Analyses of some of the opaque minerals (Table I) show that there is a considerable range already present in *in situ* Fe–Ni alloys at Red Mountain. The patchy distribution of iron described by Challis has not been observed in Red Mountain alloys, but compositions ranging from $Ni_{66.1}$ $Fe_{33.9}$ to $Ni_{90.9}$ $Fe_{9.1}$ have been determined. Cobalt is also present in significant amounts (Table I).

Compositional relations among analysed Ni–Fe–S minerals are shown in fig. 2. Tie lines connect analyses of mineral grains that occur within single samples but which do not necessarily represent equilibrium assemblages. However, the arrangement of tie lines is consistent with equilibrium at temperatures of less than 550 °C (Kullerud *et al.*, 1969). The data also suggest that Fe/Ni of the alloys is mainly controlled by bulk composition (i.e. rock plus fluid) during serpentinization. The most iron-rich alloys occur with pyrrhotine (po), whereas iron-poor alloys occur with pentlandite (pn).

Although the mechanism proposed by Challis (1975) may be valid, the natural refining process is unnecessary to explain the compositional range of Fe–Ni alloys in the north-west Otago–south-Westland region, since a considerable range is represented in the source serpentinites of the Red Mountain area. This range probably reflects the Fe–Ni range of bulk compositions during hydrothermal alteration.

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Volborthite in Liguria, Northern Italy

VOLBORTHITE $Cu_3(VO_4)_2.3H_2O$, so far described in few localities (Guillemin, 1956; Witkind, 1961; Leonardsen and Petersen, 1974), has been found in two parts of Liguria. In the Cassagna Mine (Eastern Liguria), where Mn-ores occur within the M. Alpe Chert Formation (Passerini, 1965) that lies on the top of ophiolite sequences volborthite is mainly associated with the Cu-bearing minerals chalcosine, cuprite, malachite, azurite, and native copper, in a mineralization related to fossil araucaria trunks (Cortesogno and Galli, 1974). In the upper Neva Valley (Albenga, Western

Liguria) volborthite occurs within a chalcopyrite–azurite–malachite–galena–aurichalcite–sphaerocobaltite mineralization (Pelloux, 1926) in Triassic dolomitic limestones (Vanossi, 1971).

TABLE I. *Physical data on Ligurian and synthetic volborthite*

h k l	*I*	1	2	3	*h k l*	*I*	1	2	3
0 0 1	100	7·17 Å	7·17 Å	7·16 Å	222/402	25	2·047 Å	2·045 Å	2·045 Å
2 0 0	5	5·293	5·262	5·262	4 2 $\bar{1}$	5	1·9277	—	1·9239
1 1 0	10	5·112	5.097	5·112	1 3 $\bar{1}$ / 4 0 $\bar{3}$	10	1·8521	—	1·8557
2 0 $\bar{1}$	5	4·429	—	4·418					
1 1 $\bar{1}$	25	—	4·241	4·241	5 1 $\bar{2}$	—	—	—	—
111/201	25	4·105	4·124	4·087	0 0 4	20	1·7942	1·8041	1·7958
0 0 2	15	3·576	3·583	3·583	2 2 $\bar{3}$	20	1·7876	1·7876	1·7876
2 0 $\bar{2}$	30	3·095	3·090	3·090	4 2 $\bar{2}$	5	—	—	1·7683
3 1 0	—	—	—	—	223/11$\bar{4}$	20	1·7204	—	1·7144
1 1 $\bar{2}$	45	2·993	3·008	2·998	1 3 $\bar{2}$	20	—	—	1·7056
0 2 0	—	—	—	—	5 1 2	20	1·6725		1·6810
1 1 2	40	2·885	2·885	2·885					
31$\bar{1}$/202	35	2·858	—	2·858	2Vγ		63°	—	—
021/311	30	2·715	—	2·711	α		1·820	—	—
4 0 0	30	2·648	2·626	2·637	β		1·835	—	—
2 2 0 / 4 0 $\bar{1}$	50	2·571	2·543	2·564	γ		1·920	—	—
					a		10·643 Å	10·671 Å	10·583 Å
2 2 1	45	2·392	2·399	2·383	*b*		5·874	6·037	5·866
4 0 $\bar{2}$	10	2·238	2·222	2·217	*c*		7·202	7·275	7·208
2 2 $\bar{2}$	—	—	—	—	β		95·17°	92·78°	94·90°

1. Volborthite of Cassagna Mine.
2. Volborthite of Neva Valley.
3. Synthetic volborthite.

α, β, γ and *a*, *b*, *c* all $\pm$0·002.

In the Cassagna Mine volborthite appears as 'rose flowers' up to 1 mm in diameter in veins and small geodes: the mineral shows lamellar shape and pseudohexagonal habit, with a {001} cleavage, micaceous brightness, and variable colour from yellow to greenish-yellow. In thin section the lamellae show an intense yellow colour, weak pleochroism ($\alpha = \beta$ = yellow; γ = yellow-green), straight extinction and fast along the length related to the {001} cleavage; strong dispersion. The volborthite of Neva Valley is present as yellow-green dusty coats and veins without a defined habit, replacing Cu-bearing minerals, mainly malachite and azurite.

Physical data are listed in Table I together with those of volborthite synthesized by the method of Guillemin (1956), starting from Na-metavanadate.

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