

SEPIOLITE FROM THE MALVERN HILLS

by

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Summary

A new discovery of sepiolite is described and the possibility of sepiolite being a common constituent in the Keuper Marl is discussed.

Introduction

Sepiolite is a comparatively rare hydrous magnesium aluminosilicate which has been recorded only three times from this country, namely from Kynance Cove, Cornwall (Caillere and Henin 1949); Mullion, Cornwall (Midgley, 1957); and from an unstated Midland locality in the Keuper Marl (Keeling, 1956). Hitherto the formation of sepiolite has been attributed either to alteration of magnesium rich rocks, such as serpentine, or to sedimentation in basic saline lakes (Millot, 1949). The Cornish sepiolites are examples of the alteration of serpentines and the Keuper Marl exemplifies the sedimentary mode of formation. The recent discovery of sepiolite in a tension vein in the Malvern Hills suggests that there may be a third method of formation of this mineral - by direct crystallation from a hydrothermal liquid.

The Malvern Hills Material

Specimens were first found in dumps in the lowermost Wyche quarries (G.R. SO 771441) by Mr. J. M. A. Pontin and the writer in the summer of 1964. The material consisted of thin sheets, 1-2 mm thick, of a creamy white fibrous mineral, the fibres all being parallel to the wall rock and all orientated in one direction. Each fibre consists of bundles of microscopically thin components, which can be teased out of the bundles in a similar manner to asbestos fibres. Sheets consisting solely of the fibrous mineral can be bent almost double without breaking, like cardboard. Sheets containing calcite tend to be more brittle, but it is clear that fibres wrapping round the calcite have considerable strength. This asbestiform character was confirmed later when trying to grind the material in a pestle and mortar. Although intrinsically soft (hardness $2\frac{1}{2}$ to 3) the fibres have a high tensile strength which makes powdering difficult. Some of the original material is deeper yellow than average and material collected this year from an in situ vein is browner and has a waxier lustre than any of the original material. It is not clear whether these colours are due to superficial staining or inherent changes in composition.

TABLE 1

X-ray powder diffraction data for sepiolites from Malvern and Mullion

Malvern		Mullion (Midgley, 1959)	
d (Å)	I	d (Å)	I
12.07	vvs	12.1	vvs
7.50	m	7.45	w
6.68	w	6.74	w
4.92	vvw	5.02	vw
4.50	vw	4.54	m
4.30	s	4.28	ms
3.75	s	3.74	m
3.50	vw	3.55	vw
3.35	s	3.35	m
3.19	m	3.17	m
2.97	m	3.03	vw
2.81	vvw	2.82	vw
2.685	vw	2.70	vw
2.615	vvw	-----	
2.55	ms	2.57	s
2.44	vvw	2.44	m
2.40	vvw	2.40	vw
2.25	mb	2.26	m
		2.13	vw
2.06	vvw	2.06	w
etc.		etc.	

Identification and Chemistry

Microscopic examination shows that the fibres have straight extinction, low birefringence, positive elongation and refractive indices about 1.522 - 1.528. This information is not sufficient to identify the mineral. That it is a member of the sepiolite group of minerals was confirmed by X-ray analysis. The X-ray powder patterns compare closely with sepiolite from Mullion (Midgley, 1957) (see Table I) but research into the sepiolite group is not sufficiently advanced to allow the precise chemical composition to be deduced from the optical and X-ray data. Chemical analyses were therefore necessary, but, owing to the fibres being intimately intergrown with calcite, difficulty was experienced in obtaining a pure sample large enough for analysis. Treatment with dilute acetic acid successfully removed all the calcite but there is a risk that the sepiolite might also have been attacked, although X-ray photographs showed no sign of such a change. For this reason two analyses were undertaken, one of the sepiolite after acid treatment and one of the complete vein (i. e. calcite and sepiolite). This latter has been recalculated (Table II) on the assumption that all the calcium is contained in the calcite. The two analyses are so remarkably different, particularly in their Si/Al ratios, that there must be more than one form of sepiolite present and further investigations are now being undertaken.

Whether or not there are two or several forms of sepiolite present, they are markedly different from sepiolites previously described (see Table II and Text-fig. 1). According to the structure proposed by Brauner and Preisinger (1956) and favoured by Caillère and Hénin, the likely formula of a half unit cell of ideal sepiolite is $(\text{Si}_{12})(\text{Mg})_8\text{O}_{30}(\text{OH})_4(\text{OH}_2)_4\cdot 8\text{H}_2\text{O}$. The dehydrated mineral should therefore have the formula $\text{Si}_{12}\text{Mg}_8\text{O}_{32}$. Recalculation of analyses on the basis of 32 oxygens shows that the Si in the tetrahedral position may be partially replaced by trivalent elements such as Al and Fe^{3+} . Magnesium in the octahedral position may be replaced by Al, Fe^{3+} , Fe^{2+} , Ni or Mn^{2+} (Caillère and Hénin 1961). The Malvern sepiolites are distinguished from all other sepiolites by having a large amount of aluminium in tetrahedral co-ordination (Text-fig. 1). Although they contain less Al_2O_3 than the aluminous sepiolite from South Australia (Rogers, Quirk and Norrish 1956), twice as much is in tetrahedral co-ordination. The asbestiform nature of the Malvern material may well be related to its unusual chemical composition.

