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General classification and nomenclature of sedimentary deposits and rocks, a review

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ABSTRACT

A new general and genetic classification is proposed that can be applied to sedimentary deposits and rocks (sedimentites), in six main groups depending on the processes that originate them, this classification seeks the standardization and systematization of the criteria and the most used terms, and proposes some new terms: (1) detrital sedimentites formed by fragmentation of rocks "*in situ*"; (2) clastic sedimentites formed by erosion, transport and sedimentation of solid materials; (3) biogenic sedimentites formed by biological productivity and activity "*in situ*"; (4) chemical sedimentites formed by crystal precipitation from solutions "*in situ*" within the basin; (5) mixed sedimentites, those formed by mixed sedimentary processes, e.g., biogenic accumulation and clastic sedimentation, among others; and (6) diagenetic modification-transformation sedimentites, entities formed "in situ" by compaction- reorganization, alteration-transformation, dissolution-collapse, precipitation-cementation, crushing and grinding, or deformation-remobilization processes. Additionally, a new compositional-mineralogical classification of the sedimentites in eleven groups are proposed: silicate; carbonate; phosphate; iron, manganese, aluminum and titanium oxides and hydroxides; sulfate and salts; organic rich; nitrate; sulphide; borate; native rich (metals and the non-metals); and mixed. This systematization offers the advantage of allowing a better and easier sequencing of the classification of the sedimentites and facilitates the improvement in the teaching and learning processes.

Keywords: Sedimentites; detrital; clastic; chemical; biogenic; diagenetic

Clasificación general y nomenclatura de los depósitos y las rocas sedimentarias, una revisión

RESUMEN

Se propone una nueva clasificación genética que puede ser aplicada tanto a depósitos sedimentarios como a rocas sedimentarias (sedimentitas), en seis grandes grupos dependiendo de los procesos que los originan, esta clasificación busca la estandarización y sistematización de los criterios y términos más utilizados, y propone algunos nuevos términos: (1) sedimentitas detríticas formados por la fragmentación de las rocas "*in situ*"; (2) sedimentitas clásticas formadas por erosión, transporte y sedimentación de materiales sólidos; (3) sedimentitas químicas formadas por precipitación de cristales de soluciones "*in situ*" dentro de la cuenca; (4) sedimentitas biogénicas formadas por productividad y actividad biológica "*in situ*"; (5) sedimentitas mixtas, aquellas que se formaron por procesos sedimentarios mixtos, por ejemplo, acumulación biogénica y sedimentación clástica, entre otros; y (6) sedimentitas de modificación-transformación diagenética "*in situ*", entidades formadas por procesos de compactación-reorganización, alteración-transformación, disolución-colapso, precipitación-cementación, trituración y pulverización, o deformación-removilización. Adicionalmente, se propone una nueva clasificación composicional-mineralógica de las sedimentitas en once grupos principales: silicatadas; carbonatadas; fosfatadas; ricas en óxidos e hidróxidos de hierro, manganeso, aluminio y titanio; ricas en sulfatos y en sales; ricas en materia orgánica; ricas en nitratos; ricas en sulfuros; ricas en boratos; ricas en elementos nativos (metales y no metales), y mixtas. Esta sistematización ofrece la ventaja de permitir una mejor y más sencilla secuenciación de la clasificación de las sedimentitas, y facilita la mejora en los procesos de enseñanza y aprendizaje.

Palabras clave: Sedimentitas; detríticas; clásticas; químicas; biogénicas; diagenéticas

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Introduction

The intention of geologists is to see the sedimentary record (deposits and rocks) and try to interpret the products of these processes. They want to use the field observation of the deposits and rocks strata, to interpret the physical, chemical, biogenic, and diagenetic processes that were responsible for forming and accumulation or depositing the specific materials, and for transforming them into rocks.

In dealing with natural processes, geologists are confronted not with the products of processes that operate in isolation but with products of associated processes that operate collectively. The reasoning is forward from processes to products. This working backward from finished products to the formative processes involves scientific reasoning that is specific to geology and foreign to other field science.

Geologists and sedimentologists use various criteria to categorize sedimentites based on their origin, geometry of the deposits, mineral-composition, texture, and internal structures. It is worth noting that sedimentary rocks often have complex origins, and some may fit into multiple categories depending on their characteristics.

Some classification of sedimentites combines both descriptive and genetic objectives, and compositional- mineralogical, these proposals show and use different types of sedimentary materials. Most important aspects in the classification of sedimentites appeared in Figure 1.

Grabau (1904) divided carbonate rocks into two main groups, which were termed clastic and biogenic. Krynine (1948) by mode of origin: Clastic or fragmental, chemical precipitates, biogenic products (plants and animal); Folk (1968 and 1974) divided sedimentary rocks into: terrigenous, allochemical, and orthochemical constituents. Folk's (1959) classification include the autochthonous limestones in *biolithite*.

Allochemical constituents of Folk (1974) include pellets, fossils, intraclasts and ooids, "which are abnormal chemical precipitates because in general they have been later moved as solids within the basin" (Folk, 1974). Allochemical of Folk (1974) "because in general they have been later moved as solids within the basin" correspond to particles that are not solid breakdown products of older deposits of Friedman and Sanders (1978). According to Friedman and Sanders (1978) sedimentary particles are those that were transported physically in the solid state before being deposited.

Furthermore, pellets, and intraclasts are not abnormal chemical precipitates, because they are not substances precipitated from a solution. Pellets are biodeposition materials because they are produced by organisms (deposits-feeding of Friedman and Sanders, 1978; fecal pellets of Boggs, 2006, and Selley *et al.,* 2005; biodepositions of Cruz *et al.,* 2024), therefore, they are biogenic materials.

Intraclasts are pieces of penecontemporaneous, usually weakly consolidated carbonate sediment that have been torn up and redeposited by currents (Folk, 1974). Intraclasts are materials produced by erosion, transport, and deposition, therefore, they are clasts or depositional materials as their name indicates. In conclusion, pellets and intraclasts are not allochemical materials.

There is another inconsistency in the allochemical term, fossils and ooids can be considered as abnormal chemical precipitates (Folk, 1974). Fossils according to their origin (Kidwell *et al*, 1986) are biogenic (biocenosis association), sedimentologic (resedimented), or diagenetic concentration (e.g., solution-collapse of original skeletal association). Ooids are formed by chemical processes (see Folk, 1974; Friedman and Sanders, 1978, among others), or by chemical and biogenic processes. In conclusion, it is better and more practical to consider fossils as biogenic materials, and ooids as chemical or biochemical materials. In conclusion, the allochemical term proposed by Folk (1974) can be replaced by clastic juvenile materials (Cruz *et al*., 2017), because according to Folk (1974) they have been transported and consequently, they are sedimentary particles.

Dunham (1962) proposes a classification of carbonate rocks according to depositional texture as mudstone, wackestone, grainstone, and packstone; furthermore, rocks retaining too little of their depositional texture are classified aside as crystalline carbonates; and finally, rocks in which his original components were bound together during deposition are named boundstone. Dunham (1962) made the same as Folk (1959) and grouped all autochthonous limestones into the term boundstone.

Comparing mudstones, wackes, and arenites of Dott (1964) with the prepositions of Dunham (1962) (see Figure 2), it is clear that mudstone and wackes correspond to both clastic limestone and clastic silicate, because both are clastic sedimentites; and packstone and grainstone are useful to differentiated clastic arenites. Because of that we propose the use of the Dunham (1962) mudstone, wackestone, grainstone, and packstone classification, not only for the clastic limestones but also for all the sedimentary clastic deposits.

<table>
<tr><th rowspan="1">History of classifications</th><th colspan="2">Nomeclature of classifications</th></tr>
<tr><td rowspan="4">Grabau (1904): "the classification must be descriptive, systematic and precise".
Duham (1962): Crystalline, bounstone, grainstone, packstone, etc.
Folk (1974): Terrigenous, allochemical, orthochemical.
Friendman & Sanders (1978): Intra-basin, extra-basin, etc.
Kidwell *et al*. (1986): Biogenic, sedimentary and diagenetic fossil concentrations.
Wright (1992): Biological, depositional, diagenetic.
Hallsworth & Knox (1999) not genetic: siliclastic, carbonated, based on grain size.</td><td colspan="2">Genetic
Textual
Structural</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Sedimentary materials (SMs)</td></tr>
<tr><td>Detritus
Clastic
Biogenic
Chemica
Diagenetic</td><td>Ancient derived juvenile</td></tr>
</table>

Figure 1. The most important aspects in the classification of sedimentites. History of classification of sedimentary rocks, e.g., classification of limestone using essential components (Wright, 1992), etc. The fundamental aspects in the classification of sedimentites. The sedimentary materials.

Dunham's (1962) proposition is broader for the differentiation of clastic sedimentites than Dott's (1964), and could be very useful to take into account packstones and grainstones in silica and terrigenous sedimentites.

	Sedimentary particles: original components, not bound together during deposition (Dunham, 1962); materials transported as particles (Folk 1968, 1974).			
	Mud supported		Grain-supported	
Main carbonate rocks group according to Dunham (1962)	Mudstone < 10% grains	Wackestone >10% grains	Packstone Contains mud	Grainstone Lacks mud
Main silicate sandstone rock group according to Dott (1964); Folk (1974).	Mudstone >75% mud	Wackes Muddy sandstone mud between 10 and 75%	Arenites <10% mud	

Figure 2. Comparison between the clastic rock classification of Dott (1964) and Dunham (1962).

Friedman and Sanders (1978) divide sedimentary rocks into five major kinds based on compositional-mineralogical- genetic classification: carbonate, authigenic, carbonaceous, terrigenous, and pyroclastic rocks. This classification uses genetic parameters in terrigenous, pyroclastic, and authigenic rocks, and forgets their use in others, instead, they use compositional- mineralogical classification (for example, carbonate and carbonaceous rocks).

The classification of Friedman and Sanders (1978) include carbonate, authigenic and carbonaceous rocks in intrabasinal group; and terrigenous in extrabasinal group. Intrabasinal materials derived from within the basin; and extrabasinal sedimentary particles derived outside the basin.

It is clear that extrabasinal sediments includes allochthonous materials: terrigenous materials eroded from ancient rocks (RFs, mineral fragments and reworked fossils); it also includes juvenile clasts formed outside of the basin and deposited in the basin, e.g., new materials formed by weathering such as argilo- phyllosilicates (kaolin, montmorillonite, smectite, etc.), and biogenic, chemical and pyroclastic materials. Biogenic materials such as detritus of plants and animals that live in the continental environment and can be transported and deposited in lacustrine and marine environments. Chemical materials, for example, evaporitic materials crystalized in near-shore sabkha conditions and transported and deposited in marine environments. Pyroclastic materials originated in continental environments and deposited in marine realms. All biogenic, chemical and pyroclastic materials previously listed are considered extrabasinal materials because they were deposited outside their basin.

Intrabasinal sedimentary materials include juvenile weathering, biogenic and chemical materials produced inside of the basin (materials without transportation, therefore they are autochthonous materials); but also include ancient derived and juvenile materials transported inside of the basin, e.g., ancient RFs and minerals; and juvenile weathering, biogenic and chemical materials. Examples of juvenile bioclastic materials are fragments of juvenile test of mollusks removed by currents and deposited in other parts of the basin, but within it. Chemical materials include, e.g., gypsum formed in littoral sabkha conditions and deposited in the adjacent eolic environment forming dunes (gypsum dunes of White Sand National Park New Mexico, USA). Pyroclastic materials originated and deposited near the volcano generator. All of them are autochthonous- intrabasinal materials, not extrabasinal.

Kidwell *et al*. (1986) propose a conceptual framework for the genesis of skeletal accumulation based on concentrating processes: biogenic, sedimentologic, and diagenetic concentrations. Wright (1992) classification of limestone, uses a more genetic division and emphasizes the distinction between carbonate strata influenced by depositional (physical), biological, or diagenetic processes (both synsedimentary and post-depositional), like Kidwell *et al*. (1986) proposition.

Wright (1992) proposes to classify limestones into three types of rocks: depositional, biological and diagenetic rocks. The conceptual propositions of Kidwell *et al*. (1986) and the general and genetic classification of Wright (1992), such as depositional, biological, and diagenetic, are the basic structure in the general genetic classification of sedimentites proposed here.

