Crimson Publishers
Wings to the Research

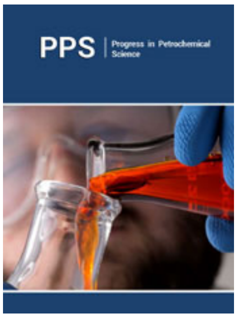
Letter to Editor

Physicochemical Mechanics Approach for Geological Soft Mater (Including Inorganic Polymer and Liquid Crystal Structures) in Analysis of Weathering and Formations of Chemogenic, Mechanogenic and Biogenic Mineral Sediments

Gradov OV*

FRC CP RAS, Senior Researcher, Russia

ISSN: 2637-8035



***Corresponding author:** Gradov OV, FRC CP RAS, Senior Researcher, Russia

Submission: May 01, 2024
Published: May 10, 2024

Volume 6 - Issue 3

How to cite this article: Gradov OV*. Physicochemical Mechanics Approach for Geological Soft Mater (Including Inorganic Polymer and Liquid Crystal Structures) in Analysis of Weathering and Formations of Chemogenic, Mechanogenic and Biogenic Mineral Sediments. Progress Petrochem Sci. 6(3). PPS. 000636. 2024.
DOI: 10.31031/PPS.2024.06.000636

Abstract

This article is a brief summary of my lecture entitled "Physicochemical mechanics approach for natural soft mater (including inorganic polymer and liquid crystal structures) in analysis of weathering's and formations of chemogenic, mechanogenic and biogenic sediments", which was prepared in 2018 for the 19th International Conference "Physical-Chemical and Petrophysical Research in Earth Sciences" (Moscow, Institute of Geochemistry and Analytical Chemistry named after. V.I. Vernadsky RAS (GEOKHI RAS) - Borok, Schmidt Institute of Physics of the Earth). This material has never been told in English and has not been published in English-language literature, which has made the corresponding discourse less widespread, although it is based on quite fundamental problems that can help applied geologists, geochemists, soil scientists and petrographers solve their applied problems. Therefore, the author considers it necessary, despite the lack of time, to provide an abbreviated machine translation of the notes from that lecture in order to support the dissemination of the ideas indicated in this lecture in the international community. The author obviously apologizes for possible inaccuracies in context and synonymy associated with machine translation (AI-Assisted Translation).

Keywords: Sedimentology; Colloids in the earth's crust; Van der Waals forces; Volterra process; Kano geometry; Colloidal and metacolloidal mineral systems; Bernal holes; Deryagin-Landau-Verwey-Overbeck theory; Helfrich theory; Physico-chemical mechanics; Inorganic soft matter; Pourbaix diagrams

Letter to Editor

The formation of sedimentary rocks, starting from the early stages (before diagenesis and accordingly, an increase in the compactness and hardness of the substance of sedimentary rocks) is determined by the physics of disperse systems and the chemical physics of sedimentation processes. Consequently, according to Rebinder ideas, such a process can be described on the basis of the concepts of physicochemical mechanics/physicochemical geomechanics. This is qualitatively different from simplified mechanistic ideas, since for dispersed systems ideas about the mechanical nature of the interaction forces leading to the adhesion of particles are ineffective and do not provide an adequate approximation of empirical data. It is necessary to take into account surface physical and chemical phenomena, especially absorption, adhesion, wetting, electrochemical processes on active developed surfaces, etc., and therefore the forces that determine this class of processes. The interaction of particles of dispersed phases, without taking into account specific chemistry, can be studied within the framework of the soft matter physics. This implies the introduction of a number of approaches exotic for classical sedimentology, such as:

A. The problem of mesoscopic distances between particles interacting with each other, and in particular, the concept of "coherence lengths", which determine the lengths of mesoscopic distances at which certain types of order can be transmitted with weakening force from one boundary to another. Mean field approximation for a number of inorganic mineral polymers in sedimentary systems.

B. The emphasis of the study is on taking into account non-covalent interactions-dispersion forces/van der Waals forces (Keesom, London and Debye interactions/effects), which are extremely necessary for an adequate description of phenomena in a disperse system. Accordingly, taking into account the geometric limitation of fluctuations that cause interaction between particles, within the framework of Casimir interactions, and different dielectric and orientation characteristics of particles, since the van der Waals interaction depends not only on the scalar distances between particles, but also on the mutual orientation of anisotropic dielectric media. The need for sedimentology to analyze processes taking into account van der Waals forces can also be proven by the fact that only by taking into account the Casimir-Polder effect and as a consequence, assuming the absence of lag up to a scale of about 30μm, is a plausible analysis of real sedimentological samples possible, so as, in fact, the retardation effect is significant in the range from 5 to 20nm.

