Electrochemical Oxide Reduction of Plutonium

Alistair M Parkes & Steve M Wilcock

alistair.parkes@awe.co.uk

www.awe.co.uk

© British Crown Owned Copyright 2014 /AWE
Published with the permission of the Controller of Her Britannic Majesty's Stationery Office

Introduction

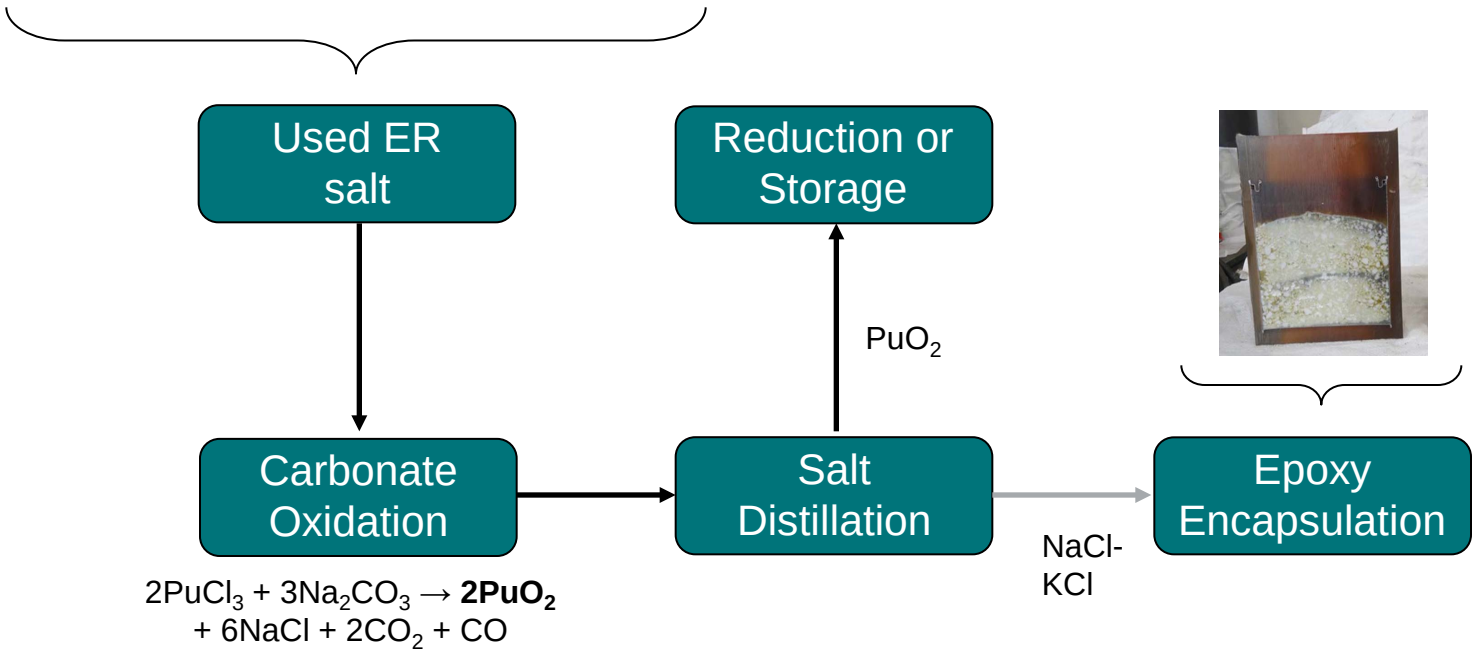
- Electrorefining in molten salts used to recycle Pu
  - Plutonium has a limited ‘Shelf Life’ owing to radioactive decay
  - Purification required to produce metal for manufacturing
  - Pyrochemical processing very efficient for metal recycle
- Developed in early 1960’s at LANL
  - Focus was on metal recovery
  - Other factors are becoming increasingly important such as by-product management
- Originally carried out in equimolar NaCl-KCl
- ER now carried out in $CaCl_2$ but majority of residues are NaCl-KCl salts and crucible waste

© British Crown Owned Copyright 2014 /AWE
Published with the permission of the Controller of Her Britannic Majesty's Stationery Office

