Gravels, Conglomerates, and Breccias

<u>Introduction</u>

A **gravel** is an unconsolidated accumulation of rounded fragments larger than sands (Larger than 2 mm.). Material in the 2 to 4 mm. range has been termed *granule gravel* or *very fine gravel*.

Siliciclastic sedimentary rocks that consist predominantly of consolidated accumulation gravel-size (>2mm) clasts are called **conglomerates**. The Latin-derived term **rudite** is also sometimes used for these rocks. **Conglomerates** are common rocks in stratigraphic sequences of all ages, but make up less than about one percent by weight of the total sedimentary rock mass.

In contrast to sandstones, conglomerates contain a significant fraction of gravel-size particles. The percentage of gravel-size particles required to

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distinguish a conglomerate from a sandstone or mudstone (shale). Folk (1974) sets the boundary between gravel and gravelly mud or gravelly sand at 30 percent gravel. That is, he considers a deposit with as little as 30 percent gravel-size fragments to be a gravel. On the other hand, Gilbert (Williams et al., 1982) indicates that a sedimentary rock must contain more than 50 percent gravel-size fragments to be called a conglomerate. Siliciclastic sedimentary rocks that contain fewer than 50 percent gravel-size clasts (possibly fewer than 30 percent according to Folk's usage) are conglomeratic sandstones (pebbly sandstone) or conglomeratic mudstones (pebbly mudstone).

Gilbert reserves these terms for rocks with less than about 25 percent gravel-size clasts. Crowell (1957) suggested the term pebbly mudstone for any poorly sorted sedimentary rock composed of dispersed pebbles in an abundant mudstone matrix. Flint et al.(1960) proposed the term diamictite for non sorted to poorly sorted, siliciclastic sedimentary rocks that contain larger particles of any size in a muddy matrix

Thus, there are two kinds of conglomerates: (1) conglomerates with low to moderate amounts of matrix, and (2) conglomerates with abundant matrix (diamictites). Although the term diamictite is often applied to poorly sorted glacial deposits, it may be used for any sedimentary rock having the characteristics described .

If mud or sand matrix is so abundant that the clasts in a rudite or gravelly sediment do not form a supporting framework, the fabric is commonly referred to as **matrix-supported**.

Rudites or gravelly sediments that contain so little matrix that the gravel-size framework grains touch and thus form a supporting framework are called **clast-supported**.

The gravel-size material in **conglomerates** consists mainly of rounded to sub rounded rock fragments (clasts). By contrast, **breccias** are aggregates of angular, gravel-size fragments.

The particles in **breccias** are distinguished from those in conglomerates by their sharp edges. Many breccias, such as volcanic and tectonic breccias, are non sedimentary in origin.

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Composition of conglomerates

1 - Composition of framework clasts

Gravel-size particles are the framework grains of conglomerates. Conglomerates may contain gravel-size pieces of individual minerals such as vein-quartz; however, the framework fraction of most conglomerates consists of rock fragments (clasts). Virtually any kind of igneous, metamorphic, or sedimentary clast may be present in a conglomerate, depending upon source rocks and depositional conditions. Some conglomerates are made up of only the most stable and durable types of clasts, that is, quartzite, chert, or vein-quartz clasts. The term ***oligomict conglomerate*** is often applied to stable conglomerates composed mainly of a single clast type,

as opposed to ***polymict conglomerates***, which contain a mixture of clasts. Polymict conglomerates made up of a mixture of largely unstable or metastable clasts such as basalt, limestone, shale, and phyllite are called **petromict conglomerates (**Polymict conglomerates)**.**

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Some conglomerates that are enriched in quartzose clasts may be first-cycle deposits that formed by erosion of a quartzite, quartz arenite, or chert-nodule limestone source. Others were probably derived from mixed parent-rock sources that included less-stable rock types. Continued recycling of mixed ultrastable and unstable clasts through several generations of conglomerates leads ultimately to selective destruction of the less-stable clasts and concentration of stable, quartzose clasts.

