PETROGRAPHIC STUDY OF ANDING UTARA-1ST1 DITCH CUTTINGS

ANDING UTARA-1 ST1
MALAYSIA

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PETROGRAPHIC STUDY OF ANDING UTARA-1ST1 DITCH CUTTINGS

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SUMMARY

This report presents the results of a petrographic study of thirteen ditch cutting samples from Anding Utara-1ST1 well, Block PM12, Offshore Terengganu, Malaysia. The objectives of the study are to describe the lithologies and obtain thin section characteristics of the lithologies.

A total of thirteen ditch cutting samples were described in thin sections. The ditch cutting samples are dominated by claystone lithologies with lesser iron-oxide cemented sandstones at 2830m-2840m and 2850m-2860m while samples 2880m-2890m, 2900m-2910m, 2910m-2920m, 2920m-2930m, 2950m-2960m, 2960m-2970m, 2990m-3000m, 3010m-3020m, and 3020m-3030m are dominated by iron-oxide cemented sandstones of predominantly litharenitic in composition. The deepest ditch cutting sample, at 3070m-3080m, comprises almost equally common sandstone and metamorphic cuttings.

Iron oxide mineral, tentatively identified as hematite, is the principal pore-filling, intergranular cement in the sandstone cuttings. Argillaceous sandstone cuttings contain abundant dispersed clay matrix with common undifferentiated, dispersed clay intermix with silt. Other cements include minor polycrystalline quartz and ferroan calcite noted in closed fractures within metamorphic cuttings.

These iron oxide-cemented sandstone cuttings with lesser metamorphic cuttings may be categorized as tight reservoirs, ranging up to 3% visible porosity. However porosity measurement may have been affected by grain rearrangement and fabric disturbance during drilling. Visible porosity types identified are mainly secondary dissolution porosity and microporosity associated with clay matrix.

1. INTRODUCTION

This report presents the results of a petrographic study of thirteen (13) ditch cutting samples taken from Petronas Carigali Sendirian Berhad, Anding Utara-1ST1 well, located in Block PM12, Offshore Terengganu, Malaysia.

2. STUDY OBJECTIVES

The main objective of this study is:
i. to describe the lithologies present and thin section characteristics of the lithologies.

3. DATA, SAMPLES AND METHODS

A total of thirteen (13) ditch cutting samples were selected for thin section description from sample depth intervals ranging from 2830m to 3080m. Sampling of rock fragments was mainly around 10m intervals. A listing of sample depths and summary of lithologies is provided in Table 1.

Thin sections were prepared using standard techniques and were stained with Alizarin Red-S and potassium ferricyanide to aid in distinguishing carbonate minerals and to identify iron-bearing carbonates. Before sectioning, all samples were impregnated with blue-dyed epoxy using the vacuum and pressure technique to facilitate recognition of pore spaces and prevent the clay from being washed away.

The examined samples are ditch cuttings and therefore may contain a mixture of lithologies from different beds; the representative samples were picked under the binocular microscope. The original rock fabric is often disturbed in ditch cutting samples and it is often difficult to distinguish the effects of physical compaction, grain shattering and deformation related to the drilling.

4. PETROGRAPHIC CHARACTERISTICS

4.1 THIN SECTION PETROGRAPHY

Thin section samples comprise ditch cuttings taken from 2830m-2840m, 2850m-2860m, 2880m-2890m, 2900m-2910m, 2910m-2920m, 2920m-2930m, 2950m-2960m, 2960m-2970m, 2990m-3000m, 3010m-3020m, 3020m-3030m, 3050m-3060m, and 3070m-3080m.

Based on thin sections, the cutting samples are dominated by claystone lithologies at 2830m-2840m and 2850m-2860m while deeper ditch cuttings are dominated by sandier lithologies of predominantly litharenitic in composition. The deepest ditch cutting sample, at 3070m-3080m, comprises almost equally common sandstone and metamorphic cuttings. Most ditch cuttings are covered by abundant reddish iron oxide material. This makes the estimation of the percentage of these lithologies difficult.

4.2 THIN SECTION LITHOLOGICAL DESCRIPTIONS

1. Sample depth : 2830m - 2840m

Sample cuttings lithology is dominated by claystone (89%) with common opaque fragments (7%) and lesser sandstone (4%) cuttings. The claystone cuttings are generally composed of dark brown randomly dispersed clays intermix with scattered very fine opaque nodules. The claystone cuttings also contain minor (2%) silt-sized quartz grains. Microporosity may be significant in the claystone cuttings.

The sandstone cuttings in this sample are mainly upper fine to lower medium grained, argillaceous, iron oxidised (tentatively identified as hematitic), comprising subequant to elongate, angular to subangular grains and poor sorting. Framework grains in the sandstone cuttings are mainly polycrystalline quartz with lesser carbonate-replaced grains and mica-rich metamorphic rock fragments. Trace amounts secondary porosity are identified.

2. Sample depth : 2850m - 2860m

Sample lithology is dominated by shale cuttings (73%) with abundant ?hematitic sandstone (27%). The shale cuttings are generally composed of dark-brown dispersed clays. The shale cuttings also contain minor silt-sized quartz grains.

The sandstone cuttings are mainly lower medium grained, argillaceous to ?hematitic, massive, comprise subequant to elongate, mainly subangular grains, with point-to-point grain contacts to occasionally almost 'floating' grain fabric, and poorly sorted. Framework grains comprise dominant mica-rich metamorphic rock fragments with lesser quartzite, volcanic rock fragments, and polycrystalline quartz. Common dispersed clays with abundant opaque/iron oxide material fills interstitial/intergranular areas. Visible porosity is negligible, rarely noted within grains.

3. Sample depth : 2880m - 2890m

Dominant cuttings lithology is sandstone of generally lower medium grained, massive, and poorly sorted sandstone. Sandstone cuttings can be classified as litharenites. Framework grains comprise predominant rock fragments (41%) of mainly quartz-rich metamorphics with lesser mica-rich metamorphics, traces of volcanic rock fragments, and shale fragments. Other grains include common quartz (5%), carbonate-replaced grains, clay-replaced grains, and feldspars (1%). Intergranular areas are filled by abundant iron oxide (?hematitic) material with common undifferentiated, dispersed clay intermix with silt. Common large intergranular pores in the sandstone cuttings are probably not original visible porosity. Minor secondary dissolution pores (2%) are present.

4. Sample depth : 2900m - 2910m

Cuttings are mostly medium to very coarse grained, subangular to angular grains, poorly sorted, argillaceous to iron oxidized sandstone cuttings with generally massive texture. Framework grains are mainly mica-rich metamorphic rock fragments with subequal amounts of quartz-rich metamorphic fragments, common quartz and minor feldspars. Other grains include minor carbonate-replaced grains and opaque. Matrix comprises abundant iron oxide matrix with common but uneven distribution of undifferentiated dispersed clays. Visible porosity is difficult to assess in these sandstone cuttings as large intergranular pores are likely to be artificial although minor secondary dissolution pores (3%) are noted within partially leached grains.

5. Sample depth : 2910m - 2920m

Cuttings lithology is mainly very fine grained to granule grade, massive, poorly sorted, iron oxidized sandstone. Sandstone cuttings can be classified as litharenites. Framework grains comprise mainly quartz-rich metamorphic rock fragments with lesser mica-rich metamorphics rock fragments (metasediment), common quartz, and minor feldspars. Accessories grains are mainly carbonate-replaced grains, clay-replaced grains, and opaque grains. Cements and clays observed are mainly iron oxides/?hematitic matrix. Visible porosity is estimated to be very poor (2%) with minor secondary dissolution pores.

6. Sample depth : 2920m - 2930m

Cuttings are mainly very fine to very coarse grained, poorly sorted, argillaceous to iron oxidized sandstone (litharenitic in composition) with massive fabric. Framework grains comprise predominantly quartz-rich and mica-rich metamorphic rock fragments, common quartz, clay-replaced grains, with lesser carbonate-replaced grains and opaque grains. Matrix comprises extensive iron oxides/?hematitic matrix infilling intergranular areas. Only traces of visible porosity are observed due to a tight fabric.

7. Sample depth : 2950m - 2960m

Cuttings lithology is mainly argillaceous to iron oxidized sandstone. Sandstone cuttings can be classified as litharenites. Sandstone cuttings are generally very fine to very coarse grained, poorly sorted with overall massive fabric. Framework grains comprise predominant mica- and quartz-rich metamorphic rock fragments with common quartz, clay-replaced grains, carbonate-replaced grains, opaque grains and minor feldspars. Matrix comprises iron oxide matrix/?hematitic material filling a large part of intergranular areas. Clay matrix is mainly undifferentiated dispersed clays and silts. Visible porosity is very poor (1%), mainly secondary dissolution pores.

8. Sample depth : 2960m - 2970m

Sandstone cuttings are mainly very fine grained to granule grade, poorly sorted, argillaceous to iron oxidized sandstone with massive texture. Framework grains are mainly quartz-rich and mica-rich metamorphic rock fragments with very common polycrystalline and monocrystalline quartz. Other grains include clay-replaced grains. Cement comprises extensive iron oxide/hematite surrounding grains and filling intergranular areas. Overall visible porosity is very poor (1%) made up of secondary dissolution pores.

9. Sample depth : 2990m - 3000m

Sandstone cuttings are mainly argillaceous to iron oxidized, very fine to very coarse grained, massive, and poorly sorted fabric. Framework grains comprise predominantly quartz-rich and mica-rich metamorphic rock fragments, with minor monocrystalline and polycrystalline quartz. Other grains include clay-replaced grains and minor carbonate-replaced grains. Cements are mainly iron oxide/ hematite occluding most intergranular areas. Common undifferentiated, dispersed clays are unevenly distributed. Generally visible porosity is almost negligible (1%) with mainly secondary dissolution porosity.

10. Sample depth : 3010m - 3020m

Sandstone cuttings are mainly very fine to very coarse grained, poorly sorted, ?hematitic, argillaceous sandstone with massive fabric. Generally they comprise abundant quartz-rich and mica-rich metamorphic rock fragments, common polycrystalline quartz with lesser monocrystalline quartz and minor clay-replaced grains. Cement comprises abundant iron oxides/ hematite while clay matrix comprises common dispersed undifferentiated clays.

Visible porosity is very poor (2%) with mainly secondary dissolution pores.

11. Sample depth : 3020m - 3030m

Sandstone cuttings are mainly hematitic and argillaceous, very fine to very coarse grained, poorly sorted with massive fabric. Framework grains comprise mainly quartz-rich and mica-rich metamorphic rock fragments, common polycrystalline quartz, and monocrystalline quartz. Other grains include carbonate-replaced grains and clay-replaced grains. Cement is mostly iron oxides which fills intergranular areas and surrounding grains. Clay matrix is common undifferentiated, dispersed clays. Visible porosity is very poor (3%) with mainly secondary dissolution pores.

