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Catastrophic pressure drops in subduction zones: an unsuspected process recorded in metamorphic rocks

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When deeply buried in subduction zones, rocks undergo mineral transformations that record the increase of pressure and temperature. The fact that high-pressure metamorphic parageneses are found at the Earth's surface proves that rock burial is followed by exhumation. Here we use analysis of available data sets from high-pressure metamorphic rocks worldwide to show that the peak pressure is proportional to the subsequent decompression occurring during the initial stage of retrogression. We propose, using a simple mechanical analysis, that this linear relationship can be explained by the transition from burial-related compression to extension at the onset of exhumation. This major switch in orientation and magnitude of principal tectonic stresses leads to a catastrophic pressure drop prior to actual rock ascent. Therefore, peak pressures are not necessarily, as commonly believed, directly dependent on the maximum burial depth, but can also reflect a change of tectonic regime. Our results, which are in agreement with natural data, have significant implications for rock rheology, subduction zone seismicity, and the magnitudes of tectonic pressures sustained by rocks at the subduction interface. These implications for subduction dynamics will be discussed.