CURRICULUM VITAE OF LAURA GUADAGNINI

Consultant Geologist

Born:

Education. Graduated in Geology, Università degli Studi di Modena, Modena, Italy (1991). Certified geologist (National Professional Habilitation in 1992). Doctoral Degree in Engineering Geology, Politecnico di Milano, Milano, Italy (1998).

Academic Record. Research and teaching activity, Politecnico di Milano, Milano, Italy (1994 - 1997). Visiting student, University of La Coruña, E.T.S. de Ingenieros de Caminos, Canales y Puertos, La Coruña, Spain (1997). Research associate, Politecnico di Milano, Milano, Italy (2000 – 2018). Visiting Scientist, Universitat Politècnica de Catalunya, Barcelona, Spain (2019).

Research activity. Recent research activity of Laura Guadagnini focuses on the analysis of inverse modeling for the characterization of geologic media, geostatistics, well hydraulics, flow and transport processes and uncertainty quantification in heterogeneous groundwater systems. Emphasis is given to hydrogeochemical processes taking place in heterogeneous aquifer system. She has participated in numerous base and applied research projects at national and international levels (including EU-funded activities).

Key research projects.

2000-2003. European Union, FP5. L. Guadagnini was investigator within the European Consortium W-SAHaRA (Stochastic Analysis of Well-Head Protection and Risk Assessment). W-SAHaRA was a European level consortium operating in the context of the probabilistic analysis of drinking wells protection. The consortium was funded by the European Union (Contract No. EVK1-1999-CT-00041), within the Fifth Framework Program (April 2000 - December 2003).

2004. Bologna Ponente s.c.r.. Title: "*Preliminary conceptual model of a contaminated site*". Key topic and objective: formulation of the conceptual model of aquifer functioning and contaminant migration and spreading at a contaminated site.

2005-2006. Bologna Ponente s.c.r.. Title: "*Conceptual and mathematical modeling of contaminated sites*". Key topic and objective: conceptual and mathematical model of field scale contaminant spreading in the presence of limited lithological, chemical and hydraulic data.

2006-2007. Società finanziaria Bologna Metropolitana s.p.a. Title: "*Conceptual and mathematical modeling of groundwater quality at construction sites*" Key topic and objective: design of multilevel sampling of PCE, TCM and heavy metal concentrations; data analysis and interpretation; modelling of preferential flow paths of heavy metals in the presence of competitive reactive processes.

2006-2008. MIUR (Ministry of Education, Research and University of Italy). Title: "*Statistical estimation of heterogeneity in complex randomly heterogeneous geologic media*". Key topic and objective: formulation of geostatistical inverse models of groundwater flow in randomly heterogeneous media; theoretical framework and application for statistical interpretation of pumping tests.

2006-2008. CARIPLO Foundation. Title: "*Mathematical modeling of the interactions between natural springs and groundwater for a sustainable use of the water resource*". Key topic and objective: characterization and stochastic modeling of interactions between natural springs and the groundwater system in the presence of limited geological and sedimentological/geological information.

2010-2013. ARPA - Agenzia Regionale per la Prevenzione e l'Ambiente dell'Emilia Romagna-Direzione Tecnica (Regional Angency for Environmental Protection). Title: "*Identification of arsenic natural levels in deep aquifer systems for the classification of chemical status of groundwater bodies according to Directive 2000/60/CE*". Key topic and objective: experiments and geochemical modeling of the effects of Arsenic partitioning and dynamics on the assessment of groundwater background levels.

2012-2015. ARPA - Agenzia Regionale per la Prevenzione e l'Ambiente dell'Emilia Romagna-Direzione Tecnica (Regional Angency for Environmental Protection). Title: "*Evaluation of hexavalent chromium natural levels in mountain groundwater bodies for the classification of chemical status of groundwater bodies according to Directive 2000/60/CE*". Key topic and objective: analysis of the mechanisms of hexavalent chromium ion mobilization from host ophiolitic rocks and soil matrices to groundwater.

2015-2016. Eni s.p.a. Title: "Three-Dimensional modeling of flow coupled with geochemical and mechanical compaction in sedimentary basins subject to glaciation events (STREAM-3D)". Key topic and objective: Formulation and characterization of a mathematical model for the simulation of coupled processes (fluid flow and geochemical/mechanical compaction) in sedimentary basins including the effects of glaciation and isostatic processes.

2016-2018. Water JPI project WE-NEED (2016-2019) "WatEr NEEDs, Availablity, Quality and Sustainability" funded by MIUR (Ministry of Education, Research and University of Italy, 2016-2019), within the ERA-NET Cofound Water Works 2014.

Teaching activity. Teaching activity has comprised tenure/co-tenure of courses (including Hydrogeology, Environmental Hydraulics, Groundwater Hydraulics) within the curricula of Engineering Geology (University of Parma) and of Civil and Environmental Engineering (Politecnico di Milano), Italy, as well as responsibilities associated with the design, development of teaching material and delivery of course-related activities within the context of

the courses of Groundwater Hydraulics (curriculum of Civil, and Environmental Engineering - Master level - at the Politecnico di Milano, Italy).

