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Deformation of chlorite–mica aggregates in cleaved psammitic and pelitic rocks from Islesboro, Maine, U.S.A.

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Abstract—Chlorite–white mica aggregates are large porphyroblasts found in weakly metamorphosed and deformed pelitic and psammitic rocks throughout the world. They are usually considered to originate either as detrital white mica layers surrounded by crystallized chlorite or as synkinematic porphyroblasts. In chlorite–muscovite aggregates observed at Islesboro, the chlorite layers were found to represent prekinematic porphyroblasts that have been strongly deformed and rotated during cleavage development. The muscovite layers in the aggregates formed by crystallization along split and dislocated (001) surfaces in the chlorite, or by alteration within intensely deformed sections of chlorite grains, such as kink-bands.

INTRODUCTION

CHLORITE–mica aggregates are large porphyroblastic grains in which the two layer-silicate components occur as distinct laminae that can be resolved in the optical microscope. Since they were first described by Sorby (1853) these grains have been noted in many slates and their textures have been cited as evidence for various hypotheses regarding the origin of cleavage. Mosebach (1952) described their occurrence as 'unoriented' lenses between cleavage planes in roofing slates of the Hunsrückschiefer. Hoeppener (1956) first used the term 'aggregate' in his descriptions of these grains and their relationship to cleavage in weakly foliated shales from the Rheinische Schiefergebirge. More recently, a number of authors have noted the presence of such grains in cleaved pelitic and psammitic rocks from many different areas (Weber 1972, Williams 1972, Loeschke & Weber 1973, Holeywell & Tullis 1975, Weber 1976, Beutner 1978, White & Knipe 1978, Spang *et al.* 1982, Gardner 1982, Borradaile 1982). Some of these authors have used their interpretations of the textures displayed by these aggregates to support such diverse conclusions as synchronous crystallization of the two components within and outside cleavage domains (Mosebach 1952) and the tectonic dewatering origin of cleavage (Roy 1978). This diversity of opinion is probably less a reflection of the variability in origin of the aggregates as it is a result of insufficient study of their microstructure. This paper provides information on typical chlorite–white mica aggregates from Islesboro, Maine, U.S.A. In it I have attempted to show in detail the internal microstructure of the aggregates, to document changes in them due to deformation, and to suggest the origin of both the chlorite and the mica layers in the aggregate.

GEOLOGIC SETTING

The specimens used in this study were collected from the northern tip of the island of Islesboro on a promontory called Turtle Head (see Gregg, in press, fig. 1). They are part of the early Paleozoic Islesboro Formation of low grade metasediments that, together with a few small bodies of Precambrian rocks, comprise the 'Islesboro block'. This structural block is bounded by right-lateral strike-slip faults that separate simply deformed low greenschist facies Islesboro rocks from the high grade, polyphase deformed rocks of the mainland (Stewart 1974).

The siltstones in the study area consist of white, finely cross-laminated beds, 5–20 cm thick, with sharp bases and gradational tops. Pelitic intervals between these beds are typically less than 5 cm thick and consist of either dark silty shale or thin pelitic beds with laminae of siltstone less than 1 mm thick. On a microscopic scale, S_0 is typically a fine cross-bedding marked by thin pelitic layers or by thin placer beds of heavy minerals. The detail of this fine sedimentary layering can be observed even inside thick S_1 secondary mica-rich layers (*M*-domains) in highly strained rocks (Fig. 1).

First generation folds are common at Turtle Head and display an S_1 cleavage that varies in intensity, whereas second generation structures are limited to rare kink bands less than 10 cm wide that contain no axial surface foliation. The microstructures described here occur in siltstones that show no detectable overprint by second generation microstructures (Gregg 1985).

Mica particles occur in these rocks either as fine white mica (0.5–4 μm) or as large aggregates (20–150 μm) of interlayered white mica and chlorite. X-ray diffractometry has shown that the white mica in both cases is muscovite. All of the fine white mica has been shown to be associated with the formation of mica films during cleavage development (Gregg, in press). The chlorite–white mica aggregates generally occur along fine pelitic laminae and can be followed in thin section from weakly strained areas through thick mica-rich cleavage domains (Fig. 1). The observations presented here were made along such a pelitic horizon (Fig. 1). The curves presented in various figures represent regression models