2 - Composition of matrix and cements

The matrix of conglomerates is composed mainly of clay- and sand-size particles. Conglomerate matrix is simply the finer material that fills the interstitial spaces among gravel-size clasts. Any kind of mineral or small rock fragment, can be present as matrix. Thus, the matrix may consist of various kinds of clay minerals and fine micas and/or silt- or sand-size quartz, feldspars, rock fragments, heavy minerals, and so on. The matrix itself may be cemented with quartz, calcite, hematite, clay, or other cements. Together, these cements and matrix materials bind the framework grains of the conglomerates.

Sedimentary structures in conglomerates

Many conglomerates are massive (structure less); however, crude to well-developed planar horizontal or inclined stratification is moderately common. Tabular and trough cross-bedding is also present in some conglomerates, such as fluvial conglomerates; however, cross-bedding is much less common in conglomerates than in sandstones. Conglomerates may be non graded, or they may display normal, inverse, or normal-to-inverse size grading. Other structures include gravel-filled scours and channels, and gravel lenses. Conglomerates may be associated with sandstones that display a much greater variety of sedimentary structures.

classification of conglomerates

1 - General statement

Geologists use a variety of names for conglomerates. Some of these names are based on composition of the clasts (e.g. quartzite conglomerates), others on grain size (e.g. pebble conglomerates), and still others on presumed depositional environment or depositional process (e.g. fluvial conglomerates, debris-flow conglomerates).

2 - Classification by relative clast stability

One way to deal with the composition of conglomerates for the purpose of classification is to place clasts into two groups on the basis of relative clast stability: (1) ultrastable clasts (quartzite, chert, vein quartz), and (2) metastable and unstable clasts (all other clasts).

Thus, on the basis of clast stability, we recognize two kinds of conglomerates. Conglomerates made up of framework grains that consist dominantly of ultrastable clasts (>~90 percent) are quartzose conglomerates. Conglomerates that contain fewer ultrastable clasts are petromict conglomerates. As indicated before the term petromict conglomerate is in common use for conglomerates containing abundant unstable or metastable clasts.

Some ***quartzose conglomerates*** probably originate as a result of intense chemical weathering of source rocks such as chert-nodule limestones. Others form as a result of prolonged transport or multiple recycling of clasts, processes that mechanically eliminate less-durable clasts. By contrast, ***petromict conglomerates*** are more likely to be first-cycle deposits that originate under less-intensive weathering conditions or that undergo less-prolonged transport and abrasion.

3- Classification by clast lithology

For classification purposes, conglomerate clasts can be grouped into three kinds: igneous, metamorphic, and sedimentary. The relative abundance of the different kinds of clasts (e.g. basalt, schist, sandstone) in a conglomerate is established in the field by clast counts. Once composition has been determined, clasts are grouped by genetic type (igneous, metamorphic, sedimentary) as end members of a classification triangle. Thus, all clasts, including ultrastable clasts, are normalized in terms of these three fundamental end members.

Figure below shows how conglomerates can be classified on the basis of these end-member clast types. The classification triangle in the figure is divided into four fields to yield four kinds of conglomerates: **metamorphic** (clast) conglomerates, **igneous** (clast) conglomerates,

sedimentary (clast) conglomerates, and **polymict** conglomerates. The term polymict can be applied to all conglomerates containing clasts of mixed lithology; however, it is used in a formal sense in this classification to denote conglomerates made up of roughly subequal amounts of metamorphic, igneous, and sedimentary clasts. Although this classification is largely descriptive, these conglomerate names obviously have some provenance significance because the terms identify major genetic categories of source rocks from which conglomerates are derived.

