



NORTHERN CROSS

Birch B-34 and E-53, Wells, Eagle Plains, Yukon Territory

Thin Section Study: Permian Conglomerates, June 2000

Introduction and Purpose of the Study

Northern Cross (Yukon) Limited ("NCY") is the operator and major interest owner of SDL 20, which was assessed by two wells, Birch B-34 (drilled in 1965) and Birch E-53 (drilled in 1972).

The purpose of petrographic examination of thin sections prepared from cored conglomeratic reservoir of the Permian Jungle Creek Formation was to evaluate:

- grainsize, sorting and roundness of grains
- grain provenance variations
- intergranular pore space geometry
- diagenetic processes which may have occluded porosity
- cementation history

In addition, grains were examined for evidence of physical fracturing, which could be expected from permafrost conditions existed in the reservoir.

Another objective was to determine how poor DST flow rates for both wells matched up with the reservoir quality observed through petrographic examination.

Procedure

Birch B-34

For Birch B-34, thin sections available from the NEB Core & Sample Repository library were used rather than resample this well.

Birch E-53

For Birch E-53, cores 1-5 from the Jungle Creek interval were sampled, focusing on medium to coarse-grained chert and quartz pebble conglomerate intervals. Sampling involved cutting out 1" x 1 ½" sample blocks from the core (Alan Scott). These sample blocks were sent to AGAT Laboratories, Calgary, where all samples were impregnated with blue epoxy and thin sections prepared.

Thin sections were examined and described by Peter Moignard P. Geol., consulting geologist to NCY; using the microscope facilities at AGAT. Photomicrographs and descriptions of typical microscope views constitute the results of this report.

Results

The attached thin section photomicrographs and descriptions are a self-explanatory documentation of the observed results.

Interpretation

The variable conglomeratic grainsize, ranging from pebble to medium sand, and the poor, generally bimodal sorting, combine with angular to subrounded grains to indicate that transport distances were short. These conglomerates are proximal to source.

The grains are a mixture of chert and quartz, more commonly dominated by chert in the coarser fraction. The color of the conglomerate intervals in the core varies from light cream-grey to dark grey. The lighter color zones tend to be higher in the section. The appearance color was not evident in the thin sections as a chert grain color, but darker grains were often diagenetically altered such that degraded grains have pyrite inclusions. Chert color variations may depend on the degree of diagenetic alteration of individual chert grains.

The source of the chert is possibly various Carboniferous and Devonian carbonates which were exposed by pre-Permian and syn-depositional tectonic episodes.

The Permian Jungle Creek at Birch is an excellent open pore reservoir with evidence of some hydrothermal fluid invading the primary pore space, and depositing diagenetic limonite/pyrite and dolomite. Timing of diagenetic fluid invasion is unknown.

No reason for poor DST performance was evident from the thin sections, but freezing of pore fluid upon DST may be an explanation.

Grain fracturing was evident in some thin sections, but the cause of fracturing may have been either depressuring after core removal, or possibly freezing of fluid in the reservoir under either present day interglacial permafrost or deep paleo-permafrost formed during Pleistocene glacial periods.

Further Work

No further work is contemplated as a result of these observations.

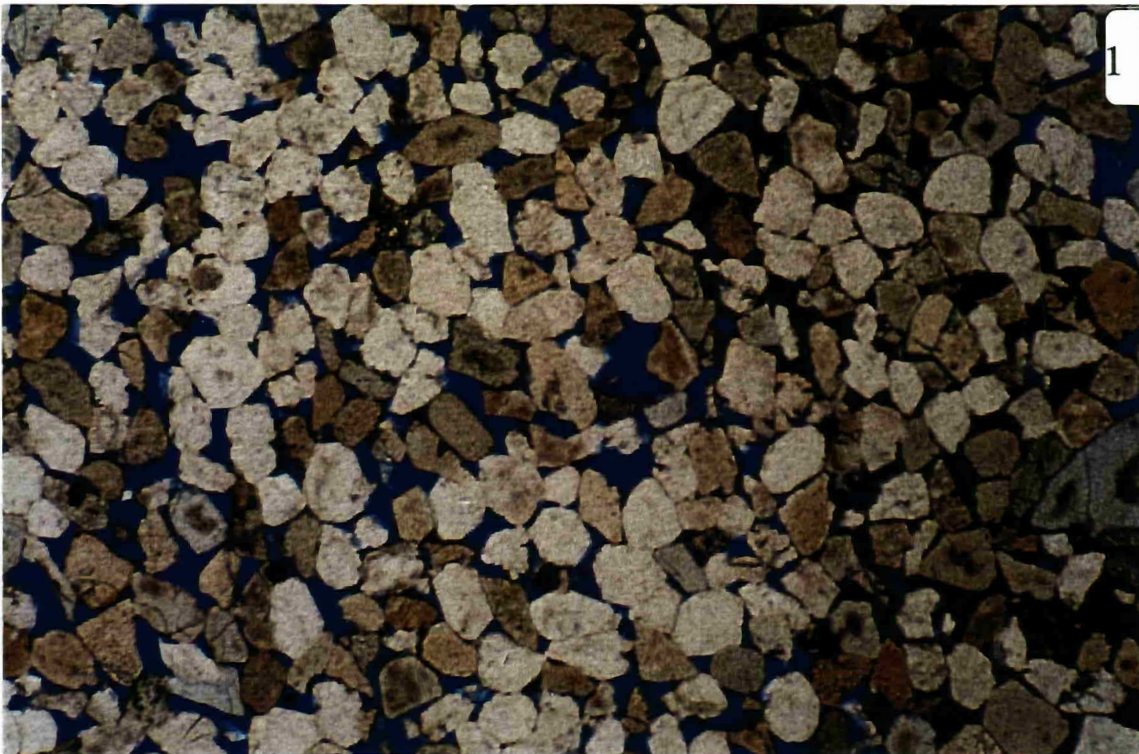
Submitted by:

Peter Moignard (P. Geol)

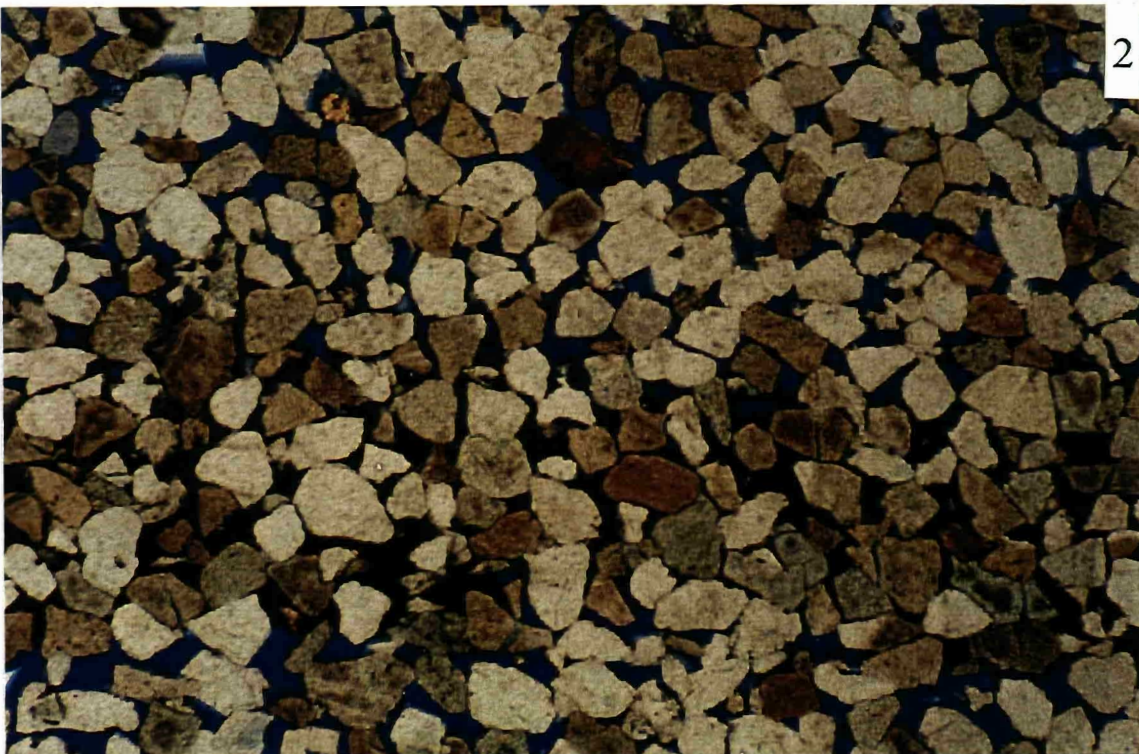
Geological Consultant

Northern Cross (Yukon) Limited August, 2000

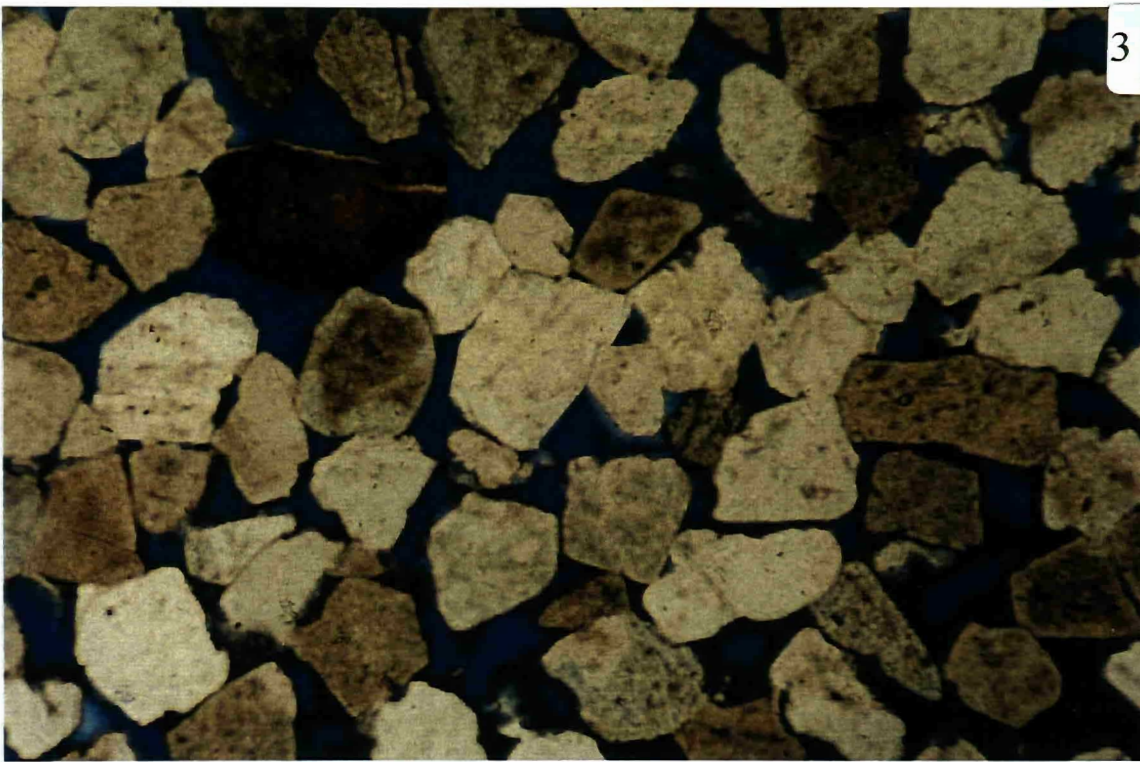
Thin Section Descriptions: Birch B-34 and Birch B-53



