Siliciclastic sedimentary rocks

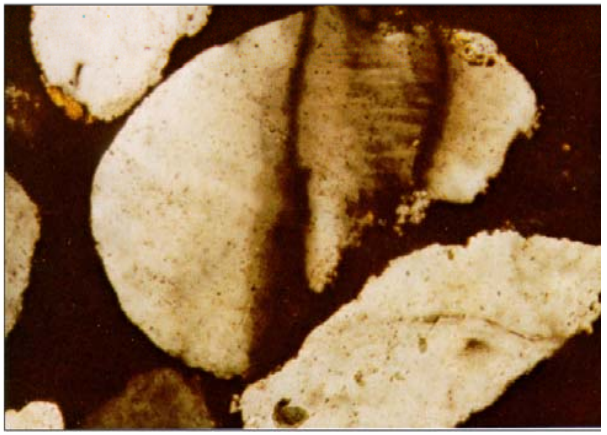
Conglomerates, sandstones, and shales

Sandstones

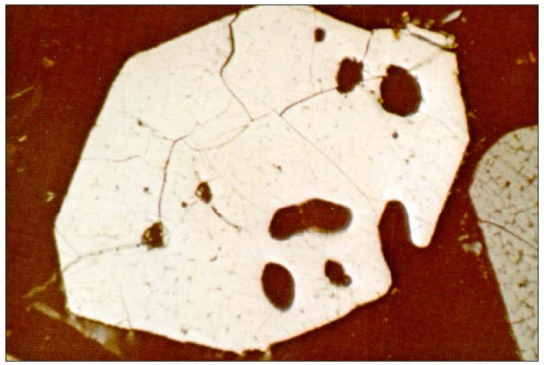
- 20-25 % of all sedimentary rocks
- Silicate grains ranging 1/16 – 2 mm
  - Framework fraction
- Cement and very fine size material (< 0.03 mm)
  - Matrix

Framework mineralogy - Quartz

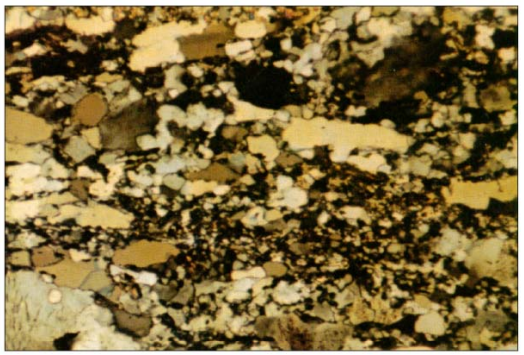
- Dominant mineral in most sandstones
- Can survive multiple recycling
- Single grains
- Composite grains
- Optical properties
  - Used to distinguish between different source rocks



Single grain, undulatory extinction (metamorphic source and igneous)



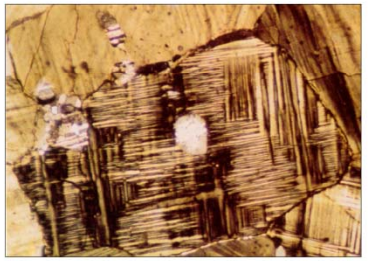
Volcanic Quartz grain



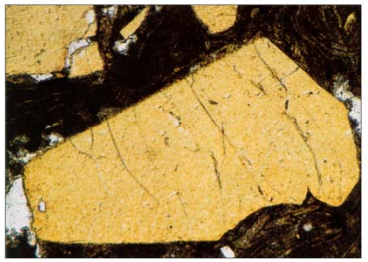
Composite grain (high-grade metamorphic)

Framework mineralogy - Feldspars

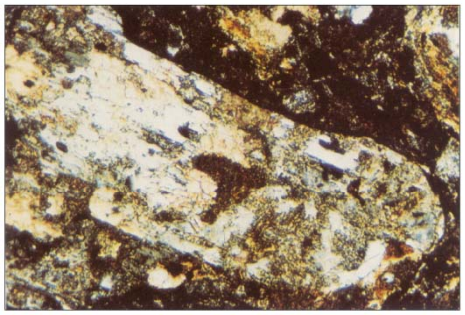
- 10-20% of the framework grains
  - Alkali feldspars
  - Plagioclase feldspars
- Optical properties
  - Twinning
- Staining techniques
  - Help identify untwinned K-feldspars
- Less stable than quartz
  - Chemical weathering
  - Mechanical weathering (cleavage)



