This Week's Citation Classic

CC/NUMBER 29
JULY 16, 1979

Eugster H P & Wones D R. Stability relations of the ferruginous biotite. annite.
J. Petrology **3:**82-125, 1962.
[Johns Hopkins Univ., Baltimore. MD and US Geological Survey. Washington. DC]

Description of the oxygen buffer method for studying redox reactions in supercritical steam is combined with the application to the stability relations of the iron biotite (mica) annite, $KFe_3AlSi_3O_{10}(OH)_2$. The standard oxygen buffer curves are given in terms of oxygen fugacity as a function of T and P. [The *SCI*® indicates that this paper has been cited over 195 times since 1962.]

H.P. Eugster
Department of Earth
and Planetary Sciences
Johns Hopkins University
Baltimore, MD 21218

June 20, 1978

"In late 1956, working at the Geophysical Laboratory in Washington, I faced the following problem: How to grow hydrous ferrous silicates in supercritical steam (say 2000 bars) Until then we had invariably produced magnetite. Fe_3O_4. To prevent oxidation, I enclosed the charge in a sealed platinum capsule and surrounded that with hydrogen, relying on the osmotic membrane effect. The first hydrogen source was Zn + HCl and it produced beautiful palegreen mica plates, no magnetite I knew I had it, but didn't much like HCl in my autoclave So I switched to Zn + H_2O and it worked, then Fe+ H_2O and it worked. Almost a year later, and after considerable boning up in physical chemistry, I hit upon the idea of using pairs of oxides, such as Fe_2O_3+Fe_3O_4+H_2O, because they would provide a fixed and known hydrogen fugacity That was the birth of the oxygen buffers.

"About that time, David Wones, a predoctoral student from MIT joined me and I assigned him a closely related thesis, the Mg-Fe biotites By 1960 we had enough material for two sizable papers.[1] We decided to write them together, alternating authorship. That was my smartest idea. Dave looked into the thermodynamic properties of the seven standard buffer curves and expressed them in terms of log $f_{O_2} = \frac{A}{T} + B + \frac{C(P-1)}{T}$ From this dates the general acceptance of fugacity in the geochenical literature as well as the pressure correction term C. Dave's summary takes up two pages of the paper and I am sure that over 95% of the citations refer to those pages and their A,B, and C's. I doubt that many people have read the remaining 41 pages Consequently some of the beautiful philosophy we stuck in was not appreciated until years later. It has to do with buffered components and ways to calculate earth fluid compositions from their associated minerals. In fact, even the techniques section had rough sledding at first, because it was too outlandish. It was only the persistence of my students and their students that saved the day. Eventually even my enemies found it necessary to adopt the method.

"My students and I have since written many more elegant papers on supercritical electrolyte solutions, but none will become Citation Classics.[2] They are more sophisticated and better written –in 1960 I had only a tenuous hold on English –but the audience has shrunk and people are less excited about this kind of work. Yet we feel we are only at the beginning

"When my friends ask me how they can get the people out there to read their stuff, my standard advice to them is to find a method for doing an experiment or a calculation which people cannot do without in their work. That way you Save a surefire Citation Classic. Ideas will do too, but they are much harder to come by, and more difficult to get accepted."

1. **Wones D R & Eugster H P.** Stability of biotite: experiment, theory and application.
Am. Mineral. **50**:1228-72. 1965.
2. **Eugster H P.** Compositions and thermodynamics of metamorphic solutions.
Thermodynamics in geology.
(Frazier D G. ed.) Holland: D. Rcidel Publishing Co.. 1977. (p. 183-202) 410p.