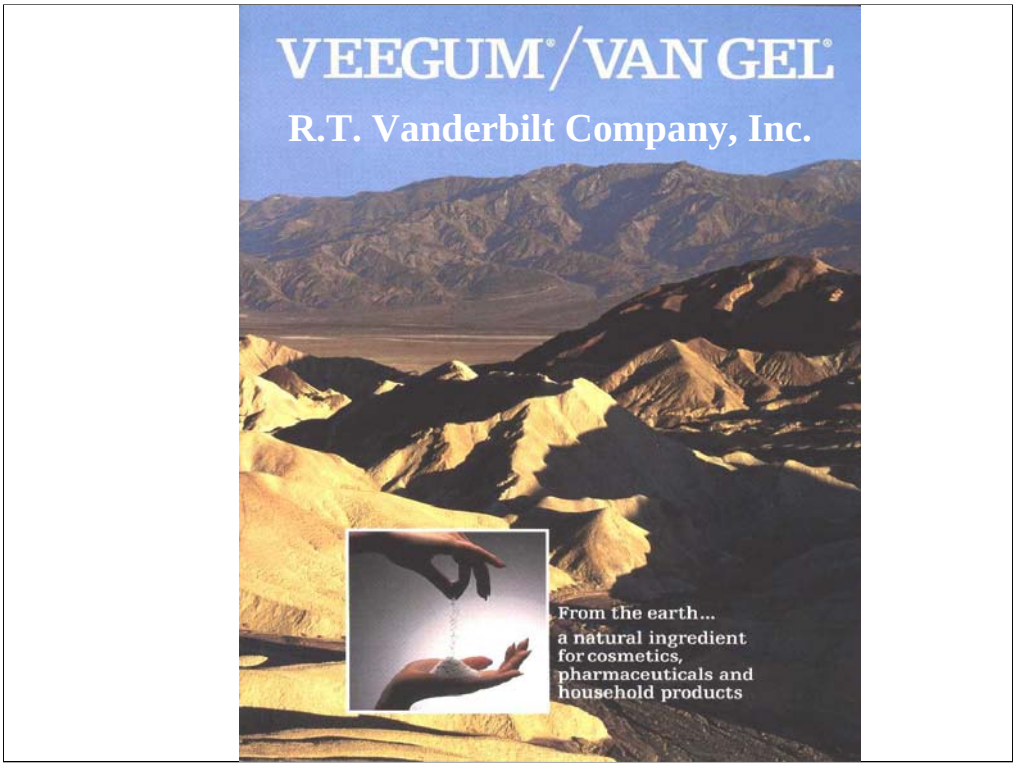


VEEGUM® Magnesium Aluminum Silicate

This presentation is available in three parts. This is Part 2.

Part 1:

What **VEEGUM** Magnesium Aluminum Silicate is

How it's made

How it works

- Clay structure
- Hydration Mechanism
- Colloidal structure in water

Part 2:

VEEGUM Magnesium Aluminum Silicate dispersion rheology

Effect of additives

Part 3:

Guidelines for best use

- Dispersion preparation
- Hydration time guide

Synergism with organic thickeners

VEEGUM Magnesium Aluminum Silicate grades

Rheology

VEEGUM

Magnesium Aluminum Silicate

Dispersions are **THIXOTROPIC**

Dispersions are **PSEUDOPLASTIC**

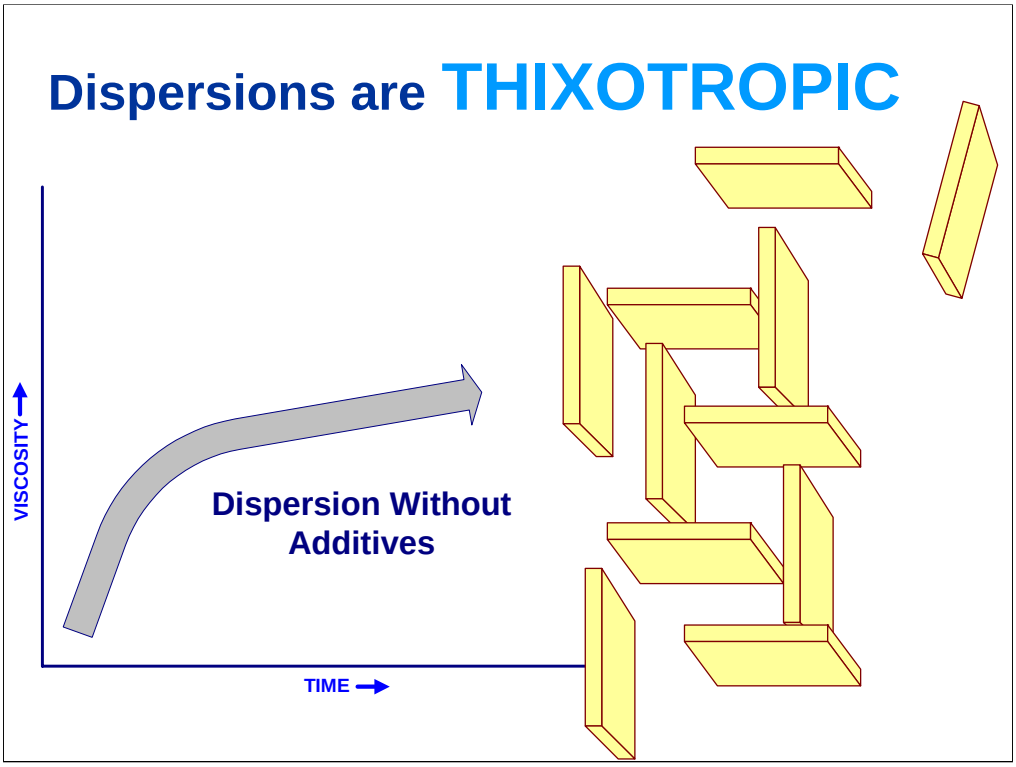
Dispersions have **YIELD VALUE**

Three characteristics of a **VEEGUM** Magnesium Aluminum Silicate dispersion in water define its rheology.

