Pacific Northwest
NATIONAL LABORATORY
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# Department of Energy's Technology Development Programs on Waste Forms

## An Overview

JD Vienna
*Pacific Northwest National Laboratory, Richland, WA, USA*

NWTRB Meeting:
Richland, WA
*April 16, 2013*

PNNL-SA-94901

# Current Research Programs

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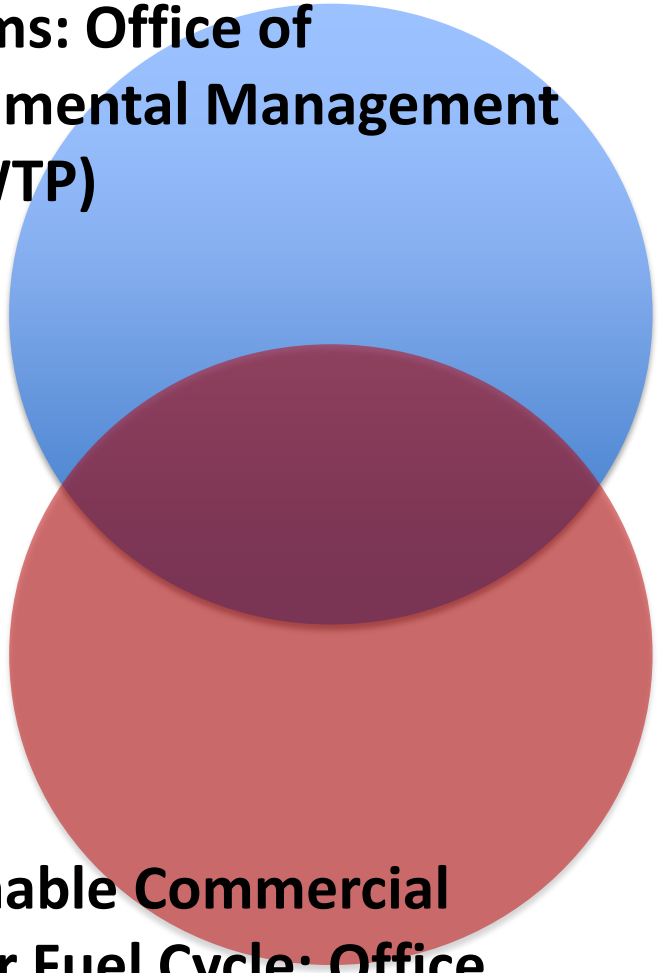
**Legacy Wastes from Defense Programs: Office of Environmental Management (ORP-WTP)**



