Gravel-Filling of Shrinkage Cracks in Gold Refining Residue and its Impact on Rehabilitation in Southwest Australia. 1. Vegetation Establishment and Growth

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Introduction
Gold ore refining residue is deposited as a slurry into residue storage areas where consolidation and drying takes place. Drying of the slurry involves significant loss of volume, which is expressed as consolidation, and shrinkage that results in vertical cracking. The cracks form an interconnected network that represents an opportunity for improving the surface drainage of the residue material that has low hydraulic conductivity, and low surface gradient and is therefore prone to waterlogging in the winter.

A novel approach was trialed where a sandy ferruginous gravel substrate was applied to large shrinkage cracks in gold residue to prevent their closure following rainfall and to maintain their structural integrity. It was hypothesised that such gravel application would preserve the role of shrinkage cracks in preferential flow of water and ions and perhaps enhance root growth. In this paper we report on two field experiments to examine the effect of gravel filling on soil properties and growth of the test species, Agropyron elongatum (Tall wheat grass), Triticosecale spp. (triticale) and Atriplex amnicola (saltbush). In a following paper, we report on the effects of gravel filling of shrinkage cracks on Ca2+ leaching from surface-incorporated gypsum.

Materials and Methods
Test cells for the two field experiments were constructed with compacted earth wall banks, and filled with gold refining residue slurry to an average depth of 1.7 or 3.7 m, respectively. The residue dried for 4-6 months over summer and designated plots were filled in autumn with sandy ferruginous gravel recovered from sub-soils in the surrounding landscape. Gravel was pushed across the residue surface with a blade and dropped into cracks. Subsequently surfaces of plots were prepared for planting by ripping (1 m depth), ploughing (30 cm depth), gypsum (30, 60 t/ha) and poultry manure application (4-6 cm depth), rotary hoeing (30 cm depth), and finally topsoil application (8-10 cm depth). Further details of the experiments can be found in Ho et al. (1999). Residue in Experiment 2 was treated with 5 t of NaCl/ha to raise salinity levels. Two trenches were excavated by backhoe after 2 years growth in plots treated with 20 cm of topsoil and gravel in Experiment 1. Sections of residue were collected from the trench walls at depths 0-20, 20-40, 40-60 and 80-100 cm. Roots were separated from the residue by washing and sieving, then oven-dried and their dry weights were recorded.

Results
Residue collected from areas without gravel filling of cracks had higher electrical conductivity than from areas where cracks were filled with gravel. This was particularly evident at the surface in the predominantly topsoil material, where mean electrical conductivity was 3.34 dS/m in areas without gravel filling, compared to 1.36 dS/m with gravel filling. Gravel filling of cracks also decreased pH (mean of 6.8 compared to 7.3 for residue without gravel filling). This suggests that gravel filling was facilitating the leaching of salts out of the residue. In the first experiment, salinity levels were moderate with an electrical conductivity (EC1:5) in the residue of 1.4 ± 0.5 dS/m. Growth of saltbush was increased in plots with gravel filling of cracks (Figure 1). By contrast the growth of Tall wheat grass was depressed and triticale was not affected.

Roots were observed to have a preference for growing in the cracks, large and small in the residue. Furthermore, residue sampled from plots with gravel filled cracks had greater root densities than those without, particularly near the residue surface (Figure 2).

In the second experiment, salinity in the residue was higher (EC1:5 5.3 ± 1.1 dS/m) and growth of all species with or without gravel in cracks was depressed, relative to experiment 1. At the higher salinity levels in this residue, gravel filling of cracks increased growth of all three species in the first year, but these effects disappeared in the following year.
Dry Matter (t/ha)

Gravel in cracks

Figure 1. Effect of gravel filling on aboveground dry matter (t/ha) of tall wheat grass and triticale (right) and saltbush (left). Experiment 1. Plants harvested in Feb 1993, after 8 months growth in gold oxide residue. Vertical bars denote standard errors.

Figure 2. The effect of gravel filling of shrinkage cracks in gold oxide residue on root density after 2 years growth at various depths in Experiment 1. Vertical bars denote the standard error.

In conclusion, gravel filling of cracks appeared to improve establishment growth of plants especially waterlogging sensitive plants and under strongly saline conditions. By year two, there was little effect of gravel filling on aboveground dry matter. However, the increase in root density at 0-50 cm depth in residue with gravel filling of cracks suggests this treatment may produce longer term benefits for plant growth, amelioration of the residue and pedogenesis. In a following paper we explore the effects of gravel filling of shrinkage cracks on calcium movement in gold oxide residue.

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References