Dispersions are THIXOTROPIC

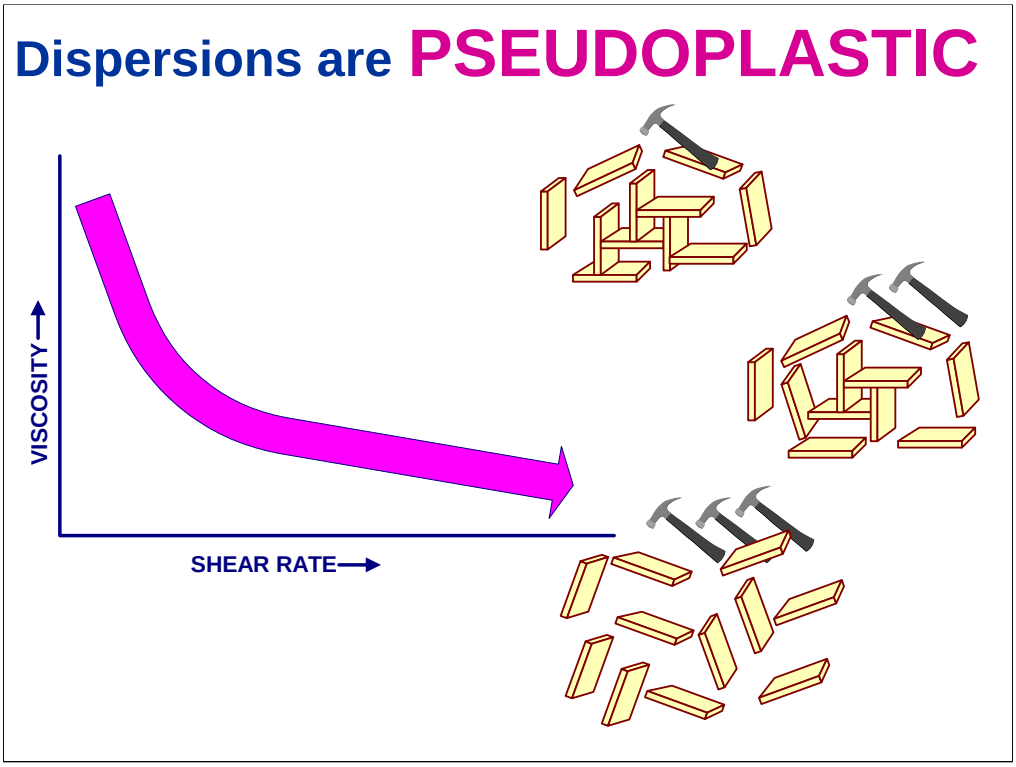
Dispersions are PSEUDOPLASTIC

Dispersions have YIELD VALUE

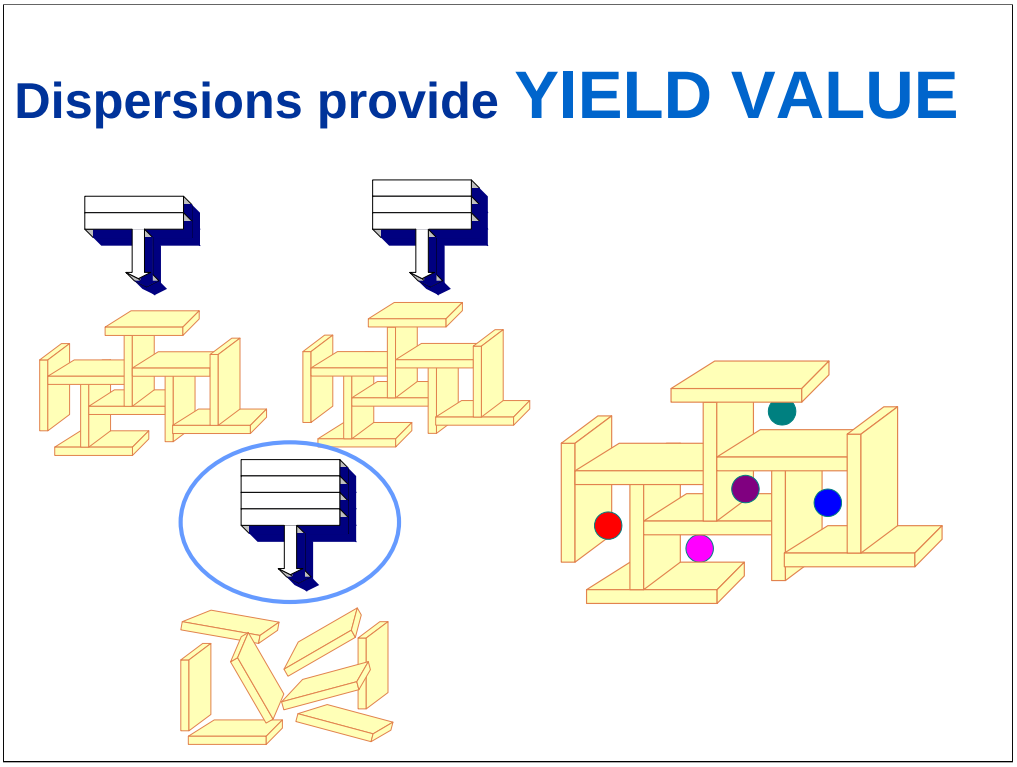


After the clay is hydrated, the three dimensional “house of cards” colloidal structure builds rapidly at first, giving a quick increase in viscosity. As time passes, the remaining free platelets take a longer time to find an available site in the structure, so viscosity increases at a progressively slower rate. Conversely, when a given shear is applied, most of the structure is disrupted quickly, with subsequent breakdown becoming more gradual.

