DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2003/68

Results of Petrographic, X-Ray and SEM Analyses of core samples from the Enreca-1 well; Upper Miocene – Pliocene, Krong Pa Graben (Song Ba Trough) Central Vietnam

Hoang Anh Tuan, Ngo Xuan Vinh, Duong Duc Quang,
Tran Van Nhuan, Pham Thi Hong, Cao Van Dao
and Lars Henrik Nielsen

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF THE ENVIRONMENT

GEUS

DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2003/68

Results of Petrographic, X-Ray and SEM Analyses of core samples from the Enreca-1 well; Upper Miocene – Pliocene, Krong Pa Graben (Song Ba Trough) Central Vietnam

Integrated Analysis and Modelling of Geological Basins in Vietnam and an Assessment of their Hydrocarbon Potential
First Phase: Phu Khanh Basin

Hoang Anh Tuan, Ngo Xuan Vinh, Duong Duc Quang,
Tran Van Nhuan, Pham Thi Hong, Cao Van Dao
and Lars Henrik Nielsen

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF THE ENVIRONMENT

GEUS

ENRECA Project

Integrated analyses and Modelling of Geological Basins in Vietnam and an Assessment of their Hydrocarbon Potential

First Phase: Phu Khanh Basin

Results of Petrographic, X-Ray and SEM analyses of core samples from the Enreca-1 well; Upper Miocene - Pliocene, Krong Pa Graben (Song Ba Trough), Central Vietnam

Hoang Anh Tuan*, Ngo Xuan Vinh*, Duong Duc Quang*, Tran Van Nhuan*, Pham Thi Hong*, Cao Van Dao*, Lars Henrik Nielsen**

*Vietnam Petroleum Institute (VPI), **Geological Survey of Denmark and Greenland (GEUS)

GEUS
Geological Survey of
Denmark and Greenland

&

VPI
Vietnam Petroleum
Institute

GEUS, Denmark
September 2003

CONTENTS

PREFACE

This study was performed as an integrated part of the DANIDA funded Enreca project entitled "Integrated analyses and modelling of Geological Basins in Vietnam and an Assessment of their Hydrocarbon Potential – First Phase: Phu Khanh Basin".

The analyses were carried out at Vietnam Petroleum Institute (VPI) in Hanoi, while the reporting was finalized at Geological Survey of Denmark and Greenland (GEUS).

I- SUMMARY

The main objectives of this study are to contribute to the interpretation of the depositional environment and diagenetic history of Upper Miocene (N_1^3sb) sediments in the Song Ba Trough, central Vietnam by using results of petrographic, X-Ray Diffraction (XRD), Scanning Electron Microscope (SEM) analyses and the well site log from the Enreca-1 well. A total of nineteen core samples from this well were selected and prepared for these analyses. The obtained results indicate that the grain sizes of the studied samples are quite variable ranging from fine-grained sandstones to very coarse-grained sandstones. The grains are predominantly subangular to subrounded, while the sorting is moderate to poor. Most of the studied samples contain mainly quartz and K-feldspar, commonly plagioclase, mica/clay and clay minerals. The clay minerals are composed of abundant kaolinite, common illite and illite-smectite. Pore types of studied samples are predominantly primary intergranular, whereas a lesser amount of intragranular secondary pores occur. The pore connectivity of most of the sandstone is good to poor and the reservoir quality is considered to be fair. According to the results of the analyses, the investigated sediments were probably deposited in fluvial and lacustrine environments. The sediments are weakly altered, corresponding to the early diagenetic stage. The weak diagenetic changes of the sediments correspond to the immature nature of the organic matter in the well section and suggest a shallow burial depth.

II- INTRODUCTION

The Enreca-1 well was drilled in the Krong Pa Graben in order to investigate the sedimentary succession of the Song Ba Trough, central Vietnam (see the location map – figure 1). This well penetrated Upper Miocene (N_1^3sb) sediments, overlying granitic basement.

Nineteen core samples were selected from the whole interval of the well, and approximate 500 meters of their petrographic compositions were analysed by means of X-Ray, SEM and Thin section (see the table 1).

For petrographic analyses, the thin section preparations involved vacuum impregnation with blue resin to aid recognition of visible porosity. Eight thin sections were detailedly analysed in terms of mineralogy composition, texture, rock classification, depositional environment and diagenetic characteristics. Determination of the composition and visual porosity is performed by analyses that involve counting of 300 points in each thin section. Statistical evaluation of grain size and grain sorting is based on of at least 100 measurements in each thin section. The classification of the sandstone is based on Folk (1968). The grain size scale used for sediments based on Wentworth'

scale (1922). The textural terminology for detrital sediments including sorting, roundness and grain contacts are after Pettijohn et al. (1957).

Eleven samples were analysed for whole rock and clay fraction composition. The XRD analyses for whole rock were conducted in order to give proportion of different minerals within a whole rock, and distinguish the individual minerals of the each mineral group such as calcite, dolomite, etc., of the carbonate group, or anhydrite and gypsum of the sulphate group. The XRD analyses for clay fraction were performed in order to determine the type and approximate amount of clay minerals. The results of XRD analyses also aid assessing depositional environment, alteration of the rocks, and they also provide valuable supplementary information to petrographic and SEM relationships. The XRD analyses were carried out on the D8 ADVANCE, automatic diffraction system, and running parameters were set up as following: Generator setting: 40 kV, 40mA; Radiation: Cu K alpha (Ni filter); Scanning speed: $1^o2\theta$/min. The XRD analysis for whole rock was run from $3^o2\theta$ to $50^o2\theta$ while XRD analysis for clay fraction was run from $3^o2\theta$ to $30^o2\theta$. For clay fraction analyses, four XRD traces were run for each sample as follows (see appendix):

1 – Black trace: untreated samples were run at room temperature and room humidity (angular range: $3^o2\theta$ to $30^o2\theta$).

2 – Green trace: Samples were solvated by ethyleneglycol at the temperature of 50^oC to 60^oC during 24 hours in order to detect the presence of swelling clays (angular range: $3^o2\theta$ to $30^o2\theta$).

3 – Dark blue trace: Samples were heated to 300^oC during one and a half hour. This causes the coincidence of Illite-Smectite and discrete Illite at 10Å (angular range: $3^o2\theta$ to $30^o2\theta$).

4 – Red trace: Samples were heated to 500^oC during one and a half hour. This causes the collapse of Kaolinite at 7Å (angular range: $3^o2\theta$ to $30^o2\theta$).

Four samples were analysed by SEM to carefully describe the distribution of pore systems and diagenetic phases as well as their influences on reservoir quality (i.e. studying morphology, type of authigenic minerals relationship to framework grains and pore network, degree of cementation, dissolution of unstable minerals, etc.). Small fragments (less than 1cm in size) were prepared for SEM analyses and mounted on aluminum stubs. Electrical conductivity was established by applying a thin coating of gold in polaron sputter coater. SEM analyses were carried out on the JEOL instrument (model JSM-5600 LV). Four SEM photomicrographs were made to illustrate the characteristics that are mentioned below.

III- RESULTS OF PETROGRAPHIC, XRD AND SEM ANALYSES

III.1- Petrographic analyses

III.1.1- Rock type

The results of petrographic analyses are shown in the table 2.

Sandstones are represented by dots in the triangular schema according to Folk's classification (1974) for sandstones with less and more than 15% detrital matrix (figure 1 and 2). The Q:F:R components are Q = all of quartz but not chert; F = feldspar + granitic fragments; R = all of the rock fragments.

Among eight studied samples, four samples are feldspathic graywacke, two samples are lithic arkose, two samples are feldspathic litharenite sandstones (see table 2; figure 2 and figure 3).

Most feldspathic graywacke samples are encountered in the interval of 94.25—139.8m, except one sample at 354.85m. The lithic arkose sandstones are found in the interval of 175.80—236.25m. And finally two feldspathic litharenite samples are found at the depth of 164.75m and 342.90m.

III.1.2- Texture

The modal analyses of textural grain data of the studied samples are summarized in table 3. The obtained results indicate that the grain size of the studied samples is quite different from one sample to another. It changes from fine-grained sandstones (most samples at interval of 94.25—175.80m) to medium-grained sandstones (samples at interval of 342.90—354.85m), to even coarse to very coarse-grained sandstone (samples at 236.25m).

The grain shape is predominantly subangular to subrounded, occasionally very narrow angular. The sorting of most fine-grained sandstones is generally moderate to poor. For coarse to very coarse-grained sandstones, the sorting is very poor.

III.1.3- Composition

Framework grains

Quartz is the most abundant component of the detrital grains, varying from 25.3% (sample at 175.80m) to 34.7% (sample at 94.25m). In the fine-grained sandstones, monocrystalline quartz is the predominant constituent, while in the medium to very coarse-grained sandstones it includes mainly monocrystalline and common amounts of polycrystalline quartz. The monocrystalline quartz shows a weak to strong undulose extinction, while the polycrystalline quartz shows strongly undulose extinction. Rare quartz grains contain inclusion of mica, zircon, apatite, tourmaline, or rutile needles. Obviously, most of the quartz detritals have originated from plutonic rocks.

Feldspar grains are the secondly most abundant component after detrital quartz grains. The amount changes from 12.3% (sample at 139.80m) to 17.0% (sample at 342.90m). Feldspar consists mainly of K-feldspar (often more than 15%), with minor plagioclase (often less 5%). K-feldspar includes mainly orthoclase and minor microcline. Microcline and plagioclase grains are generally fresh, whereas most orthoclase has been more or less altered and replaced by kaolinite, sericite scabs or occasionally calcite or anhydrite. Some of them have been weakly dissolved and a minor amount of intragranular pores is created.

Rock fragments are mainly of volcanic and sedimentary origin, with lesser amounts of granitic, and metamorphic fragments.

Volcanic rock fragments, which range from 3.3% (sample at 139.80m) to 12.0% (sample at 354.85m), are mostly fundamental groundmass fragments of acidic extrusives. Much of these volcanic rock fragments have been strongly compacted and extensively weathered or replaced mainly by kaolinite, sericite and opaque minerals.

Sedimentary rock fragments are present in all mud clasts and/or sandstones – carbonates, except for the sample at 175.80m. The highest content is 6.3% (sample at 342.90m).

Granitic fragments appear in some samples and the content ranges from 1.7% in fine-grained sandstones (samples at 94.25m and 117.75m) to 5.3% in coarse-grained sandstone (sample at 236.25m). Most of the granitic fragments are strongly sericitized and kaolinitized.

Metamorphic rock fragments are composed mainly of low-metamorphic types, consisting of quartzite/microquartzite (average value of 2.9%) and schist (average value of 2.3%). The schist fragments are mainly of sericite schist, quartz-sericite schist and minor quartz-mica schist.

Mica varies from 0.3% (samples at 164.75m, 236.25m, 354.85m) to 3.7% (sample at 117.75m). Mica consists of mainly biotite with minor amounts of muscovite. Most biotite grains have been chloritized at various degrees, while most muscovite flakes are still fresh.

Accessory minerals are present in most samples. They occupy a very small amount of the rocks, from traces (most samples) to 1.0% (sample at 117.75m), and often consist of epidote, zircon, tourmaline, with rare apatite and rutile.

Detrital matrix

Detrital matrix is present in most samples, except for the sample at 175.80m, and consists mainly of clay matrix and minor amounts of organic matter. The amount of clay matrix varies from 2.5% (sample at 164.75m) to 36.5% (sample 139.80m), averaging 14.5% for all studied samples. The composition of clay matrix is mainly kaolinite, illite, with lesser amount of illite/smectite and other clays (see XRD analyses, table 4) and they occur mainly as pore-filing phase, with a minor occurrence as coating on detrital grains.

Cements and Authigenic minerals

Cements and authigenic minerals consist mainly of diagenetic clays, carbonate minerals, quartz, anhydrite and opaque minerals.

Diagenetic clay minerals range from 2.0% (sample at 94.25m) to 4.0% (sample 354.85m) and they are mainly represented by kaolinite, less amount of illite, illite/smectite and other clays. In most samples, authigenic clays occur mainly as the filling of intergranular pore spaces, and a smaller amount of them as replacement mineral of feldspar and lithic grains.

Quartz cement ranges from traces (sample at 139.80m) to 1.3% (sample at 342.90m). It occurs mostly as a pore-filling phase, rarely as overgrowths around detrital quartz grains.

Carbonate cement is clearly observed in the sample at 175.80m. It mainly consists of calcite and is almost filling the pores of the rocks.

Anhydrite cement is encountered in the sample at 175.80m, with an amount of 2.3% and it occurs as pore filling together with calcite cement.

Opaque minerals are encountered in most samples and range from traces to 1.7%. They fill pore spaces or to a lesser degree occur as partial replacing of altered mica grains.

III.1.4- Visible Porosity

In general, the visual porosity of most studied sandstones is poor, except in the sandstones at 164.75m, 236.25m and 342.90m, where a fair to good visible porosity occurs. Pore types are predominantly primary intergranular, while a lesser amount of intragranular secondary pores are formed by dissolution of unstable grains. Pore size commonly varies from 0.02—0.20mm. The pore connectivity is changing from very good in high visual porosity sandstones to poor in low visual porosity sandstones.

III.2- XRD analyses

Results of XRD analyses of whole rock and clay fraction are shown in table 4 and 5, respectively. Table 4 indicates that most rocks contain mainly quartz, K-feldspar, commonly plagioclase, mica/clay minerals and clay minerals. Calcite is present in some samples with minor content, except for the sample at 175.80m, where its content exceeds 29%. Anhydrite is also present in some samples with a content of less than 3% (see table 3).

Results of XRD analyses of the clay fraction (table 4) indicate that clay minerals in most studied samples are composed of abundant kaolinite, common illite, smectite and illite-smectite. Illite-smectite often appears but amount value in most samples is only about 6% of the clay content. The content of kaolinite in most sample ranges from 54% to 70% of total clay content, except samples of the interval 410.80—451.10m, where its amount is considerably enhanced, varying from 73% to 82%. Smectite is present in most samples with a content of 5—18.6%. Illite is ranging from 13.0% to 21.8% and is present in most of the studied samples.

III.3- SEM analyses

Four core samples from the depth interval 117.75—175.80m have been studied by SEM analyses in order to identify pore spaces, diagenetic processes, authigenic minerals and their influences on reservoir quality.

The diagenetic processes of most of the examined samples are characterized by the occurence of authigenic minerals and mechanical compaction. The authigenic minerals recognized by the SEM analyses include kaolinite, illite, illite/smectite, quartz and minor amounts of chlorite.

Authigenic kaolinite often appears in all samples in minor amounts. It is arranged in elongate stacks or books in the form of subeuhedral to euhedral crystals of 2—7μm in diameter, filling pore spaces or coating detrital grain surfaces. A minor amount of secondary kaolinite occuring as partial replacements of feldspar detrital grains is also recognized in some samples.

Secondary illite is also present in all samples in minor amounts. Most illite occurs as thin crenulated to flake or ribbon coatings on detrital grain surfaces and filling pore spaces between detrital grains. Rare secondary chlorites are present. They are mainly formed due to alteration of detrital biotite grains (sample at 117.75m).

Quartz overgrowth appears in all samples in minor proportion. It occurs mainly as fine subhedral to euhedral crystals of 3—10μm, filling pore space together with other secondary minerals (sample 164.75m and 139.8m).

Porosity and permeability

In general, the reservoir quality of most of the studied sandstones is fair, except for the sample at 164.75m, where the primary porosity is considered to be of good to very good quality. The primary intergranular pores are the principally component of the porosity of most examined sandstones. Especially in the sample 164.75m, the intergranular pores of 100—150 μm in size, show very good connectivity. Apart from that a minor amount of dissolution pores are often observed in all samples. Reservoir quality of other sandstones are considered fair to poor, because many pore throats have been partly or nearly completely blocked by detrital matrix and authigenic cements.

IV- INTERPRETATION

IV.1- Depositional environment

Most sandstones are fine to medium or coarse to very coarse-grained, moderately to very poorly sorted, with subangular to subrounded grains. The presence of some gravels and conglomerates scattered in the coarse-grained sandstones (interval depth 187—198m; 212—215m; 477—478.5m) is described on the well site log (enclosure 1). These characteristics suggest that the coarse clastic sediments were subjected to relatively short distances of transport and were deposited in a moderate to high-energy environment. A likely environment could be fluvial channel. The occurrences of schist and quartzite/microquartzite fragments suggest that rocks of this lithology were present in the source region. Abundance of kaolinite is consistent with deposition in an environment subjected to considerable flushing with oxidized meteoric water. Coal beds (depth interval 165—166m, 323—324.5m, 329—331m, 392—393.5m, etc) and claystones rich in organic matter, occasionally grading to coaly claystones, are also recognized. The combined evidence from the analyses and the well site description of the cores thus suggests that the depositional environment was dominated by lakes and fluvial channels with some swamps.

IV.2- Diagenetic sequence

Most of the investigated sandstones are friable (layers 17, 21) to soft (layer 112), weakly consolidated. The carbonate-cemented sandstone beds are moderate consolidated, for example, at 175.80m. The content of authigenic minerals and cement in most sandstone is minor (often smaller than 5%) indicating an initial stage of the cementation processes. The carbonate-cemented sandstone has a high content of cement (sample at 175.80m). The grain contact of the detrital grains is mostly of point type, with minor amount of straight contacts, indicating weak mechanical compaction processes.

The majority of the claystones and siltstones are soft, friable (layer 100) and are easily dissolved in water (layer 64, 95). Some layers are moderately to weakly consolidated (e.g. layer 71).

The weak signs of mechanical compaction indicate a limited burial depth of the investigated samples. The limited dissolution of especially the volcanic rock fragments, various feldspars, biotite and epidote further support a small burial depth, probably of less than 800 m.

The diagenetic events mentioned above have considerably reduced the pore volume as well as the size of intergranular pores, i.e. they are adversely effected the reservoir quality. There is only one process that increases the porosity, and that is the dissolution of unstable grains. Dissolution processes is observed in most sandstones and a certain amount of dissolution pores is created.

V- CONCLUSIONS

The integrated results from lithology, XRD, SEM analyses, as well as the well site log of the Enreca-1 well indicate that most of the studied samples contain mainly quartz and K-feldspar, commonly plagioclase, mica/clay and clay minerals. The grain sizes are quite variable ranging from fine-grained sandstones to very coarse-grained sandstones. The grains are predominantly subangular to subrounded, while the sorting is moderate to poor. The clay minerals are composed of abundant kaolinite, common illite and illite-smectite. Pore types of studied samples are predominantly primary intergranular, whereas a lesser amount of secondary pores are intragranular. The reservoir quality of most of the sandstone is considered to be fair. According to the results of the analyses, the investigated sediments were probably deposited in fluvial and lacustrine environments. The sediments are only weakly altered, corresponding to the early diagenetic stage. The weak diagenetic changes of the sediments correspond to the immature nature of the organic matter in the well section (L.V.Hien & H.I.Petersen, oral communication, 2003) and suggest a shallow burial depth, probably of less than 800 m.

VI- ACKNOWLEDGEMENT

The results presented herein were obtained from an ongoing research project on the development and hydrocarbon potential of the Phu Khanh Basin. The project is carried out by Geological Survey of Denmark and Greenland (GEUS) together with Vietnam Petroleum Institute (VPI) and Petrovietnam (PV). Danida (Danish International Development Assistance) is thanked for funding the project.

VII- REFERENCES

- Folk, R.L., 1968, *Petrology of Sedimentary Rocks*. Austin, Tex.: Hemphill's Book Store.
- Pettijohn, F.J. 1957, *Sedimentary Rocks.* 2nd ed. New York: Harper & Bros.
- Wentworth, C.K., 1922, "A Scale of Grade and Class Term for Clastic Sediments", *Jour. Geol*., **30**, 377-392.

Appendix of Figures, Tables, Descriptions, Diffractograms and Enclosure 1

***Figure 1*: Location map of the Enreca-1 well**

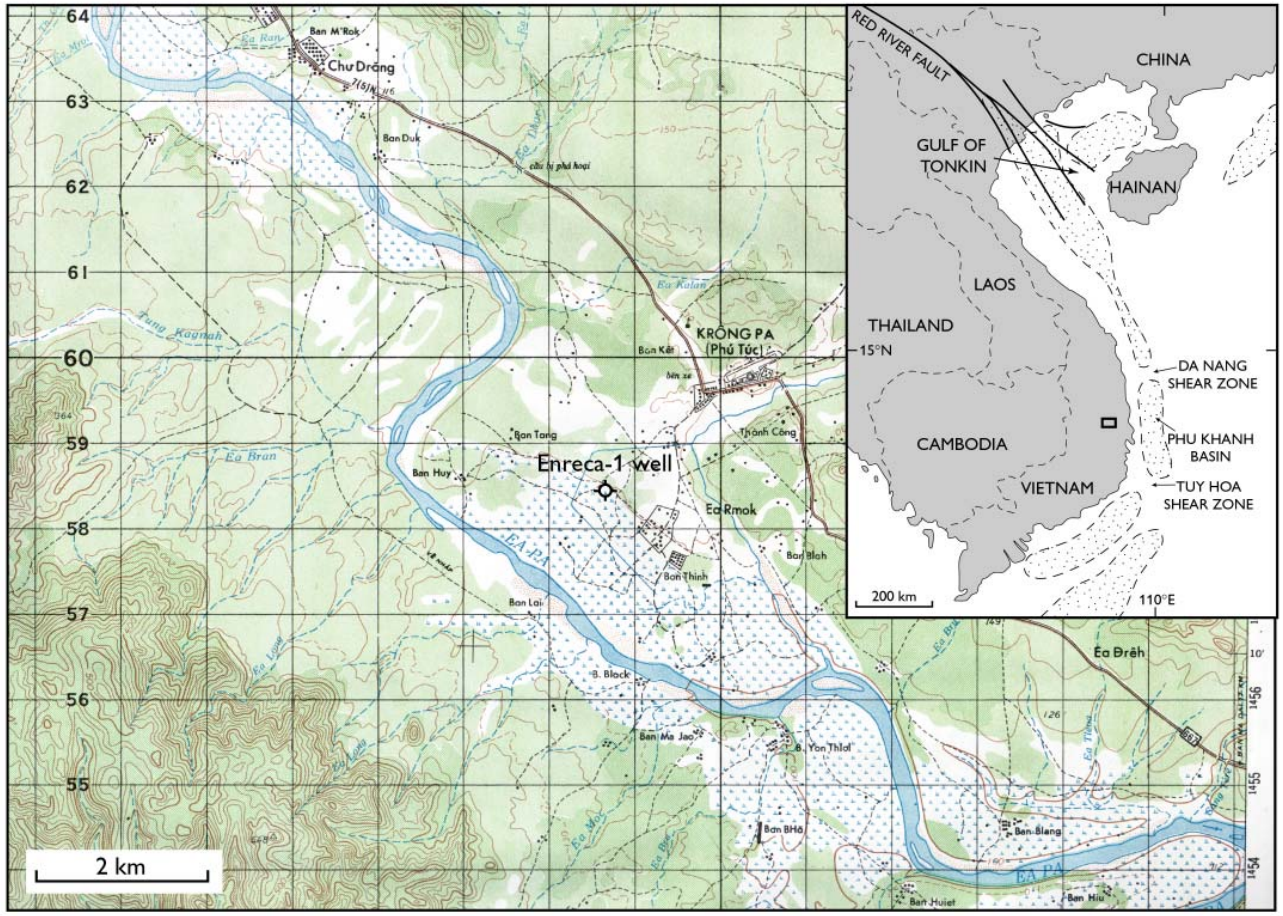


Table 1: List of core samples for Petrographic, X-Ray and SEM analyses from the Enreca-1 well

N^0	Depth (m)	Box N^0	Purpose of analyses
1	15.75	3	X-Ray
2	94.25	18	Sandstone Petrography & X-Ray
3	107.15	20	X-Ray
4	117.75	22	Sandstone Petrography, X-Ray & SEM
5	122.85	23	X-Ray
6	139.80	25	Sandstone Petrography, X-Ray & SEM
7	164.75	29	Sandstone Petrography, X-Ray & SEM
8	175.80	31	Sandstone Petrography, X-Ray & SEM
9	183.30	33	X - Ray
10	230.20	40	X - Ray
11	236.25	41	Sandstone Petrography & X-Ray
12	302.25	52	X - Ray
13	332.75	57	X - Ray
14	342.90	59	Sandstone Petrography & X-Ray
15	354.85	60	Sandstone Petrography & X-Ray
16	364.20	62	X - Ray
17	410.80	70	X - Ray
18	444.45	77	X - Ray
19	451.10	77	X - Ray

MÔ TẢ LỖ KHOAN SỐ 01_NGHIÊN CỨU ĐỊA TẦNG

KHU VỰC PHÚ CẦN, KRÔNG PA, GIA LAI

THUỘC ĐỀ ÁN ENRECA

Toạ độ: X: 1158.970m Y: 248.5m
H: 120m.
Độ sâu: 494.5 m

Đơn vị thi công: Đoàn thi công công trình Địa chất - Liên đoàn Địa chất Trung trung bộ

Ngày Khởi công: 14-3-2002
Ngày Kết thúc: 30-4-2002
Công nghệ Khoan: Máy 3AM-500

Thước tỷ lệ	Tuổi địa chất	Thứ tự lớp	Bản vẽ lõi Khoan	Đường kính lõi Khoan (mm)	Góc dốc lớp (độ)	Mức độ thu hồi lõi Khoan: Chiều dài hiệp (m)	Chiều dài lõi Khoan (m)	Tỷ lệ mẫu %	Số hiệu các cục mẫu: Từ ... m, Đến ... m	Lấy các loại mẫu	MÔ TẢ VÀ KẾT QUẢ PHÂN TÍCH	GHI CHÚ
	Q_{II-IV}	1				2.0	2.0	100	0-2m Mẫu bở rời			
5		2		168		2.0	2.0	100	2-4m "			
						2.0	1.5	75	4-6m "			
10		3				2.0	1.4	70	6-8m (2-1)-(2-9)			
						2.0	1.4	70	8-10m (2-10)-(2-16)			
15		4			30	2.0	1.5	75	10-12m (2-18)-(2-22)			
						2.0	1.8	90	12-14m (2-23)-(3-11)			
20		5			20	1.5	1.0	66	14-15.5m (3-12)-(3-18)			
					25	1.5	1.0	66	15.5-17m (3-19)-(3-26)			
25		6				2.0	1.4	70	17-19m (4-1)-(4-11)			
						1.0	0.7	70	19-20m Mẫu bở rời			
						1.0	0.8	80	20-21m "			
		7				1.0	0.8	80	21-22m "			
30	N_2^3sb	8		110		1.8	1.4	77	22-23.8m (4-12)-(5-2)			
						2.2	1.7	77	23.8-26m (5-3)-(5-8)			

[illegible]

MÔ TẢ VÀ KẾT QUẢ PHÂN TÍCH

1. Cát, sạn, sỏi xen lẫn ít cuội hạt nhỏ bở rời màu xám vàng. Phần cuối chứa cuội, sỏi ϕ 10mm nằm rải rác trong cát, sét, sạn.
2. Lớp cuội đa khoáng màu xám trắng, xám vàng. Thành phần là thạch anh, riolit, granit ϕ 1-10cm tròn cạnh, gắn kết yếu rời rạc.
3. Cát kết thạch anh chứa sạn màu nâu vàng, xám xanh, gắn kết yếu, phân lớp dày.
4. Bột kết màu xám xanh, gắn kết yếu dạng khối.
5. Cát kết thạch anh, màu xám xanh, xám đen, chứa một ít vật chất hữu cơ hoá than, phân lớp mỏng.
6. Bột kết xen lẫn cát kết màu xám xanh, xám trắng, gắn kết yếu.
7. Bột kết màu xám xanh, gắn kết yếu, phân lớp mỏng.
8. Sét kết màu xám xanh phân lớp dày, gắn kết chặt.
9. Cát kết thạch anh hạt nhỏ, màu xám trắng, xám xanh, gắn kết yếu, mềm bở dạng khối.
10. Sét kết xen lẫn ít bột kết màu xám xanh gắn kết chặt phân lớp mỏng.
11. Cát kết thạch anh màu xám trắng phớt xanh gắn kết yếu.
12. Sét kết màu xám xanh khi ướt dẻo mịn.
13. Cát kết thạch anh chứa sạn màu xám xanh gắn kết yếu phân lớp dày.
14. Sét bột kết màu xám trắng vàng nâu, phân lớp dày.
15. Cát kết màu xám trắng xám xanh, độ gắn kết yếu bở rời, phân lớp dày, phần cuối có chứa một ít vật chất hữu cơ hoá than. Than có màu đen nâu phân lớp mỏng, chiều dày gần 1cm.
16. Bột kết màu xám xanh, gắn kết chặt phân lớp dày.
17. Cát kết thạch anh màu xám trắng gắn kết yếu mềm bở.
18. Bột kết màu xám xanh phân lớp dày, gắn kết chặt.
19. Cát kết thạch anh đa khoáng màu xám trắng, tại 68.5m có chứa một ít vật chất hữu cơ hoá than, có chiều dày 2-3cm. Than có màu đen nâu phân lớp mỏng dạng lá.
20. Bột kết xen lẫn ít sét kết màu xám trắng, phớt xanh, gắn kết chặt, phân lớp dày.
21. Cát kết thạch anh đa khoáng hạt trung màu xám trắng, bở rời.
22. Cát kết thạch anh hạt nhỏ xen lẫn ít sét màu xám xanh, ngậm nước dẻo mịn, phân lớp không rõ ràng.
23. Cát kết thạch anh đa khoáng hạt trung màu xám trắng, gắn kết yếu, bở rời, phân lớp không rõ ràng.
24. Sét kết màu xám xanh phân lớp mỏng, xen kẹp cát kết đa khoáng có chứa ít vật chất hữu cơ hoá than.
25. Bột kết màu nâu đỏ gắn kết chặt phân lớp dày.
26. Cát kết thạch anh đa khoáng màu xám trắng, gắn kết chặt.
27. Sét kết màu xám xanh, gắn kết chặt, ngậm nước dẻo mịn.
28. Cát kết thạch anh đa khoáng màu xám trắng, gắn kết yếu mềm bở dạng khối.
29. Sét kết màu xám xanh phớt nâu, gắn kết chặt phân lớp dày.
30. Cát kết thạch anh đa khoáng màu xám trắng, xám xanh, xen kẹp hai lớp bột kết dày 1m, màu xám xanh, xám nâu.
31. Bột kết xen lẫn ít sét kết màu xám xanh, ngậm nước dẻo mịn.
32. Cát kết thạch anh đa khoáng hạt trung màu xám trắng. Tại 144.6m có chứa ít vật chất hữu cơ hoá than, phân lớp mỏng dày 4cm. Than có màu đen nâu, ánh mờ, dễ tách thành tấm mỏng dạng lá.
33. Sét kết màu xám xanh, xen lẫn ít cát kết hạt nhỏ, có chứa lớp than nâu, màu đen nâu, rắn chắc, dày 0.1m, có độ tro cao, bên cạnh còn chứa ít vật chất hữu cơ hoá than dạng lớp mỏng.
34. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.
35. Sét kết xen lẫn ít cát kết màu xám xanh, khi khô nứt nẻ mảnh, phân lớp dày.
36. Cát kết thạch anh đa khoáng màu xám trắng, mềm bở, gắn kết yếu, phân lớp dày.
37. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng. Tại 158.1-158.4m cát kết hạt mịn màu xám trắng có chứa ít than nâu dạng lớp mỏng, than có màu đen nâu, ánh mờ, vết vạch màu nâu.
38. Cát kết thạch anh hạt nhỏ, xen kẹp cát kết thạch anh hạt thô, màu xám trắng phân lớp dày. Ở đây có chứa hai lớp than nâu, màu đen ánh mờ, bề mặt rạng nứt tạo thành lớp mỏng, nhẹ, dòn, dễ đập vụn nát, góc nghiêng của vỉa 28°. Cát kết có độ gắn kết yếu mềm bở.
39. Bột kết màu xám xanh, phân lớp dày, gắn kết chặt, ngậm nước dẻo mịn, khi khô thường nứt theo mặt lớp.
40. Cát kết thạch anh hạt nhỏ, gắn kết yếu bở rời, xen kẹp cát kết thạch anh đa khoáng hạt thô, gắn kết chặt phân lớp dày.
41. Bột kết màu xám xanh gắn kết chặt, xen kẹp 0.3m cát kết màu xám trắng, gắn kết yếu mềm bở.
42. Cát kết xen lẫn cuội kết màu xám trắng. Thành phần cuội: Granit, thạch anh, ϕ lớn nhất 2-4cm. Trong lớp này có chứa lớp than nâu dày 0.6m, màu đen nâu, xốp, nhẹ, còn lại dấu vết dạng cành lá của cây hoá than.
43. Sét kết xen lẫn ít cuội đa khoáng màu xám xanh. Cuội rất tròn cạnh, có đường kính ϕ 1.5-2cm.
44. Cát kết hạt mịn, màu xám xanh, phân lớp không rõ ràng.
45. Cát kết thạch anh hạt thô màu xám trắng, xen lẫn cuội thạch anh granit tròn cạnh, cuội có đường kính ϕ 1cm, gắn kết yếu dễ sụp lở.
46. Cát kết thạch anh hạt mịn, màu trắng xám xanh, có chứa ít vật chất hữu cơ hoá than.
47. Bột kết màu xám xanh, gắn kết chặt phân lớp dày.
48. Cát kết thạch anh hạt nhỏ, màu trắng xám xanh, gắn kết yếu.
49. Cuội kết đa khoáng màu xám trắng, xám xanh. Thành phần gồm: Thạch anh, granit, granosyenit, granodiorit. Cuội có đường kính lớn ϕ 6-7cm, có độ mài tròn chọn lọc kém, gắn kết yếu, thành phần xi măng là sét, sạn, sỏi, thạch anh.
50. Sét kết màu xám xanh, gắn kết chặt, xen kẹp một ít cát kết.
51. Bột kết màu xám xanh, gắn kết chặt.
52. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.
53. Sét kết màu xám xanh, gắn kết chặt, ngậm nước dẻo mịn.
54. Cát kết thạch anh màu xám trắng, gắn kết yếu bở rời.
55. Sét kết màu xám xanh, gắn kết chặt, phân lớp dày.
56. Cát kết thạch anh đa khoáng hạt thô, gắn kết yếu, mềm bở.
57. Bột kết màu xám xanh, gắn kết chặt, góc nghiêng của lớp 10°.
58. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.
59. Bột kết màu xám trắng, xám nâu, gắn kết chặt, góc nghiêng mặt lớp 10-14°, phân lớp mỏng.
60. Cát kết thạch anh đa khoáng hạt thô màu xám trắng.
61. Bột kết màu xám trắng, gắn kết yếu, mềm bở.
62. Cát kết thạch anh hạt nhỏ, xen kẹp cát kết thạch anh đa khoáng, gắn kết yếu mềm bở.
63. Bột kết màu xám nâu, gắn kết chặt, phân lớp dày.
64. Sét kết màu xám xanh, ngậm nước dẻo mịn.
65. Bột kết màu xám xanh, xám trắng, gắn kết yếu mềm bở.
66. Sét kết màu xám trắng vàng nâu, gắn kết chặt.
67. Cát kết thạch anh hạt thô màu xám trắng, gắn kết yếu bở rời.
68. Bột kết màu xám trắng gắn kết chặt.
69. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.
70. Bột kết xen lẫn ít cát kết hạt nhỏ, gắn kết yếu mềm bở.
71. Sét kết màu xám trắng gắn kết chặt, phân lớp không rõ.
72. Cát kết thạch anh màu xám trắng, gắn kết yếu bở rời.
73. Bột kết màu nâu xám, xen kẹp một ít sét kết màu xám trắng, đá phân lớp mỏng, ở đây còn chứa 5-10% vật chất hữu cơ hoá than, có góc nghiêng 3-5°, đá khi khô dễ tách theo mặt lớp.
74. Sét kết chứa 3-5% vật chất hữu cơ hoá than màu xám đen.
75. Bột kết màu xám nâu gắn kết chặt phân lớp mỏng.
76. Bột kết chứa 5-10% than nâu, có màu đen nâu, nhẹ, xốp, dòn, góc nghiêng của lớp 18°.
77. Bột kết màu xám nâu, xám đen, có xâm nhiễm từ 1-3% vật chất hữu cơ hoá than. Tại 310.5-310.6m có một lớp than mỏng, nhẹ, xốp, có màu đen nâu, ánh mờ, có góc nghiêng của lớp 20°.
78. Bột kết màu xám nâu, xen kẹp lớp mỏng cát kết, góc nghiêng của lớp thoải 10°. Tại 316.3-316.6m lớp than nâu, xốp, nhẹ, ánh mờ, vết vạch màu nâu, góc nghiêng lớp 14°.
79. Cát kết hạt nhỏ màu xám trắng, xen kẹp những lớp than mỏng có màu nâu đen.
80. Bột kết màu xám nâu, gắn kết chặt. Tại (320.8-320.9), (323-324.8m) là lớp than nâu màu đen nâu, ánh mờ, nhẹ, xốp, dòn, dễ tách thành tấm mỏng, có góc nghiêng 15-16°.
81. Sét kết màu xám trắng, gắn kết yếu, phân lớp không rõ ràng.
82. Bột kết màu xám nâu xám trắng, gắn kết chặt. Tại 328.6-330.6m than màu nâu ánh nhựa, vết vạch màu nâu mờ, trong than có xen kẹp lớp mỏng bột sét kết, than có góc nghiêng 15-16°.
83. Cát kết thạch anh đa khoáng, màu xám trắng gắn kết chặt.
84. Sét kết màu xám trắng, phân lớp dày.
85. Cát kết hạt thô màu xám trắng gắn kết yếu bở rời.
86. Bột kết màu xám trắng, gắn kết chặt.
87. Sét kết màu xám trắng, xám xanh. Tại 340-340.8m chứa 5-10% vật chất hữu cơ hoá than có góc nghiêng 16°.
88. Cát kết thạch anh hạt nhỏ màu xám xanh xen lẫn ít sạn hạt thô.
89. Sét kết màu xám xanh, gắn kết chặt, phân lớp không rõ.
90. Bột kết màu xám xanh, gắn kết yếu dạng khối.
91. Sét kết màu xám xanh, gắn kết chặt, phân lớp không rõ ràng.
92. Cát kết thạch anh đa khoáng màu xám trắng, gắn kết chặt có xen kẹp một lớp than nâu dày 0.1m.
93. Sét kết màu xám xanh, gắn kết yếu, phân lớp mỏng.
94. Bột kết màu xám đen nâu, gắn kết chặt phân lớp mỏng.
95. Sét sạn, dăm kết bở rời, màu xám xanh, xám đen, ngậm nước dẻo mịn, khi khô cứng chắc, có chứa 1-3% vật chất hữu cơ hoá than.
96. Bột kết màu xám nâu, xám đen, gắn kết chặt, phân lớp mỏng.
97. Sét sạn, dăm mảnh, gắn kết yếu bở rời, màu xám xanh.
98. Sét kết màu xám nâu đen.
99. Bột kết màu xám nâu xám trắng xen kẹp cát kết hạt nhỏ chứa từ 3-5% vật chất hữu cơ hoá than.
100. Bột kết màu xám nâu, xám đen, gắn kết yếu mềm bở, chứa 10-15% vật chất hữu cơ hoá than, than có màu đen nâu nhẹ xốp dòn.
101. Than nâu có màu đen nâu, ánh mờ, nhẹ, dòn, có độ tro cao, góc nghiêng 15°, trong than có xen kẹp lớp mỏng sét kết.
102. Bột kết xen kẹp cát kết hạt nhỏ chứa 5-10% vật chất hữu cơ hoá than, tại 394-394.3m có một lớp mỏng than nâu màu đen nằm dọc theo mặt lớp của đá.
103. Than nâu màu đen nâu, xốp, nhẹ, có độ tro cao, vết vạch màu nâu.
104. Bột kết xen kẹp cát kết hạt nhỏ chứa 3-5% vật chất hữu cơ hoá than, phần cuối là sét kết màu xám nâu, xám xanh.
105. Bột kết màu xám xanh, xen lẫn ít cát kết màu xám trắng.
106. Sét kết màu xám xanh, xám nâu, phần cuối lớp chứa 10-20% vật chất hữu cơ hoá than.
107. Bột kết màu xám xanh, xen kẹp lớp mỏng cát kết hạt nhỏ, ở giữa có một lớp sét kết chứa 20-30% vật chất hữu cơ hoá than.
108. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết chặt.
109. Sét kết, bột kết màu xám xanh, gắn kết yếu mềm bở. Tại 444.1-444.7m có chứa 1-3% vật chất hữu cơ hoá than.
110. Cát kết hạt nhỏ màu xám trắng, xám xanh, chứa 3-5% vật chất hữu cơ hoá than dạng lớp mỏng, kiểu lượn sóng yếu.
111. Sét kết màu xám nâu, xám xanh, phần cuối bột kết màu xám xanh, gắn kết chặt.
112. Cát kết thạch anh đa khoáng hạt thô, màu trắng xám vàng, gắn kết yếu mềm bở, phân lớp mỏng, có chứa 5-10% vật chất hữu cơ hoá than dày 3cm (458.5m) dạng lá, dễ tách thành tấm mỏng.
113. Bột kết màu xám xanh lục gắn kết chặt, xen kẹp một ít cát kết thạch anh hạt nhỏ và sét kết, ở đây có chứa một ít vật chất hữu cơ hoá than (460.5m) dày 2cm, than có màu đen nâu, nhẹ, xốp, dòn, có độ tro cao, ánh mờ, vết vạch màu nâu, góc nghiêng 7°, phân lớp mỏng.
114. Cuội kết đa khoáng, gắn kết yếu bở rời. Thành phần cuội: Granit, thạch anh, riolit, xi măng là sét cát hạt nhỏ màu xám xanh.
115. Đá granit biotit-horblen hạt trung màu trắng xám đen, đá bị cà ép mạnh phong hoá dở dang mềm bở. Quan sát ở lõi khoan thấy chứa khoáng vật màu biotit tập trung dạng ổ nhỏ. Tại 493-495.2m đá mạch diorit xuyên cắt granit, đá có màu xám đen, tươi rắn chắc.

