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SADME /AMDEL PROJECT NO. 1/1/271

PETROLOGY AND GEOCHEMISTRY OF THE BURRA COPPER MINE

PROGRESS REPORTS FOR THE PERIOD NOVEMBER 1981 TO MARCH 1982

Submitted by
South Australia. Department of Mines and Energy
1982

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PRIMARY INDUSTRIES AND RESOURCES SA

CONTENTS ENVELOPE 4472 DME 54/82

TENEMENT: NOT REALTED

TENEMENT HOLDER: TEH AUSTRALAIN MINERAL DEVELOPMENT LABORATORIES

REPORTS:

ROWLEY, D.K. 1982

Project Report AC 1/1/271
Dated 2nd February 1982
Data layout for metalscan. (pgs. 3-8)
(No Plans)

Kemp, A. Dr. March, 1982

Petrology and Geochemistry of Burra Copper Mine PR No. 2 (pgs. 9-136)

The Australian
Mineral Development
Laboratories

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In reply quote:

amdel

AC 1/1/271 - 3081/82

2 February 1982

NATA CERTIFICATE

The Director-General,
S.A. Department of Mines & Energy,
P.O. Box 151,
EASTWOOD S.A. 5063

PROJECT REPORT AC 1/1/271

YOUR REFERENCE:	11-03-0900
IDENTIFICATION:	As listed
DATE RECEIVED:	30 November 1981

PROGRESS REPORT No. 1

D.K. Rowley
Manager
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ij

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THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

DATA LAYOUT FOR METALSCAN

METALLIC RESOURCES
FORM DP 29

AMDEL PROJECT NO 3081/82 SADM PROJECT NO SHEET 1 OF 5

AMDEL REPORT NO SADM PROJECT NAME DATE 004

Detection Limit	200	5	20	10	3	5	10	50	100	10	0.1	50	1	1	1	30	1	20	3	100		
A-G NUMBER	Ba	Co	Cr	Mn	Mo	Ni	V	W	La	Y	Ag	As	Bi	[illegible]	Pb	Sb	Sn	Zn	Au	P		
B1/80	x	x	20	300	x	20	40	x	x	x	x	x	x	2000	x	x	x	x	x	1000		
2	x	x	x	500	x	5	40	x	x	x	x	x	x	400	1	x	x	x	x	200		
3	x	20	60	80	x	80	80	x	x	30	0.6	x	x	9998	2	x	x	x	x	2000		
4	400	15	60	60	x	30	100	x	x	20	0.6	x	x	9997	2	x	x	x	x	9997		
5	600	x	x	20	x	x	60	x	x	20	x	x	x	400	x	x	1	x	x	200		
7	1500	10	100	20	x	60	200	x	50	40	x	x	x	300	4	x	6	x	x	800		
8	x	5	x	1000	x	10	40	x	x	10	x	x	x	100	1	x	2	x	x	x		
10	1500	20	150	60	30	80	400	x	100	30	x	x	x	1000	20	x	20	x	x	800		
11	x	10	60	80	x	40	150	x	x	20	x	x	x	9999	40	x	x	100	x	8000		
12	x	x	x	80	x	x	10	x	x	x	x	x	x	150	15	x	x	x	x	400		
13	200	x	x	150	x	x	40	x	x	x	x	x	x	600	6	x	x	x	x	200		
14	x	x	20	150	x	x	60	x	x	10	x	x	x	9998	25	x	1	80	x	8000		
15	x	x	40	100	x	40	40	x	x	x	x	x	x	300	10	x	1	x	x	300		
16	200	10	20	200	x	5	60	x	x	x	x	x	x	400	15	x	4	x	x	1500		
17	200	x	x	80	x	x	40	x	x	x	x	x	x	60	20	x	x	20	x	100		
18	x	x	x	50	x	x	20	x	x	x	x	x	x	30	6	x	x	x	x	200		
19	x	x	x	150	x	x	60	x	x	x	x	x	x	60	25	x	1	x	x	300		
20	x	10	20	200	x	x	80	x	x	x	x	x	x	100	15	x	x	x	x	300		
21	x	x	80	100	30	80	30	x	x	x	x	x	x	60	x	x	x	x	x	100		
28	x	x	x	150	3	x	20	x	x	x	x	x	x	60	3	x	x	x	x	x		
29	x	x	x	100	3	x	40	x	x	x	x	x	x	40	1	x	x	x	x	x		
31	x	x	x	60	x	x	20	x	x	x	0.6	x	x	80	6	x	x	20	x	x		
32	x	x	60	150	15	80	20	x	x	x	x	x	x	15	3	x	x	x	x	400		
33	x	x	60	300	15	30	40	x	x	x	x	x	x	60	6	x	x	60	x	100		
34	1000	x	20	200	x	30	40	x	x	x	x	x	x	30	x	x	x	x	x	100		
36A	600	10	80	20	x	40	200	x	100	60	0.2	x	x	9997	15	x	x	x	x	300		
36B	x	x	80	20	x	40	200	x	100	30	x	x	x	9997	6	x	x	x	x	300		
37	x	x	x	60	x	5	40	x	x	10	0.8	x	x	9999	3	x	x	20	x	9998		
39	x	10	x	500	x	x	40	x	x	x	0.8	x	x	1000	2	x	x	x	x	600		
41	400	x	40	30	3	30	20	x	x	10	0.4	x	x	9997	1	x	x	x	x	800		
42	x	10	60	60	x	60	150	x	100	60	0.2	x	x	3000	6	x	2	x	x	800		
43	x	10	60	60	10	60	200	x	x	20	0.8	x	x	9997	1	x	x	x	x	200		
B44/80	x	x	20	800	x	5	60	x	x	x	x	x	x	1000	x	x	x	x	x	400		

NOTE: 9997 : 10000 ppm 9998 : > 10000 ppm 9999 : >> 10000 ppm

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

DATA LAYOUT FOR METALSCAN

METALLIC RESOURCES
FORM DP 29

AMDEL PROJECT NO 3081/82 SADM PROJECT NO SHEET 2 OF 5

005

AMDEL REPORT NO SADM PROJECT NAME DATE

Detection Limit	200	5	20	10	3	5	10	50	100	10	0.1	50	1	1	1	30	1	20	3	100		
A-G NUMBER	Ba	Co	Cr	Mn	Mo	Ni	V	W	La	Y	Ag	As	Bi	Cu	Pb	Sb	Sn	Zn	Au	P		
B45/80	1500	x	x	600	x	5	40	x	x	x	x	x	x	800	x	x	x	x	x	100		
46	200	10	200	50	50	80	300	x	100	40	x	x	x	3000	x	x	x	x	x	8000		
47	x	5	60	40	x	60	80	x	x	20	x	x	x	9998	x	x	x	60	x	300		
48	x	20	80	100	3	100	200	x	x	20	x	x	x	9998	x	x	x	x	x	100		
49	x	5	60	100	x	30	100	x	x	20	08	x	x	9998	2	x	x	20	x	1500		
50	600	x	80	20	x	60	30	x	x	20	04	x	x	1000	x	x	x	x	x	200		
51	x	x	x	20	x	x	30	x	150	10	x	x	x	9998	x	x	x	x	x	800		
52	x	x	x	2000	x	x	20	x	x	x	40	x	x	9998	1	x	x	x	x	100		
53	1000	x	x	100	x	5	40	x	x	30	x	x	x	300	x	x	x	x	x	6000		
54	x	x	20	3000	x	5	30	x	x	x	80	x	x	9998	1	x	x	20	x	100		
55	x	x	x	60	x	x	x	x	x	x	08	x	x	9998	x	x	x	x	x	300		
56	x	x	x	600	x	x	40	x	x	x	02	x	x	400	1	x	x	20	x	1000		
57	x	x	x	60	x	x	10	x	x	x	08	x	x	9998	x	x	x	x	x	600		
58	400	30	80	80	6	80	100	x	x	20	02	x	x	9998	1	x	x	x	x	200		
59	9998	x	x	10	x	30	40	x	x	20	30	x	x	9998	x	x	x	x	x	600		
60	400	x	x	30	x	x	20	x	150	x	08	x	x	1500	x	x	x	x	x	1000		
62	x	x	20	100	x	x	80	x	x	x	02	x	x	600	10	x	x	x	x	300		
63	x	5	x	150	x	x	60	x	x	x	x	x	x	100	15	x	x	x	x	200		
64	x	x	x	250	x	x	40	x	x	x	02	x	x	150	3	x	x	x	x	400		
65	x	x	x	100	x	x	80	x	x	x	x	x	x	60	2	x	x	x	x	3000		
66	200	x	x	80	x	x	20	x	x	x	x	x	x	40	2	x	x	20	x	200		
67	800	150	x	4000	x	40	80	x	100	40	06	x	x	3000	6	x	1	x	x	3000		
68	600	x	20	60	60	20	100	x	x	30	20	x	2	9998	3	x	x	x	x	800		
70	x	15	20	300	3	60	40	x	x	x	x	x	x	160	x	x	x	20	x	x		
71	x	5	20	1000	x	40	80	x	x	x	x	x	x	600	x	x	x	x	x	300		
72	x	x	20	3000	x	15	40	x	x	x	30	x	x	9998	3	x	x	x	x	300		
73	1500	10	100	100	x	60	150	x	50	30	04	x	x	4000	1	x	x	20	x	4000		
74	400	x	20	300	x	30	80	x	x	100	10	x	x	4000	10	x	x	80	x	9998		
75	1000	30	100	1000	x	60	200	x	50	40	02	x	x	2000	4	x	x	x	x	600		
76	x	x	60	80	x	60	200	x	x	10	04	x	x	9998	x	x	x	40	x	400		
77	x	x	40	800	x	20	60	x	x	x	x	x	x	9998	2	x	x	x	x	100		
78	x	x	x	800	x	40	60	x	x	x	04	x	x	9997	2	x	x	x	x	300		
B79/80	200	x	x	300	x	x	60	x	x	x	04	x	x	3000	1	x	x	x	x	200		

NOTE: 9997 : 10000 ppm 9998 : > 10000 ppm 9999 : >> 10000 ppm

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

DATA LAYOUT FOR METALSCAN

METALLIC RESOURCES
FORM DP 29

AMDEL PROJECT NO 3081/82 SADM PROJECT NO SHEET 3 OF 5 006

AMDEL REPORT NO SADM PROJECT NAME DATE

Detection Limit	200	5	20	10	3	5	10	50	100	10	0.1	50	1	1	1	30	1	20	3	100		
A-G NUMBER	Ba	Co	Cr	Mn	Mo	Ni	V	W	La	Y	Ag	As	Bi	Cu	Pb	Sb	Sn	Zn	Au	P		
B80/80	x	x	x	400	x	x	30	x	x	x	30	x	x	6000	2	x	x	x	x	200		
83	x	x	20	300	x	20	60	x	x	10	x	x	x	200	2	x	x	x	x	400		
84	x	x	40	200	10	40	100	x	x	30	08	x	x	9998	30	x	x	150	x	9997		
86	x	10	80	60	x	60	80	x	50	10	x	x	x	2000	3	x	x	20	x	6000		
87	x	x	20	600	x	15	40	x	x	10	02	x	x	800	3	x	x	x	x	800		
88	x	40	x	1000	x	80	100	x	x	30	08	300	x	8000	15	x	x	250	x	9998		
92	600	x	80	40	10	40	300	x	x	20	30	x	x	400	10	x	x	x	x	600		
94	800	80	60	3000	x	40	150	x	x	10	04	x	x	1500	10	x	x	x	x	2000		
97	400	10	40	150	x	40	60	x	x	20	06	x	x	4000	25	x	x	x	x	9998		
98	200	5	20	150	x	40	80	x	x	x	04	x	x	9999	x	x	x	x	x	800		
101	x	x	100	x	10	40	300	x	x	10	06	x	x	300	10	x	3	x	x	x		
103	x	5	x	1500	x	x	30	x	x	x	06	x	x	1000	10	x	x	x	x	1000		
104	1500	80	40	9998	10	200	80	x	x	10	40	x	x	9998	30	x	x	60	x	9997		
105	600	30	80	3000	10	80	200	x	x	30	06	x	x	2000	15	x	x	40	x	6000		
107	400	10	80	300	x	30	150	x	x	30	06	x	x	800	1	x	1	x	x	300		
112	x	x	x	200	x	x	40	x	x	x	x	x	x	100	10	x	x	x	x	200		
113	x	x	x	300	x	x	30	x	x	x	02	x	x	300	6	x	x	x	x	600		
114	x	x	x	80	x	x	x	x	x	x	02	x	x	100	x	x	x	x	x	200		
115	x	x	x	300	x	x	60	x	x	x	x	x	x	600	x	x	x	x	x	200		
116	x	x	20	150	x	30	80	x	x	10	06	x	x	9998	3	x	x	x	x	6000		
117	x	x	x	1000	x	5	40	x	x	x	x	x	x	1000	x	x	x	x	x	x		
119	x	x	x	100	x	x	60	x	x	x	04	x	x	9998	10	x	x	x	x	2000		
123	x	x	x	80	x	5	60	x	x	x	06	x	x	9998	3	x	x	x	x	400		
128	x	x	x	300	x	x	40	x	x	x	x	x	x	300	3	x	x	x	x	600		
135	x	x	20	40	x	15	80	x	x	10	20	x	x	9998	15	x	x	20	x	9997		
137	x	x	20	300	x	5	80	x	x	x	02	x	x	300	15	x	x	x	x	600		
140	x	x	x	80	x	x	30	x	x	x	02	x	x	400	60	x	x	x	x	200		
141	x	x	20	40	x	5	60	x	x	10	08	x	x	9998	1	x	6	x	x	6000		
142	x	x	x	200	x	x	x	x	x	x	x	x	x	300	1	x	x	x	x	200		
145	x	x	x	400	x	15	20	x	x	x	06	x	x	400	10	x	x	x	x	300		
146	x	x	40	60	x	10	80	x	x	30	04	x	x	9999	4	x	x	40	x	9998		
159	x	15	20	40	x	40	200	x	x	x	x	x	1	600	60	x	x	60	x	x		
B162/80	600	5	80	20	x	5	150	x	100	30	x	x	x	9998	1	x	x	x	x	8000		

NOTE: 9997 : 10000 ppm 9998 : > 10000 ppm 9999 : >> 10000 ppm

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

DATA LAYOUT FOR METALSCAN

METALLIC RESOURCES
FORM DP 29

AMDEL PROJECT NO . . . 3081/82 . . . SADM PROJECT NO . . . . . SHEET . 4 . OF . 5 . . .

AMDEL REPORT NO . . . . . SADM PROJECT NAME . . . . . DATE 007

Detection Limit	200	5	20	10	3	5	10	50	100	10	0.1	50	1	1	1	30	1	20	3	100		
A-G NUMBER	Ba	Co	Cr	Mn	Mo	Ni	V	W	La	Y	Ag	As	Bi	Cu	Pb	Sb	Sn	Zn	Au	P		
B163/80	x	40	x	100	x	60	100	x	x	10	20	800		9998	40	x	x	60	x	2000		
164	800	x	60	300	x	5	200	x	x	20	0.2	x		1500	10	x	x	x	x	8000		
165	x	x	40	400	x	15	40	x	x	x	x	x		150	3	x	x	x	x	600		
166	x	x	60	80	x	30	80	x	x	10	0.2	x		600	2	x	x	x	x	600		
167	600	x	150	30	x	5	150	x	150	30	x	x		9998	x	x	x	x	x	8000		
169	x	x	20	100	x	x	40	x	x	x	0.4	x		9998	6	x	x	20	x	6000		
171	x	x	x	200	x	x	40	x	x	x	0.2	x		800	60	x	x	x	x	9998		
172	x	x	x	300	x	x	40	x	x	x	x	x		400	60	x	x	40	x	9997		
174	1000	x	100	20	x	5	200	x	100	30	x	x		9998	2	x	x	x	x	6000		
176	x	x	x	60	x	x	30	x	x	x	0.2	x		9999	1	x	x	20	x	8000		
181	x	x	x	40	x	60	20	x	x	x	0.6	x		9998	x	x	x	x	x	600		
184	x	30	40	250	3	80	200	x	x	30	x	x		3000	2	x	x	x	x	400		
185	x	x	20	100	x	30	80	x	x	x	x	x		9998	2	x	x	40	x	400		
186	x	x	40	150	x	80	150	x	x	x	0.4	x		9998	x	x	x	100	x	200		
187	x	x	20	400	x	15	60	x	x	x	0.6	x		400	x	x	x	x	x	200		
189	400	x	x	600	x	15	60	x	x	10	x	x		200	x	x	x	x	x	200		
191	600	x	60	30	6	5	100	x	50	20	0.6	x		4000	x	x	x	x	x	6000		
192	400	x	60	30	x	30	80	x	x	10	1.0	x		9998	15	x	x	20	x	2000		
195	x	60	x	1000	x	5	x	x	x	30	5.0	x		9997	x	x	x	x	x	800		
199	x	10	40	100	x	60	80	x	x	10	1.0	x		4000	6	x	x	x	x	6000		
200	x	15	20	500	x	15	60	x	x	20	100	x		9998	1	x	1	40	x	8000		
201	x	5	x	20	x	30	150	x	x	80	x	x		6000	x	x	x	x	x	400		
206	x	30	20	100	x	40	800	x	x	800	x	x		9998	1	x	2	60	x	8000		
207	x	5	40	800	x	40	200	x	x	20	0.6	x		9998	x	x	x	20	x	1000		
208	200	x	x	20	x	x	40	x	x	20	x	x		1000	x	x	x	x	x	3000		
209	400	30	20	100	x	60	100	x	100	10	8.0	x		9998	2	x	3	20	x	2000		
214	x	x	x	40	x	x	x	x	x	x	1.0	x		9998	1	x	x	x	x	800		
215	1000	x	x	20	x	x	100	x	x	40	x	x		800	x	x	x	x	x	3000		
216	x	5	40	100	x	60	80	x	x	30	0.6	x		9998	3	x	x	20	x	9998		
218	200	x	x	800	x	5	60	x	x	x	0.8	x		9998	x	x	2	20	x	300		
219A	600	x	x	10	x	5	40	x	x	20	100	x		9998	x	x	x	x	x	1500		
220	x	x	20	250	x	15	80	x	x	10	2.0	x		9998	3	x	x	x	x	8		
B226/80	x	x	x	40	x	5	40	x	x	10	x	x		9998	2	x	x	x	x	9997		

NOTE: 9997 : 10000 ppm 9998 : > 10000 ppm 9999 : >> 10000 ppm

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

DATA LAYOUT FOR METALSCAN

METALLIC RESOURCES
FORM DP 29

AMDEL PROJECT NO 3081/82 SADM PROJECT NO SHEET 5 OF 5 008

AMDEL REPORT NO SADM PROJECT NAME DATE

Detection Limit	.200	5	20	10	3	5	10	50	100	10	0.1	50	1	1	1	30	1	20	3	100		
A-G NUMBER	Ba	Co	Cr	Mn	Mo	Ni	V	W	La	Y	Ag	As	*Bi	Cu	Pb	Sb	Sn	Zn	Au	P		
B227/80	400	10	60	40	x	40	200	x	50	30	04	x	x	9998	3	x	x	x	x	8000		
233	1000	10	80	40	x	60	200	x	50	30	04	x	x	9998	3	x	x	x	x	8000		
234	x	x	20	600	3	40	150	x	x	20	02	x	x	9998	10	x	x	x	x	800		
235	400	x	40	150	x	30	80	x	50	10	x	x	x	9998	2	x	x	x	x	600		
236	x	10	40	1000	15	40	200	x	x	30	04	x	x	8000	x	x	x	20	x	400		
239	x	x	x	80	x	15	40	x	x	x	06	x	x	9999	2	x	x	20	x	200		
244	x	15	x	2000	x	30	20	x	x	x	x	x	x	1000	1	x	x	x	x	100		
246	x	5	40	60	x	15	100	x	x	x	80	x	x	9999	40	x	x	20	x	9997		
247	x	5	x	20	x	5	60	x	x	10	20	x	x	9998	2	x	1	20	x	600		
248	200	x	20	3000	x	15	60	x	x	x	150	x	x	9998	1	x	x	x	x	200		
250	600	40	80	8000	x	40	200	x	x	30	02	x	x	9997	x	x	x	x	x	800		
251	400	x	x	60	x	x	60	x	50	40	x	x	x	9997	x	x	x	x	x	2000		
252	400	10	x	80	x	15	80	x	100	40	x	x	x	8000	x	x	x	20	x	2000		
253	200	x	60	60	x	x	150	x	x	30	04	x	x	9998	3	x	x	x	x	1000		
254	x	5	x	10	x	x	40	x	100	20	02	x	x	9998	x	x	x	x	x	600		
256	x	x	40	20	x	20	80	x	x	x	80	x	x	9999	1	x	x	x	x	2000		
264	x	x	40	800	x	30	80	x	x	x	02	x	x	9997	x	x	x	20	x	600		
269	x	x	40	2500	80	20	60	x	x	x	04	x	x	9997	3	x	x	x	x	x		
276	x	x	20	400	15	15	40	x	x	x	x	x	x	600	1	x	x	x	x	x		
277	x	15	20	60	x	60	100	x	x	40	04	x	x	200	10	x	x	40	x	400		
278	x	x	x	150	x	x	20	x	x	x	x	x	x	100	x	x	x	x	x	600		
279	800	10	20	300	x	20	60	x	x	x	x	x	x	100	2	x	x	x	x	400		
280	x	x	x	3000	x	x	30	x	x	x	80	x	x	9998	x	x	x	x	x	x		
282	x	x	x	800	x	x	30	x	x	x	100	x	x	9999	3	x	x	x	x	x		
B285/80	x	60	x	40	x	20	80	x	x	30	40	800	4	9998	3	x	1	40	x	800		

NOTE: 9997 : 10000 ppm 9998 : > 10000 ppm 9999 : >> 10000 ppm

0009

PETROLOGY AND GEOCHEMISTRY OF BURRA COPPER MINE

Department of Mines & Energy

PR No. 2

1/1/271 March 1982

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31 March 1982

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Attention: J.F. Drexel and W.S. McCullum

PETROLOGY AND GEOCHEMISTRY

OF

BURRA COPPER MINE

PROGRESS REPORT NO. 2

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1. INTRODUCTION

A total of 98 rock samples were submitted to AMDEL by J.F. Drexel and W.S. McCallum of South Australian Department of Mines and Energy, for evaluation.

82 for thin section petrography only.
6 for thin section and polished section petrography.
6 for polished section petrography only.
2 for thin section and XRD examination.
4 for XRD examination only.

After further discussions between W.S. McCallum, J.F. Drexel (SADME) and A.W. Kemp (AMDEL) and a days inspection of the Burra Copper Mine, a further four samples were submitted for thin section examination.

During petrological examination of the samples an additional five were submitted for XRD determination of optically indeterminate phases.

Sample: B5; TSC34940

Hand Specimen:

A fine grained vesicular quartzo-feldspathic rock. Quartz forms thin (∿1mm) veins and pinkish brown feldspathic patches appear associated with these veins. The pinkish-brown colour is probably due to secondary alteration. Opaque crystals (?chalcopyrite) up to ∿2 mm across are occasionally associated with malachite.

Thin Section

A visual estimate of the constituents gives:

	%
Feldspar	80
Quartz	20
Opaques (including malachite)	<1

The rock is a highly altered volcaniclastic, possibly a welded tuff.

The unaltered 'groundmass' is made up of very fine-grained (<0.01 mm) to glassy material, probably K-feldspar. Spherulites up to 0.1 mm across occur in patches and stringers, indicating devitrification of volcanic glass.

Feldspar phenocrysts are of untwinned orthoclase and microcline up to 0.7 mm long. They are commonly partially altered giving a brown 'dusted' appearance.

Feldspar also occurs as a major replacement mineral, commonly forming irregular patches up to ∿1 cm across. Within these patches crystals up to ∿0.6 mm across of K-feldspar have highly irregular shapes with sutured and diffuse boundaries between grains. They are occasionally intergrown with minor amounts of quartz. Alteration of this feldspar is similar to that of the feldspar phenocrysts.

Quartz occurs as single crystals and in aggregates and veins. Individual crystals are up to 1.5 mm across with irregular boundaries and exhibit undulose extinction.

Veins of quartz are up to 2 to 3 mm thick. Rare thin (<0.01 mm) veins of ?chlorite and quartz also occur.

Opaque minerals are rare, forming crystals up to 0.8 mm across. Radiating fibrous malachite is pseudomorphous after ?chalcopyrite.

Conclusion:

A silicified and feldspathised ?welded tuff.

Sample: B10; TSC34941

0013

Hand Specimen:

The sample is of a creamy brown thinly laminated (av. ∿0.5 mm) siltstone which has been slightly deformed giving a weak crenulation. Blebs of opaque minerals up to 1 x 6 mm are generally elongate parallel to the lamination.

Thin Section:

A visual estimate of the constituents gives the following approximate percentages:

	%
Feldspar and ?kaolinite	80
Opaque	15
Quartz	5
?White mica	<1
?Chlorite	<1

The thin section is of a finely laminated siltstone or shale.

Feldspar forms rare small (up to 0.15 mm) crystals of untwinned ?K-feldspar and microcline in a thinly laminated groundmass of microcrystalline feldspar, kaolinite and opaque grains.

Quartz forms small (up to 0.1 mm) angular to subangular 'phenocrysts' and occasional irregular patches up to 1 mm across.

A yellow fibrous ?chlorite forms patches up to 0.3 mm across, commonly associated with opaque grains. It is also associated with white mica in what appear to be pseudomorphs of phenocrysts.

Opaque minerals form aggregates (up to 4 mm in length) elongate parallel to the lamination. These are frequently surrounded by thin (up to 0.5 mm) rims of quartz made up of undulose elongate bent crystals which appear to have formed in pressure shadows.

Small needle shaped crystals of ?white mica up to 0.3 mm in length are elongate parallel to the lamination, with minor amounts intergrown with quartz in pressure shadows around opaque grains. One crystal of ?clinozoisite 0.05 mm across was observed.

