



Comparison of zirconium redistribution in BISONEBR-II models using FIPD and IMIS databases with experimental Post Irradiation Examination

August 2022

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**Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517**

Comparison of zirconium redistribution in BISON EBR-II models using FIPD and IMIS databases with experimental Post Irradiation Examination

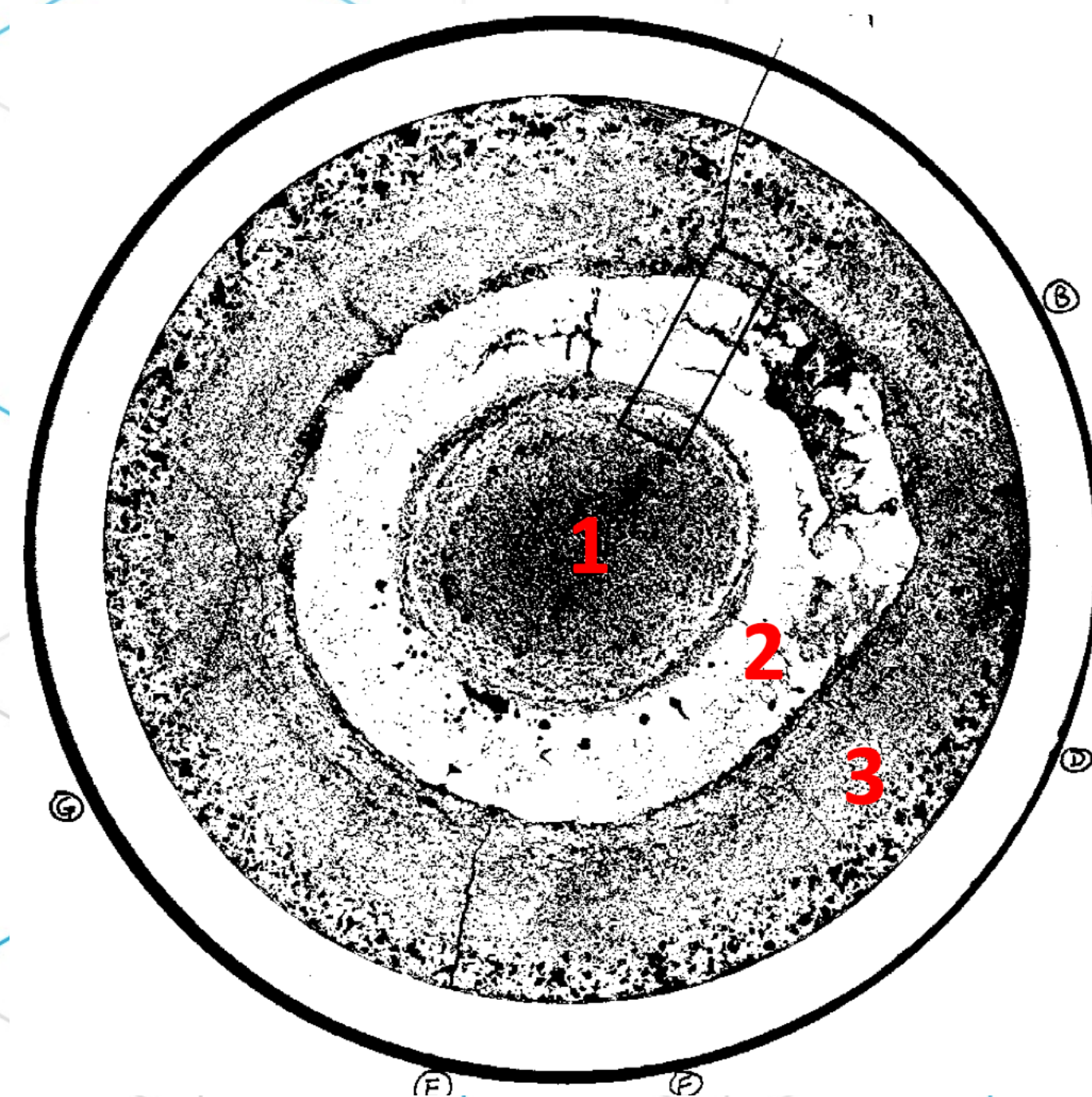
Spencer Christian, Ohio State University | Mentor: Kyle Paaren | C620 Fuel Development, Performance, & Qualification

Purpose

Programming tools and software need to be validated against past data before being applied to, analyzing, and simulating fuels in the future. BISON, a thermomechanical nuclear solver, has been utilized for LWR fuels, TRISO fuels, and metallic fuels. However, improvements are still necessary to properly reflect all fuel characteristics.

Renewed interest in metallic fuels has sparked the need to further tune BISON capabilities, particularly with respect to zirconium redistribution.