Smectite dispersions are therefore thixotropic: undisturbed they increase in viscosity over time, and under a constant shear rate they decrease in viscosity over time.

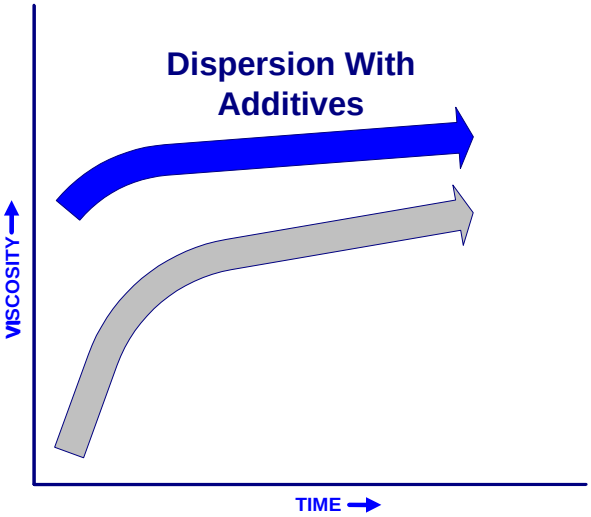


Smectite dispersions are also pseudoplastic, because increasing the rate of applied shear (thereby increasing structure breakdown) results in decreasing viscosities.



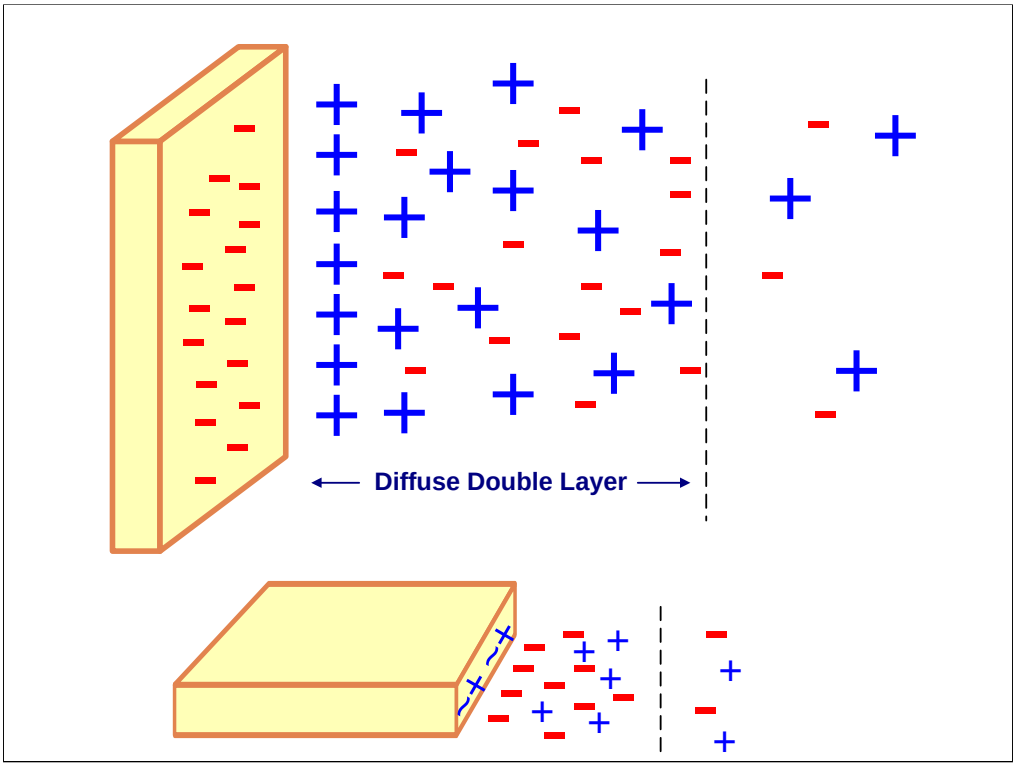
The colloidal structure also provides the clay's most useful property: yield value. This is a measure of the resistance of the structure to breakdown. A certain minimum force, the yield value, must be applied to start disrupting the structure. Solids, oils and gases are trapped and segregated by the structure. They must exert a force greater than the yield value to be able to move through the liquid. This means that the greater the yield value, the more stable the suspension, emulsion or foam.