12. Sample depth : 3050m - 3060m

Cuttings lithologies comprise predominantly ?hematitic sandstone, compositionally can be classified as litharenites. The sandstone cuttings are mainly very fine to very coarse grained, poorly sorted, slightly argillaceous sandstone with massive texture. Cuttings comprise almost subequally common metamorphic rock fragments (mica-rich and quartz-rich types) and quartz grains. Other grains are minor, include feldspars, carbonate-replaced grains, clay-replaced grains, mica fragments, and opaque grains. Cement is predominantly iron-oxides filling most intergranular areas within the sandstone cuttings. Clay matrix is very common undifferentiated, dispersed clays. Visible porosity is very poor (1%) with mainly secondary dissolution porosity type.

13. Sample depth : 3070m - 3080m

Cuttings lithologies are mainly hematitic sandstone (45%) with lesser sericitised metamorphic fragments (40%), metaquartzite fragments (10%), and opaque grains (5%). Closed fractures filled by polycrystalline quartz and ferroan calcite are commonly noted within metamorphic cuttings.

Sandstone cuttings are generally very fine to very coarse grained. Intergranular areas are filled with opaque material (iron oxides). Framework grains present are mainly polycrystalline quartz grains and mica-rich metamorphic fragments. Visible porosity is not observed.

5. PORE-FILLING CONSTITUENTS

These sandstone cuttings appear to be moderate to well cemented/consolidated. Iron oxide mineral, tentatively identified as hematite, is the principal pore-filling, intergranular cement in the sandstone cuttings. Argillaceous sandstone cuttings contain abundant dispersed clay matrix with common undifferentiated, dispersed clay intermix with silt.

The origin and abundance of iron oxide are problematical as it may be due to drilling contamination or original rock constituent. However, due to the extensive occurrence throughout most of the ditch cutting sampled intervals, it is likely that much of the iron oxides were derived from the formation. Other cements include polycrystalline quartz and ferroan calcite, commonly noted in closed fractures within metamorphic cuttings.

6. THIN SECTION POROSITY

These iron oxide-cemented sandstone cuttings with lesser metamorphic cuttings are consolidated and may be categorized as tight reservoirs. The majority of the iron oxide-cemented sandstone cuttings have porosity that are less than 3% however porosity measurement may have been affected by grain rearrangement and fabric disturbance during drilling. Visible porosity types identified are mainly secondary dissolution porosity. Most of the large, open, intergranular pores (ie. Plates 4A, 5A) are artificially induced. Micropores associated with clay matrix are common in the claystone cuttings (Plate 1A).

7. CONCLUSIONS

A petrographic study of the ditch cutting samples from Anding Utara -1ST1 well has led to the following conclusions:

1. Thin section analysis shows that the cutting samples are dominated by claystone lithology at 2830m-2840m and 2850m-2860m while deeper ditch cuttings are dominated by sandy lithologies of predominantly litharenitic in composition. The deepest ditch cutting sample, at 3070m-3080m, comprises almost equally common sandstone and metamorphic cuttings.
2. These iron oxide-cemented sandstone cuttings with lesser metamorphic cuttings may be categorized as tight reservoirs. The majority of the iron oxide-cemented sandstone cuttings have porosity that are less than 3%. Visible porosity types identified are mainly secondary dissolution porosity and microporosity associated with clay matrix.

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Table 1: List of Sample Depths and Summary of Lithology
Well: Anding Utara-1ST-1
Sample Type: Ditch Cuttings

BotDepth_m	Lithologic Summary	% Sand & Silt	% Meta	% Shale	% Others
2830-2840	Claystone, Sandstone	4	0	89	7
2850-2860	Claystone, Sandstone	27	0	73	0
2880-2890	Sandstone	100	0	0	0
2900-2910	Sandstone	100	0	0	0
2910-2920	Sandstone	100	0	0	0
2920-2930	Sandstone	100	0	0	0
2950-2960	Sandstone	100	0	0	0
2960-2970	Sandstone, Metasediment	100	Trace	0	0
2990-3000	Sandstone	100	0	0	0
3010-3020	Sandstone	100	0	0	0
3020-3030	Sandstone	100	0	0	0
3050-3060	Sandstone, Metasediment	97	3	0	0
3070-3080	Metasediment, Sandstone	45	50	0	5

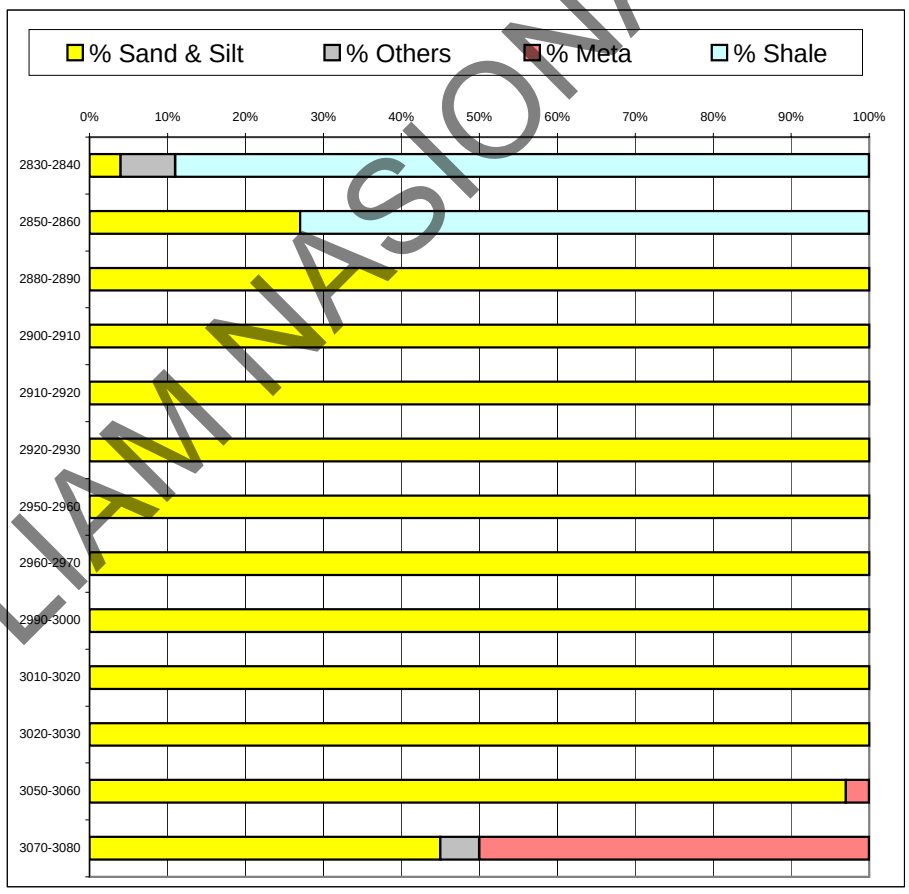


Table 2 : Point-counted components of ditch cutting samples

SAMPLE ID				THIN-SECTION POINT-COUNTED MINERALOGICAL COMPONENTS (ROCK VOLUME, %)																																	
				FRAMEWORK GRAINS																																	
				QUARTZ (Q)			FELDSPARS (F)					ROCK FRAGMENTS																OTHER GRAINS									
												SEDIMENTARY							VOLCANIC				METAMORPHIC														
WELL	DEPTH (m)	CUTTING LITHOLOGY	CLASSIFICATION	MONOCRYSTALLINE QUARTZ	POLYCRYSTALLINE QUARTZ	SUBTOTAL	PLAGIOCLASE FELDSPAR	UNTWINNED FELDSPAR	FELDSPAR, MICROCLINE	PLUTONIC ROCK FRAGMENT	SUBTOTAL	CHERT	SANDSTONE/SILTSTONE FRAG.	SHALE\CLAY-RICH FRAGMENT	SEDIMENTARY ROCK FRAG., UNDIFF	ROCK FRAG., UNDIFF	RIP-UP CLASTS	SUBTOTAL	FELSIC VOLCANIC RK FRAG.	MAFIC\INTERMEDIATE VOLC. RK. FRAG.	TUFF/GLASS	SUBTOTAL	META. RK FRAG., UNDIFF.	MICA-POOR META. RK FRAG.	MICA-RICH META. RK FRAG.	SUBTOTAL	SUBTOTAL	MICAS, UNDIFF	MUSCOVITE	CHLORITE	BIOTITE	GLAUCONITE	FOSSILS\PHOSPHATIC	CARBONACEOUS FRAGMENTS	HEAVY MINERAL & OPAQUES	SUBTOTAL	SUBTOTAL
Anding Utara-1ST1	2880-2890	Sandstone	Litharenite	5.0	tr	5.0	1.0	-	-	-	1.0	-	-	1.0	-	-	-	1.0	tr	-	-	0.0	-	28.0	12.0	40.0	41.0	-	-	-	-	-	-	-	-	0.0	47.0
Anding Utara-1ST1	2900-2910	Sandstone	Litharenite	1.0	7.0	8.0	-	2.0	-	-	2.0	-	-	-	-	-	-	0.0	-	-	-	0.0	-	20.0	23.0	43.0	43.0	-	-	-	-	-	-	-	1.0	1.0	54.0
Anding Utara-1ST1	2910-2920	Sandstone	Litharenite	3.0	3.0	6.0	tr	1.0	-	-	1.0	-	-	-	-	-	-	0.0	-	-	-	0.0	-	22.0	15.0	37.0	37.0	-	-	-	-	-	-	-	2.0	2.0	46.0
Anding Utara-1ST1	2920-2930	Sandstone	Litharenite	4.0	7.0	11.0	-	-	-	-	0.0	-	-	-	-	-	-	0.0	-	-	-	0.0	-	19.0	12.0	31.0	31.0	-	-	-	-	-	-	-	2.0	2.0	44.0
Anding Utara-1ST1	2950-2960	Sandstone	Litharenite	5.0	7.0	12.0	1.0	-	-	-	1.0	-	-	-	-	-	-	0.0	4.0	-	-	4.0	-	9.0	17.0	26.0	30.0	-	-	-	-	-	-	-	3.0	3.0	46.0
Anding Utara-1ST1	2960-2970	Sandstone	Litharenite	5.0	12.0	17.0	-	-	-	-	0.0	-	-	4.0	-	-	-	4.0	-	-	-	0.0	-	12.0	5.0	17.0	21.0	-	-	-	-	-	-		-	0.0	38.0
Anding Utara-1ST1	2990-3000	Sandstone	Litharenite	4.0	2.0	6.0	-	1.0	-	-	1.0	-	-	-	-	-	-	0.0	1.0	-	-	1.0	-	20.0	12.0	32.0	33.0	-	-	-	-	-	-	-	-	0.0	40.0
Anding Utara-1ST1	3010-3020	Sandstone	Litharenite	4.0	6.0	10.0	-	1.0	-	-	1.0	-	-	-	-	-	-	0.0	-	-	-	0.0	-	16.0	8.0	24.0	24.0	-	-	-	-	-	-	-	-	0.0	35.0
Anding Utara-1ST1	3020-3030	Sandstone	Litharenite	5.0	10.0	15.0	tr	3.0	-	-	3.0	-	-	-	-	-	-	0.0	-	-	-	0.0	-	23.0	5.0	28.0	28.0	-	-	-	-	-	-	-	-	0.0	46.0
			MINIMUM VALUE	1.0	2.0	5.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	9.0	5.0	17.0	21.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	35.0
			MAXIMUM VALUE	5.0	12.0	17.0	1.0	3.0	0.0	0.0	3.0	0.0	0.0	4.0	0.0	0.0	0.0	4.0	4.0	0.0	0.0	4.0	0.0	28.0	23.0	43.0	43.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0	54.0
			AVERAGE	4.0	6.8	10.0	1.0	1.6	0.0	0.0	1.1	0.0	0.0	2.5	0.0	0.0	0.0	0.6	2.5	0.0	0.0	0.6	0.0	18.8	12.1	30.9	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.9	44.0

tr	OBSERVED (NOT COUNTED); PRESENT IN TRACE AMOUNT
-	NOT OBSERVED (ZERO VALUE)

Note: Above are point-counted components taken from 100% sandstone cutting lithology

Table 2 : continued..