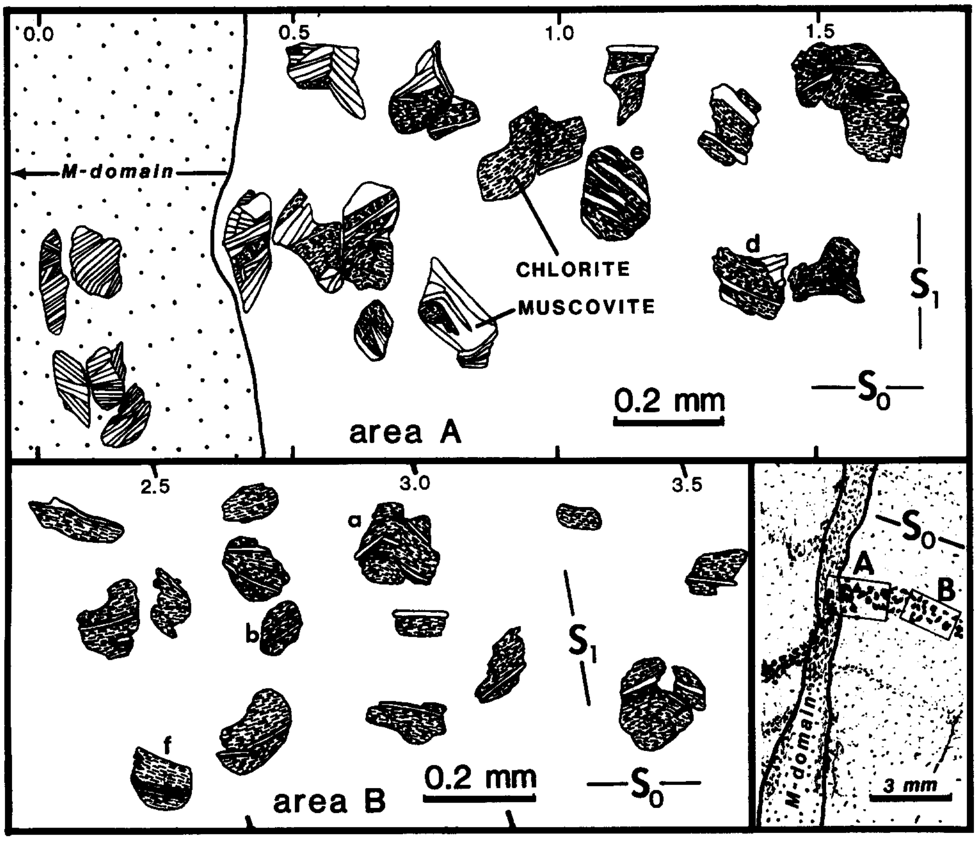

Fig. 1. Distribution of chlorite–muscovite aggregates along a pelitic layer in siltstone. Fine dashes indicate chlorite, undecorated layers are muscovite. Small letters indicate grains that appear in Fig. 2.

with correlation coefficients (r). All data were collected by measurements made on photographs of thin sections. They are presented in Table 1.

DESCRIPTION OF CHLORITE LAYERS

Chlorite layers inside the aggregates display many features that indicate deformation, including displacement of grain segments along (001), bending and kinking of (001) traces inside chlorite layers, severe undulose extinction, and microcrenulation of (001) layers.

Displacement of grain sections parallel to (001) is relatively common (Figs. 2a,b & e) and is marked by a stepped appearance along the grain boundary. This stepped appearance has been cited previously as an indicator of displacements parallel to (001) in mica porphyroblasts (Gregg 1980). Surfaces that show the largest apparent displacements are typically marked by thin white mica layers. Those that have incurred minor displacements show only a darkening of the chlorite parallel to (001) along the translation surface (Fig. 2). Grains such as those in Fig. 2(b) give simple equidimensional shapes when the displaced sections are reassembled photometrically and the intervening white mica layers removed.

The sense of displacement of (001) sections is symmetrically related to S_1 cleavage. Grains with (001) oriented as in Fig. 2(b) display right lateral displacement whereas grains with (001) oriented as in Figs. 2(e) and (f) display left lateral displacement. In addition to displacements parallel to (001) the chlorite layers display separation and splitting of the layers on the grain boundaries of some aggregates. In such cases the displacements of the chlorite layers occur at high angles to (001) and the intervening spaces are filled by a thin wedge of crystallized white mica (Fig. 2f).

Bending and kinking of (001) traces is common and is usually associated with large displacements of chlorite sections (Figs. 2a & e). In some examples where kink band boundaries are well developed, the kinked section of the grain consists entirely of white mica (Fig. 2d). Strong undulose extinction always accompanies kinking and bending of chlorite layers. In a few examples, such as Fig. 2(c), very small crenulations are developed along (001) inside and along the boundary of chlorite layers. All the deformational features discussed occur more frequently in aggregates situated close to the boundaries of thick S_1 mica-rich domains (M-domains in Fig. 1).

DESCRIPTION OF WHITE MICA LAYERS

The muscovite layers in the chlorite–white mica aggregates are typically very thin structures showing sharp extinction under crossed nicols and without internal crystallographic cleavage traces. Bending, kinking or fraying of the muscovite usually occurs only in aggregates inside or close to the M-domains, where deformation is most severe. No displacements of adjacent white mica layers have been observed in any aggregates.

