Review of Frictional Ignition Information

Coal Mines Inspectorate
Resources Safety & Health Queensland

Simtars
Safety in Mines Testing and Research Station

Queensland Government

Report Information

Title: *Review of Frictional Ignition Information*

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1 Introduction

Simtars were requested by Shaun Dobson, Deputy Chief Inspector of Coal Mines, to undertake a review of information relating to frictional ignition, as supplied below:

1. Data from Geochempet Services reviewing rock samples taken from Grosvenor Mine boreholes DDG214 and DDG295 (x16 samples in total);
2. A report prepared by Mr Rob Thomas of Strata[2] (a geotechnical expert engaged by the Coal Mines Inspectorate);
3. A report prepared by Mr Ray Williams (an expert engaged by the Coal Mines Inspectorate), which includes information about the location of boreholes DDG214 and DDG295; and
4. A desktop review prepared by Dr Ray Low of UQ Materials Performance into the "Plausibility of Mechanical Interactions Causing the Grosvenor Mine Explosion" which evidences some consideration of frictional ignition from strata falls.

These documents were commissioned by the Coal Mines Inspectorate as part of the investigation into the serious accident at Grosvenor Mine on 6 May 2020.

This report prepare by Simtars provides a synopsis of this information and the main findings.

2 Synopsis

The information supplied to the Coal Mines Inspectorate are summarised below.

Geochempet Sample Testing Reports (x 16 samples) – Frictional Ignition Testing on Drill Core Samples (Boreholes DDG214 and DDG295) – Appendix 1**.** The Geochempet Services report provides a petrographic examination of drill core samples of sedimentary rock with a view to determining its incendive sparking potential.

The report by Dr Ray Williams [1] presents findings of an independent review of coal-seam-gas-related aspects in the general area of the ignition of the 6th May 2020 on longwall 104 at Grosvenor Coal Mine (GCM). Of particular interest for this report is the location of the borehole positions, as shown below in Figure 1.

The report by Strata[2] [2] provides a review of the geotechnical environment and the prevailing ground conditions on the lead up to the methane ignition event which occurred on LW 104's face in Grosvenor Mine on the 6th May 2020.

Dr Ray Low [3] undertook a desktop review into the possibility that mechanical interactions in conveyor parts and in the mine could have created sparks and ignited the incident fire at Grosvenor Mine on the 6th May 2020.

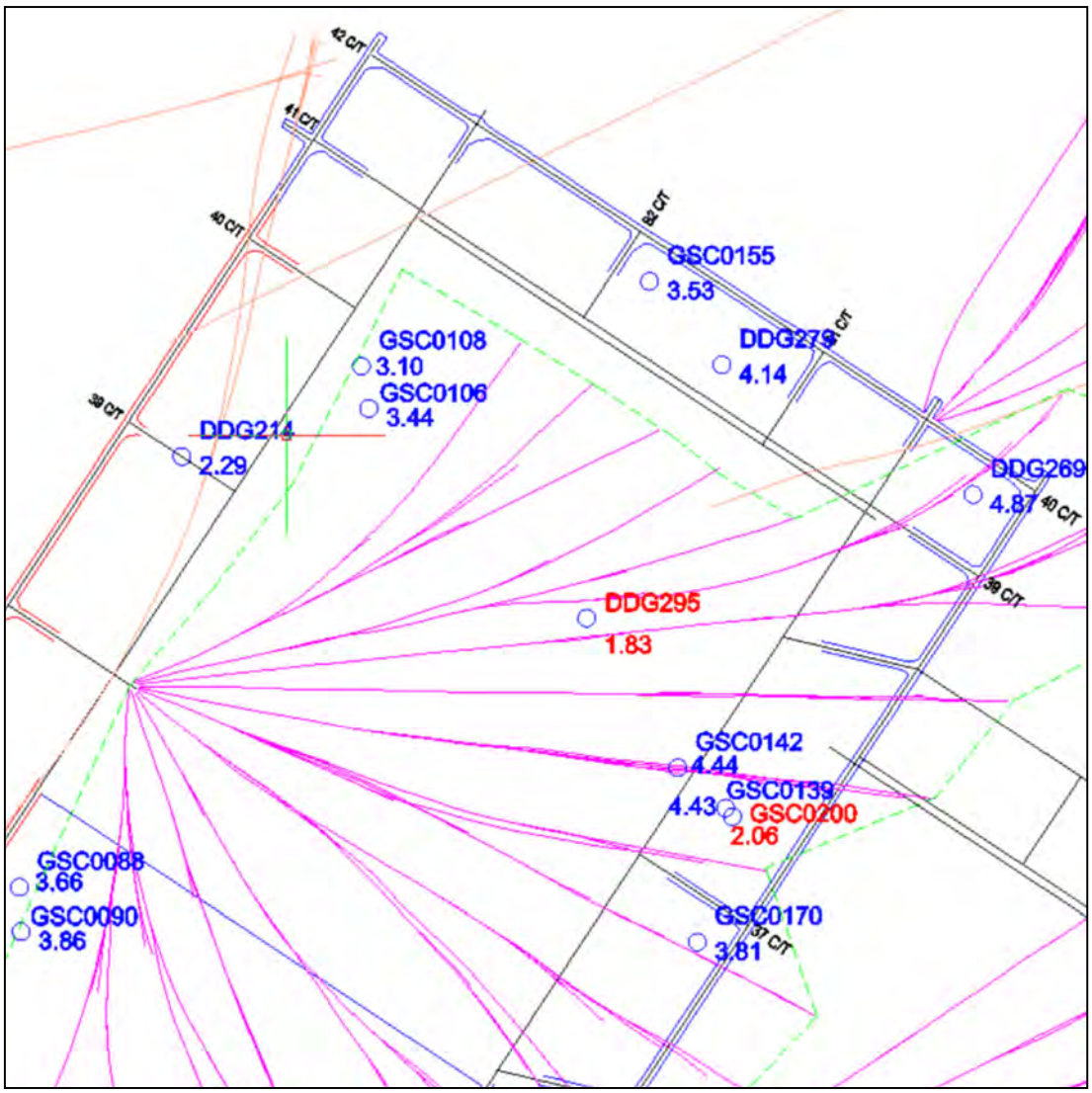

Figure 1 Borehole Locations [1]

3 Main Findings

3.1 Rock on Rock Ignition Category (IGCAT) Zones

The ignition category (IGCAT) zones were determined in a previous study by Ward *et al*. [4] through a series of tests using small rock specimens (slider) pressed with a measured force against a 150 mm diameter cylindrical rock wheel. These tests were conducted in a test chamber containing a 7% methane-air atmosphere. The rotating wheel was set to 300, 500 and 700 rpm providing circumference velocities of 2.2, 3.7 and 5.1 ms^{-1} respectively. Rock on rock tests were conducted using various specimens of rock types, where the slider and wheel were prepared from the same rock type. Figure 2 shows the equipment set up for the rock on rock tests.

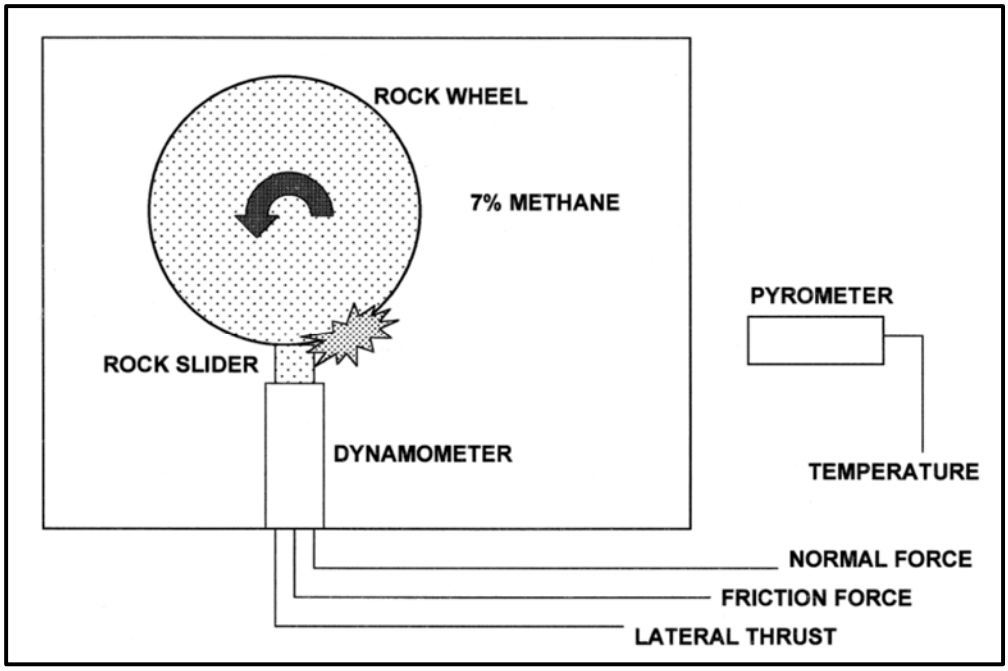

Figure 2 Schematic diagram of rotating rock on rock test rig [4]

Ward *et al.* [4] conducted a series of experiments to determine an ignition category for different materials. These results are shown below in Figure 3. Zone 5 (IGCAT = 5) indicates the highest incendive potential and Zone 1 (IGCAT = 1) is an indication of the lowest incendive potential. The IGCAT value, therefore, provides a measure of the incendive sparking potential of the sample. Ward *et al*. [4] produced ternary plots showing the relation of the IGCAT to other rock properties based on petrographic data including relative proportions of quartz, feldspar, rock fragments, clay matrix and carbonate minerals.

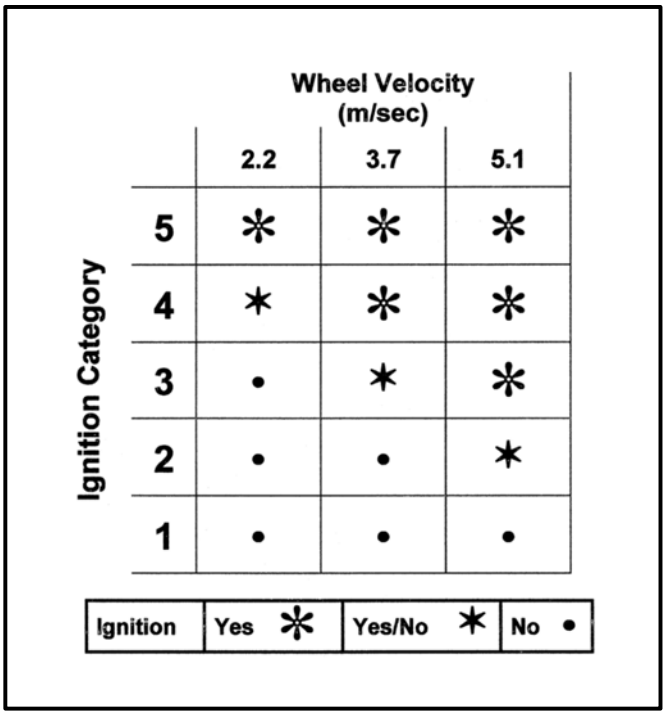

Figure 3 Ignition categorisation IGCAT system, based on rock on rock ignition at different speeds [4]

3.2 Geochempet Results

Core samples from Grosvenor Mine boreholes DDG214 and DDG295 were petrographically examined (refer full results in Appendix 1). The aim of the examination was to determine the incendive sparking potential of the samples [4]. The method is based on detailed mineralogical counting using transmitted polarised light microscopy. This allows the termination of the approximate composition, expressed in volume percent, based on identification and counting of microscopically observed components. The results from this process for the different core samples are presented in Table 1 and Table 3. The results, from the two tables, were then recalculated to generate the following parameters:

Q = Quartz + rock fragments + feldspar + pyrite,

Cl = Clay matrix cement + mica + clay pellets,

Ca = Carbonate but no organics

The results for the calculated parameters are presented in Table 2 and Table 4.

Table 1 Point counting of Petrographic Constituents from borehole DDG214

Sample No	FI101	FI102	FI103	FI104	FI105	FI106	FI107	FI108	FI109
Depth (m)	387.04 — 387.24	376.92 — 377.33	364.10 — 364.37	359.00 — 359.45	357.80 — 358.07	355.15 — 355.57	354.12 — 354.47	344.98 — 345.32	341.62 — 342.05
Quartz (Vol %)	6	19	8	23	12	15	15	8	19
Feldspar (Vol %)	1	4	2	12	9	10	8	4	6
Opaque oxides/leucoxene (Vol %)	<1	<1	—	—	<1	<1	<1	1	<1
Lithic fragments (Vol %)	—	—	2	25	26	47	42	24	45
Soft Lithic Fragments (Vol %)	<1	13	—	—	—	—	—	—	—
Mica	2	—	4	4	2	5	2	1	3
Mica/chlorite (Vol %)	—	7	—	—	—	—	—	—	—
Matrix cement (Vol %)	55	28	68	9	3	5	3	2	2
Argillizes fragments (Vol %)	—	—	—	7	4	3	3	5	7
Sericitized fragments (Vol %)	—	—	—	—	2	2	1	—	2
Soft lithics (Vol %)	—	—	—	—	4	1	1	1	—
Carbonate (Vol %)	26	23	13	19	38	12	25	54	16
Organics (Vol %)	10	6	3	1	—	—	—	—	—

Table 2 Recalculated parameters and IGC zone for borehole DDG214

Sample No	Depth (m)	Rock Type	Co-ordinates			IGCAT Zone
			Q (Quartz + rock fragments + feldspar + pyrite)	Cl (Clay + mica)	Ca (Carbonate)	
FI101	387.04 — 387.24	carbonated siltstone with coaly wisps and rare silt sized grains of quartz and feldspar	7.8	63.3	28.9	1
FI102	376.92 — 377.33	carbonated siltstone with minor coaly wisps and some interbedded sandstone layers	24.5	51	24.5	1
FI103	364.10 — 364.37	carbonated siltstone with minor organics	12.4	74.2	13.4	1
FI104	359.00 — 359.45	carbonated quartzofeldspathic and lithic sandstone	60.6	20.2	19.2	2
FI105	357.80 — 358.07	carbonated quartzofeldspathic and lithic sandstone	47	15	38	1
FI106	355.15 — 355.57	carbonated quartzofeldspathic and lithic sandstone	72	16	12	3
FI107	354.12 — 354.47	carbonated quartzofeldspathic and lithic sandstone	65	10	25	2
FI108	344.98 — 345.32	carbonated quartzofeldspathic and lithic sandstone	37	9	54	1
FI109	341.62 — 342.05	carbonated siltstone with minor organics	70	14	16	3

Table 3 Point counting of Petrographic Constituents from borehole DDG295

Sample No	FI107	FI106	FI105	FI104	FI103	FI102	FI101
Depth (m)	427.35 — 427.72	383.74 — 384.00	379.63 — 379.80	367.97 — 368.15	350.60 — 350.92	345.60 — 345.95	341.27 — 341.59
Quartz (Vol %)	9	11	12	9	13	7	14
Feldspar (Vol %)	10	5	9	2	14	10	9
Leucoxene (Vol %)	4	2	4	4	1	3	2
Lithic Fragments (Vol %)	24	4	12	17	42	26	42
Mica/sericite/chlorite (Vol %)	<1	6	8	1	1	<1	<1
Matrix cement (Vol %)	19	48	12	17	14	4	12
Pyrite (Vol %)	<1	<1	<1	<1	<1	<1	<1
Argillizes lithics (Vol %)	12	6	7	10	8	10	11
Carbonate (Vol %)	22	9	31	40	6	40	10
Organics (Vol %)	<1	9	5	<1	1	<1	<1

Table 4 Recalculated parameters and IGC zone for borehole DDG295

Sample	Depth (m)	Rock Type	Co-ordonates			IGCAT Zone
			Q (Quartz + rock fragments + feldspar + pyrite)	**Cl** (Clay + mica + iron oxide)	**Ca** (Carbonate)	
FI107	427.35 — 427.72	carbonated quartzofeldspathic and lithic sandstone	47	31	22	2
FI106	383.74 — 384.00	Interbedded labile siltstone and quartzofeldspathic and lithic sandstone	24.2	65.9	9.9	1
FI105	379.63 — 379.80	Interbedded, partly carbonated siltstone and quartzofeldspathic and lithic sandstone	39	28.4	32.6	1
FI104	367.97 — 368.15	carbonated quartzofeldspathic and lithic sandstone	32	28	40	1
FI103	350.60 — 350.92	quartzofeldspathic and lithic sandstone	70.7	23.2	6.1	3
FI102	345.60 — 345.95	carbonated quartzofeldspathic and lithic sandstone	46	14	40	1
FI101	341.27 — 341.59	quartzofeldspathic and lithic sandstone	67	23	10	3

The calculated parameters were then used for comparison with a ternary plot classification as developed by Ward *at al*. [4]. The samples were assigned an appropriate IGCAT value, based on location of the parameters on a ternary plot, as shown in Figure 4 and Figure *5*.

Nine samples were categorised in DDG214, and seven samples in DDG295, 16 samples in total. The highest IGCAT observed from either set of borehole samples were Zone 3. There were two Zone 3 IGCAT results in each of the borehole samples. The remaining samples were either Zone 2 or Zone 1. The IGCAT Zone 3 occurred at the 341.27 - 341.59 m and 350.60 - 350.92 m depths for borehole DDG295 and at the 341.62 - 342.05 m and 355.15 - 355.57 m depths for borehole DDG214.

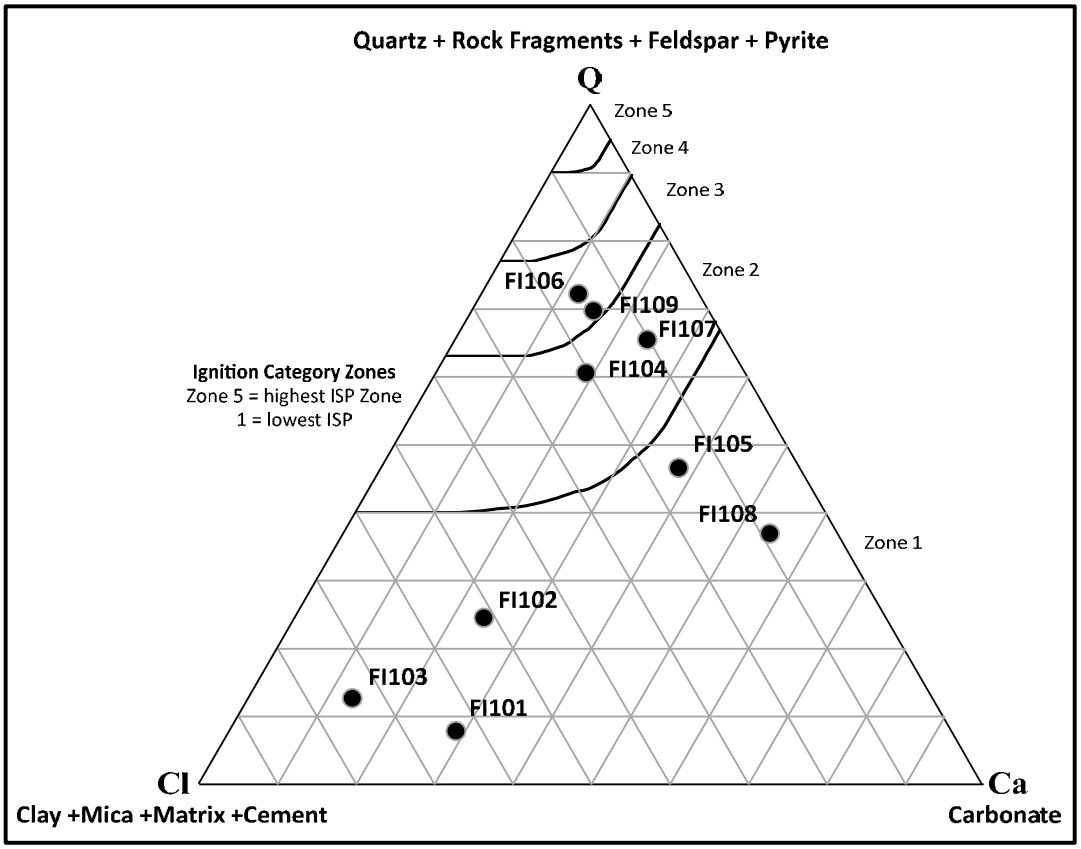

Figure 4 Incendive Sparking Potentials determination for borehole DDG214

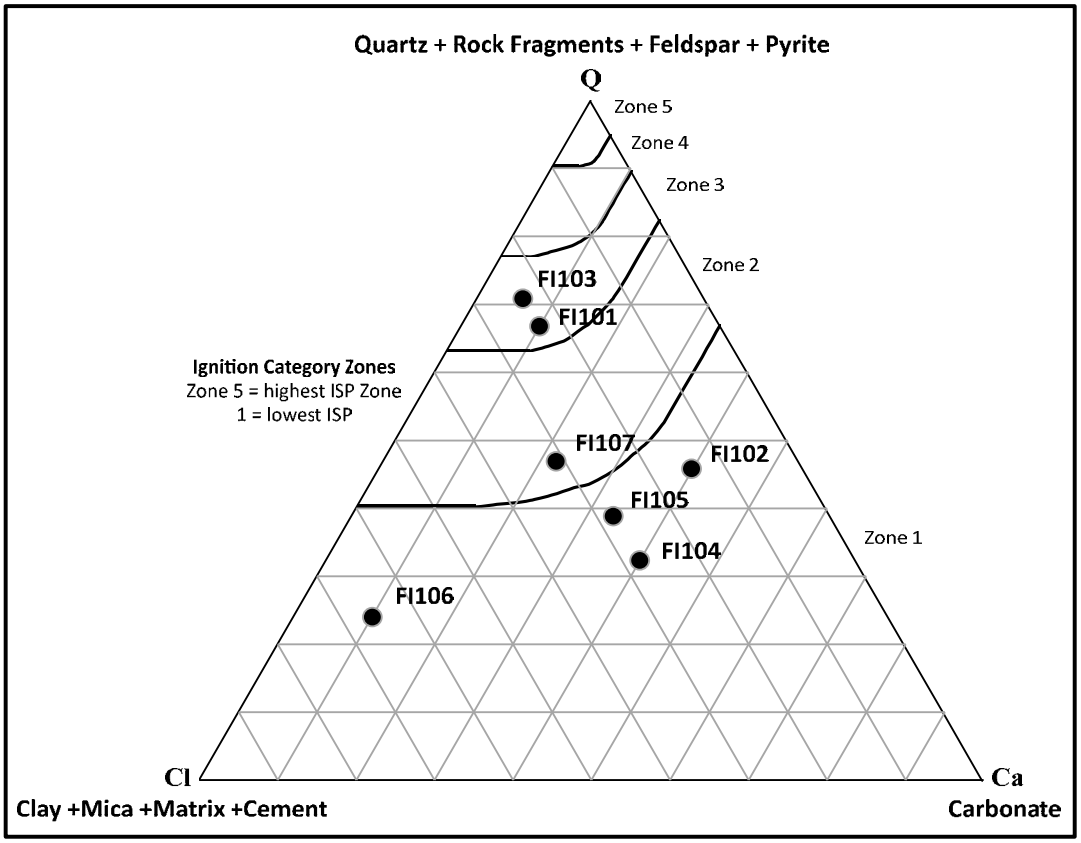

Figure 5 Incendive Sparking Potential determination for borehole DDG295

3.3 Desktop Review

This section is a summary of the literature review of previous work as presented by Dr Ray Low of UQ Materials Performance [3].