Potential residues flowsheet

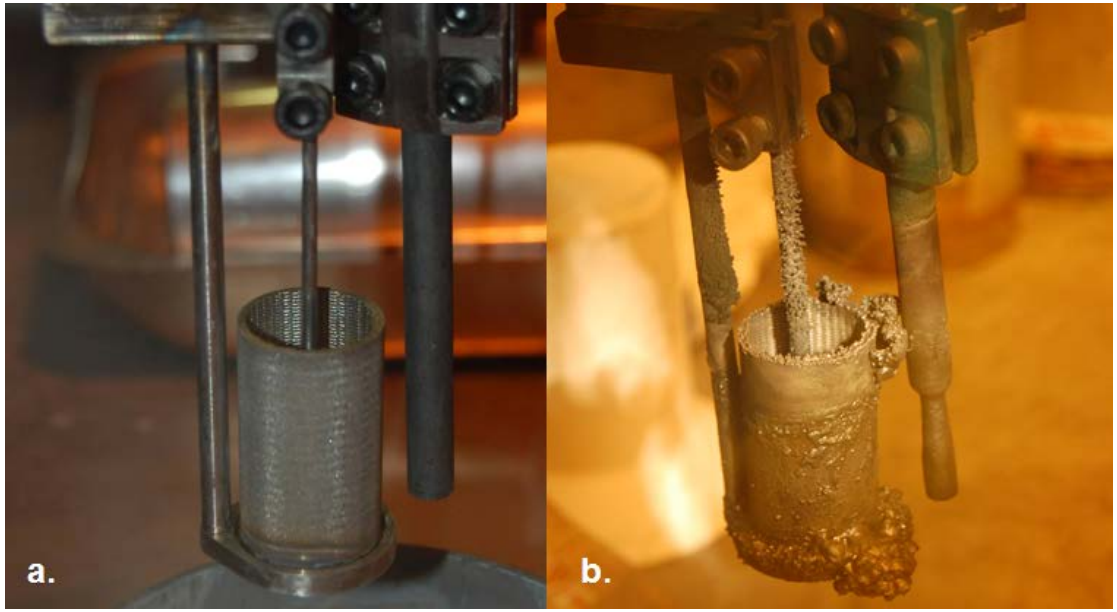
$PuCl_3$
$PuOCl$
PuO_2
NaCl-KCl

Reduction Options:
- Direct Oxide Reduction
- Direct Oxide Reduction (with recycle)
- **Electrochemical Oxide Reduction**

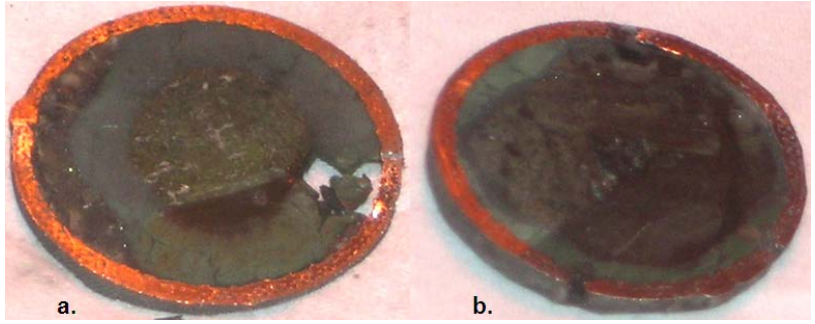


© British Crown Owned Copyright 2014 /AWE
Published with the permission of the Controller of Her Britannic Majesty's Stationery Office

Previously…..



- PuO_2 contained within a steel basket
- 1% CaO in $CaCl_2$
- 6.7 times charge equivalent passed
- Pu metal produced

