

**Figure 14. Metamorphosed limestone. Shierglas, Blair Atholl, Perthshire, Scotland. (sample 58/13).** A finely crystalline, folded rock with bands of different compositions. (See Table 8). Calcite, muscovite, and quartz are the major minerals with lesser amounts of zoisite, feldspars and biotite. The bands have increased amounts of zoisite, muscovite and quartz and almost no calcite. The optical image is in plane polarised light. All minerals are listed, although some are not visible in the larger image and not present in the inset.

Sample number	Shierglas, Perthshire Scotland		Nuneaton, Warwickshire		Meldon, Okehampton Devon			
	Meta-limestone		Quartzite		Chert		Hornfels	
	%	Size $\mu\text{m}$	%	Size $\mu\text{m}$	%	Size $\mu\text{m}$	%	Size $\mu\text{m}$
58/13	58/13	5/13	66/13	67/13				
Quartz	13.22	43	88.70	552	47.27	53	0.42	17
K-Feldspar	1.11	17	5.28	36	26.90	30	2.14	17
Plagioclase	7.93	29	0.55	24	2.82	19	48.05	52
Biotite	1.58	46	0.34	18	5.37	20	27.93	36
Muscovite	19.52	43	3.40	42	11.47	26	0.17	17
Chlorite	0.78	49	0.14	23	4.24	26	7.39	21
Zircon	-	-	<0.01	46	0.02	17	<0.01	15
Rutile	-	-	0.02	27	0.61	17	0.08	15
Ilmenite	-	-	<0.01	16	<0.01	15	0.80	28
Titanite	-	-	<0.01	16	0.03	18	1.66	23
Calcite	48.36	117	1.51	50	0.03	16	<0.01	16
Dolomite	0.84	16	-	-	<0.01	23	-	-
Actinolite	-	-	<0.01*	18	0.01	15	8.79	50
Epidote	-	-	0.02	16	0.03	16	0.39	156
Zoisite	5.05	36	-	-	-	-	-	-
Apatite	0.22	27	0.03	23	0.09	21	2.10	60
Monazite/Xenotime	-	-	<0.01	16	<0.01	18	-	-
Allanite	0.05	45	-	-	0.02	24	0.03	22
Fe-Mn Ox/CO3	<0.01	<15	-	-	-	-	-	-
Ti minerals	0.96	21	-	-	-	-	-	-
Pyrite	-	-	<0.01	17	1.05	20	0.04	41
Pyrrhotite	0.38	68	-	-	-	-	-	-
Sphalerite	-	-	-	-	0.01	20	0.01	22
Chalcopyrite	-	-	<0.01	17	0.01	35	<0.01	17
Others	0.01	16	<0.01	<17	0.02	<18	0.01	<16

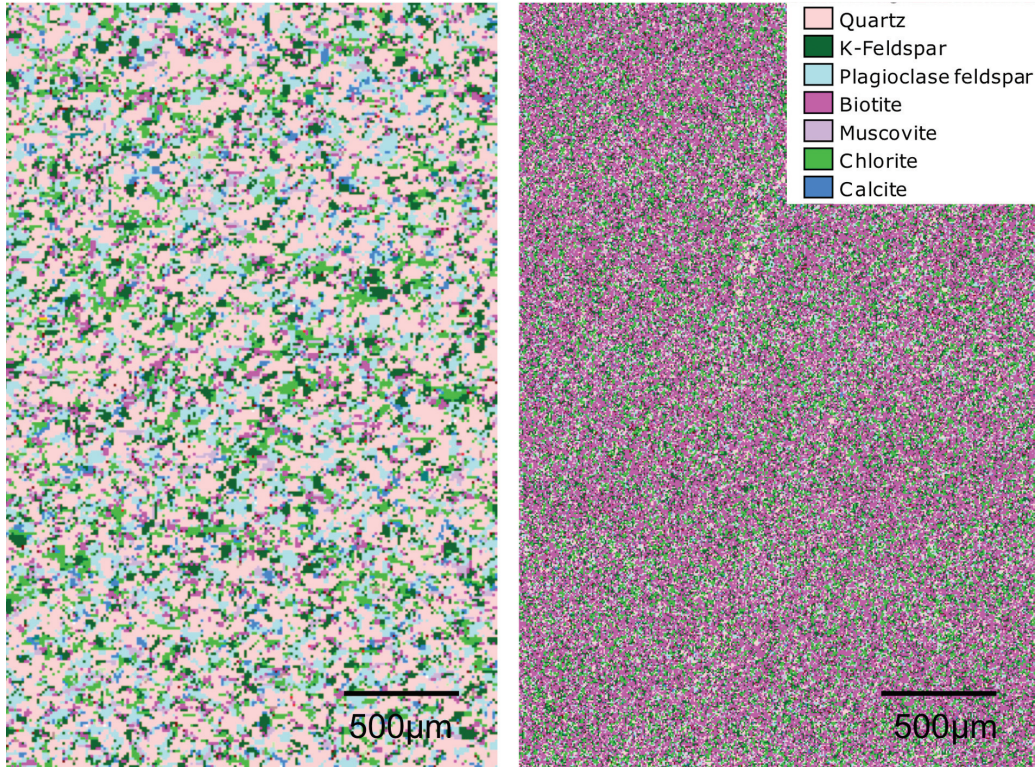
Note: Fe-Mn Ox/CO3; Iron and manganese oxides or carbonates. \* Unidentified amphibole species.