Table 5 Summary of frictional ignition conditions
(Excerpt from Table 6 of [3]*: Summary of conditions required to ignite a methane-air mixture)*

Source of Ignition	Comments
Interactions between steel and rock	**Sliding Friction** The energy required to cause ignition of methane-air when a high carbon steel block was pressed on a rotating sandstone wheel was 1885 J at 7.1 m/s. Conversely, a sandstone block on a rotating steel wheel caused ignition at a minimum speed of 10 m/s at a load of 45 kg. The minimum contact time required for ignition was between 1 to 1.8 seconds, depending on load, speed and experimental arrangement. This is an approximate frictional work of 450 to 1600 J (assuming a coefficient of friction of 0.1 to 0.2). **Impacts** Experiments involving glancing steel on rock impacts more closely represent a tool-on-rock scenario rather than a free-falling rock impacting a steel plate. The lowest velocity that ignited methane-air was 1.5 m/s. The energies required for ignition by impacts (140 to 300 J) were significantly lower than the energies involved during frictional sliding (> 1885 J). The hot streak on the sandstone surface, rather than the sparks, are incendive and have been measured to reach peak temperatures of approximately 1420°C. Attention should also be paid to soft, 'spark-resistant' tools since sandstone may become imbedded in the metal surface and generate highly incendive sandstone-on-sandstone impacts. Water sprays behind picks are believed to reduce the probability of ignition but cannot completely eliminate it.
Rock-on-rock interactions	**Sliding Frictions** Frictional sliding between blocks and wheels both consisting of quarzitic sandstone were most incendive. The lowest sliding speed required to ignite methane-air was 1.6 m/s at a load of 72.7 kg with a contact time of 5 to 50 seconds. The lowest load was 5.3 kg at a speed of 21.3 m/s with a contact time of 1 to 20 seconds. The minimum length of contact for ignition to occur was approximately 5.4 m for sandstone on sandstone. **Impacts** Ignition of methane-air by a glancing rock-on-rock impact merely requires an expended energy of 5 to 18 J and a velocity of 4.3 m/s. This velocity is achievable in a free-fall of 1 m. Golledge's study determined that impacts with a short contact time (20 ms) and moderate velocity (from a 3.3 m rock fall) have a reasonable probability of ignition. Quarzitic sandstone was the most incendive due to its high melting point. The incendivity of rocks sampled from mines can be assessed according to a 5-point scale based on measured chemical and physical properties.

Blickensderfer [5] [6] also carried out steel on rock impact experiments where a rotating steel tool was used to produce a glancing impact against a sandstone block. A wheel fitted with a steel tool was rotated at a constant speed and a rock sample was slowly advanced towards the wheel at a controlled feed rate. The energy was calculated from the change in angular velocity measured just before and after impact, with corrections for the frictional losses of the moving parts. The results are summarised in Table 6.

The rock material was the greatest factor in determining the incendivity of steel on rock impacts. Of the five different types of rock tested, only the two sandstones caused ignitions (see Table 6) [6]. Notably, the probability of ignition was generally one in several hundred impacts.

Table 6 Impact-abrasion incendivity tests of several steels and rocks, taken from [6]

(Gas mixture, air-7.0 pct natural gas)

Speed, fpm	Feed, milli-inch/impact	Quartzitic sandstone								Silty sandstone				Ordinary limestone				Sulfur balls			
		Coal-cutter steel		17-4PH stainless steel		Armco iron		Rene 41		Coal-cutter steel		17-4PH stainless steel		Coal-cutter steel		17-4PH stainless steel		Coal-cutter steel		17-4PH stainless steel	
		N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
300.... 1.5 m/s	0.8	308	99	326	69	250	78	300	87	-	-	-	-	-	-	-	-	-	-	-	-
	3	190	80	130	85	137	80	137	94	-	-	-	-	-	-	-	-	-	-	-	-
450.... 2.3 m/s	0.8	178	73*	342	90	333	77	302	94	386	93	447	85	307	27	298	40	309	71	314	75
	3	161	217	97	140	131	158	59	110*	177	133	134	136	100	40	127	37	120	145	132	103
	6	61	179	60	180	61	222	115	127	73	157	85	106	67	62	74	34	65	107	129	65
	12	30	231	36	155	31	237	26	156*	43	190	30	134	43	73	40	56	36	137	41	144
600.... 3.0 m/s	0.8	175	71*	166	101*	79	42*	300	101	483	97*	147	74	295	25	290	56	302	97	311	75
	3	154	92*	126	191	126	140	124	148	172	155	56	87*	137	64	135	37	124	116	130	132
	6	29	164*	24	190*	73	140	42	148*	77	147	85	153	71	37	60	91	92	145	64	104
	12	30	102*	16	132*	32	307*	39	156	40	171	11	159*	38	56	44	19	47	101	74	98
750.... 3.8 m/s	0.8	172	84*	306	78	170	85*	310	87	129	69*	123	58*	318	30	293	60	302	49	314	37
	3	165	174	92	111	120	137*	115	97*	124	100	37	98*	133	41	124	88	144	120	127	86
	6	27	57*	20	134*	75	210	38	108*	65	111	27	94*	73	51	67	58	73	116	68	136
	12	14	20*	28	164	32	309*	21	172*	-	-	-	-	-	-	-	-	-	-	-	-
900.... 4.6 m/s	0.8	76	65*	93	64*	125	82*	305	99	263	65*	388	80	312	46	405	70	292	89	310	95
	3	55	68*	86	109	108	120*	128	130	50	75*	136	144	126	24	128	40	133	144	143	98
	6	63	171*	14	120*	48	151	40	170*	27	96*	16	123*	69	54	66	53	62	126	62	99
	12	11	151*	9	119*	24	255*	22	196*	-	-	-	-	-	-	-	-	-	-	-	-
1,100.... 5.6 m/s	0.8	70	- *	103	41*	143	19*	305	119	134	86*	188	114*	-	-	-	-	387	52	-	-
	3	132	159*	74	106*	97	112*	136	158	-	-	-	-	-	-	-	-	132	171	-	-
	6	28	195*	18	112*	53	95	60	193	-	-	-	-	-	-	-	-	99	127	-	-
	12	8	- *	4	111*	15	219*	10	201*	-	-	-	-	-	-	-	-	-	-	-	-
Total ignitions...		16		11		11		9		6		7		0		0		0		0	
Total impacts.....		2,137		2,170		2,263		2,934		2,243		1,910		2,089		2,151		2,720		2,219	
Av impact energy..		123		118		149		134		116		110		45		53		113		96	
Av ignition energy		105		112		153		151		81		92		-		-		-		-	

NOTE.--N denotes the total number of impacts for the run.
E denotes the maximum impact energy during the run or the impact energy which produced the ignition, ft-lb.
Ignition is denoted by *.

4 Conclusions

The Geochempet results were summarised in tables and graphical form. Nine samples were categorised in DDG214, and seven samples in DDG295; 16 samples in total. The highest IGCAT value observed from either set of borehole samples were Zone 3.

The study in [2] concluded that the reported airblast which resulted in the expulsion of methane into the mine workings was in all probability related to a reasonably large goaf fall located in the tailgate end of the face and that more so, the factors which contributed to this goaf fall included (i) the presence of a thick spanning sandstone unit in the near-seam overburden, (ii) one or more faults which caused the sandstone to fail suddenly and fall onto the goaf material below and (iii) the limited amount of bulking material in the goaf, which thereby created a pathway for the goaf gases to pass through and onto the longwall face.

The desktop review by Low [3] summaries various frictional ignition conditions observed in previous studies. Low [3] concluded, based on the literature, a rock fall of 3 m is potentially incendive. Moreover, if rock fragments are large, highly quarzitic in nature, and the total volume of the cavity is large (i.e. involving a high number of rock impacts), then it is plausible that a rock fall of this nature could cause ignition. A sizable rock fall in the goaf

could also create a significant wind blast of explosive gas into the working area of the longwall. Explosions caused by rock falls in the goaf have not been reported in Australia but there are various reports of it having occurred in other countries. Furthermore, Golledge *et al*. [7] reported the lowest velocity at which an ignition was observed was 7 - 8 ms^{-1}, which is attainable in a free-fall of 2.5 to 3.5 m. It was also found that rocks with quartz contents of 68%, 61% and 48% gave ignition frequencies of 7 in 160, 1 in 150 and 0 in 123, respectively.

Based on the review of the information provided and other related sources reviewed, the potential for a frictional ignition exists although the probability of such an event occurring is low.

5 References

[1] R. Williams, “Final Report – Supporting Investigation - Gas Reservoir, Emission and Drainage, Grosvenor Coal Mine - methane ignition of 6th May 2020 Ref: RSH1920_05. Report No 2020-001,” Brisbane, 2020.

[2] R. Thomas, “Geotechnical Factors Associated with the Methane Ignition Event on LW 104 in Grosvenor Mine,” Strata2, Brisbane, 2020.

[3] R. Low, “Desktop Review into the Plausibility of Mechanical Interactions Causing the Grosvenor Mine Explosion. Project No. C04312-001,” The University of Queensland, Brisbane, 2020.

[4] C. R. Ward, A. Crouch and D. R. Cohen, “Identification of potential for methane ignition by rock friction in Australian coal minesq,” *International Journal of Coal Geology,* vol. 45, pp. 91-103, 2001.

[5] R. Blickensderfer, “Methane ignition by frictional impact heating,” *Combustion and Flame,* vol. 25, no. 2, pp. 143-152, 1975.

[6] R. Blickensderfer, D. Deardorff and J. Kelley, “Incendivity of Some Coal-Cutter Materials by Impact-Abrasion in Air-Methane,” Bureau of Mines Report of Investigation (RI7930), 1974.

[7] P. Golledge, I. Gray, R. Story and R. Davis, “Frictional and Impact Ignitions of Methane-Coal Dust Mixtures, NERDDC PROJECT C1222, REPORT NUMBER 987,” ACARP, 1991.

Appendix 1 - Geochempet Services Results

GEOCHEMPET SERVICES

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG214_FI101) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number G2111563

Client Ref: Daniel Collins

Issued by [redacted]

T. F. D. Spring
BAppSc. MAppSc. MAusIMM
30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF DRILL CORE SAMPLES (DDG214_FI101) AT 387.04 - 387.24 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG214	**Project**:	Grosvenor
RSHQ Ref.:	Sample 1	**Anglo Ref.**:	FI101
Date Received:	10/11/2020	**Uncorrected Depth**:	387.04 – 387.24 m

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

GEOCHEMPET SERVICES, BRISBANE

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

The results were then recalculated to yield the necessary parameters;

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG214_FI101 at 387.04 – 387.24 m.

Grain Type	**Vol %**
Quartz	6
Feldspar	1
Opaque oxides/leucoxene	<1
Soft Lithic Fragments	<1
Mica	2
Matrix cement	55
Carbonate	26
Organics	10

GEOCHEMPET SERVICES, BRISBANE

RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG214_FI101 at 387.04 – 387.24 m.

Seam Interval (m)	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. +pyrite)	Cl (= clay + mica)	Ca = carbonate	
Seam 1 Roof 387.04 – 387.24 m	carbonated siltstone with coaly wisps and rare silt sized grains of quartz and feldspar	7.8	63.3	28.9	**1**

From the tabulated FI results and Figure 3, it is noted that Sample DDG214_FI101 at 387.04 – 387.24 m has an IGCAT value that places it within Zone 1 (the lowest frictional ignition risk category).

PHOTOMICROGRAPH

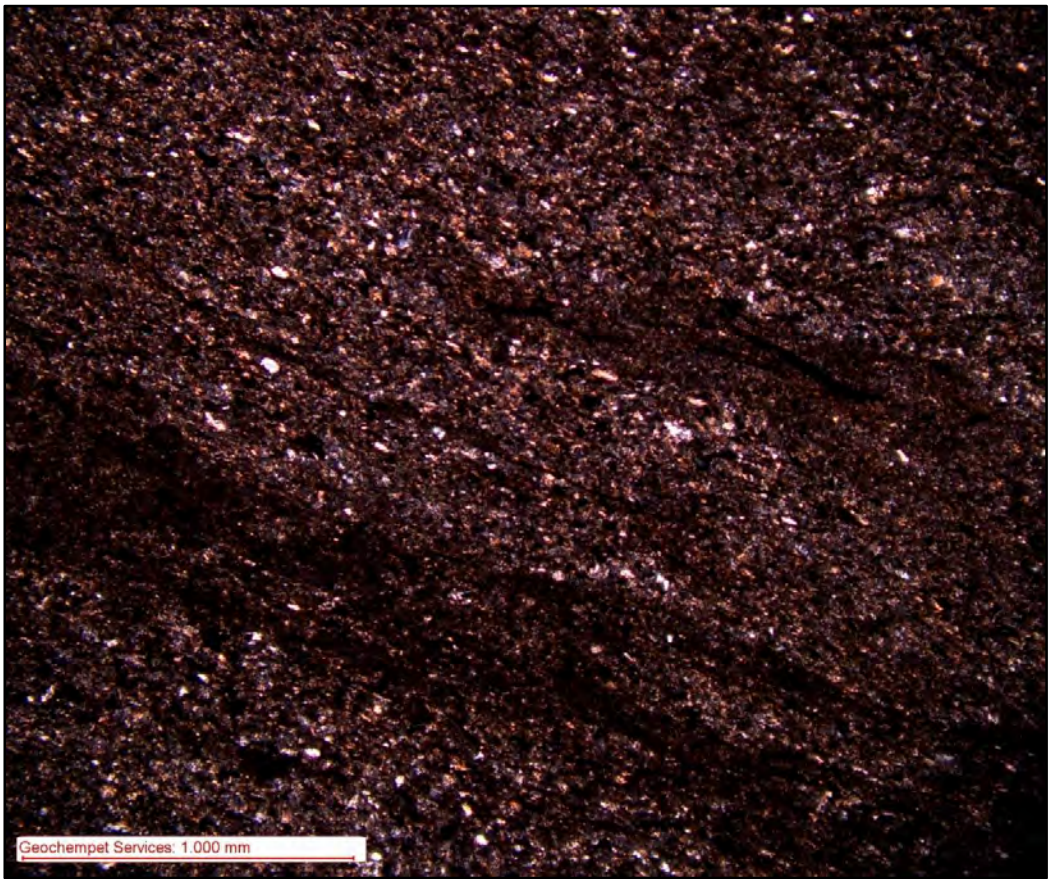

Figure 2: Photo-micrograph taken at low magnification in transmitted cross polarised light. Image shows the typical mineral assemblage observed within the supplied drill core. The carbonated siltstone consists of mainly matrix material of clays and micas with carbonate clasts, minor silt sized suspended grains of quartz and lithic clasts and common coaly wisps.

GEOCHEMPET SERVICES, BRISBANE

APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

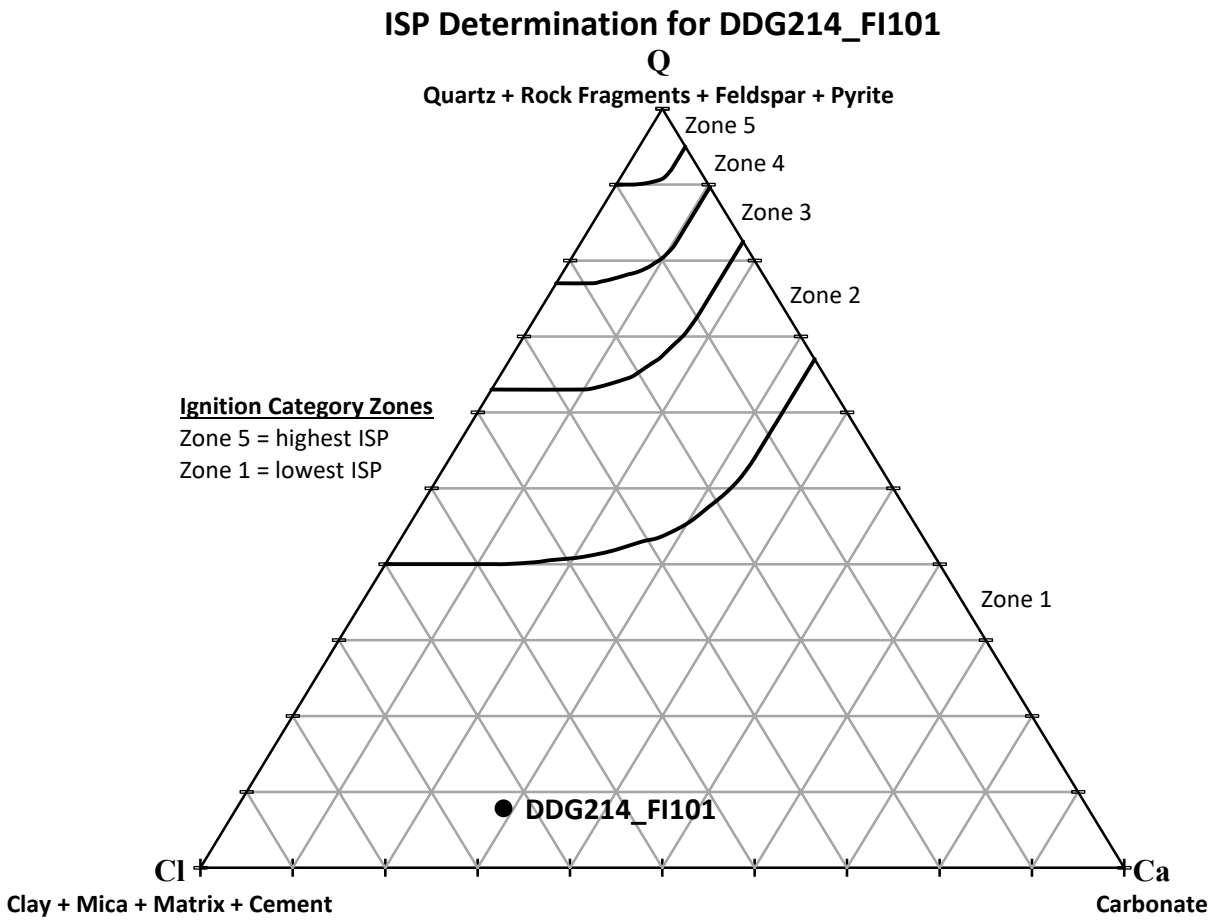

Figure 3: Classification of the incendive parking potential for drill core sample DDG214_FI101 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG214_FI102) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]

T. F. D. Spring
BAppSc. MAppSc. MAusIMM
30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF DRILL CORE SAMPLES (DDG214_FI102) AT 376.92 – 377.33 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG214	**Project**:	Grosvenor
RSHQ Ref.:	Sample 2	**Anglo Ref.**:	FI102
Date Received:	10/11/2020	**Uncorrected Depth**:	376.92 – 377.33 m

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

GEOCHEMPET SERVICES, BRISBANE

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

The results were then recalculated to yield the necessary parameters;

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG214_FI102 at 376.92 – 377.33 m.

Grain Type	**Vol %**
Quartz	19
Feldspar	4
Opaque oxides/leucoxene	<1
Soft Lithic Fragments	13
Mica/chlorite	7
Matrix cement	28
Carbonate	23
Organics	6

GEOCHEMPET SERVICES, BRISBANE

RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG214_FI102 at 376.92 – 377.33 m.

Seam Interval (m)	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. +pyrite)	Cl (= clay + mica)	Ca = carbonate	
376.92 – 377.33 m	carbonated siltstone with minor coaly wisps and some interbedded sandstone layers	24.5	51.0	24.5	**1**

From the tabulated FI results and Figure 3, it is noted that Sample DDG214_FI102 at 376.92 – 377.33 m has an IGCAT value that places it within Zone 1 (the lowest frictional ignition risk category).

PHOTOMICROGRAPH

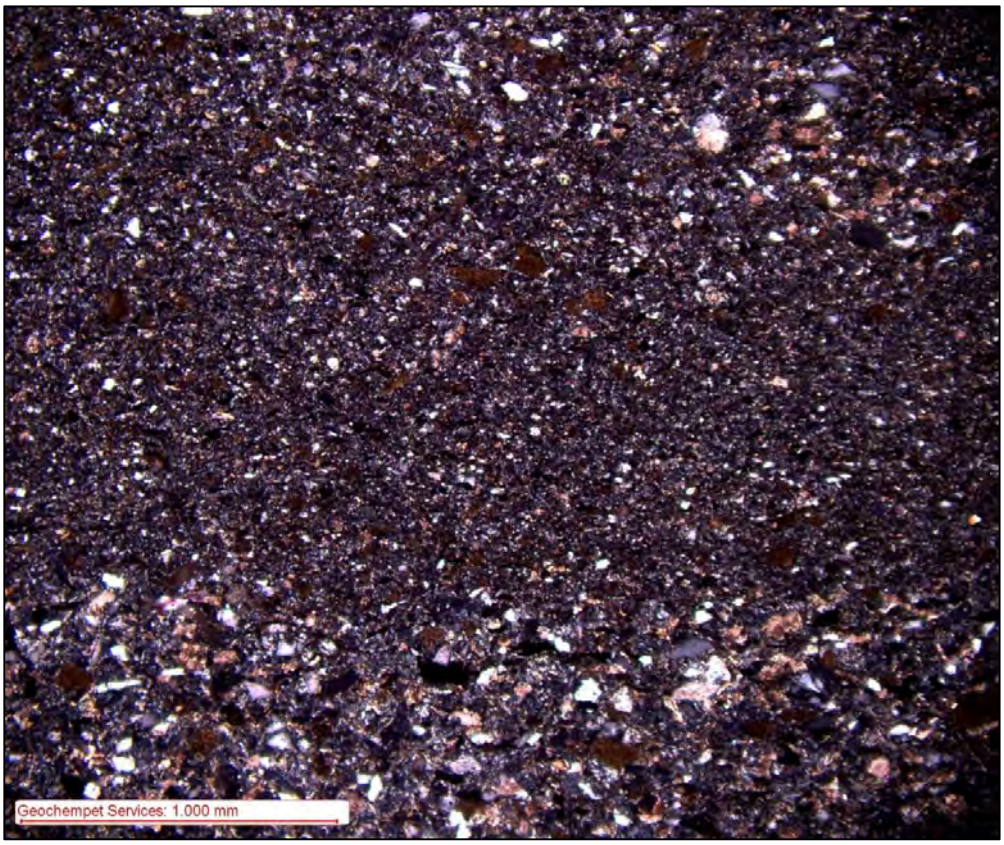

Figure 2: Photo-micrograph taken at low magnification in transmitted cross polarised light. Image shows the typical mineral assemblage observed within the supplied drill core. The carbonated siltstone consists of mainly matrix material of clays and micas with carbonate clasts, minor silt sized suspended grains of quartz and lithic clasts and coaly wisps. Some coarser interbedded sandstone layers with argillized lithic clasts are observed as at the bottom of the image.

