

REPORT DOCUMENTATION PAGE

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Aluminum Alloy Susceptibility of Sulfide Derivitization

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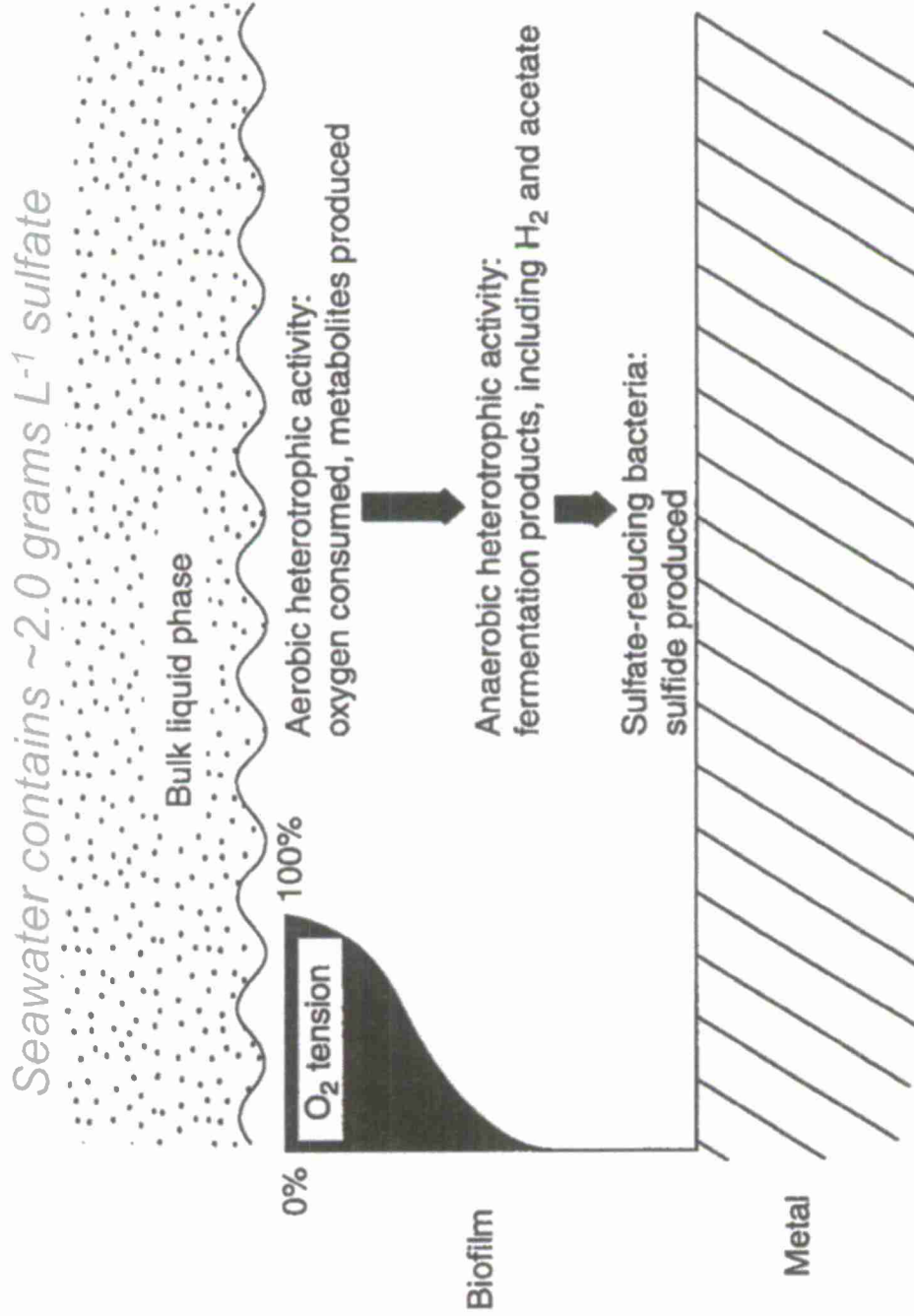
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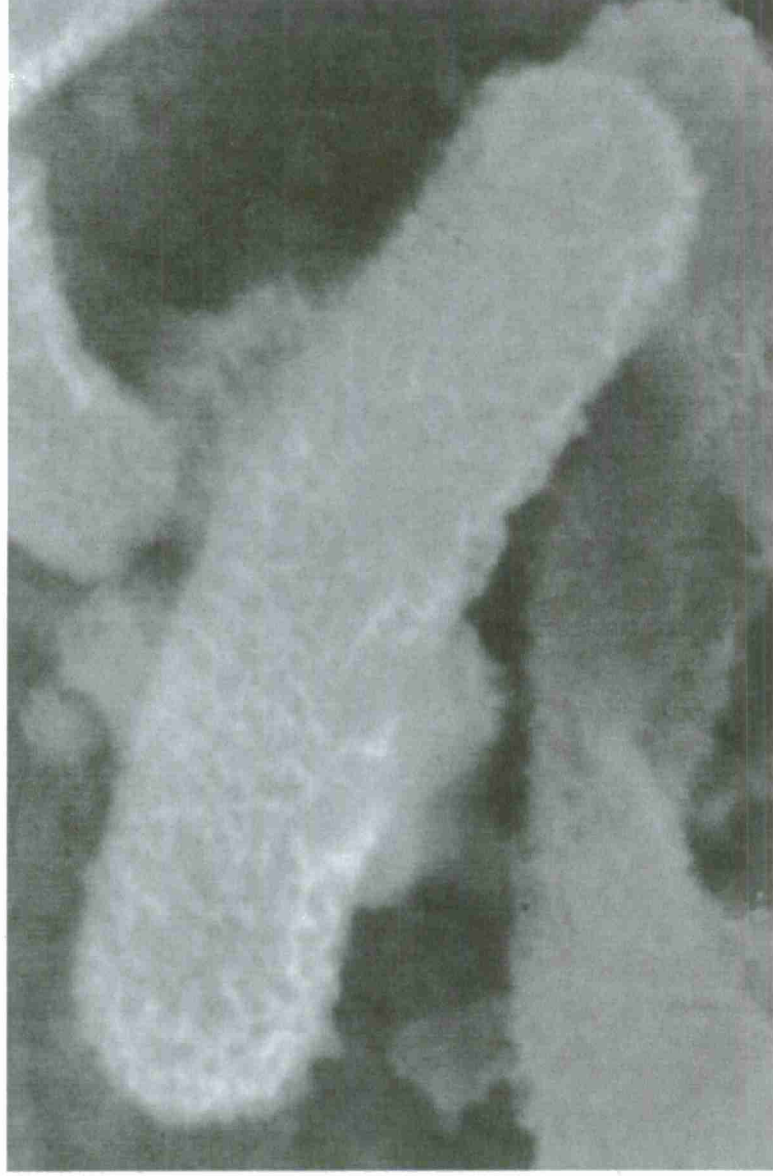