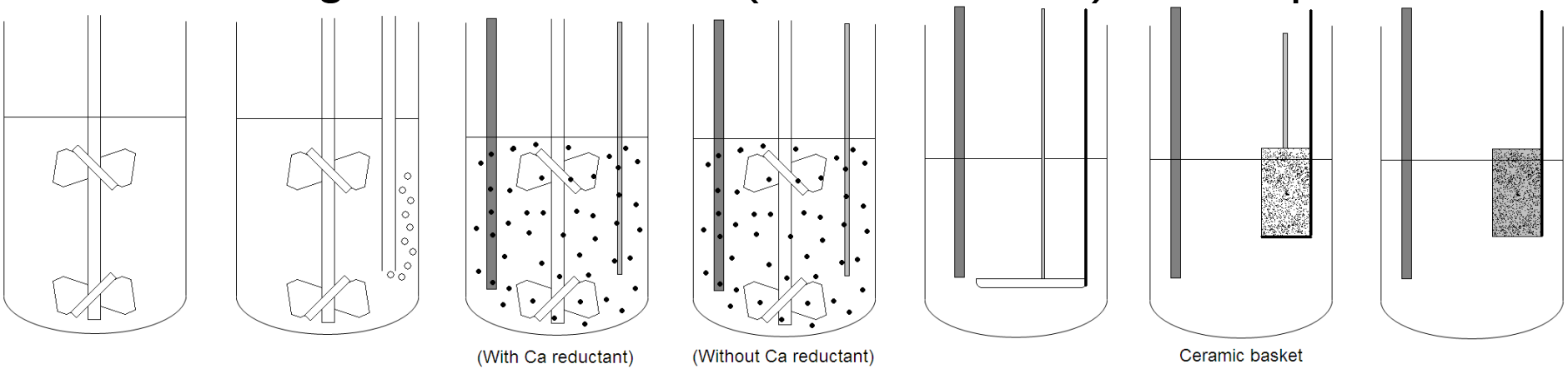


	Weight %			
Section	**Pu metal**	**PuO_2**	**Ca metal**	**CaO**
1 (Top)	28.09	-10.45[(a)]	13.3	3.12
3	36.58	1.12	11.77	3.02
4	39.53	4.07	7.82	2.8
6 (Bottom)	42.56	3.79	9.49	3.9

© British Crown Owned Copyright 2014 /AWE
Published with the permission of the Controller of Her Britannic Majesty's Stationery Office

Development options…

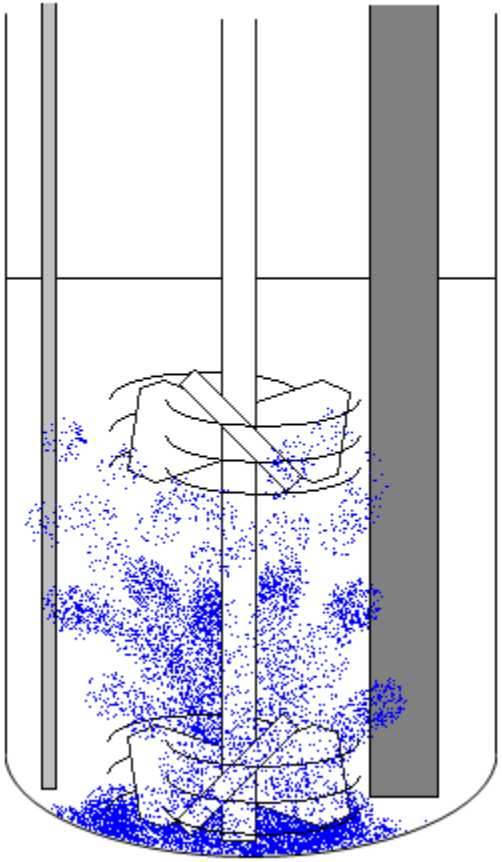
- AIM: Metal oxide *powder* reduction with minimal waste
- OPTIONS:
  - Salt system – $CaO/CaCl_2$ vs. $Li_2O/LiCl$ vs. other
  - Electrode materials – graphite, platinum, other
  - Configuration – basket (ceramic/metal) vs. suspended



© British Crown Owned Copyright 2014 /AWE
Published with the permission of the Controller of Her Britannic Majesty's Stationery Office

DOR-like EOR

- See Dan Brett & co-workers @ UCL* but simplified
- Powdered SnO_2 to molten Sn metal (at $CaO/CaCl_2$ melt temperature)
  - Use consolidated metal / shot as near real time diagnostic
- Operate at ~ 3 V
  - Greater than both Ca^{2+} and Sn^{4+} reduction potential



* Electrochemistry Communications, 41 (2014) 44-46

© British Crown Owned Copyright 2014 /AWE
Published with the permission of the Controller of Her Britannic Majesty's Stationery Office

DOR-like EOR

- Metal product & ‘clean’ salt ✓
- Product quality, reproducibility etc. ???

