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Neutron-induced changes in porosity, density and mechanical properties for sandstones, chert and limestone

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The U.S. NRC has started approving second license renewals for the Light Water Reactor fleet. The prolonged operation of these reactors has revived interest on the effects of irradiation on plant components, including concrete, which constitutes the biological shield that surrounds the reactor pressure vessels. Concrete is composed by cement paste and aggregates. The latter are locally sourced in the proximity of construction sites, which makes their composition linked to the geology of the area and unique for almost every plant. Minerals suffer radiation induced volumetric expansion and metamictization with exposure to neutrons. The extent of expansion depends on the mineral structure and composition, being larger for silicates than for carbonates. Aggregates, that are conformed by several minerals, will be subjected to stresses after due to differential expansion within their constitutive minerals after neutron irradiation. This will give rise to voids and cracks that will have a negative effect on the density and the mechanical properties of the materials. Studying the effects of neutrons on rocks of different mineralogical composition is key to understand irradiation effects for different concrete formulations. Investigations on neutron-irradiated chert, four different sandstones and a limestone will be discussed. The porosity increase at the nano and micro scales will be interrogated with USAXS, the density decrease with He pycnometry, and the decay in mechanical properties with UPV. The results will be linked to the mineralogical composition of the different rocks.