Zr redistribution is an important property of irradiated fuels—affecting porosity, thermal conductivity, and reactivity. Refined modeling of zirconium redistribution is necessary to capture this behavior, which can significantly impact fuel performance, in future fuels.



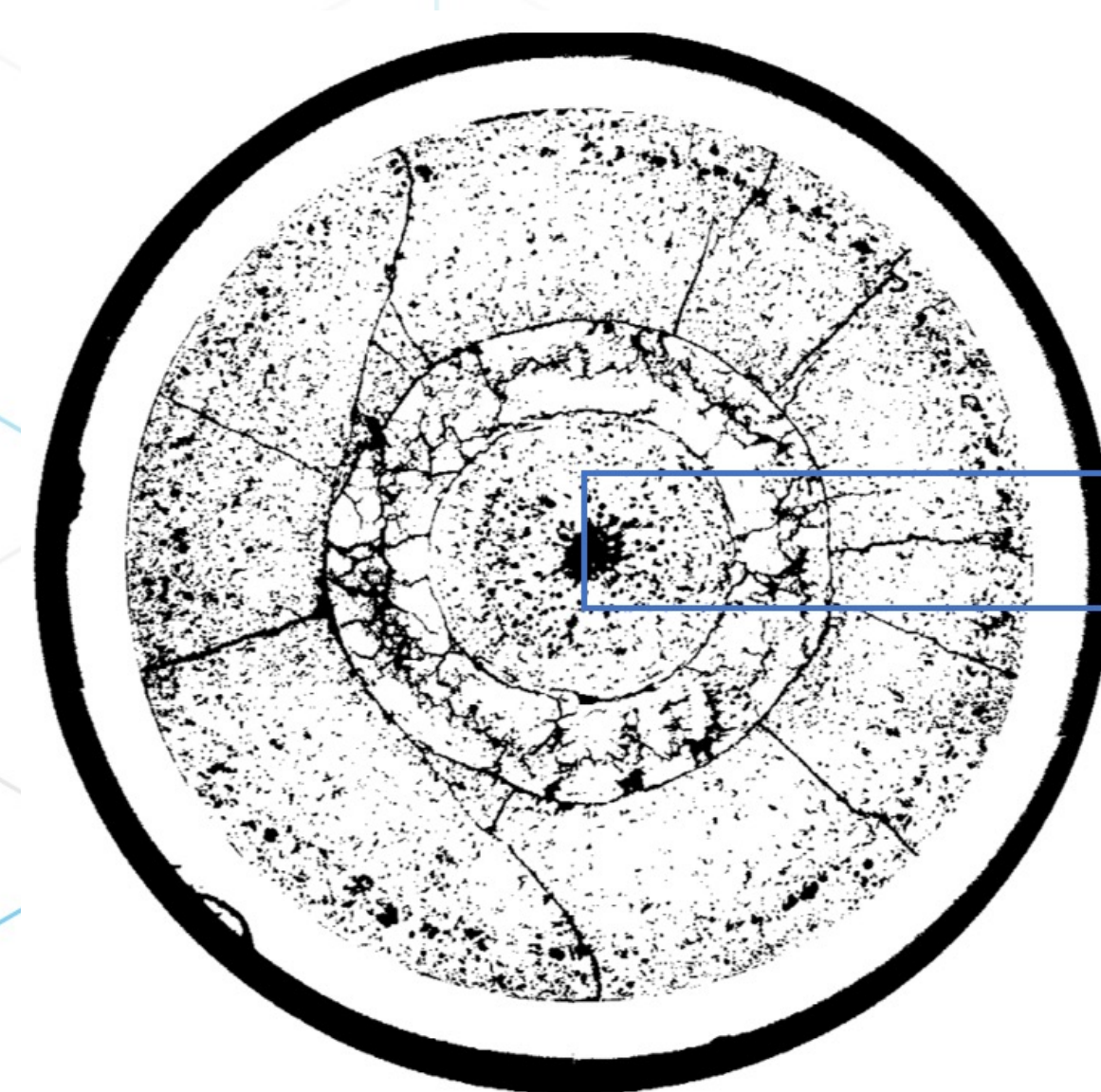
There are typically 3 zones present in irradiated U-Pu-Zr fuels. Zone 1: Zr rich. Zone 2: Zr Depleted and U rich. Zone 3: moderate Zr.

Methods

Model and test EBR-II pins in BISON to analyze the capabilities of the software against PIE data.

