Ethix POWER EMERGING

ETHIX WATER CONDITIONER

(An ISO 9001:2015 & ISO 14001-2015 Certified Company)

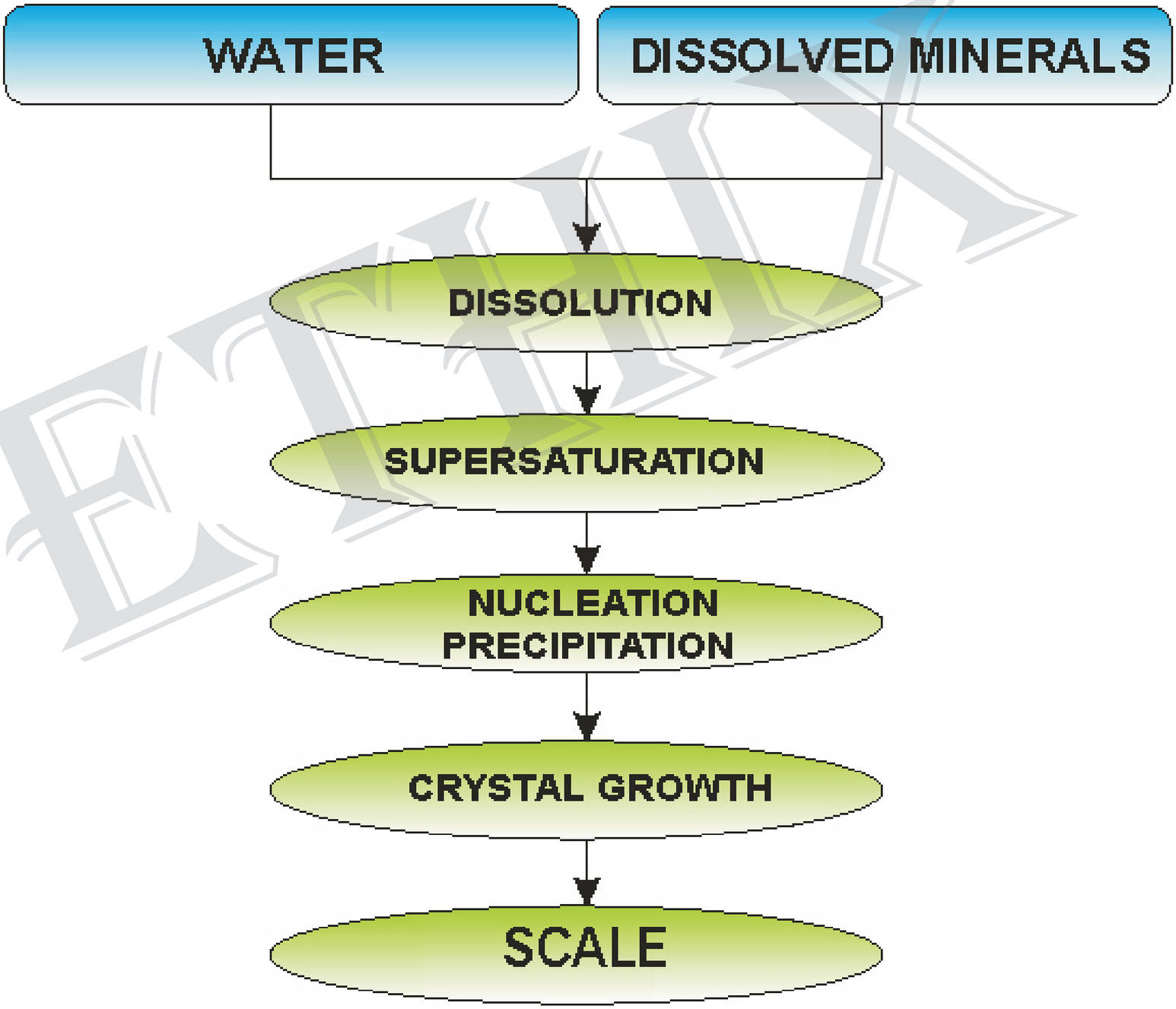
Principles of Scale Formation

Ethix® POWER EMERGING

Principals of Scale Formation

Before **After**

SUMMARY CHART OF HOW SCALE FORMS



❖ What is Dissolution?

How scale (calcium carbonate) gets into the water stream

❖ Stage 1: Water becomes acidic

Whenever it rains, water in contact with air will absorb the CO2 gas in the air.