Birch B34 962.5' Jungle Creek
25x Chert & Qtz arenite; f-med grained; some sutured grain boundaries; ~20%-25% porosity.



Birch B34 962.5' Jungle Creek
25x Chert & Qtz arenite; f-med gr; some sutured grain boundaries; ~20%-25% porosity; dk cly min or pyritic? band, clays possibly derived from degradation of chert grains.



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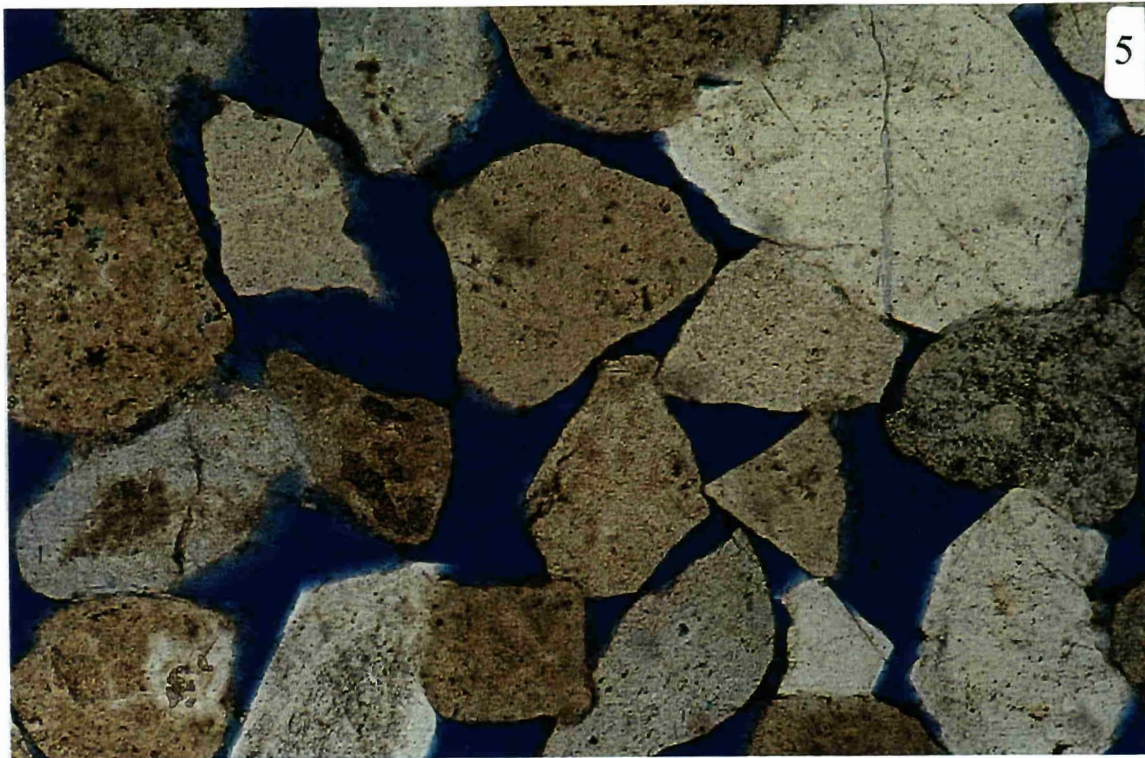
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Birch B34 962.5' Jungle Creek
 Chert & Qtz arenite; f-med gr; some sutured grain boundaries;
 ~20%-30% primary porosity; quartz overgrowths; dk cly min or pyritic (?)
 band.
 25x



4

Birch B34 962.5' Jungle Creek
 Chert & Qtz arenite; f-med gr; some sutured grain boundaries;
 ~20%-30% primary porosity; quartz overgrowths; band detail shows diagenetic
 organic-rich clay or pyritic clay (?)
 100x



5

3

Birch B34 962.5' Jungle Creek
 Chert & Qtz arenite; f-med gr; some sutured grain bdries; grains
 100x dominantly chert and altered chert. Grain contact detail: some pressure solution
 boundaries on chert grain edges, some orthogonal quartz overgrowths; excellent
 Intergranular porosity about 30%. Weak cementation, but thin diagenetic illite?
 and qtz overgrowth cement.



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Birch B34 960.5' Jungle Creek
 Rock fragment, chert and quartz Conglomerate, buff-brown.
 25x Volcanic rock fragments form large composite clasts. Quartz
 grains are polycrystalline, strained. Matrix of orthoquartzitic cement.

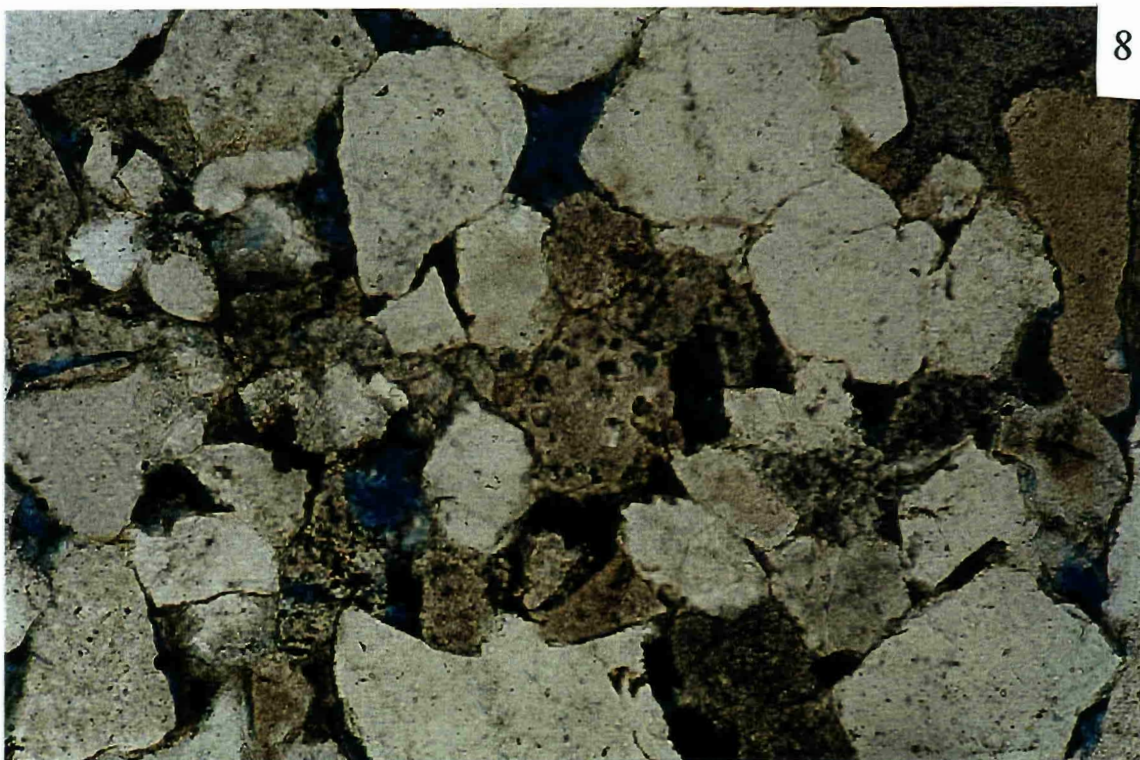


Birch B34 1290.8'

Jungle Creek

25x

Quartz and chert arenite, med-coarse grained; approx. 50-50 mix of qtz and chert bimodal ~ 10% porosity, some porosity occluded by dark intergranular fill chert grains sutured and discolored by weathering; some zoned degradation of chert grains. Compaction evident and sutured grains common. Some cherts dissolution provide improved intergranular and porosity.

