

Short Paper

An Original Metallogenic Process? Trace Element Concentration by Coal Combustion

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Abstract

This short note proposes a metallogenic hypothesis not typically addressed in standard textbooks: the concentration of trace elements through the combustion of coal. Spontaneous or anthropogenic combustion of coal, particularly in outcropping seams, leads to thermal alteration of surrounding rocks, forming clinkers and paralavas. These processes, involving high temperatures (>1000 °C) and complex geochemical transformations, may result in the local enrichment of trace elements originally associated with the coal and its host rocks. Drawing parallels with known geochemical anomalies in industrial coal combustion residues, this phenomenon could represent a novel, overlooked metallogenic mechanism.

Keywords: Coal combustion, Clinkers, Paralavas, Trace element concentration, Metallogenic process

Introduction

Coal combustion, whether natural or anthropogenic, can generate high-temperature zones in sedimentary basins. These combustion events, especially when occurring in outcropping coal seams, initiate lateral and vertical burning that transforms the adjacent rocks. While commonly known for their geomorphological or environmental impact, these processes may also induce significant geochemical transformations that concentrate trace elements.

Field Context and Pyrometamorphic Rocks

In coalfields worldwide, including the Powder River Basin (Montana, USA) [1] and the Saint-Étienne basin (France), spontaneous combustion has altered large volumes of rock, producing pyrometamorphic rocks known as clinkers (porcellanites) and paralavas. Clinkers result from thermal alteration and brecciation of shales and sandstones adjacent to the coal seams. These rocks are typically varicolored and contain angular fragments. Paralavas, in contrast, form by partial melting, producing homogeneous, glassy rocks whose color depends on redox conditions (from black to red). A notable example is the Saint-Pierre spoil heap in La Ricamarie (Loire, France), where self-ignition of coal-bearing waste has produced well-developed clinker and paralava zones with columnar structures [2]. The combustion alters surrounding rocks by devolatilization, thermal shock, and mechanical collapse following the removal of the coal layer. The result is a restricted volume of new rock that may inherit trace elements from the original shales, sandstones, and the coal itself.

Geochemical Considerations

Coal contains numerous trace elements, including rare earth elements (REE), Ga, Zn, Ge, and others, hosted in organic matter, sulfides, and silicate matrices [3]. During combustion, volatile and

semi-volatile elements may be mobilized but also locally retained by condensation or incorporation into neoformed phases. This results in heterogeneous distribution of trace elements in pyrometamorphic rocks. Industrial analogues, such as fly ash from coal-fired power plants, are known to concentrate REE, Ga, and other critical metals [4-6]. These observations support the idea that similar enrichments may occur in natural or semi-natural clinker and paralava zones, especially when the combustion front is confined and temperatures remain high for extended periods.

Metallogenic Hypothesis

The core of the proposed hypothesis is a metallogenic mechanism driven by combustion: the partial destruction of coal removes major volatile components (C, H, S, H₂O), concentrating residual trace elements into a smaller rock volume. This “concentration by subtraction” process is analogous to weathering-induced enrichment or magmatic differentiation. Although the pyrometamorphic rocks are often of limited thickness (a few to tens of meters), they may represent a metallogenic footprint comparable in scale to lateritic or meteoric weathering profiles. Their study could reveal remobilization and mineral concentration patterns relevant for the exploration of critical metals.

Outlook and Research Needs

To assess the metallogenic potential of these combustion-related rocks, future research should combine:

- Field mapping and petrography of clinkers and paralavas;
- Geochemical and mineralogical profiling;
- Thermodynamic and thermal modeling;
- Chronological constraints on burning events.

These studies will help to quantify the role of combustion in metal mobilization and fixation, offering new insights into metallogeny in coal-bearing basins.

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References

1. Guy B, Thiéry V, Garcia D, Bascou J, Broekmans MATM (2020) Columnar structures in pyrometamorphic rocks associated with coal-bearing spoil-heaps burned by self-ignition, La Ricamarie, Loire, France. *Mineralogy and Petrology* 114: 465-487.
2. Dai S, Finkelman RB (2018) Coal as a promising source of critical elements: Progress and future prospects. *International Journal of Coal Geology* 186: 155-164.
3. Taggart RK, Hower JC, Hsu-Kim H (2016) Rare earth elements in coal and coal fly ash. *International Journal of Coal Geology* 147-148: 1-27.
4. Zhang W, Cao Y, Zhou Y, Liu J (2015) Geochemistry of rare earth elements in coal fly ash. *Fuel* 150: 292-297.
5. Blissett RS, Rowson NA (2012) A review of the multi-component utilisation of coal fly ash. *Fuel* 97: 1-23.
6. Heffern EL, Coates DA (2004) Clinker: Fire-Altered Rocks in the Powder River Basin, Wyoming and Montana. *U.S. Geological Survey Professional Paper* 1676.

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