Contaminant mobilisation by fluid-rock interaction and related transport mechanisms in platinum tailings

Submitted in full requirement for the degree

M.Sc. Engineering- and Environmental Geology

To:

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2013

Declaration and Acknowledgements:

I, Altus Huisamen, student number 27188176, submit this dissertation to the Department of Geology, University of Pretoria, in accordance with the full requirements and prerequisites for the degree Masters in Sciences (M.Sc. Engineering and Environmental Geology). I declare that everything contained in this dissertation is my own work unless noted otherwise. All external sources have been referenced diligently and all credit for previously published work is acknowledged to the respective authors.

I furthermore acknowledge the following parties:

- My Heavenly Father for guidance and wisdom.
- Mr. Matthys A. Dippenaar and the University of Pretoria for mentorship and valuable input.
- Prof J. Louis van Rooy and the University of Pretoria for mentorship and valuable input.
- Mr. A. Huisamen (snr.) for assistance in the construction of the falling head permeameter.
- Miss. Nelda Breedt for support and motivation.
- Mr. Eduan Hattingh for assistance during the pumping tests.
- Dr. van der Ahee Coetsee and Geo Pollution Technologies for opportunities, mentorship, financial assistance, time and resources.
- Dr. Gideon J. du Toit and Geo Pollution Technologies for opportunities, mentorship, financial assistance, time and resources.
- The entire Geo Pollution Technologies staff for motivation, support and advice.
- Mr. Pieter Badenhorst and the staff of Soil and Groundwater Remediation Services for the direct push probe drilling on the tailings.
- Mr. P.S. Rossouw and the University of Pretoria for mentorship and valuable input.
- Dr. S. Adams and the Water Research Commission for funding.
- Mr. Terry Harck and SolutionHPlus for mentorship and valuable input.
- The relevant personnel at the undisclosed mine site where field work was conducted, for their hospitality and accommodating the research project.
- The Huisamen Family for support and motivation.

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27/07/2012

ABSTRACT

Contaminant release and transport in platinum tailings are poorly studied in literature. This study serves to characterise these processes. The tailings facility is located in Steelpoort, Mpumalanga, South Africa on Critical Zone rocks of the Rustenburg Layered Suite in The Bushveld Igneous Complex. Tailings material samples were collected by hand auger- and direct push probe drilling at specific locations to represent the different materials present in the tailings facility. Water samples were collected from monitoring boreholes as well as the Steelpoort River. The samples were analysed using XRD, XRF, ABA, NAG, Reflected Light Microscopy, Acid Leaching Tests and ICP scans. Using the collected data, a geochemical model was constructed for the interpretation of mineral phase dissolution and to trace the mineral phases releasing contaminants. Analysis-, test- and modelling results showed that alteration mineral phases formed within ten years in the tailings material and that the existing alteration phases viz. talc and chlorite, as well as sulphides, are the major contributors of contaminants. Elevated pH values as well as major cation and anion concentrations were found in the fluid discharging from the tailings as well as the in groundwater, with little to no heavy metals, which were traced directly to the chromite phase. This suggests that platinum tailings do not contribute to heavy metal contamination or acid rock drainage but may increase aquifer salinity and alkalinity. The flow through the tailings, underlying vadose zone and fractured rock aquifer was characterised using permeameter- and pumping tests. From the data collected, an unsaturated flow model was developed to characterise the flow through the tailings. From the model, discharge from the tailings was calculated to take place at 0.7m per decade into the underlying vadose zone with fracture flow in the aquifer ranging from 0.46-0.026m/d, as calculated from pumping test results. Contaminant migration into the Steelpoort River is possibly inhibited by the Dwarsriver Fault, based on the chemical data and hydraulic conductivities calculated. Therefore, groundwater is considered to be the major receptor in the system and groundwater users may be negatively impacted by increasing groundwater salinity and major ion concentrations.

LIST OF ABBREVIATIONS

ABA = Acid Base Accounting
AH = Auger hole
Al = Aluminium
As = Arsenic
BDL = Below detection limit
BH = Borehole
BIC = Bushveld Igneous Complex
Ca = Calcium
Cl = Chloride
Co = Cobalt
Cr = Chromium
Cu = Copper
EC = Electrical Conductivity
F = Fluoride
Fe = Iron
GRDM = Groundwater Resource Directed Measures
GW = Groundwater
GWB = Geochemist's Workbench
HCO_3 = Bicarbonate
ICP-OES = Inductively Coupled Plasma Optical Emission Spectroscopy
ICP-MS = Inductively coupled plasma mass spectroscopy
K = Potassium
L = liter
m = meters
mamsl = meters above mean sea level
mbgl = meters below ground level
Mg = Magnesium
mg/l = milligrams per liter
Mn = Manganese
n.a. = not analysed
Na = Sodium
Ni = Nickel
NO_3 = Nitrate
Pb = Lead
ppm = parts per million
Si = Silica
SO_4 = Sulphate
SWL = Static Water Level
TDS = Total Dissolved Solids
Ti = Titanium
TLC = Temperature, Level, Conductivity Meter
TSF = Tailings Storage Facility
V = Vanadium
XRF = X- Ray Fluorescence
XRD = X- Ray Diffraction
Zn = Zinc

TABLE OF CONTENTS

FIGURES

TABLES