© British Crown Owned Copyright 2014 /AWE
Published with the permission of the Controller of Her Britannic Majesty's Stationery Office

Future work

- DOR-like EOR
  - Robustness
  - Sheath designs for carbon management
  - Gas purge requirement?
  - Salt volume reduction & salt re-use
  - PuO_2 reduction in active glovebox
- Alternatives
  - Reduction in LiCl (DOR/EOR)
- Implement residue treatment flowsheet

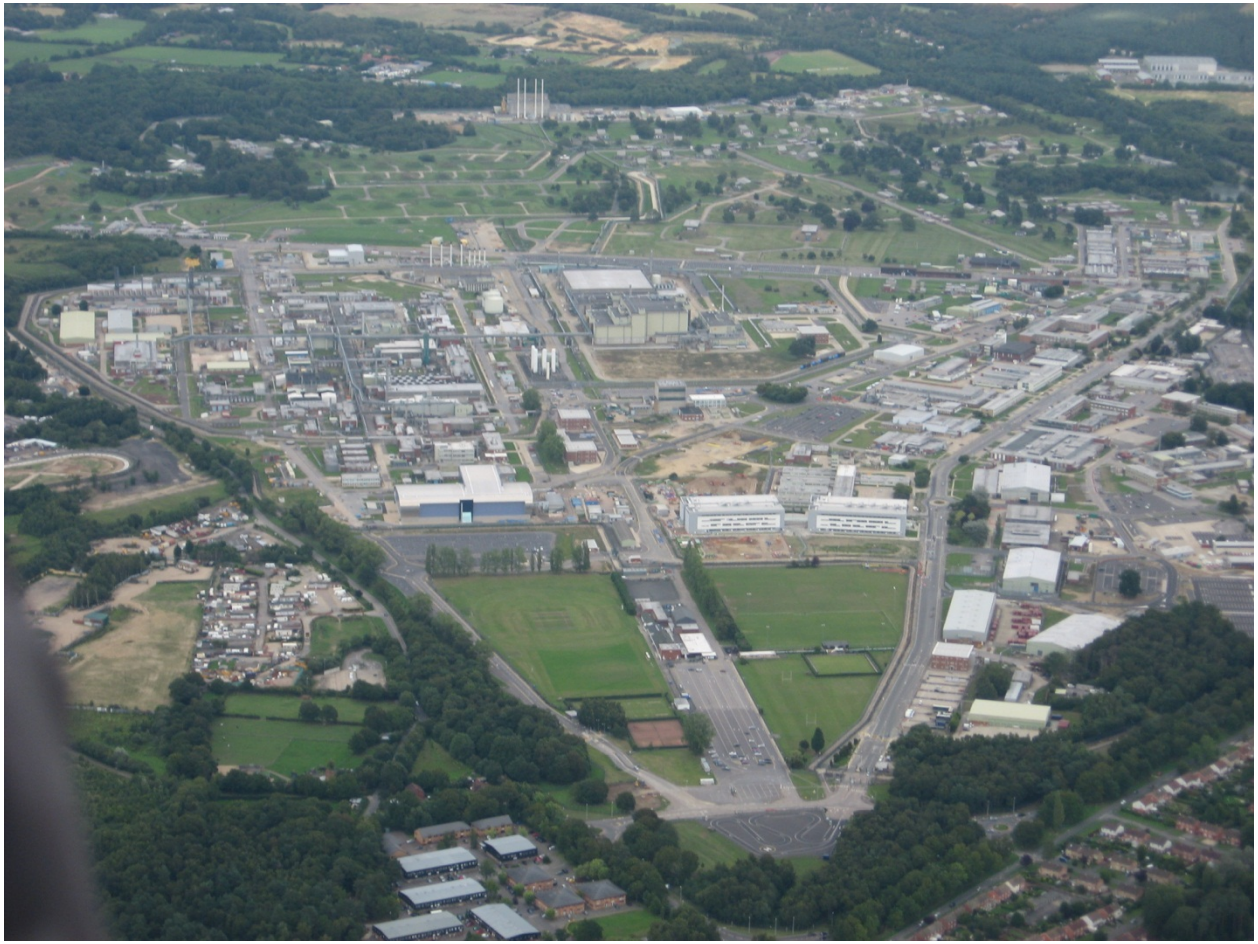
© British Crown Owned Copyright 2014 /AWE
Published with the permission of the Controller of Her Britannic Majesty's Stationery Office

Acknowledgements

- Arfon Jones
- Robert Watson
- Tim Paget
- Tom Caldwell
- Rob Campbell-Kelly
- Clare Stawarz
- Aaron Roffey

© British Crown Owned Copyright 2014 /AWE
Published with the permission of the Controller of Her Britannic Majesty's Stationery Office

Thank you



© British Crown Owned Copyright 2014 /AWE
Published with the permission of the Controller of Her Britannic Majesty's Stationery Office