Some authors like Lazar *et al*. (2015) use this conceptual framework in the nomenclature guidelines for fine-grained sedimentary rocks, such as detrital, biogenic, authigenic fine-grained quartz, or carbonate.

Hallsworth and Knox's (1999) classification of sedimentites is based on actual, descriptive attributes, not interpretative attributes. It is therefore essentially nongenetic and based on the compositional-mineralogical attributes present at the time of deposition.

Sedimentites are according to Hallsworth and Knox's (1999) classification are siliciclastic, carbonate, phosphate-sediments and phosphorites, iron-sediments and ironstones, organic-rich, non-carbonate salts, non-clastic siliceous, miscellaneous hydroxide, oxide, and silicate, based on grain size or crystal size, hybrid, and with volcaniclastic debris.

Sedimentary rocks classification according to Boggs (2006, 2009) can be placed into three fundamental groups on the basis of composition and origin: siliciclastic, chemical/biochemical (carbonate, cherts, phosphorites, and iron-rich sedimentary rocks), and carbonaceous, but in reality, Boggs' classification use both genetic and compositional-mineralogical classification in siliciclastic sedimentary rocks, and use compositional-mineralogical classification in carbonate, cherts, iron-rich, phosphorites and carbonaceous sedimentary rocks, and use genetic classifications in chemical, biochemical and evaporites sedimentary rocks.

This paper summarizes our efforts to standardize nomenclature for the field and laboratory description and classification (genetic and compositional-mineralogical) of sedimentary materials, deposits, and rocks. Here We have aimed for a system that is simple and yet as inclusive and general as possible.

Our proposal outlines address clarification of some terms and proposal of new ones that are intended to complement rather than replace; proposition that can be very useful for the description, naming and classification of sedimentites. This classification uses the conceptual framework of genetic classification of skeletal concentrations of Kidwell *et al*. (1986); and major processes, biological, depositional, and diagenetic, that influence limestone texture of Wright (1992).

Here we also use the concept "ancient derived" and "juvenile" of the sedimentary particles proposed by Friedman and Sanders (1978); and the chemical or orthochemical constituents according to Folk (1974), Friedman and Sanders (1978) and Boggs (2006) among others.

We will use the term sedimentite in the text when referring to sedimentary deposits and rocks as proposed by Pfeiffer *et al.* (1980).

Sedimentary processes

The sedimentary processes (SPs) are any physical, biological, or chemical processes to take part in the formation of the sedimentites. These processes occurred on the external lithosphere and are of interest in many ways for understanding the dynamics of the modern world.

SPs include the formation of regolith, the depositional processes, the biological activity and productivity, the chemical precipitation-accumulation of crystals, and the diagenetic-transformation processes that convert the sedimentary deposits into sedimentary rocks.

The sedimentary process begins when the minerals and rocks on the external lithosphere are transformed, broken, and fragmented forming loose materials and ions in solution. Loose materials (LMs) in the external lithosphere constitute the regolith, and because of the conditions and processes present there LMs could be eroded, transported, and deposited.

Also, LMs and ions are used by simple and complex organisms to carry out their vital functions. Additionally, organisms produce materials (shells, etc.), and make transformation of other materials (e.g., bioperturbation). Furthermore, ion-saturated solutions by pure chemical processes or by bacterial mediation produce the precipitation-accumulation of crystals. And finally, the sedimentary deposits formed initially could be buried and transformed into sedimentary rocks.

The sedimentary processes never exceeded a temperature of ~210ºC and pressures are <1,5 kb, in their geological history.

Specific geological processes that form regolith, and sedimentites are presented on Tables 1 and 2.

The description of the specific sedimentary processes is presented by different authors: Friedman and Sanders, 1978; Boggs, 2006; Cruz *et al*, 2024; among others. Sedimentary processes exclude materials formed by (a) endogenous metamorphic processes that include among others, e.g., pyrometamorphic rocks associated with naturally burned coal bed: paralava, clinker, and relatives (Grapes, 2006), and (b) endogenous igneous process and exogenous lava process.

Specific sedimentary anthropogenic effects, processes, objects, materials or structures, those derived from human activities are not part of these document, they need a special publication.

Except for depositional processes where materials are eroded, transported, and deposited in different places that they were formed (allochthonous materials), the other processes presented in Table 1 form loose materials that remain in the same place where they were formed (autochthonous materials).

They may undergo some processes of formation, e.g., weathering alteration or diagenesis, etc., but essentially the materials do not get transported to a different location after their formation. Common examples of autochthonous materials are crystals and biogenic production that accumulate at the site of formation, such as in swamps, lakes, or shallow marine environments, etc. For this reason, the deposits formed by depositional processes are named clastic deposits, and the others could be grouped in autochthonous deposits.

Table 1. Geological processes involved in the formation of autochthonous sedimentites, and regolith. Their specific products and landforms.

Geological processes	**Products**	**Landforms**
Weathering of sedimentary deposits and rocks, e.g., weathering processes of McQueen and Scott (2008).	Residual deposits (Merril, 1897; Tyrrel, 1978; Selley, 2000), rock of weathering (Waldo, 2018).	Regolith and soil mantle
Fracturing, crushing, and grinding of rocks and minerals by tectonic stress (compressive and distensive).	Tectonic-breccias (Morrow, 1982; Shukla and Sharma, 2018); fault breccias and related fault rocks (Woodcock and Mort, 2008)	Irregularly shaped of tectonic regolith
Lava cooling fragmentation, e.g., magma fragmentation (Edwards *et al.*, 2020; Skilling *et al.*, 2002)	Cooling lava fragmentation-breccias (Grubensky *et al.,* 1998)	Irregularly shaped of lava cooling regolith
Fragmentation and mixing of wet sedimentary deposits with lava (Peperites by Skilling *et al*., 2002)	Peperite-breccias (White *et al.,* 2000)	Irregularly shaped of peperites regolith
Rock fragmentation by caldera-collapse and the formation of caldera collapse-breccia (Lipman, 1976; Millone *et al.*, 1994; Eggleton *et al*., 2001).	Caldera-collapse deposits (Lipman, 1976); breccias formed by fracturing of previous volcanic products (e.g., Palladino and Simci, 2005).	Cylindrical- sub cylindrical structure
Rocks-dissolution-collapse and breccias formation.	Dissolution collapse-breccias (Friedman, 1997; Ryu *et al.,* 2002; Dong *et al.,* 2018).	Cylindrical- irregularly structure with inside breccias deposits.
Fragmentation of minerals and rocks by hydrothermal alteration.	Hydrothermal detrital materials (Murphy, 2009).	Irregularly shaped of hydrothermal alteration regolith
Anthropogenic activity and productivity.	Garbage-breccia, etc., (Howard, 2017; Luberti *et al.,* 2019).	Irregularly shaped garbage dumps, etc.
Fragmentation, formation of new materials, and mixing of materials caused by an extraterrestrial impact.	Impact breccias of Shukla and Karma, (2018); Pati *et al*. (2017).	Irregularly shaped of impact deposit
Chemical precipitation-accumulation of crystals (Folk, 1974; Friedman and Sanders, 1978; Tyrrel, 1978; Selley, 2000; Boggs, 2009).	e.g., Megacrystalline gypsum deposits, etc.	Irregular shape of chemical deposit (sabkha, etc.).
Biogenic activity and productivity (Grabau, 1904; Retallack, 1977; Friedman and Sanders, 1978; Kidwell *et al*., 1986; Buol *et al*., 1997; Birkland, 1999; Buol *et al*., 2003; Boggs, 2006; Lazar *et al*., 2015; Cruz *et al.,* 2024)	e.g., Biogenic-breccias, sandy breccias of corporal materials and structures, etc.	Hemispherical shape of reef, etc.
Diagenetic transformation-reorganization of material, e.g., dissolution collapse of sedimentary deposits (Abelson *et al*., 2006; Oz *et al*., 2016)	Diagenetic crackle-breccias of Morrow (1982) (diagenetic crack structures of Chen *et al.,* 2010); Diagenetic dyke infilling-breccia (SDIB) from a soft sedimentary deformation (SSD) after hydraulic fracturing (Morrow, 1982); and Diagenetic solution-collapse-breccias (Morrow, 1982).	Irregular shape of crackle-breccias deposit, etc.,

Note: Collapse-breccias are formed by the following processes: Caldera-collapse (Lipman, 1976), dissolution collapse of rocks (Friedman, 1997) and dissolution collapse of sedimentary deposits (Abelson *et al.,* 2006; Oz *et al.,* 2016). More information about landforms sees Gutierrez and Gutierrez (2016).

Table 2. Geological processes involved in the formation of depositional and mixed sedimentites, and regolith. Their specific products and landforms.

Geological processes		Products	Landforms
Depositional processes (Folk, 1974; Friedman and Sanders, 1978; Selley, 2000; Nichols, 2009; Boggs, 2009)	Colluvial (gravity dominated) (Kernif *et al.,* 2022)	Clastic-breccias, etc. (Eggleton, 2001)	Fan-breccias, etc.
	Eolian	Clastic sand dunes, silt loess, breccias desert pavement, etc., (Bradley, 2015).	Dunes, and irregular shape of loess, and desert pavement (lag deposits),
	Fluvial	Clastic fluvial sands, conglomerates and breccias (Miall, 2006)	Fluvial terraces
	Lake	Clastic fine deposits (Bradley, 2015); biogenic fine silica deposits (Liu *et al*, 2019).	Delta, delta collapse, floods, volcanic, pelagic abiogenic and biogenic deposits. More information in Sabatier *et al.* (2022)
	Glacial	Glacial poorly sorted breccias (Friedman and Sanders, 1978)	Hemispherical, streamlined, irregular moraines, etc. see Glasser and Bennett (2004).

(*Continued*)

Geological processes		Products	Landforms
	Pyroclastic	Pyroclastic-breccias, sands, silts, etc.	Pyroclastic flow fan, tuffs mantle, etc., (Coira *et al.,* 2022).
	Mixed depositional	e.g., Hemipelagic materials (biogenic and clastic argilo-phyllosilicates, and with pyroclastic ash cloud)	Tabular laminated of hemipelagic with pyroclastic rocks, glass, and crystals deposits
Sedimentary deposits could also be formed by mixed sedimentary processes, e.g., biogenic, and clastic, e.g., stromatolites and hemipelagic deposits, and natural and anthropogenic (Bunke *et al*., 2019).		e.g., Stromatolite finely laminated biogenic-microcrystalline calcareous with clastic sand and silt-sized materials.	Hemispherical shape of laminated algal stromatolite with clastic lamina
		e.g., hemipelagic and pelagic materials (biogenic and clastic argilo- phyllosilicates, and with pyroclastic ash cloud)	Tabular laminated hemipelagic with pyroclastic glass, and mineral deposits.

Sedimentary products refer to the various materials and structures that formed because of the processes involved in the formation of sedimentites. Sedimentary products also include sedimentary deposits and sedimentary rocks, and these are arranged in sequential sedimentary facies (SSFs).

Sedimentary materials (SMs) are defined here as any kind of material formed, deposited, accumulated, or modified-transformed by an exogenous geological earth process under low temperature and pressure.

Sedimentary materials are the essential building blocks of sedimentites and are formed by the fourteen (14) processes described before in Table 1 and 2. The SMs are described by different authors, e.g., Folk (1974); Friedman and Sanders (1978); Boggs (2006), among others. SMs include terrigenous, allochemical, and orthochemical constituents (Folk, 1974); sedimentary particles, biological secretion of skeletons, predation, trapping and baffling of lime mud, pelletization, burrowing and stirring by organisms, and activities of microorganisms which assist precipitation of diverse minerals, chemical, and authigenic materials (Friedman and Sanders, 1978); biological, depositional and diagenetic materials and processes (Wright, 1992); products of subaerial weathering, particles, cements, evaporites, chert, phosphorites, iron rich, and organic matter (Boggs, 2006).

