

SERPENTINE AND MODAL COMPOSITIONS OF CM CHONDRITES

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INTRODUCTION: The CM chondrites are mineralogically and texturally diverse, prompting attempts to define models of their evolution involving systematic compositional and mineralogical changes. Because of clear evidence of such processes, these models have generally concerned mineralogical changes accompanying progressive aqueous alteration on the CM parent body or bodies. Briefly, McSween [1] has proposed that production of CM matrix proceeds from alteration, with the most heavily altered CM chondrites necessarily having the highest modal percentage of matrix. Tomeoka and Buseck [2] have refined this model based upon their microstructural examination of three CM chondrites, Mighei, Murchison and Murray. They propose that serpentine-like minerals (we include cronstedtite and antigorite together here for simplicity) become progressively enriched in Mg (and depleted in Fe) as aqueous alteration proceeds. They further suggest that the modal abundance of tochilinite peaks at an intermediate point during alteration, being consumed by its completion. Our own geochemical modeling of CM alteration suggests that once formed, tochilinite may be resistant against destruction by further aqueous alteration, providing temperature and Eh do not dramatically increase [3]. We have tested these proposals through bulk chemical analyses of the matrix, modal analysis and serpentine analyses of 20, 19 and 7 CM chondrites, respectively.

PROCEDURES: We performed focussed beam microprobe analyses of matrix and chondrule rims from ALH 83100, EET 83389, Bells, Y791198, Murchison, Cochabamba, Nogoya, Mighei, LEW 85307, MAC 88107, ALH 83016, ALH 84029, Murray, LEW 87148, ALH 81002, MAC 88101, LEW 88001, EET 83334, Y82042 and ALH 88045. We also performed modal analyses of most of these. We then performed microprobe or analytical electron microscopy analyses of 180 serpentine grains from seven of the above CM chondrites.

RESULTS AND DISCUSSION: Previous work has demonstrated that the dominant matrix and chondrule rim minerals of CM chondrites are serpentine, tochilinite, pyrrhotite (\pm pentlandite) and a coherent tochilinite-serpentine intergrowth (TS) [4]. Figure 1a shows the results of our serpentine analyses plotted onto a reduced ternary diagram of wt% elements Fe, Si and Mg. Figure 1b shows our average CM matrix and chondrule rims analyses plotted along with the compositional ranges of the dominant matrix and matrix rim phases (serpentine range taken from Fig. 1a). Clearly, serpentine volumetrically dominates matrix and chondrule rims in CM chondrites, as previously noted by McSween [5].

We further note that the serpentine analyses in Fig. 1a may be divided into three clear types: high Fe (Mighei, MAC 88101 and Murray), intermediate (Murchison, ALH 88045 and EET 83334) and high Mg (Nogoya, ALH 83100 and ALH 84029).

Table 1 shows results of our modal analyses pertinent to this report, with meteorites listed in groups according to membership in the serpentine compositional groups (high Fe, intermediate and high Mg, respectively). The final category, modal sum of matrix, chondrule rims and phyllosilicate grains, is an approximate tally of total serpentine in a meteorite, as matrix and chondrule rims consist dominantly of serpentine. We do not find direct correlations between serpentine composition and either modal matrix or tochilinite percentage. This result is compatible with previous comparisons of CM matrix composition and modal matrix content [6]. However, we do find a direct correlation between Mg content of serpentine and total modal amount of serpentine in these CM chondrites.

CONCLUSIONS: We conclude that serpentine composition is tied to serpentine production, and ultimately to the degree of aqueous alteration. Modal content of tochilinite is not a reliable indicator of the degree of aqueous alteration. Iron excluded from serpentine at

CM CHONDRITES: Browning L. et al.

mature stages of alteration must partition into both tochilinite and pyrrhotite (\pm pentlandite).

