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The Grischun-Malenco fossil Ocean-Continent-Transition: the fate of the subcontinental mantle in a Wilson cycle and its significance for H2 exploration

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Serpentinization is a fluid–rock interaction process occurring in specific geodynamic settings, whereby aqueous fluids react with mantle-derived source rocks to produce serpentinite, ± magnetite, and native hydrogen (H□). Among the key parameters controlling this process, the Fe^{2}□ content of primary mantle minerals is directly linked to the capacity for H□ generation. Because serpentine minerals themselves may incorporate Fe^{2}□, serpentinites may retain a degree of "fertility" for continued H_2production. In the context of the energy transition, this aspect is of fundamental importance, as zones potentially suitable for H_2 extraction are commonly associated with partially to fully serpentinized mantle rocks. Such continental environments are typically suture zones, i.e. rift-inversion orogen that once hosted the subcontinental mantle exhumed along ocean–continent transitions (OCTs).

Several mountain belts worldwide preserve continental-margin ophiolites, consisting of subcontinental lithospheric mantle directly overlain by basaltic lavas and intruded by small gabbroic plutons and rare mafic dikes. However, only a few are sufficiently well constrained in terms of tectonic evolution and petrology. The Grischun–Malenco area (southeastern Swiss and northern Italian Alps) represents the type locality of a fossil OCT, whose history has been precisely reconstructed from pre- to post-rift stages through numerous fundamental studies. The Grishun–Malenco OCT developed along the Jurassic Alpine Tethys and facilitated the subcontinental mantle exhumation to the seafloor. These mantle rocks experienced variable degrees of serpentinization, whereas more proximal domains (present-day Malenco), remaining beneath the continental crust, may undergone only limited serpentinization. During subsequent Eo-Alpine convergence, the Grischun–Malenco area was buried within a potential serpentinization window above the subducting slab, i.e. within a supra-subduction zone located in the hanging wall of the compressional system. Finally, during Meso-Alpine convergence, the area was incorporated into the orogenic lid and tectonically emplaced onto the European plate. Tectonic reconstructions suggest that, structural inheritance, particularly Jurassic rift segmentation, facilitated the emplacement of large mantle bodies into the hanging wall, rather than their dismemberment into thin tectonic slices.

The Grischun–Malenco area therefore constitutes a natural laboratory for investigating serpentinization-driven H_2production in continental settings. Integrated investigation of

serpentinization processes in continental and supra-subduction environments; combined with constraints on the pressure–temperature conditions of multiple serpentinization events and assessments of source-rock fertility based on Fe^{2+}/Fe^{3+} ratios; will provide critical guidance for future hydrogen exploration.