PS Relationship between Deep Diagenetic Quartz Cementation and Sedimentary Facies in a Late Ordovician Glacial Environment (Sbaa Basin, Algeria)*

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Abstract

The origin, conditions and timing of quartz cementation in glacial Ordovician sandstones of the Sbaa basin, Algeria, were constrained on the basis of fluid inclusion microthermometry, electron microprobe data, quantification by image analyses, combined with optical and cathodoluminescence microscopic studies. Samples of the Cambro-Ordovician Formation in the Sbaa basin were investigated in seven different wells, at a burial depth between 2.0 and 2.5km and at present temperature of 110 to 130°C.

Quartz cements are present in all studied wells, their abundance ranging from 1 to 27%. Three separate stages of quartz cementation are readily distinguished by cathodoluminescence microscopy. Aluminium content data for each phase of quartz cement suggest different silica sources. Two majors internal silica sources are discussed: dissolution of feldspar grains and pressure-solution of detrital quartz grains. Fluid inclusions data from samples presently lying at 2km subsurface (110°C) indicate that globally quartz cementation precipitated at 109 to 154°C. This range of temperature corresponds to the Namurian burial phase according to the basin thermal history.

Quantification of image analyses shows enhanced intergranular pressure-solution supported by the presence of thin illite coatings (rims) around quartz grains. These clay coatings can occur beneath the ice sheet by pressurized water circulation within a sandy subglacial soft bedrock, initially clay-free, porous and permeable. The subglacial bedrock lithology is then essential: an increase of clay content can prevent formation of clay coatings, or block the circulation of fluids flowing below the ice sheet. All observations confirm the enhancement of pressure-solution between quartz grains by illite coatings. Quartz cements result mainly from pressure-solution; they precipitate largely within low-compacted levels, where clay coatings are not present and porosity is high. Thus, a relationship between the sedimentary facies, the ice dynamic and the diagenetic architecture of the formation is highlighted, controlling porosity-permeability distribution through quartz cementation and compaction by pressure-solution.

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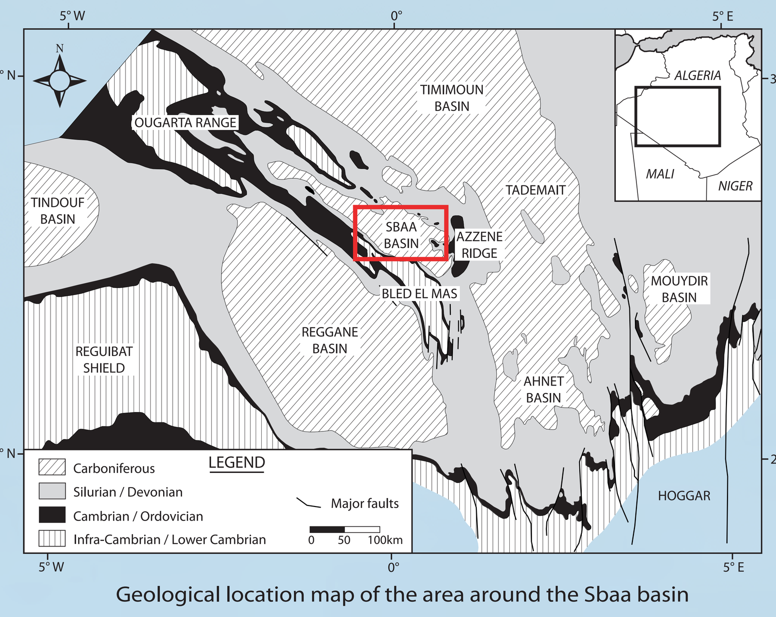
I. Objectives

The glacial Ordovician is a major play in North Africa, with challenging geology and generally low reservoir quality. This study was made to investigate the relationship between diagenesis, sedimentary facies and reservoir properties in the glacial Ordovician sandstones of the Sbaa basin in Algeria.

II. Sample locations

The studied samples were extracted from cores of 3 wells. The present burial depth of the Ordovician reservoir is ranging between 2000 and 2500m (100 to 120°C).



