

1981/48. Pyrite mineralisation in limestone at Lune River.

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Abstract

A 3.5 m thick intersection of massive and disseminated pyrite with high As and Pb and low Sn, W, and Mo contents occurs within dolomitised Gordon Limestone at Lune River. The massive pyrite has an average $\delta^{34}\text{S}$ value of +39.6 per mil, and is geochemically similar to black shale in the Lune River area. Gossan cropping out in the Lune River quarry contains anomalous As, Ni, Pb, and Zn, and is probably derived from ironstone and sulphides in black shale. The massive and disseminated pyrite mineralisation is of biogenic origin, and is not of economic significance.

INTRODUCTION

In July 1980, during the course of investigation of limestone in Newlands quarry at Lune River, the senior author discovered ironstone hosted by the limestone. Analyses of the ironstone revealed notably anomalous concentrations of base metals.

Subsequent to this discovery, the stratigraphic drilling programme being conducted by the Department was extended by collaring a vertical diamond drill hole, DLR-7, in November, 1980 (see Summons, 1981). This hole intersected 3.5 m of carbonate-hosted massive and disseminated pyrite, and it is the composition and genesis of this pyrite that are discussed in this report.

Interest in the pyrite mineralisation was stimulated by the coincident occurrence of a negative gravity anomaly to the east of Lune River which is believed to be due to a granitoid mass at relatively shallow depth (Leaman *et al.*, 1980).

GEOLOGICAL SETTING

The stratigraphy, lithologies, and geochemistry of the Gordon Limestone in the Lune River area, and in particular the limestone in Newlands quarry, are described by Summons (1981). The stratigraphy was defined by means of lithostratigraphic and chemistratigraphic correlation between two stratigraphic drill holes (DLR-2 and DLR-7), and outcrop in the general vicinity of Newlands quarry. The Gordon Limestone is recognised as consisting of three sequences: the 'upper', 'middle' and 'lower'. The 'upper' and 'lower' sequences were deposited under intertidal/subtidal conditions, with the 'middle' sequence deposited under supratidal/intertidal conditions.

Geochemical trends in the limestone between the 'upper' and 'middle' sequences have been interpreted as being due mainly to the effects of hypersaline dolomitising brines, which originated in the 'middle' sequence, and moved generally downwards, causing extensive dolomitisation, particularly of permeable lithotypes such as the Lower Oncolite Horizon (fig. 1; Summons, 1981).

The late diagenetic or secondary dolomite is typically granular and grey (fresh) to pale brown (oxidised) in colour. The grain size ranges from 0.1-2.0 mm, with an average size of approximately 0.5 mm. Replacement of the limestone by dolomite was variable, with relict textures (burrows *etc.*)

commonly visible. The dolomite is generally porous and vuggy, and contains disseminated pyrite.

The dolomite is characterised by a general dissemination of pyrite, relative to undolomitised limestone, and which frequently occurs as blebs up to 20 mm diameter. The dolomite is also characterised by ubiquitous oxidation which probably post-dates formation of the pyrite. Although the affect of post-diagenetic oxidising groundwater cannot be discounted, it is most probable that the dolomite formed at shallow depths which were still subject (during diagenesis) to influx of oxidising (?terrestrial) groundwater, and/or that subaerial exposure of the sediments occurred.

IRONSTONE AND PYRITE MINERALISATION

The ironstone in Newlands quarry crops out as a small body, measuring approximately 1.5 x 1.0 m, beneath bench number 6. It occurs within the 'upper sequence' in virtually unaltered grey calcisiltite with minor iron staining, and is located directly beneath a major thrust fault (Newlands thrust fault; fig. 1). The orange to brown coloured ironstone is composed predominantly of goethite, and is variably massive (with possible boxwork) to friable.

A 3.5 m thick interval of massive and disseminated pyrite has been intersected in diamond drill hole DLR-7 between 311.3 m and 314.8 m, followed by 2.2 m (314.8-317.0 m) of disseminated and blebby goethite hosted by granular dolomite (Appendix 1). The massive and disseminated pyrite occurs within a zone of dolomitised limestone extending from 286.4-334.4 m, and which includes an original oncolitic calcarenite (Lower Oncolite Horizon) at 301.4-333.7 m (fig. 1).