The lamination on the rock is due to variations in concentration of finely disseminated opaque grains, and to a lesser extent to variation in concentrations of feldspar and quartz 'phenocrysts'.

Conclusion:

The rock appears to be a finely lamined siltstone or shale.

Sample: B16; TSC34942

0014

Hand Specimen:

The sample is of a light to dark grey thinly laminated dolomite. One laminae ∿8 mm thick contains randomly orientated flaky ?crystals up to ∿1.5 mm in lengths. Elongate cavities up to 2 mm x 10 mm are lined with calcite. One thin (< 2 mm) laminae appears to be dominantly composed of kaolinised feldspar crystals.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	97
Quartz	1
Feldspar	1
Opaque	1

The thin section is of a fine grained thinly laminated dolomite. The dolomite is microcrystaline (<0.01 mm); occasional round patches up to 0.5 mm across contain crystals up to 0.2 mm across and may be recrystallised organic material.

A layer approximately 8 mm thick contains pseudomorphs of ?muscovite crystals (up to 1.3 mm in length) replaced by sericite and quartz. These make up ∿10% of this layer. These pseudomorphs occur rarely in other layers.

Quartz occurs as rare small (<0.1 mm) crystals partially replaced by dolomite. Feldspar (untwinned ?K-feldspar and microcline) has a similar occurrence.

Opaque grains are finely disseminated, up to 0.25 mm across, although commonly much smaller. The lamination present is due to variation in concentration of opaque grains and quartz and feldspar crystals.

Sample: B37; TSC34943 0015

Hand Specimen:

The host rock is composed of fine grained creamish brown to brown indistinct laminae 0.5 to 3.0 mm thick. The colour variation is due to oxidation of varying amounts of finely disseminated opaque material. Fresh material is a dark greenish grey with very indistinct lamination. The rock is extensively veined with malachite and azurite, occasionally intergrown. Oxidation is apparently related to these veins.

Thin Section:

The host rock is very similar to samples B10 and B46. Due to the high degree of veining and alteration a visual estimate of the constituents is not possible.

The rock is composed dominantly of small grains of quartz and feldspar set in a microcrystalline groundmass of feldspar and quartz. Finely disseminated opaque and carbonaeous material has a variable concentration which imparts the banding to the rock.

Occasional circular patches up to 0.6 mm across have a low percentage of carbonaceous matter and may be due to organic activity.

Chalcedonic quartz makes up the groundmass in small areas of the rock adjacent to veins, where the same material forms patches up to 0.6 mm across and frequently lines the veins. The characteristic radiating pattern is well displayed.

Feldspar forms small (up to $\sim$0.15 mm) grains of untwinned orthoclase and of microcline. Untwinned grains are occasionally zoned.

Rare flakes of muscovite up to 0.1 mm in length appear unaltered as do occasional grains of epidote of similar size.

Fine fibres of a colourless mineral occur in the groundmass, as small (< 0.1 mm) spherulites in veins, often intergrown with chalcedony and as thin (0.03 mm) films between azurite growth phases and frequently between azurite and malachite This is tentatively identified as chrysocolla.

Azurite occurs as thin tabular crystals up to 5 mm in length, commonly with a sheaf-like habit, in veins up to 2 to 3 mm thick, and replacing the host rock. Alteration to malachite is occasionally seen. Some azurite and malachite appears pseudomorphous, possibly after chrysocolla encrusted libenthenite, (see QGN No.76) with rare azurite crystals continuous across the ?chrysocolla films.

Occasional relicts of a pale yellowish green mineral may be of libenthenite.

Malachite forms monomineralic veins and composite veins with azurite. The two minerals are frequently separated by a thin film of chrysocolla, suggesting the formation of the malachite is later than that of azurite and not all by replacement.

Pseudomorphs of malachite after ?chalopyrite are also observed.

Opaque grains are up to 0.2 mm across and finely disseminated, with some blood red ?cuprite. Occasional thin veins are also lined with opaque material.

Sample: B39; TSC34944 0017

Hand Specimen:

The sample has a non porous irregular centre of quartz, surrounded by highly porous silica. Porosity is possibly due to solution of non-silicified components, probably kaolinite.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	99
Feldspar	<1
Opaque	Tr
Sericite	Tr
Kaolinite	Tr

This sample is similar to B41, 57, 224.

Quartz crystals are up to ∿1 mm across, with coarser and finer crystals forming irregular patches up to ∿3 to 5 mm across. Quartz crystals in coarser patches are dusted with minute opaque inclusions and these frequently form lines which cross quartz/quartz boundaries. These boundaries are commonly smooth, curved to straight and recrystallisation can be seen to have occurred along boundaries and at triple junctions.

Euhedral finer grained quartz crystals (generally <0.2 mm) form patches of equigranular mosaic, crystals having straight boundaries and ∿120° triple points. These patches of quartz also contain lines of minute opaque inclusions crossing grain boundaries and appear to have formed by recrystallisation of the coarser grained quartz.

Small patches up to ∿1.5 mm across are composed of fine grained (<0.08 mm) untwinned ?K-feldspar, partially altered to sericite and kaolinite, and quartz crystals of approximately the same size. Rare opaque grains up to ∿0.15 mm across are commonly associated with these patches.

The sample appears to be of an extensively silicified fine grained ?volcanic rock.

Sample: B41; TSC34945

0018

Hand Specimen:

Similar to B39, the sample is of porous crystalline quartz with ?kaolinite in some pores suggesting the porosity is due to removal of non-silicified components by circulating waters.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	98+
Muscovite	<1
Feldspar	<1

Quartz crystals are up to 0.8 mm across; patches of coarser and finer grain size occur. Boundaries between patches with widely different grain sizes are frequently distinct with gradational boundaries also occurring.

In areas where the grain size is ∿0.05 mm quartz forms an approximately equigranular mosaic with straight grain boundaries and approximately equal angle triple points. In some places the coarser grained quartz appears to be recrystallising with small grains nucleating along boundaries and at triple junctions.

One muscovite flake ∿0.15 mm across was observed.

A band approximately 0.3 mm thick contains microcrystalline ?K-feldspar, partially altered to sericite with fine crystallites. Thus is suggestive of a possible volcanic origin.

Sample: B42; TSC34946

0019

Hand Specimen:

The sample is of a soft light brown highly weathered rock with many small (< 1 mm) blebs of kaolinite. Lack of lamination and uniformity of size of kaolinite patches are suggestive of a ?volcanic origin.

Thin Section:

A visual estimate of the constituents gives:

	%
Kaolinite	70
Iron oxides	15
Quartz	10
Opaque	5
Feldspar	<1

The sample consists of patches of kaolinite, with an approximately bimodal size distribution, set in a fine groundmass composed dominantly of iron oxides, with subsidiary quartz and feldspar.

Kaolinite patches have a botryoidal to cauliflower-like form with a round to slightly flattened general outline. Large patches average ∿0.7 mm across; smaller patches are generally <0.15 mm across. Patches of intermediate size are uncommon.

Patches are relatively free of opaque material and contain rare angular grains of quartz and feldspar less than 0.05 mm across.

Angular grains of quartz and feldspar (microcline and untwinned) ?K-feldspar) <0.3 mm across in the groundmass are generally fresh with only very slight marginal alteration.

Anhedral crystals of secondary quartz up to 0.3 mm across form thin irregular veinlets up to ∿2 mm in length and small blebs up to 1 mm across. Quartz/quartz boundaries are frequently sutured and many crystals show the effect of strain.

Opaque grains up to 0.7 mm across are commonly associated with occurrences of secondary quartz and are marginally altered to ?haematite.

The origin of the kaolinite patches is unclear but they do not appear to be of sedimentary origin; a volcanic origin seems likely.

Sample: B44; TSC34947

Hand Specimen: 0020

The sample is of a medium-grained siliceous dolomitic breccia. A coarse lamination is suggestive of a sedimentary origin and sub-rounded quartz grains are up to 7 mm across. Opaque grains up to ∿3 mm across are extensively oxidised.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	80
Quartz	10
?Talc	8
Feldspar	2
Malachite	Trace
Opaque	Trace

Dolomite forms occasional single crystals up to 5 mm across with inclusions of quartz, altered feldspar and malachite. Boundaries of these crystals are slightly irregular and some are tectonically fractured. Smaller dolomite crystals are highly variable in size and shape. The euhedral outlines of some crystals are due to secondary overgrowth on rounded grains and in some areas a mosaic of crystals up to ∿0.5 mm has developed.

Quartz forms crystals up to 1.5 mm across; some of these have undulose extinction and rounded outlines and appear to have a detrital origin with occasional grains showing evidence of secondary quartz overgrowths. Quartz also occurs between dolomite crystals and is occasionally replaced by it.

Feldspar crystals are of microcline and untwinned K-feldspar up to 1.5 mm in length. Rare feldspar aggregates up to 3.0 mm across also occur. In both occurences the feldspar appears to have a non-replacive origin.

Talc occurs as a fibrous mass between dolomite and quartz grains, frequently partially replacing dolomite and forming occasional needle shaped crystals up to ∿0.3 mm in length.

Malachite occurs in occasional vugs up to 0.5 mm across between grains as small (0.02 mm) fibrous to platy crystals. It also occurs in cracks and inclusions in dolomite crystals and has formed after dolomite and quartz overgrowths.

Rare opaque grains are up to 0.3 mm across and frequently occur in the centre of vugs lined by malachite.

Conclusion:

The rock appears to be an altered and mineralised dolomitic breccia of uncertain origin.

Sample: B46; TSC34948

0021

Hand Specimen:

The sample is of a thinly laminated (av. ∿1-2 mm),light to dark brown siltstone with small (<0.5 mm), ∿round, randomly distributed patches of ?kaolinite. The laminations are not parallel, having a "braided" appearance and this suggests a possible non-sedimentary origin; ?volcaniclastic.

Thin Section:

This rock is very similar to sample B10 in thin section and a visual estimate gives approximately the same mineral proportions.

The colour of the rock is due to finely disseminated Fe oxides and the banded appearance is due to variation in the concentration of these and small feldspar and quartz crystals.

The mass of the rock is made up of microcrystalline K-feldspar, variably altered to sericite and fine-grained opaque material. Some bands contain very fine-grained (<0.01 mm) flakes of a yellowish-brown ?clay mineral.

Occasional,approximately round,"shadowy' patches up to 0.7 mm across of quartz, feldspar and opaque minerals are of uncertain origin.

One small 0.5 mm thick lens shaped layer contains a fine-grained quartz mosaic, similar to those seen in sample B41, possibly crystallized from microcrystalline silica.

The occurrence of elongate aggregates of opaque minerals, up to 4 mm in length, is similar to that described in sample B10 and a similar origin is ascribed to this rock.

Sample: B47; TSC34949

0022

Hand Specimen:

The sample is of an arkosic sandstone, with the matrix extensively replaced by malachite in a band ∿1-2 mm thick with a 2-3 mm thick malachite vein approximately at its centre.

The weathered part of the sample is highly porous, probably due to selective removal by weathering of kaolinized feldspar.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	60
Feldspar	15
Malachite	10
?Mica	5
Opaque	5
?Brucite or Talc	3
?Unknown	1

The rock is very badly sorted and most grains are angular to subangular.

Individual quartz grains up to 0.6 mm across have irregular boundaries and exhibit a wide variation in grain size. Quartz also forms irregular aggregates and veins up to 2 mm across, made up of euhedral crystals up to 0.4 mm across.

Individual untwinned K-feldspar and muscovite crystals up to 0.2 mm across are partially altered and partially replaced by malachite. Irregular feldspar aggregates up to 0.4 to 0.5 mm across also occur.

Malachite occurs dominantly in veins up to 0.6 mm thick; it is also pseudomorphous after ?chalcopyrite and patchily replaces feldspar. Anastomosing malachite veins are the latest feature of the rock.

A colourless to pale brown pleochroic mineral occurs as lath-shaped, approximately equidimensional plates up to 0.25 mm across with a well developed cleavage and random orientation in areas with a greater concentration of finely disseminated opaque material. Optically it resembles a mica and has been tentatively identified as such. It alters to a pale green pleochroic chlorite.

?Brucite or talc occurs as bent fibres up to ∿0.3 mm in length forming part of the "groundmass" between quartz and feldspar grains.

An unknown colourless to pale yellow mineral occurs as radiating needles up to 0.6 mm long replacing quartz and feldspar. It may be crocidolite.

Opaque minerals form grains up to 0.2 mm across and thin veins and films between grains.

Sample: B50; TSC34950

0023

Hand Specimen:

The sample is of a light coloured "glassy" rock composed dominantly of quartz and cut by quartz veins and partially replaced by pink feldspar along veins and in patches up to 1 cm across. Small (<0.5 mm),∿round, ?vesicles may be of volcanic origin.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	85
Feldspar	15
Opaque	<1
Apatite	<1
Lithic fragments	<1

The thin section is similar to that of sample B5. The rock is composed dominantly of fine-grained quartz crystals <0.05 mm across and most <0.07 mm. Spherulites indicate devitrification of a volcanic glass.

Orthoclase and microcline phenocrysts,up to 1.5 mm in length, average approximately 0.2 mm.

Irregular altered crystals of secondary,untwinned K-feldspar and microcline up to ∿0.6 mm across form irregular patches up to ∿5 mm across.

Quartz crystals up to 0.7 mm across form veins up to 4-5 mm thick. The rock is also cut by a tracery of quartz veinlets ∿0.05 mm thick. Quartz also forms round blebs ∿0.2 mm across which may represent vesicles.

The"groundmass" of the rock along the borders of some quartz veins is feldspathised, suggesting that silicification followed feldspathisation along some of the same fractures.

Opaque minerals form occasional single crystals up to 0.7 mm across and occur with quartz, feldspar and minor chlorite as pseudomorphs.

Apatite occurs as small (<0.01 mm) crystals, frequently bordering infilled ?vesicles.

One angular lithic fragment ∿3 mm+ across was observed. It is of a similar composition to the host, with fine (∿0.1 mm) laminations.

Conclusion:

The rock appears to be a tuff.

Sample: B51; TSC34951

0024

Hand Specimen:

The sample is of a microcrystalline to glassy, light coloured quartzo-feldspathic rock. The pinkish colouration is due to extensive feldspathisation. It is unclear if some of the smaller "vesicles" are of primary or secondary origin; the larger "vesicles" (2.5 mm and >) are irregular in outline and appear secondary.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	90
Quartz	10
Opaque	<1

This sample is similar to B5 and B50, but more feldspathised.

Rare phenocrysts of orthoclase up to 0.5 mm in length are set in a fine-grained (<0.01 mm) groundmass composed dominantly of K-feldspar. Rare quartz grains up to 0.8 mm across display undulose extinction and have highly irregular margins. Quartz also forms pseudomorphs after orthoclase. Small round quartz/feldspar aggregates may represent infilled vesicles.

Much of the rock is replaced by microcline and untwinned K-feldspar crystals up to 0.5 mm across. These have highly sutured and diffuse margins, lack orientation and are commonly altered to give a "dusty" appearance in thin section.

Malachite forms rare patches up to 0.6 mm across; opaque material is finely disseminated.

The rock appears to be a highly feldspathised tuff.

Sample: B52; TSC34952

0025

Hand Specimen:

The sample is of a mineralised dolomite. Rare individual dolomite crystals are up to 3 mm across. Opaque grains up to ∿1 mm across are apparently randomly distributed through the rock; malachite forms thin (1.0 mm) anastomosing veins through the non-laminated, massive host rock.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	75
Quartz	15
Feldspar	6
Opaques	3
?Mica	<1

The sample is very similar to B44. Dolomite forms occasional crystals up to 3 to 4 mm across with inclusions of quartz and feldspar. The grain size and shape of the dolomite crystals is highly variable, with occasional patches of fine-grained (<0.03 mm) mosaic.

Some of the euhedral dolomite crystals are ?intergrown with quartz and feldspar and can be seen to have a secondary origin.

Quartz forms veins up to 3 mm x 1 mm with minor dolomite, and highly irregular patches up to 8 mm across where it is intergrown with subsidiary feldspar, and replaced by dolomite.

Feldspar occurs in two forms; as single elongate twinned crystals up to 0.3 to 0.4 mm in length, much replaced by dolomite, and intergrown with quartz in veins and patchy replacements.

Malachite and opaque material forms small patches up to 1.5 mm across and thin veins. Cracks radiate from these patches and appear to have been formed by development of the malachite and opaque material.

A white to very pale brown pleochroic ?mica occurs as rare tabular flakes ∿0.08 mm across replacing dolomite and commonly in close proximity to veins of malachite and opaque material. Rare flakes are also scattered through the rock. Traces of pale yellow to pale green pleochroic, highly birefringent mineral, possibly libenthenite, are seen replacing quartz.

Some of the dolomitised feldspar and possibly quartz appears to have been "derived", although the source is unclear and the rock may be termed a dolomitised breccia.

Sample: B53; TSC34953

0026

Hand Specimen:

The sample is made up of fine-grained volcanic fragments up to ∿2 cm across set in a groundmass of similar composition. Oxidation of some fragments to a brownish-reddish colour appears not to be a weathering feature. The rock has a volcaniclastic origin.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	85
Opaque	10
Quartz	5
Sericite	<1

Quartz and feldspar phenocrysts, averaging 0.2 to 0.3 mm in length, up to a maximum of 1.3 mm, are apparently randomly orientated in a very fine-grained (<0.01 mm) to glassy groundmass. Feldspar phenocrysts are occasionally marginally altered, or pseudomorphed by quartz.

Spherulitic and perlitic textures are common and microvesicles are infilled with quartz, feldspar and opaque material.

The rock also contains fine-grained volcanic fragments up to 5 mm across, some of these are monomineralic, made up of fine-grained (∿0.06 mm), altered untwinned feldspar, while others appear to have been of vesicular glass. These commonly have a margin of fine-grained feldspar crystals, probably due to chilling effects and contain minute needles of ?rutile. Many of these fragments appear to have been deformed while in a plastic state.

Opaque material is dominantly finely disseminated, and also forms occasional patches up to ∿2 mm x 0.5 mm and thin discontinuous veins.

The rock is probably a welded tuff.

Sample: B54; TSC34954

0027

Hand Specimen:

The specimen is composed dominantly of fine-grained dolomite; laminae of non-dolomitic material (including opaque minerals) display open folds with a wavelength of approximately 3 to 4 cm. The rock is partially replaced by thin veins and small patches of azurite and malachite.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	70
Quartz	20
Feldspar	5
Opaque	3
Malachite	1
Azurite	1

Dolomite forms a fine-grained (<0.6 mm and most <0.1 mm) mosaic of subhedral to euhedral crystals replacing quartz and feldspar, with feldspar apparently more resistant to replacement.

Quartz crystals are up to 2 mm across and, intergrown with minor feldspar, form patches up to 1.5 cm x 5 mm. Within these areas, extensive replacement by dolomite, azurite and malachite has occurred. Boundaries of these patches are generally not sharp, passing into rock composed dominantly of equigranular dolomite rhombs with occasional partially replaced crystals of feldspar and quartz.

Lines of inclusions within the quartz frequently cross grain boundaries, indicating a secondary nature for much of the quartz. These lines are cut by boundaries of dolomite crystals, showing the dolomite to be later than the quartz.

Feldspar crystals are up to ~1.0 mm across and of untwinned K-feldspar and microcline. They generally have slightly irregular boundaries and appear in some cases to be partially replaced by quartz as well as dolomite.

Opaque material occurs as small intergranular blebs and films in areas of coarser dolomite crystals and as blebs up to 1.5 mm across in quartz-rich areas.

Malachite and azurite have a similar occurrence and also form thin (<0.08 mm) veins. Malachite occasionally replaces azurite, but more commonly appears to be partially or wholly replacing ?chalcopyrite.

Sample: B56; TSC34955 0028

Hand Specimen:

The sample is of a thinly laminated grey-white to limonitic brown ?dolomitic rock, with some thin (∿1mm) laminae composed dominantly of kaolinite.

Thin Section:

A visual estimate of the constituents gives:

		%
Carbonate		80
Quartz		<1
Sericite	)	
Kaolinite	)	∿20
Chlorite	)	
Opaque		<1

This sample is of a thinly laminated carbonate rock, with the lamination being due to concentrations of non-carbonate components and variations in grain size of the carbonate. In veins dolomite forms subhedral to euhedral crystals up to ∿1 mm across, intergrown and replacing minor quartz. In the host rock anhedral dolomite crystals are mainly less than 0.01 mm across with occasional thin laminae containing crystals up to 0.25 mm across. Due to anomalous results from staining with alizarin red-S, it is not possible to estimate the relative proportions of dolomite and calcite. Much, if not all, of the fine-grained carbonate material may be calcite.

Small anhedral single quartz grains <0.3 mm across are apparently randomly distributed through the rock. In rare patches up to ∿1.4 mm across, quartz crystals up to 0.3 mm across are intergrown with patches up to 0.25 mm across made up of kaolinite and sericite. These patches have a tabular form and may be pseudomorph of feldspar or mica. Similar patches are the dominant non-carbonate component of the rock frequently displaying what appears to be crystal outlines. Kaolinite and sericite fibres in these patches are commonly parallel and this may be related to cleavage in the original mineral. Highly irregular patches of similar material up to 2 mm across and thin partings of this material seem to indicate that the sericite, kaolinite and minor chlorite have formed from a fine-grained non-to micro-crystalline material and this origin appears the most likely. Why small patches should appear to possess rational crystal faces is unclear.

Opaque minerals form disseminated grains <0.15 mm across and thin veins.

The rock appears to have been a fine-grained ?bedded tuff which has been partially silicified, and dolomitised and calcified.

Sample: B57; TSC34956

0029

Hand Specimen:

This sample is of massive, fine-grained quartz. The rock is extensively fractured and many of these fractures are partially unfilled with malachite and ?limonite. Limonite also coats much of the surface of the sample.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	99+

This is similar to sample B41.

Quartz crystals range in size from <0.01 mm to ∿0.8 mm.and form irregular patches differing in grain size. Distinct boundaries exist between patches with widely differing grain sizes; more commonly one patch will merge into another with crystals of a different size.

In the finer grained patches, quartz frequently forms equigranular mosaics with crystals having straight boundaries and approximate 120° triple junctions. Some crystals are dusted with inclusions.

In some places it appears that the finer grained quartz is replacing the coarser crystals.

Slight iron staining is the only impurity; the origin of the rock is uncertain.

Sample: B59; TSC34957

0030

Hand Specimen:

A highly mineralised and altered rock, consisting dominantly of kaolinite with much oxidised opaque material and malachite. The sample is extremely friable, and possibly comes from a fault zone where it has been altered by mobile groundwater.

Thin Section.

Due to the degree of alteration of this rock and the number and size of the vacancies in the thin section, a visual estimate of the constituents is not possible.

Feldspar is the dominant mineral present, forming the fine-grained (<0.01 mm) groundmass; much is altered to kaolinite and sericite. Anhedral microcline and untwinned ?orthoclase crystals up to 0.3 mm across are intergrown with quartz in patches up to ∿3 mm across. Colourless to very pale brown mica flakes up to 0.3 mm across are apparently randomly distributed through the rock.

Quartz forms small (<0.15 mm) phenocrysts in the host and forms veins up to ∿0.7 mm thick.

Malachite is the other common vein mineral, forming crystals up to 0.6 mm in length. It also extensively replaces the host rock in patches up to 3 to 4 mm across and occurs as alteration of ?cuprite. Also occurring in patchy replacements is a pale yellow to green pleochroic mineral with high birefringence and straight extinction, possibly atacamite.

Cuprite occurs in blebs up to 1.5 mm across and in veins, is blood red and appears to be partially replaced by malachite around the margins and along fractures.

The rock has a well developed structure resembling perlitic texture and may be a highly altered volcanic glass.

Sample: B60; TSC34958

0031

Hand Specimen:

The sample is of a hard, pink to whitish-grey, feldspathic and siliceous microcrystalline ?volcanic rock with many limonite-lined "vesicles" up to ∿1 to 2 mm across and is cut by quartz veins up to 4 mm thick.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	70
Quartz	25
Opaque	1
Tourmaline	<1
Vacancies (probably originally opaque)	4

The sample is of a feldspathised and silicified volcanic rock, probably a ?welded tuff.

Rare small "phenocrysts" of K-feldspar less than 0.4 mm across have subhedral outlines and are set in a groundmass of microcrystalline feldspar. Occasional fragments up to 1 mm across are composed of feldspar crystallites and one rounded elongate fragment ∿1.5 mm long contains well developed spherulites of orthoclase around the margins with anhedral orthoclase crystals forming the centre.

Feldspar also forms irregular patches up to ∿5 mm across, of anhedral crystals of microcline and untwinned K-feldspar with highly irregular sutured margins and a dense "dusting" of opaque inclusions. These patches are of secondary origin.

Quartz crystals up to 2 mm across form a major vein up to 4 mm thick. Lines of fine opaque inclusions cross quartz/quartz boundaries. Minor patches and veins of quartz are common. Small phenocrysts are of the same order of size as those of feldspar.

Opaque grains are up to 4 mm across and are frequently associated with quartz veins. Vacancies in the slide (and hand specimen) are of the same order of size but frequently display a different (cubic) form and may represent ?bornite.

Sample: B72: TSC34959

0032

Hand Specimen:

The sample is of a fine-grained, light grey, dolomite rock with irregular thin (0.5 mm) iron strained partings approximately 3 to 5 mm apart, occurring in some sections. Fractures are infilled with malachite.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	70
Feldspar	25
Quartz	5
Opaque	Trace
?Goethite	Trace
Malachite	Trace
Tourmaline	Trace

The sample is of a rock which was composed dominantly of feldspar, with minor quartz, and has been extensively dolomitised. Dolomite crystals up to ∿1 mm across occur where dolomite has replaced (and partially pseudormorphosed) coarse-grained quartz in a vein. Most crystals are subhedral and <0.075 mm across.