Người thành lập: Châu Văn Tuấn
Người Kiểm tra: Trần Văn Thịnh

Bản vẽ số 01
Mô tả lỗ khoan số 01 nghiên cứu địa tầng trầm tích Neogen Sông Ba.
Khu vực Phú Cần, Krông Pa, Gia Lai.
Đoàn trưởng: [stamp] Trần Văn Thịnh

Appendix of Petrographic Description

Depth 94.25m, No 18, core sample from the Enreca-1 well

Hand specimen description

Fine-grained sandstone, greenish grey, massive structure, weakly consolidated, good visible porosity.

Microscope description

- Lithology: Fine-grained sandstone

- Classification: Feldspathic graywacke

Total rock composition (300 point counts)

Framework grains	%	***Cement and Auth. minerals***	%
Quartz	34.7	Quartz	0.3
K-feldspar	12.7	Clay minerals	2.0
Plagioclase	2.7	Opaque minerals	0.7
Mica	1.0		
Rock fragment:			
Granitic	1.7		
Quartzite/Microquartzite	1.3		
Schist	3.0		
Chert	1.0		
Volcanic	6.3		
Sediment	5.3		
Accessory minerals:			
Zircon	Tr.		
Epidote	0.3		
Tourmaline	Tr.		
Sphene	Tr.		
Detrital matrix		***Visible porosity***	***%***
Clay matrix	21.3	Intergranular pores	5.7
Organic matter	Tr.	Intragranular pores	Tr.
Grain size	Sorting: Moderate good		
Max: 0.3mm	Grain shape: Subangular to subrounded		
Min: 0.03mm	Grain contact: Point, straight		
Average: 0.1-0.2mm			

The rock is classified as a Feldspathic Graywacke according to classification (Folk 1974)

Mineralogy description

Detrital quartz grains are dominated by monocrystal, accompanied with subordinate polycrystal grains. Most of them are moderately sorted. The grain shapes are subangular to subrounded. Their undulose extinction could be observed clearly.

Feldspar consists of mainly orthoclase, rare microcline and minor proportion of plagioclase. Plagioclase has prismatic shapes and flakes and was strongly sericitized. Some microclines are still fresh.

Mica contains a minor amount of bent muscovite flakes.

The lithic grains occupy high proportions. They are metamorphic, altered volcanic, and sedimentary fragments. Volcanic fragments are strongly chloritised. Metamorphic fragments consist of microquarzite, quartz schist, quartz-mica schist and sericite schist. Sedimentary fragments consist of mud clasts and chert.

Accessory minerals include epidote, sphene, zircon and tourmaline.

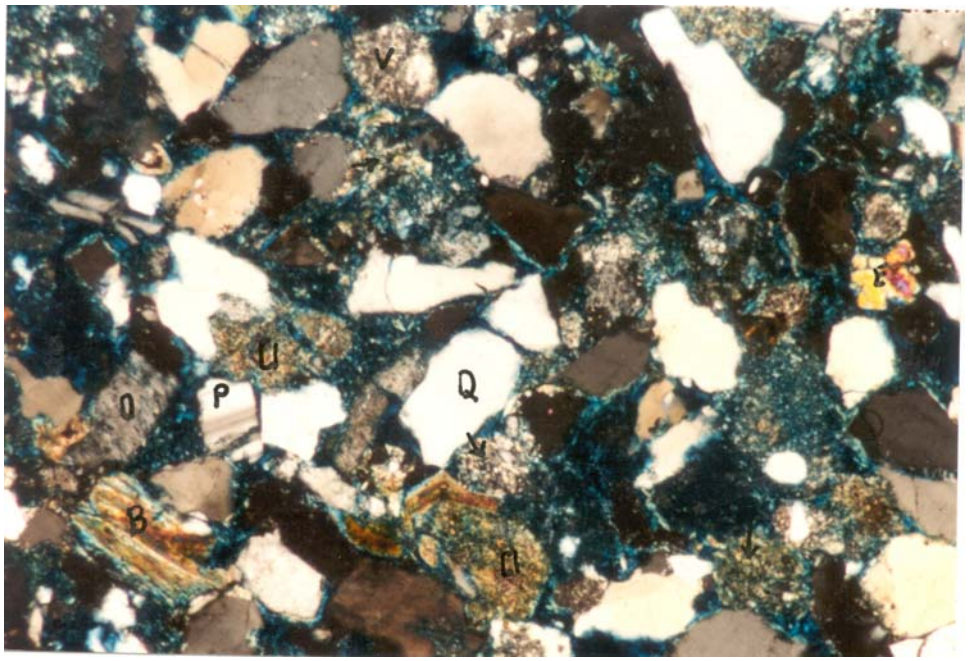
The clay matrix is composed of clay minerals and traces of organic matter. It consists mainly of kaolinite and illite, fill mostly the intergranular pores and is heterogeneously distributed in the sample. The organic matter is brownish black and occurs on the grains.

Cement and authigenic minerals

Authigenic minerals consist of mainly clay minerals, minor amounts of authigenic quartz and opaque minerals. Clay minerals consist mostly of kaolinite, smaller amount of illite and other clays that fill the intergranular pores of the sample.

Visual porosity

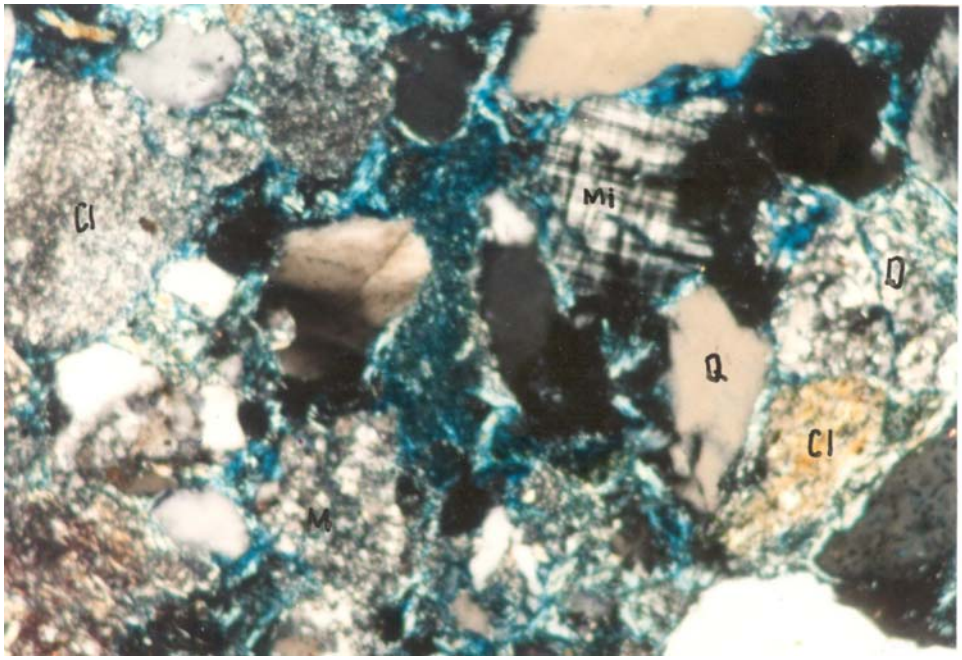
The intergranular pores are minor due to the high content of clay matrix. They are heterogeneously distributed in the sample and only observed in the places where proportion of clay matrix is low.



250µm Crossed Nicols

Plate 1: ***Core sample from the Enreca-1 well, No 18, depth 94.25m***

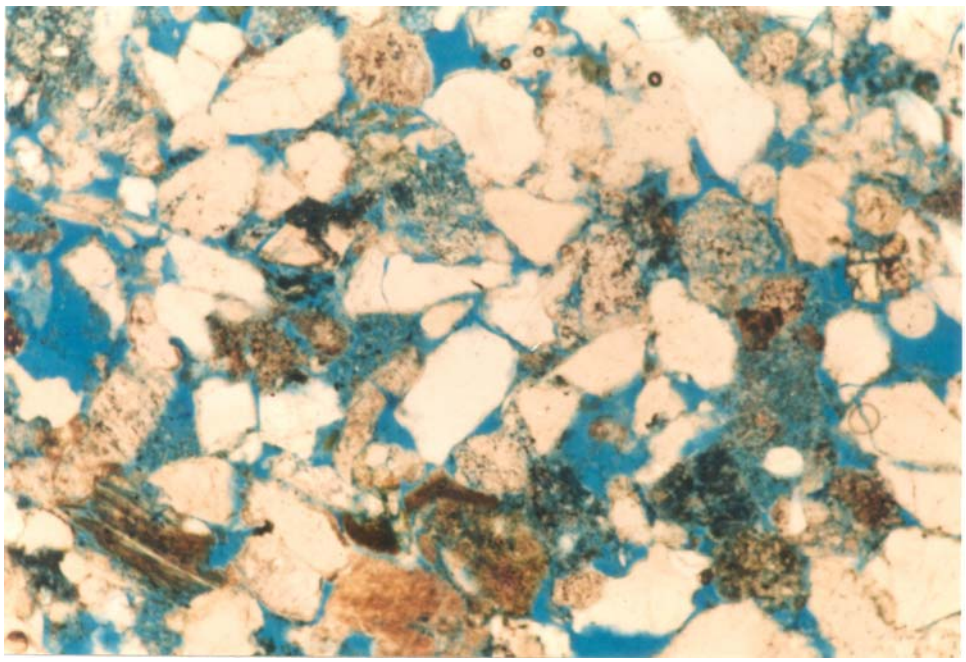
Moderately sorted, subangular-subrounded grains, fine-grained feldspathic graywacke. Detrital grains are composed of quartz (Q), orthoclase (O), chloritised biotite (B), and rock fragments, such as claystones (Cl), volcanics (V) and rare epidotes (E). The detrital clay matrix (arrow) is abundant and filling pore space.



125µm Crossed Nicols

Plate 2: ***Core sample from the Enreca-1 well, No 18, depth 94.25m***

Fine-grained sandstone similar to plate 1, but with higher magnification to show clearly the presence of microcline (Mi), claystone fragment (Cl) and detrital matrix (M). Other components like those in plate 1.



250µm Plane Nicols

<u>Plate 3:</u> Core sample from the Enreca-1 well, No 18, depth 94.25m
The visual porosity (blue) is composed mostly of intergranular pores of 0.05–0.1mm in size with moderate connectivity.

Depth 117.75m, No 22, core sample from the Enreca-1 well

Hand specimen description

Fine-grained sandstone, whitish to greenish grey, massive structure, weakly consolidated, rather soft and friable.

Microscope description

- Lithology: Fine-grained sandstone

- Classification: Feldspathic graywacke

Total rock composition (300 point counts)

Framework grains	%	***Cement and Auth. minerals***	%
Quartz	29.7	Quartz	0.7
K-feldspar	14.7	Clay minerals	2.7
Plagioclase	2.7	Opaque minerals	1.0
Mica	3.7		
Rock fragment:			
Granitic	1.7		
Quartzite/Microquartzite	3.0		
Schist	3.3		
Chert	1.0		
Volcanic	6.0		
Sediment	4.7		
Accessory minerals:			
Zircon	0.2		
Epidote	0.5		
Tourmaline	0.3		
Sphene	Tr.		
Rutile	Tr.		
Detrital matrix		***Visible porosity***	***%***
Clay matrix	17	Intergranular pores	6.7
Organic matter	0.3	Intragranular pores	Tr.
Grain size	Sorting: Moderate to poor		
Max: 0.3mm	Grain shape: Subangular to subrounded		
Min: 0.03mm	Grain contact: Point		
Average: 0.1-0.2mm			

The rock is classified as a Feldspathic Graywacke according to classification (Folk 1974)

Mineralogy description

Detrital quartz grains are dominated by monocrystal, accompanied with subordinate polycrystal grains. Most of them are moderately sorted. The grain shapes are subangular to subrounded. Their undulose extinction could be observed clearly. Some quartz grains contain inclusion of zircon and rutile.

Feldspar consists of mainly orthoclase, rare microcline and minor proportion of plagioclase. Plagioclase has prismatic shapes and flakes and is strongly sericitized.

Mica consists of mainly biotite and minor of bent muscovite flakes. Biotite grains have been strongly chloritised.

The lithic grains consist of metamorphic, altered volcanic, and sedimentary fragments. Metamorphic fragments consist of microquarzite, quartz-feldspar schist, quartz-chlorite schist and quartz-sericite schist. Sedimentary fragments consist of mud clasts, minor amount of silt and chert.

The clay matrix is composed of clay minerals and traces of organic matter. It consists mainly of kaolinite and illite, fill mostly the intergranular pores and is heterogeneously distributed in the sample. The organic matter is brownish black and occurs on the grains.

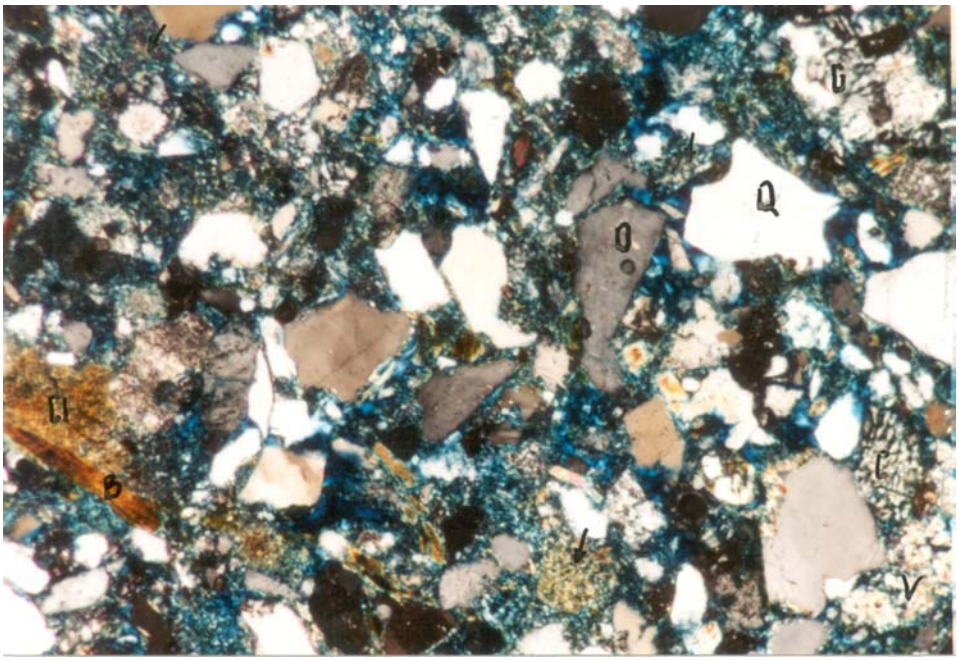
Accessory minerals include epidote, sphene, and tourmaline.

Cement and authigenic minerals

Authigenic minerals consist of mainly clay minerals, minor authigenic quartz and opaque minerals. Clays minerals compose of kaolinite, less amount of illite, sericite scab and other clays that fills pores of the sample. The pores are mainly intergranular pores and minor pores formed by dissolution of feldspar grains.

Visual porosity

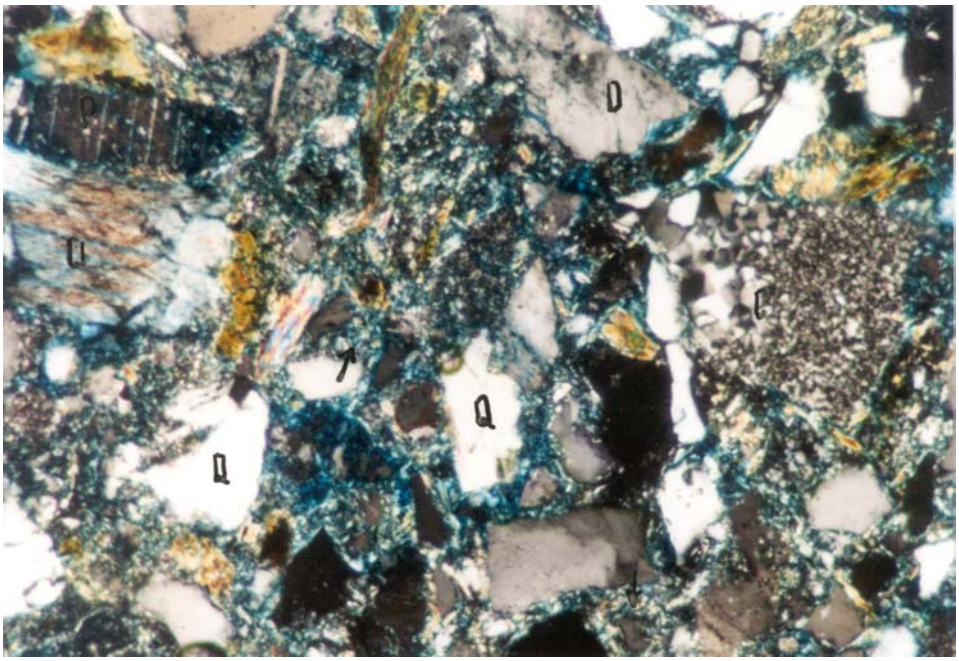
The pores are mainly intergranular pores and minor pores formed due to the dissolutions of feldspar grains.



250µm Crossed Nicols

Plate 1: ***Core sample from the Enreca-1 well, No 22, depth 117.75m***

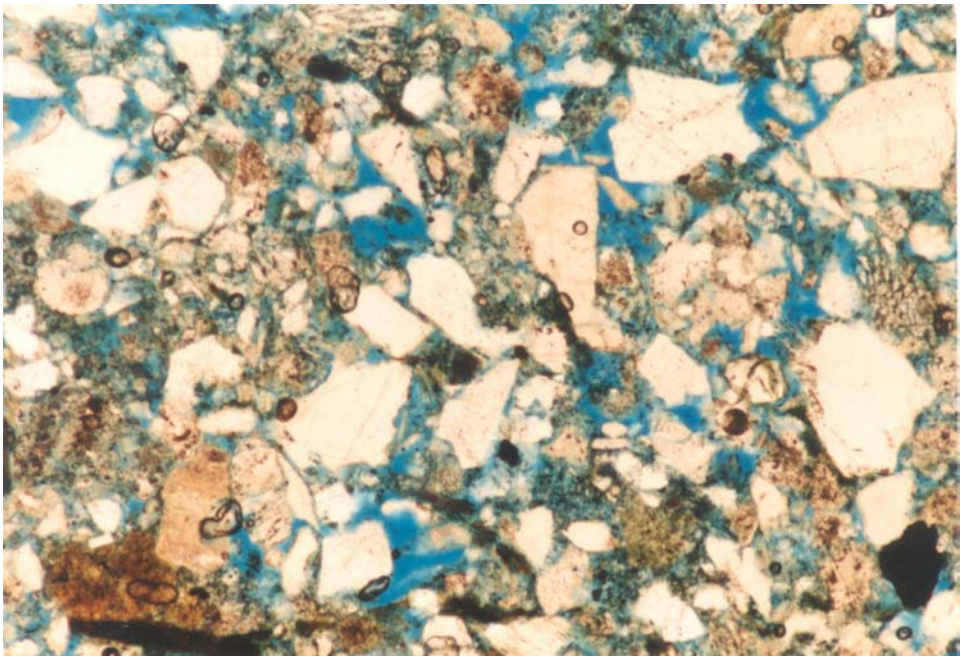
Moderately to poorly sorted, subangular-subrounded grains, fine-grained feldspathic graywacke. Detrital grains are composed of quartz (Q), orthoclase (O), chloritised biotite (B), and rock fragments, such as claystone (Cl), volcanic (V), granitic (G), chert (C). The clay matrix (arrow) is abundant and filling pore space.



125µm Crossed Nicols

Plate 2: ***Core sample from the Enreca-1 well, No 22, depth 117.75m***

Fine-grained sandstone similar to plate 1, but with higher magnification to show clearly the presence of plagioclase (P), and rock fragments such as chert (C) and claystone (Cl). The detrital matrix (arrow) and other components are similar to those in plate 1.



250µm Plane Nicols

Plate 3: ***Core sample from the Enreca-1 well, No 22, depth 117.75m***

Field of view in this plate is the same of plate 1, but with Plane Nicols to show that the visual porosity (blue) is fair to poor and composed mostly of intergranular pores of 0.05–0.1mm in size with poor connectivity.

Depth 139.80m, No 25, core sample from the Enreca-1 well

Hand specimen description

Very fine-grained sandstone, greenish grey, fair consolidated and well sorted.

Microscope description

- Lithology: Fine-grained sandstone

- Classification: Feldspathic graywacke

Total rock composition (300 point counts)

Framework grains	%	***Cement and Auth. minerals***	%
Quartz	28.7	Quartz	Tr.
K-feldspar	12.3	Clay minerals	2.7
Plagioclase	3.7	Opaque minerals	1.7
Mica	2.7		
Rock fragment:			
Quartzite/Microquartzite	2.0		
Schist	1.0		
Chert	1.3		
Volcanic	3.3		
Sediment	2.0		
Accessory minerals:			
Zircon	Tr.		
Epidote	0.7		
Apatite	Tr.		
Detrital matrix		***Visible porosity***	***%***
Clay matrix	36.5	Intergranular pores	0.7
Organic matter	0.7	Intragranular pores	Tr.
Grain size	Sorting: Moderate		
Max: 0.1mm	Grain shape: Subangular to subrounded		
Min: 0.025mm	Grain contact: Floating, point		
Average: 0.04-0.1mm			

The rock is classified as a Feldspathic Graywacke according to classification (Folk 1974)

Mineralogy description

Detrital quartz grains are mainly monocrystal, and rare polycrystal grains. Most of them are moderately sorted. The grain shapes are subangular to subrounded.

Feldspar consists of mainly orthoclase, rare microcline and minor proportion of plagioclase. Most of feldspar grains have been kaolinitized, sericitized at various degrees.

Mica consists of mainly biotite that has been strongly chloritised and minor of muscovite flakes.

The lithic grains consist of acidic volcanic, quartzite/microquartzite, mica-quartz schist and sedimentary fragments. Sedimentary fragments contain a lot of brownish black clays.

The clay matrix occupies a very high proportion, composes of clay minerals and traces of organic matter. The clay matrix consists mainly of kaolinite and illite, that fill mostly the intergranular pores. The organic matter is brownish black and occurs on the grains.

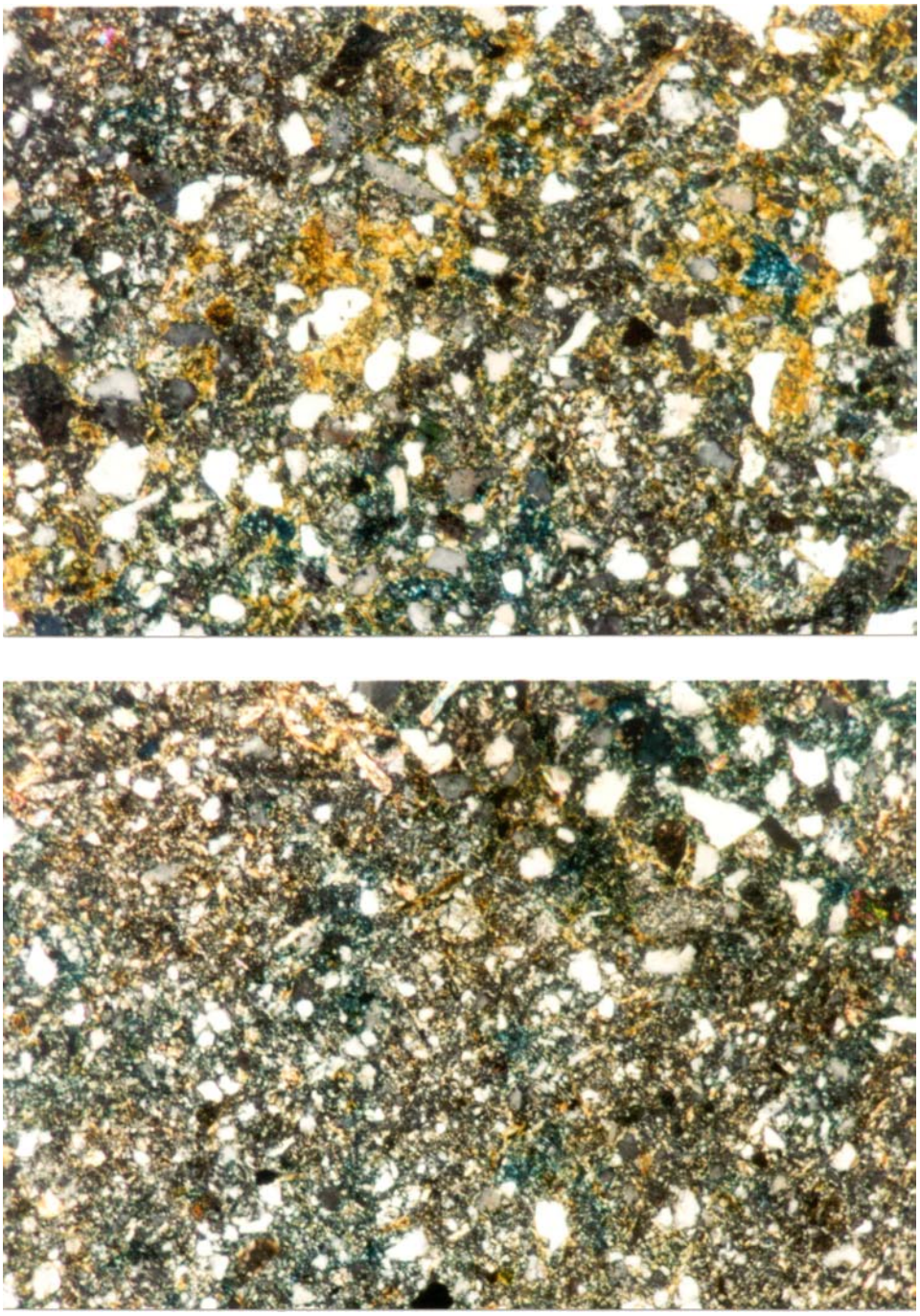
Accessory minerals include epidote and zircon.

Cement and authigenic minerals

Authigenic minerals consist of mainly clay minerals, minor authigenic quartz and opaque minerals. Clay minerals compose of mainly kaolinite, and smaller amount of illite and others that fill pores of the sample.

Visual porosity

It is difficult to see the visible porosity because the clay matrix occupy high proportions and they are nearly filled whole the intergranular pores.



250µm Crossed Nicols

***Plate 1 and Plate 2*: Core sample from the Enreca-1 well, No 25, depth 139.80m**

Moderately sorted, subangular-subrounded grains, medium-grained siltstone to very fine-grained feldspathic graywacke. The clay matrix is very abundant and its components composed mainly of kaolinite and illite (grey), with minor amount of smectite (yellow).

Depth 164.75m, No 29, core sample from the Enreca-1 well

Hand specimen description

Fine-grained sandstone, light to whitish grey, massive structure, moderate consolidated and fair visual porosity.

Microscope description

- Lithology: Fine-grained sandstone

- Classification: Feldspathic Litharenite

Total rock composition (300 point counts)

Framework grains	%	***Cement and Auth. minerals***	%
Quartz	32.0	Quartz	0.7
K-feldspar	12.7	Clay minerals	3.0
Plagioclase	0.7	Opaque minerals	0.3
Mica	0.3		
Rock fragment:			
Quartzite/Microquartzite	3.0		
Schist	3.7		
Chert	2.0		
Volcanic	7.7		
Sediment	5.7		
Others	1.0		
Accessory minerals:			
Zircon	Tr.		
Epidote	0.3		
Detrital matrix		***Visible porosity***	***%***
Clay matrix	2.5	Intergranular pores	22
Organic matter	0.7	Intragranular pores	1.7
Grain size	Sorting: Moderate to poor		
Max: 0.3mm	Grain shape: Subangular to subrounded		
Min: 0.03mm	Grain contact: Point		
Average: 0.1-0.2mm			

The rock is classified as a Feldspathic Litharenite according to classification (Folk 1974)

Mineralogy description

Detrital quartz grains are mainly monocrystal with weak undulose extinction and minor polycrystal with strong undulose extinction. Some quartz grains contain inclusion of mica and tourmalin.

Feldspar consists of mainly orthoclase, rare microcline and minor proportion of plagioclase. Most of the feldspar grains have been kaolinitized and sericitized at various degrees, many of them have been completely solvated, consequently created the intergranular pores.

Mica consists of some muscovite flakes and minor biotite that has been strongly chloritised.

The lithic grains occupy a high proportion. They consist of acidic volcanic, quartzite/microquartzite, quartz schist, mica-quartz schist and sedimentary fragments. Sedimentary fragments include chert, silt and mud clasts.

The clay matrix consists of clay minerals and minor amounts of organic matter. The organic matters are brownish black with the size of 0.1mm wide and 1.8mm long. Clays minerals fill intergranular pores of the sample.

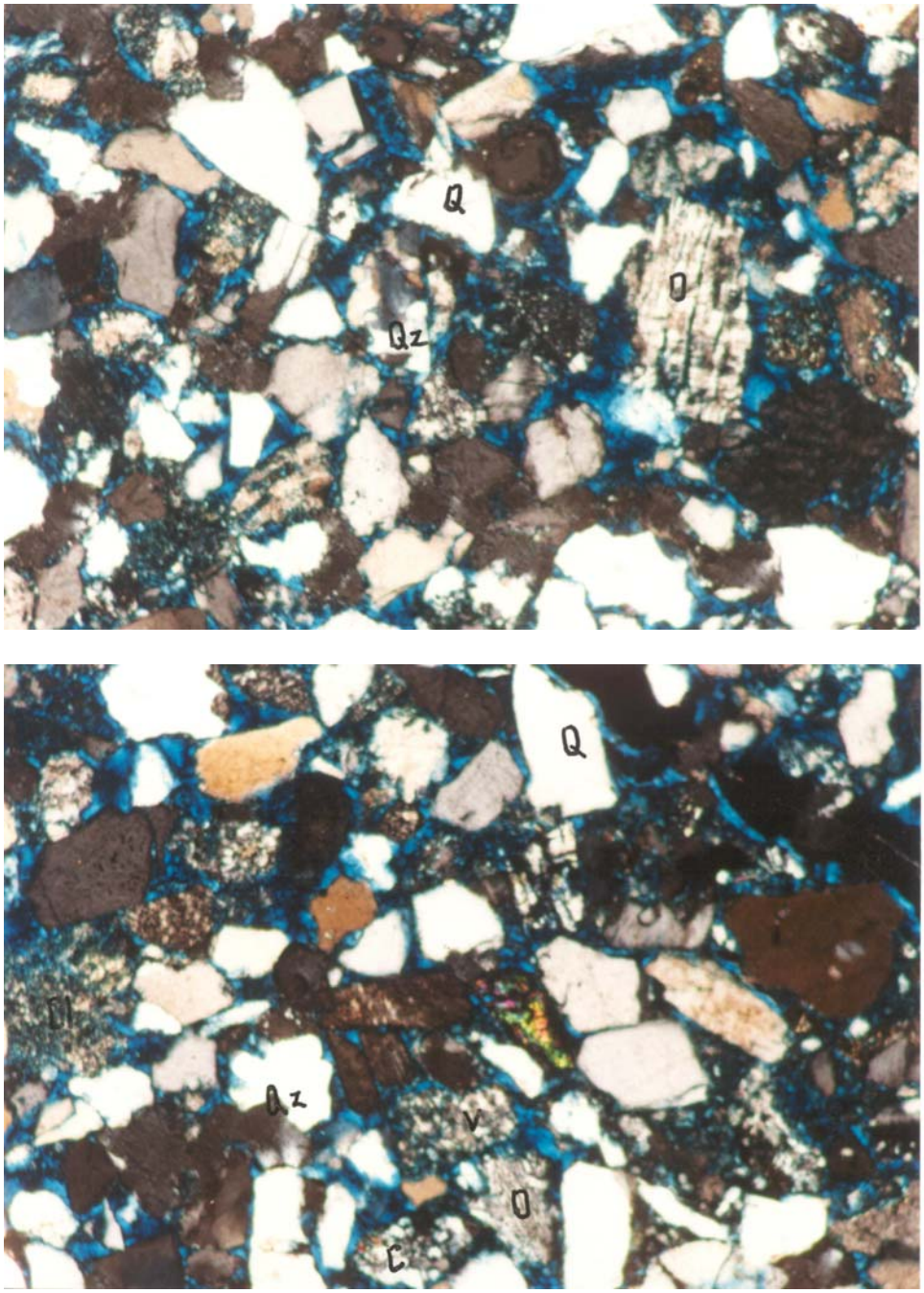
Accessory minerals include epidote and zircon.

Cement and authigenic minerals

Authigenic minerals consist of mainly clay minerals, minor authigenic quartz and opaque minerals. Clay minerals compose of mainly kaolinite, and less amount of illite and others that fills pores of the sample.

Visual porosity

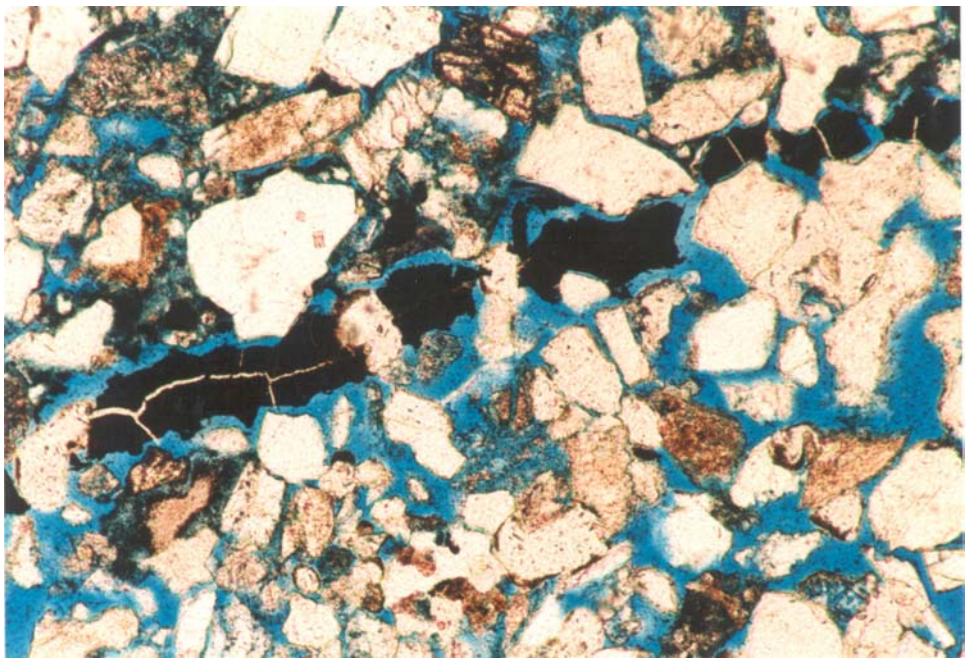
The porosity of this sample is considered good with the size of pores changes from 0.075mm to 0.15mm. The intergranular pores are good connected and homogeneously distributed in the sample.



250µm Crossed Nicols

<u>Plate 1 and Plate 2</u>: Core sample from the Enreca-1 well, No 29, depth 164.75m

Moderately to well sorted, subangular-subrounded grains, fine-grained feldspathic litharenite. The detrital grains are composed of mainly quartz (Q), orthoclase (O) and rock fragments, such as quartzite (Qz), acidicic volcanic (V) and claystone (Cl), rare zircon (gaudy in plate 2).



250µm Plane Nicols

Plate 3: ***Core sample from the Enreca-1 well, No 29, depth 164.75m***

The visual porosity (blue) is good and it composed mostly of intergranular pores of 0.075–0.15mm in size with moderate to good connectivity. Note that organic matter (black band) is also present.

Depth 175.80m, No 31, core sample from the Enreca-1 well

Hand specimen description

Fine-grained sandstone, whitish grey to grey, massive structure and relatively hard

Microscope description

- Lithology: Fine-grained sandstone

- Classification: Lithic arkose

Total rock composition (300 point counts)

Framework grains	%	***Cement and Auth. minerals***	%
Quartz	25.3	Carbonate	36
K-feldspar	16.7	Clay minerals	3.7
Plagioclase	1.0	Opaque minerals	0.3
Mica	2.7	Anhydrite	2.3
Rock fragment:			
Quartzite/Microquartzite	1.0		
Schist	1.7		
Chert	1.3		
Volcanic	5.7		
Others	2.3		
Accessory minerals:			
Zircon	Tr.		
Epidote	Tr.		
Tourmaline	Tr.		
Detrital matrix		***Visible porosity***	***%***
Clay matrix	-	Intergranular pores	-
Organic matter	-	Intragranular pores	-
Grain size	Sorting: Moderate		
Max: 0.3mm	Grain shape: Subangular - Minor angular		
Min: 0.05mm	Grain contact: Point		
Mod: 0.1-0.15mm			

The rock is classified as a Lithic Arkose according to classification (Folk 1974)

Mineralogy description

Detrital quartz grains are mainly of monocrystal grains and show weak undulose extinction.

Feldspar consists of mainly K-Feldspar, most orthoclase, rare microcline and minor proportion of plagioclase. Most of the feldspar grains have been kaolinitized at various degree, many of them have been completely replaced by calcite minerals.

Mica consists of some bent muscovite flakes that were strongly influenced by compactions and minor biotite that have been strongly chloritised.

The lithic grains consist of metamorphic, acidic volcanic, and sedimentary fragments. Metamorphic fragments consist of microquarzite, quartz-sericite schist, and sericite schist. Acidic volcanic fragments occupy high proportions. They were strongly kaolinitized, chloritized and calcitized. Sedimentary fragments consist of siltstones, claystones, and minor amounts of silt, clay and chert.

