

According to the EMS model, it is the EM injection-like intrusions, in a wedge like manner, that act like a real double pair of shear stresses and cause the inner fracturing (Fig. 4b, 4c). Therefore, in the EMS model, the double pair of shear stresses acting at the earthquake focus is not some imaginary construct, but very real forces. Fig. 4b is a redrawing, showing the mechanism of solid EM wedge intrusion, with a crystal sized width ($\sim 10^{-6}$ m). The original figure is from Anderson (1951) and refers to the mechanism of dyke intrusion. In the EMS framework, the driving force cannot, for the earlier stated reasons, be heat. On the other hand the concepts of the ***wedging effect*** and of ***internal pressure exceeding external pressure*** are applicable in both instances.

As shown in Table 3, all existing evidence indicate that the Earth's interior behaves like an ***inelastic-plastic*** solid material, that is, like a stiff material which is below yielding strength, and which raptures above yielding strength. The small deformation before rapture, in the order of 1-5%, could result in creep in a pseudo-viscous material, and/or it could be exhibited as a threshold elastic behavior in an otherwise essentially inelastic material. The fact that the elastic moduli increase with depth at a faster rate than density does, indicates that it is the elasticity and not the plasticity that increases with depth inside the Earth. In that context earthquakes could not be the result of slow accumulation of strain (i.e., 2 cm/yr) caused by the constant action on an elastic medium (i.e., for 500 years) via some unknown secular stress (i.e., at a rate of 0.2 bar/yr), but from a rapidly accumulating strain (i.e., 10 m) as a result of a small, and rapid incremental stress (i.e., 100 bars), using as reference an initial isotropic state in which the stress may be as large as 10^{6} bars, but strains are zero (Aki and Richards

1980). The stress drop is only 10-100 bars; a small but implosive cumulative stress which acts as a trigger, i.e., ***an additional hammer like stroke on one more wedge is enough to split a piece of wood into two pieces. A quantized process.***