Feldspar crystals are dominantly of microcline, and commonly lathlike up to ∿1.5 mm in length x 0.15 mm across. This lathlike to cigar shaped form is well developed in this sample; orientation of these laths appears random. Many feldspar crystals have a more equqnt to anhedral habit and are intergrown with minor quartz. Lamination in the rock is due to a higher percentage of feldspar and consequent lower percentage of dolomite and may be of secondary origin.

Quartz occurs dominantly in veins where it frequently exhibits undulose extinction and crystals are commonly elongate with highly sutured margins. Rare quartz grains in the host are up to ∿0.8 mm across and unstrained.

Rare opaque grains occur as partial replacements of quartz in quartz/dolomite veins. In some instances these grains are partially replaced by malachite and ?cuprite, and in others ?goethite is the dominant oxidation product. Veins <0.1 mm thick are dominantly of malachite with minor dolomite.

Sample: B73; TSC34960

0033

Hand Specimen:

The sample is of a weathered pinkish-white to brown, thinly laminated non-carbonate rock, composed dominantly of feldspar.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	75
Muscovite & ?sericite	10
Limonite	10
Quartz	5
Opaque	∿1

The fine discontinuous, irregular lamination or foliation is due to concentrations of muscovite/sericite, limonite and opaque grains and fine-grained feldspar and quartz. This foliation is disturbed by a later crenulation cleavate.

The rock is composed dominantly of crystals of microcline and untwinned K-feldspar. These are up to ∿0.6 mm across and are generally subhedral to anhedral, with some having a poorly developed lathlike form. Crystals contain many fine opaque inclusions which impart a 'dusty' appearance. Rare untwinned poikiloblastic feldspar grains, elongate parallel to the foliation, appear to be of secondary origin.

Anhedral quartz crystals generally less than 0.3 mm across, are intergrown with feldspar and form small irregular 'clots' up to ∿0.6 mm across.

Muscovite flakes are less than 0.1 mm in length and are commonly aligned parallel to the foliation; they appear to be of primary origin. Sericite flakes <0.05 mm in length have formed by alteration of feldspar.

Opaque grains are up to ∿0.3 mm across and are dominantly concentrated in thin lamellae.

The sample appears to be of a bedded tuff.

Sample: B74; TSC34961 0034

Hand Specimen:

The sample is of a weathered, friable, iron stained quartz-rich ?sandstone with an irregular patchy vein of opaque minerals and malachite.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	45
Feldspar	35
Clay minerals	15
Opaque	2-3
Muscovite	1-2
Talc	<1
Malachite	<1
Chrysocolla	Trace
Chlorite	Trace
Tourmaline	Trace

The sample is of a poorly sorted and bedded medium to coarse-grain "acid" volcaniclastic.

Quartz crystals form individual grains up to 0.75 mm across and polycrystalline "aggregates" up to 2 mm across. Grains composed of single quartz crystals are anhedral to rarely subhedral with rounded, embayed to delicately "cuspate" outlines. They appear to have an explosive volcanic origin, with their present form being due to corrosion by hot gases and/or fluids. Many of the smaller aggregate grains with similar outlines are probably of the same origin. It is possible that quartz forming some of the larger aggregates has recrystallised after deposition, as fine lines of opaque inclusions cross quartz/quartz boundaries. Thus recrystallisation may also have occurred prior to incorporation into the rock.

Subhedral to euhedral crystals of untwinned K-feldspar and microcline up to ∿0.15 mm across, but commonly much smaller, are occasionally lath shaped, but display no apparent preferred orientation.

Flakes of muscovite up to ∿0.2 mm in length are concentrated in thin (0.25 mm) irregular and discontinuous lamellae, with their long axes commonly parallel to the lamination.

Quartz, feldspar and muscovite grains are in a fine-grained groundmass now composed dominantly of clay minerals. Variations in grain/groundmass ratios also impart a crude lamination approximately parallel to that defined by muscovite concentrations. In some areas (up to 5 mm across) opaque minerals, malachite and chrysocolla have partially replaced the groundmass.

In some areas the groundmass has been partially replaced by fibrous talc, which has itself been partially chloritized, forming thin (∿0.1 mm), irregular veins approximately parallel to the lamination. Rare cross cutting veins up to 0.25 mm thick contain iron-rich chlorite and opaque material.

Sample: B80; TSC34962

0035

Hand Specimen:

The sample is of a dolomitic breccia; lithic fragments are up to 1 cm+ across and individual dolomite crystals are up to 8 mm across. Rare small (<5 mm) cavities are lined with dolomite crystlas.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	70
Quartz	20
Feldspar	10
Muscovite	<1
Opaque	<1

A thin irregular parting, dominantly infilled with opaque minerals, separates two parts of the thin section, one in which the dolomite grains appear dominantly of detrital origin and the other where they appear mainly secondary.

Dolomite crystals occur as "primary" detrital grains and as secondary growths replacing quartz and feldspar; crystals are commonly subhedral to euhedral in outline and up to 5 mm across. Occasional large poikiloblastic crystals appear to be secondary and many crystals up to ∿2 mm across have formed by replacement of coarse-grained quartz. Margins of some dolomite crystals up to 2 mm across do not cut boundaries between other grains and appear "primary". Many of the smaller dolomite crystals (∿0.3 mm) have partially rounded outlines, possibly due to abrasion; only very minor secondary dolomite overgrowths were noted.

In some irregular discontinuous layers up to 2-3 mm thick, dolomite crystals <0.03 mm across are intergrown with small muscovite flakes and are replacing untwinned K-feldspar and microcline.

Quartz grains in the section of the rock where dolomite grains appear to be mainly of detrital origin appear to be of similar origin. Grains are generally of single crystals, up to ∿0.8 mm across with subangular to sub-rounded outlines. Rare composite grains of quartz, up to ∿3 mm across are also present. Many quartz grains show evidence of partial replacement by dolomite.

In the section of the rock where dolomite appears to be dominantly secondary, quartz crystals commonly form a coarse-grained mosaic with very minor amounts of feldspar. The quartz crystals are anhedral and more equant grains (∿0.8 mm) are unstrained with smooth grain boundaries. In some areas, quartz grains are elongate (up to ∿4 mm x 0.8 mm), highly strained with sutured boundaries. The strain may be related to the 'bent' form of most of these crystals.

The feldspar present is commonly microcline and untwinned K-feldspar; one small (0.2 mm) grain of ?albite was noted.

In the "non-detrital" section of the rock, feldspar crystal outlines range from anhedral to euhedral with lathlike and "cigar" shaped forms common. In 'clots' up to ∿1.5 mm across, crystals are ∿0.3 mm across, more equant in form and dusted with opaque inclusions.

In the "detrital" section of the rock, feldspar grains are of the same order of size as the dolomite and quartz grains, but more angular than the latter with lathlike and "cigar" forms being common.

The dominant occurrence of muscovite has been noted above; flakes are generally <0.3 mm in length and parallel alignment imparts a poor foliation.

In the 'detrital' section of the rock, muscovite flakes up to 0.3 mm in length appear to have a similar origin as the other constituents and some (up to 0.3 mm in length) are bent around quartz and feldspar grains.

Opaque grains are up to 1 mm across and are more common in the 'detrital' section.

A possible alternative explanation for the formation of the 'detrital' section is brecciation by hydraulic fluids and the writer is inclined to favour this explanation.

Sample: B83; TSC34963

0037

Hand Specimen:

This is of a pale greyish-brown rock composed dominantly of dolomite with thin (0.5 mm) irregular opaque-rich partings. Occasional cavities elongate parallel to the lamination are lined with crystalline calcite.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite & high Mg calcite	70
Quartz	25
Feldspar	5
Muscovite	<1
Opaque	<1

Irregular,discontinuous, thin quartz-rich lenses and partings of muscovite and opaque minerals give the coarse lamination.

Dolomite crystals are mainly fine-grained (<0.1 mm) but occasional crystals up to 0.4 mm are seen and these commonly appear to have formed where dolomite has replaced coarse-grained quartz.

Quartz crystals are anhedral to subhedral up to ∿0.7 mm across and form irregular lenses and patches up to ∿1.5 mm across. Crystals are unstrained and have smooth curved to straight quartz/quartz boundaries. Quartz is extensively replaced by dolomite. In some areas quartz (and feldspar) can be seen to be replacing a microcrystalline ?volcanic rock containing microphenocrysts of untwinned K-feldspar.

Feldspar crystals are dominantly of microcline with subsidiary untwinned K-feldspar. Microcline crystals are frequently lathlike (i.e. 0.7 mm x 0.1 mm) and dusted with opaque inclusions. One crystal is ∿1.5 mm in length.

Rare patches of microcrystalline volcanic rock are generally less than 0.3 mm across and are partially replaced by quartz, feldspar and dolomite. Microphenocrysts of untwinned ?K-feldspar are less than 0.015 mm across.

Muscovite flakes are generally less than 0.3 mm in length, bent, and concentrated in parallel"microstylolite"-like partings with ?iron oxide. They appear to have formed at the same time as the dolomite.

Rare opaque grains are <0.2 mm across and tend to be concentrated in layers parallel to the partings.

The rock appears to have been a fine-grained volcanic which has been feldspathised, silicified and then dolomitised.

Staining of the section with Clayton yellow gave somewhat anomalous results but it is possible that much of the carbonate may be high Mg-calcite.

Sample: B84; TSC34964

0038

Hand Specimen:

This sample is of friable,highly weathered rock which has been extensively stained by iron oxide and malachite. An indistinct coarse lamination is defined by concentrations of ?kaolinite.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	55
?Kaolinite	20
Opaque	10
Malachite	5
Limonite	5
Sphalerite	2-3
Feldspar	∿1
Muscovite	Trace
Dolomite	Trace
Calcite	Trace
?Chrysocolla	Trace
?Rutile	Trace

This sample is very similar to B207 and B202.

Quartz crystals up to ∿1 mm across have angular to subrounded outlines which frequently appear corroded with some crystals being deeply embayed. Quartz aggregates are up to ∿3 mm across with irregular outlines and frequently showing partial recrystallisation of coarser grained quartz along quartz/quartz boundaries. Grain boundaries and fractures in grains are frequently "infilled" with opaque minerals, limonite, malachite, sphalerite and ?chrysocolla.

Rare feldspar crystals of microcline and untwinned K-feldspar up to 0.6 mm across, commonly with lathlike and cigar shaped outlines, are heavily dusted with fine opaque inclusions and partially altered to kaolinite.

Sphalerite forms irregular grains up to 2.0 mm across, frequently extensively altered along fractures to opaque material. Occasional grains have inclusions of ?rutile.

Muscovite, dolomite and calcite crystals <0.1 mm across are all included in quartz grains.

Rhomb shaped outlines up to ∿0.3 mm across, mainly included in quartz,are commonly vacant or partially infilled with opaque material.

Sample: B86; TSC34965

0039

Hand Specimen:

The sample is of a thinly laminated,limonitic,brown non-carbonate rock with thin (<0.1 mm),discontinuous to lensoid,whitish laminae composed dominantly of ?feldspar.

Thin Section:

A visual estimate of the constituents gives:

	% (very approximate)
Feldspar	80
Sericite	15
Quartz	1
Opaque	1-2
Apatite	Trace
Tourmaline	Trace

The sample is of an extremely fine-grained, thinly laminated ?tuff or siltstone composed dominantly of microcrystalline feldspar. Microphenocrysts of untwinned ?K-feldspar and rare microcline less than 0.03 mm across are partially altered to sericite. Rare lathlike and 'cigar' shaped crystals of microcline, up to 0.6 mm x 0.07 mm, appear to be of primary origin, i.e. not formed by K-metasomatism. They occur in elongate "clots" up to ∿3 mm in length with crystals of untwinned K-feldspar, quartz and opaque minerals. Small, generally approximately round, clear patches up to ∿0.6 mm across may represent fragments of volcanic glass.

Rare, generally anhedral,quartz crystals are up to 0.3 mm across with inclusions of apatite, tourmaline and round blebs of partially sericitised microcrystalline feldspar. One approximately round 'clot' of quartz ∿0.6 mm across is made up of crystals <0.15 mm across sieved with fine inclusions of ?mica and opaque grains.

Quartz also forms microphenocrysts of approximately the same size as those of feldspar.

Opaque grains are generally <0.6 mm across with larger grains occurring in coarser grained patches with K-feldspar and quartz.

0040

Sample: B87; TSC34966

Hand Specimen:

The sample is of a thinly laminated (<2 mm) creamish white, fine-grained dolomite rock. One irregular layer up to ∿2 mm thick is rich in calcite. The slightly friable, silty nature of the sample may be due to a relatively high percentage of non-carbonate material.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	∿85
Quartz	10
Feldspar	5
Muscovite	<1
Opaque	<1

The sample is of a poorly laminated quartz-rich, fine-grained, dolomitic rock, with the lamination being due to thin, discontinuous quartz-rich layers; muscovite flakes are commonly aligned parallel to this lamination.

Dolomite crystals are generally less than 0.05 mm across, ranging up to rare crystals ∿0.6 mm across. The coarser grained dolomite appears to have formed by replacement of coarse-grained quartz.

Quartz crystals up to 0.7 mm are anhedral to euhedral in outline and occur as single crystals, surrounded and partially replaced by dolomite, and in elongate'clots' up to ∿2 mm in length. Crystals are unstrained and quartz/quartz boundaries are curved to straight. Quartz and feldspar are rarely seen in contact, possibly due to preferential dolomitisation along grain boundaries. Where contacts are observed, it is not possible to state if quartz is replacing feldspar.

Feldspar crystals are commonly of microcline with subsidiary untwinned K-feldspar and are generally <0.3 mm in length. Rare crystals are lath-like to cigar shaped, but most are anhedral, possibly due to marginal replacement by dolomite.

Muscovite flakes are up to ∿0.5 mm in length with larger flakes ?intergrown with fine-grained dolomite. Flakes tend to be concentrated in some layers and absent in others.

Euhedral grains of ?pyrite are <0.3 mm across and finely disseminated through the rock.

The quartz and most of the feldspar is probably secondary; the status of the lath shaped feldspars is unclear and the original rock may have been volcanic in part.

Sample: B92; TSC34967

0041

Hand Specimen:

The sample is of a ?weathered volcaniclastic, composed of clasts up to 5 to 6 mm across, quartz and partially kaolinised feldspar crystals, both clasts and groundmass being extensively iron-stained.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	∿85
Quartz	10
Sericite	3
Opaques	2-3
Talc	Trace
Muscovite	Trace
Dolomite	Trace
Tourmaline	Trace

The sample is of a breccia composed dominantly of volcanic fragments up to 6 mm across and quartz crystals up to ∿2.5 mm across in a fine-grained matrix of similar composition. Fragments are of two very similar lithologies. The dominant of these consists of small (<0.04 mm) angular crystals of microcline, untwinned K-feldspar and quartz in a micro-crystalline ?feldspar groundmass which has been partially sericitised. The other lithology is similar to this but contains a high percentage of very finely disseminated opaque material and muscovite flakes up to ∿0.25 mm length.

Feldspar crystals occurring in the 'groundmass' of the rock are dominantly of untwinned K-feldspar. Many have highly irregular outlines and a 'poikilitic' texture. Rare grains of ?albite up to 0.2 mm across are also seen.

Quartz forms angular single crystals and composite grains up to 2.5 mm across. In some composite grains, strained crystals up to 0.3 mm across are partially recrystallized to finer unstrained grains. Some quartz grains are partially replaced by dolomite rhombs 0.01 mm across which occur less commonly in grains of other compositions.

Rare round quartz grains ∿0.3 mm across made up of an equigranular mosaic of grains ∿0.015 mm across may represent blebs of crystallised silica glass.

Bent fibres of talc are up to 0.6 mm in length and have an apparent random distribution and orientation. Rare muscovite flakes are up to 0.15 mm in length. Patches of very fine-grained opaque minerals are generally <0.3 mm across and are concentrated around the margins of volcanic fragments.

The angularity of most of the fragments and the delicate outlines of many of the feldspar and quartz crystals all indicate that the components could not have undergone much, if any, abrasion.

Sample: B94; TSC34968 0042

Hand Specimen:

The sample is of a friable light grey to white thinly laminated ?siltstone White laminae up to ∿1 mm thick are composed dominantly of kaolinite and much of the sample has reduced to a kaolinitic powder.

Thin Section:

A visual estimate of the constituents gives:

	%	(very approximate)
Feldspar	∿85	(dominantly kaolinised
Quartz	10-15	in the groundmass)
Opaque	1-2	
?Muscovite	<1	
Chlorite	Tr	

The sample is of a laminated ?tuff or siltstone consisting dominantly of small crystals of feldspar and quartz set in a microcrystalline groundmass of partially ?kaolinised feldspar. Lamination is due to variations in proportions between feldspar and quartz crystals, and matrix.

Angular feldspar crystals are generally less than 0.05 mm across and are dominantly of microcline and untwinned ?K-feldspar. Quartz crystals are commonly of the same order of size, but occasional crystals are up to ∿0.3 mm across. Quartz also forms discontinuous veins up to ∿2 to 3 mm thick; crystals are up to 1 mm across, subhedral, with smooth curved to straight outlines and are generally only slightly strained. Lines of inclusions in the quartz are parallel to lamination in the host. Brecciation of these veins appears due to processes involved in preparing the section.

Flakes of ?muscovite <0.01 mm in length in some parts of the thin section do not appear to be due to alteration, but, given the extremely altered state of the rock, a secondary origin appears likely.

Sample: B97; TSC34969

0043

Hand Specimen:

The sample is of a fine grained crystalline rock, much iron stained with occasional ovoid vesicles up to 2 mm in length in filled with ?quartz. Opaque minerals occur in randomly distributed elongate blebs up to 4 m x 1 m which display slight dimensional parallism.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	∿80
Clay minerals and sericite	15
Quartz	5
Opaque	∿1-2
Apatite	Tr

This sample is of a partially silicified, fine grained, volcanic derived rock, possibly a tuff.

Feldspar forms small (0.1 m) angular crystals, dominantly of microcline and untwinned K-feldspar, in a microcrystalline groundmass, now much replaced by clay and sericite. Crystals of quartz of approximately the same dimensions as the feldspar crystals are subsidiary in amount. Small rounded elongate blebs of microcrystalline quartz may represent recrystallised glass or pumice fragments.

Most of the quartz is of secondary origin occurring in small irregular patches and thin veins. One vein, approximately 0.15 mm thick has 6 parallel lines of opaque inclusions which may indicate 3 phases of quartz growth.

Opaque minerals form thin(0.05 mm) veins with quartz and small (<0.4 mm) grains disseminated through the rock.

Sample: B103; TSC34970

0044

Hand Specimen:

The sample is of a thinly laminated, dominantly cream-coloured rock composed mainly of dolomite, with thin (<0.5 mm) calcite rich partings 1 to 5 mm apart and thin calcite veins cross-cutting the lamination.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite and calcite	90
Opaque	5
Feldspar	2
Muscovite	2
Quartz	1

Staining with alizarin red-S gave anomalous results; it is likely that much of the unstained to very faintly stained carbonate, ostensibly dolomite, may in fact be a high-Mg calcite.

The sample is of a thinly laminated dolomite with crystals of non-carbonate of direct volcanic origin that appear to have undergone no transport by water.

Dolomite crystals are dominantly less than 0.01 mm across ranging up to rare crystals ∿0.3 mm across. Coarser dolomite occurs where replacement of feldspar and quartz rich laminae has occurred.

Euhedral feldspar crystals <0.15 mm across are dominantly of microcline with subsidiary untwinned K-feldspar and very minor ?albite. Some microcline crystals contain minute opaque inclusions and are zoned.

Euhedral equant to tabular muscovite flakes are up to 0.7 mm in length with apparent random distribution. Many of the more lath-shaped flakes have their long axes very approximately parallel to the lamination.

Muscovite is not replaced by dolomite and many have a partial rim of orientated dolomite crystals. Rare subhedral quartz grains up to ∿0.5 mm across also show no replacement by dolomite, although more commonly quartz grains show extensive marginal replacement by dolomite.

Opaque minerals are concentrated in lamellae of coarser grained dolomite where they frequently form the matrix to elongate patches up to ∿1.5 mm in length.

There is a strong similarity between this sample and Sample B16 and the alternation of calcite and dolomite laminae is probably an original sedimentary feature.

Sample: B105; TSC34971

0045

Hand Specimen:

The sample if of a finely laminated ?limonitic shale or siltstone with finely disseminated opaque material. Occasional white 'spots' <0.5 mm across may be of kaolinised feldspar.

Thin Section:

A visual estimate of the constituents give:

	%
Feldspar	30
Opaque (including limonite and haematite)	50
Quartz	15
Mica	5
Malachite	Tr

The sample is of a finely laminated ?limonitic/?pyritic shale.

Feldspar grains generally ≤0.07 mm across are dominantly of microcline and untwinned ?K-feldspar; some grains are zoned. Occasional approximately round clots of feldspar up to 0.6 mm across with a low percentage of opaque and limonitic material are extensively replaced by flakes of white mica up to 0.1 mm in length. These clots may represent recrystallised fragments of volcanic glass.

Discontinuous lens shaped lamellae up to ∿4 mm x 0.5 mm are composed dominantly of quartz grains up to ∿0.3 mm across with minor opaques and malachite. Malachite fibres are up to 0.3 mm in length and rare basal sections display zoning.

Finely disseminated ?pyrite grains are generally <0.05 mm across with occasional larger grains up to ∿0.4 mm. Coarser grains are commonly found in coaser quartz rich 'lenses' with one clot (∿1.5 mm in length) containing quartz and feldspar inclusions.

Variations in concentration of opaque grains and oxidised matter imparts the fine lamination. Flakes of ?secondary mica up to 0.6 x 0.03 mm, occasionally bent, and partially altered to a pale brown chlorite, are commonly aligned parallel to the lamination.

Sample: B107; TSC34972 0046

Hand Specimen:
This sample is of a very fine grained extremely soft grey to red non-laminated material consisting dominantly of ?kaolinite with veins up to 2 mm thick, also of kaolinite.

Thin Section
A visual estimate of the constituents gives:

	%	
Feldspar	∿95	(extensively kaolinised)
Opaque	5	
Carbonate (? dolomite)	Tr	
Tourmaline	Tr	

The sample is of a fine grained rock of volcanic origin; Angular feldspar crystals are generally less than 0.05 mm across and dominantly of untwinned K-feldspar. Feldspar crystals are highly altered to ?kaolinite along fractures and cleavage planes, and feldspar occurring in veins and irregular patches is similarly altered. These patches and veins are of K-feldspar crystals up to 0.3 mm in length frequently displaying Carlsbad twinning. Patches and veins are up to ∿1.2 mm thick, and are distinctly seen due to their lack of opaque minerals.

Opaque minerals occur dominantly as grains <0.07 mm across finely disseminated through the rock. These seldom show any good crystal form and occur frequently as 'atolls' with the centres containing host rock. In occasion patches (?rock fragments) up to 2 mm across, opaque minerals form irregular skeletal grains up to 0.3 mm across. These ?fragments also contain small feldspar laths and may represent recrystallised pumice or volcanic glass.

Fine grained carbonate is found in two patches, up to 0.4 x 0.2 mm across in veins dominantly composed of K-feldspar. The form of these patches suggests they may be pseudomorphs.

Tourmaline occurs as small (<0.03) angular crystals displaying a pale yellowish green pleochroism.

Sample: B116; TSC34973

0047

Hand Specimen:

The sample is of an iron rich ?siltstone, with irregular patches of secondary quartz <2 mm across. The rock has been partially replaced by malachite and azurite.

Thin Section:

A visual estimate of the constituents gives:

	% (very approximate)
Feldspar	70
Quartz	30
Limonite	10
Opaque	5
Chrysocolla	3
Mica	1
Malachite	<1

The sample is of a fine grained thinly laminated siltstone or shale with strong volcanic affinities.

Angular feldspar crystals of microcline and untwinned ?K-feldspar are less than 0.15 mm across. Lathlike and cigar shaped forms are rarely seen and most crystals are partially replaced by limonite.

Primary quartz grains commonly of the same order of size as the feldspar are anhedral and have suffered much marginal replacement by limonite.

Generally round to slightly elongate blebs up to ∿1.5 mm across are formed of subhedral to euhedral crystals of quartz <0.1 mm across with minor K-feldspar. Lamination is slightly deformed around these blebs which may represent recrystallised ?volcanic glass.

Occasional muscovite flakes up to ∿0.1 mm length which may be primary are concentrated in the laminae <0.2 mm thick with finer grained ?sericite which appears to be of secondary origin.

Opaque grains up to ∿0.8 mm across are concentrated in and around occurrences of coarser grained secondary quartz.

Microcrystalline chrysocolla forms a patchy to botryoidal replacement up to ∿1 cm across with inclusions of quartz and feldspar. Rare inclusions of cuprite up to 0.15 mm across are rimmed by malachite. Chrysocolla also lines thin (<0.1 mm) irregular veins of chalcedony.

Malachite also occurs in veins up to 0.3 mm thick and frequently has a fibrous radiating habit.

Sample: B121; TSC34974

0048

Hand Specimen:

The sample is of a dolomitic breccia, with fine-grained angular dolomite ?clasts up to 3 cm across set in a granular dolomitic groundmass, with single dolomite crystals up to 1 mm across.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	60
Quartz	40
Feldspar	<1
Opaques	Tr

Dolomite occurs in two forms; as a very fine grained equigranular mosaic with minor amounts of quartz and feldspar and as coarse frequently rhomb shaped grains with approximately equal amounts of quartz, and of essentially detrital origin.

Coarser, frequently subhedral to euhedral dolomite grains are up to 0.7 mm across. In many an original rounded grain can be seen to be surrounded by a secondary dolomite overgrowth which imparts the euhedral form.

Many of the smaller (∿0.2 mm) euhedral crystals are probably entirely of secondary origin and frequently replace the quartz grains.

Single and aggregate quartz grains are up to ∿1.0 mm across and generally have rounded to subrounded outlines. Secondary overgrowths of quartz on quartz are also present and these appear to predate the formation of the dolomite overgrowths.

Many of the aggregate quartz grains contain trails of minute inclusions and these grains may be derived from the ?erosion of a silicifed volcanic rock.

