



Jianxing Liao (Autor)

Development of coupled THM models for reservoir stimulation and geo-energy production with supercritical CO₂ as working fluid



<https://cuvillier.de/de/shop/publications/8265>

Copyright:

Cuvillier Verlag, Inhaberin Annette Jentzsch-Cuvillier, Nonnenstieg 8, 37075 Göttingen, Germany

Telefon: +49 (0)551 54724-0, E-Mail: info@cuvillier.de, Website: <https://cuvillier.de>

List of contents

1. Introduction	- 1 -
1.1. Motivation, objectives and scientific challenges	- 1 -
1.2. Thesis outline	- 7 -
2. Engineered applications of CO₂ in geo-energy.....	- 10 -
2.1. The carbon dioxide challenge in climate change.....	- 10 -
2.2. Properties of CO ₂	- 11 -
2.3. Phase path of CO ₂ in engineering processes	- 14 -
2.4. CO ₂ -EGS	- 16 -
2.4.1. Status of CO ₂ -EGS	- 16 -
2.4.2. Competitive advantage	- 17 -
2.4.3. Chemical react with mineral and geological sequestration of CO ₂	- 18 -
2.4.4. Challenges of CO ₂ -EGS	- 21 -
2.5. Supercritical CO ₂ fracturing in unconventional gas reservoir	- 21 -
2.5.1. Status of CO ₂ fracturing in unconventional gas reservoir	- 21 -
2.5.2. Different CO ₂ fracturing fluids.....	- 23 -
2.5.3. Challenges of CO ₂ fracturing in unconventional gas reservoir	- 24 -
2.6. Enhanced oil and gas recovery using CO ₂	- 25 -
2.6.1. Status of CO ₂ applications in enhanced oil and gas recovery	- 25 -
2.6.2. Challenges of CO ₂ enhanced oil and gas recovery	- 27 -
3. Fundamentals of the THM model	- 28 -
3.1. Hydraulic flow in porous medium.....	- 28 -
3.1.1. Multi-phase and -component flow in porous medium.....	- 28 -
3.1.2. Heat conservation	- 30 -
3.1.3. Space and time discretization	- 32 -

3.1.4.	Equations of state	- 36 -
3.1.5.	Thermal dynamic properties of mixtures.....	- 40 -
3.2.	Mechanic response	- 44 -
3.2.1.	Governing equations.....	- 44 -
3.2.2.	Space discretization.....	- 46 -
3.2.3.	Plastic deformation and failure criterions.....	- 48 -
3.3.	THM coupling processes.....	- 51 -
3.3.1.	Coupling concept.....	- 51 -
3.3.2.	Data flow in THM modeling.....	- 53 -
4.	CO₂ fracturing in unconventional gas reservoirs	- 55 -
4.1.	CO ₂ fracturing concepts	- 55 -
4.2.	Description of relevant models.....	- 56 -
4.3.	Working schema and data flow of the CO ₂ fracturing model	- 67 -
4.4.	Verification of implemented numerical models	- 69 -
4.4.1.	Verification of fracture model in FLAC3D.....	- 69 -
4.4.2.	Verification of multi-component and -flow in THOUGH2MP.....	- 71 -
4.4.3.	Verification of proppant transport model in THOUGH2MP-FLAC3D	- 73 -
4.5.	A generic model of a tight gas reservoir and the initial condition.....	- 74 -
4.6.	Viscosity variation of the injected thickened CO ₂	- 77 -
4.7.	Comparing performance of thickened CO ₂ with traditional fracturing fluid.....	- 83 -
4.8.	Thermal impact on fracture-making ability of thickened CO ₂	- 89 -
4.9.	Optimization proppant densities and placement.....	- 92 -
4.10.	Summary	- 97 -
5.	Geothermal energy exploitation with supercritical CO₂	- 99 -
5.1.	Basic idea	- 99 -
5.2.	Description of anisotropic damage-permeability model.....	- 100 -

5.3.	Implementation of numerical models and working schema	- 105 -
5.4.	Verification of implemented numerical model.....	- 108 -
5.4.1.	Verification of implemented damage model	- 108 -
5.4.2.	Verification of implemented anisotropic permeability model.....	- 109 -
5.4.3.	Small scale fracturing test	- 113 -
5.5.	Influence factors on reservoir stimulation	- 117 -
5.6.	Description of planned EGS project in Dikili	- 122 -
5.7.	Numerical model of Dkili EGS and initial condition	- 125 -
5.8.	Reservoir stimulation using supercritical CO ₂	- 129 -
5.9.	Heat production using supercritical CO ₂	- 132 -
5.10.	CO ₂ sequestration in the lifetime of Dikili EGS	- 139 -
5.11.	Summary	- 141 -
6.	Conclusion	- 143 -
7.	References.....	- 146 -