Massive pyrite occurs in the intervals 311.50-311.95 m, 312.05-312.20 m and 312.36-313.05 m. Polished sections of the massive pyrite (same samples as S-isotope analyses) show it to be composed of 60-90% pyrite with 1-3% arsenopyrite, plus quartz and carbonate (dolomite). The pyrite occurs as irregular masses of euhedral to subhedral grains up to 3 mm diameter (though generally about 0.5 mm) which are commonly fractured and broken and healed with quartz and carbonate, and as disseminated fine anhedral grains, less than 0.1 mm diameter. There is no evidence of annealing or recrystallisation of the pyrite. Arsenopyrite occurs as anhedral to prismatic grains, generally 0.05 mm in length. It occurs as either inclusions in pyrite or intergranular with the pyrite. Despite a relatively high Pb content, galena has not been observed.

In addition to the sulphide mineralisation in DLR-7, diamond drill hole DLR-9 intersected a major fault (Lune Sugarloaf fault) at 27.3-46.0 m (fig. 1) in which fragments of foliated quartzite, pyritic black shale, and intraformational breccia occur. Sulphides, mainly pyrite with minor chalcocopyrite, comprise up to 10% of the rock in the fault zone.

ANALYTICAL RESULTS

Two sets of analyses of the ironstone (Table 1) revealed anomalous concentrations of As, Mo, Ni, Pb, Sb, Sn, and Zn, and slightly anomalous concentrations of Ag and Cu. The erratic and higher Sn values in 801600-602 may be due to sample contamination. The high proportion of anomalous pathfinder elements indicate that the ironstone is probably a gossan, using the criteria of Taylor (1979).

Analyses of the massive and disseminated pyrite in DLR-7 (Table 2)

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Table 1. ANALYSES OF IRONSTONE AND HEMATITE/LIMONITE CALCISILTITE (802526/527) IN NEULANDS QUARRY, LUNE RIVER

Item (%)	801600	801601	801602	802522	802523	802524	802525	802526	802527
SiO ₂	10.5	9.6	14.3						
Al ₂ O ₃	0.69	0.55	0.83						
Fe ₂ O ₃	75.4	76.6	56.2						
CaO	0.84	0.56	9.9						
MgO	0.20	0.15	0.28						
P ₂ O ₅	0.43	0.32	0.43						
Loss on Ignition	10.7	11.1	16.4						
Total	98.76	98.88	98.34						
Trace elements (g/t)									
Ag	2.8	3.0	2.5	9	11	7	8	<5	<5
As	0.76*	1.0*	0.61*	1049	1436	2169	9020	755	631
Au	<1	<1	<0.3	-	-	-	-	-	-
Bi	<0.005*	<0.005*	<0.005*	13	<5	6	<5	<5	6
Co	<5	<5	<5	-	-	-	-	-	-
Cu	0.005*	0.003*	0.003*	71	87	71	69	49	23
Mn	0.006*	0.008*	0.011*	-	-	-	-	-	-
Mo	0.004*	0.004*	0.003*	6	<5	<5	33	<5	<5
Ni	267	300	261	403	382	404	265	48	35
Pb	0.34*	0.026*	0.018*	40	48	75	306	124	118
Sb	-	-	-	17	24	38	300	32	40
Se	-	-	-	<5	<5	<5	<5	<5	<5
Sn	122	55	930	37	23	12	15	9	11
Sr	-	-	-	25	10	21	18	3490	1513
U	-	-	-	<5	<5	<5	<5	<5	<5
V	<20	<20	<20	-	-	-	-	-	-
W	<0.01 ⁺	<0.01 ⁺	<0.01 ⁺	<5	<5	<5	<5	<5	220
Y	-	-	-	44	32	32	16	14	17
Zn	0.04*	0.03*	0.02*	735	541	527	28	388	92

Analysts: M. Frith, L.M. Hay, R. Roby, Department of Mines Laboratories, Launceston.

* results in mass%.

+ results as mass% WO₃

The high W content of 802527 may be due to sample contamination.