Water-solubles increase dispersion viscosity and yield value, decrease thixotropy.

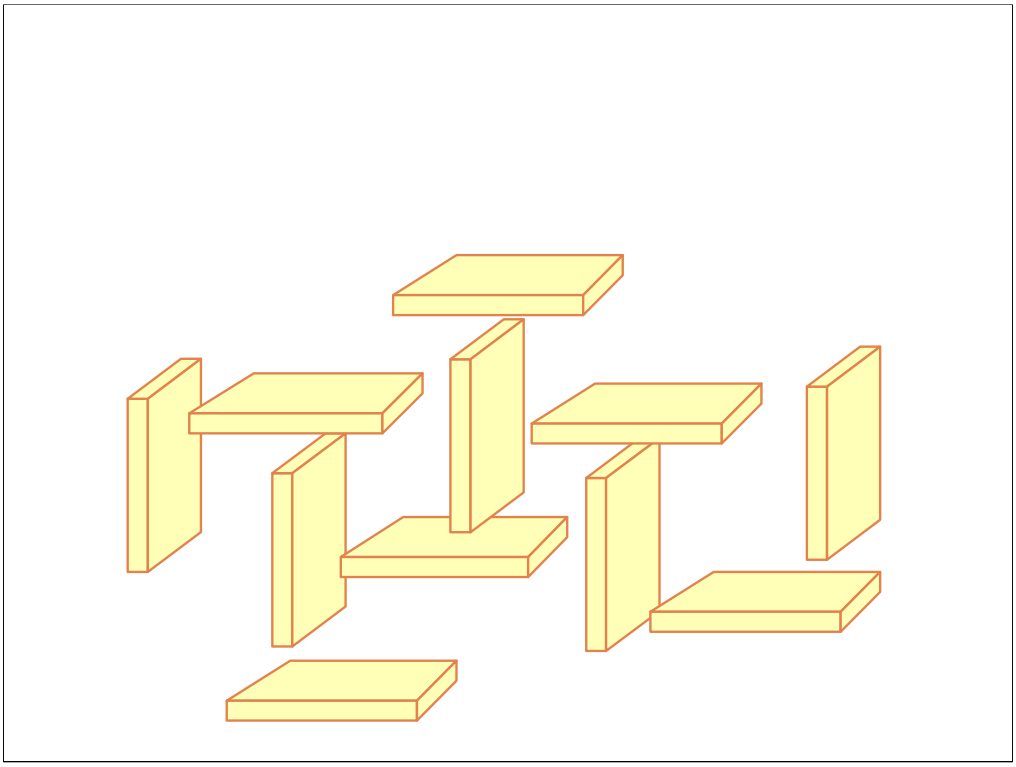


Too much destabilizes the clay dispersion.

