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From Mediterranean evidence to Global tectonics and geodynamics: a new interpretation of the active margins

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A common interpretation can be found – an uprising of lithospheric material –, for a number of observable phenomena in the Mediterranean region. This field evidence is linked with the well know – and still unexplained – extreme irregularity of the Mediterranean Wadati-Benioff zones. The existence of only very short segments where deep earthquakes occur on the Africa-Eurasia interaction-margin, has led the geoscience community to believe that this long margin is largely aseismic. Indeed, if we search for a different interpretation, the alleged extremely uneven distribution of the deep seismicity suggests a new kind of regularity. The same kind of regularity in the pattern of the deep hypocentres can be recognised on global scale along the major active margins. Cluster or filaments of hypocentres characterize all the Wadati-Benioff zones, and single filaments are present in the Mediterranean region (South Tyrrhenian, Vrancea, South Aegean) under the zones of maximum curvature and uplift rate of the fold-belts. The same holds for the two Himalayan zones of deep seismicity – few filaments –, which coincide with the Western and Eastern Syntaxial zones of the orogen. In the case of South American earthquakes, an earthquakes-volcanic eruptions correlation is recognisable. The origin of the disturbance seems to lie in the depth and its propagation is more plausibly toward the surface, a process at odds with subduction. Further support to this interpretation is the direction of displacement of the Earth's instantaneous rotation pole (near 3.0 mas, 10 cm, exactly towards an azimuth opposite to the epicentre azimuth) observed in the occasion of the great Sumatran earthquake (26 December 2004) besides a number of other geophysical clues provided by this extreme seismic event (geomorphologic data, satellite data of gravity and uplift/subsidence,

CMT fault plane solution, etc. ...).

The aforementioned clues, can be considered each separated from the other, with the obvious result of finding non-unitary explanations, but if they are scrutinized all together, the whole set points to a deep origin of disturbances, vertical displacements of materials and phase changes as the main process responsible of earthquakes or silent-slow events in Wadati-Benioff zones, orogenesis and volcanic phenomena. Then a model of the evolution of an idealised fold belt, without using the subduction concept, in a non-collisional view, should be searched for. A reinterpretation of the geodynamics of the active margins and mountain building is proposed with a heuristic model that does not resort to large-scale subduction, but only to isostatic uplift of deep material intruding between two decoupling plates in a tensional environment. Concomitant phase changes toward less-packed lattice and buoyancy effect caused by the Clapeyron slope can help the extrusion of deep material over the m.s.l., constituting an orogenic process.

The uplift and extrusion of materials – and their occupation of room above the sea level – will be the cause of pushing and warping of crustal layers, exposition of the top of the doming zone to the action of gravitational spreading and erosion, all phenomena well documented on fold belts. The lateral pushing of the extruded materials can co-operate with gravity to the creation of the diffusely observed very long sub-horizontal overthrusting (also many tens of kilometres), which never have been explained by gravitational spreading alone. The heterogeneous geological and physical conditions can lead to asymmetrical or symmetrical spreading (mono-vergence or bi-vergence) of the extruding material. The produced nappes are driven to overthrust the sediments of the pre-existing trough and their underlying crust, forcing both of them along a burial path that simulates the subduction process, but without reaching depths greater than 50-70 km. At the boundary between uplifting mantle material and down-pushed crust and lithosphere, metamorphism, mixing, migmization, upward transport of fragments of the buried lithosphere, inverted metamorphism etc. can occur. The exposure on the Earth's surface of the 'granite series' and of the HT/HP-UHP metamorphic facies can be explained by the action of the 'piston' of the increasing volume phase changes.

The presence of fluids and gaseous compounds is also a source of strong variation in the P and T condition of phase changes (ERNST, 2005). CO2 is reputed to favour crystal formation and also to increase the order of magnitude of the viscosity of the material in which it is dissolved. The presence of a deep source and rising of CO2 can be a factor in the generation of deep and intermediate earthquakes. Although static tectonic pressure is limited by the typical mechanical strength of rocks ($\approx$1 kb), earthquakes can be additional factors in creation of an impulsive condition of very high stress and non pressure, which in turn can be the cause of phase transformation of little slice-like portions of materials. Moreover, deviatoric stress has long been recognized as a factor in lowering the depth (and the apparent hydrostatic pressure) needed to produce facies like coesite, blue shists, eclogite and many other HP-assemblies. In other words, deviatoric stress is a source of localized nonlithostatic overpressure. The tectonic environments in which the phase transformations happen – orogenic continental belts and trench-arc-backarc active margins – are unquestionably centres of significant deviatoric stress. Earthquakes are the most important circumstantial evidence for local storing and releasing of deviatoric stress. The mere existence of earthquakes in the brittle portion of the lithosphere (the first few tens of kilometres of depth) is at odds with the existence of the two-way subduction channel – a low viscosity channel. Finally, the possibility that lenses-like HP-UHP exhumed fragments could be mechanical products (an anvil effect) of major earthquake occurrence at depths not exceeding a few tens of kilometres should be considered.

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