THIN-SECTION POINT-COUNTED MINERALOGICAL COMPONENTS (ROCK VOLUME, %)																																										
MATRIX							CEMENTS										CLAYS					REPLACEMENT MINERALS														VISIBLE PORES					TOTAL
CLAY MATRIX, UNDIFF.	SILICEOUS MATRIX	CARBONATE MATRIX	ORGANIC MATRIX	OXIDISED/HEMATITIC MATRIX	SUBTOTAL	PORE-FILL, UNDIFF./UNKNOWN	NON-FERROAN CALCITE CEMENT	FERROAN CALCITE CEMENT	NON-FERROAN DOLOMITE CEMENT	FERROAN DOLOMITE CEMENT	SIDERITE CEMENT	SILICA CEMENT/ QUARTZ OVERGROWTHS	PYRITE/MARCASITE CEMENT	IRON OXIDE CEMENT	ZEOLITE	SUBTOTAL	CHLORITE CEMENT	KAOLINITE CEMENT	ILLITE, SMECTITE OR I/S CLAY	AUTHIGENIC CLAY, UNDIFF	SUBTOTAL	REPLACEMENT, UNDIFF	CARBONATE REPL, UNDIFF	CALCITE REPLACEMENT	DOLOMITE REPLACEMENT	SIDERITE REPLACEMENT	SILICEOUS REPLACEMENT	PYRITE/MARCASITE REPLACEMENT	CLAY REPLACEMENT, UNDIFF	CHLORITE REPLACEMENT	KAOLINITE REPLACEMENT	ILLITE, SMECTITE OR I/S REPL.	SUBTOTAL	INTERGRANULAR PORES	SECONDARY PORES	INTRAGRANULAR PORES	UNDIF. VISIBLE POROSITY (MATRIX)	SUBTOTAL	
6.0	-	-	-	35.0	41.0	-	-	-	-	-	-	-	-	-	-	0.0	-	-	-	-	0.0	-	6.0	-	-	-	-	-	4.0	-	-	-	10.0	-	2.0	-	-	2.0	100.0
4.0	-	-	-	36.0	40.0	-	-	1.0	-	-	-	-	-	-	-	1.0	-	-	-	-	0.0	-	2.0	-	-	-	-	-	-	-	-	-	2.0	-	3.0	-	-	3.0	100.0
10.0	-	-	-	30.0	40.0	-	-	-	-	-	-	-	-	-	-	0.0	-	-	-	-	0.0	-	8.0	-	-	-	-	-	4.0	-	-	-	12.0	-	2.0	-	-	2.0	100.0
19.0	-	-	-	27.0	46.0	-	-	-	-	-	-	-	-	-	-	0.0	-	-	-	-	0.0	-	3.0	-	-	-	-	-	7.0	-	-	-	10.0	-	-	-	-	0.0	100.0
13.0	-	-	-	27.0	40.0	-	-	-	-	-	-	-	-	-	-	0.0	-	-	-	-	0.0	-	5.0	-	-	-	-	-	8.0	-	-	-	13.0	-	1.0	-	-	1.0	100.0
20.0	-	-	-	37.0	57.0	-	-	-	-	-	-	-	-	-	-	0.0	-	-	-	-	0.0	-	-	-	-	-	-	-	4.0	-	-	-	4.0	-	1.0	-	-	1.0	100.0
9.0	-	-	-	42.0	51.0	-	-	-	-	-	-	-	-	-	-	0.0	-	-	-	-	0.0	-	2.0	-	-	-	-	-	6.0	-	-	-	8.0	-	1.0	-	-	1.0	100.0
18.0	-	-	-	43.0	61.0	-	-	-	-	-	-	-	-	-	-	0.0	-	-	-	-	0.0	-	-	-	-	-	-	-	2.0	-	-	-	2.0	-	2.0	-	-	2.0	100.0
10.0	-	-	-	34.0	44.0	-	-	-	-	-	-	-	-	-	-	0.0	-	-	-	-	0.0	-	6.0	-	-	-	-	-	1.0	-	-	-	7.0	-	3.0	-	-	3.0	100.0
4.0	0.0	0.0	0.0	27.0	40.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.0	0.0	1.0	0.0	0.0	0.0	100.0
20.0	0.0	0.0	0.0	43.0	61.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	13.0	0.0	3.0	0.0	0.0	3.0	100.0
12.1	0.0	0.0	0.0	34.6	46.7	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	7.6	0.0	1.9	0.0	0.0	1.7	100.0

T OBSERVED (NOT COUNTED); PRESENT IN TRACE AMOUNT

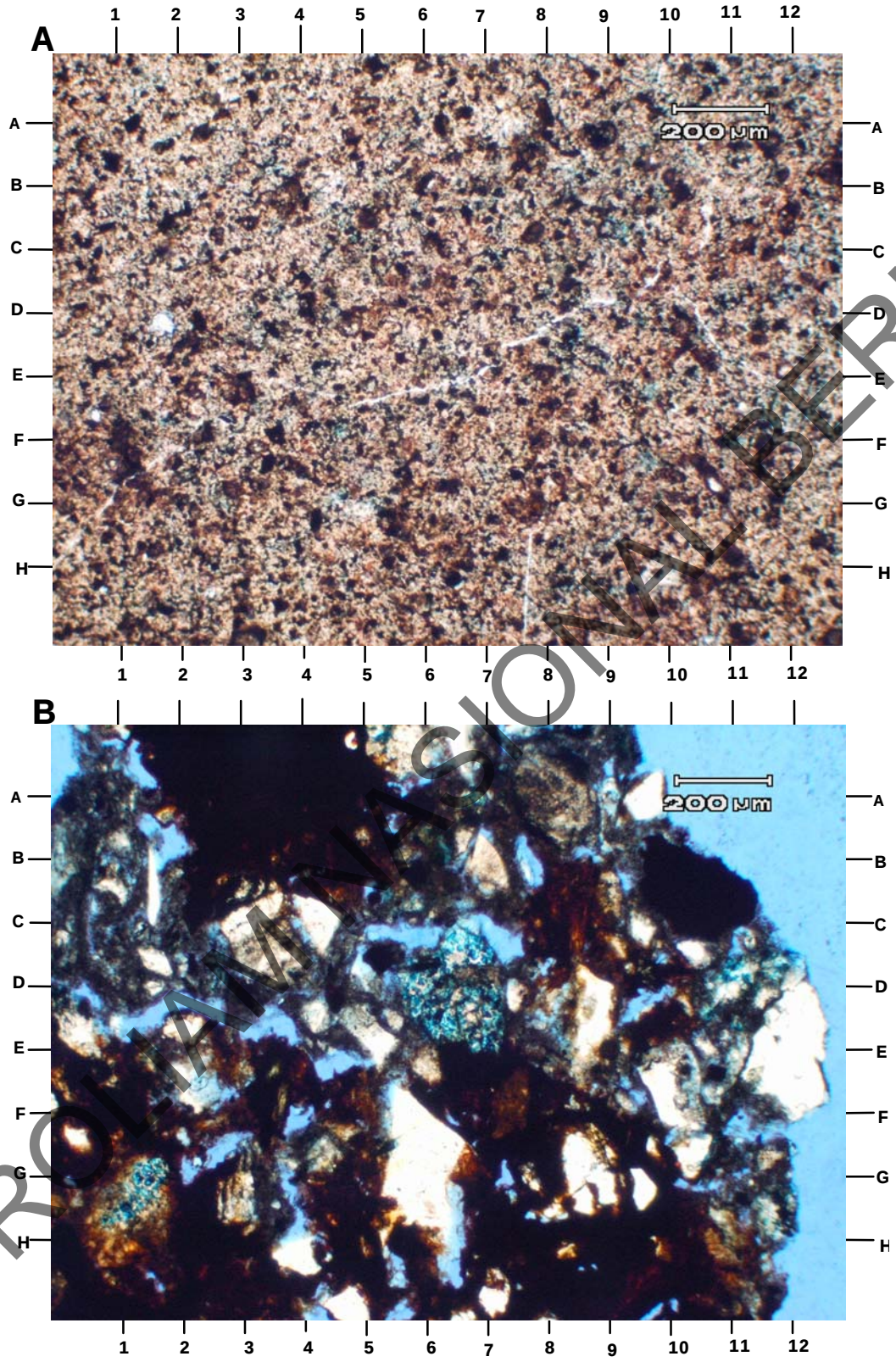
- NOT OBSERVED (ZERO VALUE)

