Appendix B: Aggregate Petrographic Reports

Appendix B of *NCHRP Research Report 1083: Alkali-Silica Reactivity Potential and Mitigation: Test Methods and State of Practice* (NCHRP Project 10-103).

Appendix B: Aggregate Petrographic Reports

Appendix B of *NCHRP Research Report 1083: Alkali-Silica Reactivity Potential and Mitigation: Test Methods and State of Practice* (NCHRP Project 10-103)

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Petrographic report

Sample identification	Type (Particle size)
CA1	5-20 mm
Analysis date	**Petrographer**
Winter 2022	Andreia Rodrigues

Introduction

The main objective of this report is to describe the composition of the different rock types/facies and particularly those that contain reactive types of silica in their composition. This petrographic study consisted of a visual (macroscopic) classification followed the examination of representative particles of each facies in thin sections under a petrographic microscope. The report includes macroscopic and a microscopic descriptions of the aggregate and a series of macroscopic photos of the rock facies; micrographs of the thin sections are presented in the appendix.

Methodology

The petrographic analysis was conducted on a representative subsample of 1438.9g of the aggregate CA1 (5-20 mm). The sample was first washed for a better observation of its mineralogical and textural characteristics. Each particle was then examined separately to identify the type of rock (or *facies*). When applicable or appropriate, a distinction was made between the different sub-types of lithology as a function of their mechanical quality or degree of alteration. After sorting, the mass of each facies/lithology was determined to the nearest 0.1 g, and its relative abundance in the sample was calculated to the nearest 0.1%.

Polished thin sections were prepared from representative grains of each of the main petrographic facies identified during macroscopic examination of the aggregate. The grains were mounted in an epoxy matrix and the block thus produced was cut, glued to a glass slide, and then thinned to a thickness of 30 µm. A thin section was thus prepared. The thin sections were examined in transmitted light on a Zeiss Axio Scope.A1 petrographic microscope at up to 50X magnification. The nature of the opaque minerals was determined, in reflected light on this same microscope, when their size allowed.

General description of the aggregate CA1

The aggregate is essentially composed of metagranite (macroscopically divided into three sub-facies). The macroscopic examination permitted to characterize the following facies:

Metagranite: dark gray, sub-angular, massive. High hardness. (Figure 1).

Fine-grained metagranite: dark gray, sub-angular, massive. High hardness. (Figure 2).

Rusted metagranite: pink, sub-angular to sub-rounded particles. Shows traces of oxidation. High to medium hardness (Figure 3).

Table 1: Proportion of the main facies of the Aggregate CA1.

Facies	**CA1 (5-20mm)**	
	Mass (g)	**Proportion (%)**
Metagranite	1225.9	85.20
Fine-grained metagranite	53.1	3.69
Rusted metagranite	159.9	11.11
Total	**1438.9**	**100**

Macroscopic photos of the different rock facies in the Aggregate CA1

Figure 1 : Metagranite (Aggregate CA1).

Figure 2: Fine-grained metagranite (Aggregate CA1).

Figure 3: Rusted metagranite (Aggregate CA1)

Microscopic descriptions of the rock facies observed in thin sections

Table 2: Metagranite (Aggregate CA1)

General description	Igneous slightly metamorphosed rock (Figure 4)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Feldspars	38	low birefringence	altered	< 1,15
Quartz	20	low birefringence	see table 5	≥ 1.0 mm
Biotite	20	brown	not observed	< 0.20 mm
Muscovite	10	high birefringence	not observed	< 0.10 mm
Chlorite	5	green	not observed	< 0.20 mm
Epidote	5	Arlequin mantle	Not observed	< 1.10
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Zircon	traces	high birefringence	not observed	< 0.10 mm
Pyrrhotite	2	peach pink	oxidated	< 0,60 mm
Chalcopyrite	traces	tin yellow	not observed	< 0,15 mm

Table 3: Fine-grained metagranite (Aggregate CA1)

General description	Igneous rock slightly metamorphosed (Figure 5)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	30	low birefringence	see table 5	< 0.60 mm
Muscovite	10	high birefringence	not observed	≥ 0.25 mm
Biotite	15	brown	not observed	< 0.10 mm
Feldspars	25	low birefringence	altered	< 0.50 mm
Plagioclase	10	polysynthetic twinning	altered	< 0.25 mm
Microcline	10	Tartan twinning	altered	< 0.25 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Zircon	traces	high birefringence	not observed	< 0.04 mm
Pyrrhotite	traces	peach pink	oxidated	< 0.05 mm

Table 4: Rusted metagranite (Aggregate CA1)

General description	Igneous rock slightly metamorphosed (Figure 6)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Feldspars	43	low birefringence	altered	< 4.3 mm
Quartz	30	low birefringence	see table 5	< 4.2 mm
Biotite	15	brown	not observed	< 0.50 mm
Muscovite	10	high birefringence	not observed	< 1.55 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Zircon	traces	high birefringence	not observed	< 0.08 mm
Microcline	traces	Tartan twinning	altered	< 0.30 mm
Plagioclase	traces	polysynthetic twinning	altered	< 0.25 mm
Pyrrhotite	2	peach pink	oxidated	< 0.01 mm
Chalcopyrite	traces	tin yellow	not observed	< 0.01 mm

Micrographs of the different rock facies (Aggregate CA1)

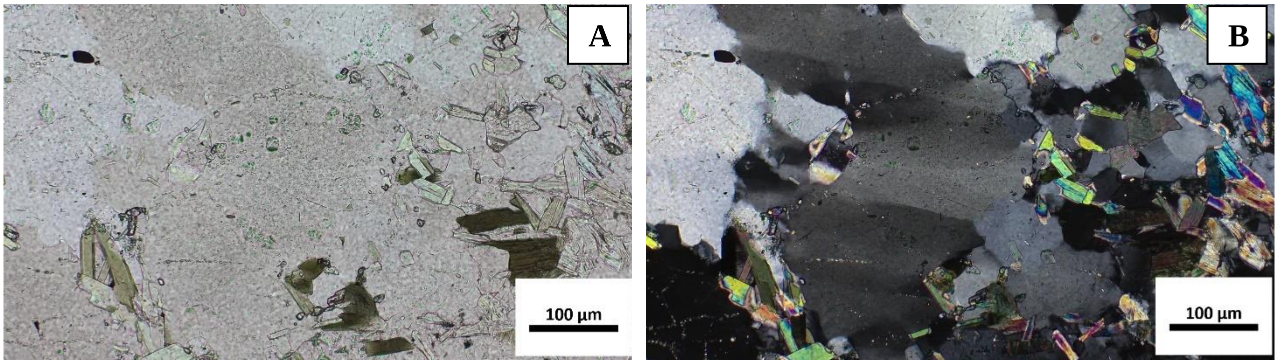

Figure 4: Micrograph of metagranite. Large grains of strained quartz (wavy banding in the central grain) and fine muscovite grains (bright colors) (A) Plane-polarized light. (B) Crossed polarized light.

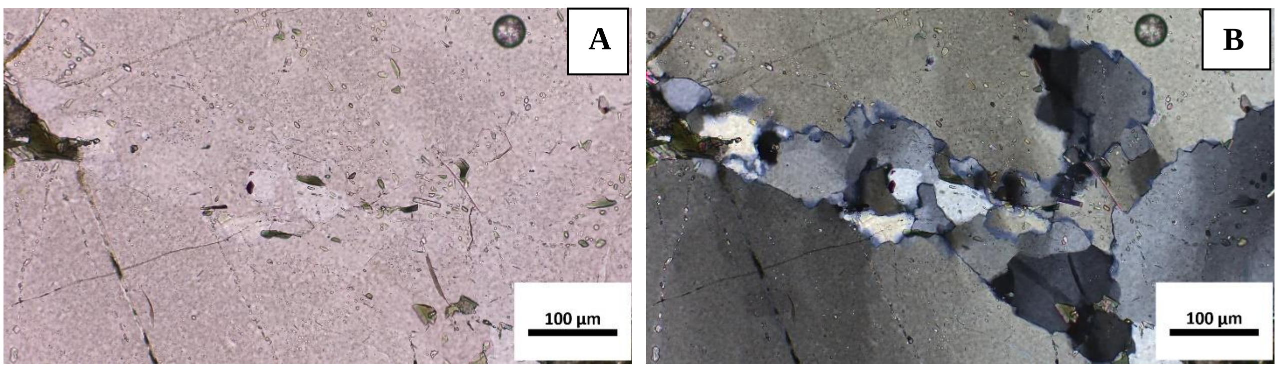

Figure 5: Micrograph fine-grained metagranite. Fine-grained quartz (interlocking texture) and quartz showing undulatory extinction (wavy banding) (A) Plane-polarized light. (B) Crossed polarized light.

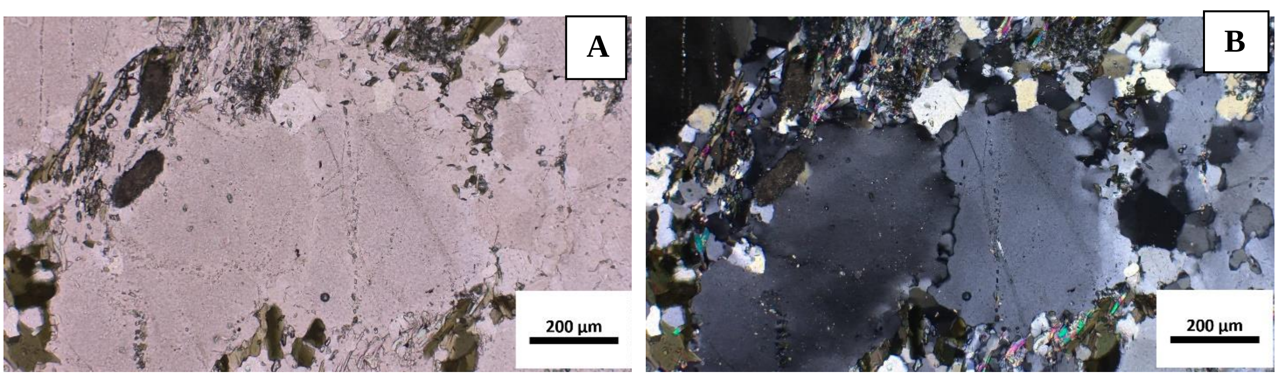

Figure 6: Micrograph of rusted metagranite. Strained quartz grains and smaller quartz (microcrystalline) grains showing an interlocking texture (A) Plane-polarized light. (B) Crossed polarized light.

Table 5: Potentially reactive phases in the Aggregate CA1

Facies	**Aggregate CA1 (5-20 mm)**
Metagranite	The quartz presents undulatory extinction (strained quartz grains) and the boundaries between the quartz grains are irregular with interlocking texture. Some of the quartz is microcrystalline.
Fine-grained metagranite	The quartz presents undulatory extinction (strained quartz grains) and the boundaries between the quartz grains are irregular with interlocking texture. Some of the quartz is microcrystalline.
Rusted metagranite	The quartz presents undulatory extinction (strained quartz grains) and the boundaries between the quartz grains are irregular with interlocking texture. Some of the quartz is microcrystalline.

Petrographic report

Sample identification	**Type (Particle size)**
CA2	5-20 mm
Analysis date	**Petrographer**
Winter 2022	Andreia Rodrigues

Introduction

The main objective of this report is to describe the composition of the different rock types/facies and particularly those that contain reactive types of silica in their composition. This petrographic study consisted of a visual (macroscopic) classification followed the examination of representative particles of each facies in thin sections under a petrographic microscope. The report includes macroscopic and a microscopic descriptions of the aggregate and a series of macroscopic photos of the rock facies; micrographs of the thin sections are presented in the appendix.

Methodology

The petrographic analysis was conducted on a representative subsample of 1260.7g of the aggregate CA2 (5-20 mm). The sample was first washed for a better observation of its mineralogical and textural characteristics. Each particle was then examined separately to identify the type of rock (or *facies*). When applicable or appropriate, a distinction was made between the different sub-types of lithology as a function of their mechanical quality or degree of alteration. After sorting, the mass of each facies/lithology was determined to the nearest 0.1 g, and its relative abundance in the sample was calculated to the nearest 0.1%.

Polished thin sections were prepared from representative grains of each of the main petrographic facies identified during macroscopic examination of the aggregate. The grains were mounted in an epoxy matrix and the block thus produced was cut, glued to a glass slide, and then thinned to a thickness of 30 µm. A thin section was thus prepared. The thin sections were examined in transmitted light on a Zeiss Axio Scope.A1 petrographic microscope at up to 50X magnification. The nature of the opaque minerals was determined, in reflected light on this same microscope, when their size allowed.

General description of the Aggregate CA2

The aggregate is a gravel composed of different types of lithologies. The macroscopic examination permitted to characterize the following facies:

Granite: pink-whitish, sub-angular, massive. High hardness. (Figure 1).

Granitic gneiss: pink-gray, sub-angular, massive. High hardness. (Figure 2).

Quartz veins / quartzite: whitish, sub-angular to sub-rounded particles. High hardness (Figure 3).

Chert: beige, sub-angular to sub-rounded particles. High hardness (Figure 4).

Rhyolite: reddish, sub-angular to sub-rounded particles. High hardness (Figure 5).

Sandstone: gray, sub-angular to sub-rounded particles. High hardness (Figure 6).

Undifferentiated altered grains: different colors, sub-angular to sub-rounded particles. Medium hardness.

Table 1: Proportion of the main facies of the Aggregate CA2.

Facies	**CA2 (5-20mm)**	
	Mass (g)	**Proportion (%)**
Granite	189.0	15.0
Granitic gneiss	687.3	54.5
Quartz veins / quartzite	119.7	9.5
Chert	59.9	4.8
Rhyolite	15.4	1.2
Sandstone	42.9	3.4
Undifferentiated altered grains	146.5	11.6
Total	**1260.7**	**100**

Macroscopic photos of the different rock facies in the Aggregate CA2

Figure 1 : Granite (Aggregate CA2).

Figure 2: Gneiss granitique (Aggregate UT-06).

Figure 3: Quartz veins (Aggregate CA2).

Figure 4: Chert (Aggregate CA2).

Figure 5: Rhyolite (Aggregate CA2).

Figure 6: Sandstone (Aggregate CA2).

