Environments of Corrosion: Update

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Effects of Conc. HCl, Nitric Acids, and NaF on Corrosion of C-22 Alloy at 25 and 90°C; a Model for Rapid Penetration of C-22

A Study Commissioned and Supervised by Dr. R.W. Staehle on behalf of the State of Nevada

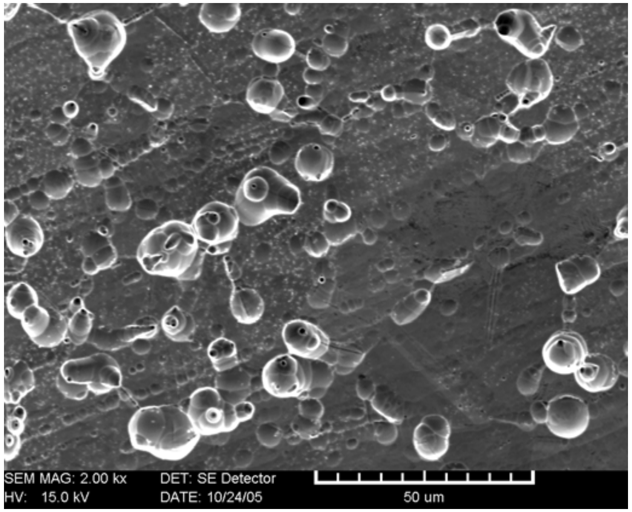
Purpose: Develop a basis for modeling the phenomenological results already obtained from the work at CUA by Pulvirenti and Barkatt for the accelerated corrosion of C-22, which is produced from accumulations of corrosive solids and which result from pore water being concentrated on heated surfaces as applicable to conditions at Yucca Mountain.

Work utilized electrochemical methods, SEM, and electron dispersive spectroscopy.

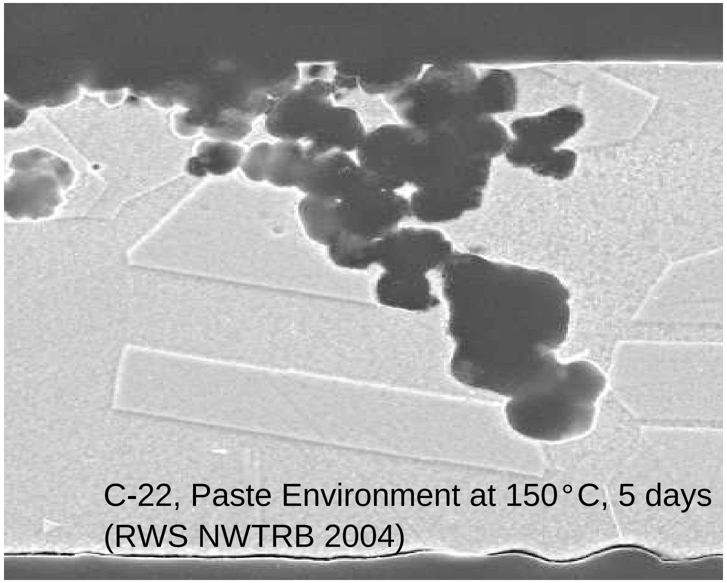
Conclusions of Study

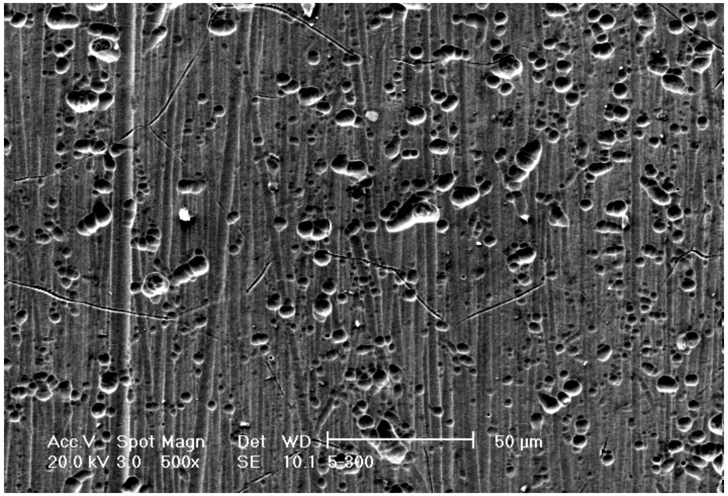
1. A model (Spherical Perforation Pitting-SPP) has been developed for explaining and quantifying the rapid perforation of C-22 in concentrated mixed acids. This model is based on the continued nucleation of spherical domains that move through the C-22 without being stifled.
2. The SPP model is consistent with all of the work performed in this project as well as with the work of Pulvirenti.
3. The SPP is capable of perforating C-22 in times as short as ten years or less assuming that environment of concentrated mixed HCl-HNO3 can be accumulated.
4. The SPP occurs over a broad range of compositions of the mixed acid, HCl and HNO3 where these concentrations exceed several molar in concentration.
5. The activation energy for the SPP process indicates that it can occur over a range of temperatures including room temperature.
6. Attention should be given to a terrace-ledge-kink process that occurs in concentrated HCl. This process can produce high rates. Rapid propagation of IG corrosion also occurs but this process has not been quantified as has the SPP.
7. There is no evidence that the NO3- anion is functioning as an inhibitor.
8. Additional experimental work should be undertaken to establish the applicability of the SPP mechanism as well as IG corrosion and possible TLK to C-22 containers. The data, which have been developed here, provide a credible foundation for early perforation of the C-22.