GEOCHEMPET SERVICES, BRISBANE

APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

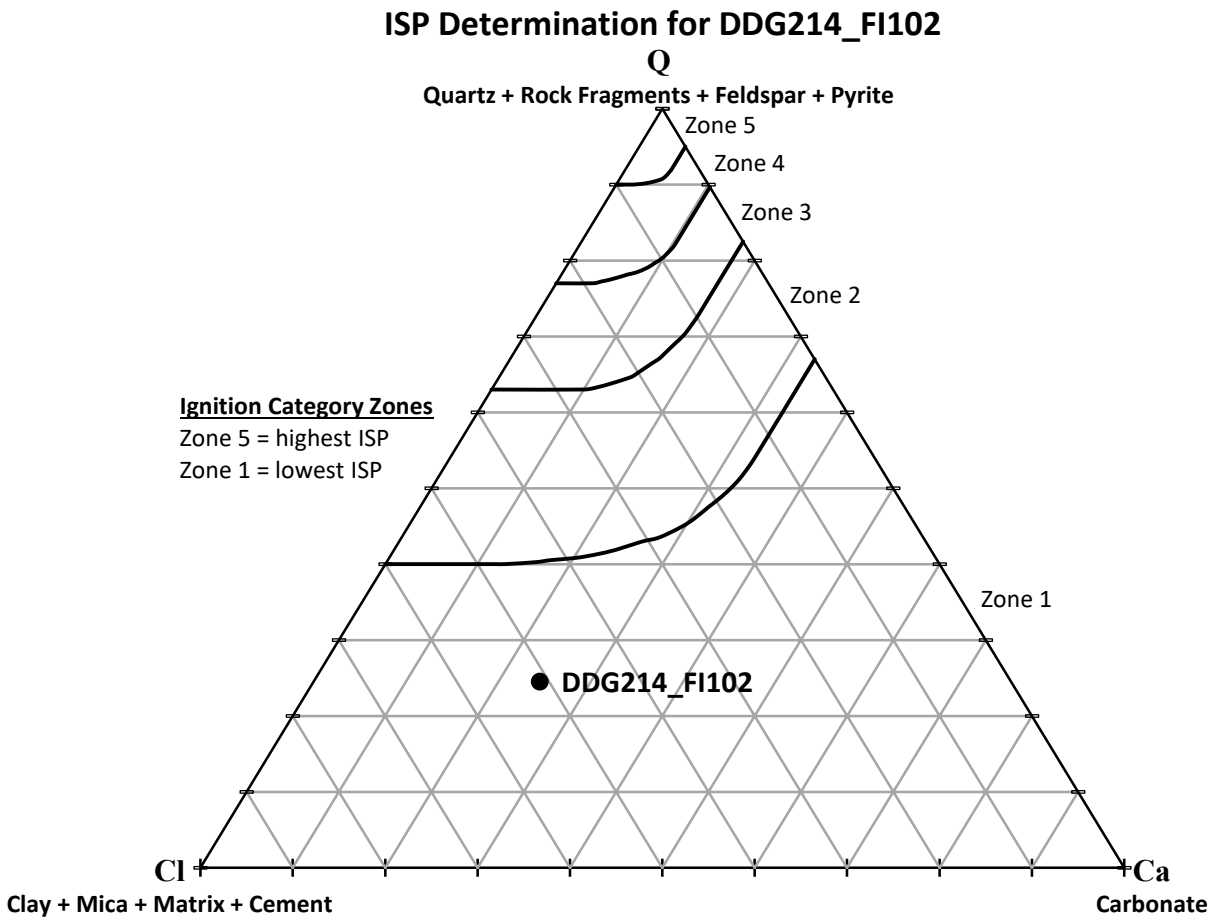

Figure 3: Classification of the incendive parking potential for drill core sample DDG214_FI102 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG214_FI103) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]

T. F. D. Spring
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30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF DRILL CORE SAMPLES (DDG214_FI103) AT 364.10 – 364.37 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG214	**Project**:	Grosvenor
RSHQ Ref.:	Sample 3	**Anglo Ref.**:	FI103
Date Received:	10/11/2020	**Uncorrected Depth**:	364.10 – 364.37 m

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

GEOCHEMPET SERVICES, BRISBANE

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

The results were then recalculated to yield the necessary parameters;

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG214_FI103 at 364.10 – 364.37 m.

Grain Type	Vol %
Quartz	8
Feldspar	2
Lithic fragments	2
Mica	4
Matrix cement	68
Carbonate	13
Organics	3

GEOCHEMPET SERVICES, BRISBANE

RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG214_FI103 at 364.10 – 364.37 m.

Seam Interval (m)	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. +pyrite)	Cl (= clay + mica)	Ca = carbonate	
364.10 – 364.37 m	carbonated siltstone with minor organics	12.4	74.2	13.4	**1**

From the tabulated FI results and Figure 3, it is noted that Sample DDG214_FI103 at 364.10 – 364.37 m has an IGCAT value that places it within Zone 1 (the lowest frictional ignition risk category).

PHOTOMICROGRAPH

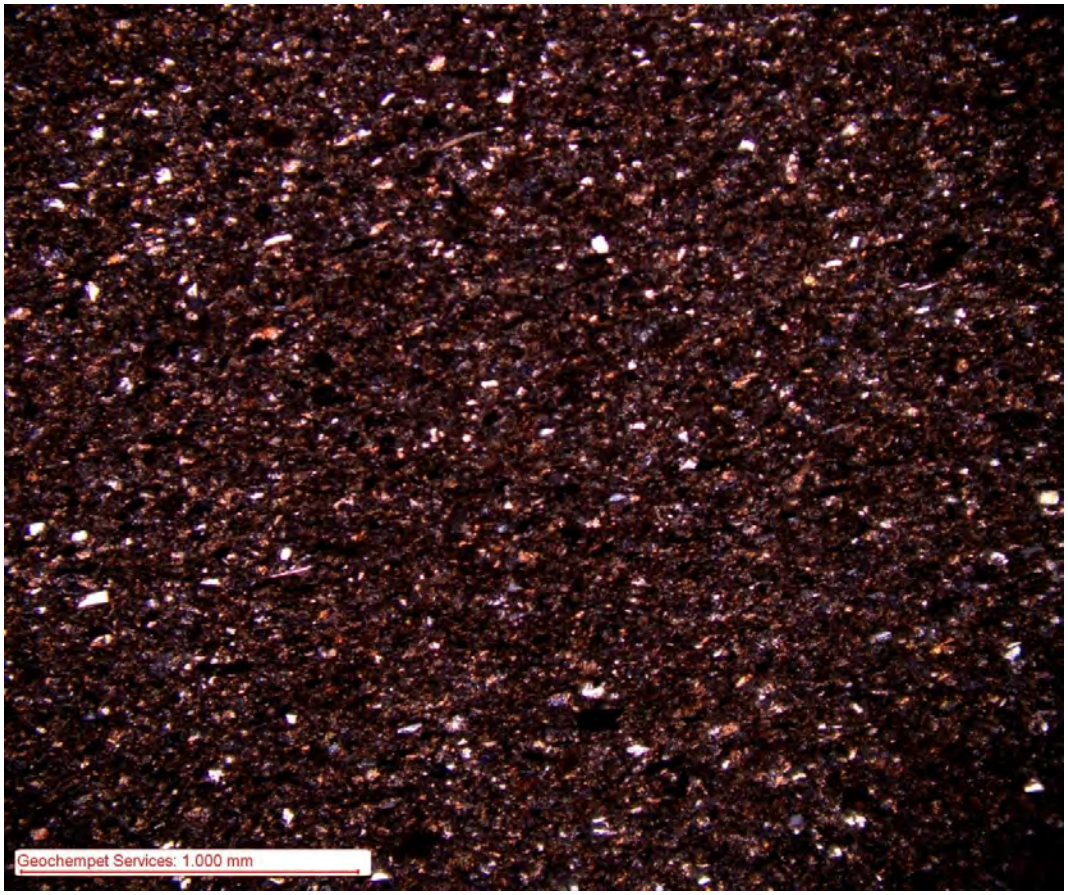

Figure 2: Photo-micrograph taken at low magnification in transmitted cross polarised light. Image shows the typical mineral assemblage observed within the supplied drill core. The carbonated siltstone consists of mainly matrix material of clays and micas with carbonate clasts, minor silt sized suspended grains of quartz and lithic clasts and coaly wisps. Some coarser interbedded sandstone layers with argillized lithic clasts are observed as at the bottom of the image.

GEOCHEMPET SERVICES, BRISBANE

APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

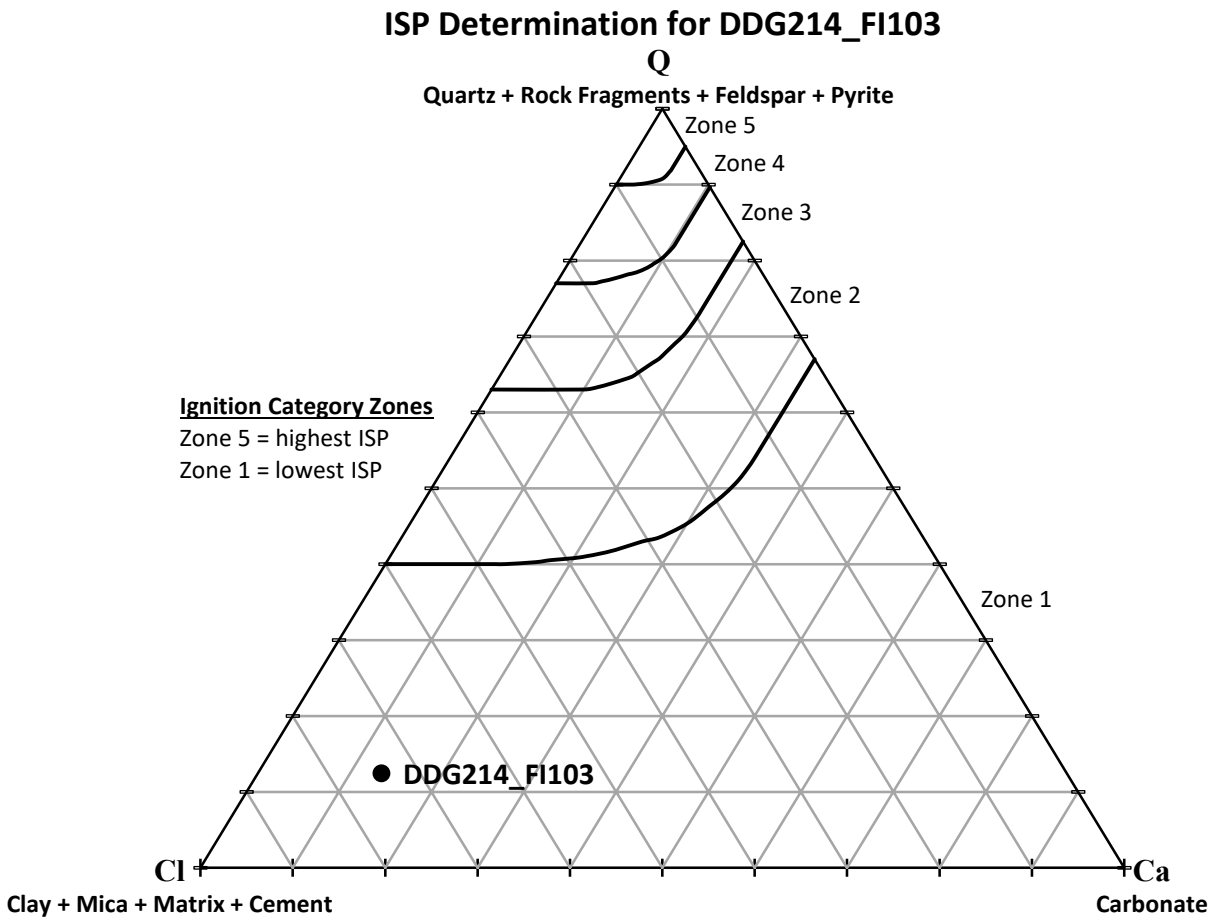

Figure 3: Classification of the incendive parking potential for drill core sample DDG214_FI103 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG214_FI104) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]

T. F. D. Spring
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30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF DRILL CORE SAMPLES (DDG214_FI104) AT 359.00 – 359.45 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG214	**Project**:	Grosvenor
RSHQ Ref.:	Sample 4	**Anglo Ref.**:	FI104
Date Received:	10/11/2020	**Uncorrected Depth**:	359.00 – 359.45 m

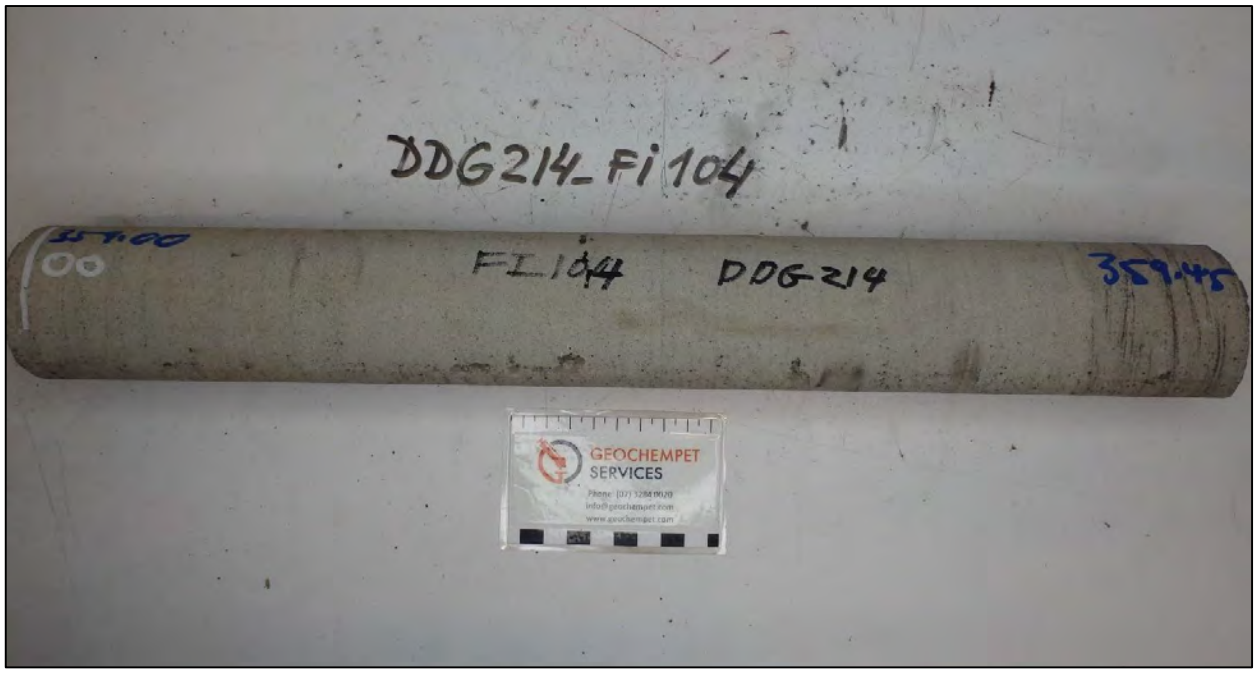

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

GEOCHEMPET SERVICES, BRISBANE

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

The results were then recalculated to yield the necessary parameters;

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG214_FI104 at 359.00 – 359.45 m.

Grain Type	**Vol %**
Quartz	23
Feldspar	12
Lithic fragments	25
Mica	4
Matrix cement	9
Argillized fragments	7
Carbonate	19
Organics	1

GEOCHEMPET SERVICES, BRISBANE

RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG214_FI104 at 359.00 – 359.45 m.

Seam Interval (m)	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. +pyrite)	Cl (= clay + mica)	Ca = carbonate	
359.00 – 359.45 m	carbonated quartzofeldspathic and lithic sandstone	60.6	20.2	19.2	**2**

From the tabulated FI results and Figure 3, it is noted that Sample DDG214_FI104 at 359.00 – 359.45 m has an IGCAT value that places it within Zone 2 (the second lowest frictional ignition risk category).

PHOTOMICROGRAPH

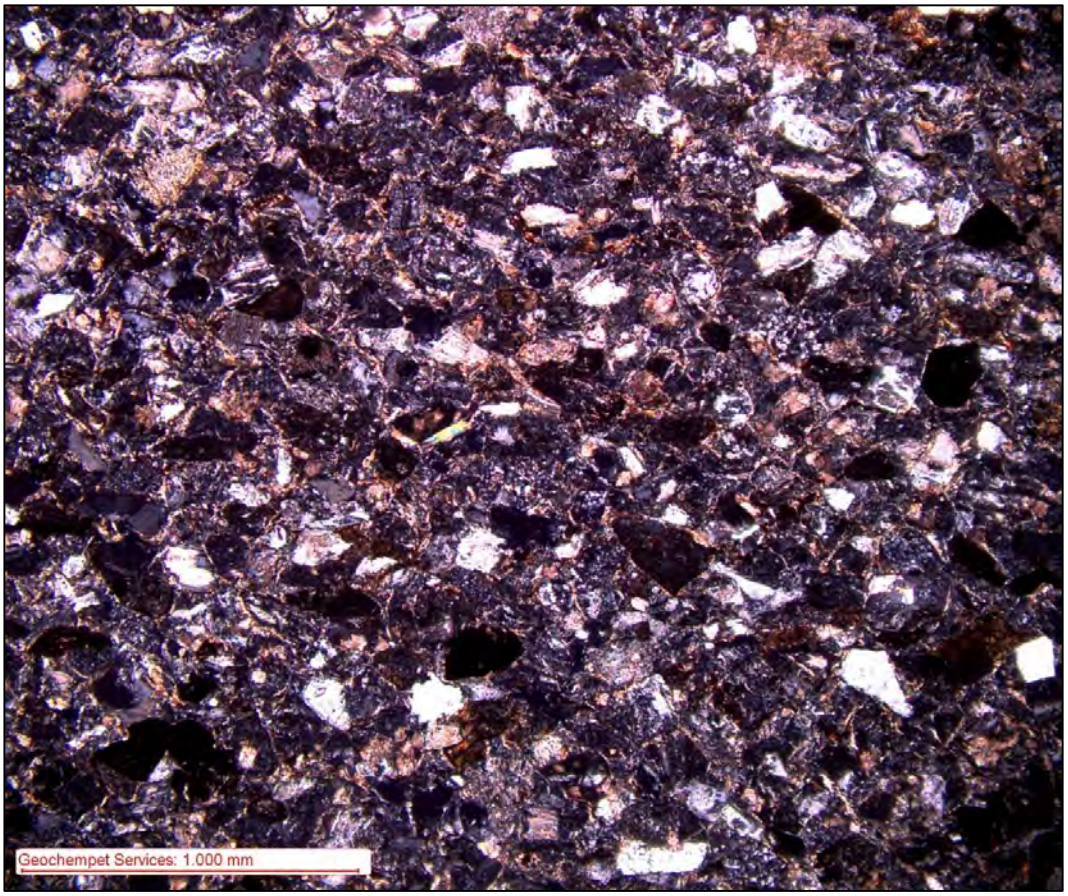

Figure 2: Photo-micrograph taken at low magnification in transmitted cross polarised light. Image shows the typical mineral assemblage observed within the supplied drill core. The carbonated quartzofeldspathic and lithic siltstone consists of mainly quartz, feldspar, lithic clasts and carbonate clasts. Some free micas and argillized clasts are also present.

GEOCHEMPET SERVICES, BRISBANE

APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

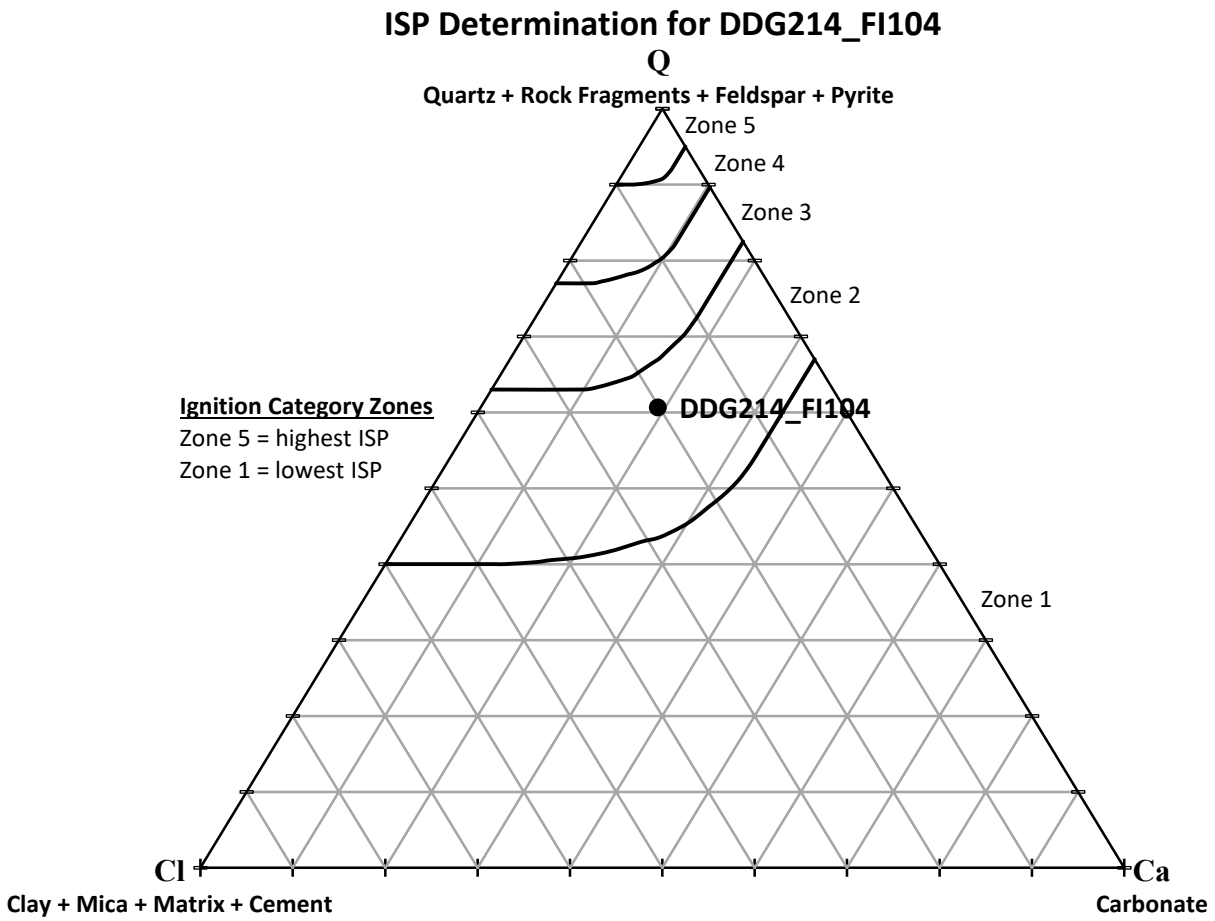

Figure 3: Classification of the incendive parking potential for drill core sample DDG214_FI104 adapted from Ward et. al. (2001).

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG214_FI105) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]

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30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF DRILL CORE SAMPLES (DDG214_FI105) AT 357.80 – 358.07 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG214	**Project**:	Grosvenor
RSHQ Ref.:	Sample 5	**Anglo Ref.**:	FI105
Date Received:	10/11/2020	**Uncorrected Depth**:	357.80 – 358.07 m

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

GEOCHEMPET SERVICES, BRISBANE

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

The results were then recalculated to yield the necessary parameters;

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG214_FI105 at 357.80 – 358.07 m.

