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FIVE PARA-MYTHS AND ONE COMPREHENSIVE PROPOSITION IN GEOLOGY

A myth could be an allegoric representation of the actual. In the ancient Greek literature a myth the potential truth of which is not verified by observation, and/or experiment, and/or logic is a para-myth, a fabricated myth. Below we will discuss some of what we consider para-myths in geology.

Constant Size Earth

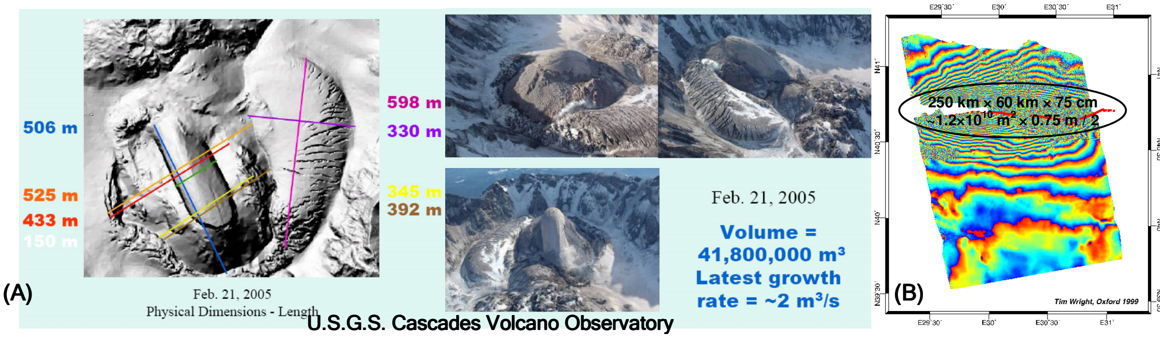

Figure 1. (A) From Sept 24 through Oct 14, 2004 most of a new dome in Mount St Helens was formed. In Feb 21, 2005 its measured volume was $\sim 4.2\times 10^7$ $m^3/\sim 1.3\times 10^{11}$ kg, and its growth rate ~ 2 m^3/s or $\sim 6\times 10^3$ kg/s. (B) New dome 250 km × 60 km × 75 cm, or $\sim 4.4\times 10^9$ $m^3/\sim 1.3\times 10^{13}$ kg of the 7.4 Izmit earthquake, 17-8-1999. ESA's Interferogram Radar acquisitions: 13-8 and 17-9-1999 (Hanssen et.al., Delft University of Technology).

The formation of a new dome in Mt St Helens in about 20 days (Fig. 1A), and of a new dome connected with the Izmit earthquake in less than 35 days (Fig. 1B) are two examples of episodic growth of the Earth in association with volcanoes and earthquakes. It is also known that geoid highs are gravity highs, and positive free-air gravity anomalies (Fig. 2A) coincide with elevation (e.g., Andes, Himalayans, Hawaii), volcanoes and earthquakes. The implication is that, contrary to Airy's isostacy, there is 'Excess Mass' below elevation (Fig. 2B), i.e., volume and density increase, because if it was only for more mass in the same volume, i.e., greater density, there will be no uplift.