PLATE 1

Sample Identification

Well: Anding Utara-1ST1
Sample depth: 2830m - 2840m

Reservoir : Basement
Sample Type: Ditch Cutting



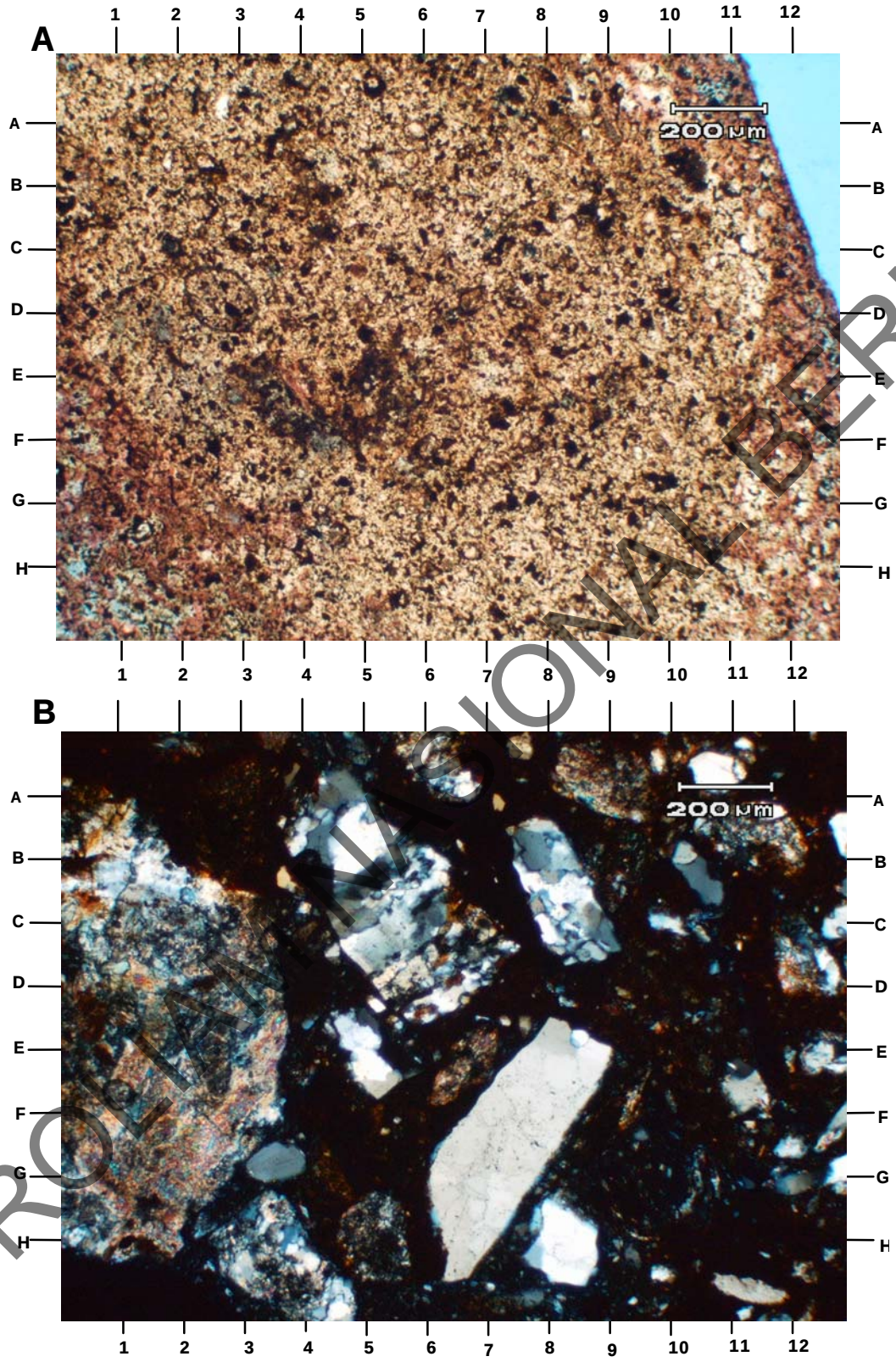
Description: **(a)** General low magnification view showing shale cutting. The claystone is generally massive, composed of dark brown randomly dispersed clay intermix with scattered very fine opaque nodules. Minor silt-sized quartz grains are also observed. Microporosity (blue-dyed epoxy) may be significant in the claystone. **(b)** The sandstone in this sample is mainly upper fne to lower medium grained, argillaceous, iron-oxidised, subequant to elongate, angular to subangular, with poor sorting. Framework grains are mainly polycrystalline quartz with lesser carbonate-replaced grains (D7) and mica-rich metamorphic rock fragments. Porosity is considered secondary.

PLATE 2

Sample Identification

Well: Anding Utara-1ST1
Sample depth: 2850m - 2860m

Reservoir : Basement
Sample Type: Ditch Cutting



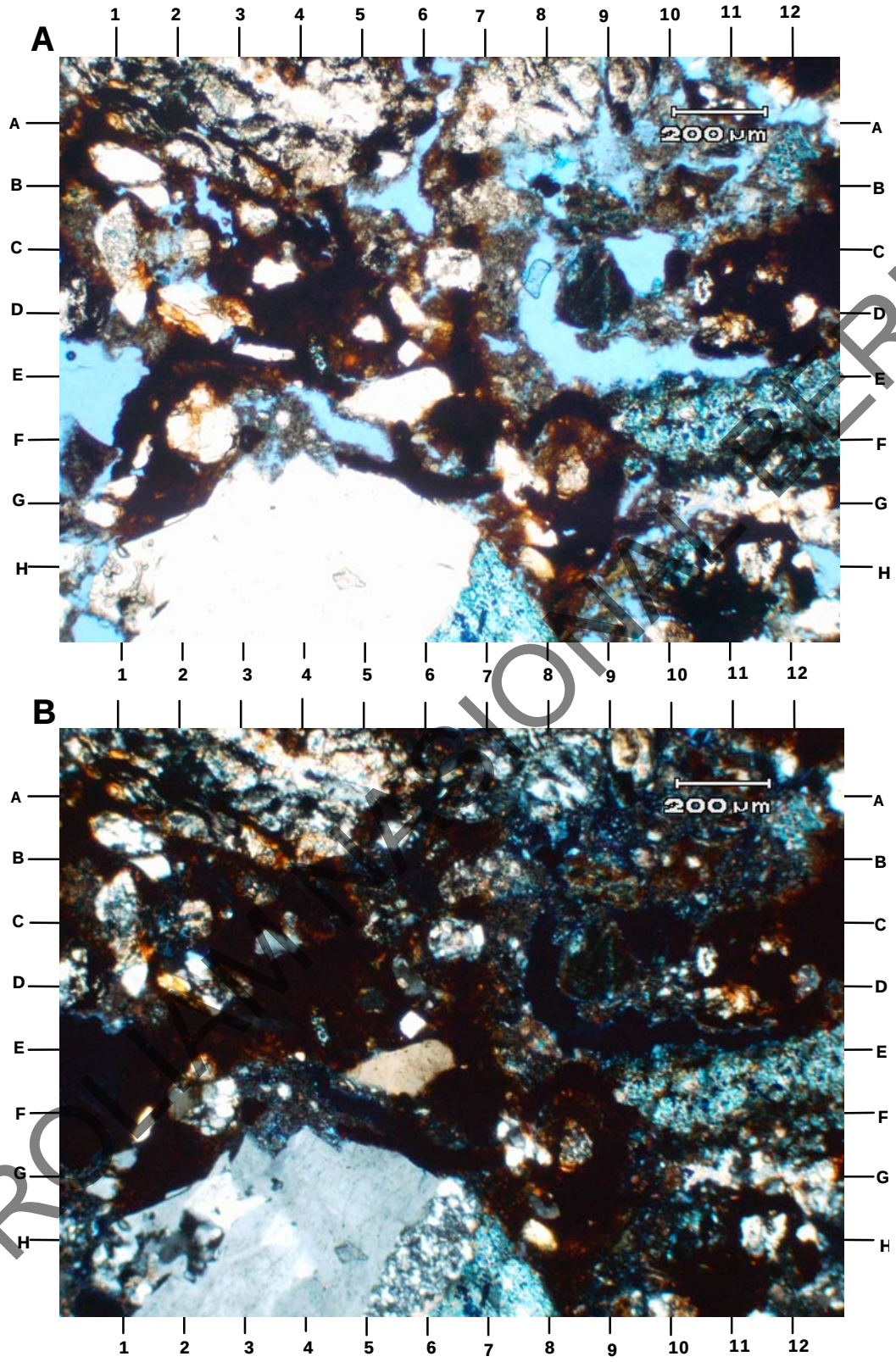
Description: **(a)** General low magnification view showing shale cutting composed of dark brown dispersed clays. Claystone also contains minor silt-sized quartz grains. **(b)** Cross-polarised view of sandstone cutting. Sandstone cuttings are mainly lower medium grained, argillaceous to hematitic, massive, subequant to elongate, subangular grains, point-to-point with lesser floating grain contacts, and poorly sorted. Framework grains comprise dominant mica-rich metamorphic rock fragments with lesser quartzite, volcanic rock fragments, and polycrystalline quartz (B8, G7). Common dispersed clays with abundant iron-oxide material filling interstitial areas. Visible porosity is negligible.

PLATE 3

Sample Identification

Well: Anding Utara-1ST1
Sample depth: 2880m - 2890m

Reservoir : Basement
Sample Type: Ditch Cutting



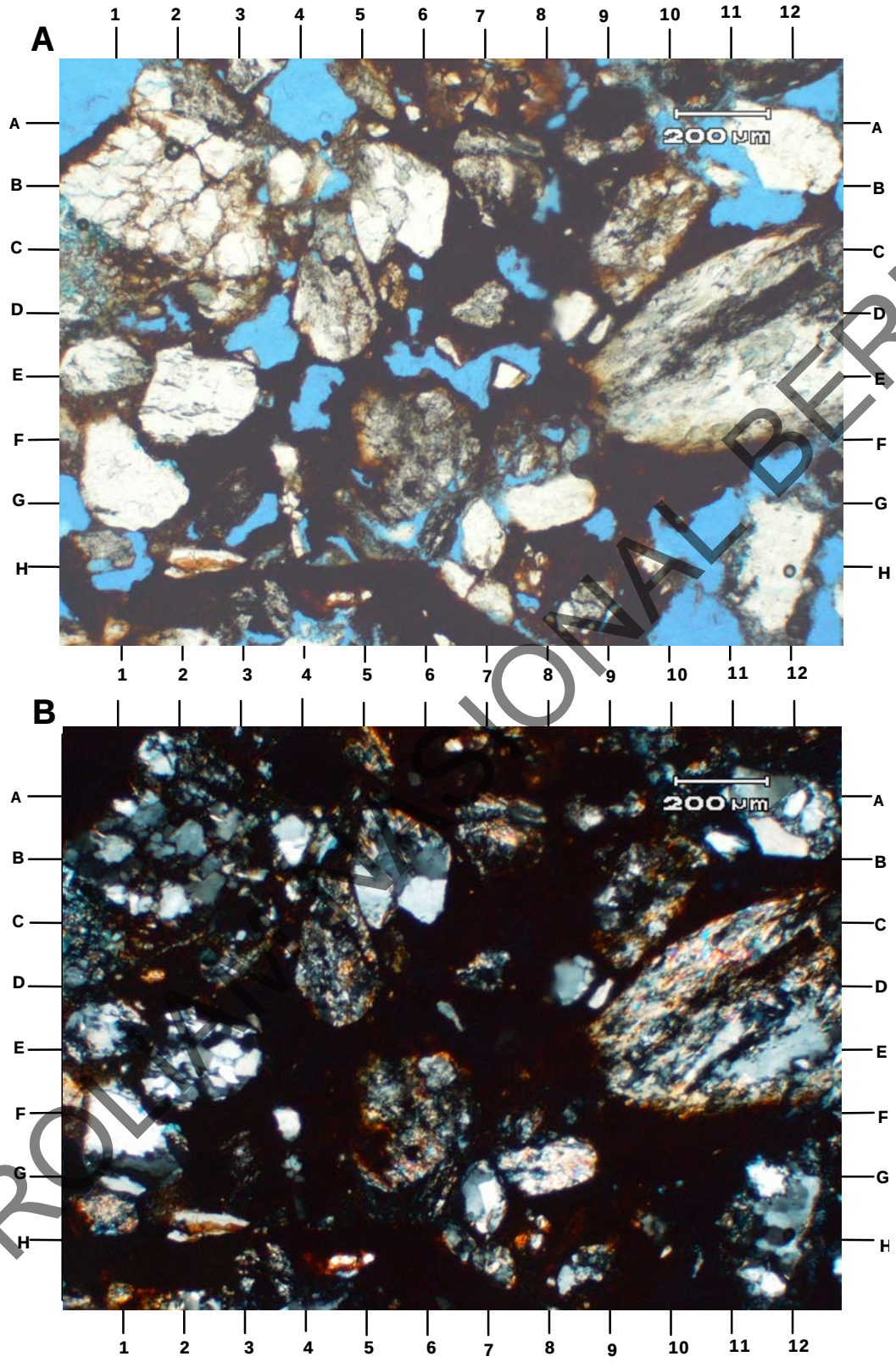
Description: **(a)** General low magnification view showing generally lower medium grained, massive, upper fine to lower medium grained, poorly sorted sandstone cutting. Framework grains comprise predominant rock fragments of mainly quartz-rich metamorphics with lesser mica-rich metamorphics, traces of volcanic rock fragments, and shale fragments. Other grains include common quartz, carbonate-replaced grains, clay-replaced grains, and feldspars. Intergranular areas are filled by abundant iron-oxide material with common undifferentiated, dispersed clay intermix with silt. Common large intergranular pores (E1, D8) are likely to be artificial although minor secondary dissolution pores are noted within partially leached grains. **(b)** Cross-polarised view of above.