Grain Type	Vol %
Quartz	12
Feldspar	9
Lithic fragments	26
Opaque oxides/leucoxene	<1
Mica	2
Matrix cement	3
Argillized fragments	4
Sericitized fragments	2
Soft lithics	4
Carbonate	38

GEOCHEMPET SERVICES, BRISBANE

RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG214_FI105 at 357.80 – 358.07 m.

Seam Interval (m)	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. +pyrite)	Cl (= clay + mica)	Ca = carbonate	
357.80 – 358.07 m	carbonated quartzofeldspathic and lithic sandstone	47.0	15.0	38.0	**1**

From the tabulated FI results and Figure 3, it is noted that Sample DDG214_FI105 at 357.80 – 358.07 m has an IGCAT value that places it within Zone 1 (the lowest frictional ignition risk category).

PHOTOMICROGRAPH

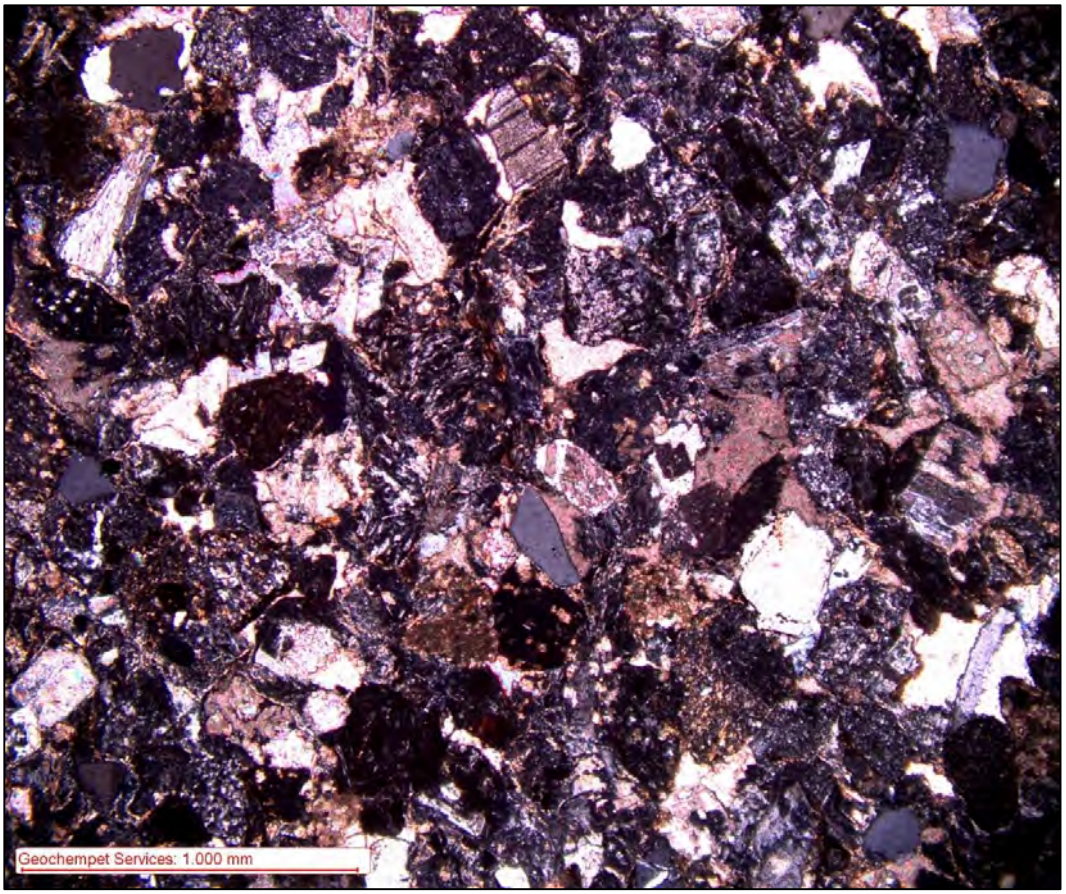

Figure 2: Photo-micrograph taken at low magnification in transmitted cross polarised light. Image shows the typical mineral assemblage observed within the supplied drill core. The carbonated quartzofeldspathic and lithic siltstone consists of mainly quartz, feldspar, lithic clasts and carbonate clasts. Some free micas and argillized clasts are also present.

GEOCHEMPET SERVICES, BRISBANE

APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

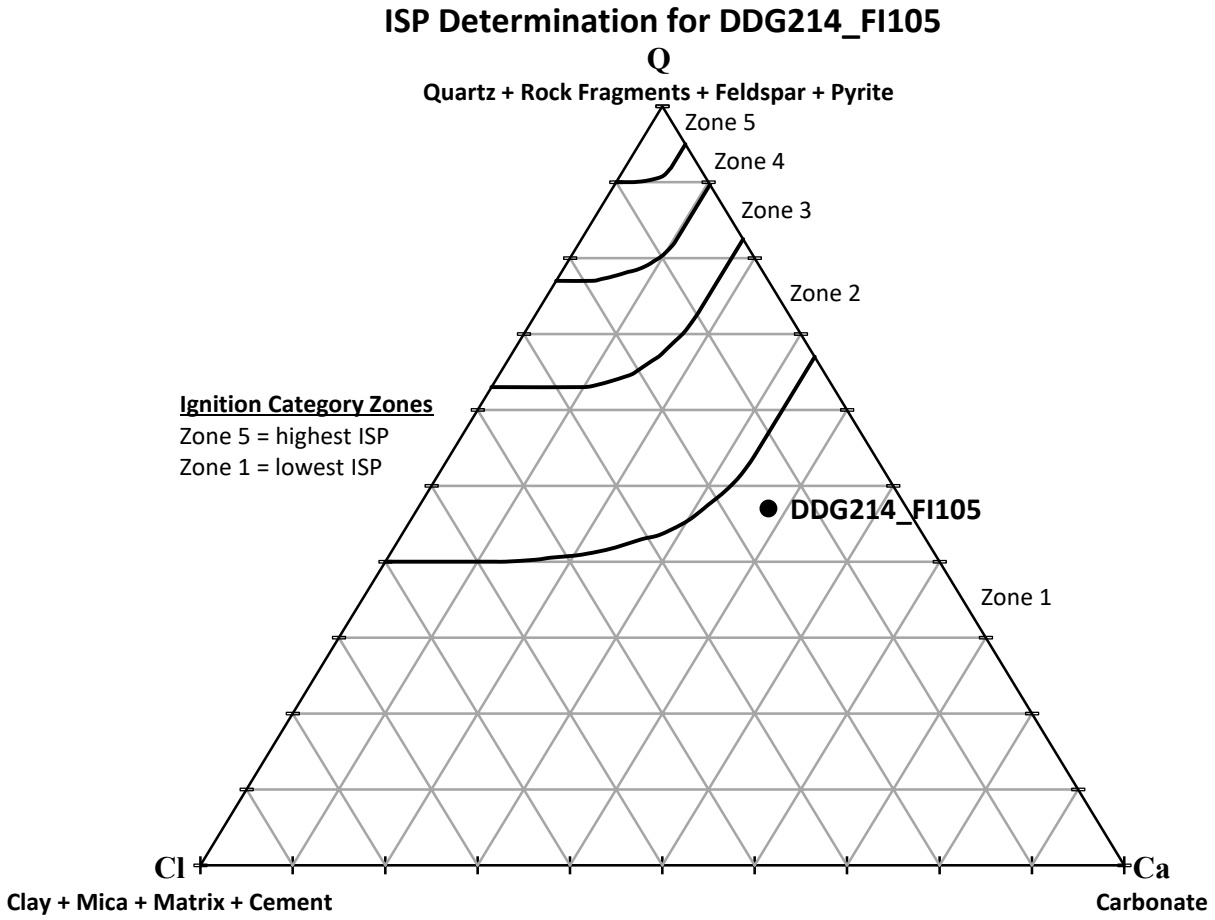

Figure 3: Classification of the incendive parking potential for drill core sample DDG214_FI105 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG214_FI106) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]

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30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF DRILL CORE SAMPLES (DDG214_FI106) AT 355.15 – 355.57 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG214	**Project**:	Grosvenor
RSHQ Ref.:	Sample 6	**Anglo Ref.**:	FI106
Date Received:	10/11/2020	**Uncorrected Depth**:	355.15 – 355.57 m

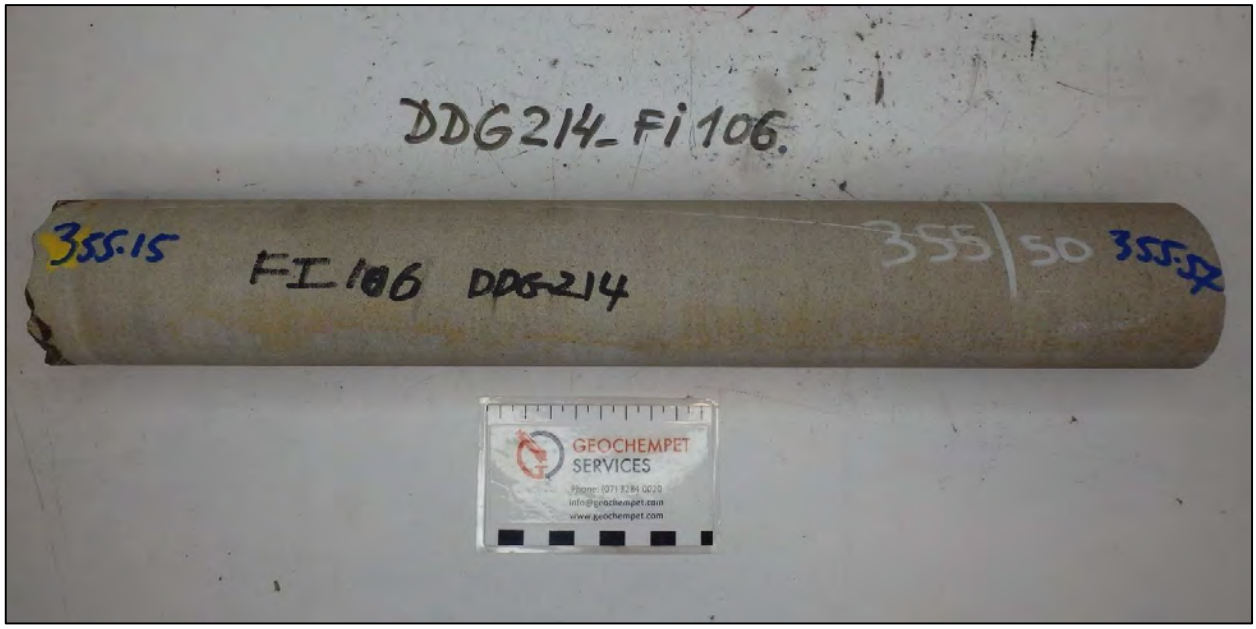

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

GEOCHEMPET SERVICES, BRISBANE

The results were then recalculated to yield the necessary parameters;

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG214_FI106 at 355.15 – 355.57 m.

Grain Type	**Vol %**
Quartz	15
Feldspar	10
Lithic fragments	47
Opaque oxides/leucoxene	<1
Mica	5
Matrix cement	5
Argillized fragments	3
Sericitized fragments	2
Soft lithics	1
Carbonate	12

GEOCHEMPET SERVICES, BRISBANE

RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG214_FI106 at 355.15 – 355.57 m.

Seam Interval (m)	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. +pyrite)	Cl (= clay + mica)	Ca = carbonate	
355.15 – 355.57 m	carbonated quartzofeldspathic and lithic sandstone	72.0	16.0	12.0	**3**

From the tabulated FI results and Figure 3, it is noted that Sample DDG214_FI106 at 355.15 – 355.57 m has an IGCAT value that places it within Zone 3 (the third highest frictional ignition risk category).

PHOTOMICROGRAPH

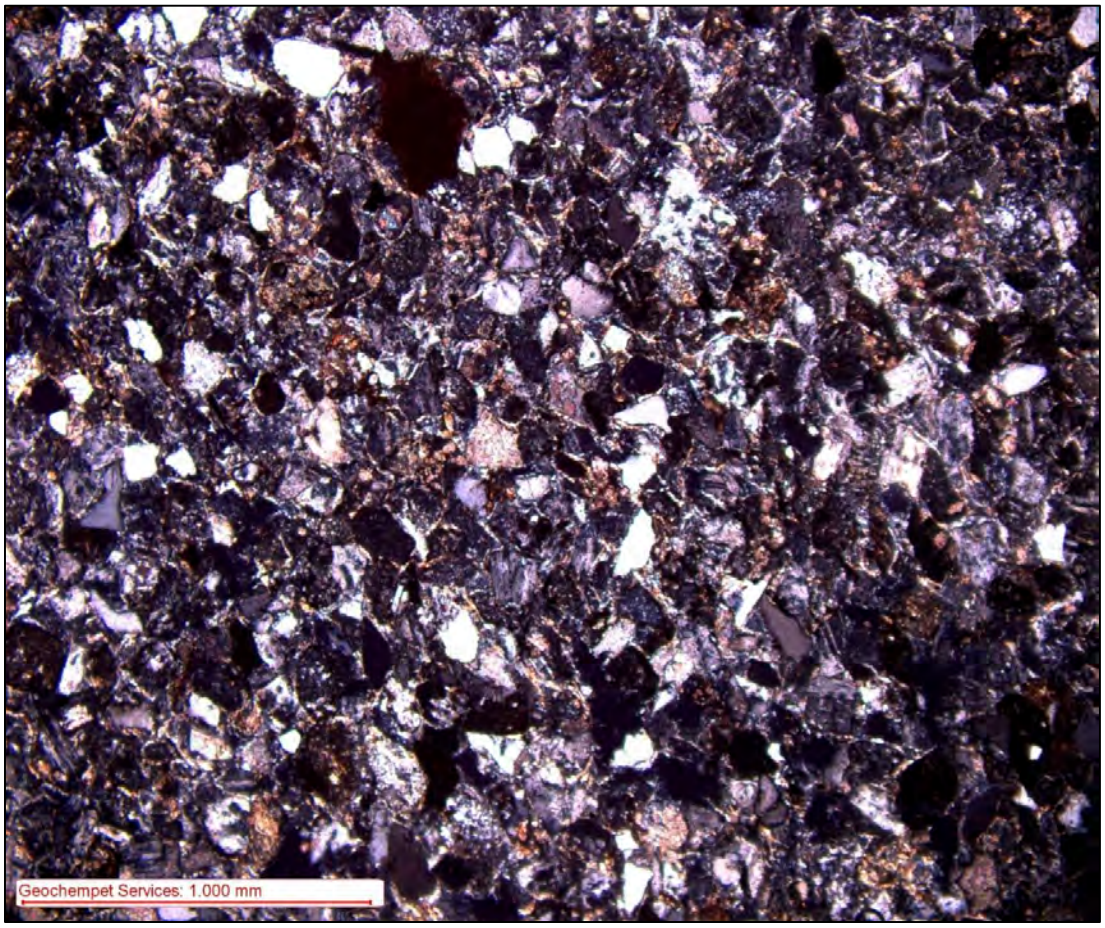

Figure 2: Photo-micrograph taken at low magnification in transmitted cross polarised light. Image shows the typical mineral assemblage observed within the supplied drill core. The carbonated quartzofeldspathic and lithic siltstone consists of mainly quartz, feldspar, lithic clasts and carbonate clasts. Some free micas and argillized clasts are also present.

GEOCHEMPET SERVICES, BRISBANE

APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

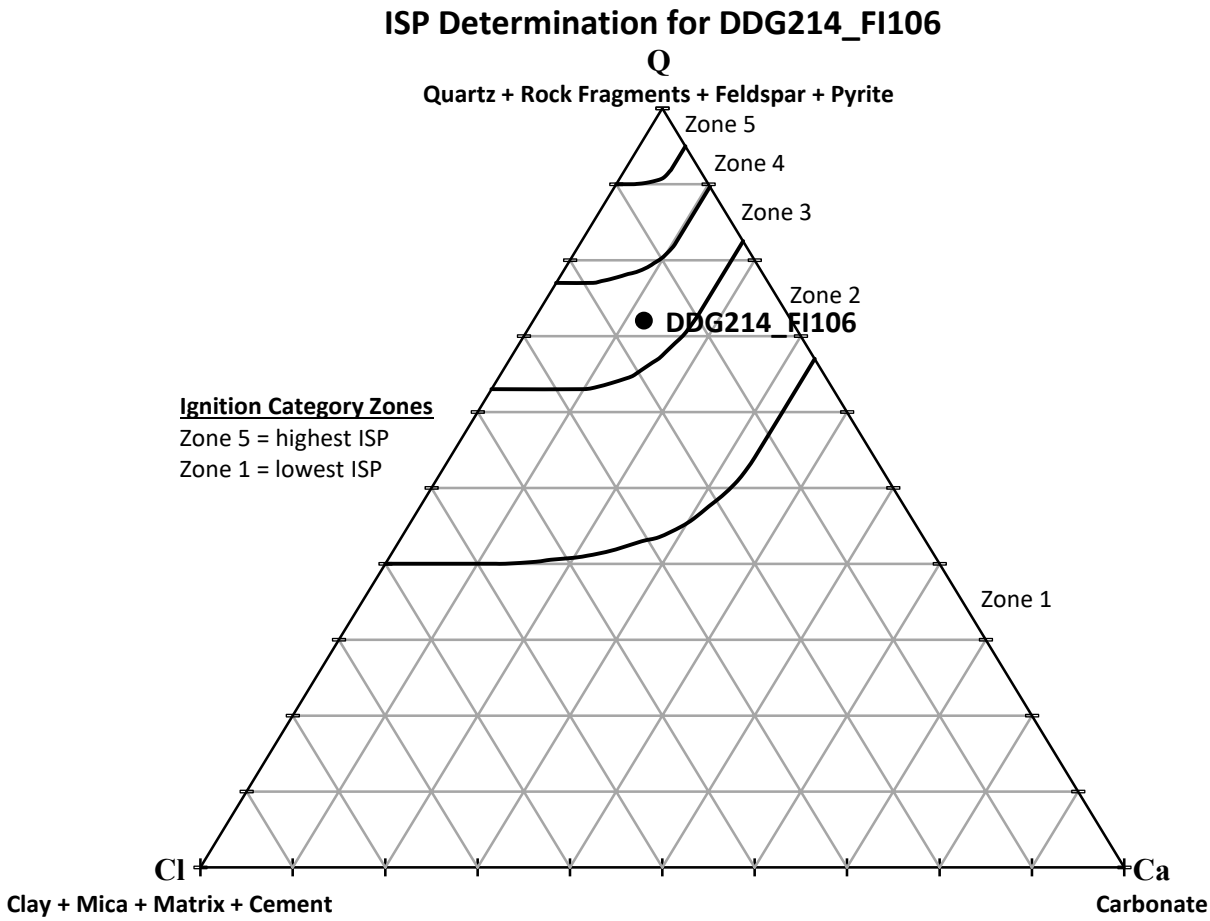

Figure 3: Classification of the incendive parking potential for drill core sample DDG214_FI106 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG214_FI107) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]
T. F. D. Spring
BAppSc. MAppSc. MAusIMM
30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF DRILL CORE SAMPLES (DDG214_FI107) AT 354.12 – 354.47 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG214	**Project**:	Grosvenor
RSHQ Ref.:	Sample 7	**Anglo Ref.**:	FI107
Date Received:	10/11/2020	**Uncorrected Depth**:	354.12 – 354.47 m

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

GEOCHEMPET SERVICES, BRISBANE

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

The results were then recalculated to yield the necessary parameters;

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG214_FI107 at 354.12 – 354.47 m.

Grain Type	**Vol %**
Quartz	15
Feldspar	8
Lithic fragments	42
Opaque oxides/leucoxene	<1
Mica	2
Matrix cement	3
Argillized fragments	3
Sericitized fragments	1
Soft lithics	1
Carbonate	25

GEOCHEMPET SERVICES, BRISBANE

RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG214_FI107 at 354.12 – 354.47 m.

Seam Interval (m)	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. +pyrite)	Cl (= clay + mica)	Ca = carbonate	
354.12 – 354.47 m	carbonated quartzofeldspathic and lithic sandstone	65.0	10.0	25.0	**2**

From the tabulated FI results and Figure 3, it is noted that Sample DDG214_FI107 at 354.12 – 354.47 m has an IGCAT value that places it within Zone 2 (the second lowest frictional ignition risk category).

PHOTOMICROGRAPH

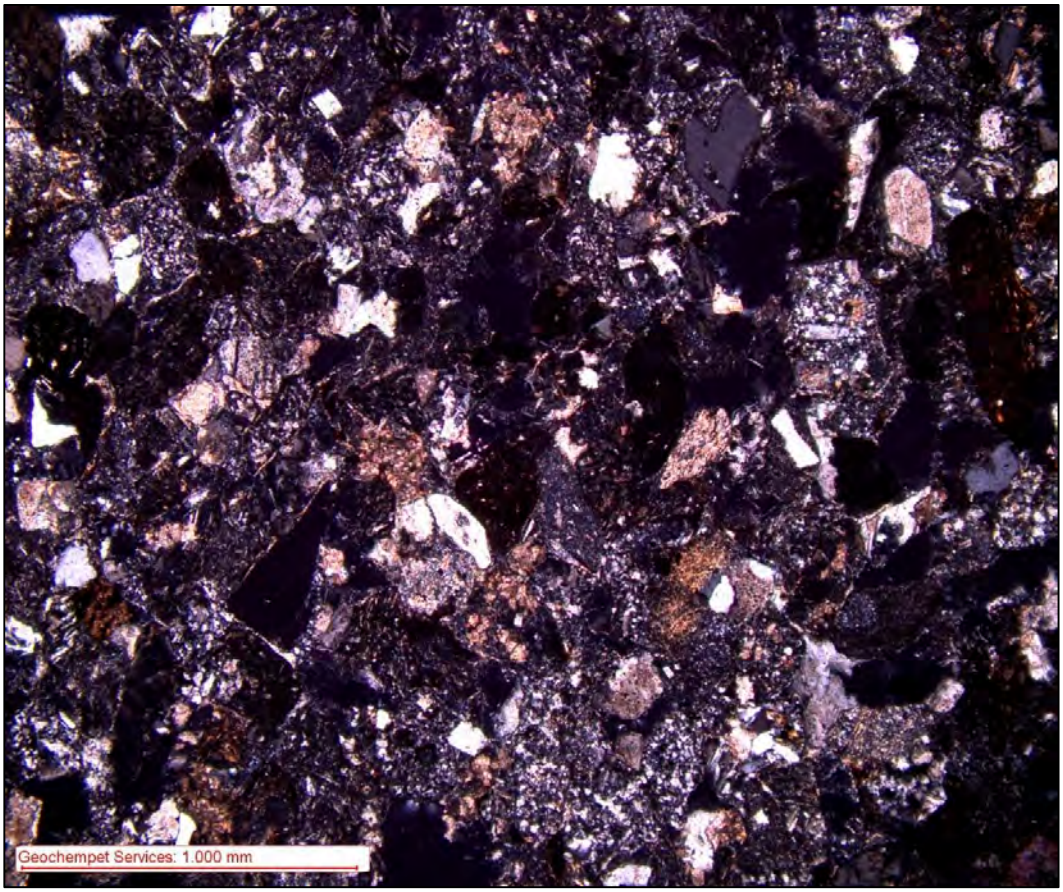

Figure 2: Photo-micrograph taken at low magnification in transmitted cross polarised light. Image shows the typical mineral assemblage observed within the supplied drill core. The carbonated

quartzofeldspathic and lithic siltstone consists of mainly quartz, feldspar, lithic clasts and carbonate clasts. Some free micas and argillized clasts are also present.

APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

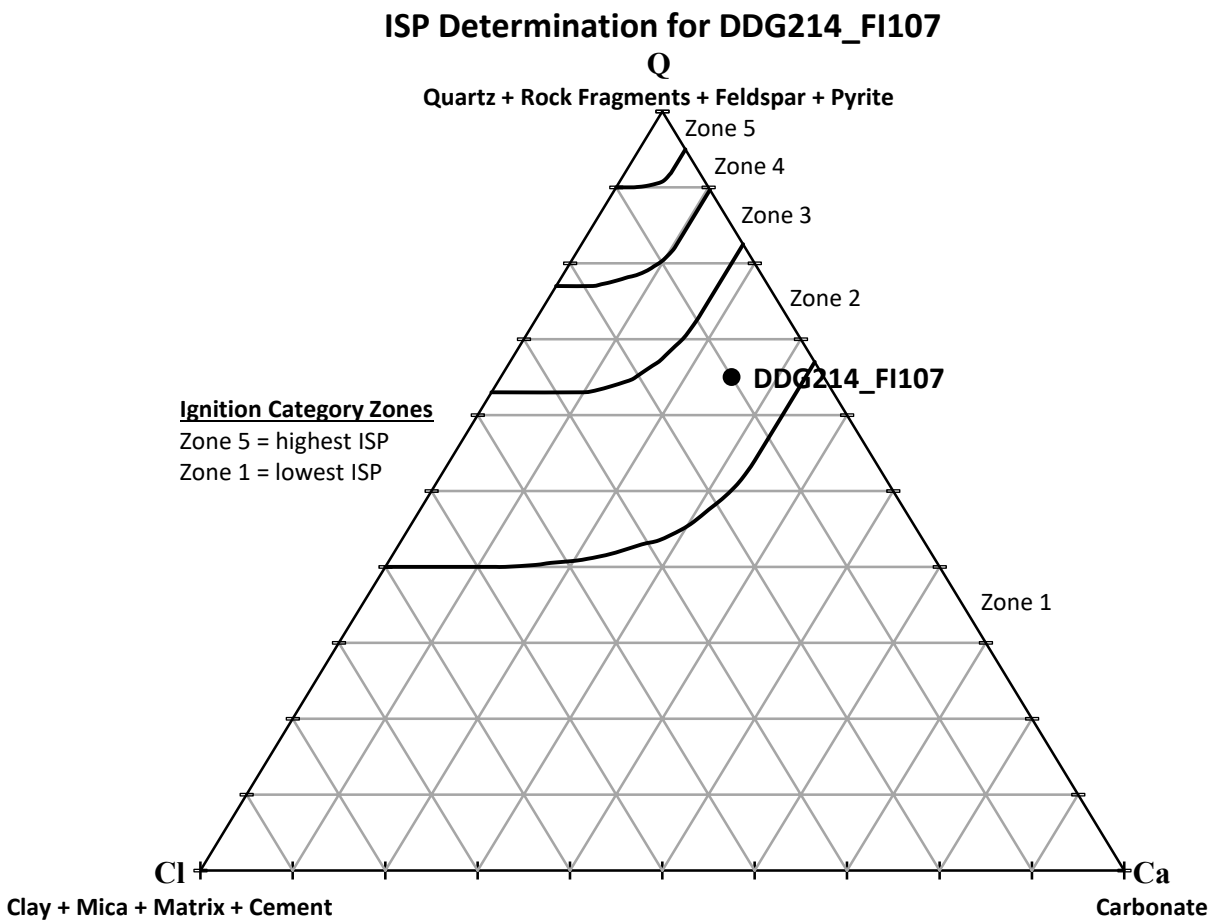

Figure 3: Classification of the incendive parking potential for drill core sample DDG214_FI107 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG214_FI108) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]

T. F. D. Spring
BAppSc. MAppSc. MAusIMM
30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF DRILL CORE SAMPLES (DDG214_FI108) AT 344.98 – 345.32 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG214	**Project**:	Grosvenor
RSHQ Ref.:	Sample 8	**Anglo Ref.**:	FI108
Date Received:	10/11/2020	**Uncorrected Depth**:	344.98 – 345.32 m

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

GEOCHEMPET SERVICES, BRISBANE

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

The results were then recalculated to yield the necessary parameters;

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG214_FI108 at 344.98 – 345.32 m.

Grain Type	**Vol %**
Quartz	8
Feldspar	4
Lithic fragments	24
Opaque oxides/leucoxene	1
Mica	1
Matrix cement	2
Argillized fragments	5
Soft lithics	1
Carbonate	54

GEOCHEMPET SERVICES, BRISBANE

RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG214_FI108 at 344.98 – 345.32 m.

Seam Interval (m)	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. +pyrite)	Cl (= clay + mica)	Ca = carbonate	
344.98 – 345.32 m	carbonated quartzofeldspathic and lithic sandstone	37.0	9.0	54.0	**1**

From the tabulated FI results and Figure 3, it is noted that Sample DDG214_FI108 at 344.98 – 345.32 m has an IGCAT value that places it within Zone 1 (the lowest frictional ignition risk category).

PHOTOMICROGRAPH

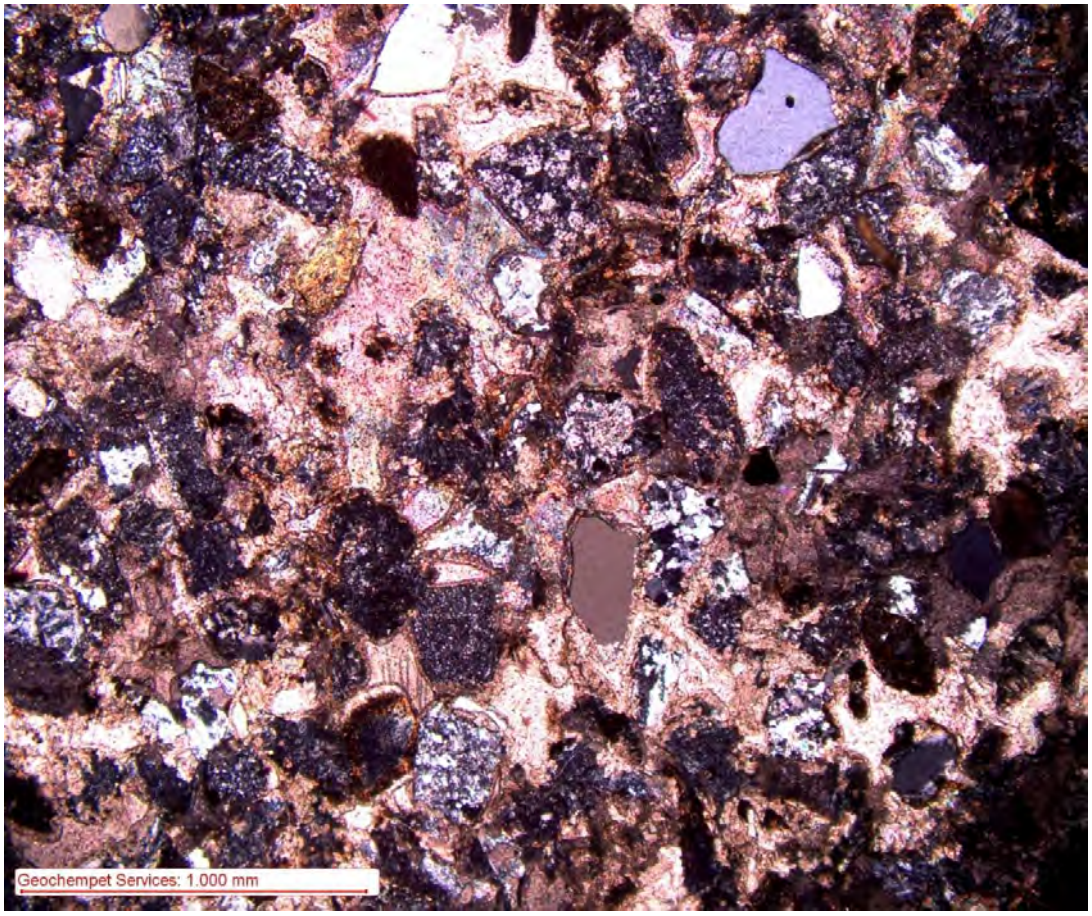

Figure 2: Photo-micrograph taken at low magnification in transmitted cross polarised light. Image shows the typical mineral assemblage observed within the supplied drill core. The carbonated quartzofeldspathic and lithic siltstone consists of mainly quartz, feldspar, lithic clasts and significant carbonate clasts. Some minor free micas and argillized clasts are also present.

GEOCHEMPET SERVICES, BRISBANE

APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

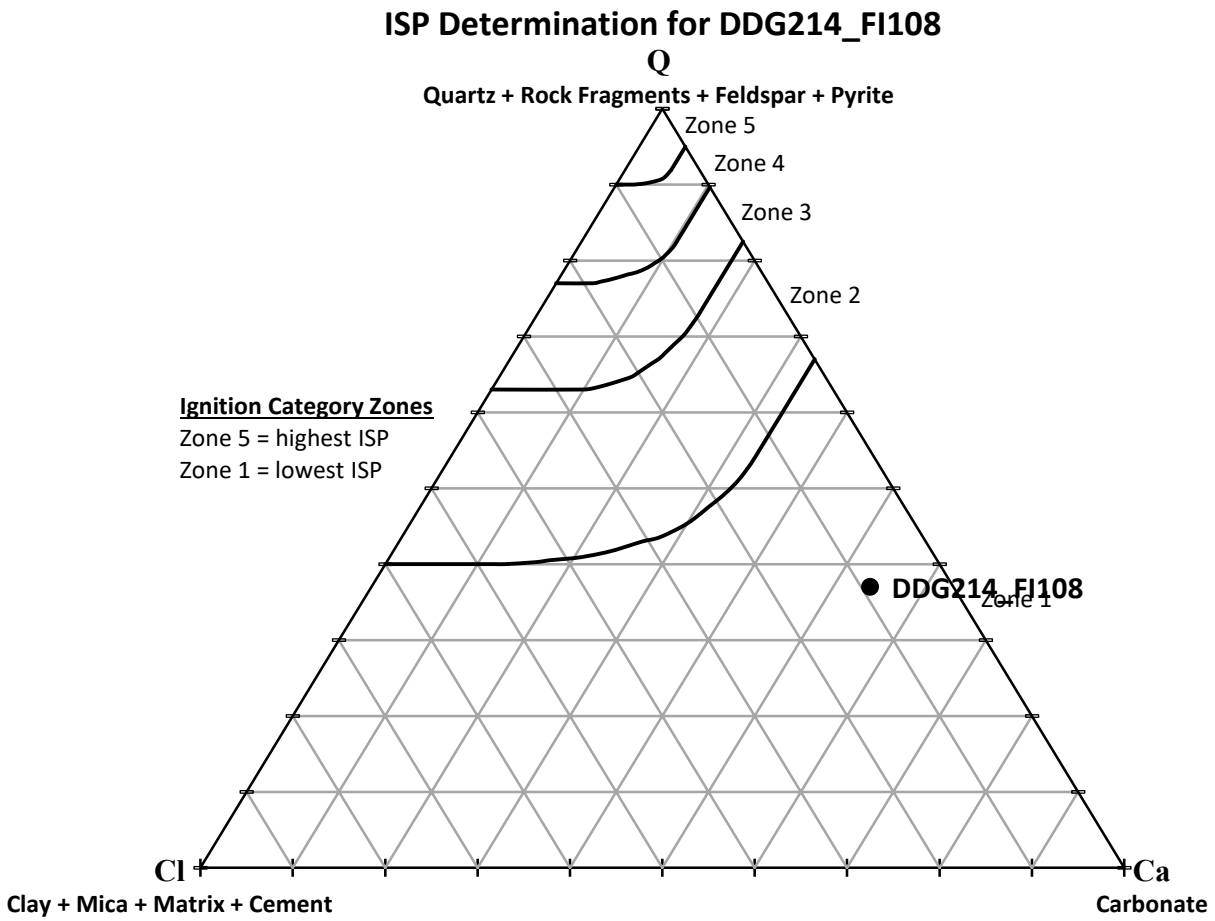

Figure 3: Classification of the incendive parking potential for drill core sample DDG214_FI108 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG214_FI109) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]
T. F. D. Spring
BAppSc. MAppSc. MAusIMM
30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF DRILL CORE SAMPLES (DDG214_FI109) AT 341.62 – 342.05 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG214	**Project**:	Grosvenor
RSHQ Ref.:	Sample 8	**Anglo Ref.**:	FI108
Date Received:	10/11/2020	**Uncorrected Depth**:	341.62 – 342.05 m

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

GEOCHEMPET SERVICES, BRISBANE

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

The results were then recalculated to yield the necessary parameters;

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG214_FI109 at 341.62 – 342.05 m.

Grain Type	**Vol %**
Quartz	19
Feldspar	6
Lithic fragments	45
Opaque oxides/leucoxene	<1
Mica	3
Matrix cement	2
Argillized fragments	7
Sericitized fragments	2
Carbonate	16

GEOCHEMPET SERVICES, BRISBANE

RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG214_FI109 at 341.62 – 342.05 m.

Seam Interval (m)	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. +pyrite)	Cl (= clay + mica)	Ca = carbonate	
341.62 – 342.05 m	carbonated quartzofeldspathic and lithic sandstone	70.0	14.0	16.0	**3**

From the tabulated FI results and Figure 3, it is noted that Sample DDG214_FI109 at 341.62 – 342.05 m has an IGCAT value that places it within Zone 3 (the third highest frictional ignition risk category).

PHOTOMICROGRAPH

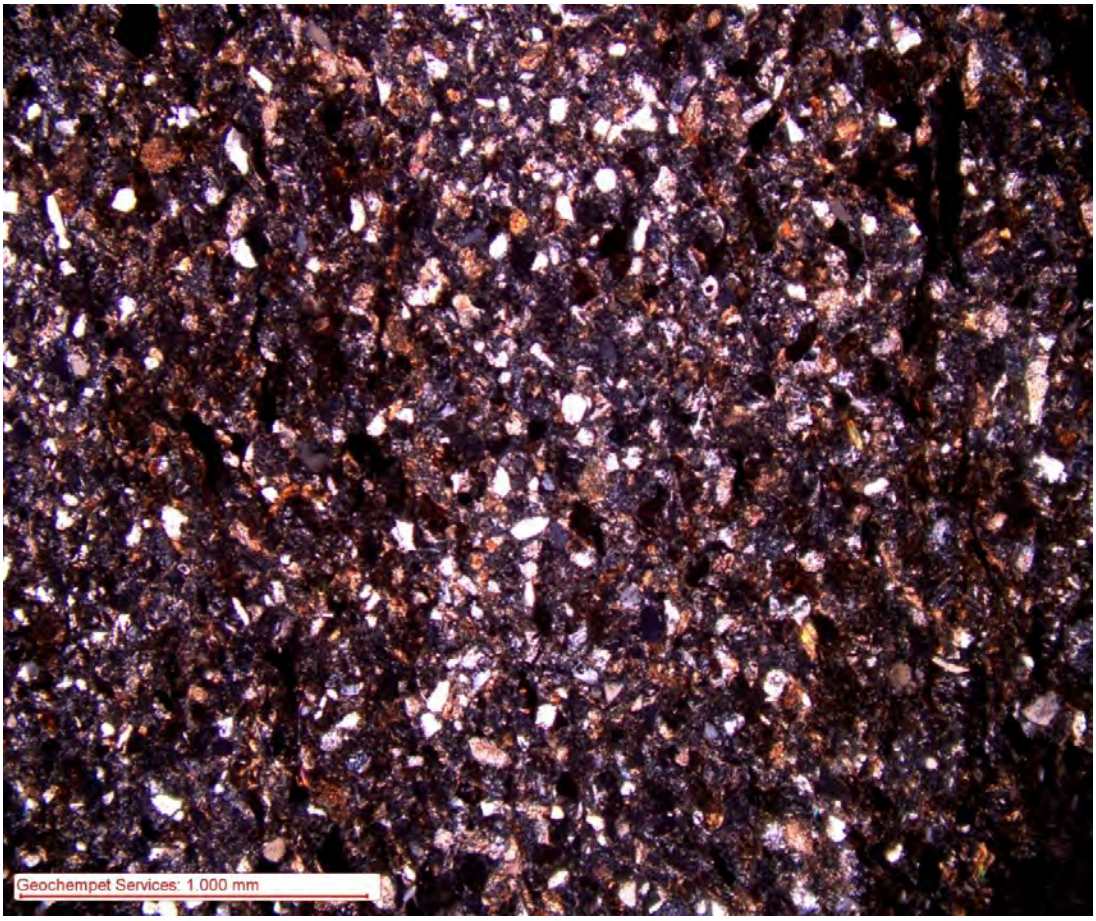

Figure 2: Photo-micrograph taken at low magnification in transmitted cross polarised light. Image shows the typical mineral assemblage observed within the supplied drill core. The carbonated quartzofeldspathic and lithic siltstone consists of mainly quartz, feldspar, lithic clasts and significant carbonate clasts. Some minor free micas and argillized clasts are also present.

GEOCHEMPET SERVICES, BRISBANE

APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

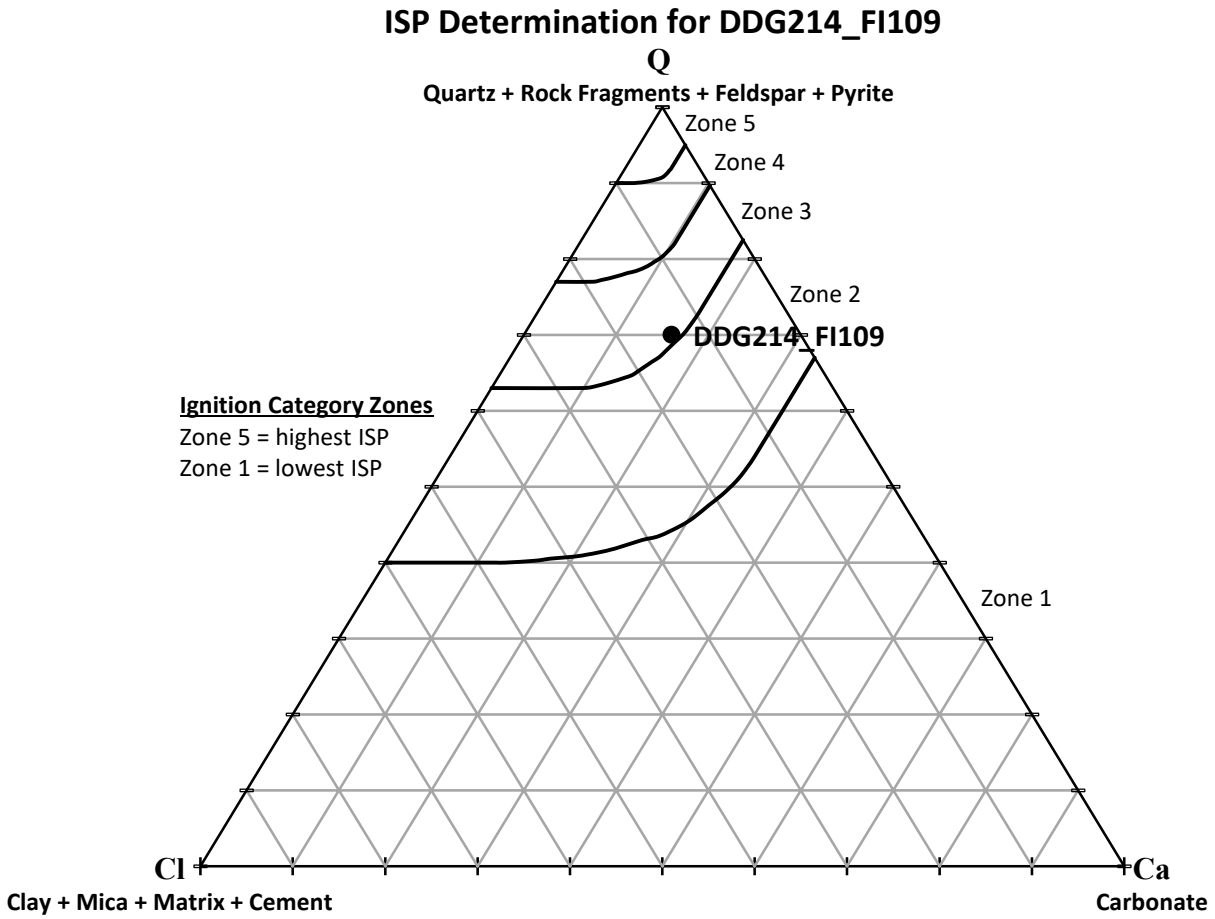

Figure 3: Classification of the incendive parking potential for drill core sample DDG214_FI109 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG295_ FI107) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]

C. A. Bruggemann
BAppSc, MEngSC, MIEAust
30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF A DRILL CORE SAMPLE (DDG295_FI107) AT 427.35 - 427.72 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG295	**Project**:	Grosvenor
RSHQ Ref.:	Sample 1	**Anglo Ref.**:	FI107
Date Received:	10/11/2020	**Uncorrected Depth**:	427.35 - 427.72 m

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

GEOCHEMPET SERVICES, BRISBANE

The results were then recalculated to yield the necessary parameters;

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential. Additionally, pores will be normalised out of the calculations as they are encountered in each sample.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG295_FI107 at 427.35 - 427.72 m.

Grain Type	**Vol %**
Quartz	9
Lithic Fragments	24
Feldspar	10
Leucoxene	4
Pyrite	<1
Argillized lithics	12
Mica/sericite/chlorite	<1
Matrix cement	19
Carbonate	22
Organics	<1

GEOCHEMPET SERVICES, BRISBANE

RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG295_FI107 at 427.35 - 427.72 m

Seam Interval	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. + pyrite)	Cl (= clay + mica + iron oxide)	Ca = carbonate	
427.35 - 427.72 m	carbonated quartzofeldspathic and lithic sandstone	47.0	31.0	22.0	**2**

From the tabulated FI results and Figure 3, it is noted that Sample DDG295_FI107 at 427.35 - 427.72 m has an IGCAT value that places it within Zone 2 (the second lowest frictional ignition risk category).