Spherical Propagating Pits

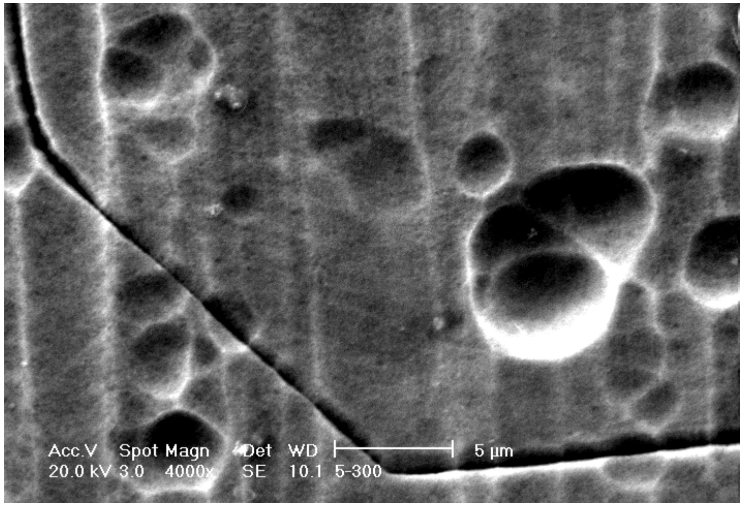


C-22, 3HCl:1HNO3 v:v
(Pulvirenti notes to RWS 2005)