Microcline



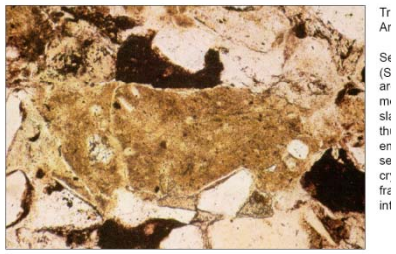
Stained sanidine



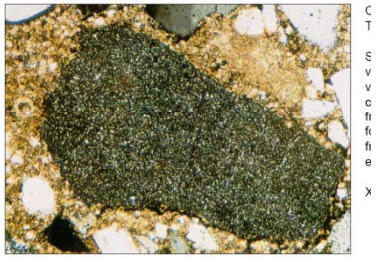
Altered plagioclase

Framework mineralogy – Rock fragments

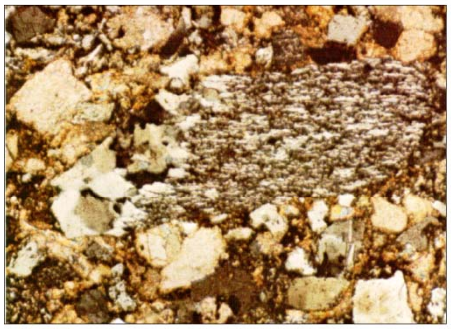
- 15-20% of the average framework (highly variable)
- Volcanic rocks (abundant)
- Slate, schist, quartzite
- Shale (less abundant)
- Detrital carbonates (also less common)
- Reliable indicators of source rock types



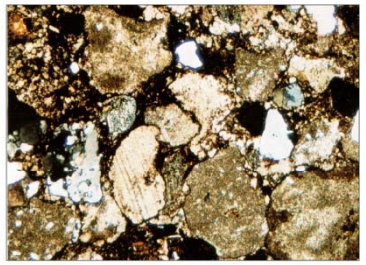
Shale fragment



Chert



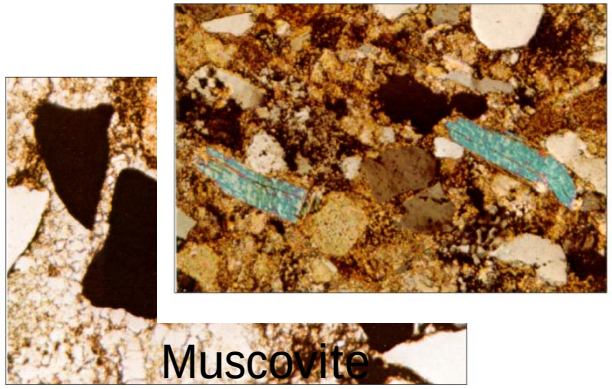
Metamorphic rock fragment



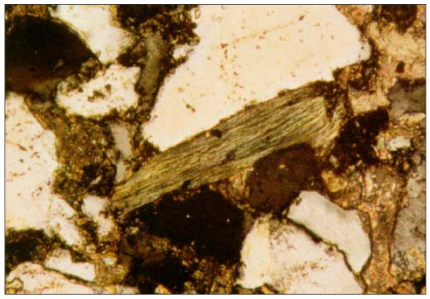
Carbonate rock fragments

Framework mineralogy – Acc. Mx

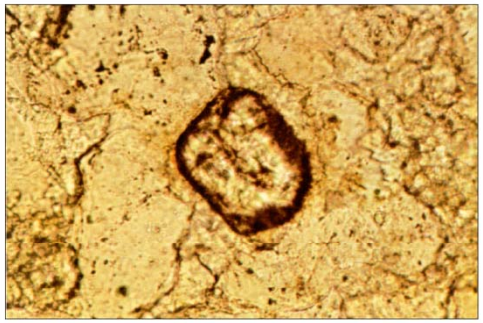
- 1-2 % and less
  - Micas
  - Heavy minerals
    - Zircon, rutile, pyroxene, etc.
    - Useful indicators of source rocks



