Lithostratigraphic Units
And a Quick Review of Sedimentary Rocks and Processes
North American Stratigraphic Code

A formulation of current views on stratigraphic principles and procedures designed to promote standardized classification and formal nomenclature of rock materials. Most recently updated –2005

Purpose: The North American Stratigraphic Code seeks to describe explicit practices for classifying and naming all formally defined geologic units.

The objective of a system of classification is to promote unambiguous communication in a manner not so restrictive as to inhibit scientific progress. To minimize ambiguity, a code must promote recognition of the distinction between observable features (reproducible data) and inferences or interpretations.
Stratigraphy

The study of layered sequences of sedimentary and/or volcanic rock that conform to the principles of superposition.

A **geologic rock unit** is a naturally occurring body of rock or rock material distinguished from adjoining bodies of rock on the basis of some stated property or properties. Commonly used properties include composition, texture, included fossils, magnetic signature, radioactivity, seismic velocity, and age.

A **lithostratigraphic unit** is a geologic rock unit that conform to the principles of superposition.

**Biostratigraphy** is the branch of stratigraphy that deals with the distribution of fossils in the stratigraphic record and the classification of bodies of rock or rock material into **biostratigraphic units** based on their contained fossils.
The Birth of Stratigraphy
Great Britain

Rock Units vs. Time Units

From A. Hallam
Great Geological Controversies
Oxford Press, 1989

<table>
<thead>
<tr>
<th>Author</th>
<th>1</th>
<th>2</th>
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<th>7</th>
<th>8</th>
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<tbody>
<tr>
<td>SEDGWICK 1855</td>
<td>Silurian</td>
<td>Upper Cambrian</td>
<td>Middle Cambrian</td>
<td>Lower Cambrian</td>
<td></td>
<td></td>
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<tr>
<td>MURCHISON 1859</td>
<td>Upper Silurian</td>
<td>Lower Silurian</td>
<td>(Primordial Silurian)</td>
<td>Cambrian</td>
<td></td>
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<tr>
<td>GEOLOGICAL SURVEY 1866</td>
<td>Upper Silurian</td>
<td>Lower Silurian</td>
<td>Cambrian</td>
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<td>JUKES 1857</td>
<td>Upper Silurian</td>
<td>Cambro-Silurian</td>
<td>Cambrian</td>
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<td></td>
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<tr>
<td>PHILLIPS 1855</td>
<td>Upper Silurian</td>
<td>Lower Silurian</td>
<td>Cambrian</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>LYELL 1865</td>
<td>Upper Silurian</td>
<td>Middle Silurian</td>
<td>Lower Silurian</td>
<td>Cambrian</td>
<td></td>
<td></td>
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<tr>
<td>LYELL 1871</td>
<td>Upper Silurian</td>
<td>Lower Silurian</td>
<td>Cambrian</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>HICKS 1874</td>
<td>Upper Silurian</td>
<td>Middle Silurian</td>
<td>Lower Silurian</td>
<td>Cambrian</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>LAPWORTH 1879</td>
<td>Silurian</td>
<td>Ordovician</td>
<td>Cambrian</td>
<td></td>
<td></td>
<td></td>
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<table>
<thead>
<tr>
<th>Principal formations</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ludlow</td>
<td></td>
<td>Wenlock</td>
<td>Upper Llandovery</td>
<td>May Hill</td>
<td>Lower Llandovery</td>
<td>Bala = Cardiac Sandstone</td>
<td>Llandilo</td>
<td>Arenig</td>
<td>Tremadoc</td>
</tr>
</tbody>
</table>
Categories of Geologic Rock Units

**Units based on content or physical limits**

- Lithostratigraphic
- Lithodemic
- Magnetopolarity
- Biostratigraphic
- Pedostratigraphic
- Allostratigraphic

A **lithodemic unit** is a defined body of predominantly intrusive, highly deformed, and/or highly metamorphosed rock, distinguished and delimited on the basis of rock characteristics. In contrast to lithostratigraphic units, a lithodemic unit generally does not conform to the Law of Superposition.
Classes of Geologic Units