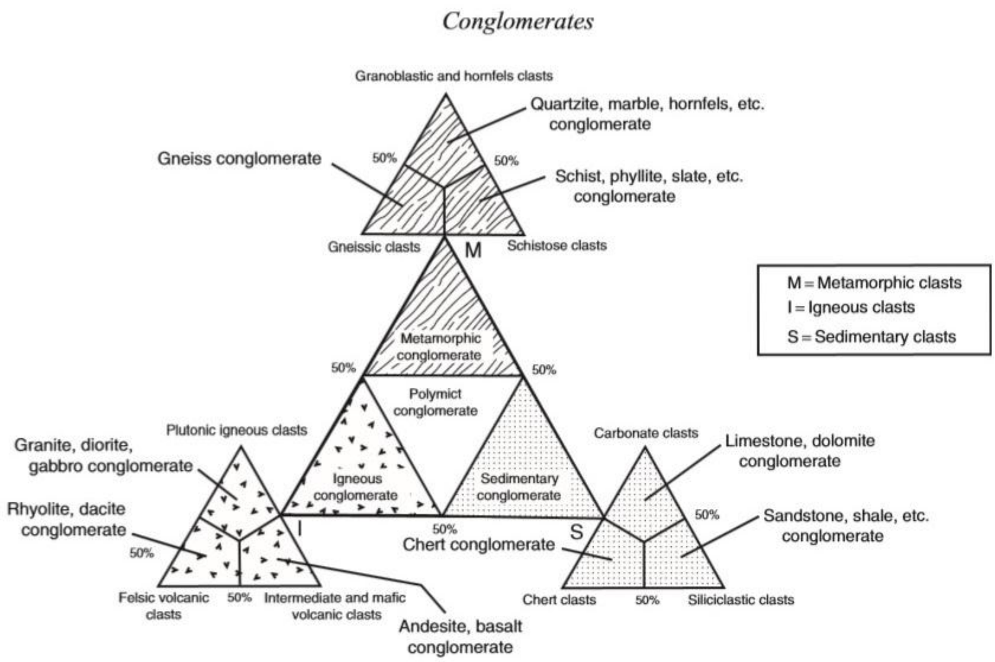

Figure Classification of conglomerates on the basis of clast lithology. Note that conglomerates can be either clast-supported or matrix-supported.

<u>4 - Classification by clast size</u>

Finally, terms for the relative sizes of clasts in a conglomerate can be used as adjectives that are added to appropriate compositional terms, if desired. Thus, we could have a cobble-rich quartzose conglomerate, a boulder-rich petromict conglomerate, and so on.

Pettijohn's (1975) classification is probably the best known of the few published conglomerate classifications.

Conglomerate and Breccias belong to five major categories, The most common kinds are ***epiclastic***, 1 - **extraformational** (***terrigenous gravel***) conglomerates and breccias. These rocks are called extraformational because they are composed of clasts that originated outside the formation itself. They are called **epiclastic** because they are generated by break down of older rocks through the processes of weathering and erosion. Thus, they are formed by the same kinds of processes that create epiclastic sandstones.

Ta b l e ( ) lists the major kinds of conglomerates and breccias, classified on the basis of origin.

Table *Fundamental genetic types of conglomerates and breccias*

Major types	Subtypes	Origin of clasts
Epiclastic conglomerate and breccia	Extraformational conglomerate and breccia	Breakdown of older rocks of any kind through the processes of weathering and erosion; deposition by fluid flows (water, ice) and sediment gravity flows
	Intraformational conglomerate and breccia	Penecontemporaneous fragmentation of weakly consolidated sedimentary beds; deposition by fluid flows and sediment gravity flows
Volcanic breccia	Pyroclastic breccia	Explosive volcanic eruptions, either magmatic or phreatic (steam) eruptions; deposited by airfalls or pyroclastic flows
	Autobreccia	Breakup of viscous, partially congealed lava owing to continued movement of the lava
	Hyaloclastic breccia	Shattering of hot, coherent magma into glassy fragments owing to contact with water, snow, or water-saturated sediment (quench fragmentation)
Cataclastic breccia	Landslide and slump breccia	Breakup of rock owing to tensile stresses and impact during sliding and slumping of rock masses
	Tectonic breccia: fault, fold, crush breccia	Breakage of brittle rock as a result of crustal movements
	Collapse breccia	Breakage of brittle rock owing to collapse into an opening created by solution or other processes
Solution breccia		Insoluble fragments that remain after solution of more soluble material; e.g. chert clasts concentrated by solution of limestone
Meteorite-impact breccia		Shattering of rock owing to meteorite impact

A second group are **Intraformational conglomerates and breccias** are deposits that formed by penecontemporaneous fragmentation of weakly consolidated beds and subsequent redeposition of the resulting fragments within the same general depositional unit. Sedimentary processes, such as storm waves or mass flows, that bring about fragmentation and redeposition of clasts to create intraformational conglomerates and breccias. These intraformational deposits commonly occur as thin units that are generally localized in extent. The fragments in these deposits may be well rounded or angular depending upon the amount of transport and reworking. Very commonly, they are flat or disc-shaped, giving rise to the term **flat-pebble conglomerate.**

Flat-pebble conglomerates characterized by flattened pebbles stacked virtually on edge, owing to strong current activity, are called **edgewise conglomerates**.