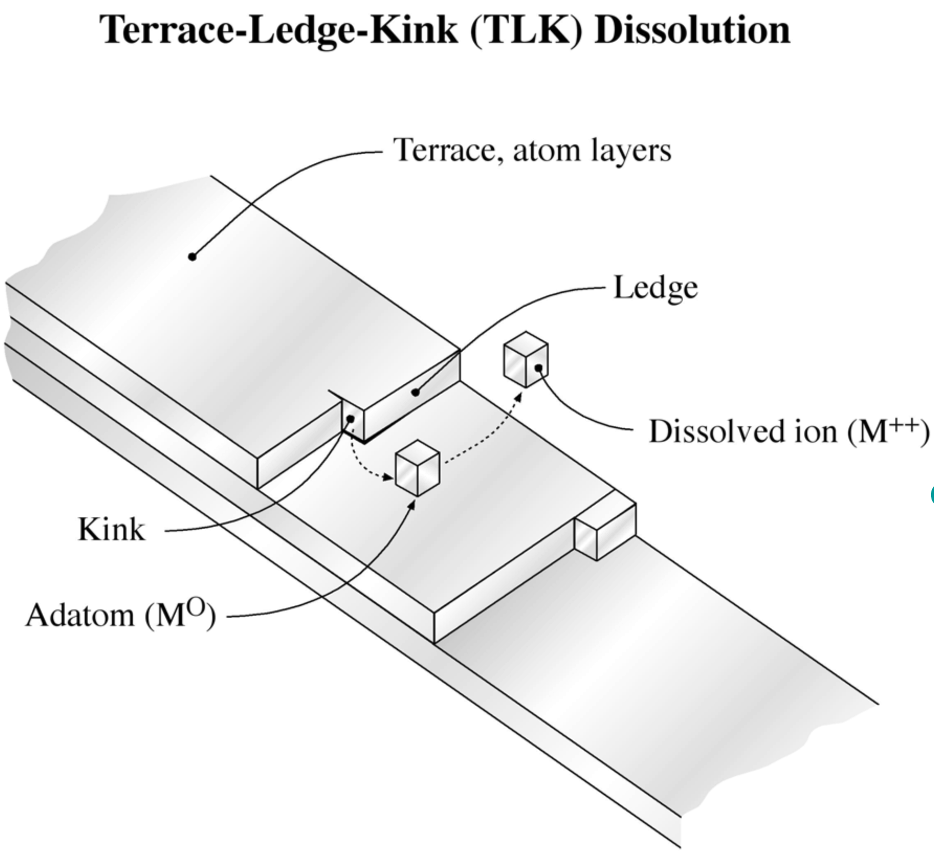


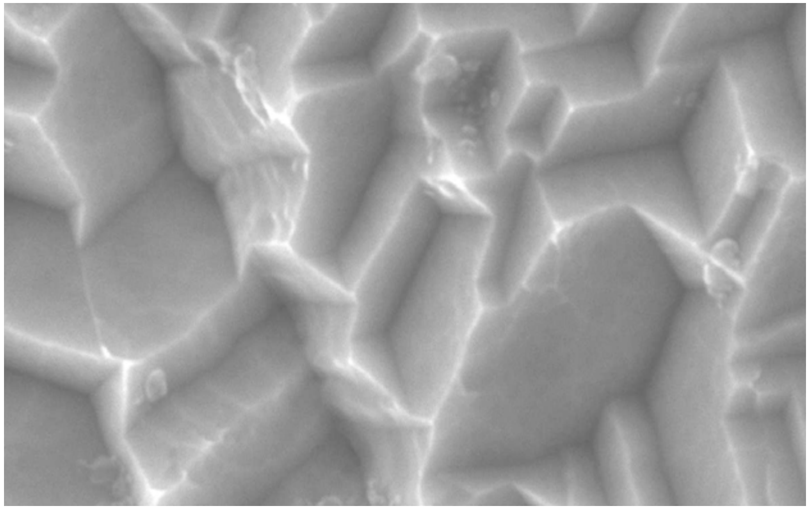
15.62M HNO3 + 2.84M HCl, +300mV (present work)



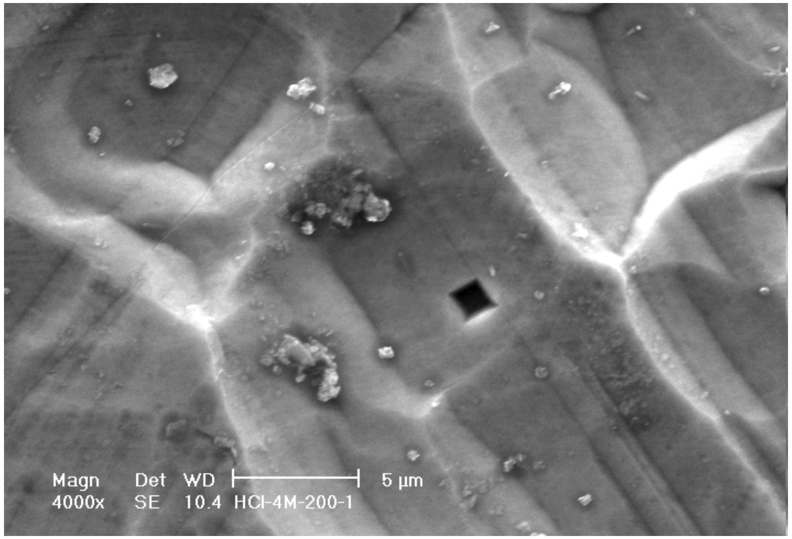
15.62M HNO3 + 2.84M HCl, +300mV (present work)

Terrace-Ledge-Kink Dissolution





C-22, Boiling HCl at 110°C, 42 Hours (RWS NWTRB 2004)



4M HCl, +200mV (present work)