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Sulfide Derivatization



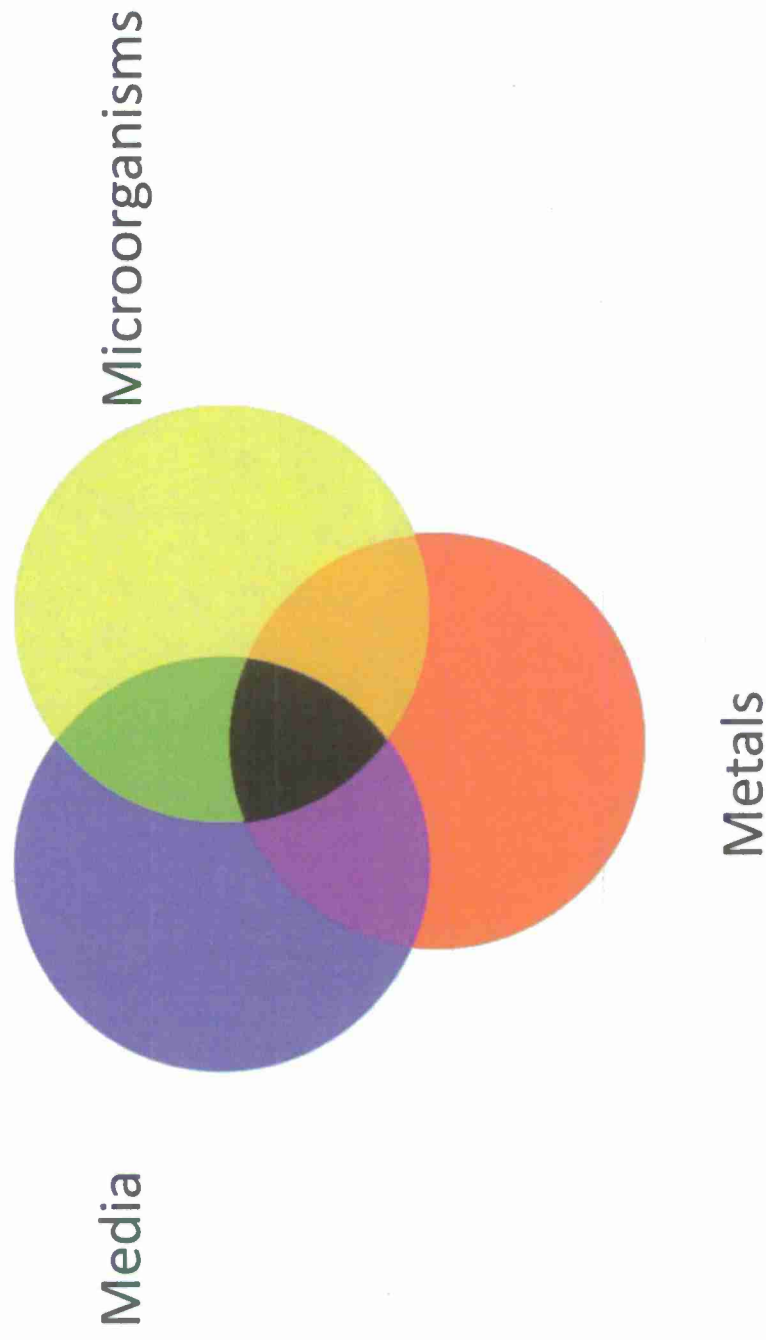
Sulfate-Reducing Bacteria



Initial Seawater Chemistries

Seawaters	pH	Salinity (g/L)	Total Organic Carbon (mg/L)	Sulfate (mg/L)
Key West	7.82	38	1.79	3864
Persian Gulf	7.98	44	1.94	4696

Microbiologically Influenced Corrosion



Scientific Question

Aqueous Corrosion

- Can microbial colonization of aluminum alloys initiate and sustain localized corrosion by sulfide derivitization?

Hypothesis – Sulfate reducing bacteria can derivitize aluminum alloys and produce localized corrosion.

Approach

1. AA in natural seawater (NRLKW & NRLSSC).
2. Characterize corrosion and corrosion products
 - Electrochemistry
 - Microbiology
 - Environmental Scanning Electron Microscopy
 - Transmission Electron Microscopy
 - White Light Profilometry
 - **Focused Ion Beam Milling**



Principal Aluminum Alloys

1xxx series	minimum 99% aluminum
2xxx series	copper
3xxx series	manganese
4xxx series	silicon
5xxx series	magnesium
6xxx series	magnesium and silicon
7xxx series	zinc
8xxx series	lithium and other elements