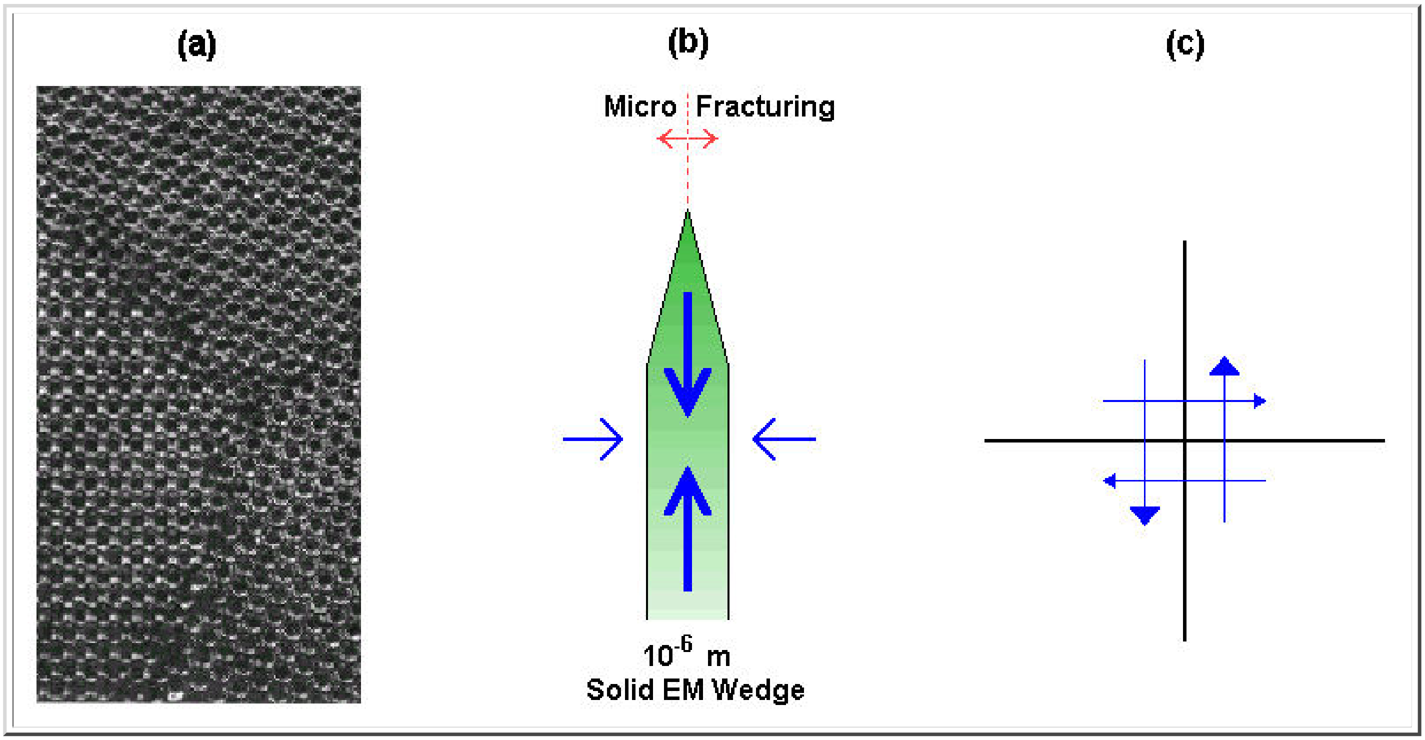

Fig. 4. (**a**) Defects and imperfections in the structure of crystalline solids, (**b**) EM crystal 'wedges', and (**c**), the equivalent double pair of active shear stresses within the EMS model for earthquake genesis and triggering.

When the effect of pressure is removed, the Earth is a homogeneous and isotropic body. The idea that the mass of the Earth is more or less uniformly distributed laterally, except for the upper ~100 km, is supported by the fact that the theoretical flattening of Earth with uniform mass distribution is 1/288.4, while the observed flattening is 1/298.25. This deviation from lateral uniformity of mass distribution is ~3.4%. On the other hand the deviation from vertical uniformity of mass distribution is ~21%, i.e., the moment of inertia of an oblate vertically homogeneous Earth is $0.4MR^2_{eq}$, while the observed value is of the order of $0.33MR^2_{eq}$. The vertical non-uniformity is the result of the increase of pressure with depth. Therefore, the Earth could be considered as a ***rotating nonspherical*** (oblate),***laterally homogeneous and vertically inhomogeneous body.*** The implication is that at depths greater than ~100 km, it is not gravity (i.e., lateral density differences), which is responsible for any vertical movements inside the Earth. Also the significant departure from a liquid Earth implies nonhydrostatic stresses and nonhydrostatic flattening (Verhoogen et.al. 1970).

Because of its small dimensions, this EM mantle 'wedge' emplacement and triggering process is compatible with minimumal frictional resistance, and better explains the elasticity at greater depths and the plasticity at shallower depths. Close to the surface, the rise of temperature makes the process of fracturing more complex because the material becomes more ductile with the increasing dominance of energy transport by longer wavelength thermal processes. In this case, the material flows (creeps), before it can arrive at rapture. As the EM 'wedges' approach the surface and coalesce in a much more massive way, dykes and finally volcanoes are produced, with a subsequent rise of temperature, and the formation of lavas with very low viscosity, of the order of 10^3 poises, on the Earth's surface.

Earthquake clustering is not so much a result of inhomogeneity of the seismogenic volume, but of clustering, in time and space, of rising EM 'wedges'. That is why an area, when one strong shock sequence is considered, will appear homogeneous, i.e., no preshocks are observed, and extremely inhomogeneous when a cluster of strong shocks occurs, i.e., a swarm of shocks. In conventional seismology, swarms of small shocks are associated with volcanic activity and are also considered as an indication of extreme inhomogeneity. But the real implication of the volcanic origin of earthquake swarms is that, it is the ascending excess mass which causes the earthquakes, not the movement of plates.