PLATE 4

Sample Identification

Well: Anding Utara-1ST1
Sample depth: 2900m - 2910m

Reservoir : Basement
Sample Type: Ditch Cutting



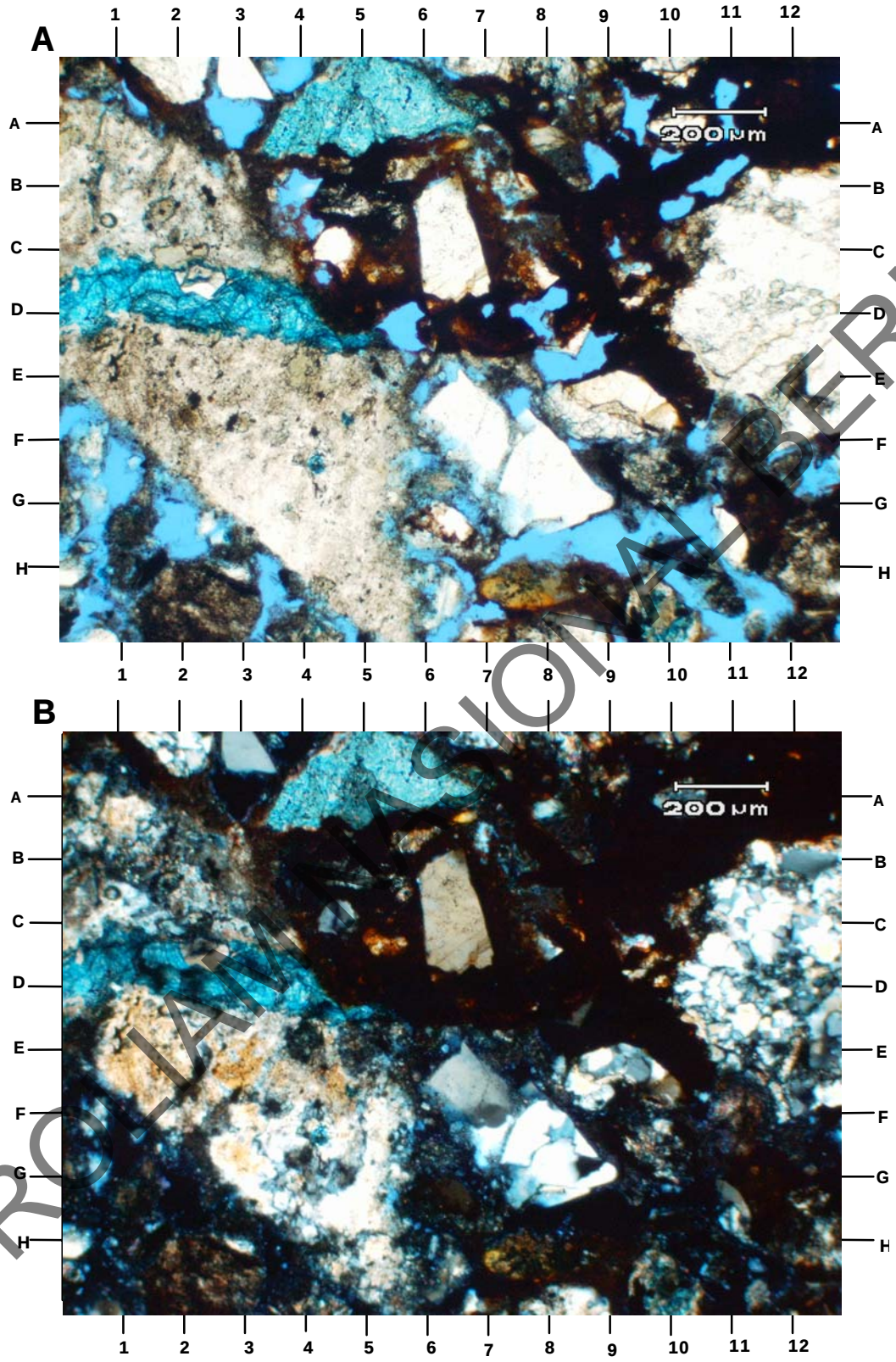
Description: **(a)** Medium to very coarse grained, subangular to angular grains, poorly sorted, argillaceous to iron-oxidised sandstone cuttings with generally massive texture. Framework grains consist of mainly mica-rich metamorphic rock fragments with subequal amounts of quartz-rich metamorphic fragments, common quartz, minor feldspars, carbonate-replaced grains, and opaque grains. Matrix comprises abundant iron-oxide with uneven distribution of undifferentiated dispersed clays. Visible porosity is difficult to assess as large intergranular pores are likely to be artificial although minor secondary dissolution pores are noted within partially leached grains. **(b)** Cross-polarised view of above.

PLATE 5

Sample Identification

Well: Anding Utara-1ST1
Sample depth: 2910m - 2920m

Reservoir : Basement
Sample Type: Ditch Cutting



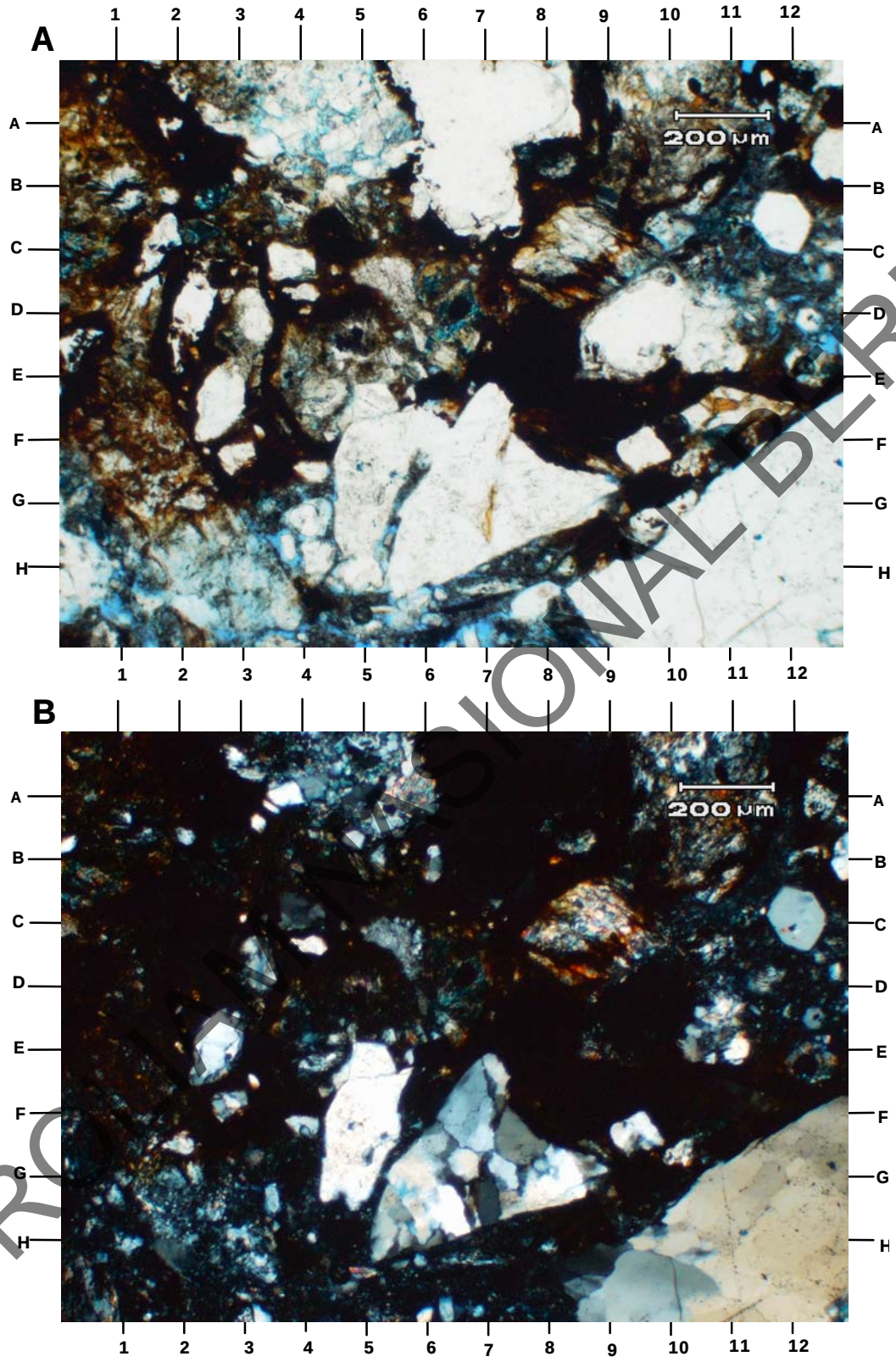
Description: **(a)** Very fine grained to granule grade, massive, poorly sorted, iron-oxidised sandstone. Framework grains consist of mainly quartz-rich metamorphic rock fragments with lesser mica-rich metamorphic rock fragments, common quartz and minor feldspars. Accessory grains are mainly carbonate-replaced grains, clay-replaced grains, and opaque grains. Cements and clays observed are mainly iron-oxides/?hematitic matrix. Visible porosity is estimated to be very poor with minor secondary dissolution pores. **(b)** Cross-polarised view of above.