Table 2. ANALYSES OF MASSIVE AND DISSEMINATED PYRITE AND OXIDISED DOLOMITE IN DIAMOND DRILL HOLE DLR-7, LUNE RIVER

Sample number	Depth (m)	Ag (g/t)	As (g/t)	Cu (g/t)	Mo (g/t)	Pb (g/t)	Sn (g/t)	W (g/t)	Zn (g/t)	Remarks
802730	310.68-311.31	10	22	<50	<5	403	208	<5	<5	
731	311.31-311.50	6	908	110	<5	835	74	<5	<5	
732	311.50-311.95	13	2379	220	6	349	54	<5	51	Massive pyrite
733	311.95-312.05	10	1088	120	<5	580	38	<5	<5	
734	312.05-312.20	18	1871	180	6	894	41	<5	20	Massive pyrite
735	312.20-312.36	11	194	60	<5	246	34	<5	<5	
736	312.36-313.05	17	2303	180	<5	754	9	<5	20	Massive pyrite
737	313.05-313.41	9	292	53	<5	100	22	<5	<5	
738	313.41-314.00	6	<5	<50	<5	28	6	<5	<5	
739	314.00-314.80	<5	117	<50	<5	33	11	<5	<5	
740	314.80-315.00	<5	144	<50	<5	28	22	6	<5)	Goethite in dolomite
741	315.00-315.65	7	<5	<50	<5	6	<5	7	<5)	
742	315.65-316.00	<5	<5	<50	<5	7	7	<5	<5)	
743	316.00-317.00	<5	<5	<50	<5	15	12	<5	<5)	
Massive pyrite		15	2280	194	<5	629	29	<5	31	

Analysts: M. Frith and R. Roby, Department of Mines Laboratories, Launceston.

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Table 3. REPEAT AND DUPLICATE ANALYSES OF MASSIVE AND DISSEMINATED PYRITE IN DIAMOND DRILL HOLE DLR-7, LUNE RIVER

Sample number	Ag (g/t)	As (g/t)	Au (g/t)	Bi (g/t)	Cu (g/t)	Mo (g/t)	Pb (g/t)	Sn (g/t)	Ta (g/t)	W (g/t)	Zn (g/t)	Remarks
802731 P	3	900	<0.01	10	24	1	820	24	10	15	14	
802731 C	3	1250	<0.01	10	24	2	520	<4	<10	<10	26	
802732 P	3	2100*	<0.01	<10	24	<1	310*	<4	<10*	<10*	38	Massive pyrite
802732 C	2	2100*	<0.01	10	26	<1	260*	6	<10*	<10*	44	
802733 P	1	1150	<0.01	<10	10	<1	560	8	<10	<10	12	
802733 C	2	110	<0.01	<10	14	<1	260	6	<10	<10	16	
802734 P	3	1650*	<0.01	<10	20	<1	820*	<4	15	<10	20	Massive pyrite
802734 C	3	1700*	<0.01	10	20	<1	780*	<4	15	<10	18	
48-5 802735 P	2	190	<0.01	<10	8	<1	230	10	<10	<10	12	
802735 C	2	230	<0.01	<10	8	<1	270	4	10	10	8	
802736 P	3	2050*	<0.01	<10	20	<1	660*	<4	<10*	<10*	18	Massive pyrite
802736 C	3	2050*	<0.01	<10	20	1	620*	6	<10*	<10*	20	
802737 P	2	300	<0.01	<10	8	<1	95	6	<10	<10	10	
802737 C	1	290	<0.01	<10	8	<1	95	6	<10	<10	14	
DLR-7	290	1150	<0.01	10	180	1	350	<4	<10	25	50	
813286	325	1200	<0.3	<100	200	<100	400	<100	<100	<100	<100	
Detn limit	(1)	(2)		(10)	(2)	(1)	(2)	(4)	(10)	(10)	(2)	

Analysts: Australian Mineral Development Laboratories, Adelaide, South Australia; except 813286 by M. Frith and J.R. Lethborg, Department of Mines Laboratories, Launceston.

Samples suffixed 'P' are pulp samples of previously analysed specimens.

Samples suffixed 'C' are quarter core samples of the same intervals previously analysed (see Table 2).

Samples DLR-7 and 813286 are of diamond saw sludge collected during sampling of quarter core.

The AMDEL analytical results are published by courtesy of the Electrolytic Zinc Company of Australasia Limited.

