

Textures of Ore Deposits

Importance of studying textures

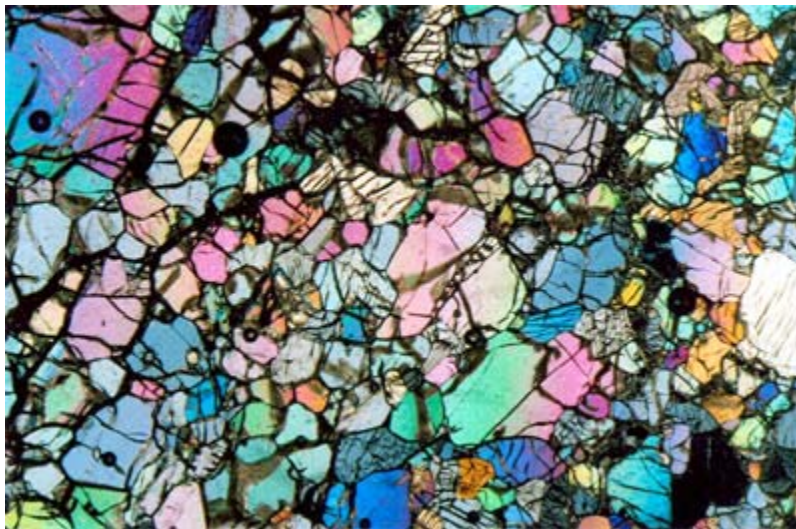
Textural identification and interpretation for ore deposits and associated gangue minerals are tools necessary for understanding the processes involved in the genesis of these deposits, which in turn is very important for prospecting for other similar economic bodies. Specifically, textural studies are useful for:

- 1- Understanding the timing of formation of the ore minerals relative to the host rocks and their structures
- 2- Determining the sequence of events or depositional history within an ore body
- 3- Determining the rates of cooling or of ore mineral accumulation (in some cases).
- 4- Identifying the equilibrium mineral assemblages, which in turn are necessary for understanding phase relations and the correct interpretation of geothermometric results.

Textures of economic ore deposits

I- Magmatic ores:

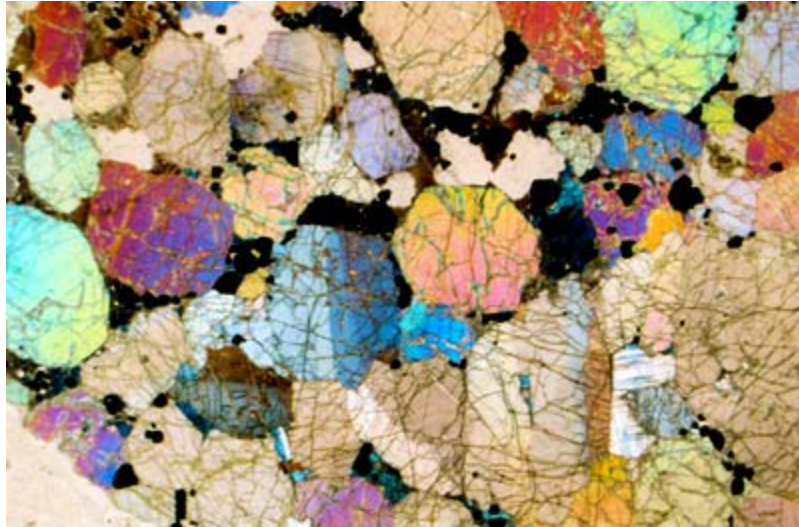
- 1- *Cumulus textures*: result from the settling of an ore deposit from a crystallizing magma. The most common example is chromite which occurs as a cumulus phase relative to pyroxenes.