PHOTOMICROGRAPH

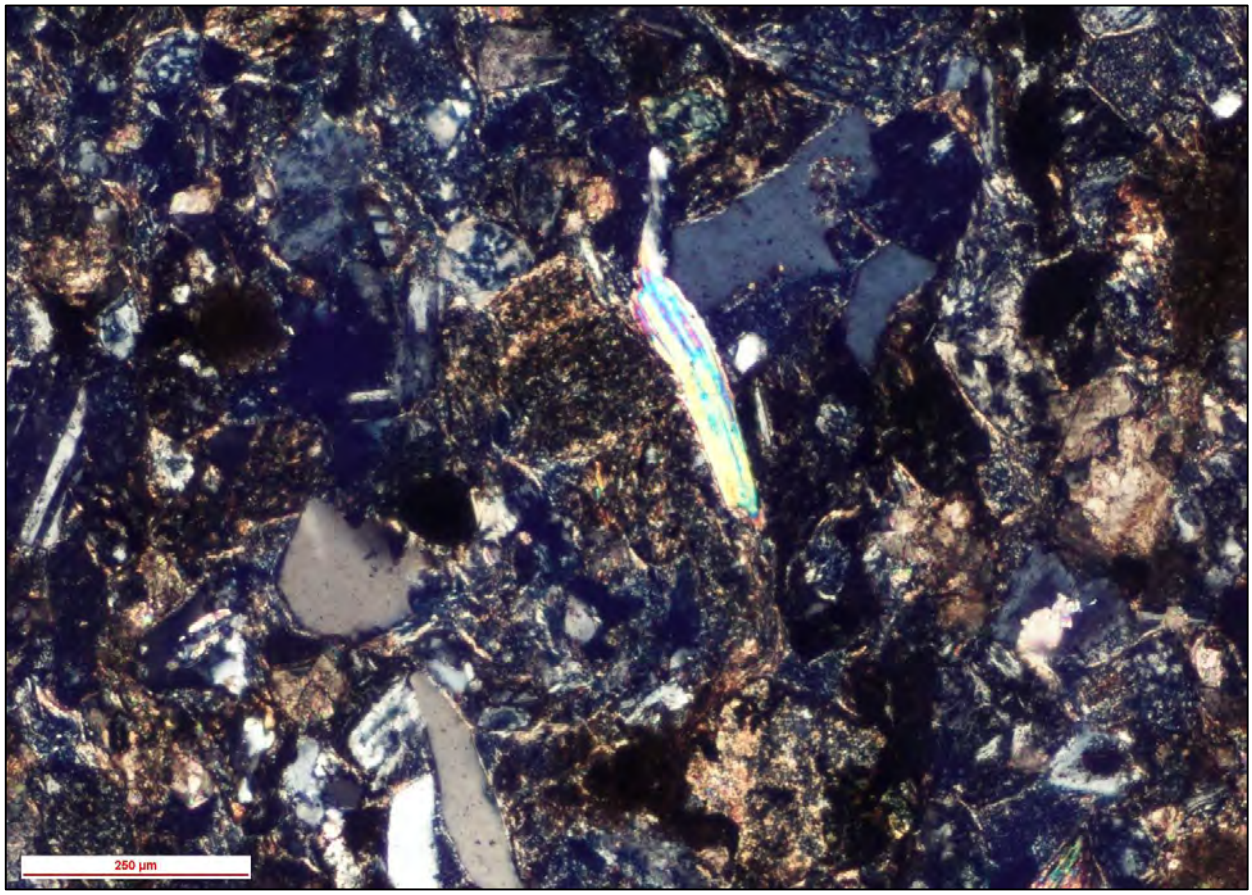

Figure 2: Photo-micrograph taken at medium magnification in transmitted, cross polarised light. Image shows a typical view of the sandstone, with relatively common quartz, lithic clasts and minor mica, with the matrix and some clasts being partly carbonated.

GEOCHEMPET SERVICES, BRISBANE

APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

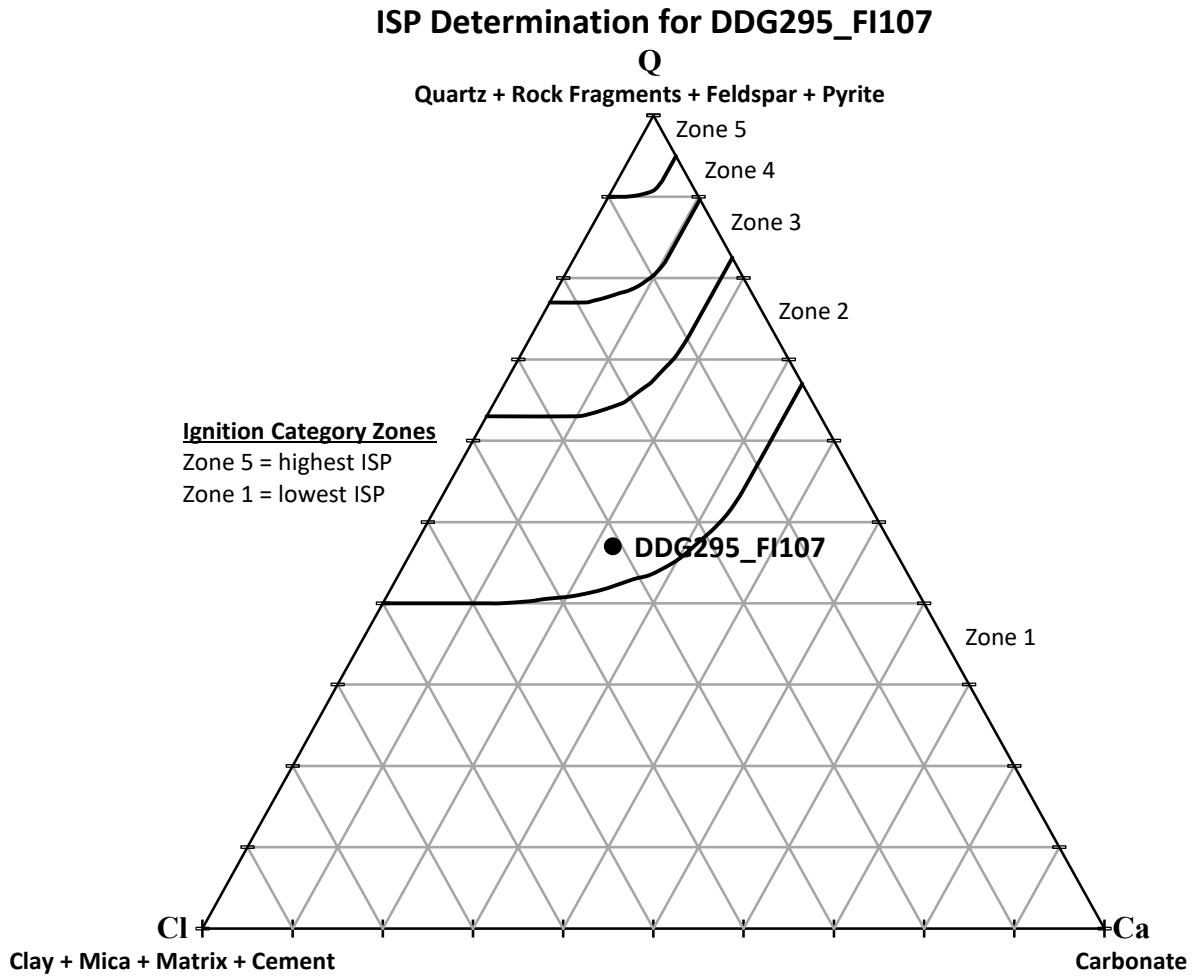

Figure 3: Classification of the incendive sparking potential for drill core sample DDG295_FI107 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG295_ FI106) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]

C. A. Bruggemann
BAppSc, MEngSC, MIEAust
30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF A DRILL CORE SAMPLE (DDG295_FI106) AT 383.74 - 384.00 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG295	**Project**:	Grosvenor
RSHQ Ref.:	Sample 2	**Anglo Ref.**:	FI106
Date Received:	10/11/2020	**Uncorrected Depth**:	383.74 - 384.00 m

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

GEOCHEMPET SERVICES, BRISBANE

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

The results were then recalculated to yield the necessary parameters:

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential. Additionally, pores will be normalised out of the calculations as they are encountered in each sample.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG295_FI106 at 383.74 - 384.00 m.

Grain Type	**Vol %**
Quartz	11
Lithic Fragments	4
Feldspar	5
Leucoxene	2
Pyrite	<1
Argillized lithics	6
Mica/sericite/chlorite	6
Matrix cement	48
Carbonate	9
Organics	9

GEOCHEMPET SERVICES, BRISBANE

RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG295_FI106 at 383.74 - 384.00 m

Seam Interval	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. + pyrite)	Cl (= clay + mica + iron oxide)	Ca = carbonate	
383.74 - 384.00 m	Interbedded labile siltstone and quartzofeldspathic and lithic sandstone	24.2	65.9	9.9	**1**

From the tabulated FI results and Figure 3, it is noted that Sample DDG295_FI106 at 383.74 - 384.00 m has an IGCAT value that places it within Zone 1 (the lowest frictional ignition risk category).

PHOTOMICROGRAPH

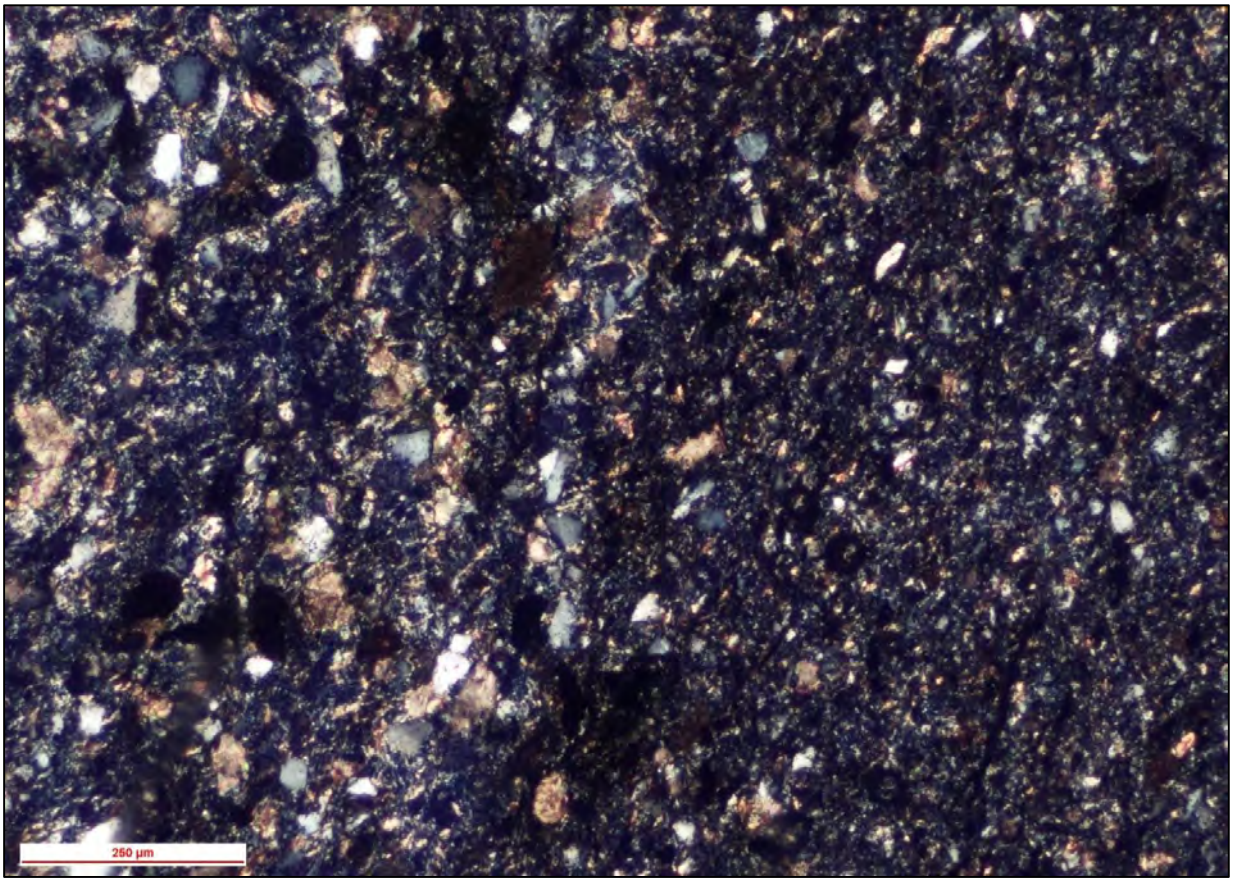

Figure 2: Photo-micrograph taken at medium magnification in transmitted, cross polarised light. Image shows a typical view of the interbedded sandstone (left) and siltstone (right).

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APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

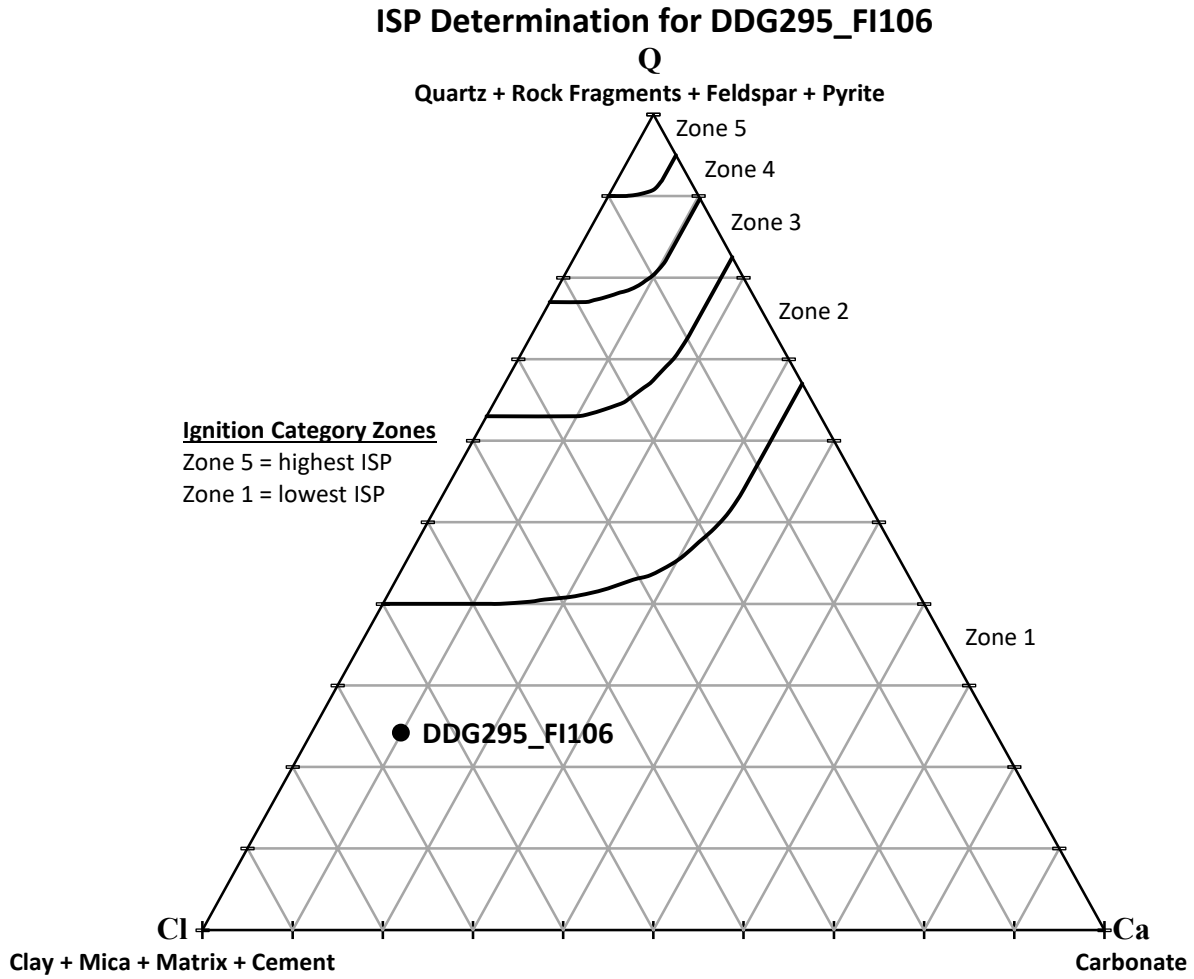

Figure 3: Classification of the incendive sparking potential for drill core sample DDG295_FI106 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG295_ FI105) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]

C. A. Bruggemann
BAppSc, MEngSC, MIEAust
30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF A DRILL CORE SAMPLE (DDG295_FI105) AT 379.63 - 379.80 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG295	**Project**:	Grosvenor
RSHQ Ref.:	Sample 3	**Anglo Ref.**:	FI105
Date Received:	10/11/2020	**Uncorrected Depth**:	379.63 - 379.80 m

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

GEOCHEMPET SERVICES, BRISBANE

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

The results were then recalculated to yield the necessary parameters:

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential. Additionally, pores will be normalised out of the calculations as they are encountered in each sample.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG295_FI105 at 379.63 - 379.80 m.

Grain Type	**Vol %**
Quartz	12
Lithic Fragments	12
Feldspar	9
Leucoxene	4
Pyrite	<1
Argillized lithics	7
Mica/sericite/chlorite	8
Matrix cement	12
Carbonate	31
Organics	5

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RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG295_FI105 at 379.63 - 379.80 m

Seam Interval	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. + pyrite)	Cl (= clay + mica + iron oxide)	Ca = carbonate	
379.63 - 379.80 m	Interbedded, partly carbonated siltstone and quartzofeldspathic and lithic sandstone	39.0	28.4	32.6	**1**

From the tabulated FI results and Figure 3, it is noted that Sample DDG295_FI105 at 379.63 - 379.80 m has an IGCAT value that places it within Zone 1 (the lowest frictional ignition risk category).

PHOTOMICROGRAPH

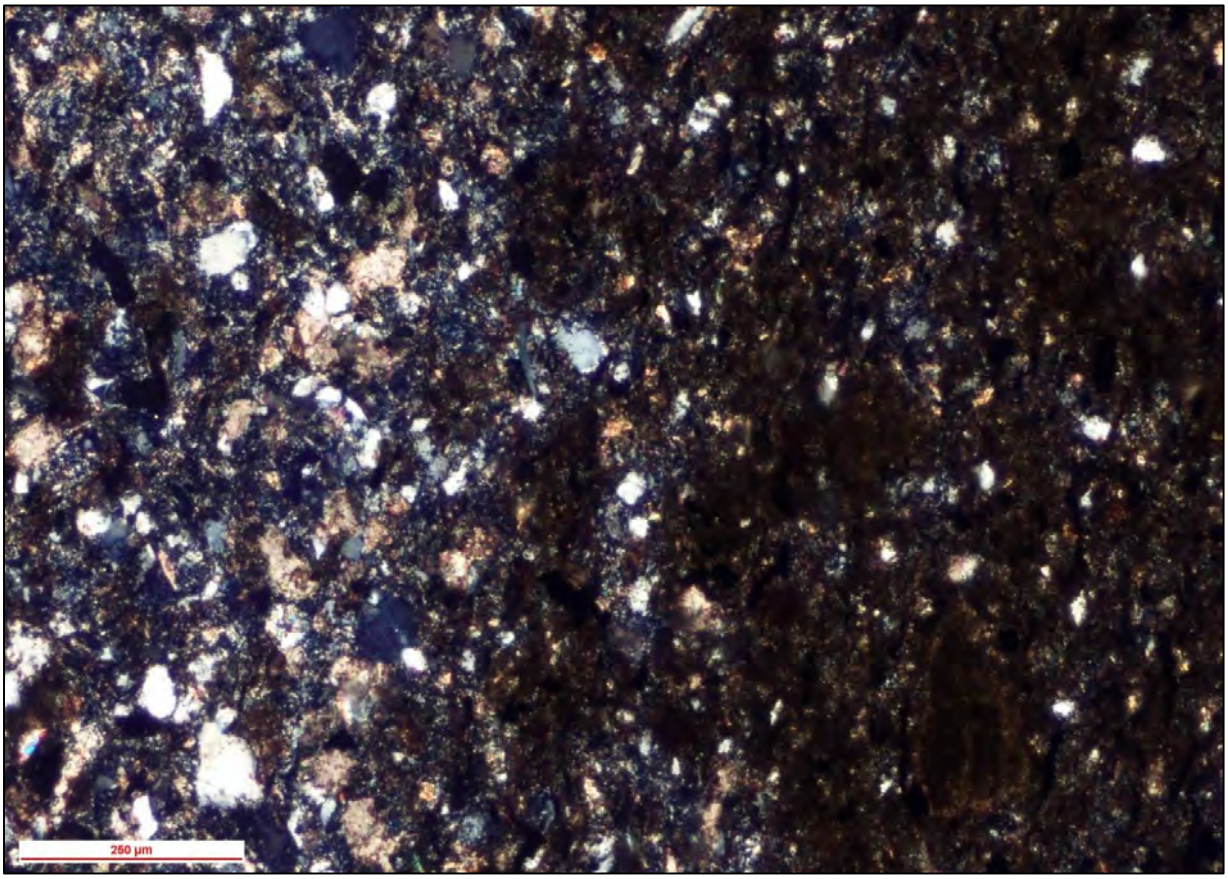

Figure 2: Photo-micrograph taken at medium magnification in transmitted, cross polarised light. Image shows a typical view of the carbonated siltstone on the right and the sandstone on the left.

GEOCHEMPET SERVICES, BRISBANE

APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

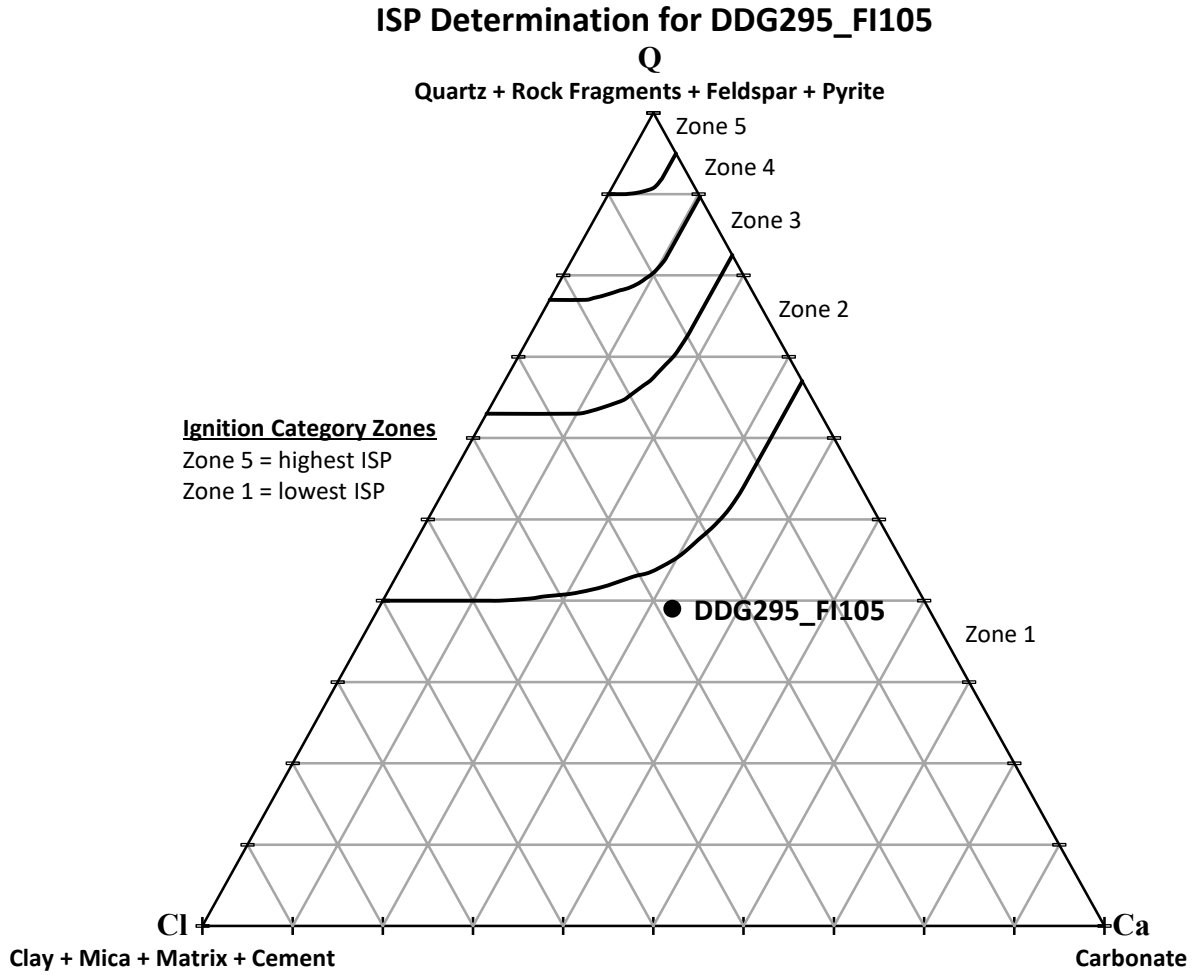

Figure 3: Classification of the incendive sparking potential for drill core sample DDG295_FI105 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG295_ FI104) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]

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BAppSc, MEngSC, MIEAust
30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF A DRILL CORE SAMPLE (DDG295_FI104) AT 367.97 - 368.15 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG295	**Project**:	Grosvenor
RSHQ Ref.:	Sample 4	**Anglo Ref.**:	FI104
Date Received:	10/11/2020	**Uncorrected Depth**:	367.97 - 368.15 m

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

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An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

The results were then recalculated to yield the necessary parameters:

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential. Additionally, pores will be normalised out of the calculations as they are encountered in each sample.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG295_FI104 at 367.97 - 368.15 m.