Special Professional Activities. Member of the scientific committee of the International Conference geoENV (Conference on Geostatistics for Environmental Applications) (2004). Member of the reviewer committee of the workshop "Developments in aquifer sedimentology and ground water flow studies in Italy" (2004). Member of the reviewer committee of the workshop "Multidisciplinary approach for porous aquifer characterization" (2009).

Supervision of PhD Students. In addition to about 15 Master Level thesis projects, the following Ph.D. students and Postdoctoral fellows have been co-supervised by L. Guadagnini: (1) PhD Candidate: Giulia Ceriotti (graduated: April 2018): Thesis: *Modeling under uncertainty of reactive processes in subsurface systems across scales.* (2) PhD candidate: Antonio Molinari (graduated: March 2013); Thesis: *Effects of Arsenic partitioning and dynamics on the assessment of groundwater background levels*; Fellowship funded by the "Agenzia Regionale per la Prevenzione e l'Ambiente dell'Emilia-Romagna" (ARPA – Regional Agency for Environmental Protection). (3) PhD Candidate: Raul Perulero-Serrano (graduated: March 2014); Thesis: *Stochastic analysis of nonuniform flows in randomly heterogeneous composite media*; Fellowship funded by the EU (IMVUL, FP7 Marie Curie Initial Training Network). (4) PhD Candidate: Brigitta Toth (graduated: 2011 - University of Pannonia, Hungary); Thesis: *Calculation and characterization of water retention of major Hungarian soil types using soil survey information*; Fellowship funded by the Government funds (Hungary).

Consulting professional activity. L. Guadagnini also operates as private consultant since 1992. Her activity is mainly developed within the context of projects funded by public administrations. The conceptual and theoretical research developments and results achieved are applied to practical situations involving aquifer systems in complex geological media and the interactions between anthropogenic activities and the subsurface.

Funding Agency: Emilia Romagna Region - Geological, seismic and soil survey; Key task: Analysis of hydrogeological parameters to evaluate water exchanges/fluxes between the Po river and the surrounding aquifer system in selected areas of the Emilia Romagna Region (2012)

Funding Agency: Municipality of Nogara (Northern Italy). Key task: Geological and hydrogeological investigation in light of the city urban development plan.

Funding Agency: Municipality of Bologna (Northern Italy). Key task: Geological and hydrogeological investigation for quarry planning (2002)

Funding Agency: Municipality of Valeggio sul Mincio (Northern Italy). Key task: Hydrogeological and hydrogeochemical analysis of the municipal area (2000-2002).

Funding Agency: Municipality of Povegliano Veronese (Northern Italy). Key task: Geological investigation for environmental impact assessment of the city development plan (2002).

Funding Agency: A.S.M. – Brescia (Northern Italy). Key task: geological, hydrogeological and environmental investigation for the delineation of well capture zones in the heterogeneous aquifer system supplying the city (1999).