PLATE 6

Sample Identification

Well: Anding Utara-1ST1
Sample depth: 2920m - 2930m

Reservoir : Basement
Sample Type: Ditch Cutting



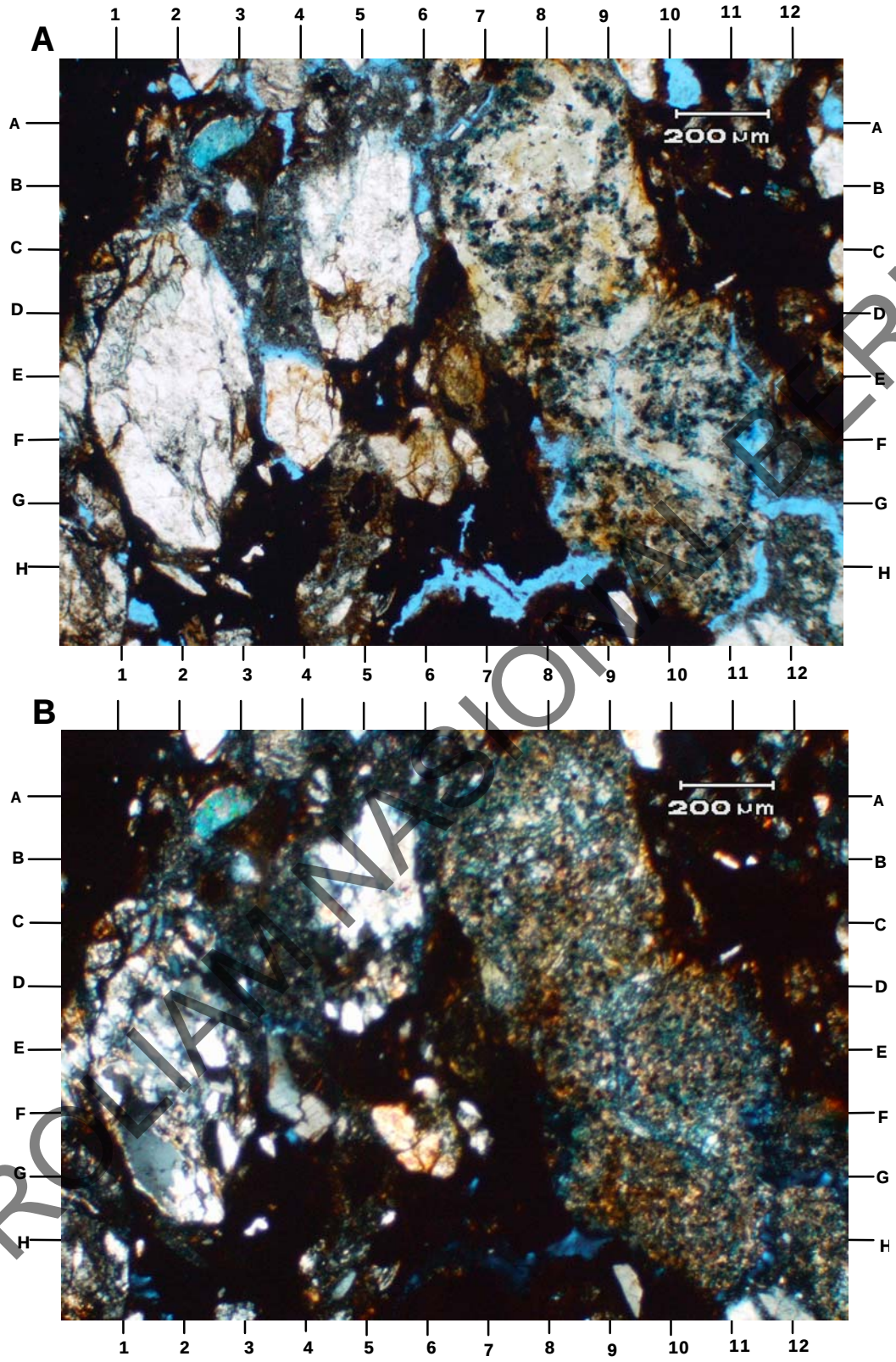
Description: **(a)** General view showing very fine to very coarse grained, poorly sorted, argillaceous to iron-oxidised sandstone with massive fabric. Framework grains comprise predominantly quartz-rich and mica-rich metamorphic rock fragments, common quartz, clay-replaced grains, with lesser carbonate-replaced grains and opaque grains. Matrix comprises extensive iron-oxides/?hematitic matrix infilling intergranular areas. Only traces of visible porosity observed due to tight fabric. **(b)** Cross-polarised view of above.

PLATE 7

Sample Identification

Well: Anding Utara-1ST1
Sample depth: 2950m - 2960m

Reservoir : Basement
Sample Type: Ditch Cutting



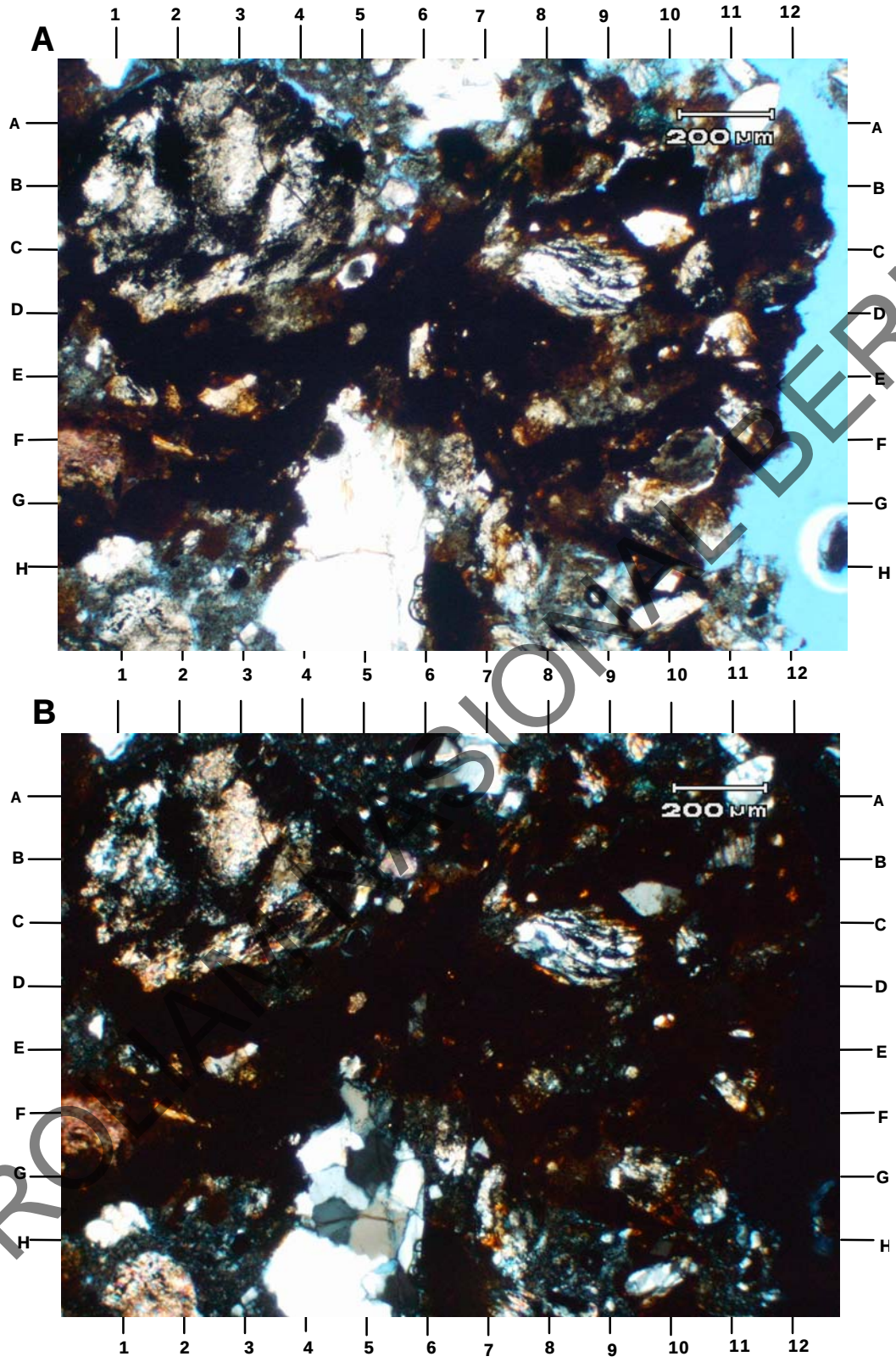
Description: **(a)** Generally very fine to very coarse grained, poorly sorted with overall massive fabric sandstone. Framework grains consist of predominant mica- and quartz-rich metamorphic rock fragments with common quartz, clay-replaced grains, carbonate-replaced grains, opaque grains, and minor feldspars. Matrix comprises iron-oxide/?hematitic material filling large part of intergranular areas. Clay matrix is mainly undifferentiated dispersed clays and silts. Visible porosity is very poor, mainly secondary dissolution pores. **(b)** Cross-polarised view of above.