* Matrix difficulties render these results subject to error.

indicate anomalous concentrations of As, Cu, Pb, and Sn and weakly anomalous levels of Ag and Zn, mainly in the interval 310.68-313.41 m. The analytical data also show that As, Cu, Pb, and Zn tend to be concentrated in the massive pyrite, which averages 2280 g/t As, 629 g/t Pb, 194 g/t Cu, 31 g/t Zn, 15 g/t Ag and an indicated 29 g/t Sn. The Sn values show a tendency to decrease down the hole, starting at 208 g/t Sn in the first sample, and sample contamination is suspected.

Subsequent to the above analytical results, the Electrolytic Zinc Company of Australasia Ltd undertook to re-analyse pulps of samples 802731-737 and analyse duplicate quarter-core samples of the intervals between 311.31-313.41 m. These analyses (Table 3) confirm the anomalous concentrations of As and Pb, but downgrade the Ag, Cu, and Sn values. The results also confirm the tendency for higher As, Cu, Pb, and Zn in the massive pyrite compared to the disseminated pyrite and goethitic dolomite (cf. Tables 2 and 3).

The abnormally high Ag values in the sludge samples (DLR-7 and 813286, Table 3) may be accounted for by contamination from the diamond saw blade, as the alloy in which the diamonds are embedded contains a few percent Ag (N.F. Rutherford, pers. comm.; M.K. Diamonds Products, U.S.A., pers. comm.). The reason for the anomalous Cu and relatively high W is not known, but they too are probably due to contamination from the saw.

Analyses of sulphide-bearing sections of the fault zone intersected in DLR-9 indicate slightly anomalous concentrations of As, Cu, Pb, and Zn (Table 4) which probably reflect the black shale porphyroclasts, but the relatively high Sn values require checking before assigning an explanation.

A comparison of analytical data for the ironstone (gossan) in the Lune River quarry, the massive pyrite in DLR-7, and black shale occurrences in the Lune River area (Table 5) reveals that the anomalous elements in the ironstone and the massive pyrite (*i.e.* As, Cu, Pb, and Zn) are also relatively enriched in black shale. The gossan in the quarry and the massive pyrite have similar concentrations of Ag, As, Cu, and W, but the gossan is depleted in Pb, and enriched in Zn and to a lesser degree Mo. These discrepancies in metal concentrations indicate the gossan did not form by oxidation of pyrite (of the composition of the massive pyrite in DLR-7) to goethite. It may be a gossan derived from pyrite mineralisation of similar, but not identical, composition to the massive pyrite.

Alternatively, the gossan in the quarry, the massive pyrite, and a narrow band of goethite within black shale in DLR-5 (analysis 4, Table 5) all have similar metal concentrations, particularly As, Cu, Ni, and W, but the two ironstones are depleted in Pb and enriched in Zn and Mo, similar to black shale (analyses 5 and 6, Table 5). Thus the gossan in the quarry is probably derived from original base metal-bearing sulphides in black shale.

SULPHUR ISOTOPES

The sulphur isotopic composition of the pyrite was determined to obtain further information on the origin of the pyrite. The five samples of massive pyrite analysed are from the same core intervals as the mineralogical samples. Combustion of pyrite to liberate SO₂, and mass spectrometry were undertaken at the University of Tasmania.

The δ³⁴S values of the massive pyrite (Table 6) are unusually high and have a limited range of +39.0 to +40.2 per mil. Such high values are un-

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Table 4. ANALYSES OF SULPHIDE-BEARING CORE, DIAMOND DRILL HOLE DLR-9, LUNE RIVER

Sample number	Depth (m)	Ag (g/t)	As (g/t)	Cu (g/t)	Mo (g/t)	Pb (g/t)	Sn (g/t)	W (g/t)	Zn (g/t)
802949	29.20-29.45	7	367	250	<5	23	78	<5	48
950	29.45-30.20	<5	23	110	<5	9	32	<5	67
951	30.20-30.50	<5	34	230	<5	45	25	7	114
952	30.50-30.55	6	19	80	<5	26	17	<5	31
953	30.55-31.10	<5	10	<50	<5	<5	16	7	45
954	31.80-32.70	14	<5	70	<5	10	15	<5	377
955	38.00-38.50	<5	44	70	<5	<5	13	<5	32
956	40.53-41.00	8	127	60	<5	16	<5	<5	66
957	41.00-41.24	8	16	60	<5	12	14	<5	27
958	41.24-41.40	8	265	70	<5	28	23	<5	197
Weighted average		6	61	94	<5	14	21	<5	134