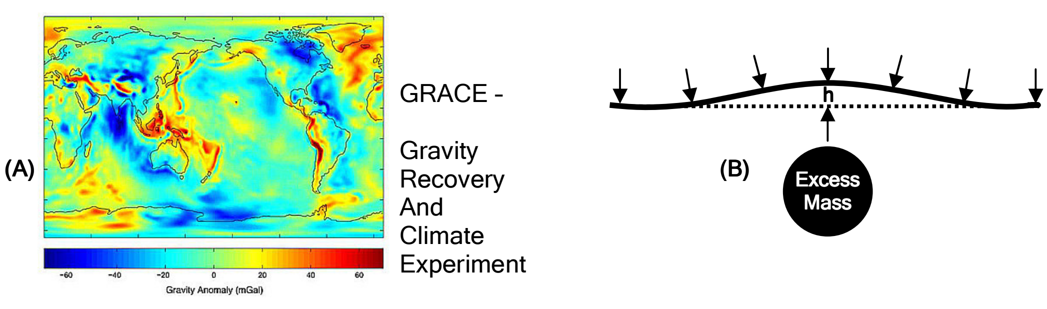

Figure 2. (A) The geoid heights are between $\sim$+70 and -100 m, and the corresponding indirect effect of >+20 and ~ -30 mGal, has to be added on the >+60 and <-60 mGal, respectively, of free-air gravity anomalies, which are a measure of total mass under the point of measurement. (B) The geoid surface (dashed line) is the shape a fluid Earth would have if it had exactly the gravity field of the Earth. In that context the vertical coordinate, h (elevation), is referenced to the geoid, and it is attributed to 'Excess Mass'.

Unless there is a physically possible process of eliminating this 'Excess Mass', e.g., the 1.3×10^{11} kg of Mt St Helens and the 1.3×10^{13} kg of the Izmit earthquake, Earth's growth is an inevitable result. The question is: Where and how this 'Excess Mass' is formed? This question we will try to answer.

Plate Tectonics

According to plate tectonics the formation of oceanic crust takes place at rift zones located in the Mid-Oceanic Ridges - MORs. Beneath the rift zone convection currents of magma occur in the mantle. The added rock along the MORs, produced from the solidification of magma, pushes previously formed oceanic crust horizontally away from the rift zone like a raft on a conveyor belt. Ocean crust is returned to the mantle through subduction, caused by the slab pull of the down-going slab. The movement of oceanic crust under the continents is considered as the mechanism responsible for the friction between the oceanic and continental plates that generates earthquakes along the Wadati-Benioff zones, and creates hot plumes of magma which migrate up through the continental mass to form plutonic and extrusive igneous features, like volcanoes (Fig. 3A and 3B).

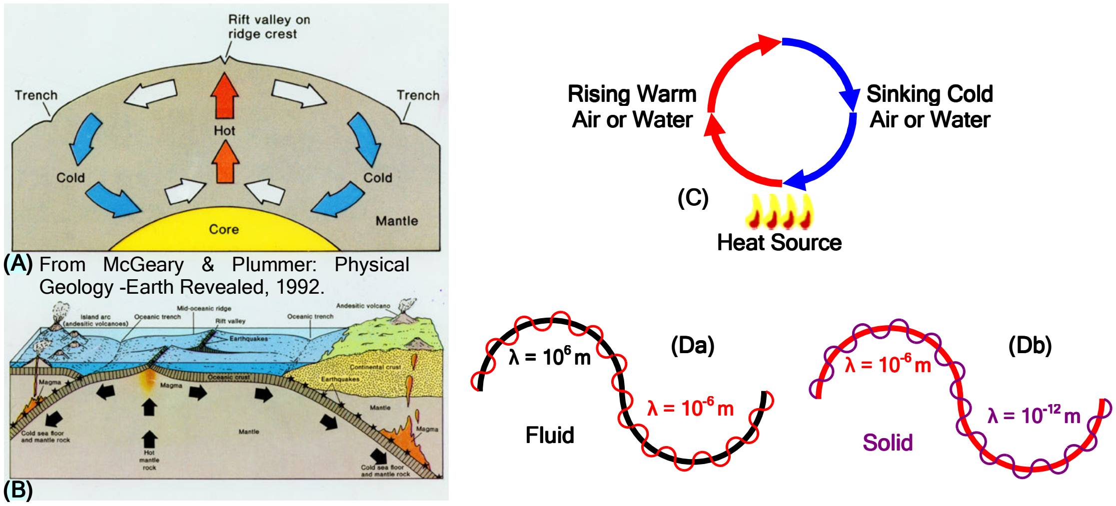

Figure 3. Plate Tectonics: Convection Currents (A) and Subduction (B). But, the possibility of the chimney or buoyancy effect, i.e., the rise of heated lower density material, and the subsequent descend of cold higher density material, has only been demonstrated in gases and liquids (C). In fluids the carrier waves have wavelengths in the order of 10^{6} m (Da), whereas in solids the carrier waves are the 10^{-6} m heat waves (Db).

