

Curriculum Vitae

Anna Scotti

Via Ennio 25,
20137, Milano (MI), Italia
anna.scotti@polimi.it

Place of Birth: Milano, Italy
Date of Birth: 3rd May 1982
Nationality: Italian

Education

- | | |
|-----------------------|---|
| Jan. 2007 - Mar. 2010 | <i>PhD in Mathematical Engineering</i> , MOX, Dip. di Matematica, Politecnico di Milano, Italy. |
| Sep. 2004 - Oct. 2006 | <i>Master Degree, two years curriculum, in Aeronautic Engineering (Laurea specialistica in Ingegneria Aeronautica)</i> . Politecnico di Milano, Italy. Final mark: 110/110 with honors. |
| Sep. 2001 - July 2004 | <i>Bachelor Degree, three years curriculum, in Aerospace Engineering (Laurea triennale in Ingegneria Aerospaziale)</i> . Politecnico di Milano, Italy. Final mark: 110/110 with honors. |
| 2001 - 1996 | <i>Diploma (Maturità scientifica)</i> , Liceo A. Einstein, Milano. Final mark: 100/100 with honors. |

Experience

- | | |
|-----------------------|--|
| since July 2013 | Assistant professor (Ricercatore TD tipo "A") at the Department of Mathematics of Politecnico di Milano. |
| Jan. 2010 - June 2013 | Post Doc fellow in the Department of Mathematics of Politecnico di Milano. Title of the research program: "Modelling of single and multiphase flows in fractured porous media" |
| Mar. 2007 - today | Teaching assistant for courses of Scientific Calculus at Politecnico di Milano. |

Visits to other universities and research centers

- | | |
|---------------|---|
| November 2014 | University of Bergen, Department of Mathematics, visiting prof. F.A.Radu. |
|---------------|---|

June 2014	MIT, Department of Civil and Environmental Engineering, visiting prof. R.Juanes in the scope of a Rocca project.
November 2013	MIT, Department of Civil and Environmental Engineering, visiting prof. R.Juanes in the scope of a Rocca project.
October 2007	SINTEF Petroleum Research, Trondheim, visiting prof. U. Ritter for a joint project with Eni Spa.

Participation in grant projects

Project R. Rocca 2012-2013	Project <i>Coupled flow and geomechanics of faults – Application to CO2 sequestration</i> in collaboration with the Department of Civil and Environmental Engineering of MIT, PI L. Formaggia and R. Juanes.
PRIN 2009	Participation in the research program <i>Modelli numerici per il calcolo scientifico ed applicazioni avanzate</i> (Numerical Analysis), coordinator A. M. Quarteroni.
PRIN 2008	Participation in the research program <i>Approssimazione Numerica con Tecniche Adattive e Non-Conformi di Problemi Multifisica</i> (Numerical Analysis), coordinator F.Brezzi.
PRIN 2007	Participation in the research program <i>Modellistica matematica e numerica per applicazioni cardiovascolari e in dinamica dei fluidi</i> (Numerical Analysis), coordinator A. M. Quarteroni.

Participation in industrial projects

2015 - 2016 BioGen	Scientific responsible for the research project financed by Eni Spa titled <i>Modelling of biogenic gas generation in the source rock</i> .
2014 - 2015 GasSystem	Scientific responsible for the research project financed by Eni Spa titled <i>Modelling of organic porosity</i> .
2014 - 2015 Geomech	Participation in the research project financed by Eni Spa titled <i>Modelling of seismicity induced by fault slip</i> .
2012 - 2014 SimbaGe1Ds	Participation in the research project financed by Eni Spa titled <i>Models of secondary compaction of the source rock</i> .

2012 - 2013 KaFRes	Participation in the research project financed by Eni Spa titled <i>Karstified and Fractured Reservoir Simulation (KaFres)</i> .
2010 - 2013 CompGeo	Participation in the research project financed by Eni Spa titled <i>Modelling of geochemical compaction processes at the basin scale</i> .
2008 - 2012 iMigro	Participation in the research project financed by Eni Spa titled <i>iMigro</i> .
2007-2010 PMOD+	Participation in the research project financed by Eni Spa titled <i>Expulsion and primary migration of hydrocarbons</i> .