**Table 8. Modal composition and mean crystal sizes of metamorphic rocks (including metamorphic limestone).**

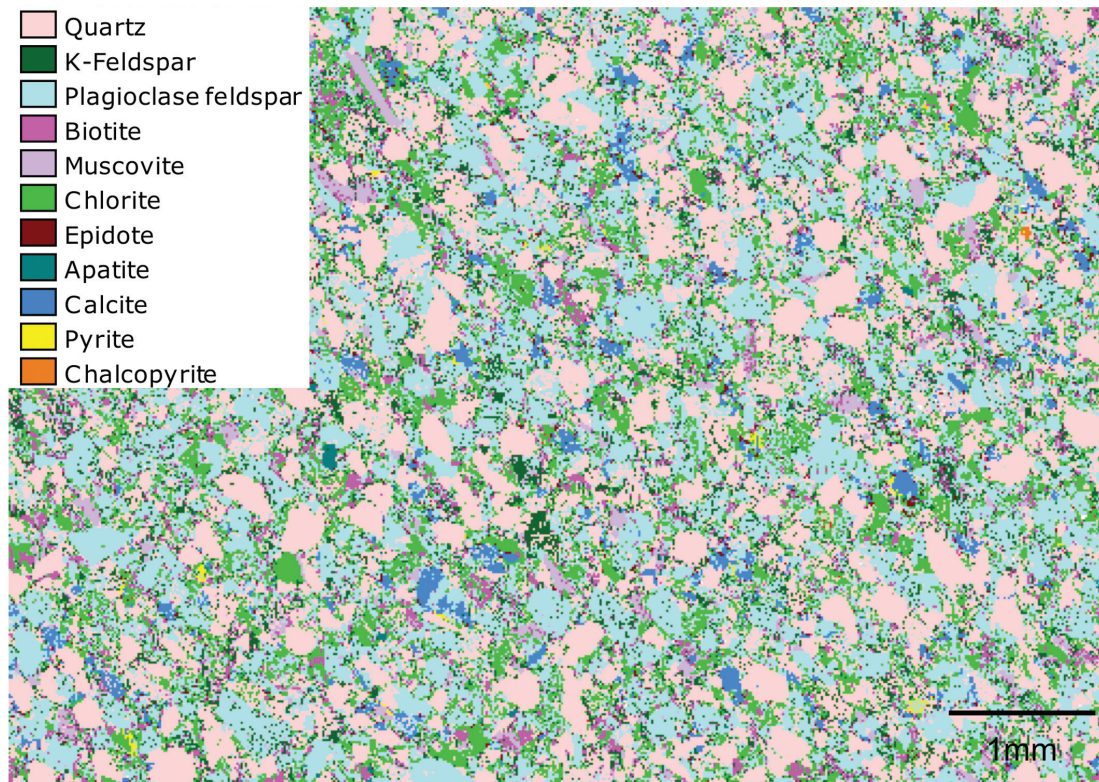
**E. Gritstones and greywacke**

Four examples of these siliciclastic sedimentary rocks from Northern England are illustrated in Figures 15, 16 and 17 with the modal mineralogy and grain-size data given Table 9. Their mineralogies are dominated by quartz, feldspars, micas and chlorite with amounts varying between samples. The two samples from Roan