Microscopic descriptions of the rock facies observed in thin sections

Table 2: Granite (Aggregate CA2)

General description	Igneous rock (Figure 7)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Plagioclase	55	polysynthetic twinning	altered	< 0.55 mm
Quartz	35	low birefringence	see table 9	< 1.0 mm
Chlorite	5	green	not observed	< 0.20 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Apatite	traces	high relief	not observed	< 0,01mm
Ilmenite	2	gray	not observed	< 0.20 mm
Hematite	3	gray	not observed	< 0.07mm
Green hornblende	traces	2 120^{o} cleavages	not observed	< 0.20
Epidote	traces	Arlequin mantle	not observed	< 0.10

Table 3: Granitic gneiss (Aggregate CA2)

General description	Metamorphic rock from igneous origin (Figure 8)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	25	low birefringence	see table 9	< 0.95 mm
Muscovite	15	high birefringence	not observed	< 0.10 mm
K Feldspars	60	low birefringence	altered	< 1.25 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Orthose	traces	Carlsbad twinning	not observed	< 0.90 mm
Apatite	traces	Arlequin mantle	not observed	< 0.07 mm

Table 4: Quartz veins / quartzite (Aggregate CA2)

General description	Metamorphic rock (Figure 9)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	100	low birefringence	see table 9	< 4.0 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Biotite	traces	pleochroic	not observed	< 0.60 mm

Table 5: Sandstone (Aggregate CA2)

General description	Sedimentary rock (Figure 10)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	98	low birefringence	see table 9	< 0.90 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Opaque minerals	traces	gray	not observed	< 0.01mm
Epidote	2	Arlequin mantle	not observed	< 0.10 mm

Table 6: Chert (Aggregate CA2)

General description	Sedimentary rock (Figure 11)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	90	low birefringence	see table 9	< 0.90 mm
Clay minerals	10	brown	not observed	< 0.01mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Plagioclase	traces	polysynthetic twinning	altered	< 0.25 mm

Table 7: Rhyolite (Aggregate CA2)

General description	Igneous rock (Figure 12)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	45	low birefringence	see table 9	< 0.35 mm
Feldspars	50	low birefringence	altered	< 1.40 mm
Volcanic glass	15	brown	not observed	< 0.01mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Opaque minerals	traces	gray	not observed	< 0.01 mm

Micrographs of the different rock facies of the Aggregate CA2

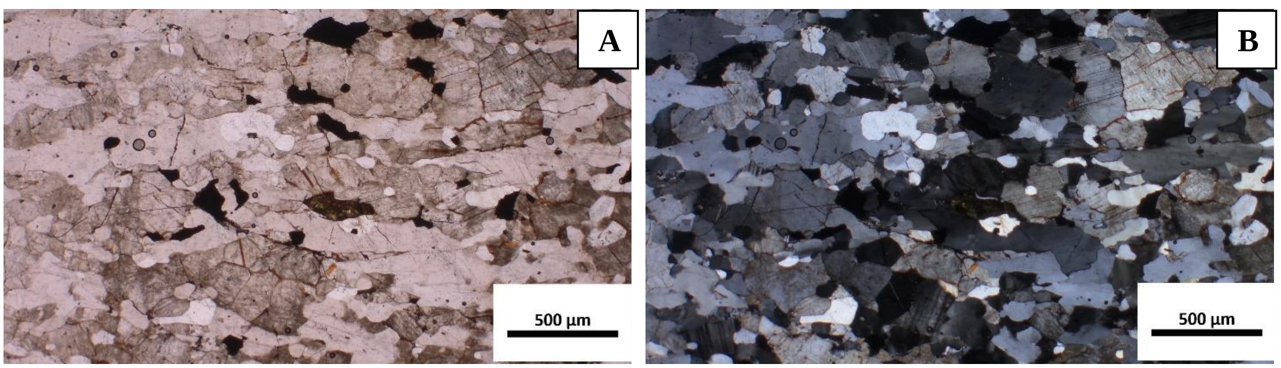

Figure 7: Micrograph of granite. Mixture of plagioclase and quartz grains; some of the quartz grains show wavy banding (strained quartz grains). (A) Plane-polarized light. (B) Crossed polarized light.

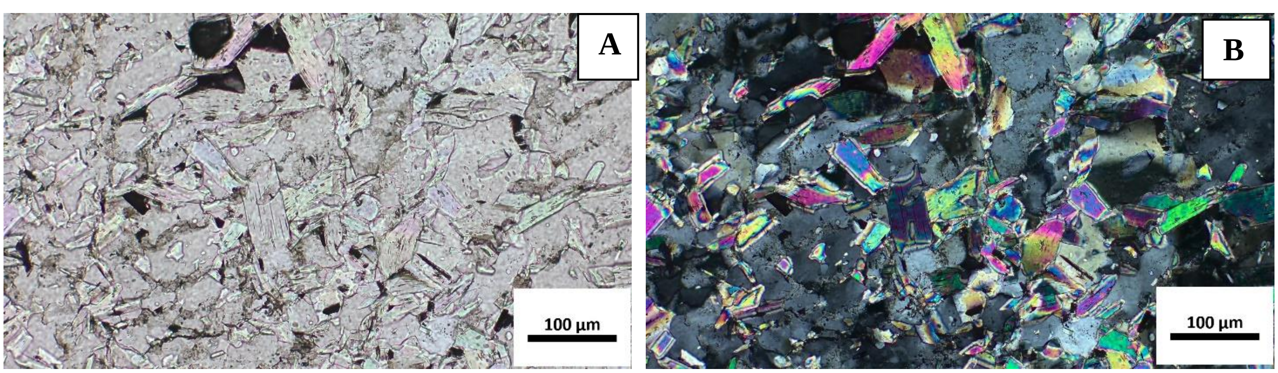

Figure 8: Micrograph granitic gneiss. Mixture of alkali feldspar, quartz and muscovite (bright colors). (A) Plane-polarized light. (B) Crossed polarized light.

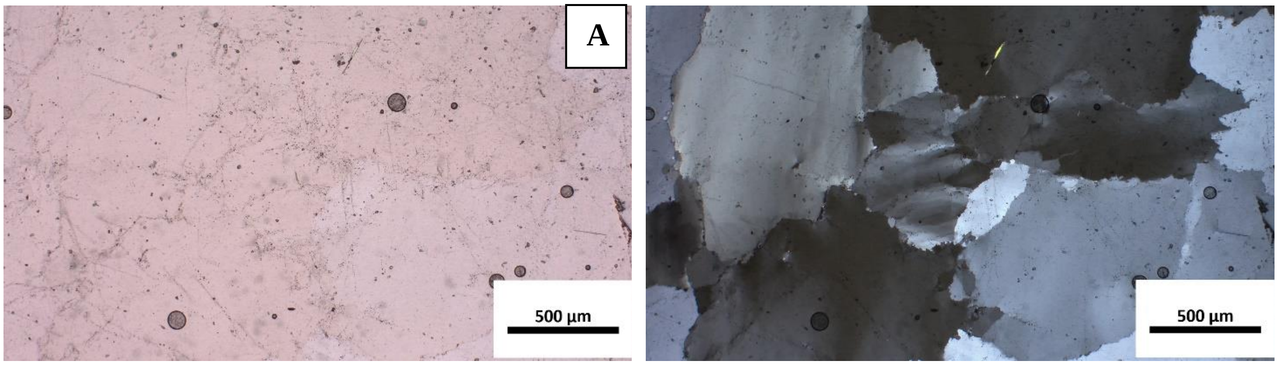

Figure 9: Micrograph of quartz veins / quartzite. The quartz grains show wavy banding (strained quartz). (A) Plane-polarized light. (B) Crossed polarized light.

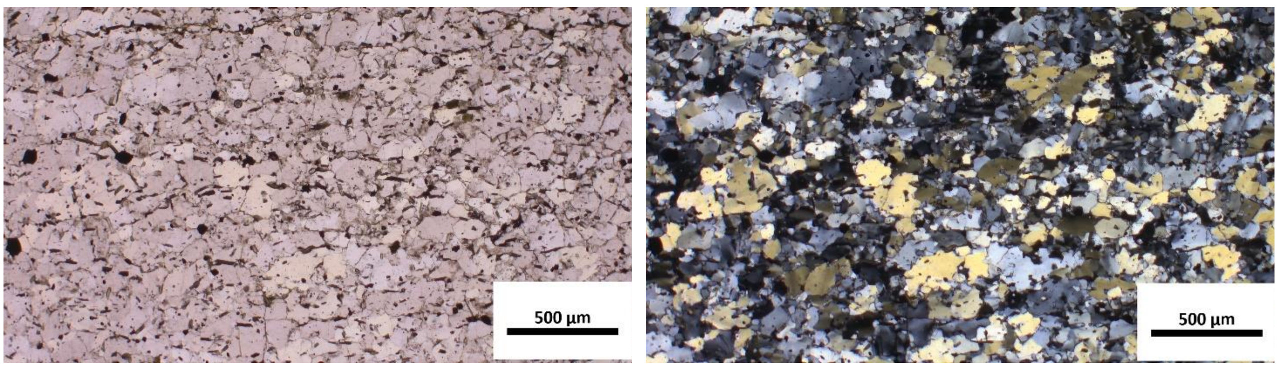

Figure 10: Micrograph of sandstone, strained quartz and biotite (brown minerals). (A) Plane-polarized light. (B) Crossed polarized light.

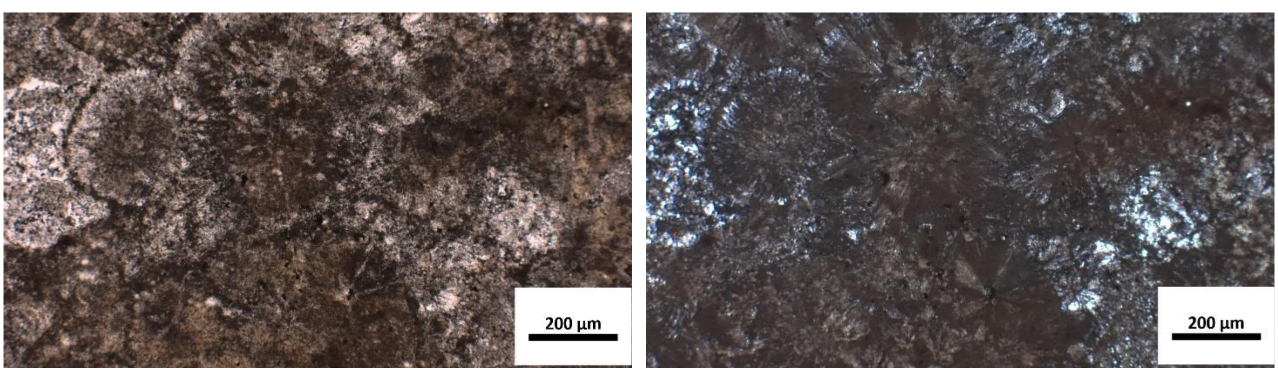

Figure 11: Micrograph of chert, feather-like crystals of chalcedony and cryptocrystalline quartz. (A) Plane-polarized light. (B) Crossed polarized light.

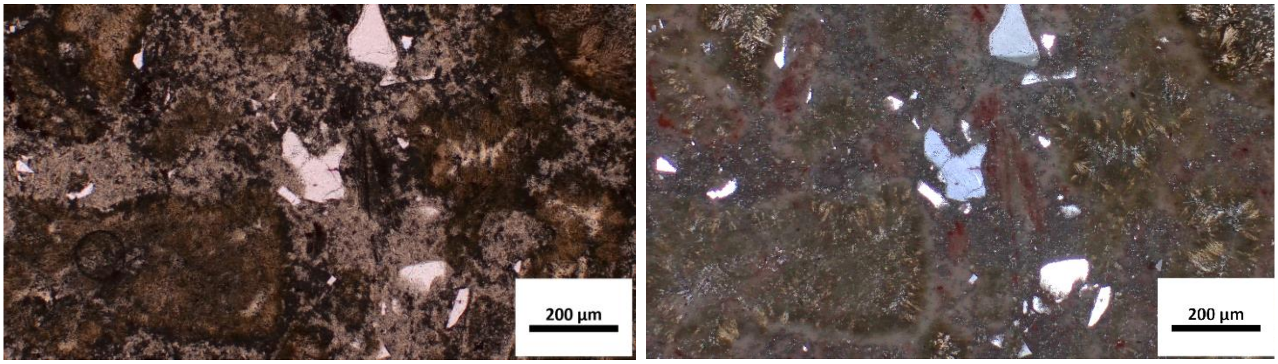

Figure 12: Micrograph of rhyolite. Quartz grains disseminated in a fine-grained groundmass of quartz and feldspar, including volcanic glass. (A) Plane-polarized light. (B) Crossed polarized light.

Table 9: Potentially reactive phases in the Aggregate CA2.

Facies	**CA2 (5-20mm)**
Granite	The quartz presents undulatory extinction.
Granitic gneiss	The quartz presents undulatory extinction and the boundaries between the quartz grains are irregular with interlocking texture. Some of the quartz is microcrystalline.
Quartz veins	The quartz presents undulatory extinction and the boundaries between the quartz grains are irregular with interlocking texture. Some of the quartz shows lamellae.
Chert	The chert presents feather-like crystals of chalcedony and cryptocrystalline quartz.
Rhyolite	The volcanic glass as a matrix in this rock can be reactive. It is also possible to observe feather-like crystals of quartz.
Sandstone	The quartz presents undulatory extinction and the boundaries between the quartz grains are irregular with interlocking texture.

Petrographic report

Sample identification CA3	**Type (Particle size)** 5-20 mm
Analysis date Winter 2022	**Petrographer** Andreia Rodrigues

Introduction

The main objective of this report is to describe the composition of the different rock types/facies and particularly those that contain reactive types of silica in their composition. This petrographic study consisted of a visual (macroscopic) classification followed the examination of representative particles of each facies in thin sections under a petrographic microscope. The report includes macroscopic and a microscopic descriptions of the aggregate and a series of macroscopic photos of the rock facies; micrographs of the thin sections are presented in the appendix.

Methodology

The petrographic analysis was conducted on a representative subsample of 1830 g of the aggregate CA3 (5-20 mm). The sample was first washed for a better observation of its mineralogical and textural characteristics. Each particle was then examined separately to identify the type of rock (or *facies*). When applicable or appropriate, a distinction was made between the different sub-types of lithology as a function of their mechanical quality or degree of alteration. After sorting, the mass of each facies/lithology was determined to the nearest 0.1 g, and its relative abundance in the sample was calculated to the nearest 0.1%.