Sulfur Corrosion Products

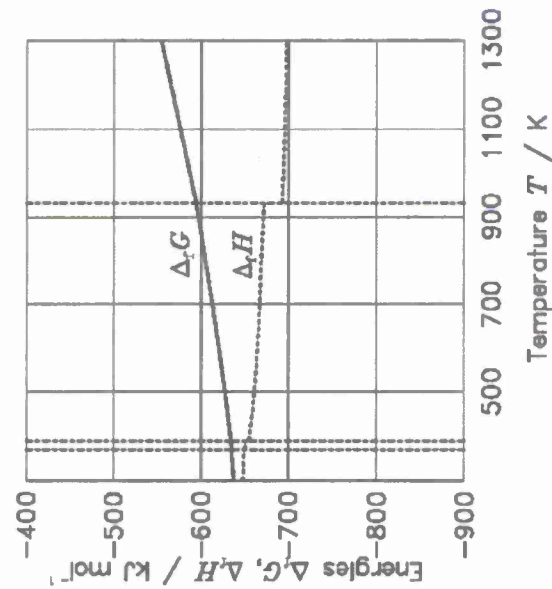
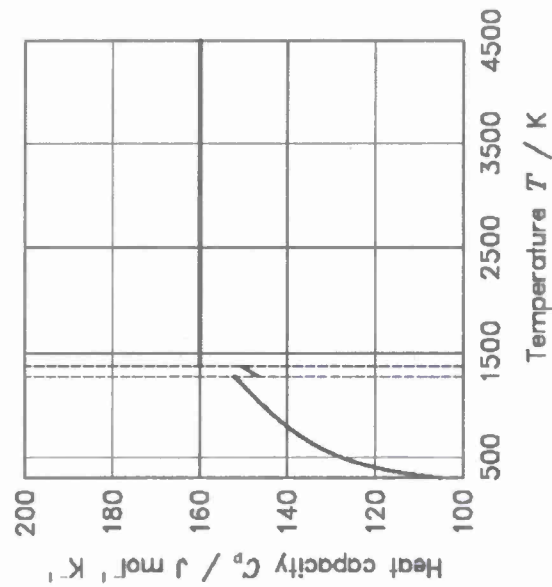
- Al - ND
- Ag - acanthite (Ag_2S).
- Ag-Cu alloys - acanthite, argentite (the high temperature polymorph of Ag_2S or jalpaite (Ag_3CuS_2)).
- Cu - complex suites of sulfide minerals: the most common product is chalcocite (Cu_2S). Final product in many cases is blue-remaining covellite (CuS_{1+x}).
- Cu-Ni alloys - Sulfide corrosion products similar to those of Cu but with significant djurite ($\text{Cu}_{31}\text{S}_{16}$). No Ni minerals observed.
- Cu-Sn alloys - Corrosion products similar to those in Cu.
- Fe (carbon steel) - Final product is pyrite (FeS) with numerous intermediates.
- Fe (stainless alloys) - Rates are slower than pure Fe or carbon steel. No Ni minerals have been detected. Stainless steels with 6% or more Mo appear to be very resistant.
- Mg - ND
- Ni - millerite (NiS).
- Pb - galena (PbS).
- Zn - sphalerite (ZnS)

Al-S: Thermodynamics

Al₂S₃ (Aluminium Sulphide)

[94SGTE]

T	S°	$H_{298}^\circ - H_0^\circ$	$\Delta_f H^\circ$	$\Delta_f S^\circ$	$\Delta_f G^\circ$	$\Delta_{\text{trs}} H^\circ$	$\Delta_{\text{trs}} S^\circ$	type
298.15	116.860	18632.0	-648500.0	-35.950	-637782.0	0.0	0.000	S → S
1273.0						66000.0	48.070	S → L
1373.0								S → L

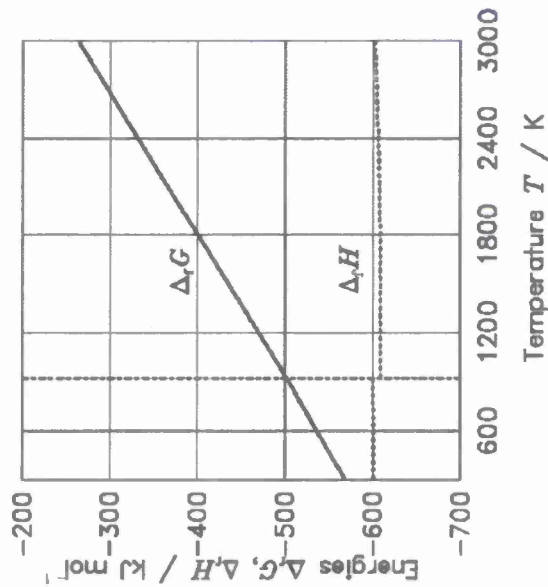
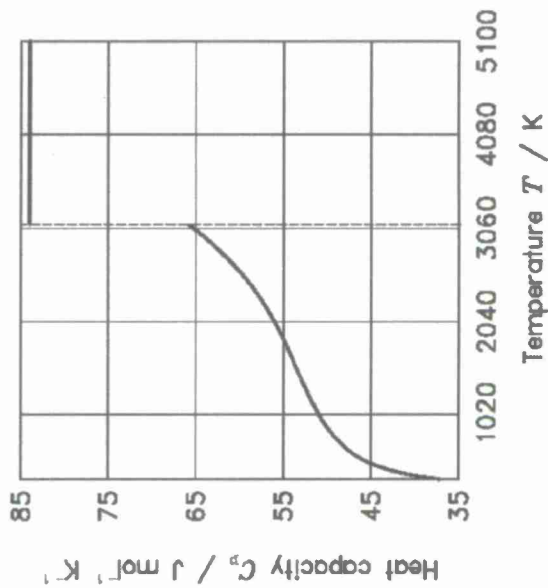