CO2 gases (carbon dioxide)

The following chemical reaction takes place:

$$CO_2 + H_2O \rightarrow H_2CO_3$$

❖ Stage 2: Acidic water dissolves calcium carbonate

As the acidic rain water reaches the surface, it passes over and permeates through rocks such as limestone, marble and seashells, forming soluble calcium ions and bicarbonate ions.

$$CaCO_3 + H_2CO_3 \rightarrow Ca^{++}2HCO_3$$

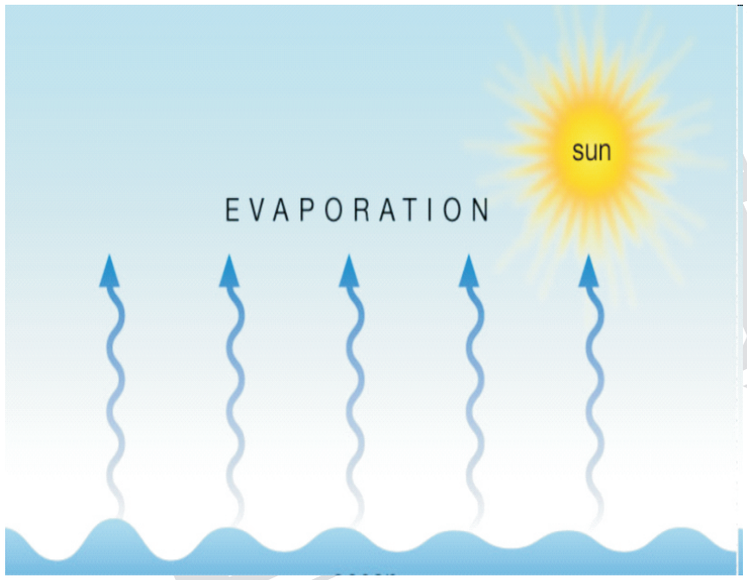
(calcium carbonate) (carbonic acid) (in solution)

❖ *Stage 3: Any condition which alters the solubility of calcium bicarbonate will result in the precipitation of calcium carbonate (scale)*

There are three (3) major factors that can alter the solubility of calcium bicarbonate and thus cause scale:

A.) Temperature effect on solubility.

A change from cold to hot water will cause scale to form.



The reason?

When the temperature increases, CO2 evaporates, allowing scale to precipitate. Heating water also causes evaporation, leaving minerals behind.