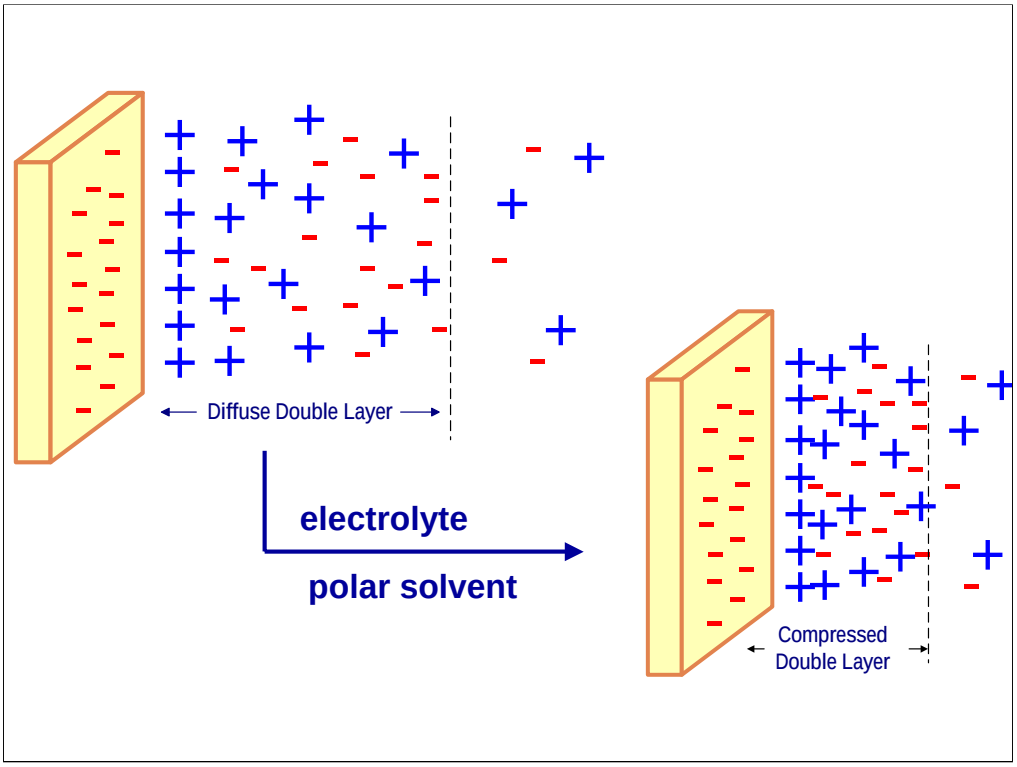
Formulators are more concerned with the behavior of **VEEGUM** Magnesium Aluminum Silicate in the presence of other ingredients, rather than in water alone. Most water-soluble components will modify the rheological properties of smectite clay, usually beneficially. Salts, surfactants and water-miscible solvents will increase the smectite's viscosity and yield value contribution and decrease thixotropy, but still enable a shear-thinning composition. Excess water-solubles will destabilize the smectite's colloidal structure. This may appear as a relatively stable thick gel or as flocculated masses with syneresis.