Muscovite



Chlorite

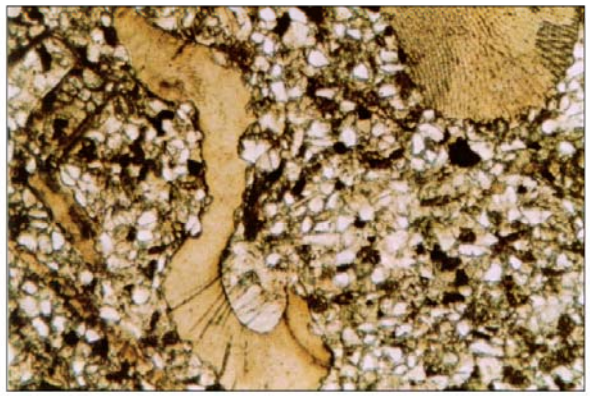


Zircon

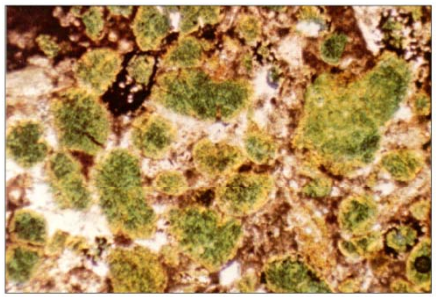
Magnetite

Framework mineralogy – other detrital components

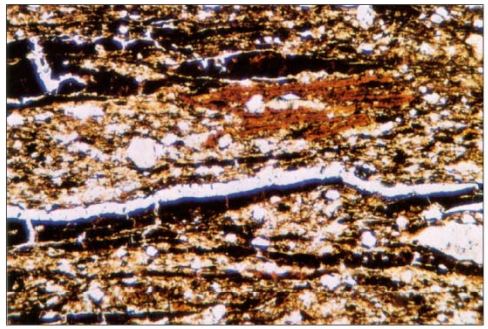
- Fossil fragments, ooids and peloids intraclasts
  - Skeletal phosphate
- Detrital glauconite
- Disseminated organic matter



Trilobite and crinoid fragments



Glauconite

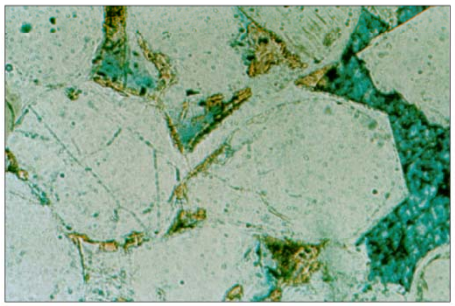


Organic matter

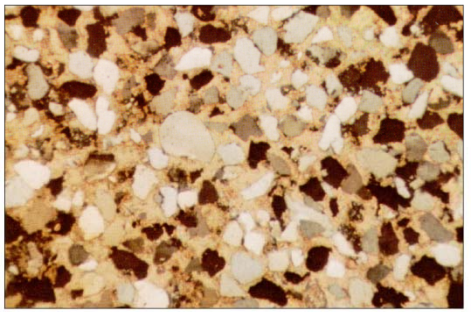
Conodont elements

Mineral cements

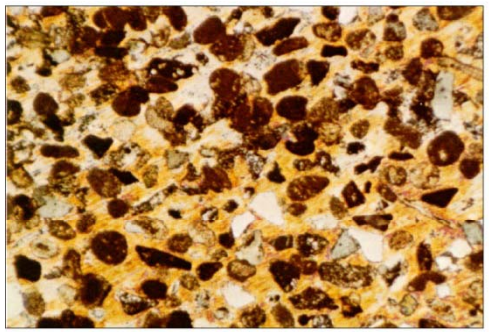
- Cementing material
  - Silicate cement (quartz)
    - Overgrowths
  - Carbonate cement (calcite, dolomite)
  - Iron oxide minerals (hematite)
  - Gypsum
  - Clay minerals (chlorite)
  - Zeolites