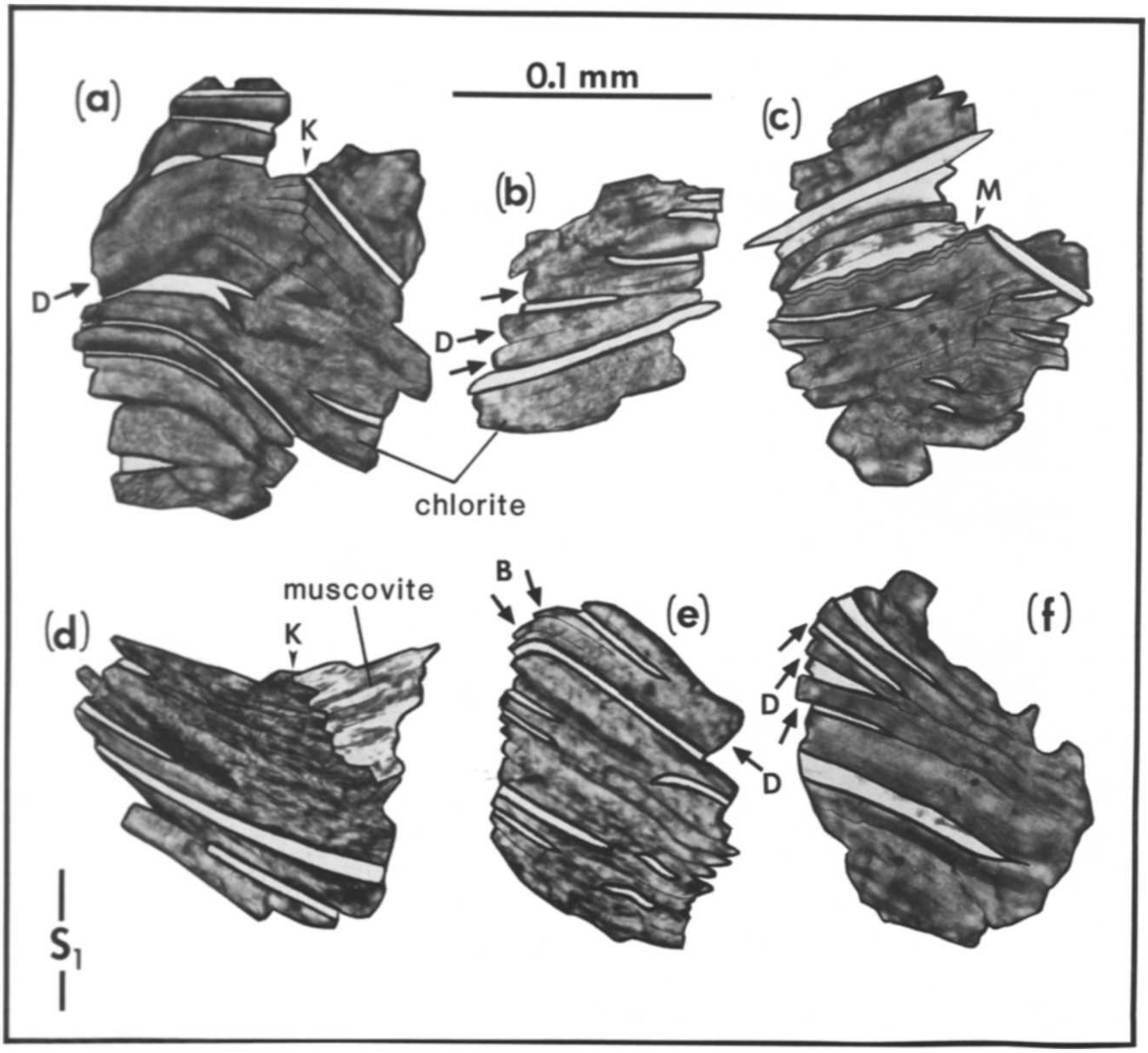

Fig. 2. Photomicrographs showing internal features of aggregates. All examples are from the pelitic bed shown in Fig. 1. 'D' indicates displaced grain section, 'K' indicates location of kinked region, '*M*' indicates microcrenulation and 'B' indicates bending of (001) traces.

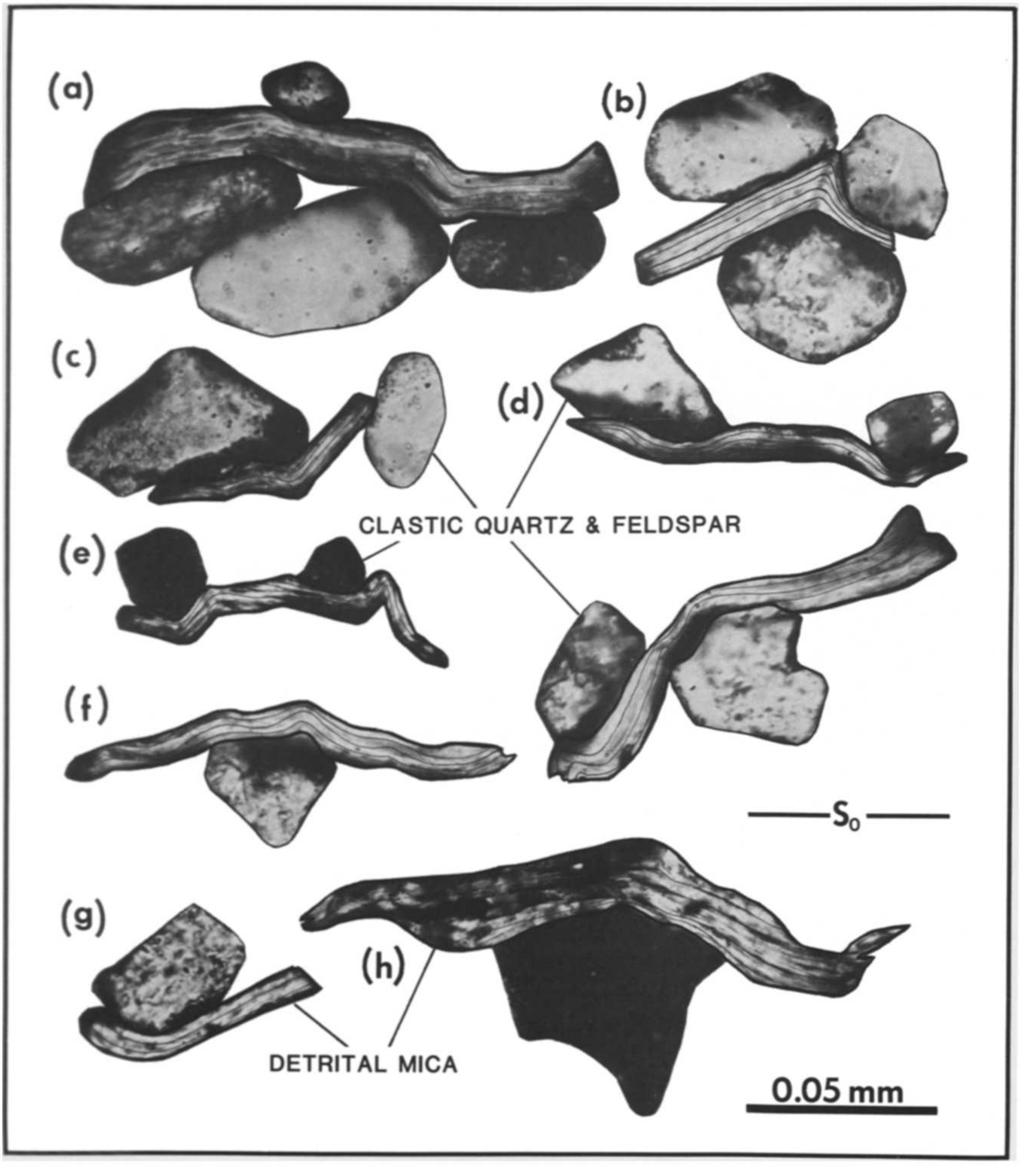

Fig. 7. Photomicrographs of typical detrital micas from undeformed sedimentary rocks, for comparison with white mica layers in Fig. 2. Specimens (a)–(g) from Freda siltstone, Houghton Co., Michigan and (h) from sandstone near Tulsa, Oklahoma. Note hydrodynamic equivalent size of mica compared to neighboring clastic grains. Micas are rarely more than ten times longer in the (001) direction than the average diameter of clastic quartz and feldspar grains.