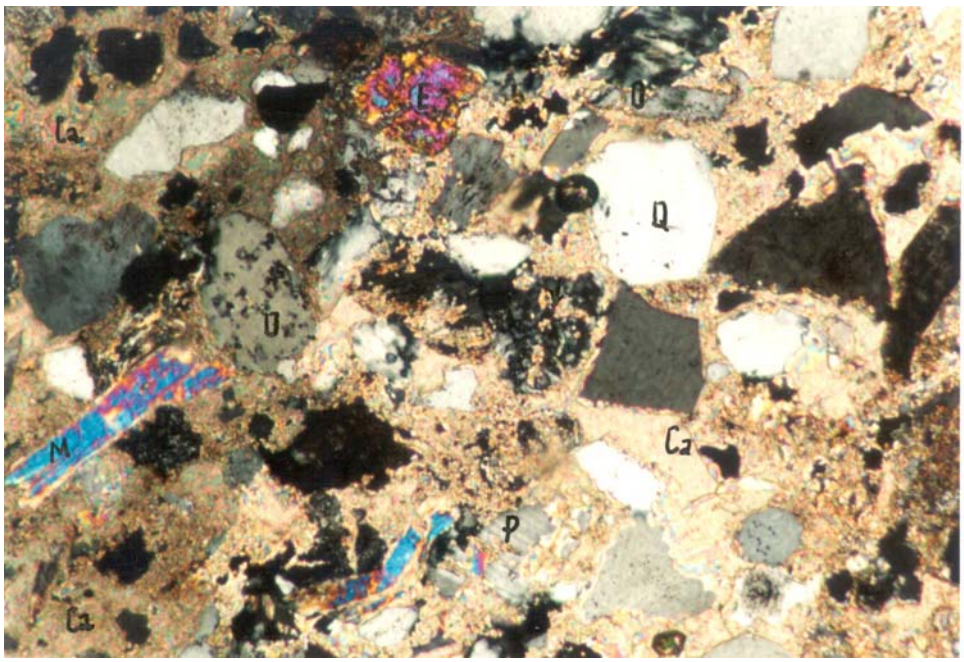
Some traces of accessory minerals such as epidote, tourmalin and zircone can be recognized.

Cement and authigenic minerals

Authigenic minerals consist mainly of clay and carbonate minerals, with minor amount of anhydrite and opaque minerals. Carbonate is mainly calcite that nearly fills the pores of the sample.

Visual porosity

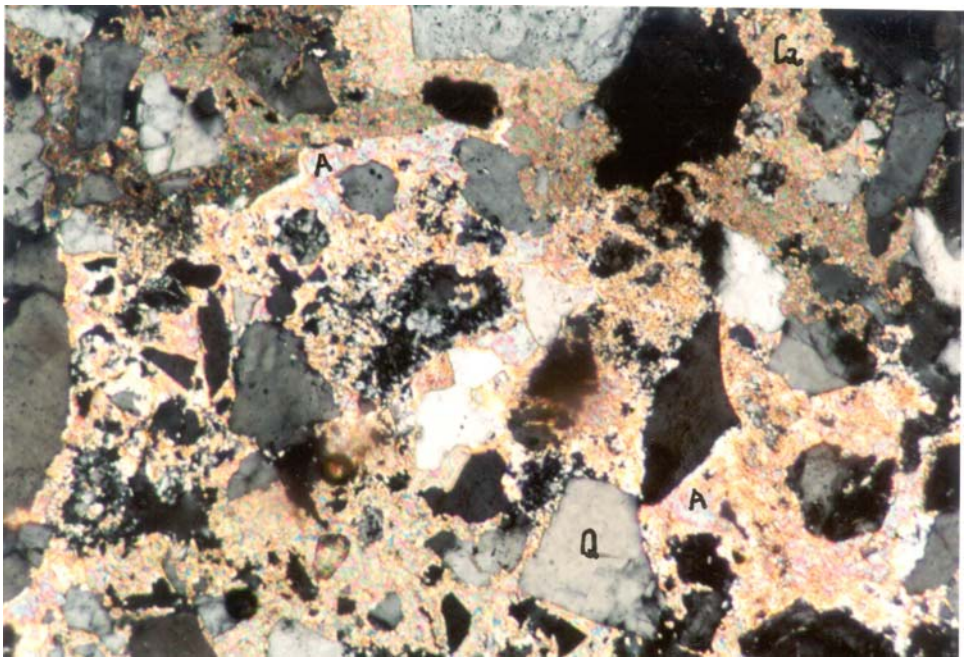
In general, pores of the sample are mostly filled by calcite and smaller amount of clay minerals.



125µm Crossed Nicols

Plate 1: ***Core sample from the Enreca-1 well, No 31, depth 175.80m***

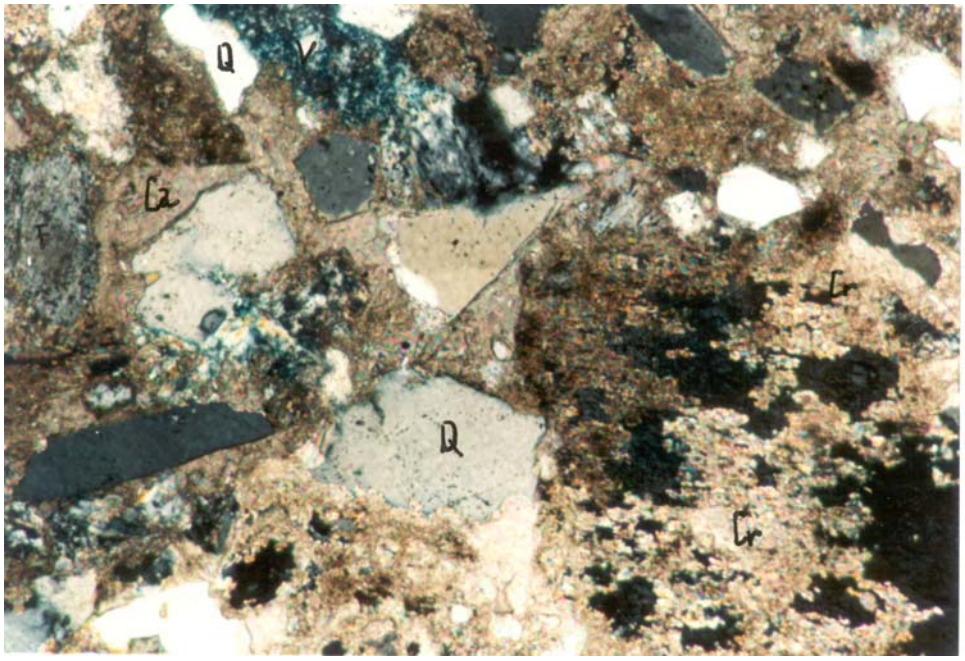
Moderately sorted, subangular-subrounded grains, fine-grained lithic arkose. Detrital grains are composed of quartz (Q), orthoclase (O), muscovite (M), and epidote (E) floating on the poikilotopic calcite cement (Ca).



125µm Crossed Nicols

Plate 2: ***Core sample from the Enreca-1 well, No 31, depth 175.80m***

Fine-grained sandstone that is similar to plate 1. The presence of anhydrite cement (A) mixed together with calcite cement (Ca).



125µm Crossed Nicols

Plate 3: ***Core sample from the Enreca-1 well, No 31, depth 175.80m***

This plate shows the presence of volcanic rock fragment (V) and many feldspar grains that have been nearly completely replaced by calcite cement (Cr). Other components are similar to that described in plate 1 and plate 2. (Q = Quartz; Ca = Calcite).

Depth 236.25m, No 41, core sample from the Enreca-1 well

Hand specimen description

Coarse- to very coarse-grained sandstone, light to whitish grey, massive structure, weakly consolidated, rather soft and friable.

Microscope description

- Lithology: Coarse- to very coarse-grained sandstone

- Classification: Lithic arkose

Total rock composition (300 point counts)

Framework grains	%	***Cement and Auth. minerals***	%
Quartz	33.7	Quartz	0.7
K-feldspar	15.7	Clay minerals	3.7
Plagioclase	0.3	Opaque minerals	Tr.
Mica	0.3		
Rock fragment:			
Granitic	5.3		
Quartzite/Microquartzite	6.0		
Schist	2.0		
Chert	1.7		
Volcanic	5.7		
Sediment	3.7		
Others	1.7		
Accessory minerals:			
Rutile	Tr.		
Epidote	Tr.		
Tourmaline	Tr.		
Detrital matrix		***Visible porosity***	***%***
Clay matrix	6.7	Intergranular pores	12
Organic matter	Tr.	Intragranular pores	1.3
Grain size	Sorting: Very poor		
Max: 1.75mm	Grain shape: Subangular to subrounded		
Min: 0.05mm	Grain contact: Point, straight		
Average: 0.8-1.6mm			

The rock is classified as a Lithic Arkose according to classification (Folk 1974)

Mineralogy description

Detrital quartz grains are dominated by monocrystal, accompanied with subordinate polycrystal grains. Most of them are moderately sorted. The grain shapes are subangular to subrounded. Their undulose extinction could be observed weakly. Some quartz grains contain inclusion of mica and rutile.

Feldspar consists of mainly orthoclase, rare microcline and plagioclase. Most of the feldspar grains have been altered and replaced by kaolinite and sericite at various degrees.

Mica consists of some muscovite flakes.

The lithic grains consist of metamorphic, acidic volcanic, and sedimentary fragments. Metamorphic fragments consist of microquarzite, quartz-mica schist, quartz-sericite schist and sericite schist. Acidic volcanic fragments were strongly kaolinitized and chloritized. Sedimentary fragments consist of siltstones and claystones. Granitic fragments have been strongly altered.

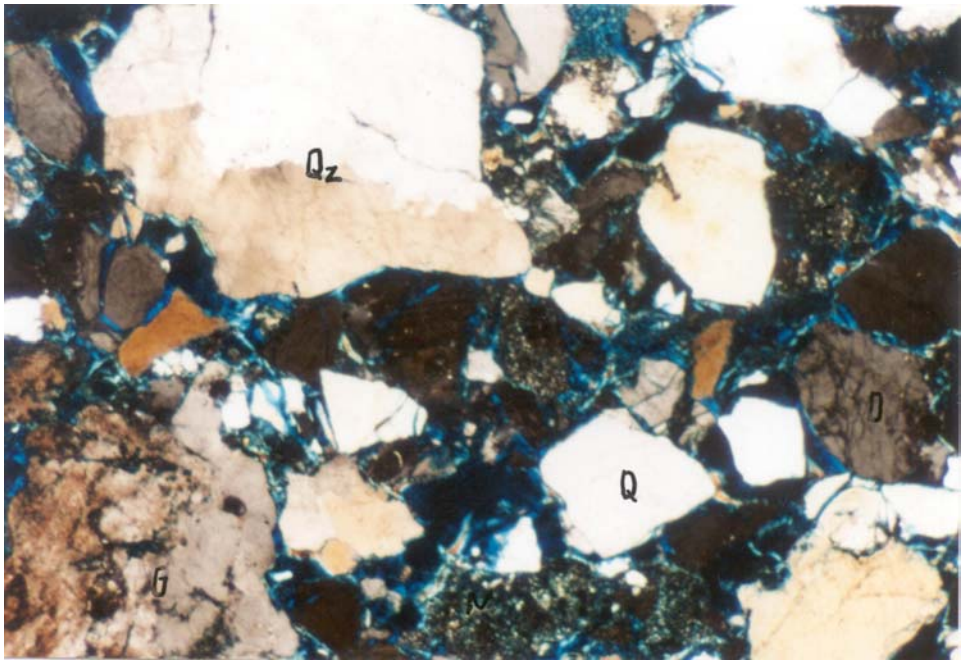
Some traces of accessory minerals such as epidote and tourmalin can be recognized.

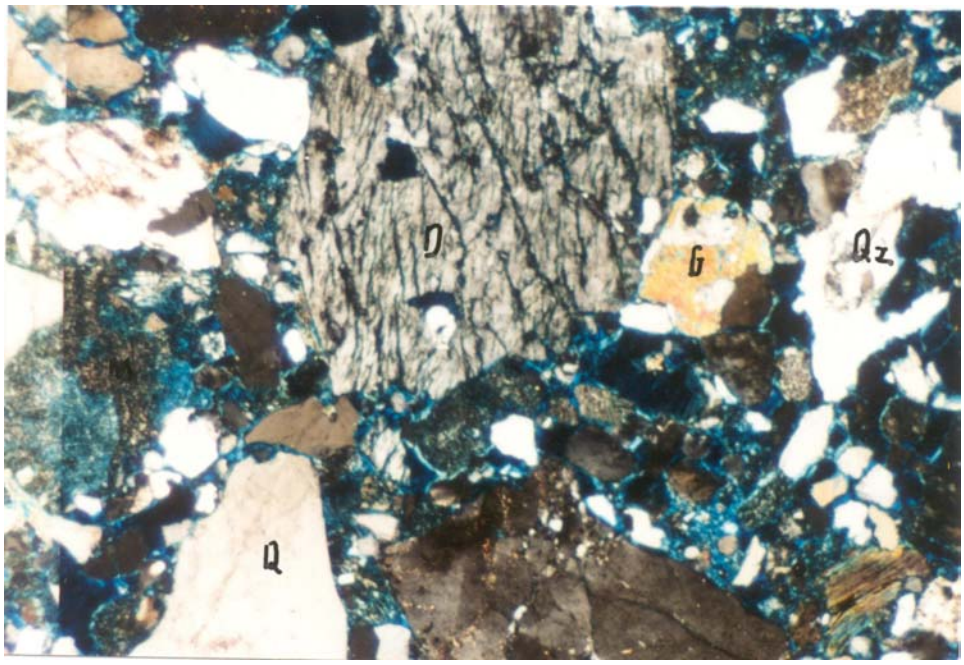
Cement and authigenic minerals

Authigenic minerals consist of mainly clay minerals, minor authigenic quartz and traces of opaque minerals. Clay minerals consist of mainly kaolinite, less amount of illite/smectite and others that fills pores of the sample.

Visual porosity

The pores are mainly intergranular pores and minor pores formed by dissolution of feldspar grains. They are heterogeneously distributed in the sample and their connections are considered fair.

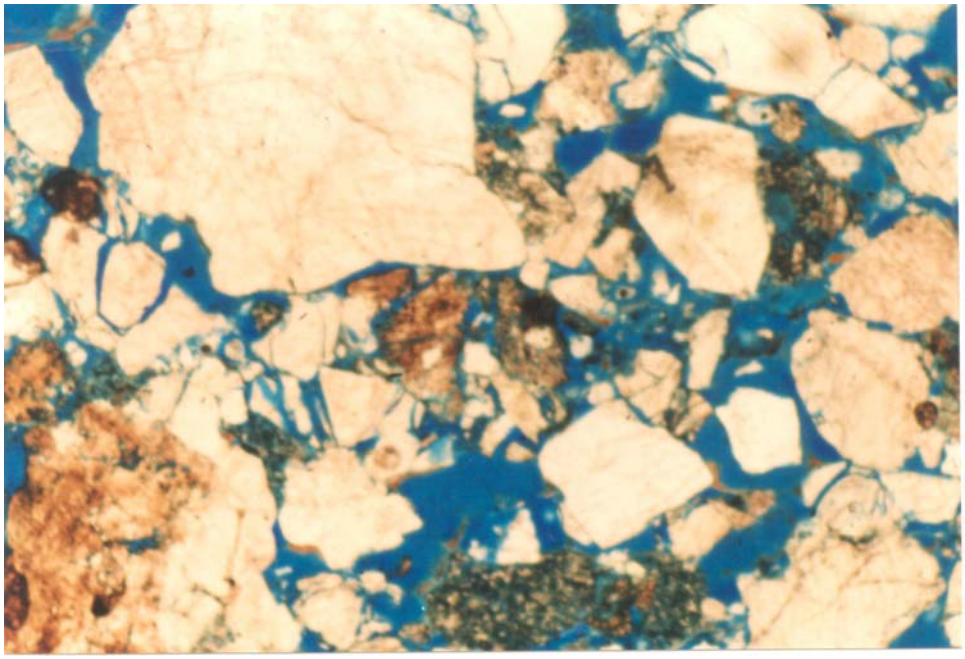




500µm Crossed Nicols

<u>Plate 1 and Plate 2:</u> Core sample from the Enreca-1 well, No 41, depth 236.25m

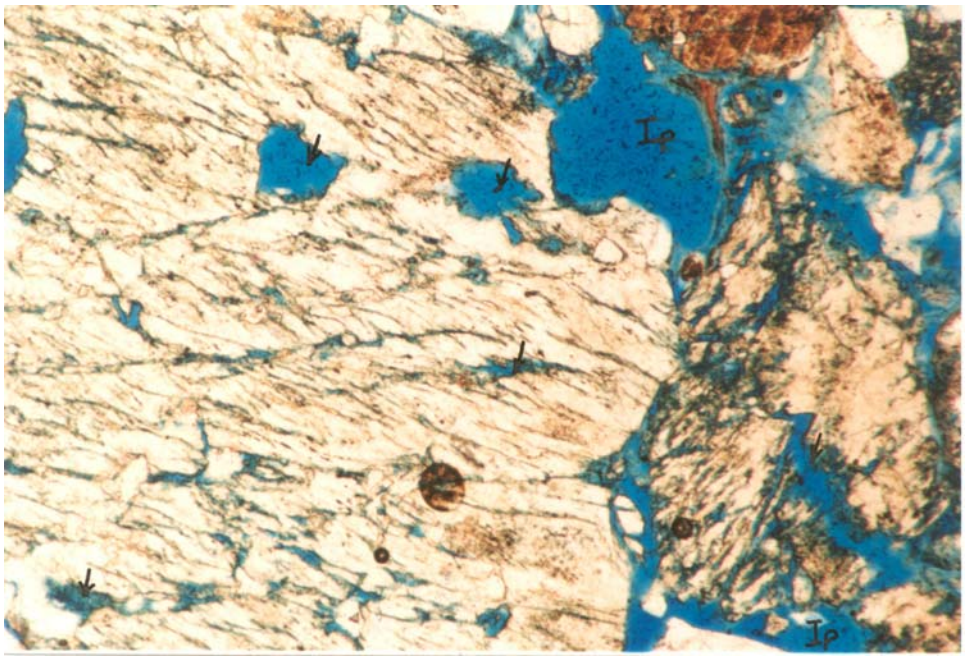
Very poorly sorted, subangular-subrounded grains, coarse- to very coarse-grained sandstone. The sandstone is composed of quartz (Q), orthoclase (O), and rock fragments such as granitic (G), quartzite (Qz); detrital clay matrix (M) is filling pore space.



500µm Plane Nicols

Plate 3: ***Core sample from the Enreca-1 well, No 41, depth 236.25m***

The visual porosity (blue) is composed mostly of intergranular pores of 0.075–0.15mm in size with moderate to poor connectivity.



250µm Plane Nicols

Plate 4: ***Core sample from the Enreca-1 well, No 41, depth 236.25m***

The visual porosity (blue) is composed mostly of intergranular pores of 0.075–0.15mm in size (Ip) and minor intragranular pores (arrow) due to dissolution of detrital feldspar grains.

Depth 342.90m, No 59, core sample from the Enreca-1 well

Hand specimen description

Medium- to coarse-grained sandstone, light to whitish grey, massive structure, weakly consolidated, friable.

Microscope description

- Lithology: Medium-grained sandstone

- Classification: Feldspathic litharenite

Total rock composition (300 point counts)

Framework grains	%	***Cement and Auth. minerals***	%
Quartz	30.7	Quartz	1.3
K-feldspar	17.0	Kaolinite	3.0
Plagioclase	0.3	Opaque minerals	Tr.
Mica	1.0		
Rock fragment:			
Granitic	2.0		
Quartzite/Microquartzite	3.3		
Schist	1.7		
Chert	1.7		
Volcanic	9.0		
Sediment	6.3		
Accessory minerals:			
Epidote	Tr.		
Zircon	Tr.		
Detrital matrix		***Visible porosity***	***%***
Clay matrix	9.7	Intergranular pores	11.7
Organic matter	Tr.	Intragranular pores	1.3
Grain size	Sorting: Poor		
Max: 0.8mm	Grain shape: Subangular to subrounded		
Min: 0.03mm	Grain contact: Point, straight		
Average: 0.25-0.5mm			

The rock is classified as a Feldspathic Litharenite according to classification (Folk 1974)

Mineralogy description

Detrital quartz grains are dominated by monocrystal that show weak undulose extinction, and subordinate polycrystal grains of clear undulose extinction. Some quartz grains contain inclusion of mica and epidote.

Feldspar consists of mainly orthoclase, less plagioclase and rare microcline. Most of the feldspar grains have been altered and replaced by kaolinite at various degrees.

Mica consists of both biotite and muscovite flakes.

The lithic grains occupy a high proportion. They are composed of metamorphic, acidic volcanic, sediment and granitic fragments. Metamorphic fragments consist of quartzite, microquarzite, minor quartz-sericite schist and sericite schist. Acidic volcanic fragments were strongly altered. Sedimentary fragments consist of siltstones, claystones and minor fine-grained sandstones.

Accessory minerals include epidote and zircon.

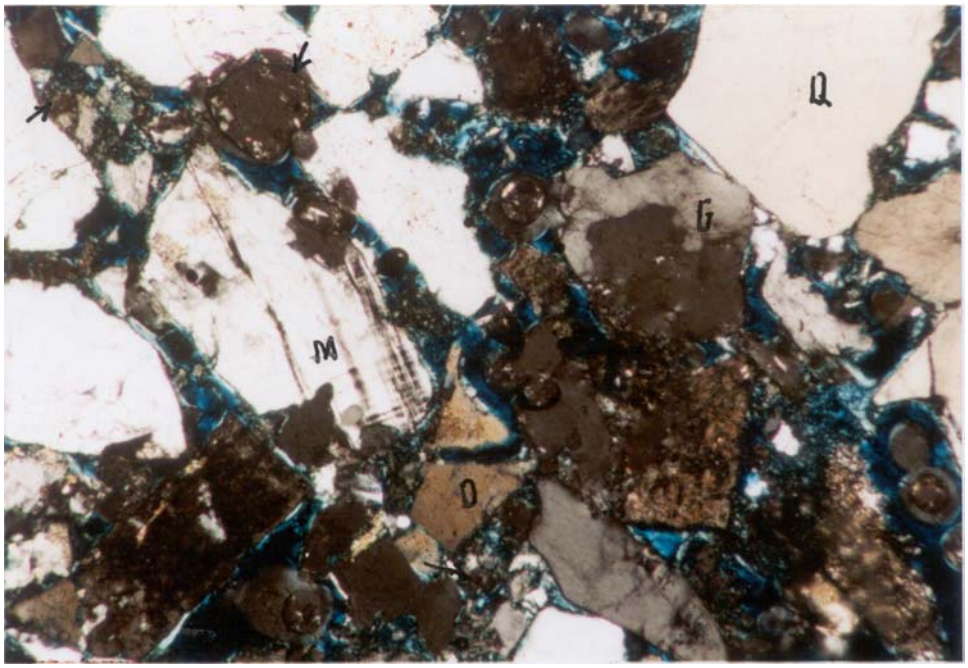
Clay matrix composes of clay minerals and traces of organic matter.

Cement and authigenic minerals

Authigenic minerals consist of mainly clay minerals, minor authigenic quartz and traces of opaque minerals. Clay minerals consist of mainly kaolinite, smaller amount of illite/smectite and others that fill pores of the sample.

Visual porosity

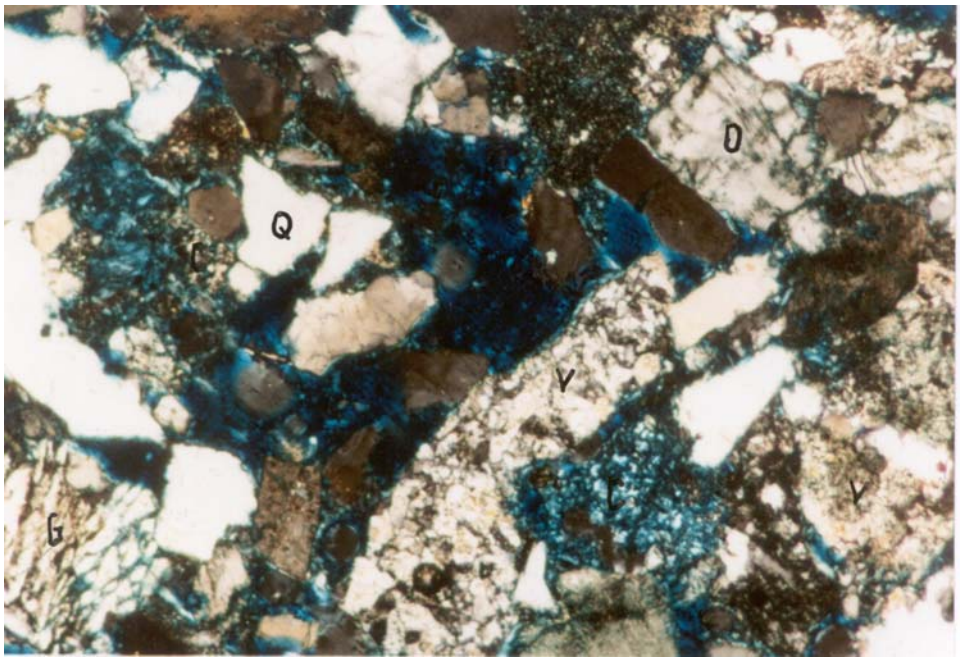
The pores are mainly intergranular pores with the size of 0.1-0.2mm and minor intragranular pores with the size <0.1mm formed by dissolution of feldspar grains.



250µm Crossed Nicols

Plate 1: ***Core sample from the Enreca-1 well, No 59, depth 342.90m***

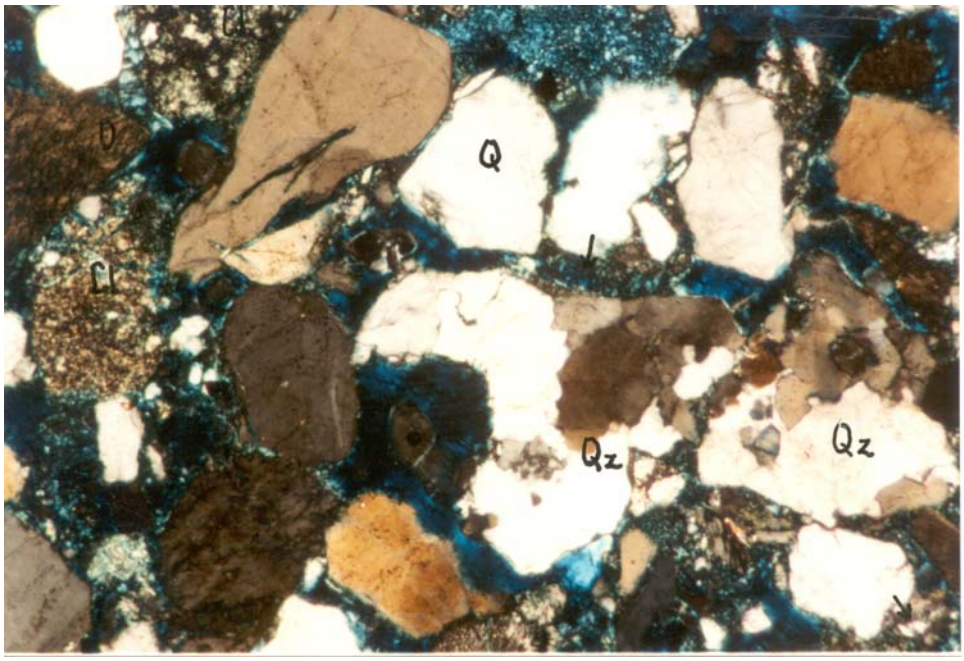
Poorly sorted, subangular-subrounded grains, medium-grained feldspathic litharenite. Detrital grains are composed of quartz (Q), orthoclase (O), microcline (M) and granitic rock fragments (G). The detrital clay matrix (arrow) is filling pore space.



250µm Crossed Nicols

Plate 2: ***Core sample from the Enreca-1 well, No 59, depth 342.90m***

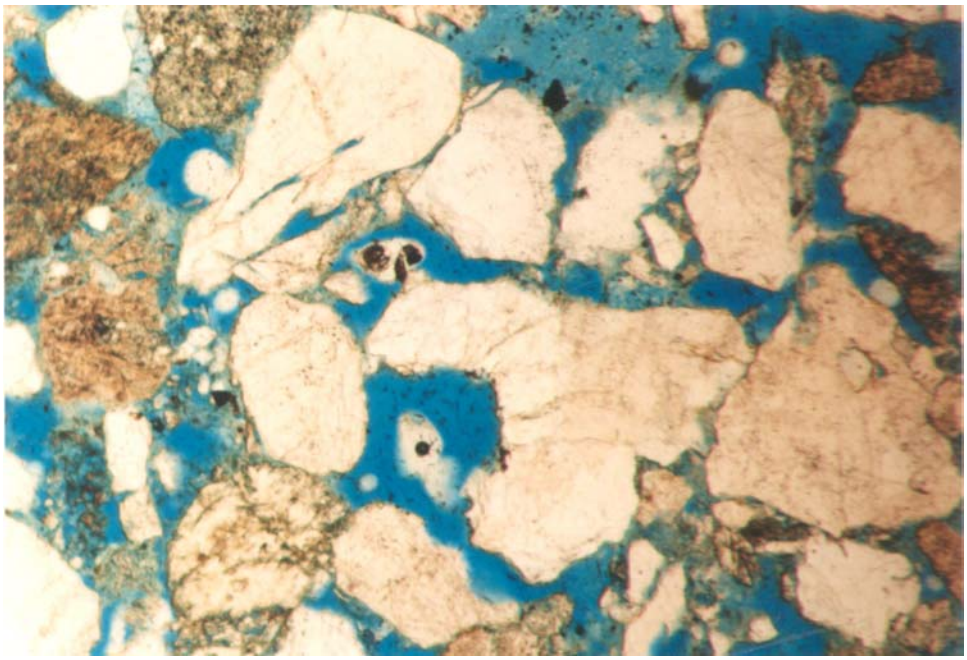
Medium-grained sandstone similar to plate 1, but this plate shows mainly presence of acidic volcanic rock fragments (V) and clay matrix (C). Other components are similar to these of plate 1.



250µm Crossed Nicols

Plate 3: ***Core sample from the Enreca-1 well, No 59, depth 342.90m***

Subangular-subrounded grains, medium-grained sandstone. Detrital grains are composed of quartz (Q), orthoclase (O) and rock fragments, such as quartzite (Qz) and clay fragment (Cl). Detrital clay matrix (arrow) is filling the pore space.



250µm Plane Nicols

Plate 4: ***Core sample from the Enreca-1 well, No 59, depth 342.9m***

The visual porosity (blue) is composed mostly of intergranular pores of 0.05–0.15mm in size with moderate connectivity.

Depth 354.85m, No 60, core sample from the Enreca-1 well

Hand specimen description

Medium-grained sandstone, light grey, massive structure, weakly consolidated, fair sorted.

Microscope description

- Lithology: Medium-grained sandstone

- Classification: Feldspathic graywacke

Total rock composition (300 point counts)

Framework grains	%	***Cement and Auth. minerals***	%
Quartz	29.7	Quartz	0.3
K-feldspar	15.3	Clay minerals	4.0
Plagioclase	-	Opaque minerals	Tr.
Mica	0.3		
Rock fragment:			
Granitic	3.7		
Quartzite/Microquartzite	3.7		
Schist	2.7		
Chert	1.3		
Volcanic	12.0		
Sediment	3.0		
Accessory minerals:			
Rutile	Tr.		
Apatite	Tr.		
Detrital matrix		***Visible porosity***	***%***
Clay matrix	22	Intergranular pores	1.7
Organic matter	-	Intragranular pores	0.3
Grain size	Sorting: Moderate to poor		
Max: 1.5mm	Grain shape: Subangular to subrounded		
Min: 0.03mm	Grain contact: Point, straight		
Average: 0.25-0.5mm			

The rock is classified as a Feldspathic Graywacke according to classification (Folk 1974)

Mineralogy description

Detrital quartz grains are dominated by monocrystal, accompanied with subordinate polycrystal grains. Their undulose extinction could be observed clearly. Some quartz grains contain inclusion of rutile.

Feldspar consists of mainly orthoclase and rare microcline grains. They were strongly kaolinitized and sericitized at various degrees.

Minor amount of muscovite could be found in mica composition.

The lithic grains consist of metamorphic, altered acidic volcanic, and sedimentary fragments. Acidic volcanic fragments are strongly replaced by kaolinite and silicate. Metamorphic fragments consist of quartzite, microquarzite, quartz-feldspar schist and quartz-sericite schist. Sedimentary fragments consist of siltstones, claystones and chert.

Some traces of accessory minerals such as apatite and tourmalin can be recognized.

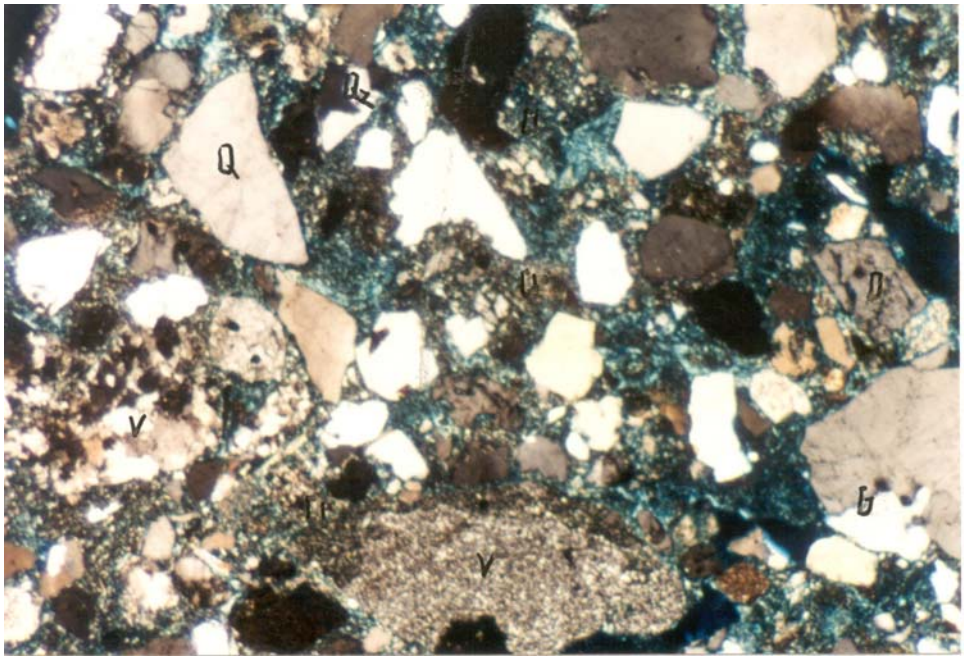
Clay matrix composes of clay minerals and traces of organic matter. Clay matrix is mainly kaolinite and illite, filling mostly the intergranular pore space.

Cement and authigenic minerals

Authigenic minerals consist of mainly clay minerals, minor authigenic quartz and opaque minerals. Clay minerals consist abundantly of kaolinite, lesser amounts of illite and other clays. Authigenic quartz grains fill the intergranular pores of the sample.

Visual porosity

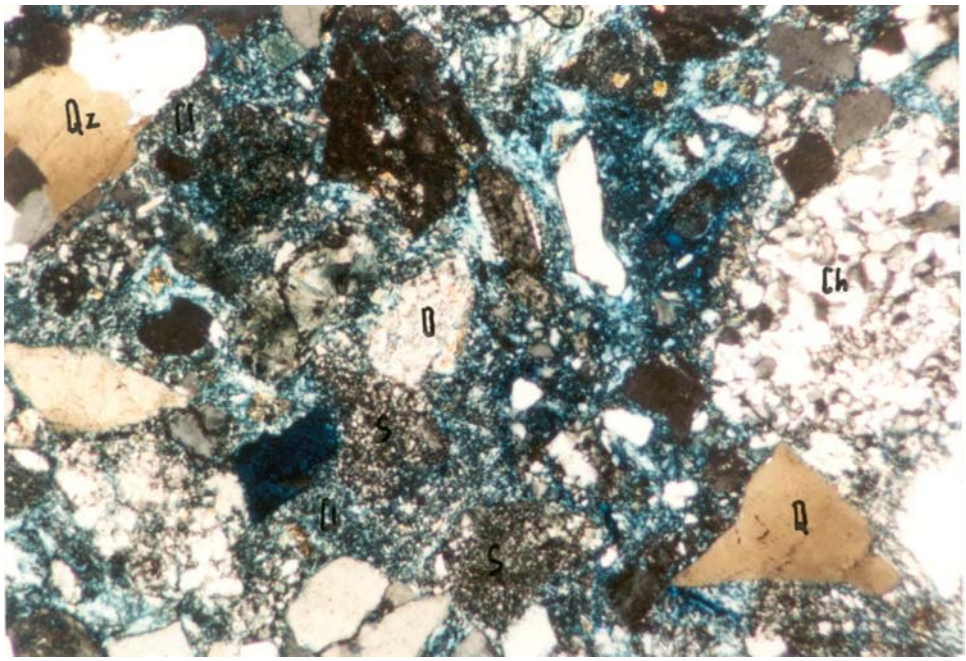
The intergranular pores are minor, due to the high content of clay matrix. They are heterogeneously distributed in the sample and only observed in places where proportion of clay matrix is low.



500µm Crossed Nicols

Plate 1: ***Core sample from the Enreca-1 well, No 60, depth 354.85m***

Poorly sorted, subangular-subrounded grains, medium-grained feldspathic graywacke. Detrital grains are composed of quartz (Q), orthoclase (O), and rock fragments such as granitic (G), volcanic (V) and quartzite (Qz). Detrital clay matrix (Cl) is abundant and filling mostly the pore space.



250µm Crossed Nicols

Plate 2: ***Core sample from the Enreca-1 well, No 60, depth 354.85m***

Medium-grained sandstone similar to plate 1, but the plate shows the dominance of acidic volcanic rock fragments (V) and clay matrix (C). Other components are similar to those of plate 1.