Geological location map of the area around the Sbaa basin

The relationship between sedimentary facies and petrographic facies is not obvious. Quartzose sandstones were deposited in proximal to distal environments, by tractive and turbiditic processes.

Presently, two quartzose sandstones petrographic facies are distinguished with a clear vertical organization : QS2 facies is always located below QS1 facies.

III. Results

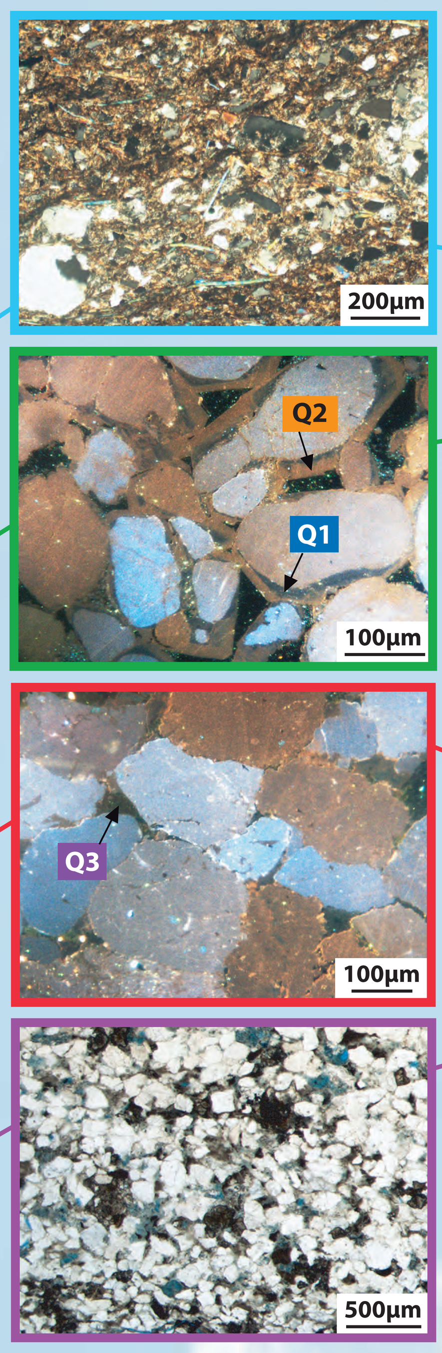
1. Petrographic observations