B.) PH Change on Solubility

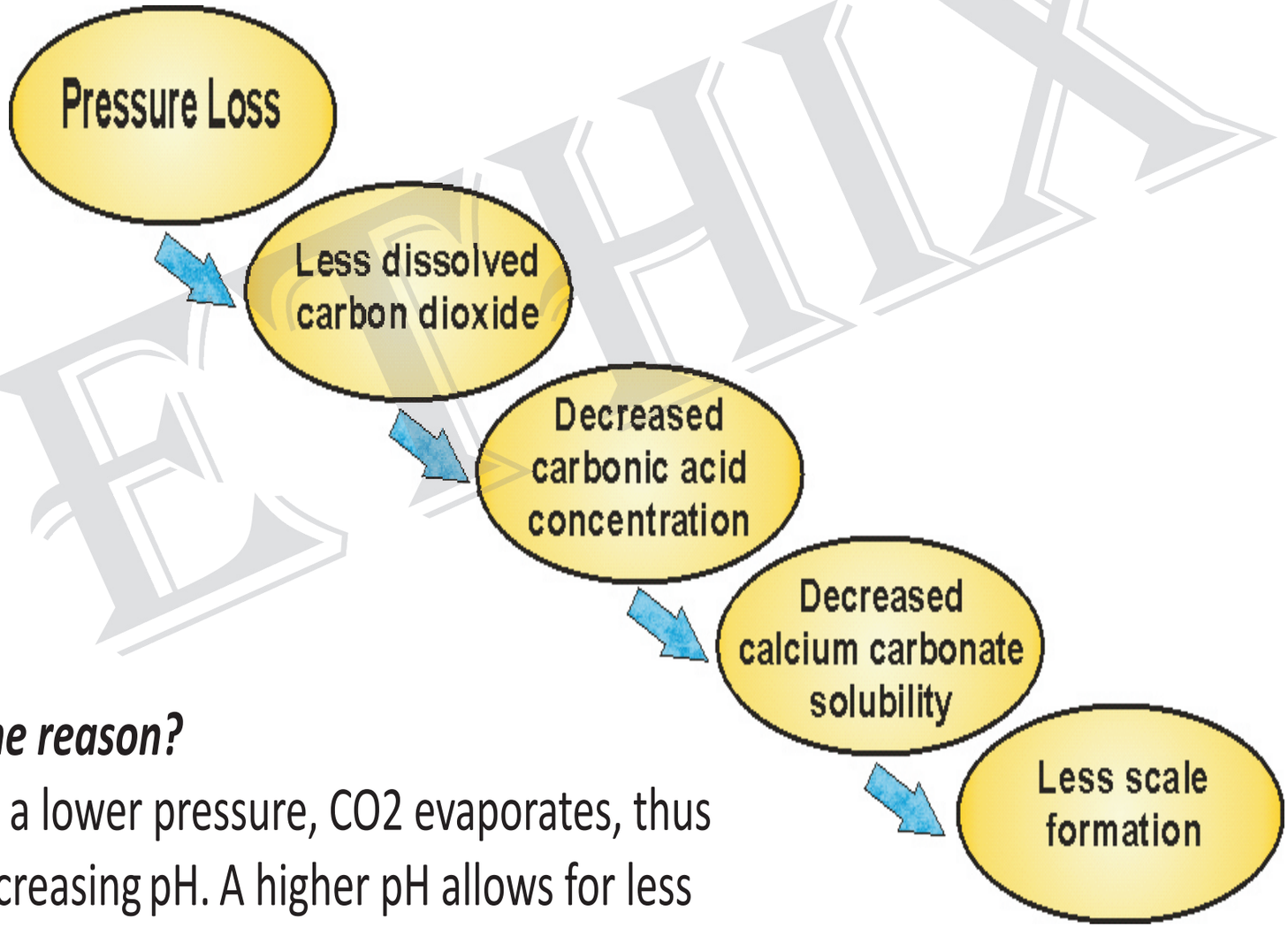
Solubility of CaCO3 decreases with an increase to thepH.

The reason?

PH is a measure of the acidity of the liquid. The lower the pH, the higher the acid content. This will dissolve more calcium carbonate.

C.) Pressure Effect on Solubility

A change in water pressure from high to low will cause scale to form. Pressure drop may occur from internal friction between the molecules of water, external friction between the water and the walls of the piping system, or rough area in the channel through which the water flows

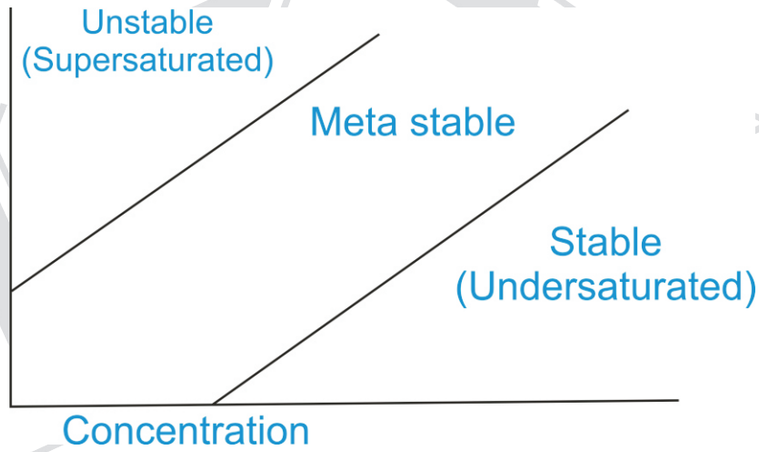


The reason?

At a lower pressure, CO_2 evaporates, thus increasing pH. A higher pH allows for less scale formation.

❖ What is Supersaturation ?

Supersaturation at the point of crystallization is the primary cause of scale deposition.

