

# CONTENTS

## ABSTRACT

## ZUSAMMENFASSUNG

1. INTRODUCTION	1
2. GENERAL ASPECTS	3
2.1. Geographical setting of the Cerro Maricunga project	3
2.1.1. Location, accessibility, exploration history	3
2.1.2. Topography, hydrography, climate and vegetation	5
2.2. Geological setting and gold mineralization of the Maricunga belt	7
2.2.1. Geology	7
2.2.1.1. Regional framework	7
2.2.1.2. Geology of the Maricunga belt	14
2.2.2. Alteration and mineralization in the Maricunga belt	19
2.2.2.1. Mineralization styles in the Maricunga belt	19
2.2.2.2. Alteration styles in the Maricunga belt	25
2.2.3. Exploration history of the Maricunga belt	28
3. SAMPLING AND ANALYTICAL METHODS, DATA EVALUATION/PROCESSING	30
3.1. Field and drillcore sampling	30
3.2. Sample processing and applied analytical methods	30
4. RESULTS AND INTERPRETATION	32
4.1. Lithology and petrography	32
4.1.1. Field work	32
4.1.2. Bulk rock petrography	36
4.1.2.1. Andesite flows	36
4.1.2.2. Porphyritic andesites	57
4.1.2.3. Andesitic dikes	58
4.1.2.4. Andesitic ignimbrites	67
4.1.2.5. Litho-crystal tuff	67

4.1.2.6. Monomictic (andesitic) breccias	68
4.1.2.7. Polymictic breccias	68
4.1.2.8. Magmatic breccia	73
4.1.2.9. Magnetite breccias	73
4.1.2.10. Daci-andesites	74
4.1.2.11. Dacites	74
4.1.2.12. Pervasively argillic altered and metasomatic modified igneous rocks	74
4.1.2.13. Tuffisite dikes	74
4.1.2.14. Pebble dikes	75
4.1.2.15. So-called “mingling zones”	75
4.1.3. Veinlet petrography	82
4.1.3.1. A-veinlets	82
4.1.3.2. B-veinlets (banded quartz veinlets)	82
4.1.3.2.1. Dark phyllosilicates	119
4.1.3.3. Replacive gypsum-veinlets and accessory carbonate replacement veinlets	119
4.1.3.4. Fissures and cracks	126
4.1.4. Alteration, ore mineralogy, metasomatic overprint	126
4.1.4.1. Argillic alteration	126
4.1.4.2. Silicification	129
4.1.4.3. Ore mineralogy	129
4.1.4.3.1. Late magmatic magnetite	129
4.1.4.3.2. Hydrothermal overprint	133
4.1.4.3.3. Supergene ore	133
4.1.4.4. Metasomatic overprint	134
4.1.5. Bulk rock discrimination	134
4.2. Geochemistry	145
4.2.1. Harker diagrams	145

4.2.2. Bulk element enrichment and depletion	145
4.2.3. Correlation matrix	148
4.2.4. Element distributions	149
4.2.5. REE patterns	151
4.2.6. Multielement plots	151
4.2.7. Adakite features	156
4.2.8. Geochronology	158
4.2.8.1. Re-Os dating of molybdenite	158
4.2.8.2. U-Pb dating of zircon	158
4.3. Selected features of the igneous system	159
4.3.1. Quartz-eyes	159
4.3.2. Feldspar	166
4.3.2.1. Feldspar zoning, inclusions and alteration features	166
4.3.2.2. Trace element composition of plagioclase	167
4.3.3. Clinopyroxene (Hedenbergite-Diopside series)	169
4.3.4. Apatite	169
4.3.5. Nd Isotopes	171
4.3.5.1. Calculation magma mixing and AFC processes	176
4.4. Selected features of the (magmatic-)hydrothermal system	178
4.4.1. Pyrite	178
4.4.1.1. Gold distribution in pyrite	178
4.4.2. Au in other hydrothermal sulfides	188
4.4.2.1. Au in Cu sulfides	188
4.4.2.2. Molybdenite	189
4.4.3. Disseminated (magmatic-)hydrothermal magnetite (and ilmenite)	195
4.4.3.1. Trace element pattern of disseminated magnetite and ilmenite	197
4.4.3.2. Trace element populations of disseminated magnetite and ilmenite	200

