

# Oxic-Seawater-Like REY Features in Cambrian Organic-Rich Black Shale in the Western Hubei Province, South China

Huan Luo<sup>1</sup>, Bo Qiao<sup>1</sup>, Tongwei Zhang<sup>2</sup>

<sup>1</sup>School of Earth Sciences and Gansu Key Laboratory of Mineral Resources in Western China, Lanzhou University; <sup>2</sup>Bureau of Economic Geology

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## Abstract

Whole-rock rare earth elements and yttrium (REY) characteristics of shale reflect the relative contribution of terrestrial REY versus authigenic REY. Terrestrial minerals display a flat REY pattern under PAAS normalization, but authigenic minerals would inherit REY features of seawater or other aquatic systems. Shale typically manifests a flat REY pattern because of the dominance of the terrestrial component in whole-rock REY, however, the REY pattern of Cambrian organic-rich black shale from EYY1 cored well shows a distinct feature. EYY1 well is located in Changyang county, western Hubei province, South China. From bottom to top, about 200 m thick continuous core interval is composed of TOC-lean marlstone and carbonate of Yanjiahe formation (YJH) and TOC-rich black shale with some carbonate intercalations in the base of Shuijingtuo formation (SJT). The lowermost Cambrian from 2970 m to 3070 m of EYY1 were selected for REY features and possible sources. Four units with distinct REY features upwards are divided. Unit I (3057 m - 3070 m interval) covers the whole YJH, and it has most REY features of oxic seawater, but its heavy-REY (Gd - Lu, and Y) is depleted relative to light-REY (La - Eu). Unit II (n = 16; 3057 m - 3040 m) and Unit III (n = 19; 3040 m - 3000 m) cover the lower part of SJT, they both have all the REY features typical of oxic seawater: positive anomaly for La and Y, negative Ce anomaly and HREY enrichment. However, Unit II has some carbonate intercalations and shows stronger seawater features than Unit III. Unit IV (n = 12; 3000 m - 2970 m) covers the middle part of SJT and REY of it is almost flat. Further, there is a positive correlation between

total inorganic carbon (TIC) content and REY enrichment factor in EYY1 section, this indicates that carbonate minerals are the carrier of authigenic REY. U/Th of Unit I and IV is basically lower than 1.25 and their TOC is low (~2%) so that they were deposited in oxic-suboxic condition. U/Th of Unit II and III is about 10 times higher than Unit I and IV and their TOC is higher (~5%), thus they should be a highly anoxic interval within this section. Then it seems to be a contradiction for Unit II and III that carbonate minerals inside the high TOC anoxic black shale interval possess REY features of oxic seawater. A reasonable explanation should be that these carbonate minerals might have precipitated in oxic seawater elsewhere. In fact, during the deposition time of SJT in western Hubei province, EYY1 was located at the deep shelf facies and quite close to the carbonate platform which was in its northeast direction. The carbonate minerals inside Unit II and III could be intraclasts formed by wave erosion in the platform. Therefore, they would provide a rigid framework for those deep-buried Cambrian black shale and protect the organic matter pores from being compacted, resulting in the Cambrian shale with abundant OM hosted-pores and favorable to shale gas reservoirs.