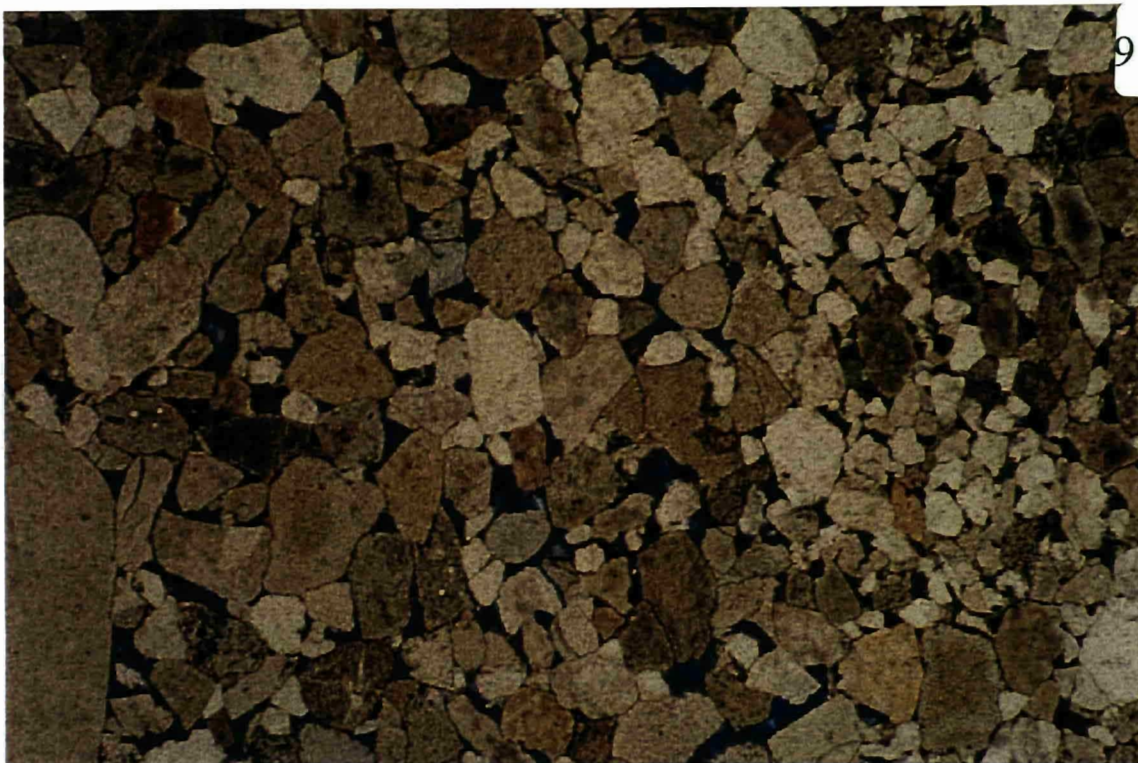


Birch B34 1290.8'

Jungle Creek

100 x

At higher power, breakdown of chert grains evident with sutured, compacted boundaries and interpenetration of chert grain boundaries. Quartz overgrowths. Some porosity infill with clay mineral and possibly micrite.

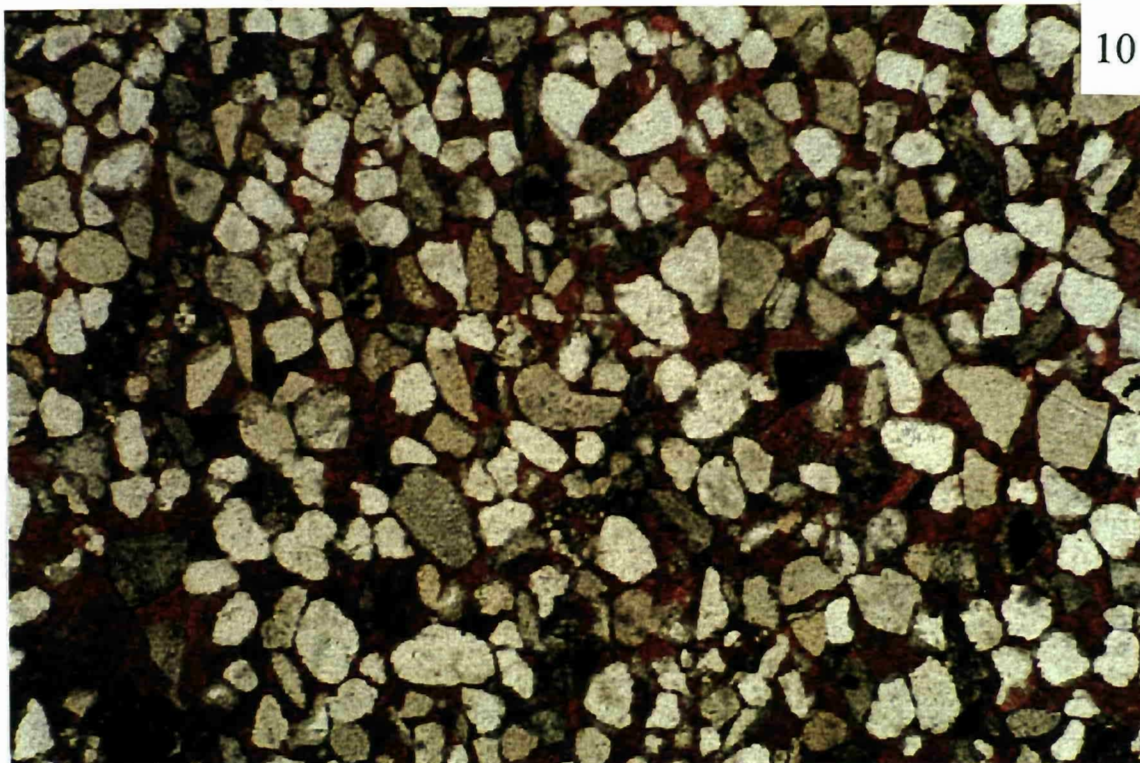


Birch B34 1290.8'

Jungle Creek

25x

Field of view showing slightly better porosity and pore continuity bimodal medium and coarse grains form different compaction gradients higher porosity using higher grain fraction. Some grains show evidence of fracturing.



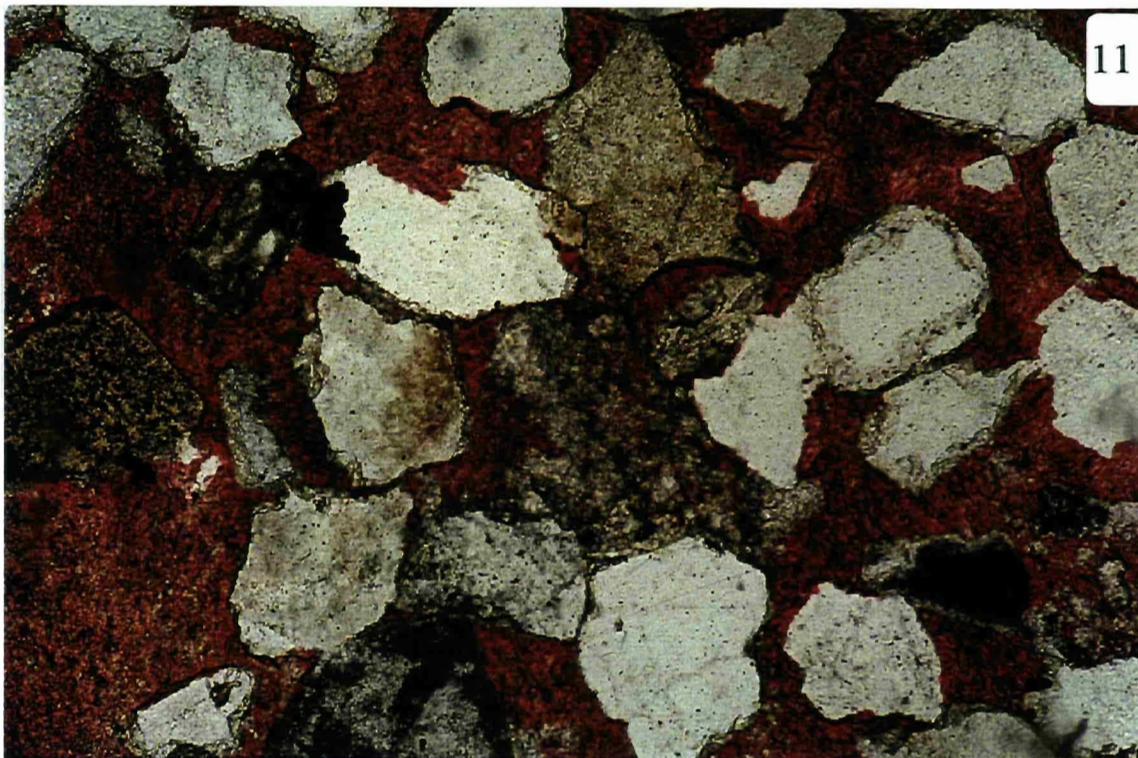
Birch B34

2321'