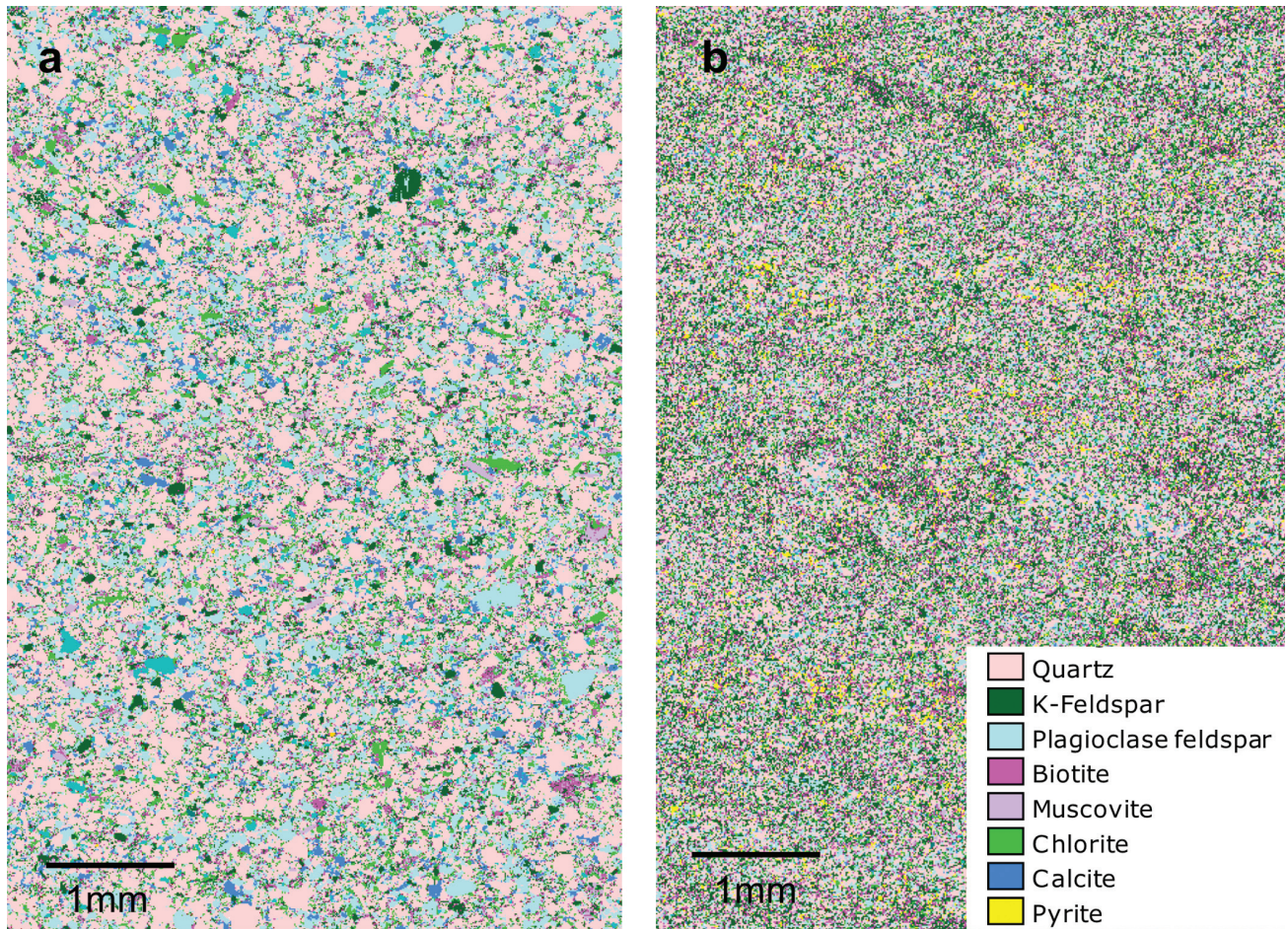
Edge illustrate that mineral proportions and sizes vary within the product from a single quarry. This is to be expected in aggregates from a quarry in a turbidite succession and relates to variations in the depositional sequence. Similar variation is likely to be present in Arcow and Dry Rigg quarries.



**Figure 15. Gritstones. Roan Edge, New Hutton, Kendal, Cumbria** (coarse grained sample 30/13 (left) and fine grained sample 31/13 (right)). Very fine grained indurated sandstone (gritstone) showing differences in grain size and mineralogy between two samples from the same quarry. (See Table 9). Quartz dominates the left image with lesser but similar amounts of plagioclase, K-feldspar, biotite and muscovite, the image on the right has biotite, K-feldspar and chlorite as major minerals.



**Figure 16. Greywacke. Ingleton, North Yorksbire** (sample 33/13). (See Table 9). An indurated rock made up of angular medium- to fine-sand grains of quartz, and feldspar (dominantly plagioclase) with minor biotite and muscovite. Intergranular minerals are dominantly chlorite and calcite with epidote and sulphides (pyrite and chalcopyrite).