Table 1.

Grain	D (mm)	G (mm²)	C (mm²)	C%	M (mm)	A (deg.)	L/W
1	0.00	0.0053	0.0000	0.0	0.1020	55	3.20
2	0.09	0.0052	0.0000	0.0	0.0782	50	2.30
3	0.13	0.0083	0.0000	0.0	0.1326	55	2.70
4	0.10	0.0038	0.0000	0.0	0.0782	42	2.14
5	0.19	0.0067	0.0000	0.0	0.0748	49	1.95
6	0.09	0.0079	0.0000	0.0	0.0742	42	2.41
7	0.03	0.0079	0.0000	0.0	0.1620	33	4.00
8	0.12	0.0109	0.0000	0.0	0.1380	36	1.41
9	0.07	0.0062	0.0000	0.0	0.1010	−40	2.71
10	0.13	0.0068	0.0000	0.0	0.1080	15	1.89
11	0.18	0.0062	0.0000	0.0	0.0742	42	1.94
12	0.57	0.0132	0.0011	8.2	0.0708	−49,22	*
13	0.41	0.0150	0.0020	13.4	0.0708	30	2.87
14	0.54	0.0147	0.0082	55.5	0.0472	31	2.00
15	0.64	0.0186	0.0078	41.7	0.0160	34	2.42
16	0.64	0.0057	0.0033	58.7	0.0135	−62	1.60
17	0.77	0.0172	0.0101	58.9	0.0211	28	−1.28
18	0.81	0.0164	0.0015	9.2	0.0877	−48	2.13
19	0.88	0.0163	0.0026	16.1	0.0624	16	−1.07
20	1.14	0.0094	0.0066	69.6	0.0118	16	1.82
21	1.12	0.0195	0.0130	66.7	0.0077	−39	1.41
22	1.34	0.0127	0.0088	69.3	0.0160	−41	1.34
23	1.37	0.0144	0.0108	74.8	0.0101	−27	1.38
24	1.51	0.0115	0.0102	88.8	0.0028	−27,20	*
25	1.79	0.0065	0.0050	77.0	0.0059	8	−2.18
26	1.75	0.0027	0.0015	56.3	0.0067	−28	−2.50
27	1.83	0.0069	0.0040	57.4	0.0186	16	−1.52
28	1.84	0.0039	0.0039	50.5	0.0000	*	*
29	1.80	0.0128	0.0045	50.5	0.0287	*	*
30	1.89	0.0134	0.0099	73.7	0.0054	−17	1.43
31	2.08	0.0102	0.0079	76.8	0.0135	24	−1.92
32	1.99	0.0058	0.0055	94.4	0.0034	38	−1.76
33	1.98	0.0058	0.0047	80.8	0.0101	− 1	1.04
34	2.15	0.0122	0.0083	67.5	0.0240	4	1.89
35	2.34	0.0072	0.0064	89.8	0.0068	−19	*
36	2.34	0.0108	0.0104	96.4	0.0051	12	1.31
37	2.46	0.0054	0.0042	78.9	0.0040	−15	1.55
38	2.36	0.0099	0.0086	87.3	0.0051	−14	1.32
39	2.66	0.0053	0.0052	98.1	0.0034	14	−1.83
40	2.64	0.0099	0.0079	79.8	0.0038	−16	1.40
41	2.65	0.0052	0.0050	96.9	0.0034	23	1.50
42	2.56	0.0138	0.0128	92.5	0.0051	16	1.70
43	2.91	0.0177	0.0150	84.9	0.0062	−8	1.10
44	2.92	0.0042	0.0035	82.9	0.0085	−1	−2.42
45	2.85	0.0080	0.0074	92.7	0.0034	−4	−2.59
46	3.25	0.0026	0.0026	100.0	0.0000	−4	−2.18
47	3.32	0.0183	0.0162	88.5	0.0048	2	1.30
48	3.50	0.0056	0.0053	95.3	0.0068	2	−2.22
49	3.70	0.0062	0.0055	89.8	0.0068	5	1.00
50	3.54	0.0113	0.0078	68.6	0.0082	14	1.50
51	3.63	0.0086	0.0078	91.4	0.0085	*	1.60
52	3.51	0.0074	0.0060	81.9	0.0041	4	1.60
53	3.60	0.0086	0.0084	97.5	0.0068	−8	1.10
54	3.79	0.0082	0.0063	77.6	0.0085	9	1.50
55	3.89	0.0185	0.0164	89.0	0.0085	−4	1.45
56	3.97	0.0094	0.0077	82.0	0.0034	6	1.80
57	4.07	0.0152	0.0123	80.6	0.0076	−8	1.56

Chlorite–muscovite aggregate data. D, distance from center of *M*-domain; G, total grain area; C, area of chlorite component; C%, proportion of chlorite component; M, average thickness of muscovite layers; A, angle between (001) and S_0 in Fig. 5(a) (positive) and Fig. 5(b) (negative); L/W, aspect ratio for Fig. 6(a) (positive) and Fig. 6(b) (negative). Asterisk indicates measurement not obtainable. Grains 1 to 11 occur inside *M*-domain.