Many breccias are generated by non sedimentary processes such as volcanism. Volcanic breccias are formed by primary volcanic processes that may include explosive volcanism, or quench fragmentation of hot magmas that come into contact with water, snow, or water-saturated sediment.

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Less-common breccias are those that form through the processes of cataclasis or collapse (**cataclastic breccias**), Glacial action and resulting **till** and **tillite**, commonly considered with coarse clastics, could be considered cataclastic (the result of earth movement- movement of one rock over another). Solution of soluble rocks such as limestone or salt, leaving insoluble gravel-size residues (**solution breccias**). **Meteorite-impact breccias** are even less common.

The dominant group, are ***epiclastic***, **extraformational** (***terrigenous gravel***) conglomerates and breccias can be divided into two subgroup, gravels collected by water currents have clast-supported framework **(*Orthoconglomerates*).** Those deposited by subaqueous turbidity flows and slides, by glacial ice or other modes of mass transport do not have an intact framework of gravel clasts but display, instead, a dominants matrix of fine grained materials in which the larger clasts are embedded, These have been called **(*Paraconglomerates*)** or **(*Diamictites*)**.

extraformational (*terrigenous gravel*) conglomerates and breccias

<<<<<<(((*Orthoconglomerates*)))>>>>>>

Orthoconglomerates may consist of a single rock type (vein-quartz, for example), because all other debris has been eliminated by weathering or by long transport, such conglomerates have been termed ***Oligomict***. Others with a mixed composition, including many unstable materials (granite, basalt and limestone), are referred to as ***petromict*** (polymict).

Orthoconglomerates divided into two groups :(1-) mature Orthoquartzitic (Oligomictic) conglomerates and (2-) immature petromictic (polymict) conglomerates.

1- Orthoquartizitic (Quartzose, Oligomictic) conglomerates

These conglomerates have a simple composition. Their pebbles are materials very resistant to wear and decomposition, such as metaquartzite, vein-quartz, or chert clasts, are derived from metasedimentary, sedimentary, and some igneous rocks. As suggested by Pettijohn (1975, p. 166), these clasts are a residuum concentrated by destruction of a much larger volume of rock. **Quartzite clasts** are derived

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from metasedimentary sequences containing quartzite beds. Less-stable metasedimentary clasts such as argillite, slate, and schist, originally present in such metasedimentary sequences, must have been destroyed by weathering, erosion, and sediment transport. **Quartz-filled veins** occur broadly scattered through mainly igneous and metamorphic rocks. Concentrations of vein-quartz clasts in quartzose conglomerates implies destruction of large bodies of such primary igneous or metamorphic rock. Likewise, the concentration of **chert clasts** in a conglomerate implies destruction of large volumes of chert-nodule limestone to yield a chert-clast concentrate. Some chert clasts may be derived also by erosion of bedded chert deposits. Such wholesale destruction of rock masses to yield relatively small concentrates of quartzose clasts implies either extremely intensive chemical weathering or vigorous transport that mechanically destroyed less durable clasts. More than one cycle of weathering and transport could be involved. The source rocks that yield quartzose clasts are most likely to occur in recycled orogen or continental block provenances. Because quartzose clasts represent only a small fraction of a much larger original body of rock, the total volume of quartzose conglomerates is commonly small. They tend to occur as scattered pebbles, thin, pebbly layers, or lenses of pebbles in dominantly sandstone units (Pettijohn, 1975, p. 166). They appear to be largely of fluvial, particularly braided-stream, origin, but marine, wave-worked quartzose conglomerates also exist.