In order to satisfy the false axiom of constant size Earth, subduction is considered as the process responsible for the elimination of new material added along MORs. Leaving aside the deep continental roots, down to 600 km; the fact that new material is not only or even not mainly being added in MORs, and not all MORs are coupled with subduction zones, e.g., Mid-Atlantic Ridge; there is an insuperable mechanical problem. For a solid to penetrate into another solid the binding forces that keep the atoms of a solid in place, have to be surpassed. Gravity is pathetically weak. It is known that the electrostatic force is about 10^{40} times stronger than gravity. A simple experiment shows that a nail cannot penetrate into a wooden table only due to the fact that it is several times denser. More so this is impossible when the down going slab is assumed to be only 2-3% denser relative to the surrounding mantle. Even that though is a false assumption, because it is known that granite is lighter than basalt, and basalt is lighter than peridodite.

Convection currents, meant as transport of bulk matter to long distances, of the order of millions of meters (Fig. 3A), as in the supposed Earth's convection currents, are applicable to fluids (Fig. 3C), not to solids. In real fluids the low resistance is expressed by the very low viscocities, e.g., ~10^{-5} for air and 10^{-3} Pa.s for water. If we treat fluids as waves, then their 10^{6} m wavelength (Fig. 3Da), is a carrier wave that can almost instantaneously conduct-carry heat, with its 10^{-6} m wavelength. In real solids the 10^{-6} m thermal waves are the carrier waves; any higher frequency/lower wavelength waves, e.g., 10^{-12} m, are carried by them (Fig. 3Db). Thus the dimensions of convection currents in materials in the Earth's interior, with viscosities of the order of 10^{20} Pa.s, is similar to the 10^{-6} m wavelength of thermal radiation. Convection currents of 10^{6} m, twelve orders of magnitude higher, could only occur if the Earth's mantle had the elastic properties of the atmospheric air.

Heat Engine Earth

According to plate tectonics, but also to alternative theorizations the Earth is a heat engine, i.e., all geologic and geodynamic processes are fuelled by heat. In order for that to occur the temperature of the inner core should be about 5000 K, and the temperature in the mantle should increase with depth to ~3800 K at the mantle-outer core boundary (Fig. 4A). Overall, the temperature of more than 99% of the Earth's interior should be higher than 1000 ^{o}C.

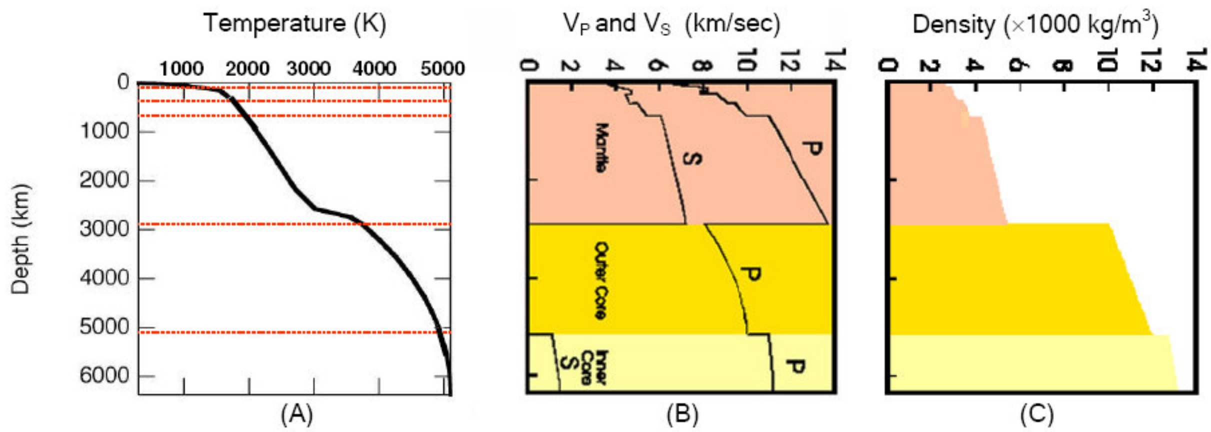

Figure 4. Temperature (A), Seismic Wave Velocity (B), and Density (C) Profiles, in the Earth's Interior.

