

Contents

List of Figures	xiii
List of Tables	xxiii
1 Introduction	1
1.1 Context	1
1.2 Experimental approaches of rocks mechanical behavior and its influence on the transfer properties	3
1.3 Numerical approaches of rocks micromechanical behaviors	5
1.4 Microstructural complexity	6
1.5 Objectives	7
1.6 Outline	8
2 Computational modelling	11
2.1 Introduction	11
2.2 Rock microstructure modelling	12
2.2.1 Exploitation of 3D imaging techniques	12
2.2.2 Virtual geometry generation	13
2.2.3 Selection of geometrical descriptions to consider	14
2.3 Mechanical simulations on rocks	15
2.3.1 Discretization methods	16
2.3.2 Selection of the discretization approach to consider	19
2.4 Permeability evaluation	20
2.4.1 (Semi)-empirical models	21
2.4.2 Traditional Computational Fluid Dynamics	21
2.4.3 Lattice-Boltzmann method	21
2.4.4 Pore network modelling	22
2.4.5 Selection of the permeability evaluation approach to consider	22
2.5 Conclusion and methodology adopted	23

3	Computational tools for geometry representation	27
3.1	Introduction	27
3.2	Geometry representation	27
3.2.1	Implicit geometries and level sets	28
3.2.2	Explicit geometries	29
3.2.3	Conversion between implicit and explicit geometries	30
3.3	Image processing	33
3.3.1	Morphological operators	33
3.3.2	Filters	37
3.3.3	Segmentation	38
4	An integrated approach for the conformal discretization of complex inclusion-based microstructures	41
4.1	Introduction	42
4.1.1	Context	42
4.1.2	Related work	44
4.1.3	Outline	45
4.2	Input Geometries	46
4.2.1	Implicit Geometries	46
4.2.2	Implicitly defined RVEs	47
4.3	Mesh generation for implicit geometry of homogeneous structures	48
4.3.1	Global discretization process	48
4.3.2	Mesh quality optimization	49
4.4	Extension to complex heterogeneous RVEs mesh generation	52
4.4.1	Global meshing strategy	52
4.4.2	Size Function $h(\mathbf{x})$	54
4.4.3	Initial nodes distribution	58
4.4.4	Inclusion boundaries meshing	59
4.4.5	RVE Boundaries meshing	64
4.4.6	Volume Meshing	65
4.4.7	Extended Persson-Strang truss analogy	67
4.4.8	Summary	68
4.5	Applications	68
4.6	Discussion	71
4.7	Conclusion	74

5	Comparison of advanced discretization techniques for image-based modelling of heterogeneous porous rocks	75
5.1	Context	76
5.2	Problem statement and segmentation	78
5.3	Image-based modelling for heterogeneous geomaterials	82
5.3.1	Conforming discretization of implicit geometries	82
5.3.2	Embedded weak discontinuity models	87
5.4	Comparison of FEM and EFEM methods based on a segmented sandstone sample	90
5.4.1	Conforming model	93
5.4.2	Embedded discontinuity model	96
5.4.3	Comparison of FEM and EFEM results	99
5.5	Discussion	101
5.6	Conclusion	104
6	Image-based modelling of stress induced permeability alterations in sandstones	105
6.1	Context	106
6.2	Problem statement	110
6.3	Numerical modelling of deformation-induced permeability alterations	111
6.3.1	Image processing	113
6.3.2	Signed distance-based meshing process	114
6.3.3	FE simulations of rock mechanical loading	115
6.3.4	Permeability evaluation	119
6.3.5	Pore size distribution	122
6.4	Applications	123
6.4.1	Materials	123
6.4.2	Assumptions/Questions	124
6.4.3	Pre-processing	126
6.4.4	Results	130
6.5	Discussion	147
6.6	Conclusion	150
7	Conclusion & Perspectives	153
7.1	Conclusion	153
7.2	Perspectives	157
	Bibliography	161