According with the fourteen geological process there are six fundamental and contrasting kinds of sedimentary materials, and three more types of mixed sedimentary materials are proposed (After Cruz *et al*, 2017), they are:

1. Detrital materials (DMs), those materials formed in the external lithospheric region by fragmentation of rock, materials not transported physically as solid objects.
2. Chemical precipitation-accumulation materials (CHPAMs) or "sedimentary crystals", those materials precipitated chemically from ion saturated solution and accumulate in an exogenous inorganic process on the earth's surface, materials not transported physically as solid objects.
3. Biogenic materials and structures (BMSs), those formed in exogenous processes by biological activity and productivity, whatever autochthonous or parautochthonous or accumulated, materials not transported physically as solid objects.
4. Clastic materials (CLMs), those originated by exogenous processes that involve erosion and physical transport of materials in the solid state before being deposited.
5. Diagenetic overprint materials and structures (DOMSs), those materials or structures that result or formed by modifications-transformations in the changing of the sedimentary deposits into sedimentary rocks. And finally
6. natural liquids and gasses materials (NLGMs).

Natural liquids and gasses materials, include "atmospheric water" in their liquid state, they are usually as primordial components filling porous space, and minerals present in sedimentites such as gypsum that have water in their structure.

Additionally, connate water (CWs), water trapped in the pores of a rock since their formation (Schilthuis, 1938). CWs can also yield information on the provenance of aquifers and of the thermal history of the host rock. The "liquid hydrocarbons" and biogenic-liquid compounds (corporal fluids and relatives) are from this group. "Liquid hydrocarbons" because they are products of organic compounds degradation during the diagenetic process. Biogenic-liquid compounds because they are biogenic materials.

The natural gasses materials include "atmospheric air" in their gas state because they are part of the sedimentites, usually trapped as components filling porous space in sediments when they are deposited, and frequently used to establish paleoclimatic conditions, e.g., "high polar natural ice sheets" because they trap and keep samples of the atmosphere and trace gasses (Bender *et al*., 1997; Walker *et al*., 2008, among others).

"Hydrocarbon gasses" (methane and relatives) are excluded from this group because they are organic compounds product of degradations of organic compounds in residual regolith formation or in a diagenetic process.

The mixed sedimentary materials and structures are those produced by more than one sedimentary process, they are:

1. Mixed biogenic accumulation with clastic sedimentation materials and structures, they are biostratification or biogenic granule classification structures from algal or bacterial activity; and
2. Mixed coated microbial- chemical precipitation materials and structures, those formed or grown in place by a mixed chemical coated-biogenic (microbial- induced) process, or biochemical precipitation concentrically micro-coated calcareous materials.

General classifying and naming of sedimentary deposits and rocks

The genetic classification of sedimentites proposed here start using the conceptual classification for genesis of skeletal concentration of Kidwell *et al*. (1986) and essential components and limestone classification of Wright (1992), and according to the fourteen sedimentary processes (describe before in the text), and also six kind of sedimentary materials that formed or constituted sedimentites. Because of that it is convenient to divide the sedimentites in six genetic types (Table 3): Detrital, chemical, biogenic, clastic, diagenetic and mixed.

Although genetic classification could be difficult to carry out in field work, it can be done, e.g., in the field it is essential to determine the types of materials, their state of conservation, the relationship of different materials. With laboratory tests and more special techniques it is possible to know much more about the genesis of the materials that make up a deposit or a rock and with this information it is relatively easy to determine its general and specific genetic classification.

Traditional compositional-mineralogical classification of carbonate, phosphorite, silicate and carbonaceous deposits and rocks can be integrated into this genetic classification (detrital, clastic, biogenic, chemical, diagenetic, or mixed deposits and rocks), e.g., Silicate-clastic, carbonate-clastic, carbonate-biogenic, etc.

Detrital deposits (DDs) are sedimentary deposits formed in the external lithospheric region by fragmentation of rocks "in situ" and the formation of autochthonous regoliths. DDs correspond in part with sedentary materials of Tyrrel (1978).

Detrital deposits are formed by any of the following exogenous geological processes (as shown in Table 1): weathering; tectonic stress; lava-cooling-fragmentation; fragmentation and mixing of materials by interaction of wet sedimentary deposits with lava; caldera-collapse; dissolution collapse of rocks; hydrothermal alteration; and by fragmentation "in situ" of materials caused by an extraterrestrial impact.

Since human activity and productivity produce anthropogenic deposits of loose materials (anthropogenic regolith), such a way that these types of deposits must be a part of the group of detrital deposits.

According to this specific detrital formation processes, there are the following specific detrital deposits (DDs) (Table 4).

Table 3. General genetic classification of sedimentary deposits and rocks, based on the genetic classification of sedimentary materials. After Grabau (1904); Krynine (1948); Kidwell *et al* (1986); and Wright (1992).

General kind of sedimentary deposit or rock	Description	Specific sedimentary materials
1.- ***Detrital deposits and rocks*** (DDs and DRs) formed in the outer lithospheric by the transformation of rocks into rock fragments and minerals.	Deposits formed by fragmentation of rocks by the following processes: weathering; tectonic stress; lava-cooling-fragmentation; fragmentation and mixing of materials by interaction of wet sedimentary deposits with lava; caldera-collapse; dissolution collapse of rocks; hydrothermal alteration; fragmentation "in situ" of materials caused by an extraterrestrial impact; and finally, by human activity and productivity.	Breccias, sandy breccias, brecciated sand deposits consisting of Inherited-conserved rock (RFs) and mineral fragments released from ancient rocks, e.g., by weathering. Juvenile minerals, e.g., argilo-phyllosilicates formed during weathering processes. Juvenile RFs formed e.g., by lava-cooling-fragmentation processes, etc.
2.- ***Chemical deposits and rocks*** (CHD and CHR) formed by materials precipitated from ion-saturated solution and accumulated.	Chemical or orthochemical sedimentites are those entities where autochthonous and juvenile sedimentary chemical materials are more than 50% of the deposits or rocks.	Deposits consisting mainly of autochthonous and juvenile chemical sedimentary materials, e.g., deposits formed by halite or gypsum crystallization-accumulation, amorphous silicate precipitation-accumulation, snow crystals accumulation.
3.- ***Biogenic deposits and rocks*** (BD and BR) formed by biological activity and productivity.	Biogenic deposits or rocks are those entities where autochthonous or parautochthonous (accumulated), and juvenile biogenic materials or structures are more than 50% of the deposits or rocks.	Consists mainly of autochthonous and juvenile biogenic materials and structures, e.g., deposits formed by accumulation of: fragments of plants, test of organisms (diatoms, foraminifera, coccolithophorids), coralline reefs, etc.
4.- ***Clastic deposits and rocks*** (CLD and CLR) form by loose-solid materials eroded and transported before being deposited.	Clastic sedimentary deposits or rocks, where sedimentary particles are more than 50% of the deposits or rocks.	Deposits consist mainly of ancient derived-conserved materials (RFs and minerals), and also juvenile materials, e.g., biogenic shell, abiogenic materials, etc.
5- ***Diagenetic transformation-modification of sedimentary deposits*** (DTMDs and DTMRs)	Any original sedimentary deposits have diagenetic overprint modifications and forms diagenetic materials and structures, it occurs in the changing of the sedimentary deposit into rock, e.g., the formation of solution-collapse breccias.	Deposits consisting of materials and structures inherited and conserved from the original sedimentary deposits, with incorporated materials, and structures that result of diagenetic overprint transformation, e.g., deposits formed by ironstone ooids, cherts, diagenetic dolostone, and high polar natural ice sheets.
6.- ***Mixed sedimentary deposits or rocks*** (MXSD- MXSR)	Those sedimentites that were formed by mixed sedimentary processes, e.g., biogenic accumulation and clastic sedimentation (algal stromatolite), among others.	

Note: Detrital, chemical, biogenic, and diagenetic deposits and rocks are considered autochthonous or In-situ, because their materials have not had transport after their formation. These Autochthonous deposits could be related to intrabasinal deposits and rocks of Friedman and Sanders (1978).

Table 4. General Detrital Deposits Classification (Detrital regolith).

Conditional	Main category	Specific name
1) According to the formation processes: Weathering, tectonic stress, lava-cooling fragmentation, etc. (as show in Table 1)	Residual deposit (RDs)	Residual RF-breccias granite-derived; Residual RF-breccias basalt-derived; Residual RF-breccias doleite-derived; Calcrete RDs; etc.
	Tectonic deposits (TDs)	Granite-RF-breccia by tectonic, etc.
	Lava-cooling fragmentation deposits (LCFDs)	Basalt RF-breccias by LCF, etc.
	Peperites deposits (PDs) mixing of wet sedimentary deposits with lava.	Peperite RF-breccia, etc.
	Caldera collapse deposits (CCDs)	e.g., basalt RF-breccia deposits by CC
	Dissolution-collapse deposits (DCDs)	RF or lithic-breccia by RDC, etc.
	Hydrothermal alteration deposits (HADs)	RF-breccias and mineral-sandy-breccia by hydrothermal alteration, etc.
	Anthropogenic deposits (ADs)	Garbage dumps by anthropogenic activity, etc.
	Extraterrestrial impact deposits (EIDs)	RF-breccias and mineral sandy-breccia by EI, etc.

Note: Calcrete residual deposits (CRDs) is a microcrystalline calcareous deposit formed by weathering processes of both calcareous deposits and rocks. RFs are rock fragments, also named lithics, they are ancient and juvenile: ancient, e.g., residual RF-breccias granite-derived, granite-RF-breccia by tectonic, etc.; juvenile, e.g., basalt RF-breccias by LCF.

Detrital deposits have the following kinds of materials: (1) Inherited-conserved RFs and minerals released from ancient rocks, e.g., by weathering or tectonic, and from sedimentary deposits involved in the case of Peperites formation; (2) Juvenile materials, e.g., minerals formed by weathering transformation (argilo-phyllosilicates); and juvenile rock fragments formed, e.g., by lava-cooling fragmentation. Any detrital deposits, tectonic, lava cooling fragmentation, peperites, etc., exposed to the weathering conditions could be modified to some degree, so a specific classification of residual- detrital deposits is necessary (Table 5, based on Avendaño and Cruz, 2017; and Cruz *et al*, 2020).

Table 5. Specific detrital residual deposits classification.

Conditional	Specific category	Specific name
1) If weathering and according to the inherited-conserved sequential facies (I-C SFs)	Sedimentary bed sequences, cycles, etc.	I-C quartz sandstones intercalated with clay argilo-phyllosilicates, etc.
	Metamorphic foliation sequences of schist, gneiss, etc.	I-C schist foliation SFs
	Igneous cumulates, cumulus, etc.	I-C granite SFs
2) If weathering and according to the new residual and overprint sequential facies (NR-O SF). I-C versus transformations, and incorporation materials. Residual regolith with NR-O SF: O, A, and B horizon	Heavy transformed	*Heavy transformed RD*
	Moderate transformed	*Moderate transformed RD*
	Slight transformed	*Slight transformed RD*
	Conserved substratum	*Conserved rock fragments and minerals; conserved sedimentary deposits; conserved detrital deposits.*

Specific descriptions for residual deposits, e.g., slightly transformed sienogranite- derived RFs residual-breccia, and clayed sand deposit with overprint A and B horizon residual sequential facies and incorporated well-developed O horizon (Figure 3) after Avendaño and Cruz (2017). Thin section of sienogranite RFs slightly transformed from B (Figure 4) (Avendaño and Cruz, 2017).

Chemical deposits (CHDs) are sedimentary deposits where autochthonous and juvenile sedimentary chemical materials are more than 50% of the deposits. Sedimentary deposits form mainly through the precipitation of minerals from solution. Unlike clastic sedimentary deposits, which are composed of sediments (mineral and rock fragments, etc.), chemical deposits are created by the direct chemical precipitation of minerals, often from evaporating or supersaturated solutions.

Chemical or orthochemical constituents of Folk (1974) are materials that grew as solids in the waters of the depositional basin because of the chemical precipitation of Friedman and Sanders (1978), e.g., syngenetic dolostone. Evaporites are chemical sedimentary deposits that form when saline water evaporates and precipitates minerals (Boggs, 2006).

Common evaporite minerals include halite, gypsum, and anhydrite. These rocks typically occur in arid or semi-arid regions, where evaporation rates exceed precipitation, leading to the concentration of dissolved salts. Sabkha environments (Boggs, 2006) refer to specific coastal or shallow, arid, and saline environments that are characterized by the deposition of evaporite minerals, especially gypsum and halite, along with other chemical sedimentary minerals.