Granoblastic texture with cumulate olivine and **chromite**

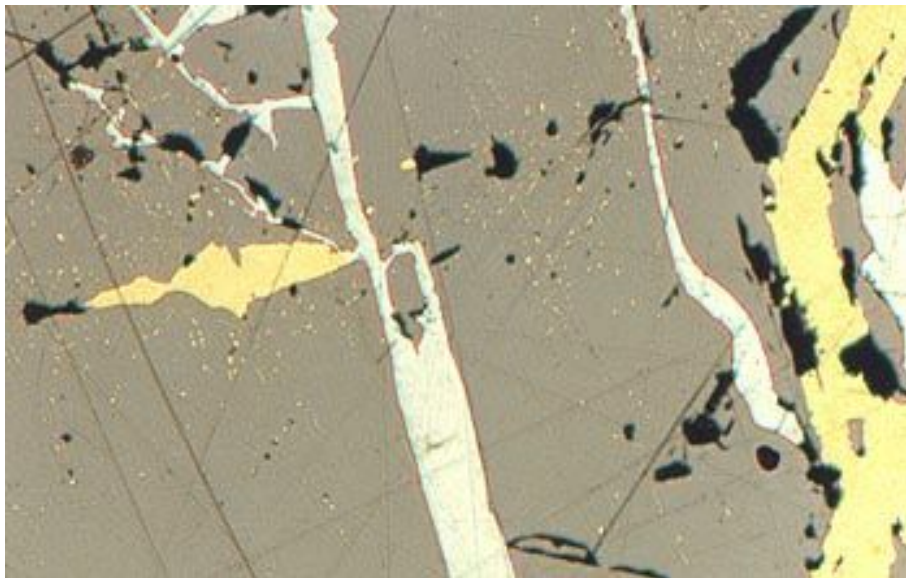
- 2- *Intergranular or intercumulus textures*: where the ore mineral occurs as an intergranular anhedral phase relative to the other gangue minerals. In such cases, this ore mineral crystallizes late in the magmatic sequence (relative to the other

gangue minerals) so takes up the shape of the intergranular spaces left behind. Examples include numerous sulfides, in many cases crystallizing from liquids immiscible with, and of lower melting point than the silicate magma. \

