LITHOS 514–515 (2025) 108219

Contents lists available at ScienceDirect

LITHOS

journal homepage: www.elsevier.com/locate/lithos

Provenance of the Late Triassic-Early Jurassic Gano bauxite deposit in Alborz Orogen, Northern Iran: A multi-proxy geochronological approach by detrital zircon and rutile

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ARTICLE INFO

Keywords:
Cimmerian orogeny
Sedimentary provenance
Detrital zircon
Detrital rutile
Tethys

ABSTRACT

A significant Eo-Cimmerian unconformity developed during the Late Triassic-Early Jurassic in the Alborz Orogen, Iran, resulting in the formation of bauxite on the surface of carbonate rocks. Provenance analysis of such bauxite can help understand the Tethyan tectonic evolution, but strong geochemical weathering eliminates most geochemical information for source tracing. The multiproxy geochronology method is emerging for bauxite provenance studies and remains unexplored in Iran. Here, we supplemented a multi-proxy approach (detrital zircon and rutile) with zircon trace elements, Hf isotopes, and machine learning methods to constrain the provenance of Gano bauxite in the Alborz Orogen. New data present a dominant zircon age cluster (250–200 Ma), indicating magmatic provenance from the Alborz Orogen. The Semi-supervised Random Forest algorithm indicates a transition from S-type to A-type granites as detrital zircon sources. This shift correlates with the initial collision of the Central Iran and Eurasia blocks, likely occurring during the Late Triassic Carnian stage ($\geq \sim$231 Ma). Two rutile age groups (1100–500 Ma and 500–400 Ma) indicate local recycled basement contributions. These two types of provenance were deposited in a foreland basin and underwent bauxitization in the Late Triassic-Early Jurassic. Zircon and rutile U—Pb ages in Gano bauxite show a young, near-unimodal zircon age spectrum with several older rutile age fractions, reflecting provenance fertility imbalance in the active continental margin. The application of detrital zircon alone for bauxite provenance analysis in active continental margins is constrained. Employing diverse detrital accessory minerals could better clarify the complex origins.

1. Introduction

As a residue of strong chemical weathering, bauxite is mainly composed of Al-oxyhydroxides, Fe-oxides/−oxyhydroxides and Ti-oxides (mainly TiO_2 phases) (Bárdossy, 1982; Bárdossy and Aleva, 1990; D'argenio and Mindszenty, 1995; Retallack, 2010). Bauxite deposits can be classified into three types based on their bedrock composition: (1) lateritic bauxite, which develops through weathering of aluminosilicate rocks; (2) karst bauxite, which is formed by the transportation and redeposition of weathered material on karst surfaces (there may be sediment supply from underlying carbonate rocks, though this is rare); (3) sedimentary bauxite, which is formed through the transportation and redeposition of weathering materials on aluminosilicate rocks (Bárdossy, 1982). As an important type of bauxite, karst bauxites are closely related to regional tectonic activity (Bárdossy, 1982; Combes and Bardossy, 1995; Yang et al., 2022). More than 70 % of karst bauxite deposits are located in orogenic belts, based on the statistical results from Bárdossy (1982). During the oceanic subduction phase of orogenic belt formation, extensive arc volcanism provided abundant volcaniclastic materials for both peri-cratonic and isolated carbonate platforms, serving as the primary driver for bauxite formation on the latter. During the arc accretion phase of orogenic belt formation, weathered remnants were mainly transported from complex nappes into intracontinental carbonate depressions (Yang et al., 2022). Furthermore, the tectonic setting affects the composition of bauxite. Bauxites that have formed in Subduction Provenance Zones (SPZ) and Orogenic

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https://doi.org/10.1016/j.lithos.2025.108219
Received 5 February 2025; Received in revised form 31 July 2025; Accepted 5 August 2025
Available online 8 August 2025
0024-4937/