Production of scientific software for industry

GeCO	In the scope of the CompGeo project I developed, in collaboration other researchers, a Matlab code for the simulation of diagenetic processes in compacting sedimentary basins. The code has been used, in collaboration with Eni and the Department of Environmental and Hydraulic Engineering of Politecnico di Milano to perform direct simulations and sensitivity analysis.
PMOD+	In the scope of project PMOD+ I developed an extension of the pre-existing software PMOD (Fortran) used by Eni to simulate hydrocarbon generation, to account for retention processes and more complex chemistry. This new code is currently used by Eni e&p.
PMOD1D	During my PhD I developed a Matlab code for the simulation of the processes involved in the generation and expulsion of hydrocarbons from the source rock. An improved version of this code has been used by Eni e&p.
PMOD1Ds	In the scope of the project SimbaGE1Ds I developed an extension of the previous Pmod1D to account for the aforementioned processes in a compacting medium, i.e., in a deforming domain. This code is currently used by Eni e&p.
EDFM	In the scope of project KaFRes I developed part of a code called EDFM for the computation of geometric and hydraulic properties of a fractured reservoir discretized with a Corner Point type grid. This software is currently used by Eni.

Teaching

Bachelor courses

Sept. 2014 - Jan. 2015 *Curve e superfici: analisi geometrico-differenziale* (Numerical analysis), Politecnico di Milano, Credits: 10.

Sept. 2013 - Jan. 2014 *Curve e superfici: analisi geometrico-differenziale* (Numerical analysis), Politecnico di Milano, Credits: 10.

Sept. 2012 - Jan. 2013 *Curve e superfici: analisi geometrico-differenziale* (Numerical analysis), Politecnico di Milano, Credits: 10.

PhD courses

April 2014 Seminar in the PhD course *Mathematical and numerical methods for multiphase flow in porous media* (Numerical analysis), Politecnico di Milano.

Febr.- Mar. 2015 Laboratory for the PhD course *Numerical methods for engineering applications*, Politecnico di Milano.

Moreover, I have worked as teaching assistant from 2007 to 2012 in several courses in the area of Numerical Analysis for Engineering and Design.

Reviewing activity

- Reviewer and opponent for a PhD thesis at the Department of Mathematics of the University of Bergen, (Norway), titled *Modeling of heat transfer in porous media in the context of geothermal energy extraction*, October 2015.
- Reviewer for the ACS Petroleum Research Fund.
- Reviewer for *Siam Journal of Scientific Computing*, *Water Resources Research*, *Journal of Petroleum and Gas Engineering*, *Journal of Mathematical Analysis and Applications*, *Computational Geosciences*, *Transport in porous media*, *Numerical Algorithms*, *Multiscale Modeling and Simulation*, *Journal of Computational Fluid Dynamics*, *Advances in Water Resources*.

Theses supervision

Master theses

- *Numerical modeling of fractured porous media subject to compaction*, Andrea Rossetti, 2014, Politecnico di Milano.
- *3D Upscaling of Reservoir Properties using the Mixed Finite Element Method on Non-Matching Grids*, Calogero Rizzo, 2014, Politecnico di Milano
- *Flusso in un mezzo poroso fratturato: approssimazione numerica tramite Differenze Finite Mimetiche*, Nicola Verzotti, 2014, Politecnico di Milano
- *Numerical modeling of porosity evolution in source rock during kerogen breakdown*, Bianca Giovanardi, 2013, Politecnico di Milano (as co-supervisor).
- *Approssimazione numerica di ODE con forzante discontinua per flussi reattivi in mezzi porosi*, Massimiliano Beccaria, 2012, Politecnico di Milano (as co-supervisor).
- *Transmissibility Upscaling for Fluid Flow in Porous Media on Non-Matching Grids*, Luca Turconi, 2012, Politecnico di Milano (as co-supervisor).

PhD theses (ongoing)

- Co-supervisor of Bianca Giovanardi within the program *Modelli e metodi matematici per l'ingegneria*, Politecnico di Milano.
- Co-supervisor of Daqing Liu within the program *Modelli e metodi matematici per l'ingegneria*, Politecnico di Milano.