But, it is well known that the velocity of both P and S seismic waves is proportional to incompressibility, *K*, and rigidity, μ, and inversely proportional to density, ρ, as per:

$$V_P = \sqrt{\frac{K + \frac{4}{3}\mu}{\rho}} \qquad V_S = \sqrt{\frac{\mu}{\rho}}$$

Then seismology tells us that the velocity of both P and S waves increases with depth in the mantle (Fig. 4B). Density also increases with depth (Fig. 4C). So, if it was only for density the velocity of seismic waves should decrease with depth. There is no other physically possible way for seismic wave velocity to increase with depth but for the elastic moduli to increase with depth at a faster rate than density. This is impossible though if temperature increases with depth. Experiment has shown that the elastic moduli are very sensitive to temperature; rigidity decreases as temperature increases, and vice versa, and at temperatures above 800 ^{o}C rigidity diminishes rapidly. This decrease cannot in any way be compensated by pressure-depth, because the pressure at any depth is below the rigidity and incompressibility thresholds. For example according to the Preliminary Reference Earth Model – PREM the density of crustal rocks at ~10 km depth, is ~2900 kg/m^3, the pressure ~0.3 GPa, whereas rigidity μ, and incompressibility *K*, are ~26.6 and ~52 GPa, respectively. At 77 km the density is ~3375 kg/m^3, the static stress ~2.45 GPa, the rigidity ~67.4 GPa, and the incompressibility modulus ~130 GPa. At the depth of 667 km the corresponding values for density ρ, pressure, rigidity μ, and incompressibility *K* are ~4381 kg/m^3, ~23.8, ~155 and ~300 GPa, and at 2888 km they are ~5566 kg/m^3, ~136, ~294, ~656 GPa.

The implication is quite clear: Depth and therefore static stress-pressure has no effect on elastic moduli. For seismic wave velocity to increase with depth in the mantle rigidity has to increase with depth; as a result temperature cannot increase with depth. Therefore the seismic wave velocity profile is an approximation of the actual, whereas the conventional temperature profile is not based on observation, experiment and logic, i.e., it is not an approximation of the actual.

Associated with the heat engine Earth is the belief that all igneous rocks came from the solidification of magma and their texture depends on the rate of cooling/depth. The microcrystalline texture is considered indicative of fast rate of cooling/surface, and the megacrysts of slow rate of cooling/greater depth. But, how can this be true if we know from petrology that the cooling rates of rocks inside the Earth are of the order of 50 K per billions years, the microcrystalline texture refers to deep mantle rocks like gabbro and peridodite, and the megacrysts to the surface granite?

But, there is another insurmountable problem. Where all this heat comes from? The conventionally suggested heat sources are: (1) remnant primordial heat trapped in Earth at the time of the Earth's supposed origin, about 4.6 billion years ago, (2) tidal heating, and (3) decay of radioactive elements.
With regard to the first option, the 2×10^{30} J of the supposed primordial heat could have lasted for only the first 50 million years (!), given constant expenditure at the present annual global energy requirements, which are of the order of $\sim4\times10^{22}$ J/yr, or $\sim10^{15}$ W. For the second option, the 10^{12} W of tidal frictional heat induced in rocks by the about 11 cm oscillatory uplift of the mantle due to the moon's gravitational attraction amounts to an insignificant 0.1% of the necessary annual energy requirement for a thermally driven Earth.