Chemical sedimentites include chemical precipitates of Krynine (1948); Tyrrel (1978); Friedman and Sanders (1978); Boggs (2006); among others. Autochthonous sediments of Selley (2000) (carbonates, coal, iron ores, phosphates, and evaporites).

Figure 3. Residual deposit (Residual regolith) developed on sienogranite lithology (Pescadero Granite, Piedecuesta, Colombia) (Avendaño and Cruz, 2017). O horizon black color at top, A and B horizon.

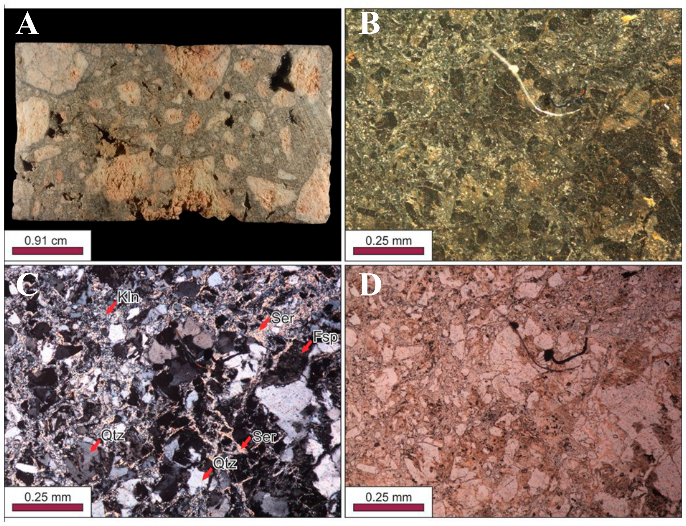

Figure 4. Sienogranite, mainly quartz, muscovite, and sericite by alteration product of plagioclase and potassium feldspar materials. B, C and D are thin section photography, with 5x objective and 10x ocular, residual regolith from B horizon. A. photography of altered sienogranite with reflected monochromatic light B. with polarization analyzer. C. photography with cross polarized light (XPL). D. photography with plain polarized light (PPL). Ser: sericite, Fsp: feldspar, Kln: kaolinite, Qtz: quartz (Avendaño and Cruz, 2017).

Chemical deposits provide valuable information about ancient environments, as their formation is directly linked to specific geochemical conditions. For instance, the presence of evaporites suggests a history of arid conditions and evaporation of water bodies.

Biogenic deposits (BDs) formed mainly by biological activity and productivity. Biological products are any kind of materials or structures that are produced, built, modified, or used by living organisms (Cruz and Cruz, 2017; Cruz *et al.*, 2024). Include autochthonous and parautochthonous assemblage proposed by Kidwell *et al*, (1986), and materials that are the result of *taphonomic-accumulation* in the sense of Fernández *et al.*, (2002).

There are the following kinds of deposits formed by biogenic activity and productivity: deposits of direct production; deposits formed by biological modification of materials; deposits created and built by organisms; and finally, deposits formed by microbial activity and productivity (Cruz *et al*, 2024).

Biogenic deposits and rocks were proposed and used by: Grabau (1904) biogenic carbonate rocks; Krynine (1948) biogenic products; Tyrrel (1978) as organic (deposited through the agency of organisms); Wright (1992) as biological (in situ) deposits and rocks; biolithite by Folk (1974); boundstone by Dunham (1962); bindstone by Embry and Klovan (1971).

Example of biogenic deposits are the following:

1. Biogenically produced of directly skeletal materials and accumulation of corporal products release by natural physiological processes: mantle-shaped accumulation of corporal detritus from the vegetal wood forest; mantle-shaped accumulation of corporal radiolarians, coccolithophorids and planktonic foraminifera.
2. Irregular-shaped or tabular deposits formed by biological modification of materials: aggregates of corporal detritus produced by predation-disarticulation- fragmentation of previously formed corporal entities (skeletons, tissue, etc.), e.g., deposits in caves and rock shelters of human and other predators (Stiner, 1991; Moncel *et al*., 2008; Diedrich, 2011; Enloe, 2012); faunal accumulations (Samper and Martinez, 2014); shell-crushing accumulation by durophagous and opportunistic-generalists, most probably fishes (Zaton and Salomon, 2008).

   Original sedimentary deposits, or also sand or finer regolith that are modified by intense biological activity (Figure 5); deposits formed by animal activity that produces debris dumps during the construction of their galleries, and throw out the excess material, deposits called biodetritus waste-dumps (Figure 6) (Cruz *et al*, 2024).
3. Constructions produced by living organisms (plants, animals, and microorganisms), structures made by secreting skeletons and corporal entities directly, e.g., mound-shaped bioherms; and also, construction made using external materials (Cruz *et al*, 2024), e.g., ant nests (Tschinkel, 2003); fossil bee nest (Genise *et al*, 2002); Jurassic termite nests (Hasiotis, 2003); among other. Bioherms are classified as biolithites by Folk (1974) and as boundstone by Dunham (1962).

Figure 5. Intense bioturbation by arthropods (*Thalassinoids*) formed on early diagenesis. Horizontal ramified to T-branched box-works, mazes, and shafts, unlined and unornamented. Arenisca Dura Formation, Upper Cretaceous, Iza, Colombia.

Figure 6. Biodetritus waste-dumps of loose materials, removed during maintenance and cleaning of their shelter by ants with entrance and ventilation-shaft (arrow) to the shelter galleries of the colony (Piedecuesta, Colombia).

4. There are numerous kinds of structures formed by the mediation of microbes, e.g., microbialite, helictites, etc., (Tisato *et al.*, 2015; Sanchez *et al.*, 2014; Noffke *et al.*, 2001; Noffke, 2014); microbial peloids (Flügel, 2004); embryo fossilization (Raff *et al.*, 2008); and include microbially induced sedimentary structures (Noffke *et al.*, 2001; Noffke, 2014).

Microbially induced sedimentary structures are not considered traces, and neither are structures resulting from bioclaustration (Bertling *et al.*, 2020). Microbialite is a generic name for the benthic sedimentary materials and deposits of mineral- microcrystalline (diameter <16 μm) that is formed with the mediation of microbes by accretion-coated or mineral precipitation-accumulation (initially proposed by Burne and Moore, 1987).

Being formed in situ, a microbialite can be seen as a type of boundstone where builders are microbes, and the precipitation-accumulation of carbonate is biotically induced instead of forming tests, shells, or skeletons. Microbialites can also be defined as microbial mats of Schieber *et al* (2007); and biofilm of Krumbein *et al* (2003).

Diagenetic transformation-modification (DTM) *deposits and rocks.* The diagenetic transformation of original deposits can conserve the original distribution of materials with some minor changes (Figure 7). Also, diagenetic processes can form a new distribution of materials as observed in the following cases: when occurs solution-collapse; due to the effect of soft sedimentary deformation structures (SSDSs); by extensive recrystallization processes; or when other diagenetic changes may destroy the original textures of non-siliciclastic sedimentary rocks and produce crystalline textural fabrics that are largely of secondary origin (Boggs, 2006).

DTM sedimentites include diagenetic deposits of Wright (1992); crystalline carbonate rocks (in part) of Dunham (1962); authigenic rocks (in part) of Friedman and Sanders (1978), e.g., diagenetic dolostone, chert, evaporites, etc.

Diagenetic breccias are an example of diagenetic deposits formed by transformation during diagenesis of the original deposit structure. Diagenetic-breccias include: cement-stones, spar-stones, and microspar-stones of Wright (1992); crackle-breccias of Morrow (1982); diagenetic crack structures of Chen *et al* (2010); sedimentary dyke infilling breccia (SDIB) results from a soft sedimentary deformation (SSD), after hydraulic fracturing (Morrow, 1982); sedimentary collapse-breccias formed during a solution-collapse diagenetic event (Morrow, 1982).

Cement-stones of Wright (1992) are limestone composed almost totally of fibrous cement (commonly replaced and/or recrystallized), in which grains or *in-situ* biogenic material does not constitute a framework; Grainstone of Mazzullo and Birdwell (1989), are grainification of calci-mudstones to packstones, caused by desiccation.

Limestones (not dolostones) which have lost their depositional fabric because of complete obliterative recrystallization or replacement can be divided into two types based on crystal size (spar-stones, and microspar-stones) (Wright, 1992). A crackle breccia denotes a fabric in which there is little relative displacement of fragments (Morrow, 1982), or even the result of expansion due to the hydration of anhydrite (see Bassett, 1961; Morrow and Meijer-Drees, 1981), or tidal-flat, desiccation-crack origin on early diagenesis.

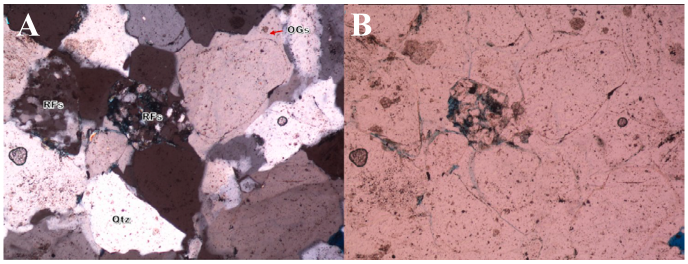

Figure 7. Quartz coarse sandstone with some minor diagenetic changes, e.g., quartz cement overgrowth is observed. Geology UIS, SO16 sample. 10X, A with XPL and B with PPL. RFs: rock fragments, Qtz: quartz, Ogs: overgrowth.

Clastic deposits (CDs) are deposits formed mainly by clastic materials, materials that are eroded, transported, and deposited. Clastic carbonate rocks of Grabau (1904); clastic or fragmental of Krynine (1948); sedimentary (transported as solid in suspension) of Tyrrel (1978); depositional rocks of Wright (1992); depositional mudstones, wackestones, packstones, and grainstones of Dunham (1962); terrigenous rocks (mudstones, sandstones, and conglomerates) of Folk (1974); terrigenous (extrabasinal) and pyroclastic rocks of Friedman and Sanders (1978); siliciclastic rocks (sandstones, conglomerates and shales) formed by particles derived by the weathering breakdown of older rocks (Boggs, 2006); and pyroclastic volcanism deposits (Boggs, 2006). Clastic materials (terrigenous and pyroclastic deposits) correspond to allochthonous sediments of Selley (2000).

There are two kinds of clastic materials: ancient-derived and juvenile. Ancient- derived clastic (ADCMs) are materials inherited and conserved from rocks, e.g., by weathering or tectonic processes, etc., and eroded, transported, and deposited as solids. ADCMs term was proposed by Friedman and Sanders (1978) when they wrote "solid breakdown products of older deposits".

Ancient derived-conserved clastic materials are rock fragments (RFs) and minerals, e.g., quartz, zircon, and fossils (remanie, zombie). Ancient derived-conserved clastic materials include terrigenous components of Folk (1974), those substances derived from erosion of land area outside the basin of deposition and carried into basin as solids; extrabasinal materials (terrigenous) or solids breakdown products of older deposits and derived from outside the basin deposition (Friedman and Sanders, 1978).

Juvenile clastic materials consist of the following materials: biogenic (shells, bones, fragments of plants, etc.), and abiogenic materials (recently formed RFs, minerals, etc.). Materials that are transported after their initial-recently formation, because of that named as juvenile bioclasts, juvenile crystal-clast, juvenile RFs, etc.

Juvenile materials also include weathering argilo-phyllosilicates, because there are new materials formed initially by weathering, e.g., kaolin, smectite, etc. The conserved and the transformation material formed by weathering processes are presented by Kew and Gilkes (2006), among others.

Examples of ancient clastic deposits are fluvial litho-conglomerate, glacial litho-breccias, colluvial litho-breccias, fluvial sandstones (quartz, feldspathic-quartz, lithic-quartz, etc.), lacustrine argilo-phyllosilicate deposits, etc. The deposit of the Ebro basin (Spain) is the predominantly calcareous conglomerates (Uncastillo Fm., Litho- limestone conglomerate) of the Athenian- Middle Aragonian (Villena *et al*, 1992).