Short summary of research

My recent research has concerned mostly on modelistic and numerical aspects in the study of flows in porous media, with a particular focus on geophysical application, and more recently, on biomedical ones.

In particular, I have worked on:

- the study and development of numerical techniques for heterogeneous and fractured porous media,
- the study of reactive flows, with a particular focus on the processes of diagenesis (rock transformation).

As concerns the study of fractured porous media my work is based on the representation of fractures and faults as $n - 1$ dimensional domains embedded in a surrounding n dimensional porous matrix, a technique that was already popular in literature but limited to the case of conforming grids, i.e. where the grid honors the geometry of the fractures. My original contribution consists in the use of the eXtended Finite Elements (XFEM) [4,6,7,11] to account for discontinuities in the coefficients and in the solution (pressure and Darcy velocity) within grid elements. Moreover, I used XFEM to handle intersecting fractures with suitable coupling conditions at the crossing points: on one hand, to enrich the fracture grids that can intersect in an arbitrary way, on the other hand to approximate the solution in elements cut by more than one interface, further enriching the FEM space.

The aforementioned enrichment of the FEM spaces in the case of saddle point problems such as Darcy in mixed form, or Stokes problem, should be inf-sup stable. This is not always guaranteed even if the original FEM pair is stable: to this aim we have analyzed the conditions on the geometry and on the grids that give inf-sup stability, and suitable stabilization techniques [5,26].

With the same aim of developing numerical methods robust with respect to geometry I have worked on the application of Mimetic Finite Differences to the problem of the flow in fractured porous media [1,14]. Moreover, in the scope of project KaFRes in collaboration with Eni, I have collaborated in the study and development of techniques of numerical upscaling for the simulation of fractured reservoirs [17].

A recent evolution of this line of research consists in the coupling of the fluid flow with the mechanics of the porous medium. In the scope of project Geomech, in collaboration with Eni, we are studying the effect of fluid injection/production from the subsurface on the stability of pre-existing faults, to assess the risk of triggered earthquakes. While the main activity is based on the use of commercial software and on standard FEM/finite volume techniques, I have employed, in simple two-dimensional configuration, the XFEM to discretize both the mechanical and the fluid dynamic problem. Moreover, I am supervising a PhD thesis on the numerical simulation of crack growth, where the XFEM are used in conjunction with a phase-field model to obtain a physically accurate, but at the same time efficient method.

As concerns the study of reactive flows and their effects on the evolution of sedimentary basins, I have studied the coupling of the fluid dynamic problem with the heat and the compaction of the media that occurs over millions of years, accounting for mineral dissolution/precipitation/transformation. One of the major difficulties consists in the coupling among the equations, that has been handled both by means of iterative splittings and monolithically. Another case of reactive flow of particular interest is the process of oil generation in the source rock, which is the subject of several research projects in collaboration with Eni from 2007 to 2015. Here, a particular attention was devoted to computational efficiency in conjunction with reliability to develop a numerical tool that was suitable for industrial use. Indeed, numerical integration should preserve mass conservation and positivity of the solution [2,12,25] even in the presence of stiff ODEs, or in the case of ODEs with discontinuous right hand side which require ad hoc techniques both for the numerical integration, as well as for the analysis [3,13,27].