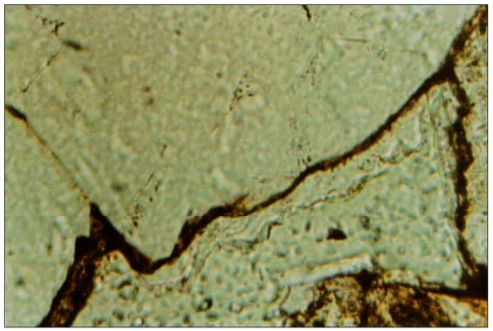
Quartz overgrowth



Calcite cement



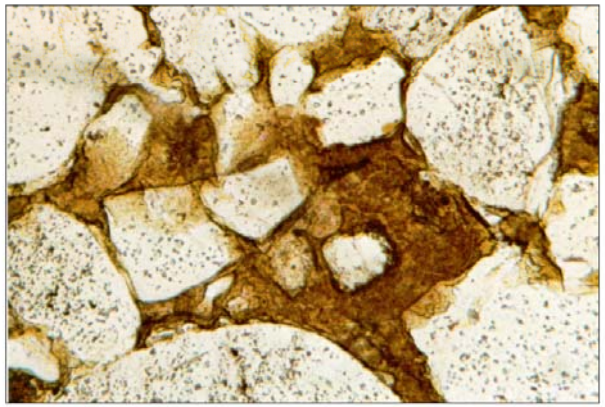
Gypsum cement



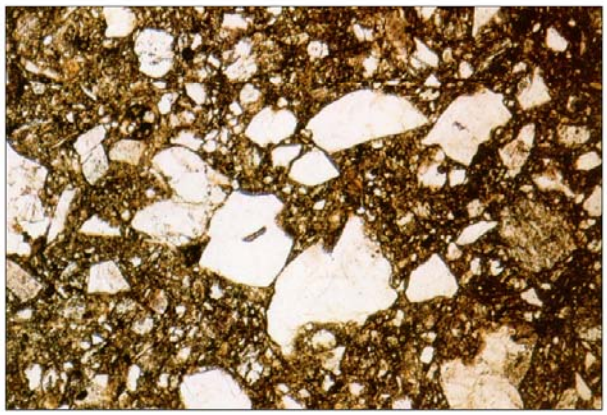
Hematite cemented sandstone

Matrix minerals

- Grains < 0.03 mm filling interstitial spaces
  - Micas, Quartz, feldspars, **clay minerals**