*Units based on content or physical limits*

Lithostratigraphic

Lithodemic

**Magnetopolarity** – alternating normal and reversed polarity

Biostratigraphic

Pedostratigraphic

Allostratigraphic

A *magnetostratigraphic unit* is a body of rock unified by specified remanent-magnetic properties and is distinct from underlying and overlying magnetostratigraphic units having different magnetic properties.
Classes of Geologic Units

*Units based on content or physical limits*

Lithostratigraphic

Lithodemic

Magnetopolarity

Biostratigraphic – based on the principles of faunal succession and superposition

Pedostratigraphic

Allostratigraphic

A **biostratigraphic unit** is a body of rock that is defined or characterized by its fossil content.
Classes of Geologic Units

*Units based on content or physical limits*

Lithostratigraphic

Lithodemic

Magnetopolarity

Biostratigraphic

**Pedostratigraphic** - Soil horizons (regolith)

Allostratigraphic

A *pedostratigraphic unit* is a body of rock that consists of one or more pedologic horizons
An allostratigraphic unit is a mappable body of rock that is defined and identified on the basis of its bounding discontinuities.
Classes of Geologic Time Units

A *chronostratigraphic unit* is a body of rock established to serve as the material reference for all rocks formed during the same span of time. Example: Devonian System.

A *geochronologic unit* is a division of time distinguished on the basis of the rock record preserved in a chronostratigraphic unit. Example: Devonian Period.
### Subdivisions of Geologic Units

<table>
<thead>
<tr>
<th>Lithostratigraphic</th>
<th>Lithodemic</th>
<th>Magnetopolarity</th>
<th>Biostratigraphic</th>
<th>Pedostratigraphic</th>
<th>Allostratigraphic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supergroup</td>
<td>Supersuite</td>
<td>Polarity Superzone</td>
<td></td>
<td></td>
<td>Allogroup</td>
</tr>
<tr>
<td>Group</td>
<td>Suite</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formation</td>
<td>Lithodeme</td>
<td>Polarity Zone</td>
<td>Biozone (Range, Interval, Linneage, Assemblage or Abundance)</td>
<td>Geosol</td>
<td>Alloformation</td>
</tr>
<tr>
<td>Member (or Lens, or Tongue)</td>
<td>Polarity Subzone</td>
<td>Subbiozone</td>
<td></td>
<td></td>
<td>Allomember</td>
</tr>
<tr>
<td>Bed(s) or Flow(s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### IIA. Material Categories Used to Define Temporal Spans

<table>
<thead>
<tr>
<th>Chronostratigraphic</th>
<th>Polarity Chronostratigraphic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eonothem</td>
<td>Polarity Superchronozone</td>
</tr>
<tr>
<td>Era (Supersystem)</td>
<td></td>
</tr>
<tr>
<td>System (Subsystem)</td>
<td>Polarity Chronozone</td>
</tr>
<tr>
<td>Series</td>
<td></td>
</tr>
<tr>
<td>Stage (Substage)</td>
<td>Polarity Subchronozone</td>
</tr>
<tr>
<td>Chronozone</td>
<td></td>
</tr>
</tbody>
</table>

#### IIB. Non-Material Categories Related to Geologic Age

<table>
<thead>
<tr>
<th>Geochronologic</th>
<th>Polarity Chronologic</th>
<th>Diachronic</th>
<th>Geochronometric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eon</td>
<td>Polarity Superchron</td>
<td>Episode</td>
<td>Eon</td>
</tr>
<tr>
<td>Era (Superperiod)</td>
<td>Polarity Chron</td>
<td>Phase</td>
<td>Era (Superperiod)</td>
</tr>
<tr>
<td>Period (Subperiod)</td>
<td>Polarity Subchron</td>
<td>Span</td>
<td>Period (Subperiod)</td>
</tr>
<tr>
<td>Epoch</td>
<td></td>
<td>Cline</td>
<td>Epoch</td>
</tr>
<tr>
<td>Age (Substage)</td>
<td>Polarity Subchron</td>
<td></td>
<td>Age (Substage)</td>
</tr>
<tr>
<td>Chron</td>
<td></td>
<td></td>
<td>Chron</td>
</tr>
</tbody>
</table>

From NASC, 2005
A lithostratigraphic unit is a defined body of sedimentary, extrusive igneous, metasedimentary, or metavolcanic strata which is distinguished and delimited on the basis of lithic characteristics and stratigraphic position. A lithostratigraphic unit generally conforms to the Law of Superposition and commonly is stratified and tabular in form.