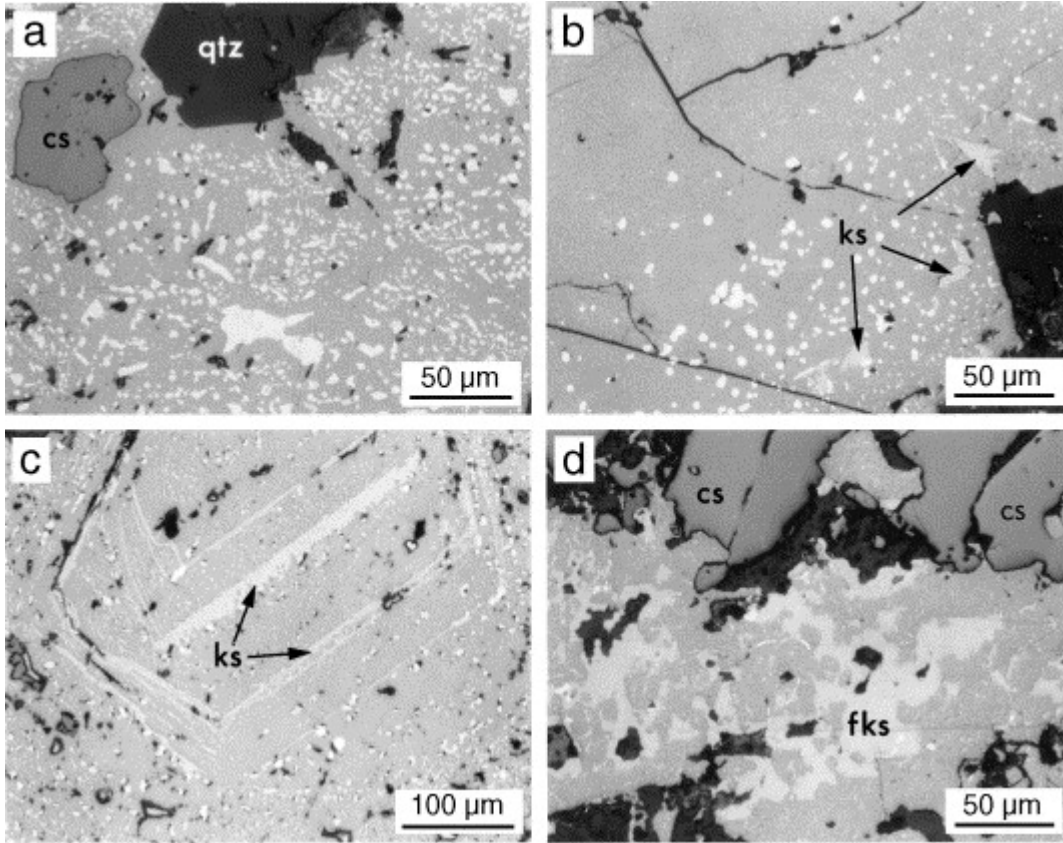


Orthocumulate **texture** - Harzburgite with cumulate olivine and **chromite**

3- *Exsolution textures*: Where one phase separates from another as a result of incomplete miscibility during cooling, and has a tendency to concentrate along certain crystallographic directions (e.g. cleavage planes). Examples include the occurrence of ferrian ilmenite in titanohematite or ilmenite in ulvospinel. Exsolution textures usually indicate a slow or intermediate cooling rate. In some cases, exsolution textures are difficult to tell apart from some textures that form by replacement.



Chalcopyrite blebs near the vein are a **texture** known as "**chalcopyrite disease**"



Sphalerite (light grey) with abundant inclusions of **chalcopyrite**

BIF



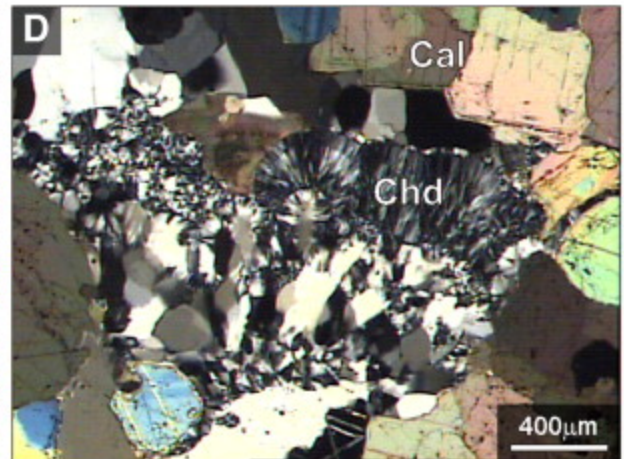
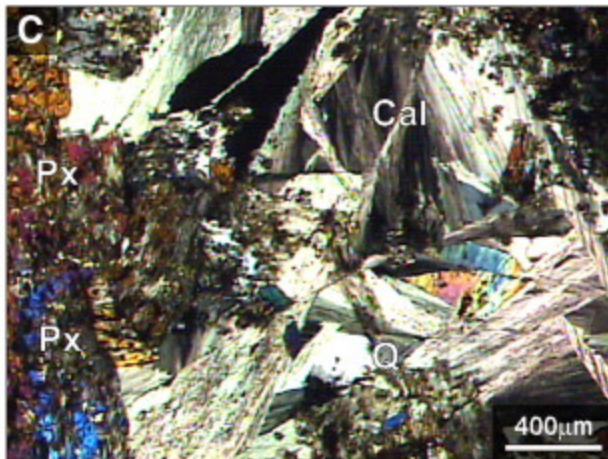
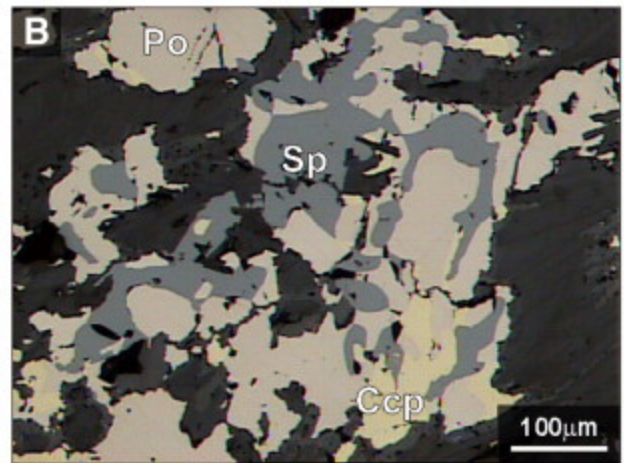
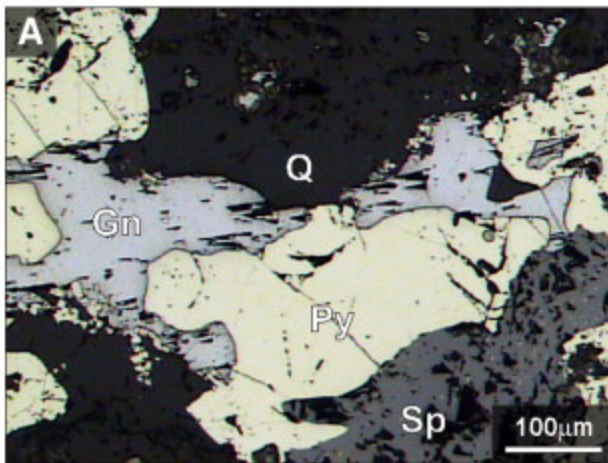
II- Textures of hydrothermal ore deposits and skarns:

