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Multi-Scale Fracture Damage Associated with Underground Chemical Explosions

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Abstract

Understanding rock damage induced by explosions is critical for a number of applications including the monitoring and verification of underground nuclear explosions, mine safety issues, and modeling fluid flow through fractured rock. We use core observations, televiewer logs, and thin section observations to investigate fracture damage associated with two successive underground chemical explosions (SPE2 and SPE3) in granitic rock at both the mesoscale and microscale. We compare the frequency and orientations of core-scale fractures, and the frequency of microfractures, between a pre-experiment core and three post-experiment cores. Natural fault zones and explosion-induced fractures in the vicinity of the explosive source are readily apparent in recovered core and in thin sections. Damage from faults and explosions is not always apparent in fracture frequency plots from televiewer logs, although orientation data from these logs suggests explosion-induced fracturing may not align with the pre-existing fracture sets. Core-scale observations indicate the extent of explosion-induced damage is 10.0 m after SPE2 and 6.8 m after SPE3, despite both a similar size and location for both explosions. At the microscale, damage is observed to a range distance of 10.2 ± 0.9 m after SPE2, and 16.6 ± 0.9 and 11.2 ± 0.6 in two different cores collected after SPE3. Additional explosion-induced damage, interpreted to be the result of spalling, is readily apparent near the surface, but only in the microfracture data. This depth extent and intensity of damage in the near-surface region also increased after an additional explosion. This study highlights the importance of evaluating structural damage at multiple scales for a more complete characterization of the damage, and particularly shows the importance of microscale observations for identifying spallation-induced damage.