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Magnetic anisotropy of carbonate minerals at room temperature and 77 K

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ABSTRACT

The relationship between magnetic properties and chemical composition of 19 natural carbonate single crystals of the calcite, aragonite, and dolomite groups and of azurite were investigated. Magnetic susceptibility was determined in low fields, and magnetic anisotropy was measured at room temperature and at 77 K using a high-field torque magnetometer. The chemical composition was analyzed using LA-ICP MS. Planar arrangement of the CO_3-groups generates an oblate diamagnetic anisotropy with the minimum susceptibility k_3 along the crystallographic **c**-axis in all investigated anhydrous carbonate minerals. A prolate paramagnetic anisotropy with the maximum susceptibility k_1 along the **c**-axis is produced by Fe^{2+} in the trigonal carbonate lattice, which can lead to a transition from oblate to prolate shape of the total anisotropy. The transition occurs in the calcite structure above an Fe concentration of 400 ppm at room temperature and 150 ppm at 77 K. The susceptibility difference $k_1 - k_3$ for pure calcite is 4.06×10^{-10} m^3/kg and increases to 9.4×10^{-9} m^3/kg for 10800 ppm Fe. In the hexagonal aragonite structure, no paramagnetic anisotropy due to Fe^{2+} was detected. Azurite shows a strong anisotropy with $k_1 - k_3 = 1.5 \times 10^{-8}$ m^3/kg, which is assigned to Cu^{2+}. The paramagnetic anisotropy due to Fe^{2+} increases at 77 K in minerals of the calcite and dolomite group and in azurite, but not in minerals of the aragonite group. Upon cooling from room temperature to 77 K, $k_1 - k_3$ increases 13.3 times for 500 ppm to 100000 ppm Fe^{2+} in the trigonal lattice and 7.2 times for siderite.

Keywords: Carbonate minerals, magnetic properties, anisotropy, calcite, siderite, rhodochrosite, LA ICP-MS