Mode of formation

Since the original material was collected from dumps, it was not possible to postulate the mode of formation except that, since it occurred in straight edged veins, it could be hydrothermal. Subsequent investigation led to the discovery of a vein in the wall of the quarry by Mr. A. J. Rundle. This approximately vertical vein has the character of a dilation fissure, its walls being lined with horizontal fibres of sepiolite. Calcite is sandwiched between the sepiolite. Although this certainly looks like a hydrothermal occurrence, it is possible that the sepiolite is replacing an earlier vein filling or that the sepiolite is replacing hornblende of the feldspathised hornblende country rock. The fibres have certainly not grown at right angles to the walls, as one might expect had the mineral been crystallising freely from the liquid, but this could be due to favourable crystallising surfaces, such as minute horizontal slickensides, which encouraged nucleation in this orientation. The variable composition might equally well be due either to successive members of a solid solution series crystallising or to differences in wall rock replacements. Further detailed work will be necessary to solve this problem.

Sepiolite in the Keuper Marl

Sepiolite should be of considerable interest to members of the East Midlands Geological Society not only because of its recent discovery in the Malverns, but because of its possible abundance in the Keuper Marl.

TABLE II

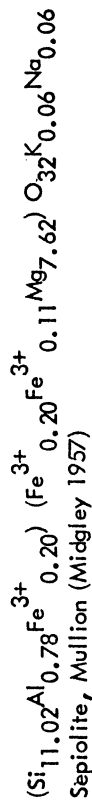
Analyses and structural formulae of sepiolites with tetrahedrally co-ordinated Aluminium

	(1)	(2)	(3)	(4)	(5)	(6)
	Malvern acid treated	Malvern partial analysis recalculated	Mullion	Aluminous sepiolite	Little Cottonwood, Utah	Madagascar
SiO ₂	45.20	48.29	50.06	52.43	52.97	52.50
TiO ₂			0.16			
Al ₂ O ₃	5.89	2.94	1.27	7.05	0.86	0.60
Fe ₂ O ₃	0.35	2.29	3.49	2.24	0.70	2.90
FeO	0.11	0.55		2.40		0.70
MgO	21.39	22.20	22.24	15.80	22.50	21.31
CaO	0.70		0.04			0.47
Mn ₂ O ₃			0.06		3.14	
Na ₂ O	0.81	0.15	0.08			
K ₂ O	0.01	0.11	0.10			
H ₂ O ⁺	17.96	23.34	10.40	9.45	9.90	9.21
H ₂ O ⁻	6.60		12.02	10.48	8.80	12.06
	99.01		99.92	99.71	99.74	99.75
			incl. 0.58 NH ₃	incl.	0.87 CuO	

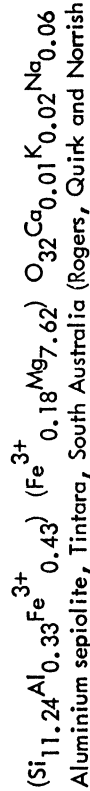
(1) Sepiolite Malvern (this paper). Acid treated.



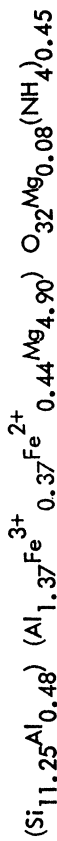
(2) Sepiolite Malvern (this paper). Complete vein recalculated.



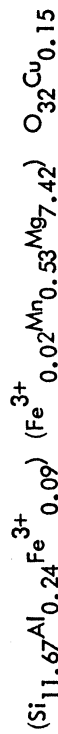
(3) Sepiolite, Mullion (Midgley 1957)



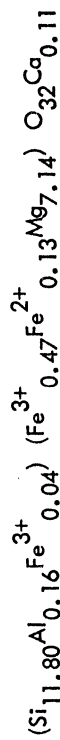
(4) Aluminium sepiolite, Tintara, South Australia (Rogers, Quirk and Norrish, 1956)