This coarser grained quartz/dolomite rock passes into a rock which is>90% fine grained dolomite containing small (<0.1 mm) crystals of K-feldspar partially replaced by dolomite and subsidary grains of quartz of similar size.

The contact between this lithology and the coarser grained rock is highly irregular; patches of fine grained dolomite occur within the coaser rock and it appears that the fine grained dolomite has partially replaced the coarser quartz rich material. A quartz vein has been noticeably resistant to replacement.

The rock is a dolomitised quartz/dolomite sandstone.

Sample: B123; TSC34975

0049

Hand Specimen:

This sample is of a white to pale grey slightly irregularly foliated rock composed of fine-grained 'granular' quartz veined and patchily replaced by opaque grains, azurite and malachite. Azurite frequently partially replaces opaque minerals.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	90
Muscovite	10
Opaque	Tr
Malachite	Tr
Azurite	Tr

This sample is of a porphyroblastic quartz-muscovite schist. Much of the rock is composed of a mosaic of quartz grains with minor flakes of muscovite. The quartz can frequently be seen to have an approximate bimodal grain size distribution with the coarser grains averaging ∿0.1 mm and the smaller ∿0.02 mm. Coarser grains are unstrained with slightly curved boundaries and irregular outlines. Smaller grains have straight boundaries and are more euhedral. It appears that the coarser quartz has partially recrystallised into the finer.

Quartz porphyroblasts are up to 1.5 mm across, subhedral and generally unstrained. Many are poikiloblastic and internal alignment of muscovite flakes has a similar orientation to the external alignment.

Muscovite flakes are generally <0.3 mm in length and are generally concentrated into bands up to ∿2 mm thick. Parallel alignment of flakes imparts a foliation and deflection of this around porphyroblasts is slight to absent.

Deflection is generally greatest around porphyroblasts which are slightly strained and do not display a well developed internal foliation. Many of these quartz grains contain lines of minute opaque inclusions.

Malachite and azurite occur in discontinuous veins up to 0.15 mm thick; opaque grains up to 0.7 mm across are partially replaced by azurite and rare azurite pseudomorphs up to 0.2 mm across are also seen.

Sample: B127; TSC34976

0050

Hand Specimen

The sample is of an iron stained grey, thinly laminated dolomitic rock with thin (∿2 mm) discontinuous laminae of non-carbonate material. Small (< 3 mm) frequently approximately spherical cavities are occasionally lined with calcite.

Thin Section:

A visual estimate of the constitutents gives:

	%
Dolomite	80
Quartz	20
Feldspar	<1
Opaque	Tr

The sample is of a laminated dolomitised ?sedimentary rock. Quartz and minor feldspar forms discontinuous irregular layers up to 0.7 mm x 1.5 mm and irregular patches up to 3 mm across. Quartz grains are up to ∿0.5 mm across and some have rounded outlines and appear of detrial origin; secondary quartz overgrowths can be observed on some grains. Feldspar grains are of microcline and untwinned K-feldspar and have more angular outlines.

Within the irregular quartz rich patches remnants of the original fine grained matrix can be seen represented by iron stained clay minerals.

Where dolomite has only partially replaced quartz and feldspar it occurs as well formed rhombs up to ∿0.15 mm across; in other areas anhedral crystals are generally <0.015 mm across. No detrital dolomite grains were observed.

The rock appears to be a dolomitised sandstone, with the coarser layers being possibly more resistant to alteration.

0051

Sample: B128; TSC34977

Hand Specimen:

The sample is of a white to brownish cream thinly laminated carbonate rock, with 'kinks' due to tectonic activity. Reaction with HCl is slow indicating the carbonate is not pure calcite.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	90
Quartz	10
Muscovite	<1

The sample of a thinly laminated dolomite with subhedral to euhedral dolomite crystals generally <0.15 mm across. Coarser crystals of approximately this size are found in laminae containing quartz and muscovite crystals. Thin (0.2 mm laminae of finer grained dolomite (∿0.025 and <) contain no non-carbonate material.

Anhedral quartz crystals form single and composite grains up to ∿0.4 mm across which are only slightly replaced by fine grained dolomite.

Muscovite flakes up to 0.75 mm in length are subhedral, frequently displaying "ragged" terminations, and are generally concentrated in laminae with a high percentage of quartz grains. Many have an extremely small 2v, approximately 0.

Irregular voids, elongate parallel to the lamination and small open fractures cross-cutting the laminations appear to be due to removal of a component (possibly calcite) by weathering.

Small scale open folds with a wavelength of 2-3 cm are probably of tectonic origin.

Etching with HCl showed alternating laminae to be soluable and partially soluable, possibly due to variations in the amount of Mg in the dolomite.

Sample: B138; TSC34978

0052

Hand Specimen:

The sample is of a thinly laminated to massive fine-grained grey dolomitic rock with white discontinuous laminae and irregular patches of ?calcite; brownish-white ∿round to "cauliflower" shaped patches are of non-carbonate material.

Thin Section:

A visual estimate of the constituents gives:

	%
?Dolomite & calcite	85
Quartz	15
Feldspar	<1
Opaque	Trace
?Calcite	Trace

?Dolomite occurs as fine-grained crystals, generally <0.05 mm across, replacing quartz and feldspar. Coarser crystals replacing quartz are frequently rhomb shaped and are not stained by alizarin red-S. Crystals making up the finer grained mass of the rock are subhedral to anhedral and have stained to varying degrees. Rare patches of quartz crystals contain calcite between the crystals and calcite forms rare anhedral crystals up to 0.15 mm across which have been partially replaced by dolomite rhombs.

Quartz occurs as single grains generally <0.05 mm across and as crystalline aggregates up to ∿3 mm across. In these quartz crystals are unstained with straight to curved boundaries. In both occurrences quartz is partially replaced by dolomite.

Feldspar occurs as dominantly small single crystals of untwinned K-feldspar and microcline generally <0.05 mm across; crystals of similar composition are rarely intergrown with quartz.

Rare opaque grains are approximately hexagonal in outline and <0.03 mm across. The lack of lines of minutes inclusions in the coarser grained quartz aggregate may indicate that the quartz has not originated by silicification of a fine-grained volcanic rock.

The occurrence of calcite, and the slight staining of the dolomite, may also indicate that the dolomite has not formed by replacement of a quartz/feldspar rock. Anomalous staining results and slow reaction with hydrochloric acid may indicate a variable Mg content in the carbonate.

These are, however, very strong similarities between this sample and samples B52, 54,121 and 127.

Sample: B141; TSC34979

0053

Hand Specimen:

The specimen consists dominantly of fine-grained angular ?feldspathic siltstone or tuff clasts up to 5 cm across set in a "clayey" malachite and azurite-rich matrix; some clasts are partially replaced by the matrix.

Thin Section:

A visual estimate of the constituents gives:

	% (very approximate)
Feldspar	50
Quartz	35
Sericite	5
Clay minerals	5
Malachite	2
Talc	1
Chrysocolla	1
Opaque	Trace
Rutile	Trace
Tourmaline	Trace
Apatite	Trace
?Crocidolite	Trace

The rock is a breccia composed dominantly of volcanic fragments and fragments of ?siltstone.

The dominant rock type is made up of small (generally <0.05 mm) angular crystals of untwinned K-feldspar, microcline and quartz in a fine-grained groundmass now mainly altered to sericite and clay minerals. Alternation occurred prior to incorporation of the fragments into the breccia. Small (generally less than 0.7 mm in length) frequently elongate ?vesicles are lined by fibrous chrysocolla. Thin veins, generally <0.05 mm thick, are infilled with chrysocolla, and chrysocolla and chalcedony.

Another type of rock fragment contains dominantly angular quartz and microcline crystals generally <0.1 mm across in a fine-grained groundmass replaced by sericite and ?chrysocolla. In these fragments the ratio of "phenocrysts" to groundmass is approximately 50:50.

Small, irregular fragments of volcanic glass are common, frequently displaying spherulitic and "flame" structures.

Quartz forms individual grains up to ∿1.0 mm across and compound grains up to 2.5 mm across. In the larger fragments quartz crystals are up to 1.0 mm across and contain lines of minute inclusions that cross individual quartz boundaries; rare fragments are of a fine-grained (0.3 mm and less), approximately equigranular quartz mosaic. Many quartz grains have inclusions of rutile and tourmaline.

Malachite forms irregular patches up to ∿3 mm across; in some of these it appears to have selectively replaced the fine-grained groundmass. In others it has totally replaced the host rock. It also forms discontinuous veins up to ∿0.15 mm thick. Rare fibrous replacements of chrysocolla are seen.

Fibrous ?talc occurs in the matrix of the breccia, partially replacing quartz and feldspar. Fibres are up to 0.5 mm in length and commonly bent.

Rare fibres of ?crocodilite up to 1.0 mm in length are seen in one rock fragment. They form a poorly developed spherulitic structure and replace quartz. This fragment is almost totally replaced by flakes of white mica averaging ∿0.03 mm in length. Replacement has occurred prior to incorporation in the breccia.

The origin of this rock is unclear, but it may be a fault breccia, or a breccia in which explosive volcanic activity has played a large part in the formation.

Sample: B157; TSC34980 0055

Hand Specimen:

The sample is of fine-grained, grey microcrystalline dolomite, with irregular patches up to 1 cm across composed dominantly of iron-stained granular quartz and/or feldspar, some of these appear to be composed mainly of kaolinite where they cut weathered surfaces.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	80
Quartz	20
Feldspar	<1
Opaques	<1

Dolomite forms a fine, approximately equigranular mosaic, replacing quartz and feldspar. In the host rock, crystals are less than 0.03 mm across and commonly less than 0.015 mm. In veins, where dolomite occurs with minor quartz, crystals are up to 0.15 mm across.

Quartz forms small (∿0.1 mm) single crystals, small (1.5 mm) fine-grained (0.05 mm) irregular patches and larger (up to 5-6 mm) coarser grained (up to 2 mm) patches. In all these occurrences it is partially replaced by dolomite. Some of the coarser grained patches have an "atoll" structure with a highly dolomitised centre. This zone appears to have been formed of microcrystalline volcanic glass with occasional phenocrysts of microcline and ?untwinned K-feldspar. Coarse-grained quartz contains lines of minute inclusions which cross individual grain boundaries.

The degree of replacement of quartz by dolomite appears to be related to the grain size of the quartz, the coarser material being less susceptible than the finer.

Rare, small (generally <0.15 mm), individual crystals of microcline occur in the dolomite and are partially replaced by it. These are rarely intergrown with quartz.

Opaque minerals occur as rare hexagonal euhedral crystals, up to ∿0.2 mm across and have formed later than the dolomite.

The rock appears to have been a fine-grained volcaniclastic which has been extensively silicified and then dolomitised.

Sample: B163; TSC34981

0056

Hand Specimen:

The sample is extensively oxidised and is composed dominantly of azurite, ?limonite and cuprite forming the matrix to, and partially to completely replacing, the host rock.

Thin Section:

A visual estimate of the constituents gives:

	%
Azurite	65
Opaque (including cuprite and limonite)	25
Quartz	5
Dolomite	3
Chrysocolla	<1
Feldspar	<1
?Chlorite and Talc	<1

The sample is extensively replaced with little of the original rock remaining; Fragments ∿2 mm across show the rock to have been a fine grained siltstone or tuff with small (generally ∿0.1 mm and less) angular quartz and untwinned K-feldspar and microcline crystals set in a fine grained groundmass now totally replaced by limonite and ?cuprite.

Azurite occurs in many different habits; it forms an approximately equigranula mosaic of crystals up to ∿0.15 mm across, many with pseudorhombohedral form, intergrown with ?segregations of chalcedonic quartz up to 0.5 mm across, Much of the chalcedony displays and well developed radiating structure. Much of the azurite forms an approximately equigranular mosaic lacking quartz; here the crystals are anhedral and average ∿0.07 mm across. Azurite also displays tabular to bladed and radiating fibrous habits. In much of the rock it is intergrown with cuprite and opaque minerals and dolomite. The latter mineral frequently appears to replace the azurite. In some places azurite appears to have pseudomorphed other minerals, with thin skeletons of opaque minerals and chrysocolla remaining. The relationship of the cuprite to the azurite is not always clear; in some places it is replacing it, but in others it appears to be intergrown with it.

Cuprite forms irregular masses up to ∿4-5 mm across; these are commonly highly fractured, fractures being infilled with opaque minerals, azurite, chalcedonic quartz and chrysocolla, ?chlorite and ?talc.

Quartz grains up to 0.4 mm across rarely occur, surrounded by cuprite and limonite. They are unstrained and partially replaced by the surrounding material. In occasional small patches up to 0.6 mm across quartz is intergrown with partially altered untwinned K-feldspar and microcline.

Small ?rock fragments up to 4 mm in length made up of quartz crystals up to 0.05 mm across with fine wisps of opaque material may represent silicified parts of the original rock. Fine grained ?chlorite and microcrystalline

azurite also occur in fragments of similar composition.

In some fragments the opaque wisps appear to be due to an original flow structure in the rock; in others, they are secondary and crystallographically controlled.

Sample: B169; TSC34982 0058

Hand Specimen:

Angular clasts,up to 2-3 cm across,of brown feldspathic ?siltstone are set in and frequently partially replaced by a structureless,pale greenish, creamy, fine-grained matrix which makes up ∿70% of the sample.

Thin Section:

The sample consists of fine-grained, thinly laminated, angular, lithic clasts in an unbedded, poorly sorted quartzo-feldspathic matrix with subsidiary muscovite and a high percentage of kaolinite. This sample is very similar to B174.

A visual estimate of the constituents of the clasts gives:

	%
Feldspar	45
Clay minerals	30
Opaque	20
Quartz	5
Tourmaline	Trace

Subhedral to euhedral feldspar crystals up to ∿0.2 mm in length of microcline and untwinned ?K-feldspar are fresh to highly altered to ?kaolinite and fine opaque material. Occasional lath shaped grains have their long axes aligned approximately parallel to the lamination.

Opaque grains generally <0.15 mm across occur throughout the clasts and are concentrated into thin lamellae. Lamination is also caused by variations in the grain/clay ratio. Many of the opaque grains are oxidised, with oxidization (and alteration of feldspar) less common in zones up to 0.5 mm thick either side of the cross cutting fractures. These fractures are now open, or contain minor chlorite and ?chrysocolla.

Small (∿0.1 mm) commonly rhombohedral pseudomorphs now infilled with Alizarin red-S-stained clay are later than other structures. Rare clasts of ?chloritized talc are up to ∿2 mm in length. One clast of similar composition to that of the finely laminated material contains anhedral poikiloblasts of quartz up to 0.5 mm across which grade into secondary quartz aggregates lacking inclusions.

A visual estimate of the constituents of the matrix gives:

	%
Quartz	35
Clay minerals (including fine-grained sericite and chlorite)	30
Feldspar	25
Muscovite	5
Opaque	2
?Chrysocolla	4
Tourmaline	Trace

Anhedral to subhedral quartz grains composed of single crystals are up to ∿0.4 mm across. Polycrystalline quartz aggregates are up to ∿1.0 mm across. Quartz grain outlines range from angular through slightly rounded to highly corroded and delicately "cuspate". Amounts of corrosion do not appear to be related to grain size and may be due to the action of hot gases and/or fluids.

Feldspar grains up to 0.5 mm across with anhedral to euhedral (occasionally lathlike) outlines are of microcline and untwinned K-feldspar and display a range of forms similar to those displayed by quartz grains. Feldspar grains are generally fresh although occasional sericite/chlorite grains may represent highly altered feldspar crystals.

Muscovite flakes are generally <0.15 mm in length and appear randomly orientated and distributed.

Some irregular sections of groundmass are much finer grained (generally <0.05 with occasional quartz crystals up to 0.25 mm) and boundaries between coarse and fine matrix are gradational.

Sample: B171; TSC34983

0060

Hand Specimen:

The sample is of a fine to medium grained crystalline and laminated ?dolomite, cut by veins of coarsely crystalline dolomite and calcite. A pale yellow amorphous vein mineral is associated with the dolomite/calcite veins.

Etching of the hand specimen with hydrochloric acid showed a wide range of susceptibility of the laminae and this may represent a range of carbonate composition from calcite through high Mg-calcite to dolomite. In most cases individual laminae are composed of the same carbonate mineral and this variation in composition is thought to be an original depositional feature.

Thin Section:

A visual estimate of the constituents gives:

	%
Carbonate	98+
Quartz	<1
Feldspar	Tr
Opaque	Tr
Calcite	Tr
Unknown	1 (Palygorskite)

The sample is of a finely laminated dolomite limestone which has been extensively recrystallised and veined by dolomite. In the finer grained portion subhedral calcite and ?dolomite crystals are <0.05 mm across forming an equigranular 'sugary' texture. Rare euhedral feldspar crystals are of microcline and untwinned ?K-feldspar.

In the more recystalline parts of the rock dolomite crystals up to ∿1.5 x 0.7 mm are frequently elongate parallel to the lamination, which is present in these areas. Rare euhedral feldspar crystals dusted with opaque inclusions are only very slightly marginally replaced by dolomite; Quartz crystals, in contrast, are anhedral and extensively marginally replaced.

Subhedral ?high Mg calcite crystals up to ∿2 mm across form a vein up to 3 mm thick and an unknown mineral is assocated with this vein. It forms a highly irregular vein up to ∿1.5 mm across. Dolomite surrounding the vein is highly 'corroded' and partially altered to calcite. The mineral has a fibrous banded form with wavy "satin" extraction. RI is <1.54 and it is biaxial +ve with moderate 2V, colourless with straight extinction one of the zeolites is a possibility. XRD examination showed the mineral to be palygorskite.

Sample: B172; TSC34984 0061

Hand Specimen:

The sample is of a weathered thinly laminated (<1 mm) iron rich carbonate rock. Etching with HCl shows the rock to be made up of approximately alternating layers of calcite and dolomite; thin cross cutting veins are of calcite.

Thin Section:

A visual estimate of the components gives:

	%
Calcite and dolomite	∿90
Iron oxides	10
Clay minerals	<1
Opaque	Tr
Feldspar	Tr
Quartz	Tr

The above percentages are approximate due to removal of components by ?weathering. The sample is of an oxidised thinly laminated fine grained dolomitic limestone.

Subhedral carbonate crystals are generally <0.05 mm across; coarser crystals up to 0.15 mm are found in thin (generally <0.8 mm) discontinuous lamellae where carbonate appears to have partially replaced non-carbonate material. Much of this material has been removed (?by weathering), but rare patches containing fine grained feldspar, quartz and clay minerals may represent fragments of fine grained volcanic material.

Staining with Alizarin Red-S gave somewhat anomalous results (most crystals staining a pale reddish pink) which may indicate variations in the amount of Mg in dolomite and calcite.

Sample: B174; TSC34985

0062

Hand Specimen:

The sample consists of angular feldspathic ?siltstone clasts set in a pale green structureless fine grained ?feldspathic groundmass which partially replaces the clasts.

Thin Section:

The sample consists of two components; angular fragments of fine grained tuff or siltstone up to 3 to 4 cm across set in a matrix of possibly volcanic origin. Some rock fragments appear to have been partially replaced by this matrix.

A visual estimate of the constituents of the rock fragments gives:

	%
Feldspar	60
'Clay minerals' (including sericite, kaolinite and ?montmorillonite)	25
Opaque	10
Quartz	5

The sample consists of small (<0.1 mm) angular crystals of microcline, untwinned K-feldspar and quartz set in a very fine grain groundmass of feldspar, partially altered to clay minerals. Lamination is due to occasional thin laminae containing a higher percentage of quartz and a concommitantly lower percentage of feldspar and clay minerals. Rare thin (∿0.3 mm) veins of 'matrix' material cut the rock fragments producing ?silicified zones up to ∿1.5 mm thick.

Opaque grains less than 0.1 mm across are disseminated through the rock fragments; rare grains up to 0.6 mm across are intergrown with secondary quartz in the discontinuous irregular veins. One euhedral rhomb shaped grain ∿1.5 mm across is partially replaced by quartz and ?iron oxide.

'Matrix' material consists of crystals of quartz, untwinned ?K-feldspar and microcline and mica flakes in a groundmass of ?kaolinite and sericite. These crystals are generally angular and less than 0.2 mm across and occasional euhedral feldspar crystals are seen. One acicular quartz crystal is ∿0.6 mm in length. Rare opaque grains are up to 0.1 mm across. Crystals of secondary quartz up to 0.25 mm across patchily replace the 'matrix' in areas up to 5 mm x 2 mm.

The rock appears to be a volcanic breccia.

Sample: B181; TSC34987

0063

Hand Specimen:

The sample is of a dominantly quartz sand; rare kaolinised fragments are up to 4 to 5 mm across.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	95
Feldspar	5
Mica	<1

The above figures are misleading as most of the matrix of the rock is missing.

Quartz occurs as single and composite grains up to 0.8 mm across mainly with rounded embayed outlines; few show undulose extinction and boundaries within composite grains are commonly straight to curved. Many grains contain lines of fine inclusions cutting across the grain boundaries.

Feldspar grains are generally small (∿0.1 mm) and angular and consist of microcline and untwinned K-feldspar. In rare areas where the matrix is preserved it appears to be made up of microcrystalline feldspar. Mica flakes up to 0.15 mm in length appear to be due to alteration of this matrix, although one area they appear to define a faint flow structure.

Two small (∿0.025 mm) crystals of dolomite were seen as inclusions in quartz.

Due to the degree of alteration, it is not possible to determine the original rock type with any accuracy, but it may have been some type of 'acid' tuff.

Sample: B184; TSC34988

0064

Hand Specimen:
The sample is of a soft friable reddish brown rock with highly irregular laminations and patches of white ?kaolinite.

Thin Section:
A visual estimate of the constituents gives:

	% (very approximate)
Feldspar	60
Quartz	20
?Sericite	10
Opaque	5
Iron oxides	5
Cuprite	2

The sample is of a mineralised and oxidised ?brecciated feldspar quartz rock, possibly a tuff.

Feldspar crystals of microcline and untwinned K-feldspar have irregular angular outlines and many are lathlike and cigar shaped up to ∿1.5 mm length. All are dusted with fine opaque inclusions due to alteration and preferential zonal development of these inclusions is thought to be due to compositional variations. Some lathshaped crystals are bent.

Single quartz crystals are subhedral to rounded up to ∿0.25 mm across and are generally free of inclusions. Veins and patches of secondary quartz are fractured, veined and partially replaced by opaque material.

Fine bent fibres of ?sericite up to ∿0.5 mm long form irregular felted masses where they are commonly intergrown with opaque minerals, cuprite and iron oxides. Much of the ?sericite appears to have formed from fine grained 'groundmass' material. In rare patches of unaltered 'groundmass' it can be seen to be made up of microcrystalline feldspar.

Opaque minerals form subhedral grains up to ∿1 mm across and thin rims around grains up to ∿1.5 mm across composed dominantly of cuprite.

The status of the feldspar (and some quartz) in the rock is unclear. Forms displayed may possibly be due to brecciation of a secondarily feldspathised rock, but a primary volcanic origin seems more likely. These forms occur in many of the samples and where much of the sample is dolomitised, may give an indication as to the original composition of the rock.

This rock is therefore termed a coarse crystal tuff.

Sample: B185; TSC34986

0065

Hand Specimen:

The sample is of a talc and chlorite rich schistose quartz rich rock, with asymmetric tight to open folds of variable wave-length (5 mm to 3 to 4 cm). There is slight patchy development of malachite.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	50
Talc	20
Clay minerals	15
Feldspar	10
Chlorite	3
Opaque	<1

The sample is of a folded and sheared talcose quartzo-feldspathic rock, probably of volcaniclastic origin.

Anhedral to subhedral quartz crystals up to 0.7 mm across form single grains and polycrystalline aggregates of up to ∿10-15 crystals. Many quartz grains have 'corroded' outlines and crystal faces exhibited by some grains can be seen to be due to secondary quartz overgrowths. Many grains are also fractured and exhibit undulose extinction, indicating strain.

Subhedral crystals of untwinned K-feldspar and microcline up to 1.5 mm in length commonly display cigar or lathlike outlines and are commonly highly fractured and partially replaced by talc and clay minerals.

Quartz and feldspar grains are set in a groundmass of talc, clay minerals and chlorite. In some areas up to ∿5 mm across, talc forms up to 90% of the rock and lamination is due to varying concentrations of groundmass and quartz and feldspar grains. Chlorite flakes up to ∿0.1 mm in length are intergrown with talc and appear pseudomorphous after mica.

Opaque grains are up to ∿0.4 mm across and partially replace groundmass material; much of the groundmass is also stained by iron oxides.

The sample may be a sheared and folded equivalent of sample B259.

Sample: B189; TSC34989 0066

Hand Specimen:
The sample is of a light grey breccia with dolomitic clasts (and single dolomite crystals up to 4 mm across) set in a groundmass composed dominantly of calcite.

Thin Section:
A visual estimate of the constituents gives:

	%
Quartz	10
Feldspar	10
Dolomite	15?
Calcite	60?
Talc	3
Chlorite	1
Mica	<1
Opaque	Tr
Unknown	Tr

The sample is of an impure carbonate breccia with a highly variable composition.

Subhedral to euhedral dolomite crystals are up to 1.5 mm across. Many of the larger euhedral crystals are zoned with a thin irregular secondary overgrowth of dolomite separated from the main crystal by a thin line of opaque inclusions. Many of these larger crystals contain inclusions of mica, feldspar, dolomite and quartz. From purely textural consideration it is not possible to say if these larger zoned crystals have an entirely secondary origin in the rock in which they now occur.

Unzoned euhedral dolomite crystals up to ∿0.6 mm across can be seen to be secondary in origin, frequently occurring as a a partial replacement of quartz grains.

Much of the finer grained dolomite has been partially replaced by calcite, but anomalies in staining results make an accurate estimate of the proportions impossible.

Replacement of dolomite by calcite is shown by thin calcite veins cutting large unaltered dolomite crystals.