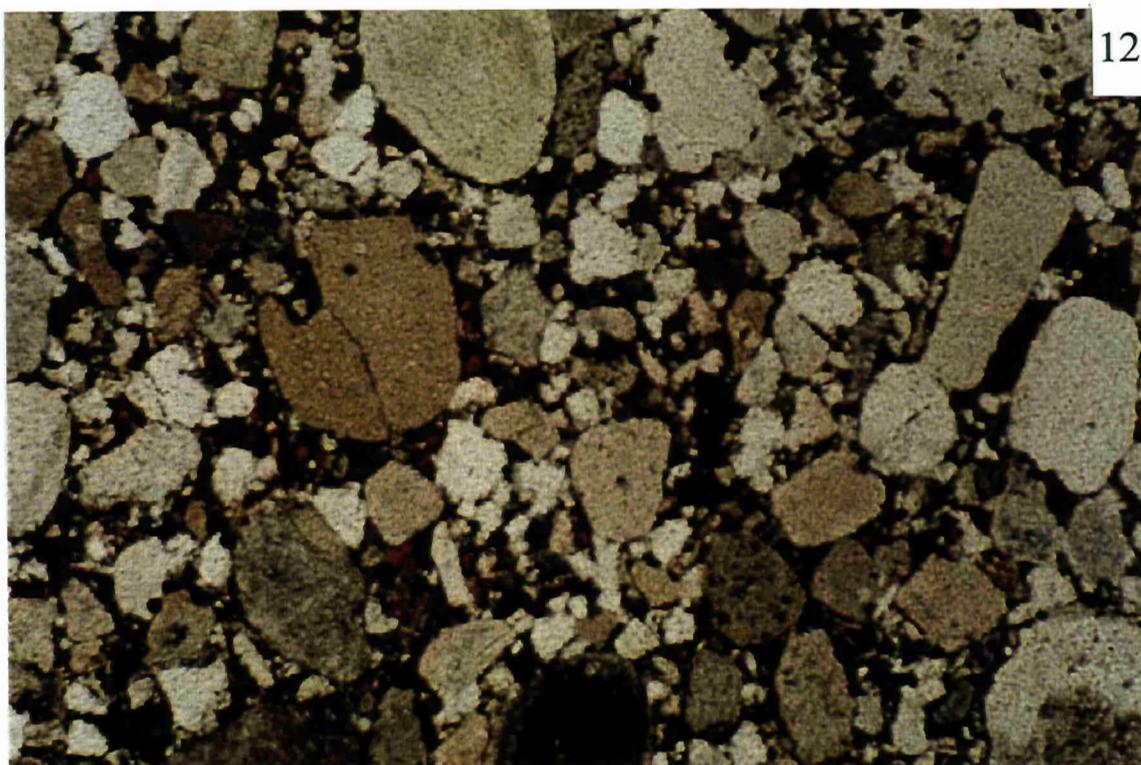
Jungle Creek

25 x

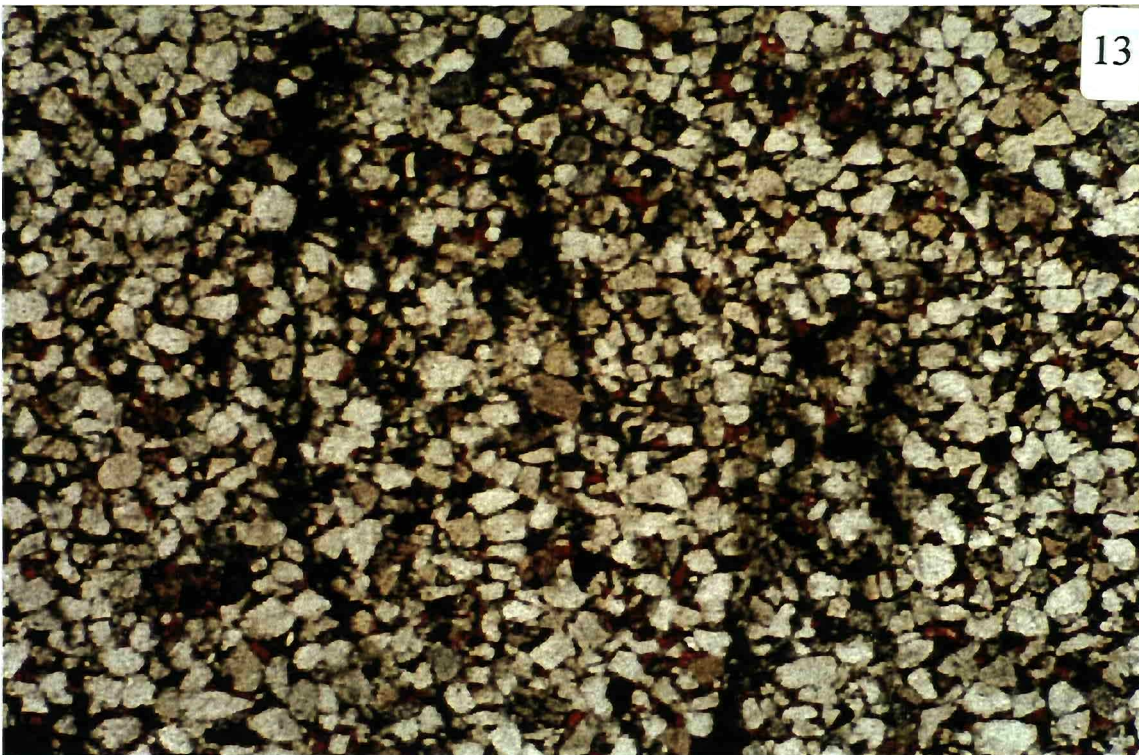
Medium grain sandstone with lime micrite matrix; grains are complete embedded in lime micrite. Thin section is stained in alizarin red to show carbonate. It is difficult to tell whether the micrite is primary or secondary cement.



Birch B34 2321' Jungle Creek – lower sand
 100 x Grains are similar to the chert and quartz in the 1290.8' sample but are set entirely in calcareous cement. Cement appears to be micrite with some areas of oriented, wavy extinction which appear to be dolomite rombs. Perimeter of grains, dolomite and quartz are heavily scalloped and appear to have been eroded prior to cementation. Chert grains are highly degraded and pyrite (?) infilled.

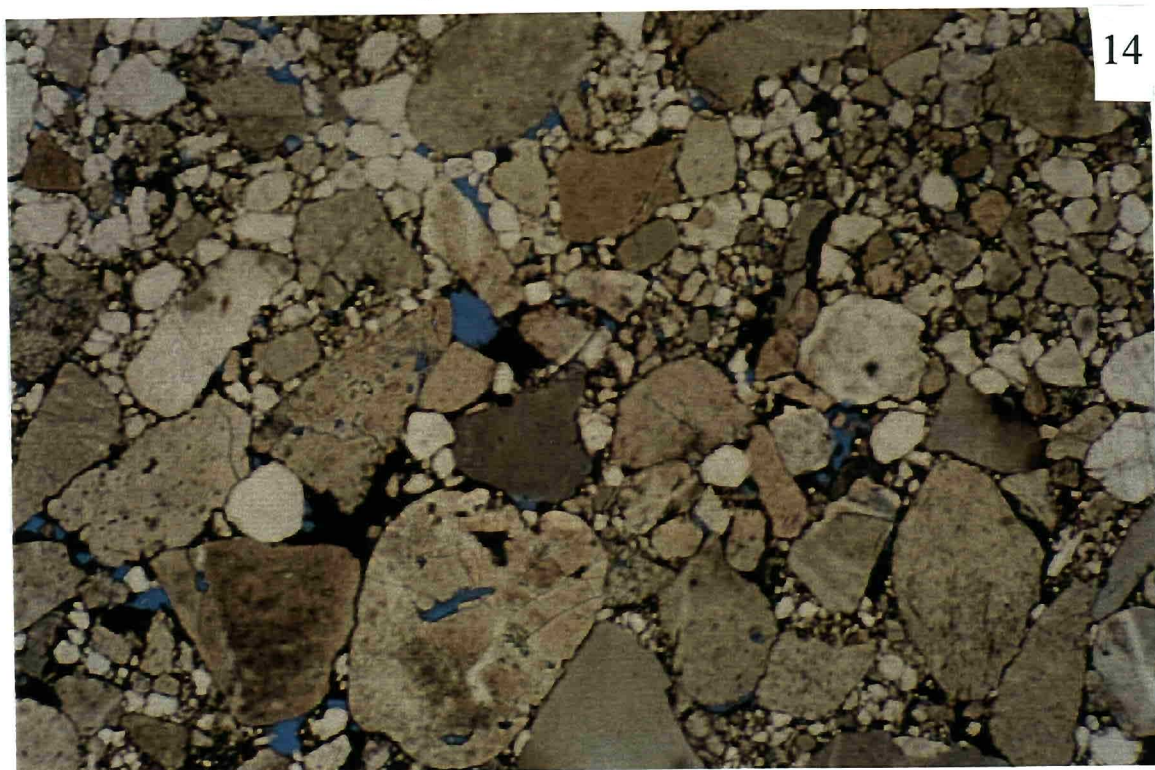


Birch B34 4896' Lower Chance or Hart River
 63 x Lime micrite matrix surrounding bimodal conglomeratic coarse-medium-fine grained chert and quartz. Grains are rounded to subrounded; some organic or hybridic material interspersed in amongst lime matrix. Lime matrix appears to be micrite but, grains are scalloped and eroded, so it may be secondary cement. Matrix is stained with alizarin red to show carbonate.



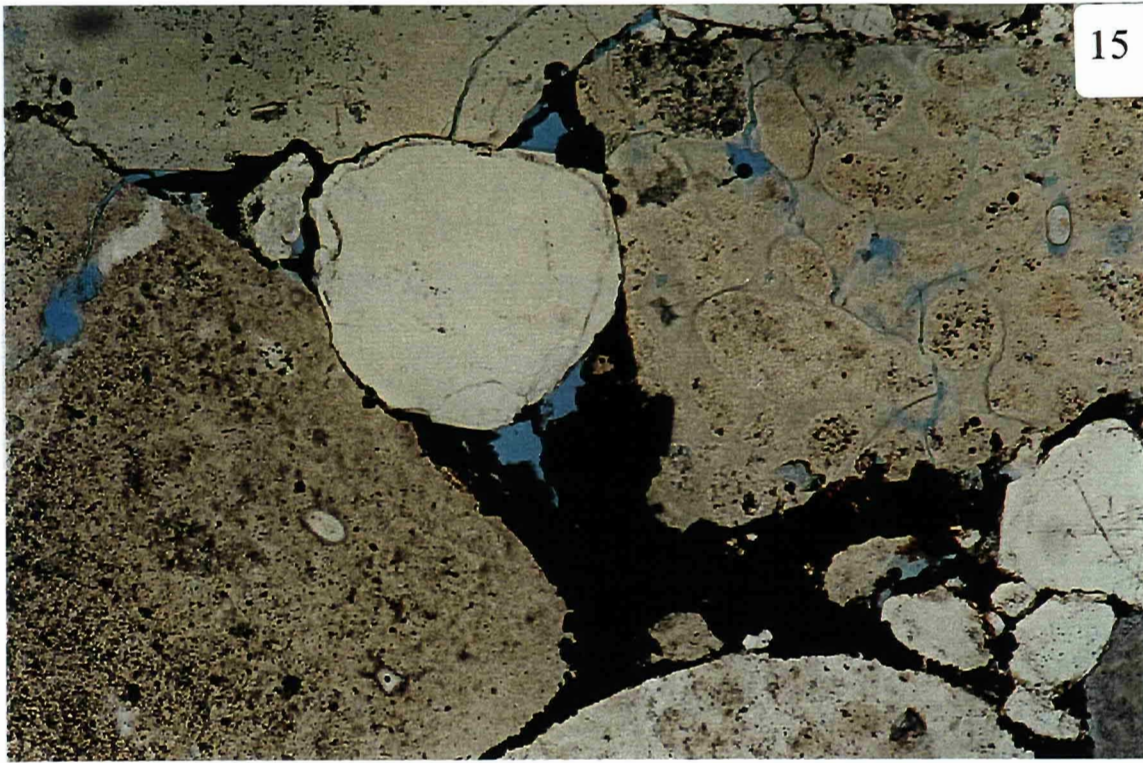
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Birch B34 5051' Hart River
 Even grained portion of same thin section showing streaky domains of organic material within the micrite cement/matrix.
 25x