Implement various models:

- Porosity Models
 - Fractional (Default)
 - Partially-Logged
 - Logged
- Thermal Conductivity
 - LANL
 - Galloway
- Diffusion Coefficient Factors
 - Default (1)
 - Galloway
 - Kim
- Phase Transition Temperatures
 - Default
 - Galloway

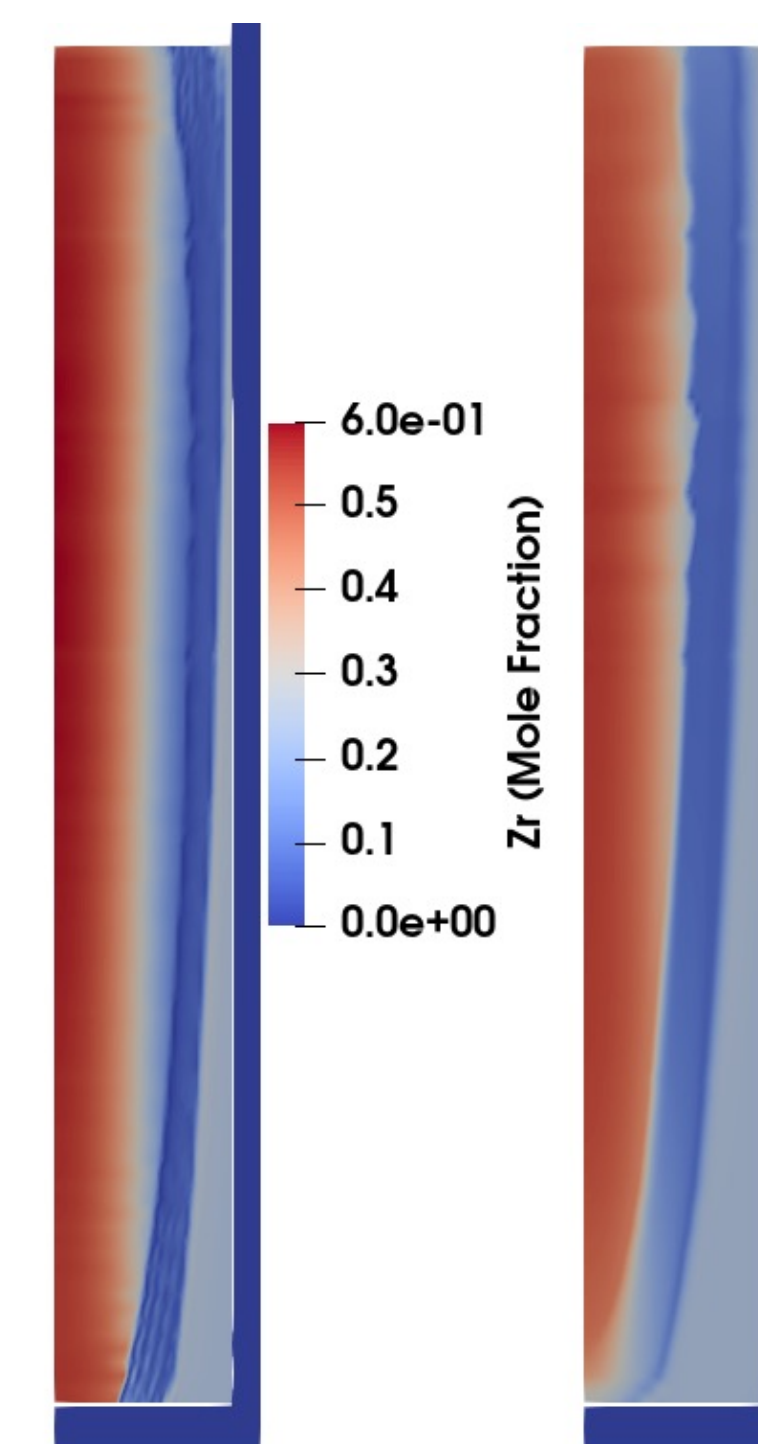


DP 45 X/L = 0.5

Metallography images of pin DP45 from experiment 441. BISON simulation results match well with the three zones seen in the images. Red indicates the Zr rich zone, blue indicates the Zr depleted zone. Model Run: Logged porosity, LANL thermal conductivity, Default diffusion coefficient factors, and Galloway phase transition temperatures.

Results

There were slight variations across the implemented models. The porosity model had the most influence on the Zr migration, followed by the diffusion scale coefficient factors. The LANL and Galloway thermal conductivity models had minimal differences.



Comparison of Fractional and Logged Porosity Models. The fractional model causes increased Zr migration compared to Logged model. Partially-Logged model did not converge.

