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Is There a Solid-Phase Sulphide Level Below Which No ARD Is Possible?

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Abstract

Is there a generic solid-phase sulphide level below which no ARD is possible? Based on case studies, values down to at least 0.02%S can still generate net acidity and thus ARD. Detailed testwork on rock below 0.02%S is lacking, but we have seen no indications that a sulphide criterion may lie in the narrow range between 0.02%S and the common detection limit of 0.01%S. Therefore, if a sulphide criterion exists, it probably lies below 0.01%S.

1. Introduction

We have noticed a great desire by some to ignore the potential for ARD from sulphide-bearing rocks if the solid-phase sulphide level is below a certain value. It may sound reassuring to say, "Below X%S, there is no possibility of ARD no matter how much Neutralization Potential (NP) is present". Is there evidence that such a sulphide criterion exists?

Part of the answer is dependent on the detection limit for solid-phase sulphide. If the sulphide criterion is below the detection limit, commonly around 0.01%S today, then there is no way to determine the criterion.

One commonly mentioned sulphide criterion is 0.3%S, traceable to the Government of British Columbia (Price, 1997). While British Columbia did use that value in the past, Price (1997) revised the criterion to say that no further testing for ARD should be conducted below 0.3%S with subsoil pH above 5.5, except if

> "the rock matrix consists entirely of base poor minerals (for example, quartz and sericite, in pervasive phyllic alteration) or where the sulphide minerals contain heavy metals, such as As and Zn, which are soluble in weakly acidic leachate".

In essence, no further testing was required below 0.3%S if a sample were near neutral pH and contained sufficient NP. Because this was already generally applied to materials with more than 0.3%S, it suggested no sulphide criterion was recognized by British Columbia any longer.

2. Low-Sulphide Case Study #1

Is it possible for mined rock to release ARD with sulphide levels below 0.3%S? Black et al. (2003) explained that tailings and rock at the closed East Kemptville Tin Minesite in Nova Scotia, Canada, generally contain less than 0.3%S, yet produced widespread, weak to moderate ARD (acidity generally less than 5000 mg/L). This site is located in volcanic rock dominated by quartz, plagioclase (An35), muscovite and sericite, and potassium feldspar. The common sulphide minerals are pyrrhotite, sphalerite, chalcopyrite, and pyrite.

The East Kemptville Closure Plan included four Sobek well-flushed humidity cells (procedure in Morin and Hutt, 1997) operated for nearly two years, containing fresh or oxidized tailings. Based on paste pH (Table 1), one sample was already acidic and the remaining three were near neutral. The Sulphide Net Potential Ratios (SNPR) ranged from 1.0 to 1.8.

Table 1. Pre-Test Analyses of the Four East Kemptville Tailings Samples Tested in Sobek Humidity Cells (adapted from the Closure Plan)

	Tailings 1	Tailings 2	Tailings 3	Tailings 4
Description	well oxidized older tailings	some oxidation	highly oxidized newer tailings	grey fresh unoxidized tailings below saturation level
Measured Paste pH	4.7	6.1	6.3	6.2
Measured Total Sulphur (%S)	0.18	0.20	0.11	0.26
Measured Sulphide (%S)	0.13	0.16	0.07	0.19
Calculated Sulphide Acid Potential (kg $CaCO_3$ eq/t)	4	5	2	6
Measured NP (kg $CaCO_3$ eq/t)	5	7	4	6
Calculated Sulphide Net Potential Ratio (NP / SAP)	1.23	1.40	1.83	1.04
Calculated Sulphide Net Neutralization Potential (NP - SAP, in kg $CaCO_3$ eq/t)	+1	+2	+2	0

By the time the four samples were placed in cells, their weekly pH values were acidic (Figure 1), showing (1) despite near-neutral paste pH for three, all quickly became acidic, and (2) the measured NP values of 4 to 7 kg $CaCO_3$ equivalent/t represented "unavailable NP" (Morin and Hutt, 1997 and 2001). After approximately 70 weeks, weekly pH values from all four cells were typically between 3.5 and 3.8.

The sulphate production rate in mg SO_4/kg of sample/week was initially high (Figure 2), probably reflecting the rapid flushing of leachable sulphate. After Week 60, the rates began to stabilize, eventually converging on 7-8 mg/kg/wk.