**Supergroup.** A supergroup is a formal assemblage of related or superposed groups, or of groups and formations. Such units have proved useful in regional and provincial syntheses. Supergroups should be named only where their recognition serves a clear purpose.

**Group.** A group is the lithostratigraphic unit next higher in rank to formation; a group may consist entirely of named formations, or alternatively, need not be composed entirely of named formations.

**Formation.** The formation is the fundamental unit in lithostratigraphic classification. A formation is a body of rock identified by lithic characteristics and stratigraphic position; it is prevailing but not necessarily tabular and is mappable at the Earth's surface or traceable in the subsurface.

**Member.** A member is the formal lithostratigraphic unit next in rank below a formation and is always a part of some formation. It is recognized as a named entity within a formation because it possesses characteristics distinguishing it from adjacent parts of the formation. A formation need not be divided into members unless a useful purpose is served by doing so. Some formations may be divided completely into members; others may have only certain parts designated as members; still others may have no members.

**Bed(s).** A bed, or beds, is the smallest formal lithostratigraphic unit of sedimentary rocks.

**Flow.** A flow is the smallest formal lithostratigraphic unit of volcanic flow rocks. A flow is a discrete, extrusive, volcanic body distinguishable by texture, composition, order of superposition, paleomagnetism, or other objective criteria.

From NASC, 2005
Boundaries of lithostratigraphic units are placed at positions of lithic change. Boundaries are placed at distinct contacts or may be selected at some arbitrary level within zones of gradation. Both vertical and lateral boundaries are based on the lithic criteria that provide the greatest unity and utility.
Correlation is a procedure for demonstrating correspondence between geographically separated parts of a geologic unit. The term is a general one having diverse meanings in different disciplines. Demonstration of temporal correspondence is one of the most important objectives of stratigraphy.
Formal and Informal Lithostratigraphic Units

Formally named units are those that are named in accordance with an established scheme of classification; the fact of formality is conveyed by capitalization of the initial letter of the rank or unit term (for example, Morrison Formation). Informal units, whose unit terms are ordinary nouns, are not protected by the stability provided by proper formalization and recommended classification procedures.

Requirements for Formally Named Geologic Units. Naming, establishing, revising, redefining, and abandoning formal geologic units require publication in a recognized scientific medium of a comprehensive statement which includes:

- intent to designate or modify a formal unit;
- designation of category and rank of unit;
- selection and derivation of name;
- specification of stratotype (where applicable);
- description of unit;
- definition of boundaries;
- historical background;
- dimensions, shape, and other regional aspects;
- geologic age;
- correlations; and possibly
- genesis (where applicable).

From NASC, 2005
Quick Review of Sedimentary Rocks and Processes

**SEDIMENTARY ROCK** – Compacted and cemented accumulations of sediment, which can be of two general types – clastic and chemical.

**Clastic** – composed of fragments of pre-existing rock that have been weathered, eroded and transported by wind, water, ice, or mass movement to a site of deposition.

**Chemical** – composed of minerals precipitated from water (usually ocean water) due to evaporation or to the metabolic action of organisms (biogenic).
Clastic Sedimentary Rocks
Composed of fragments of pre-existing rock that have been weathered,...

Mechanical Weathering
Clastic Sedimentary Rocks
Composed of fragments of pre-existing rock that have been weathered,...

Chemical Weathering
Clastic Sedimentary Rocks
Composed of fragments of pre-existing rock that have been weathered, **transported**...

*by Ice (Glaciers)*
Clastic Sedimentary Rocks

Composed of fragments of pre-existing rock that have been weathered, transported,...

by Water
Clastic Sedimentary Rocks

Composed of fragments of pre-existing rock that have been weathered, eroded, and transported ... to a site of deposition.
Grain Size – particle size reflects **energy** (velocity) of the transport and depositional system.