Polished thin sections were prepared from representative grains of each of the main petrographic facies identified during macroscopic examination of the aggregate. The grains were mounted in an epoxy matrix and the block thus produced was cut, glued to a glass slide, and then thinned to a thickness of 30 µm. A thin section was thus prepared. The thin sections were examined in transmitted light on a Zeiss Axio Scope.A1 petrographic microscope at up to 50X magnification. The nature of the opaque minerals was determined, in reflected light on this same microscope, when their size allowed.

General description of the Aggregate CA3

The aggregate is essentially composed of green schist (macroscopically divided into three sub-facies). The macroscopic examination permitted to characterize the following facies:

Green schist: gray to greenish, sub-angular and foliated particles. High hardness. (Figure 1).

Fine-grained green schist: gray to greenish, sub-angular and foliated particles. High hardness. (Figure 2).

Altered green schist: gray to greenish, sub-angular particles. Medium hardness. (Figure 3).

Table 1: Proportion of the main facies of the Aggregate CA3.

Facies	**CA3 (5-20mm)**	
	Mass (g)	**Proportion (%)**
Green schist	1182.1	64.6
Fine-grained green schist	539.6	29.5
Altered green schist	108.3	5.9
Total	**1830**	**100**

Macroscopic photos of the different rock facies in the Aggregate CA3.

Figure 1 : Green schist facies (Aggregate CA3).

Figure 2: Fine-grained green schist facies (Aggregate CA3).

Figure 3: Altered green schist facies (Aggregate CA3).

Microscopic descriptions of the rock facies observed in thin sections

Table 2: Green schist (Aggregate CA3)

General description	Foliated metamorphic rock (Figure 4)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	55	gray	not observed	< 0.30 mm
Chlorite	25	green	not observed	< 0.70 mm
Epidote	10	Arlequin mantle	not observed	< 0.10 mm
Muscovite	5	2^{nd} order birefringence	not observed	< 0.15 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
K Feldspar	traces	gray	yes	< 0.20 mm
Plagioclase	traces	Albite twinning	yes	< 0.10 mm
Magnetite	traces	gray	not observed	< 0.01 mm
Calcite	traces	high birefringence	not observed	< 0.10 mm

Table 3: Fine-grained green schist (Aggregate CA3)

General description	Foliated metamorphic rock (Figure 5)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	60	gray	not observed	< 0.30 mm
Chlorite	25	green	not observed	< 0.70 mm
Calcite	5	high birefringence	not observed	< 0.25 mm
Muscovite	5	2^{nd} order birefringence	not observed	< 0.01 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Feldspar	traces	gray	yes	< 0.06 mm

Micrographs of the different rock facies of the Aggregate CA3

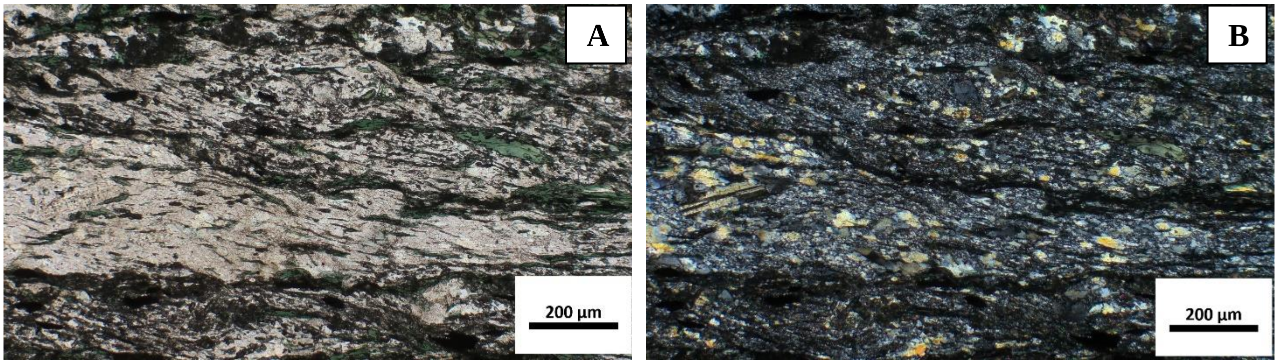

Figure 4: Micrograph of green schist facies. Chlorite, foliation (preferential alignment of chlorite grains) and finely-disseminated quartz readily visible (A) Plane-polarized light. (B) Crossed polarized light.

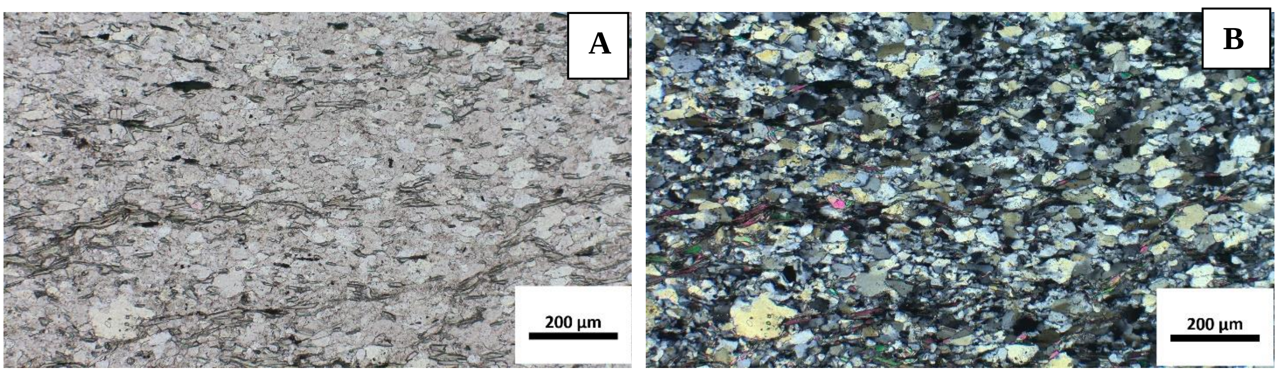

Figure 5: Micrograph of the fine-grained green schist facies. Chlorite, slight foliation (preferential alignment of chlorite grains) and finely-disseminated quartz (grey fine grains) readily visible (A) Plane-polarized light. (B) Crossed polarized light.

Table 4: Potentially reactive phases in the Aggregate CA3

Facies	**Aggregate CA3 (5-20mm)**
Green schist	Some quartz grains present undulatory extinction (strained grains) and the boundaries between the quartz grains are irregular with interlocking texture. Most of the quartz is micro- to cryptocrystalline (very fine grained).
Fine-grained green schist	Some quartz grains present undulatory extinction (strained grains) and the boundaries between the quartz grains are irregular with interlocking texture. Most of the quartz is micro- to cryptocrystalline (very fine grained).

Petrographic report

Sample identification CA4	**Type (Particle size)** 5-20 mm
Analysis date Winter 2022	**Petrographer** Andreia Rodrigues

Introduction

The main objective of this report is to describe the composition of the different rock types/facies and particularly those that contain reactive types of silica in their composition. This petrographic study consisted of a visual (macroscopic) classification followed the examination of representative particles of each facies in thin sections under a petrographic microscope. The report includes macroscopic and a microscopic descriptions of the aggregate and a series of macroscopic photos of the rock facies; micrographs of the thin sections are presented in the appendix.

Methodology

The petrographic analysis was conducted on a representative subsample of 1215 g of the aggregate CA4 (5-20 mm). The sample was first washed for a better observation of its mineralogical and textural characteristics. Each particle was then examined separately to identify the type of rock (or *facies*). When applicable or appropriate, a distinction was made between the different sub-types of lithology as a function of their mechanical quality or degree of alteration. After sorting, the mass of each facies/lithology was determined to the nearest 0.1 g, and its relative abundance in the sample was calculated to the nearest 0.1%.

Polished thin sections were prepared from representative grains of each of the main petrographic facies identified during macroscopic examination of the aggregate. The grains were mounted in an epoxy matrix and the block thus produced was cut, glued to a glass slide, and then thinned to a thickness of 30 µm. A thin section was thus prepared. The thin sections were examined in transmitted light on a Zeiss Axio Scope.A1 petrographic microscope at up to 50X magnification. The nature of the opaque minerals was determined, in reflected light on this same microscope, when their size allowed.

General description of the Aggregate CA4

The aggregate is essentially composed of green schist (macroscopically divided into three sub-facies). The macroscopic examination permitted to characterize the following facies:

Metagranite: dark-gray, sub-angular and massive particles. High hardness. (Figure 1).

Granitic gneiss: dark-gray, sub-angular to sub-rounded and massive particles. High hardness. (Figure 2).

Quartz and epidote veins: green and white sub-angular particles. High hardness. (Figure 3).

Table 1: Proportion of the main facies of the Aggregate CA4.

Facies	**CA4 (5-20mm)**	
	Mass (g)	**Proportion (%)**
Metagranite	1154	95.0
Granitic gneiss	18.5	1.5
Epidote and quartz vein	42.5	3.5
Total	**1215**	**100**

Macroscopic photos of the different rock facies in the Aggregate CA4

Figure 1 : Metagranite (Aggregate CA4).

Macroscopic photos of the different rock facies in the Aggregate CA4

Figure 2: Granitic gneiss (Aggregate CA4).

Figure 3: Epidote and quartz vein (Aggregate CA4).

Microscopic descriptions of the rock facies observed in thin sections for Aggregate CA4

Table 2: Metagranite (Aggregate CA4)

General description	Igneous rock slightly metamorphosed (Figure 4)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Feldspar	45	low birefringence	very altered	< 3.0 mm
Quartz	30	low birefringence	see Table xx	< 1.8 mm
Muscovite	10	2^{nd} order birefringence	not observed	< 0.01 mm
Biotite	15	pleochroic	not observed	< 0.2 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Pyrite	traces	yellow	not observed	< 1 mm
Microcline	traces	low birefringence	altered	
Zircon	traces	high birefringence	not observed	

Table 3: Granitic gneiss (Aggregate CA4)

General description	Metamorphic rock from igneous origin (Figures 5 to 7)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	30	low birefringence	see Table 2	< 3.5 mm
K Feldspar	30	low birefringence	altered	< 0.40 mm
Plagioclase	10	Albite twinning	altered	< 0.30 mm
Biotite	20	pleochroic	not observed	< 0.70 mm
Muscovite	10	high birefringence	not observed	< 0.20 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Zircon	traces	yellow	not observed	< 0.01 mm
Microcline	traces	low birefringence	not observed	< 0.40 mm
Pyrrhotite	traces	peach pink	not observed	< 0.01 mm
Chalcopyrite	traces	tin yellow	not observed	< 0.10 mm

Table 4: Epidote and quartz veins (Aggregate CA4)

General description	Veins probably resulting from metamorphism (Figure 8)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	57	high birefringence	see Table xx	< 0.7 mm
Epidote	10	high birefringence	not observed	< 0.20 mm
Biotite	15	pleochroic	not observed	< 0.2 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Pyrite	3	yellow	not observed	< 0.8 mm
Calcite	Traces	high birefringence	not observed	< 0.2 mm

Micrographs of the different rock facies of the Aggregate CA4

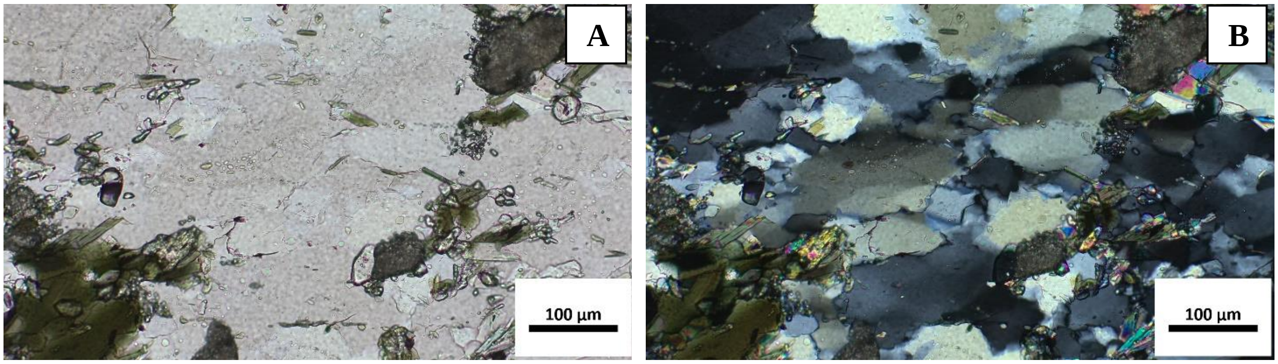

Figure 4: Micrograph of metagranite facies. Large areas of strained quartz (wavy light to dark-grey grains) are readily visible. (A) Plane-polarized light. (B) Crossed polarized light.

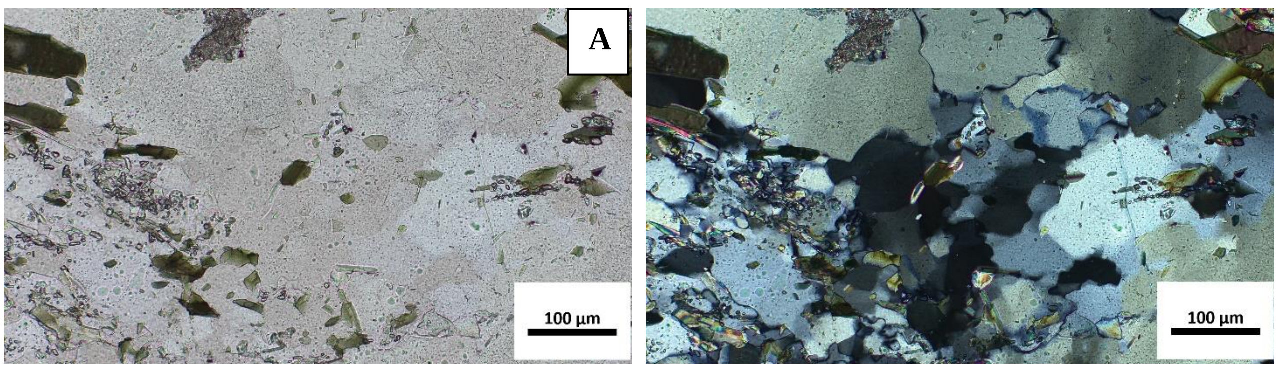

Figure 5: Micrograph of granitic gneiss facies. Mixture of quartz (wavy light to dark-grey areas) and alkali feldspars grains is visible. (A) Plane-polarized light. (B) Crossed polarized light.