Analyst: J. Furst, Department of Mines Laboratories, Launceston

Table 5. COMPARATIVE ANALYTICAL DATA FOR IRONSTONE, SULPHIDE MINERALISATION AND BLACK SHALE OCCURRENCES IN THE LUNE RIVER AREA

Element (g/t)	1	2	3	4	5	6	7
Ag	9	15	2	<5	4	10	6
As	3418	2280	2024	5917	278	86	61
Au	<0.3	-	<0.01	-	-	-	-
Bi	7	-	<10	<5	4	3	-
Co	<5	-	-	-	-	-	-
Cu	75	194	22	110	39	54	94
Mo	12	<5	<1	10	7	10	<5
Ni	363	-	-	232	60	78	-
Pb	117	629	534	126	70	38	14
Sb	95	-	-	363	27	-	-
Sn	22	29	4	16	18	-	21
Sr	18	-	-	120	66	1667	-
U	<5	-	-	7	13	15	-
V	<20	-	-	-	-	-	-
W	<5	<5	<10	<5	<5	-	<5
Y	31	-	-	8	14	57	-
Zn	458	31	26	1647	125	88	134

1. Ironstone (gossan), Lune River quarry. Average of samples 802522-525, except Au, Co, and V from 801600-602.
2. Massive pyrite, DLR-7. Weighted average 802732, 734, 736 (Table 2).
3. Massive pyrite, DLR-7. Weighted average 802732, 734, 736 P/C (Table 3).
4. Black shale ironstone, DLR-5 at 34.85-34.86 m (802544).
5. Black shale, Lune River quarry. Average of five grab samples from bench 5 (802531-535) and four drill core samples from DLR-5 at 33.7-34.85 m (802540-543).
6. Black shale, Surprise Bay. Average of two grab samples (802538, 539).
7. Sulphides in fault zone, DLR-9. Weighted average 802949-958 (Table 4).

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PHOTOGRAPHIC SLIDES

The following colour photographic slides of the pyrite mineralisation are held in the Department of Mines photographic slide collection:

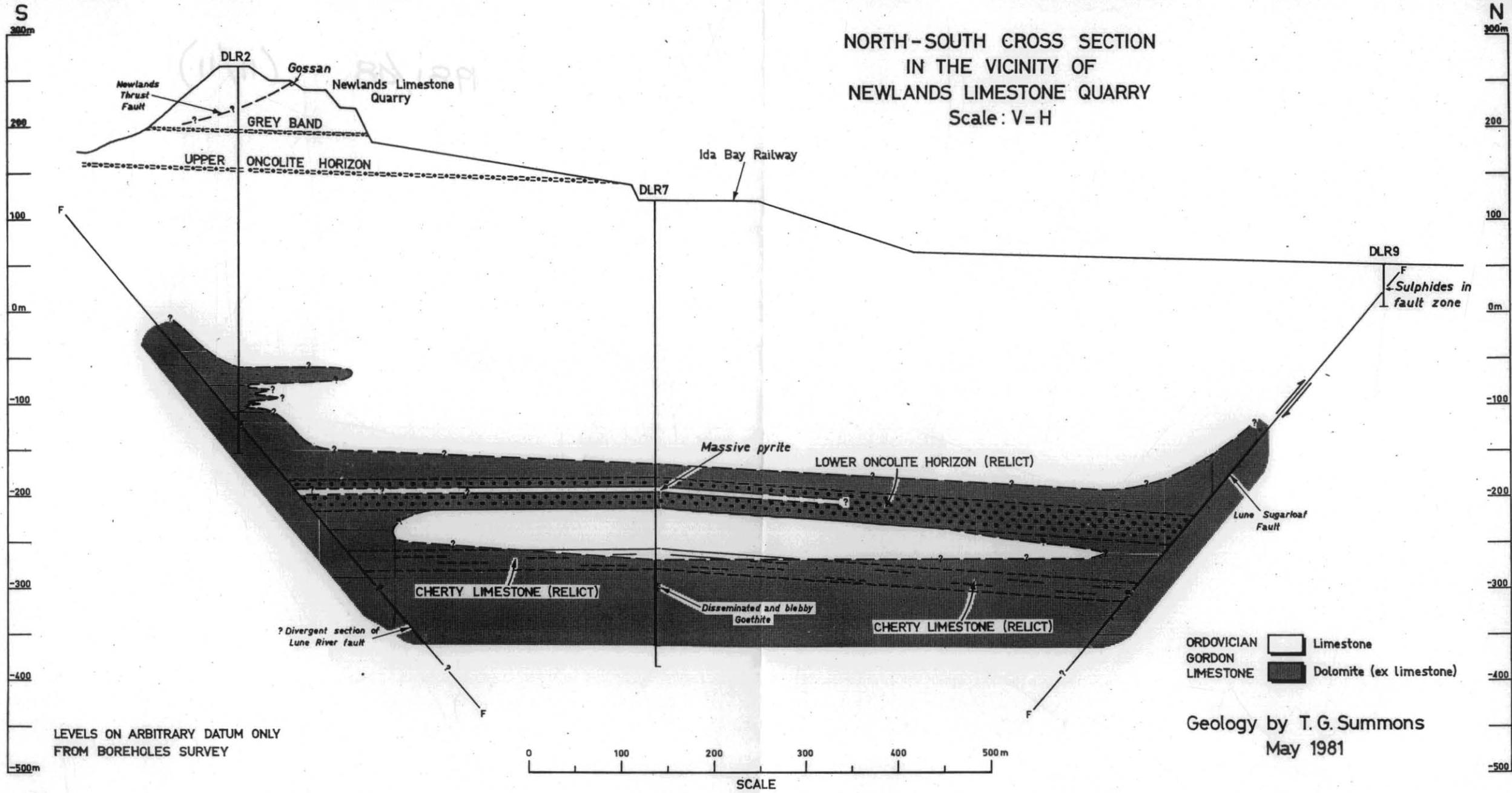
<i>Slide no.</i>	<i>Description</i>
2222)	
2223)	Pyrite in limestone, Lune River, diamond
2224)	drill hole DLR-7
2225)	

[20 October 1981]

APPENDIX 1

Log of diamond drill hole DLR-7, 311.31-317 m

<i>Depth (m)</i>	<i>Description</i>
311.31-311.50	Medium grey granular dolomite (ex oncolite limestone) with 15-20vol% disseminated and blebby pyrite.
311.50-311.95	Massive (>90vol%) pyrite fine-grained and dark coloured with interstitial calcite/dolomite.
311.95-312.05	Partly oxidized granular dolomite, 10vol% disseminated pyrite.
312.05-312.20	Massive (>90vol%) pyrite, including coarse-grained brassy pyrite; vuggy with calcite/dolomite crystals in the voids.
312.20-312.36	Oxidized granular dolomite (?ex oncolite limestone), vuggy, with ≈ 5vol% pyrite (blebby and disseminated).
312.36-313.05	Massive (>80vol%) pyrite, both fine-grained dark coloured and brassy coarse-grained types; grey granular dolomite and calcite/dolomite veinlets.
313.05-313.41	Grey granular dolomite (ex oncolite limestone), with <10vol% disseminated pyrite.
313.41-314.00	Oxidized granular dolomite (ex oncolite limestone), with ≈ 5vol% goethite.
314.00-314.80	Grey granular dolomite (ex oncolite limestone), stringers and disseminated pyrite ≈ 2vol%.
314.80-315.00	As for 313.41-314.00 m, with ≈ 15vol% goethite.
315.00-315.65	Medium grey granular dolomite (ex oncolite limestone).
315.65-316.00	Partly oxidized granular dolomite (ex oncolite limestone) with <10vol% goethite.
316.00-317.00	As for 315.65-316.00 m, with average 2vol% goethite, including a single large (50 mm) bleb at 317.00 m.



LEVELS ON ARBITRARY DATUM ONLY FROM BOREHOLES SURVEY

Geology by T. G. Summons
May 1981

5 cm