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Dynamical similarities between the relief evolution of the orogens and the cyclonal patterns – Weather fronts in the upper mantle?

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The crustal thickness of the Earth's crust/mantle boundary beneath central-southwestern Europe is strikingly similar to a meteorological cyclone: the crustal depth pattern forms two steeply dipping, arcuate zones separated by sudden horizontal changes appearing as warm and cold fronts. Considering the two systems analogous, the dynamic behaviour explains several phenomena and fits to plate tectonic reconstructions. Using this analogy, several arcuate systems are recognised as analogues of meteorological fronts termed as geovortices. By studying the geological setting from this point of view, several less understood problems become clear. With further applications of this analogy a number of tectonic situations can be revealed with a previously unavailable accuracy and provides new insights into the arcuate orogens worldwide.

This similarity in the arcuate shapes of mountain chains has already attracted the attention of some researchers in the mid-1930's. Later the idea (hereafter referred to as FTK-theory after the authors S. Fujiwhara, T. Tsujimura and S. Kusamitsu who published on this topic already in 1934) has been reinvented several times before the appearance of the concepts of plate tectonics. The FTK-theory has been formulated in several forms: as local vortical solutions for regional scale problems, as well as

extended to globally valid hypotheses. After the widespread acceptance of the plate tectonics, the concept has seen a decline, since the geodynamical setting of the Earth can be explained by the plate tectonics in the majority of the cases, consequently, most of the geoscientists consider the problem as solved and the FTK-theory as unneccessary and not validable.

However, at several orogenic chains of the Earth the plate boundaries are not well defined and the observed phenomena are difficult to interpret in the classic plate tectonic framework. To overcome this problem a reconsidered model is presented here on the lateral and temporal changes in crustal thickness as an expression of Alpine orogenic processes. In the case of the European Alps – Apennines setting the most striking feature is the "Genova geovortex", an orogenic vortex which highly resembles to the notorious Genova cyclones or, rather, the large Atlantic low-pressure zones. We believe that, despite the differences in the physical principles governing the motion patterns in meteorology, and in crustal/lithospheric domain, meteorological experience can be extended and used for numerical calculations to reconstruct certain orogenic patterns formed in the geologic past and expressed by crustal thickness changes. This way the evolution of the orogenic fronts may be better understood and new models can be created for arcuate orogenic belts worldwide.

A look with the eyes of a meteorologist on the map showing the European crustal depth makes obvious the similarity to a complex meteorological front system consisting of a warm front and a cold front. The structure seems to be analogous to a developing meteorological low-pressure cell which migrated northeastward forming a comma cloud system. In terms of meteorology a warm front with a medium gradient and a cold front with a steep gradient would still be separated and not yet occluded. The space in-between (the Po plain and a part of the Adriatic Sea) would represent a typical short fair weather period in the sector of warm air. Flattening parts to the north would match to a stable and large high-pressure cell with no clouds. In the south a half circle structure is present which does not match with typical pressure gradients but could be equivalent to a larger compact field of clouds related to an already inactive former low-pressure cell, which is often pulled back in the back of a cold front.

The theory, yet as a purely phenomenological one, can be extended to other orogens of the world as well. In the last decades the number of observed phenomena that fits to the theory has increased. If we accept the theory for the moment as it is, without considering the consequences on (geo)physical models, several features can be classified as supporting observations. For instance, based on the spatial pattern of the volcanoes (not related to hot spots) can be taken as the analogues of the thunderstorms and their locations support well the above speculations. Similarly, the wind can be interpreted as the analogue of the real vertical movements of the plate fragments, while the air

pressure can be a meteorological counterpart of the geoid undulation. A geodynamical map of a region can be easily translated to a meteorological synoptic map.

These speculations that had appeared as several mosaicstones earlier in the scientific literature, but they have never been summarized and been used for modelling to derive the past and future image of the Earth's surface. This is due to the fact that, despite the dynamical similarities in observations, the present geophysical and rheological models are in strong contradiction with such an explanation. The viscosity and other material-specific properties are expected to differ by several orders of magnitude according to our current knowledge. This problem that separates the models from the observations, seems to form a difficult, yet uncrossable barrier between theoretical workers and phenomenologists. It is clear that to prove this concept, extensive research activity is needed in various fields of geoscience, like volcanology, geochemistry, geodesy, geodynamics, gravity research, rheology, palaeomagnetism, thermochronology, dynamical modelling, etc. We assume that such an integrated effort leads to the resolution of contradiction between theory and observations, and than the FTK-theory, extended to a general upper mantle behaviour model, will provide an explanation for the geodynamical movements that is compatible both with physics of the Earth and the widely accepted theory of plate tectonics.