Balancing of geological acidity and buffering potentials of Mid German lignite open casts by long-term experiments

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Problem and Solution

Open cast lignite mining induces sulphide weathering associated with Acid Mine Drainage - phenomena (mobilisation of acidity, sulphate, heavy metals). This partial weathering of sulphides is embedded in hydro-geochemical buffering reactions. Essential buffers are carbonates, aluminium/ iron hydroxides and aluminium silicates. Especially the carbonate buffering is important [1].

For sustainable strategic activities to reduce the acidification of ground waters by the lignite dump sites Peres and Schleenhain (Germany, South of Leipzig/Saxony), it is essential to evaluate the acidification and buffer potentials of the overburden units. These investigations need to consider the applied mining technology [2].

In long-term experiments (>500d), wet samples of forefield drillings of the five aquifers and some aquiclude units were exposed to weathering (T = 10 °C).

These tests shows clearly that the Oligocene aquifers (Aquifer 2 and 3) are the main problem sediments. The low pH values are coupled to a high acidity, iron and sulphate release. In contrast the glacial marly till contributes by buffering carbonates.

The subsequent buffering tests with aquifer 2 and 3 material in combination with the glacial till sediments, shows a clear effective buffering with increasing addition of glacial till. A release of iron and heavy metals can be completely prevented for longer times. The detailed investigation of the already existing water phase of the dump site Peres confirms the buffering effect by these carbonates.

Therefore the overburden dumping technology will be even more directed to the effective buffering by mixing the problematic materials with the buffering tills.

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Ca isotopes of Central American arc basalts lack carbonate component

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Subduction of sediment fundamentally represents a loss of continental crust and a gain of relatively enriched components to the mantle. Provided that possible mixing end members can be defined, stable Ca isotope signatures provide a powerful probe for identifying various sources in volcanic arc magmas. For example, marine carbonates are enriched in light Ca isotopes by about -0.2 to > -1.0‰ [1], relative to igneous rocks and should clearly implicate subducted sediment. Here we present Ca isotopic compositions for basalts from along the active Central American volcanic arc front that represent the range of trace element signatures indicative of various amounts of sediment recycling through the subduction zone (e.g. based on Ba/La values).

In an attempt to balance sedimentary input and arc volcanic output across the Nicaraguan margin [2] compared sediment input (i.e. high Ba/La) in arc magmas to offshore sedimentary drill cores, concluding that over the last ~20 Ma as much as 75% of the modern sedimentary column has been subducted. Despite measuring samples with trace element signatures that imply large amounts of subducted carbonate, we find no resolveable evidence for a low $^{44}Ca/^{40}Ca$ component. In detail, arc basalts from Guatemala, Honduras, and Nicaragua range from 0.04 to -0.18‰ in $^{44}Ca/^{40}Ca$ (mantle=0 scale). These nearly indistiguishable results are somewhat surprising given the fact that $CaCO_3$ has ≥4 times more Ca than the basalts. Mass balance shows that ~2-10% carbonate should produce resolvable effects.

Several potential reasons for the missing Ca isotopic signal are considered, including that: (1) subducted carbonate has an isotopic composition similar to mantle Ca, cf. [1], (2) subducted carbonate is largely dolomite, and/or (3) the record found in the drill cores is not representative of subducted sediment in the modern arc. Our new Ca isotope data imply that, at least for the Nicaraguan volcanic arc, trace element geochemistry may be less well understood than we believe. This is supported by the fact that the highest $\delta^{18}O$ values are associated with low Ba/La [3], and not the high Ba/La values typically correlated with increasing fluids from the slab.

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