Grain Type	**Vol %**
Quartz	9
Lithic Fragments	17
Feldspar	2
Leucoxene	4
Pyrite	<1
Argillized lithics	10
Mica/sericite/chlorite	1
Matrix cement	17
Carbonate	40
Organics	<1

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RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG295_FI104 at 367.97 - 368.15 m

Seam Interval	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. + pyrite)	Cl (= clay + mica + iron oxide)	Ca = carbonate	
367.97 - 368.15 m	carbonated quartzofeldspathic and lithic sandstone	32.0	28.0	40.0	**1**

From the tabulated FI results and Figure 3, it is noted that Sample DDG295_FI104 at 367.97 - 368.15 m has an IGCAT value that places it within Zone 1 (the lowest frictional ignition risk category).

PHOTOMICROGRAPH

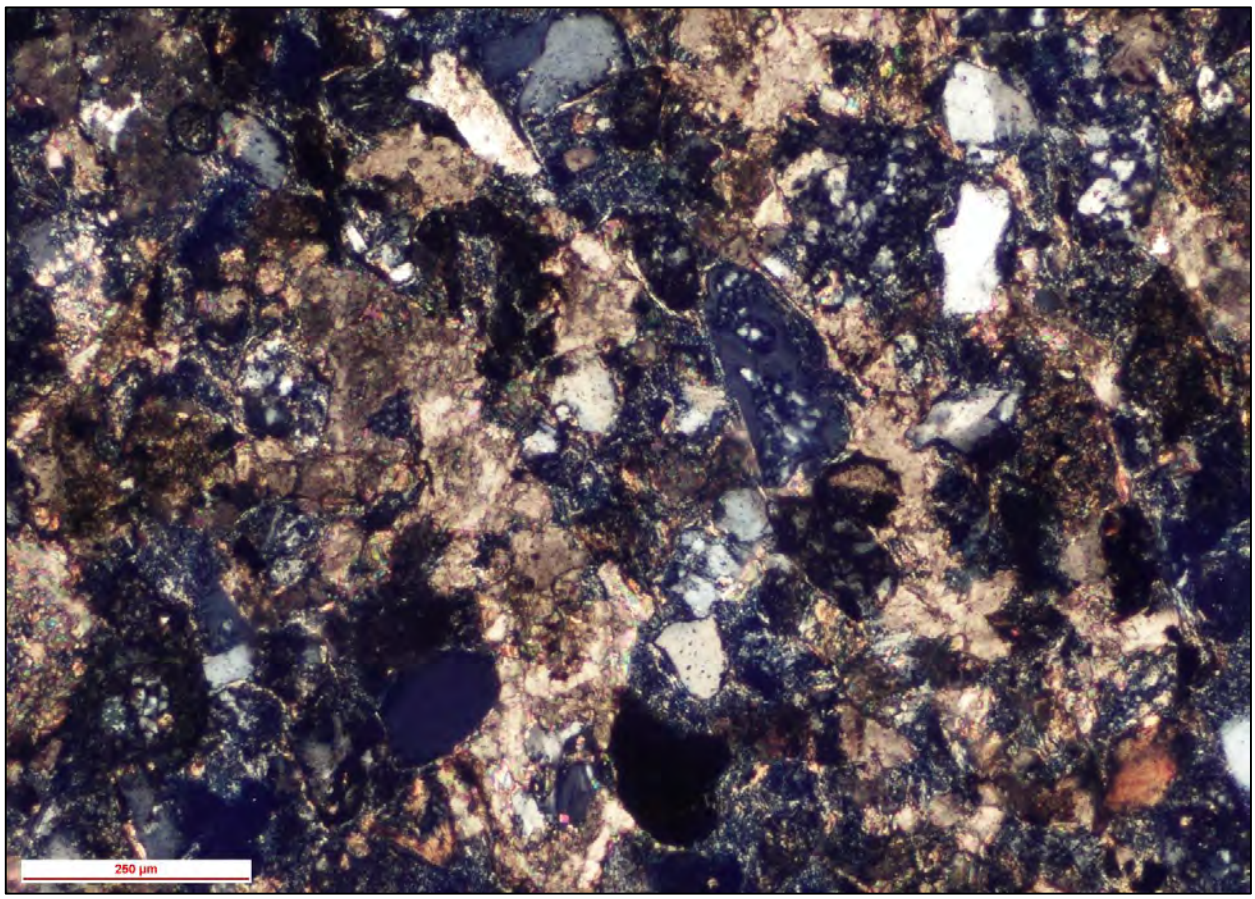

Figure 2: Photo-micrograph taken at medium magnification in transmitted, cross polarised light. Image shows a typical view of the sandstone, with relatively common quartz and lithic grains with the matrix and some clasts being partly carbonated.

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APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

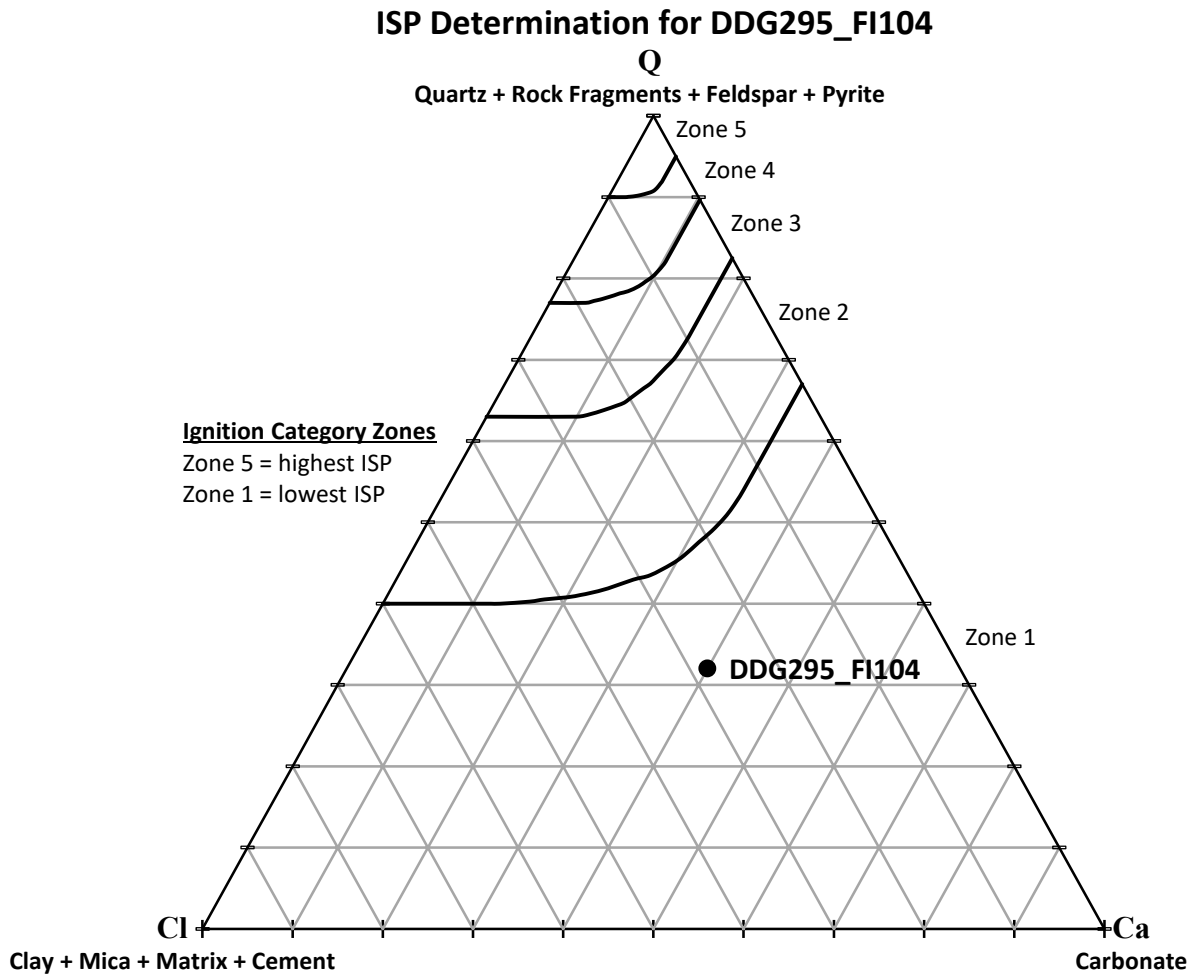

Figure 3: Classification of the incendive sparking potential for drill core sample DDG295_FI104 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG295_ FI103) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]

C. A. Bruggemann
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30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF A DRILL CORE SAMPLE (DDG295_FI103) AT 350.60 - 350.92 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG295	**Project**:	Grosvenor
RSHQ Ref.:	Sample 5	**Anglo Ref.**:	FI103
Date Received:	10/11/2020	**Uncorrected Depth**:	350.60 - 350.92 m

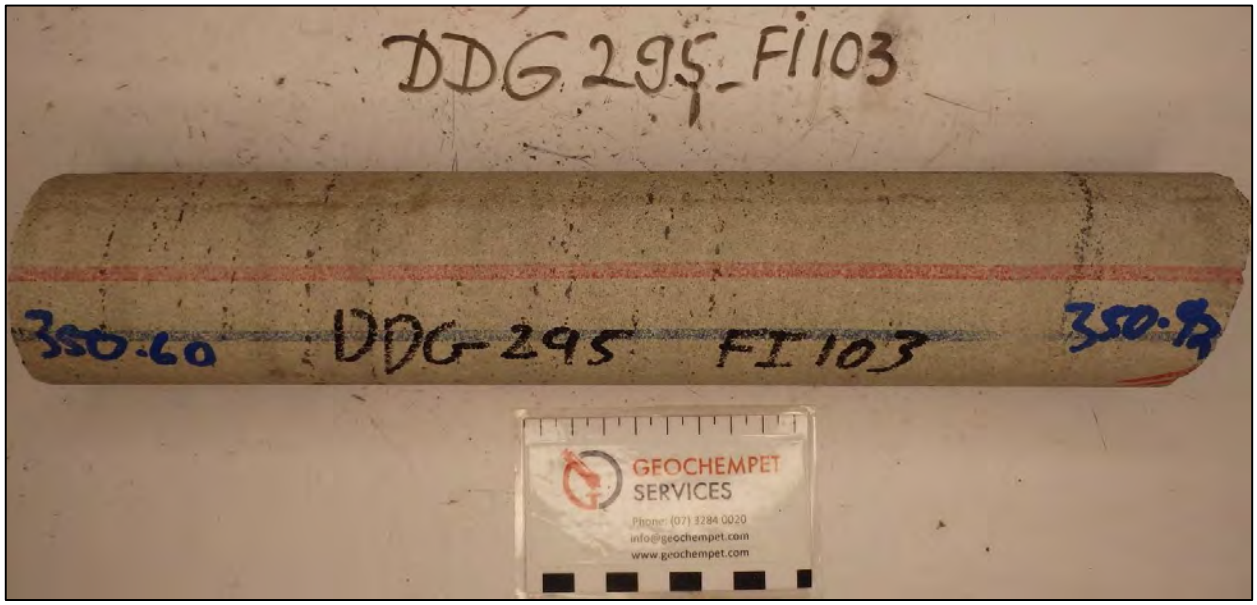

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

GEOCHEMPET SERVICES, BRISBANE

The results were then recalculated to yield the necessary parameters:

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential. Additionally, pores will be normalised out of the calculations as they are encountered in each sample.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG295_FI103 at 350.60 - 350.92 m.

Grain Type	**Vol %**
Quartz	13
Lithic Fragments	42
Feldspar	14
Leucoxene	1
Pyrite	<1
Argillized lithics	8
Mica/sericite/chlorite	1
Matrix cement	14
Carbonate	6
Organics	1

GEOCHEMPET SERVICES, BRISBANE

RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG295_FI103 at 350.60 - 350.92 m

Seam Interval	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. + pyrite)	Cl (= clay + mica + iron oxide)	Ca = carbonate	
350.60 - 350.92 m	quartzofeldspathic and lithic sandstone	70.7	23.2	6.1	**3**

From the tabulated FI results and Figure 3, it is noted that Sample DDG295_FI103 at 350.60 - 350.92 m has an IGCAT value that places it within Zone 3 (the mid-range frictional ignition risk category).

PHOTOMICROGRAPH

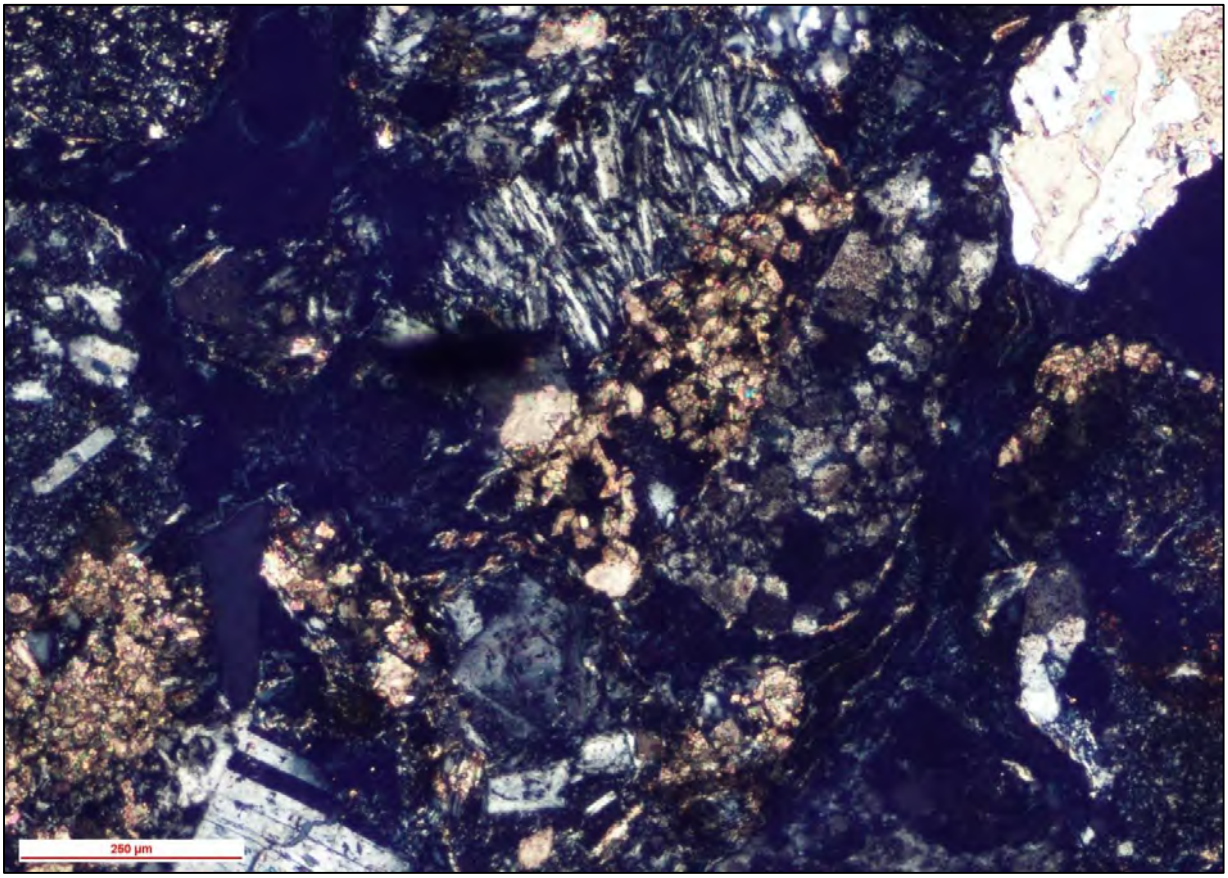

Figure 2: Photo-micrograph taken at medium magnification in transmitted, cross polarised light. Image shows a typical view of the sandstone, with relatively common lithic grains with minor carbonate alteration.

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APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

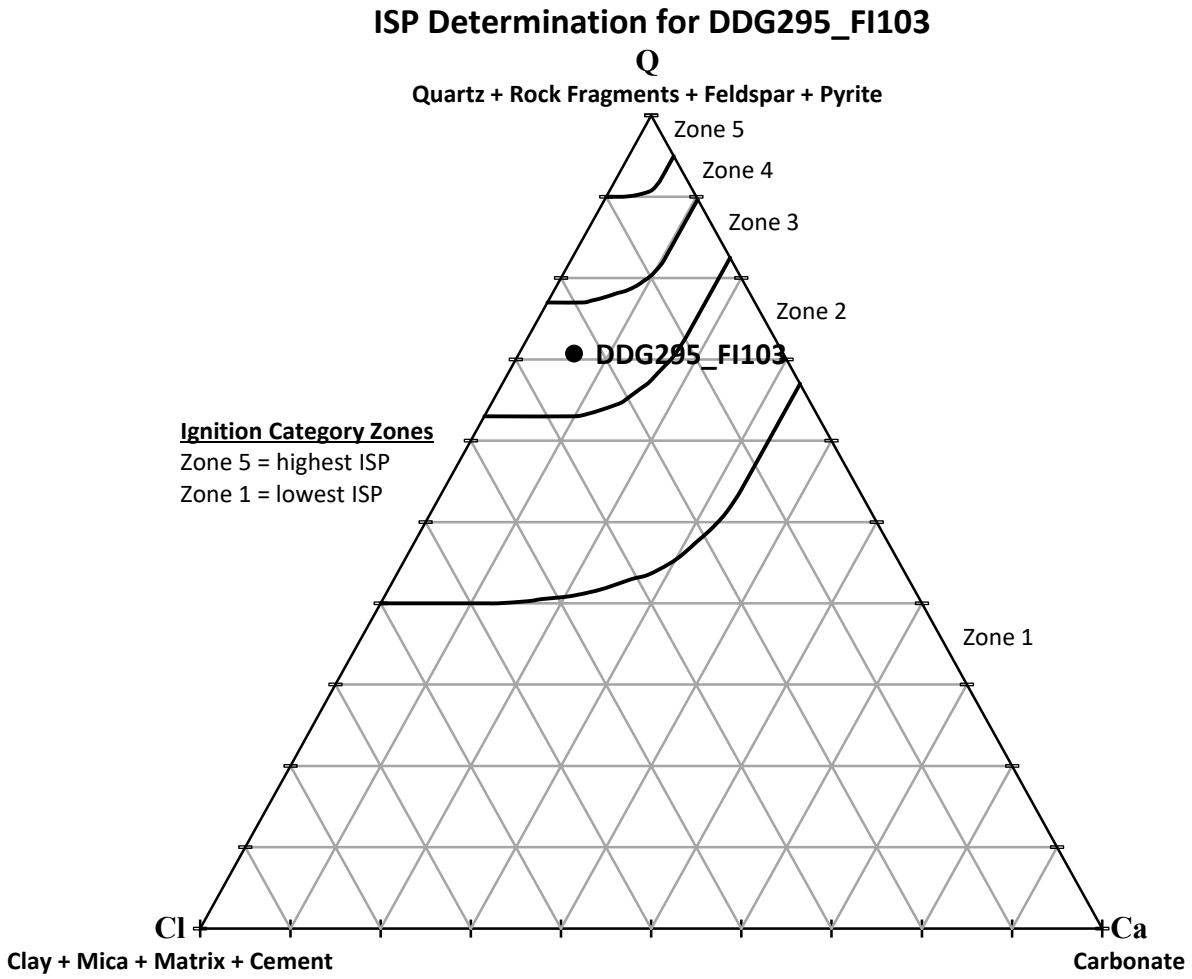

Figure 3: Classification of the incendive sparking potential for drill core sample DDG295_FI103 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG295_ FI102) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]

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30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF A DRILL CORE SAMPLE (DDG295_FI102) AT 345.60 - 345.95 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG295	**Project**:	Grosvenor
RSHQ Ref.:	Sample 6	**Anglo Ref.**:	FI102
Date Received:	10/11/2020	**Uncorrected Depth**:	345.60 - 345.95 m

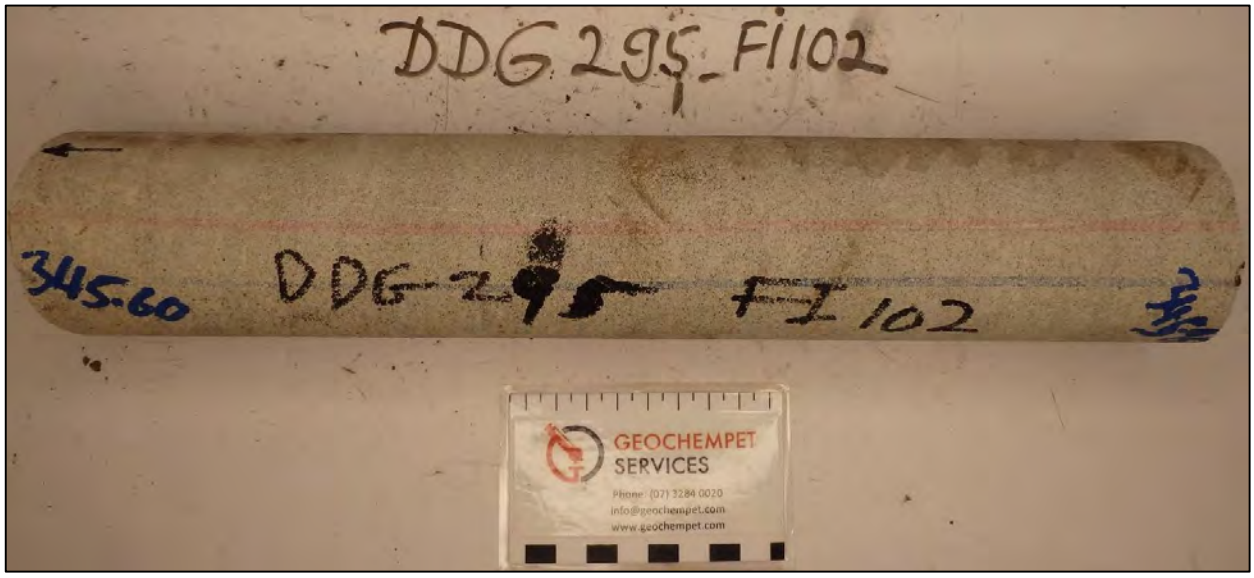

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

GEOCHEMPET SERVICES, BRISBANE

The results were then recalculated to yield the necessary parameters:

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential. Additionally, pores will be normalised out of the calculations as they are encountered in each sample.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG295_FI102 at 345.60 - 345.95 m.

