Genesis of the Weishan REE deposit in the Shandong Province, eastern China: evidences from Rb-Sr isochron age, LA-MC-ICPMS Nd isotopic composition and fluid inclusions

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Weishan REE deposit, a pegmatite-type REE deposit related to alkaline rocks, is located at Luxi Block, south-eastern North China Craton. According to muscovite Rb-Sr isochron, it formed at the age of 119.5 Ma, which belonged to the early Cretaceous large-scale mineralization in the North China Craton. LA-ICPMS Nd isotopic compositions of bastnaesite and monazite indicate that the source of the REE minerals is the enriched lithospheric mantle. Observation of fluid inclusions in quartz, fluorite and barite shows that four types of inclusions can be identified, including (1) H_2O inclusions, (2) pure CO_2 inclusions, (3) H_2O+CO_2 inclusions and (4) H_2O+CO_2+daughter mineral inclusions. The H_2O inclusions are secondary inclusions while others are primary inclusions. The daughter minerals in H_2O+CO_2+daughter mineral inclusions include thenardite, barite, celestine, calcite, aphthitalite and glauberite. The homogenization temperature and capture pressure of H_2O+CO_2 and H_2O+CO_2+daughter mineral inclusions range from 205 ℃ to 433 ℃ and 120 MPa to 200 MPa, respectively. Coupled with the existence of abundant daughter minerals and sulphur stable isotopic compositions, it can be deduced that the initial ore-forming fluids were high-temperature, moderate-pressure and high-concentration orthomagmatic fluids, which were characterized by enrichment of HCO_3^-/CO_3^{2-}, SO_4^{2-} and F^- and multicomponent (e.g., Na^+, K^+, Ca^{2+}, Ba^{2+}, Sr^{2+} and REE^{3+}). The coexistence of C, HC and HCD inclusions and the wide range of liquid/vapour ratios between these inclusions suggest that fluid unmixing may have occurred during ore-forming process. REE were most probably transported as $REEF^{2+}$ and precipitated through fluid boiling. Fluids mixing, which contributed little to the REE precipitation, also happened in the late stage of the ore-forming process.