Examples of juvenile clastic deposits are the following: beach breccia deposits of shell fragments of recently bivalves, echinoderms, cnidarians, etc.; beach breccia deposits of fragments of recently trunk of tree; eolian-sand deposits formed by recently gypsum-crystals, e.g., white sand eolian deposits of New Mexico. Eolian deposits of gypsum have been reported since the Jurassic, samples of ancient eolian sand gypsum deposits are distributed all along the USA (Stone *et al*, 1920).

Mixed sedimentary deposits (MXDs). Sedimentary deposits in which their formation is dominated by more than one sedimentary process, the following are examples of MXDs: biogenic production and chemical accumulation; biogenic accumulation and clastic sedimentation, e.g., stromatolite deposit; hemipelagic marine deposits; residual-tectonic; deflation-residual (deflational or lag deposits of Krapf and Sheard, 2018; desert pavement of McFadden *et al*., 1987); tectonic-hydrothermal of Wang *et al.* (2020); tectonic-diagenetic deposits of Reid *et al*. (2013) (tectonic-diagenetic breccias of Haldar, 2020); among others. Biogenic-clastic deposits e.g., stromatolite formed by corporal algal or bacterial accumulations with clastic materials sedimentation, described by Friedman and Sanders (1978).

General classification represented in the tetrahedral diagram

Three independent variables can be represented by the corners of an equilateral triangle, four variables can be replaced by only one tetrahedron graph and without any projection errors. It can be possible to use tetrahedral diagrams for the general genetic classification of sedimentary deposits and rocks using only four parameters: biogenic, clastic, chemical, and detrital materials and structures (Figure 8).

Nowadays Analysen-Tetraeder software (Keesmann and Schmitz, 2002) overcomes the difficulties of the calculation of data positions and of understanding the spatial distribution of analytical data in tetrahedral graphs, this software could be free download in https://www.monkeybreadsoftware.de/Analysen-Tetraeder/.

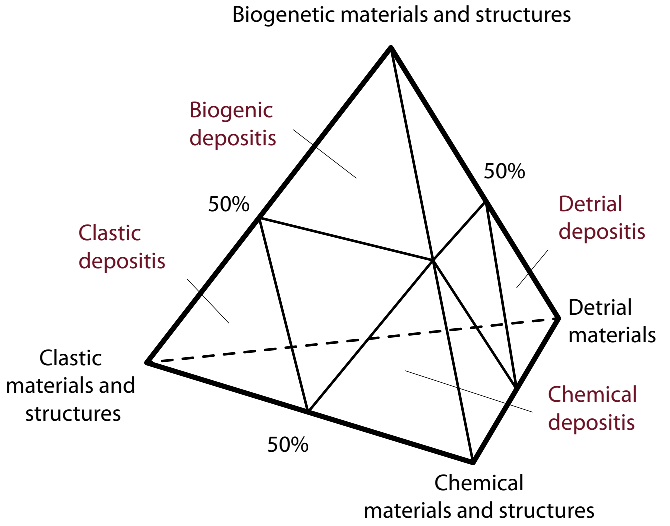

Figure 8. General genetic classification of sedimentary deposits based on detrital, clastic, biogenic, and chemical materials. After Wright (1992) classification of limestone (depositional, biological, and diagenetic).

Compositional-mineralogical classifying of sedimentary deposits and rocks.

Complementary to the genetic general classification of sedimentites it is necessary propose a new compositional-mineralogical general classification of them, using only compositional-mineralogical terms (Table 6), after Merril (1897); Krynine (1948); Pettijohn *et al* (1973); Folk (1954, 1974); Friedman and Sanders (1978); Hallsworth and Knox (1999); Boggs (2006, 2009); and Milliken (2014).

The compositional classification of sedimentites can become quite complex due to variations in mineral content. Hallsworth and Knox (1999) use compositional-mineralogical parameters in their classification in some cases, e.g., carbonate, phosphorites, ironstones, organic-rich, non-carbonate salts, miscellaneous hydroxide, oxide, and silicate; but also use mixed compositional-mineralogical with genetic and textural-interpretative parameters in other cases, e.g., siliciclastic, phosphate and iron sediments, non-clastic siliceous, based on grain size and non-clastic siliceous; and genetic parameters only in another case, e.g., with volcaniclastic debris.

The common minerals in sedimentites are, e.g., quartz, amorphous silica, feldspar, calcite, dolomite, phosphates, argilo- phyllosilicates, micas (muscovite, etc.), oxides and hydroxides of Fe, Al, Mn, sulfates and salts, etc. They are found as monominerals but also associated with other minerals in rock fragments (RFs or lithic), or forming complex structures such as shells, oolites, pisolites, oncolites, etc. There are also accessory minerals (commonly heavy minerals): magnetite, ilmenite, leucoxene, gold, diamond, garnet, apatite, pyroxene, amphibole, kyanite, rutile, zeolites, staurolite, etc.

The information that can be obtained by investigating the composition of sedimentary deposits and rocks includes the knowledge on the source area of sedimentary clast constituents (sink to source), the information concerning the sedimentary knowledge of formed deposits, and the information that reflects the post-sedimentary transformation of the sedimentary deposits.

Compositional-mineralogical classification of sedimentites (CMCSs), given the great variety of materials present in them, must be based on the groups of fundamental minerals proposed by Dana and Ford (1922) and Dana and Hurlbut (1959). CMCSs using the following sedimentary minerals and relatives are presented on Table 6: silicates (quartz, amorphous silica, feldspar, zircon, illite, glauconite, smectite, kaolinite, muscovite, etc.); carbonates (calcite, aragonite, dolomite, magnesite, siderite); phosphates (apatite, wavellite, etc.); iron, manganese, aluminum and titanium oxides and hydroxides (limonite, goethite, ilmenite, pyrolusite, spinel, bauxite, etc.); sulphates and salts (gypsum, halite, etc.); organic rich materials (coal, carbonaceous, bitumen, asphalts, kerogen, petroleum, etc.); nitrates and ammonium (nitratine, nitre, etc.), organically bound nitrogen associated with sediment, also forming nitrate deposits accumulated in arid and semi-arid regions, and elevated nitrogen concentrations in residual-regolith (Holloway and Dahlgren, 2002); sulfides (pyrite, pyrrhotite, etc.) materials formed by biological sulfate reduction in marine anoxic environments (Trudinger, 1981); borates (borasite, borax, etc.) borate deposits interlayered in continental volcaniclastic rocks (Helvaci and Alonso, 2000); and native elements minerals (gold, diamond, graphite, silver, sulphur, uranium, among others), e.g., nanodiamonds from the impact event, and diamond, gold, platinum, copper in placer deposits.

Table 6. General genetic and compositional-mineralogical classification of sedimentary deposits and rocks.

Compositional-mineralogical classification. After Merril (1897), Krynine (1948), Pettijohn et al (1973), Folk (1974), Friedman and Sanders (1978), Hallsworth and Knox (1999), Boggs (2006, 2009), and Milliken (2014)
1.- Silicate sedimentites, including amorphous silica, chert, silcretes, quartz, feldspar, argillaceous and heavy silicates, among others.
2.- Carbonate sedimentites, including limestones, dolostones, among others.
3.- Phosphorites, sedimentites rich in phosphorous compounds.
4.- Iron, manganese, aluminum and titanium oxide and hydroxide rich sedimentites.
5.- Sulfate and salts rich sedimentites.
6.- Organic rich sedimentites, include solids or semisolid (tars, bitumen, asphalts, kerogens); also include CHONS- components (peat, humus and coal), liquid (petroleum oil), and gasses (methane).
7.- Nitrates rich sedimentites.
8.- Sulfides rich sedimentites.
9.- Borates rich sedimentites.
10.- Native elements rich sedimentites.
11.- Mixed compositional-mineralogical sedimentites (silicate-carbonate, silicate-phosphorite, oil shale, oil sands and so on).
Note: The last 7 to 10 groups of sedimentites are less abundant in the geological record but economically important.

Note: Sedimentites also have natural gasses and liquids filling their porous space, including atmospheric air, methane and other natural gasses, meteoric water, organic liquid and other natural liquid. This compositional-mineralogical classification is based also in the general compositional-mineralogical classification of soils deposits (residual regoliths) (Cruz *et al*, 2020).

Silicate-rich sedimentary deposits and rocks are sedimentites consisting fundamentally of silicates (Table 7). The silicate sedimentary materials are monomaterials (detritus and clasts), biogenic and bioclast materials, chemical constituents, or diagenetic materials.

Silicate monomaterials include the following materials: light sedimentary silicates as amorphous and microcrystalline silica and quartz, feldspar, muscovite, argillaceous weathering materials (illite, glauconite, smectite, kaolinite, etc.); and heavy sedimentary silicates (zircon, garnet, sillimanite, kyanite, etc.).

Silicates are essential material forming residual-argilo-phyllosilicates regolith, residual-microcrystalline amorphous silica regolith, clastic, biogenic, and chemical microcrystalline-silica deposit. Most of the silica set free during weathering hydrolysis goes into solution as silicic acid (H_4SiO_4); however, some of the silica may separate as colloidal or amorphous SiO_2 and be left behind during weathering to combine with aluminum to form clay minerals (Boggs, 2006).

Microcrystalline-silica are also the essential materials of diagenetic transformation of sedimentary deposits (e.g., chert). Silicate minerals dominate in most residual-regolith (Karathanasis, 2009), enrichment or accumulation of minerals due to weathering, e.g., microcrystalline amorphous silica in rich paleo-regoliths or silcretes.

Some silicate sedimentary materials zircon, monazite is found in placer deposits; argilo-phyllosilicate-residual deposits, e.g., argillaceous-rich or clay-rich eluvial-illuvial deposits of Turniski *et al*, 2023. Silicate-clastic deposits and rocks, e.g., quartz arenites, arkoses, argilo-phyllosilicate-clastic deposits, etc.

Silicate-biogenic materials conformed by test of porifera, radiolarians, diatoms, algae, phytoliths of amorphous silica, e.g., phytolith-rich tropical regolith, formed on the volcanic island of Reunion (Indian Ocean) (Lacroix, 1936; Riquier, 1960). Crystal chemical of "microcrystalline" amorphous silica precipitated on lagoons, e.g., Coorong lagoons Western Australia (Friedman and Sanders, 1978).

Diagenetic silicate materials occur mainly as cements like chalcedony or feldspar or quartz or argilo-phyllosilicates.

Silicate rocks include chert by diagenetic transformation of volcaniclastic deposits, e.g., chert of Saldaña Formation, Neiva basin (Colombia) (Cruz, 1983); extrabasinal silicate rocks as shales (argilo-phyllosilicates rocks), sandstones, arkoses, wackes of Friedman and Sanders (1978); siliciclastic and non-clastic siliceous of Hallsworth and Knox (1999).

Carbonates-rich sedimentary deposits and rocks. Sedimentites consisting fundamentally of calcite, aragonite, dolomite, magnesite, siderite (ferrous carbonate). Carbonates are present in sedimentites as detritus, clasts, biogenic, chemical, and diagenetic materials (Table 8). Carbonate sedimentites include limestone and dolomites (syngenetic, diagenetic and epigenetic dolostones) of Folk (1974); and Boggs (2006); carbonate sediments and rocks of Hallsworth and Knox (1999), among others.

Carbonates are forming sedimentary detritic materials as, e.g., residual regolith (microcrystalline calcite rich residual regolith or calcretes), and tectonic regoliths. Carbonate-rich residual-regoliths were characterized by enrichment with microcrystalline-carbonate, e.g., calcrete. The enrichment with calcium carbonate is not only due to inheritance from calcium carbonate-rich parent material, but also translocation of calcium carbonate within residual-regolith profiles, and possible aeolian silt contribution (incorporate materials). Translocation latter depending on regolith stratification (Kowalska *et al*, 2019). Residual detrital regoliths include calcretes of Friedman and Sanders (1978); calcitic and dolomitic caliche of Folk (1974).

Clastic carbonate sedimentites: rudites of juvenile bioclastic and terrigenous calcareous-RFs. Bioclastic rudites (transported juvenile biogenic shell of molluscan, brachiopods, etc.). Clastic carbonate sedimentites include depositional of Wright (1962); clastic limestone (mudstone, wackestone, packstone, and grainstone) of Dunham (1962); intraclastic, and bioclastic limestones of Folk (1974).