**Sustainable Commercial Nuclear Fuel Cycle: Office of Nuclear Energy (FCT)**

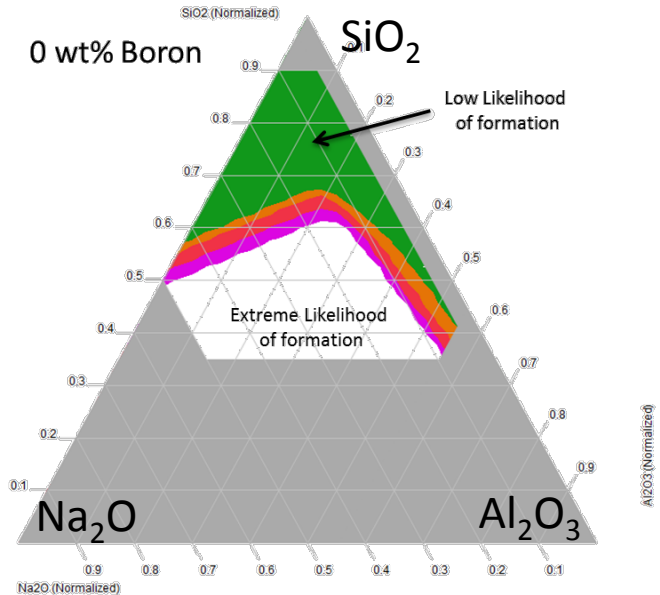
## Research Focus Areas

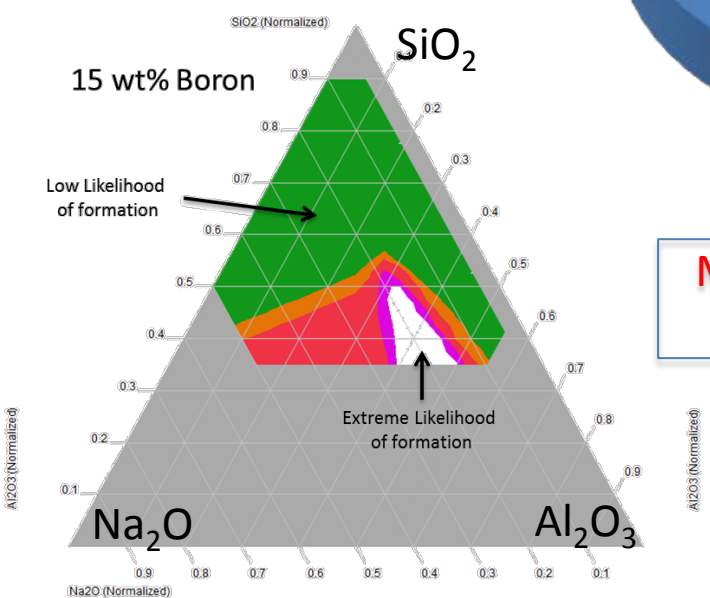
- Improved loading of tank waste in glass → improve economics (ORP)
- Understanding the melting process → improve process schedule (ORP)
- Understand long-term performance of glass → increase disposal options (FCT+ORP)
- Advanced "glass ceramics" or crystal tolerant glasses → higher loading (ORP+FCT) and higher performance (FCT)
- Advanced waste forms for Tc → increase treatment options (ORP), improve long-term performance (FCT+ORP)
- Waste forms for pyrochemical processing wastes → enabling technology (FCT)
- Waste forms for gaseous fission products → enabling technology (FCT)
- Alternate HLW forms → improved performance (FCT)

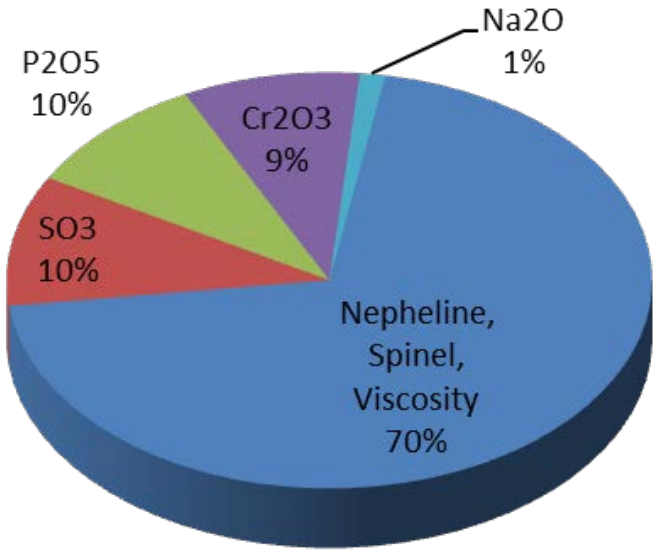
# Improved Waste Loading (ORP-WTP)



- Evaluate limiting property/composition constraints (HLW):
  - $Al_2O_3$ concentration without nepheline formation
  - Spinel formation in the melter
  - $SO_3$ in glass without salt
  - $P_2O_5$ and CaO in melt
  - $Cr_2O_3$ in melt without salt or crystals
- New nepheline model:



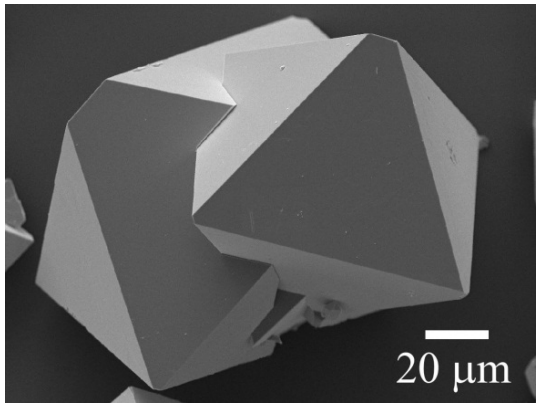

Max $Al_2O_3$ increased from ~20 wt% to ~28 wt%

# Crystal Tolerant Glasses (ORP-WTP)



- Crystals in the HLW may disrupt pouring or power to the melt
  - for WTP design clogging of the pour-spout riser is the most significant risk
    - bubbling in the riser will not prevent the build-up of the spinel layer
- Current practices use liquidus temperature ($T_L$) (DWPF) or one percent crystal ($T_{1\%}$) (WTP) to avoid accumulation of crystals in the melter
- Crystal/agglomerate size influence accumulation far more than do $T_L$ or $T_{1\%}$ but are harder to predict
- Developing a new "crystal-tolerant glass" modeling approach to predict the spinel accumulation rate in the pour spout riser
  - preliminary estimates show a significant improvement in waste loading and concurrently a reduction in the risk of melter failure