Lastly, the radioactive isotopes, such as U^{238}, Th^{232}, and K^{40}, are assumed as the most probable mantle heating energy source. But, the concentrations of Th^{232}, U^{238}, and K^{40} in granite are about 13, 4, and 4 ppm, respectively, a total of 21 ppm; in basalt the total is only 4 ppm, and in peridodite, which is considered to be a typical mantle rock, their total concentration is the very low 0.1 ppm.

Furthermore, these isotopes are only found within the uppermost level of granitic-continental crust rocks, making up a minor fraction of Earth's outer-most thin skin, and are effectively absent from all known rocks of direct mantle origin, such as peridodite. The direct annual energy equivalent of the 21 ppm radiogenic elements in the crust is ~0.03 J/kg/yr, or $\sim10^{-9}$ W/kg, and of the 0.1 ppm in peridotite, about 3×10^{-12} W/kg. We have no reason to accept a proposition that the concentration, if any, of radiogenic elements in the mantle and core, i.e., in the about 6×10^{24} kg of Earth's mass, is greater than 0.1 ppm. Therefore, the maximum amount of heat all such radiogenic sources could optimally provide is a meagre 1.8×10^{13} W; i.e., less than 1.8% of Earth's annual energy requirements. In other words, conventional geodynamic models misguidedly presume radioactive isotopes to be an adequate heat source from an essentially non-radioactive mantle. So, we can with good reason argue that the heat engine Earth is not verified by observation, experiment and logic.

Elastic Rebound

Conventionally rocks are an elastic medium. Horizontal static stress changes along a potential fault plane (Fig. 5A) produce the accumulation of elastic strain, i.e., rocks bend (Fig. 5B), then frictional sliding, rupture, inelastic slip (Fig. 5C), and finally an earthquake occurs.

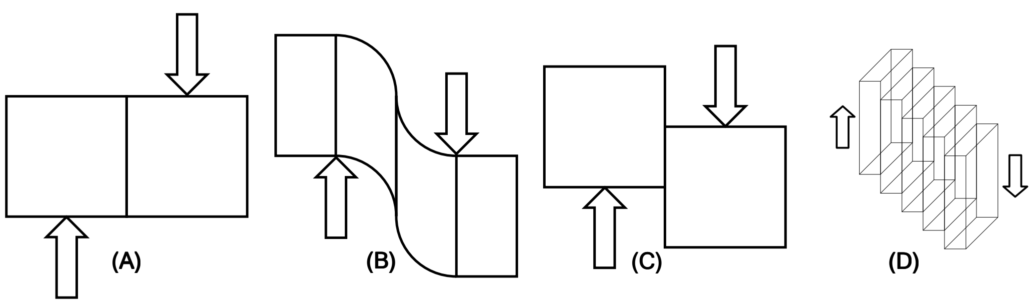

Figure 5. According to the elastic rebound, static stress changes along a potential fault plane (A) produce the accumulation of elastic strain, i.e., rocks bend (B), then frictional sliding, rupture, inelastic slip (C), and finally an earthquake occurs. Actually, and depending on the degree of micro- and macro-cracking, when rocks are under the action of a weak static stress, they do not deform at all, or they deform non-elastically through the slower creep and the faster slip. In effect they act as a series of separate blocks, like a deck of cards that move linearly the one relative to the other, as in (D), and remove elastic strain energy from the system.

In other words, a more or less constant static stress, in the range of 10^4 Pa/year ($\sim3\times10^{-4}$ Pa/s), slowly, e.g., in ~10,000 years, builds up elastic strain along a fault until it reaches the local strength ($>10^8$ Pa), defined as the critical stress necessary for failure, and then an earthquake occurs with a sudden stress drop. The estimated average value of stress drop is $\sim10^6$ Pa, but estimates as low as 10^4, or even 10^3 Pa, are not unusual, implying an equal low value of strength. Thus, immediately after the shock the possibility of generation of another strong shock in that region is reduced, and a new earthquake cycle begins. The time between two strong shocks is called seismic gap.