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Birch E53 1335' Jungle Creek
 Chert hibble conglomerate; light brown; bimodal medium sand to pebble-sized grains. Pebbles are moderately rounded; small grains sizes angular some quartz grains in medium to fine sand fractions but not pebbles. Many of the larger grains are composite with veining and internal textures which appear to have been involved in structural deformation and limestone depositional textures; Medium sand grains are well compacted. Bimodal jumbling of grains yields intergrainular porosity between larger clasts which is partially filled with pyrite (evidence of some hydrothermal influence?). Minor grain fracturing evident in larger grains.
 25x



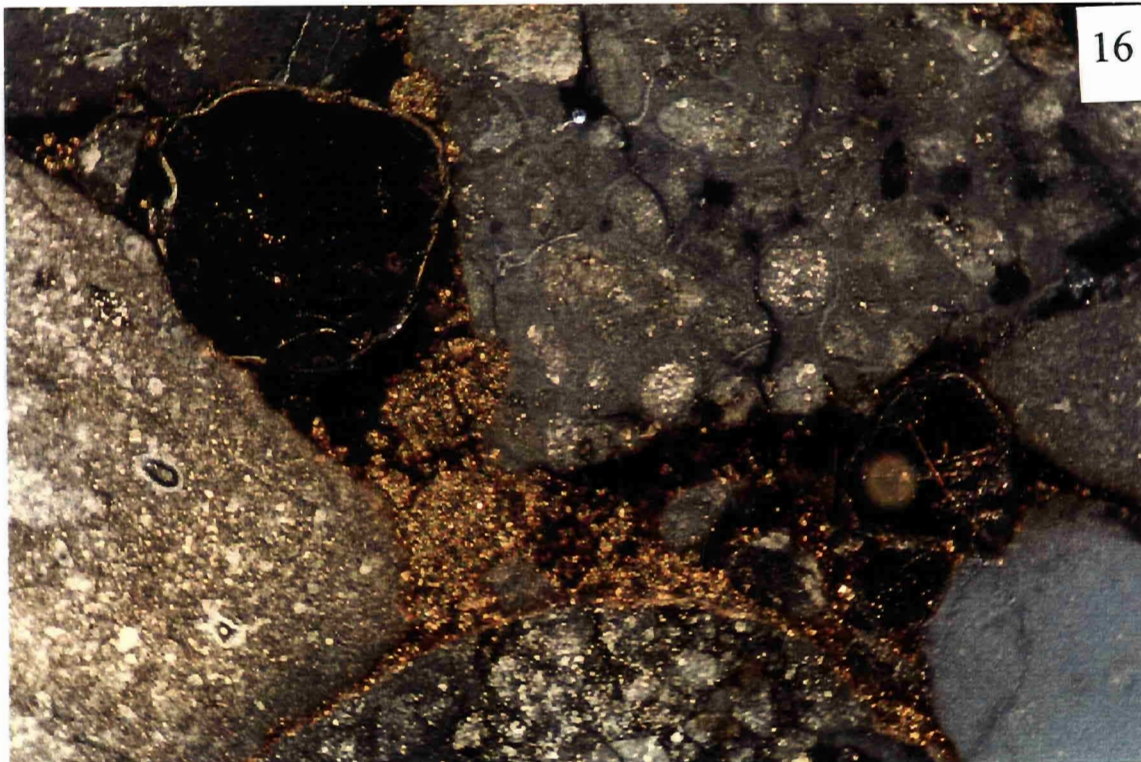
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Birch E53 1335' Jungle Creek

100 x

Enlarged view in polarized light (ppl) of quartz grain with overgrowth surrounded by variety of composite grains. Grain on right may be cemented composite fine-grained sand rock fragment or have formed in limestone nodule and display limestone fabric. Original open porosity has been first eroded by corrosive fluid then infilled with pyrite and dark clay mineral or pyrobitumen.

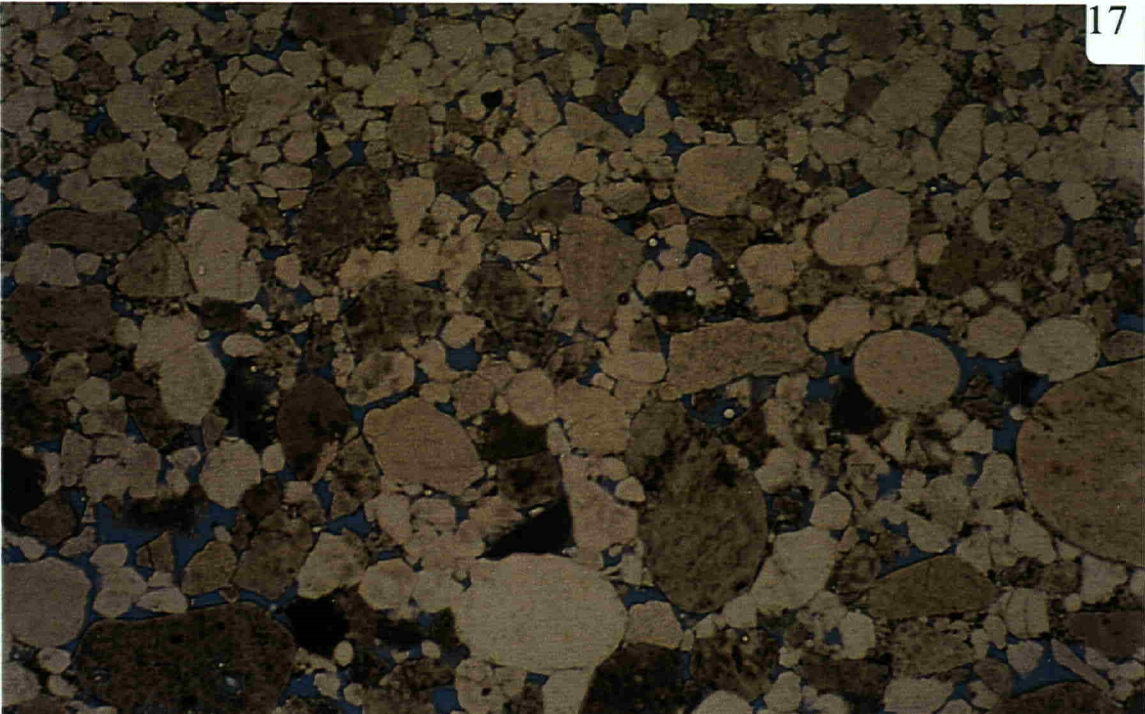


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Birch E53 1335' Jungle Creek

100x

Same view but in reflected light showing domains of pyrite (and possible pyrobitumen) largely filling intergranular cavity.



Birch E53 1335' Jungle Creek

25x

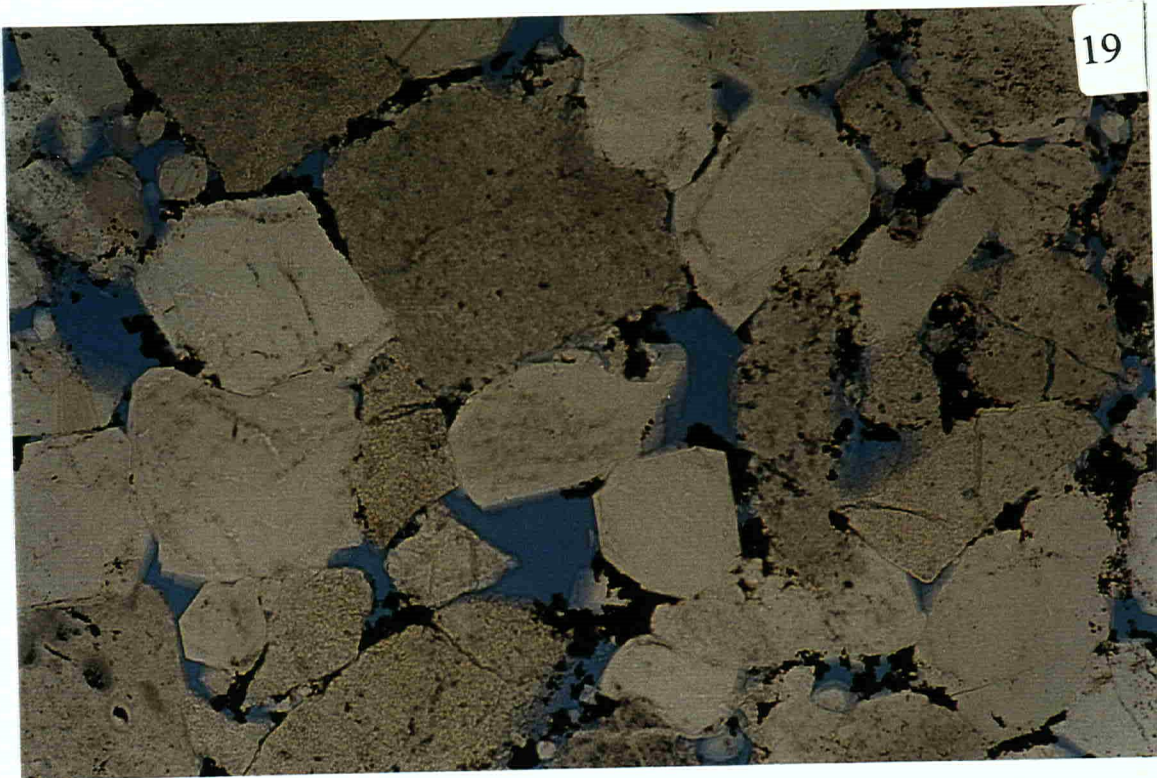
Chert and quartz pebble conglomerate; bimodal medium to coarse grain angular grains, and coarse chert and pebbles with some quartz pebbles present. Chert ranges in colour from dark brown to buff to cream. Chert is white with overgrowths. Pebbles are rounded to subrounded, some are angular. Generally excellent porosity (around 20 – 25%), intergranular; very minor quartz cement and some quartz overgrowths. Some cracked grains evident adjacent to porosity, permeability appears excellent. Minor to trace of pyrite as blebs in intergranular niches.