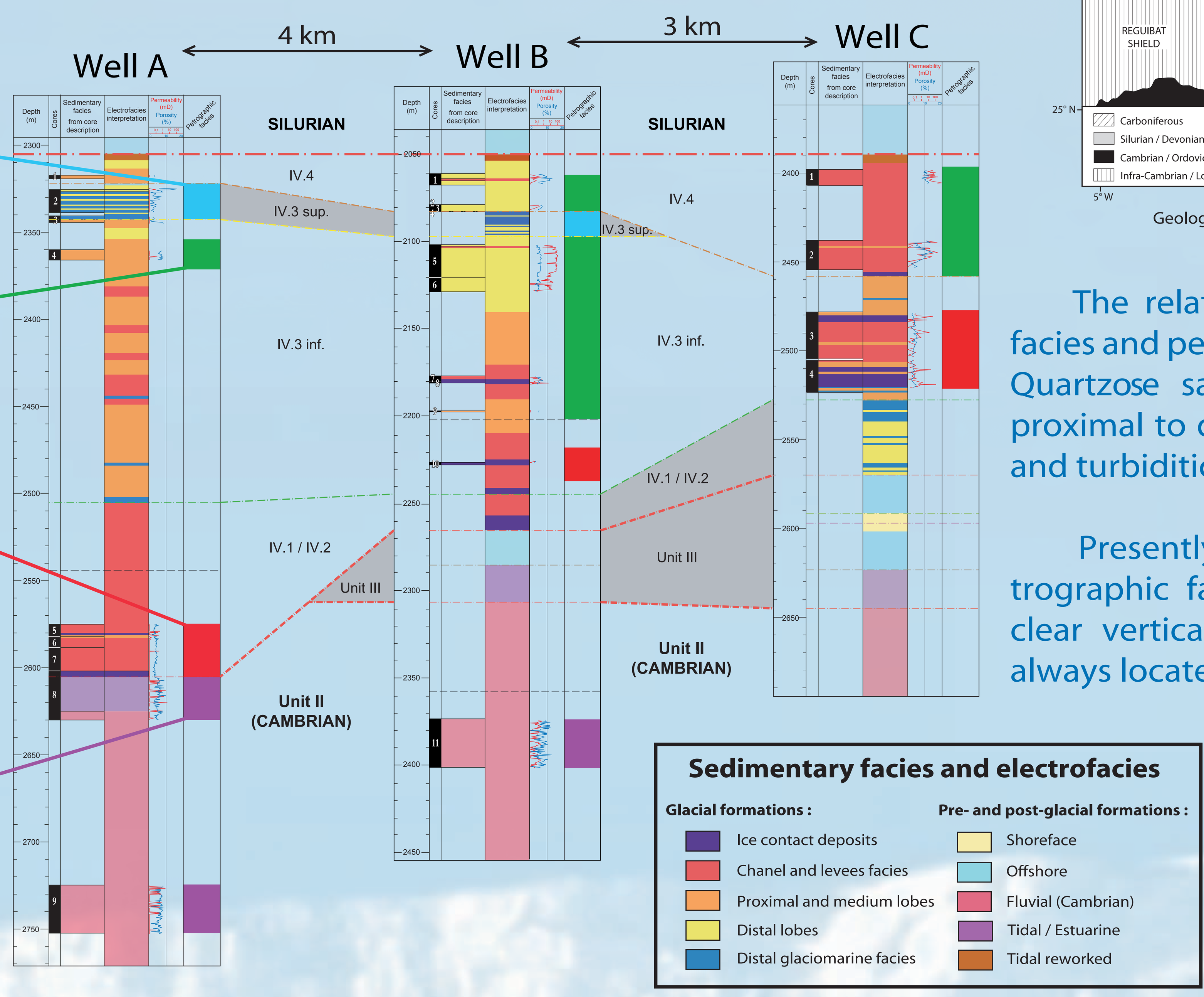
AS1 : Argillaceous Sandstones of interglacial unit IV.3 sup. (glaciomarine distal facies)

QS1 : Quartzose Sandstones of upper glacial Ordovician with :
- **Low compaction**
- **High quartz cementation**
- **Good reservoir properties**

QS2 : Quartzose Sandstones of lower glacial Ordovician with :
- **High compaction**
- **Low quartz cementation**
- **Poor reservoir properties**

AS2 : Argillaceous Sandstones of Cambrian unit II (fluviomarine facies)