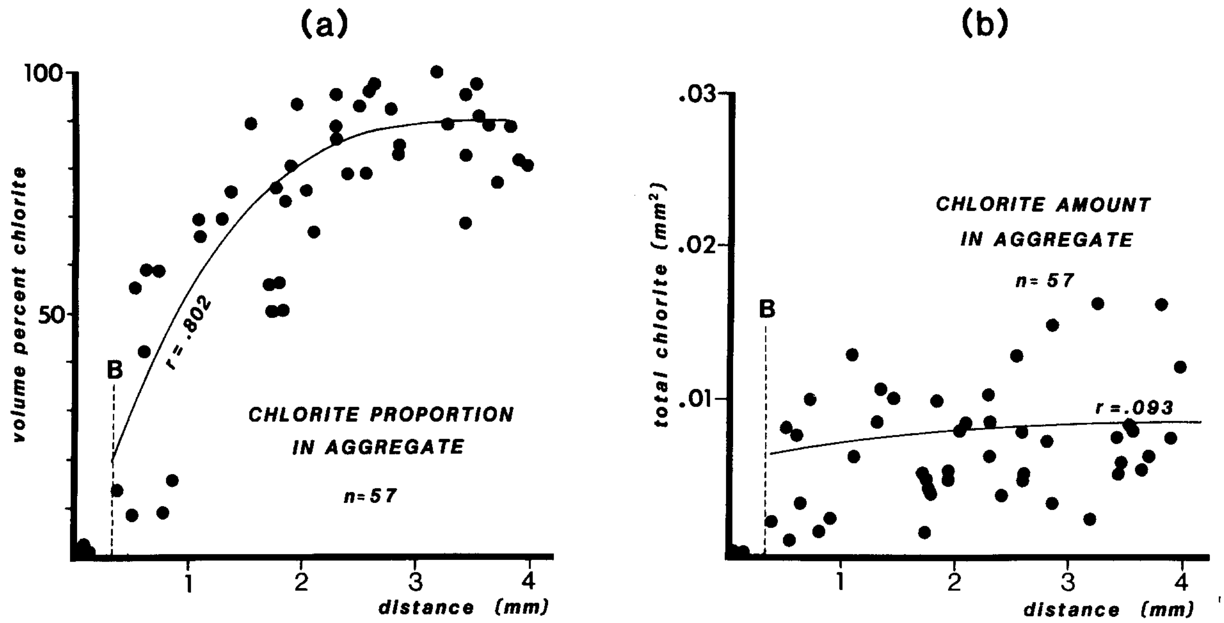

Fig. 3. Changes in the chlorite portion of the aggregates shown along the pelitic band in Fig. 1 showing (a) decrease in chlorite proportions in grains closest to *M*-domain boundary 'B' and (b) absence of any significant change in the amount of chlorite up to the *M*-domain boundary.

Outside the *M*-domain boundaries, white mica occurs in three distinct configurations within the aggregates. In the most common form, white mica occurs as very thin layers that lie along the boundary between displaced chlorite sections (Figs. 2a–c & f). These layers are either continuous and of uniform thickness, or slightly tapered, depending upon the nature of the displacement. The layers conform to the shape of translation surfaces where they are kinked or bent, but in such cases the white mica displays sharp extinction, whereas the adjacent chlorite shows strong undulose extinction.

A second common form for the occurrence of white mica is shown in Fig. 2(d). In this case a kinked area has been developed in a portion of the aggregate, and the material in the slipped region has been replaced entirely by white mica. The white mica displays a fairly sharp extinction compared to the chlorite in the unslipped portion of the grain.

A third form of white mica is shown in Fig. 2(f). In this example the white mica occurs as wedge shaped layers situated between split chlorite segments that have been separated by displacements along the aggregate grain boundary. Again, unlike the highly distorted chlorite, the white mica shows no evidence of deformation and displays sharp, uniform extinction.

CHANGES IN TEXTURE ASSOCIATED WITH PROXIMITY TO *M*-DOMAINS

Chlorite/white mica ratio

Of the two layer-silicate components, only chlorite displays increasing deformation of (001) traces in grains situated closer to *M*-domain boundaries. This increase in deformation of the chlorite component is accompanied by a decrease in the chlorite proportion in the aggregate (Fig. 3a) as the *M*-domain boundary is approached. Inside the *M*-domain chlorite is absent. There are two distinct aspects to this change in chlorite distribution. Outside the *M*-domain the decrease in chlorite proportion toward the boundary is not accompanied by a comparable decrease in the amount of chlorite in the aggregates (Fig. 3b). Instead, it is the increase in white mica layer thickness (Fig. 4a), and a corresponding increase in the amount of white mica, that results in the relative decrease in chlorite. If the amount of chlorite in the aggregate is constant, but the white mica increases in amount, then an increase in grain size of the aggregate must result. Figure 4(b) displays the average grain size of the aggregate and clearly shows this to be the case, up to the *M*-domain boundary.

The second aspect of the change in chlorite/white mica ratio concerns the aggregates that lie inside the *M*-domain (Fig. 1). The chlorite proportion (Fig. 3a) and the chlorite amount (Fig. 3b) in these aggregates drop abruptly to zero as the *M*-domain boundary (labeled 'B' in the figures) is crossed. White mica layers continue to increase in thickness until they incorporate the entire aggregate (Fig. 4a). The grain size of the aggregates drops significantly (Fig. 4b) inside the *M*-domain, probably by the loss of chlorite, although the exact mechanism for this reduction cannot be determined. The loss of chlorite can only be partly explained by alteration to white mica, however, since this alone would not result in a decrease in grain size.