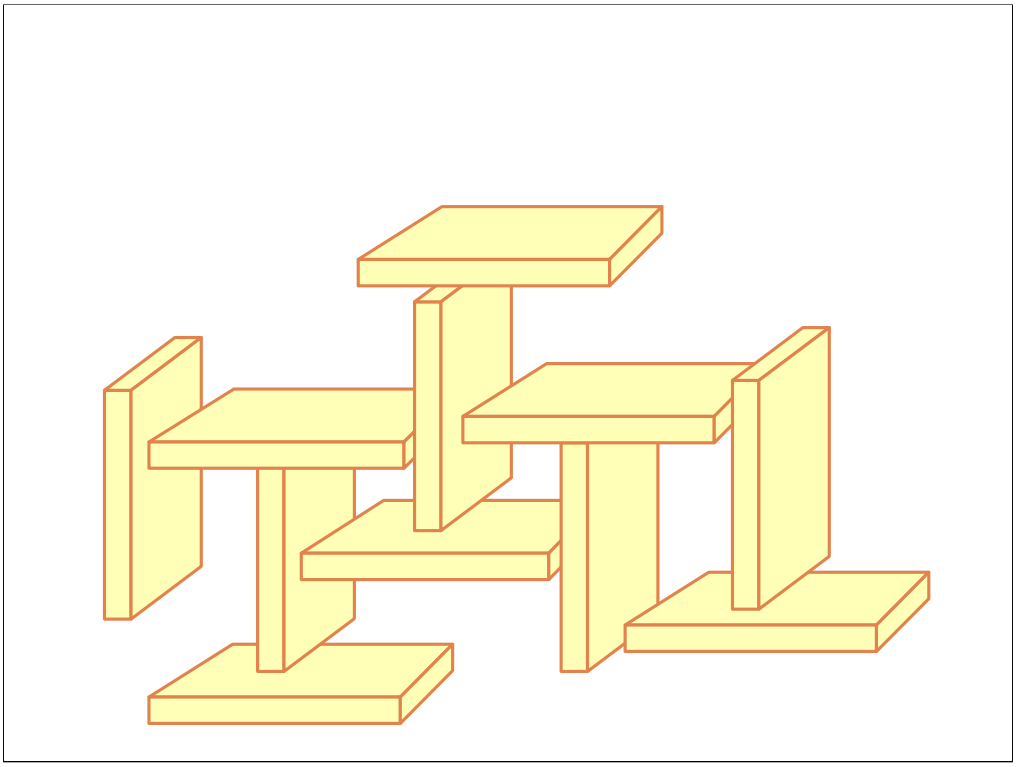
The effect of electrolytes and water miscible-solvents on a smectite clay dispersion can be explained in relation to double layer theory. According to this model, most of the exchangeable ions in the clay dispersion tend to accumulate, due to electrostatic attraction, near the negative faces of the platelets, but simultaneously have a tendency to diffuse away from platelet surfaces toward the bulk of the water where their concentration is low. The equilibration of these opposing effects causes the formation of a diffuse atmosphere of counterions, with concentration diminishing with distance from the platelet face. A negative “double layer” is thus established, consisting of the negative surface charge plus the diffuse counterions. The analogous positive double layer is established in association with platelet edges.



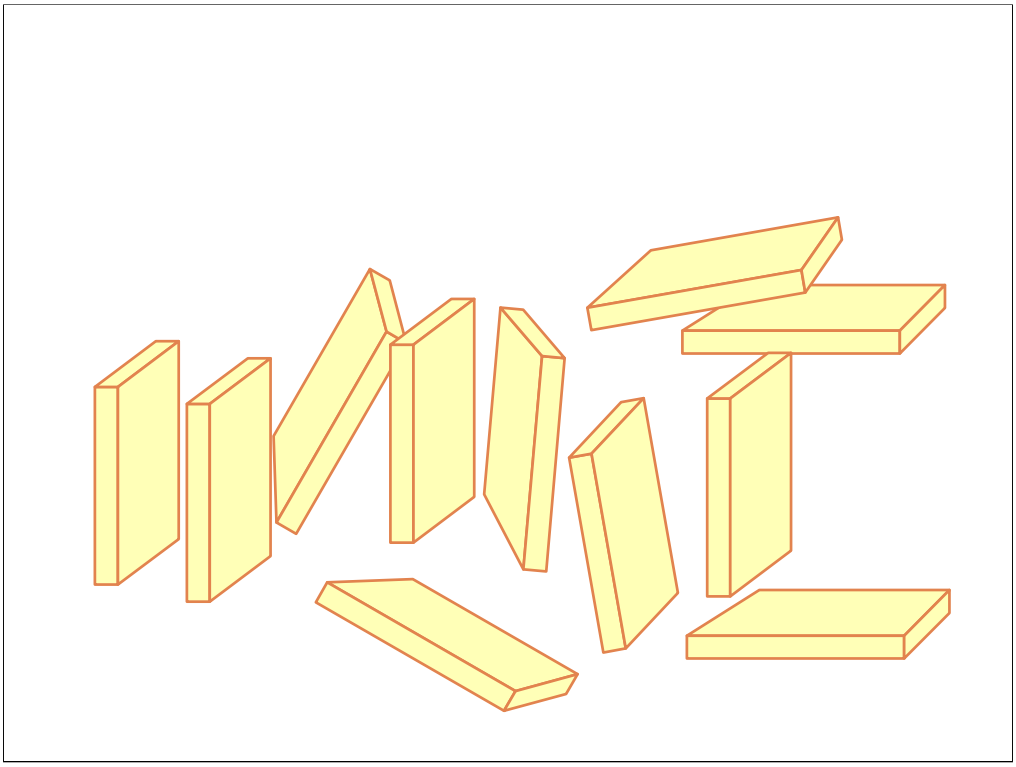
The house of cards colloidal dispersion is therefore based on the interaction of smectite platelet edge double layer and face double layer.