Biogenic-juvenile calcareous deposits made by text of invertebrates mollusca, foraminifera, echinodermata, etc. Continental shelf carbonate deposits in equatorial to tropical environments because of their high biological activity, in the absence of continental input sediments, are biogenic-calcareous dominated materials, forming e.g., reef carbonate biogenic structure. Biogenic-juvenile calcareous deposits include biogenic limestones (boundstones) of Dunham (1962); biological limestone of Wright (1992); pelsparites, pelmicrites of Folk (1974).

Table 7. Classification of silicate sedimentites. Based on the type of silicate: detrital, clastic, biogenic, chemical and diagenetic.

Main group	Description	Specific name
Detrital silicate (DeS) deposits, if DeS materials are the main component. Residual, tectonic, lava cooling, etc.	Residual-argilo-phyllosilicates (kaolin, smectite, illite, glauconite, etc.)	e.g., residual-clay rich regolith (Turniski *et al*, 2023).
	Residual-microcrystalline amorphous silica by solution-precipitation	e.g., residual-silcrete deposits (Wopfner, 1983).
	Residual inherited-conserved quartz with juvenile argilo-phyllosilicates and/or juvenile iron-manganese-aluminum-titanium oxides and hydroxides	e.g., laterite-bauxite regolith (Kew and Gilkes, 2006); residual regolith (Avendaño and Cruz, 2017).
Clastic silicate (ClS) deposits, if CIS materials are the main component.	Transported materials: light minerals (quartz, feldspar, calcite, etc.); and heavy minerals (zircon, amphibole, biotite, etc.)	e.g., quartz arenite, arkose, etc.
Biogenic silicate (BS), if BS materials are the main component.	Amorphous silica test of radiolarian, diatoms, and porifera	e.g., fine silty clay biogenic silica deposits (Oehler, 1979).
Chemical silicates (CHS) deposits, if CHS materials are the main component.	e.g., microcrystalline amorphous silica precipitated from solution in Coorong Lake, Australia (Friedman and Sanders, 1978).	e.g., fine chemical silica deposits.
	Microcrystalline zeolite precipitation when pyroclastic materials with saline or alkaline waters, Friedman and Sanders (1978).	e.g., fine chemical zeolite deposits.
Diagenetic silicate (DiS) deposits, if DiS materials are the main component.	e.g., cements of microcrystalline amorphous silica, quartz, feldspar, chalcedony, and argillic, etc. Illite deposits by diagenetic transformation of kaolinite and smectite (Boggs, 2006)	e.g., Illite claystone; etc.

Table 8. Classification of carbonate sedimentites. Based on the type of carbonate: detrital, clastic, biogenic, chemical and diagenetic.

Main group	Description	Specific deposits
Detrital carbonate (DeC) deposits, if DeC materials are the main component of residual, tectonic, etc.	e.g., inherited-conserved calcite release by weathering	Residual-detrital ancient calcite deposits.
	Residual-microcrystalline calcite by solution-precipitation	Calcrete deposits (soil carbonates of Dart, 2009; calcisol of Mack *et al*, 1993; caliche-calcrete of Lamplugh, 1902).
	Tectonic calcareous regoliths	Fragmentation due to tectonic stress of calcareous rock sequences. Tectonic-breccias (Morrow, 1982; Boggs, 2006).
Clastic carbonate (ClC) deposits, if ClC materials are the main component:	Ancient limestone RFs and remanie fossils (extraclast of Scholle and Ulmer, 2003).	Ancient (terrigenous) lithic-limestone breccia with remanie fossils
	Juvenile bioclastic carbonate	Wackestone, packstone, grainstone of Dunham (1962), e.g., beach-bioclastic rudite of bivalves, foraminifera, etc.
Biogenic carbonate (BC) deposits, if BC materials are the main component:	Autochthonous and parautochthonous biogenic carbonates	Bioherms and biostromes (Cumings, 1932; Chevalier, 1961; Klement, 1967; Zonneveld *et al*, 2012). Auto-biostrome and parabiostromes by Kershaw (1994)
Chemical carbonate (CHC) deposits, if CHC materials are the main component:	Calcite and aragonite crystals by chemical precipitation from saturated solution.	Chemical carbonate deposits (Friedman and Sanders, 1978).
Diagenetic carbonate (DiC) deposits, if DiC materials are the main component:	Limestone by recrystallization, e.g., calcite cements, diagenetic dolomite, etc.	Crystalline limestone (e.g., Dunham, 1962; Banner and Wood, 1964)

Chemical sedimentites of crystal chemical calcite precipitated, e.g., on sabkha condition environments. Include chemical crystalline carbonate limestones of Dunham (1962); orthochemical limestones, e.g., oosparites, and oomicrites of Folk (1974).

Diagenetic sedimentites include, e.g., diagenetic limestone and dolomites of Friedman and Sanders (1978), Wright (1992), and Boggs (2006).

Phosphates rich sedimentary deposits and rocks are sedimentites consisting fundamentally of phosphate minerals as apatite, wavellite, etc., (Table 9). Phosphates are forming detrital deposits like residual regolith (soil or paleosols), biogenic (Figure 9) and bioclastic materials of corporal bones, teeth, or bio-depositional materials as excrements and urine, crystal chemical and authigenic of phosphatic rich materials.

Detrital residual-regolith, where weathering causes dissolved phosphate from primary minerals (especially as apatite, calcium phosphate, Tiessen *et al*, 1984) to precipitate with some cations and lead, e.g., to the neo-formation of calcium phosphate in alkaline residual-regolith (Beck and Sánchez, 1994); adsorbed phosphate by functional groups of iron or aluminum oxides to form thermodynamically stable complexes (Bortoluzzi *et al.*, 2015; Fink *et al.*, 2016).

Detritus inherited and conserved apatite from weathering of igneous and metamorphic rocks. Phospho-detritus represents phosphate material formed by the disintegration (physical breakdown) of larger phosphate materials by very active mechanical actions and if transported and deposited then phosphoclast. Phosphate rich sedimentites include biogenic and bioclastic phosphates deposits with bones, teeth, pellets, coprolite, cololite, etc.

Phosphate rich deposits can form by biological deposition of excrement (Schnug *et al*, 2018; Carreiro *et al*, 2021); or form biologically active organic compounds that remain as organic phosphates in regolith (Conte *et al.*, 2002; Martinazzo *et al.*, 2007; Dodd and Sharpley, 2015). Also, predation phosphate detritus, phosphate material formed by the disintegration (physical breakdown) of larger phosphate materials (bones) by very active predation biological processes. Diagenetic phosphorite, include coated chemical-phosphorite, phosphate coated grains formed by accretion of cryptocrystalline phosphate to any detrital material.

Phosphates or phosphorites (the two terms are synonymous), here referred to as sedimentary phosphate deposits and rocks, are composed of the mineral apatite. This rock-building mineral consists of three kinds, which form an isomorphous series: (1) fluorapatite [$Ca_5(PO_4)_3F$], (2) chlorapatite [$Ca_5(PO_4)_3CI$] and (3) hydroxyapatite [$Ca_5(PO_4)_3OH$].

Phosphate sedimentary rock whose essential mineral component is usually a fluorapatite carbonate [$Ca_5(PO_4)_3(F, CO_3)$], a variety of apatite known as francolite. Isotropic cryptocrystalline fluorapatite carbonate (francolite) is the basic raw material for many phosphorus-containing compounds on which modern technological developments depend.

When the apatite-like phase cannot be identified, the name colophane is commonly applied. Ca, P (or PO_4), and F may be substituted by other elements. Some of these substitutions are potentially of economic interest, because many trace elements are present in higher-than normal concentrations. Phosphate rock occurs on the modern sea bottom and in ancient deposits.

Factors that favor phophoritization include a broad continental shelf adjacent to an ocean, slow shallow marine sedimentation, low terrigenous input, and high organic productivity (Selley *et al*, 2005). Phosphate deposits are of three types: bedded, placer, and guano (Selley *et al*, 2005). Guano is the youngest phosphate rock, this is a fertilizer rich in phosphates and nitrates that forms from the accreted excreta of birds and bats (Selley *et al*, 2005).

Phosphate-rich sediments are present on the modern continental shelves off southwest and northwest Africa, southeastern United States, southern California, northern South America (eastern mountain range of Cundinamarca and Boyacá, Colombia), eastern Australia, and eastern New Zealand. Phosphate rock occurs as nodules on the modern sea bottom extending from shallow to great water depths. Such nodules occur off the coast of California. In some nodules, the concentration of phosphate reaches 95%, but in others, abundant impurities of various marine products are included, such as organic matter, siliceous tests of organisms, calcareous shells, some of which are partly phosphatized, (vertebrate bone) shark teeth, and various detrital materials.

Table 9. Classification of phosphate sedimentites. Based on the type of phosphate: detrital, clastic, biogenic, chemical, and diagenetic

Main group	Description	Specific deposits
Detrital phosphate (DeP) deposits, if DeP materials are the main component.	E.g., phosphatic RFs and biogenic ancient phosphates bones, and teeth. Phosphatic RFs, etc., release by weathering from ancient rocks.	Detrital ancient-derived phosphatic lithic breccia, etc.
Clastic phosphates (ClP) deposits, if ClP materials are the main component.	Phosphatic RFs and biogenic ancient and juvenile phosphates bones, and teeth transported and deposited (Teleki *et al*, 2012).	Fluvial ancient-derived phosphatic-lithic breccia; beach juvenile shark teeth rudite.
Biogenic phosphates (BP) deposits, if BP materials are the main component.	Autochthonous and parautochthonous bones, teeth, and excrements.	Parautochthonous bone deposits of elephants, mastodon, etc., (Santona *et al*, 2005; Holen *et al*, 2017), e.g., Ambrona site (Figure 9).
Chemical phosphates (CHP) deposits, if CHP materials are the main component.	Microcrystalline phosphates precipitated from solution	Phosphatic deposits on marine shelf (Selley, 2000).
Diagenetic phosphates (DiP) deposits, if DiP materials are the main component.	Recrystallization, and solution, remobilization, and crystallization of phosphates (Blatt and Tracy, 1996)	Microcrystalline-diagenetic phosphatic rocks nodules (Garcia *et al,* 2020).

Figure 9. Ambrona site of large vertebrates (elephant graveyard type), e.g., *Palaeoloxodon antiquus* skeletal accumulation (Medinaceli, Spain) described by Santona *et al*. (2005).

Ancient deposits of phosphate rock occur in extensive phosphogenic provinces. These provinces include (1) the Upper Precambrian province of central and southeast Asia; (2) the Cambrian province of central and southeast Asia, extending into northern Australia; (3) the Permian province of North America, specifically the Phosphoria Formation, which extends through Wyoming, Utah, Colorado, Idaho, Montana, and Nevada; (4) the Jurassic-Lower Cretaceous province of eastern Europe; (5) the Upper Cretaceous-Eocene province of the Middle East and North Africa (Morocco, Egypt, Israel) extending into West Africa and the northern part of South America; and (6) the Miocene province of the southeastern United States.

Each of these provinces extends for several thousand square kilometers. In ancient deposits, phosphate rock may occur (bone, fragments, sand-sized pellets of possible fecal origin (100 to 400 µ., in diameter), ooids, pisolites, phosphatized tests of various calcareous-shells, and large pellets (2 to 5 mm, which have been termed coprolites), also diagenetic peloids and intraclast.

Phosphate rocks are a vital resource for world food supply and security. They are the primary raw material for phosphoric acid and fertilizers used in agriculture and are increasingly considered to be a potential source of rare earth elements (El Bamiki *et al*, 2021).

Phosphate rocks occur either as sedimentary deposits or igneous ores associated with alkaline rocks (El Bamiki *et al*, 2021). About three-quarters of the world's supply of phosphates comes from sedimentary deposits (Selley *et al*, 2005).

Phosphate sedimentites include phosphate rock of Friedman and Sanders (1978); phosphate-sediments and phosphorites of Hallsworth and Knox (1999); and sedimentary phosphorites of Boggs (2006).