2 -Petromict conglomerates

Petromict conglomerates contain significant amounts of metastable rock fragments. Most are polymictic conglomerates, made up of a variety of metastable clasts. They may be derived from many different types of plutonic igneous, volcanic, metamorphic, or sedimentary rock. Conglomerates composed dominantly of plutonic igneous clasts appear to be uncommon, probably because plutonic rocks such as granites tend to disintegrate into sand-size fragments rather than forming larger blocks. Among petromict conglomerates containing significant amounts of sedimentary clasts, clasts of siliciclastic sedimentary rock are generally more common than clasts of carbonate rocks. On the other hand, some conglomerates are composed mainly of carbonate clasts. Owing to their lesser stability compared to quartzose clasts, the clasts of petromict

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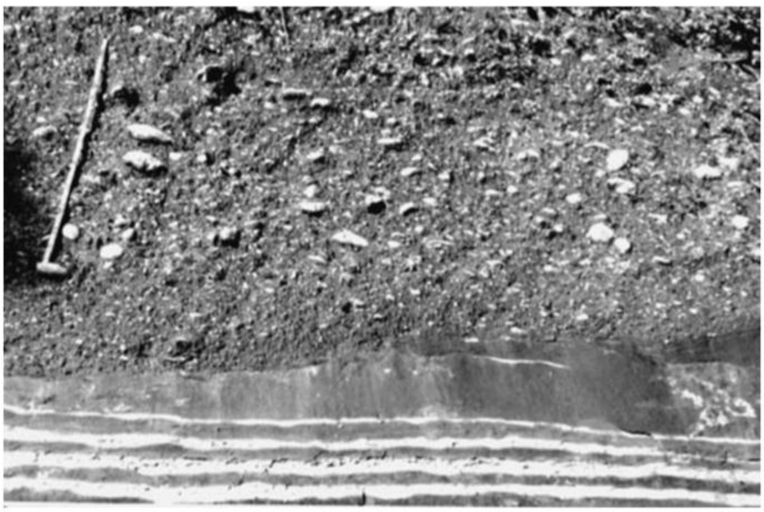
conglomerates are more likely than quartzose clasts to be of first-cycle origin. Nonetheless, the fact that some petromict conglomerates contain clasts of a previous generation of petromict conglomerates shows that some metastable clasts can survive recycling.

The volume of ancient petromict conglomerates is far greater than that of quartzose conglomerates. They may reach thicknesses of thousands of meters. Some conglomerates composed mainly of volcanic clasts form especially thick sequences. The preservation and accumulation of such thick sequences of metastable clasts, particularly clasts of highly soluble limestone or dolomite, imply rapid erosion of sharply elevated high-lands (or areas of active volcanism in the case of volcanic conglomerates). Alternatively, some petromict conglomerates, such as some limestone conglomerates, may have accumulated at lower elevations but under very cold conditions where glacial activity provided the erosion mechanism. In any case, the metastable clasts of petromict conglomerates must have been stripped from source areas before chemical weathering processes could bring about solution or promote disintegration to sand-size particles. Furthermore, they must have been transported only short distances from the source, or they were transported by processes that did not mechanically destroy the clasts. Petromict conglomerates can accumulate in any tectonic provenance (continental block, recycled orogen, or magmatic arc) where the requisite conditions that allow their preservation are met. They are deposited in environments ranging from fluvial through shallow-marine to deep-marine, although the bulk of the truly thick petromict conglomerate bodies are probably non marine.



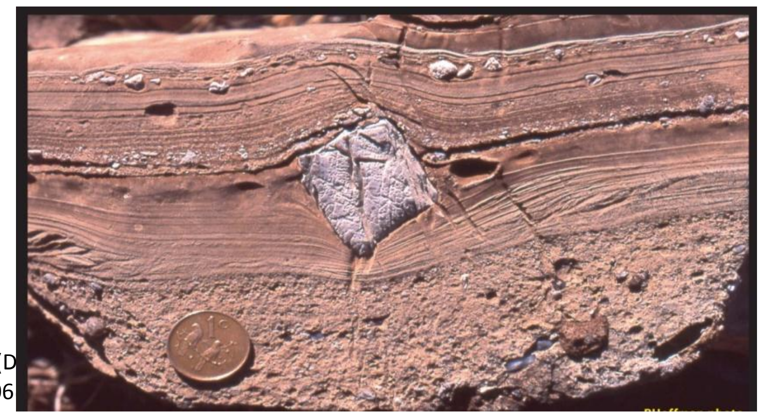
(((*Paraconglomerates* (Conglomeratic Mudstone))))

Conglomerates with more matrix than clasts have been term Paraconglomerates. The pebble form 10% or less of the rock. These are commonly described as conglomerates rather than as mudstone. These rocks are not the products of normal aqueous transports. More recently the term **diamictite** has been proposed for any nonsorted or poorly sorted terrigenous sediment that consist of sand and/or larger particles in a muddy matrix, these are the rocks which folk (1954) would call conglomerate mudstone. Crowell (1957) termed them pebbly mudstone.