**Distinguishing Characteristics of Clastic Sediments:**

<table>
<thead>
<tr>
<th>Size Range (millimeters)</th>
<th>Particle Name</th>
<th>Common Sediment Name</th>
<th>Detrital Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 256</td>
<td>Boulder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>64–256</td>
<td>Cobble</td>
<td>Gravel</td>
<td>Conglomerate or breccia</td>
</tr>
<tr>
<td>4–64</td>
<td>Pebble</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2–4</td>
<td>Granule</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/16–2</td>
<td>Sand</td>
<td>Sand</td>
<td>Sandstone</td>
</tr>
<tr>
<td>1/256–1/16</td>
<td>Silt</td>
<td>Mud</td>
<td>Shale or mudstone</td>
</tr>
<tr>
<td>&lt;1/256</td>
<td>Clay</td>
<td></td>
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</tbody>
</table>
Distinguishing Characteristics of Clastic Sediments

**Sorting** – Well-sorted sediment indicates prolonged reworking by wind or water; poorly sorted sediment may indicate rapid deposition, or deposition by ice or mass movement.

Angularity/Roundness and Shape – Well rounded sediment also indicate prolonged reworking by transporting agent; the shape of grains often indicates the transport system, but also may be related to the type of mineral or rock fragment.
Distinguishing Characteristics of Clastic Sediments

**Compositional Maturity** – mature sediment contains only Quartz and Clay and reflects prolonged weathering of the source rocks. Immature sediment contains other minerals or rock fragments that may imply mostly mechanical weathering in the source region and short transport distance.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Residual Products</th>
<th>Material in Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>Quartz grains</td>
<td>Silica</td>
</tr>
<tr>
<td>Feldspars</td>
<td>Clay minerals</td>
<td>Silica, K⁺, Na⁺, Ca²⁺</td>
</tr>
<tr>
<td>Amphibole</td>
<td>Clay minerals</td>
<td>Silica, Ca²⁺, Mg²⁺</td>
</tr>
<tr>
<td>(hornblende)</td>
<td>Limonite</td>
<td></td>
</tr>
<tr>
<td>Olivine</td>
<td>Limonite</td>
<td>Silica, Mg²⁺</td>
</tr>
<tr>
<td></td>
<td>Hematite</td>
<td></td>
</tr>
</tbody>
</table>
### Distinguishing Characteristics of Clastic Sediments

**Bedding/Stratification** – Sediments transported by water and wind are typically bedded (or stratified) due to fluctuations in the velocity of transport and sediment load. **Graded bedding** is a gradual change from coarse particles at the base to fine particles at the top of a bed that reflects a gradual decrease in the energy of the depositional environment. **Cross-bedding** forms by dune migration in fluvial (stream), marine, or eolian environments. Sediment transported by ice or mass movement are typically unbedded (massive).
- **MUDSTONE/SHALE** – Well-sorted, mature, clay-sized particles; generally implies deposition into quiet water.

- **SANDSTONE** – Well-sorted, mature, commonly bedded, sand-sized particles typically transported by wind or moderate water movement (e.g. rivers, beaches).

- **GREYWACKE** – Moderately sorted, immature, clay-to-sand-sized particles commonly showing graded bedding. Commonly deposited in deep waters off mountainous coasts.

- **CONGLOMERATE** – Poorly sorted, immature, clay to boulder-sized particles transported only a short distance from their source and typically deposited by fast moving water.

- **TILL** – Very poorly sorted, clay to boulder-sized particles; non-bedded; deposited from glaciers.
Chemical Sedimentary Rocks

composed of minerals precipitated from water (usually ocean water) due to evaporation or to the metabolic action of organisms (biogenic)

- **IRON–FORMATION** – Iron oxide minerals, usually magnetite (taconite ore) or hematite (natural ore), interlayered with chert (microcrystalline quartz) and clay minerals. Common chemical sedimentary rock biogenically formed in shallow marine environments older than about 1.8 billion years.

- **LIMESTONE** – Calcium carbonate (calcite) typically composed of abundant marine fossils. Most common type of chemical sediment forming today by biogenic processing of seawater. Dolomite (or dolostone) is created by replacement of calcium by magnesium after shallow burial of limestone. Forms in tropical shallow marine environments.

- **EVAPORITE DEPOSITS** (Gypsum, Halite, Anhydrite) – mineral precipitated from saline water in arid environments with high evaporation rates (e.g., playa lakes)

- **PEAT/COAL** – Carbonaceous material created by the accumulation, compaction and heating of organic matter. Forms in temperate to tropical, low energy, terrestrial environments (lagoons, floodplains).
Environments of Chemical Sedimentation

- Evaporites
- Coal
- Limestone