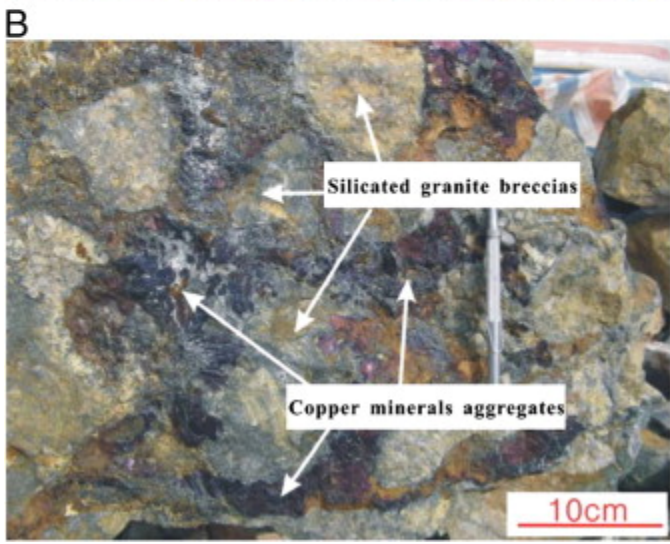
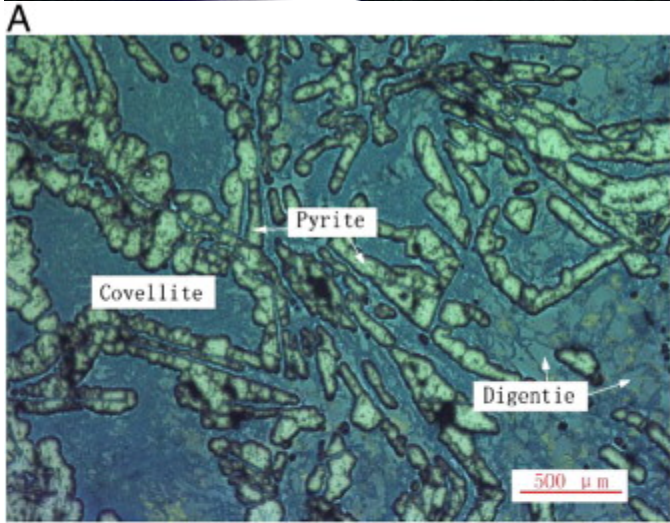
A- Replacement textures:

Replacement is the process of almost simultaneous solution and deposition by which a new mineral of partly or totally different chemical composition may grow in the body of an old mineral or mineral aggregate. According to this definition, replacement is accompanied by very little or no change in the volume of the rock. However, in practice, this process is accompanied by expansion or contraction (and it has proven quite challenging to write balanced chemical reactions representing replacement textures in which the volume of the products and reactants is the same!). Replacement is more common at high T and P where open spaces are very limited or unavailable, and fluid flow is rather difficult. It also depends largely on the chemical composition and reactivity of both the host rock and the hydrothermal solution.

In general, it has been observed that certain minerals replace others preferentially. Accordingly, a set of "rules" has been proposed:

- a) Sulfides replace gangue or ore minerals





- b) Gangue minerals replace host rock, but not the ore minerals

- c) Oxides replace host rock and gangue, but rarely replace sulfides.