Birch E53 1335' Jungle Creek

100x

View of intergranular porosity shows well developed orthogonal quartz overgrowths, degraded chert grains and clean, open pore space. Very little cement other than quartz overgrowth tacking of grains.



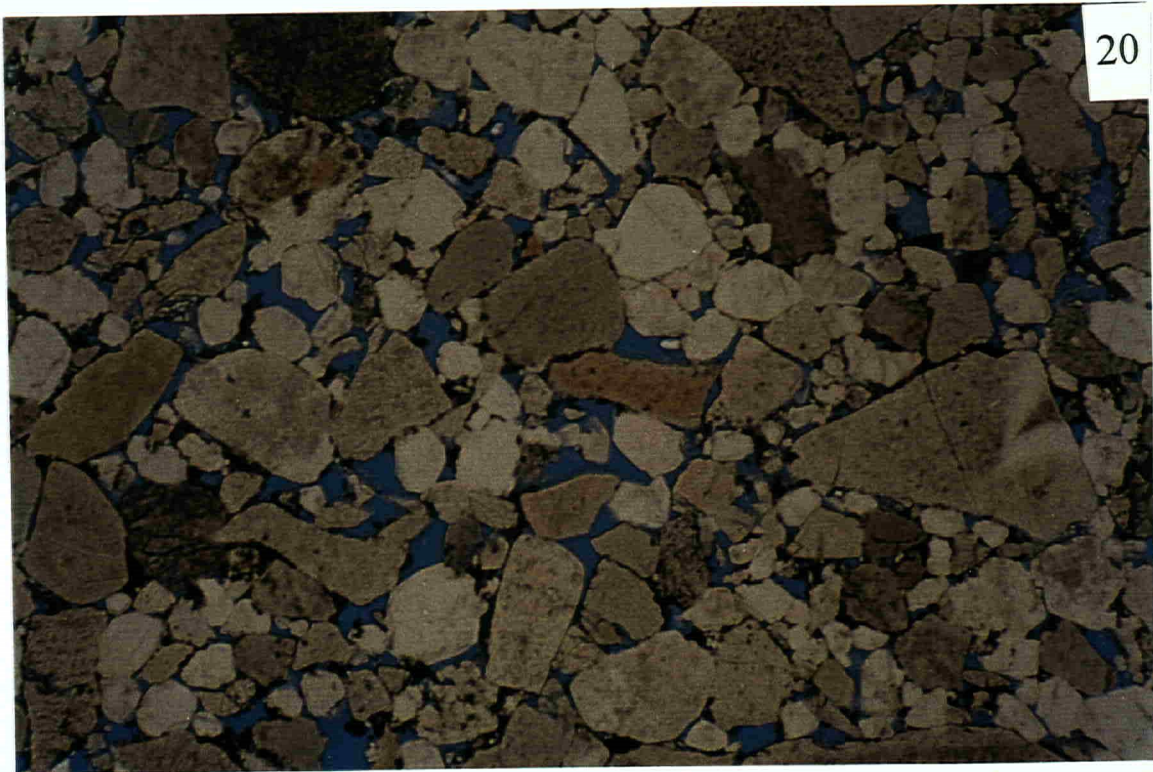
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Birch E53 1348.3'

Jungle Creek

25 x

Chert and quartz pebbly arenite, or conglomeratic sandstone; strongly bimodal angular to subrounded larger pebbles and angular coarse sand; 5 -7% interstitial pyrobitumen (not pyrite – has no reflectants under ppl). Excellent intergranular porosity of 20 – 25% and excellent permeability.

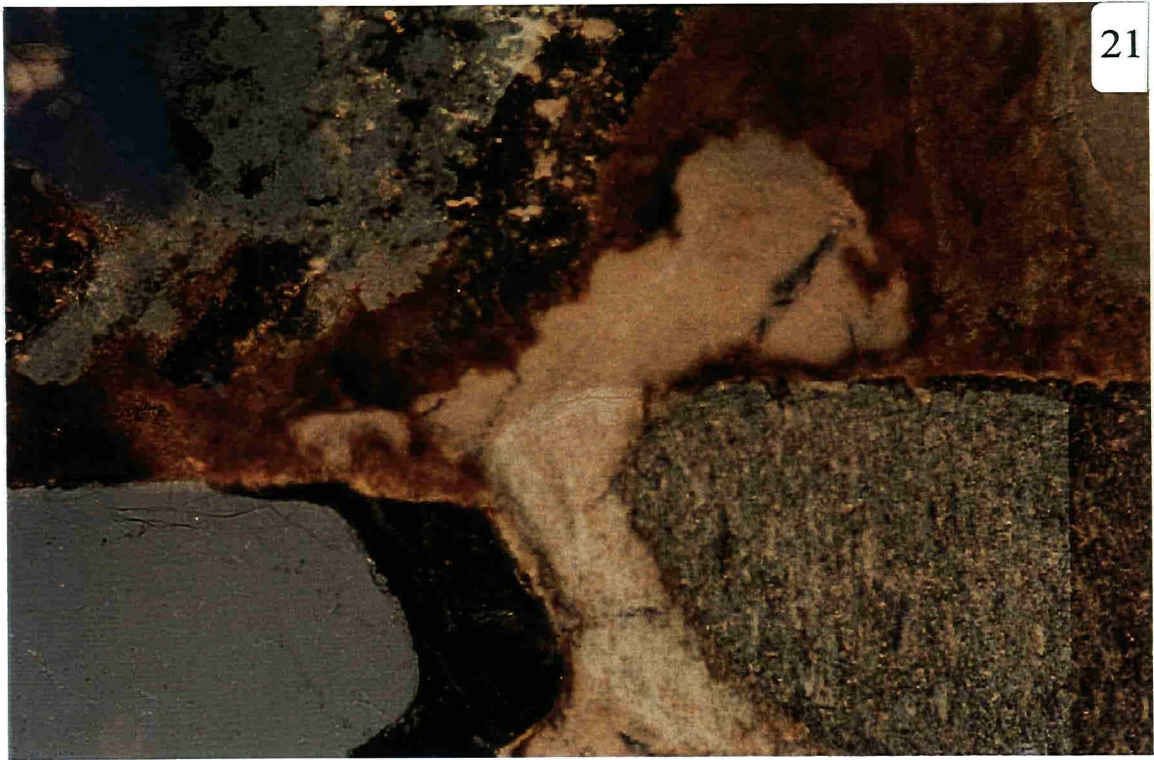


Birch E53 1348.3'

Jungle Creek

100x

Chert and quartz conglomerate interstitial pyrobitumen detail. Appears similar to pyrite but did not have reflectants; strong quartz overgrowth evident. Some chert grains fractured.



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11

Birch E53 1365' Jungle Creek

100x

Coarse chert and quartz pebble conglomerate. Excellent porosity, partially infilled by hydrothermal flow of pyritic fluid into pore space. Pyrite/Limonite/Hematite pore fill shows flow structures, otherwise porosity is excellent. Photo is reflected light.

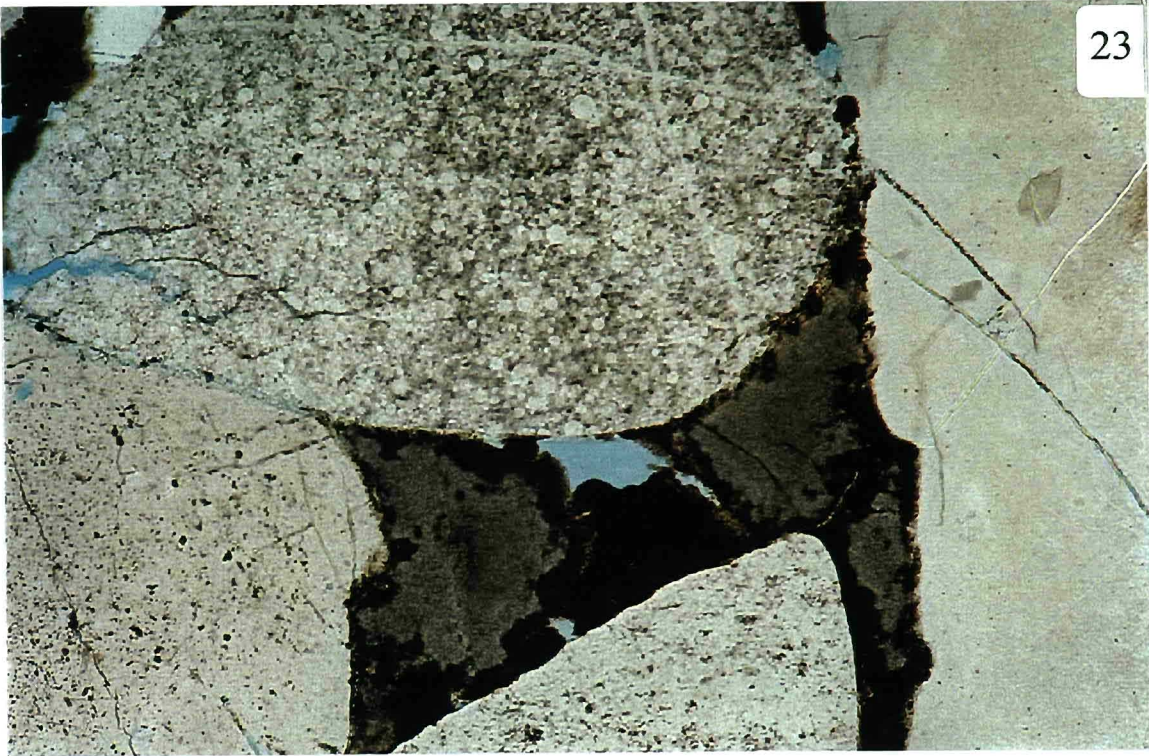


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Birch E53 1365' Jungle Creek

100x

Chert pebble conglomerate angular to subrounded pebbles excellent intergranular porosities and permeability. Photo taken in ppl shows zoned flow structure of limonite/hematite and possibly pyrobitumen partially infilling large intergranular area.