When an electrolyte or polar solvent is added to the dispersion, the double layers are compressed.



This allows the platelet edges and faces to more closely approach, resulting in a more rigid structure and consequently higher viscosity and yield value.



If the double layers become sufficiently compressed, face-face van der Waals attraction will predominate and the house of cards colloidal structure will be lost, as will thickening and suspending efficiency.

VEEGUM Magnesium Aluminum Silicate **compatibility with electrolytes (and solvents):**

Water-soluble components modify smectite rheology.

Monovalent > Divalent >Trivalent

The effect of electrolytes on the clay dispersion depends on cation valence as well as concentration. The higher the cation valence, the less electrolyte the clay can accommodate before the colloidal structure collapses.

Lyotropic Series:

The relative ability of ions to replace one another if present in equivalent quantities.

$$Al^{3+} > Ca^{2+} > Mg^{2+} > K^{+} = NH_4^{+} > Na^{+} > Li^{+}$$

$$PO_4^{3-} > SO_4^{2-} > Cl^{-} > NO_3^{-}$$

Schulze-Hardy Rule:

Critical flocculation concentration values are determined by cation valence.

3+>>2+>>+

Ion exchange magnifies the differences. Adding Ca^{2+} to a Na clay first forms a Ca clay, which is much easier to flocculate.

The lyotropic series indicates the relative ability of cations to replace one another if present in equivalent quantities based on ionic charge and size (hydrated radius). Cations with greater positive charge and/or smaller hydrated radius are more strongly attracted than cations with lower positive charge and/or larger hydrated radius, because they can get closer to the clay surface and/or satisfy more negative charges. By the Law of Mass Action, nevertheless, adding large amounts of one cation will replace others, regardless of their position in the lyotropic series.

According to the Schulze-Hardy Rule, critical flocculation concentration values are determined by cation valence. Ion exchange magnifies the differences. Adding Ca^{2+} to a Na clay first forms a Ca clay, which is subsequently much easier to flocculate.

In considering the lyotropic series and the Schulze-Hardy rule as they pertain to smectite clay dispersions, higher cation valence reduces the concentration required to successively increase dispersion viscosity and yield value, and then cause instability.

Influence of water-solubles is controlled by grade selection and gum combinations.

Water-soluble components modify smectite rheology.

VEEGUM HS > VEEGUM K > VEEGUM

VEEGUM/Xanthan Gum, VEEGUM/CMC

The properties of individual smectite clays – e.g., viscosity, hydration rate, electrolyte tolerance – vary according to their particular structure, exchange cations and exchange capacity. For **VEEGUM** Magnesium Aluminum Silicate products, each of these properties can be manipulated by the choice of smectite, based on location and type, and by blending smectites from different locations so as to obtain the desired balance of properties.

For example, for electrolyte tolerance, VEEGUM HS > VEEGUM K > VEEGUM, while for thickening, VEEGUM > VEEGUM K > VEEGUM HS. In addition, certain gums, such as xanthan gum and CMC, act as protective colloids when used with VEEGUM products. They can significantly improve the compatibility of these clays with relatively high levels of water-solubles.

A library of technical literature on the properties and uses of VEEGUM Magnesium Aluminum Silicate products is available for download at

www.rtvanderbilt.com

Please proceed to

Part 3:

Guidelines for best use

- **Dispersion preparation**
- **Hydration time guide**

Synergism with organic thickeners

VEEGUM Magnesium Aluminum Silicate grades