Criteria for identifying replacement textures:

- 1) Pseudomorphs.
- 2) Widening of fractures (Fig. 1).
- 3) Vermicular unoriented intergrowths (Fig. 2).
- 4) Islands (of the host or replaced mineral) having the same optical orientation and surrounded by the new mineral (Fig. 3).
- 5) Relicts (Fig. 4).
- 6) Cusp and caries texture: (host or replaced mineral). Cusps are relict protuberances of the replaced mineral or host rock between "caries". The caries are embayed surfaces concave towards the replacing mineral into the replaced one (Fig. 5).
- 7) Non-matching walls of a fracture. This is a feature common when replacement works outward from a central fissure (compare with open space filling textures) (Fig. 6).
- 8) The occurrence of one mineral crosscutting older structures.
- 9) Topotactic and epitactic replacement: Topotaxy is a process where the replacing mineral overgrows the replaced one along certain crystallographic directions controlled by the structure of the replaced mineral. Epitaxy is the same process except that the structure of the replacing (new) mineral is not controlled by the replaced mineral, but instead by other "matrix" minerals.
- 10) Selective association: Since replacement is a chemical process, specific selective associations of pairs or combinations of minerals can be expected. For example, chalcopyrite is more likely to replace bornite by a change in the Cu/Fe ratio or in fS_2 than it is to replace quartz. Therefore, the occurrence of minerals with some chemical similarity in some textural relationship is often a good indication of replacement (Fig. 7).
- 11) The presence of a depositional or paragenetic sequence in which minerals become progressively richer in one or more elements (Fig. 8).
- 12) Gradational boundaries: In contrast to open space deposition which produces abrupt textures and structures between the hydrothermally deposited minerals and their host rocks, replacement is often accompanied by gradational boundaries between both minerals. Accordingly, gradational boundaries are a good indication of replacement.
- 13) Deposition of one or more hydrothermal minerals along a clear alteration front.
- 14) Doubly terminating crystals: If a crystal grows within an open cavity, it is normally attached to one of the walls of the fracture, and can develop crystal faces only on the other end (i.e. the one away from this wall). In contrast, the process of replacement may result in the growth of euhedral crystals with well developed faces on more than one end.
- 15) The lack of offset on a fracture intersected by the replacing mineral: In contrast to open space filling which may be associated with displacement of a preexisting

structure by the fracture being filled by hydrothermal fluids, replacement across a preexisting structure will not be accompanied by such offset. The same holds true for two intersecting fractures (Fig. 9).

B- Open space filling textures

Open space filling is common at shallow depths where brittle rocks deform by fracturing rather than by plastic flow. At these shallow depths, ore bearing fluids may circulate freely within fractures, depositing ore and gangue minerals when sudden or abrupt changes in P and/or T take place. As such, open space filling textures will be different from those resulting from replacement, and a set of criteria may be used to identify this process. Nevertheless, many hydrothermal ore deposits form by the combined effects of replacement and open space filling, which requires a lot of caution in textural interpretation.

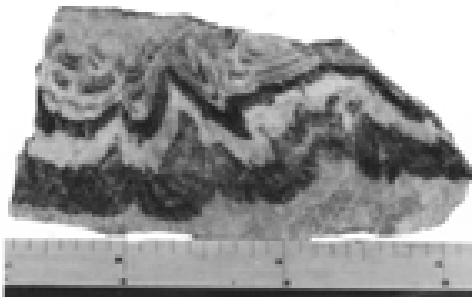


Criteria for identifying open space filling processes:

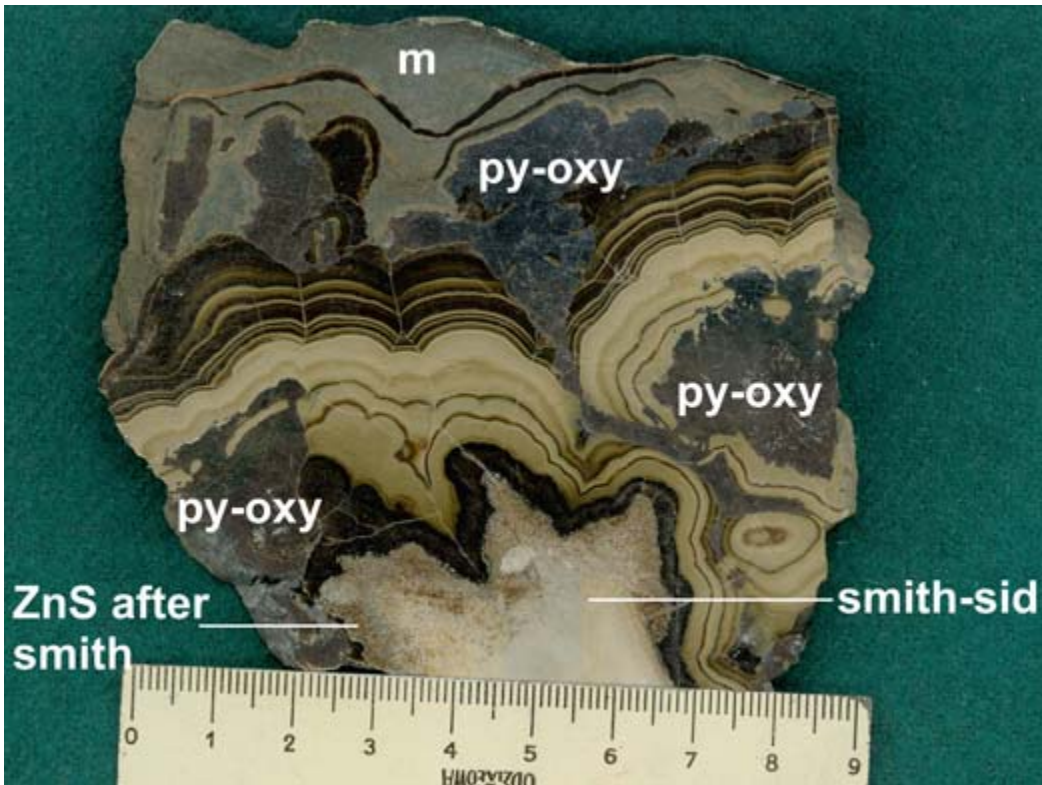
- 1- Many vugs and cavities
- 2- Coarsening of minerals from the walls of a vein to its centre
- 3- Comb structure: Euhedral prismatic crystals growing from opposite sides of a fissure symmetrically towards its centre develop an interdigitated vuggy zone similar in appearance to that of the teeth of a comb (Fig. 10).



- 4- Crustification: Crustification results from a change in composition and/or physicochemical conditions of the hydrothermal solution, and is represented by layers of different mineralogies one on top of the other.



- 5- Symmetrical banding (Figs. 10 & 11)
- 6- Matching walls: If an open fissure has been filled without replacement, the outlines of opposite walls should match (Fig. 10).
- 7- Cockade structure: Mineralization within the open spaces of a breccia or any other fragmental rock will commonly produce a special pattern of symmetrical banding and crustification where each opening acts as a centre for sequential deposition (Fig. 12).



8- Offset oblique structures (Fig. 13)

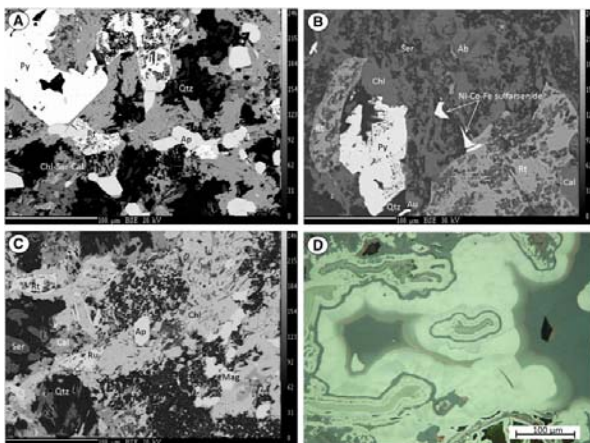
In addition to replacement and open space filling textures, very low temperature hydrothermal deposits (epithermal and telethermal deposits) are often characterized by colloform habits (Fig. 14) and banding described in the following section.

III- Textures characteristic of surficial or near surface environments and processes:

Under surficial conditions, ore minerals may be deposited from colloidal solutions. A colloid is defined as a system consisting of two phases; one diffused in the other. Colloidal particles range in size between ions in a true solution and particles that are $< 10^{-3}$ cm in a coarse suspension. The colloidal material may be solid, liquid or gas dispersed in another solid, liquid or gas.