Table 2: Results of petrographic analyses (300 point counts) of core samples from the Enreca-1 well

No	Depth (m)	Composition / Classification	Texture					Framework grains (%)										Acce. mineral					Detrital matrix		Cement & Au. mineral						Integranular pores	Secondary porosities
			Min grain size (mm)	Max grain size (mm)	Mod grain size (mm)	Grain shape	Sorting	Quartz	K-Feldspar	Plagioclase	Mica	Microquartzite	Granitic	Chert	Schist	Volcanic	Sediment	Others	Sphene	Zircon	Apatite	Epidote	Tourmaline	Clay matrix	Organic matter	Clay minerals	Kaolinite	Carbonate minerals	Anhydrite	Quartz	Opaque minerals		
18	94,25	Feldspathic graywacke	0,03	0,3	0.1-0.2	SA-SR	M	34,7	12,7	2,7	1,0	1,3	1,7	1,0	3,0	6,3	5,3		Tr	Tr		0,3	Tr	21,3	Tr	2,0				0,3	0,7	5,7	Tr
22	117,75	Feldspathic graywacke	0,03	0,3	0.1-0.2	SA-SR	M-P	29,7	14,7	2,7	3,7	3,0	1,7	1,0	3,3	6,0	4,7		Tr	0,2		0,5	0,3	17,0	0,3	2,7				0,7	1,0	6,7	Tr
25	139,80	Feldspathic graywacke	0,025	0,1	0.04-0.1	SA-SR	M	28,7	12,3	3,7	2,7	2,0		1,3	1,0	3,3	2,0			Tr	Tr	0,7		36,5	0,7	2,7	-			Tr	1,7	0,7	Tr
29	164,75	Feldsparthic Litharenite	0,03	0,4	0.5-0.25	SA-SR	M-P	32,0	12,7	0,7	0,3	3,0		2,0	3,7	7,7	5,7	1,0		Tr		0,3		2,5	0,7	3,0				0,7	0,3	22,0	1,7
31	175,80	Lithic Arkose	0,05	0,3	0.1-0.15	A-SA	M	25,3	16,7	1,0	2,7	1,6		1,3	1,7	5,7		2,3		Tr		Tr	Tr			3,7		36,0	2,3		0,3	-	-
41	236,25	Lithic Arkose	0,05	1,8	0.8-1.6	SA-SR	P	33,7	15,7	0,3	0,3	6,0	5,3	1,7	2,0	5,7	3,7	1,7				-	-	6,7	Tr	3,7				0,7	Tr	12,0	1,3
59	342,90	Feldsparthic Litharenite	0,03	0,8	0.25-0.5	SA-SR	P	30,7	17,0	0,3	1,0	3,3	2,0	1,7	1,7	9,0	6,3			Tr		Tr		9,7	Tr		3,0			1,3	Tr	11,7	1,3
60	354,85	Feldspathic graywacke	0,03	1,50	0.25 -0.5	SA-SR	M-P	29,7	15,3		0,3	3,7	3,7	1,3	2,7	12,0	3,0				Tr		-	22,0	-	4,0				0,3	Tr	1,7	0,3

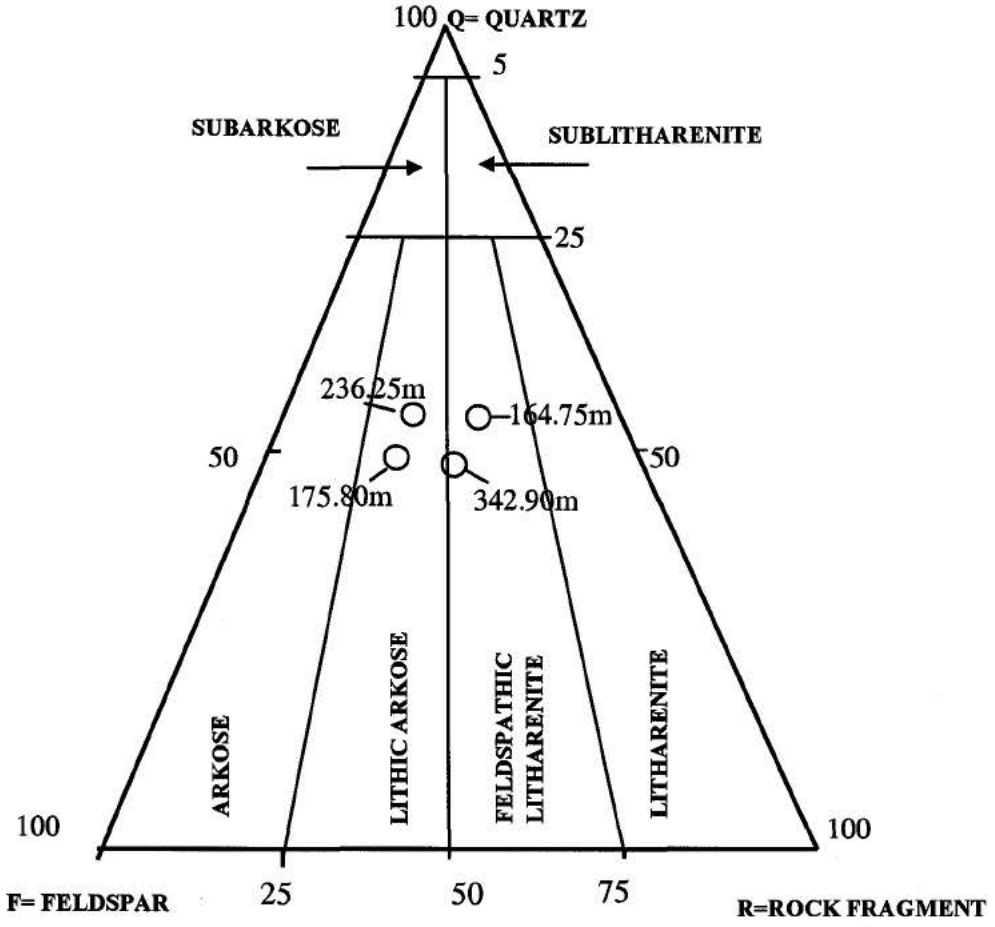


Figure 2: **Classification of sandstone with less than 15% fine-grained matrix; core samples from the Enreca-1 well (After Folk, 1968)**

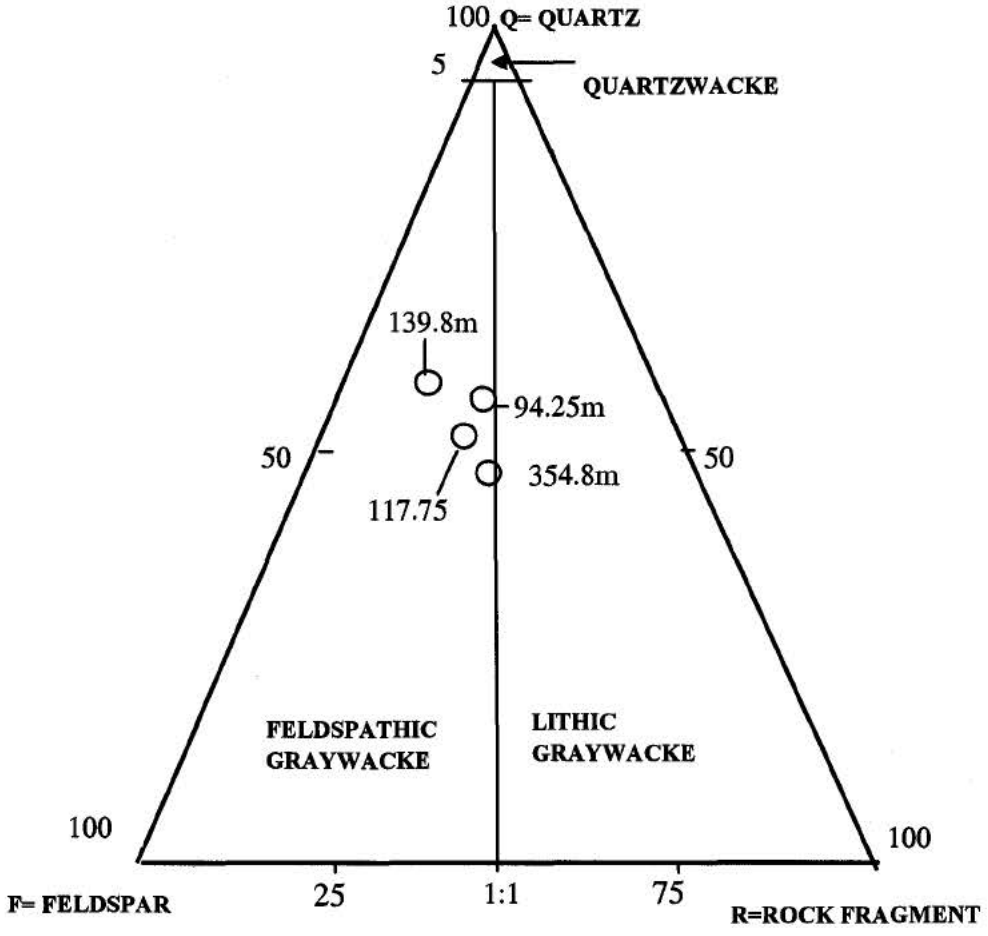


Figure 3 **: Classification of sandstone with more than 15% fine-grained matrix; core samples from the Enreca-1 well (After Folk, 1968)**

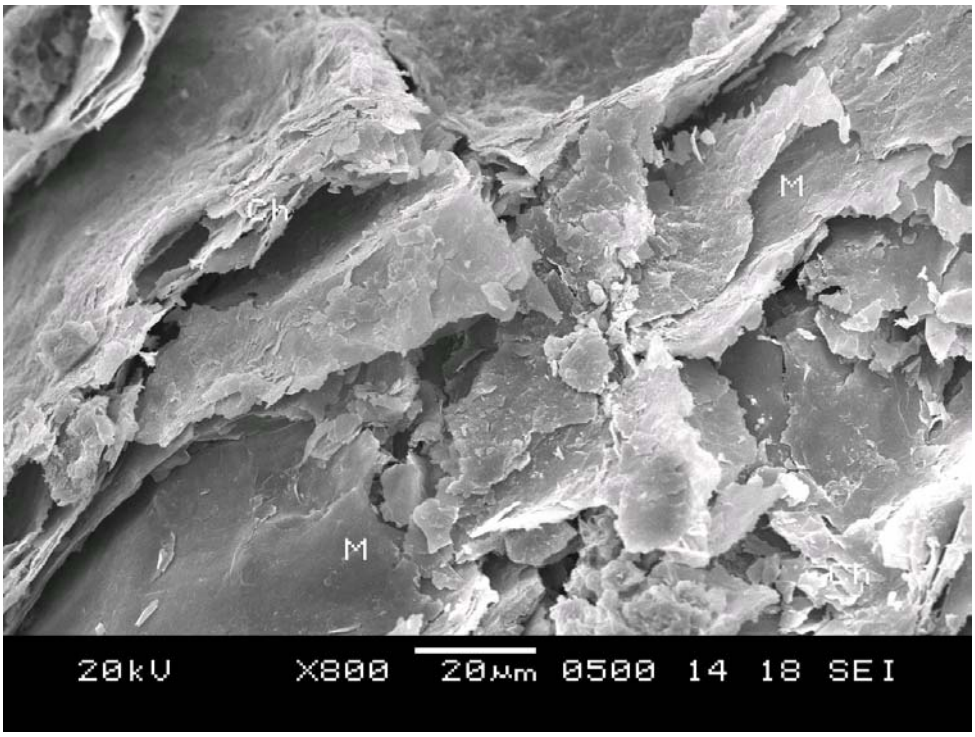
Appendix of SEM Description

Depth 117.75m, No 22, core sample from the Enreca-1 well

Poorly to moderately sorted sandstones, angular to subrounded grains. The authigenic minerals consist of kaolinite, illite/smectite, and quartz. Some detrital feldspar and mica grains have been partly or nearly completely replaced by diagenetic clays.

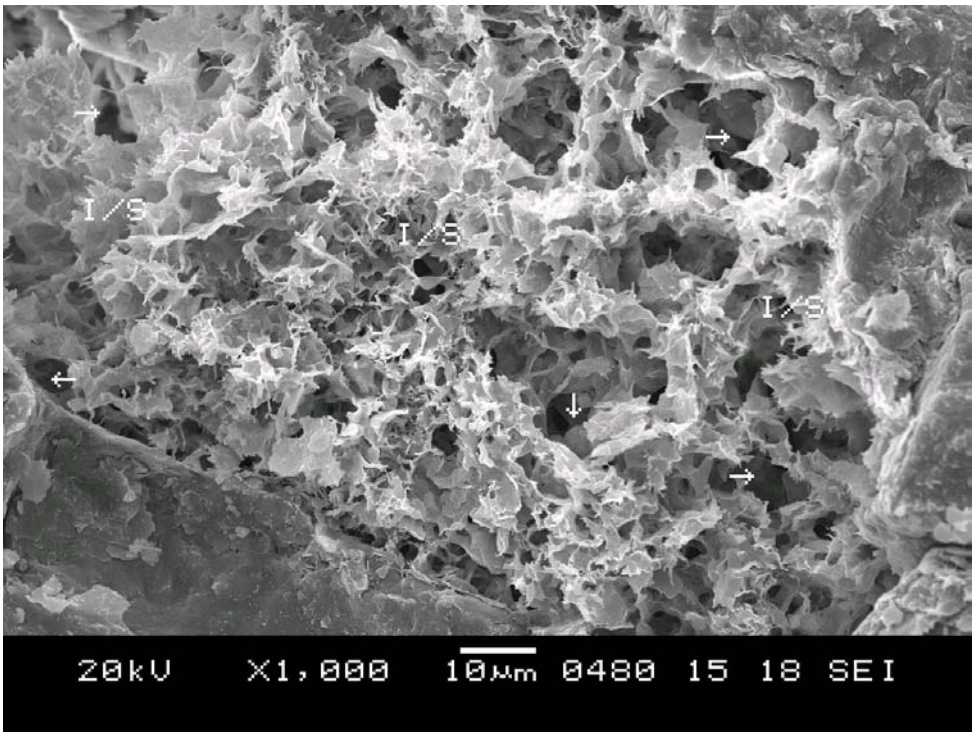
The kaolinite is occurring as subhedral to euhedral crystals with size of 3—7μm. They are arranged face to face into small patches that fill up intergranular pores. A common amount of secondary kaolinite (K) also occurs as partial to nearly complete replacement of some detrital feldspar grains (F) (plate 0466).

The detrital mica grains (M) have been partially dissolved or replaced by authigenic chlorites (Ch) (plate 0500), because chlorites often appear along mica cleavage and occur as partial replacement of them. In this case, micropores often appear between these secondary chlorites.



Secondary quartz crystals (q) are commonly present and they occur mainly as fine subhedral to euhedral crystals of <10µm in size, and fill intergranular pores (→) or surrounds detrital grains (plate 0491).

Illite/smectite (I/S) occurs as thin ribbons and flaky, filamentous coatings on detrital grains or is filling pore spaces (→) (plate 0480).

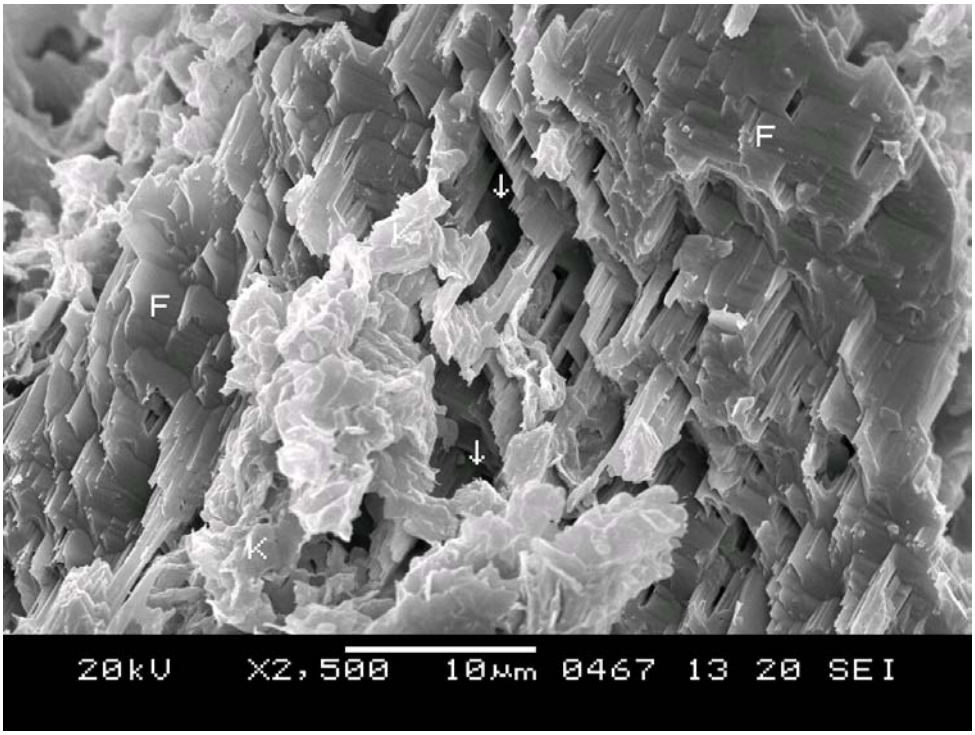


The intergranular pores of this sample are very few with poor connectivity, because most of them are completely filled both by clay matrix and authigenic clays. Remaining primary pores are rarely recognized and most are of small size. The pore network of the sample is principally formed by micropores (→) appearing mainly within pore-filling kaolinite (K) patches (plate 0483), and some intragranular pores due to partial dissolution of unstable minerals such as mica and feldspar. The connectivity of the micopores is moderate within pore-filling patchs (plate 0483). Such pores would more or less reduce the effective porosity as well as the permeability of this sample.


K
K
K
K
K
20kV X2,700 5µm 0483 13 18 SEI

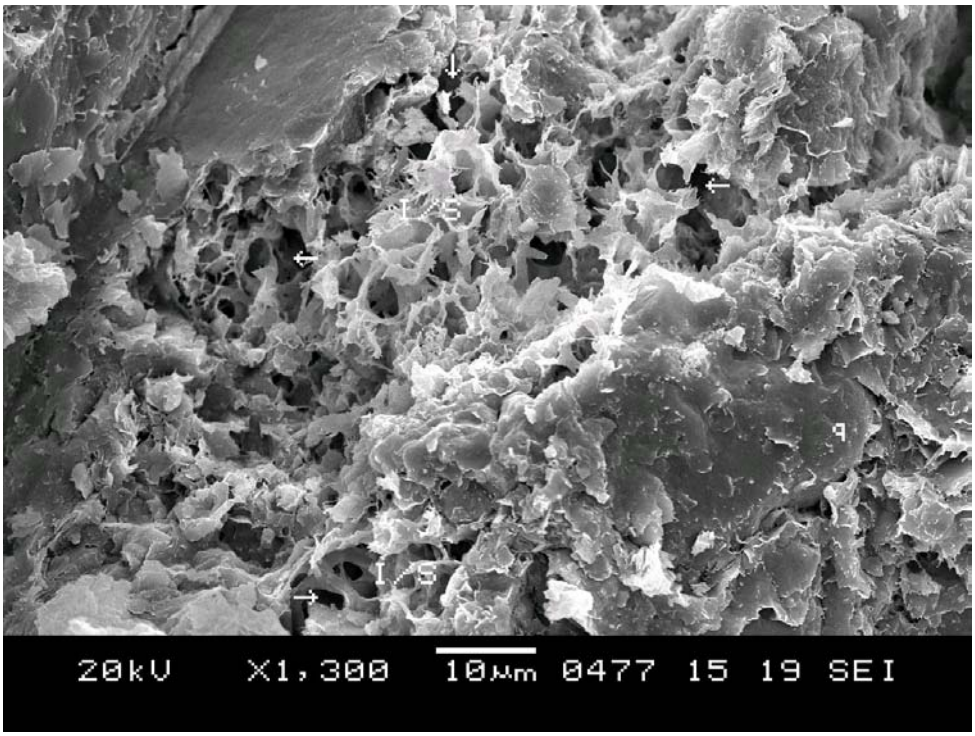
Depth 139.80m, No 25, core sample from the Enreca-1 well

Poorly to moderately sorted sandstones, subangular to subrounded grains. The authigenic minerals consist of kaolinite, illite/smectite, and quartz. Feldspar grains (F) have been replaced by authigenic clay minerals at various degrees (Kaolinite = K), and some of them are weakly dissolved, consequently creating intragranular micropores (→) (plate 0467).



The clay minerals are mainly of kaolinite and minor illite, illite/smectite. The authigenic kaolinite (K) is subhedral to euhedral crystals of 2—6µm in size, filling intergranular pore spaces (plate 0482). Other secondary kaolinite appears as partial replacement of the feldspar detrital grains (plate 0467). Some feldspar grains are partly dissolved and a minor amount of intragranular micropores of 2µm to 5µm in size have been created (→).

Secondary quartz crystals (q) are commonly present in this sample. They occur mainly as small subhedral to euhedral crystals, 10—15µm in size. The illite/smectite (I/S) occurs as slightly crenulated to flaky or thin ribbon, filamentous coating on detrital grain surfaces (plate 0477) or filling intergranular pore spaces.



The intergranular pores constitute only a minor part and are poorly preserved, because most of them have been nearly completely occluded by the detrital clay matrix. Only a very little amount of remaining primary pores are observed, but most are of small sizes (often smaller than 15μm in size).

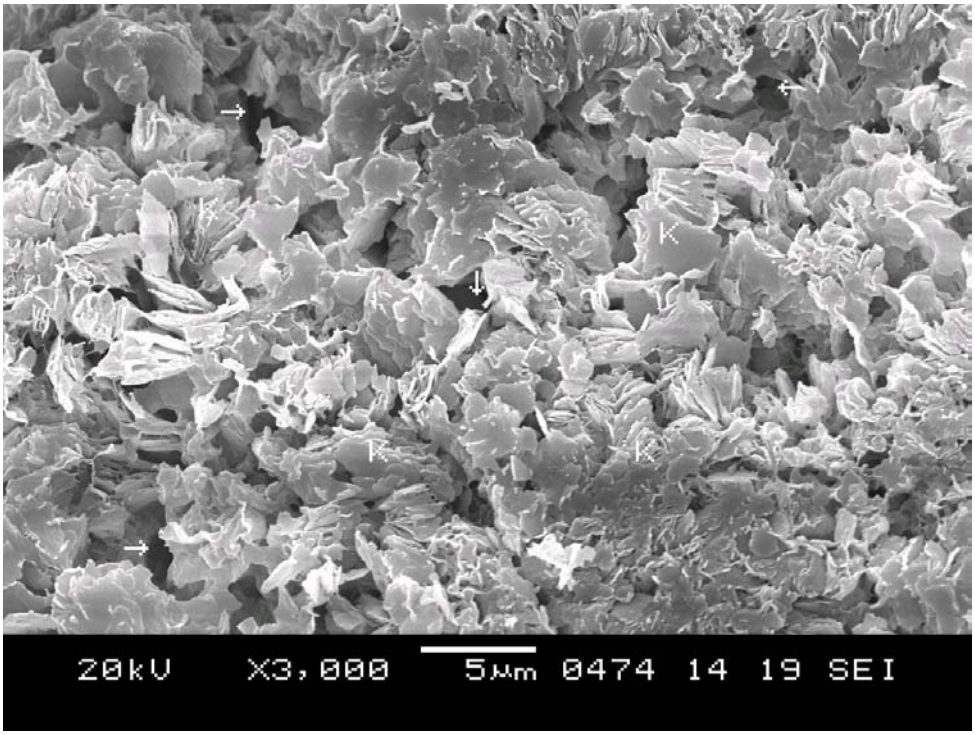
The secondary micropores (→) are smaller than 5μm in size, appear mainly within the diagenetic clay minerals. Other intragranular pores (→) are also present due to the partial dissolution of unstable minerals such as detrital feldspar grains (F) (plate 0467). Such pores would more or less reduce the effective porosity as well as the permeability of this sample.

In general, the sample is considered to have poor reservoir quality.

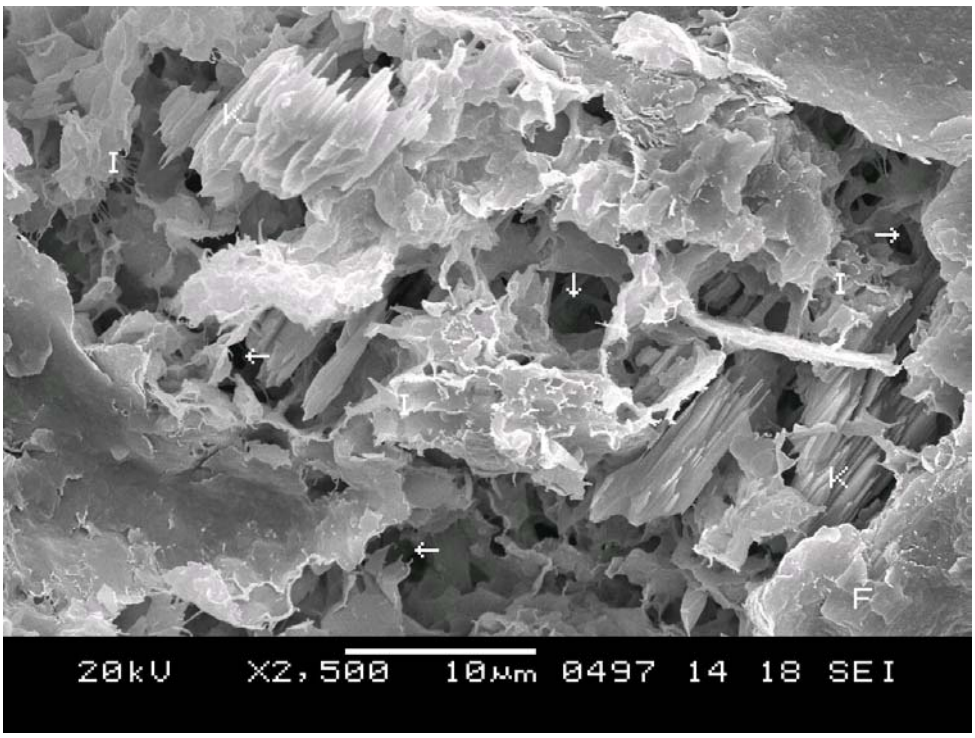
Depth 164.75m, No 29, core sample from the Enreca-1 well

Moderately to well sorted sandstones, subangular to subrounded grains. The authigenic minerals consist of quartz, kaolinite, illite and minor amounts of other minerals.

Secondary quartz is commonly of 5—10μm in size and fill intergranular pore spaces. Kaolinite occurs as subhedral to euhedral crystals of 3—5μm in size and fill intergranular pore spaces (plate 0474).

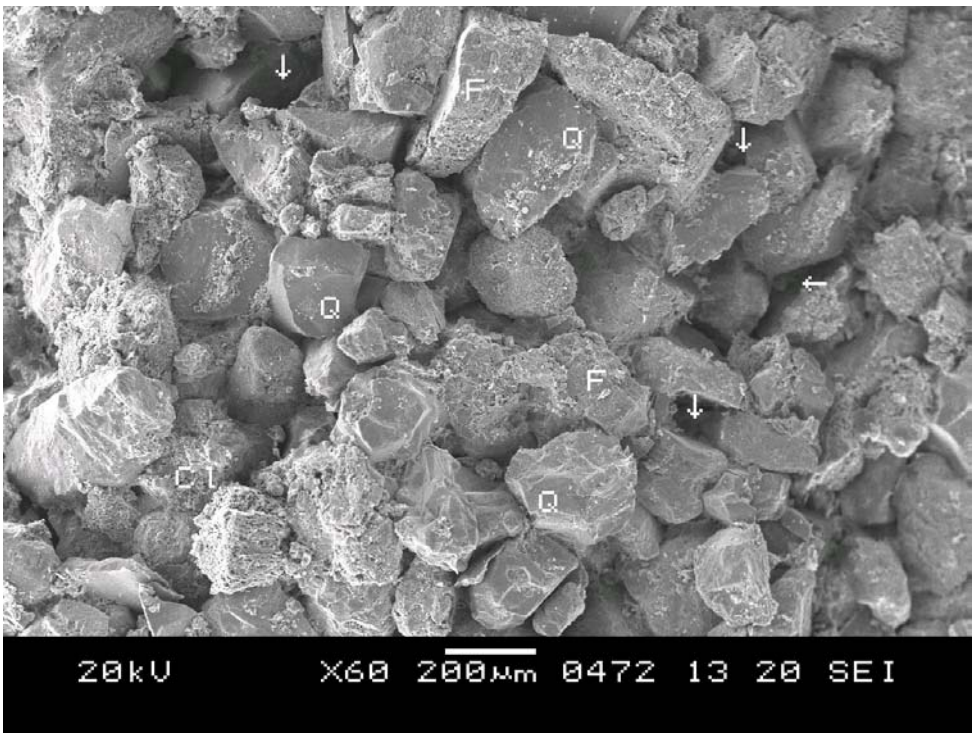


Minor amounts of secondary kaolinite (K) also occur as partly to completely replacements of the detrital feldspar grains. Authigenic illite (I) occurs as slightly crenulated to flaky or thin ribbon, filamentous coating on detrital grain surfaces (plate 0497) or filling pore spaces.



Secondary micropores (→) is present in small amounts and they also appear in the areas where kaolinite crystals are developed (plate 0474). Apart from that, there are also a few intragranular micropores due to weak dissolution of feldspar grains (plate 0497), but mostly these micropores are heterogeneously distributed, all of small size (often <5μm), very narrow and tortuous in shapes. Therefore, they are not considerably contributed to open porosity as well as permeability of this sample.

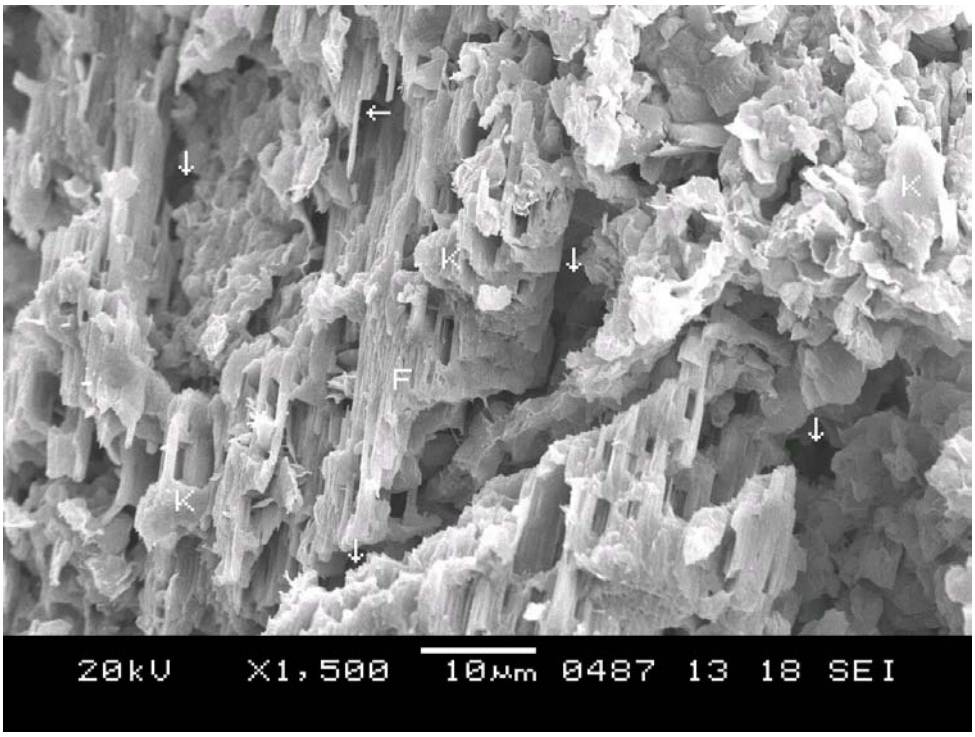
The primary porosity is good (plate 0472), pores (→) are distributed homogeneously and their connectivity is good, suggesting that permeability to fluids is probably good in all direction. The sample is thus considered to represent a very good reservoir.



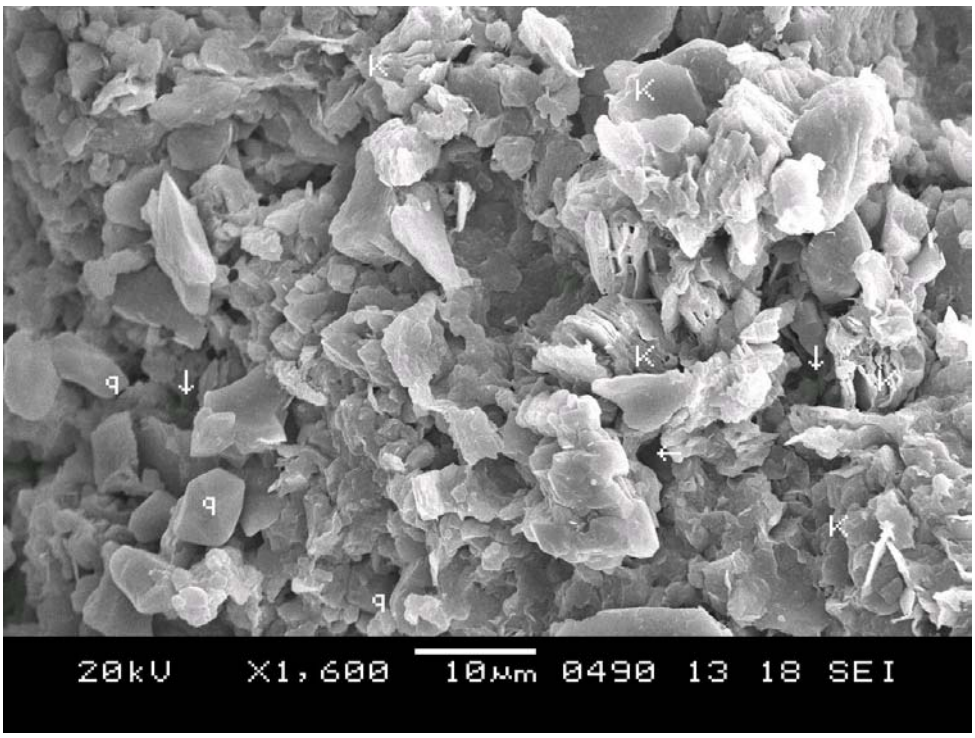
Q = Quartz crystal; F = Feldspar crystal; Cl = Claystone

Depth 175.80m, No 31, core sample from the Enreca-1 well

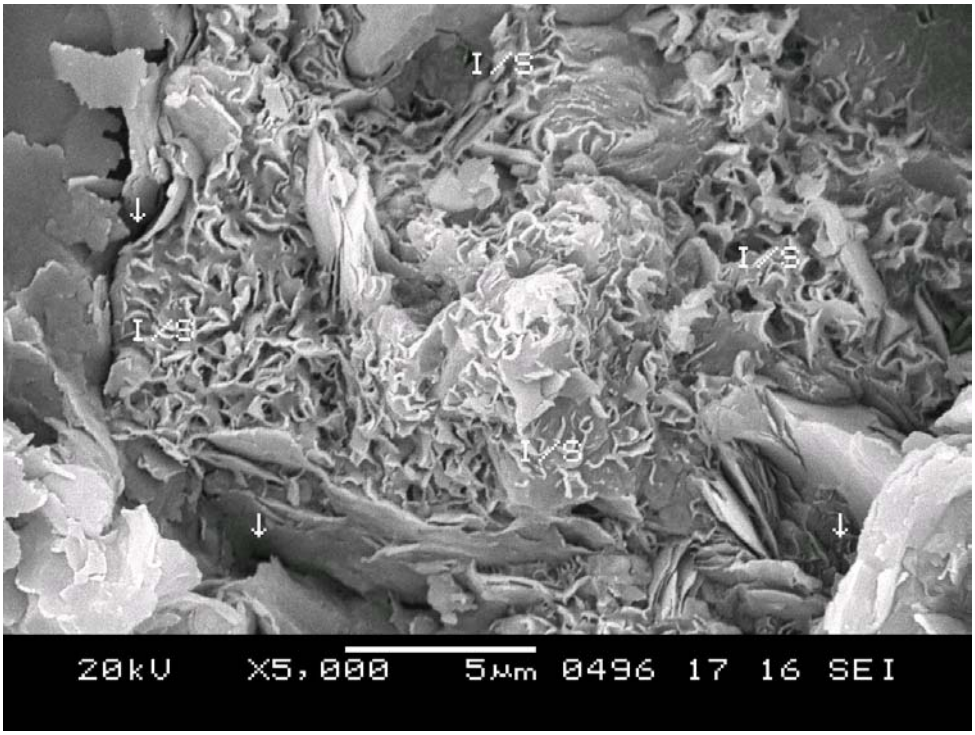
Medium-grained sandstones, poorly to moderately sorted, angular to subrounded grains. The authigenic minerals consist of diagenetic clay, which occur as matrix, coating on detrital grains and fill the pore spaces. Some detrital feldspar grains (F) are partly replaced by kaolinite (K), consequently created some intragranular micropores (→) (plate 0487).

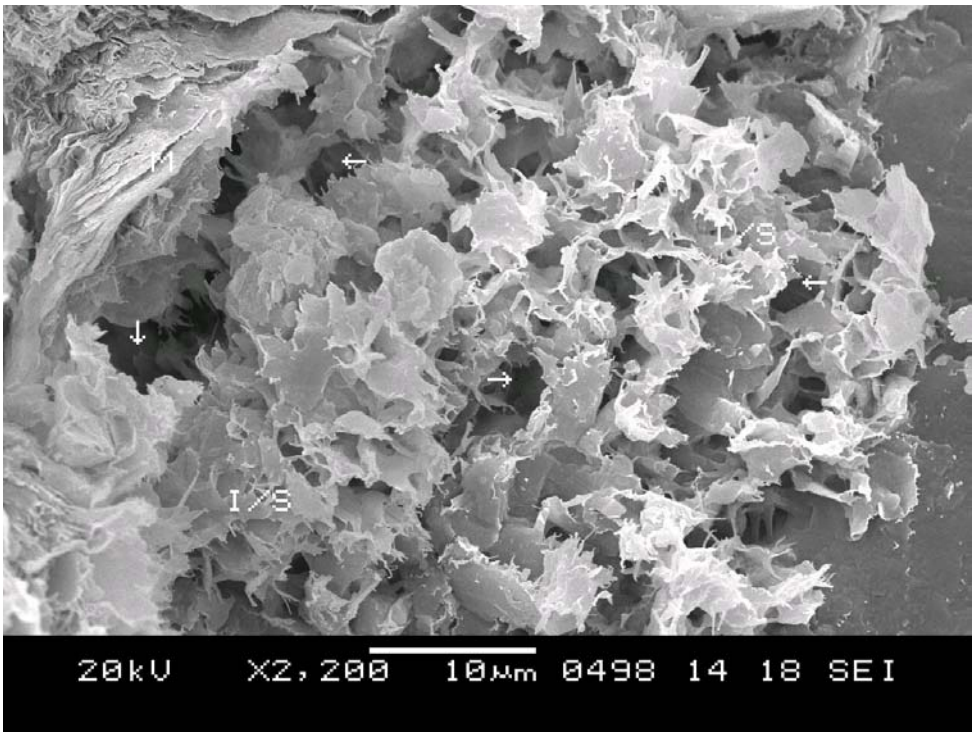


Kaolinite (K) is subhedral to euhedral arranged into the small patches or face to face stacks (plate 0490); (q = quartz crystal)



Illite/smectite (I/S) occurs as slightly crenulated to flaky or thin ribbon, filamentous and as coatings on detrital grain surfaces (plate 0496) or fill the pore spaces (plate 0498). A minor amount of mica crystal grains (M) show strong bending and deformation (plate 0498), which suggests a moderate to strong degree of mechanical compaction.





The cements and authigenic minerals consist mainly of kaolinite, illite/smectite, and minor quartz.

The primary intergranular pores are nearly absent in the sandstone because they have been completely occluded by clay matrix and diagenetic clays as described above. The secondary micropores appear within pore-filling diagenetic clay patchs and some of them appear due to partial dissolution of minor detrital feldspar grains.

In general, the porosity and permeability of the sandstone are poor.