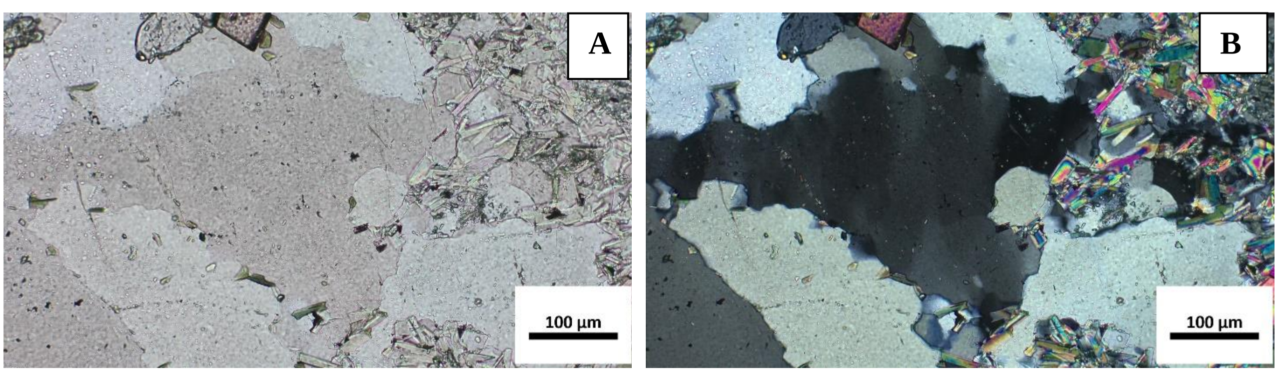

Figure 6: Micrograph of granitic gneiss facies. Mixture of quartz (wavy light to dark-grey areas) and muscovite (upper right; bright colors) is visible. (A) Plane-polarized light. (B) Crossed polarized light.

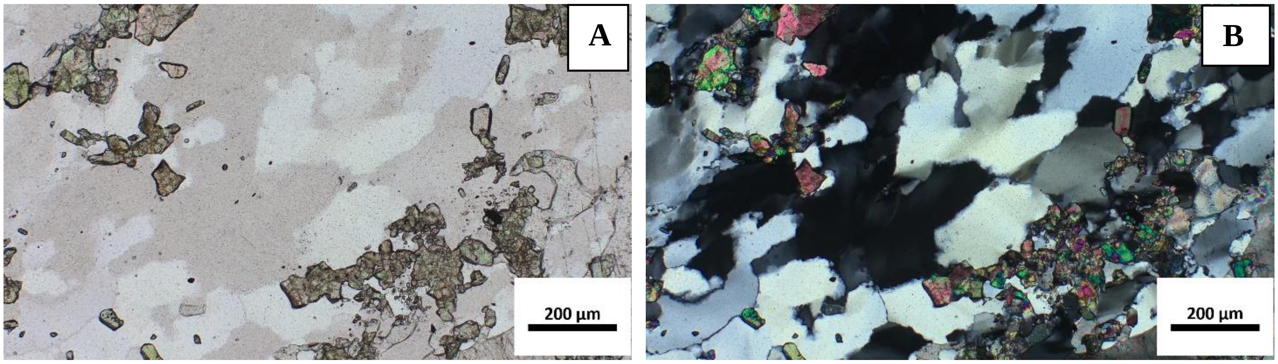

Figure 7: Micrograph of granitic gneiss facies. Mixture of quartz (wavy light to dark-grey areas) and muscovite grains is visible. (A) Plane-polarized light. (B) Crossed polarized light.

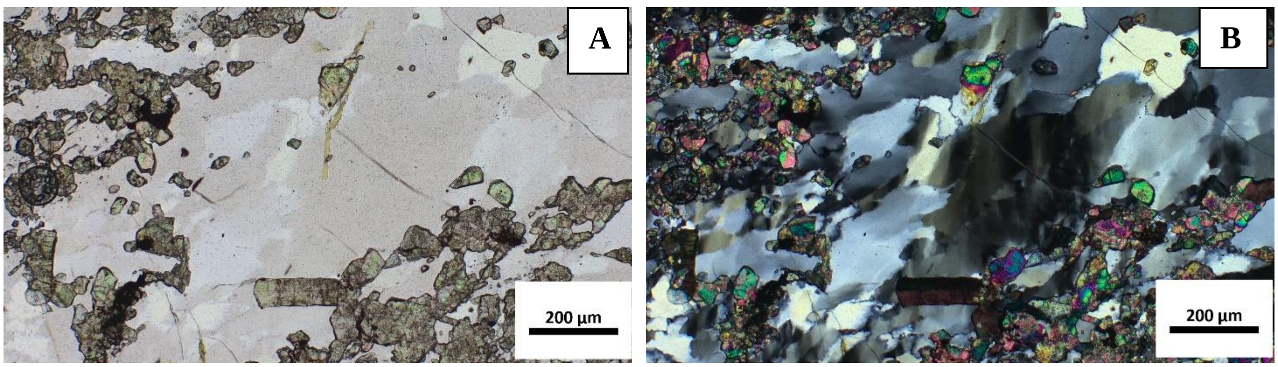

Figure 8: Micrograph of epidote and quartz vein facies. Mixture of quartz (wavy light to dark-grey areas) and epidote is visible. (A) Plane-polarized light. (B) Crossed polarized light.

Table 5 : Potentially reactive siliceous phases in the Aggregate CA4.

Facies	**Aggregate CA4 (5-20mm)**
Metagranite	Quartz with deformation lamellae, strained (with undulatory extinction) and myrmekites (intergrowth of plagioclase and vermicular quartz).
Granitic gneiss	Quartz with undulatory extinction and interlocking texture.
Epidote and quartz veins	Quartz with deformation lamellae, strained (with undulatory extinction)

Petrographic report

Sample identification RAT1	**Type (Particle size)** Sand (0-5mm)
Analysis date Winter 2022	**Petrographer** Andreia Rodrigues

Introduction

The main objective of this report is to describe the composition of the different rock types/facies or minerals in the aggregate examined and particularly those that contain reactive types of silica in their composition. This petrographic study consisted of the examination of two size fractions of the sand in thin sections under a petrographic microscope. The report includes macroscopic photos of the two size fractions examined and micrographs of the main rock types in those fractions, as determined by the examination under the petrographic microscope.

Methodology

The petrographic analysis was conducted on a representative subsample of aggregate RAT1 (0 - 5 mm).

A representative subsample of the sand was first sieved with a Ro-Tap sieving machine. Polished thin sections were then prepared from representative subsamples of the fractions 4.75-2.36 mm and 2.36-1.18 mmm. The grains were mounted in an epoxy matrix and the block thus produced was cut, glued to a glass slide, and then thinned to a thickness of 30 µm. A thin section was thus prepared. The thin sections were examined in transmitted light on a Zeiss Axio Scope.A1 petrographic microscope at up to 50X magnification. The nature of the opaque minerals was determined, in reflected light on this same microscope, when their size allowed.

General description of the Aggregate RAT1

The aggregate is a natural sand; it is composed of sub-rounded grains of different lithologies. The microscopic examination permitted to identify the following minerals / lithologies: Microcline, quartz and microcline, quartz and chert.

Table 1: Proportion of the main facies of the Aggregate RAT1.

Facies	**RAT1 (4.75-1.18mm)**
	Proportion (%)
Quartz and microcline	10
Microcline	40
Quartz	58
Chert	2
Total	**100**

Macroscopic photos of the two size fractions examined of the Aggregate RAT1

A

B

Figure 1 : Photographs of the fine Aggregate RAT1. A & B: fraction 4 – 8 mesh (2.36 – 4.75mm). The scale on the photographs is 10 mm.

A

B

Figure 2 : Photographs of the fine Aggregate RAT1. A & B: fraction 8 – 16 mesh (1.18 – 2.36 mm). The scale on the photographs is 10 mm.

Microscopic descriptions of the rock facies and or minerals observed in thin sections (Aggregate RAT1)

Table 2: Microcline and quartz (Aggregate RAT1)

General description	Fragments of igneous rock (?) (Figure 3)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Microcline	nd	Tartan twining	not observed	nd
Quartz	nd	Low birefringence	see table 5	nd
Notes: Nd: The percentages of each mineral and the grain dimension vary from one particle to another				

Table 3: Chert (Aggregate RAT1)

General description	Sedimentary rock (Figure 4)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	95	Low birefringence	see table 5	< 0.03 mm
Clay minerals	5	brown	not observed	< 0.01mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Pyrite	traces	yellow	not observed	< 0.01mm

Table 4: Main minerals (Aggregate RAT1)

General description	Pure minerals (Figures 5 and 6)			
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Microcline	40	Tartan twinning	not observed	< 4.75 mm
Quartz	58	Low birefringence	See table 5	< 4.75 mm

Micrographs of the different rock facies and minerals in the Aggregate RAT1

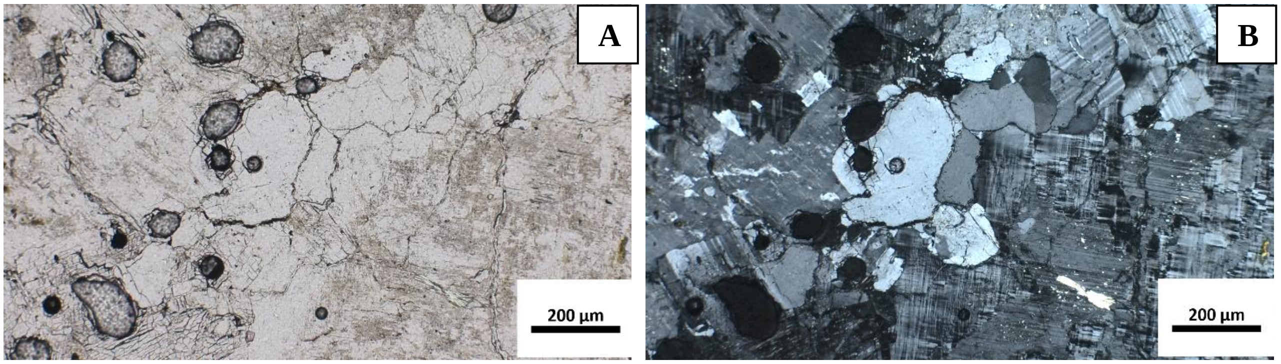

Figure 3: Micrograph of quartz and microcline. Microcline (alkali feldspar) presents the typical tartan twinning (parallel lines in the microcline grains). (A) Plane-polarized light. (B) Crossed polarized light.

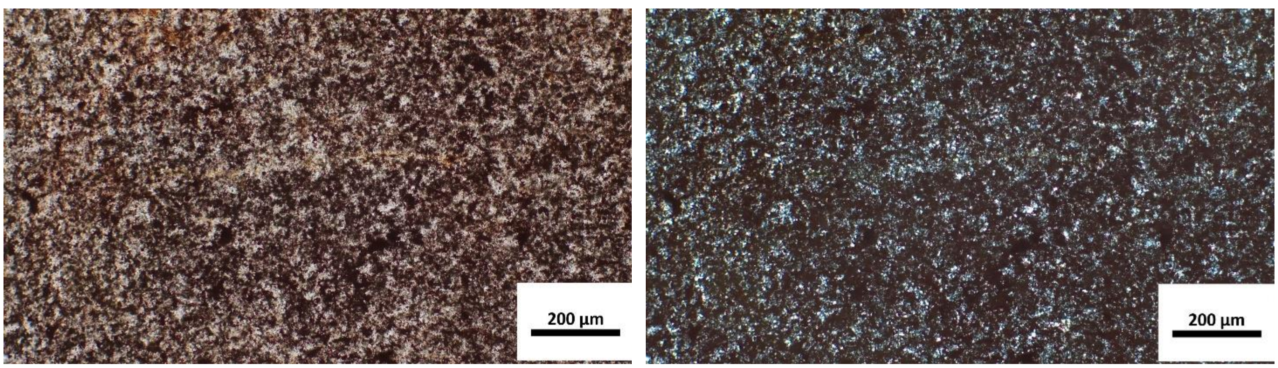

Figure 4: Micrograph of chert. Chert is composed of microcrystalline quartz, sometimes showing feather-like crystals of chalcedony (common in chert). (A) Plane-polarized light. (B) Crossed polarized light.

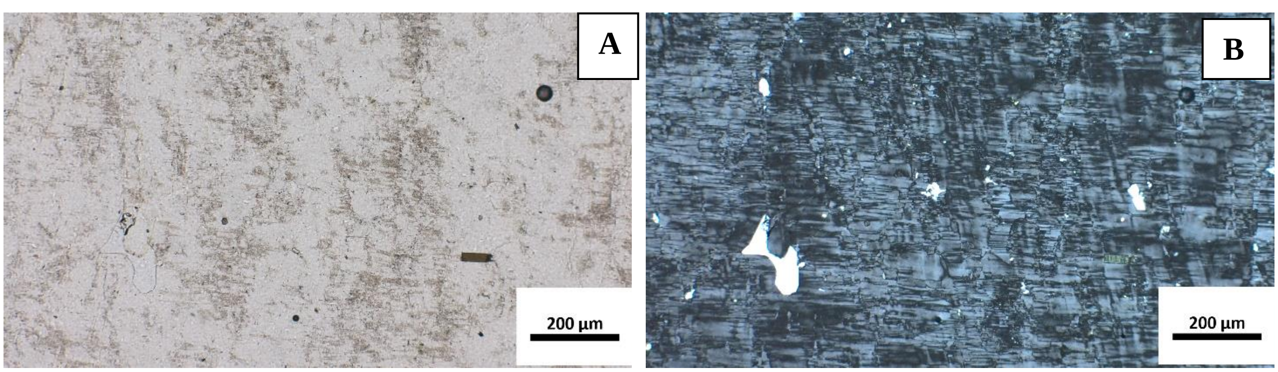

Figure 5: Micrograph of microcline. Microcline (alkali feldspar) presents the typical tartan twinning (parallel lines in the microcline grains). (A) Plane-polarized light. (B) Crossed polarized light.