But, the question is: can rocks deform elastically when a weak horizontal static stress acts on them? Or, strain is released through creep (slowly) or slip (faster) due to the coalescence of microcracks (Fig. 5D), and for the elastic response of a rock block a strong vertical dynamic stress is required?

In the elastic rebound - seismic gap model the repeating rupture of a single section of a fault is conceived as a 'stuck patch' on the fault's surface, around which strain energy builds up. When the patch ruptures, the strain is released and the loading process begins again. If the loading rate (plate motion) is constant (static stress), the timing of the earthquakes would be regular. The static stress energy after a strong shock is depleted, thus preventing future earthquakes nearby until the stress is restored, i.e., the probability of a strong event to recur increases with time. But, contrary to the seismic gap hypothesis, observation indicates that immediately after the generation of a strong shock in an area the probabilities of an equally strong shock in that area greatly increase. Furthermore, stress drop values, as low as 10^3 Pa are compatible with slip but are incompatible with elastic deformation and seismic waves.

Since, slip rate = stress rate/rigidity, and the co-seismic slip rate, in large events, is considered to be in the range of 10^{-4}/s, there are two opposing solutions:

1. The stress rate remains very low, in the range of 10^{-4} Pa/s, and the rigidity is reduced to 1 Pa, or
2. The stress rate is raised, e.g., to 10^6 Pa/s, and the rigidity remains constant, e.g., $>10^{10}$ Pa.

The first solution explains co-seismic slip rates without having to resort on a dramatic stress rate increase, but it requires a reasonable explanation as to how the reduction of rigidity, by at least 10 orders of magnitude, to 1 Pa, is attained. But, this solution is unacceptable because the rigidity of 1 Pa can only support a shear wave velocity more than five orders of magnitude lower than that of the 10^3 m/s of seismic waves.

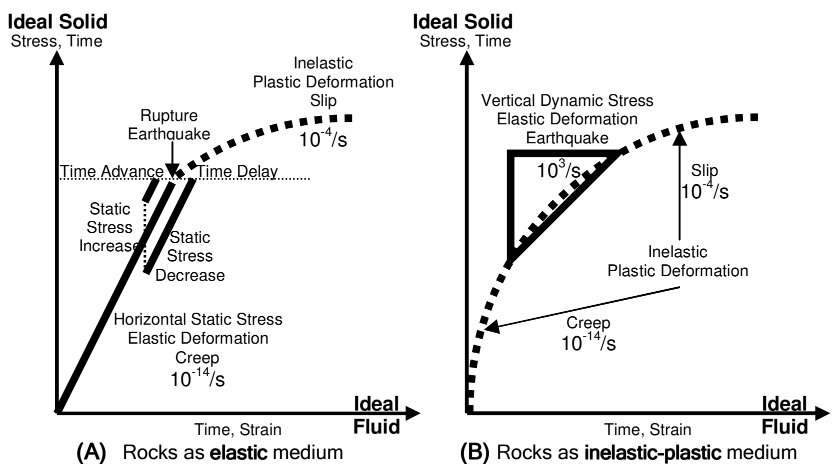

Figure 6. Earthquake generation in an elastic (A), or inelastic-plastic medium (B).

The second solution provides the rigidity, $>10^{10}$ Pa, which can support the seismic wave strain rates of $>10^3$ m/s, but it requires a dynamic stress rate in the order of 10^6 Pa/s, like a hammer strike, ten orders of magnitude higher than the 10^{-4} Pa/s of the supposed horizontal static stress rates. Logically this dynamic stress cannot be horizontal; it can only be vertical, like the sudden collapse of an uplifted great volume of rock, the size of which determines the magnitude of an earthquake. This solution is in compliance with observation, experiment and logic, and therefore is considered as the right one. The question is: How this great volume of rock is uplifted and then suddenly collapses; or, how this great concentration of energy/power occurs in space and time? In a following paper we will try to answer these fundamental questions.