These late-stage sulphate rates are relatively low, but still significant according to the International Kinetic Database (Morin and Hutt, 1997 and 2001; www.mdag.com/ikd.html). Therefore, the low sulphide levels were still oxidizing and generating acidity after nearly two years of oxidation. Mass-balance calculations indicated the remaining sulphide levels in these cells were as low as 0.05%S. Thus, at least under some conditions, even 0.05%S can generate net acidity and thus release ARD.

3. Low-Sulphide Case Study #2

In this case study, petrographics indicated a rock sample was 99.5% cryptocrystalline quartz (chert) with possible minor feldspar, 0.2% rutile, 0.2% pyrite, and a trace of sericite. Based on ABA, it contained no measurable NP, no detectable carbonate, no detectable leachable sulphate, 0.15%S sulphide, and a paste pH of 4.7.

When 767 g of this rock was placed in a Sobek well-flushed humidity cell, it was acidic from the start (Figure 3). Weekly pH fell below 3.0 by Week 10, to as low as 2.6 (Figure 3). During the period of lowest pH, as remaining sulphide fell below 0.10%S, sulphate production reached a peak around 200 mg/kg/wk. This is considered "high" in the International Kinetic Database (www.mdag.com/ikd.html). By the end of testing at Week 63, sulphate production was still detectable at 8 mg/kg/wk (equivalent to 14 mg/L of sulphate) at pH 3.7. At the end, the calculated remaining sulphide was 0.02%S, with post-test ABA indicating 0.03%S.

4. "Very Low Sulphur" Case Study #3

At the Ekati Diamond Minesite in Canada, the granitic waste rock contained an average Acid Potential less than 1 kg/t (thus sulphur less than 0.03%S) and an average NP of 6 kg/t (Morin, 2003). The consultants for this site concluded, "Due to the very low sulfur concentration and low NP, this rock type has negligible potential to influence drainage chemistry." Within a year of startup, ARD was seeping from the waste-rock pile. Although the exact cause of the ARD remains unknown, it appears that "very low" average sulphur levels below 0.03%S can still release ARD under some conditions.

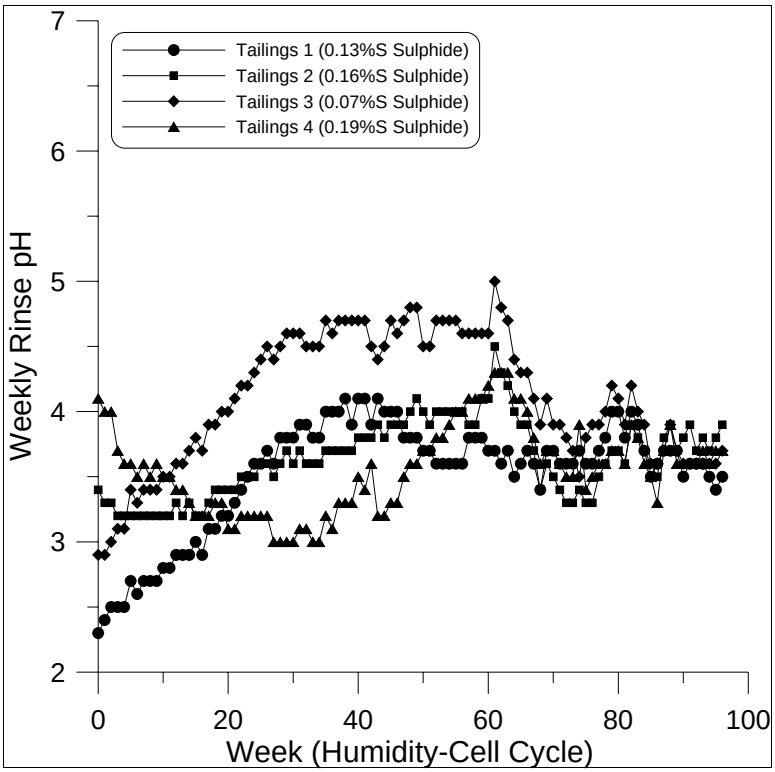

Figure 1. Weekly Rinse pH from the Four Low-Sulphur Tailings Humidity Cells.