**Figure 17. Gritstones. a. Arcow, Stainforth, North Yorkshire** (sample 34/13). **b. Dry Rigg, Stainforth, North Yorkshire** (sample 35/13). (See Table 9). Both gritstones are made up of indurated fine-sand grains of predominantly of quartz and feldspars with lesser amounts of micas. Intergranular minerals are dominantly chlorite and calcite. The Dry Rigg sample has areas containing disseminated pyrite. The quartz grains appear to be more rounded compared with the sample from Ingleton (Figure 16).

	Roan Edge, Kendal, Cumbria. Gritstone				Ingleton, North Yorkshire Greywacke		Arcow, Stainforth, North Yorkshire Gritstone		Dry Rigg, Stainforth, North Yorkshire Gritstone	
	Coarse		Fine		%	Size $\mu\text{m}$	%	Size $\mu\text{m}$	%	Size $\mu\text{m}$
Sample number	30/13		31/13							
	%	Size $\mu\text{m}$	%	Size $\mu\text{m}$	%	Size $\mu\text{m}$	%	Size $\mu\text{m}$	%	Size $\mu\text{m}$
Quartz	37.22	41	9.93	18	33.08	50	48.57	61	31.85	28
K-Feldspar	14.40	23	16.70	18	7.40	19	8.58	25	23.44	22
Plagioclase	15.88	28	7.60	17	31.92	41	18.00	36	16.12	21
Biotite	10.39	21	41.21	30	3.46	20	4.35	19	10.15	18
Muscovite	5.53	21	5.85	16	3.72	23	2.58	23	3.62	17
Chlorite	12.74	25	15.82	23	13.93	26	9.16	23	6.40	20
Zircon	0.02	20	<0.01	15	0.01	29	0.03	26	0.02	18
Chrome spinel	0.01	22	<0.01	$\leq 15$	<0.01	22	0.01	38	0.00	19
Rutile	0.47	17	0.31	15	0.79	17	0.46	19	0.46	16
Ilmenite	0.03	15	<0.01	15	0.04	15	0.01	15	<0.01	$\leq 15$
Titanite	0.23	17	0.03	15	0.12	16	0.07	16	0.05	15
Calcite	2.21	21	0.48	15	3.95	32	4.60	28	1.60	17
Dolomite	<0.01	17	np	np	<0.01	$\leq 15$	1.79	35	0.96	21
Hornblende	0.17	16	0.33	15	0.19	16	0.79	18	0.91	17
Epidote	0.53	16	1.65	15	0.97	17	0.74	16	0.63	15
Apatite	0.18	22	0.09	16	0.29	23	0.21	27	0.17	18
Monazite/Xenotime	<0.01	17	<0.01	$\leq 15$	<0.01	16	0.01	21	0.01	17
Allanite	<0.01	23	<0.01	20	<0.01	$\leq 15$	<0.01	$\leq 15$	<0.01	17
Pyrite	<0.01	16	<0.01	$\leq 15$	0.11	23	0.04	22	3.61	17
Sphalerite	np	np	<0.01	$\leq 15$	np	np	<0.01	23	0.01	19
Chalcopyrite	<0.01	$\leq 15$	np	np	0.01	25	<0.01	19	<0.01	20
Others	<0.01	<16	<0.01	$\leq 15$	<0.01	<15	<0.01	$\leq 15$	<0.01	<15

Note: np; not present.