Iron, manganese, aluminum and titanium (IMNALTIT) oxides and hydroxides rich sedimentary deposits and rocks are sedimentites consisting fundamentally of iron oxide and hydroxide materials (goethite, limonite, ferrihydrite), manganese oxides (pyrolusite, lithiophorite, hollandite, and birnessite), aluminum hydroxide (gibbsite), iron and titanium oxide (ilmenite), magnesium/aluminum oxide (spinel), and titanium oxides and hydroxides (rutile, anatase, etc.) (Table 10).

IMNALTIT oxide and hydroxide are forming genetic materials like residual regoliths (iron- manganese rich nodules, lateritic soils and paleosols), crystal chemical and authigenic of IMNALTIT oxide and hydroxide rich materials. IMNALTIT sedimentites include manganese, iron-rich sedimentary rocks of Friedman and Sanders (1978); iron-sediments and ironstones of Hallsworth and Knox (1999); iron bearing sedimentary rocks of Boggs (2006). Pyrolusite is important as an ore of manganese (Reidies, 2002).

Table 10. Classification of iron, manganese, aluminum and titanium oxides and hydroxides sedimentites. Based on the type of oxide and hydroxide: detrital, clastic, biogenic, chemical, or diagenetic.

Main group	Description	Specific deposits
Detrital oxides and hydroxides (DeOH) deposits.	Iron and ferromanganese oxides nodules release from weathering	Iron and ferromanganese oxides nodules detrital breccias Pedogenic ferromanganese nodules (Huang, 2022); Iron-oxide concretion from early diagenetic origin (Loope *et al*, 2012).
Clastic oxides and hydroxides (ClOH) deposits.	Iron and ferromanganese oxides nodules transported and deposited	Clastic breccias of ferromanganese-oxides nodules
Biogenic oxides and hydroxides (BOH) deposits.	Microbial polymetallic nodules formed on the deep-sea bottom (Tully and Heidelberg, 2013; Sujith and Gonsalves, 2021; and references therein)	
Chemical oxides and hydroxides (CHOH) deposits.	Ferromanganese nodules found in the seafloor without biological mediation.	Ferromanganese-nodules breccias (Verlaan and Cronan, 2022)
Diagenetic oxides and hydroxides (DiOH) rocks.	Iron and ferromanganese oxides nodules by diagenetic solution-precipitation.	Iron-oxide concretion from late diagenetic origin (Loope *et al*, 2012)

Sulfates and salts rich sedimentary deposits and rocks. Sedimentites consisting fundamentally of sulfates (anhydrite and gypsum, Figure 10), and chlorides (particularly halite, sylvite, and carnallite) (Table 11). Sulfates and salts rich sedimentites include non-carbonate salts of Hallsworth and Knox (1999); evaporites of Boggs (2006) and Friedman and Sanders (1978). Salt-rich deposits occur in all continents and under almost all climatic conditions. Their distribution, however, is relatively more extensive in the arid and semi-arid regions compared to the humid regions (Deocampo and Jones, 2014). Salts released through weathering in the arid regions with limited rainfall are usually deposited at some depth in the residual-regolith profile, the depth depending on such factors as the water retention capacity of the materials, seasonal, annual, and maximum rainfall, etc., (Yaalon, 1975). Samples of chemical sulphate and chlorides (salt rich deposits) are presented by Kendall *et al.,* (1994); Zamannejad *et al.,* (2013); and Deocampo and Jones (2014).

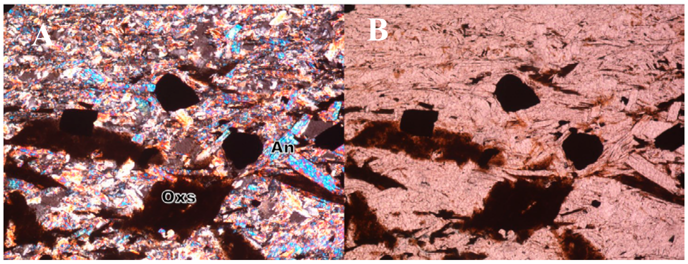

Figure 10. Sedimentary rock composed almost entirely of anhydrite (An). This mineral is distinguished from gypsum by its greater relief and strong birefringence. Oxs: oxides. Geology-UIS, S023 sample, 10X, A. XPL and B. PPL.

Table 11. Classification of sulfate and salt sedimentites. Based on the type of sulphate and salt: chemical, clastic and diagenetic.

Main group	Description	Specific deposits
Chemical sulfate and salt (CH SS) deposits.	Directly precipitation accumulation of crystals from solutions	Sabkha deposits of gypsum, salt, etc. (Friedman and Sanders, 1978).
Clastic sulfate and salt (Cl SS) deposits.	Chemical crystals transported and sedimented, e.g. forming gypsum dunes	Gypsum sand-dunes (e.g., White gypsum dunes USA). Gypsum dunes have been reported since Jurassic (see Stone *et al*, 1920)
Diagenetic sulfate and salt (Di SS) deposits.	Recrystallization of crystalline sulfate and salt deposits	Medium to coarse crystalline gypsum rocks (e.g., evaporites illustrated by Adams *et al*, 1984).

Organic rich sedimentary deposits and rocks. Sedimentites consisting fundamentally of solids or semisolid (tars, bitumens, asphalts, kerogens), also include carbonaceous deposits and rocks (peat, humus and coal), liquid (petroleum oil), and gasses (methane) (Table 12). Sedimentary materials formed by degradation- transformation-maturation process of corporal materials (organs and tissues of lipid, protein, carbohydrate and ash contents, nail, hair, hoof, and horn of protein composition). Organic rich sedimentites include intrabasinal carbonaceous rocks (lignite, subbituminous, bituminous, sub-anthracite and anthracite) of Friedman and Sanders (1978); organic rich sediments and rocks of Hallworth and Knox (1999); carbonaceous sedimentary rocks (coal, oil shale, bitumen) of Boggs (2006).

Most sedimentites, including rocks of Precambrian age, contain at least a small amount of organic matter consisting of the preserved residue of plant or animal tissue (Boggs, 2009). Residual regoliths with organic content higher than 30% are termed highly organic regoliths or peats. Many residual regoliths have a superior-external organic mantle (O horizon) and an underlaying A horizon, both of which have the greatest accumulation of organic compounds.

Organic matter is a complex mixture of organic compounds of carbon-hydrogen-oxygen-nitrogen, and sulphur (CHONS), produced originally by living organisms (plant, animal, and microorganisms). Residual regoliths contain CHONSs at various stages of decomposition.

Organic compounds are named so because they are associated with living organisms. A biogenic organic compound (BOC or BCHONS) is the general term used to describe a mixture of organic compounds such as plant alkanes, sterols and sterones, fatty acids and fatty alcohols, and waxes and wax esters biosynthesized by living organisms. The main types of organic compounds are carbohydrates, lipids, nucleic acids, resin, and proteins.

Table 12. Classification of CHONS rich sedimentites. Based on the type of organic materials (CHONS): biogenic, clastic or diagenetic.

Main group	Description	Specific deposits
Biogenic CHONS deposits	Remains of plants, insects, worms, etc. produced, released, and accumulated directly over the external lithosphere.	Detrital-biogenic-CHONS materials rich deposit (horizon O of regolith)
Clastic CHONS deposits	Biogenic CHONS remains transported outside of their original formation place.	Clastic-CHONS rich deposit (e.g., carbonaceous organic debris deposits of Friedman and Sanders, 1978).
Diagenetic CHONS rocks	Biogenic- bioclastic of corporal (plant, animal, and microorganisms) rich deposits transformed into coals, hydrocarbons, etc.	Coals results from carbonization of detrital biogenic plant rich deposits. Some coals result from carbonization of clastic rich-plants deposits. Argillite-, sand- and rudite-hydrocarbons rich rock (oil shale and sand-hydrocarbon rich rock, etc., described by hydrocarbon companies; Tucker and Wright, 1990; Friedman and Sanders, 1978; Selley et al, 2005; Boggs, 2006; among others)

Nitrates and ammonium rich sedimentary deposits and rocks. Sedimentites consisting fundamentally of nitratine, nitre, etc. Organically bound nitrogen associated with sediment, also forming nitrate deposits accumulated in arid and semi-arid regions, and elevated nitrogen concentrations in soil (Holloway and Dahlgren, 2002), also present in biodepositional liquid materials (urine).

The nitrate concentration in regoliths or water is generally low, indicating that the nitric nitrogen formed is quickly taken up by plant assimilation or microbial transformations. The availability of usable nitrogen thus often appears to be a limiting factor in these transformations. However, nitrate concentrations in regoliths may be higher in media enriched with organic matter, either naturally or under human action.

Thus, the accumulations of guano in Chile and Peru were a source of natural nitrates accumulated excrement of seabirds (Schnug *et al.*, 2018) or bats, used in agriculture. Bat guano is found in caves throughout the world. Nitrogen Guanos are formed only under the special climatic conditions of the subtropical-edge tropical high-pressure belt with coastal deserts (Schnug *et al.,* 2018).

Guano is a highly effective fertilizer due to the high content of nitrogen, phosphate, and potassium. In Colombia, especially in Santander region, guano from breeding and processing chickens has been used since 1970 as a plant substrate fertilizer.

Sulphides rich sedimentary deposits and rocks. Sedimentites consist fundamentally of (pyrite, pyrrhotite, etc.) materials formed by biological sulfate reduction in marine anoxic environments (Trudinger, 1981). Sulphide minerals are compounds in which sulphur is combined as an anion with a metal (or semimetal) cation or cations. The sulphide in residual regoliths is mainly derived from the products of sulphate-reducing bacteria, which are currently responsible for oxidizing over half the organic matter flux reaching sediments, and pyrite is the mineral overwhelmingly produced (Rickard 2012).

In wetland regoliths and underwater sedimentary deposits of marine, brackish and freshwater systems, the strong phytotoxin sulphide may accumulate because of microbial reduction of sulphate during anaerobiosis, its level depending on prevailing edaphic conditions (Lamers et al., 2013).

The accumulation of reduced sulphur in sedimentary deposits of aquatic systems and permanent or riparian wetlands (including estuarine and marine) generally causes physiological toxicity stress for the community involved, such as plants, animals and microorganisms (Bagarinao, 1992).

Other sulphides in regoliths are inherited-conserved from igneous and metamorphic rocks, e.g., galena, argentite, chalcocite, sphalerite, etc. Sulphides are ore of different minerals and are commonly associated with regoliths.

Borates rich sedimentary deposits and rocks. Sedimentites integrated mainly with borasite, borax, etc. The common borates minerals in borax-rich regoliths include kernite, colemanite or ulexite as well as a lot of rare minerals, e.g., rivadavite, ameghinite, ezcurrite, teruggite, macallisterite, inderite, inyoite, kaliborite, pandermite, and pinnoite.

An example of borates rich deposits is saline (salt-containing) regoliths containing a high proportion of borax at a salt pan in the Mojave Desert, USA. Borax is a white, monoclinic crystalline mineral composed of hydrated sodium borate. It forms during solar evaporation of saline water bodies, such as lakes and desert salt pans.

Economically significant deposits of boron-bearing minerals, mostly borate salts, are found in saline paleolake deposits in several areas around the world, most notably the famous borax deposits around Boron, California, and the borate ores of Turkey (Deocampo and Jones, 2014). Borate deposits interlayered in continental volcaniclastic rocks (Helvaci and Alonso, 2000).

Native elements rich sedimentary deposits and rocks. Sedimentites consist fundamentally of native metals (gold, silver, uranium, among others), and the non-metals (sulphur, diamond, graphite) (Table 13). Weathering of ultramafic rocks can lead to the formation of residual-regolith profiles with high contents of Fe, Ni, Co, platinum-group elements and gold (Rivera *et al.*, 2018). Diamonds formed from the extraterrestrial impact event (Ohfuji *et al.*, 2015). Diamond microcrystals found in impact melt rocks and impact breccias at the Popigai impact structure in Siberia (Koeberl *et al.,* 1997). Diamond, gold, platinum, ilmenite, copper, among others, found in placer deposits (Els and Eriksson, 2006). Placer gold, platinum and diamonds have been found in gravel deposits, e.g., Mudaliar *et al.,* (2007); and Kvasnitsa *et al*., (2016).

Reduction of gypsum or of anhydrite by sulphate reducing bacteria forms native sulphur, which occurs in modern salt lakes or playas or in caprocks atop salt plugs (Friedman and Sanders, 1978).