Single quartz crystals up to 2 mm across generally have rounded outlines and contain inclusions of mica. Many show partial replacement by dolomite (and calcite). One highly irregular poikiloblastic quartz crystal has inclusions of microcline and untwinned K-feldspar and has formed by preferential replacement of the fine grained groundmass of a 'porphyritic' volcanic rock. This appears to have occurred prior to incorporation in the present rock.

Irregular aggregates of quartz up to ∿6 mm across are formed of quartz crystals up to ∿3 mm across. These are subhedral with smooth curved to straight quartz/quartz boundaries and in some cases fine lines of opaque inclusions cross these boundaries. These aggregates are probably fragments of a silicified ?volcanic rock.

Feldspar crystals are of microcline and untwinned K-feldspar. Individual crystals are generally subhedral with irregular angular outlines and frequently lathlike or cigar shaped forms up to ∿0.7 mm in length.

'Patches' of feldspar up to 6 mm across made up of anhedral microcline and untwinned ?K-feldspar crystals ∿0.1 mm across (and subsidiary quartz) are extensively replaced by white mica (? sericite) dolomite and calcite. Small (0.4 mm) patches of microcrystalline feldspar contain small (0.1 mm) zoned crystals of untwinned ?K-feldspar and appear to represent volcanic fragments.

Rounded fine grained partially dolomitised and calcified rock fragments up to ∿2 mm across also appear to be dominantly composed of microcrystalline feldspar

Talc fibres up to ∿1.0 mm in length partially replace dolomite, quartz, feldspar and the 'unknown' mineral. In rare small irregular patches up to ∿1.5 mm across talc occurs as the dominant mineral.

Mica flakes up to ∿0.3 mm in length are of a pale yellowish brown variety. These are extensively replaced by green to pale yellow pleochroic, biaxially-ve penninite (the more Mg rich variety). Rare small (0.05 mm) crystals of penninite replacing dolomite appear to have grown as a separate phase. Rare opaque grains up to 0.4 mm across, but commonly much smaller, are distributed through the rock, with slightly greater development in feldspar rich fragments.

The unknown mineral forms anhedral crystals up to ∿0.5 mm across. It is colourless, biaxial-ve, has 2 cleavage ∿ at 90°, an RI 1.54, replaces quartz and is replaced by talc, and dolomite. It's birefringence is about the same as that of feldspar and it may be a zeolite.

Restaining of this section with Clayton fellow showed that the calcite is a high-Mg variety occurring in the matrix; large carbonate crystals were not stained and are of dolomite.

Sample: B191; TSC4990

0068

Hand Specimen:

The sample is of a microcrystalline hard pale orange-pink to white non-laminated rock with irregular 'vesicles' up to 7 mm across due to ?preferential removal of ?opaque constituents.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	77
Quartz	20
Opaque	3
?Rutile	Tr
Apatite	Tr
Tourmaline	Tr
Calcite	Tr

This sample is of a partially feldspathised and silicified ?tuff.

Subhedral phenocrysts of untwinned K-feldspar are up to ∿0.6 mm across and with rotation under cross polarised light tend to partially 'fade back' into the microcrystalline feldspar groundmass. This may be due to only partial crystallisation from this groundmass.

Much of the feldspar occurs as anhedral crystals of untwinned K-feldspar and microcline with highly irregular margins forming irregular patches up to 3 to 4 mm across. Fine opaque inclusions gave this feldspar a dusty brown appearance.

Quartz forms irregular patches up to 4 to 5 mm across and irregular veins up to ∿2 mm thick; crystals up to 1.5 mm across are subhedral with smooth curved to straight boundaries. Lines of fine opaque inclusions frequently cross these boundaries. Crystals of secondary feldspar adjacent to these veins are coarsergrained than those further away and feldspathisation and silicification may have proceeded along the same fractures. Quartz also forms fine wispy ;veinlets' ∿0.3 x 0.07 mm which may represent recrystallised glass.

Opaque grains form clots up to 0.8 mm across; fine needles of rutile <0.07 mm in length are concentrated in patches ∿0.3 mm across. Euhedral apatite crystals ∿0.1 mm across have a patchy distribution; tourmaline grains ∿0.05 mm across are far less common and one crystal of calcite ∿0.01 mm across was observed partially replacing feldspar.

Sample: B194/80; TSC34991

0069

Hand Speciment:

The sample is of light brown friable material, now dominantly reduced to a sand; occasional angular fragments up to ∿1.8 cm across are dominantly of quartz.

Thin Section:

A visual estimate of the constituents is not possible due to the altered and fractured nature of the specimen and the consequent number and size of the voids in the thin section.

Some fragments consist of a mosaic of quartz grains; in the coarser areas these are up to 3 mm across, anhedral with slightly sutured boundaries. Faint lines of minute inclusions across grain boundaries. In some fragments a mixture of coarse and fine (∿0.15 mm) quartz, with occasional K-feldspar grains, is seen.

Rare small (<0.05 mm) dolomite rhombs are replacing quartz.

Fragments of volcanic glass up to 4 mm across also occur; the contain small (0.2 mm and less) phenocrysts of K-feldspar and quartz and all contain a thin (<0.03 cm) band of fibrous ?feldspar parallel to, and up to 0.4 mm from their margins. This band may be a chilling effect.

Other fragments appear to be of volcanic origin and to have been extensively feldspathised. Some now consist of up to 100% of partially altered dominantly untwinned K-feldspar crystals commonly 0.4 mm and less across with highly irregular and diffuse margins. In many of these fragments quartz crystals up to 0.3 mm across have smooth irregular and embayed outlines and may be primary. Opaque grains of ?cuprite up to ∿3.5 mm across frequently contain inclusions of quartz and K-feldspar.

The rock appears to have been a tuff which has been heavily feldspathised in some areas and silicifiedin others; later dolomitisation is only very rarely seen. The pattern of inclusions in the coarse grained quartz is identical to that seen in sample B54 where dolomitisation is much more advanced; both samples may have the same origin.

0070

Sample: B195; TSC34992

Hand Specimen:

The sample is of a structureless white to pale green friable rock composed of medium to coarse grains of quartz and grains now composed of kaolinite. Rare grains of soft black opaque material are up to 4 mm across.

Thin Section:

A visual estimate of the constituents gives:

	% (very approximate)
Quartz	75
Kaolinite	25
Malachite	<1
Opaque	<1
Dolomite	Trace
Cuprite	Trace

Euhedral to rare subhedral quartz crystals, up to ∿0.7 mm across occurring as single grains and aggregates up to 2 mm across are set in a groundmass of fine-grained kaolinite. Most grains display highly corroded boundaries in contact with kaolinite. Quartz/quartz boundaries are smooth, curved to straight and lines of fine opaque inclusions occasionally cross these boundaries. These inclusion may also form thin bands near the margins of quartz grains. Inclusion patterns are the same as those displayed by secondary quartz in many of the "tuffaceous" samples and much of this quartz is probably of similar origin.

Opaque material occurs dominantly as thin coatings on quartz grains. Malachite forms the matrix in irregular patches up to 2 mm across; cuprite forms fine grains <0.05 mm across.

Dolomite rhombs <0.1 mm across are included in quartz crystals.

The sample is probably of a highly altered silicified volcanic rock, probably a tuff.

Sample: B196; TSC34993

0071

Hand Specimen:

The sample is a soft, friable, laminated rock, with highly irregular, whitish and pale greenish-brown laminations. The specimen contains a high percentage of kaolinite.

Thin Section:

A visual estimate of the constituents gives:

	%
Kaolinite	70
Feldspar	15
Quartz	10
Opaque	3
Iron oxides	∿1

The sample is of a fine-grained,"?volcanic" rock, with most of the groundmass altered to kaolinite and fine-grained "dusty" opaque material.

In a small, less altered section, the rock can be seen to consist of small (∿0.2 mm) subhedral crystals of untwinned K-feldspar and microcline, with subsidiary quartz, in a fine-grained (∿0.02 mm) groundmass of feldspar. Small approximately round patches of kaolinite approximately 0.25 mm across grade into a groundmass of this material with scattered individual crystals of quartz and feldspar and irregular veins, patches and layers of quartz, and quartz and feldspar.

Quartz crystals up to 1 mm across form "rounded" individual grains and polycrystalline aggregates up to ∿1 mm across. Most of this quartz is secondary.

Much of the lamination in the specimen is due to variations in concentration of "dusty" opaque material in the kaolinite.

Fine subhedral to euhedral grains of ?pyrite <0.1 mm across, and iron oxides, are also concentrated into thin laminae approximately parallel to those mentioned above. It is thought that the lamination is probably a secondary effect, which may be related to a ?primary layering caused by concentration of feldspar (and subsidiary quartz) crystals into irregular laminae <2 mm thick.

The original rock type is obscured by the degree of alteration, but some kind of volcanic origin seems likely.

Sample: B199; TSC34994

0072

Hand Specimen:

The sample is of a very fine-grained, faintly laminated to massive, pale grey rock with small (<0.5 mm) white spots, randomly distributed throughout. Thin veins of ?dolomite cut the rock.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	60
Dolomite	15
?Sericite	15
Opaque	8
Feldspar	2

Microcrystalline quartz and sericite forms the groundmass which contains small (generally <0.03 mm), angular grains of quartz. Larger, irregular, elongate, "patchy" grains up to 0.3 mm in length frequently contain inclusions of ?sericite with a similar orientation to that in the groundmass. Wispy, ?sericite flakes up to 0.01 mm in length show dimensional parallelism imparting a weak foliation. This may be an original depositional feature, or be due to tectonism.

Opaque grains are generally euhedral up to 0.7 mm across although dominantly <0.15 mm across. Larger grains are partially rimmed by fine-grained quartz which has grown in "pressure shadows".

Dolomite occurs dominantly as small (<0.05 mm) rhombs randomly distributed through the rock. Rare, small patches up to 0.6 mm across also occur. Dolomite replaces all other minerals and also occurs in a thin (∿0.3 mm thick) vein with quartz.

The rock appears to be a fine-grained acid volcanic which has been silicified and then dolomitised.

Sample: B201; TSC34995 0073

Hand Specimen:

The sample is of a soft, friable, faintly laminated greyish-white, kaolinite rock "dusted" with fine crystals of tourmaline and with occasional oxidised opaque grains.

Thin Section:

A visual estimate of the constituents gives:

	%
Kaolinite	∿90
Tourmaline	10
Opaque	1
Feldspar	Trace
Sericite	Trace
Opaque	Trace

The sample has a faint layered structure caused by slight variation in the texture of the kaolinite and concentration of tourmaline crystals.

Rare subhedral crystals of untwinned K-feldspar up to 0.3 mm across are zoned and dusted with fine opaque inclusions; they show only slight marginal alteration to kaolinite.

Rare zoned, bent and slightly fractured crystallites of untwinned ?K-feldspar are up to 0.5 mm x 0.03 mm. Fibrous sericite forms irregular patches up to 0.5 mm across. Anhedral patches of optically continuous kaolinite may represent altered secondary feldspar crystals.

Tourmaline crystals up to 0.5 mm in length of a pale greenish-brown variety show a slight concentration into irregular discontinuous layers. They are absent from a kaolinite vein which cuts this layering.

The rock may be of fine-grained volcanic origin.

Sample: B202; TSC34996

0074

Hand Specimen:

The sample is of a soft, friable, light brown, weathered rock with irregular thin (∿1 mm) ?kaolinite laminae comprising about 30 to 40% of the specimen.

Thin Section:

A visual estimate of the constituents gives:

	% (very approximate)
Quartz	65
Clay minerals and Fe-oxides	30
Feldspar	2
Opaques	2
White mica	1
Dolomite	Trace

Quartz grains ranging in size from <0.01 mm to ∿0.8 mm are poorly sorted; they are angular to subrounded in outline and many are highly embayed. Most quartz grains are clear, but some contain lines and patches of fine opaque inclusions. Some are partially ?replaced by dolomite rhombs up to ∿0.05 mm across.

Crude, irregular lamination is due to variations in proportions of coarser grained quartz and fine-grained matrix. The matrix is now composed dominantly of fine clay minerals and Fe-oxides and contains small (<0.15 mm) crystals of microcline and untwinned K-feldspar and flakes of white mica up to 0.3 mm in length.

Opaque grains are up to 0.3 mm across and tend to be concentrated in lamellae, rich in fine-grained "matrix" material.

The rock could be called a sandstone, but a simple sedimentary origin appears unlikely; a volcaniclastic origin should be considered.

Sample: B207; TSC34998

0075

Hand Specimen:

The sample is of a highly ?weathered, brown friable rock composed dominantly of quartz grains and "grains" of kaolinite with extensive development of secondary quartz and malachite.

Thin Section:

A visual estimate of the constituents gives:

	% (very approximate)
Quartz	60
Kaolinite	20
Opaque oxides	10
Feldspar	5
Sphalerite	5
Malachite	1
Rutile	Trace

This sample is of a slightly less weathered, more mineralised ?equivalent of B195.

Quartz crystals up to ∿0.8 mm across form single grains and aggregates up to ∿3 mm across. Single quartz grains commonly display rounded outlines and are corroded along fractures. Quartz crystals in aggregates display similar features to those in Sample B195 and a similar secondary origin is proposed.

Most of the feldspar in the rock has been replaced by kaolinite; euhedral pseudomorphs wholly or partially included in secondary quartz are common.

Most feldspar grains present are of microcline with lathlike to cigar shaped outlines and up to∿0.8 mm in length. More equant euhedral crystals are also seen. Many feldspar crystals contain fine opaque inclusions and zonal arrangement of these may be due to compositional variations within the crystals.

Grains of sphalerite up to ∿1.4 mm across are slightly fractured with rounded outlines. Slight alteration has occurred along fractures and around margins of the grains.

Malachite forms diffuse irregular patches up to ∿3 mm across and small irregular veins and blebs up to ∿0.4 mm across.

Needles of rutile <0.01 mm in length are included in quartz.

Sample: B208; TSC34999

0076

Hand Specimen:

The sample is of a hard, microcrystalline, pinkish to white rock, with extensive development of secondary feldspar and quartz; much of the feldspar is altered to ?clay minerals.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	65
Quartz	20
Sericite with minor ?kaolinite	15
Opaque	<1
Tourmaline	Trace
?Chrysocolla	Trace
Rutile	Trace

The sample is of a feldspathised and silicified fine-grained ?tuff, which has been extensively sericitised.

Rare anhedral to subhedral crystals, dominantly of untwinned K-feldspar with subsidiary microcline, are up to 2 mm in length, dusted with fine opaque inclusions and extensively altered to sericite with fractures infilled with quartz. These crystals have a patchy distribution and appear to be of secondary origin.

Most of the feldspar is microcrystalline, forming the matrix to small quartz crystals, and is extensively altered to sericite. Much of the fine-grained quartz in this rock may be of secondary origin. Grains are generally <0.15 mm across, most averaging ∿0.05 mm and have highly irregular margins.

Subhedral quartz crystals up to ∿0.3 mm across form discontinuous veins up to ∿1.25 mm thick. In some patches quartz crystals appear highly corroded and replaced by sericite and ?kaolinite.

Rare opaque grains are up to 0.3 mm across; most are <0.1 and are disseminated in patches up to ∿2 mm across.

Sample: B212; TSC35000

0077

Hand Specimen:

The sample is of a soft, structureless, friable, dark grey, partially oxidised rock with flecs, small patches and highly irregular veins of ?kaolinite.

Thin Section:

A visual estimate of the constituents gives:

	%
Clay minerals (?montmorillonite and kaolinite)	60-70
Quartz	15-20
Tourmaline	10-25
Iron oxides	3
Feldspar	<1
Opaques	1
?Talc	<Trace
Rhombohedral relicts	Trace
Rutile	Trace

The sample is of a fine-grained volcanic rock, extensively replaced by tourmaline and quartz.

?Montmorillonite forms lamellar to slightly spherulitic aggregates up to ∿1 mm in length with irregular boundaries and is frequently ?intergrown with quartz. These aggregates are distinct from kaolinite which forms the matrix to ?montmorillonite, quartz and feldspar.

Individual anhedral quartz crystals up to ∿0.2 mm across are disseminated through the rock and are partially replaced by tourmaline and kaolinite. Quartz crystals frequently form irregular, extensively replaced aggregates up to ∿1.5 mm across, intergrown with minor amounts of untwinned K-feldspar and microcline.

Undulose quartz crystals with irregular to sutured margins also form veins up to ∿1.25 mm thick which are frequently partially replaced by opaque material and rutile.

Extensively fractured and replaced anhedral to subhedral crystals of microcline and untwinned K-feldspar up to ∿1 mm across, occur as randomly orientated and distributed individual grains and as irregular "clots" up to 2-3 mm across. One crystal of ?albite 0.6 mm in length was seen.

Pale greenish-brown tourmaline crystals generally <0.4 mm in length extensively replace quartz, feldspar and ?kaolinite, with only minor replacement of montmorillonite.

Rare fibres of talc up to 1.5 mm in length are extensively replaced by opaque oxides which form thin irregular veins (frequently associated with secondary quartz veins) and patchy replacement up to ∿4 mm across.

Other fine-grained (<0.2 mm) opaque constituents form irregular patches up to ∿0.75 mm across.

Rhombohedral relict grains replaced along cleavages and around their margins by iron oxide (up to 0.75 mm across) replace secondary quartz and tourmaline.

Sample: B215; TSC35001

0078

Hand Specimen:

The sample is of a hard, fine-grained, pinkish to white quartzo-feldspathic rock lacking any lamination. Slight alteration to clay minerals has occurred along fractures with slight malachite staining.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	85
Quartz	15
Kaolinite and sericite	<1
Opaque	<1
Apatite	Trace
Rutile	Trace

The sample is of a fine-grained "acid" volcanic, probably a tuff. Primary feldspar forms phenocrysts and much of the groundmass; secondary feldspar replaces much of the rock, frequently along veins.

Subhedral, slightly "rounded", feldspar phenocrysts of untwinned K-feldspar with rare Carlsbad twinning and microcline are occasionally poikilitic, with inclusions of fine-grained feldspathic groundmass. Under XPL, many of the phenocrysts "fade" into the groundmass on rotation ?due to partial recrystallization.

The texture of the groundmass is quite variable with variations in grain size defining angular fragments up to 2 mm across. In many areas coarser anhedral untwinned K-feldspar crystals ($\sim$0.1 mm across) grade into finer grained material ($\sim$0.01 mm). Many of these coarser grained patches up to 6 to 7 mm across are probably of secondary origin.

Some quartz veins have the same "line" as feldspar veins and in them quartz partially replaces feldspar. It appears that in some areas feldspathisation and silicification have proceeded along the same fractures.

Rare euhedral ?pyrite grains are up to 0.5 mm across, occasionally have a thin partially developed rim of secondary quartz.

Fine (<0.025 mm) opaque grains are disseminated through irregular patches and veins up to $\sim$1.25 mm across/in length.

Sample: B217; TSC35002

0079

Hand Specimen:

The sample is of a hard, microcrystalline, pinkish-red feldspathic rock cut by a quartz vein up to 1.3 cm thick. Fracture surfaces are 'spotted' with malachite.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	70
Feldspar	30
Opaque	<1
Malachite	Trace
Rutile	Trace

The above figures are misleading as over half the thin section consists of a quartz vein; in the remainder, secondary quartz makes up ∿10% of the rock.

Quartz crystals making up the veins are anhedral, up to 1.2 cm across, fractured and with undulose extinction. Brecciation has occurred along major fractures with comminution of the quartz producing fragments between 2.5 mm x 0.01 mm across. Growth of secondary quartz in the fractures has welded the fragments together.

Boundaries between the vein and the host are smooth to highly irregular and some patches of secondary quartz in the host are in optical continuity with quartz in the vein. Anhedral poikiloblastic individual crystals of secondary quartz are up to ∿1.25 mm across; polycrystalline aggregates also with inclusions of host are up to ∿2.5 mm across.

Primary feldspar forms anhedral to euhedral phenocrysts of untwinned K-feldspar up to ∿1.5 mm across. Crystals of microcline and with Carlsbad twins are subsidiary. These are set in a groundmass of microcrystalline feldspar.

Anhedral to subhedral crystals of secondary untwinned K-feldspar, with subsidiary microcline, up to ∿1.25 mm across form extensive vein-like and patchy replacements. These crystals are dusted with fine opaque inclusions (?due to alteration) imparting a pinkish-brown colouration. Fine-grained opaque material (∿0.025 mm grains) forms irregular patches up to ∿2 mm across which are partially replaced by malachite.

The sample is of a feldspathised and silicified acid ?tuff.

Sample: B218B; TSC35004

0080

Hand Specimen:

This sample is of a grey, coarsely crystalline, non-laminated dolomitic rock, with irregular 'patches' of quartz and yellowish feldspar. The rock is partially replaced by irregular veins and blebs of opaque material and malachite.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	70
Quartz	20
Feldspar	10
Malachite	1
Opaque	1
?Barite	Trace
?Chrysocolla	Trace

The sample is of an extensively dolomitised quartz/feldspar rock. Dolomite crystals are subhedral to euhedral, less than 0.6 mm across and partially replace quartz and feldspar. Some smaller euhedral crystals are skeletal with a core of quartz and feldspar. Zoning of some crystals may be observed due to the presence of fine opaque inclusions, with up to 3 growth stages being observed.

Quartz crystals are up to 5 mm across, anhedral and strained. Boundaries are irregular to sutured and grains contain lines of minute opaque inclusions that cross quartz/quartz boundaries. Recrystallisation of coarse-grained quartz to fine-grained unstrained grains has occurred around grain boundaries and along closely spaced fractures in areas up to ∿1 cm across where quartz forms ∿100% of the rock. Colourless to very pale yellowish-green, faintly pleochroic ?chrysocolla fibres occur in veins <0.1 mm thick between quartz grains in these areas. Some quartz-rich areas contain very minor amounts of feldspar.

Frequently elongate crystals of feldspar, up to 0.6 mm in length are anhedral with feldspar/feldspar boundaries being highly irregular and diffuse. Crystals are commonly of microcline with subordinate untwinned K-feldspar and are only lightly 'dusted' with fine opaque grains. Rare feldspar crystals are partially replaced by quartz along twin planes.

Malachite occurs in irregular patches up to 0.6 mm across, in thin veins and fractures and as an intergranular 'matrix' where replacement has occurred selectively along grain boundaries. It commonly occurs as a replacement of opaque minerals, but may have formed as a separate phase in some occurrences.

Poikiloblastic ?barite crystals are up to 0.4 mm across, partially replacing feldspar and quartz. The diagenetic relationship of the barite to the dolomite in this section is not clear.

Sample: B218E; TSC35003 0081

Hand Specimen:

The sample consists of angular quartz and feldspar grains and occasional lithic clasts in a pale green ?feldspathic structure-less matrix which is extensively replaced by malachite and chrysocolla.

Thin Section:

A visual estimate of the constituents gives:

	% (very approximate)
Quartz	45
Feldspar	40
Clay minerals	10
Volcanic glass	1-2
Malachite	1-2
Opaque	1
Chrysocolla	<1
Muscovite	Trace
Tourmaline	Trace
Apatite	Trace
Chlorite	Trace
Dolomite	Trace

The sample is of a feldspathised and silicified volcaniclastic which has been copper mineralised and slightly dolomitised.

Quartz crystals are of primary volcanic and secondary origin. Primary quartz form small microphenocrysts in a microcrystalline groundmass of K-feldspar and quartz. Small (∿0.05 mm) crystals are also present in volcanic glass fragments.

Anhedral to subhedral crystals of secondary quartz up to ∿3 mm across occur in veins up to ∿5 mm in length and irregular patches up to 3-4 mm across. Small approximately straight veinlets of quartz up to ∿0.5 mm x 0.05 mm are common.

Anhedral crystals of secondary microcline and untwinned K-feldspar up to ∿0.4 mm across replace fine-grained volcanic material and are commonly marginal to and partially replaced by crystals of secondary quartz occurring in veins.

Wispy feldspar crystallites in volcanic glass commonly show a partial spherulitic texture.

Amorphous to crystalline, frequently fibrous malachite forms irregular patches up to ∿1.5 across, commonly partially pseudomorphing opaque material and partially replacing quartz and feldspar. Malachite is also found infilling irregular fractures and in veins when it appears to be later than the associated chrysocolla.

Films of fibrous chrysocolla ∿0.015 mm thick form and line veins and occur as irregular sinuous to spherulitic replacements of fine-grained volcanic material. Rare brown colouration is probably due to iron or copper oxides.

Rare anhedral muscovite flakes are up to 0.5 mm across and are partially replaced by malachite and tourmaline.

Tourmaline commonly occurs as radiating accicular crystals up to ∿0.15 mm in length partially replacing secondary K-feldspar in patches up to ∿1.5 mm across.

Rare anhedral dolomite crystals up to ∿0.2 mm across occurring in dominantly chrysocolla pseudomorphs of ?secondary K-feldspar are partially replaced by the chrysocolla.

Sample: B224; TSC35005

0083

Hand Specimen:

The sample consists dominantly of pale brown to colourless, fine-grained, quartz with a high percentage of irregular patches and "veins" (both with diffuse margins) of white, 'sugary' quartz, which is frequently highly porous and permeable. Rare small (<2 mm) patches of kaolinite also occur.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	99
Dolomite	<1

This is very similar to samples B41 and B57, consisting of a mosaic of quartz grains. Patches of coarse grained (up to ∿2 mm) quartz contain anhedral crystals with a wide range in size and shape; boundaries are straight to curved and in many places recrystallization to smaller more euhedral grains has occurred.

In many fine-grained areas, quartz crystals ∿0.015 mm across are approximately round with diffuse margins.

These areas also appear to have partially recrystallised to coarser grained quartz.

Between these two extremes of grain size are areas where quartz forms an approximately equigranular mosaic of subhedral to euhedral crystals up to ∿0.2 mm across. These crystals have straight boundaries and a 120° triple points and it is suggested that this is an equilibrium microstructure to which the coarser and finer quartz has partially recrystallised.

Rare small (<0.03 mm) dolomite rhombs are replacing quartz.

Inclusions in coarse-grained quartz are similar to those seen in other samples (i.e. B194/80) and it appears extreme silicification of a fine-grained volcanic rock is a likely origin of this lithology.

