

Schriftenreihe zur Aufbereitung und Veredlung

herausgegeben von

Univ.-Prof. Dr.-Ing. Thomas Pretz  
Univ.-Prof. Dr.-Ing. Peter Quicker  
Univ.-Prof. Dr.-Ing. Hermann Wotruba

Band 73

**Christian Schropp**

**Integrated mineral processing in underground  
mining operations and impact on the mine project**

Shaker Verlag  
Düren 2019

## IV Content

I	Acknowledgement .....	1
II	Executive summary .....	3
III	Zusammenfassung .....	5
IV	Content .....	7
1	Introduction .....	11
1.1	Motivation for the research .....	11
1.2	Aim of the study .....	12
1.3	Thesis structure .....	13
2	Concept of mine-to-mill integration .....	15
2.1	Underground mine-to-mill integration .....	15
2.2	Current mineral processing in underground mines .....	18
3	Technologies for underground processing .....	23
3.1	Liberation .....	23
3.2	Dilution .....	24
3.3	Separation technologies .....	26
3.3.1	Comminution and screening .....	28
3.3.2	Flash flotation .....	28
3.3.3	Dense media separation .....	28
3.3.4	Jigging .....	29
3.3.5	Magnetic separation .....	29
3.3.6	Electrostatic separation .....	29
3.3.7	Hand sorting .....	30
3.3.8	Sensor-based sorting .....	30
3.3.9	Assessment of separation technologies .....	34
3.3.10	Conclusion .....	37
4	Implementation of mineral processing steps underground .....	39
4.1	Infrastructure and underground excavations .....	39
4.2	Ore extraction and mine development .....	41
4.2.1	Suitable mining methods .....	42
4.2.2	Backfill .....	42
4.2.3	Critical volume for backfilling .....	44

4.3	Underground waste rejection .....	45
4.3.1	Plant design .....	46
4.3.2	Crushing .....	50
4.3.3	Screening .....	51
4.3.4	Sensor-based sorting .....	52
4.4	Impact on mineral processing .....	55
4.4.1	Bond index reduction .....	57
4.4.2	Fewer Consumables.....	58
4.4.3	Economy of scale.....	58
4.4.4	Cut-off-grade reduction.....	58
4.5	Material handling .....	59
4.6	Material storage .....	60
4.7	Hoisting technologies .....	60
4.8	Conclusion .....	65
5	Development of the evaluation model.....	67
5.1	Model structure.....	67
5.2	General model assumptions.....	69
5.3	Cost estimation and process calculation.....	70
5.3.1	Regressions analysis .....	71
5.3.2	Cost estimations .....	72
5.3.3	Extraction.....	73
5.3.4	Transportation.....	73
5.3.5	Backfill.....	74
5.3.6	Mineral processing .....	74
5.3.7	Side processes .....	76
5.3.8	Personnel costs.....	76
5.4	Scenario development.....	76
5.5	Evaluation methodology.....	83
5.6	Conclusion .....	85
6	Integrated underground processing case studies .....	87
6.1	Case study: cut-and-fill mine polymetallic ore .....	87
6.1.1	Base case description .....	87

6.1.2	Scenario implementation .....	91
6.1.3	Simulation results .....	93
6.1.4	Conclusion .....	100
6.2	Case study: Sub-level stoping polymetallic ore mine .....	100
6.2.1	Base case description .....	100
6.2.2	Scenario implementation .....	103
6.2.3	Simulation results .....	105
6.2.4	Conclusion .....	111
6.3	Case study: room-and-pillar potash mine .....	111
6.3.1	Base case description .....	111
6.3.2	Scenario implementation .....	115
6.3.3	Simulation results .....	117
6.3.4	Conclusion .....	123
7	Conclusion and discussion .....	125
8	References .....	127
V	List of figures .....	133
VI	List of tables .....	137
VII	List of abbreviations .....	139
VIII	Glossary .....	141
IX	List of notations .....	143
X	Appendix .....	145
	Appendix I: Example of simplified flowsheets for sensor-based sorting .....	145
	Appendix II: Three chamber feeder system for hydraulic hoisting .....	145
	Appendix III: Modules in the semi-mobile sensor-based sorting plant .....	146
	Appendix IV: Sorting test work results of the cut-and-fill case study .....	151
	Appendix V: Typical particle sizes for hydraulic, long-distance slurry transport .....	152
	Appendix VI: Geotechnical design methodology for underground excavations .....	152
	Appendix VII: Reduced pillar dimension by using waste rock as backfill material .....	153
	Appendix VIII: Mining method selection matrix .....	154
XI	List of publications .....	155