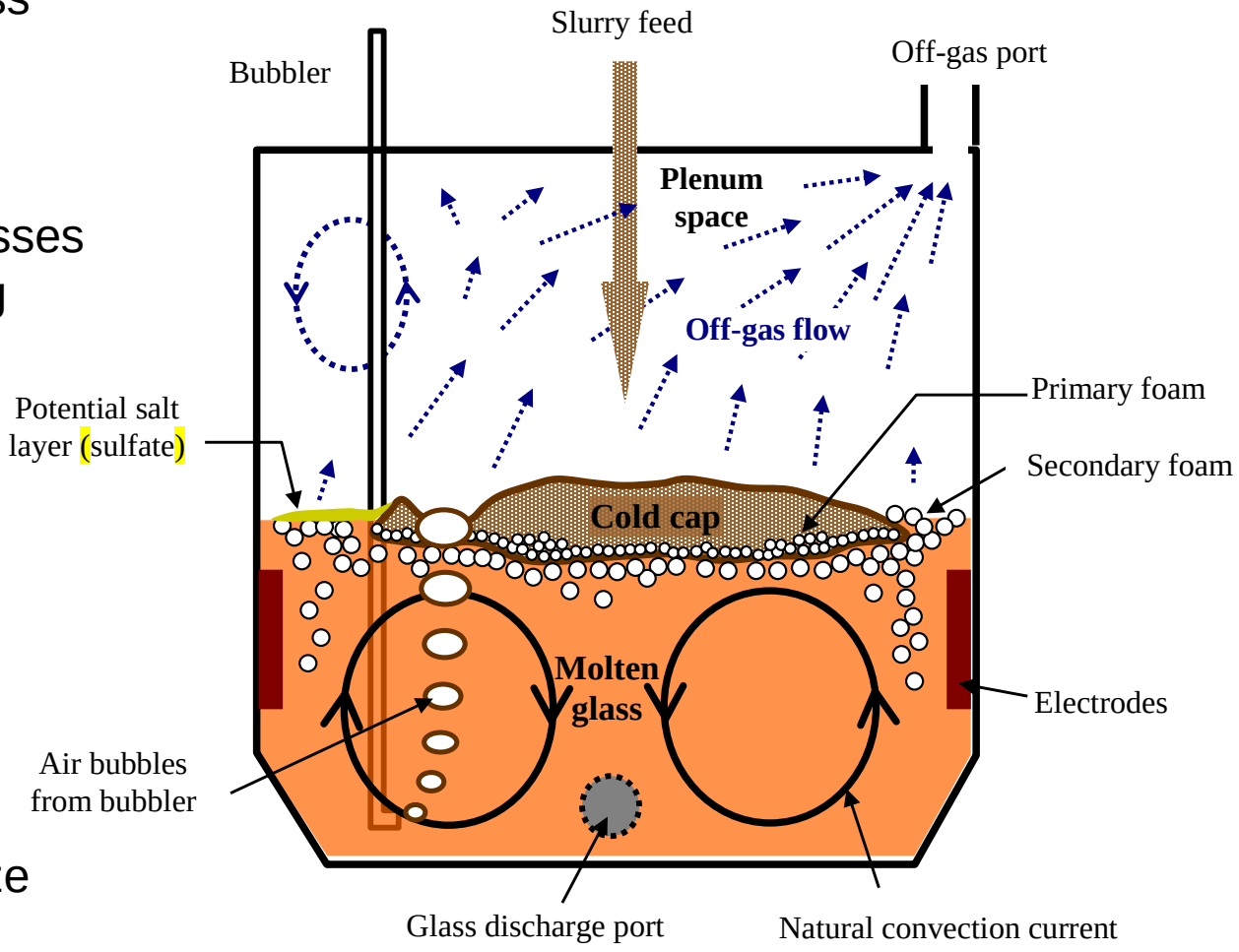
Spinel:
$[Fe,Zn,Mn][Fe,Cr,Mn,Al]_2O_4$




# Understanding the Melting Process (ORP-WTP)



- Melting rate can vary dramatically between melter feed compositions and may even show significant process upsets (e.g., killer scum)
  - 60-70% difference in rate for the same glass composition with different forms of Al
  - 4x difference in rate between different glasses with the same melting conditions
- To predict and improve performance we need to predict the complex reactions that lead from melter feed to melt
  - 1-D model completed
  - testing to parameterize model underway



# Long-Term Performance of Glass (EM-HQ and NE-FCT)



- Current glass performance models are bounding and appropriate for Yucca Mountain safety case
- Improved understanding of glass performance in a range of potential disposal environments may enable more disposal options
- To have a significant impact on disposal, conditions for stage III need to be identified and managed
- An international program based on closely coupled theory, experiment, and modeling is underway to understand and predict the long-term rate of glass