Sample: B212; TSC35000

0084

Hand Specimen:

The sample is of a soft, structureless, friable, dark grey, partially oxidised rock with flecs, small patches and highly irregular veins of ?kaolinite.

Thin Section:

A visual estimate of the constituents gives:

	%
Clay minerals (?montmorillonite and kaolinite)	60-70
Quartz	15-20
Tourmaline	10-25
Iron oxides	3
Feldspar	<1
Opaques	1
?Talc	<Trace
Rhombohedral relicts	Trace
Rutile	Trace

The sample is of a fine-grained volcanic rock, extensively replaced by tourmaline and quartz.

?Montmorillonite forms lamellar to slightly spherulitic aggregates up to ∿1 mm in length with irregular boundaries and is frequently ?intergrown with quartz. These aggregates are distinct from kaolinite which forms the matrix to ?montmorillonite, quartz and feldspar.

Individual anhedral quartz crystals up to ∿0.2 mm across are disseminated through the rock and are partially replaced by tourmaline and kaolinite. Quartz crystals frequently form irregular, extensively replaced aggregates up to ∿1.5 mm across, intergrown with minor amounts of untwinned K-feldspar and microcline.

Undulose quartz crystals with irregular to sutured margins also form veins up to ∿1.25 mm thick which are frequently partially replaced by opaque material and rutile.

Extensively fractured and replaced anhedral to subhedral crystals of microcline and untwinned K-feldspar up to ∿1 mm across, occur as randomly orientated and distributed individual grains and as irregular "clots" up to 2-3 mm across. One crystal of ?albite 0.6 mm in length was seen.

Pale greenish-brown tourmaline crystals generally <0.4 mm in length extensively replace quartz, feldspar and ?kaolinite, with only minor replacement of montmorillonite.

Rare fibres of talc up to 1.5 mm in length are extensively replaced by opaque oxides which form thin irregular veins (frequently associated with secondary quartz veins) and patchy replacement up to ∿4 mm across.

Other fine-grained (<0.2 mm) opaque constituents form irregular patches up to ∿0.75 mm across.

Rhombohedral relict grains replaced along cleavages and around their margins by iron oxide (up to 0.75 mm across) replace secondary quartz and tourmaline.

Sample: B215; TSC35001 0085

Hand Specimen:

The sample is of a hard, fine-grained, pinkish to white quartzo-feldspathic rock lacking any lamination. Slight alteration to clay minerals has occurred along fractures with slight malachite staining.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	85
Quartz	15
Kaolinite and sericite	<1
Opaque	<1
Apatite	Trace
Rutile	Trace

The sample is of a fine-grained "acid" volcanic, probably a tuff. Primary feldspar forms phenocrysts and much of the groundmass; secondary feldspar replaces much of the rock, frequently along veins.

Subhedral, slightly "rounded", feldspar phenocrysts of untwinned K-feldspar with rare Carlsbad twinning and microcline are occasionally poikilitic, with inclusions of fine-grained feldspathic groundmass. Under XPL, many of the phenocrysts "fade" into the groundmass on rotation ?due to partial recrystallization.

The texture of the groundmass is quite variable with variations in grain size defining angular fragments up to 2 mm across. In many areas coarser anhedral untwinned K-feldspar crystals (∿0.1 mm across) grade into finer grained material (∿0.01 mm). Many of these coarser grained patches up to 6 to 7 mm across are probably of secondary origin.

Some quartz veins have the same "line" as feldspar veins and in them quartz partially replaces feldspar. It appears that in some areas feldspathisation and silicification have proceeded along the same fractures.

Rare euhedral ?pyrite grains are up to 0.5 mm across, occasionally have a thin partially developed rim of secondary quartz.

Fine (<0.025 mm) opaque grains are disseminated through irregular patches and veins up to ∿1.25 mm across/in length.

Sample: B217; TSC35002

0086

Hand Specimen:

The sample is of a hard, microcrystalline, pinkish-red feldspathic rock cut by a quartz vein up to 1.3 cm thick. Fracture surfaces are 'spotted' with malachite.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	70
Feldspar	30
Opaque	<1
Malachite	Trace
Rutile	Trace

The above figures are misleading as over half the thin section consists of a quartz vein; in the remainder, secondary quartz makes up ∿10% of the rock.

Quartz crystals making up the veins are anhedral, up to 1.2 cm across, fractured and with undulose extinction. Brecciation has occurred along major fractures with comminution of the quartz producing fragments between 2.5 mm x 0.01 mm across. Growth of secondary quartz in the fractures has welded the fragments together.

Boundaries between the vein and the host are smooth to highly irregular and some patches of secondary quartz in the host are in optical continuity with quartz in the vein. Anhedral poikiloblastic individual crystals of secondary quartz are up to ∿1.25 mm across; polycrystalline aggregates also with inclusions of host are up to ∿2.5 mm across.

Primary feldspar forms anhedral to euhedral phenocrysts of untwinned K-feldspar up to ∿1.5 mm across. Crystals of microcline and with Carlsbad twins are subsidiary. These are set in a groundmass of microcrystalline feldspar.

Anhedral to subhedral crystals of secondary untwinned K-feldspar, with subsidiary microcline, up to ∿1.25 mm across form extensive vein-like and patchy replacements. These crystals are dusted with fine opaque inclusions (?due to alteration) imparting a pinkish-brown colouration. Fine-grained opaque material (∿0.025 mm grains) forms irregular patches up to ∿2 mm across which are partially replaced by malachite.

The sample is of a feldspathised and silicified acid ?tuff.

Sample: B218B; TSC35004

0087

Hand Specimen:

This sample is of a grey, coarsely crystalline, non-laminated dolomitic rock, with irregular 'patches' of quartz and yellowish feldspar. The rock is partially replaced by irregular veins and blebs of opaque material and malachite.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	70
Quartz	20
Feldspar	10
Malachite	1
Opaque	1
?Barite	Trace
?Chrysocolla	Trace

The sample is of an extensively dolomitised quartz/feldspar rock. Dolomite crystals are subhedral to euhedral, less than 0.6 mm across and partially replace quartz and feldspar. Some smaller euhedral crystals are skeletal with a core of quartz and feldspar. Zoning of some crystals may be observed due to the presence of fine opaque inclusions, with up to 3 growth stages being observed.

Quartz crystals are up to 5 mm across, anhedral and strained. Boundaries are irregular to sutured and grains contain lines of minute opaque inclusions that cross quartz/quartz boundaries. Recrystallisation of coarse-grained quartz to fine-grained unstrained grains has occurred around grain boundaries and along closely spaced fractures in areas up to ∿1 cm across where quartz forms ∿100% of the rock. Colourless to very pale yellowish-green, faintly pleochroic ?chrysocolla fibres occur in veins <0.1 mm thick between quartz grains in these areas. Some quartz-rich areas contain very minor amounts of feldspar.

Frequently elongate crystals of feldspar, up to 0.6 mm in length are anhedral with feldspar/feldspar boundaries being highly irregular and diffuse. Crystals are commonly of microcline with subordinate untwinned K-feldspar and are only lightly 'dusted' with fine opaque grains. Rare feldspar crystals are partially replaced by quartz along twin planes.

Malachite occurs in irregular patches up to 0.6 mm across, in thin veins and fractures and as an intergranular 'matrix' where replacement has occurred selectively along grain boundaries. It commonly occurs as a replacement of opaque minerals, but may have formed as a separate phase in some occurrences.

Poikiloblastic ?barite crystals are up to 0.4 mm across, partially replacing feldspar and quartz. The diagenetic relationship of the barite to the dolomite in this section is not clear.

Sample: B218E; TSC35003

0088

Hand Specimen:

The sample consists of angular quartz and feldspar grains and occasional lithic clasts in a pale green ?feldspathic structure-less matrix which is extensively replaced by malachite and chrysocolla.

Thin Section:

A visual estimate of the constituents gives:

	% (very approximate)
Quartz	45
Feldspar	40
Clay minerals	10
Volcanic glass	1-2
Malachite	1-2
Opaque	1
Chrysocolla	<1
Muscovite	Trace
Tourmaline	Trace
Apatite	Trace
Chlorite	Trace
Dolomite	Trace

The sample is of a feldspathised and silicified volcaniclastic which has been copper mineralised and slightly dolomitised.

Quartz crystals are of primary volcanic and secondary origin. Primary quartz form small microphenocrysts in a microcrystalline groundmass of K-feldspar and quartz. Small (∿0.05 mm) crystals are also present in volcanic glass fragments.

Anhedral to subhedral crystals of secondary quartz up to ∿3 mm across occur in veins up to ∿5 mm in length and irregular patches up to 3-4 mm across. Small approximately straight veinlets of quartz up to ∿0.5 mm x 0.05 mm are common.

Anhedral crystals of secondary microcline and untwinned K-feldspar up to ∿0.4 mm across replace fine-grained volcanic material and are commonly marginal to and partially replaced by crystals of secondary quartz occurring in veins.

Wispy feldspar crystallites in volcanic glass commonly show a partial spherulitic texture.

Amorphous to crystalline, frequently fibrous malachite forms irregular patches up to ∿1.5 across, commonly partially pseudomorphing opaque material and partially replacing quartz and feldspar. Malachite is also found infilling irregular fractures and in veins when it appears to be later than the associated chrysocolla.

Films of fibrous chrysocolla ∿0.015 mm thick form and line veins and occur as irregular sinuous to spherulitic replacements of fine-grained volcanic material. Rare brown colouration is probably due to iron or copper oxides.

Rare anhedral muscovite flakes are up to 0.5 mm across and are partially replaced by malachite and tourmaline.

Tourmaline commonly occurs as radiating accicular crystals up to ∿0.15 mm in length partially replacing secondary K-feldspar in patches up to ∿1.5 mm across.

Rare anhedral dolomite crystals up to ∿0.2 mm across occurring in dominantly chrysocolla pseudomorphs of ?secondary K-feldspar are partially replaced by the chrysocolla.

Sample: B224; TSC35005

0090

Hand Specimen:

The sample consists dominantly of pale brown to colourless, fine-grained, quartz with a high percentage of irregular patches and "veins" (both with diffuse margins) of white, 'sugary' quartz, which is frequently highly porous and permeable. Rare small (<2 mm) patches of kaolinite also occur.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	99
Dolomite	<1

This is very similar to samples B41 and B57, consisting of a mosaic of quartz grains. Patches of coarse grained (up to ∿2 mm) quartz contain anhedral crystals with a wide range in size and shape; boundaries are straight to curved and in many places recrystallization to smaller more euhedral grains has occurred.

In many fine-grained areas, quartz crystals ∿0.015 mm across are approximately round with diffuse margins.

These areas also appear to have partially recrystallised to coarser grained quartz.

Between these two extremes of grain size are areas where quartz forms an approximately equigranular mosaic of subhedral to euhedral crystals up to ∿0.2 mm across. These crystals have straight boundaries and a 120° triple points and it is suggested that this is an equilibrium microstructure to which the coarser and finer quartz has partially recrystallised.

Rare small (<0.03 mm) dolomite rhombs are replacing quartz.

Inclusions in coarse-grained quartz are similar to those seen in other samples (i.e. B194/80) and it appears extreme silicification of a fine-grained volcanic rock is a likely origin of this lithology.

Sample: B234; TSC35006

0091

Hand Specimen:

The sample is friable, highly oxidised and composed dominantly of white feldspar and quartz with extensive veining and patchy replacement by malachite and subsidiary chrysocolla.

Thin Section:

A visual estimate of the constituents gives:

	% (very approximate)
Feldspar	40
Quartz	20
Malachite	20
Opaque	10
Limonite	5
Mica	5
Chrysocolla	<1

The sample appears to be of an extensively feldspathised and silicified volcanic rock which has been mineralised.

Feldspar crystals are anhedral, up to ∿0.7 mm across, and commonly of microcline, with subsidiary untwinned K-feldspar. All the feldspar is altered to some degree, with fine-grained opaque inclusions giving a 'dusty' appearance. Minor inclusions of quartz and ?sericite appear to be due to alteration.

Feldspar is intergrown with anhedral crystals of quartz up to ∿1 mm across. Boundaries between quartz crystals are smooth and irregular and crystals contain fine-grained opaque inclusions.

Tabular mica flakes up to 0.3 mm across of a pale yellow pleochroic variety are intergrown with quartz and feldspar and appear in many places to be partially replacing the feldspar.

Much of the rock has been replaced by opaque minerals, in some places only the mica flakes surviving and these have been partially altered to limonite and replaced by malachite. Malachite may also have been introduced as a separate phase in areas when no evidence of a replacive origin can be observed.

Amorphous to fibrous chrysocolla forms patches up to 0.4 mm across and thin veins and films in and between feldspar and quartz grains.

Sample: B236; TSC35007

0092

Hand Specimen:

The sample is of a medium-grained, faintly laminated non-crystalline rock ranging in colour from greenish to brownish purple with crystals and lens shaped aggregates of white ?feldspar crystals.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	30
Feldspar	30
Quartz	25
Altered ?talc	5
Mica	5
Clay minerals	3
Opaque	2
Chlorite	Trace
Chrysocolla	Trace
Tourmaline	Trace

The sample is of a partially dolomitised medium-grained, quartzo-feldspathic rock in which the quartz and feldspar appear to be of secondary origin.

Subhedral to euhedral crystals of dolomite up to 2 mm across are frequently zoned and poikiloblastic with inclusions of quartz and feldspar. In some crystals the inclusion to dolomite ratio is up to 50% and inclusions commonly partially separate a thin secondary dolomite growth from the main part of the crystal. Larger, more euhedral dolomite crystals are more common in sections of the rock with an absence or very low percentage of mica.

Anhedral to subhedral crystals of microcline and K-feldspar up to ∿0.8 mm across form areas up to ∿1 cm across where they are intergrown with very minor amounts of quartz and are extensively replaced by mica, dolomite and talc. In some areas feldspar is also replaced by quartz.

Sections of the rock now formed of clay minerals, with small (∿0.15 mm) feldspar crystals, appear to be partially replaced by coarser grained feldspar and quartz and may represent the 'original' non-feldspathised/ silicified rock.

Anhedral to subhedral quartz crystals up to ∿1 mm across form highly irregular patches and veins partially replacing feldspar. Large crystals are frequently fractured and some show marginal recrystallisation to a fine-grained, more euhedral quartz mosaic. Lines of fine opaque inclusions crossing quartz/quartz boundaries are typical of 'secondary' quartz seen in other samples.

Approximately equidimentional subhedral flakes of a pale yellowish-green pleochroic 'fibrous' mica are up to ∿0.15 mm across with an apparently random orientation. Rare flakes are partially altered to a green chlorite (?penninite). Mica and dolomite appear to be of the same age.

?Talc fibres up to 0.8 mm in length replace quartz, feldspar, dolomite and mica and form irregular fibrous patches up to 1 to 2 mm across. Many fibres are partially altered to chlorite, but due to staining with alizarin red-S, it is not possible to identify other alteration products.

Partially oxidised opaque grains are up to 0.2 mm across; chrysocolla forms rare films around quartz and feldspar grains.

The sample appears to be of a partially feldspathised and silicified fine-grained volcanic which has been partially replaced by dolomite and mica, with later development of talc.

Sample: B242; TSC35008

0094

Hand Specimen:

The sample is of a pale brown to cream fine-grained, thinly laminated 'flinty' siltstone. Irregular colour variations may be due to growth of secondary quartz or varying states of oxidation of the opaque components.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	85
Opaques	10
Feldspar	5
Tourmaline	Trace

The sample is of a thinly laminated ?siltstone.

Subhedral feldspar crystals of untwinned ?K-feldspar and microcline less than 0.1 mm across are unaltered and anhedral to subhedral primary quartz grains are approximately the same size.

These crystals are set in a microcrystalline groundmass of quartz; lamination is imparted by rare concentrations of coarser feldspar and quartz grains, and concentrations of opaque grains.

Anhedral poikiloblasts of secondary quartz are up to 0.6 mm across and occur as single crystals and clots up to 0.8 mm across. Inclusions are of opaque grains and microcrystalline groundmass.

Coarser opaque grains up to 0.15 mm across are concentrated in lamellae with coarser quartz and feldspar crystals; generally opaque grains are <0.1 mm across and are disseminated through the rock. Rare crystals of tourmaline <0.05 mm across have a similar distribution.

Sample: B243; TSC35009

0095

Hand Specimen:

The sample is of a soft, finely laminated ?limonitic ?siltstone with flattened elongate quartz blebs up to ∿4 mm in length. These appear to represent infilled vesicles and the sample is probably of a bedded tuff.

Thin Section:

A visual estimate of the constituents gives:

	%
Clay minerals	50
Feldspar	20
Quartz	20
Opaque	10

The sample is of a fine-grained, faintly laminated siltstone (or ?tuff) with the matrix altered to clay minerals with extensive staining by opaque oxides. Lensoid blebs up to ∿4 mm x 1.5 mm, aligned with their long axes parallel to the lamination; are dominantly of fine-grained quartz.

Anhedral to rare euhedral crystals of feldspar up to ∿0.2 mm across are of microcline and untwinned ?K-feldspar, Rare irregularly shaped aggregate grains up to ∿0.2 mm across are of feldspar and quartz and feldspar.

Lensoid quartz blebs are composed dominantly of subhedral quartz crystals 0.03 mm across, with rare crystals up to 0.6 mm across. Grain size distribution within individual blebs appears random with a faint suggestion of coarser crystals in the centre of some blebs. Some blebs are partially replaced by opaque minerals and in some orientation of quartz grains around these appears to be related to the boundaries of the opaque grains; some opaque grains have thin discontinuous overgrowths of "orientated" quartz, possibly due to growth of quartz crystals in pressure shadows. Some blebs contain small (∿0.15 mm) patches of host material marginally replaced by quartz. A thin (0.1 mm) quartz vein appears to be of the same generation as the quartz blebs. The size, shape, regular distribution and the secondary nature of the quartz infill all suggest these blebs are deformed infilled vesicles.

The lamination in the rock is due to variation in the grain size of the feldspar and quartz.

Euhedral ?pyrite grains are up to ∿0.3 mm across and partially altered to ?haematite. Larger grains are frequently associated with quartz blebs.

Sample: B250; TSC35010

0096

Hand Specimen:

The sample is of a brownish-grey, ?crystalline rock, extensively replaced by dolomite and a blue amphibole forming fibres up to ∿1 cm in length.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	40
Feldspar	40
Amphibole	10
Mica	5
Dolomite	3
Tourmaline	1
Opaque	<1

The rock consists of amphibole and dolomite porphyroblasts in a fine-grained crystalline 'groundmass' of quartz, feldspar, mica, tourmaline and opaque minerals.

Anhedral crystals of untwinned ?K-feldspar and microcline up to ∿0.3-0.5 mm across are commonly clear with vestigal alteration along cleavage planes. They are partially replaced by amphibole, dolomite, tourmaline and plagioclase. Quartz grains of similar form and size are similarly partially replaced.

Plagioclase crystals are subhedral, generally <0.2 mm across and have a maximum extinction angle of 15°, indicating a probably albitic composition. They commonly occur in irregular patches up to 2 to 3 mm across, intergrown with quartz and partially replaced by crystals of dolomite and amphibole.

Anhedral to subhedral tabular mica flakes, generally <0.1 mm across, are of a pale yellowish-greenish-brown to colourless pleochroic variety. They are apparently randomly orientated and are finely disseminated through the rock with the exception of plagioclase/quartz patches.

Tourmaline crystals have a similar distribution and are up to ∿0.15 mm in length and display a yellow and green to colourless pleochroism.

Amphibole poikiloblasts up to 2 mm in length are fibrous to lathlike with euhedral cross sections. Very rare fibres display approximately parallel extinction; the maximum extinction is ∿14°. Crystals are deeply coloured with violet-blue to bottle green pleochroism. A maximum extinction angle of 14° combined with other properties indicates the crystals to be of magnesioriebeckite or magnesiocrocodilite.

Subhedral to euhedral porphyroblasts of dolomite up to ∿1.5 mm across, commonly poikiloblastic with inclusions of quartz and albite, are intergrown with crystals of amphibole. They occur dominantly in patches composed mainly of plagioclase and quartz.

Rare opaque grains are up to 0.8 mm across with inclusions of K-feldspar and mica and marginal alteration to ?haematite.

The rock appears to have been composed dominantly of K-feldspar and quartz; this has partially recrystallised to form quartz, albite, mica and tourmaline.

Mg metasomatism has then led to the formation of magnesioriebeckite and dolomite. There is no indication that the fibrous amphibole has developed by transformation of the non-fibrous variety.

Sample: B253; TSC35011 0098

Hand Specimen:

The sample is of a highly porous and permeable rock composed dominantly of pink feldspar crystals and blebs up to 3 mm across of secondary quartz cemented by ?chrysocolla and malachite and partially replaced by rare blebs of azurite up to 5 mm across.

Thin Section:

A visual estimate of the constituents gives:

	% (very approximate)
Feldspar	60
Quartz	20
Chrysocolla	10
Chalcedony	5
Clay minerals	3
Malachite	1
Muscovite	<1
Sericite	<1
Opaque	Trace
Dolomite	Trace
Apatite	Trace
Azurite	Trace

The sample is of a chrysocolla and chalcedony cemented ?vocaniclastic composed dominantly of feldspar.

Anhedral to rare euhedral grains of feldspar up to ∿1.25 mm across, dominantly of microcline with subsidiary untwinned K-feldspar, are 'dusted' with fine opaque inclusions. Some grains are fractured and a few are extensively altered to sericite.

Grains of quartz are seen to partially replace feldspar; they are commonly poikiloblastic, up to ∿6 mm across and anhedral with inclusions of feldspar and rare muscovite flakes. Muscovite flakes not included in quartz are subhedral and up to ∿0.15 mm in length.

Feldspar, quartz and mica grains are commonly surrounded by films of fibrous chrysocolla <0.03 mm thick. Pore spaces between these films are infilled with chalcedony and/or clay minerals.

Generally fibrous malachite forms scattered, usually approximately circular patches up to ∿2 mm across. Chrysocolla is absent from the margins of grains included within these patches, although rare vacancies within these patches are lined with chrysocolla. Formation of malachite appears to have taken place at about the same time as chrysocolla, followed by chalcedony.

Rare subhedral dolomite crystals up to ∿0.15 mm across are included in quartz.

Opaque minerals form rare infills between chrysocolla rimmed grains and one of these infills is ?partially altered to azurite.

Sample: B259; TSC35012 0099

Hand Specimen:

The sample is of a brown oxidised, friable, medium to coarse-grained crudely laminated micaceous ?volcaniclastic. The rock is partially replaced by irregular blebs of secondary quartz up to 1.5 cm across.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	50
Quartz	30
Mica	10
Talc	3-5
Opaque	3-5
Chlorite	<1
Apatite	Trace

The sample is of a poorly sorted and laminated, weakly foliated rock, probably of volcaniclastic origin.

Anhedral to euhedral crystals of microcline and untwinned K-feldspar up to 1.75 mm in length, commonly slightly fractured and rarely bent frequently display slightly irregular lathlike and cigar shaped forms. Elongation ratios are up to x8 and long axes are crudely parallel to the lamination, although occasional elongate crystals have their long axis at up to 90° to the lamination.

Laminations up to 5 mm thick were composed of virtually 100% feldspar and these laminae are partially replaced by white mica, especially where they are finer grained. Mica flakes are generally <0.075 mm in length and many have an irregular, equant form; chlorite is the main alteration product.

Fibrous talc occurs between grains, and partially replaced them where feldspar layers are coarser grained, or where laminae contain quartz.

Quartz is of primary and secondary origin. Primary grains are either single crystals or polycrystalline aggregates of up to 3-4 crystals and in many cases it is difficult to distinguish between primary and secondary aggregates. Primary grains up to 0.75 mm across composed of single crystals are anhedral to subhedral, commonly with slightly rounded outlines.

Secondary quartz forms irregular "augens" up to 5 mm x 1.5 mm parallel to the lamination and occasional irregular patches up to 3-4 mm across.

In many places the matrix to primary grains has been replaced by mica or talc but in some places it can be seen to consist of fine-grained ?K-feldspar.

Opaque grains up to 0.25 mm across are commonly concentrated in mica-rich layers.

Sample: B261; TSC35013

0100

Hand Specimen:

The sample is of a friable, oxidised, pale brown, medium-grained, coarsely laminated rock composed dominantly of partially kaolinised feldspar. Lamination is due to variations in concentration of feldspar and oxidised opaque minerals.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	65
Quartz	20
Opaque	10
Clay minerals (including sericite)	5
Tourmaline	Trace
Dolomite	Trace

Subhedral to euhedral feldspar crystals, dominantly of microcline with subsidiary untwinned K-feldspar and up to 1.75 mm in length frequently display lath-like to 'cigar' shaped outlines. These crystals exhibit very poor dimensional parallelism, and many crystals have their long axis at high angles to the lamination. Feldspar crystals are only very rarely intergrown; some are bent and most are highly fractured and dusted with fine opaque incluions. Partial alteration of feldspar to quartz and partial replacement by fine opaque minerals are also common features.

Quartz crystals up to ∿0.5 mm across form single grains, frequently with rounded to corroded cuspate outlines. Patches of secondary quartz up to 2 mm across are slightly elongate parallel to the lamination.

Feldspar and quartz crystals are set in a fine-grained matrix composed dominantly of clay minerals and subsidiary sericite, extensively replaced by opaque minerals.

Lamination is due to varying proportions of matrix to crystals, irregular concentrations of primary and secondary quartz and varying concentrations of opaque constituents.

The sample is of a partially silicified feldspathic tuff.

Sample: B264; TSC35014

0101

Hand Specimen:

The sample consists of soft, fine-grained, grey material, extensively replaced by feldspar, quartz, dolomite and talc with patchy development of malachite.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	55
Quartz	30
Feldspar	10
Talc	1
Chlorite	<1
Mica	<1
Cuprite	<1
Opaque	Trace
Malachite	Trace
Chrysocolla	Trace

The sample consists of grains of dolomite, quartz and feldspar set in a groundmass of fine-grained feldspar, talc and chlorite.

