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CREEP-2: Long-term time-dependent rock deformation in a deep-sea observatory.

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Earthquake rupture and volcanic eruptions are the most spectacular manifestations of dynamic failure of a critically stressed crust. But these are actually rather rare events, and most of the crust spends most of its time in a highly-stressed but sub-critical state. Below a few hundred metres, the crust is saturated, and water-rock chemical reactions lead to time-dependent deformation that allows rocks to fail over extended periods of time at stresses far below their short-term strength by the mechanism of stress corrosion crack growth. This process is highly non-linear and a change in applied stress of around 5% can lead to a change in the time-to-failure of more than an order of magnitude. Theoretical calculations based on reaction rate theory suggest that such cracking may occur down to stresses as low as 20% of the rock strength, implying that time-dependent cracking will be an important deformation mechanism over geological time and at typical tectonic strain rates. A number of theoretical models have been proposed to explain this behaviour. However, it is currently not possible to discriminate between these competing models due to the relatively narrow bandwidth of strain rates that are practicably achievable in conventional laboratory experiments. Ultra-long-term experiments at very low strain rates are clearly essential to address this problem.

We have therefore used the stability of the deep-sea environment to conduct ultra-long-term experiments. At depth, the temperature remains constant throughout the year and water pressure also remains essentially constant, especially in the Ionian Sea where the tidal range is minimal. We have successfully conducted a pilot experiment (CREEP-1) in which we used the constant sea-water pressure at depth to provide both a constant confining pressure and a constant deforming stress for our rock samples. Building on that success, we are now building a multi-sample deformation observatory (CREEP-2) to be deployed at approximately 2000m water depth at the NEMO-SN1 test site in the Ionian Sea using the deep-sea shuttle (DSS) operated by INGV. CREEP-2 will be connected to the underwater electro-optical cable operated by INFN and INGV that runs some 25 km from the test site to the shore station sited in the laboratory of LNS-INFN at the port of Catania. This arrangement provides for both power to the deformation apparatus and fast, real-time data transfer from the apparatus.