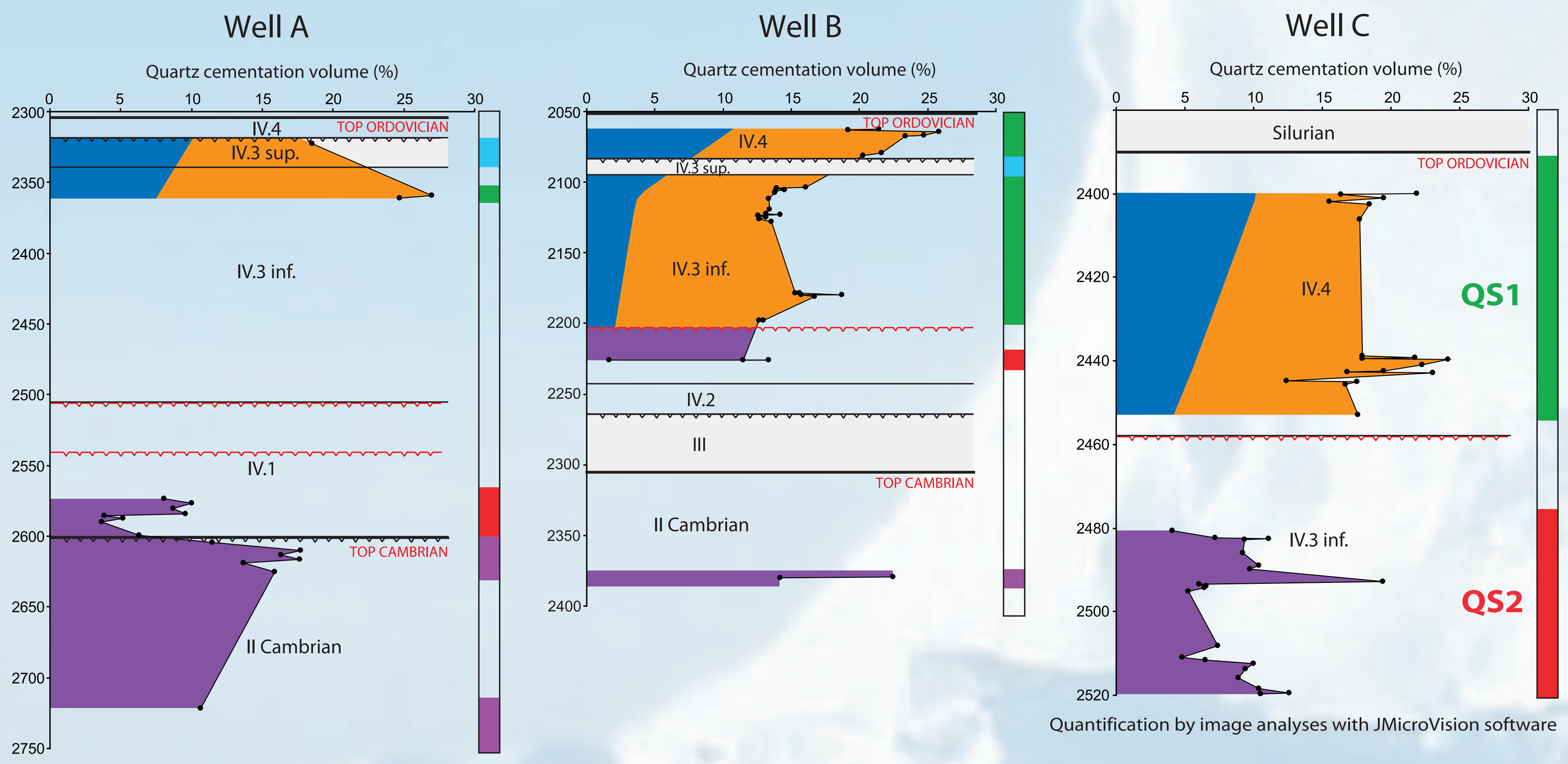




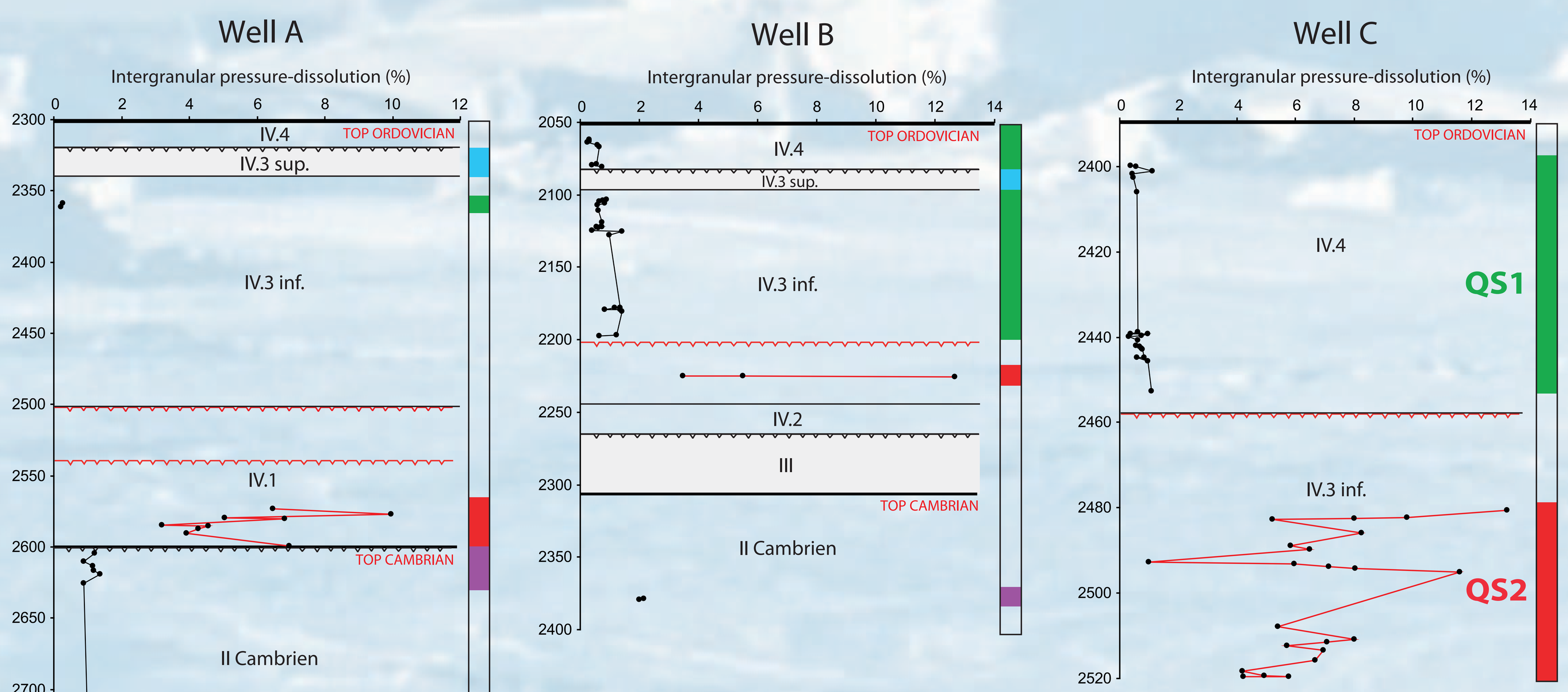
2. Quartz cementation and pressure-dissolution volume

Quartz cementation volume is highly variable between QS1 and QS2 facies (5 to 25%). Quartz cements originate essentially from pressure-dissolution of detrital quartz grains (Q2+Q3) and detrital feldspar dissolution (Q1+Q3) (Tournier et al., submitted).

