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## Quantifying the Dynamic and Static Porosity/Microstructure Characteristics of Irradiated Graphite through Multi-technique Experiments and Mesoscale Modeling

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### ABSTRACT:

One of the distinguishing features of nuclear graphite is the presence of pores and cracks with a wide distribution of size, shape and morphology characteristics. The pores can be filled, partially filled or unfilled, and can form and proliferate during the initial mixing phase, or during the baking/cooldown phase when the volatiles are removed, or during in-service conditions. A key metric used in the microstructure characterization is the volume fraction of the pores or porosity; typically, nuclear graphite grades have 14-21% porosity. It is known that porosity together with pore morphology and interconnectivity affects the thermomechanical properties, gas transport, oxidation behavior and fission product retention. Although there is now an overall consensus that pore and crack regions have a formidable influence on the microstructural behavior of graphite, their characteristics and their influence on mechanical properties are not well-elucidated.

We propose a host of experimental methods and computational modeling to uncover the pertinent microstructural features and mechanisms at the mesoscale that control the macroscopic mechanical behavior in different nuclear graphite grades. Of primary importance is the characterization of pores/cracks and defect structures, which needs a multi-technique approach as no single method can access the relevant scales or has the fidelity to probe the details at different length scales. We will, therefore, adopt a suite of state-of-the-art experimental characterization methods and modeling tools in this project, which include in situ and conventional mechanical tests, electron microscopy, X-ray tomography, gas adsorption porosimetry, and mesoscale modeling and simulations. We will investigate a spectrum of irradiated, thermal and oxidative conditions in this project to develop a comprehensive understanding of the graphitic microstructural/mesoscale features and their correlation to macroscopic mechanical properties.