Birch E53 1371.5'

Jungle Creek

100x

Chert quartzite and quartz pebble conglomerate. Chert population is mixed radiolarian fine-grained and altered grain types. Larger grains are rounded to subangular grain boundaries are relatively uneroded, some grains show a bit of fracturing; view shows hematite/pyrite pore lining detail but most pores are open with excellent porosity.



Birch E53 1371.5'

Jungle Creek

63x

Chert quartzite and quartz pebble conglomerate; Detail of porosity showing pore lining partially occluding some of the porosity and pore grain packing, leaving open pore permeability. Note that many grains are fractured partially at pressure point contacts due to compaction but some may be post-compaction.

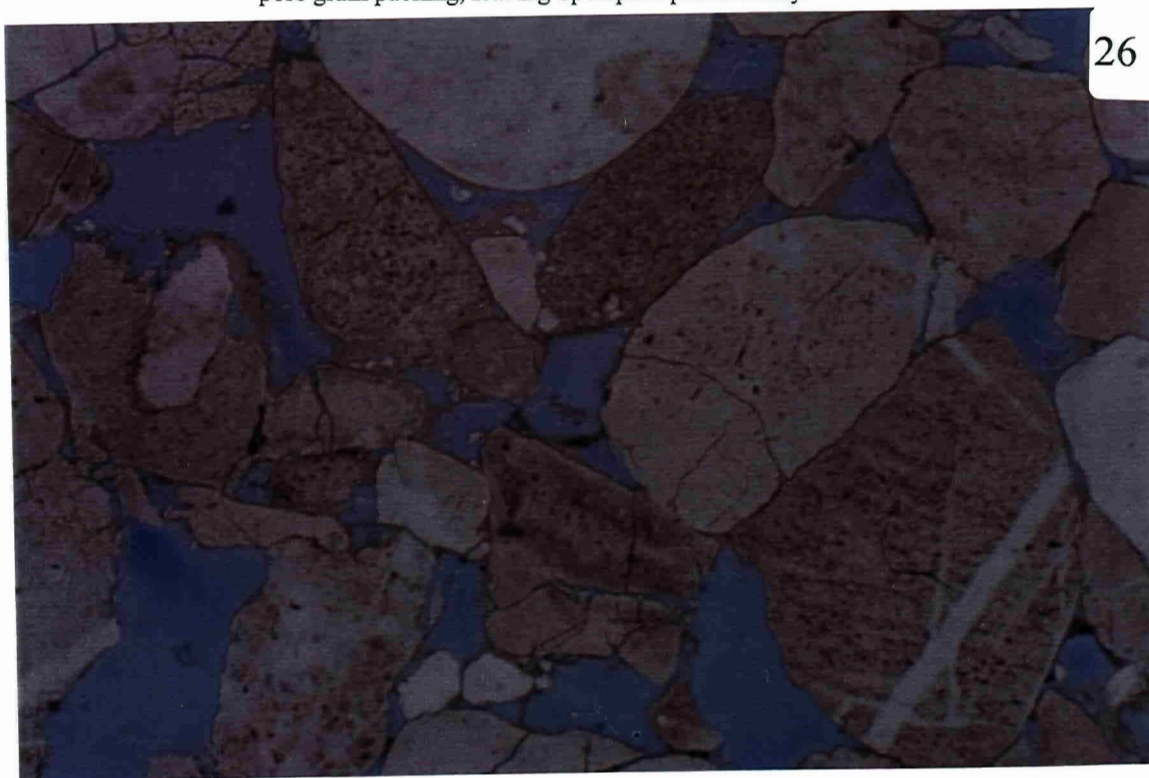


Birch E53 1371.5'

Jungle Creek

100x

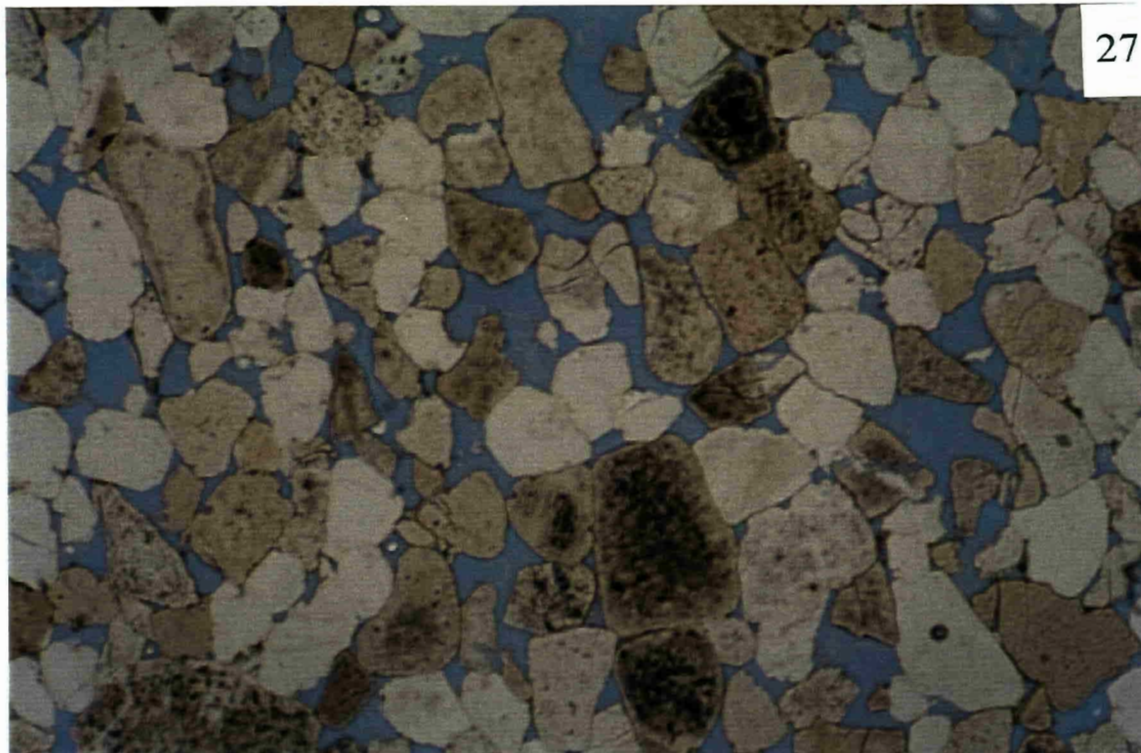
Chert quartzite and quartz pebble conglomerate; Detail of porosity showing pore lining partially occluding some of the porosity and pore grain packing, leaving open pore permeability.



Birch E53 1636' Jungle Creek

100x

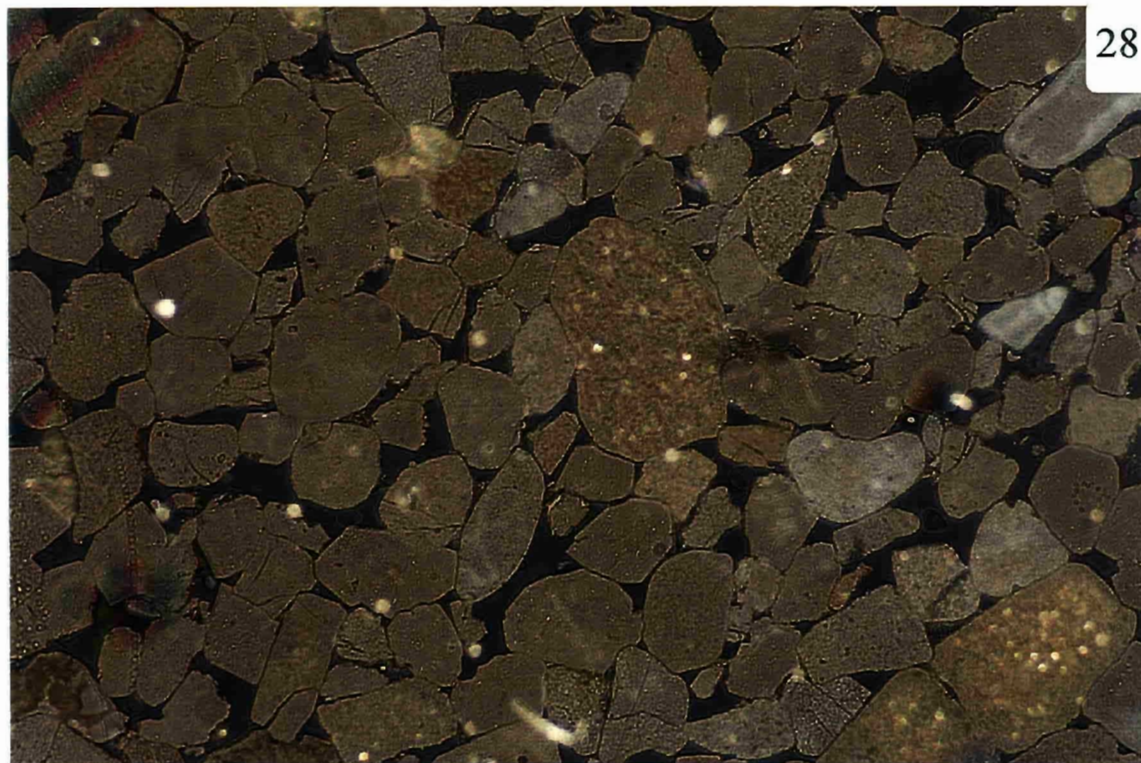
Chert and quartz pebble conglomerate; grains tacked lightly together with illite or some other clay with fibrous habit. Clay forms thin grain coating and it remains where some grains have been possibly dissolved out diogenetically. Porosity excellent, up to 35%, excellent permeability. Much grain fracturing, probably largely due to open pore space weakening grain support, but some secondary fracturing may be present.



Birch E53 1638' Jungle Creek

63x

Chert and quartz pebbly conglomerate; approximately one-third of chert grains are pyritized. Huge, open pore space gives porosity of 30% plus, excellent permeability. Very minor illite cement, some sutured grain contacts, some fractured quartz grains due to compaction. Black colouration of chert grains is diagenetic pyrite.