Rotation of aggregates

Aggregates situated at large distances from *M*-domain boundaries (Area 'B' in Fig. 1) typically have (001) oriented sub-parallel to the trace of bedding in thin section. Toward the *M*-domain boundary (001) becomes progressively rotated away from bedding and toward S_1

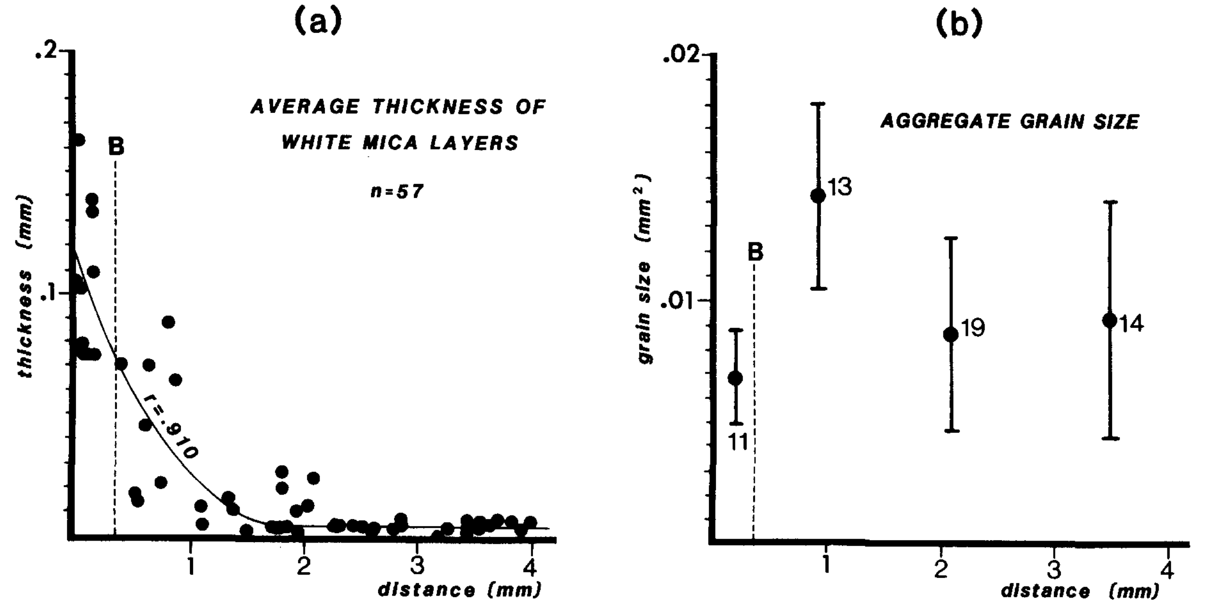

Fig. 4. (a) Increase in average thickness of white mica layers in aggregates near or within M-domain boundary 'B'. (b) Increase in aggregate grain size toward M-domain boundary, with sudden decrease in grain size within the domain. Plotted data represent average grain sizes with standard deviations shown, as well as sample size for each interval.

in most aggregates (Fig. 5). The amount of rotation appears to depend somewhat on the original sense of inclination of the aggregate (Figs. 5a & b). When compared to the data set in Fig. 5(a), the regression line in Fig. 5(b) displays an 'r' value of only 0.302, however, an adequate statistical evaluation of the differences between the data sets is precluded by low sample size.

In both graphs (Figs. 5a & b) there are a few grains that show low angles with S_0 regardless of proximity to M-domain boundaries. Visual inspection of these indicates that they display internal buckling of (001) such as shown by the example in Fig. 2(a). This relationship is the same one commented upon by Sorby (1853) who recognized that grains with their laminations perpendicular to cleavage were irregularly bent, but not rotated, whereas those with their laminations at lower angles were broken up and extended.

Aspect ratio

Inspection of weakly deformed aggregates in this and other samples indicates that the original chlorite porphyroblasts were oriented with a long axis either parallel to or perpendicular to bedding, or that they were equant. For this reason aspect ratio changes in the grains shown in Fig. 1 were separated into the two categories shown in Figs. 6(a) and (b). Aggregates with long axes that were originally perpendicular to bedding display an increase in aspect ratio (Fig. 6a) whereas aggregates with long axes originally parallel to bedding display a decrease in aspect ratio (Fig. 6b). Both of these trends can be explained by the shortening of the grains in a direction approximately 90° to cleavage, or by extension of the grains parallel to cleavage, or both.

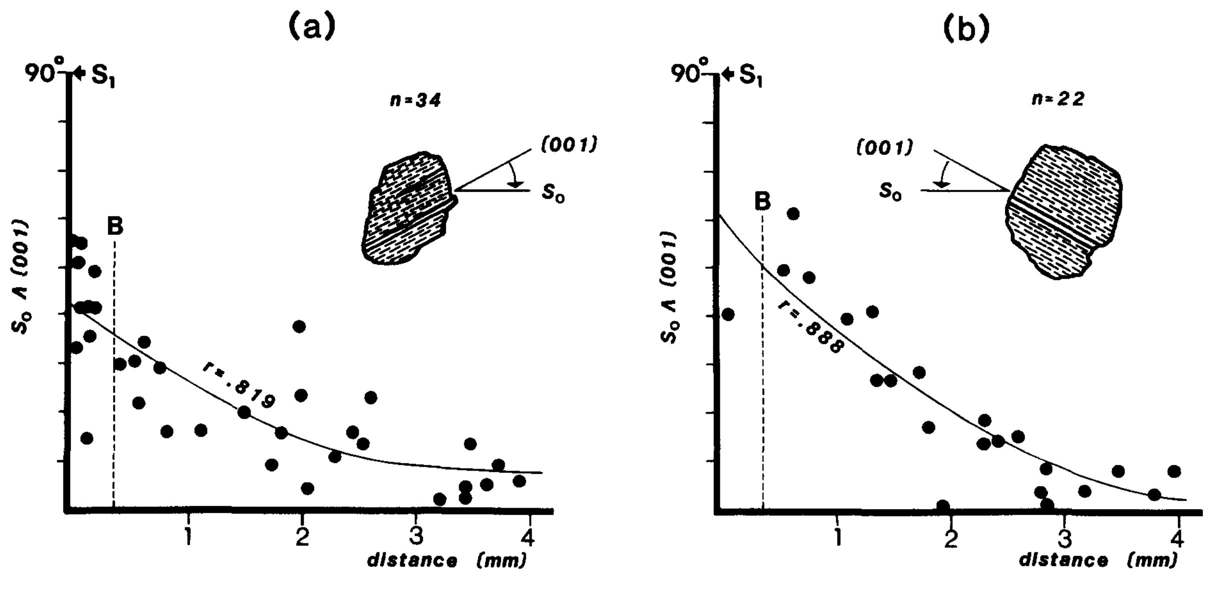

Fig. 5. Change in angle between (001) in the aggregates and the trace of sedimentary bedding in thin section, displaying rotation of the aggregates with increasing cleavage development (distance from M-domain boundary 'B').

