# FREZCHEM: A geochemical model for cold aqueous solutions

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## FREZCHEM Model

FREZCHEM is an equilibrium chemical thermodynamic model parameterized for concentrated electrolyte solutions (to ionic strengths = 20 molal) using the Pitzer approach [1] for the temperature range from –100 to 25°C (CHEMCHAU version has temperature range from 0 to 100°C) and the pressure range from 1 to 1000 bars [2]. The current version of the model is parameterized for the Na-K-$NH_4$-Mg-Ca-Fe(II)-Fe(III)-Al-H-Cl-$ClO_4$-Br-$SO_4$-$NO_3$-OH-$HCO_3$-$CO_3$-$HSO_3$-$SO_3$-HS-S-$CO_2$-$O_2$-$CH_4$-$NH_3$-$SO_2$-$H_2S$-Si-$H_2O$ system and includes 115 solid phases including ice, 16 chloride minerals, 36 sulfate minerals, 16 carbonate minerals, six sulfite minerals, five solid-phase acids, four nitrate minerals, seven perchlorates, six acid-salts, five iron oxide/hydroxides, four aluminum hydroxides, two silica minerals, two ammonia minerals, two gas hydrates, two bromide sinks, and one sulfide mineral (pyrite). Fortran codes and an Internet working model are available at http://frezchem.dri.edu.

Applications for FREZCHEM can be very diverse because of its extensive physical ranges. For example, if ammonia/ammonium and methane are prevalent on Titan, that can lead to interesting chemistries over the temperature range of 173-273 K (Fig. 1). Notice that $SO_4$ largely precipitates, but $CH_4$ (aq) increases, which may be why methane is a major component on the surface of Titan where the temperature is 94 K.

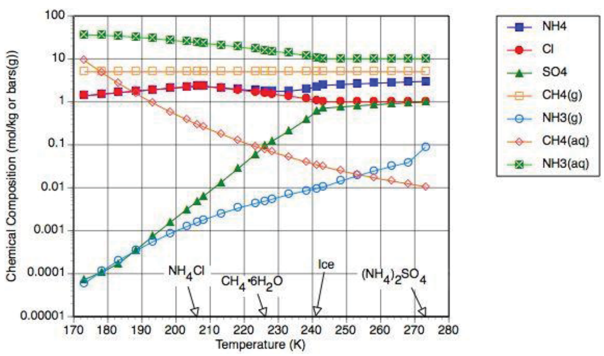


**Figure 1.** The chemical compositions as temperature decreases from 273 to 173 K beneath Titan surface. Arrows on the X-axis indicate when solid phases start to precipitate.

[1] Pitzer (1991) *Activity Coefficients in Electrolyte Solutions* CRC Press. [2] Marion & Kargel (2008) *Cold Aqueous Planetary Geochemistry with FREZCHEM* Springer.

# Post OIS6 climate-change records in the Lower Mississippi Valley and mid-Atlantic Coastal Plain

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Published and on-going investigations allow comparison of post OIS6 chrono- and pedo-stratigraphic and palynologic records in the Lower Mississippi Valley (LMV) and mid-Atlantic Coastal Plain (MACP) of the unglaciated USA. Data indicate that in both regions W-NW winds were responsible for loess and eolian-sand deposition and that in both regions depositional periods were coeval with Northern Hemisphere glaciations and characterized by boreal environments.

The LMV was the major meltwater conduit associated with the Laurentide Ice Sheet (LIS). Loess dominates the OIS6, 3, and 2 LMV stratigraphic record. Sand dunes are a minor component. The Susquehanna and Delaware rivers were conduits for glacial meltwater that had an impact on the Chesapeake Bay area of the MACP. Eolian deposits are more spatially and temporally restricted in this area than in the LMV and are most prevalent within 300 km of the glacial border. Eolian sand dominates the OIS 3 and 2 MACP stratigraphic record.

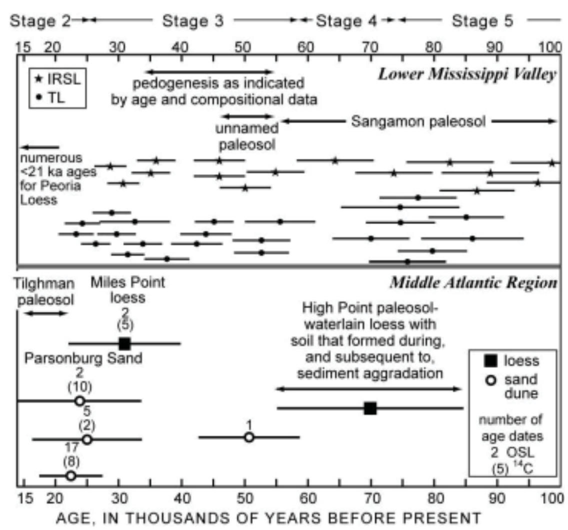


**Figure 1:** Age data for loess, eolian sand, and paleosols from the LMV[1] and the mid- Atlantic region[2][3][4].

Palynologic and paleowind data, along with the chrono- and pedo-stratigraphic records, are adequate to allow preliminary comparisons of late Pleistocene climates in the two regions.

[1] Markewich *et al.* (2011) *Geo. Soc. Am. Bull.* **123**, 21-39. [2] Lowery *et al.* (2010) *Quaternary Sci. Rev*. **29,** 1472-1480. [3] Pavich *et al.* (2010) *Geo. Soc. Am. Abs. with Prog.***42**, 231. [4] Wysocki *et al.* (2010) *Soil Sci. Soc. Am.* http://a-c-s.confex.com/crops/2010am/webprogram/Paper60303.html.