Interstitial clay minerals



Primary (detrital) clay matrix

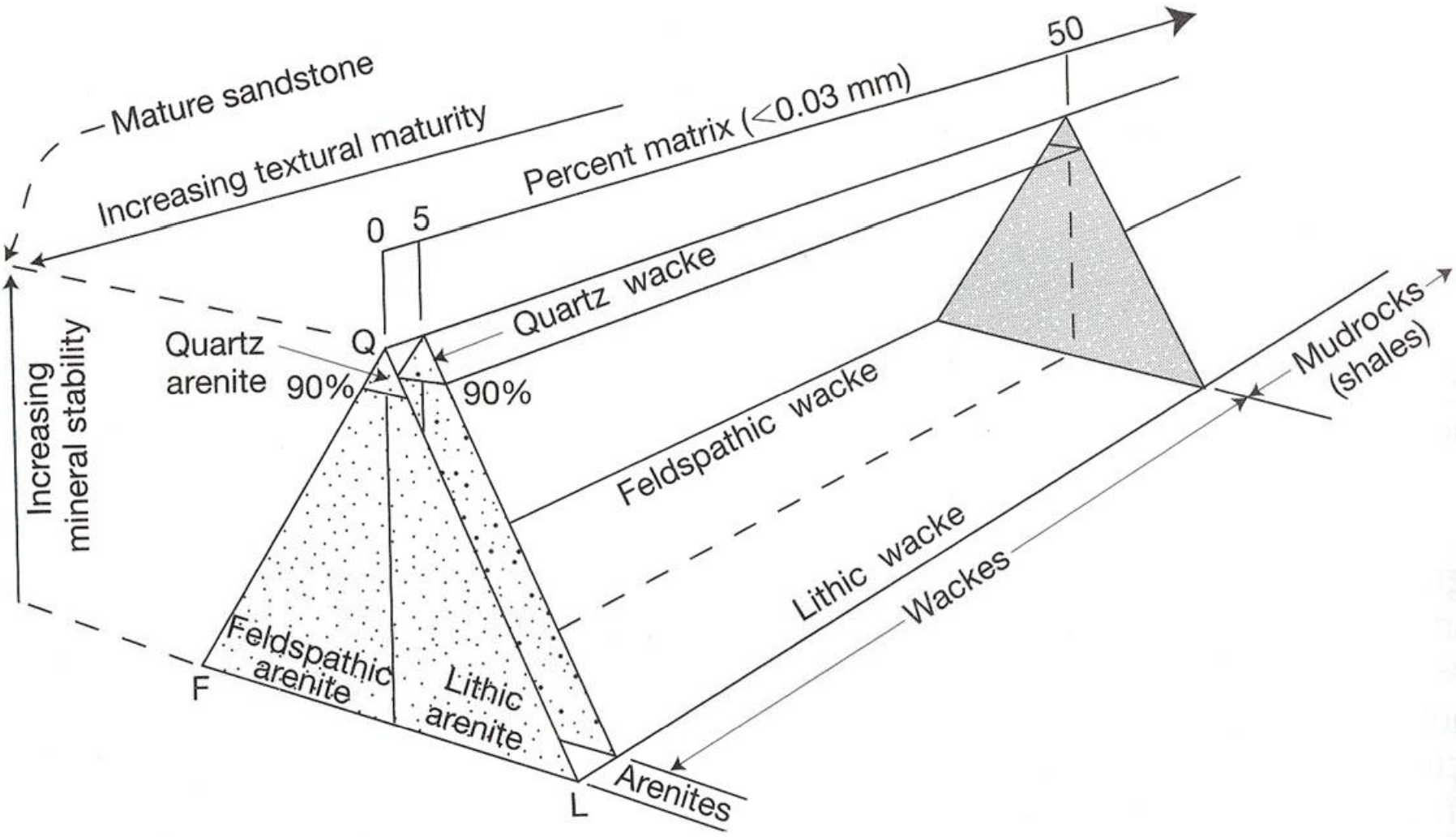
Chemical composition

- Parent rock composition
- Chemical changes (weathering and diagenesis)
  - SiO_2 and Al_2O_3 enrichment
    - Resistance to weathering
  - Depletion in Fe, Mg, Ca, Na, K
    - Dissolved constituents in rivers
  - Function of the mineralogy of the framework grains and type of matrix (presence or absence of clay mx)

Classifications of sandstones

- Framework mineralogy
  - Relative abundance of matrix
- Over 50 different classifications!!
- Triangular diagrams (QFR or QFL plots)

QFL plot and percent matrix



Sandstone maturity

- Compositional maturity
  - Relative abundance of stable and unstable minerals
- Textural maturity
  - Relative abundance of matrix
  - Degree of rounding and sorting
- Reflect weathering processes in the source area, the degree of sediment transport and reworking
  - May be affected by diagenetic processes

Quartz arenites

- > 90% siliceous grains
- White or light gray
- Well lithified
  - Silica or carbonate cement
  - But some are porous and friable
- Stable cratonic environments
  - Eolian, beach, shelf
- Interbedded with shallow-water carbonates
- Mature to supermature
- Crossbeds are common
  - Ripples moderately common
- Fossils are rare
  - Trace fossils can be locally abundant
- First-cycle = intense weathering, long transport, intensive reworking in the "surf" zone
- Most are polycyclic
- Quartz arenites are common rocks

Potsdam sandstone

Cairnside Formation (St. Lawrence Lowlands)

Feldspathic arenites - Arkoses

- < 90% quartz
- More feldspar than unstable rock fragments
- Minor amounts of other Mx
- Commonly submature to immature (
- No characteristic structure
- May contain fossils
- Cratonic and stable shelf settings
- Most are derived from granitic-type
- Cold arid climates
- Or high-relief and rapid erosion
- Do not survive recycling well

Colorado Front Range

Carboniferous (Pennsylvanian age)

