

Operation Manual
Complex Resistivity suite
(CRMod/CRTomo)

©Andreas Kemna

14th April 2010

Contents

Table of contents	1
List of figures	2
List of tables	3
1 Introduction	7
1.1 General remarks	7
1.1.1 CRMod	7
1.1.2 CRTomo	7
2 CRMod	9
2.1 Boundary value problem and FE-Method	9
2.1.1 Dirichlet	9
2.1.2 Neumann	9
2.1.3 Mixed boundary values	9
2.1.4 2D vs. 2.5D	9
2.2 Induced Polarization (IP)	10
2.2.1 Spectral IP	10
2.3 Folder structure and input files	11
2.3.1 crmod.cfg	11
2.3.2 Grid file (elem.dat)	11
2.3.3 Electrode file (elec.dat)	11
2.3.4 Configuration file (conf.dat)	11
2.3.5 Model file (model.dat)	11
2.3.6 Pseudo data file (volt.dat)	11
3 CRTomo	13
3.1 Electrical Resistivity Tomography (ERT)	13
3.1.1 Ordinary least squares (OLS) / Gauss-Newton optimization	13
3.1.2 Adjoint boundary value problem and Sensitivities	13
3.1.3 Conjugate Gradient linear solver	13
3.2 Electrical Impedance Tomography (EIT)	14
3.2.1 Complex Sensitivities	14
3.2.2 Final Phase Improvement (FPI)	14
3.3 Regularization	15
3.3.1 Smoothness constraints	15

3.3.2	Levenberg and Levenberg-Marquardt damping	15
3.3.3	Minimum Support and Minimum Gradient Support	15
3.4	Stochastic regularization	16
3.4.1	Empirical Variogram and Covariance estimator	16
3.4.2	Variogram and Covariance models	16
3.5	Error Model and Noise	17
3.5.1	Data Error Model	17
3.5.2	Noise implementation	17
3.6	Folder structure and input files	18
3.6.1	crtomo.cfg	18
3.6.2	Grid file (elem.dat)	18
3.6.3	Electrode file (elec.dat)	18
3.6.4	Pseudo data file (volt.dat)	18
3.6.5	Prior data	18
3.6.6	Difference inversion	18

List of Figures

List of Tables

Chapter 1

Introduction

1.1 General remarks

1.1.1 CRMod

The forward modelling tool CRMod is a finite-element-based program for 2.5D modelling in electrically conductive and polarizable media. It calculates the electric potential due to a low-frequency (pseudo-dc) electric current point-source in a cross-section perpendicular to the strike direction of a two-dimensionally heterogeneous medium. Since the potential is integrated along the direction of the strike in the wavenumber-frequency domain, it is a 2.5D approximation. The medium, typically represents the Earth's subsurface, but may also represent other objects as confined tanks or vessels. The finite-element method grants a huge range of flexibility in meshing the underlying medium.

For any given two-dimensional complex resistivity (comprising magnitude and phase) distribution, the modelled response is either a set of complex potential distributions in the considered cross-sectional plane for a given set of one- and/or two-pole current injection configurations; a set of impedance values for a given set of two-, three- and/or four-pole measurement configurations (one or two poles for current injection, another one or two poles for voltages measurement); and/or a set of complex sensitivity distributions in the cross-sectional plane corresponding to the given set of measurement configurations. If polarizability of the medium is disregarded, the underlying resistivity distribution, as well as the modelled potential

1.1.2 CRTomo

The inverse modelling tool CRTomo is the corresponding tomographic program to CRMod .

Chapter 2

CRMod

2.1 Boundary value problem and FE-Method

2.1.1 Dirichlet

2.1.2 Neumann

2.1.3 Mixed boundary values

2.1.4 2D vs. 2.5D

2.2 Induced Polarization (IP)

2.2.1 Spectral IP

2.3 Folder structure and input files

2.3.1 crmod.cfg

2.3.2 Grid file (elem.dat)

2.3.3 Electrode file (elec.dat)

2.3.4 Configuration file (conf.dat)

2.3.5 Model file (model.dat)

2.3.6 Pseudo data file (volt.dat)

Chapter 3

CRTomo

3.1 Electrical Resistivity Tomography (ERT)

3.1.1 Ordinary least squares (OLS) / Gauss-Newton optimization

3.1.2 Adjoint boundary value problem and Sensitivities

3.1.3 Conjugate Gradient linear solver

3.2 Electrical Impedance Tomography (EIT)

3.2.1 Complex Sensitivities

3.2.2 Final Phase Improvement (FPI)

3.3 Regularization

3.3.1 Smoothness constraints

3.3.2 Levenberg and Levenberg-Marquardt damping

3.3.3 Minimum Support and Minimum Gradient Support

3.4 Stochastic regularization

3.4.1 Empirical Variogram and Covariance estimator

3.4.2 Variogram and Covariance models

3.5 Error Model and Noise

3.5.1 Data Error Model

3.5.2 Noise implementation

3.6 Folder structure and input files

3.6.1 crtomo.cfg

3.6.2 Grid file (elem.dat)

3.6.3 Electrode file (elec.dat)

3.6.4 Pseudo data file (volt.dat)

3.6.5 Prior data

3.6.6 Difference inversion

Index

CRMod , 7

CRTomo , 7

Regularization, 15

Smoothness, 15