Publications

Papers

- 1 Antonietti P.F., Formaggia L., Scotti A., Verani M., Verzotti N., *Mimetic finite difference approximation of flows in fractured porous media*, M2AN, accepted on 11/2/2015.
- 2 Giovanardi, B., Scotti, A., Formaggia, L., Ruffo, P., *A general framework for the simulation of geochemical compaction*, Computational Geosciences, (2015) DOI: 10.1007/s10596-015-9518-3.
- 3 Agosti, A., Formaggia, L., Scotti, A., *Analysis of a model for precipitation and dissolution coupled with a Darcy flux*, JMAA, Volume 431, Issue 2, (2015), pp. 752-781.
- 4 Fumagalli A., Scotti A., *An efficient XFEM approximation of Darcy flow in arbitrarily fractured porous media*, Oil and Gas Sciences and Technologies - Revue d'IFP Energies Nouvelles 69.4 (2014), pp. 555-564
- 5 Cattaneo L., Formaggia L., Iori G. F., Scotti A., Zunino P., *Stabilized extended finite elements for the approximation of saddle point problems with unfitted interfaces*, Calcolo (2014), pp 130.
- 6 Formaggia L., Fumagalli A., Scotti A. Ruffo P.. *A reduced model for Darcys problem in networks of fractures*, ESAIM: Mathematical Modelling and Numerical Analysis 48 (2014), pp. 1089-1116.
- 7 Fumagalli, A., Scotti, A., *A numerical method for two-phase flow in fractured porous media with non-matching grids*, Advances in Water Resources, Volume 62, p. 454-464 (2013) 10.1016/j.advwatres.2013.04.001.
- 8 Formaggia, L., Guadagnini, A., Imperiali, I., Lever, V., Porta, G., Riva, M., Scotti, A., Tamellini, L., , *Global sensitivity analysis through polynomial chaos expansion of a basin-scale geochemical compaction model*, Computational Geosciences, 2013, Vol 17(1) pp 25-42, DOI: 10.1007/s10596-012-9311-5.
- 9 Tamellini, L. Formaggia, L., Miglio, E., Scotti, A., *An Uzawa iterative scheme for the simulation of floating bodies*, Computers & Fluids, Vol. 68, pp. 148-158, (2012).
- 10 Fumagalli, A. and Scotti, A., *Numerical modelling of multi-phase subsurface flow in the presence of fractures*, Communications in Applied and Industrial Mathematics, 2011, 10.1685/journal.caim.380, (2012).

Proceedings

- 11 D'Angelo C., Scotti, A., *A mixed finite element method for Darcy flow in fractured porous media with non matching grids*, M2AN, Vol. 46, pp. 465-489, (2012).
- 12 Formaggia L., Scotti, A., *Positivity and conservation properties of some integration schemes for mass action kinetics*, SIAM J. Numer. Anal. 49, pp. 1267-1288, (2011).
- 13 Agosti, A., Formaggia, L., Giovanardi, B., Scotti, A., *Numerical simulation of geochemical compaction with discontinuous reactions*, sottomesso a Proceeding of the VI conference on Coupled Problems in Science and Engineering (2015)
- 14 Formaggia L., Antonietti P., Panfili P., Scotti A., Turconi L., Verani M. and Cominelli A., *Optimal Techniques to Simulate Flow in Fractured Reservoir*, ECMOR XIV-14th European conference on the mathematics of oil recovery, (2014).
- 15 Calì F., Scotti A., *Mathematics: method and creativity in fabric design creation*, CIMODE 2014, (2014).
- 16 Ruffo P., Porta G.M., Colombo I., Scotti A., Guadagnini A., *Global Sensitivity Analysis of Geochemical Compaction in a Sedimentary Basin*, First EAGE Basin & Petroleum Systems Modeling Workshops, (2014).
- 17 Panfili, P., Cominelli, A., Scotti, A., *Using Embedded Discrete Fracture Models (EDFMs) to Simulate Realistic Fluid Flow Problems*, Second EAGE Workshop on Naturally Fractured Reservoirs, (2013).
- 18 Scrofani G., Ruffo P., Porta G.M., Riva M., Lever V., Scotti A., Imperiali I., *Preliminary Analysis of Diagenetic Effects on Basin Scale Over Pressure Dynamics*, IPTC 2013: International Petroleum Technology Conference , (2013).
- 19 Formaggia, L., Guadagnini, A., Imperiali, I., Lever, V., Porta, G., Riva, M., Scotti, A., Tamellini, L., *Uncertainty analysis of basin scale compaction processes*, EGU General Assembly 2012, (2012).
- 20 Porta G.M., Lever V., Scotti A., Imperiali I., Riva M., *Uncertainty propagation in sandstone compaction modeling*, XXXIII Convegno Nazionale di Idraulica e Costruzioni Idrauliche, (2012).
- 21 Fumagalli, A., Scotti, A., *An unfitted method for two-phase flow in fractured porous media*, CMWR2012 Proceedings, // <http://cmwr2012.cee.illinois.edu/Proceedings.html>, (2012).
- 22 Fumagalli, A. and Scotti, A., *A reduced model for flow and transport in fractured porous media with non-matching grids*,

