

# RARE EARTH ELEMENTS STUDY OF CRETACEOUS COALS FROM BENUE TROUGH BASIN, NIGERIA: MODES OF OCCURRENCE FOR GREATER SUSTAINABILITY OF MINING

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## Abstract

The rare earth elements (REE) possess a beneficial combination of chemical and physical properties, making them valuable for most advanced branches of engineering and technology. Alternative sources of REE are desirable due to limited reserves of conventional REE containing minerals over the world combined with disproportionate supply over demand in the commodity markets. This study investigated the occurrence of REE and carbon nanotubes (CNTs) in Cretaceous Nigerian coals for prospective industrial applications. Results show that the coals' crystalline mineral matter comprises quartz, kaolinite, and illite with minor quantities of feldspar, hematite, magnetite, calcite, dolomite, which indicate detrital mineral origins. Elemental relationships (such as  $Al_2O_3/TiO_2$ ,  $Cr/Th$  vs.  $Sc/Th$ , and  $Co/Th$  vs.  $La/Sc$ ) suggest sediment-source regions with mafic, intermediate or felsic compositions. REE are either strongly fractionated or characterized by light-enrichment along with outlook coefficient ( $C_{outl}$ ) values that suggest the coals are prospective substitute sources for REE and yttrium (REY) recovery. Several minerals including jarosite, goethite, epsomite, ferroxahydrate, natrojarosite, rozenite, and gypsum were detected in trace amounts. REE mineral phases were not identified but only amorphous phases containing Ce, La, Nd, Th, Pr, Sm, Gd, Tb, Dy, Ho, and Hf. Maceral composition (high vitrinite), presence of iron-containing minerals (hematite and magnetite), high carbon contents, reduced volatile matter and low ash content favoured the formation of naturally occurring multi-walled carbon nanotube (MWCNTs) structures in Maiganga (MGA) coal. Hence, the present study is the first scientific report on the naturally occurring REEs and MWC nanophases in Cretaceous coals from the Benue Trough. © 2021

## Keywords

Cretaceous coal; Multi-walled carbon nanotubes; Nano-mineralogy; Nano-particles; Rare earth elements; Trace elements