In conventional theorizations rocks act as an elastic medium under static stress. Creep rates, of the order of 10^{-14}/s are considered, at least partially, as elastic deformation; whereas a 10^{-4}/s slip is inelastic deformation (Fig. 6A). Actually, rocks under a very weak (static) extensional stress, of the order of 10^{-18}/s or lower, respond through creep and slip. Both are inelastic, irreversible deformations that produce and explain micro- and macro-cracking, which reduces rigidity, increases the shear compliance, and results to the removal of elastic strain energy from a rock block system. For the elastic response and the generation of an earthquake a dynamic stress is required (Fig. 6B).

An ideal solid can be considered as an absolutely rigid medium with infinite mass, or as an absolutely elastic medium with infinite frequency, i.e., infinite energy, but zero amplitude, i.e., zero mass. In a waving medium these two opposite states must co-exist, but the infinite mass state as an actuality and the zero mass state as an impossible potentiality. A zero mass state cannot actually exist, because waves and energy without inertia-mass cannot exist. On the other hand an ideal fluid is perceived as a medium without inertial resistance-mass. But, in actuality the 'massless' state is the equilibrium state between the inertial and the elasticity forces in a continuum. Any continuous medium the inertial resistance of which has been balanced can wave, i.e., behave both as an ideal fluid and an ideal solid for as long as the force that neutralizes its mass-inertia acts on it.

The viscosities and the relaxation times of real solids, like rocks, are of the order of 10^{20} Pa.s and 10^{10} s and higher, respectively, implying a rigidity in the unit of time $\geq 10^{20}$ Pa, and a dynamic density of the order of 10^{12} kg/m^3. In a primarily plastic medium, that is a medium which is much closer to an ideal solid, the elastic response and the generation of an earthquake requires a force capable to exceeding the resistance of its mass to move from its rest equilibrium position. A block of intact rock will respond as a perfectly elastic medium for as long as this force acts upon it. If this is a non-recurring dynamic stress the lossless elastic response will be limited to the first cycle. This is observed in many seismograms, implying a stress capable to balance the inertia of the rock block, and a stress rate in the range of seconds; an implosion. This fundamental requirement of exceeding the inertial resistance is expressed by the seismic moment, a measure of total energy involved in an earthquake, which on the average is about 20,000 times greater than the elastic energy released as seismic waves. Thus the $\sim 4\times 10^{22}$ J/yr, or $\sim 10^{15}$ W, of present annual global energy requirements, since the seismic energy released annually amounts to a magnitude 9 earthquake, or $\sim 2\times 10^{18}$ J.

The vertical dynamic stress will have two effects; a primary and a secondary. The primary is unavoidable, and refers to the elastic response of a rock block and the generation of an earthquake. The secondary is possible, involves inelastic slip and the generation of a fault, and occurs there and when the failure stress threshold has been exceeded. In that context there is no cause and effect relationship between faults and earthquakes; no static stress increase or decrease, i.e., no stress transfer, as in Figure (6A). Earthquakes and faults are two opposite processes, elastic and inelastic, respectively, that can have a common cause, the vertical dynamic stress, and concur in space and time (Fig. 6B), thus giving the false impression of their causal relationship.

That is why a 'seismic' fault has never been observed, and earthquakes do not directly relate to existing or generated faults. If the elastic rebound proposition is correct, then most, if not all seismic energy should be released along a fault. But, observation shows that almost always the maximum intensity area does not coincide with the fractured area, if any, and there are numerous examples of buildings along both sides of the San Andreas and the North Anatolian Faults that suffered no damage. Also the thousand of kilometres long faults in the Pacific basin are almost earthquake free; and it was not the movement along the fault produced by the underground thermonuclear test on January 19, 1968, in Central Nevada, the cause of seismic waves; it was the nuclear explosion itself.

The inconsistencies of the organic origin of hydrocarbons and the solid, quantified, growing and radiating Earth proposition are discussed elsewhere.