Feldspar-rich sandstone : arkose
Proximal to source

Old Red sandstone

Iron-oxide cement

Scotland

Silurian – Devonian. Erosion of a mountain belt, transport and deposition in the tropics south of the Equator in a semi-arid climate

Lithic arenites

- High content of unstable rock fragments
- Many are poorly sorted
- Substantial amount of matrix
  - Immature to submature (lithic wackes)
- Small fluvial units
- Extensive marine turbidite units
- Often derived from high-relief source areas
  - Alluvial fans
  - Marine foreland basins

Examples

Penn. Pottsville Frm
(central Appalachians)

Miss. Pocono Frm
(central Appalachians)

Other sandstones

- Hybrid rocks…
  - Glauconitic sandstones
  - Phosphatic sandstones
  - Calcarenaceous sandstones

Conglomerates and breccias

- At least 30% of gravel-size (> 2mm) particles
  - Breccias = angular fragments
- Closely related to sandstones
  - Similar structures (e.g. tabular and trough cross-beds, graded bedding)

Matrix and cement of conglomerates

- Matrix is common
  - Sand- or mud-size grains
    - Quartz, feldspars, rock fragments
    - Heavy minerals
    - Clay minerals
- Cement
  - Quartz, calcite, hematite, clay, …

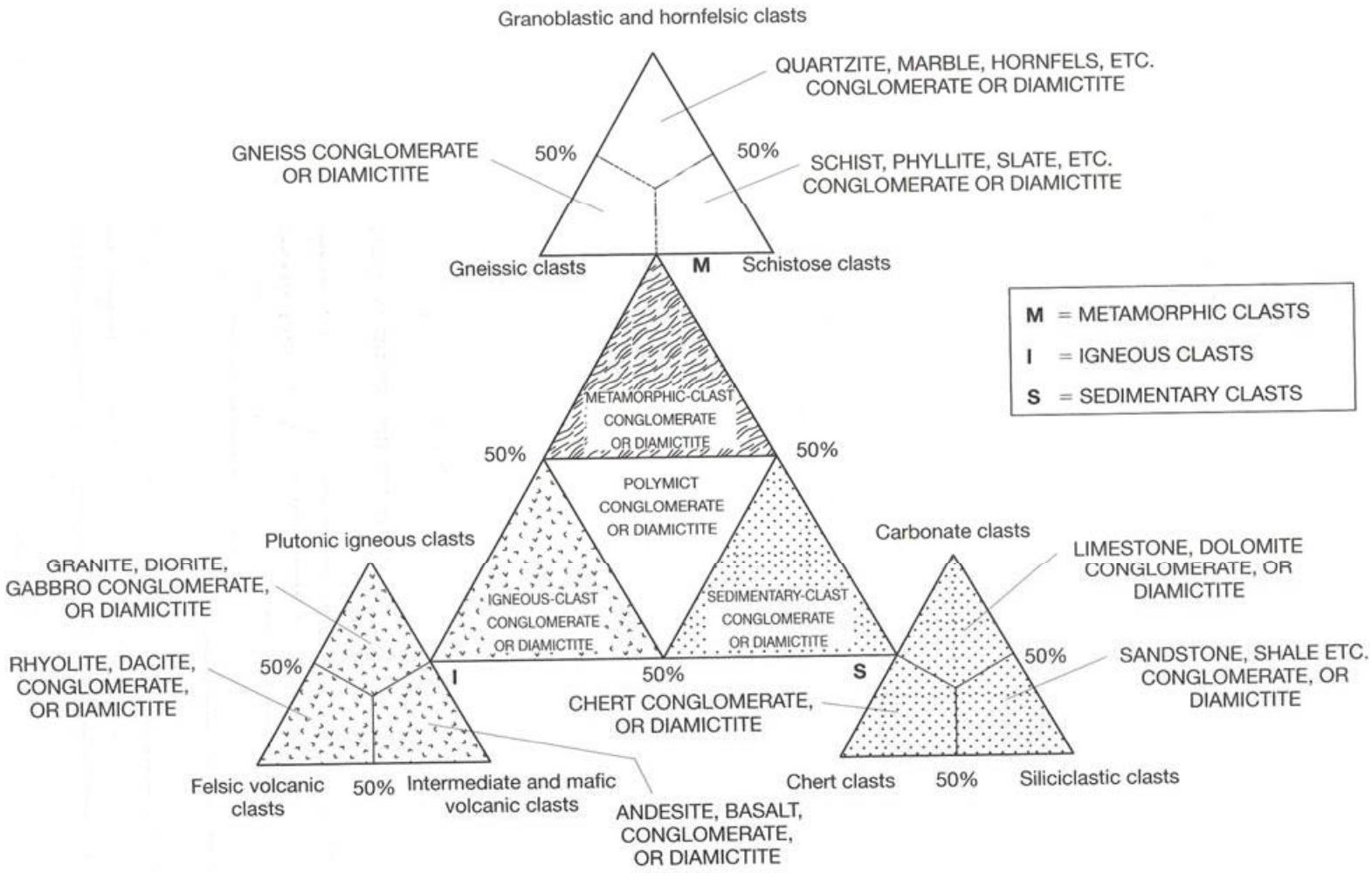
Classification

- Epiclastic conglomerates
  - Extraformational
  - Intraformational (involves reworking of weakly consolidated sedimentary beds)
- Clast-supported conglomerates
- Matrix-supported conglomerates
  - Diamictites
- Further subdivision
  - Clast stability
  - Clast lithology

Type, composition, origin

- Quartzose (Oligomict) conglomerates
  - Derived from rocks containing quartzite beds, or quartz veins, or chert beds
  - Common but tend to occur as thin layers in sandstone units
  - Most appear to be fluvial in origin (braided streams)
  - Also littoral (beach) environment
- Polymict and petromict conglomerates
  - Various lithologies; petromict contain metastable clasts
  - May reach great thicknesses (thousands of meters)
  - Rapid erosion of highlands
  - Fluid-flow and sediment gravity-flow processes
- Intraformational conglomerates
  - Clasts from within the depositional basin
