μm) and displays its characteristic parquet twinning. Bournonite encloses pyrite, sphalerite, native antimony, tetrahedrite, chalcopyrite, and galena. Small amounts are intergrown with sphalerite, chalcopyrite, and galena around the main sphalerite, or form thin rims around tetrahedrite in galena, or occur together with chalcopyrite as rims surrounding tetrahedrite in sphalerite. It alters to covelline, blaubleibender covelline, bornite, and limonite. Analyses are given in Table I.

Galena is the second most abundant sulphide after sphalerite, which it cements. Thin veinlets (1–2 μm) cut sphalerite, and it also occurs in veins with tetrahedrite and chalcopyrite which cut the main sphalerite. Galena encloses and replaces fractured pyrite, tetrahedrite, marcasite, arsenopyrite, and bournonite. It is altered to bournonite (2–5 μm rims), covelline ($< 50 \times 10$ μm aggregates), cerussite, and anglesite. A later generation of galena appears to be associated with the alteration of the primary sulphides. It occurs as 1–5 μm grains, botryoidal in texture, associated with colloform pyrite and enclosed within cerussite and anglesite.

Colloform pyrite occurs as thin veinlets (100 × 4 μm) consisting of 2–4 μm grains associated with alteration minerals around the main sphalerite, and along its cleavage. Isolated grains occur up to 5–20 μm, or it occurs as framboids (< 20 μm).

Bornite occurs as rims (< 30 μm) around altered bournonite, sphalerite, and tetrahedrite, and is itself altered to *covelline*. The latter occurs as patches of bladed crystals (< 50–60 μm) or forms fine-grained aggregates replacing galena and sphalerite at grain boundaries and along cleavages. Covelline pseudomorphs small (5–10 μm) grains of chalcopyrite, sphalerite, and tetrahedrite, or forms alteration rims 10–20 μm in width at their margins.

Smithsonite, cerussite, and *anglesite* replace galena and sphalerite and form crystals up to several millimetres across, where developed in cavities. Relict galena and sphalerite occur within these grains in addition to flecks of covelline.

It might be expected that closely related veins, such as the No. 1 and No. 3 Lodes at Le Pulec, would show broad chemical and mineralogical similarities. For the most part this is true, but there are also significant differences between the lodes which can be summarized as follows: (i) there is no dolomite or calcite gangue in the No. 1 Lode; (ii) grains of tetrahedrite and bournonite in the No. 1 Lode are considerably larger than those seen in the No. 3 Lode; (iii) no plagionite or stibnite has been detected in specimens from the No. 1 Lode, and native antimony is much less common than in the No. 3 Lode; (iv) no cubanite has been observed in the No. 1 Lode and there is less chalcopyrite than in the No. 3 Lode; (v) tetrahedrite from the No. 1 Lode has a lower silver content (6–8 wt. % Ag) than that from the No. 3 Lode (9–20 wt. % Ag), and a correspondingly higher copper content.

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Lattice parameters and composition limits of mixed Mg–Al hydroxy structures—a discussion

WE wish to thank Professor Brindley (pers. comm.) for drawing our attention to the differences in lattice parameters and the limiting values of composition between synthetic hydroxy carbonates of Mg, Al (Brindley and Kikkawa, 1979), and synthetic hydroxide structures of Mg, Al (Mascolo and Marino, 1980). The lattice parameter values for different Mg, Al ratios in the two studies are different, and in particular $\Delta a/\Delta x$ with $x = \text{Al}/(\text{Al}+\text{Mg})$ is noticeably lower for plain hydroxides (fig. 1, Brindley, 1980).

Comparing the syntheses in the two studies, no

additional ions are present in the synthesis by Mascolo and Marino (1980), while Na foreign ions were present in the synthesis by Brindley and Kikkawa (1979). The plain carbonate species, in fact, were obtained using initial products obtained through addition of NaOH solution to mixed solutions of Mg, Al perchlorates. Chemical analyses carried out by us on samples prepared according to the method of Brindley and Kikkawa (1979) showed the presence of some Na whose amount increases for lower x values (Table I). This may

TABLE I. *Na$_2$O content (wt. %) in calcined (900 °C) Mg, Al compositions prepared according to the method of Brindley and Kikkawa (1979)*

x	0.24	0.28
Na$_2$O	1.4	0.2

account for the difference in the a values between hydroxy carbonates and plain hydroxides of Mg, Al (fig. 1, Brindley, 1980). In fact, the eventual replacement of Mg or Al by Na with a higher ionic radius gives rise to an increase in the a parameter. On the other hand this replacement gives rise to a local excess of negative charge that might be mainly or wholly balanced by an adjacent local excess of positive charge due to the replacement of Mg by Al. This involves a decrease of the net positive charge of the basic layer; consequently the

layer spacing c' increases, as reported by Brindley (1980) in fig. 1 for hydroxy carbonates of Mg, Al. It can be concluded that the presence of some Na in the composition of the basic layer increases both the a and c' values in respect to those of Mg, Al compositions having the same x value and without Na content.

The lower limit of x value, less clearly indicated in the literature, suggests that the compositions with lower Al content keep foreign ions more easily and make their stacking layers broader. In these cases, in fact, there is a weaker bond strength between layer and interlayer. Foreign cation-occupied octahedra placed between pairs of Mg or Al-occupied octahedra account for the wider range of composition indicated by Gastuche *et al.* (1967). However, $0.25 \leqslant x \leqslant 0.33$ appears the true range of composition, as suggested by Allmann (pers. comm.) and Brindley (1980) for hydrotalcite-like structures.

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