Geophysical Research Abstracts
Vol. 19, EGU2017-2279, 2017
EGU General Assembly 2017

The extending lithosphere (Arthur Holmes Medal Lecture)

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Extension of the lithosphere gives birth to a wide range of structures, with characteristic widths between 10 and 1000 km, which includes continental rifts, passive margins, oceanic rifts, core complexes, or back-arc basins. Because the rheology of rocks strongly depends on temperature, this variety of extensional structures falls in two broad categories of extending lithospheres according to the initial Moho temperature T_M. "Cold extending systems", with $T_M < 750°$C and mantle-dominated strength, lead to narrow rifts and, if extension is maintained long enough, to passive margins and then mantle core complexes. "Hot extending systems", with $T_M > 750°$C and crustal-dominated strength, lead, depending on strain rate, to either wide rifts or metamorphic core complexes. A much less quoted product of extension is the exhumation of high-pressure (HP) metamorphic rocks occurring in domains of back-arc extension driven by slab rollback (e.g. Aegean; Appennines-Calabrian) or when the subduction upper plate undergoes extension for plate kinematics reasons (e.g. Norwegian Caledonides; Papua New Guinea). In these tectonic environments, well-documented pressure-temperature-time ($P-T-t$) paths of HP rocks show a two-stage retrogression path whose the first part corresponds to an isothermal large pressure drop ΔP proportional to the maximum pressure P_{max} recorded by the rocks. This linear relation between ΔP and P_{max}, which likely results from a stress switch between compression and extension at the onset of exhumation, is in fact observed in all HP metamorphism provinces worldwide, suggesting that the exhumation of HP rocks in extension is a general process rather than an uncommon case. In summary, the modes and products of extension are so diverse that, taken all together, they constitute a very versatile natural laboratory to decipher the rheological complexities of the continental lithosphere and their mechanical implications.