PLATE 8

Sample Identification

Well: Anding Utara-1ST1
Sample depth: 2960m - 2970m

Reservoir : Basement
Sample Type: Ditch Cutting



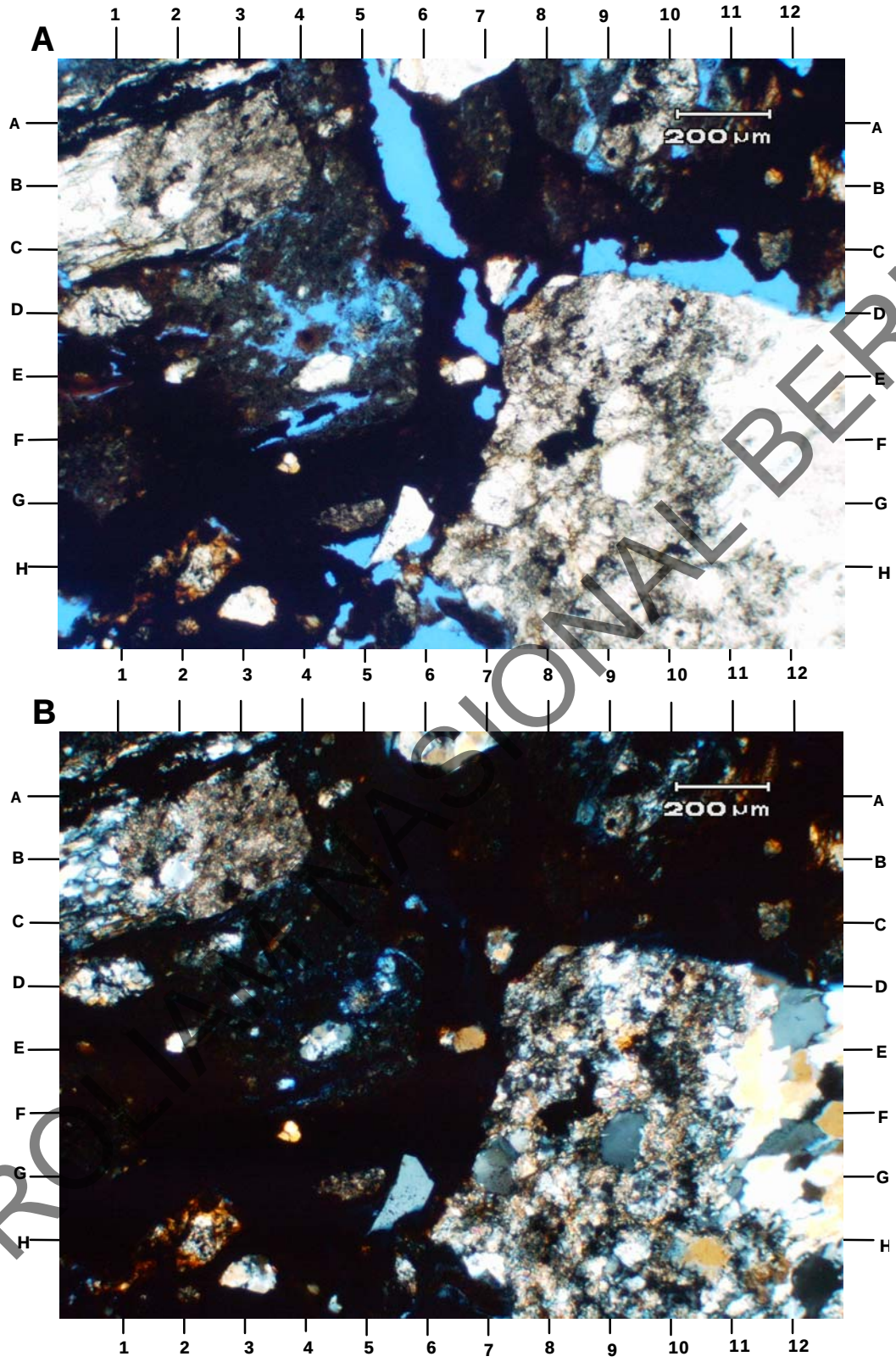
Description: **(a)** Generally very fine grained to granule grade, poorly sorted, argillaceous to iron-oxidised sandstone with massive texture. Framework grains are mainly quartz-rich and mica-rich metamorphic rock fragments, very common polycrystalline and monocrystalline quartz and minor clay-replaced grains. Cement comprises iron-oxide/?hematite surrounding grains and filling intergranular areas. Overall visible porosity is very poor, made up of secondary dissolution pores. **(b)** Cross-polarised view of above. Polycrystalline quartz grain is noted at G5.

PLATE 9

Sample Identification

Well: Anding Utara-1ST1
Sample depth: 2990m - 3000m

Reservoir : Basement
Sample Type: Ditch Cutting



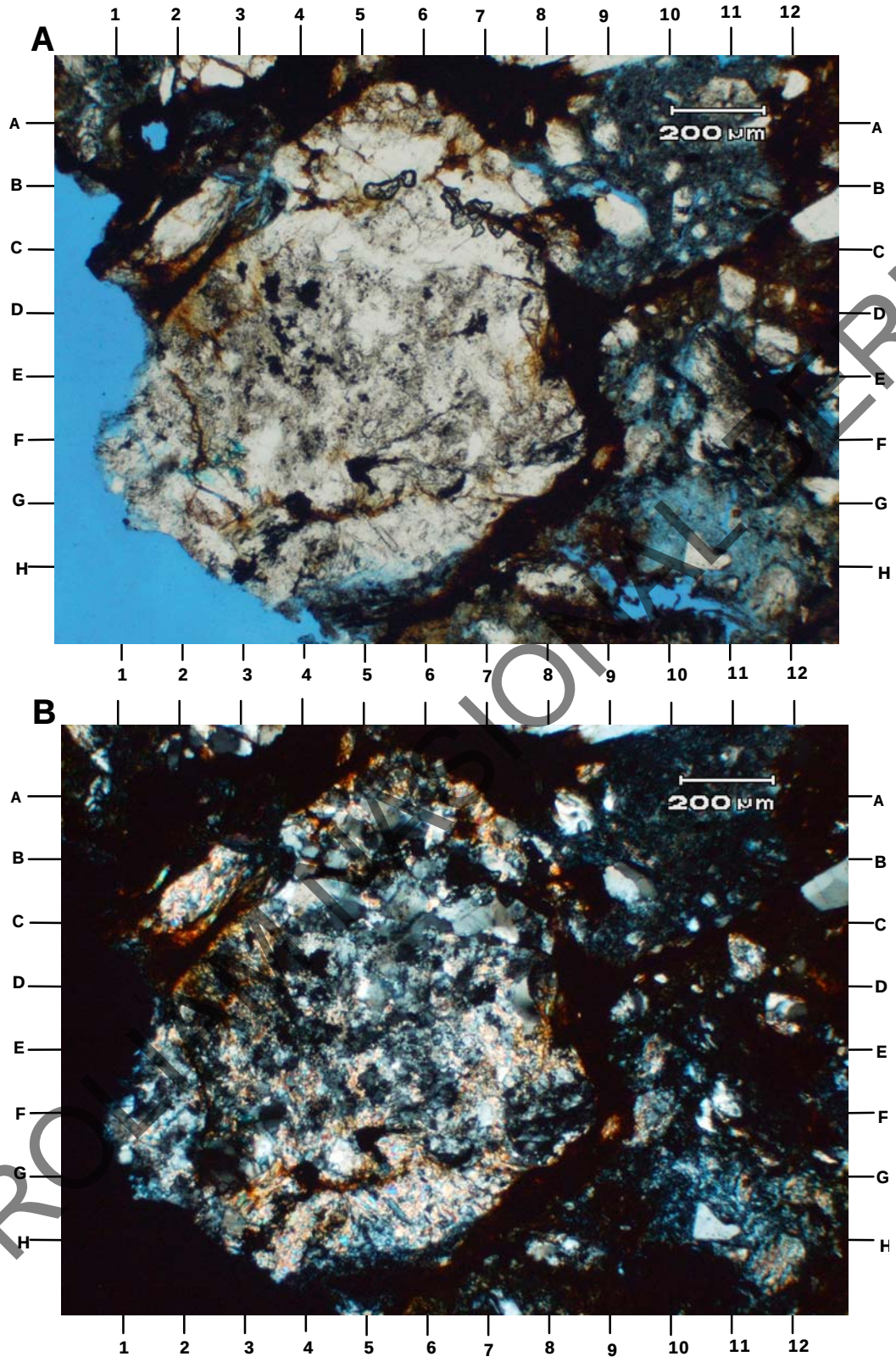
Description: **(a)** Generally argillaceous to iron-oxidised, very fine to very coarse grained, massive, poorly sorted sandstone cutting. Framework grains consist of predominantly quartz-rich and mica-rich metamorphic rock fragments, with minor monocrystalline quartz, polycrystalline quartz, clay-replaced grains, and carbonate-replaced grains. Cements are mainly iron-oxide occluding most intergranular areas. Common undifferentiated, dispersed clays are unevenly distributed. Generally, traces of visible porosity in the form of secondary dissolution pores. **(b)** Cross-polarised view of above.

PLATE 10

Sample Identification

Well: Anding Utara-1ST1
Sample depth: 3010m - 3020m

Reservoir : Basement
Sample Type: Ditch Cutting



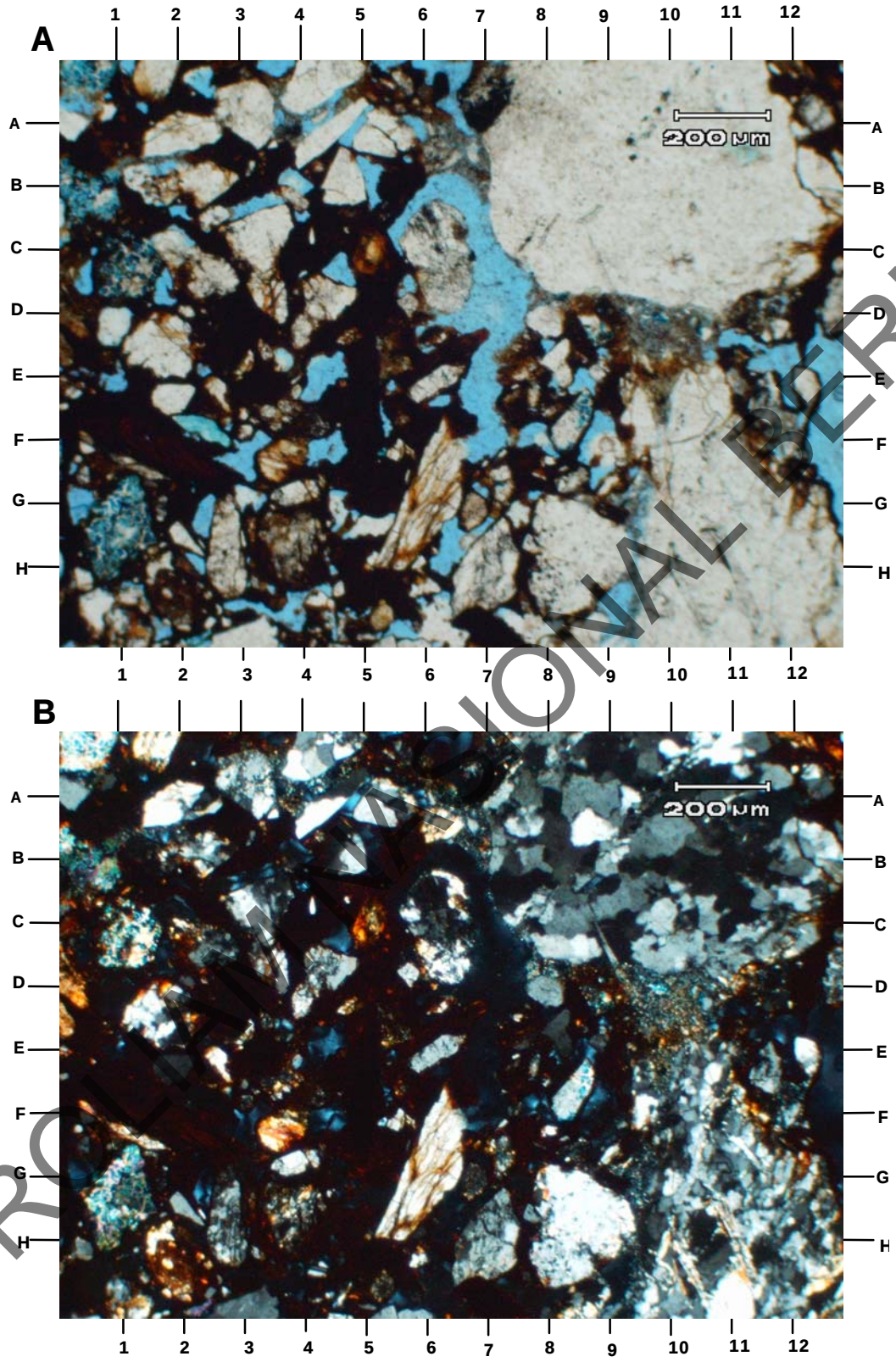
Description: **(a)** Generally very fine to very coarse grained, poorly sorted, iron-oxidised/?hematitic, argillaceous sandstone with massive fabric. Framework grains comprise abundant quartz-rich and mica-rich metamorphic rock fragments, common polycrystalline quartz with lesser monocrystalline quartz and minor clay-replaced grains. Cement comprises abundant iron-oxides/hematite while clay matrix comprises common dispersed undifferentiated clays. Visible porosity is very poor with mainly secondary dissolution pores. **(b)** Cross-polarised view of above.