  - Deformation structures, fragments of deformed sediments (e.g. mud and lime clasts)
  - Sediment rip-ups by tidal currents, storms, etc.

Clast lithology and fabric support



Breccias

Breccias

- Volcanic breccia
    - Pyroclastic (explosive eruptions; deposited by air-falls or pyroclastic flows)
    - Autobreccia (breakup of partially solidified lava)
    - Hyaloclastic (shattering of hot, coherent magma into fragments owing to contact with water or snow)
- Cataclastic breccia
    - Landslide or slump breccia
    - Tectonic breccia (breakage of rock due to tectonic movements)
    - Collapse breccia (e.g. in karst environments)
- Solution breccia (remaining insoluble fragments)
- Meteorite impact breccia

Shales (mudrocks)

- Fine-grained siliciclastic rocks (>50% grains 62 microns)
- Abundant in sedimentary successions (50%)
- Composed of clay minerals, quartz and feldspars (detrital)
  - Carbonates, sulfides, iron oxides, heavy minerals, and organic carbon

Chemical composition

- Tend to contain less SiO_2 than do sandstones
- Al_2O_3 (clay minerals, feldspars) is more abundant
- Fe is from hematite, goethite, and biotite
- K_2O, MgO, and Na are mainly related to clay minerals
- Ca is from plagioclase and carbonates

Classification of shales

- Commonly based on:
  - Silt vs. clay content
  - hardness/induration
  - Presence/absence of fissile lamination
- Few are based on the mineral composition

Classification of shales

Table 5.7 Classification of shales and siltstone (>50% grains <0.062 mm)

	Percentage clay-size constituents	0–32	33–65	66–100
	Field adjective	Gritty	Loamy	Fat or slick
NONINDURATED	Beds >10 mm	Bedded silt	Bedded mud	Bedded claymud
	Laminae <10 mm	Laminated silt	Laminated mud	Laminated claymud
INDURATED	Beds >10 mm	Bedded siltstone	Mudstone	Claystone
	Laminae <10 mm	Laminated siltstone	Mudshale	Clayshale

Origin and occurrence

- Marine environments (below the storm wave base)
- Also in lakes..., lagoons, tidal-flats...
- Most abundant type of sed. rock
- Interbedded with sandstones or limestones
  - Units = few mm to several meters
  - Laterally extensive (marine)