Birch E53 1638' Jungle Creek

63x

Reflected light, similar view to previous.

Chert and quartz pebbly conglomerate; shows approximately one-third of chert grains are pyritized.

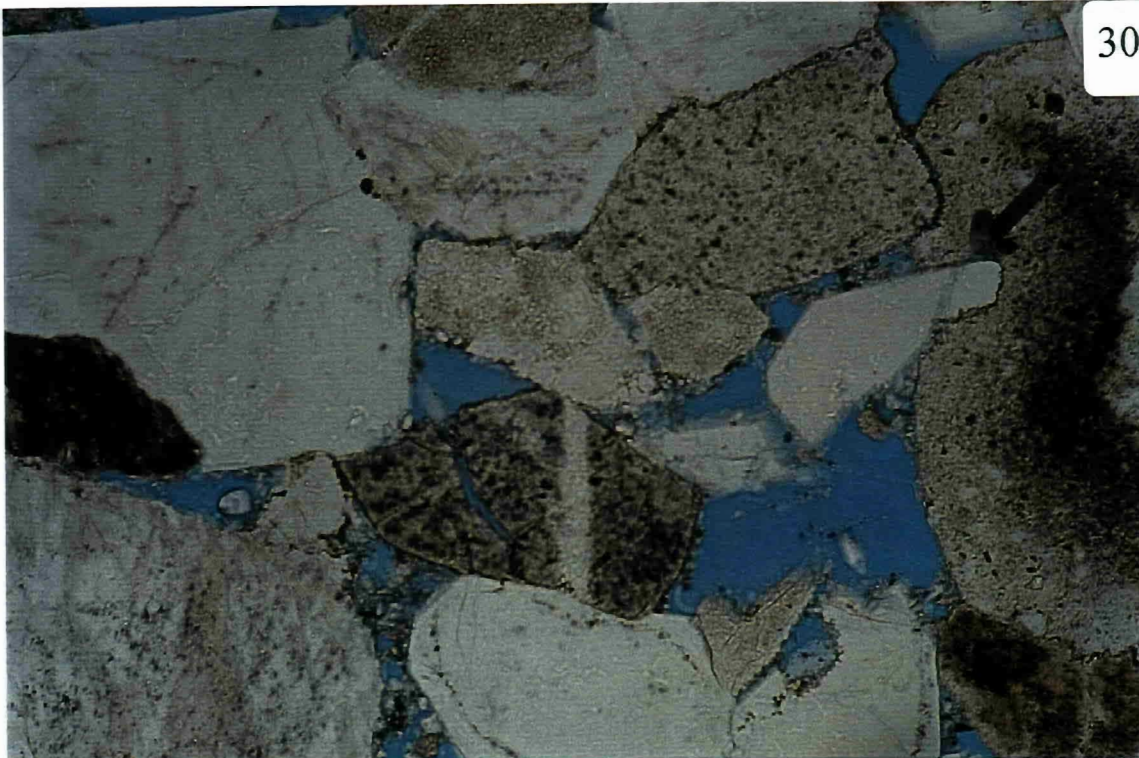


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Birch E53 1828' Jungle Creek

25x

Coarse-grained to pebble-sized chert and quartz arenite/conglomerate; angular to subrounded grains; compaction intrusion of quartz grains due to degraded chert pebbles. Very minor illite grain coatings; porosity approximately 25 – 30%.

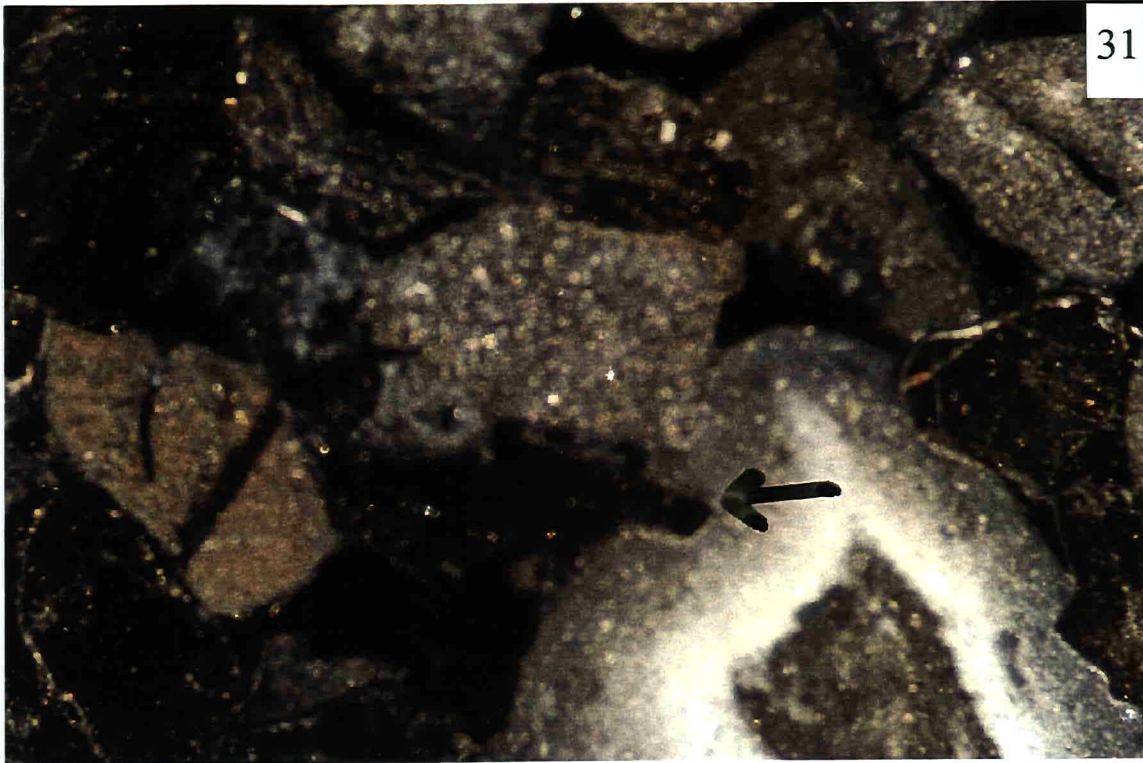


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Birch E53 1828' Jungle Creek

100x

Chert and quartz pebble conglomerate; approximately one-third of chert grains are pyritized. Huge, open pore space gives porosity of 30% plus, excellent permeability. Very minor illite cement, some sutured grain contacts, some fractured quartz grains due to compaction. Black colouration of chert grains is diagenetic pyrite.

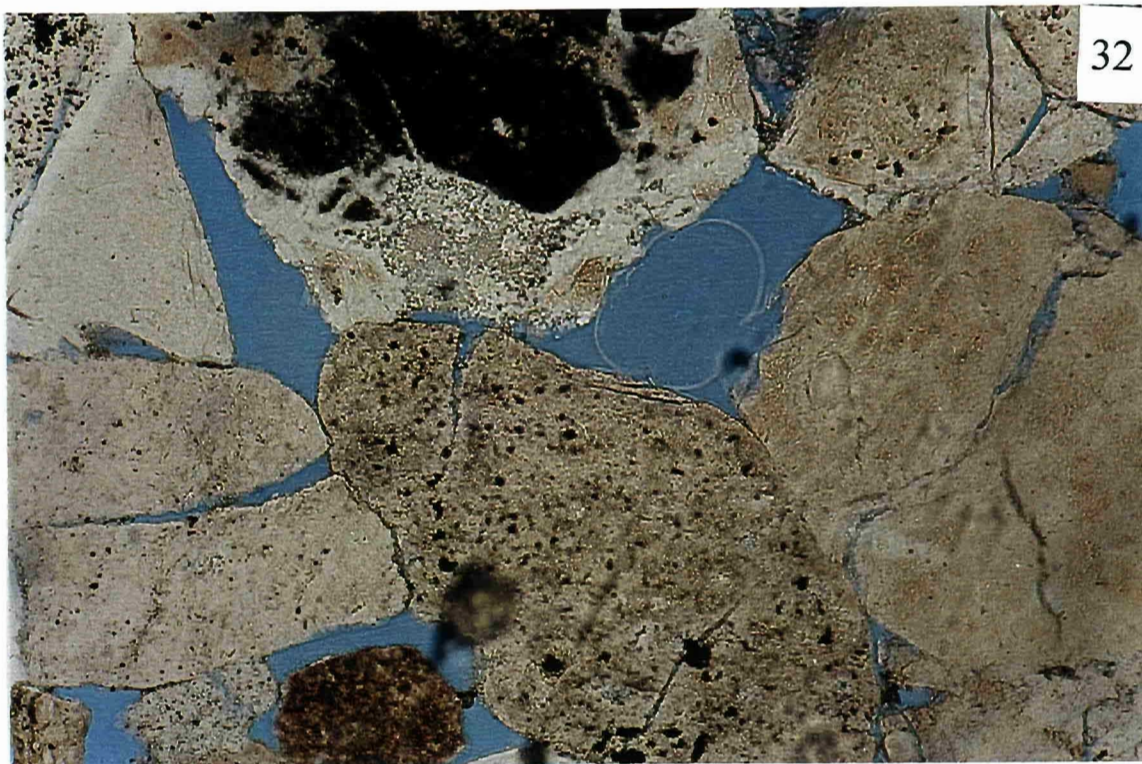


Birch E53 1828' Jungle Creek

Reflected light.

100x

Chert and quartz pebble conglomerate; approximately one-third of chert grains are pyritized. Huge, open pore space gives porosity of 30% plus, excellent permeability. Very minor illite cement, some sutured grain contacts, some fractured quartz grains due to compaction. Black colouration of chert grains is diagenetic pyrite, which shows up under reflected light or as wet luster. Arrow points to quartz overgrowth penetration of previous photograph.



Birch E53 1828' Jungle Creek

PPL

100x

Chert and quartz pebble conglomerate; approximately one-third of chert grains are pyritized. Huge, open pore space gives porosity of 30% plus, excellent permeability. Very minor illite cement, some sutured grain contacts, some fractured quartz grains due to compaction, but some fractures may be expansion due to freezing of pore fluid. Black colouration of large chert grain is diagenetic pyrite.