Poster paper

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Gravel-Filling of Shrinkage Cracks in Gold Refining Residue and its Impact on Rehabilitation in Southwest Australia. 2. Movement of Surface Incorporated Gypsum

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Introduction

Gold refining residue at the Boddington Gold Mine is alkaline (pH 9.5 - 10), saline (6.35 dS/m) and sodic (67 – 72 % exchangeable sodium). Previous research has shown that amelioration of these adverse properties can be achieved by incorporating 30 - 60 t gypsum/ha into the residue (Ho *et al.* 1999). The vertical depth of amelioration, however, is often restricted to the layer into which gypsum is incorporated (surface 30 cm), leaving the underlying residue unamended. This may have a detrimental effect on the growth of deep-rooted plant species used in the revegetation of the residue storage area. The present study was conducted to determine the importance of shrinkage cracks in the residue on the movement of calcium (Ca^{2+}), measured as exchangeable Ca^{2+} (X_{Ca}), down the profile and to evaluate the effectiveness of gravel-filling of these cracks on the depth of amelioration.

Material and Methods

A 0.7 ha field experiment was established on the R4 residue storage area at Boddington Gold Mine. Gravel was applied to shrinkage cracks (up to 15 cm in width) by pushing approximately 30 cm of sandy ferruginous gravel across the residue surface. This resulted in a portion of the gravel filling the cracks and the excess being incorporated into the residue using a disc plough followed by ripping (to 40 cm depth). Gypsum at 30, 60 and 120 t/ha was broadcast and mixed into the surface 30 cm using a rotary hoe. After 23 months (1880 mm rainfall) trenches were excavated in each treatment and residue was collected from areas adjacent to exposed cracks and 20 cm away from cracks at 0-10, 10-20, 50, 100 and 150 cm depth. Residue samples (air-dried, < 2 mm) were repeatedly washed with 70 % ethanol until the electrical conductivity of the supernatant was below 10 uS/cm. Exchangeable Ca^{2+} was extracted using 80 ml of unbuffered 0.35 M $BaCl_2$ solution in 60 % methanol. The Ca^{2+} concentration of the extracting solution was determined using ICPS.

Results

Gypsum application significantly ($p < 0.05$) increased the exchangeable Ca^{2+} levels of residue in the surface 20 cm where it was applied and this increase was enhanced with gravel incorporation..

Shrinkage cracks increased the vertical movement of Ca^{2+}. In all gypsum treatment plots, significantly ($p < 0.1$) higher exchangeable Ca^{2+} levels were found in residue adjacent to cracks, compared to residue 20 cm away from cracks at 50 cm depth; this significant increase was extended to 100 cm in cracks that were gravel-filled (Figure 1). No increase in exchangeable Ca^{2+} was observed in residue 20 cm away from cracks at 50, 100 or 150 cm for any gypsum treatment.

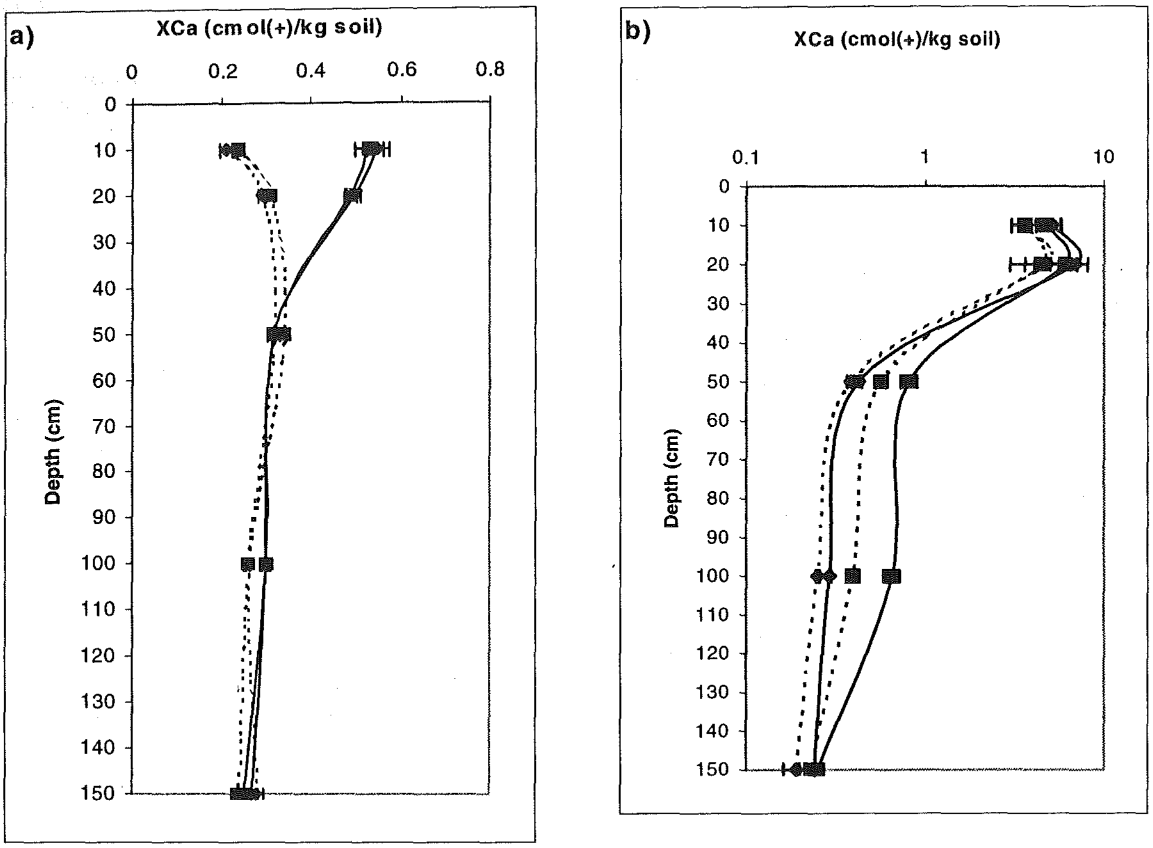

Figure 1: Exchangeable Ca^{2+} (cmol(+)/kg of soil) of residue adjacent to cracks (square symbol) and 20 cm away from cracks (diamond symbol) in the *a)* no gypsum treatment and *b)* 120 t/ha gypsum treatment. Samples collected from treatments that included gravel-filling of shrinkage cracks are indicated by the solid line.

Discussion

Shrinkage cracks play an important role in the vertical movement of Ca^{2+} from surface incorporated gypsum. Water that moves preferentially along these cracks carries dissolved gypsum that re-enters the residue matrix, along crack walls, increasing the exchangeable Ca^{2+} content of the residue. Gravel-filling of shrinkage cracks enhanced the vertical movement of Ca^{2+}, increasing the exchangeable Ca^{2+} content of residue adjacent cracks to 100 cm depth. No Ca^{2+} movement occurred through the residue matrix as a consequence of its low permeability and strong adsorption capacity. It is proposed that gravel-filling of residue cracks prevents their closure during winter periods, particularly at depth, and maintains their structural integrity. Investigation over a longer period is required to confirm this role.

Incorporation of excess gravel into the residue surface accentuated the benefits of gypsum addition. It is suggested that the gravel prevented the capillary rise of saline soil solutions and improved the permeability of the residue increasing both the dissolution of gypsum and leaching of soluble ions.

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References

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