OLI Tips #39 What is a Scaling Tendency?

A scaling tendency is the ratio of the real-solution solubility product to the thermodynamic limit based on the thermodynamic equilibrium constant.

For Example, Consider this dissolution

$NaHCO_{3(s)} = Na^+ + HCO_3^-$

The Ion Activity Product (IAP) is defined as the product of specific ions (in this case the ions resulting from the dissociation of a particular solid).

Let's consider a 1.0 molal $NaHCO_3$ solution:

$IAP = \gamma_{Na} m_{Na} \gamma_{HCO3} m_{HCO3}$

Assuming Ideal Solution Activities

$\gamma_{Na} = 1.0$ $\gamma_{HCO3} = 1.0$

$m_{na} = 1.0$ $m_{HCO3} = 1.0$

IAP = (1.0)(1.0)(1.0)(1.0)

IAP = 1.0

The Solubility Product (K_{SP}) is the thermodynamic limit of ion availability

$Ksp = \gamma_{Na} m_{Na} \gamma_{HCO3} m_{HCO3}$

$K_{SP} = 0.403780$

The Scaling Tendency is then the ratio of available ions to the thermodynamic limit.

$ST = IAP/K_{SP}$
ST = 1.0/0.403780
ST = 2.48

Was assuming ideal conditions valid??

The actual species concentration and activity coefficients are:

γ_{Na}	=	0.598	γ_{HCO3}	=	0.596
m_{na}	=	0.894	m_{HCO3}	=	0.866

This results in a different IAP

IAP= (0.598)(0.894)(0.596)(0.866)
IAP=0.276

The new Scaling Tendency is therefore:

ST = IAP/Ksp
ST = 0.276/0.40378
ST = 0.683

Why are the concentrations not equal to 1.0? Speciation and chemical equilibria tend to form complexes which provide a “Sink” for carbonate species. In this example:

CO_2^o	=	0.016 molal
$NaHCO_3^o$	=	0.101 molal
CO_3^{2-}	=	0.012 molal
$NaCO_3^-$	=	0.004 molal

What does the Scaling Tendency Mean?

If ST < 1, then the solid is under-saturated
If ST > 1, then the solid is super-saturated
If ST = 1, then the solid is at saturation
Scaling Index = Log (ST)