Early Permian - Early Triassic siderite deposits in the Southern Alps (Italy)

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Siderite occurs in different sites of the Lombardian and Venetian Southern Alps. Usually siderite is present as veins cutting the basement and Early Permian volcano-sedimentary cover (Collio Fm.), and as both veins and conformable stratabound orebodies in the Late Permian (Verrucano Lombardo, Bellerophon Fms.) and Early Triassic (Servino Fm., Werfen Fm.) sequences. All the deposits show similar major- and rare-earth (REE)-element patterns suggesting a common iron-mineralizing event. The composition of coexisting siderite, Fe-rich dolomite and calcite solid solutions, in addition to a coarse grain size and the nature of ore mineral assemblages suggest formation from hydrothermal fluids at relatively high temperature conditions (~250 °C). Geochemical modelling, supported by REE and new $d^{13}C$ and $d^{18}O$ isotopic data suggest that siderite formed by precipitation from hydrothermal fluids, derived from fresh water, leaching organic matter and Fe-proto concentrations contained in continental sediments as well as the Lower Permian volcanic rocks of the Southern Alps. On the basis of U-Th-Pb microchemical dating of uraninite associated to siderite in the Val Vedello and Novazza deposits (Lombardian Alps), the onset of hydrothermalism is constrained to Early Permian, contemporaneously to plutonism and to the volcanic-sedimentary cycle reported in the Orobic Basin. The siderite veins and conformable bodies in the Lower Triassic shallow-marine successions were formed by precipitation from similar hydrothermal fluids (in this case likely fed by sea water) interacting with the underlying Permian successions, able to replace the marine carbonates with siderite at temperatures of ~ 250° C for high water/rock ratios. The conformable siderite bodies predate the Middle Triassic magmatism of the Alps and were formed in a dilational geodynamic scenario preluding the Neo-Tethys opening along the Gondwana margin.