C. A topological approach different from the Volterra process for a solid "geological medium", which assumes relaxation and complete viscous relaxation, in a partially ordered medium. The intersections of dislocations and disclinations can be the subject of topological analysis within the framework of the "emergent" (that is, based on the formation conditions when describing and explaining the set of resulting properties) system of ideas about the formation of sedimentary rocks.

D. The difference in the considered nomenclature of phase transitions is that Landau's theory, taking into account short-range order, does not entirely take into account the phenomenology of short-range order, which is essential for first-order transitions.

E. Classification of types of precipitation according to the types of forces with which they are formed. This should have a correlation (both in the empirical and in the model aspect) with the mathematical morphology of the structures formed in this way, the reactions that ensure their transformation in the phenomena of diagenesis, and the physical and chemical mechanics of the resulting structures.

F. Qualitatively different rheological concepts of formation environments based on sedimentary structures formed in a "partially ordered" or oriented state (for example, stratified or layered microstructures in sedimentology and also, in particular, in the products of diagenesis and subsequent metamorphism and weathering, can be successfully interpreted within the framework of Kano geometry, the principle of operation of which was illustrated back in the last century using mica and silicate plates).

G. Possibility of analyzing random dense packing of particles (which is relevant for sedimentology and physical chemistry of diagenesis processes) of sedimentary rocks of arbitrary polyhedral (and in particular, deltahedral) geometries, taking into account percolation phenomena (the so-called "Bernal hole") and accordingly, developed surface. Definability of irregularity of sedimentary environments using certain classes of geometric frustration.

H. Analysis of colloidal and meta colloidal mineral systems within the framework of the concepts of colloidal mineralogy with reduction to the principles of physics of partially ordered media in model cases of physical stability of geocolloids. For example, electrochemical criteria for structural stability are applicable in practice for colloidal components of sedimentary rocks and their precursors: in the presence of a weak electrolyte in the medium, electrostatic forces propagate over significant distances and weaken fluctuations and in the presence of a strong electrolyte, charges are shielded, which promotes the development of fluctuations and, as a result, repulsion (Helfrich theory). The competition of electrostatic forces and van der Waals forces, within the framework of the Deryagin-Landau-Verwey-Overbeck theory, leads to a qualitatively different (from simple electrostatic or mechanical) nature of the interaction, which regulates the shape of sedimentary structures according to physical-chemical/colloid-chemical principles. The Gowey-Chapman length\thickness of the solution in contact with the phase boundary, containing exactly half of the counterions, regulates the behavior of geocolloids if they are in an environment of weak electrolytes (which is most often encountered in practice) and in the case of strong ones, another criterion works-the screening length (Debye-Hückel).

I. Taking into account osmotic factors that classically applied only to bio membrane and polymer structures. For example, if we take into account the energy density of the electric double layer, then the free energy (when differently charged ions are in the system) is written as the sum of electrostatic volumetric energy and excess configuration entropy-that is, the total forces of electrostatic and osmotic origin that determine the presence of repulsion (and its specific contribution to the state of the system) of geocolloids. If we use the Maxwell stress tensor, then a differentiated (longitudinal and transverse pressure) analysis of the orientation of the components of formation or physicochemical/geoelectrochemical degradation of sediment under the influence of environmental conditions and its own properties is necessary. This can become one of the multidimensional anisometric techniques for analyzing not only geomorphogenesis, but also weathering

J. Analysis of membrane phenomena in sediments (not only biogenic), including those caused by the presence of "inorganic soaps" (by Rebinder), which can take place in real mineral and, in particular, chemogenic systems. Inorganic membranes and surfactants are involved in sedimentation and diagenesis and therefore cannot be excluded from the analysis, which (alas) is often done in simplified models.

K. Analysis of mesomorphic liquid crystalline phases in sedimentary structures, the presence of which directly follows conceptually from Chukhrov's ideas about colloids in the earth's crust; in particular, analysis of the phases of associated colloids.

L. Control of sol-gel transitions, in particular irreversible ones, on the dehydration scale and with the projection of data onto Pourbaix-type diagrams. It is a well-known fact that colloidal-mineralogical structures as products of hydrothermal processes are characteristic of areas of volcanic activity, but less known is the fact of the deposition of their amorphous masses (precursor nature) in the form of gels, which is characteristic of a number of minerals - such as sulfides in particular arsenic, copper, zinc, antimony, iron. Starting with the works of L.M. Lebedev 1960s-1980s. this fact is known, but so far it has not received exhaustive argumentation as a physicochemical phenomenon.

M. Inorganic polymers, with the exception of three-dimensional networks of a rigid structure such as quartz, also cannot be eliminated from analysis within the framework of the physics of partially ordered geomedia, since their microphase separation contributes to the morphogenesis of sedimentary structures, and in the melt their chains of geopolymers can be described within the framework of the theory of average fields (Flory-Huggins).