The fact that, despite the elasticity increase, earthquakes do not occur at depths greater than ~700 km, is possibly due to the very high confining pressures and the very thin EM wedges which can only cause ***cataclastic*** microfractures that ‘heal’ quickly, i.e., cannot lower the strength of the material to such a degree as to cause ***cataclastic flow,*** i.e., ***the combined effect of fracture and frictional sliding.*** Inside the Earth, frictional forces are many orders of magnitude greater than the strength of rocks, i.e., 10^{20} as compared to 10^{10} Pa.s. Earthquakes and the threshold elastic behavior of an essentially inelastic material, are associated with the lowering of the elasticity and strength of that material, prior to the asperity rupture. At depths between 60 and 700 km, the EM wedges gradually coalesce and can produce cataclastic flow. The result is one strong shock, but very few, to absent, preshocks and aftershocks. This is the most typical case of earthquake generation in the EMS model. The high confining pressures induce dominant friction control, giving earlier fracture locations no inherent lack of shearing resistance and strength. The implication, which is also a major failure of the elastic rebound hypothesis, is that each deep focus earthquake generates a new fault. At the low pressure conditions of shallow shocks (h £ 60 km) old faults don’t completely ‘heal’ and can offer a ‘channel’ for EM wedges. Because of that in intra-plate earthquakes the number of preshocks is small to nonexistent, and aftershocks are more numerous. On the other hand in the more active inter-plate areas, preshocks and aftershocks occur. However in the absence of a progressive weakening agent, i.e., EM micro-wedging, the generation of deep and/or shallow shocks is not possible.

Table 3. Pressure, Rigidity, Incompressibility, Seismic Wave Velocity (V_P,V_S), Q factor (Q_P, Q_S), Density, and estimated Composition as a function of Depth and of Discontinuites (bold characters). Data are the average values of Anderson and Hart, 1978, CAL 8-Bolt group, 1981 and of PREM -Dziewonski and Anderson, 1981. The last column, State of Matter - Viscosity - *Type of flow* - *Composition*, is my interpretation of data.

Depth	**Pressure P**	**Rigidity m**	**Bulk modulus *k***	**V_p= {(*k*+4/3m)/r}$^{1/2}$**	**V_s= (m/r)$^{1/2}$**	**Q_p**	**Q_s**	**Density r**	**State of Matter**
Km	**kbars 10^8 N / m^2 (Pa)**			**km / sec**				**´10^3 kg / cm^3**	**Viscosity (Pa.s)** *Type of flow* ***Composition***
0	0	--	--	4.30	2.30			2.38	10^2 to 10^{20} **Pa.s viscous to inelastic-plastic**
20	**5.5**	**562**	**1261**	**7.50**	**4.30**	**~300**	**~100**	**3.08**	*viscous flow to cataclastic flow* ***basalt***
20				**8.04**	**4.51**			**3.36**	**inelastic-plastic** ***eclogite***
220	**72**	**671**	**1336**	**8.11**	**4.45**	**~350**	**~100**	**3.39**	10^{20} Pa.s *cataclastic flow*
220		**714**	**1465**	**8.40**	**4.56**			**3.43**	**inelastic-plastic** *cataclastic flow*
400	**135**	**831**	**1773**	**9.00**	**4.83**	**~400**	**~150**	**3.56**	10^{21} Pa.s ***olivine*** $(Mg,Fe)_2SiO_4$
400		**914**	**1945**	**9.27**	**5.01**			**3.68**	**inelastic-plastic** ***spinel***
670	**239**	**1341**	**2722**	**10.48**	**5.71**	**~750**	**~250**	**4.11**	10^{22} Pa.s *cataclastic flow*
670		**1495**	**2943**	**10.72**	**5.90**	**~5000**	**~2000**	**4.30**	10^{23} Pa.s **elastic-plastic** *cataclasis* $(Mg,Fe)_2SiO_4$ Fe_2O_3,Fe_3O_4
2780	**1292**	**2874**	**6490**	**13.68**	**7.22**			**5.52**	
2780						**~900**	**~400**		10^{21} Pa.s? **semisolid** *diffusion creep* **O, Si, Fe, Mg**
2885	**1356**	**2903**	**6658**	**13.55**	**7.11**			**5.75**	