Pressure-dissolution is important within QS2 facies, whilst very low in QS1 facies. High pressure-dissolution facies (QS2) are systematically located below glacial floors overlying sandy bedrocks.



Quantification by image analyses with JMicroVision software



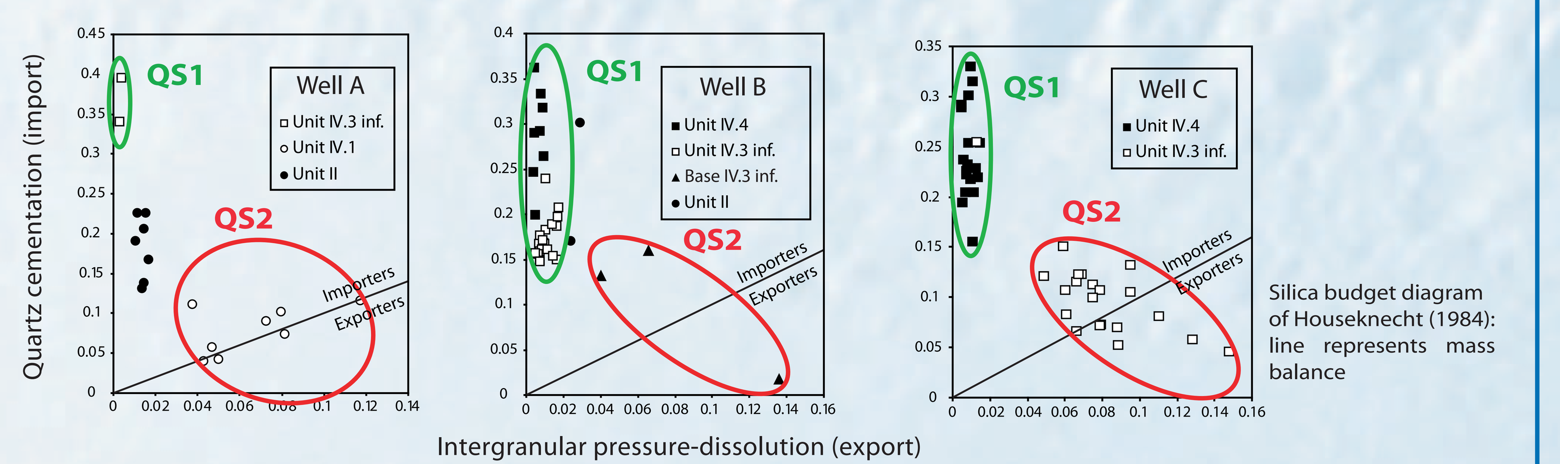
Quantification by image analyses with JMicroVision software following the procedure of Houseknecht (1984)

