-18 - ORIGIN OF THE PRESENT MEDITERRANEAN

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There is no reliable evidence for rotation, horizontal translation, or compression since approximately middle Miocene times in most of the Mediterranean. Therefore the recent tectonic history of the Mediterranean appears to be independent of plate tectonics. A model is proposed to explain such young geologic features as the Sea of Alboran, the Tyrrhenian Sea, the Po basin, the Pannonian basin and the Cyclad area. Their recent geologic history has been characterized by strong vertical movements.

We start with the assumption that tectonic processes require energy, which is mainly provided by the decay of U, Th and ^{40}K. These elements are strongly concentrated in the crust, and lateral inhomogeneities in heat production due to variations in crustal thickness should play a major role in the localization and timing of tectonic processes. Lateral changes in heat production occur across mountain chains, and the higher heat production in the thickest part of the crust causes an increase in the temperature of the mantle directly underneath. Thermal changes are transmitted slowly in the earth, and it takes more than 10 million years after the thickening of the overlying crust before the temperature rises significantly at a depth of 100 km. For an increase in crustal thickness by 10 km, the temperature rise is on the order of 200°C ; this causes an uplift of approximately 3 km due to thermal expansion and phase transitions, including partial melting in the crust and upper mantle. If erosion proceeds rapidly with respect to cooling, 3 km of uplift correspond to a total erosion of 14-20 km, due to the effects of isostasy. Vertical decompression of the mantle column due to unloading, either by simple erosion or by tectonic denudation, will cause an additional uplift. Some seismic (RITSEMA, 1970) and volcanologic (BARBERI et al., 1972) evidence seems to point to some form of spreading. It will be investigated whether a more sophisticated version of the geothermal model outclined above may account for localized spreading near hot mantle columns, in addition to their mainly vertical movements.

From geologic evidence it appears that most of the present basin areas in the Mediterranean, including those that have already been refilled with younger sediments, were structural highs in pre-Miocene times. They supplied sediments to their surroundings, and were the source also of gravity slides. These basins are commonly located at the concave sides of bends in the Alpine fold system.

It has been shown (SCHUILING, 1969) that the lateral extend of a thermal anomaly at depth is larger than the horizontal extend of the crustal thickening itself. Therefore, the heating effects of both segments of a curved fold belt will affect the same column in between.

Even though the crust of this column may itself have been of normal thickness, it will undergo a strong uplift and erosion. Heating in the mantle at depth will still continue, even after a large part of the heat sources has already been eroded away, due to the slowness of thermal conduction, which means that uplift and erosion proceed beyond "equilibrium". The disappearance of the "thermal blanket" makes itself felt too late in the mantle, after only a thin skin of continental crust remains. All the rest of the crust, in particular the most radioactive upper part of the sial, has been removed. Cooling will now succeed the earlier heating, and the basins enter their "foundering" stage.

The Cyclad area is considered to represent a younger, and possibly less violent version of the same process; until the middle Miocene, uplift and erosion characterized the area that now is sinking. The erosion almost completely stripped the area of its Alpine cover, laying bare the pre-Alpine metamorphic basement, which was pierced by young volcanism.

The volcanism that so typically is associated with the foundering stage of these basins can, in part, be explained by the fact that the temperature at a certain depth in the mantle reaches its maximum at that stage, at which time decompression as a consequence of erosion also is at its maximum. A high temperature and a low pressure both favor the formation of melts.

References :

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Interventions à la suite du 7-18 -

BIJU-DUVAL - J'ai été intéressé à divers titres par votre expose et en tant que géologue j'ai été content de voir sur votre schéma la place que vous donnez au bassin pannonien. Je pense en effet que le géologue a, là à terre, un type de bassin tout à fait comparable à ce que l'on connaît en Méditerranée, particulièrement en Mer Tyrrhénienne (pour laquelle on observe par exemple des bassins périphériques à forte épaisseur de sédiments). Le bassin pannonien a été bien étudié à terre et l'on dispose également de données géophysiques et de forages pétroliers. Il y a peut être là une source de renseignements profitables pour la compréhension de bassins actuellement immergés.

Réponse : Je crois qu'il n'y a pas de différence fondamentale parceque, enfermé dans des chaînes de montagnes, ce bassin a été empli par les dépôts.

GASPARINI - Radioactive processes are the motor for tectonic events. After the measurements made by the authors, 50% of the heat flow comes at the surface. I do not see how it can be a cause of tectonic activity. With the vertical differenciation of the mantle, the heat is not sufficient to explain tectonics phenomenes occurring. Most of the magma concentrate in liquid phasis.

Réponse : The cause of gectonic is not in the mantle, it is in the crust. Isolating effect of the crust causes the rise of temperature. Some gradients in the mantle may be 5°/km. There is an "inertie" of phenomenous with an order of 10 000 years. I may give you the detail of calculations.

MONGELLI - 1. Have you carried out any analytical calculation about your model ?

2. According to your model the heat flow increases according to the concavity, but I remember the results obtained by Professor ERIKSON in the Thyrrenian Sea. In the southeastern Thyrrenian Sea where the concavity is little he obtained heat flow values higher than those close to the Gibraltar strait where the concavity is higher.

Réponse : Non je n'ai pas fait les calculs.

J'ai comparé avec mon premier schéma = épaississement de la croûte dans deux dimensions. La surimposition des deux éléments donne un accroissement à la partie interne, une décroissance à la partie externe.

2. Tout modèle présente des désavantages. Il faut prendre en considération toutes les données locales. Dans la Mer d'Alboran la distance des segments est plus grande et la croûte plus mince.

BARBERI - J'aimerais appliquer votre théorie dans une région spéciale. La dépression des Afars a commencé au début du Miocène (25 Millions d'années). On a une élévation d'abord au commencement des rifts africains. La croûte est moins épaisse et le processus devrait s'arrêter. Aux Afars, au début c'est un rift continental avec volcanisme extensif . Plus récemment, il y a 3 Millions d'années, on assiste à une fissuration de la croûte avec apparition de croûte océanique que l'on peut suivre jusqu'au Golfe d'Aden, et avec une activité basique importante. Le Bassin Tyrrhénien pourrait être du même type.

Réponse : Je suis d'accord avec votre exemple, mais il s'explique mieux par la dérive des continents. J'ai un modèle complet pour ça.

BYRAMJEE - If the cause of tectonism is in the crust, would you say that the new global tectonics should be revised on entirely new basis, or is your concept just another way of saying about the same thing.

Réponse : Je peux décrire le mécanisme moteur du phénomène; il n'est pas question de l'expliquer en quelques minutes.