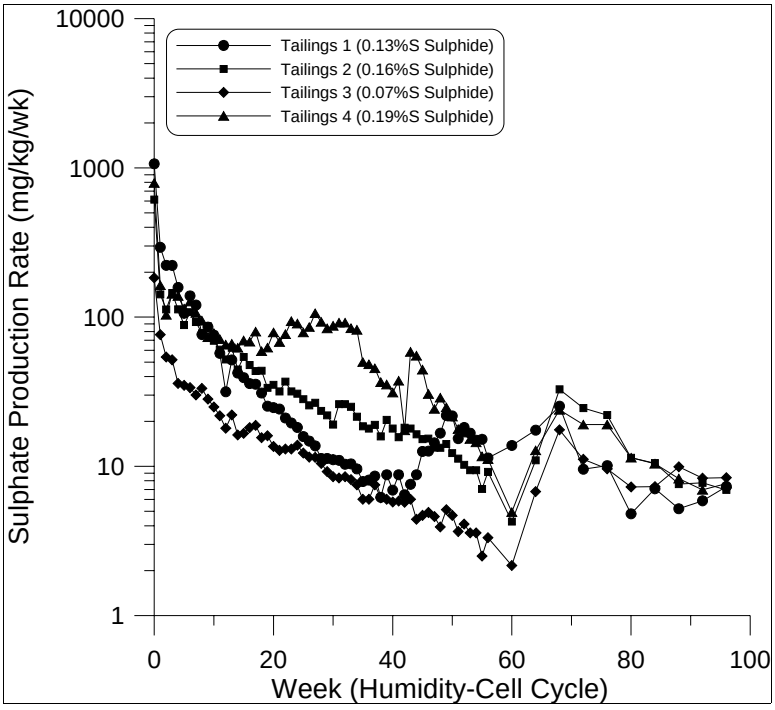

Figure 2. Weekly Sulphate Production Rate from the Four Low-Sulphur Tailings Humidity Cells.

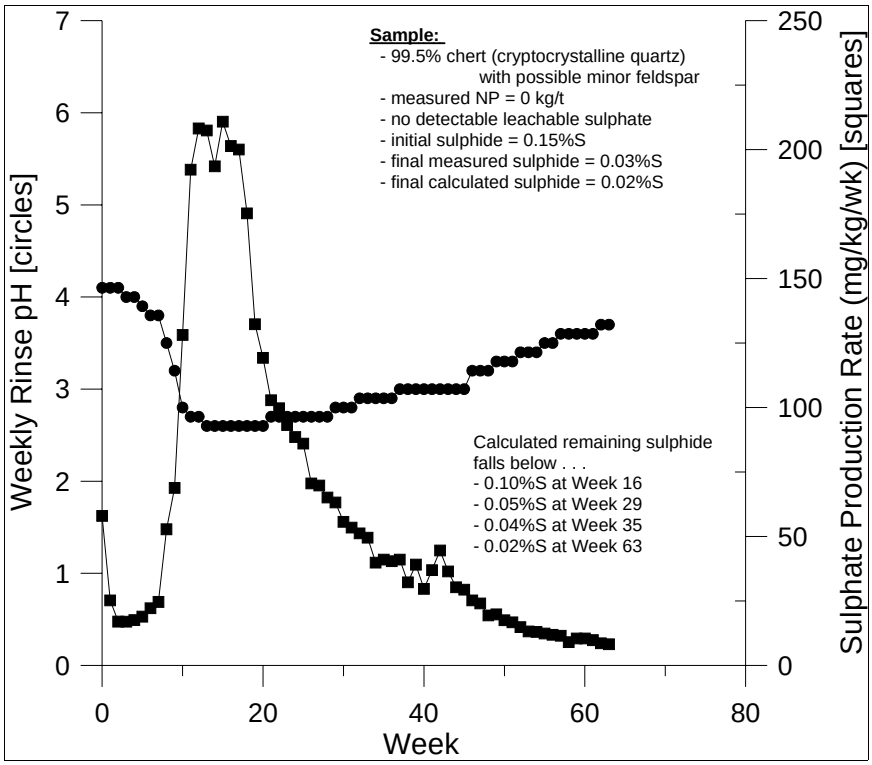

Figure 3. Weekly Rinse pH (circles and left axis) and Weekly Sulphate Production Rate (squares and right axis) from the Low-Sulphide Chert Sample.

5. Conclusion

Based on case studies and our experience, we have found no evidence of a generic sulphide criterion, below which no net acidity or ARD are possible, down to 0.02%S. Also, there are no indications that one exists between 0.02%S and the slightly lower, common detection limit of 0.01%S. Therefore, if a generic sulphide criterion exists, it probably lies below 0.01%S.

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