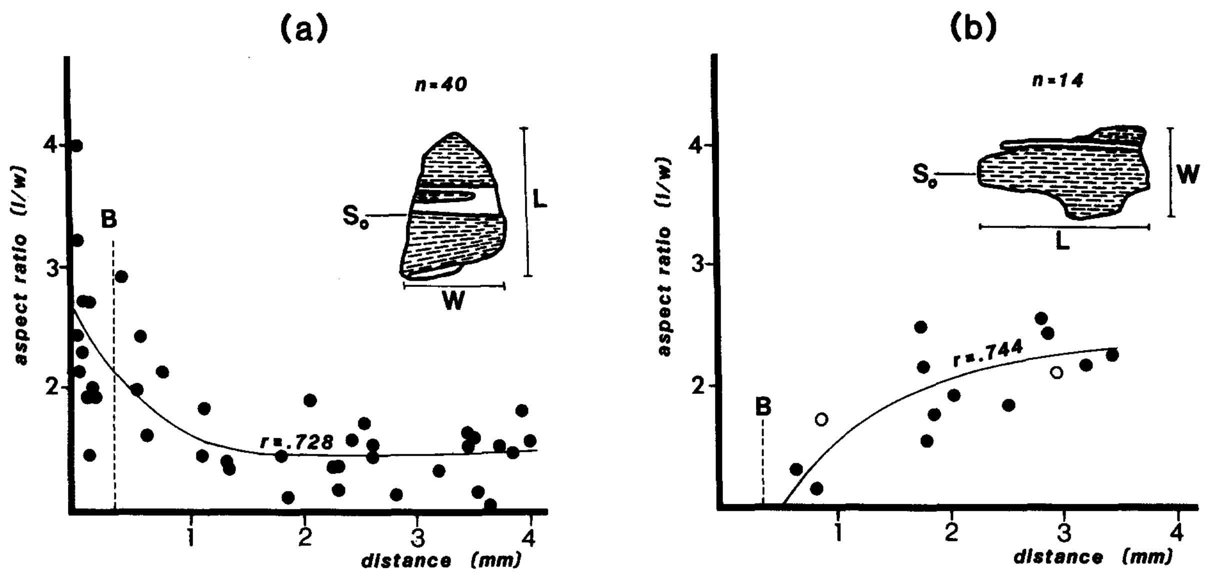

Fig. 6. Changes in aspect ratio of grains with long axes initially perpendicular (a) or parallel (b) to bedding. Open circles are points not listed in Table 1.

Interpretation of Islesboro results

The aggregates observed at Islesboro, in both pelites and siltstones, offer clear evidence for a non-detrital origin of the white mica layers. The deformation of (001) traces in the chlorite layers (Fig. 2) and the rotation of (001) in the aggregate (Fig. 5) demonstrate that the chlorite layers developed before cleavage formation. During cleavage formation, there was no growth in the chlorite layers, which remained constant (Fig. 3b) until they became entirely altered to white mica or destroyed by other processes inside the *M*-domains. In very weakly deformed rocks, white mica is entirely absent from the porphyroblasts, and there is every reason to believe that this was the case at the time of porphyroblast formation. The white mica layers present in the deformed aggregates can be compared to photomicrographs of typical detrital micas studied by the author (Fig. 7). I will refrain from making a point by point discussion of the obvious differences, which will be left to the judgement of the reader. The presence of the undeformed white mica layers along surfaces of mechanical dislocation in the aggregates (Fig. 2) and the increase in white mica content toward the *M*-domain (Fig. 4a) indicate that the white mica, not the chlorite, is a product of synkinematic crystallization. This relationship is nowhere better exemplified than in Fig. 2(f), where the white mica is emplaced in the gaps caused by separation of (001) layers in the chlorite aggregate. The extension of the aggregates in the cleavage direction, accompanied by synkinematic crystallization of mica results in an increase in aggregate grain size toward the boundaries of the *M*-domains, where the intensity of cleavage is greater (Fig. 4b). Within the *M*-domainsthe aggregate grain size decreases and the chlorite layers disappear, probably due to the effects of solution transfer and alteration to white mica. Individual white mica layers in these aggregates therefore resulted from either of two processes, by neomineralization along split or dislocated (001) surfaces in the prekinematic chlorite porphyroblasts, or by direct replacement of chlorite by white mica in areas where (001) was very strongly deformed (Fig. 2d). The emplacement of white mica in the aggregates during cleavage development represents a prograde metamorphic reaction that is reflected throughout the rock by the growth of identical white mica grains in mica films, thick *M*-domains and in strain shadows around pyrite porphyroblasts.

DISCUSSION

Previous work

Sorby (1853) provided the first descriptions of large mica porphyroblasts of nearly equant shape in a slate from North Devonshire. The particles apparently contained mostly white mica and were slightly less than 25 μm in size (one or two orders of magnitude greater than the grains in the matrix). He pointed out that when the (001) planes of the mica were perpendicular to cleavage, their equant form was retained, but they suffered internal deformation. Those grains with (001) lying parallel to cleavage were 'unaltered', whereas those with (001) inclined 30 or 40 degrees to cleavage showed disruption and extension. He commented that restoration of grains is possible with drawings made with a camera lucida, so it is likely that he observed grains similar in morphology to those in Fig. 2(b). Sorby used these grains as evidence for compression of the slate perpendicular to cleavage, and did not comment on the origin of their internal laminations.