Grain Type	**Vol %**
Quartz	7
Lithic Fragments	26
Feldspar	10
Leucoxene	3
Pyrite	<1
Argillized lithics	10
Mica/sericite/chlorite	<1
Matrix cement	4
Carbonate	40
Organics	<1

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RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG295_FI102 at 345.60 - 345.95 m

Seam Interval	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. + pyrite)	Cl (= clay + mica + iron oxide)	Ca = carbonate	
345.60 - 345.95 m	carbonated quartzofeldspathic and lithic sandstone	46.0	14.0	40.0	**1**

From the tabulated FI results and Figure 3, it is noted that Sample DDG295_FI102 at 345.60 - 345.95 m has an IGCAT value that places it within Zone 1 (the lowest frictional ignition risk category).

PHOTOMICROGRAPH

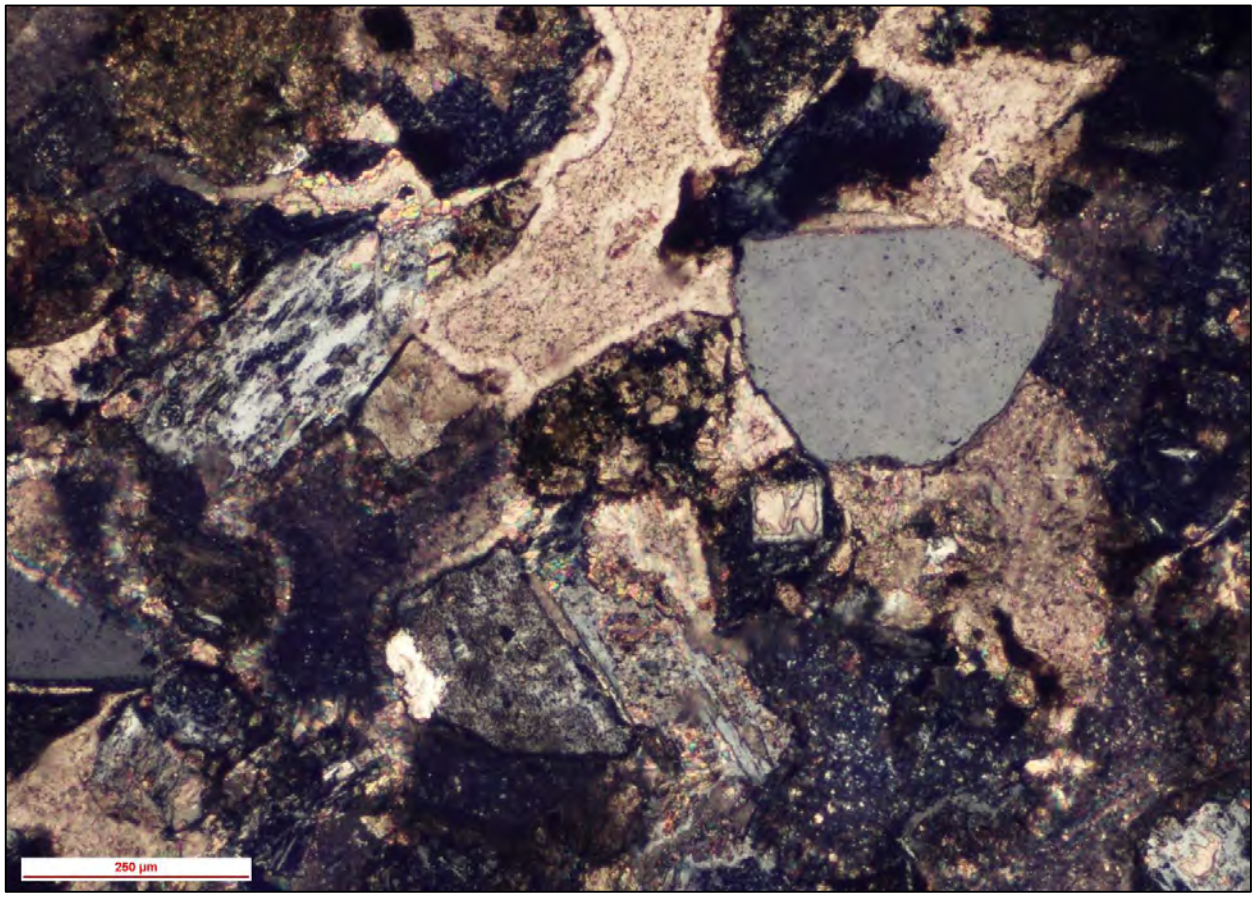

Figure 2: Photo-micrograph taken at medium magnification in transmitted, cross polarised light. Image shows a typical view of the sandstone, with relatively common quartz, feldspar and lithic grains within a carbonated matrix.

GEOCHEMPET SERVICES, BRISBANE

APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

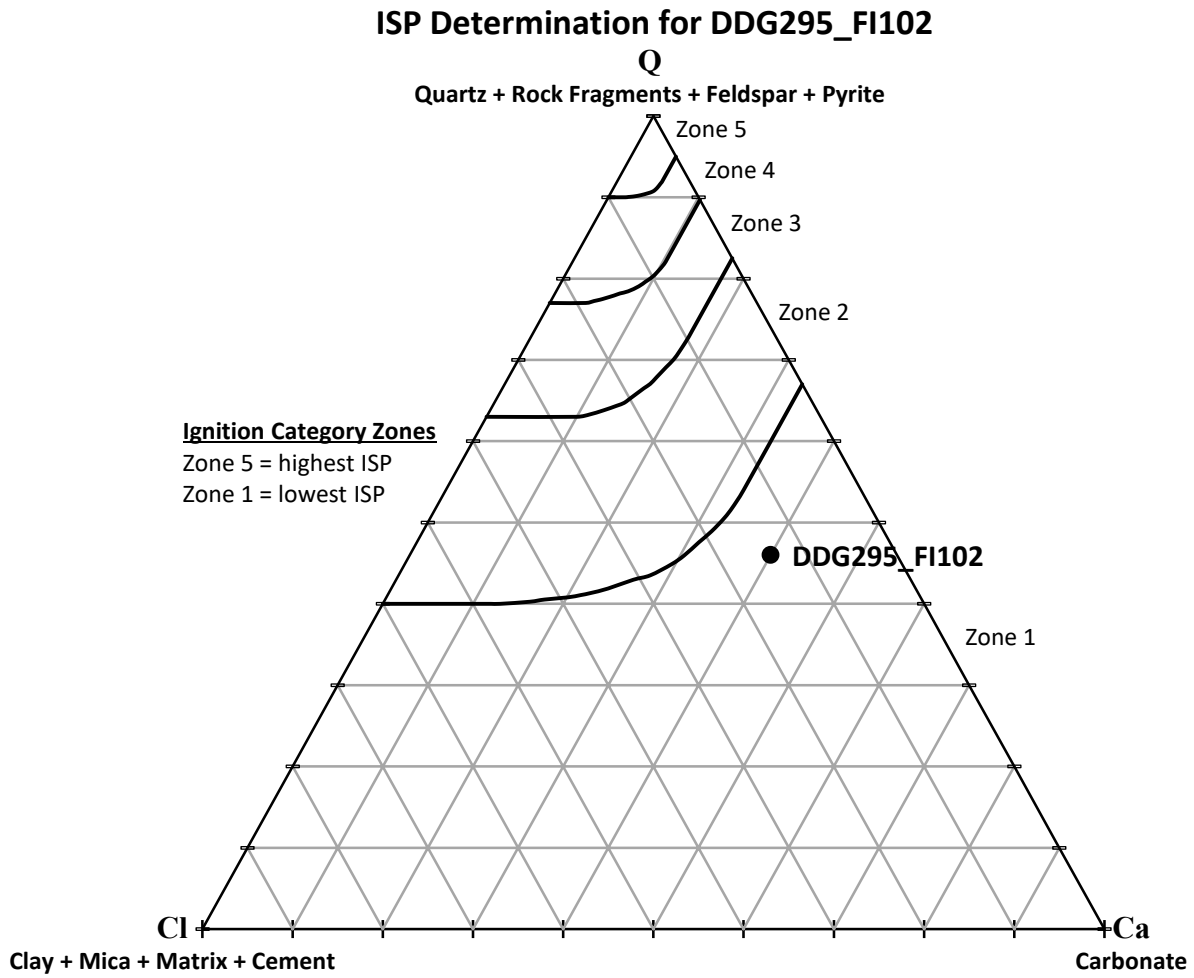

Figure 3: Classification of the incendive sparking potential for drill core sample DDG295_FI102 adapted from Ward et. al. (2001)

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FRICTIONAL IGNITION TESTING ON A DRILL CORE SAMPLE (DDG295_ FI101) FROM GROSVENOR MINE

prepared for

RESOURCES SAFETY & HEALTH
BRISBANE, QLD

Order Number: N/A

Invoice Number: G2111563

Client Ref: Daniel Collins

Issued by [redacted]

C. A. Bruggemann
BAppSc, MEngSC, MIEAust
30 November 2020

GEOCHEMPET SERVICES, BRISBANE

FRICTIONAL IGNITION TESTING OR THE "INCENDIVE SPARKING POTENTIAL" OF A DRILL CORE SAMPLE (DDG295_FI101) AT 341.27 - 341.59 m FOR GROSVENOR MINE

SAMPLE DETAILS

Borehole:	DDG295	**Project**:	Grosvenor
RSHQ Ref.:	Sample 7	**Anglo Ref.**:	FI101
Date Received:	10/11/2020	**Uncorrected Depth**:	341.27 - 341.59 m

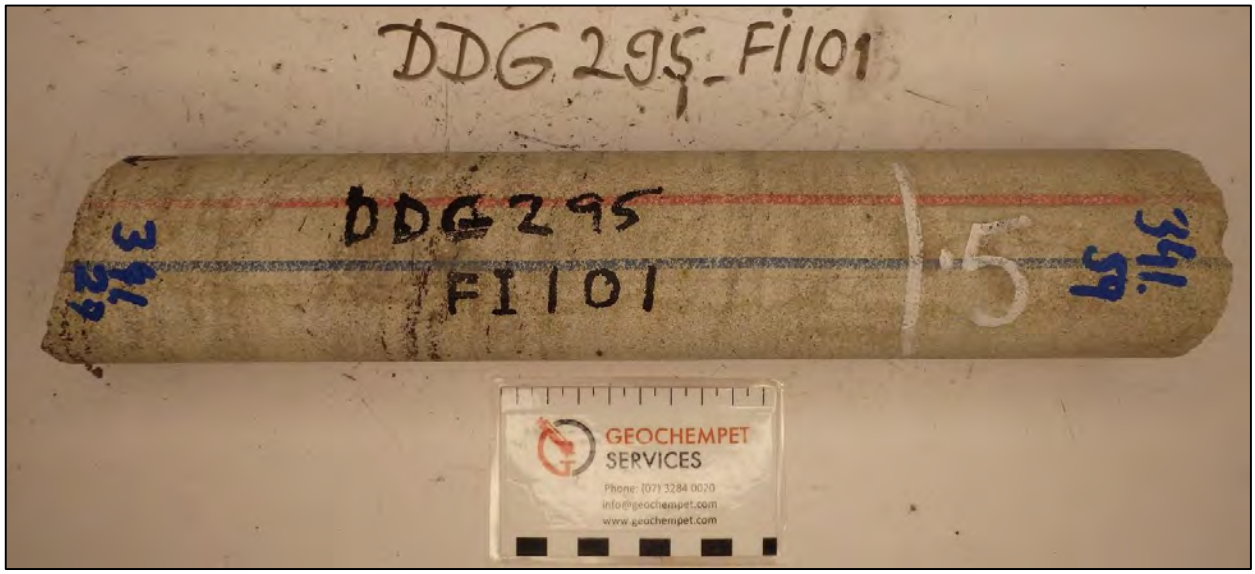

Figure 1: Photograph of the supplied drill core

WORK REQUESTED

Petrographic examination of a drill core sample of sedimentary rock with a view to determining its "incendive sparking potential" as perceived by C. R. Ward *et al*, 2001 of the University of NSW, School of Geology.

METHODS

A thin section was prepared from the drill core sample to permit detailed mineralogical counting using transmitted polarised light microscopy.

An approximate composition was determined, expressed in volume percent and based on identification and counting of the microscopically observed components at each of 100 widely spaced observation points within the thin section.

GEOCHEMPET SERVICES, BRISBANE

The results were then recalculated to yield the necessary parameters:

Quartz + rock fragments + feldspar + pyrite,
Clay matrix cement + mica + clay pellets, and
Carbonate but no organics

for comparison with a triangular classification diagram supplied by C. R. Ward from the University of NSW. Based on the calculated parameters, each sample was then assigned an appropriate IGCAT value (a measure of perceived incendive sparking potential) as designated by zones within Ward's triangular diagram (Fig. 3). Ward's ternary diagram defines five IGCAT zones, with Zone 1 corresponding with the lowest incendive potential and Zone 5 corresponding with the highest potential.

It seems that to include organics (a low frictional ignition potential component but is combustible) in the carbonate parameter minimizes the ignition values and thus lowers the frictional risk potential. Additionally, pores will be normalised out of the calculations as they are encountered in each sample.

POINT COUNTING OF PETROGRAPHIC CONSTITUENTS (VOL%)

Table 1: Results from point counting of drill core sample DDG295_FI101 at 341.27 - 341.59 m.

Grain Type	**Vol %**
Quartz	14
Lithic Fragments	42
Feldspar	9
Leucoxene	2
Pyrite	<1
Argillized lithics	11
Mica/sericite/chlorite	<1
Matrix cement	12
Carbonate	10
Organics	<1

GEOCHEMPET SERVICES, BRISBANE

RECALCULATED RESULTS

Table 2: Re-calculate parameters and IGC zone classification of drill core sample DDG295_FI101 at 341.27 - 341.59 m

Seam Interval	Rock Type	Co-ordinates			IGCAT Zone
		Q (= quartz + feldspar + rock frag. + pyrite)	Cl (= clay + mica + iron oxide)	Ca = carbonate	
341.27 - 341.59 m	quartzofeldspathic and lithic sandstone	67.0	23.0	10.0	**3**

From the tabulated FI results and Figure 3, it is noted that Sample DDG295_FI101 at 341.27 - 341.59 m has an IGCAT value that places it within Zone 3 (the mid-range frictional ignition risk category).

PHOTOMICROGRAPH

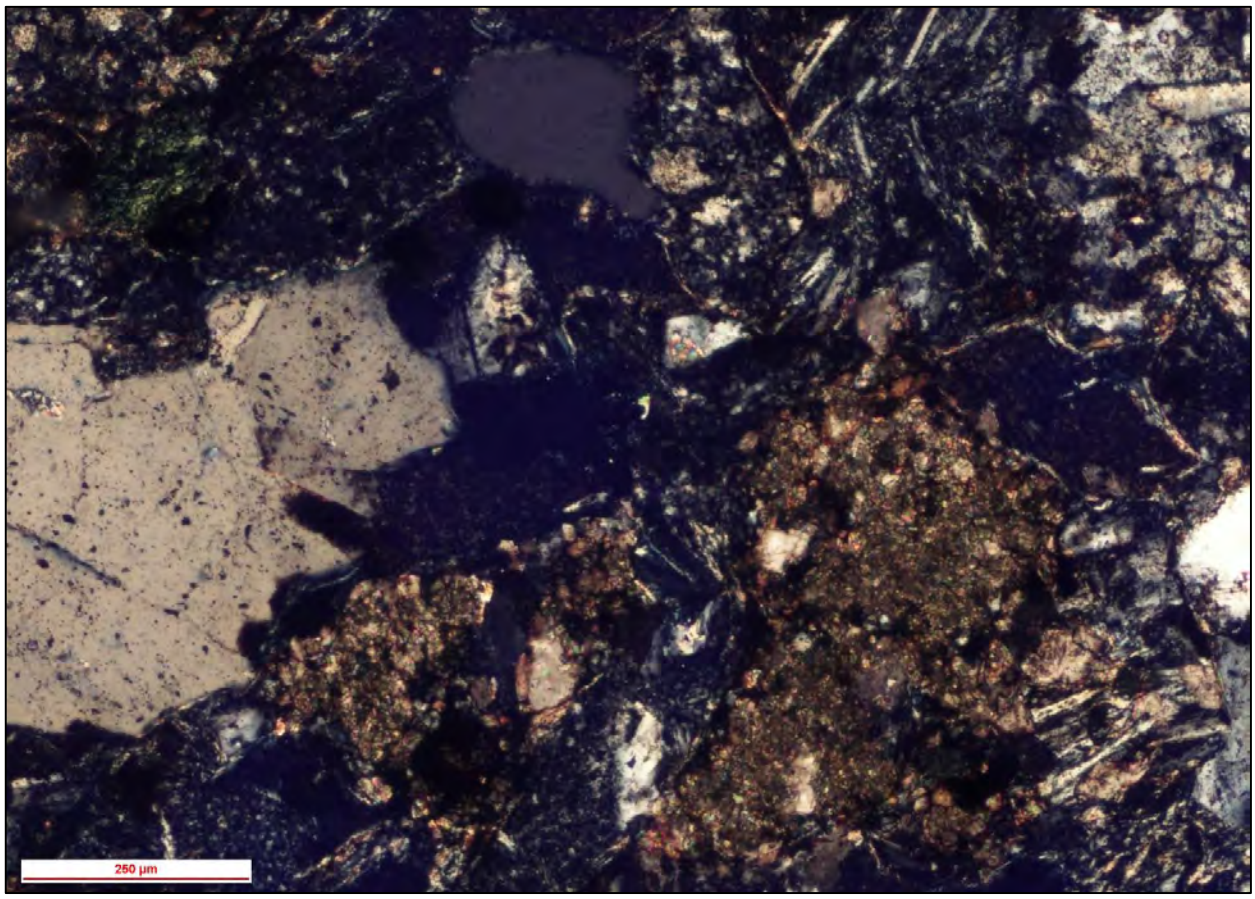

Figure 2: Photo-micrograph taken at medium magnification in transmitted, cross polarised light. Image shows a typical view of the sandstone, with relatively common quartz and lithic grains with minor carbonate alteration.

APPENDIX A

Classification of the sample frictional ignition or incendive sparking potential is the proportion of three groups of minerals. These groups are:

1. quartz + rock fragments + feldspar + pyrite (forming the **Q** corner of the triangular plot);
2. clay + mica (forming the **Cl** corner); and
3. carbonate minerals (forming the **Ca** corner).

The proportional results for these three groups were plotted on a triangular classification diagram devised by Ward *et al* (2001); the modified diagram is shown in Figure 3. Ward's classification defines five ignition category (IGCAT) zones, with the incendive sparking potential increasing from Zone 1 (the lowest sparking potential) through to Zone 5 (the highest sparking potential).

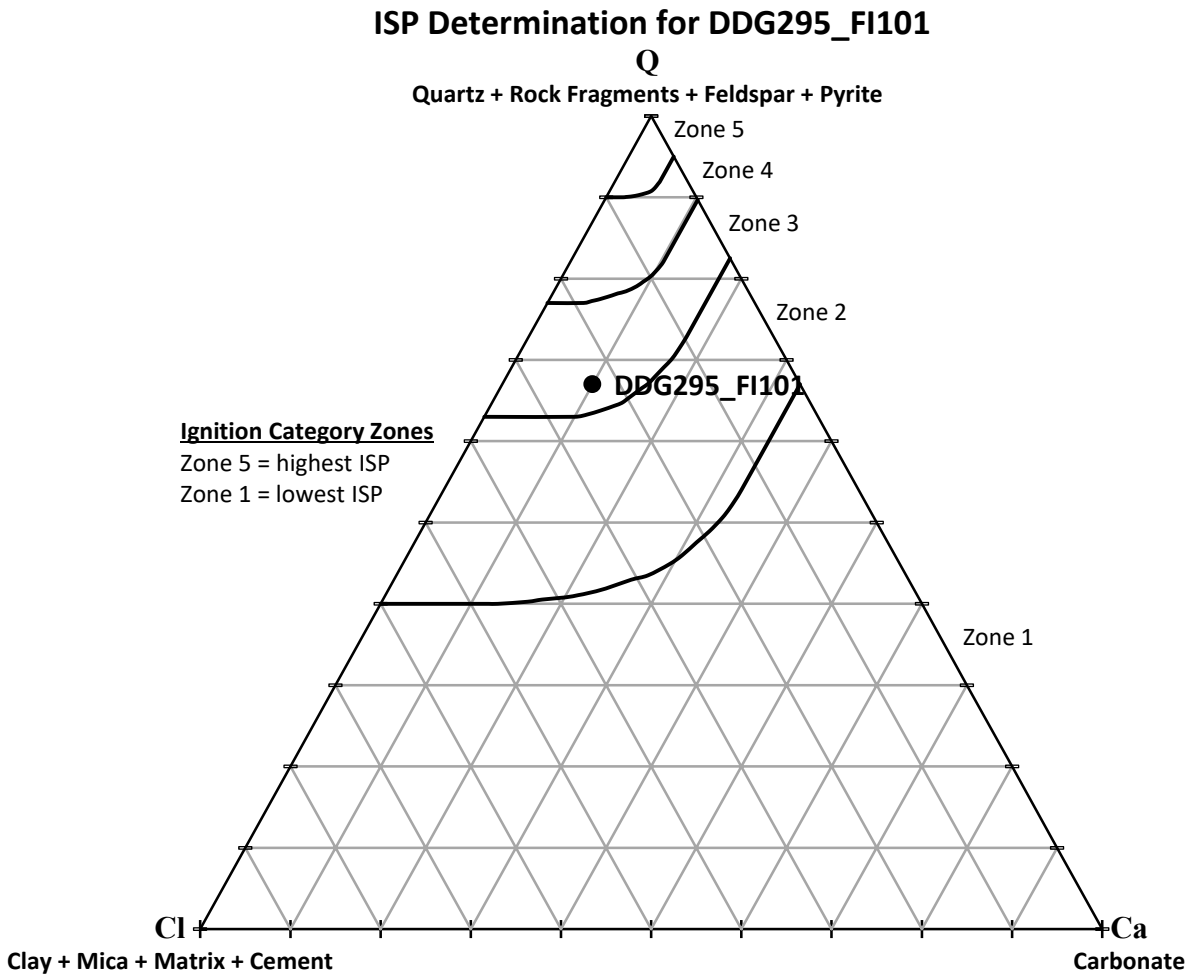

Figure 3: Classification of the incendive sparking potential for drill core sample DDG295_FI101 adapted from Ward et. al. (2001)