4.4.3.3. Correlation matrix of trace elements in disseminated magnetite	201
4.4.3.4. Magmatic versus hydrothermal magnetite	201
4.4.3.5. Porphyry affiliation of disseminated magnetite	202
4.4.3.6. Au contents in disseminated magnetite	204
4.4.4. Au distribution in banded quartz veinlets	205
4.4.4.1. Au distribution in single veinlets	205
4.4.4.2. Au distribution in a specific local veinlet system	206
4.4.4.3. Invisible Au	209
4.4.5. Stable isotopes (S, O)	219
4.4.5.1. Sulfur isotopes	219
4.4.5.2. Oxygen isotopes	223
4.5. Thermobarometry	224
4.5.1. General	224
4.5.2. Feldspar thermometers, barometers and hygrometers	225
4.5.3. Pyroxene thermometers and barometers	227
4.5.4. Magnetite/Oxide thermometers	229
4.5.5. Silica activity barometer	231
4.5.6. Quartz geothermometer	232
4.5.6.1. Aluminium in quartz geothermometer	232
4.5.6.2. TitaniQ geothermometer	232
5. FINAL DISCUSSION AND RECOMMENDATION	237
5.1. Banded quartz veinlets in the Cerro Maricunga domain	237
5.2. Hydrothermal system and mineralization in the Cerro Maricunga domain	241
5.2.1. Hydrothermal system and sulfide-Au mineralization at Cerro Maricunga	241
5.2.2. Fluid inclusions at Cerro Maricunga	243
5.3. Supergene effects at Cerro Maricunga	245
5.4. Selected lithological features	246
5.4.1. Ore-related breccias/dikes	246

5.4.2. Alteration	248
5.5. Geochemical-magmatic and temporal setting of Cerro Maricunga	248
5.6. Adakite-like rocks at Cerro Maricunga	250
5.7. Cerro Maricunga andesites in the Chilean subduction context	256
5.8. Recommendation for exploration	257
6. REFERENCES	259
APPENDIX I: DATA	
Appendix 1: Analytical data (Bulk rock)	
Appendix 2: Sample lists	
Appendix 3: Duplicate and standard deviation of ICP-ES and ICP-MS data	
Appendix 4: Technical details of EMPA and LA-ICP-MS analysis	
Appendix 5: Analytical results of EMPA and LA-ICP-MS analyses	
Appendix 6: Details: feldspar zoning (EMPA results)	
Appendix 7: Details: Magnetite and ilmenite	
Appendix 8: Details: Pyrite	
Appendix 9: Details: Feldspar	
Appendix 10: Details: Banded quartz veinlets	
Appendix 11: Details: Quartz-eyes	
Appendix 12: Details: Cu-minerals and molybdenite	
Appendix 13: Hf- isotopes	
Appendix 14: XRF pdf-files used for data evaluation with the X'Pert HighScore software from PANalytics	
Appendix 15: Details Nd data	
Appendix 16: Details: pyroxene	
Appendix 17: Description thin sections ( <i>88 documents</i> )	
Appendix 18: Additional data bulk system	
Appendix 19: Age data Maricunga belt	

## APPENDIX II: LITERATURE RESEARCH

Appendix 20: Porphyry (-Au) and epithermal (-Au) deposits

Appendix 21: El Indio – Tambo – Pascua-Lama belt

Appendix 22: Hydrothermal system

Appendix 23: Ore related breccias/dikes

Appendix 24: Thorough considerations to chapter 2.4 “Subduction zones”

Appendix 25: Adakite

Appendix 26: Sulfides

Appendix 27: Analytical methods, data evaluation/processing