Mg-O: Thermodynamics

MgO (Magnesium Oxide)

[94TCRAS]

T	S°	$H_{298}^{\circ} - H_0^{\circ}$	$\Delta_f H^{\circ}$	$\Delta_f S^{\circ}$	$\Delta_f G^{\circ}$	$\Delta_{trS} H^{\circ}$	$\Delta_{trS} S^{\circ}$	type
298.15	26.95	5160.0	-601600.0	-108.295	-569312.0	77000.0	24.839	$S \rightarrow L$
3100.00								

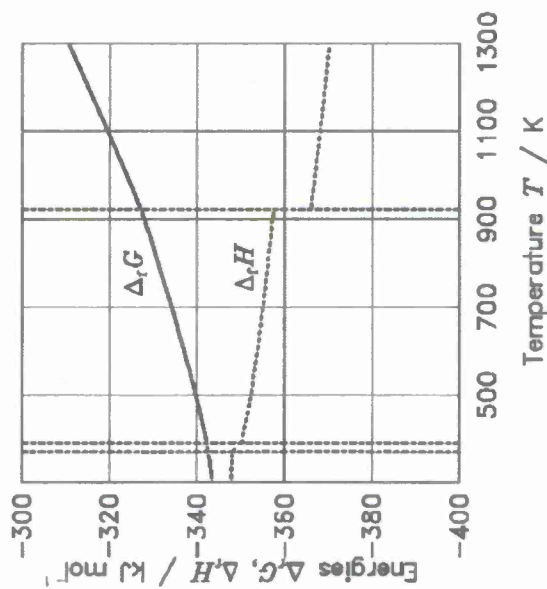
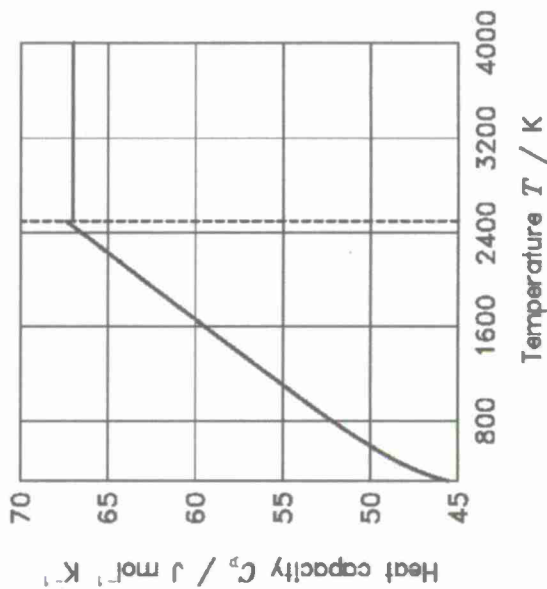


Mg-S: Thermodynamics

MgS (Magnesium Sulphide)

[94TCRAS]

T	S°	$H_{298}^\circ - H_0^\circ$	$\Delta_f H^\circ$	$\Delta_f S^\circ$	$\Delta_f G^\circ$	$\Delta_{trs} H^\circ$	$\Delta_{trs} S^\circ$	type
298.15	50.330	8330.0	-348000.0	-14.411	-343703.0	63000.0	25.200	$S \rightarrow L$
2500.00								