PLATE 11

Sample Identification

Well: Anding Utara-1ST1
Sample depth: 3020m - 3030m

Reservoir : Basement
Sample Type: Ditch Cutting



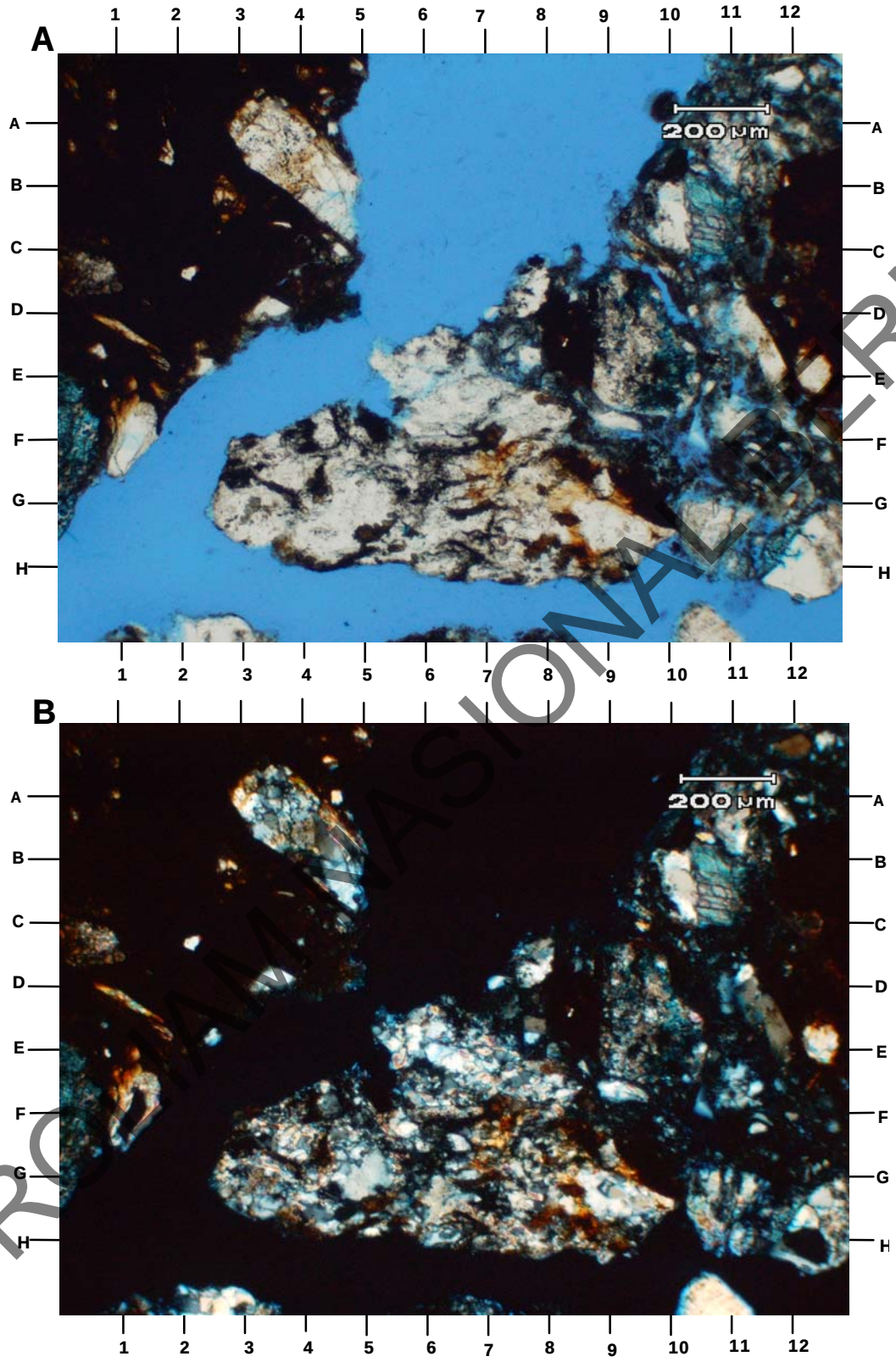
Description: **(a)** General view showing hematitic, argillaceous, very fine to very coarse grained, poorly sorted sandstone with massive fabric. Framework grains consist of predominantly quartz-rich and mica-rich metamorphic rock fragments, common polycrystalline quartz, monocrystalline quartz, carbonate-replaced grains, and clay-replaced grains. Cement is mostly iron-oxides filling intergranular areas and surrounding grains. Clay matrix is common undifferentiated, dispersed clays. Visible porosity is very poor with mainly secondary dissolution pores within grains. **(b)** Cross-polarised view of above.

PLATE 12

Sample Identification

Well: Anding Utara-1ST1
Sample depth: 3050m - 3060m

Reservoir : Basement
Sample Type: Ditch Cutting



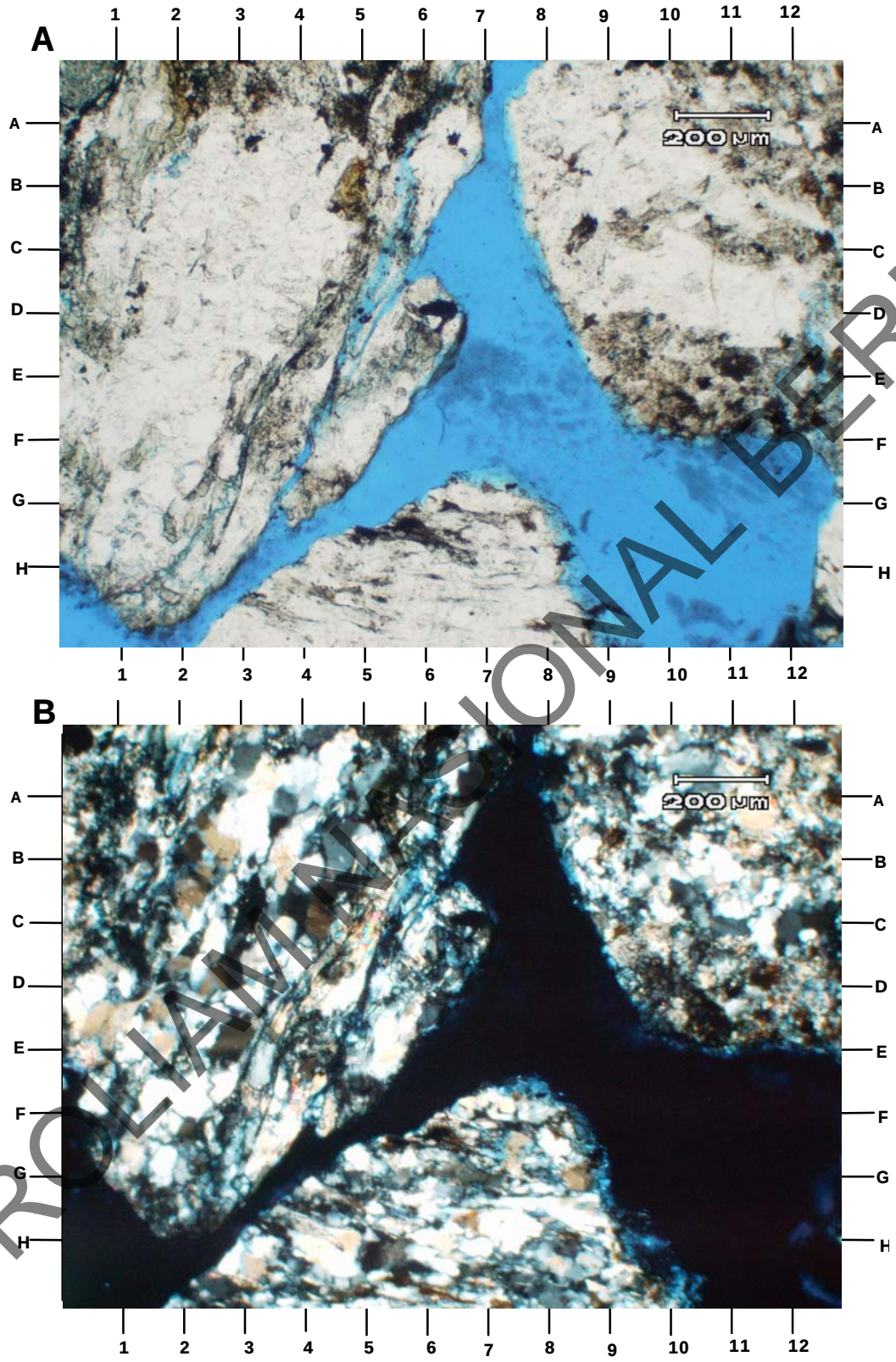
Description: **(a)** General view showing ?hematitic sandstone, very fine to very coarse grained, poorly sorted, slightly argillaceous with massive texture. Framework grains consist of subequally common metamorphic rock fragments (mica-rich and quartz-rich types) and quartz grains with minor feldspars, carbonate-replaced grains, clay-replaced grains, mica fragments, and opaque grains. Cement is predominantly iron-oxides filling most intergranular areas within the sandstone cuttings. Reservoir quality is estimated to be very poor. **(b)** Cross-polarised view of above.

PLATE 13

Sample Identification

Well: Anding Utara-1ST1
Sample depth: 3070m - 3080m

Reservoir : Basement
Sample Type: Ditch Cutting



Description: **(a)** Generally cuttings lithologies are mainly hematitic sandstone with lesser sericitised metamorphic fragments, metaquartzite fragments, and opaque grains. Closed fractures filled by polycrystalline quartz and ferroan calcite are commonly noted within metamorphic cuttings. Reservoir quality is estimated to be very poor. **(b)** Cross-polarised view of above.