**Table 9.** Modal composition and mean crystal sizes for gritstones and greywacke.

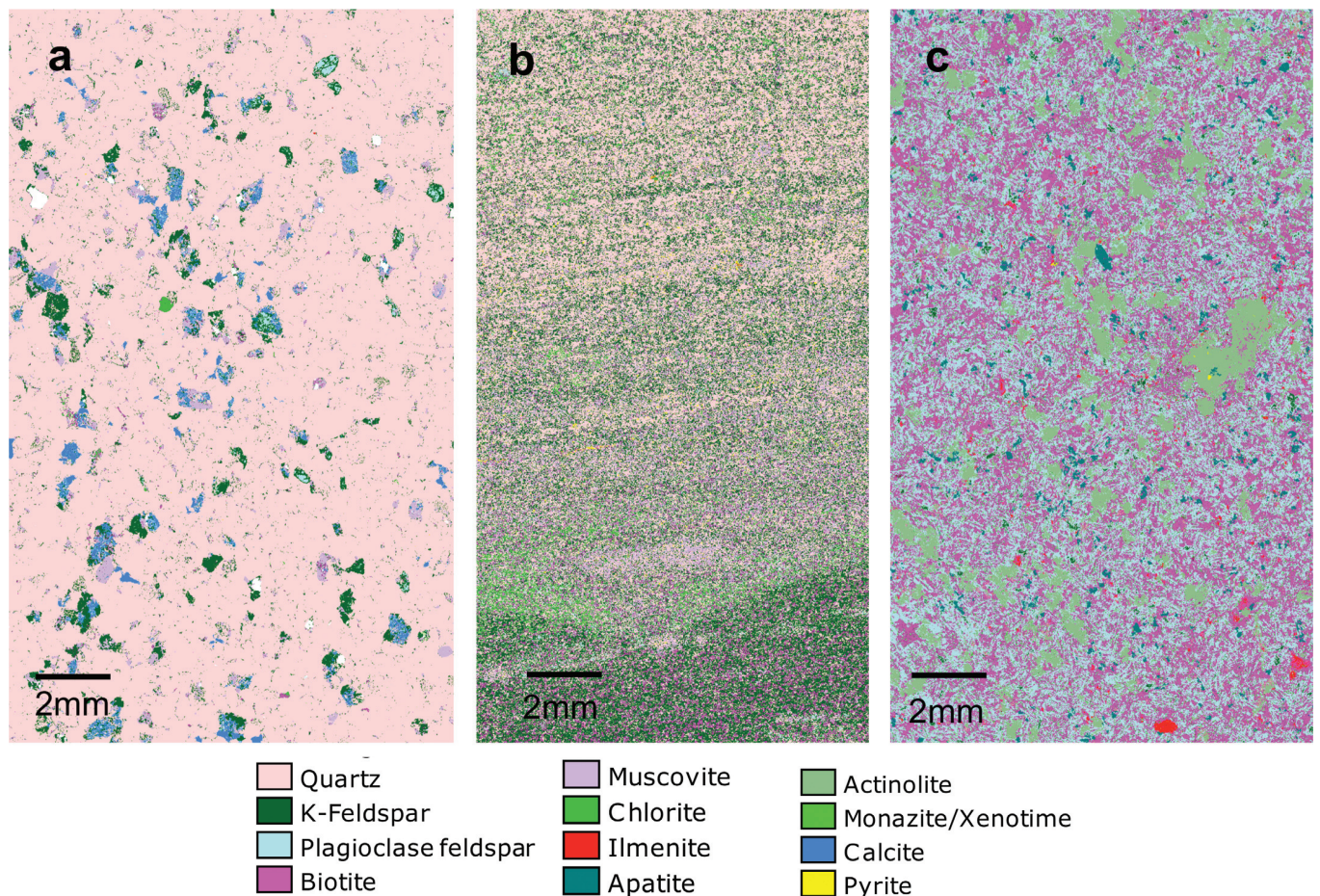
### F. Others

Samples of a quartzite aggregate from Nuneaton, Warwickshire and a heterogeneous aggregate made up of chert and a very varied hornfels from Meldon, Devon are illustrated in Figure 18, with modal percentages and crystal size data in Table 8. All show a complex mineralogy. The samples of chert and hornfels from Meldon, only partly represent the much wider range of compositions that are found in the quarry.

Two samples of metamorphosed and deformed anorthosite are illustrated in Figure 19. These were taken from exploration pits excavated as part of the assessment of a proposal for an aggregate superquarry at Lingerbay, Harris, Outer Hebrides, for which planning permission was not granted. Modal percentages and crystal size data for four samples from the same site are given in Table 10. The rock has small and variable amounts of quartz, chlorite and epidote, but is dominated by plagioclase. Anorthosites are a source of aggregates elsewhere (e.g. Norway).

Blastfurnace slag is a by-product of iron manufacture and is extensively used as an aggregate. The sample from Scunthorpe, Lincolnshire, illustrated in Figure 20, with

modal percentages and particle size data given in Table 11, is typical of the minerals and the intergrown texture of melilite and calcium silicates found in this material.



**Figure 18. Metasediments.** **a. Quartzite. Nuneaton, Warwickshire** (sample 5/13). An equigranular rock predominantly of quartz with the grain boundaries largely invisible because of quartz-quartz contacts. The shapes and size of other grains (K-feldspar, muscovite, biotite, calcite, monazite/xenotime) enable the overall equigranular texture to be recognised. The non-quartz grains show a complex mineralogy. **b. Chert. Meldon, Okehampton, Devon** (sample 66/13). A very fine-grained rock with poorly developed foliated texture. Quartz is the major mineral. The proportions of the other minerals (K-feldspar, plagioclase, muscovite, biotite, chlorite, pyrite) vary to give the foliated texture. **c. Hornfels. Meldon, Okehampton, Devon** (sample 67/13). A recrystallised rock dominated by very fine-grained plagioclase and biotite with larger areas of actinolite and significant amounts of apatite. (See Table 8).