Mosebach (1952) first discussed the relationships between the chlorite and white mica layers inside aggregates that occurred as 'lenses' between the darker mica-rich cleavage domains in slates from Kempfeld. Within the cleavage domains themselves he found no chlorite, only muscovite, and thus he hypothesized a synchronous but separate paragenesis of mineral assemblages in the two domains. He believed that enrichment of chlorite in the lenses between the '*S*-planes' and of muscovite on the cleavage planes occurred simultaneously, during the deformation responsible for cleavage. The mechanism he proposed was that the well-oriented muscovite in the cleavage planes evolved from solutions in which the "muscovite–chlorite ratio strongly favors muscovite"; whereas the bulk chemistry of the rock between cleavage planes, where solutions were less able to circulate, favored chlorite. The basis for his ideas stems mainly from his observation that the *S*-planes are "tectonic joints along which circulating solutions found easier permeability than in other directions".

Hoeppener (1956) briefly described chlorite/white mica aggregates from the vicinity of Moselmulde, Rheinische Schiefergebirge, and he suggested that the white mica layers in them represented detrital micas that served as a nucleus for accumulation of chlorite layers. He believed that the aggregates formed with (001) perpendicular to S_1, but with increasing foliation development were rotated into S_1 and "partly destroyed". The foliation in these rocks was apparently intensely developed, since Hoeppener commented that the aggregates were bounded on the sides by S_1-planes.

Weber (1972, 1976) and Loeschke & Weber (1973) described chlorite–mica aggregates occurring in clay slates from the Karawanken Mountains (Austria) and the northern Rheinische Schiefergebirge. In these rocks chlorite was said to have grown synkinematically around large sedimentary micas that are mostly muscovite. They noted that where the white micas are found in the planes of the cleavage, no chlorite occurs between or around them. Weber (1972) also noted a correlation between the amount of chlorite in the porphyroblasts and the degree of illite crystallinity in rocks sampled over a wide area. Photomicrographs displayed in Weber (1972, 1976) show intensely developed cleavage and strong deformation of the aggregates, including clear evidence for the displacement of layers in the aggregates parallel to (001) (Weber 1976, plate 9, fig. 3).

Beutner (1978) described large chlorite grains that contained one or several layers of clear mica in Martinsburg slates, and documented their parallelism with bedding in uncleaved pelites. The chlorite grains were referred to as detrital and their textural features and preferred orientations were used as evidence that "the platy minerals in this slate *did not rotate* during cleavage formation" (Beutner 1978, p. 1); thus contrasting with Sorby's (1853) observations that the deformation of such objects was largely mechanical (see also Attewell & Taylor 1969).

Williams (1972) briefly described very large white micas intergrown with chlorite in greywackes at Bermagui, Australia. In these rocks he reported bending and kinking of the white mica, with the axial planes of the kinks parallel to cleavage. In greywackes containing poorly developed cleavage the white micas were found to be statistically parallel to bedding and sometimes concentrated in thin mica-rich beds. Because of this and a correlation between sedimentary grading and the size of the white micas, Williams believed them to be detrital cores with non-detrital overgrowths of chlorite. The aggregates he illustrated are very different in morphology from those described by other workers, and the white mica layers in them bear a reasonable resemblance to detrital micas.

White & Knipe (1978) described chlorite rich pods in slates from Penrhyn (North Wales), Anglesey, and Rio Tinto (Spain) as 'mega-lenticular domains' and supported the suggestions of Attewell & Taylor (1969) that the aggregates were developed by crystallization. They also demonstrated the compression, rotation and extension of the aggregates during cleavage development.

Roy (1978) provided extensive discussion, but little evidence of, the detrital origin of white mica layers in aggregates from the slates of the Hunsrückschiefer. He claimed to see evidence for rotation of the white mica layers prior to the growth of chlorite, but offered no proof of the timing of this relationship. Based upon this presumed early rotation, he then hypothesized an early, pre-lithification deformational phase which was in turn, along with obligatory 'cleavage-parallel' clastic dikes, used to support the now defunct hypothesis of cleavage formation by soft sediment tectonic dewatering (Maxwell 1965).

In summary, many workers have followed Hoeppener's (1956) initial suggestion that the aggregates, or some portion of them, were primary in origin (Williams 1972, Weber 1972, 1976, Loeschke & Weber 1973, Beutner 1978, Roy 1978, van der Pluijm & Kaars-Sijpesteijn 1974, Woodland 1982). The textural evidence presented by these workers, with the exception of Williams (1972), has been largely inconclusive however. A few workers have suspected a non-detrital origin of the aggregates (Mosebach 1952, Attewell & Taylor 1969, White & Knipe 1978, Craig *et al.* 1982) and have cited crystallization as responsible for both chlorite and white mica layers. By and large, however, there has been general agreement that the chlorite component in these aggregates represents the later overgrowth, regardless of the origin of the white mica layers.

In the aggregates from Islesboro it is clear that the white mica layers are the later overgrowth. These form synkinematically with cleavage development by recrystallization in kinked regions or neomineralization in dislocated sections of large chlorite grains. The muscovite content of the white mica layers is compatible with the prograde metamorphism of layer silicates throughout the rock, and the layers bear no resemblance to known detrital micas. The chlorite layers are obviously pre-cleavage in origin, and display bending, kinking, rotation and alteration associated with cleavage development. Evidence supporting either a detrital or diagenetic origin for the chlorite is lacking, but the suggestion of Craig *et al.* (1982) that the chlorite was produced by mimetic replacement of clay minerals seems appropriate.

It would be incorrect to assume that the textural relationships displayed in the Islesboro rocks are representative of all other chlorite–mica aggregates throughout the world. Published photographs and textual descriptions of other aggregates do, however, show a remarkable similarity with those presented here (e.g. Hoeppener 1956, figs. 5–11; Beutner 1978, plates 1 & 2; Roy 1978, figs. 6 & 17) so it is possible that these results might be extended to slates in other regions.

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