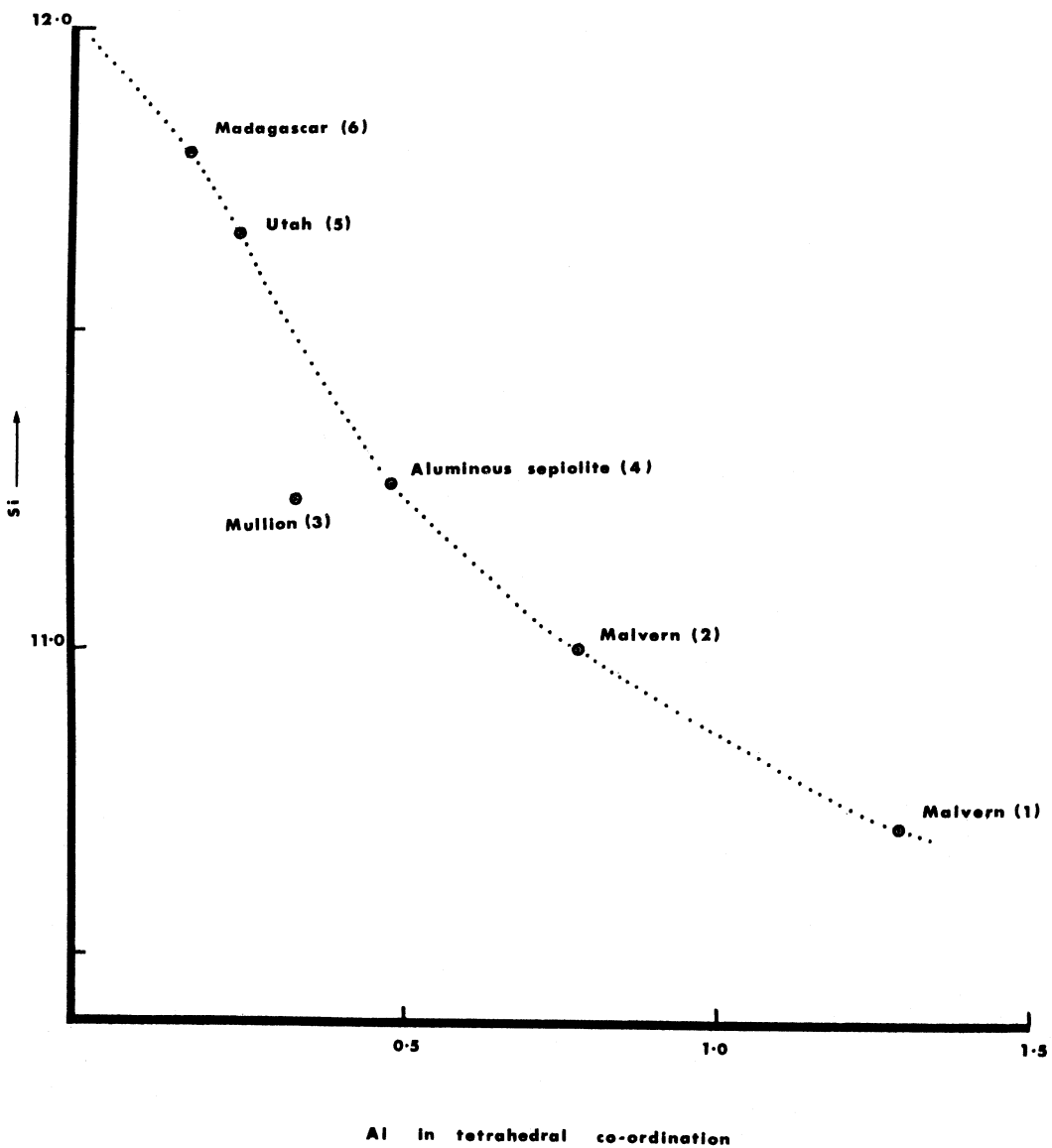


(5) Sepiolite, Little Cottonwood, Utah (Nagy and Bradley 1955)



(6) Sepiolite, Ampanradava, Madagascar (Caillière 1936)





TEXT FIG. 1.

Sepiolite with Al in tetrahedral co-ordination

Dunham (1955) comments that the average of 39 analyses of Keuper Marl show that the ratio of MgO/CaO is greater than the 0.68 required for dolomite (CaMg (CO₃)₂). Since no magnesite (MgCO₃) is present, Dunham concludes that another magnesium rich mineral must occur.

The writer's work in the Chilwell Brick Pit, Notts. (G.R. SK 513355) suggests that a magnesium rich mineral other than dolomite is present there. As much as 36% of the marl may be soluble in HCl, the principal cations in the resulting solution being iron, magnesium and calcium. The MgO/CaO ratios in these solutions are up to eight times that required for dolomite. One sample from the middle beds of the quarry has an excess of 9% MgO over that required for dolomite. If sepiolite is present in this sample, then up to 40% of the rock could be sepiolite. That this is not impossible is shown by the fact that sepiolite is readily decomposed by acids, leaving gelatinous silica, and by the discovery (Keeling 1956) of sepiolite in Keuper Marl in a Midlands locality. Keeling's analyses suggested that up to 39% of a 30 feet bed of Keuper Marl at an unnamed locality might be sepiolite. Other possibilities include montmorillonite - chlorite complexes of the type described by Honeybourne (1951).

Whatever the reason for the excess magnesia in these rocks, it is clear that a thoroughgoing study of the mineralogy of the Keuper Marls would be worth while and that sepiolite is one of the minerals likely to commonly occur. Thus detailed studies of the well crystallised sepiolite from the Malvern Hills may throw light on the local Keuper Marl.

Acknowledgements

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