Radiolysis Processes on Europa

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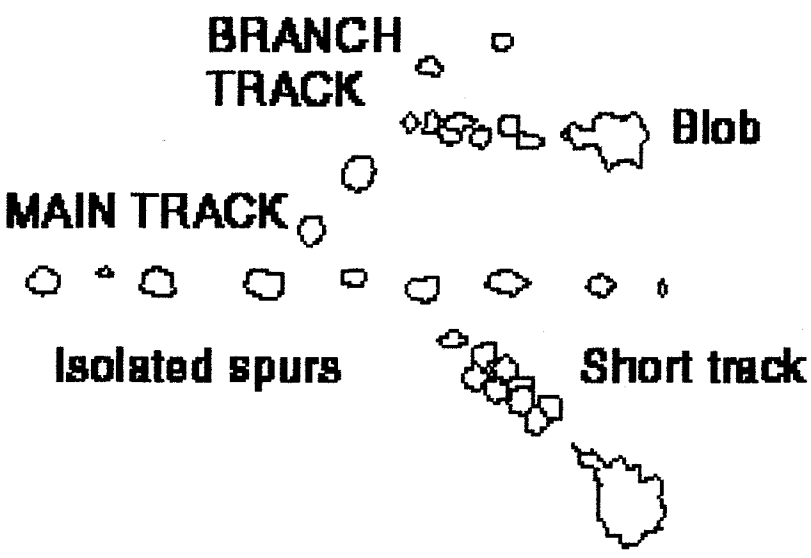
Ionizing Radiation



EXAMPLE

For one 300 keV electron, get about:

10^4 electron-ion pairs

10^4 - 10^5 dissociations

10 - 10^4 new molecules

G-values and lifetimes

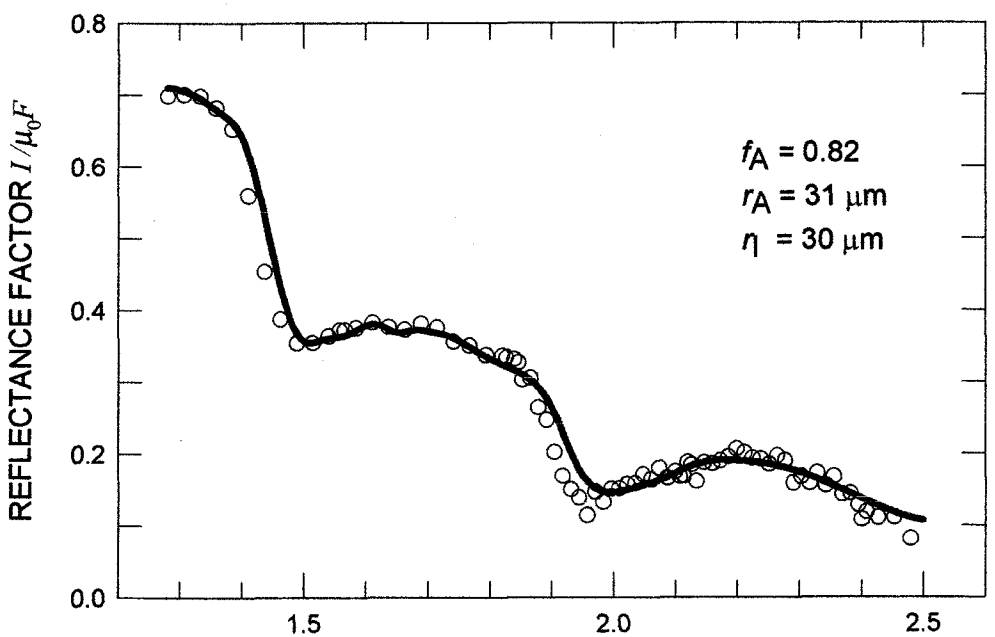
Reaction	***G***	**τ, yr**
$H_2O \rightsquigarrow H_2O_2$	0.4	200
$H_2O \rightsquigarrow O_2$	0.1	
$SO_2 + H_2O \rightsquigarrow SO_3 + H_2O \rightarrow H_2SO_4$	5	7
$SO_2 \rightsquigarrow S + O_2$	0.7	
$S + H_2O \rightsquigarrow H_2SO_4$	0.4	200
Sulfates $\rightsquigarrow$ S, sulfides, SO_2, SO_3 ions and neutrals	0.001	8000