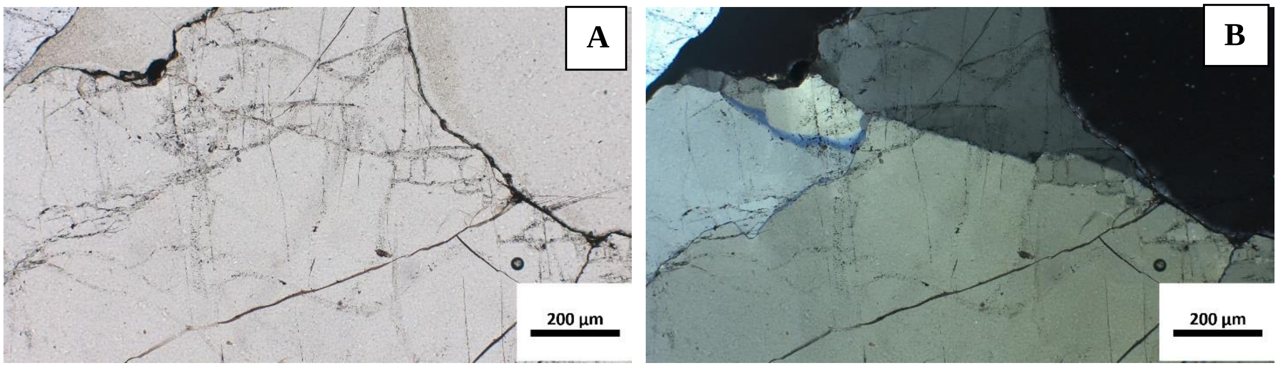

Figure 6: Micrograph of Quartz. Large crystals of quartz, sometimes with microcracking and bands with different extinctions (different grades of gray) representing strained quartz. (A) Plane-polarized light. (B) Crossed polarized light.

Table 5: Potentially reactive phases in the Aggregate RAT1

Facies	**RAT1 (4.45 - 1.18mm)**
Quartz and microcline	The quartz presents undulatory extinction (bands of different grades of gray – strained quartz) and the boundaries between the quartz grains are sometimes irregular with interlocking texture.
Microcline	Not observed
Quartz	The quartz presents undulatory extinction (bands of different grades of gray – strained quartz); the boundaries between the quartz grains are sometimes irregular with interlocking texture.
Chert	The chert presents feather-like crystals of chalcedony and cryptocrystalline quartz.

Petrographic report

Sample identification RAT2	**Type (Particle size)** Sand (0-5mm)
Analysis date Winter 2022	**Petrographer** Andreia Rodrigues

Introduction

The main objective of this report is to describe the composition of the different rock types/facies or minerals in the aggregate examined and particularly those that contain reactive types of silica in their composition. This petrographic study consisted of the examination of two size fractions of the sand in thin sections under a petrographic microscope. The report includes macroscopic photos of the two size fractions examined and micrographs of the main rock types in those fractions, as determined by the examination under the petrographic microscope.

Methodology

The petrographic analysis was conducted on a representative subsample of aggregate RAT2 (0 - 5 mm).

A representative subsample of the sand was first sieved with a Ro-Tap sieving machine. Polished thin sections were then prepared from representative subsamples of the fractions 4.75-2.36 mm and 2.36-1.18 mmm. The grains were mounted in an epoxy matrix and the block thus produced was cut, glued to a glass slide, and then thinned to a thickness of 30 µm. A thin section was thus prepared. The thin sections were examined in transmitted light on a Zeiss Axio Scope.A1 petrographic microscope at up to 50X magnification. The nature of the opaque minerals was determined, in reflected light on this same microscope, when their size allowed.

General description of the aggregate RAT2

The aggregate is a natural sand composed of different types of lithologies. The microscopic examination permitted to identify the following minerals / lithologies: Microcline, quartz and microcline, quartz and chert.

Table 1: Proportion of the main facies of the Aggregate UT-04.

Facies	UT-04 (4.75-1.18mm)
	Proportion (%)
Chert	60
Quartz	35
Limestone	5
Grauwacke	traces
Total	**100**

Macroscopic photos of the two size fractions examined of the Aggregate RAT2

A

B

Figure 1 : Photographs of the fine Aggregate RAT2. A & B: fraction 4 – 8 mesh (2.36 – 4.75mm). The scale on the photographs is 10 mm.

A

B

Figure 2 : Photographs of the fine Aggregate RAT2. A & B: fraction 8 – 16 mesh (1.18 – 2.36 mm). The scale on the photographs is 10 mm.

Microscopic descriptions of the rock facies and or minerals observed in thin sections (Aggregate RAT2)

Table 2: Chert (Aggregate RAT2)

General description	Sedimentary rock (Figure 3)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	95	low birefringence	see table 6	< 0.03
Clay minerals	5	low birefringence	not observed	< 0.01
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Opaque minerals	traces	gray	not observed	< 0.01

Table 3: Limestone (Aggregate RAT2)

General description	Sedimentary rock (Figure 4)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Calcite (micrite)	90	high birefringence	not observed	< 0.01 mm
Clay minerals	10	brown	not observed	< 0.01mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	traces	low birefringence	see table 6	< 0.02mm

Table 4: Graywacke (Aggregate RAT2)

General description	Sedimentary rock (Figure 5)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	50	low birefringence	see table 6	< 0.17 mm
Feldspars	10	low birefringence	altered	< 0.11 mm
Calcite (micrite)	30	high birefringence	not observed	< 0.01 mm
Clay minerals	10	brown	not observed	< 0.01 mm

Table 5: Main minerals (Aggregate RAT2) (Figures 5)

General description	Mineral (Figure 6)			
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	35	Low birefringence	See table 5	< 4.75 mm

Micrographs of the different rock facies and minerals in the Aggregate RAT2

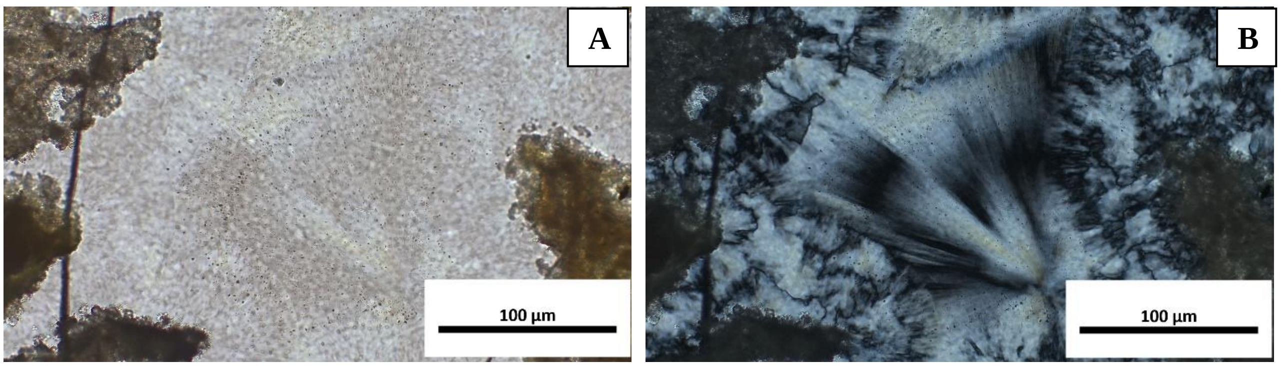

Figure 3: Micrograph of chert. Chert is composed of microcrystalline quartz, sometimes showing feather-like crystals (B) of chalcedony (common in chert). (A) Plane-polarized light. (B) Crossed polarized light.

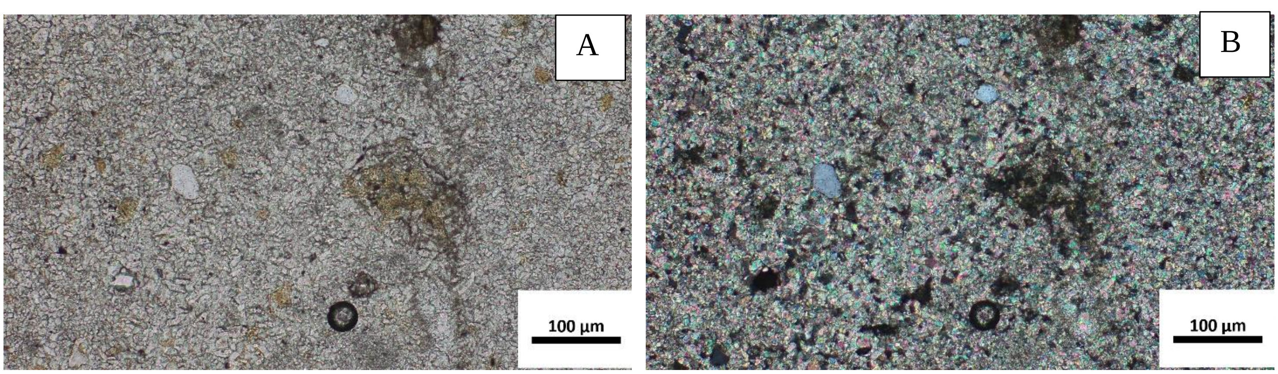

Figure 4: Micrograph of limestone. Microcrystalline calcite (microsparite). (A) Plane-polarized light. (B) Crossed polarized light.

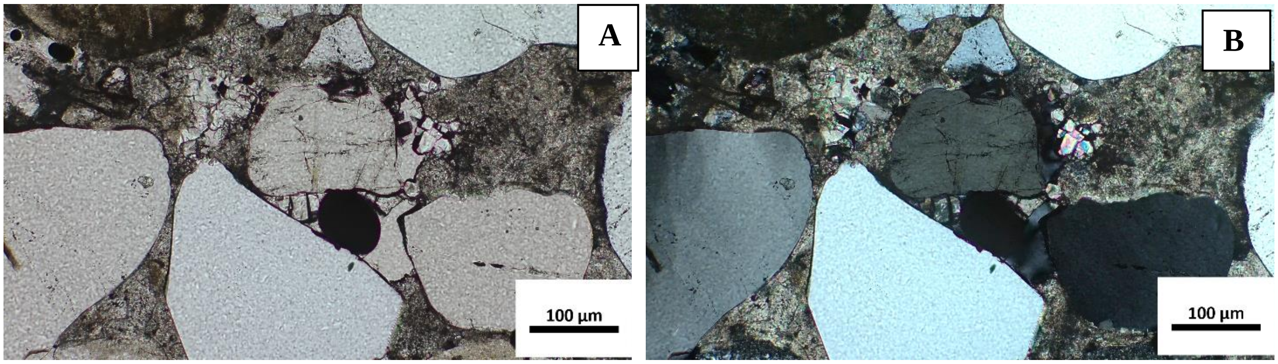

Figure 5: Micrograph of graywacke. Sub-rounded grains of quartz (sometimes strained) and feldspars in a matrix of calcite and clay minerals. (A) Plane-polarized light. (B) Crossed polarized light.

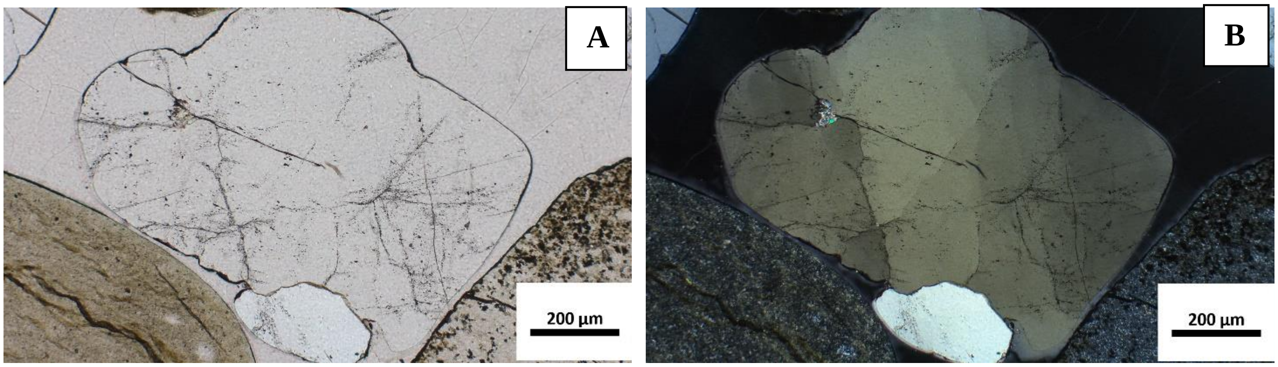

Figure 6: Micrograph of Quartz. Large crystals of quartz, sometimes with microcracking and bands with different extinctions (different grades of gray) representing strained quartz. (A) Plane-polarized light. (B) Crossed polarized light.

Table 6: Potentially reactive phases in the Aggregate RAT2

Facies	**RAT2 (4.75 - 1.18mm)**
Chert	The chert presents feather-like crystals of chalcedony and cryptocrystalline quartz.
Limestone	Not observed
Greywacke	The quartz presents undulatory extinction (bands of different grades of gray – strained quartz); the boundaries between the quartz grains are sometimes irregular with interlocking texture.
Quartz	The quartz presents undulatory extinction (bands of different grades of gray – strained quartz); the boundaries between the quartz grains are irregular with interlocking texture.

Petrographic report

Sample identification Placitas	**Type (Particle size)** 5-20 mm
Analysis date Winter 2022	**Petrographer** Andreia Rodrigues

Introduction

The main objective of this report is to describe the composition of the different rock types/facies and particularly those that contain reactive types of silica in their composition. This petrographic study consisted of a visual (macroscopic) classification followed the examination of representative particles of each facies in thin sections under a petrographic microscope. The report includes macroscopic and a microscopic descriptions of the aggregate and a series of macroscopic photos of the rock facies; micrographs of the thin sections are presented in the appendix.

Methodology

The petrographic analysis was conducted on a representative subsample of 1200.1g of the aggregate Placitas (5-20 mm). The sample was first washed for a better observation of its mineralogical and textural characteristics. Each particle was then examined separately to identify the type of rock (or *facies*). When applicable or appropriate, a distinction was made between the different sub-types of lithology as a function of their mechanical quality or degree of alteration. After sorting, the mass of each facies/lithology was determined to the nearest 0.1 g, and its relative abundance in the sample was calculated to the nearest 0.1%.