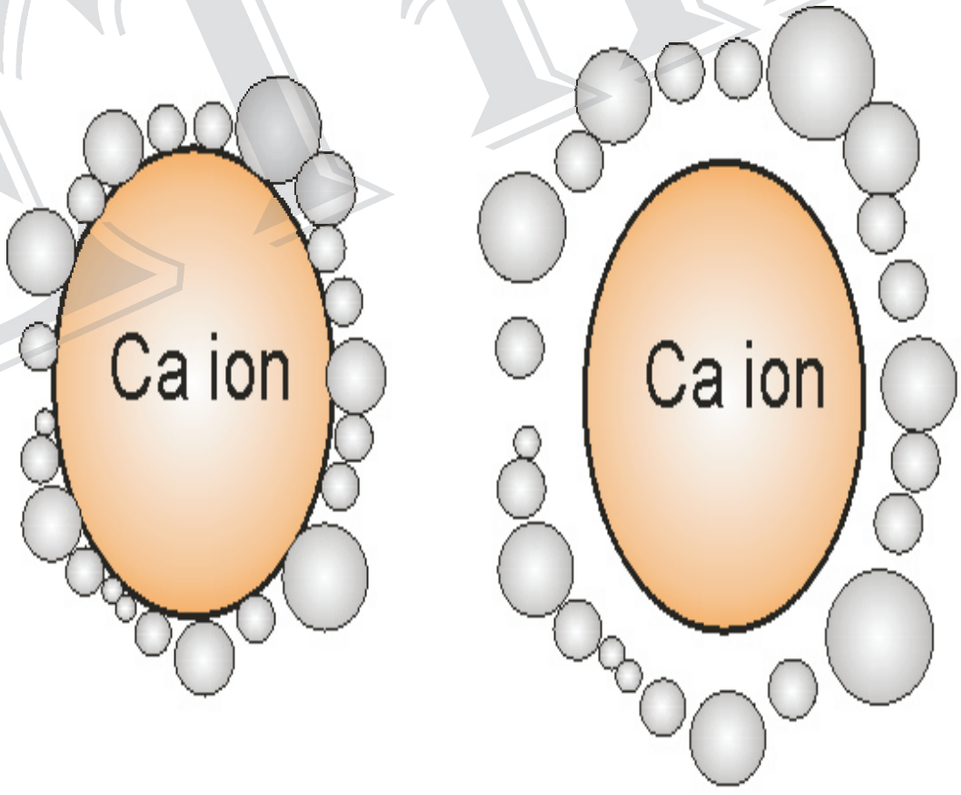


➢ Definitions:

Saturation: The maximum equilibrium concentration of a compound that will dissolve into a solution under a given set of conditions (temperature, pressure, flow velocity, etc.).

Supersaturation: The solutions that contain higher concentrations of dissolved solute than their equilibrium concentration.

To simplify "supersaturation", it can best be described as scale-causing ions that barely "hang in the water" When calcium and bicarbonate ions are hydrated, molecules are attached to the calcium and bicarbonate ions via ionic bonds, which are much stronger than the vander Waal force. In a supersaturated solution, the calcium and bicarbonate ions are 'partially' hydrated by water molecules. The harder water is, the calcium and bicarbonate ions are hydrated with much weaker hydration energy. We conclude that in a supersaturated solution, calcium ions are barely 'hanging in water'.



Fully hydrated calcium ion
stable undersaturated solution

Partially hydrated calcium ion
unstable supersaturated solution

➢ Causes of Local Supersaturation

- Increase in temperature
- Increase in pH
- Decrease in pressure
- Agitation of the solution
- Decrease in flow velocity

Even when the bulk solution is less than fully saturated, scale formation can occur due to local supersaturation.

❖ Nucleation Precipitation

You may be wondering when scale forms, why does it stick to surfaces?

The Answer: The electrostatic attraction between the metal surface and scale-causing minerals. Gravity plays no role in scale formation.

The unique characteristics of scale deposits are its uniformity. Precipitates or crystals formed in one part of a system and carried to another part are less adherent than those crystals formed on site.

➢ *The electrostatic attraction can be described in three theories:*

A) Helmholtz Model

When a metal is in contact with an ionic solution such as water with scale producing minerals, the metal surface has a high density of electrons, giving it a locally negative charge.

The solvated positive ions such as H+, Ca++ and Mg++ align themselves along the surface of the metal surface, producing an (electric) double layer no thermal motion of ions considered.

B) The Gouy-Chapman Model – Diffuse Double-Layer

Due to the thermal motion of the ions in the solution, the population of positive charges (i.e., H+, Ca++ and Mg++)
decreases exponentially with increasing distance from the metal surface.

C) Stern Model - The Previous Two are Combined.

The positive ions closest to metal surface are constrained into a rigid Helmholtz plane while outside the plane, the positive ions are dispersed as in Gouy-Chapman model. It is this electric potential (or coulombs) difference that causes the attraction of the scale to surfaces, which explains their uniform deposition.