Colloidal solutions believed to be responsible for the formation of ore deposits usually consist of solids dispersed in liquids and are called "sols". In such sols, colloidal particles commonly adsorb either cations or anions, and thus acquire similar charges which cause them to repel each other, preventing them from coagulation. If an electrolyte is added to such a sol, the colloidal particles are neutralized and flocculate giving rise to a variety of textures which include:

- a) Botryoidal or reniform aggregates

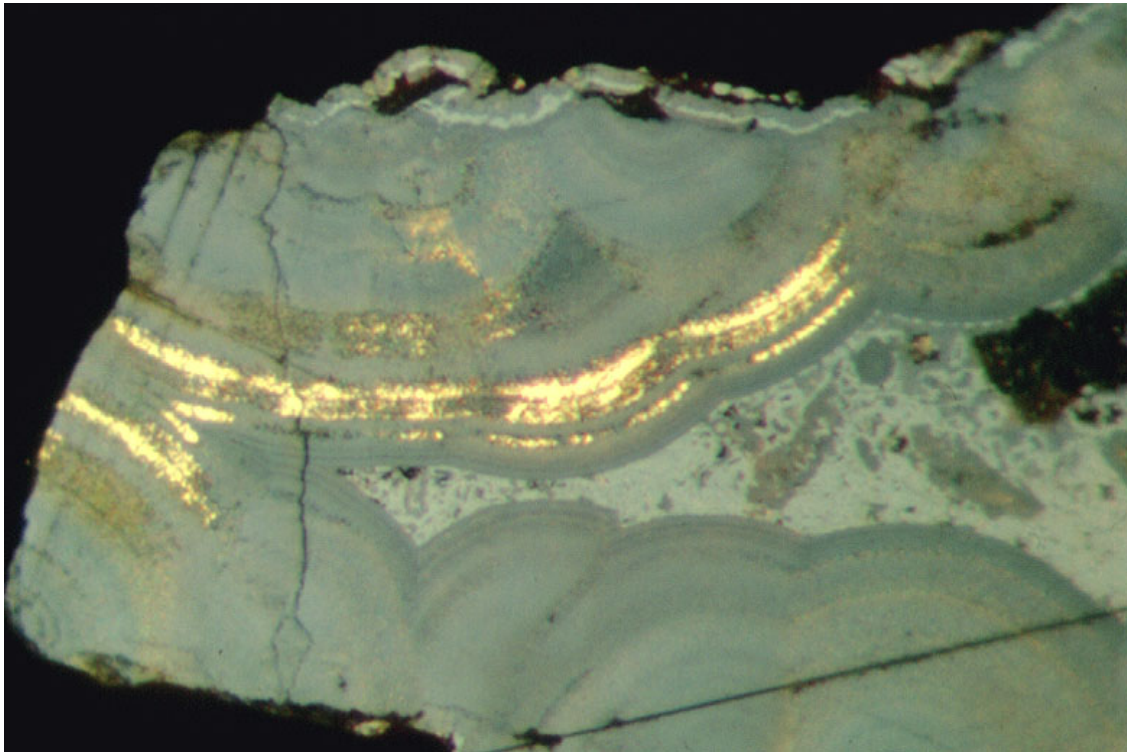


- b) Banding or very fine layering

c) Leisegang rings

These textures are broadly lumped as "**colloform**" textures (Figs. 14 & 15). Because some colloform textures were observed in some hydrothermal deposits, it was believed that some hydrothermal solutions were colloids. However, fluid inclusion analysis showed that hydrothermal solutions are too saline to have been in the colloidal state, and the term "colloform" should be considered *descriptive and non-genetic*.

In the surfacial environment, colloidal solutions are common. Criteria used to identify a colloform texture as a product of deposition from a colloidal solution include:



- 1) Shrinkage cracks: which develop due to dehydration of a gel
- 2) Liesegang rings: Are coloured bands that form when an electrolyte is allowed to diffuse into a gel. Liesegang rings are common in amorphous, cryptocrystalline and microcrystalline "minerals" or mineraloids as agate and opal.
- 3) Variable composition of bands and/or deposits: This phenomenon is due to the ability of colloids to adsorb different ions from their surroundings.
- 4) Non-crystalline structure: The occurrence of amorphous "minerals" or mineraloids (e.g. opal) is an indication of formation from a colloidal solution. However, such mineraloids will tend to crystallize with time.
- 5) Spheroidal texture: Are rounded objects similar to pisolites, which result from the low surface tension of a colloid.

