Title

Critical minerals identifications by XRD, ICP-MS/OES, and QEMSCAN and recovery by gravity, magnetic, and electrical separations from mineral sands

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Summary

Critical minerals are essential components for the transitions to conventional energy systems to the green energy technologies. The X-ray diffraction in conjunction with the quantitative mineral analysis by Rietveld refinement, ICP-MS/OES, and QEMScan methods allow to identify and to quantify the presence of critical minerals in mineral sands. After the identifications and quantifications, the specific gravity, magnetic, and electrical conductivity of the minerals can be applied for physical separation of critical minerals. These are very crucial steps for any critical mineral development project. In this study, we applied these methods for separating titanium rich minerals (rutile, ilmenite, and leucoxene), zirconium rich mineral (zircon), and REEs rich minerals (monazite and apatite) concentrates from the mineral sands.

Theory / Method / Workflow

The heavy mineral rich sands have been used for the physical separations of the mineral concentrates. The mineral composition of the raw sands has been determined by quantitative mineral analysis by XRD method. Using a heavy liquid separation, the raw sands have first fractionated into a light and a heavy fraction. The light fraction was discarded. Subsequently the heavy fraction was first treated using a magnetic separator to separate the strongly magnetic fraction from the moderately/non-magnetic fraction. The strongly magnetic fraction was predominantly magnetite with some ilmenite, which was removed by concentrating the magnetite using a hand magnet. For separating the remaining non-magnetic and moderately magnetic fractions the material was processed again with a magnetic separator after increasing magnetic field. Thereafter the non-magnetic and moderately magnetic fractions were heated to about 200°C for the electric separation. The moderately magnetic fraction was mainly composed of ilmenite, garnet, and monazite and the non-magnetic fraction mainly composed of rutile and zircon. Both fractions have been processed using an electro-static plate separator (ESPS) to separate ilmenite (conductor) and garnet and monazite (non-conductor), and rutile (conductor) and zircon (non-conductor), respectively. The garnet and monazite concentrate has again been processed by an isodynamic magnetic separator to separates monazite concentrate. Each mineral concentrates have been analysed by XRD, XRF, QEMScan, and ICP-MS/OES.

Results, Observations, Conclusions

The XRD results shows that raw sands contain 1 wt.% of monazite, which is considered the main mineral for rare earth elements (critical minerals). After gravity, magnetic, and electrical separations, the presence of monazite can be enriched up to 61 wt.%.

The ICP-MS/OES results indicate that raw sands contain 0.63 wt. of REEs (Figure-1a) and the monazite concentrate comprises 26.88 wt.% (Figure-1b).

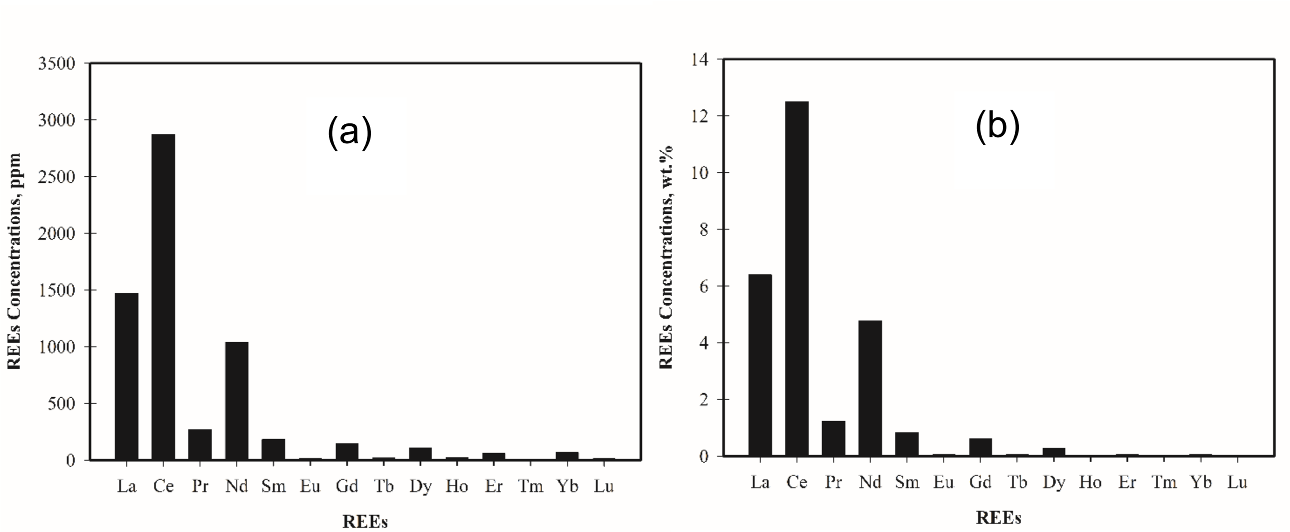

Figure-1: REEs concentrations in raw sands (a) and in monazite concentrate processed from raw sands (b)

The blend of gravity, magnetic and electrical separations can be applied to produce critical mineral rich monazite, zircon, and rutile and ilmenite concentrates from the heavy mineral rich raw sands.

As the tailings generated from the Alberta oil sands mining are rich in heavy minerals this separation method can be applied for the commercial production of critical minerals.