Polished thin sections were prepared from representative grains of each of the main petrographic facies identified during macroscopic examination of the aggregate. The grains were mounted in an epoxy matrix and the block thus produced was cut, glued to a glass slide, and then thinned to a thickness of 30 µm. A thin section was thus prepared. The thin sections were examined in transmitted light on a Zeiss Axio Scope.A1 petrographic microscope at up to 50X magnification. The nature of the opaque minerals was determined, in reflected light on this same microscope, when their size allowed.

General description of the aggregate Placitas

The aggregate is a gravel composed of different types of rocks:

Andesite - basalt: dark gray, sub-angular, massive. High hardness. (Figure 1).

Quartz and feldspar veins ("granitic/gneissic" material): pinkish to whitish, sub-angular, massive. High hardness. (Figure 2).

Quartzite: whitish, sub-angular particles. High hardness (Figure 3).

Limestone: Gray, sub-angular to sub-rounded particles. High hardness (Figure 4).

Altered particles: Altered particles with different types of lithology.

Table 1: Proportion of the main facies of the Aggregate Placitas.

Facies	**UT-06 (5-20mm)**	
	Mass (g)	**Proportion (%)**
Andesite - basalt	706.5	58.9
Quartz and feldspar veins ("granitic/gneissic" material)	132.0	11.0
Quartzite	314.1	26.2
Limestone	8.4	0.70
Altered particles	39.0	3.3
Total	1200.1	100

Macroscopic photos of the different rock facies in the Aggregate Placitas.

Figure 1 : Andesite - basalt (Aggregate Placitas).

Figure 2: Quartz and feldspar veins – "granitic/gneissic" material (Aggregate Placitas).

Figure 3: Quartzite (Aggregate Placitas)

Figure 4: Limestone (Aggregate Placitas)

Microscopic descriptions of the rock facies observed in thin sections for the Aggregate Placitas

Table 2: Andesite - basalt (Aggregate Placitas)

General description	Igneous rock (Figure 5)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Plagioclase	65	polysynthetic twinning	altered	< 0.65 mm
Pyroxenes	5	2 cleavages at 89º	not observed	< 0.25 mm
Volcanic glass	27	brown	not observed	< 0.01 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Magnetite	3	gray	not observed	< 0.10 mm

Table 3: Quartz and feldspar veins – "granitic/gneissic" material (Aggregate Placitas)

General description	Metamorphic rock (Figure 6)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	50	low birefringence	see table 5	< 4.0 mm
Plagioclase	50	polysynthetic twinning	altered	< 5.5 mm

Table 4: Quartzite (Aggregate Placitas)

General description	Metamorphic rock (Figure 7)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	100	low birefringence	see table 5	< 1.30 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Zircon	traces	high birefringence	not observed	< 0.03 mm
Muscovite	traces	high birefringence	Not observed	< 0.10 mm

Table 5: Limestone (Aggregate Placitas)

General description	Sedimentary rock (Figure 8)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Calcite micrite	75	high birefringence	not observed	< 0.20 mm
Calcite sparite	15	high birefringence	not observed	< 1.0 mm
Clay minerals	10	brown	not observed	< 0.01 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Pyrite	traces	yellow	not observed	< 0.10 mm

Micrographs of the different rock facies of the Aggregate Placitas

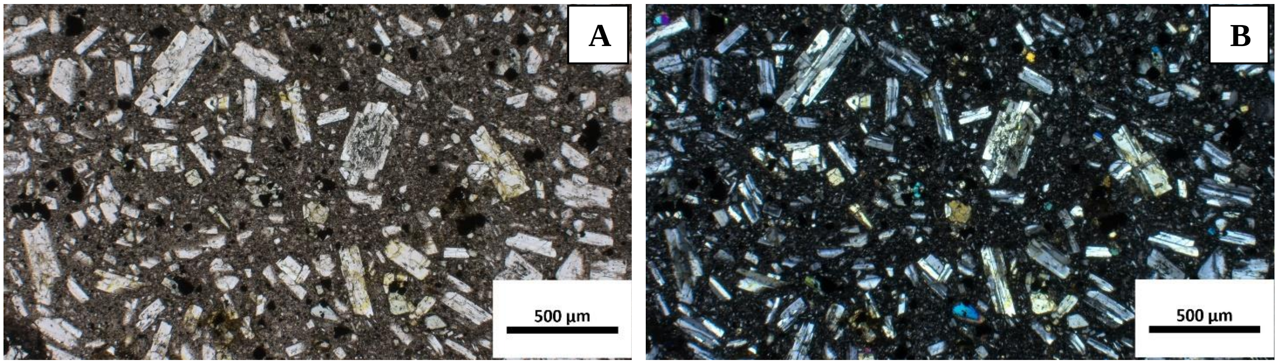

Figure 5: Micrograph of andesite - basalt. Large grains (phenocrysts) of feldspar dissiminated in a fine-grained matrix that contains volcanic glass. (A) Plane-polarized light. (B) Crossed polarized light.

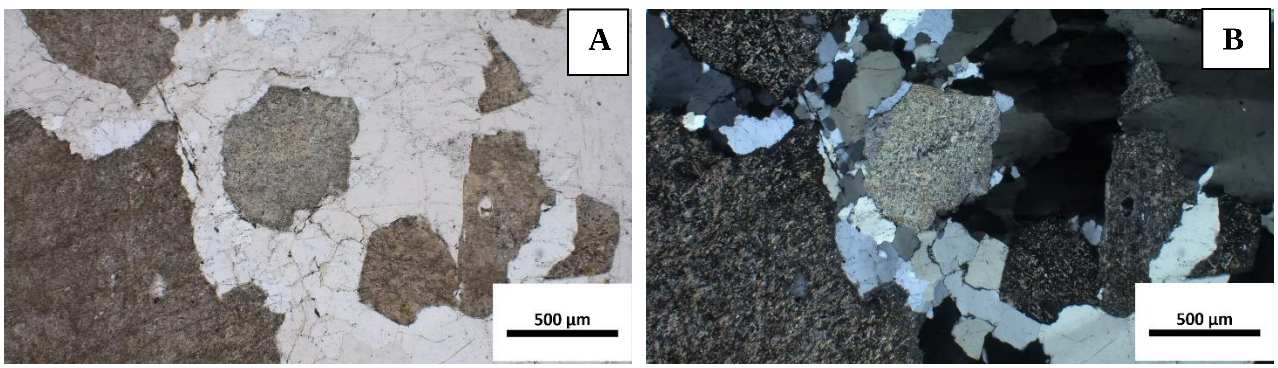

Figure 6: Micrograph of quartz and feldspar veins (granitic / gneissic" material). Mixture of altered grains of feldspar and microcrystalline quartz. (A) Plane-polarized light. (B) Crossed polarized light.

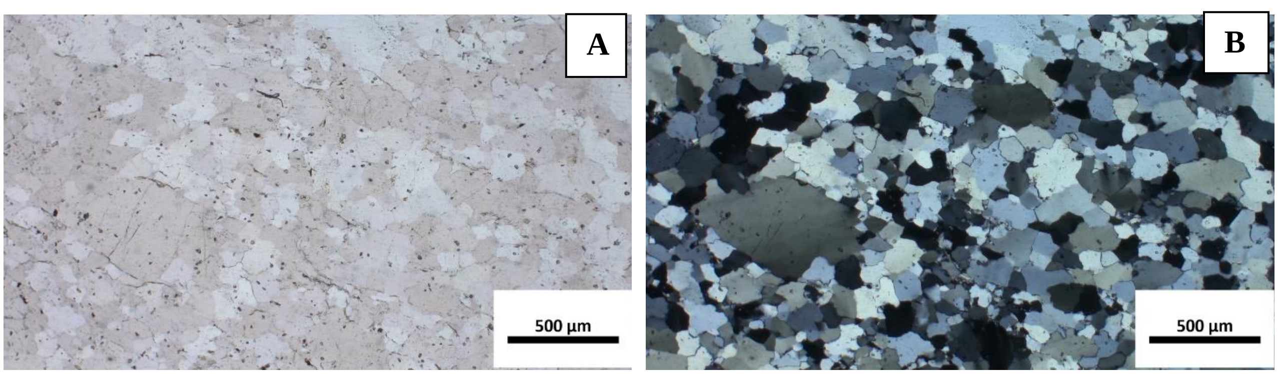

Figure 7: Micrograph of quartzite. Mosaic of fine quartz grains, sometimes showing undulatory extinction (strained quartz grains), and organized in an interlocking texture. (A) Plane-polarized light. (B) Crossed polarized light.

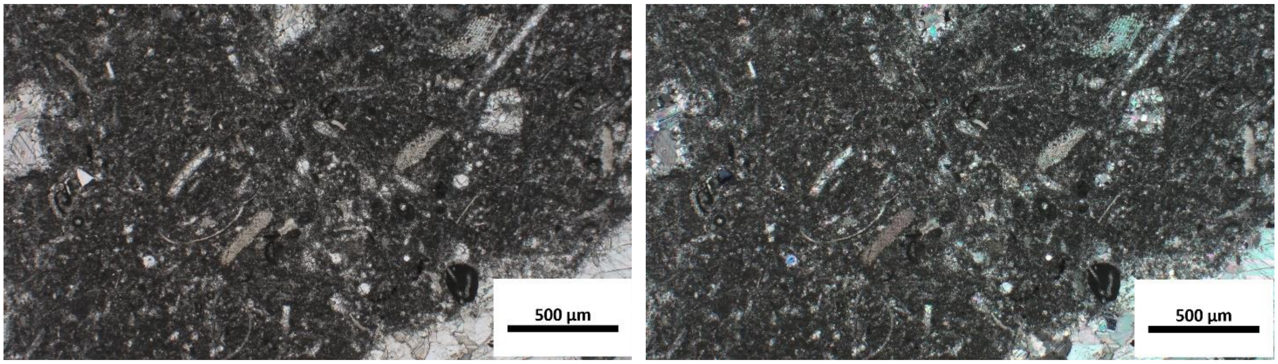

Figure 8: Micrograph of limestone. Fossil fragments (bioclasts) in a fine-grained matrix of calcite (micrite). (A) Plane-polarized light. (B) Crossed polarized light.

Table 6: Potentially reactive phases of the Aggregate Placitas

Facies	**Aggregate Placitas (5-20mm)**
Andesite - basalt	The volcanic glass as a matrix in this andesite-basalt can be reactive.
Quartz and feldspar veins (granitic/gneissic material)	The quartz presents undulatory extinction and the boundaries between the quartz grains are irregular with interlocking texture.
Quartzite	The quartz presents undulatory extinction and the boundaries between the quartz grains are irregular with interlocking texture.

Petrographic report

Sample identification Control Sudbury	Type (Particle size) 5-20 mm
Analysis date Winter 2022	**Petrographer** Andreia Rodrigues

Introduction

The main objective of this report is to describe the composition of the different rock types/facies and particularly those that contain reactive types of silica in their composition. This petrographic study consisted of a visual (macroscopic) classification followed the examination of representative particles of each facies in thin sections under a petrographic microscope. The report includes macroscopic and a microscopic descriptions of the aggregate and a series of macroscopic photos of the rock facies; micrographs of the thin sections are presented in the appendix.

Methodology

The petrographic analysis was conducted on a representative subsample of 1184.7g of the aggregate UT-10 (5-20 mm). The sample was first washed for a better observation of its mineralogical and textural characteristics. Each particle was then examined separately to identify the type of rock (or *facies*). When applicable or appropriate, a distinction was made between the different sub-types of lithology as a function of their mechanical quality or degree of alteration. After sorting, the mass of each facies/lithology was determined to the nearest 0.1 g, and its relative abundance in the sample was calculated to the nearest 0.1%.

Polished thin sections were prepared from representative grains of each of the main petrographic facies identified during macroscopic examination of the aggregate. The grains were mounted in an epoxy matrix and the block thus produced was cut, glued to a glass slide, and then thinned to a thickness of 30 µm. A thin section was thus prepared. The thin sections were examined in transmitted light on a Zeiss Axio Scope.A1 petrographic microscope at up to 50X magnification. The nature of the opaque minerals was determined, in reflected light on this same microscope, when their size allowed.

General description of the Aggregate Sudbury

The aggregate is a gravel composed of different types of lithologies. The macroscopic examination permitted to characterize the following facies:

Siltstone: dark-gray to greenish, sub-angular to sub-rounded, massive. High hardness. (Figure 1).

Sandstone: reddish, sub-angular to sub-rounded particles. High hardness (Figure 3).

Granite: dark-gray, sub-angular, massive. High hardness. (Figure 2).

Graywacke: beige, sub-angular. High hardness (Figure 4).

Table 1: Proportion of the main facies of the Aggregate Sudbury.

Facies	**Sudbury (5-20mm)**	
	Mass (g)	**Proportion (%)**
Siltstone	506.2	42.7
Sandstone	229.0	19.3
Granite ?	145.3	12.3
Graywacke	304.2	25.7
Total	**1184.7**	**100**

Macroscopic photos of the different rock facies in the Aggregate Sudbury

Figure 1 : Siltstone (Aggregate Sudbury).

Figure 2: Sandstone (Aggregate Sudbury).

Figure 3: Granite (Aggregate Sudbury).

Figure 4: Graywacke (Aggregate Sudbury).

Microscopic descriptions of the rock facies observed in thin sections

Table 2: Siltstone (Aggregate Sudbury).

General description	Sedimentary rock (Figure 5)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	87	low birefringence	see table 9	< 0.20 mm
Chlorite	3	green	not observed	< 0.13 mm
Clay minerals	10	low birefringence	not observed	< 0.01 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Plagioclase	traces	polysynthetic twinning	not observed	< 0.20 mm
Muscovite	traces	high birefringence	not observed	< 0.03 mm
Microcline	traces	Tartan twinning	not observed	< 0.35 mm

Table 3: Sandstone (Aggregate Sudbury).

General description	Sedimentary rock (Figure 6)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	98	low birefringence	see table 9	< 0.36 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Chlorite	2	green	not observed	< 0.20mm
Pennine	traces	blue-violet	not observed	< 0.45 mm
Pyrite	traces	yellow	not observed	< 0.01 mm
Magnetite	traces	gray	not observed	< 0.01 mm

Table 4: Granite (Aggregate Sudbury).