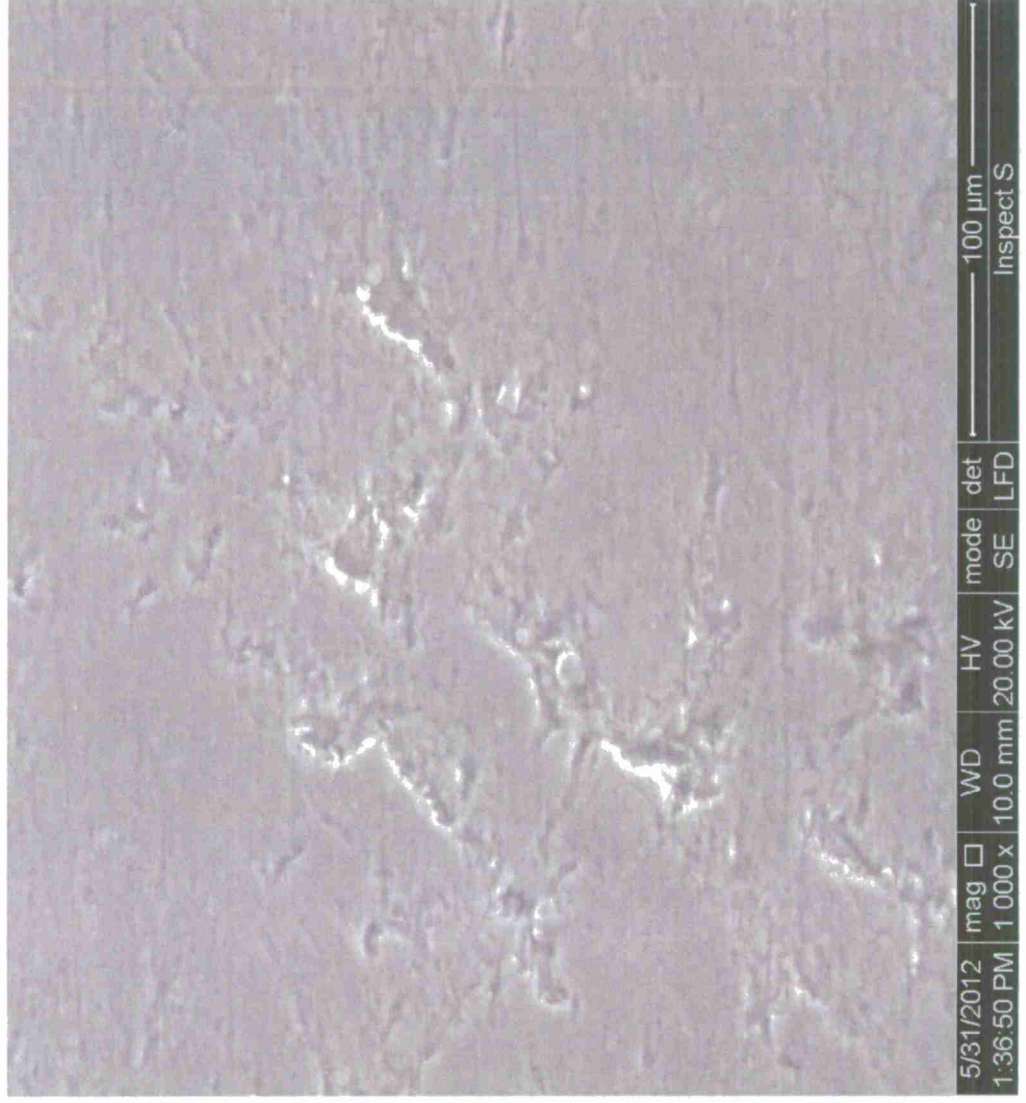
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3003



We know the following:

- 5xxx Al used above and below the waterline:

Alloys

5083

5086

5456

5745

Platforms

Landing Craft Air Cushion (LCAC)

Littoral Combat Ship (LCS)

Legacy platforms

- Corrosion problems occur above and below the waterline:
 - Pitting, cracking, crevice corrosion