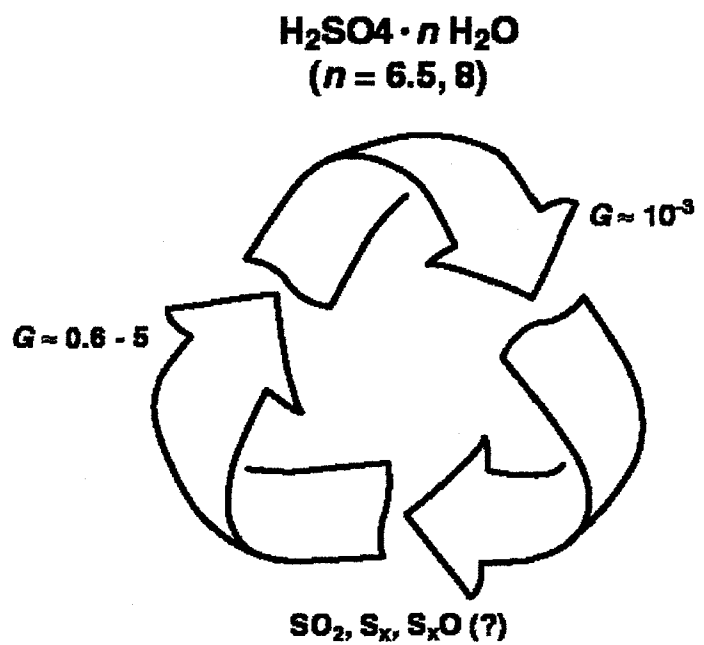
G = the number of molecules produced (or destroyed) per 100-eV absorbed energy. These values normalized to 100% concentration.

Lifetime $\tau_X = n_X R/\Phi G$, n is number density, R is range, Φ is ionizing energy flux.

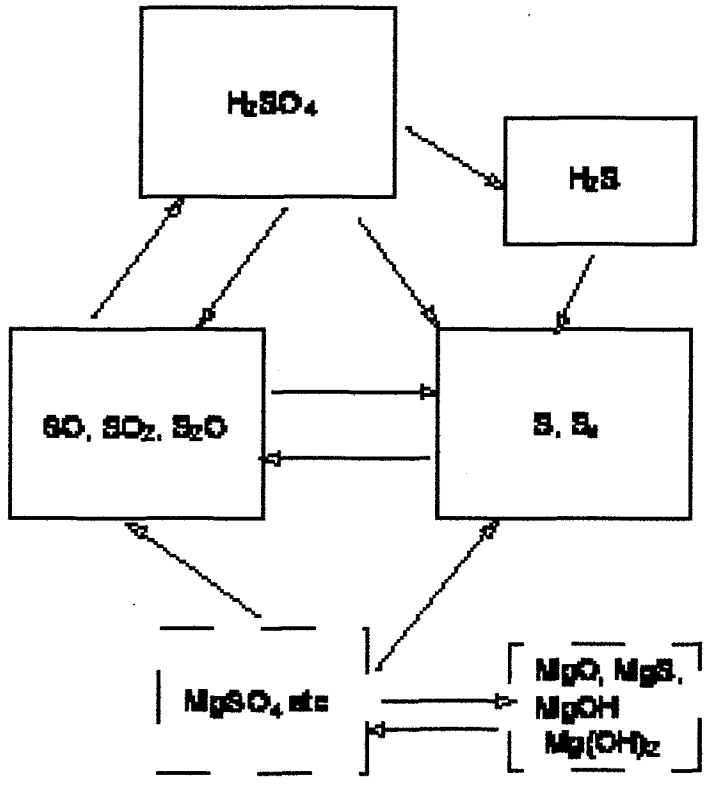
Sulfuric Acid and the Radiolytic Sulfur Cycle

