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Tectonic stress fields in subduction zones governed by frictional strength of plate interfaces

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Tectonic crustal motion in plate convergence zones varies from mountain building (e.g., Himalaya) to back-arc spreading (e.g., Mariana) [1, 2, 3]. Such difference in tectonic crustal motion reflects the diversity of tectonic stress fields. So our question is what causes the diversity of tectonic stress fields in plate convergence zones. Recently, from a theoretical study [4], we revealed that the tectonic stress field consists of basically two different sorts of stress fields; one of which is a horizontally compressional stress field due to frictional resistance at plate interfaces, and another is a horizontally tensile stress field due to steady plate subduction. On a geological timescale, the former can be regarded as constant in time, but the latter increases with time. So, if the earth's crust were infinitely strong, tectonic stress fields in plate convergence zones would become tensile in time everywhere. Actually, the earth's crust includes a number of defects with low strength, over which inelastic deformation (brittle fracture and/or plastic flow) occurs so as to release the tectonic stress caused by mechanical interaction at plate interfaces. From these considerations, we may conclude as follows. When the plate interface is very weak in comparison with the earth's crust, a horizontally tensile stress field becomes dominant, which causes back-arc spreading as in the case of Mariana. When the plate interface is very strong, a horizontal compressional stress field becomes dominant, which causes mountain building as in the case of Himalaya. Tectonic stress fields in most subduction zones, where the strength of plate interfaces are comparable to that of the earth's crust, are between these two extreme cases.

References

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Keywords: subduction zone, tectonic stress field, plate interface, frictional strength, mountain building, back-arc spreading