The terms Till and Tillite are reserved for pebbly mudstones or boulder clays of glacial origin. Of the two basic types of pebbly mudstone, one has a stratified matrix; the other (Till and Tillite) has an unstratified or structureless matrix.

1 – Laminated Pebbly Mudstone

Laminated pebbly mudstones are very rare rocks, consist of laminated argillites or slate in which occur thinly scattered phenoclasts, some no larger than sand grains others full-sized cobble or boulders.



These conglomeratic laminated argillites were produced by the dropping of pebbles (dropstones) into still bottom water in which the finest silts and muds were accumulating.

2 – Till and Tillite

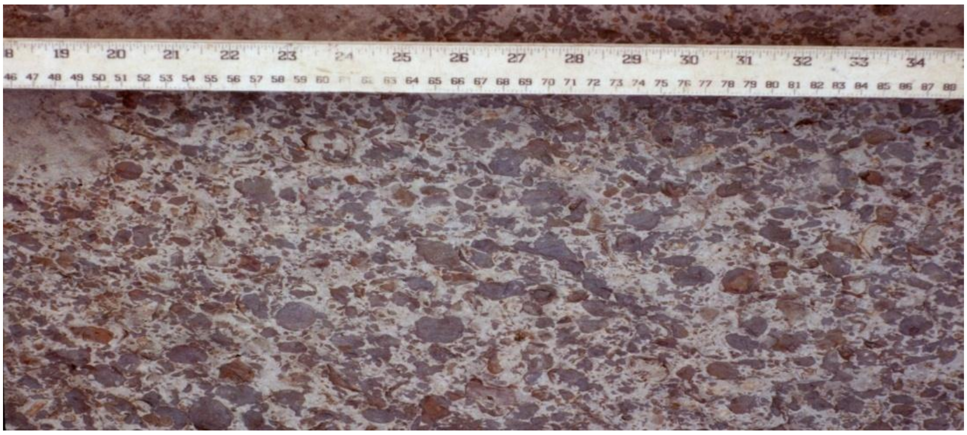
The term Till was applied to stiff , unstratified clays containing angular, subangular and rounded blocks of rock mostly polished and striated. Thus till is a genetic term applied to unstratified deposits of glacial ice.

The term Tillite has been applied to lithified tills.

The term tilloid has been applied to these till-like deposits of doubtful origin.

Intraformational Conglomerates and Breccias

Intraformational conglomerates are composed of clasts of sediments believed to have formed within depositional basins, in contrast to the clasts of extraformational conglomerates that are arrived from outside the depositional basin. Intraformational conglomerates originate by penecontemporaneous deformation of semiconsolidated sediment and redeposition of the fragments fairly close to the site of deformation. Penecontemporaneous breakup of sediment to form clasts may take place subaerially, such as by drying out of mud on a tidal flat, or under water. Subaqueous rip-ups of semiconsolidated muds by tidal currents, storm waves, or sediment–gravity flows are possible causes. In any case, sedimentation is interrupted only a short time during this process. The most common types of fragments found in intraformational conglomerates are siliciclastic mud clasts and lime clasts. The clasts are commonly angular or slightly rounded, suggesting little transport. In some beds, flattend clasts are stacked virtually on edge, apparently owing to unusually strong wave or current agitation, to form what is called **edgewise conglomerates.**



Intraformational conglomerates commonly form thin beds, a few centimeters to a meter in thickness. That may be laterally extensive. Although much less abundance than extraformational conglomerates, they nonetheless occur in rocks of many age. So called flat-pebble conglomerates composed of carbonate or limy siltstone clasts are particularly common in Cambrian-age rocks in various part of north America. Intraformational conglomerates composed of shale rip-up clasts embedded in the basal part of Sandstone units are very common in sedimentary successions deposited by sediment gravity-flow processes.

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