Conclusions

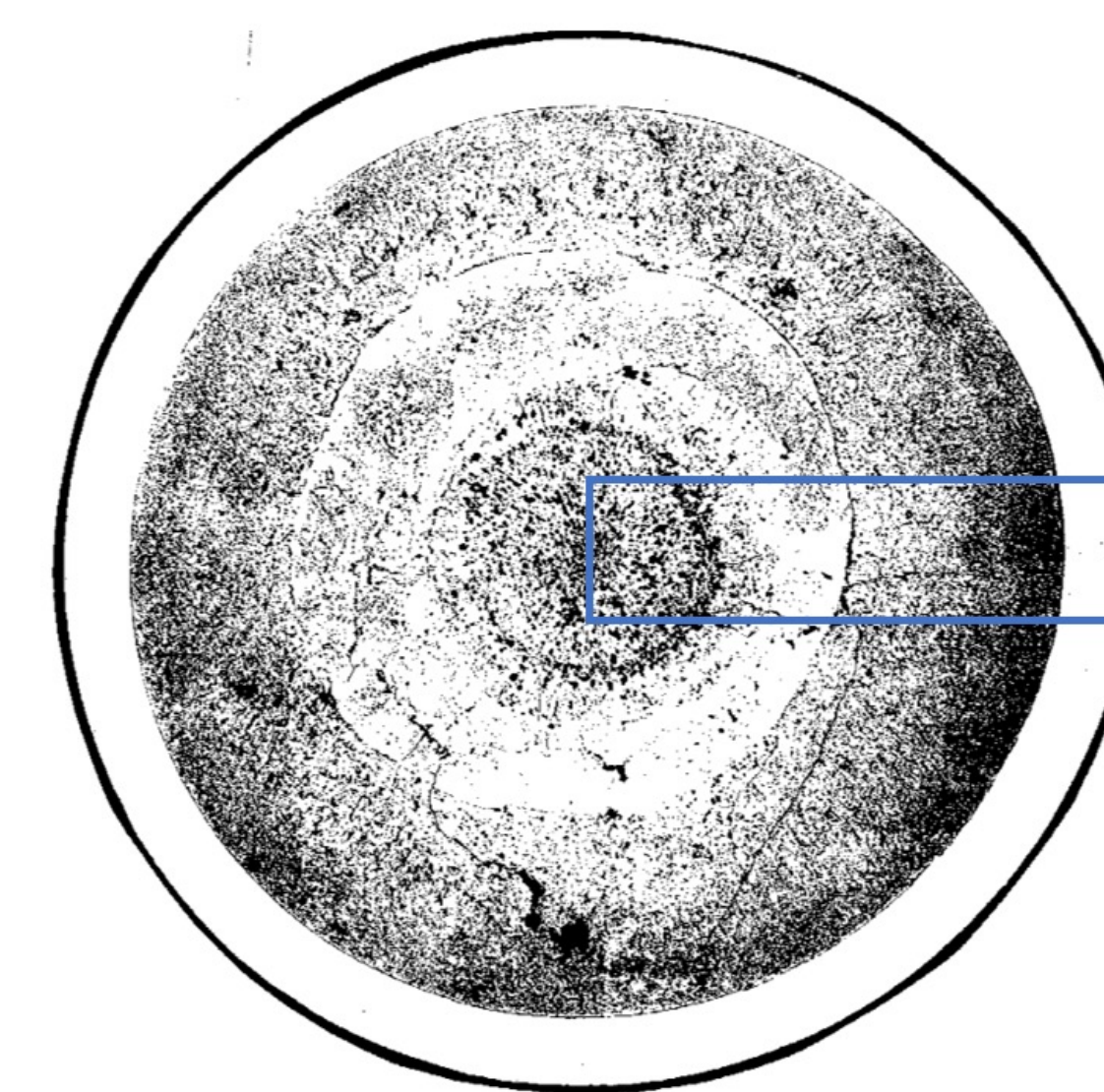
Initial tests narrowed the possible material models to the most effective models which closely reflect metallography data. Further optimization is necessary to obtain refined results. There is general agreement between past and current work. Discrepancies are likely due to the implementation of advanced models, like Logged-Porosity, which were not previously available.

Final Model Parameters

1. Porosity: Logged
2. Thermal Conductivity: LANL
3. Diffusion Coefficient Factors: Default
4. Phase Transition Temperature: Galloway

References:

1. J. Galloway, C. Unal, N. Carlson, D. Porter, and S. Hayes, "Modeling constituent redistribution in U-Pu-Zr metallic fuel using the advanced fuel performance code BISON," *Nucl. Eng. Des.*, 2015, doi: 10.1016/j.nucengdes.2015.01.014.
2. A. M. Kim, Yeon Soo and Hayes, S L and Hofman, G L and Yacout, "Modeling of constituent redistribution in U-Pu-Zr metallic fuel," *J. Nucl. Mater.*, vol. 359, no. 1–2, pp. 17–28, 2006.
3. J. D. Hales *et al.*, "BISON Users Manual - BISON Release 1.2," Idaho Falls, 2015.



DP 45 X/L = 0.78