2885		**0**	**6434**	**8.07**				**9.86**	10^{-10} Pa.s ? superfluid - *inviscid fluid*
5155	**3302**	**0**	**12842**	**10.28**	**0**	**~10000**	**0**	**12.17**	*laser* **e^-, H, He**
5155		**1596**	**13544**	**10.96**	**3.50**	**~350**	**~150**	**13.05**	**p^+** **semisolid -**
6371	3669	1761	14670	11.30	3.64	~900	~550	13.34	10^{21} Pa.s ?

The ***stress drop*** (~10 MPa) and ***strain drop*** (~3.3´ 10^{-4}) in intra-plate earthquakes is more than three times greater than in inter-plate earthquakes (~3 MPa and ~1´ 10^{-4} respectively). That means that the intra-plate initial stress is higher, and/or the inter-plate final stress (kinetic friction) is higher. The seismic efficiency of intra-plate earthquakes is ~0.05, while in inter-plate earthquakes it is only ~0.015. The fact that energy is released almost entirely as heat (i.e., 95-98.5%) by permanent strain (i.e., frictional sliding), and not as stored elastic energy, is indicative of ***irreversible, time and path related, rigid -plastic-inelastic deformation*** and not of reversible, time and path independent, elastic deformation.

In that context, the frictional forces and heat released during inter-plate earthquakes is more than three times greater than in inter-plate earthquakes, and inversely, the energy being radiated by seismic waves is more than three times greater in intra-plate earthquakes. The implications are:

> **a)** Intra-plate areas are under greater pressure and behave more elastically, than inter-plate areas. That is expected in the EMS model since in the intra-plate areas the ascending EM ‘hits’ the thick, cold and rigid continental crust.
>
> **b)** In the inter-plate areas, which are also areas of orogenesis and volcanic activity, the crust is thinner, the ductility of the material is higher and the kinetic friction is higher when compared to the intra-plate areas. Therefore the proposed inter-plate decoupling is more difficult. In other words, in the area where subduction supposedly occurs, the frictional resistance has its maximum value. From this, it paradoxically seems that subduction would be three times more likely to occur in an intra-plate setting.
>
> **c)** Vertical implosive forces offer a better driving force for the generation of earthquakes rather than the horizontal, slowly acting, heat and gravity controlled forces.

The emergence time, that is the time it takes for the movement along a fault to reach its maximum value, depends on the elasticity-ductility of the earthquake source. The more ductile the source is, the longer the emergence time will be. In strong earthquakes, the emergence time is between 1 and 10 sec, although in certain cases the emergence times are observed to be of the order of 100 to 1000 sec. The shorter emergence times at intra-plate earthquake events means that the elasticity of the material is higher and therefore the temperature is lower compared with the higher temperature in areas where the emergence time is longer, i.e., at inter-plate earthquakes. From that, we can assume that the thinner the crust and the closer to the surface the earthquake source is, the longer the emergence time will be.

Elastic wave energy released by earthquakes is about 10^{-3} times less than the heat flow of the Earth, which is ~10^{21} Joules/year. The seismic efficiency is of the order of 10^{-2}, i.e., in an earthquake only ~1-5% of the energy released is elastic wave energy, the other 95-99% being heat. It is therefore reasonable to attribute at least 10% of the heat flow to earthquakes. And why exclude the possibility that the other 90% of heat flow not be attributed to micro-cracking EM processes, caused by exactly the same EMS mechanism which produces stronger macro-scale shocks, and not to radiant conduction of energy? In other words, it is the transformation of electromagnetic energy into mechanical work, and then through frictional sliding, into heat. At greater depths inside the Earth, the frictional resistance of the thin EM ‘wedges’ is limited and the temperature is low. Closer to the surface, EM ‘wedges’ coalesce, the width of the ‘channel’ they form increases, and so does the frictional resistance per unit volume. Hence, melt generation.