- Proceedings of ENUMATH 2011, 2012, issue 03/2012, pp. 499508.
- Book chapters
- 23 Scotti, A., Villa, A. *Predictive numerical models of basin evolution and petroleum generation*, Applied and Industrial Mathematics in Italy III, E. De Bernardis, R. Spigler and V. Valente (Eds) , Series on Advances in Mathematics for Applied Science, Vol. 82, World Sci. Publ., pp. 554-566, 2009. ISBN: 978-981-4280-29-7
- 24 Formaggia L., Miglio, E., Mola, A., Scotti, A., *Numerical simulation of the dynamics of boats by a variational inequality approach*, Variational Analysis and Aerospace Engineering, Buttazzo, G., Frediani, A. (ed.). 213–227, Springer, 2009. ISBN 0387958576, 9780387958576.
- PhD thesis
- 25 Scotti, A. *A numerical model for generation and primary migration of hydrocarbons* (2010).
- Submitted papers
- 26 Del Pra M., Fumagalli A., Scotti A., *Well posedness of fully coupled fracture/bulk Darcy flow with non-matching grids*.
- 27 Agosti, A., Formaggia, L., Giovanardi, B., Scotti, A., *A numerical procedure for geochemical compaction in the presence of discontinuous reactions*.

Talks

Talks in conferences

- Numerical simulation of discontinuous reactions in diagenesis*, SCICADE 2015, 17 September 2015. Co-authors A. Agosti, L. Formaggia, B. Giovanardi, (*invited*).
- Numerical simulation of fractured and heterogeneous porous media with non-matching grids*, X-DMS 2015, 10 September 2015. Co-authors A. Fumagalli, M. Del Pra, L. Formaggia, (*invited*).
- Xfem approximation of coupled flow and mechanics in faults*, SIAM GS 2015, 1 July 2015. Co-authors A. Fumagalli, B. Giovanardi, C. Colciago, L. Vadacca, (*invited*).
- XFEM for heterogeneous problems with time dependent inclusions*, Workshop on unfitted FEM, Aachen 2015, 15 June 2015, (*invited*).
- Numerical simulation of geochemical compaction with discontinuous reactions*, Coupled problems 2015, 20 May 2015. Co-authors A. Agosti, L. Formaggia, B. Giovanardi (*invited*).
- Mathematics: method and creativity in fabric design creation*, CIMODE 2014, 6 November 2014. Co-author F. Calì.

- Approximation of flows in fractured porous media by the XFEM*, WCCM 2014, 21 July 2014. Co-authors L. Formaggia, G.F.Iori (invited).
- XFEM for flow in fractured porous media*, SIAM Annual meeting 2014, 8 July 2014. Co-authors L. Formaggia, A. Fumagalli.
- Numerical simulation of flow and transport in fractured porous media with the XFEM*, CMWR14, 12 June 2014. Co-authors L. Formaggia, A. Fumagalli.
- Simulation of fractured porous media using Extended Finite Elements*, CompGeo Workshop, University of Pittsburgh, 22-23 May 2014 (invited).
- An XFEM based approximation for flow in heterogeneous porous media*, GAMM 2014, 10-14 March 2014. Co-authors L. Formaggia, A. Fumagalli (invited).
- Numerical simulation of Darcy flows in fractured porous media with the XFEM*, 2nd NUPUS international conference, 30 Sept-2 Oct. Bergen. Co-authors L. Formaggia, A. Fumagalli.
- Numerical simulation of Darcy flows in fractured porous media with the XFEM*, AIMETA, 17-20 Sept. 2013, Torino. Co-authors L. Formaggia, A. Fumagalli (invited).
- A numerical method for two-phase flow in fractured porous media with non-matching grids*, SIAM GS13, 19 June 2013. Co-authors L. Formaggia, A. Fumagalli.
- Numerical simulation of Darcy flows in fractured porous media with the XFEM*, NUPUS annual meeting, 17-20 March 2013. Co-authors L. Formaggia, A. Fumagalli.
- Numerical methods for multiphase flows in fractured porous media*, SIMAI 2012 National Congress, 25-28 June 2012. Co-author A. Fumagalli.
- An unfitted method for two-phase flow in fractured porous media*, CMWR 2012, Urbana-Champaign, 17-21 June 2012. Co-author A. Fumagalli.
- A reduced model for flow in fractured porous media with non matching grids*, ENUMATH 2011, Leicester, 5-9 Sept. 2011. Co-authors A. Fumagalli, C. D'Angelo.
- Mixed finite element schemes for fluid flows in fractured porous media with reduced order modeling of fractures with non-matching grids*. ECCOMAS CFD 2010, Lisbon, 14-17 June 2010. Co-authors A. Fumagalli, C. D'Angelo.
- Experimental Validation of Multicomponent Hydrocarbon Differential Expulsion from Source Rock*, Modeling sedimentary basins and their