Europa NIMS spectrum fitted with ice and hydrated sulfuric acid

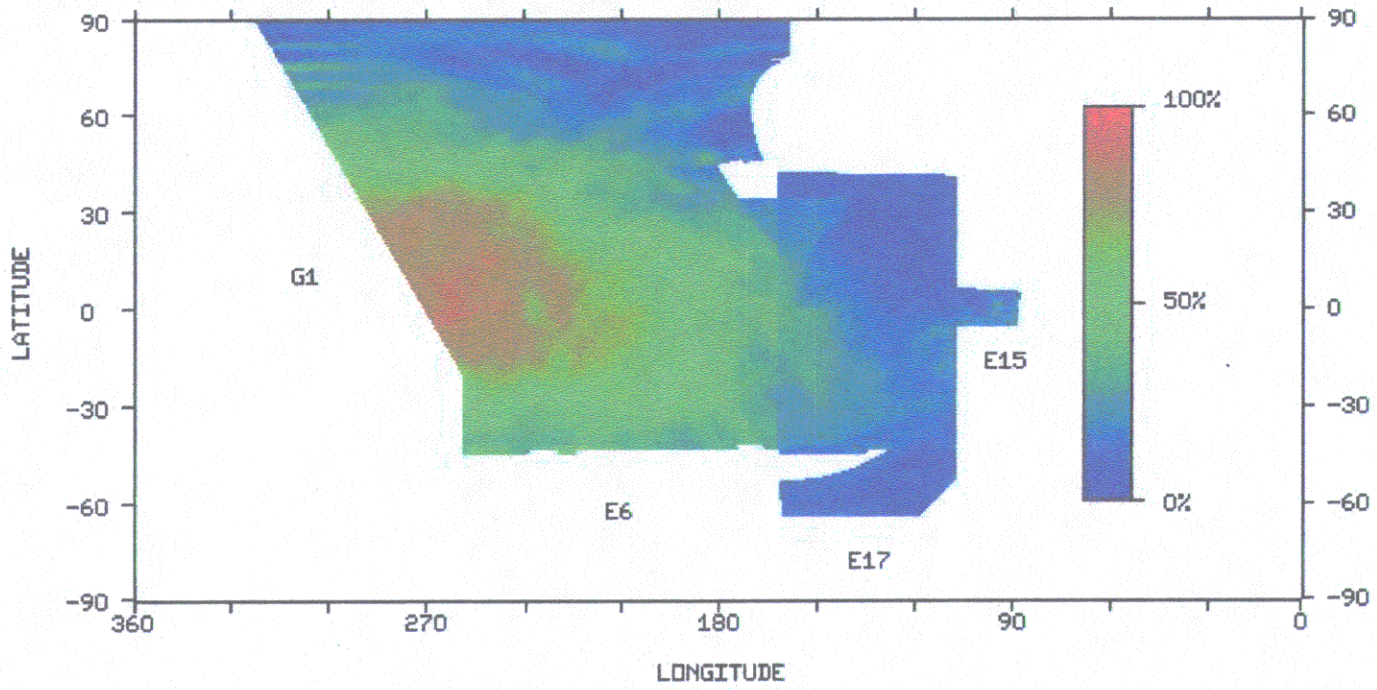




Europa:
Simplified chemical scheme

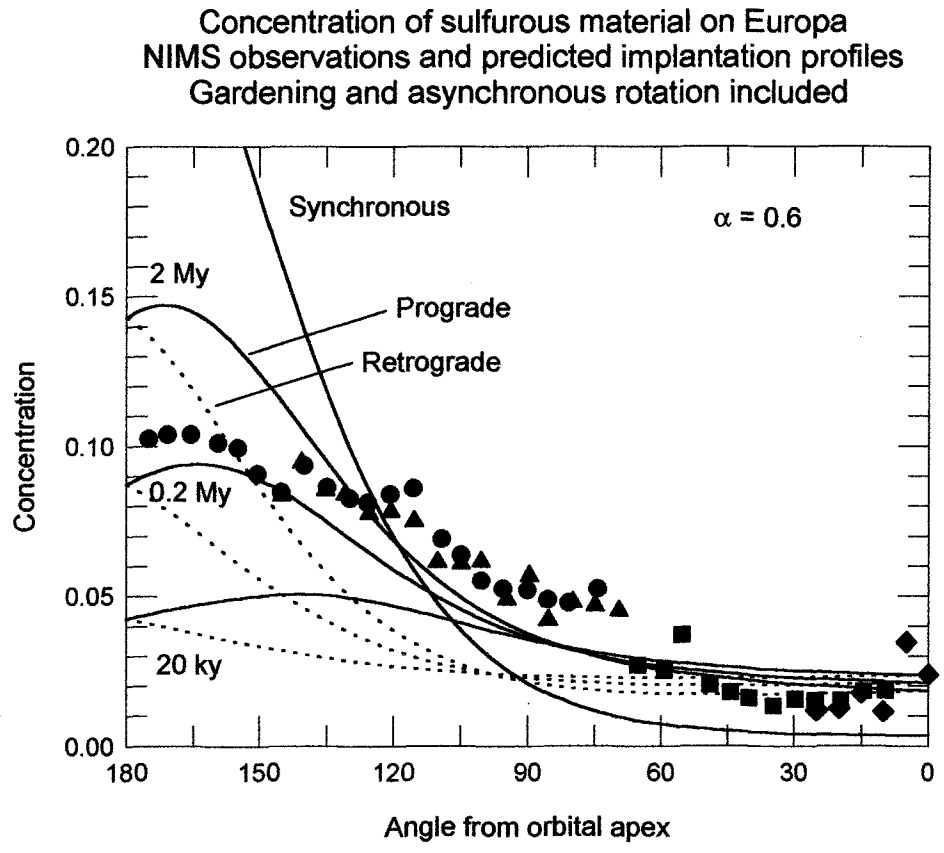


$H_2SO_4 \bullet nH_2O$ Distribution on Europa



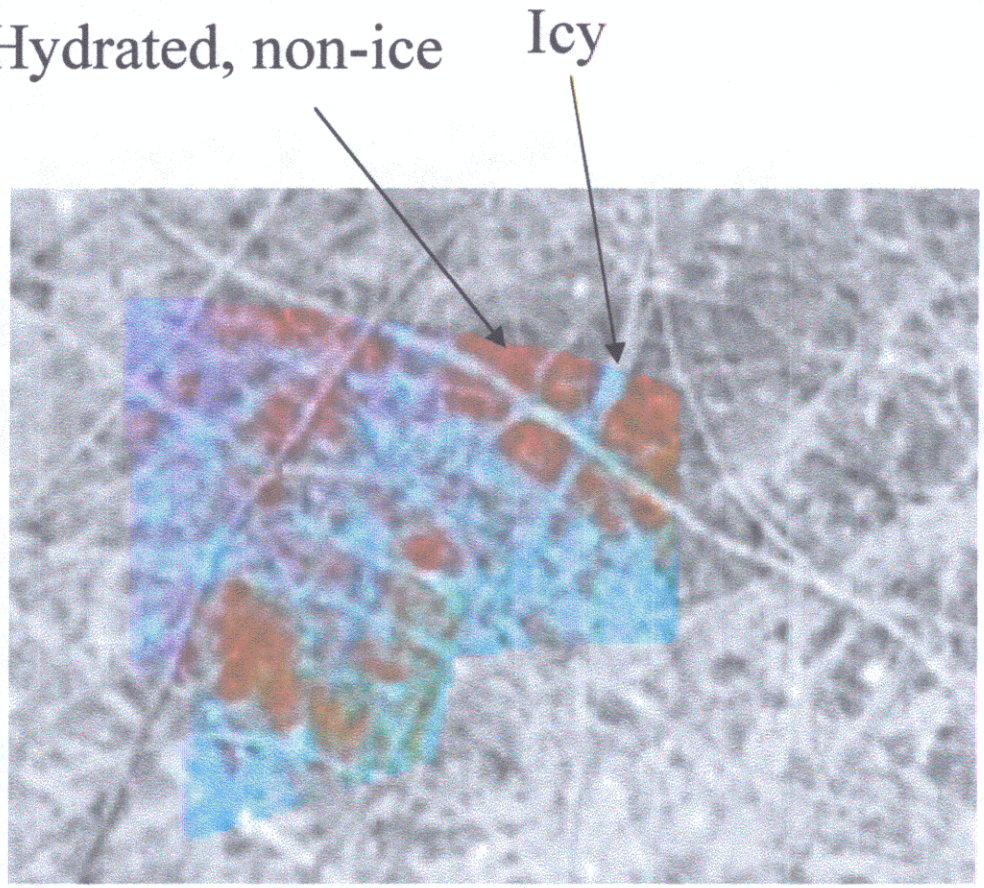
Leading/Trailing Asymmetry

- Enhanced by
  - Plasma ion (S^{n+}) implantation
  - Electron radiolysis (Paranicas et al.)
  - Gardening
- Reduced by
  - Asynchronous rotation



Endogenic Sources?

Dark lineae suggest internal sources

Dissolved SO_2,
Sulfate salts,
An acidic ocean?

But the centers of triple bands are icy!