Dolomite forms subhedral to euhedral crystals up to ∿2 mm across and irregular aggregates of smaller crystals up to the same size. Crystals frequently contain an approximately central core heavily dusted with fine opaque inclusions surrounded by an inclusion free zone. Cores have irregular forms and do not appear to be of detrital origin and zoning is probably due to two phases of dolomitisation.

Quartz commonly occurs as subrounded to rounded single grains up to ∿1.25 mm across. Occasional very slightly rounded six-sided euhedral crystals are seen. Many quartz grains exhibit secondary quartz overgrowths and secondary quartz frequently fills pore-spaces between quartz grains. Quartz is occasionally partially replaced by dolomite.

Crystals of feldspar up to 2 mm in length are of microcline, with subsidiary untwinned K-feldspar. They are frequently highly fractured and replaced by dolomite, talc, mica, chlorite and opaques.

Some feldspar crystals display lath-like, 'cigar' or coffin shaped outlines but these are less well developed than in many other samples.

Much of the "groundmass" composed of talc, mica and chlorite may be derived from alteration of feldspar. Talc forms fibrous masses frequently intergrown with these minerals and also forms approximately striaght single fibres up to 2 mm long replacing dolomite, quartz and feldspar.

Green pleochroic chlorite (?penninite) is found dominantly as an alteration of a pale yellowish-brown pleochroic mica. The mica appears to be intergrown with, or partially replacing, dolomite.

Cuprite partially replaces opaque grains up to 0.7 mm across.

Malachite, with subsidiary chrysocolla, infills irregular fractures and occasional 'pore spaces' between grains.

The sample may possibly be of a highly altered volcaniclastic rock.

Sample: B265; TSC35015

Hand Specimen: 0102

The sample is of a thinly laminated cream through pink to grey ?dolomitic rock with thin veins and cavities partially infilled with calcite. Etching with hydrochloric acid showed wide variations in suseptibility between laminae. Dark grey layers were least affected, probably reflecting a high Mg content.

Thin Section:

A visual estimate of the constituents gives:

	%	
High Mg-calcite	95	
Muscovite	1	
Quartz	1	Variable, in thin laminae
Kaolinite	<1	
Unknown	<1	
Feldspar	Trace	

Staining the section with alizarin red-S produced anomalous results; the section was restained, half with Alizarin red-S and half with Clayton yellow. The latter stain showed the carbonate to be high Mg-calcite. Crystals are up to 0.25 mm across in thin laminae where high Mg-calcite is replacing quartz, feldspar and material now altered to kaolinite. Most carbonate crystals elsewhere are <0.025 mm across.

Euhedral muscovite flakes up to 0.4 mm in length are unaltered and occur in thin laminae with subangular quartz grains, up to ∿0.3 mm across, and kaolinite. Rare euhedral crystals of microcline are scattered through the rock.

The unknown mineral occurs in a similar way to muscovite; forming single crystals up to 0.5 mm in length and clots of up to 1 mm across of up to 4-5 crystals. It is colourless, with a faint wavy, "micaceous" cleavage, low birefringence and has a uniaxial-ve character. It is very tentatively identified as damourite an altered muscovite containing more water (or more easily removed water).

The sample is of a thinly laminated magnesian limestone with rare thin laminae of non-carbonate material probably of volcanic, air-fall origin.

Sample: B266; TSC35016

0103

Hand Specimen:

The sample is of a dark grey laminated dolomite, with carbonate partings and veins which break the layers up into small blocks giving the rock a brecciated appearance.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	95+
Quartz	<1
Feldspar	<1
Muscovite	<1
Opaque	<1

The sample is of a sedimentary dolomite and can be divided into two lithologies, one 99+% pure dolomite and the other with a high percentage of muscovite, quartz and opaques.

Anhedral to euhedral dolomite crystals range in size from <0.015 mm to ∿0.6 mm. Variation in crystal size partially defines a coarse lamination in the rock. Coarser grained dolomite is also found associated with quartz in 'veins' which cross-cut the lamination. Etching with hydrochloric acid showed much of this carbonate to be more susceptible to solution, possibly indicating a lower proportion of Mg.

Quartz in these veins appears detrital, their margins are ill-defined and they are probably a pre-consolidation diagenetic structure. A careful examination of the more euhedral dolomite grains showed no rounded detrital cores with secondary overgrowths and it is assumed the dolomite was formed by direct chemical precipitation or by diagenetic alteration soon after deposition.

Quartz grains are up to ∿1 mm across and the larger grains generally have rounded outlines. Smaller grains are usually more angular and some have formed by insitu disintegration of larger grains. Minor replacement of quartz grains by dolomite is commonly marginal.

Feldspar crystals are small (0.3 mm), angular and composed dominantly of microcline with subsidiary untwinned K-feldspar. They frequently have a 'dusted' appearance due to alteration and are commonly marginally replaced by dolomite.

Muscovite flakes are up to 0.6 mm in length and some have slightly rounded ends (?due to abrasion). They are generally concentrated in thin lamellae with a higher percentage of opaque minerals and quartz. Flakes with apparent random distribution and orientation also occur in the more pure dolomitic rock.

Opaque minerals form subhedral grains <0.3 mm across; concentration of these also partially defines the laminations. Iron oxide is present in fractures and forms the matrix in fracture zones where brecciation has occurred.

Many fractures have no movement along them, but along some 'faulting' has occurred with some rotation of the 'fault blocks'. Rounded fragments of the same lithology incorporated in the rock may have originated in this way and parts of this sample could be termed a preconsolidation breccia.

Sample: B268; TSC35017

0104

Hand Specimen:

The sample consists of grey, fine-grained, angular, dolomitic clasts up to 1.5 cm across and crystalline quartz ?fragments up to 2 cm across, set in a yellowish crystalline dolomitic groundmass.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	70
Quartz	15
Feldspar	15
Mica	<1
Talc	<1
Opaque	Trace

The sample consists of subangular to subround dolomitic clasts up to ∿1.5 mm across, commonly containing quartz, feldspar and mica, set in a groundmass of similar composition.

Subhedral to euhedral dolomite crystals up to 1 mm across occurring in the groundmass partially replace quartz and feldspar and are partially replaced by fibrous talc. Approximately equant flakes of a pale yellow, faintly pleochroic mica up to ∿0.1 mm across appear to be intergrown with the dolomite.

Anhedral to subhedral quartz crystals up to 0.75 mm across in the groundmass are partially replaced by dolomite; rounded outlines of some grains may be original features of the quartz grains. Where polycrystalline aggregates of quartz occur their boundaries are due to replacement by dolomite and this quartz is probably of secondary origin.

Subhedral to euhedral crystals of untwinned K-feldspar and microcline, occasionally with lath-like and cigar shaped forms up to 0.4 mm in length, are partially replaced by dolomite. Some clasts up to 5 mm across contain up to 20-30% feldspar and some contain ∿15% feldspar and 10% muscovite.

Opaque grains up to 0.3 mm across appear randomly distributed through the rock. Iron oxide staining occurs around some clasts in the groundmass associated with patches of talc and along irregular fractures.

The sample is of a dolomitic breccia of uncertain origin.

Sample: B270; TSC35018

0105

Hand Specimen:

The sample is of a faintly laminated, pale brown to brownish-grey sandstone. Slight reaction with hydrochloric acid indicates the dominant component is probably dolomite.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	70
Quartz	15
Feldspar	10
Volcanic and dolomitic rock fragments	∿1-2
Talc	∿1
Mica (including chlorite)	<1
Opaque	<1

The sample is of a medium to coarse-grained sandstone composed dominantly of dolomite. The dolomite grains are up to ∿1.4 mm across and frequently possess a subhedral to euhedral form; in some cases this can be seen to be due to secondary dolomite overgrowths on more rounded grains and some of the smaller euhedral crystals may be entirely of secondary origin and these can frequently be seen partially replacing quartz grains.

Quartz grains are up to ∿1 mm across and composed dominantly of single crystals; composite grains of up to five crystals are also seen. Grains generally have subrounded outlines and in some cases the presence of crystal faces can be seen to be due to secondary quartz overgrowths. Undulose extinction and lines of minute opaque inclusions are common features.

Grains of feldspar are dominantly of microcline, with subsidiary untwinned K-feldspar and are frequently dusted with inclusions, subangular in outline and elongate, up to ∿0.8 mm in length.

Rare volcanic fragments have subangular outlines, are up to ∿1.5 mm across and are composed of microcrystalline feldspar extensively altered to ?sericite.

Dolomitic fragments of similar size are composed of fine-grained (<0.1 mm) subhedral dolomite and subsidiary flakes of muscovite.

Talc fibres are up to ∿1 mm in length and commonly occur in patches where they replace dolomite. Some of these "patches" may be of non-replacive origin.

Rare mica flakes are up to ∿0.15 mm across and are extensively replaced by highly birefringent pale green pleochroic chlorite.

Rare anhedral patches of opaque material are up to 0.3 mm across and frequently associated with occurrences of talc.

Sample: B271; TSC35019 0106

Hand Specimen:

The sample is of a white to light grey, coarsely crystalline dolomite with euhedral porphyroblasts of dolomite up to 1 cm across. Rare thin veins and cavities are lined with crystalline calcite.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	75
Quartz	15
Feldspar	10
Talc	1
Mica	Trace

The sample is of a porphyroblastic dolomite, with dolomite crystals partially replacing quartz and feldspar. Rare talc fibres replace quartz, feldspar and dolomite.

Dolomite crystals up to ∿1 cm across are subhedral to euhedral and frequently poikiloblastic with inclusions of quartz, feldspar and mica; large crystals are concentrated in ill-defined irregular zones. Smaller crystals are frequently zoned. Anhedral to subhedral quartz crystals up to ∿1 mm across form individual grains and vein-like and patchy aggregates up to ∿4 mm across.

Quartz/quartz boundaries are generally smooth, curved to straight and fine lines of opaque inclusions frequently cross these boundaries. Most crystals are unstrained. These features are characteristic of secondary quartz seen in other undolomitised samples.

Anhedral to euhedral crystals of microcline and untwinned K-feldspar frequently contain minute opaque inclusions which frequently show a zonal arrangement probably related to compositional variations. Many crystals have a lath-like and cigar shaped form (up to ∿1.5 mm x 0.3 mm) and are partially replaced by quartz, dolomite and ?talc.

Thin, frequently straight fibres of ?talc up to ∿2 mm in length appear to be randomly orientated and distributed and are the last crystals to form.

Mica flakes <0.03 mm across and partially altered to ?chlorite are included in dolomitic poikiloblasts.

The sample appears to be of a partially silicified and ?feldspathised coarse-grained, ?volcaniclastic which has been extensively dolomitised, with later very minor formation of talc.

Sample: B276; TSC35020 0107

Hand Specimen:

The sample is of a medium-grained, non-laminated, greenish to pinkish-white rock composed dominantly of dolomite.

Thin Section:

A visual estimate of the constituents gives:

	%	
Dolomite	95	includes rock fragments
Quartz	2	
Feldspar	1	
Talc	<1	
Mica	<1	
Opaque	<1	

Dolomite crystals are highly variable in size up to a maximum of ∿1 mm across. Coarser dolomite forms a mosaic of subhedral grains, ?intergrown with minor talc and replacing quartz and feldspar. In some areas talc can be seen to be replacing dolomite.

Quartz crystals up to ∿0.6 mm across frequently display undulose extinction, commonly contain lines of minute opaque inclusions and are partially replaced by dolomite and talc. Where quartz grains are in contact, boundaries are commonly irregular and frequently sutured and diffuse.

Feldspar crystals are dominantly of microcline and commonly have a "dusty" appearance due to many opaque inclusions. These are commonly concentrated towards the centres of the crystals which frequently have an irregular elongate form up to ∿0.6 mm in length. Crystals are marginally replaced by dolomite.

Talc forms fibrous to acicular crystals up to ∿0.4 mm in length which are commonly bent. Approximate dimensional parallelism of talc fibres imparts a coarse foliation in some parts of the thin section. White mica flakes are up to ∿0.1 mm across and commonly partially altered to a pale blue-green pleochroic chlorite. Development of talc and alteration of mica may be related to tectonism.

Opaque minerals occur as widely disseminated anhedral to subhedral grains up to ∿0.3 mm across.

Sample: B277; TSC35021

0108

Hand Specimen:

The sample is of a soft friable, light brown, highly altered rock with flecs and irregular laminae composed dominantly of ?kaolinite. Angular quartz grains up to 2 mm across are frequently associated with the kaolinite layers.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	50
Feldspar	30
Kaolinite	10
Opaque	10
Dolomite	Trace
Tourmaline	Trace

The sample is of a partially silicified, fine-grained, feldspathic siltstone or tuff.

Crystals of untwinned K-feldspar and microcline generally <0.15 mm in length form individual grains and irregular "clots" up to 0.75 mm across. Crystals display angular subhedral outlines with occasional lath-like to cigar and barrel shaped forms and are commonly dusted with fine opaque inclusions and frequently partially replaced by quartz and kaolinite.

Occasional subhedral, primary quartz grains up to ∿0.2 mm across display partially "corroded" outlines.

Anhedral to subhedral crystals of secondary quartz up to ∿0.5 mm across form irregular "patchy" replacements up to ∿2.5 mm across. Occasional lines of fine opaque inclusions in quartz cross quartz/quartz boundaries, which are commonly curved to straight.

Kaolinite and fine opaque material form the matrix to quartz and feldspar grains and kaolinite, with minor inclusions of quartz and feldspar, forms opaque-free patches up to 0.6 mm across, frequently with "rounded" outlines.

Opaque grains <0.3 mm across are concentrated in areas less extensively replaced by secondary quartz. Rare dolomite rhombs <0.15 mm across partially replace quartz.

Sample: B278; TSC35022

0109

Hand Specimen:

The sample is of a pale yellowish-brown to grey dolomite with crystals generally <2 mm across. Lamination is absent and patches up to 1 to 2 cm across are extensively recrystallised.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	∿70
Quartz	30
Mica	∿1
Opaque	Trace
Apatite	Trace

Dolomite forms subrounded to angular grains up to ∿2 mm across and many of the grains are subrounded by a thin film of iron oxide. Many grains have secondary dolomite overgrowths with well developed crystal faces.

Quartz grains are up to ∿1 mm across, unstrained and many contain lines of minute opaque inclusions. Many of the quartz grains show development of secondary quartz overgrowths and in some areas quartz grains have developed straight boundaries with 120° triple points. Growth of secondary quartz and secondary dolomite appears to have occurred at approximately the same time, although there is some evidence to suggest that the secondary dolomite developed later in some areas.

Flakes of white mica are generally <0.15 mm across and commonly occur between dolomite grains as scattered individual crystals. Flakes concentrated in small patches up to 0.6 mm across are intergrown with dolomite, and mica flakes may have developed syncronously with secondary dolomite.

Opaque minerals form small subhedral grains up to ∿0.2 mm across and thin films around dolomite grains.

Apatite forms euhedral crystals up to ∿0.05 mm across included in dolomite and quartz grains.

The rock appears to be a dolomitic/quartz sandstone, with secondary development of dolomite, quartz and mica. Dolomite crystals are variably stained by Alizarin red-S and this may be related to variations in Mg content.

Sample: B279A; TSC35023

0110

Hand Specimen:

The sample is of a light grey crystalline, calcitic breccia with dolomitice ?volcanic and quartz clasts up to 3 to 4 cm but generally less than 1 cm across and individual dolomite crystals up to 5 mm across.

Thin Section:

The sample is very similar to B279B. A visual estimate of the constituents gives:

	%	
Calcite	55	includes rock fragments
Dolomite	15	
Quartz	15	
Feldspar	5	
Talc	5	
Mica	5	
Opaque	<1	

Calcite forms most of the matrix to this breccia, where, by analogy with B279B, it has replaced dolomite. Anhedral calcite crystals are up to ∿0.6 mm across and form irregular monomineralic patches up to 2-3 mm across. Dolomite replacements of volcanic and quartz fragments are only partially calcified and in fine-grained rock fragments composed dominantly of dolomite and white mica, with subsidiary quartz and feldspar, calcite has replaced only ∿1% of the dolomite. Large euhedral crystals of dolomite up to ∿3 mm across have generally not been replaced by calcite.

Individual quartz grains are up to ∿1 mm across with irregular to rounded outlines and small inclusions of muscovite are partially replaced by dolomite and calcite. Composite quartz grains up to 5 mm across have similar characteristics and some show undulose extinction.

Single microcline crystals up to approximately 1.0 mm across have angular outlines and a dusted appearance due to partial alteration and are occasionally included in large dolomite crystals.

Volcanic fragments are up to 3 mm across with rounded to angular outlines; some are composed entirely of fine-grained (<0.05 mm) anhedral crystals of untwinned K-feldspar and microcline. In others these crystals form "phenocrysts" in a microcrystalline feldspar groundmass and other fragments are composed entirely of microcrystalline feldspar.

Bent acicular to fibrous crystals of talc occur commonly in the matrix. Mica flakes up to 0.3 mm across are of ?muscovite extensively altered to a highly birefringent pale green pleochroic chlorite.

Rare euhedral opaque grains (?pyrite) are up to 0.6 mm across.

Extensive calcification, a high percentage of talc and chloritization of mica may be genetically related features.

Sample: B279B; TSC35024

0111

Hand Specimen:

This sample is of a light yellowish-brown crystalline dolomitic breccia with dolomitic, ?volcanic, ?siltstone and quartz clasts up to 2.5 cm across. Calcite forms quite a high percentage of the matrix.

Thin Section:

The sample is very similar to B279A. A visual estimate of the constituents gives:

	%
Dolomite	35
Calcite	35
Quartz	15
Feldspar	10
Mica	5
Opaque	<1

The sample is of a partially calcified breccia composed dominantly of dolomitic and volcanic fragments.

Dolomite occurs as small (generally <0.05 mm) anhedral crystals in the matrix of the breccia, as large euhedral crystals up to 5 mm across and in angular dolomitic rock fragments up to ∿1 cm across. Large euhedral crystals have inclusions of dolomite, quartz, feldspar and mica (muscovite) Scriven (1976) has recorded the occurrence of euhedral calcite crystals in volcanic rocks from this area. Dolomite also occurs as a secondary mineral, partially replacing quartz grains and volcanic fragments.

Much of the fine-grained dolomite is replaced by calcite, forming veins up to 0.6 mm across and patches up to 1.5 mm across, where anhedral crystals are up to ∿0.6 mm across.

The calcite is coarser grained than the dolomite it replaces and replacement appears selective. It is suggested this may be related to compositional differences in the dolomite.

Dolomitic rock fragments are made up of anhedral to euhedral crystals of dolomite <0.3 mm across intergrown with white mica and partially replacing quartz and feldspar grains, with occasional thin discontinuous laminations of quartz.

Quartz commonly occurs (in the host rock) as irregular single crystals up to ∿1.5 mm across with inclusions of mica and dolomite and partially replaced by dolomite. Aggregate grains of quartz are up to ∿4 mm across with crystals up to 2 mm across. Boundaries between grains in these aggregates are generally smooth.

Quartz is also present as a partial alteration of fine-grained volcanic fragments where it forms irregular crystals up to 1.5 mm across.

Elongate "dusty" feldspar crystals up to ∿0.8 mm in length have angular to rounded outlines and are generally of microcline. Some volcanic fragments up to 1.5 mm across are composed entirely of anhedral microcline crystals; occasional fragments have minor amounts of anhedral quartz. In some fragments the microcline is extensively replaced by white mica, this having occurred prior to incorporation in the breccia.

One laminated volcanic fragment is composed of >90% microcrystalline feldspar with parallel alignment of thin flakes of muscovite up to ∿0.1 mm in length.

Opaque grains are generally <0.15 mm across and finely disseminated through the rock.

Sample: B280; TSC35025

0112

Hand Specimen:

The sample is of a pale grey to brownish-grey medium-grained, non-laminated, crystalline dolomite, patchily replaced by ?chalcocite and malachite. Azurite forms a single thin (<1 mm) vein.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	65
Quartz	15
Feldspar	10
Mica	5
Opaque	2
Malachite	1
Azurite	1
Rutile	Trace

The rock appears to have been composed of crystalline quartz, feldspar and ?mica; these have now been extensively replaced by dolomite, with subsequent mineralisation and alteration of the opaque minerals. The status of the mica in this sequence is uncertain.

Dolomite forms anhedral to euhedral crystals less than 0.4 mm across and in areas up to ∿3 mm across these may form up to 100% of the rock, frequently the only accessory being mica flakes. Commonly, however, the dolomite can be seen to be replacing quartz and feldspar. Some dolomite rhombs replacing second generation quartz have thin dolomite overgrowths, these being later than the final phase of the quartz.

Quartz appears to be of at least two generations, one the same age as the feldspar, the other as a later vein mineral; both are prior to dolomitisation.

First generation quartz occurs as irregular optically continuous "lakes" up to ∿4 mm across intergrown with feldspar and extensively "dotted" with dolomite rhombs and mica flakes. Some of these quartz crystals contain ?orientated inclusions of sericite, formed prior to dolomitisation.

Second generation quartz occurs in veins up to ∿4 to 5 mm across. Crystals, commonly with smooth irregular boundaries, are up to 1.4 mm across. Around rare, infilled cavities the crystals display good crystal faces and up to 5 or 6 growth phases. The last of these is commonly of a fibrous habit and the central "phase" of the cavity infilling is frequently fine-grained quartz, opaque minerals or malachite.

Feldspar forms irregular crystals up to ∿1.5 mm across; these are commonly of microcline with the central part of the crystals dusted with fine opaque material and frequently contain inclusions of mica.

Mica flakes are generally <0.5 mm across and are commonly of a faintly pleochroic, pale yellowish-brown variety. This may be intergrown with colourless muscovite. The genetic position of the mica is unclear; in many cases it appears intergrown with the dolomite and it is possible it is also of two generations as many flakes appear to have a coloured centre, with a discontinuous rim of colourless mica intergrown with the dolomite.

Opaque minerals occur in veins and as a patchy, discontinuous, irregular replacement up to ∿4 mm across.

Opaque minerals are commonly rimmed and partially to totally replaced by malachite with minor azurite. Patches up to ∿0.8 mm of rutile needles occur in the quartz and feldspar at the margins of the second generation quartz veins.

Malachite forms the central phase of an azurite vein ∿0.4 mm thick and azurite infills minor fractures associated with this vein.

Sample: B284; TSC35026 0114

Hand Specimen:

The rock is composed of coarsely crystalline quartz and feldspar now extensively replaced by ?chalcocite, azurite and malachite. The copper minerals appear to have a crude zonal arrangement, with an 1 cm thick 'core' of ?chalcocite surrounded by an irregular 1 cm thick zone of azurite and malachite, surrounded by a 1 cm+ zone dominantly of azurite.

Thin Section:

A visual estimate of the constituents gives:

	%
Quartz	15
Feldspar	5
Talc	10
Opaque	30
Azurite	30
Malachite	10

The rock appears to have been composed of quartz with subsidiary feldspar; it has been highly brecciated with opaque minerals, azurite, malachite and talc forming the matrix.

Fragments composed almost entirely of quartz are up to 6 mm across; crystals are anhedral up to 3 mm across with undulose extinction and highly irregular and sutured margins. In many places recrystallisation along grain boundaries has occurred. These features suggest the quartz has been subjected to quite intense tectonic stresses.

Most of the quartz is free of incluions - rare grains contain prismatic crystals of tourmaline up to 0.2 mm in length with apparent random orientation.

Individual feldspar grains up to ∿0.4 mm are of untwinned K-feldspar and microcline and are commonly highly fractured. In one area ∿3 mm across the rock appears to have been entirely composed of K-feldspar, now much replaced by talc.

Rare grains of quartz and feldspar also occur.

Bent and contorted talc fibres are up to 0.6 mm in length and occur intergrown with azurite, malachite and opaque minerals.

In patches these fibres lack any obvious orientation, but overall there is some dimensional parallelism.

Azurite growth habits are similar to those described in sample B163. It frequently appears to be replacing opaque minerals and forms optically continuous irregular crystals up to 4 mm across.

Malachite has a similar occurrence to that of azurite and in small areas may be the dominant mineral. It commonly has a fibrous or microcrystalline habit, but occasional tabular crystals up to ∿0.7 mm in length are seen.

Opaque minerals can be seen to have once formed a higher percentage of the rock. Much appears to have been introduced at the same time as the brecciation, forming the matrix. Some however, has originated as in situ replacement of feldspar.

Sample: B285; TSC35027 0115

Hand Specimen:

The sample is of a white to pale greenish-grey massive crystalline fine-grained, feldspathic rock, with patches up to 8 mm across of coarsely crystalline feldspar.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	∿80
Quartz	15
Opaque	3
Tourmaline	Trace
Rutile	Trace

The sample is of a feldspathised, fine-grained volcanic rock, probably a tuff.

Feldspar crystals are of primary volcanic and secondary origin. Subhedral to euhedral phenocrysts of microcline and untwinned K-feldspar, frequently lath shaped up to ∿1.75 mm in length are set in a groundmass composed dominantly of microcrystalline, ?K-feldspar, microcline and subsidiary quartz. In some section of the rock these small groundmass crystals have an irregular lath-like form and a flow or "bedded" structure is due to dimensional parallelism of these crystallites. This feature, combined with textural variations in the groundmass and the slightly 'rounded' corners of some phenocrysts suggests the rock may be a tuff.

Anhedral to subhedral crystals up to 1.25 mm across of untwinned K-feldspar, microcline and albite form irregular veins and patches, replacing the phenocrysts and groundmass. Up to ∿30% of this secondary feldspar appears albitic and this proportion is much higher than in most other similar samples.

Minor amounts of quartz are intergrown with secondary feldspar, and some of the microcrystalline quartz in the groundmass may also be of secondary origin.

Opaque grains less than 1 mm across are commonly associated with secondary feldspar, partially replacing it.