Table 3 : Results of XRD analyses for whole rock of core samples from the Enreca-1 well
(Amount in semi-quantitative term)

No	Depth (m)	Quartz	K-Feldspar	Plagioclase	Calcite	Siderite	Anhydrite	Pyrite	Mica/Clays*	Clays**
3	15,75	58,5	13,4	3,5					11,4	13,2
18	94,25	64,3	19,8	3,9					6,9	5,1
20	107,15	48,8	12,3	3,1	1,1			1,3	12,6	20,8
22	117,75	64,4	14,5	4,5					8,9	7,7
23	122,85	50,4	11,9	3,2					15,8	18,7
25	139,80	56,7	21,3	5,1					6,7	10,2
29	164,75	69,7	11,2	4,5	1,1		1,3		5,6	6,4
31	175,80	34,9	17,1	3,1	29,4		2,2		7,4	5,9
33	183,30	48,1	9,3	2,8	1,9				11,2	26,7
40	230,20	48,7	11,2	3,6	2,1				9,3	25,1
41	236,25	66,7	18,8	2,3					6,5	5,7
52	302,25	43,6	9,1	2,8	1,3	1,4	2,7	1,5	12,1	25,5
57	332,75	47,3	15,6	2,1		1,1			9,6	24,3
59	342,90	66,2	14,1	5,2					7,8	6,7
60	354,85	65,3	12,3	3,4					7,1	11,9
62	364,20	28,2	10,8	2,9	1,8	15,7	1,9	1,3	8,6	28,8
70	410,80	63,6	10,2	4,1					7,3	14,8
77a	444,45	62,5	11,1	3,2					7,5	15,7
77b	451,10	65,6	10,3	2,9					6,9	14,3

*: consists of mica and/or illite

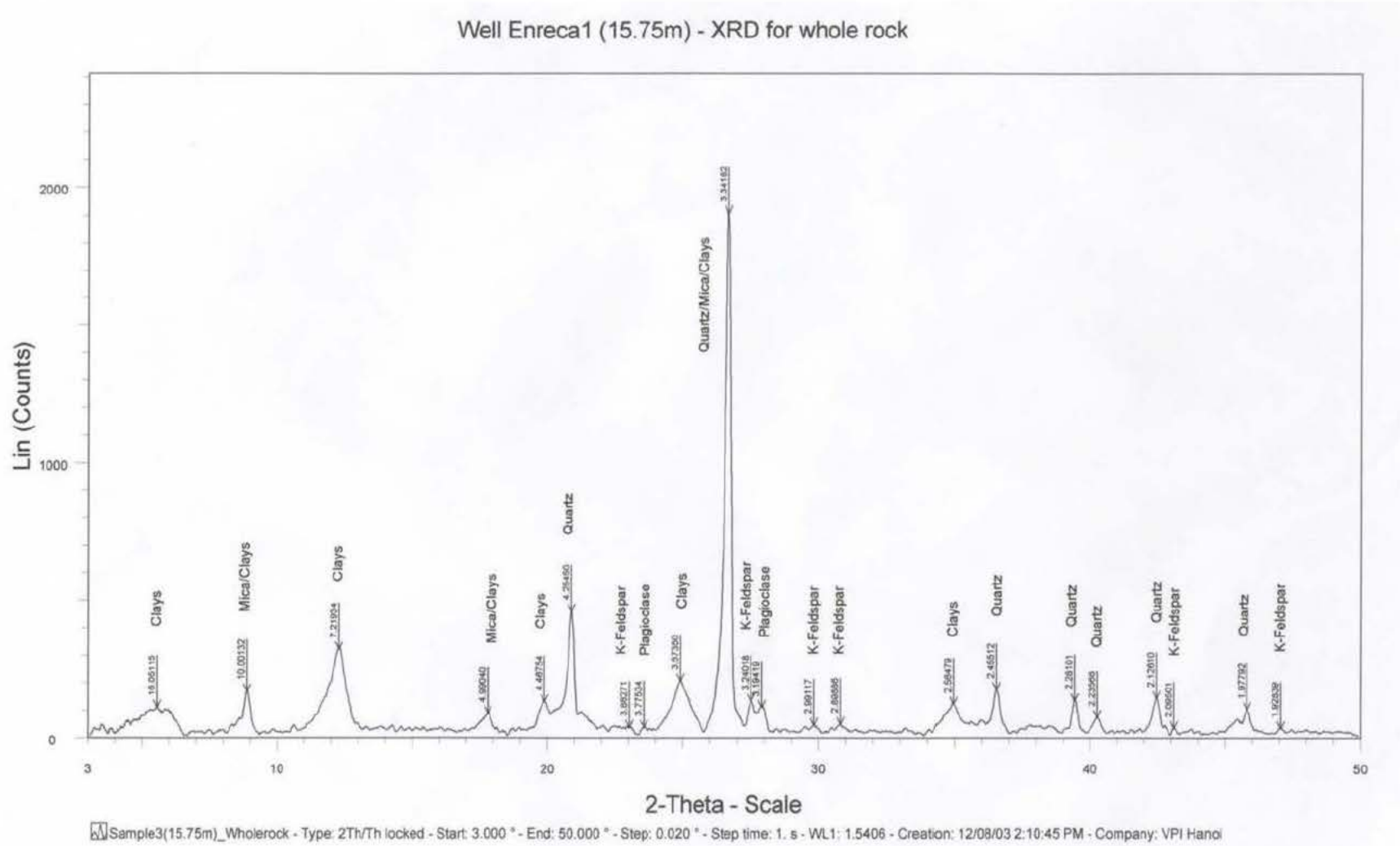
**: consists of kaolinite, smectite and other clays

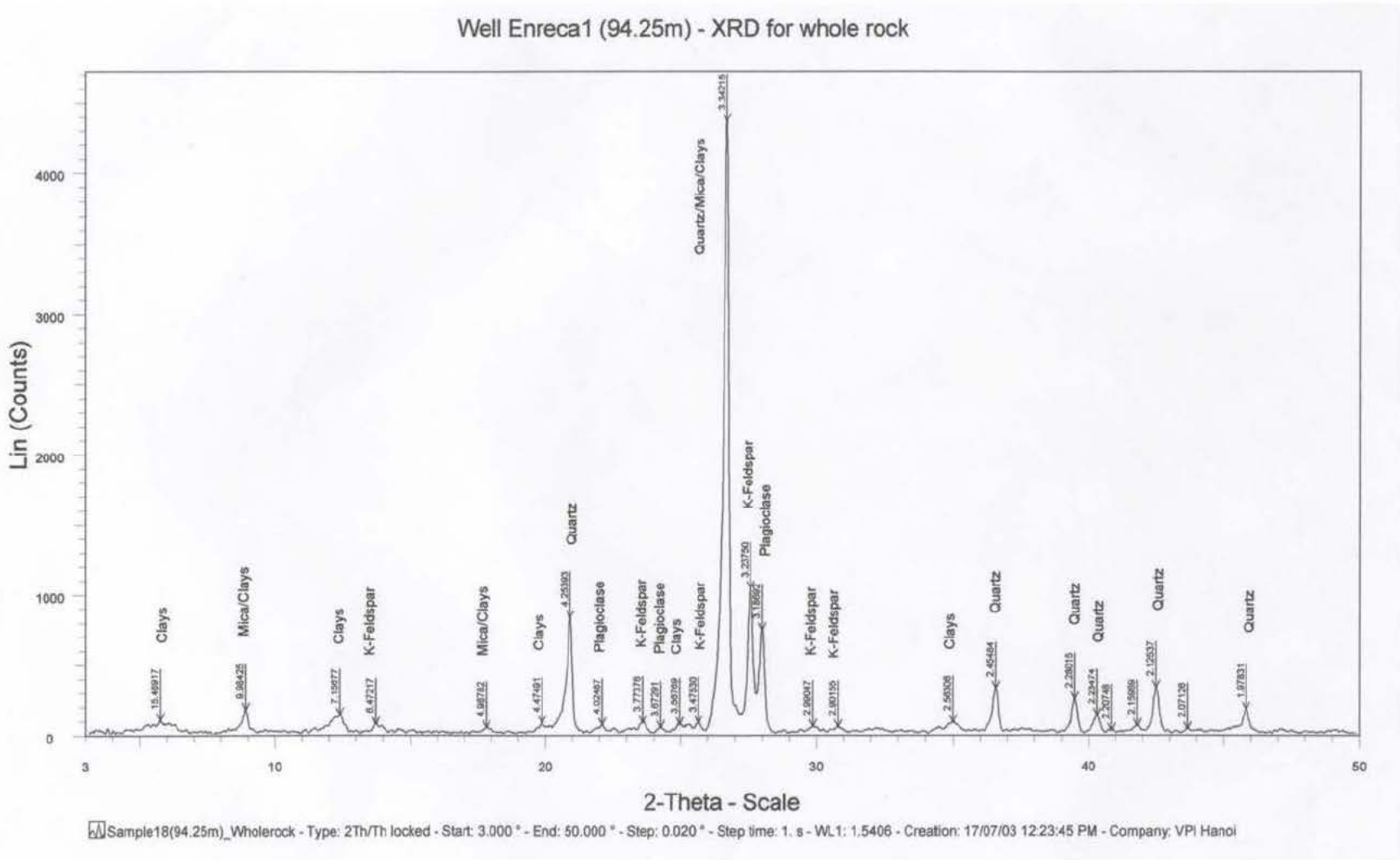
Table 4: **Result of XRD analyses for clay fraction of core samples from the Enreca-1 well**

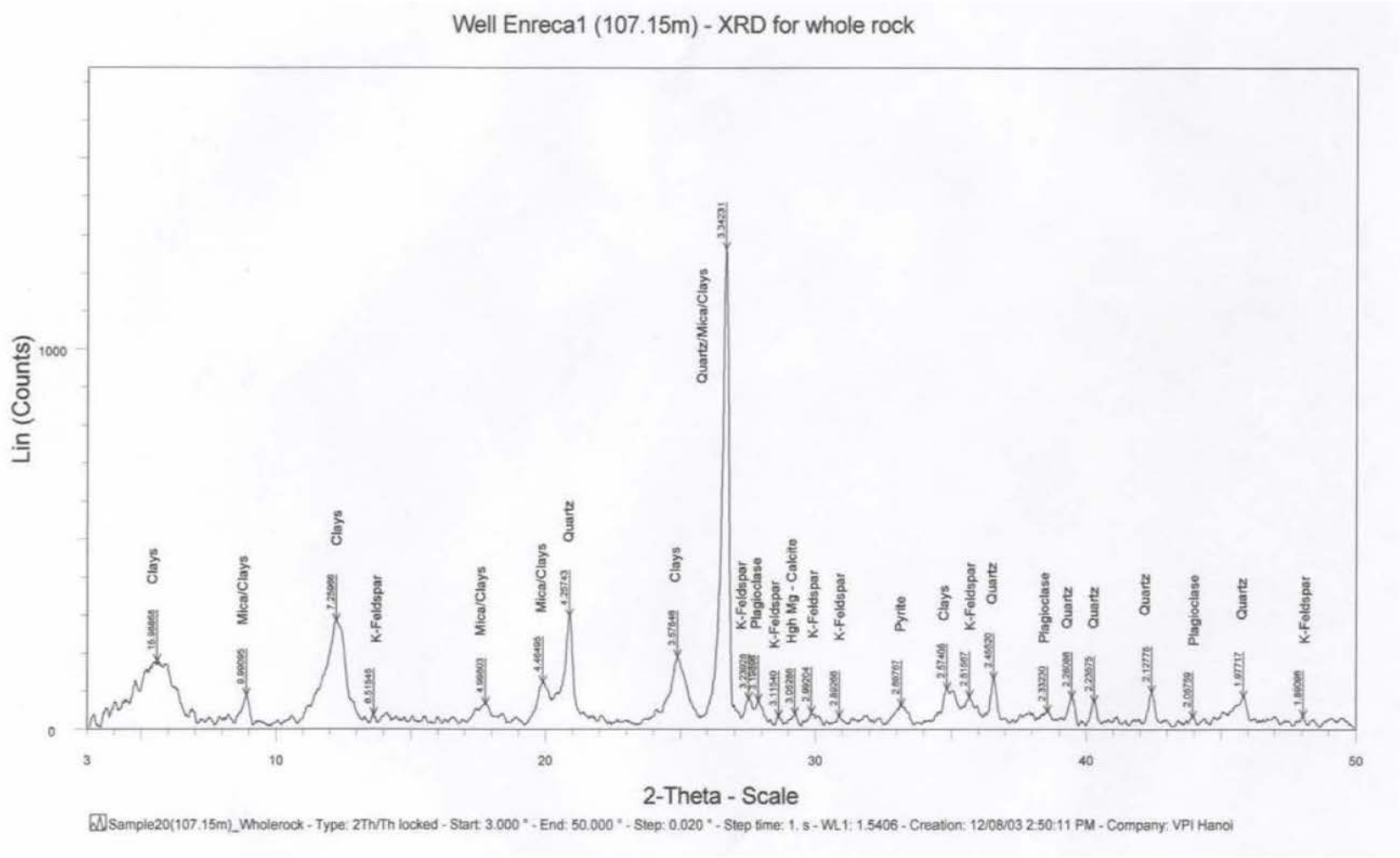
(Amount in semi-quantitative term)

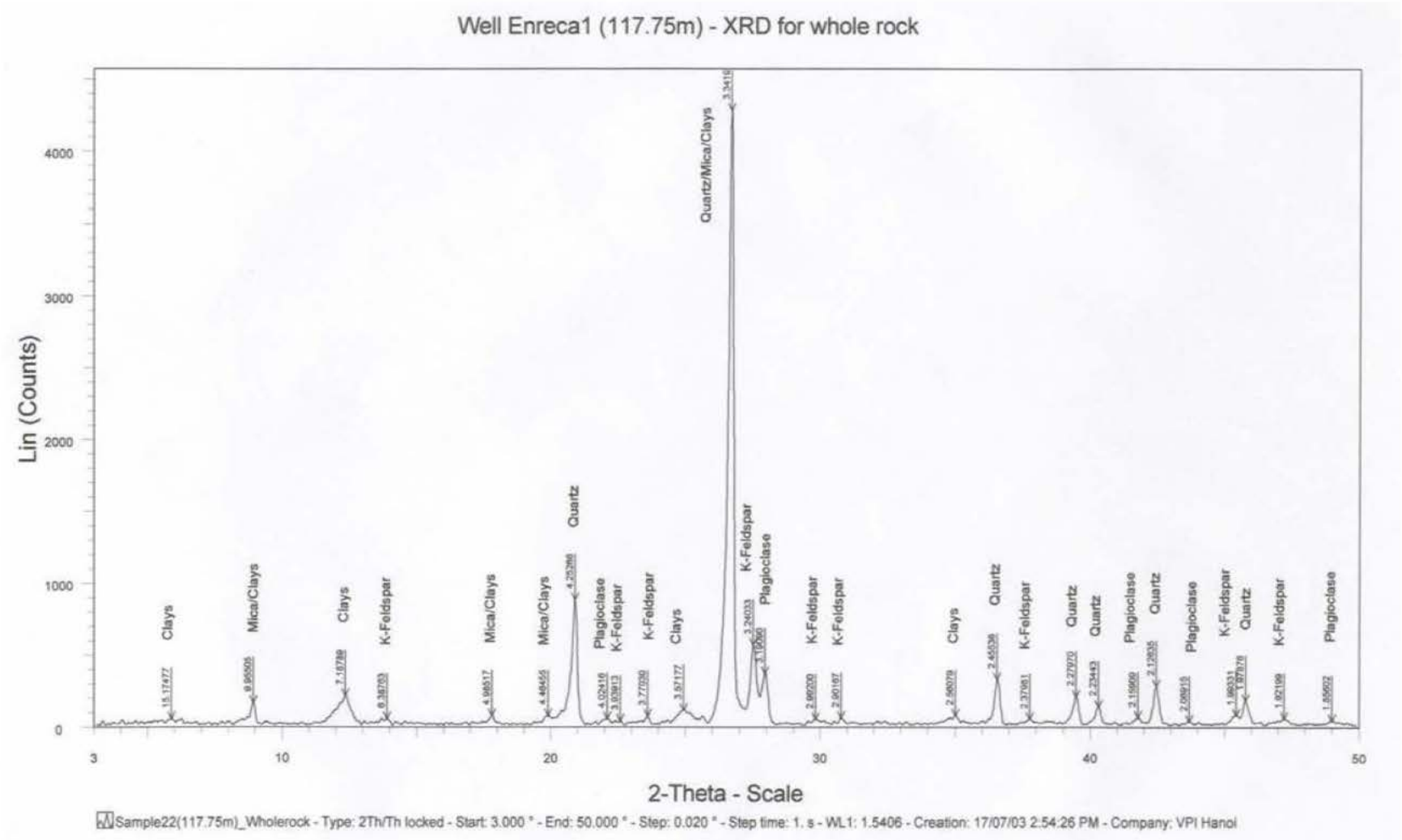
No	Depth (m)	Kaolinite	Illite	Smectite	Mixed-layer clay (Illite-Smectite)
3	15.75	55.2	21.8	17.4	5.6
20	107.15	54.4	20.2	18.6	6.8
23	122.85	55.8	20.1	17.9	6.2
33	183.30	71.2	13.4	10.4	5.0
40	230.20	67.6	14.9	11.2	6.3
52	302.25	71.3	17.6	5.3	5.8
57	332.75	77.9	15.2	-	6.9
62	364.20	64.3	16.3	12.7	6.7
70	410.80	81.4	13.0	-	5.6
77a	444.45	72.8	15.5	5.0	6.7
77b	451.10	74.0	15.3	6.2	4.5

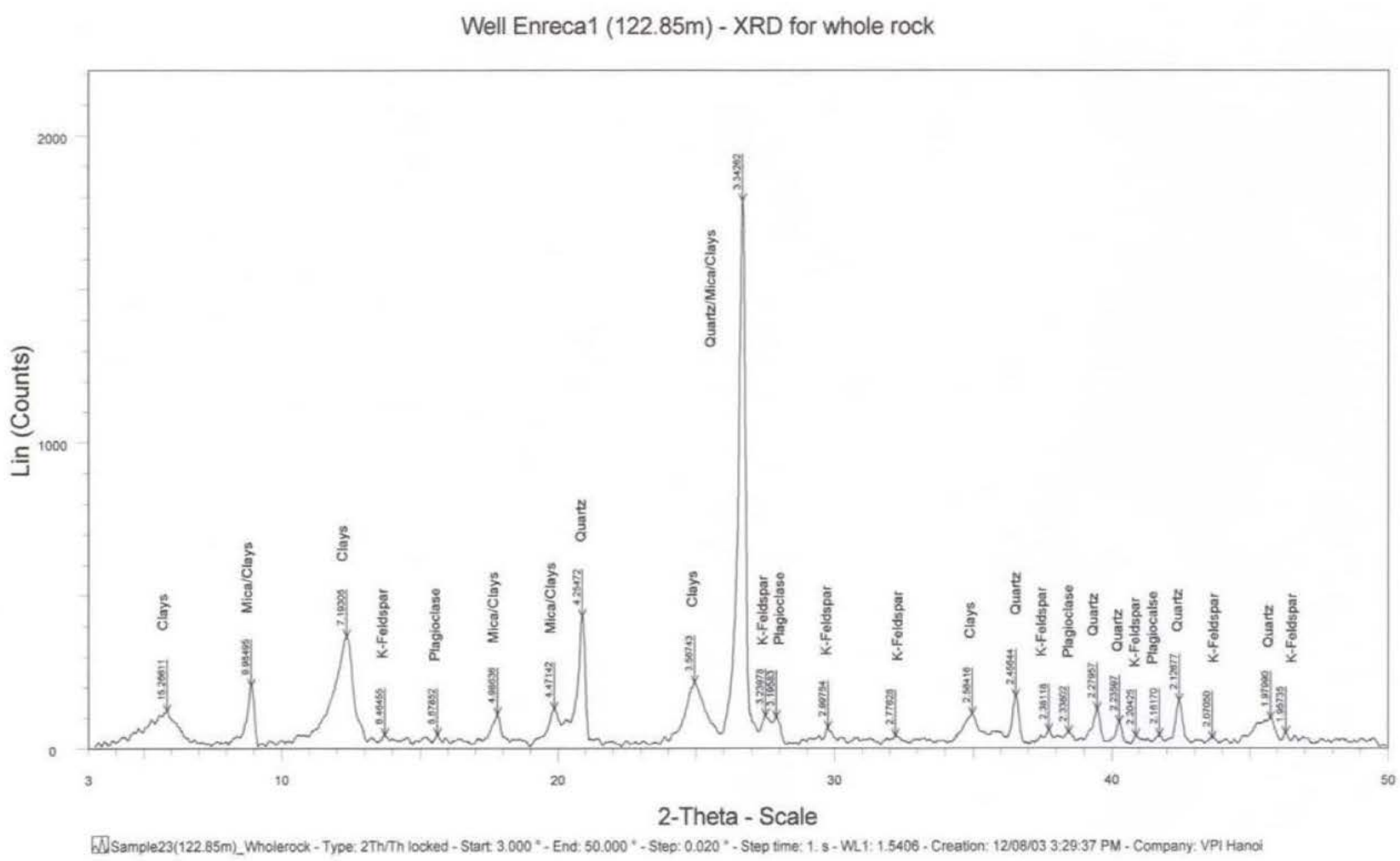
Diffractograms of X-Ray for whole rock of core samples from the Enreca-1 well

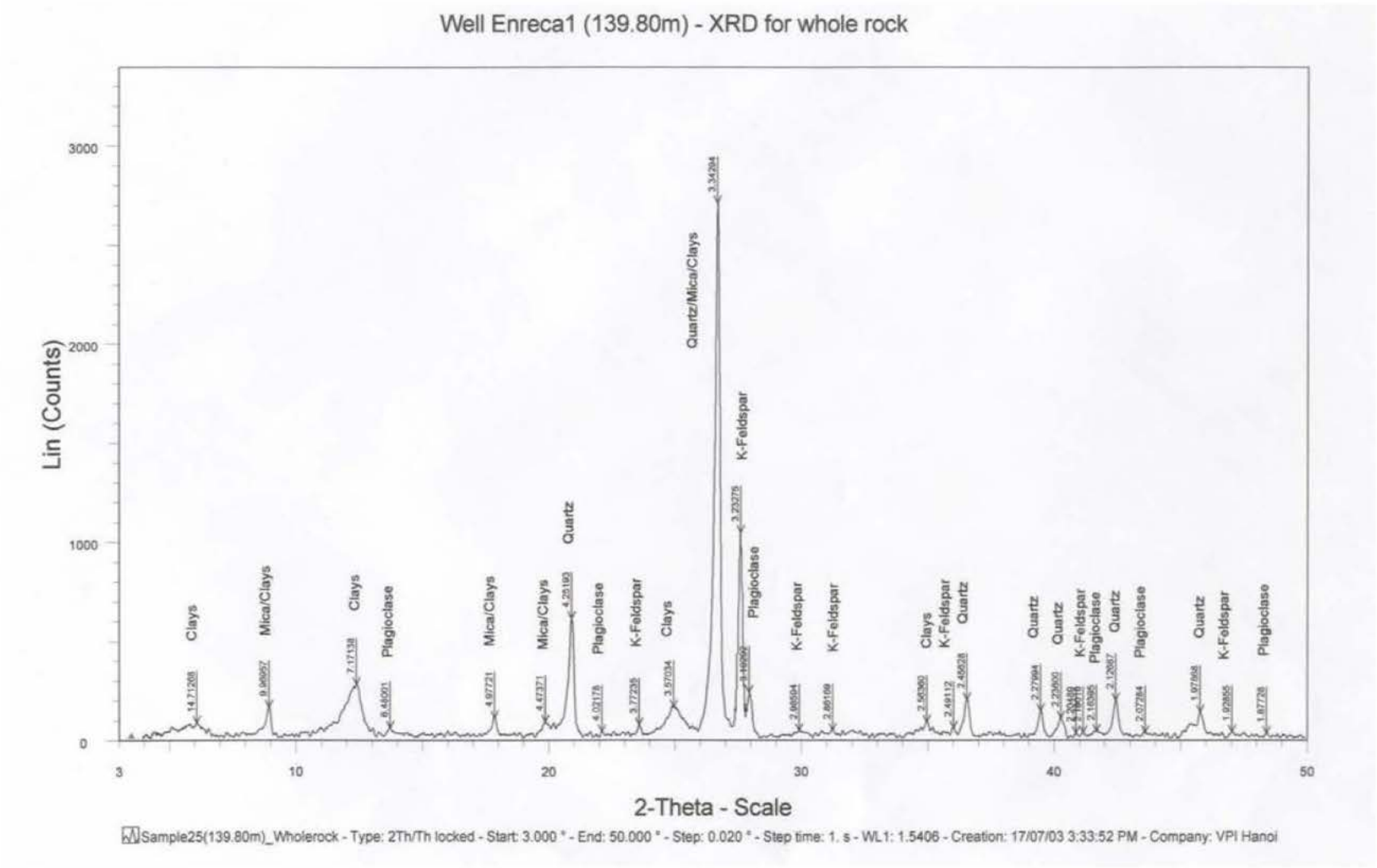

Well Enreca1 (15.75m) - XRD for whole rock
Lin (Counts)
2000
1000
0
3
10
20
30
40
50
2-Theta - Scale
Clays
Mica/Clays
Clays
Mica/Clays
Clays
Quartz
K-Feldspar
Plagioclase
Clays
Quartz/Mica/Clays
K-Feldspar
Plagioclase
K-Feldspar
K-Feldspar
Clays
Quartz
Quartz
Quartz
Quartz
K-Feldspar
Quartz
K-Feldspar
18.06115
10.00132
7.21924
4.99040
4.48754
4.25450
3.89271
3.77934
3.37350
3.34162
3.24018
3.19419
2.99117
2.88886
2.56479
2.46512
2.28101
2.23268
2.12610
2.09501
1.97792
1.92539
Sample3(15.75m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 12/08/03 2:10:45 PM - Company: VPI Hanoi

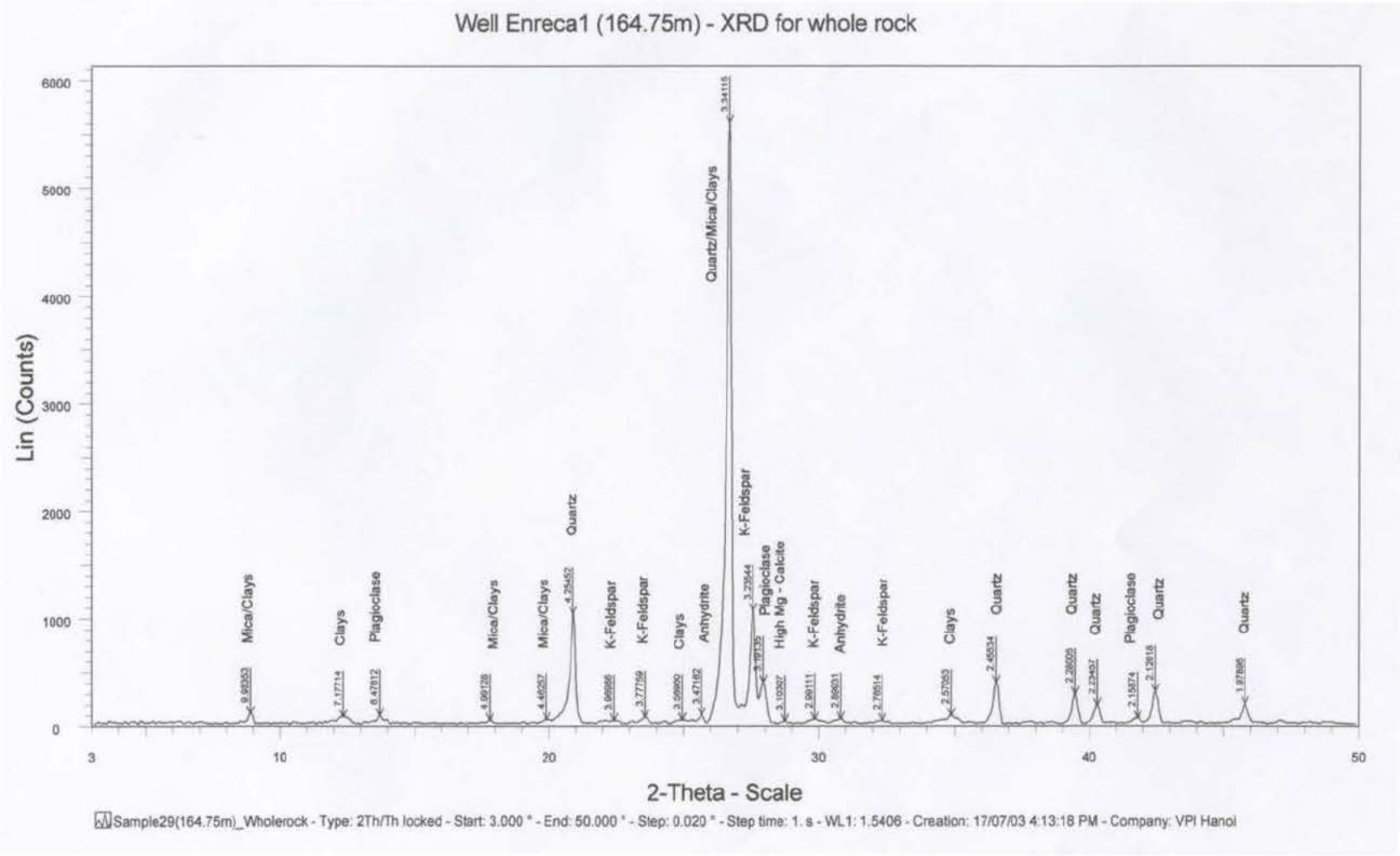

Well Enreca1 (94.25m) - XRD for whole rock
Lin (Counts)
2-Theta - Scale
Clays
Mica/Clays
Clays
K-Feldspar
Mica/Clays
Clays
Quartz
Plagioclase
K-Feldspar
Plagioclase
Clays
K-Feldspar
Quartz/Mica/Clays
K-Feldspar
Plagioclase
K-Feldspar
K-Feldspar
Clays
Quartz
Quartz
Quartz
Quartz
Quartz
Sample18(94.25m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/07/03 12:23:45 PM - Company: VPI Hanoi

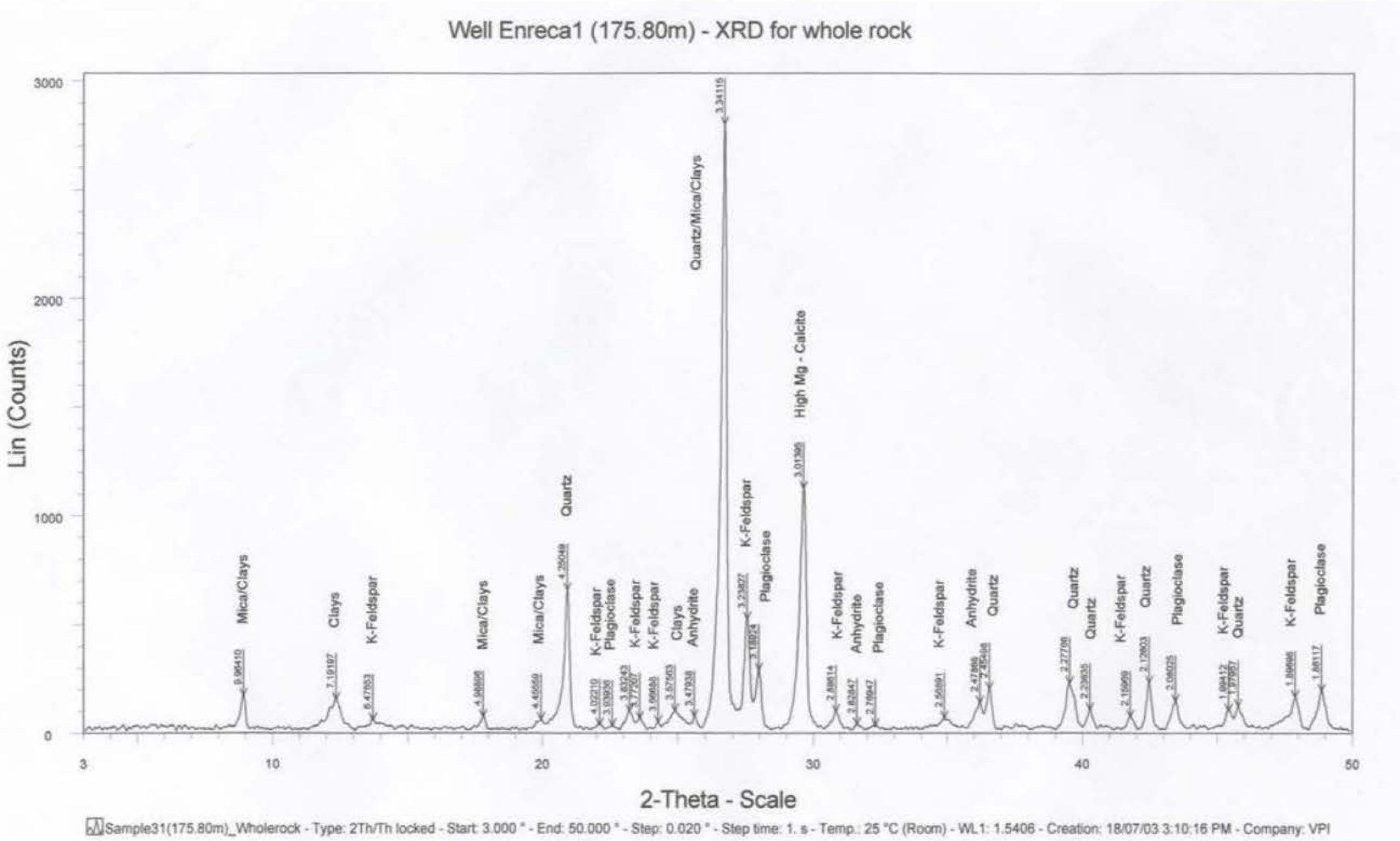

Well Enreca1 (107.15m) - XRD for whole rock
Lin (Counts)
1000
0
3
10
20
30
40
50
2-Theta - Scale
Clays
Mica/Clays
Clays
K-Feldspar
Mica/Clays
Mica/Clays
Quartz
Clays
Quartz/Mica/Clays
K-Feldspar
Plagioclase
K-Feldspar
High Mg - Calcite
K-Feldspar
K-Feldspar
Pyrite
Clays
K-Feldspar
Quartz
Plagioclase
Quartz
Quartz
Quartz
Plagioclase
Quartz
K-Feldspar
Sample20(107.15m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 12/08/03 2:50:11 PM - Company: VPI Hanoi

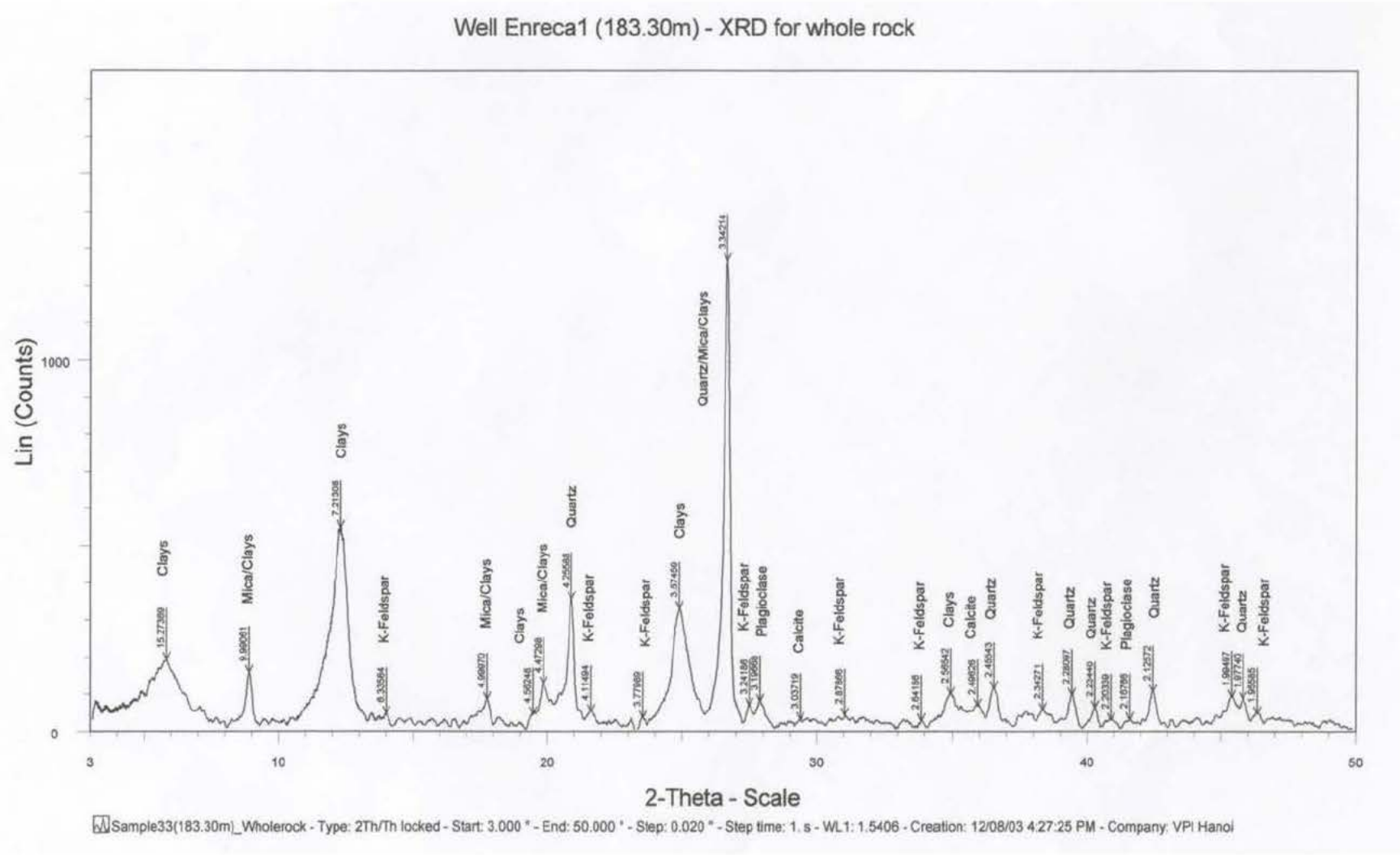

Well Enreca1 (117.75m) - XRD for whole rock
Lin (Counts)
2-Theta - Scale
Clays
Mica/Clays
Clays
K-Feldspar
Mica/Clays
Mica/Clays
Quartz
Plagioclase
K-Feldspar
K-Feldspar
Clays
Quartz/Mica/Clays
K-Feldspar
Plagioclase
K-Feldspar
K-Feldspar
Clays
Quartz
K-Feldspar
Quartz
Quartz
Plagioclase
Quartz
Plagioclase
K-Feldspar
Quartz
K-Feldspar
Plagioclase
Sample22(117.75m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/07/03 2:54:26 PM - Company: VPI Hanoi

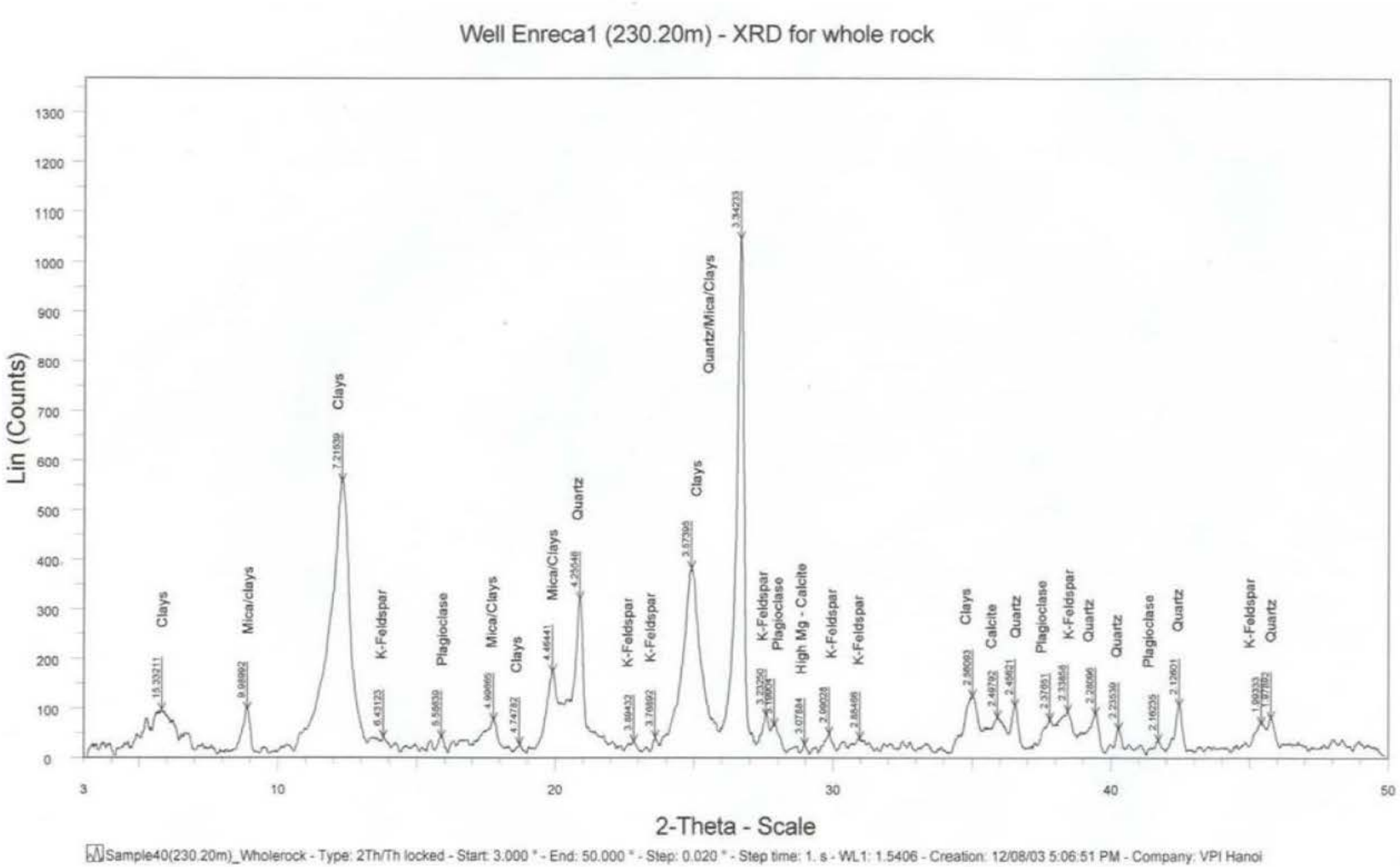

Well Enreca1 (122.85m) - XRD for whole rock
Lin (Counts)
2000
1000
0
3
10
20
30
40
50
2-Theta - Scale
Clays
Mica/Clays
Clays
K-Feldspar
Plagioclase
Mica/Clays
Mica/Clays
Quartz
Clays
Quartz/Mica/Clays
K-Feldspar
Plagioclase
K-Feldspar
K-Feldspar
Clays
Quartz
K-Feldspar
Plagioclase
Quartz
Quartz
K-Feldspar
Plagiocalse
Quartz
K-Feldspar
Quartz
K-Feldspar
Sample23(122.85m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 12/08/03 3:29:37 PM - Company: VPI Hanoi