General description	Igneous rock that suffered a hydrothermal phenomena (Figure 7)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Plagioclase	ND	polysynthetic twinning	altered	< 0.75 mm
Quartz	ND	low birefringence	see table 9	< 0.40 mm
Pyroxenes	ND	2 cleavages at 89°	alerted	< 0.80 mm
Muscovite	ND	high birefringence	altered	< 0.30 mm
Microcline	ND	Tartan twinning	altered	< 3.0 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Apatite	traces	high relief	not observed	< 0.13 mm
Calcite	traces	gray	not observed	< 0,15 mm
Biotite	traces	pleochroic	altered	< 0.10 mm
Chlorite	traces	2 cleavages at 120°	not observed	< 0.07 mm

Table 5: Greywacke (Aggregate Sudbury).

General description	Sedimentary rock (Figure 8)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Quartz	79	low birefringence	see table 9	< 0.30 mm
Calcite micrite (matrix)	17	high birefringence	not observed	< 0.01 mm
Clay minerals (matrix)	3	brown	not observed	< 0.01 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Muscovite	traces	high birefringence	not observed	< 0.13 mm

Micrographs of the different rock facies of Aggregate Sudbury

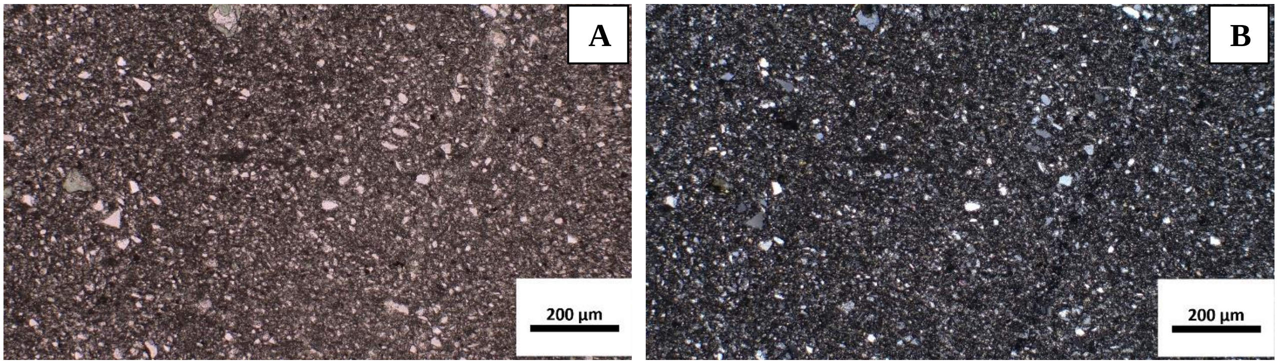

Figure 5: Micrograph of siltstone. Fine grains of quartz disseminated in a very fine grained matrix rich in quart and clay minerals. (A) Plane-polarized light. (B) Crossed polarized light.

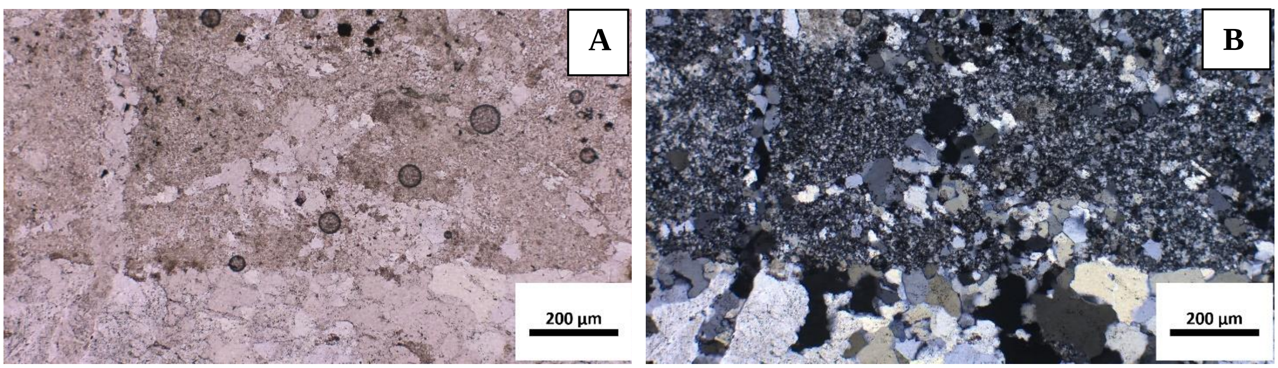

Figure 6: Micrograph of sandstone. Grains of quartz, fine to medium in size in a very fine-grained matrix of quartz. (A) Plane-polarized light. (B) Crossed polarized light.

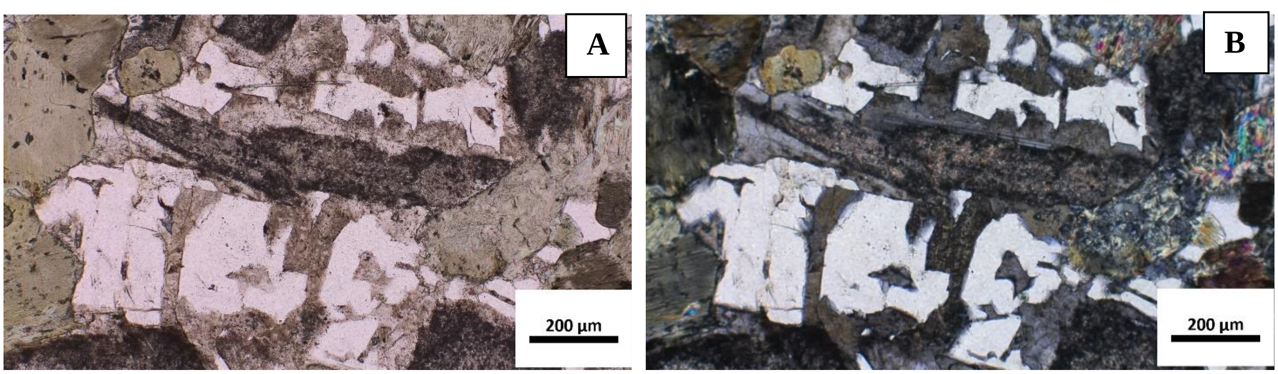

Figure 7: Micrograph of granite (?). Large grains of plagioclase with muscovite (bright colors). (A) Plane-polarized light. (B) Crossed polarized light.

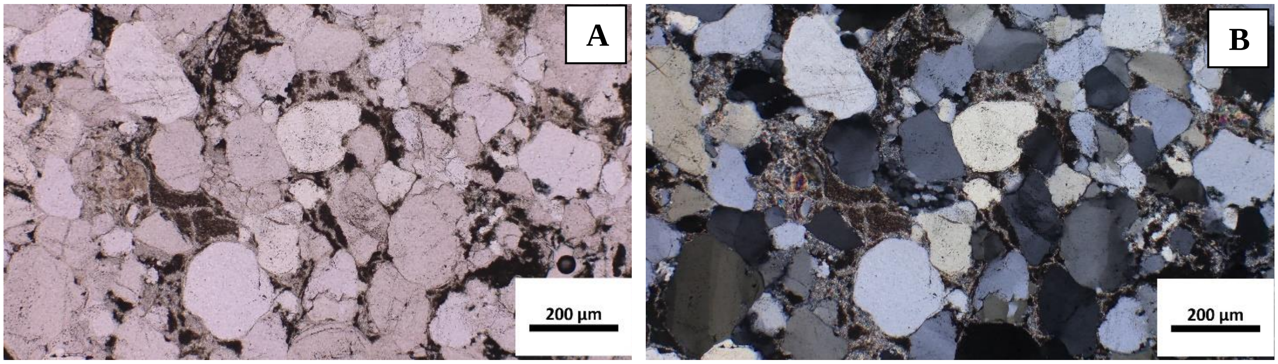

Figure 8: Micrograph of graywacke. Coarse grains of quartz disseminated in a fine-grained matrix of calcite and clay minerals. (A) Plane-polarized light. (B) Crossed polarized light.

Table 6: Potentially reactive phases in the Aggregate Sudbury

Facies	**Sudbury (5-20mm)**
Siltstone	The quartz presents undulatory extinction and some proportion is microcrystalline.
Sandstone	The quartz presents undulatory extinction and the boundaries between the quartz grains are irregular with interlocking texture. Some of the quartz is microcrystalline.
Granite (?)	The quartz presents undulatory extinction.
Greywacke	Some quartz particles present undulatory extinction and the boundaries between the quartz grains are sometimes irregular with interlocking texture. Some of the quartz is microcrystalline (matrix).

Petrographic report

Sample identification	Type (Particle size)
NR1	5-20 mm
Analysis date	**Petrographer**
Winter 2022	Andreia Rodrigues

Introduction

The main objective of this report is to describe the composition of the different rock types/facies and particularly those that contain reactive types of silica in their composition. This petrographic study consisted of a visual (macroscopic) classification followed the examination of representative particles of each facies in thin sections under a petrographic microscope. The report includes macroscopic and a microscopic descriptions of the aggregate and a series of macroscopic photos of the rock facies; micrographs of the thin sections are presented in the appendix.

Methodology

The petrographic analysis was conducted on a representative subsample of 1367g of the aggregate NR1 (5-20 mm). The sample was first washed for a better observation of its mineralogical and textural characteristics. Each particle was then examined separately to identify the type of rock (or *facies*). When applicable or appropriate, a distinction was made between the different sub-types of lithology as a function of their mechanical quality or degree of alteration. After sorting, the mass of each facies/lithology was determined to the nearest 0.1 g, and its relative abundance in the sample was calculated to the nearest 0.1%.

Polished thin sections were prepared from representative grains of each of the main petrographic facies identified during macroscopic examination of the aggregate. The grains were mounted in an epoxy matrix and the block thus produced was cut, glued to a glass slide, and then thinned to a thickness of 30 µm. A thin section was thus prepared. The thin sections were examined in transmitted light on a Zeiss Axio Scope.A1 petrographic microscope at up to 50X magnification. The nature of the opaque minerals was determined, in reflected light on this same microscope, when their size allowed.

General description of the Aggregate NR1

The aggregate is essentially composed of limestone (macroscopically divided into four sub-facies). The macroscopic examination permitted to characterize the following facies:

Light-grey to beige limestone: gray-beige, sub-angular to sub-rounded particles, massive. High hardness. (Figure 1).

Medium-grey limestone: darker gray, sub-angular to sub-rounded particles, massive. High hardness. (Figure 2).

Pink limestone: pink, sub-angular to sub-rounded particles. High hardness (Figure 3).

Altered limestone: beige, sub-rounded to rounded particles. Low hardness. (Figure 4).

Table 1: Proportion of the main facies of the Aggregate NR1.

Facies	**NR1 (5-20mm)**	
	Mass (g)	**Proportion (%)**
Light-grey to beige limestone	1061.4	77.6
Medium-gray limestone	128.0	9.4
Pink limestone	75.0	5.5
Altered limestone	102.6	7.5
Total	**1367**	**100**

Macroscopic photos of the different rock facies in the Aggregate NR1

Figure 1 : Light-grey to beige limestone (Aggregate NR1).

Figure 2: Medium-gray limestone (Aggregate NR1).

Figure 3: Pink limestone (Aggregate NR1).

Figure 4: Altered limestone (Aggregate NR1).

Microscopic descriptions of the rock facies observed in thin sections for Aggregate NR1

Table 2: Light-grey to beige limestone (Aggregate NR1)

General description	Carbonate sedimentary rock composed mainly of calcite (Figure 5)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Calcite (micrite)	20	high birefringence	not observed	< 1mm
Calcite (sparite)	70	high birefringence	not observed	≥ 5.2 mm
Clay minerals	10	brown	not observed	< 0.1mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Pyrite	traces	yellow	not observed	< 1mm

Table 3: Medium-grey limestone (Aggregate NR1)

General description	Carbonate sedimentary rock composed mainly of calcite (Figure 6)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Calcite (micrite)	80	high birefringence	not observed	< 1mm
Calcite (sparite)	15	high birefringence	not observed	≥ 3.3 mm
Clay minerals	5	brown	not observed	< 0.1mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Pyrite	traces	yellow	not observed	< 1mm

Table 4: Pink limestone (Aggregate NR1)

General description	Carbonate sedimentary rock composed mainly of calcite (Figure 7)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Calcite (micrite)	74	high birefringence	not observed	< 0.1mm
Calcite (sparite)	10	high birefringence	not observed	≥ 3.2 mm
Clay minerals	15	brown	not observed	< 0.1mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Pyrite	1	yellow	not observed	< 1mm

Table 5: Altered limestone (Aggregate NR1)

Facies	Limestone		**Sample**	NR1
General description	Carbonate sedimentary rock composed mainly of calcite (Figure 8)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Calcite (micrite)	20	high birefringence	not observed	< 1mm
Calcite (sparite)	70	high birefringence	not observed	≥ 5.2 mm
Clay minerals	10	brown	not observed	< 0.1mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Pyrite	traces	yellow	not observed	< 1mm

Micrographs of the different rock facies of the Aggregate NR1

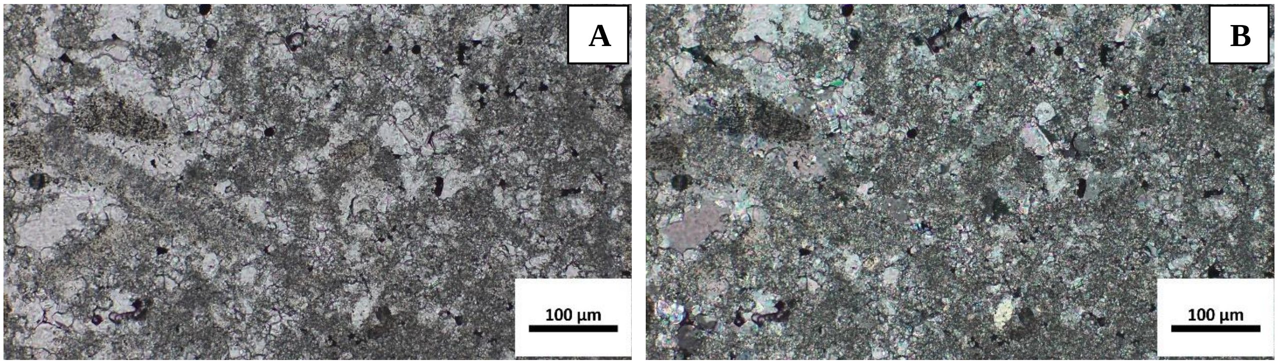

Figure 5: Micrograph of light-grey to beige limestone facies. Sparitic (coarser-grained, lighter color areas) and micritic (fine-grained, dark-grey) calcite. (A) Plane-polarized light. (B) Crossed polarized light.