Legend

Silicification phases	Petrographic facies	
Q1	QS1	Unit boundaries
Q2	QS2	Glacial floors on sandy bedrock
Q3	AS1	Glacial floors on clayey bedrock
	AS2	Argillaceous levels

IV. Discussion

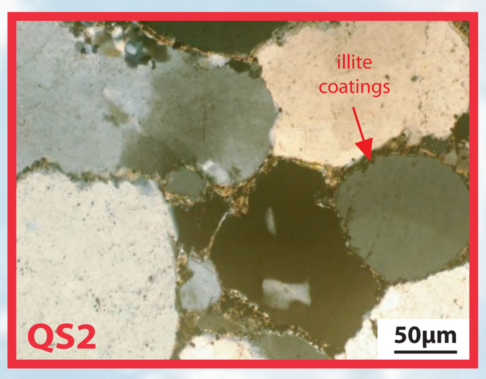
1. Silica exportation from pressure-dissolution levels



Silica budget diagram of Houseknecht (1984): line represents mass balance

Silica produced in high pressure-dissolution levels (QS2) is mainly exported upward within low compacted, porous and permeable sandstones (QS1).

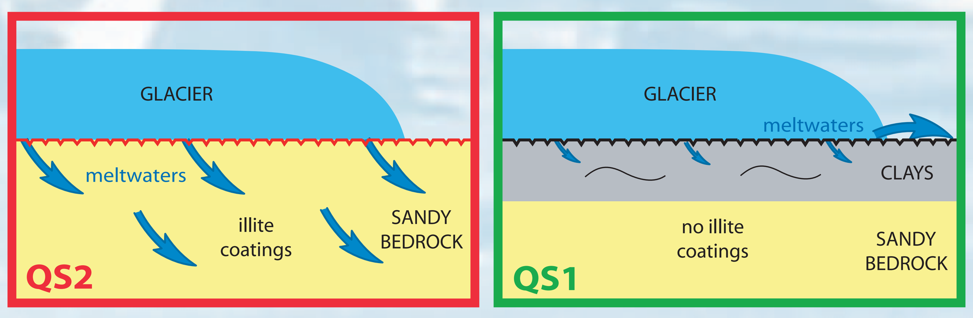
2. Pressure-dissolution enhancement by illite coatings



Pressure-dissolution is promoted by the presence of thin illite coatings around detrital quartz grains (Ehrenberg 1993, Oelkers et al. 1996). These coatings are always observed in QS2 facies, where pressure-dissolution is very important.

Illite coatings are only developed below glacial floors overlying sandy bedrocks.

3. Illite coating development in a glacial environment



Illite-coating formation is supposed to originate from clay-rich subglacial meltwaters flowing below the ice sheet during glacial readvance, within a sandy subglacial soft bedrock initially porous, permeable and clay-free. High meltwater circulation is enhanced by porosity and permeability and can reach depths up to 200m below the glacier (Piotrowski 2009). The presence of low permeable (clay-rich) layers prevents meltwater circulation and formation of illite coatings.

V. Conclusion

Illite coatings are developed by the subglacial processes when the subglacial bedrock lithology permits. They promote pressure-dissolution of detrital quartz grains which release the silica forming quartz cements.

The organization of the glacial units and their lithologic facies control the diagenetic architecture and the petrophysical properties of the reservoir.

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