There is a fairly clear-cut separation in chemical compositions, mineralogies, textures and oxygen isotopic compositions between the common CI1 chondrites (e.g., Alais, Ivuna, Orgueil) and the common CM2 chondrites (e.g., Cold Bokkeveld, Murchison, Murray, and others). The CI1 meteorites are characterized by the absence of chondrules, almost complete conversion of anhydrous silicates to clay minerals, absence of metal and abundance of magnetite. The extent of aqueous alteration of the common CM2 chondrites varies from meteorite to meteorite. Modelling of the oxygen isotopic behavior during the aqueous alteration process for CM2 chondrites allows calculation of the integrated water/rock ratio, which is always large enough to provide an excess of the water reservoir, i.e., the incompleteness of alteration is not due to the depletion of the water reservoir. The whole-rock isotopic composition is a good measure of water/rock ratios and is insensitive to the extent of reaction for individual rocks.

Three meteorites (Bells, Essebi and Niger-I) which have been classified as CM chondrites have distinctive properties, particularly in containing abundant (~10%) magnetite, which suggests conditions of aqueous alteration more like those of CI chondrites than those of typical CM chondrites. Oxygen isotopic compositions of these meteorites are shown in Fig. 1. Data for whole-rock and separated minerals from Bells and Essebi are from Rowe et al. [1]. Three new analyses of Niger-I (whole-rock, magnetite and phyllosilicate) plot together at \( \delta^{18}O = 14.5\%_e, \delta^{17}O \approx 0 \).
= 7.8‰, a composition well outside the usual CM range, and close to the values for CI whole-rocks and a single analysis of a phyllosilicate separate from Essebi.

Metzler et al. [2] note several petrographic differences in Essebi and Bells relative to other CM meteorites. They note that: “Essebi and Bells are heavily brecciated and, in addition, appear to have been extensively affected by aqueous alterations, probably on their parent body. Both meteorites contain clusters of subhedral to euhedral magnetite crystals that probably formed by aqueous processes on the parent body. These clusters are similar to those found in CI chondrites and related meteorites, e.g. Y 82162”. Comparable detailed petrographic studies have not yet been done on the matrix component of Niger-I. Desnoyers [3] studied the unaltered silicate and metal phases of Niger-I, with an emphasis on the origin of olivine grains in C2 chondrites. In a Mössbauer study comparing Niger-I and Murchison, Costa et al. [4] noted the large abundance of magnetite in Niger-I and suggested a closer similarity to Orgueil than to Murchison.

Clayton and Mayeda [5] presented an updated version of the aqueous alteration model of Clayton and Mayeda [6] to describe the systematic variations in oxygen isotopic composition of CM chondrites. They showed that interaction between two reservoirs, one rock and one water, leads to a straight line on the three-isotope plot. The position of a meteorite’s composition along this line is a measure of the integrated water/rock ratio for that rock. The data for Bells lie toward the upper end of the CM trend, while those for Essebi and Niger-I are distinctly above this trend, along with data for CI chondrites Alais, Ivuna and Orgueil. The departure from the CM trend implies a higher temperature of alteration for the magnetite-bearing rocks. Temperature estimates are 0–25°C for CM and 100–150°C for CI, Essebi and Niger.

Antarctic meteorites: B 7904, Y 82162, Y 86720 and Y 86789 constitute another group with distinctive oxygen isotopic compositions. They cannot be placed in the conventional CM2 or CI1 categories, and also show chemical and mineralogical evidence for metamorphic dehydration. The dehydration process probably involved a kinetic isotope fractionation, with preferential loss of the light oxygen isotopes in water, and concomitant heavy-isotope enrichment in the solid residue. The experimental study of Mayeda and Clayton [7] showed that this enrichment follows a mass-dependent trajectory, with an increase in $\delta^{18}O$ of about 4‰. The implication is that the pre-dehydration isotopic compositions of this group were very similar to the compositions of CI chondrites.