It is also interesting to note that heat energy released every year by volcanoes is ~10% of the heat released by earthquakes (~1% of the total heat flow). It is well known that all areas of high seismicity, except for the Himalayan zone, are also areas of intense volcanic activity. It is therefore reasonable to suggest that only a small fraction of the EM reaches the surface to form volcanoes, while the great majority of it remains below the surface causing minor and major shocks, gravity and magnetic anomalies - which are all responses to sub-crustal EM emplacement movements, and also crustal heating that results to passive folding and uplift, and could be responsible for the heat flow.

Conclusions

In the EMST model, earthquakes are a result of the quantized and triggering action of EM wedge injection. Via their emplacement process, the strength of the surrounding rock is reduced from ~10^{20} Pa.s to ~10^{10} Pa.s. In that context, it is not the exerted stress but the tensile properties, (i.e., the resistance of the rock to break apart) that determines the magnitude of the shock generated. The number of EM wedges is directly, and very likely exponentially related to the strength of the rock, and therefore the magnitude of a shock. Locations with higher strength, can act as 'barriers' or 'knots' (as in wood) and halt the fracturing or cause strong shocks if the 'enough plus one' EM wedge is suddenly injected. Smaller earthquakes require fewer EM wedge injections, while bigger ones require many more. It is like a piece of timber whereby the number of identical small wedges required to split it apart depends on its size, strength and grain fabric. Strong shocks, especially along transform faults, and rotational effects can act as an 'enough plus one' EM wedges (but horizontal in direction), and trigger earthquakes.

There is another generic form of intraplate earthquake caused by curvature adjustments of the crust within an expanding Earth seismic framework. Though even in this case, the driving force can not be gravity because the stress differences due to loading, are not sufficient to cause rapture of the crust. Most likely, the driving force is again EMS which acts as an opposing upthrust on the base of the crust, and especially at continental-oceanic crustal boundaries, i.e., ocean margin orogenic belts, where the overall curvature adjustment effect is more profound. Gravity may however be important in identifying a location where faulting may first occur.

Acknowledgements

The author wishes to express his sincere thanks to David Ford for his critical reading of the text, English language corrections, and constructive suggestions.

References.

ACHESON, D.J., 1990. **Elementary Fluid Dynamics.** Oxford University Press. Oxford 397pp.

AKI, K., and RICHARDS, P.G., 1980. **Quantitative Seismology, Theory and Methods.** W. H. Freeman, San Francisco, 910 pp.

ANDERSON, E.M., 1951. **The dynamics of faulting and dyke formation with applications to Britain**, Second Edition, Oliver and Boyd, Edinburg and london, 206 pp.

ANDERSON, D.I. and HART, R.S., 1978. **Q of the Earth.** J. Geophys. Res., 83, 5869-5882.

ANDERSON, R.N., LANGSETH, M.G. and SCLATER, J.G., 1977. **The mechanics of heat transfer through the floor of the Indian Ocean.** J. Geophys. Res., 82, 3391-3409.

ARP, H.,1994. **Empirical evidence on the creation of galaxies and quasars.** In "Frontiers of Fundamental Physics ", Barone, M. and Selleri, F. (ed), Plenum, New York 1 - 11.

BLINOF, V.F., I993. **Spreading Rate and Rate of Expansion of the Earth.** In "Expanding Earth Symposium", S.W. Carey (ed), 297- 304.

BOLT, A. B.,1982. **Inside the Earth.** W.H. Freeman and Company. San Fransisco. 191 pp.

BOTT, H. P. M.,1982. **The Interior of the Earth.** Edivard Arnold London. 403 pp.