petroleum systems, Geological Society, London, 3-4 June 2010. Co-authors P. Ruffo, A. Consonni, L. Caldiero, D. Dolci, R. Galimberti.

Generation, Retention and Expulsion of hydrocarbons, SIAM GS09 congress 2009, Leipzig, 15-18 June 2009.

A numerical model for petroleum generation and primary migration, Convegno biennale GNCS, Montecatini, 4-6 Febr. 2009.

Predictive numerical models of basin evolution and petroleum generation, Co-authors A. Villa, SIMAI national congress 2008, Rome, 15-19 Sept. 2008

Invited seminars

November, 24th 2015 *The interplay of flow, chemistry and compaction in sedimentary basins*, Workshop Flow in Deformable Porous Media, Zaragoza.

November, 18th 2015 *Numerical simulation of flow in compacting porous media in the presence of discontinuous reactions*, Reactive Transport Modeling in the Geological Sciences workshop, Paris.

November, 13th 2014 *Numerical simulation of porous media compaction in the presence of discontinuous reaction*, University of Bergen.

September, 22nd 2014 *Porosity and pressure evolution in the presence of discontinuous reaction*, Oberwolfach Workshop Reactive Flows in Deformable, Complex Media.

May, 10th 2012 *Numerical methods for multiphase flows in fractured porous media with non-matching grids*. Institut für Wasser und Umweltsystemmodellierung, University of Stuttgart. Co-authors A. Fumagalli, L. Formaggia.

October, 13th 2011 *A model reduction strategy for multiphase flows in fracture porous media with non matching grids*. SNAPLE kickoff meeting, Dipartimento di Matematica, Politecnico di Milano.

June, 16th 2011 *Numerical models for the evolution of geological basins and oil migration*. INRIA Roquencourt, Estime group. Co-authors A. Fumagalli, L. Formaggia.

Organization of conferences

Minisymposia

Sept. 9-11th 2015 *Enriched methods for flow and mechanics in heterogeneous and fractured porous media*. X-DMS 2015, Ferrara. Organizers: Anna Scotti, Alessio Fumagalli, Stefano Berrone and Oliver Sander.

June 29th - July 2nd 2015 *Advances in numerical methods for complex fractured porous media*. SIAM GS 2015 Stanford. Organizers: Anna Scotti, Alessio Fumagalli, Stefano Berrone and Sandra Pieraccini.

June, 17-20th 2013 *Mathematical modeling of fractured porous media flow with reduced models*. SIAM Conference on Mathematical and numerical issues in the geosciences, Padova. Organizers: Anna Scotti, Luca Formaggia and Jean Roberts.

June, 28th 2012 *Beyond the mesh: handling geometry with unconventional methods*. SIMAI 2012 National Congress, Torino. Organizers: Anna Scotti and Franco Dassi.

Organization of workshops and conferences

2015 Organizing committee of SIMAI 2016.

2015 Organizing committee of X-DMS 2015 <http://x-dms2015.sciencesconf.org/>

May 2015 Organizer of the workshop "Caprocks" at the Politecnico di Milano, in collaboration with Eni S.p.A.