REFERENCES: [1] McSween (1979) *Geochim. Cosmochim. Acta* **43**, 1761-1770; [2] Tomeoka and Buseck (1985) *Geochim. Cosmochim. Acta* **49**, 2149-2163; [3] Zolensky et al. (1989) *Icarus* **78**, 411-425; [4] Zolensky (1990) *LPSC XXI*, 1383-1384, [5] McSween (1987) *Geochim. Cosmochim. Acta* **51**, 2469-2477; [6] Zolensky et al. (1987) *Meteoritics* **22**, 544-545.

TABLE 1. PARTIAL RESULTS OF MODAL ANALYSIS OF 7 CM CHONDRITES

<u>Meteorite</u>	Modal %				
	<u>Toch.</u>	<u>Matrix</u>	<u>Chondrule Rims</u>	<u>Phyll.</u>	<u>Matrix+Rims+Phyll</u>
"High Iron Serpentine"					
Mighei	8	60	6	4	70
Murray	2	67	<1	7	74
"Intermediate Serpentine"					
Murchison	<1	72	1	2	75
EET 83334	<1	54	<1	26	80
ALH 88045	<1	<1	28	29	86
"High Magnesium Serpentine"					
ALH 84029	6	32	5	47	84
Nogoya	<1	81	2	5	88

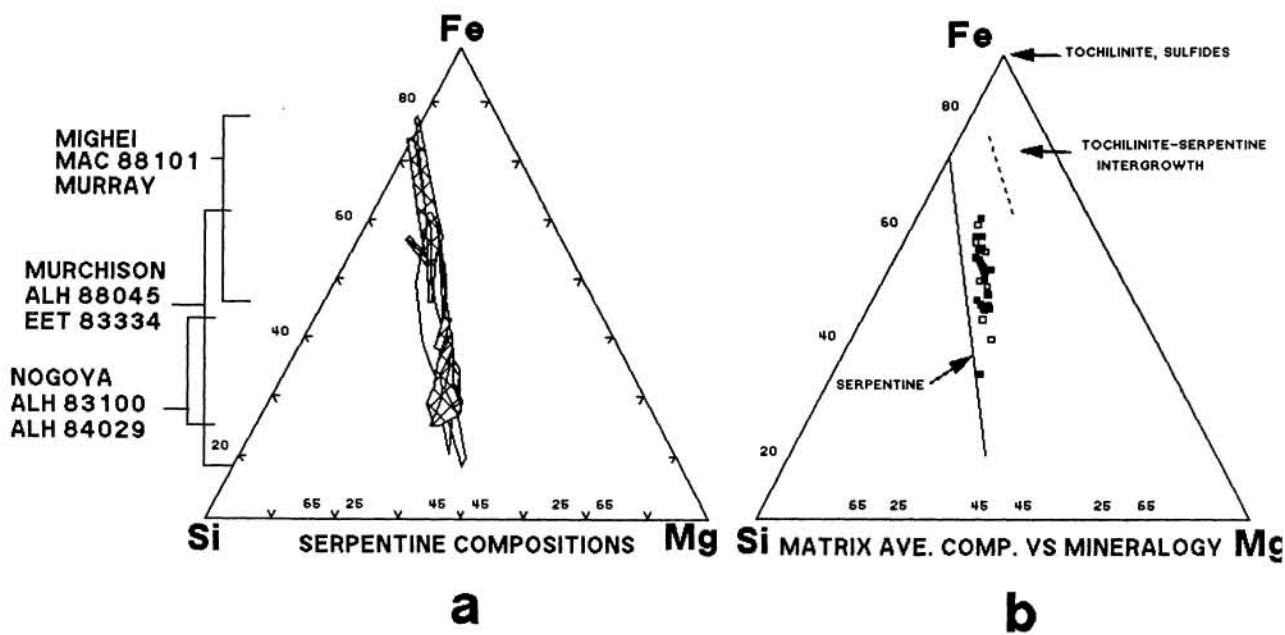


FIGURE 1