Table 13. Classification of native-minerals rich sedimentites. Based on the type of native- elements: detrital or clastic.

Main group	Description	Specific deposits
Detrital Native-elements minerals deposits.	Mineral enrichment by weathering of mineralized veins.	Residual-detrital placer deposit (Els and Eriksson, 2006; and references therein).
Clastic Native-elements minerals deposits.	Mineral enrichment by transport and depositional segregation of materials	Placer deposits in, e.g., Eluvial, terrace, stream, beach, and marine offshore environments (Selley *et al*, 2005; Boggs, 2006; and references therein).
	Mineral formation and enrichment by extraterrestrial impact event	Impact mineral-enrichment deposit (Shukla and Karma, 2018; Pati *et al*, 2017; James *et al*, 2022, and references therein).

Mixed compositional-mineralogical sedimentary deposits and rocks are sedimentites consisting fundamentally of two or more components, e.g., silicate- carbonate, silicate-phosphate, oil argilo-phyllosilicate (oil shale), oil sands and so on. Silicate-carbonate sedimentites, e.g., fine to coarse quartz arenite with calcite as cement; also, mixed sedimentites with skeletal-calcite materials, clastic sand (quartz, feldspar, etc.), and clastic argilo-phyllosilicates (Figure 11). Silicate-phosphate sedimentites, e.g., siliceous-phosphate deposits (Haddi *et al*., 2013). Silicate-carbonate-phosphate sedimentites (SCPSs) with skeletal-calcite materials (fragments or complete), skeletal-phosphate (teeths, bones, intraclasts, etc.), clastic sand (quartz, feldspar, etc.) and clastic argilo-phyllosilicates. Examples of SCPSs are the nodular layer of Tour de Croi, Jurassic, France (Adams *et al.*, 1984).

Sedimentites containing abundant kerogen are popularly known as "oil shales". Oil shales deposited in some ancient lakes, such as the Green River Formation (Friedman and Sanders, 1978). General composition of oil shales includes inorganic substance and bitumens. Oil-bearing shales are deposits that contain petroleum (tight oil) (Dyni, 2006).

Oil sands, tar sands, crude bitumen, or bituminous sands, are either loose sands or partially consolidated sandstone containing a naturally occurring mixture of sand, clay, and water, soaked with bitumen, a dense and extremely viscous form of petroleum (Dusseault, 2001).

Lithic rich sedimentary deposits and rocks are a special and common group of sedimentites consisting fundamentally of rock fragments (RFs) or lithic. RFs (sedimentology term) refers to any sedimentary polymaterial that conserves the original characteristics of their parental rocks (Figure 12).

RFs are common in detrital (in situ formation without transport) and in clastic (depositional) rocks, e.g., lithic-rudites (breccias and conglomerate) and lithic-sandstone. Lithic-rudites are detrital and clastic deposits and rocks where RFs are the main constituent, e.g., lithic- clastic-breccias, lithic-conglomerate, lithic- impact-breccias, lithic-pyroclastic- breccias, lithic-tectonic-breccias, lithic lava-cooling- breccias, lithic-peperites, etc. RFs are ancient-derived and new materials (juvenile). Ancient-derived RFs are common in sedimentites (Table 14).

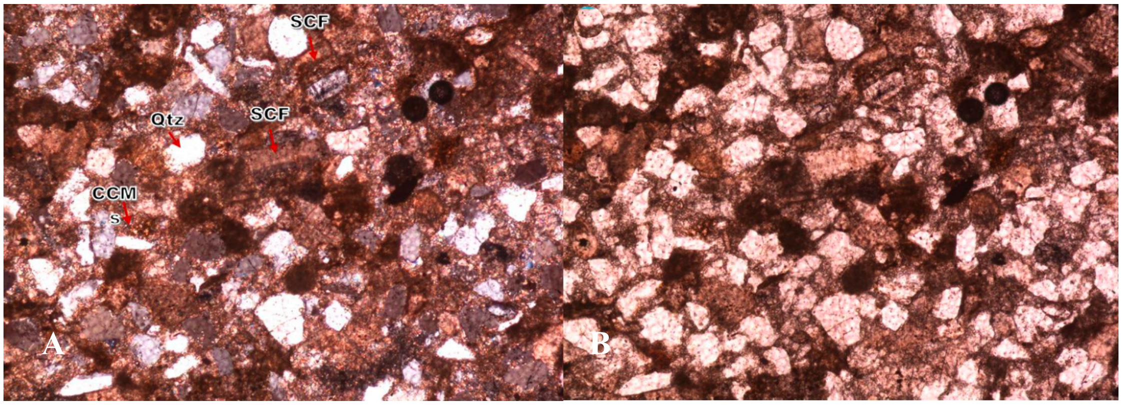

Figure 11. Mixed sedimentite, quartz fine-sand clasts (Qtz), abundant fragments of skeletal calcite (SCF), and calcareous clay materials (CCM). Geology UIS, S017 ED-120-037-001 sample, 5X. A: XPL, B: PPL.

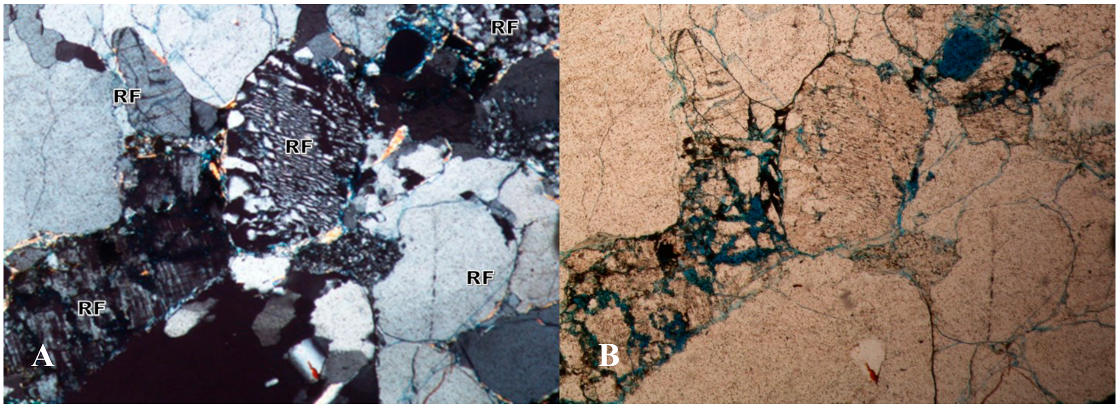

Figure 12. Lithic conglomerate (RFs of metamorphic rocks and polycrystalline quartz) subrounded to subangular, longitudinal to concave-convex contacts between clasts, quartz overgrown, some argilo-phyllosilicate cement. RF: rock fragment. Geology UIS, DM-120-024-015 sample, 5X. A: XPL, B: PPL.

Table 14. Classification of lithic sedimentites. Based on the type of rock fragments: ancient-derived RFs, juvenile RFs or mixed ancient derived plus juvenile RFs.

Main group	Description	Specific name
Ancient-derived (A-D) RFs deposits, if A-D RFs materials (lithoclast of Adams *et al*, 1984) are the main component.	Residual deposit with inherited-conserved RFs from substratum affected by weathering	Lithic ancient-residual detrital deposit (breccias, sandy breccias, brecciated sand) (Blockfield deposits of Goodfellow *et al*, 2014).
	Tectonic deposit with inherited-conserved RFs from the substratum affected	Lithic ancient-tectonic affected detrital breccias (e.g., Rasmussen *et al.,* 2011).
	Caldera-collapse deposit with inherited-conserved RFs from the substratum affected	Lithic ancient-derived caldera-collapse detrital breccias (e.g., Aguirre-Diaz, 2008).

(*Continued*)

Main group	Description	Specific name
Ancient-derived (A-D) RFs deposits, if A-D RFs materials (lithoclast of Adams *et al*, 1984) are the main component.	Rock-dissolution-collapse with inherited-conserved RFs from the substratum affected	Lithic ancient-derived collapse breccias (Collapse breccias of Friedman,1997; Christiansen and Sauer, 2001; Haldar, 2020).
	Clastic ancient-derived deposits with inherited-conserved RFs	Lithic ancient-derived clastic deposits (lithic-breccias, conglomerates, and lithic-sands). Terrigenous deposits and rocks of Folk (1974), Boggs, (2006), etc.; extrabasinal rocks of Friedman and Sanders (1978).
Juvenile RFs deposits, if juvenile RFs materials are the main component.	Juvenile lava-cooling RFs from juvenile magma	Lithic juvenile lava-cooling detrital-breccias (volcanic breccias of Morrow, 1982)
	Pyroclastic deposits with juvenile RFs, and minerals	Pyroclastic juvenil breccias, etc., (Coira *et al*., 2022).
Mixed ancient-derived (A-D) and juvenile RFs deposits, if A-D and juvenile RFs materials are the main component.	Peperites with inherited-conserved RFs from sedimentary deposits affected, and mixing with volcanic RFs	Peperite-breccias with A-D sedimentary RFs and juvenile volcanic RFs (Peperite breccias of Skilling *et al*., 2002).
	Hydrothermal deposit with juvenile hydrothermal materials and inherited-conserved RFs from substratum affected	Lithic ancient and juvenile hydrothermal detrital deposits. Hydrothermal-breccias of Jébrak (1997)
	Impact deposit with juvenile-impact materials and inherited-conserved RFs from substratum impacted	Lithic ancient and juvenile impact clastic breccias (Shukla and Sharma, 2018).
	Pyroclastic deposits with juvenile volcanic RFs, and minerals mixed with cognate-covolcanic and with accidental materials (A-D RFs and minerals)	Lithic ancient cognate and accidental, and juvenile RF and minerals, e.g., detrital flow produced during Santa Helens eruption may 18, 1980 (Korosec *et al*, 1980).

Note: If the lithic deposits consist of loose materials, then they are considered regolith. Lithic deposits commonly are breccias including some depositional ancient-derived breccias (e.g., colluvial deposits). The conglomerates are commonly litho-conglomerate and are solely depositional (e.g., fluvial deposits, etc.). Cognate-covolcanic are fragmented comagmatic volcanic rocks from previous eruptions of the same volcano (Cognate of Fisher, 1997). Accidental fragments (accidental lithoclasts) are derived from the sub-volcanic basement rocks and therefore may be of any composition of Fisher (1997).

The term rudite is the generic name used here for denoting sedimentary deposits and materials (detritus or clast) with size >2mm, independent of their shape (rounded or angular). Rudite was proposed by Grabau (1904), and used by Tucker (2003). Rudites include conglomerates and breccias. Lithic sedimentites include terrigenous breccias and conglomerate of Folk, (1974); Friedman and Sanders (1978); Tucker (2003); Selley *et al* (2005); Boggs (2006); among others.

Conclusions

The genetic classification and naming of sedimentites in six main genetic groups: biological, depositional, detrital, chemical, diagenetic, and mixed; this is supported by conceptual framework for genesis of skeletal concentration: biogenic, sedimentologic, and diagenetic (Kidwell *et al*., 1986), and by other formation processes chemical sedimentary precipitation and the regolith formation process that also forms detritus.

The conceptual and structural scheme of classification of Dana and Ford (1922), that use the relations existing between them in chemical composition, crystalline form, and other physical properties, are the best manner for the mineral-compositional classification and naming of the sedimentites: silicate, carbonate, phosphate, etc.

It is convenient to use genetic or compositional-mineralogic paradigm initially for the classification and naming of the sedimentites, e.g., detrital, biogenic, clastic, chemical, or diagenetic, or by using the mineralogical-compositional scheme: silicate, carbonate, phosphate, and so on. So, be pragmatic it could be an integration of these two classifications, first using either genetic or compositional-mineralogical classification and then by use the other and complete it, e.g., silicate residual-regolith, carbonate biogenic-rock, siliciclastic deposit, bioclastic limestone, etc.

Because clastic sedimentites include pyroclastic, it is convenient to use the same textural size classification of Wentworth (1922) for every type of size pyroclastic materials: gravel, sand, silt and clay, and retire the use of bombs, lapilli, and ash size. The term bomb, ash cloud are genetic terms and could be used complementary to the basic genetic and compositional, e.g., lithic pyroclastic breccias with some gravel-bombs, etc.

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