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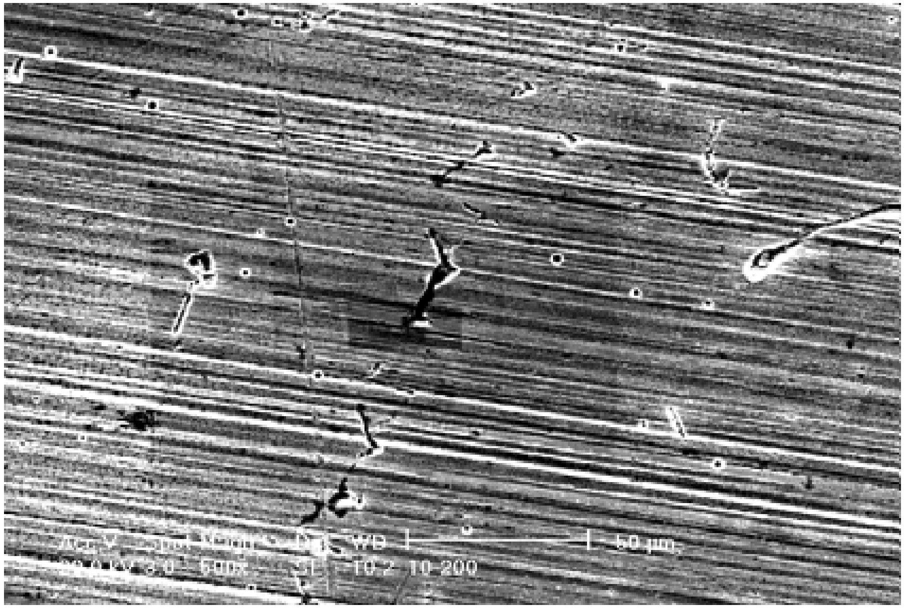
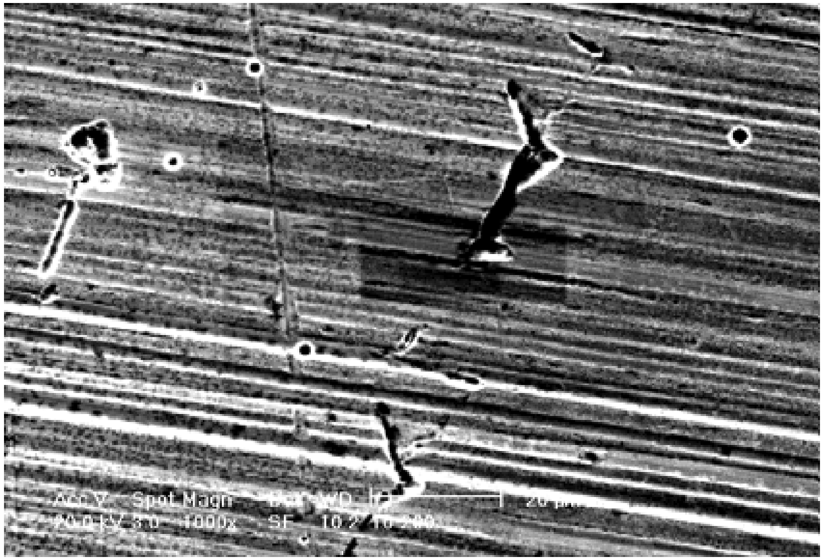
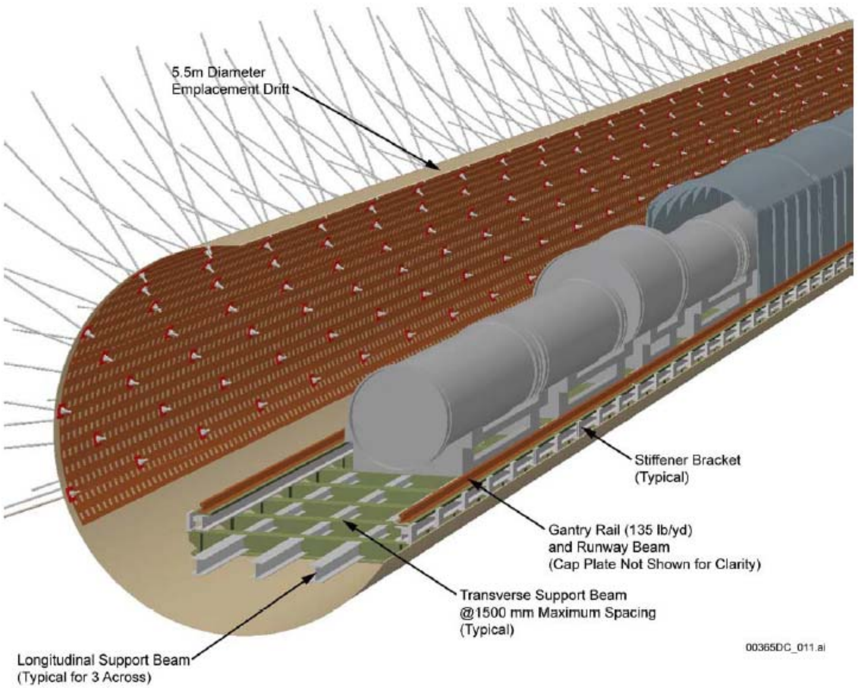
Intergranular Corrosion





2.84M HNO3 + 4.26M HCl, +200mV (present work)

Capillary Barrier?



(Harrington, 2004)

1. DOE assumes capillary barrier at wall rock, but ignores ground support in modeling.
2. Stainless steel sheet (3mm thick) contacting wall rock compromises capillary barrier.
3. Stainless steel sheet would be a good liquid barrier, except it is slotted, and has rock bolts going through it.
4. Slots would permit dripping.
5. When ground support fails, rock fall occurs, capillary barrier is compromised.
6. Conclusion: wall-rock capillary barrier is NOT a conservative assumption.

Conclusions

DOE makes optimistic non-conservative assumptions:

1. No water contacts EBS above boiling T (fingering?)
2. No episodic flow below PTn (Cl-36 at repository level?)
3. Capillary barrier at Wall Rock-Ground Support boundary
4. Only dust affects deliquescence on EBS?
5. No UZ pore water contacts EBS?

Environmental conditions for C-22 corrosion have not been bounded by DOE.
Expect the worst Environments for Corrosion, not the best.