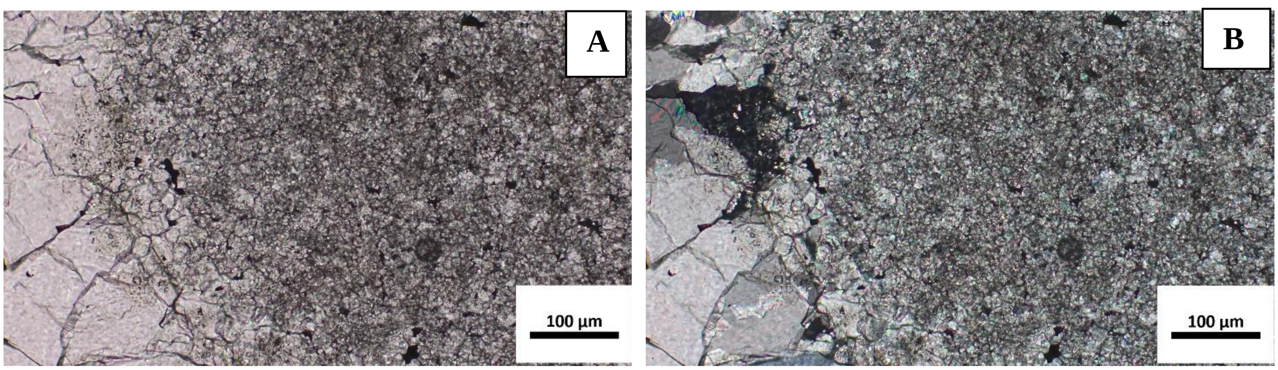

Figure 6: Micrograph of medium-gray limestone facies. Sparitic (coarser-grained, lighter-color areas) and micritic (fine-grained, dark-grey) calcite. (A) Plane-polarized light. (B) Crossed polarized light.

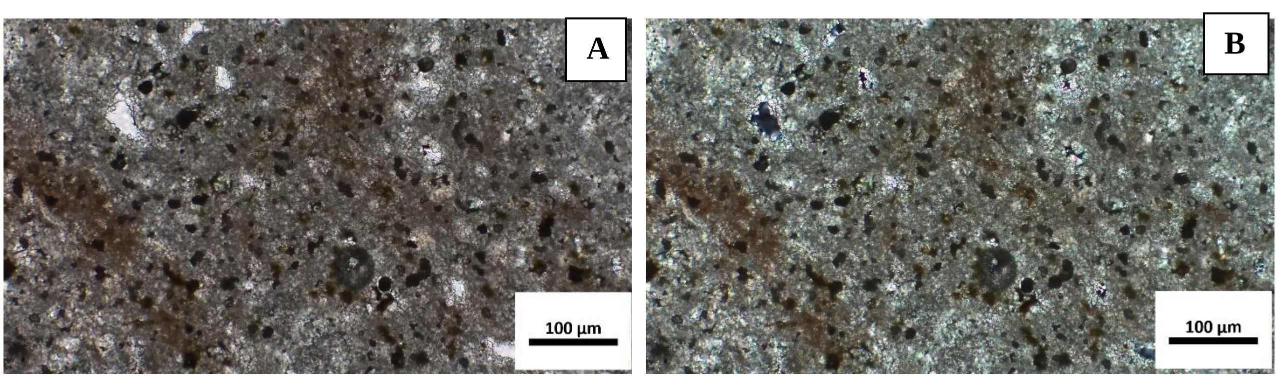

Figure 7: Micrograph of pink limestone facies. Mixture of fine-grained (micritic and microsparite) calcite areas. (A) Plane-polarized light. (B) Crossed polarized light.

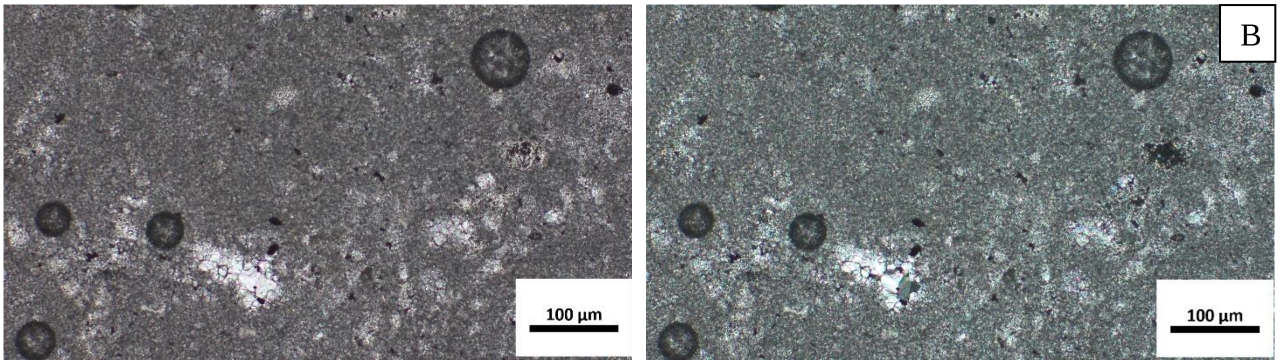

Figure 8: Micrograph of altered limestone facies. Microcrystalline (micrite) calcite (A) Plane-polarized light. (B) Crossed polarized light.

Table 6: Potentially reactive siliceous phases in the Aggregate NR1.

Facies	**NR1 (5-20mm)**
Limestone	Not observed
Gray limestone	Not observed
Pink limestone	Not observed
Altered limestone	Not observed

Petrographic report

Sample identification	Type (Particle size)
NR2	Sand (0-5mm)
Analysis date	**Petrographer**
Winter 2022	Andreia Rodrigues

Introduction

The main objective of this report is to describe the composition of the different rock types/facies or minerals in the aggregate examined and particularly those that contain reactive types of silica in their composition. This petrographic study consisted of the examination of two size fractions of the sand in thin sections under a petrographic microscope. The report includes macroscopic photos of the two size fractions examined and micrographs of the main rock types in those fractions, as determined by the examination under the petrographic microscope.

Methodology

The petrographic analysis was conducted on a representative subsample of aggregate NR2 (0 - 5 mm).

A representative subsample of the sand was first sieved with a Ro-Tap sieving machine. Polished thin sections were then prepared from representatives subsamples of the fractions 4.75-2.36 mm and 2.36-1.18 mmm. The grains were mounted in an epoxy matrix and the block thus produced was cut, glued to a glass slide, and then thinned to a thickness of 30 µm. A thin section was thus prepared. The thin sections were examined in transmitted light on a Zeiss Axio Scope.A1 petrographic microscope at up to 50X magnification. The nature of the opaque minerals was determined, in reflected light on this same microscope, when their size allowed.

General description of the Aggregate NR2

The aggregate is a manufactured sand composed of different types of lithologies. The microscopic examination permitted to identify the following lithologies: Limestone, fossiliferous limestone and coarse-grained calcite (sparite).

Table 1: Proportion of the main facies of the Aggregate NR2.

Facies	**NR2 (4.75-1.18mm)**
	Proportion (%)
Limestone	30
Fossiliferous limestone	70
Coarse-grained calcite (sparite)	Traces
Total	**100**

Macroscopic photos of the two size fractions examined of the Aggregate NR2

A

B

Figure 1 : Photographs of the fine Aggregate NR2. A & B: fraction 4 – 8 mesh (2.36 – 4.75mm). The scale on the photographs is 10 mm.

A

B

Figure 2 : Photographs of the fine Aggregate NR2. A & B: fraction 8 – 16 mesh (1.18 – 2.36 mm). The scale on the photographs is 10 mm.

Microscopic descriptions of the rock facies observed in thin sections

Table 2: Limestone (Aggregate NR2)

General description	Sedimentary rock (Figure 3)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Calcite (micrite)	70	high birefringence	not observed	< 0.10 mm
Calcite (microsparite)	25	high birefringence	not observed	< 0.30 mm
Clay minerals	5	brown	not observed	< 0.01 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Pyrite	traces	yellow	not observed	< 0.01mm

Table 3: Fossiliferous limestone (Aggregate NR2)

General description	Sedimentary rock (Figure 4)			
Essential components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Calcite	90	High birefringence	Not observed	< 0.01 mm
Clay minerals	10	high birefringence	not observed	< 0.01 mm
Other components				
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Pyrite	traces	yellow	not observed	< 0.01 mm

Table 4: Main minerals (Aggregate NR2)

General description	Mineral (Figure 5)			
Mineral	**%**	**Properties**	**Alterations**	**Grain Dimensions**
Calcite (sparite)	traces	high birefringence	Not observed	< 4.0 mm

Micrographs of the different rock facies and minerals in the Aggregate NR2

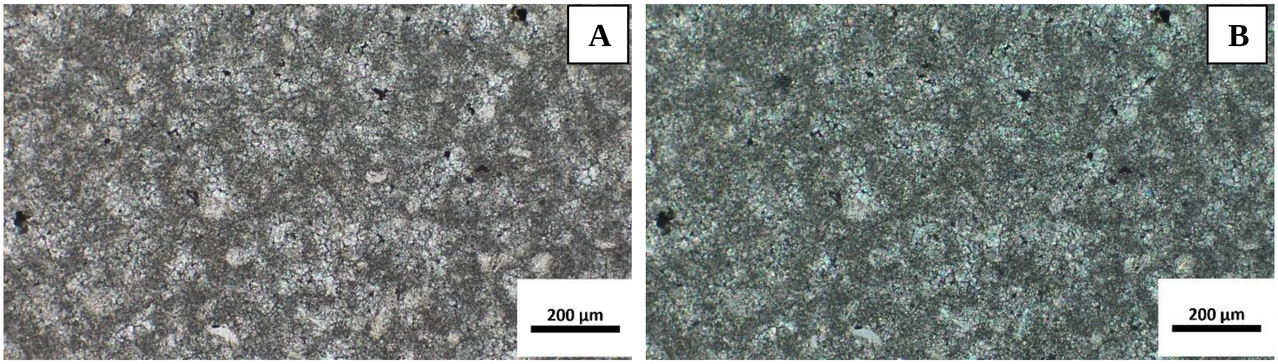

Figure 3: Micrograph of limestone. Mixture of zones of microcrystalline calcite (micrite; dark-gray to brownish areas) and slightly coarser-grained calcite (microsparite; light-gray areas). (A) Plane-polarized light. (B) Crossed polarized light.

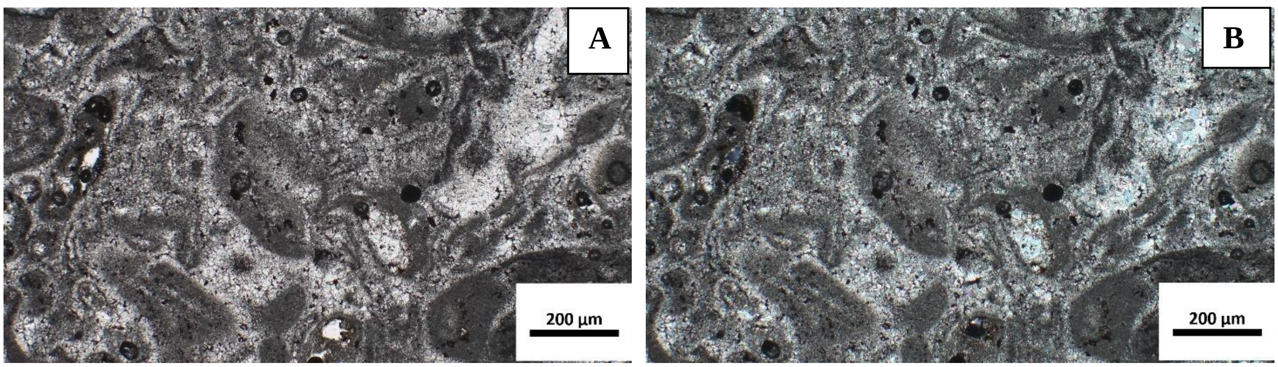

Figure 4: Micrograph of fossiliferous limestone. Fossil fragments (dark-gray to brownish color) disseminated in a matrix of fine-grained calcite (microsparite; light-gray). (A) Plane-polarized light. (B) Crossed polarized light.

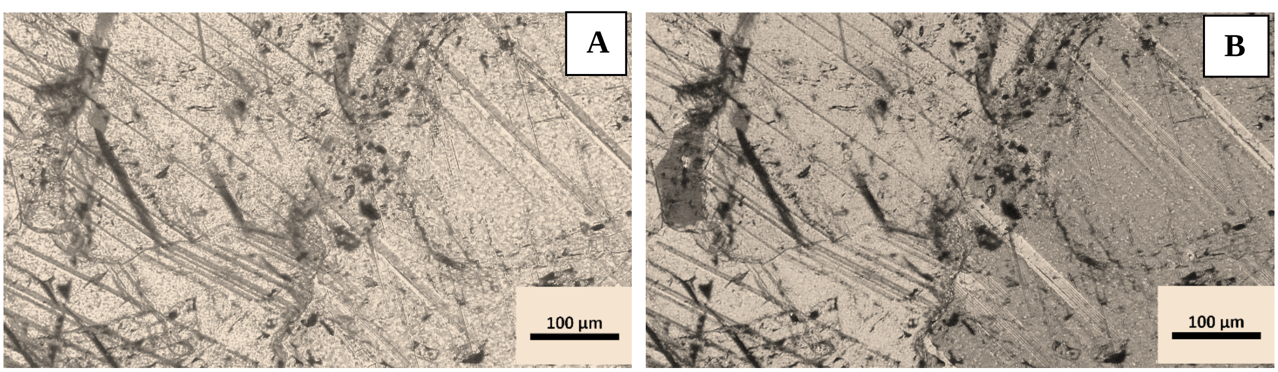

Figure 5: Micrograph of coarse-grained calcite (sparite). The clivage of the coarse-grained calcite grains are readily visible in the micrographs (parallel lines in the grains). (A) Plane-polarized light. (B) Crossed polarized light.

Table 5: Potentially reactive phases in the Aggregate NR2

Facies	**Aggregate NR2 (4.75 - 1.18 mm)**
Limestone	Not observed
Fossiliferous limestone	Not observed
Calcite sparite	Not observed