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Petrological and Geochemical Characterization of Rubies from the French Massif Central

MEREDITH MORIN[1], RÉMI COLTAT[1], ROMAIN AUGIER[1], DORIAN DARTHENAY[2], PE LAMAH[2] AND STANISLAS SIZARET[1]

[1]ISTO - Institut des Sciences de la Terre d'Orléans, Univ Orléans, CNRS, BRGM, OSUC, UMR 7327
[2]OSUC - Observatoire des Sciences de l'Univers en région Centre, Univ Orléans

The crystallization of ruby (Al_2O_3) is an exceptional phenomenon, requiring the coexistence of aluminum and chromium, two elements typically segregated in separate geochemical reservoirs. Ruby thus serves as a rare mineralogical marker of interactions among mantle-derived magmas, continental crust, and fluids, providing a unique window into deep lithospheric processes and crustal chemical evolution.

In the French Massif Central, chromium-bearing rubies occur in rocks derived from Al-poor mantle magmas. Thus, their formation requires a secondary enrichment in aluminum, achieved either through crustal contamination of the magmas or via the circulation of Al-rich liquids. These occurrences provide critical evidence of the complex chemical exchanges that shaped the deep continental crust during the Hercynian orogeny. This study focuses on the Tapon area (Haut-Allier), where ruby–pargasite assemblages occur in high-grade metamorphic rocks of the “leptyno-amphibolite group”. The latter corresponds to a transition and decoupling zone made up of migmatites, amphibolites, pyroxenites, and serpentinized peridotites interlayered with leucocratic gneisses, reflecting the mixing between deep crustal and mantle-derived materials [1]. These rare French occurrences offer a valuable natural laboratory for investigating ruby genesis in an ancient orogenic context and for comparison with major ruby deposits worldwide.

Several key questions remain unresolved: (1) What is the nature of the host rocks?; (2) What phase of the Hercynian cycle do they belong?; (3) What are the genetic mechanisms driving ruby crystallization?; (4) At what structural levels do these minerals form? And; (5) What are the sources of chromium and aluminum?

To address these questions, we combine detailed field observations, in-situ geochemical analyses, U–Pb dating of accessory minerals, and thermodynamic modeling. This integrated approach aims to constrain the pressure–temperature conditions and tectono-metamorphic context of ruby formation, as well as to reconstruct the petrogenetic evolution of the host rocks and their interactions with magmas and fluids.

By providing new petrological, geochemical and geochronological insights, this study enhances our understanding of ruby formation and the deep interactions between magmas, crust, and fluids, offering perspectives for interpreting ruby genesis in other orogenic settings worldwide.

[1] Lardeaux, Ledru, Daniel & Duchene (2001),