Sample: B288/80; TSC35319

0116

Hand Specimen:

The sample is of a pale brownish-white, crystalline, fine-grained (<3 mm) dolomitic breccia with quartz and dolomite clasts.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	75
Quartz	20
Volcanic clasts (dominantly composed of feldspar)	2
Feldspar	1-2
Opaque	1
Muscovite	Trace
Sericite	Trace

Subhedral to euhedral crystals of dolomite up to 1.75 mm across form the matrix and fine-grained dolomite (<0.05 mm) is the dominant component of subrounded to rounded clasts up to 2.5 mm across. Larger dolomite crystals in the matrix are commonly slightly poikiloblastic with inclusions of feldspar, mica and dolomite.

Dolomite clasts are of two types; the dominant has small (up to 0.4 mm) crystals of microcline and untwinned K-feldspar as the main accessory with with rare muscovite flakes. These feldspar crystals occasionally display lath shaped outlines. Subsidiary clasts are formed exclusively of dolomite.

Commonly anhedral to subhedral quartz crystals up to 1.75 mm across form single grains and multicrystalline aggregates of up to 5 crystals. Quartz crystals in aggregates frequently display undulose extinction and lines of minute opaque inclusions cross quartz/quartz boundaries. Rare quartz crystals display secondary quartz overgrowths and the occurrence of rare anhedral crystals may be due to secondary overgrowths. Quartz is slightly replaced by dolomite. Occasional quartzite clasts composed dominantly of fine-grained (<0.05 mm) equigranular quartz crystals with straight boundaries and equal angle triple points are more extensively replaced by dolomite (up to ∿50%).

Angular to subangular volcanic clasts up to ∿5 mm across are composed dominantly of small (up to 0.15 mm) microphenocrysts of untwinned K-feldspar and microcline, with subsidiary quartz, in a fine-grained groundmass of microcrystalline ?feldspar, now extensively altered to sericite and replaced by opaque minerals.

Subhedral to euhedral single crystals of microcline and ?untwinned K-feldspar up to 1 mm across are commonly 'dusted' with opaque inclusions and partially altered to sericite.

Muscovite flakes up to 0.2 mm in length are commonly found around the margins of fine-grained dolomite clasts and rare flakes are altered to ?chlorite and extensively replaced by opaque minerals.

Opaque grains up to 0.2 mm across extensively replace volcanic fragments and form the matrix to dolomite crystals in indistinct patches up to 0.5 mm across.

Sample: B289/80; TSC35320 0117

Hand Specimen:

The sample is of a white, soft, relatively heavy concentrically zoned concretion with very minor amounts of calcite. The concretion appears to be dominantly composed of barite.

Thin Section:

A visual estimate of the constituents gives:

	%
Barite	98
Clay minerals (including sericite)	1
Quartz	<1
Calcite and dolomite	<1
Opaque	Trace
Feldspar	Trace

Particles of the host rock are present on the outer surface of the concretion and as small inclusions within it. The host rock is composed dominantly of ?kaolinite and sericite with occasional anhedral quartz grains up to 0.4 mm across frequently displaying "corroded" outlines. Rare subhedral crystals of microcline and untwinned K-feldspar are up to 0.1 mm across.

Barite occurs as lamellar, to fibrous, frequently radiating crystals up to 1.25 mm in length. Crystals in the central and outer zones of the concretion are well formed and free of incluions. Those in the intermediate zone are more fibrous and dusted with inclusions.

The inner barite core is partially surrounded by a thin irregular layer of calcite and dolomite up to 0.5 mm thick and displaying up to four growth stages, two of dolomite and two of calcite.

Sample: B290/80; TSC35321

0118

Hand Specimen:

The sample is of a light grey, hard, massive, microcrystalline dolomite with highly irregular, hard patches of white ?dolomite. Irregular voids up to ∿7 mm across are partially to wholly infilled with soft white powdery material (?kaolinite). Slight reaction with hydrochloric acid around some of the voids may indicate a lower Mg-content of the dolomite in these areas.

Thin Section:

A visual estimate of the constituents gives:

	%
Dolomite	90
Quartz	8
Clay minerals (including ?sericite)	2
Opaque	Trace

Subhedral dolomite crystals generally <0.025 mm across form an approximately equigranular mosaic. Slightly coarser dolomite crystals (up to ∿0.05 mm) occur where dolomite has partially to wholly replaced quartz and material now formed of clay minerals and sericite.

Quartz forms generally anhedral single grains up to ∿0.25 mm across apparently randomly distributed through the rock and partially replaced by dolomite. It is not possible to determine optically if this quartz is a primary constituent of the rock, or formed as a secondary mineral prior to possible dolomitisation.

Quartz of probable secondary origin forms irregular elongate patches up to 3 mm in length and lines cavities up to ∿6 mm length, infilled with clay minerals and ?sericite. Quartz can be seen to have partially replaced the cavity-infilling material and both are partially replaced by dolomite. Quartz crystals are anhedral to subhedral up to ∿0.5 mm across and display slightly curved to straight grain boundaries and slightly undulose extinction. Many crystals contain fine lines of opaque inclusions which commonly "fade away" within single crystals. In some cases however, lines of inclusions cross quartz/quartz boundaries.

Clay minerals, commonly with minor amounts of quartz also occur as pseudomorphs of ?muscovite with euhedral outlines. Rare irregular patches of clay minerals not rimmed by secondary quartz are up to ∿0.5 mm across.

The origin of this rock and the structures within it are a matter for speculation.

Sample: B291; TSC35322

0119

Hand Specimen:

The sample is of a weathered volcanic breccia composed dominantly of feldspar crystals up to 1 cm in length iwth subsidiary fine-grained, dark volcanic clasts up to 1.5 cm. The rock has been partially chloritised and partially replaced by dolomite and calcite.

Thin Section:

A visual estimate of the constituents gives:

	%
Feldspar	70
Calcite	15
Dolomite	5
Chlorite	3
Opaque	3
Tourmaline	2
Mica	1
Quartz	<1

The sample is of a partially dolomitised and calcified volcanic breccia, consisting dominantly of feldspar crystals, with subsidiary coarse to fine grained feldspathic igneous fragments.

Anhedral to subhedral feldspar crystals, dominantly of microcline with subsidiary untwinned K-feldspar, frequently display lath-like and cigar to barrel shaped outlines. Crystals are commonly between 0.25 and 1.5 mm in length, unsorted, occasionally bent, and display no dimensional parallelism. Occasional rounded rock fragments up to 4-5 mm across are made up of anhedral feldspar crystals up to ∿1.0 mma cross with a typical intrusive igneous texture.

Subrounded, fine-grained rock fragments are all composed of feldspar. In some,rare microphenocrysts up to ∿0.05 mm across are set in a microcrystalline groundmass of the same material and these display a faint "bedded" texture . In one of these fragments an open fracture ∿0.15 thick contains small subrounded feldspar crystals in a groundmass of opaque and minor carbonate. It is probable these feldspar crystals were carried into the fracture by hot fluids and/or gases.

In some of the other rock fragments composed of approximately equigranular, xenomorphic microcline and untwinned K-feldspar, distinct banding can be seen.

Rare subrounded fragments up to ∿1.0 mm across of brownish-yellow non-crystallin material (?palagonite) may be of volcanic glass.

The matrix between the crystals and rock fragments is composed dominantly of opaque material and chlorite, with occasional patches of chlorite up to 2.5 mm across. Much of the feldspar contains fine "hairs" of ?chlorite up to 1.0 mm in length.

Flakes of muscovite up to ∿0.8 mm across, extensively Fe-stained, are associated with small ?palagonite fragments and feldspar in clots up to 3 mm across containing minor amounts of feldspar.

Feldspar has been partially replaced by small (<0.5 mm) crystals of light pink to dark pinkish-brown, pleochroic tourmaline which are occasionally concentrated into patches up to 1.25 x 2.5 mm.

Much of the rock has been patchily replaced by dolomite, the finer grained (generally <0.4 mm) dolomite being totally changed to calcite, with only partial alteration of larger dolomite porphroblasts. Many of these porphyroblasts are poikiloblastic with inclusions of feldspar, especially around the margins.

Rare quartz crystals up to 0.6 mm across are anhedral, fractured, display undulose extinction and are intergrown with untwinned K-feldspar and Fe-stained muscovite.

3. PETROLOGICAL EXAMINATION OF POLISHED SECTIONS

0121

Sample: B52; PS30614

Hand Specimen:

The sample is of a grey, hard, non-laminated, crystalline dolomite. Malachite occurs in fractures and small (<0.5 mm) blebs of opaque material are disseminated through the rock.

Polished Section:

Opaque minerals form 1-2% of the section. A visual estimate gives:

	%
Chalcocite	98
Covellite	1
Cuprite	1

Chalcocite occurs finely disseminated (frequently 0.005 mm and less) through patches up to 0.4 mm across of non-opaque material. These patches have sharply defined boundaries and appear interstitial to other non-opaque components. Chalcocite also forms small "micaceous" growths within these patches, with thin (<0.005 mm) lamellar inclusions of non-opaque material.

Chalcocite also forms monomineralic blebs up to 0.5 mm across. Some of these display fine rhombohedral lamellar intergrowths of pale blue and white varieties. These also frequently display marginal "micaceous" intergrowths with thin (∿0.005 mm) lamellae of non-opaque material.

Covellite occurs as alteration of chalcocite. Some small (∿0.1 mm) blebs contain up to ∿50% covellite.

Malachite occurs in thin (0.05 mm and less) veins and as a patchy replacement of chalcocite.

Cuprite forms small (<0.025 mm) crystals in clusters up to 0.1 mm across.

Sample: B54; PS30615

0122

Hand Specimen:

The sample is of a massive, white, non-laminated, crystalline dolomite extensively replaced by chalcocite and veined and patchily replaced by azurite.

Polished Section:

Opaque minerals constitute 1 to 2% of the section; they are extensively altered to azurite and malachite.

A visual estimate of the opaque constituents gives:

	%
Chalcocite	98
Covellite	1
Cuprite	1

Chalcocite occurs in irregular blebs up to 0.5 mm across. Thin lamellar intergrowths with non-opaque minerals appear to be related to cleavage planes in the chalcocite and are common around margins of the blebs. White chalcocite is the dominant variety present, with occasional blebs of pale blue ?neodigenite.

White and blue varieties also form ?rhombohedral lamellar intergrowths in some grains.

Crystals of cuprite (generally <0.025 mm) are disseminated through the rock; rare ?intergrowths of cuprite and chalcocite occur in veins where cuprite and chalcocite are commonly separated by a thin film of gangue minerals.

Sample: B199; PS30616

0123

Hand Specimen:

The sample is of a pale grey, microcrystalline, faintly laminated, ?siliceous rock with small round white ?dolomitic blebs apparently randomly distributed throughout. Occasional grains of pyrite are up to ∿1 mm across.

Polished Section:

Opaque minerals form ∿5% of the section.

A visual estimate of these gives:

	%
Pyrite	+99
Chalcocite	Trace

Pyrite is disseminated through the rock and occurs as subhedral to euhedral crystals up to ∿1 mm across. There is a wide range of grain size, with some crystals being 0.005 mm across. Many of the larger grains contain small (<0.0025 mm) inclusions.

Pyrite crystals appear to have a random distribution and this, together with their good crystal form suggests they are not of detrital origin.

Chalcocite forms small (<0.05 mm) grains commonly with pyrite; rare individual grains also occur.

Sample: B219; PS30618

0124

Hand Specimen:

The sample is of a feldspathised and silicified fine-grained, volcanic rock which has been extensively replaced by chalcocite and veined by malachite.

Polished Section:

Opaque minerals form 1 to 2% of the section. A visual estimate of these gives:

	% of opaque
Chalcocite	90
Pyrite	5
Cuprite	5

Chalccite, commonly a pale blue variety (?neodigenite) forms blebs up to 0.15 mm across and occurs in veins with non-opaque minerals; these blebs are commonly free of inclusions.

Pyrite forms small (average ∿0.05) irregular grains in chalcopyrite blebs up to 1.2 mm across. Rare grains of cuprite are frequently ?intergrown with chalcocite and appear to be an alteration product of the chalcocite.

Occurring in a patch 1 to 2 mm x 7 mm is a bright green mineral which alters to malachite. It is strongly anisotropic blue to orange/yellow. and forms sheafs of crystals 2 to 3 mm in length. It is suggested that this may be libenthenite.

Malachite is commonly fibrous, forming veins ∿0.15 mm thick where it is frequently intergrown with other non-oapque, non-Cu minerals.

Sample: B219A; PS30617

0125

Hand Speimen:

The sample is of a grey to white medium-grained, non-laminated feldspathic rock with small (<0.5 mm) blebs of chalcocite. The friable nature of the specimen suggests much of the feldspar may be partially altered to clay minerals.

Polished Section:

Opaque minerals form ∿1 to 2% of the rock; there is extensive alteration to azurite. A visual estimate of the opaque constituents gives:

	% of opaque
Chalcocite	60
Pyrite	40
Cuprite	Trace

Chalcocite forms blebs up to 0.3 to 0.4 mm across with irregular rounded, outlines and very minor inclusions of gangue minerals.

Pyrite grains up to 1.0 mm across have generally rounded, irregular outlines and are frequently rimmed by chalcocite; chalcocite also occurs along fractures and cleavage planes and some pyrite grains may be described as possessing a cataclastic texture.

One pyrite grain contains a core of pyrite, rimmed with chalcocite, which is itself surrounded by pyrite rimmed with chalcocite.

Cuprite forms small (generally <0.1 mm) disseminated blebs with rounded outlines.

Sample: B248; PS30619

0126

Hand Specimen:

The sample is of a pale cream, fine-grained, non-laminated ?feldspathic rock extensively replaced by chalcocite and malachite which form up to 70% of the specimen.

Polished Section:

Opaque minerals form approximately 40% of the section; malachite forms approximately 20%.

A visual estimate of the opaque minerals gives:

	% of opaque
Chalcocite	98
Covellite	1
Limonite	1

Chalcocite forms the matrix to the breccia and is intensely veined with non-opaque minerals. It commonly has a pale blue colour and is probably dominantly neodigenite.

Covellite occurs as fine-grained lamellar alterations of chalcocite.

Malachite occurs as veins, and patches up to 0.25 mm across where it appears to be an alteration product of chalcocite.

Limonite (?goethite) forms irregular blebs up to 0.08 mm across.

Sample: B255; PS30620

0127

Hand Specimen:

The sample is of a white calcite breccia with fragments up to ∿1 cm across, extensively replaced by cuprite and malachite which also forms the matrix to the carbonate fragments.

Polished Section:

Opaque minerals constitute over 70% of the section. A visual estimate of these gives:

	% of opaque
Cuprite	∿80
Native copper	<1
Pyrite	<1
Malachite	15
Limonite	3

The sample is of a cuprite cemented breccia. The dominant occurrence of cuprite is as a matrix to angular non-opaque fragments. These range in size from <0.01 mm to 2 to 3 mm. In some areas cuprite forms >50% of the rock; in others greater than 50% is gangue. Cuprite is rarely found in gangue free blebs up to 0.5 mm across displaying octahedral cleavage. Occasional thin (<0.1 mm) veins are exclusively of cuprite.

Irregular elongate rounded blebs of native copper up to 0.1 mm in length are surrounded by cuprite. Rare small (<0.005 mm) pyrite grains have a similar occurrence.

Malachite replaces cuprite, especially where gangue minerals form a higher percentage of the rock.

Limonite (?goethite) forms thin veins (generally <0.025 mm thick), irregular patchy replacements of ?cuprite and small (<0.05 mm) blebs associated with pyrite in cuprite.

Sample: B256; PS30621 0128

Hand Specimen:

The sample is of a brecciated fine-grained, ?limonitic, laminated, siltstone or tuff which appears to be partially feldspathised and extensively replaced by cuprite, azurite and malachite.

Polished Section:

Opaque minerals make up approximately 40% of the section; non-opaque alteration products of these constitute approximately 5%. A visual estimate of the opaque constituents gives:

	% of opaque
Cuprite	99+
Native copper	<1

Cuprite occurs in a vein up to 7 mm thick with minor inclusion of non-opaque material. In highly irregular patchy off-shoots from this it frequently appears to be pseudomorphing dolomite and in small discrete blebs up to 0.15 mm across it is frequently partially altered to malachite and azurite. Malachite and minor azurite are also present as alteration products of cuprite, along margins of the vein(s).

Native copper forms rare elongate irregular blebs up to 0.15 mm across in cuprite which appear to be later than the fractures in the cuprite. Alteration of cuprite to native copper therefore occurred after fracturing.

Sample: B280; PS30622

0129

Hand Specimen:

The sample is of a pale grey to brownish-grey, medium-grained, massive dolomite, extensively replaced by chalcotie and malachite. Azurite occurs in a thin vein.

Polished Section:

Opaque minerals form 10-15% of the section, with alteration to azurite and malachite. A visual estimate of the opaque minerals gives:

	%
Chalcocite	99
Covellite	<1

Chalcocite occurs as irregular blebs up to 4 mm across, commonly rimmed by non-carbonate gangue minerals. These also occur as minor lamellar intergrowths with the chalcocite. Occasional small (~0.1 mm) crystals of chalcocite have an approximately hexagonal outline.

Covellite occurs as minor lamellar alterations of chalcocite and some of the azurite has a similar occurrence.

Azurite and malachite also forms thin (<0.25 mm) veins.

Sample: B282; PS30623

0130

Hand Specimen:

The sample is of an extensively recrystallised dolomitic breccia, with single dolomite crystals up to ∿1 cm across, extensively replaced by chalcocite, which is intergrown with another opaque phase, and malachite.

Polished Section:

Opaque minerals make up 70% of the section. A visual estimate of these gives:

	% of opaque
Chalcocite	80
Bornite	20
?Goethite	<1

Chalcocite and bornite form the matrix of the breccia. Bornite is extensively replaced by chalcocite; it occurs as blebs up to 1 to 2 mm across with smooth outlines and cut by occasional chalcocite veins. Chalcocite forms fracture and inclusion free rims around bornite with an average thickness of 0.025 mm. Remaining chalcocite is suffused with a dense network of thin (<0.01 mm) irregular veins. Some appear to radiate from rock fragments, many of which contain very minor amounts of ?goethite.

Rock fragments up to ∿5 mm across are angular and contain blebs of chalcocite and bornite partially replaced by chalcotie. One bornite blebs ∿0.05 mm across is ∿5% altered, but most appear 25-100% replaced. Chalcocite blebs have rounded outlines and, in contrast to the chalcocite forming the matrix, are not veined and contain very few inclusions

0131

Sample: B284; PS30624

Hand Specimen:

The specimen consists of approximately concentrically zoned chalcocite, malachite and azurite replacing a coarsely crystalline quartzo-feldspathic rock.

Polished Section:

Opaque minerals, altered dominantly to azurite in over half the section, form approximately 30% of the remaining rock. A visual estimate of these gives:

	% of opaque
Chalcocite	99
Covellite	1

Chalcocite occurs as a dense network of irregular fine veins and as small (up to 0.4 mm) highly irregular patches replacing the host rock. Intensity of veining and replacement gives the impression of a breccia. The veins are frequently <0.05 mm thick with centres of non-opaque material and ∿0.01 mm thick edges of chalcocite. This commonly has a smooth contact with the non-opaque vein material and a highly irregular replacive contact with the host rock.

Covellite occurs as a minor lamellar alteration of chalcocite.

Azurite is the dominant alteration product, totally replacing chalcocite in ∿¼ of the section.

Rare veins of malachite also occur.

Sample: B285; PS30625

0132

Hand Specimen:

The sample is of a very pale greenish-grey, massive, fine-grained, ?feldspathic rock with finely disseminated pyrite and ?chalcocite.

Polished Section:

Opaque minerals constitue approximately 1-2% of the section. A visual estimate of these gives:

	% of opaque
Chalcocite	50
Pyrite	50
Bornite	Trace
Chalcopyrite	Trace

Chalcocite occurs in veins and as individual grains, forming blebs up to 0.4 mm across. Many of these, averaging ~0.2 mm, are centred with bornite, occasionally intergrown with elongate irregular lath shaped grains of chalcopyrite up to 0.15 mm in length. Chalcopyrite also forms regular orthogonal lamellar inclusions (?exsolution lamellar) in bornite.

Pyrite occurs dominantly in veins where it forms large cataclastic, irregular crystals up to 2 to 3 mm across. These are frequently partially rimmed by chalcocite and contain inclusions of bornite and chalcocite; all lack good crystal outlines.

Finely disseminated rare small (<0.15 mm) crystals of a brownish to pinkish-white to pale grey mineral are tentatively identified as cubanite.

4. XRD EXAMINATION

A total of six samples were submitted for XRD examination. Results are given below.

Sample No. (B)	Phases Present
42	Kaolinite with 10-15% quartz
176A	Chrysocolla
176B	Chrysocolla
200	Dolomite, montmorillonite and ?opaline silica
219	Montmorillonite
246	Malachite with montmorillonite and minor quartz.

An additional five samples were examined by XRD to identify phases not identifiable optically.

Sample No. (B)	Material	Composition	
171	Yellowish vein mineral	Calcite	D
		Polygorskite	Tr-A
		Dolomite	Tr
201	Soft white material	Kaolinite	D
		Tourmaline	A
		Muscovite	Tr
		Montmorillonite	Tr
		K-feldspar	Tr
206	Dark fine-grained rock	Tourmaline	D
		Malachite	Tr-A
		K-feldspar	Tr
		?Montmorillonite	Tr
212	Dark brown clayey rock	Quartz	CD
		Montmorillonite	CD
		Talc	A
		Kaolinite	A
		Tourmaline	A
		K-feldspar	Tr-A
242	Hard microcrystalline ?siltstone	Quartz	D(∿95%)
		Feldspar (K-feldspar >plagioclase)	Tr

Semi-quantitative Abbreviations:

D — Dominant. The component apparently most abundant, regardless of estimated percentage.

CD — Co-dominant. Used for two (or more) predominating components judged to be present in roughly equal amounts.

SD — Sub-dominant. The next most abundant component(s) providing their percentages are judged to be above about 20.

A — Accessory. Components judged to be present between the levels of roughly 5 and 20%.

Tr — Trace. Components judged to be below about 5%.

5. SAMPLE CORRELATION 0134

Examination of hand specimens and thin sections indicates the following tentative groupings.

	Specimen No. (B)		Suggested Name/Description
1.	141 169 174		Volcanically brecciated lithic tuff.
2.	5 50 51 60 191 215 217 285		Feldspathised and silicified feldspathic tuff.
3.	16 56 103 127 128 171 172 265	56 103 128 171 172 265 16 127 266	Thinly laminated magnesian limestone with laminae ?varying in Mg content. Thinly laminated dolomite.
4.	121 158 157 290 -	Dolomite Calcite Dolomite	Massive, fine-grained, carbonate with quartz lined vugs infilled with clay minerals.
5.	44 189 264 271 279A 279B		Dolomite breccias, with varying degrees of calcification.
6.	10 37 42 - 46 73 86 97 105 116 243 - 259 -	Dominantly kaolinite Vesicular Coarser, = 73	Thinly laminated feldspathic siltstone/lithic tuffs. Close affinities with 1.
7.	54 52 72 218B 276 280		Coarsely crystalline quartzo-feldspathic dolomite.

8.	80 83 268 270 278 288	Dolomitic sandstone. Close affinities with 5. and 7.
9.	74 181 184 202 259 261 277	Coarse-grained, volcaniclastic/tuff with high percentage of K-feldspar.
10.	53 92	Volcaniclastic/welded tuffs.
11.	39 41 57 123 194 224	Quartzite - possibly derived from silicification of a volcaniclastic rock type.

Additional samples are either of lithologies not duplicated in other specimens or of rocks too altered and/or mineralised to determine the lithology with any degree of certainty.

6. CONCLUSION AND RECOMMENDATIONS FOR FURTHER STUDY

In reply to some of the points raised in your communication DM 588/80.

1. There is no evidence to suggest that weathered rocks resembling siltstones and sandstones are weathered/altered dolomites/limestones. In most cases these samples are of weathered volcaniclastics some of which have been partially feldspathised and/or silicified.

2. In thinly laminated dolomites/limestones the distribution of Mg appears to have been determined during deposition with the formation of alternating laminae of calcite and dolomite. Staining of thin sections with Alizarin red-S in some cases gave anomalous results, with crystals in a single thin section varying in degree of staining in an apparently random way. The presence of high Mg calcite was suspected in some of these samples, but staining of the thin sections with Clayton Yellow generally failed to satisfactorily establish its presence or absence.

   It is therefore recommended that XRD examination of some of these thinly laminated samples be undertaken to determine the distribution of Mg, the phases present and the possible diagenetic history of these rocks.

3. Some coarsely crystalline dolomites and dolomitic breccias show evidence of more than one dolomite growth phase; many, however, do not and it is recommended that cathodoluminescence studies be undertaken in an attempt to determine the number of growth phases of dolomite and its primary and secondary nature. Such studies may also be of value on partially calcified dolomitic breccias, in conjunction with XRD or electron microprobe examination, to determine the reasons for the selective alteration.

4. Samples thought to be of silica-potash metasomatised dolomite/limestone are of silica-potash metasomatised feldspathic tuffs. The secondary K-feldspar in all samples contains dusty opaque inclusions, probably due to partial alteration, and this, together with the presence of partially altered primary K-feldspar, would make thses samples unsuitable for age dating. One sample (B285, TSC35027) contains relatively fresh, secondary albite and this may provide suitable material for dating.

5. The origin of some of the breccias is unclear. It is recommended that more intensive sampling of the clasts be undertaken to determine the full suite(s), which should give additional evidence for the origin(s) of these breccias.

6. Full petrological examination of all available drill cores should be undertaken before some disintegrate completely. Many of the problems encountered in sample preparation and petrological examination have been due to the highly weathered nature of many of the samples and the opportunity to examine fresh material should not be ignored.

7. Structural analysis should be undertaken (including orientated hand specimens to determine the tectonic history and in particular the sequence, amount and direction of movement along the major and numerous minor shear zones.

   From the present study it can be seen that K and Si metasomatism, and possibly the movement of Mg and Ca, is related to shear zones and fractures and it is possible that Cu mineralisation may be related to the same or similar features.