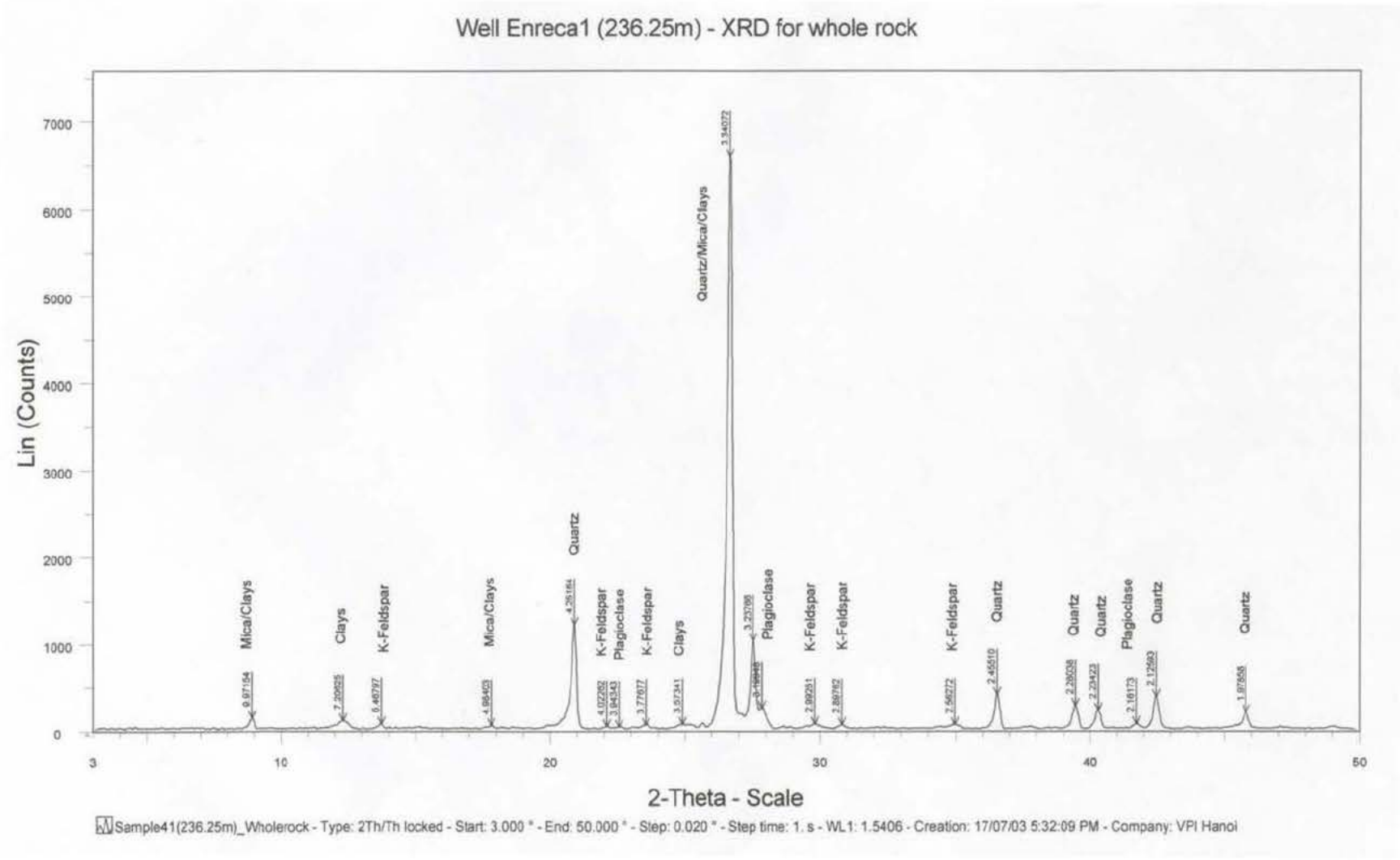

Well Enreca1 (139.80m) - XRD for whole rock
Lin (Counts)
2-Theta - Scale
Clays
Mica/Clays
Clays
Plagioclase
Mica/Clays
Mica/Clays
Quartz
Plagioclase
K-Feldspar
Clays
Quartz/Mica/Clays
K-Feldspar
Plagioclase
K-Feldspar
K-Feldspar
Clays
K-Feldspar
Quartz
Quartz
Quartz
K-Feldspar
Plagioclase
Quartz
Plagioclase
Quartz
K-Feldspar
Plagioclase
Sample25(139.80m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/07/03 3:33:52 PM - Company: VPI Hanoi

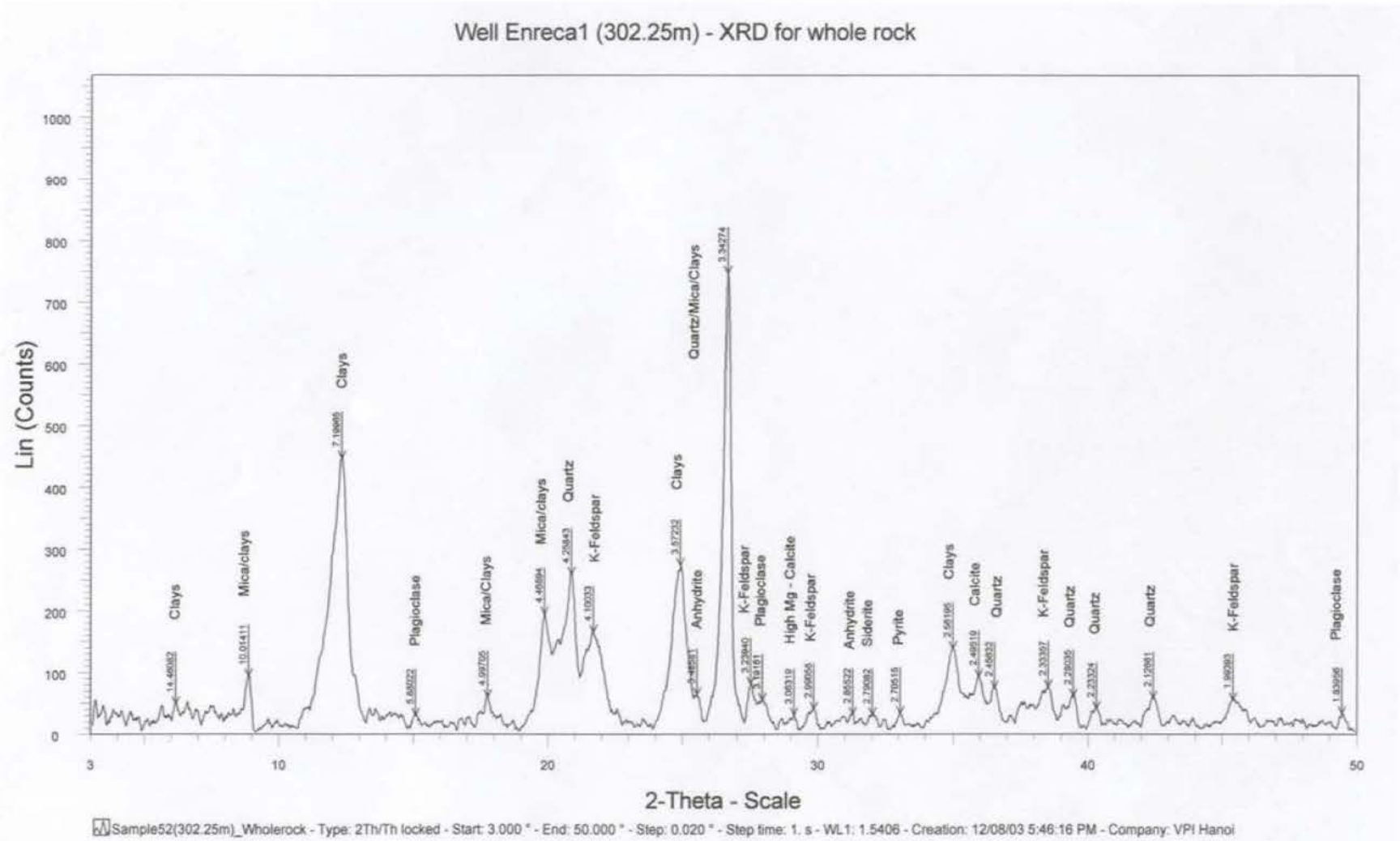

Well Enreca1 (164.75m) - XRD for whole rock
Lin (Counts)
2-Theta - Scale
Mica/Clays
Clays
Plagioclase
Mica/Clays
Mica/Clays
Quartz
K-Feldspar
K-Feldspar
Clays
Anhydrite
Quartz/Mica/Clays
K-Feldspar
Plagioclase
High Mg - Calcite
K-Feldspar
Anhydrite
K-Feldspar
Clays
Quartz
Quartz
Quartz
Plagioclase
Quartz
Quartz
Sample29(164.75m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/07/03 4:13:18 PM - Company: VPI Hanoi

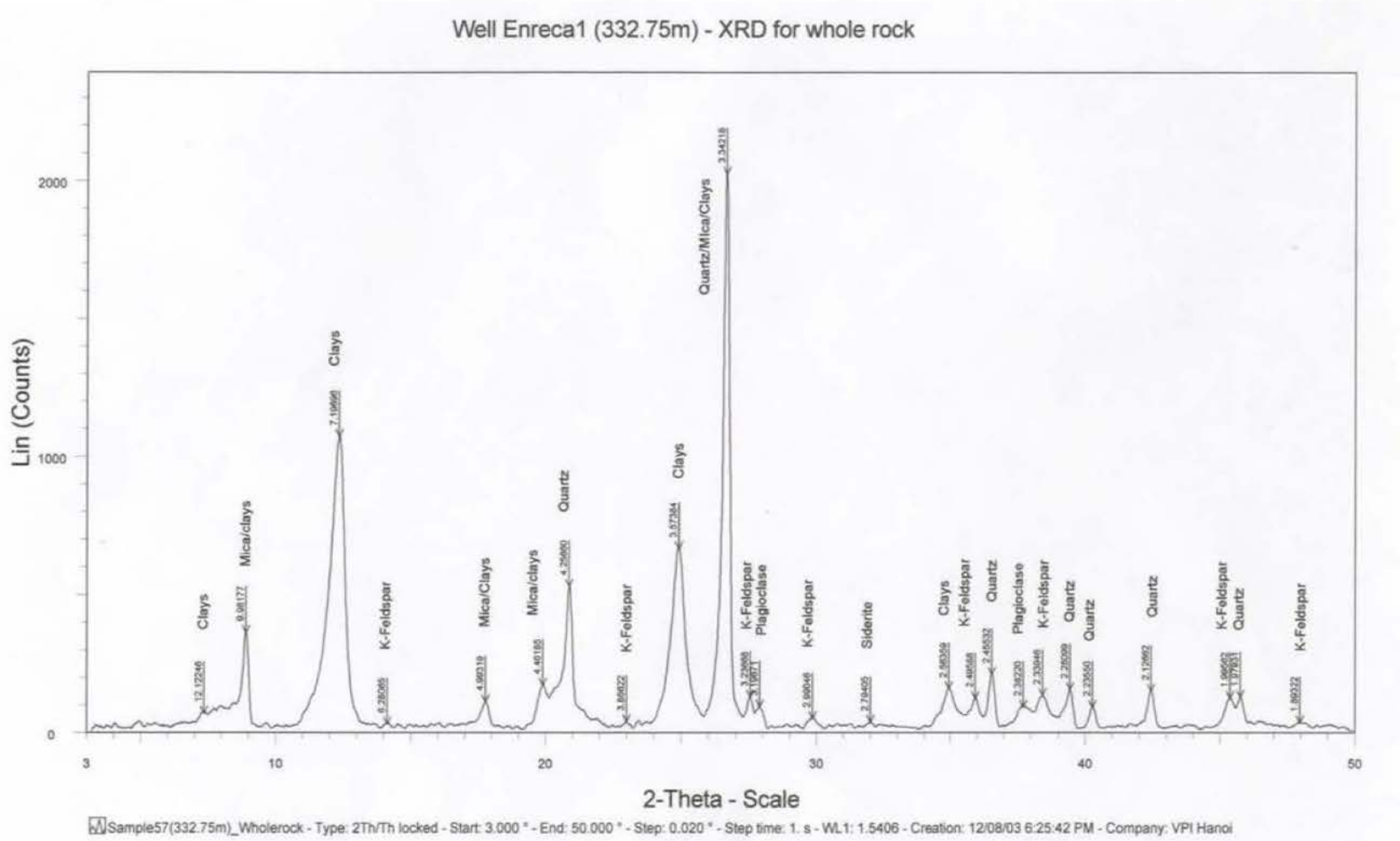

Well Enreca1 (175.80m) - XRD for whole rock
Lin (Counts)
2-Theta - Scale
Mica/Clays
Clays
K-Feldspar
Mica/Clays
Mica/Clays
Quartz
K-Feldspar
Plagioclase
K-Feldspar
K-Feldspar
Clays
Anhydrite
Quartz/Mica/Clays
K-Feldspar
Plagioclase
High Mg - Calcite
K-Feldspar
Anhydrite
Plagioclase
K-Feldspar
Anhydrite
Quartz
Quartz
Quartz
K-Feldspar
Quartz
Plagioclase
K-Feldspar
Quartz
K-Feldspar
Plagioclase
Sample31(175.80m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - Temp.: 25 °C (Room) - WL1: 1.5406 - Creation: 18/07/03 3:10:16 PM - Company: VPI

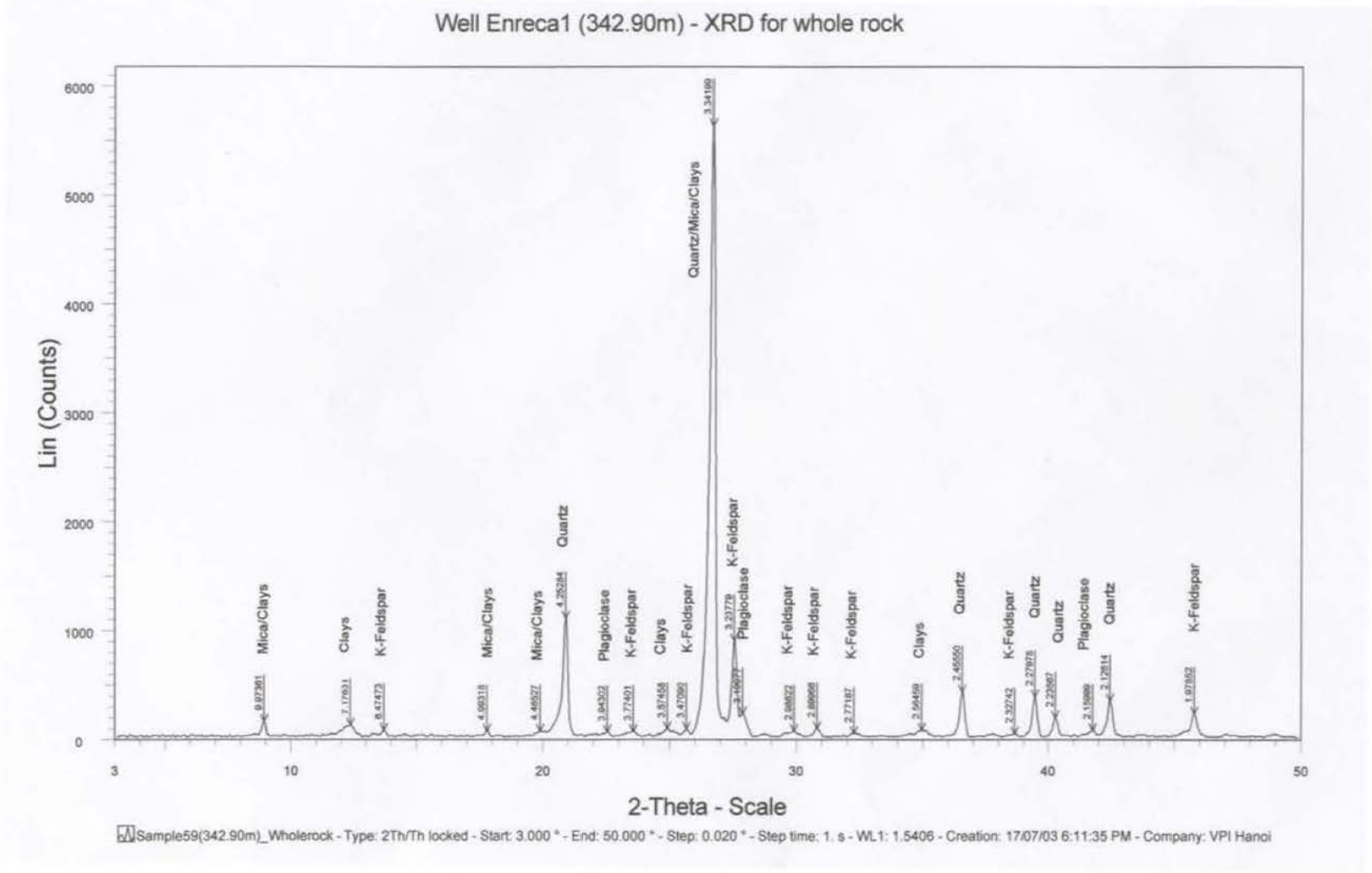

Well Enreca1 (183.30m) - XRD for whole rock
Lin (Counts)
1000
0
3
10
20
30
40
50
2-Theta - Scale
15.27389
Clays
9.99061
Mica/Clays
7.21306
Clays
6.33564
K-Feldspar
4.99872
Mica/Clays
4.56246
Clays
4.47298
Mica/Clays
4.25588
Quartz
4.11494
K-Feldspar
3.77669
K-Feldspar
3.57459
Clays
3.34214
Quartz/Mica/Clays
3.24186
K-Feldspar
3.19668
Plagioclase
3.03719
Calcite
2.87886
K-Feldspar
2.64186
K-Feldspar
2.56542
Clays
2.49528
Calcite
2.46543
Quartz
2.34271
K-Feldspar
2.28097
Quartz
2.23449
Quartz
2.20339
K-Feldspar
2.16798
Plagioclase
2.12572
Quartz
1.99497
K-Feldspar
1.97742
Quartz
1.95585
K-Feldspar
Sample33(183.30m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 12/08/03 4:27:25 PM - Company: VPI Hanoi

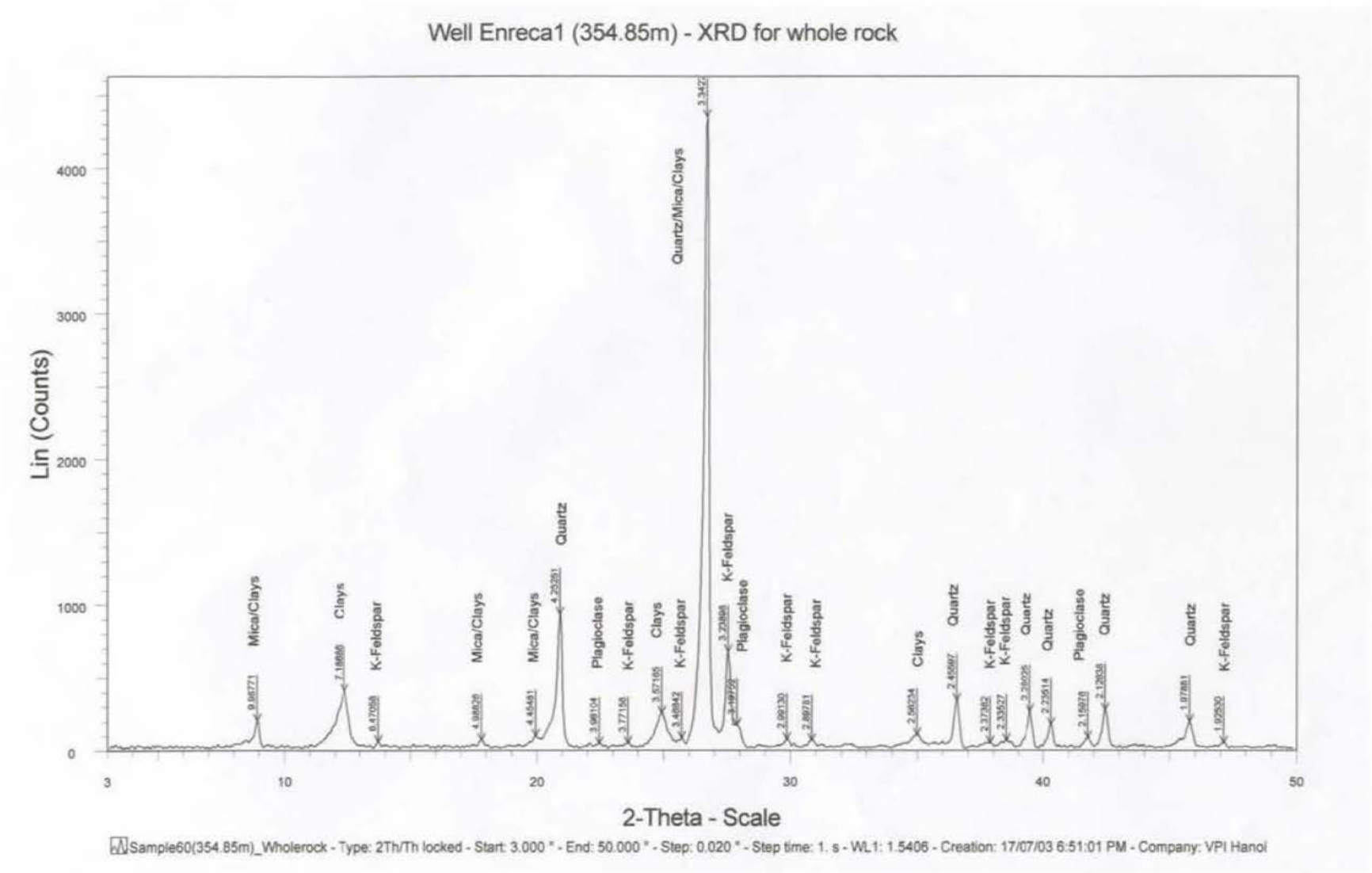

Well Enreca1 (230.20m) - XRD for whole rock
Lin (Counts)
2-Theta - Scale
Clays
Mica/clays
Clays
K-Feldspar
Plagioclase
Mica/Clays
Clays
Mica/Clays
Quartz
K-Feldspar
K-Feldspar
Clays
Quartz/Mica/Clays
K-Feldspar
Plagioclase
High Mg - Calcite
K-Feldspar
K-Feldspar
Clays
Calcite
Quartz
Plagioclase
K-Feldspar
Quartz
Quartz
Plagioclase
Quartz
K-Feldspar
Quartz
Sample40(230.20m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 12/08/03 5:06:51 PM - Company: VPI Hanoi


Well Enreca1 (236.25m) - XRD for whole rock
Lin (Counts)
2-Theta - Scale
Mica/Clays
Clays
K-Feldspar
Mica/Clays
Quartz
K-Feldspar
Plagioclase
K-Feldspar
Clays
Quartz/Mica/Clays
Plagioclase
K-Feldspar
K-Feldspar
K-Feldspar
Quartz
Quartz
Quartz
Plagioclase
Quartz
Quartz
Sample41(236.25m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/07/03 5:32:09 PM - Company: VPI Hanoi

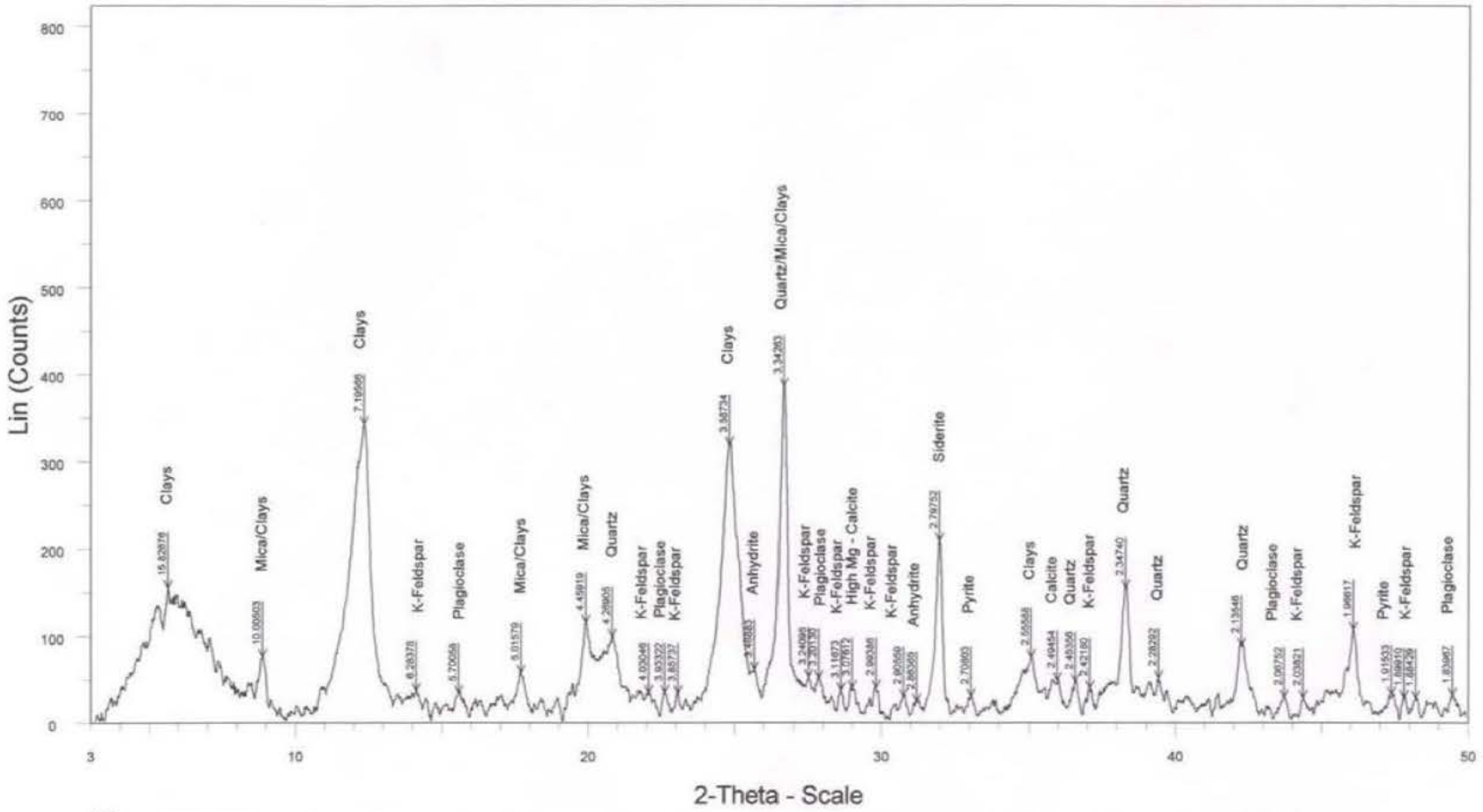

Well Enreca1 (302.25m) - XRD for whole rock
Lin (Counts)
2-Theta - Scale
Clays
Mica/clays
Clays
Plagioclase
Mica/Clays
Mica/clays
Quartz
K-Feldspar
Clays
Anhydrite
Quartz/Mica/Clays
K-Feldspar
Plagioclase
High Mg - Calcite
K-Feldspar
Anhydrite
Siderite
Pyrite
Clays
Calcite
Quartz
K-Feldspar
Quartz
Quartz
Quartz
K-Feldspar
Plagioclase
Sample52(302.25m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 12/08/03 5:46:16 PM - Company: VPI Hanoi


Well Enreca1 (332.75m) - XRD for whole rock
Lin (Counts)
2000
1000
0
3
10
20
30
40
50
2-Theta - Scale
12.17246
Clays
9.98177
Mica/clays
7.19668
Clays
6.28066
K-Feldspar
4.98319
Mica/Clays
4.46188
Mica/clays
4.25680
Quartz
3.89822
K-Feldspar
3.57384
Clays
3.34218
Quartz/Mica/Clays
3.22688
3.19671
K-Feldspar
Plagioclase
2.99048
K-Feldspar
2.79405
Siderite
2.58358
Clays
2.49568
K-Feldspar
2.45532
Quartz
2.38220
Plagioclase
2.33846
K-Feldspar
2.28099
Quartz
2.23550
Quartz
2.12992
Quartz
1.99562
K-Feldspar
1.97631
Quartz
1.89232
K-Feldspar
Sample57(332.75m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 12/08/03 6:25:42 PM - Company: VPI Hanoi

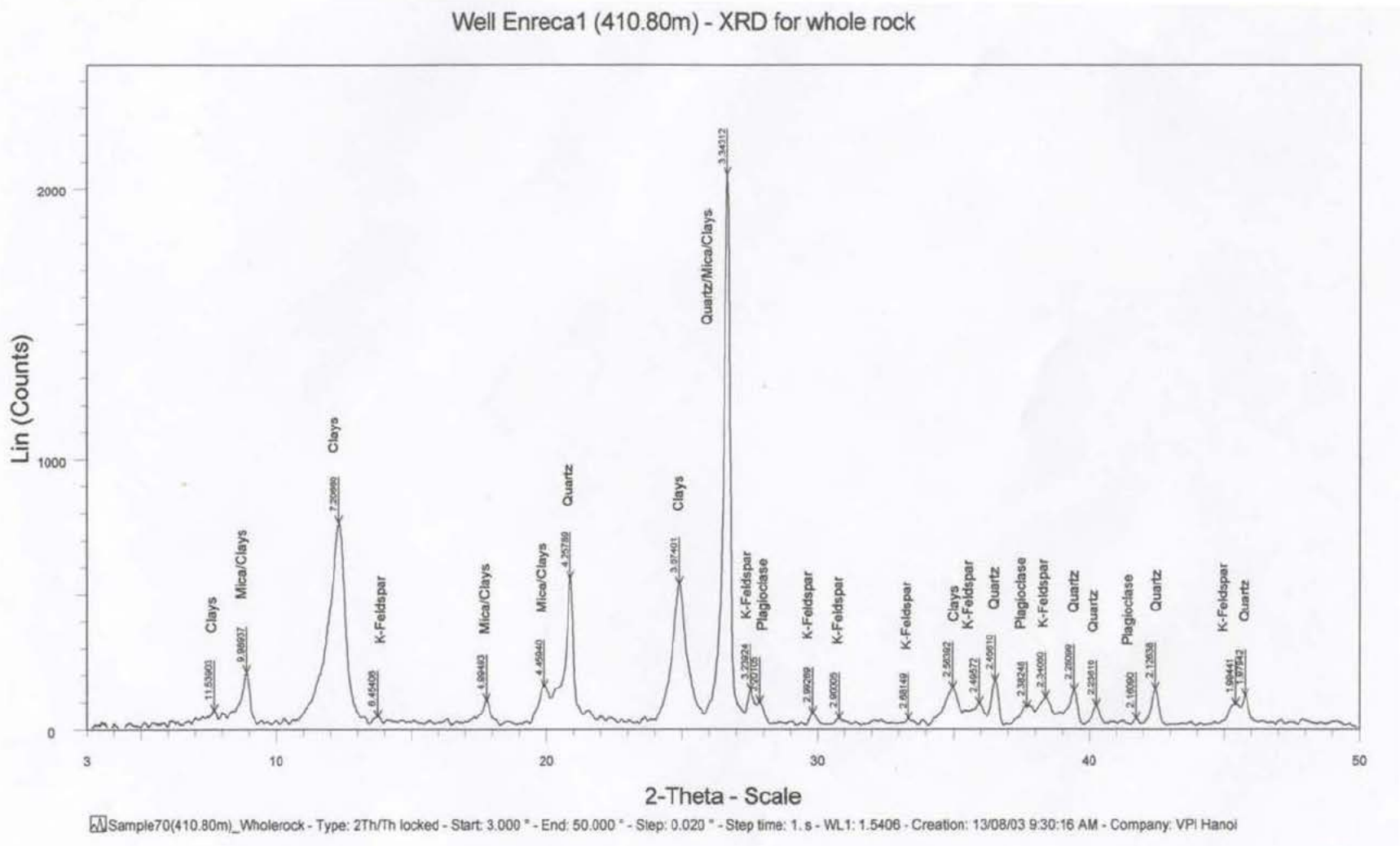

Well Enreca1 (342.90m) - XRD for whole rock
Lin (Counts)
2-Theta - Scale
Mica/Clays
Clays
K-Feldspar
Mica/Clays
Mica/Clays
Quartz
Plagioclase
K-Feldspar
Clays
K-Feldspar
Quartz/Mica/Clays
K-Feldspar
Plagioclase
K-Feldspar
K-Feldspar
K-Feldspar
Clays
Quartz
K-Feldspar
Quartz
Quartz
Plagioclase
Quartz
K-Feldspar
Sample59(342.90m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/07/03 6:11:35 PM - Company: VPI Hanoi

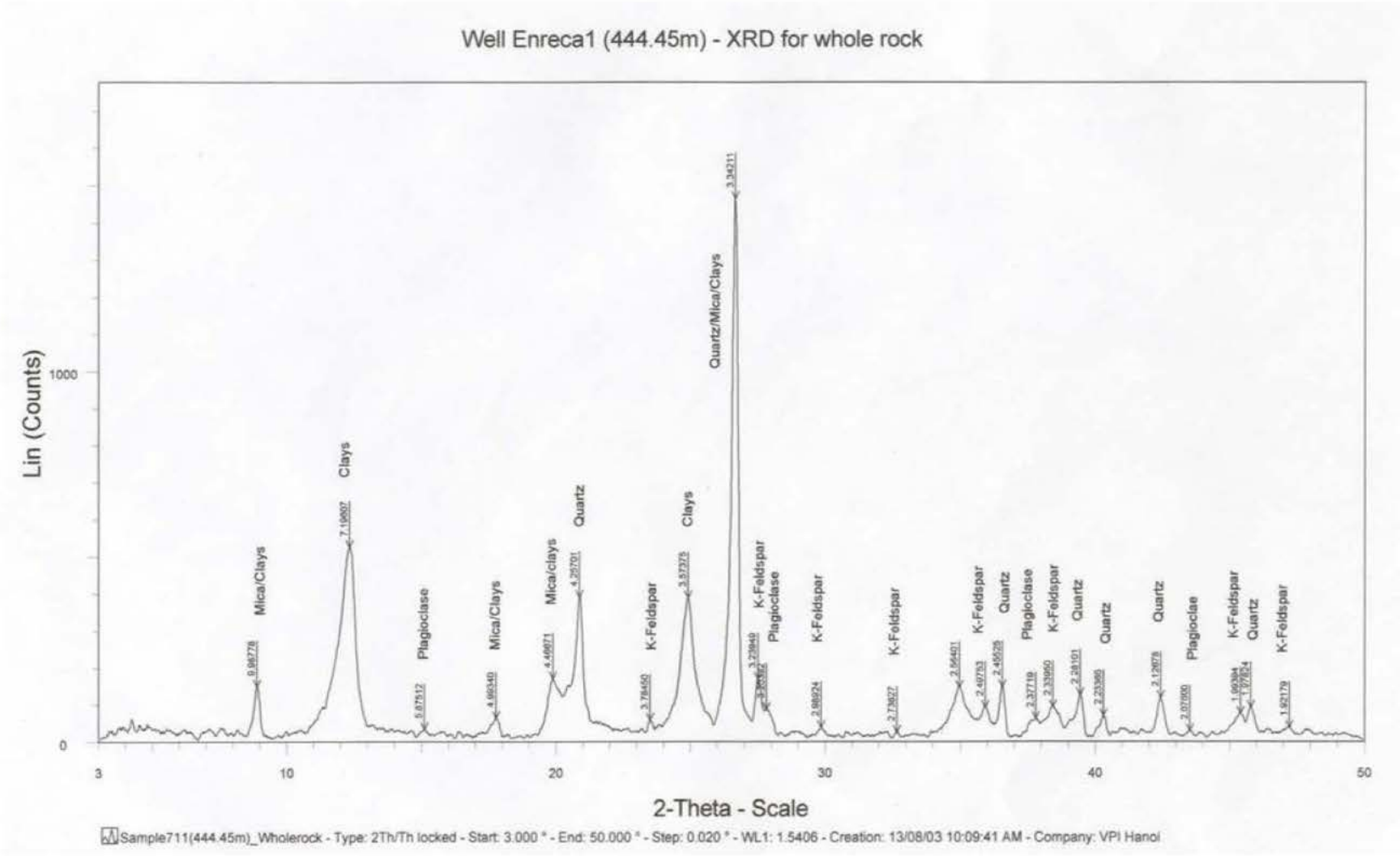

Well Enreca1 (354.85m) - XRD for whole rock
Lin (Counts)
2-Theta - Scale
Mica/Clays
Clays
K-Feldspar
Mica/Clays
Mica/Clays
Quartz
Plagioclase
K-Feldspar
Clays
K-Feldspar
Quartz/Mica/Clays
K-Feldspar
Plagioclase
K-Feldspar
K-Feldspar
Clays
Quartz
K-Feldspar
K-Feldspar
Quartz
Quartz
Plagioclase
Quartz
Quartz
K-Feldspar
Sample60(354.85m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/07/03 6:51:01 PM - Company: VPI Hanoi