BURCHFIEL, S. C., FOSTER, J. R., KELER A. E., MELHORN, N. W., BROOKlNS G. D., MINTZ, W. L., THURMAN, V. H.,1982. **Physical Geology.** Charles E. Merril Publishing Co. Columbus. 5O1 pp.

CAREY, S. W.,1976. **The Expanding Earth.** Elsevier. Amsterdam. 488 pp.

CIECHANOWICZ, S. and KOZIAR, J.,1994. **Possible Relation Between Earth Expansion and Dark Matter.** In "Frontiers of Fundamental Physics", Barone, M. and Selleri, F (ed), Plenum, New York, 321-326.

DZIEWONSKI, A. M. and ANDERSON D. I., 1981. **Preliminary Reference Earth Model.** Phy. Earth Plan. Phy., 25, 297-356.

FISHBANE, M. P., GASIOROWICZ, S., THORNTON, T. S.,1993. **Physics for Scientists and Engineers**, Extended Version. Prentice Hall International, Inc. New Jersey. 13 77 pp.

GOTTFRIED, R.,1990. Origin and Evolution of the Earth **- Chemical and Physical Verifications.** In "Critical Aspects of Plate Tectonics Theory ", Theophrastus Publications, Athens, II, 115-140.

GRANT, F.S. and WEST, G.F., 1965. **Interpretation Theory in Applied Geophysics.** McGraw-Hill Book Company, New York 584 pp.

GUTENBERG, B., 1951. Summary, In : B. GUTENBERG (ed.), **Internal Constitution of the Earth**, Dover Publications, Inc., New York, 408 - 416.

HUNT, W.C., COLLINS, L.G., SKOBELIN, E.A., 1992. **Expanding Geospheres.** Polar Publishing, Calgary, 421p.

ISACKS, B., OLIVER, B. and SYKES, L.R., 1968. **Seismology and the new global tectonics.** J. Geophys. Res., 73, 5855 -5899.

KANAMORI, H.,1977. **Seismic and Aseismic Slip along Subduction Zones and their Tectonic Implications.** In "Island Arcs, Deep Sea Trenches and Back Arc Basins ", Talwani M. and Pitman III W.C. (ed), Am. Geophys. Un., l63-l74.

PARKINSON, W.D., 1988. In "**Theories of the Earth and Universe**", S.W.Carey, 168-170.

PAPAZACHOS, B.C., 1990. **Introduction to Seismology.** Ziti Publications, Thessaloniki, 382 pp.

PARSONS, B. and SCLATER, J.G., 1977. **An analysis of the variation of ocean floor bathymetry and heat flow with age.** J. Geophys. Res., 82, 803- 827.

PRESS, F., SIEVER, R.,1978. **Earth.** Freeman. San Francisco. 649 pp.

RICHTER, C. F., 1958. **Elementary Seismology.** Freeman , San Francisco and London, 768 pp.

SAWKINS, J. F., CHASE G. C., DARBY, G. D., and RAPP, G. Jr., 1978. **The Evolving Earth.** Macmillan Publishing Co., Inc, New York 558pp.

STAUDER, W.J., 1968.. **Mechanism of the Rat Island Earthquake sequence of February 4,1965, with relation to Island Arcs and sea-floor spreading.** J Geophys. Res., 73 (12), 3847-3858.

TASSOS, S.T., 1994. **An Evolutionary Earth Expansion Hypothesis.** In "Frontiers of Fundamental Physics ", Barone. M. and Selleri, F. (ed), Plenum, New York 275-280.

TASSOS, S.T., 1997. **Earth Expansion versus Plate Tectonics, or Approaching Reality versus Mental Artifacts.** Newsletter, New Concepts In Global Tectonics, 4, 13-17.

VERHOOGEN, J., TURNER F. J., WEISS L.E., WAHRHAFTIG, C., and FYFE, W.S., 1970. **The Earth.** Holt,, Rinehart and Winston, Inc., New York, 748 pp.

Return to the Expanding Earth