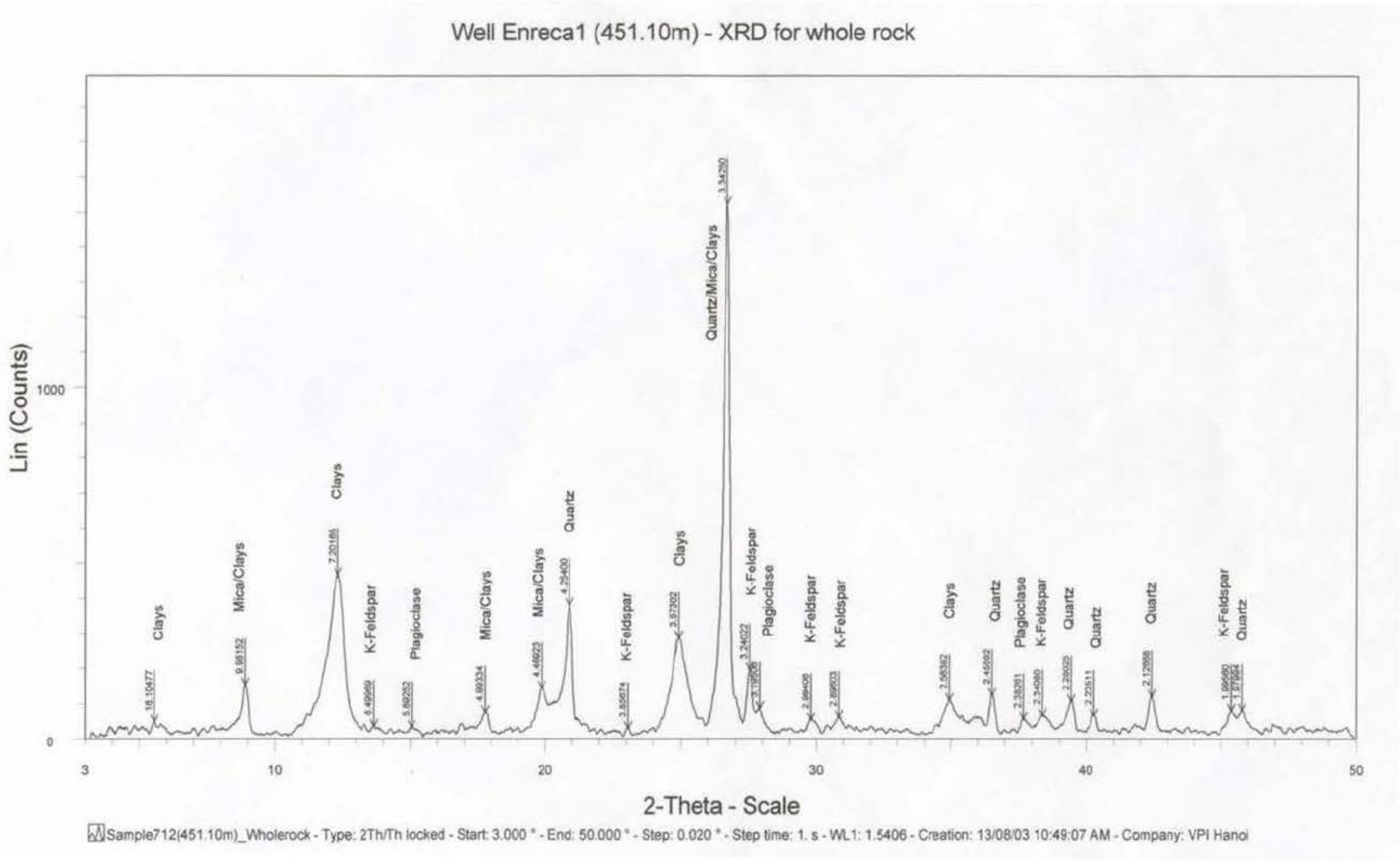
Well Enreca1 (364.20m) - XRD for whole rock



Sample62(364.2m)_Whole - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 13/08/03 3:26:17 PM - Company: VPI Hanoi

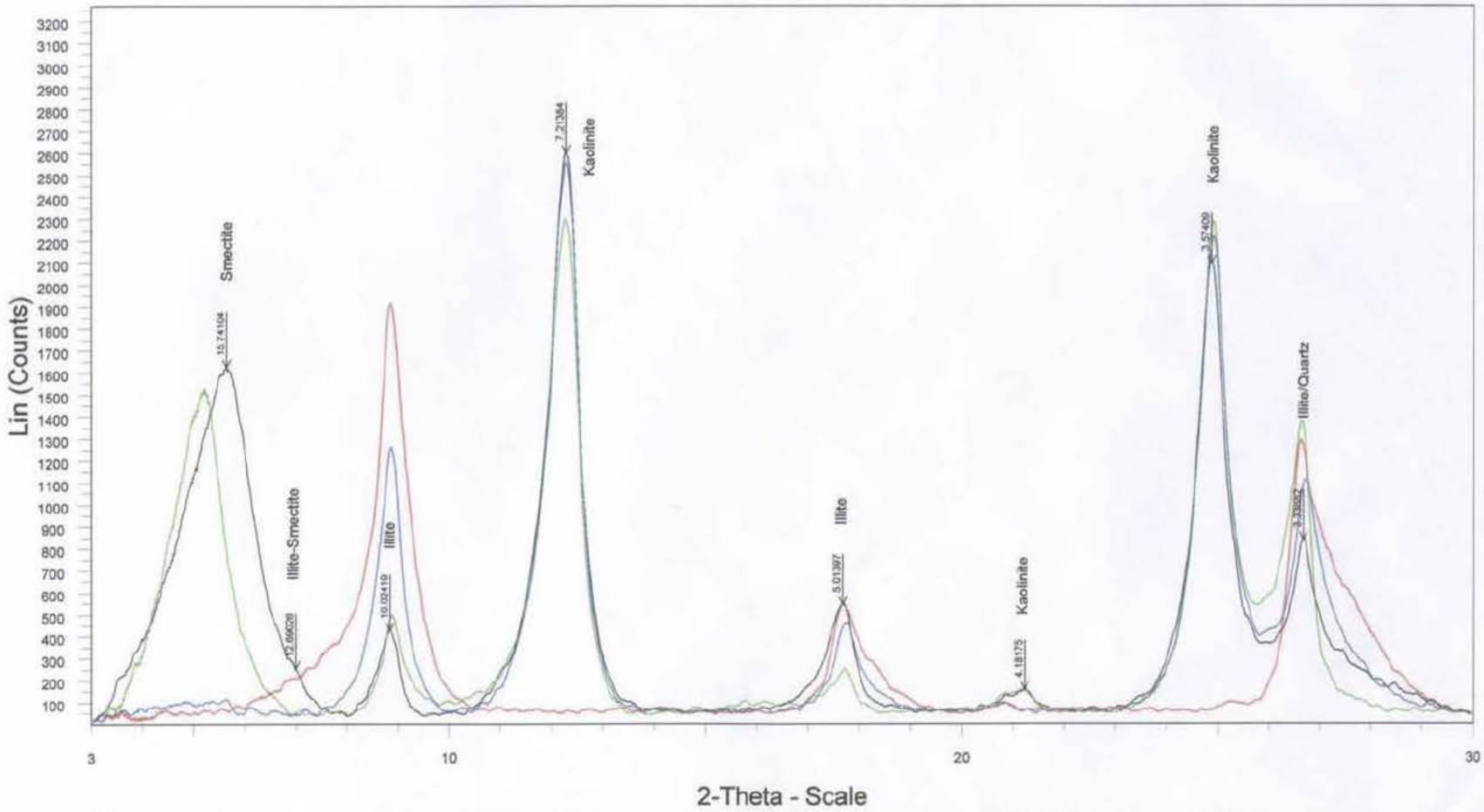

Well Enreca1 (410.80m) - XRD for whole rock
Lin (Counts)
2000
1000
0
3
10
20
30
40
50
2-Theta - Scale
Clays
Mica/Clays
Clays
K-Feldspar
Mica/Clays
Mica/Clays
Quartz
Clays
Quartz/Mica/Clays
K-Feldspar
Plagioclase
K-Feldspar
K-Feldspar
K-Feldspar
Clays
K-Feldspar
Quartz
Plagioclase
K-Feldspar
Quartz
Quartz
Plagioclase
Quartz
K-Feldspar
Quartz
11.53603
9.86937
7.20689
6.45406
4.89483
4.46940
4.25789
3.97401
3.34312
3.22924
3.20108
2.99269
2.90005
2.68149
2.56092
2.49577
2.46610
2.38248
2.34090
2.28099
2.23618
2.16990
2.12838
1.98441
1.97942
Sample70(410.80m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 13/08/03 9:30:16 AM - Company: VPI Hanoi


Well Enreca1 (444.45m) - XRD for whole rock
Lin (Counts)
1000
0
3
10
20
30
40
50
2-Theta - Scale
Mica/Clays
Clays
Plagioclase
Mica/Clays
Mica/clays
Quartz
K-Feldspar
Clays
Quartz/Mica/Clays
K-Feldspar
Plagioclase
K-Feldspar
K-Feldspar
K-Feldspar
Quartz
Plagioclase
K-Feldspar
Quartz
Quartz
Quartz
Plagioclase
K-Feldspar
Quartz
K-Feldspar
Sample711(444.45m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - WL1: 1.5406 - Creation: 13/08/03 10:09:41 AM - Company: VPI Hanoi


Well Enreca1 (451.10m) - XRD for whole rock
Lin (Counts)
1000
0
3
10
20
30
40
50
2-Theta - Scale
16.10477
Clays
9.98152
Mica/Clays
7.20166
Clays
6.49469
K-Feldspar
5.89252
Plagioclase
4.99334
Mica/Clays
4.48923
Mica/Clays
4.25400
Quartz
3.65674
K-Feldspar
3.37302
Clays
3.34250
Quartz/Mica/Clays
3.24022
K-Feldspar
3.19506
Plagioclase
2.99426
K-Feldspar
2.89503
K-Feldspar
2.58382
Clays
2.45592
Quartz
2.36261
Plagioclaso
2.34080
K-Feldspar
2.28029
Quartz
2.22511
Quartz
2.12858
Quartz
1.99660
K-Feldspar
1.97994
Quartz
Sample712(451.10m)_Wholerock - Type: 2Th/Th locked - Start: 3.000 ° - End: 50.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 13/08/03 10:49:07 AM - Company: VPI Hanoi

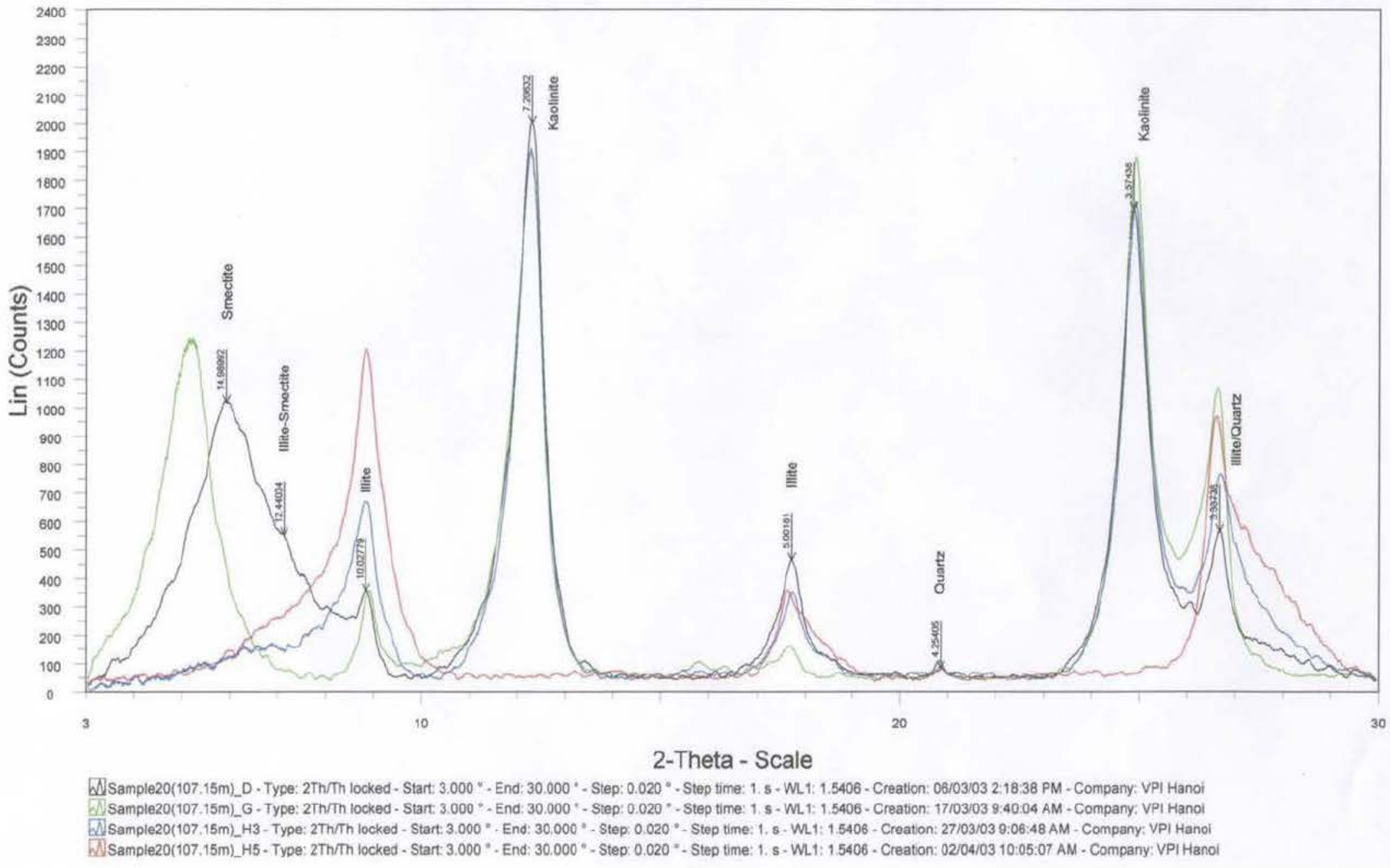
Diffractograms of X-Ray for clay fraction of core samples from the Enreca-1 well

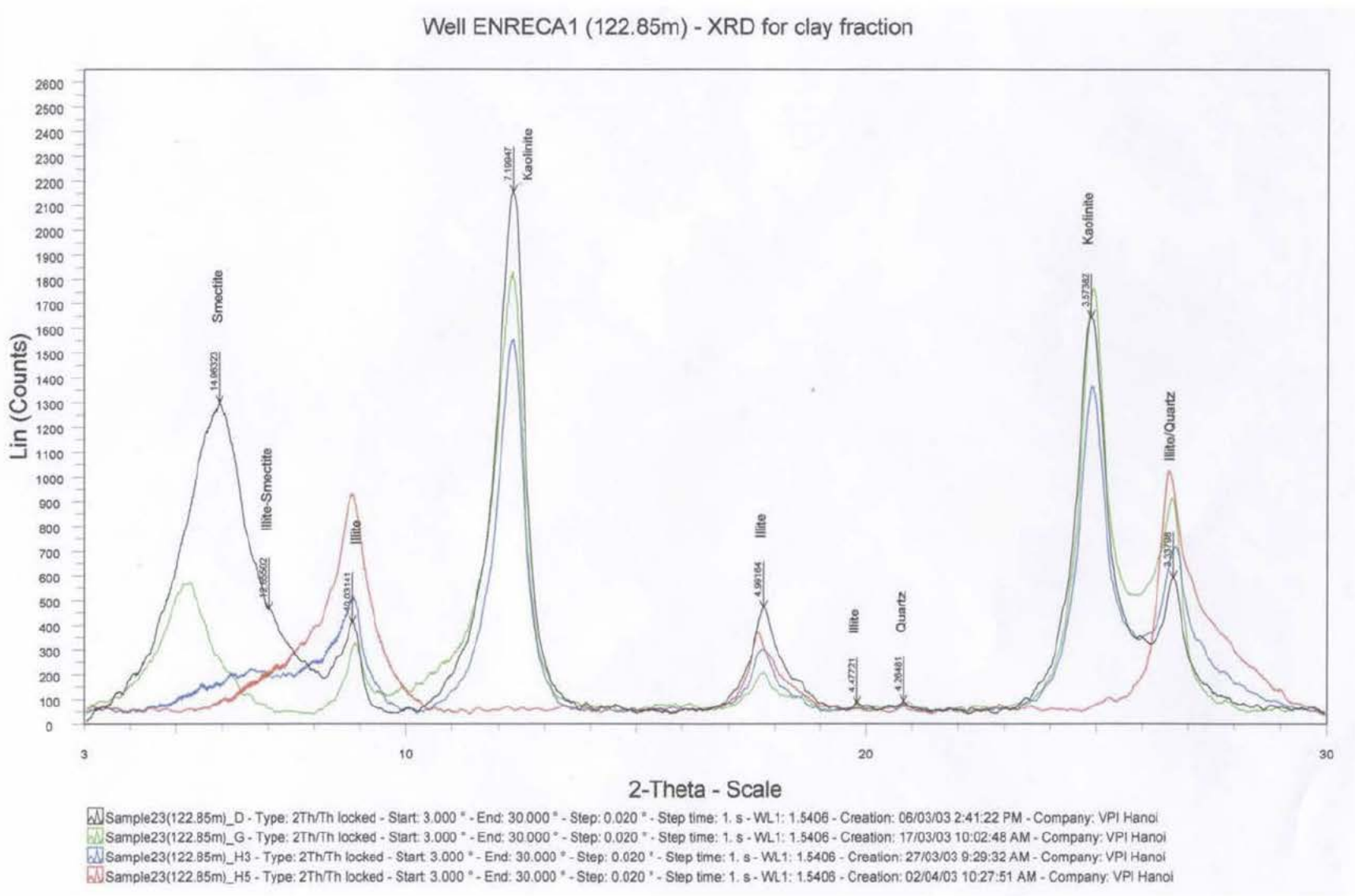
Well ENRECA 1 (15.75m) - XRD for clay fraction



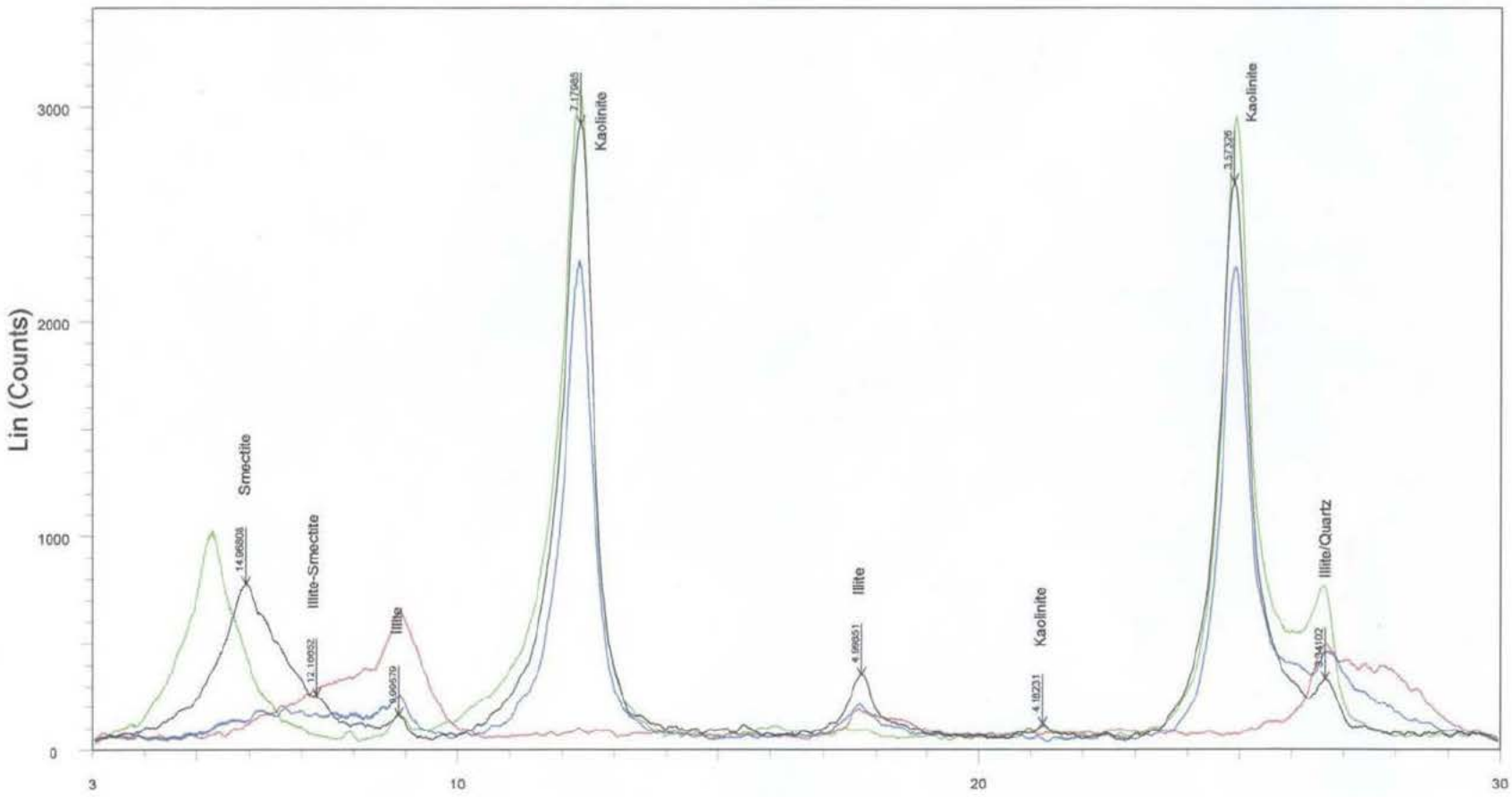
Sample3(15.75m)_D - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 28/02/03 9:31:01 AM - Company: VPI Hanoi
Sample3(15.75m)_G - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/03/03 8:54:47 AM - Company: VPI Hanoi
Sample3(15.75m)_H3 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 27/03/03 8:44:03 AM - Company: VPI Hanoi
Sample3(15.75m)_H5 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 02/04/03 9:42:23 AM - Company: VPI Hanoi

Well ENRECA1 (107.15m) - XRD for clay fraction

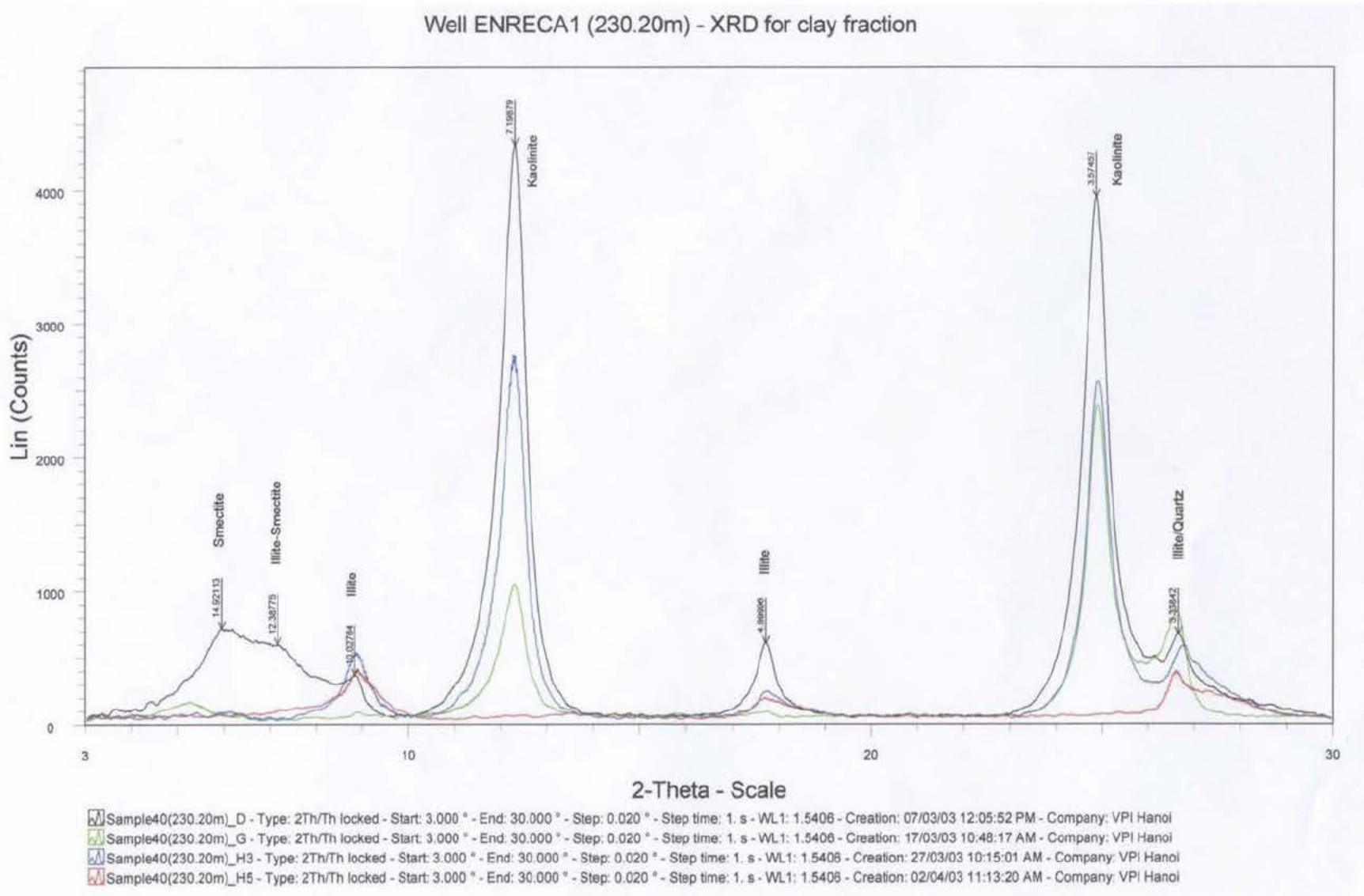


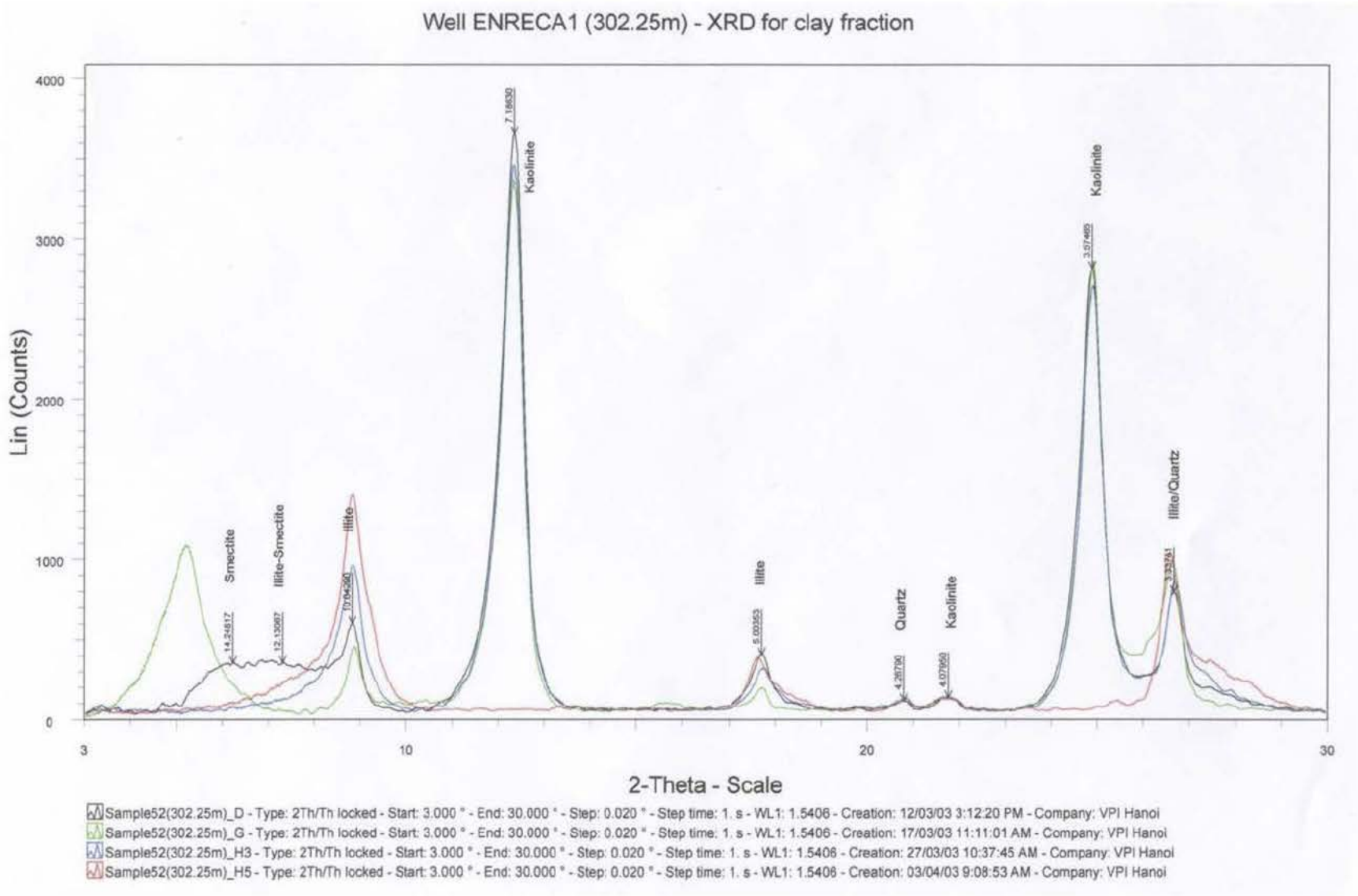

Well ENRECA1 (122.85m) - XRD for clay fraction
Lin (Counts)
2-Theta - Scale
Smectite
Illite-Smectite
Illite
Kaolinite
Illite
Illite
Quartz
Kaolinite
Illite/Quartz
14.06322
12.45502
10.03141
7.19947
4.99184
4.47721
4.26481
3.57382
3.33798
Sample23(122.85m)_D - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 06/03/03 2:41:22 PM - Company: VPI Hanoi
Sample23(122.85m)_G - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/03/03 10:02:48 AM - Company: VPI Hanoi
Sample23(122.85m)_H3 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 27/03/03 9:29:32 AM - Company: VPI Hanoi
Sample23(122.85m)_H5 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 02/04/03 10:27:51 AM - Company: VPI Hanoi

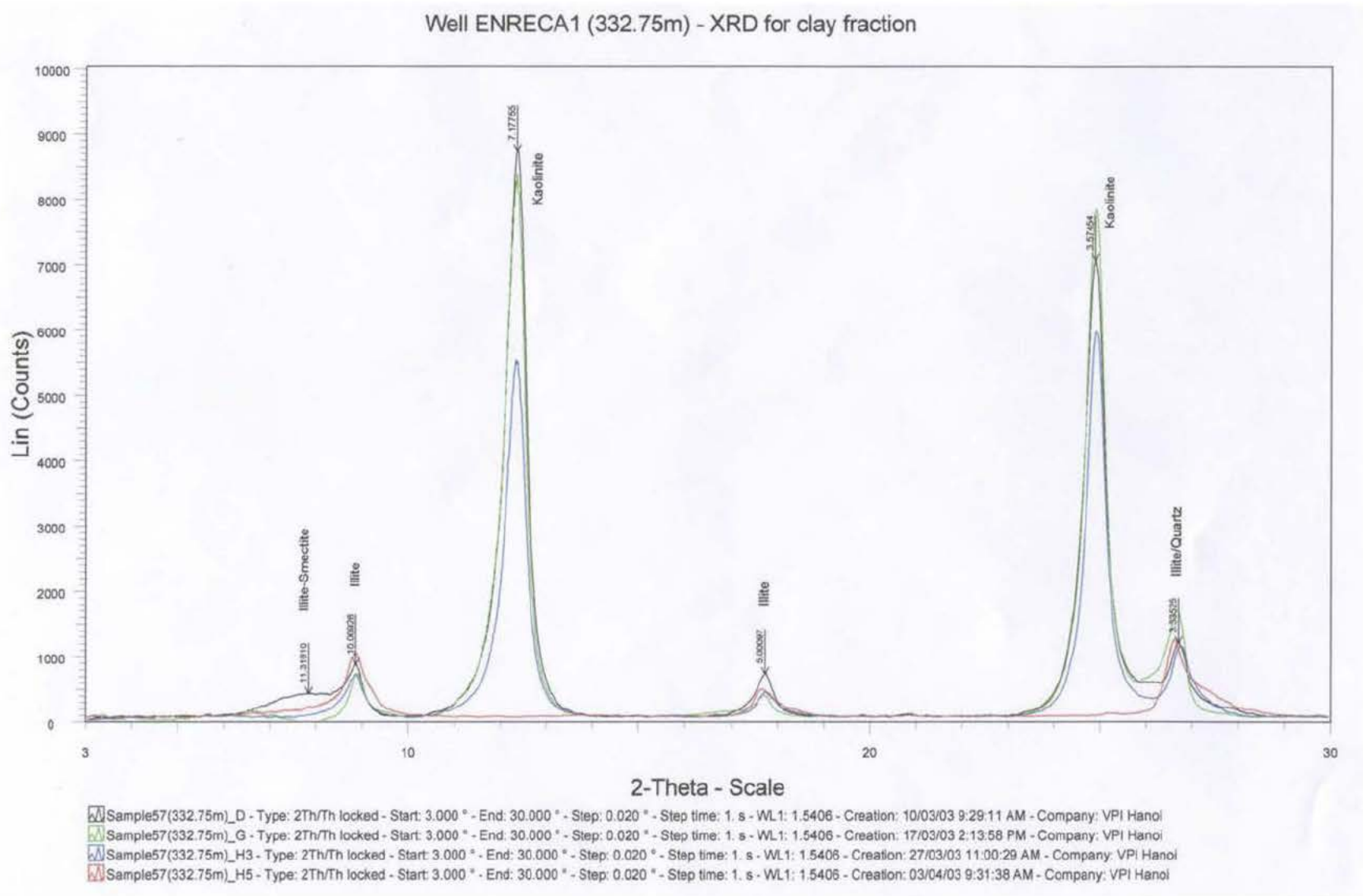
Well ENRECA1 (183.30m) - XRD for clay fraction

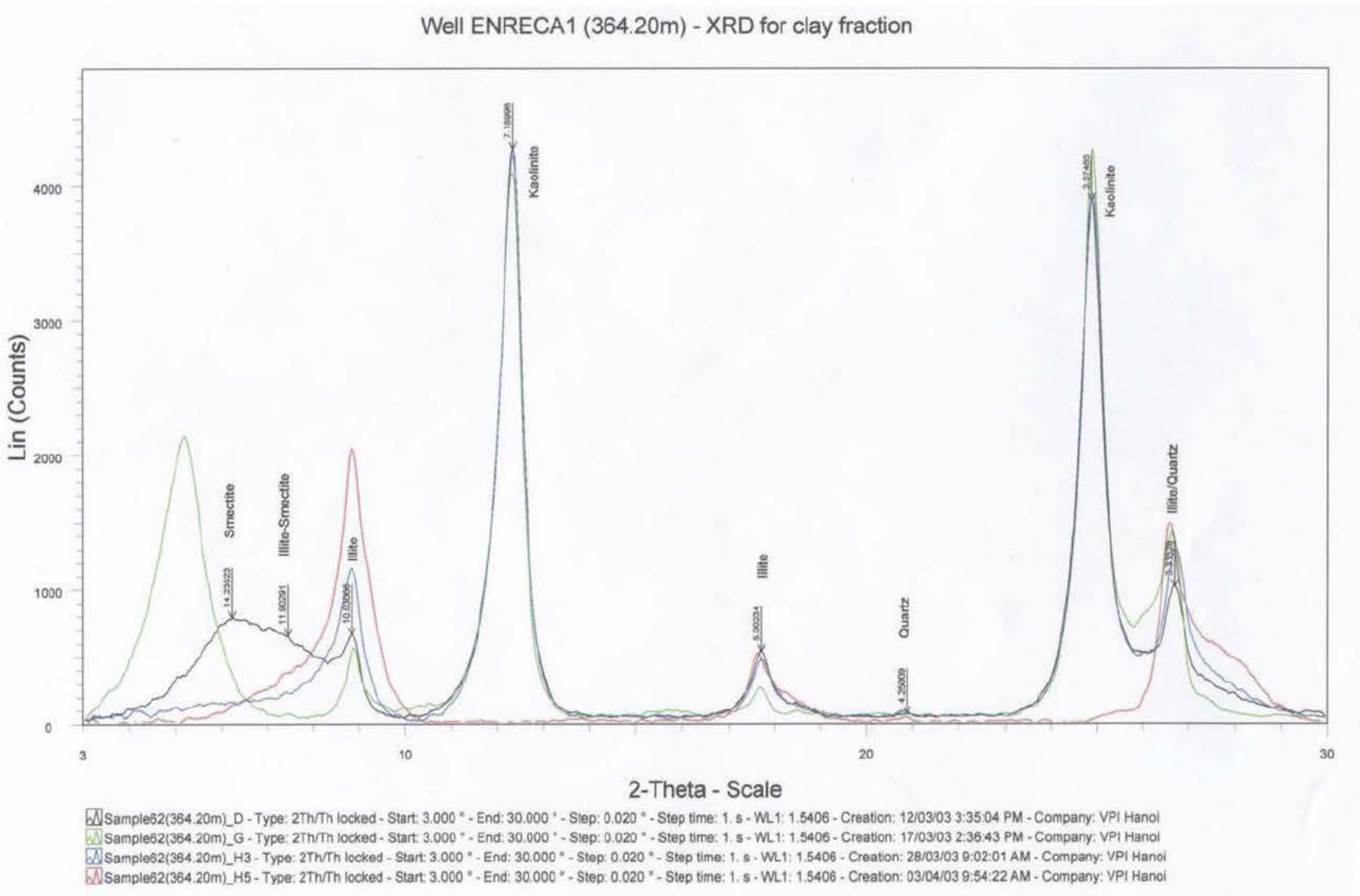


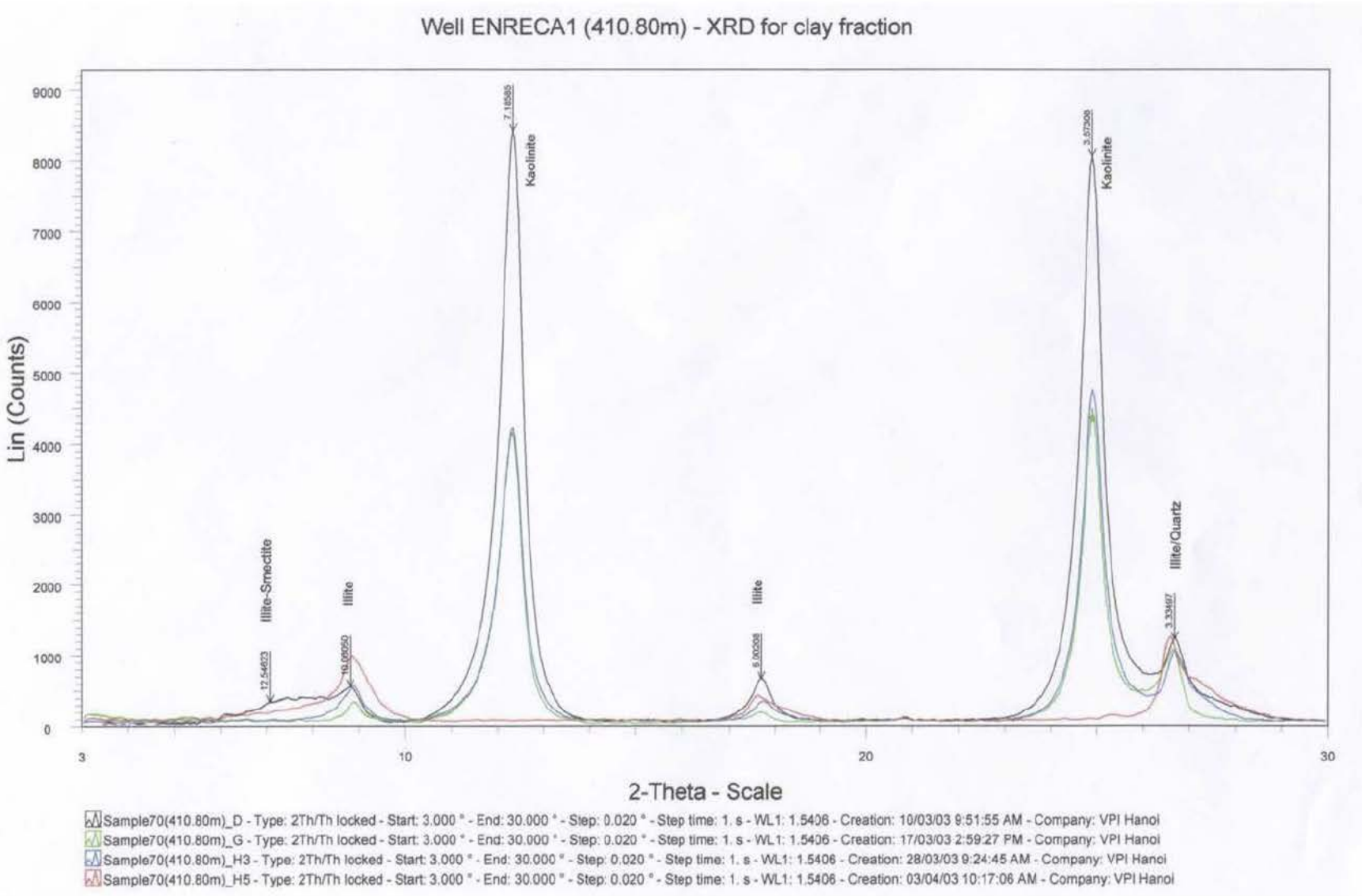
Sample33(183.30m)_D - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 07/03/03 11:43:08 AM - Company: VPI Hanoi
Sample33(183.30m)_G - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/03/03 10:25:32 AM - Company: VPI Hanoi
Sample33(183.30m)_H5 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 02/04/03 10:50:35 AM - Company: VPI Hanoi
Sample33(183.30m)_H3 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 27/03/03 9:52:16 AM - Company: VPI Hanoi


Well ENRECA1 (230.20m) - XRD for clay fraction
Lin (Counts)
2-Theta - Scale
Smectite
Illite-Smectite
Illite
Kaolinite
Illite
Kaolinite
Illite/Quartz
14.52113
12.38779
10.02784
7.19879
4.99990
3.57457
3.33842
Sample40(230.20m)_D - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 07/03/03 12:05:52 PM - Company: VPI Hanoi
Sample40(230.20m)_G - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/03/03 10:48:17 AM - Company: VPI Hanoi
Sample40(230.20m)_H3 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 27/03/03 10:15:01 AM - Company: VPI Hanoi
Sample40(230.20m)_H5 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 02/04/03 11:13:20 AM - Company: VPI Hanoi

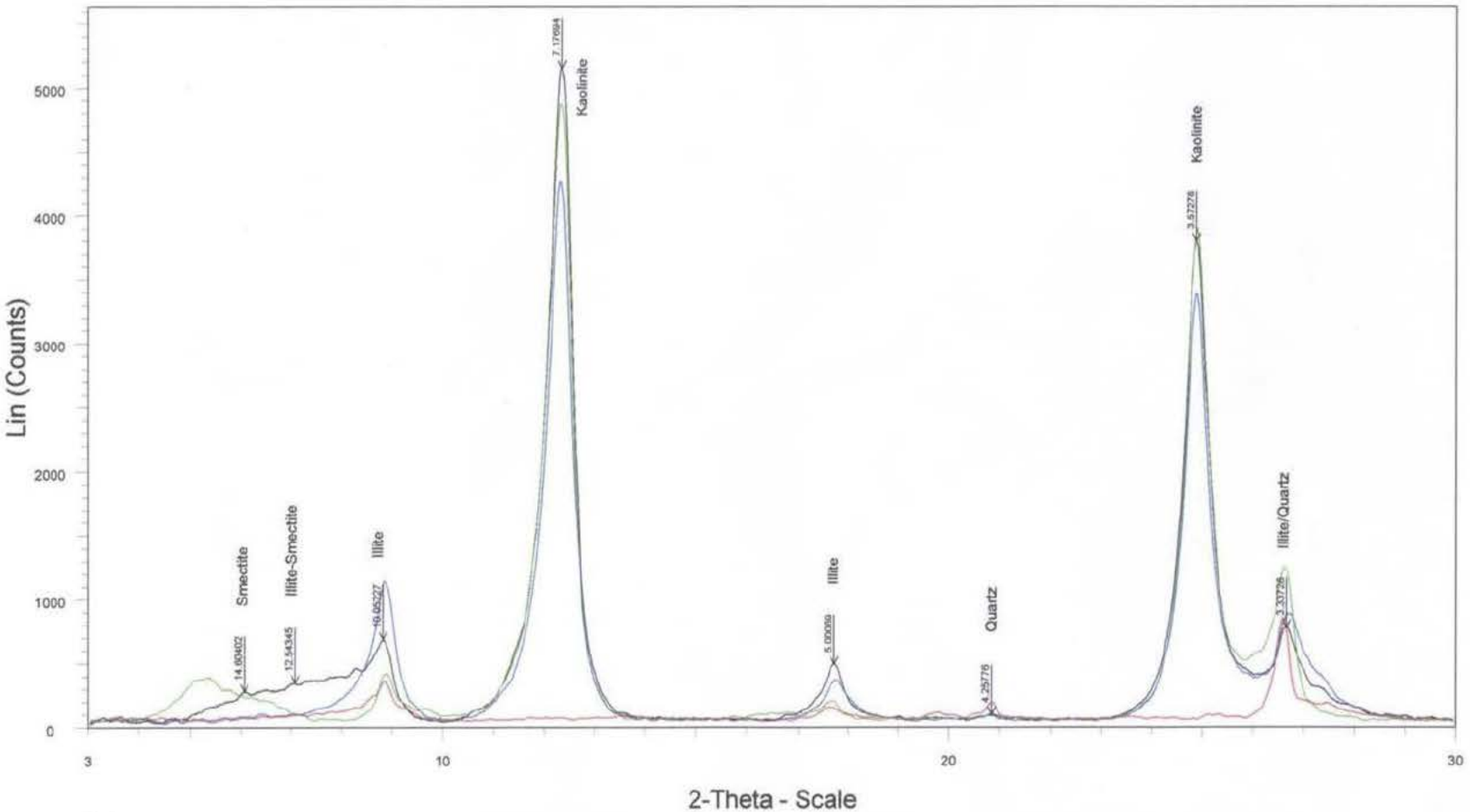

Well ENRECA1 (302.25m) - XRD for clay fraction
Lin (Counts)
2-Theta - Scale
Smectite
Illite-Smectite
Illite
Kaolinite
Illite
Quartz
Kaolinite
Kaolinite
Illite/Quartz
14.24617
12.13087
10.04590
7.18639
5.00353
4.26700
4.07969
3.57469
3.33741
Sample52(302.25m)_D - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 12/03/03 3:12:20 PM - Company: VPI Hanoi
Sample52(302.25m)_G - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/03/03 11:11:01 AM - Company: VPI Hanoi
Sample52(302.25m)_H3 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 27/03/03 10:37:45 AM - Company: VPI Hanoi
Sample52(302.25m)_H5 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 03/04/03 9:08:53 AM - Company: VPI Hanoi


Well ENRECA1 (332.75m) - XRD for clay fraction
Lin (Counts)
2-Theta - Scale
Illite-Smectite
11.31910
Illite
10.00926
7.17755
Kaolinite
5.00097
Illite
3.57454
Kaolinite
Illite/Quartz
3.33525
Sample57(332.75m)_D - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 10/03/03 9:29:11 AM - Company: VPI Hanoi
Sample57(332.75m)_G - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/03/03 2:13:58 PM - Company: VPI Hanoi
Sample57(332.75m)_H3 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 27/03/03 11:00:29 AM - Company: VPI Hanoi
Sample57(332.75m)_H5 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 03/04/03 9:31:38 AM - Company: VPI Hanoi

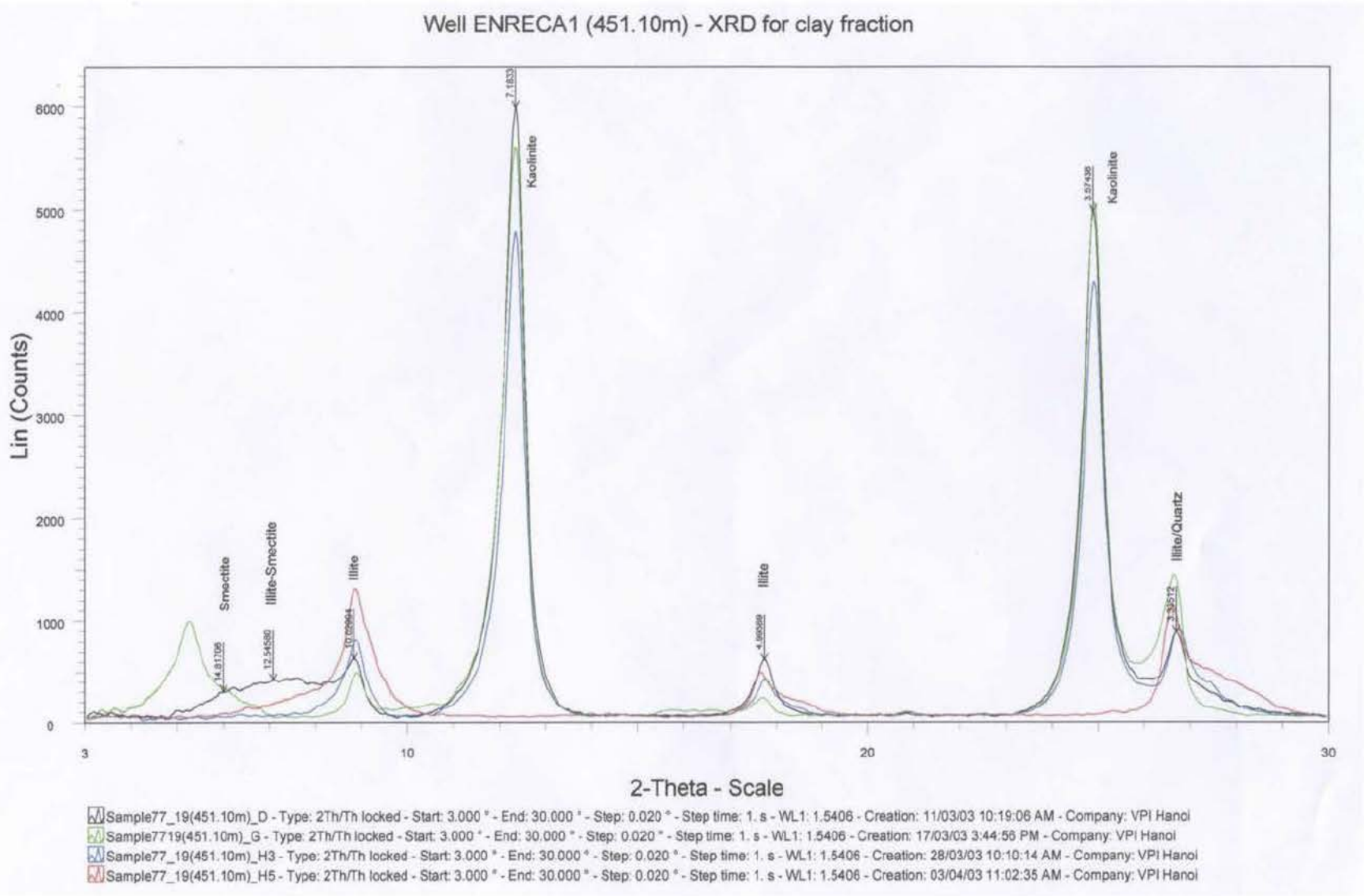

Well ENRECA1 (364.20m) - XRD for clay fraction
Lin (Counts)
2-Theta - Scale
Smectite
Illite-Smectite
Illite
Kaolinite
Quartz
Illite/Quartz
14.23523
11.90291
10.03056
7.18996
5.00234
4.25009
3.57485
3.33529
Sample62(364.20m)_D - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 12/03/03 3:35:04 PM - Company: VPI Hanoi
Sample62(364.20m)_G - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/03/03 2:36:43 PM - Company: VPI Hanoi
Sample62(364.20m)_H3 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 28/03/03 9:02:01 AM - Company: VPI Hanoi
Sample62(364.20m)_H5 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 03/04/03 9:54:22 AM - Company: VPI Hanoi


Well ENRECA1 (410.80m) - XRD for clay fraction
Lin (Counts)
2-Theta - Scale
Illite-Smectite
12.54623
Illite
10.00050
7.18585
Kaolinite
Illite
5.00008
3.57908
Kaolinite
Illite/Quartz
3.33497
Sample70(410.80m)_D - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 10/03/03 9:51:55 AM - Company: VPI Hanoi
Sample70(410.80m)_G - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/03/03 2:59:27 PM - Company: VPI Hanoi
Sample70(410.80m)_H3 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 28/03/03 9:24:45 AM - Company: VPI Hanoi
Sample70(410.80m)_H5 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 03/04/03 10:17:06 AM - Company: VPI Hanoi

Well ENRECA1 (444.45m) - XRD for clay fraction



Sample77_18(444.45m)_D - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 11/03/03 9:56:22 AM - Company: VPI Hanoi
Sample7718(444.45m)_G - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/03/03 3:22:11 PM - Company: VPI Hanoi
Sample77_18(444.45m)_H3 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 28/03/03 9:47:30 AM - Company: VPI Hanoi
Sample77_18(444.45m)_H5 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 03/04/03 10:39:51 AM - Company: VPI Hanoi


Well ENRECA1 (451.10m) - XRD for clay fraction
Lin (Counts)
2-Theta - Scale
Smectite
Illite-Smectite
Illite
Kaolinite
Illite
Kaolinite
Illite/Quartz
14.81706
12.54580
10.05964
7.16833
4.99099
3.57499
3.33512
Sample77_19(451.10m)_D - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 11/03/03 10:19:06 AM - Company: VPI Hanoi
Sample7719(451.10m)_G - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 17/03/03 3:44:56 PM - Company: VPI Hanoi
Sample77_19(451.10m)_H3 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 28/03/03 10:10:14 AM - Company: VPI Hanoi
Sample77_19(451.10m)_H5 - Type: 2Th/Th locked - Start: 3.000 ° - End: 30.000 ° - Step: 0.020 ° - Step time: 1. s - WL1: 1.5406 - Creation: 03/04/03 11:02:35 AM - Company: VPI Hanoi

Description of Wellsite Lithological Log of the Enreca-1 well

Wellsite lithological log of the Enreca-1 well

DESCRIPTION
(Numbers refer to the layers marked on the enclosed log)

1: SANDSTONE/GRAVEL/CONGLOMERATE, fine-grained, olive grey, loose. Some scattered conglomerate (diameter up to 10 cm) distributed in sandstone; claystone present at the lower part.

2: CONGLOMERATE, polymict (diameter up to 10cm), white to olive grey; comprising quartz, ryolite, granite, rounded, unconsolidated.

3: SANDSTONE, predominantly quartz, contains gravel, yellowish brown to greenish grey, unconsolidated, thickly bedded.

4: SILTSTONE, greenish grey, blackish, unconsolidated.

5: SANDSTONE, predominantly quartz, greenish grey to blackish grey, contain small amounts of coaly organic matter, thinly bedded.

6: SILTSTONE/SANDSTONE, greenish grey, white grey, unconsolidated.

7: SILTSTONE, greenish grey, unconsolidated, thinly bedded.

8: CLAYSTONE, greenish grey, consolidated, thickly bedded.

9: SANDSTONE, predominantly quartz, fine-grained, white grey, greenish grey, unconsolidated, loose, blockish.

10: CLAYSTONE/SILTSTONE, greenish grey, consolidated, thinly bedded.

11: SANDSTONE, predominantly quartz, white grey, light green, unconsolidated.

12: CLAYSTONE, greenish grey, rather soft when wet.

13: SANDSTONE, predominantly quartz, contains gravel, greenish grey, unconsolidated, thickly bedded.

14: CLAYSTONE/SILTSTONE, white grey, brownish yellow, thickly bedded.

15. SANDSTONE, white grey, greenish grey, unconsolidated, loose, thickly bedded, contains coaly organic matter in the lower part; coal is brownish black, thinly bedded (1cm).

16: SILTSTONE, greenish grey, consolidated, thickly bedded.

17: SANDSTONE, predominantly quartz, white grey, unconsolidated, loose.

18: SILTSTONE, greenish grey, consolidated, thickly bedded.

19: SANDSTONE, poly-mineral, predominantly quartz, white grey, contains coaly organic matter (2-3cm) at 68.8m. Coal is brownish black, thinly bedded with leaf imprint.
20: SILTSTONE/SANDSTONE, white grey, light green, consolidated, thickly bedded.

21: SANDSTONE, poly-mineral, predominantly quartz, medium-grained, white grey, loose.

22: SANDSTONE, predominantly quartz, fine-grained. Sandstone is interbedded with claystone (greenish grey, rather soft when wet, weakly bedded).

23: SANDSTONE, poly-mineral, predominantly quartz, medium-grained, white grey, unconsolidated, loose, weakly bedded.

24: CLAYSTONE, greenish grey, thinly bedded, interbedded by poly-mineral sandstone, which contains small amounts of coaly organic matter.

25: SILTSTONE, red brown, consolidated, thickly bedded.

26: SANDSTONE, poly-mineral, predominantly quartz, white grey, consolidated.

27: SILTSTONE, greenish grey, consolidated, rather soft when wet.

28: SANDSTONE, poly-mineral, predominantly quartz, white grey, unconsolidated, loose.

29: CLAYSTONE, greenish grey, light brown, thickly bedded.

30: SANDSTONE, poly-mineral, predominantly quartz, white grey, greenish grey, interbedded by two layers (1m) of siltstone, greenish grey, brownish grey.

31: SILTSTONE/CLAYSTONE, greenish grey, rather soft when wet.

32: SANDSTONE, poly-mineral, predominantly quartz, medium-grained, white grey, contains thin laminations of coaly organic matters (144.6m). Coal is brownish black, bright–dull, easy to split off thin laminae.

33: CLAYSTONE, greenish grey, interbedded by fine-grained sandstone, contains brownish black coal, consolidated, 0.1m thickness, high ash content, beside thin laminations of coaly organic matter.

34: SANDSTONE, predominantly quartz, fine-grained, white grey, unconsolidated, loose.

35: SANDSTONE, interbeded by claystone, greenish grey, thickly bedded, fractured when dry.

36: SANDSTONE, poly-mineral, predominantly quartz, white grey, unconsolidated, loose, thickly bedded.

37: SILTSTONE, greenish grey, consolidated, thinly bedded. In the interval 158.1–158.4m: fine-grained sandstone, white grey, contains thin laminae of brownish coal. Coal is brownish black, bright-dull, brownish trace.

38: SANDSTONE, predominantly quartz, fine to coarse-grained, thickly bedded. There are two layers of brownish coal, blackish bright-dull, thin, light, brittle, bedding is dipping 28^0. Sandstone is unconsolidated, loose.

39: SILTSTONE, greenish grey, consolidated, thickly bedded, rather soft when wet. Splits along surface of lamination when dry.

40: SANDSTONE, predominantly quartz, loose, unconsolidated, interbedded with coarse-grained, poly-mineral sandstone, consolidated, thickly bedded.

41: SILTSTONE, greenish grey, consolidated, interbedded by sandstone (0.3m), white grey, unconsolidated and loose.

42: SANDSTONE interbedded by CONGLOMERATE, white grey. The CONGLOMERATE consists of granite, quartz (maximum diameter 2-4 cm). There is a thin bed (0.6m) of coal, brownish black, light, soft and imprints of leaf are preserved.

43: CLAYSTONE interbedded by poly-mineral CONGLOMERATE, greenish grey. The CONGLOMERATE has rounded clasts (diameter of 1.5-2 cm).

44: SANDSTONE, fine-grained, greenish grey, weakly bedded.

45: SANDSTONE, predominantly quartz, coarse-grained, white grey, interbedded with CONGLOMERATE (consists of granite), rounded, (diameter of 1cm), unconsolidated.

46: SANDSTONE, predominantly quartz, fine-grained, white grey, contains small amounts of coaly organic matter.

47: SILTSTONE, greenish grey, consolidated, thickly bedded.

48: SANDSTONE, predominantly quartz, fine-grained, white grey, unconsolidated.

49: CONGLOMERATE, poly-mineral, white grey to greenish grey, consists of granite, quartz, granosyenite, granodiorite, (diameter of 6-7 cm), poorly rounded and poorly sorted, unconsolidated, the matrix is clay, gravel, quartz.

50: CLAYSTONE, greenish grey, consolidated and interbedded with sandstone.

51: SILTSTONE, greenish grey, consolidated.

52: SANDSTONE, predominantly quartz, fine-grained, white grey, unconsolidated, loose.

53: CLAYSTONE, greenish grey, consolidated, rather soft when wet.

54: SANDSTONE, predominantly quartz, white grey, unconsolidated, loose.

55: CLAYSTONE, greenish grey, consolidated, thickly bedded.

56: SANDSTONE, predominantly quartz, coarse-grained, unconsolidated, loose.

57: SILTSTONE, greenish grey, consolidated, bedding dips 10^0.

58: SANDSTONE, predominantly quartz, fine-grained, white grey, unconsolidated, loose.

59: SILTSTONE, white grey, brownish grey, consolidated, bedding dips 10^0–14^0, thinly bedded.

60: SANDSTONE, poly-mineral, predominantly quartz, coarse-grained, white grey.

61: SILTSTONE, white grey, consolidated, loose.

62: SANDSTONE, predominantly quartz, fine-grained size, interbedded with poly-mineral sandstone, unconsolidated, loose.

63: SILTSTONE, brownish grey, consolidated, thickly bedded.

64: CLAYSTONE, greenish grey, rather soft when wet.

65: SILTSTONE, brownish grey, white grey, consolidated, loose.

66: CLAYSTONE, white grey, brownish yellow, consolidated.

67: SANDSTONE, predominantly quartz, coarse-grained, white grey, unconsolidated, loose.

68: SILTSTONE, white grey, consolidated.

69: SANDSTONE, predominantly quartz, fine-grained, white grey, unconsolidated, loose.

70: SILTSTONE interbedded by fine-grained SANDSTONE, unconsolidated, loose.

71: CLAYSTONE, white grey, consolidated, weakly bedded.

72: SANDSTONE, predominantly quartz, white grey, unconsolidated, loose.

73: SILTSTONE, brownish grey, interbedded by white grey CLAYSTONE, thin laminations, coaly organic matter (5-10%), bedding dips 3^0–5^0.

74: CLAYSTONE, contains 3-5% of coaly organic matter with blackish grey color.

75: SILTSTONE, brownish grey, consolidated, thinly bedded.

76: SILTSTONE, contains 3-5% of brownish, blackish brown, light, brittle coal; bedding dips 18^0.

77: SILTSTONE, brownish grey, blackish grey, contains 1-3% of coaly organic matter. At 310.5–310.6m occurs a thin bed of light, brittle brownish black, bright-dull coal; bedding dips 20^0.

78: SILTSTONE, brownish grey, interbedded with sandstone; bedding dips 10^0. At 316.3–316.6m occurs a thin bed of brown, light, brittle, bright-dull coal; bedding dips 14^0.

79: SANDSTONE, fine-grained, white grey, interbedded with thin laminae of brownish black coal.

80: SILTSTONE, brownish grey, consolidated. At 320.8–320.9m and 323.0–324.8m occur thin beds of brown, black, light, brittle, bright-dull coal. Coal easily splits off in thin laminae; bedding dips 15^0-16^0.

81: CLAYSTONE, white grey, consolidated, weakly bedded.

82: SILTSTONE, brownish grey, white grey, consolidated. At 328.6–330.6m occurs a thin bed of brownish coal, interbedded with siltstone and claystone. Bedding planes of the coal dip 15^0-16^0.

83: SANDSTONE, poly-mineral, predominantly quartz, white grey, consolidated.

84: CLAYSTONE, white grey, thickly bedded.

85: SANDSTONE, coarse-grained, white grey, unconsolidated, loose.

86: SILTSTONE, white grey, consolidated.

87: CLAYSTONE, greenish grey, white grey, contains 5-10% of coaly organic matter (interval 340.0–340.8m), bedding dips 16^0.

88: SANDSTONE, predominantly quartz, fine-grained, greenish grey, interbedded with coarse-grained sandstone.

89: CLAYSTONE, greenish grey, consolidated, weakly bedded.

90: SILTSTONE, greenish grey, unconsolidated.

91: SILTSTONE, greenish grey, consolidated, weakly bedded.

92: SANDSTONE, poly-mineral, predominantly quartz, white grey, consolidated and interbedded by a thin bed of brownish coal (0.1m).

93: CLAYSTONE, greenish grey, unconsolidated, thinly bedded.

94: SILTSTONE, blackish grey, brownish grey, consolidated, thinly bedded.

95- CLAYSTONE, GRAVEL, AGGLOMERATE, loose, greenish grey, blackish grey, rather soft when wet, contains 1-3% of coaly organic matter when dry.

96: SILTSTONE, greenish grey, blackish grey, consolidated, thinly bedded.

97: CLAYSTONE, GRAVEL, AGGLOMERATE, loose, greenish grey, unconsolidated, loose.

98: CLAYSTONE, black-brown grey.

99: SILTSTONE, brownish grey, white grey, interbedded with coarse-grained sandstone, contain 3-5% of coaly organic matter.

100: SILTSTONE, brownish grey, blackish grey, unconsolidated, loose, contains 10-15% of coaly organic matter. Coal is brownish black, light, brittle.

101: COAL is brownish black, bright-dul, light, brittle, high ash content; bedding dips 15^0, interbedded with thin beds of claystone.

102: SILTSTONE interbedded with fine-grained sandstone, contains 5-10% of coaly organic matter. At 394-394.3m occurs a thin bed of brownish black coal along the surface of the rock.

103: COAL is brownish black, bright-dull, light, brittle, high ash content, and brownish traces.

104: SILTSTONE interbedded with fine-grained sandstone, contains 3-5% of coaly organic matter. Claystone, brownish grey, greenish grey occurs in the lower part.

105: SILTSTONE, greenish grey interbedded with white grey sandstone.

106: CLAYSTONE, greenish grey, brownish grey, contain 50-60% of coaly organic matters in the lower part.

107: Beds of CLAYSTONE contain 20-30% of coaly organic matters sandwiched by beds of greenish grey SILTSTONE and fine-grained SANDSTONE.

108: SANDSTONE, predominantly quartz, fine-grained, white grey, consolidated.

109: CLAYSTONE/SILTSTONE, greenish grey, unconsolidated, loose, contains 1-3% of coaly organic matter (interval 444.4-444.7m).

110: SANDSTONE, fine-grained, white grey, greenish grey, contains 3-5% of coaly organic matter, wavy (?) on the surface of thin laminations.

112: SANDSTONE, predominantly quartz, poly-mineral, coarse-grained, white grey, olive grey, unconsolidated, loose, thinly bedded, contain 5-10% of coaly organic matters (3cm at 458.5m), easy to split off thin laminae.

113: SILTSTONE, greenish grey, consolidated, interbedded with fine-grained sandstone and claystone, contain coaly organic matter (2cm at 460.5m). Coal is brownish black, bright-dull, light, brittle, high ash content and brownish trace. Beding plane of coal dips 1^0.

114: CONGLOMERATE, poly-mineral, unconsolidated, loose, comprising granite, quartz, ryolite, matrix is fine-grained claystone and sandstone (greenish grey).

115: GRANITE biotite-hornblende, medium-grained, white-grey, black rocks are compressed, loose due to weathering. Color minerals of biotite concentrated in a small loaf. At 493-493.2m, the granite is cut by a diorite (grey black, fresh and consolidated).

MÔ TẢ LỖ KHOAN SỐ 01 - NGHIÊN CỨU ĐỊA TẦNG

KHU VỰC PHÚ CẦN, KRÔNG PA, GIA LAI

THUỘC LÊ AN ENRECA

Cao độ: X.Mặt.....T 468.5m
H1 126m

Đơn vị thi công: Đoàn thi công công trình Địa chất - Liên đoàn Địa chất Trung trung bộ

Ngày khởi công: 14.3.2002
Ngày kết thúc: 20.4.2002
Công nghệ Khoan: Máy XM-520

Độ sâu: 494.5 m

Thước tỷ lệ	Tuổi địa chất	Thứ tự lớp	Bản vẽ lõi Khoan	Đường kính lõi Khoan (mm)	Góc độ	Mức độ thu hồi lõi Khoan		Tỷ lệ mẫu %	Lấy các loại mẫu	Số liệu các cục mẫu		MÔ TẢ VÀ KẾT QUẢ PHÂN TÍCH	GHI CHÚ
						Chiều dài hiệp (m)	Chiều dài lõi Khoan (m)			Từ	Đến		
												1. Cát, sạn sỏi xen lẫn ít cuội hạt nhỏ trở nói màu xám vàng phân cuội chưa cuội, cỡ 1-3cm, nằm rải rác trong cát sét, sạn.	
												2. Lớp cuội đa thành màu xám trắng, xám vàng. Thành phần là thạch anh, nhiễu granit ký xen kẽ trên cạnh, gắn kết yếu rời rạc.	
												3. Cát sét, thạch anh chứa sạn màu xám vàng xám xanh, gắn kết yếu phân lớp dày.	
												4. Bột kết màu xám xanh, gắn kết yếu dạng khối.	
												5. Cát kết thạch anh, màu xám xanh, gắn kết yếu dạng khối.	
												6. Cát kết thạch anh, màu xám xanh đen, chứa một ít vật chất hữu cơ hóa than, phân lớp mỏng.	
												7. Bột kết xen lẫn cát kết màu xám xanh, xám trắng, gắn kết yếu	
												8. Cát kết màu xám xanh phân lớp dày, gắn kết chặt.	
												9. Cát kết thạch anh hạt nhỏ, màu xám trắng xám xanh, gắn kết yếu, mềm bở dạng khối.	
												10. Sét kết xen lẫn ít bột kết màu xám xanh, gắn kết chặt phân lớp mỏng.	
												11. Cát kết thạch anh, màu xám trắng phớt xanh gắn kết yếu, mềm bở dạng khối.	
												12. Sét kết xen lẫn ít bột kết màu xám xanh, đôi chỗ phân lớp dày phân cuội có chứa một ít vật chất hữu cơ hóa than, than có màu đen nằm phân lớp mỏng, chiều dày giữa các	
												13. Bột kết màu xám xanh, xám đen, chất kết dính là đất	
												14. Cát kết thạch anh, màu xám trắng, gắn kết yếu, mềm bở.	
												15. Cát kết màu xám trắng, phớt xanh, đôi chỗ gắn kết yếu bở rời, phân lớp dày, gắn kết chặt.	
												16. Cát kết thạch anh, màu xám trắng, xám xanh, đôi chỗ gắn kết yếu bở rời, phân lớp dày, gắn kết chặt.	
												17. Cát kết thạch anh đa khoáng màu xám trắng, lẫn ít sạn nhỏ, chứa một ít vật chất hữu cơ hóa than, than có màu đen nằm phân lớp mỏng, chiều dày giữa các	
												18. Cát kết thạch anh đa khoáng màu xám trắng, lẫn ít sạn nhỏ, chứa một ít vật chất hữu cơ hóa than, than có màu đen nằm phân lớp mỏng dạng lá.	
												19. Cát kết màu xám trắng, phớt xanh, gắn kết chặt, phân lớp dày.	
												20. Bột kết xen lẫn ít sét kết màu xám trắng, phớt xanh, gắn kết chặt, phân lớp dày.	
												21. Cát kết thạch anh đa khoáng hạt trung màu xám trắng, hơi ẩm.	
												22. Cát kết thạch anh hạt nhỏ xen lẫn ít sét màu xám xanh, ngậm nước dẻo mịn.	
												23. Cát kết thạch anh đa khoáng hạt trung màu xám trắng, gắn kết yếu bở rời, phân lớp không rõ ràng.	
												24. Cát kết thạch anh đa khoáng hạt trung màu xám trắng, gắn kết yếu bở rời, phân lớp không rõ ràng.	
												25. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời, phân lớp dày.	
												26. Cát kết thạch anh đa khoáng màu xám trắng, gắn kết chặt.	
												27. Sét kết màu xám xanh, gắn kết chặt, phân lớp mỏng, nhiễm	
												28. Cát kết thạch anh, đa khoáng màu xám trắng, gắn kết yếu mềm, bở dạng khối.	
												29. Sét kết màu xám xanh phớt nâu, gắn kết chặt phân lớp dày	
												30. Cát kết thạch anh đa khoáng màu xám trắng xám xanh xen kẹp	
												hạt lớp bột kết dày m, màu xám xanh, xám nâu.	
												31. Bột kết xen lớp ít cát kết màu xám xanh, ngậm nước dẻo mịn	
												32. Cát kết thạch anh đa khoáng hạt trung màu xám trắng, lẫn ít	
												33. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời,	
												34. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời,	
												35. Sét kết xen lẫn ít cát kết màu xám xanh, chỉ khá nứt nẻ mạnh,	
												phân lớp dày.	
												36. Cát kết thạch anh đa khoáng màu xám trắng, mềm bở gắn	
												kết yếu, phân lớp dày.	
												37. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng, lẫn sét,	
												38. Cát kết hạt nhỏ màu xám trắng có chứa ít than nằm dạng	
												lớp mỏng. Than vụn nằm dọc các ranh mặt, có khối màu nâu	
												39. Cát kết thạch anh hạt nhỏ xen lẫn ít bột kết thạch anh hạt	
												thô, màu xám trắng phân lớp dọc. Dưới cùng có thuỷ hai lớp than nâu,	
												màu đen ánh nhẹ, bề mặt rạng nứt tạo thành lớp mỏng, nhẹ, xốp dễ	
												vỡ vụn nát, gọi nghứng cứu và xác cát kết có độ gắn kết yếu mềm	
												bở.	
												40. Bột kết màu xám xanh, phân lớp dọc chặt, ngậm nước dẻo	
												mịn, khi khô thường nứt theo mặt lớp.	
												41. Cát kết thạch anh hạt nhỏ, gắn kết yếu bở rời, xen kẹp cát kết	
												thạch anh đá khoáng hạt thô, gắn kết chặt phân lớp dày.	
												42. Bột kết màu xám xanh gắn kết chặt, xen kẹp mỏng. Cát kết màu	
												xám trắng, gắn kết yếu mềm bở.	
												43. Cát kết xen lẫn ít cuội đá khoáng màu xám trắng. Thành phần cuội Granit	
												thạch anh, ít lớn nhất 4 cm. Trong lớp này có 3 lớp than nâu đậm	
												màu đen nâu, xốp, nhẹ, than lẫn đất vỡ dạng vảnh là cuội cây	
												hóa than.	
												44. Cát kết xen lẫn ít cuội đá khoáng màu xám xanh, cuội rất trơn	
												tanh, có đường kính từ 2-5cm.	
												45. Cát kết thạch anh hạt thô màu xám trắng, xen lẫn cuội thạch anh	
												granit trên tanh, cuội có đường kính 4 cm, gắn kết yếu dễ tơi ra.	
												46. Cát kết thạch anh hạt mịn, màu trắng xám xanh, có chứa ít	
												vật chất hữu cơ hóa than.	
												47. Bột kết màu xám xanh, gắn kết chặt, phân lớp dày.	
												48. Cát kết thạch anh hạt nhỏ, màu trắng xám xanh, gắn kết yếu	
												49. Cuội kết đa khoáng màu xám trắng, gắn kết yếu mềm bở,	
												thạch anh, granitoxyaxens, phụ nhiều cuội có đường kính lớn	
												4 cm. Cuội trơn tanh, độ mài tròn, độ chọn lọc kém, giữa kết yếu thành phần kí măng	
												là cát, sạn, sỏi thạch anh.	
												50. Sét kết màu xám xanh, gắn kết chặt, xen kẹp một ít cát kết	
												51. Bột kết màu xám xanh, gắn kết chặt.	
												52. Cát kết thạch anh, hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												53. Sét kết màu xám xanh, gắn kết chặt ngậm nước dẻo mịn.	
												54. Cát kết thạch anh màu xám trắng gắn kết yếu bở rời.	
												55. Sét kết màu xám xanh, gắn kết chặt, phân lớp dày.	
												56. Cát kết thạch anh đa khoáng hạt thô, gắn kết yếu mềm bở.	
												57. Bột kết màu xám xanh, gắn kết chặt, gọi nghứng cứu có	
												58. Cát kết thạch anh hạt nhỏ màu xám trắng gắn kết yếu bở rời	
												59. Bột kết màu xám trắng, xám nâu, gắn kết chặt, gọi nghứng	
												mặt lớp nghiêng, phân lớp mỏng.	
												60. Cát kết thạch anh đa khoáng hạt thô màu xám trắng.	
												61. Bột kết màu xám trắng, gắn kết yếu mềm bở.	
												62. Cát kết thạch anh hạt nhỏ, xen kẹp cát kết thạch anh đa	
												khoáng, gắn kết yếu mềm bở.	
												63. Bột kết màu xám nâu, gắn kết chặt phân lớp dày.	
												64. Sét kết màu xám xanh, ngậm nước dẻo mịn.	
												65. Bột kết màu xám xanh, xám trắng gắn kết yếu mềm bở.	
												66. Sét kết màu xám trắng vàng nâu, gắn kết chặt.	
												67. Cát kết thạch anh, hạt thô màu xám trắng, gắn kết yếu bở rời.	
												68. Bột kết màu xám trắng gắn kết chặt.	
												69. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												70. Bột kết màu xám trắng, gắn kết yếu mềm bở.	
												71. Sét kết màu xám xanh, gắn kết chặt phân lớp dày.	
												72. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời,	
												phân lớp không rõ.	
												73. Bột kết màu xám nâu, gắn kết chặt, phân lớp dày.	
												74. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												75. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												76. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												77. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												78. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												79. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												80. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												81. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												82. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												83. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												84. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												85. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												86. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												87. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												88. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												89. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												90. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												91. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												92. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												93. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												94. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												95. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												96. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												97. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												98. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												99. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												100. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												101. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												102. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												103. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												104. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												105. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												106. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												107. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												108. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												109. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												110. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												111. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												112. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												113. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												114. Cát kết thạch anh hạt nhỏ màu xám trắng, gắn kết yếu bở rời.	
												115. Bột kết màu xám xanh, gắn kết chặt, phân lớp mỏng.	
												116. Cát kết thạch anh hạt nhỏ màu xám trắng, xám xanh, chứa ít vật chất	
												hữu cơ hóa than, than nằm dạng lớp mỏng, kích thước không	
												117. Sét kết màu xám nâu, xám xanh, phớt nâu, gắn kết chặt màu xám	
												xanh, gắn kết chặt.	
												118. Cát kết thạch anh đa khoáng hạt thô, màu trắng xám vàng,	
												gắn kết yếu mềm bở, phân lớp mỏng có chứa ít vật chất hữu cơ hóa	
												than, than nằm dạng lớp mỏng kích thước không rõ ràng.	
												119. Bột kết màu xám xanh lục gắn kết chặt, xen kẹp một ít cát kết	
												thạch anh hạt nhỏ rải rác kết, ở đây có chứa một ít vật chất hữu cơ hóa	
												than, than có màu đen nằm nhiễu xốp dọn có độ rơi	
												cục, than nhẹ vết cạnh màu nâu, gọi nghứng. Phân lớp mỏng.	
												120. Cát kết thạch anh gắn kết yếu bở rời. Thành phần cuội: Granit,	
												thạch anh, ryolit, vi măng, ít sét cát hạt nhỏ màu xám xanh	
												121. Đá gra-nô-nít, hạt trung màu trắng xám đen, độ tỷ	
												cao mạnh phong hoá độ dang mềm bở. Quan sát ở lỗ khoan	
												thấy cava. Khoáng vật màu biotit lớp trung dạng ổ nhỏ. Từ 480.	
												483,2m đá mạch đi cắt vào cuội granit, đá có màu xám đen, tỉ lệ	
												rất chặt.	

Người thành lập: Châu Văn Tuấn
Người Kiểm tra: Trần Văn Thinh

Bản vẽ số 01
Mô tả lỗ Khoan số 01 - Nghiên cứu địa tầng trầm tích Neogen sông ba.
Khu vực Phú Cần, Krông Pa, Gia Lai.
Đoàn trưởng: Trần Văn Thinh