Papers in international refereed journals

1. Menafoglio, A., Guadagnini, L., Guadagnini, A., Secchi, P. (2021), Object oriented spatial analysis of natural concentration levels of chemical species in regional-scale aquifers, *Spatial Statistics*, 43, 100494, doi: 10.1016/j.spasta.2021.100494
2. Guadagnini, L., Menafoglio, A., Sanchez Vila, F. J., Guadagnini, A. (2020), Probabilistic assessment of spatial heterogeneity of natural background concentrations in large-scale groundwater bodies through Functional Geostatistics, *Sci. Total Environ.*, 740, 1-12, doi: 10.1016/j.scitotenv.2020.140139.
3. Bianchi Janetti, E., L. Guadagnini, M. Riva, and A. Guadagnini (2019), Global sensitivity analyses of multiple conceptual models with uncertain parameters driving groundwater flow in a regional-scale sedimentary aquifer, *Journal of Hydrology*, 574, 544-556, doi: 10.1016/j.jhydrol.2019.04.035.
4. Molinari, A., L. Guadagnini, M. Marcaccio, and A. Guadagnini (2019), Geostatistical multimodel approach for the assessment of the spatial distribution of natural background concentrations in large-scale groundwater bodies, *Water Research*, 149, 522-532, https://doi.org/10.1016/j.watres.2018.09.049.
5. Ceriotti, G., L. Guadagnini, G. Porta, and A. Guadagnini (2018), Local and global sensitivity analysis of Cr(VI) geogenic leakage under uncertain environmental conditions. *Water Resour Res.*, 54(8), 5785-5802. 10.1029/2018WR022857
6. Molinari, A., L. Guadagnini, M. Marcaccio, and A. Guadagnini (2015), Arsenic fractioning in natural solid matrices sampled in a deep groundwater body. *Geoderma*, 247-248, 88-96, ISSN: 0016-7061, doi: 10.1016/j.geoderma.2015.02.011
7. Perulero Serrano, R., L. Guadagnini, M. Riva, M. Giudici, and A. Guadagnini (2014), Impact of two geostatistical hydro-facies simulation strategies on head statistics under non-uniform groundwater flow, Journal of Hydrology, 508, 343-355.
8. Molinari, A., C. Ayora, L. Guadagnini, M. Marcaccio, X. Sanchez-Vila, and A. Guadagnini (2013), Geochemical modeling of arsenic release from a deep natural solid matrix under alternated redox conditions, *Environ. Sci. Pollut. Res., published on-line*, doi:10.1007/s11356-013-2054-6.
9. Molinari, A., L. Guadagnini, M. Marcaccio, S. Straface, X. Sanchez-Vila, and A. Guadagnini (2013), Arsenic release from deep natural solid matrices under experimentally controlled redox conditions, *Sci. Total Environ.*, 444, 231-240.
10. Molinari, A., L. Guadagnini, M. Marcaccio, and A. Guadagnini (2012), Natural background levels and threshold values of chemical species in three large-scale groundwater bodies in Northern Italy, *Sci. Total Environ.*, 425, 9-19, doi:10.1016/j.scitotenv.2012.03.015.
11. Short, M., L. Guadagnini, A. Guadagnini, D.M. Tartakovsky, and D. Higdon (2010), Predicting vertical connectivity within an aquifer system, *Bayesian Analysis*, 5(3), 557-582, doi:10.1214/10-BA522.
12. Riva, M., L. Guadagnini, and A. Guadagnini (2010), Effects of uncertainty of lithofacies, conductivity and porosity distributions on stochastic interpretations of a field scale tracer test, *Stoch. Environ. Res. Risk Assess.*, 24, 955-970, doi:10.1007/s00477-010-0399-7.
13. Riva, M., L. Guadagnini, A. Guadagnini, T. Ptak, and E. Martac (2006), Probabilistic study of well capture zones distribution at the Luswiesen field site, *J. of Cont. Hydrol.*, 88, 92-118.
14. Stauffer, F., A. Guadagnini, A. Butler, H.-J. Hendricks Franssen, N. van de Wiel, M. Bakr, M. Riva, and L. Guadagnini (2005), Delineation of source protection zones using statistical methods, *Water Resour. Management*, 19(2): 163-185, doi:10.1007/s11269-005-3182-7.
15. Guadagnini, L., A. Guadagnini, and D.M. Tartakovsky (2004), Probabilistic Reconstruction of geologic facies, *J. Hydrol.*, 294, 57-67.
16. Guadagnini, A., L. Guadagnini, D.M. Tartakovsky, and C.L. Winter (2003), Random domain decomposition for flow in heterogeneous stratified aquifers, *Stoch. Environ. Res. Risk Assess.*, 17, 394-407, doi:10.1007/s00477-003-0157-1.

Papers in Italian journals

1. Marcaccio, M., A. Molinari, L. Guadagnini, and A. Guadagnini (2012), Metalli e sostanze inorganiche, la stima dei valori di fondo, *Ecoscienza*, 6, 63-65.
2. Severi, P., G. Biavati, L. Bonzi, L. Guadagnini, and L. Martelli (2012), Monitoraggio in continuo degli acquiferi del Po, *Ecoscienza*, 6, 72-74.
3. Riva, M., L. Guadagnini, and A. Guadagnini (2006), Caratterizzazione geostatistica dell'acquifero sperimentale di Lauswiesen, *L'acqua*, 6-2006.
4. Guadagnini L., M. Farina, S. Frontini, and M. Simoni (2002), La funzione degli acquitardi per la

determinazione della vulnerabilità idrogeologica – contributo geostatistico e stocastico, Atti del terzo seminario sulla cartografia geologica (a cura di P. Barchesi, A. Angelelli, S. Forni), 133-135, Bologna 26-27 febbraio 2002. Servizio Geologico Sismico e dei Suoli Regione Emilia-Romagna. Stampa Labanti, Bologna

5. Barozzi, A., G. Bissolati, V. Francani, and L. Guadagnini (2000), Le aree di salvaguardia dei pozzi dell'acquedotto di Brescia, Quaderni di Geologia Applicata, 7(3) (2000), 113-124 . Pitagora Ed. Bologna, 2000. (Edito in Italia, a Bologna, 2000).
6. Guadagnini, L., and M. Masetti (1998), Stima della qualità degli ammassi rocciosi in aree ad elevata copertura detritica, Quaderni di Geologia Applicata, 5 –2 (1998), 49-63. Pitagora Ed. Bologna, 1998. (Edito in Italia, a Bologna, 1998).
7. Guadagnini, L., and J. Samper (1997), Analisi statistiche multivariate di parametri idrochimici del bacino del T. Stirone, Quaderni di Geologia Applicata, 4 – 2(1997), 59-74. Pitagora Ed. Bologna, 1997. (Edito in Italia, a Bologna, 1997).

Papers in Proceedings of International Conferences

1. Guadagnini, A., L. Guadagnini, G. Porta, D. Cerroni, L. Formaggia, A. Scotti, P. Zunino, and P. Ruffo (2017), Modeling the feedback between glaciation, geochemical and mechanical compaction on sedimentary basin evolution, proc. of the 13th Offshore Mediterranean Conference and Exhibition (OMC2017), Ravenna (Italy), March 29-31, 2017, paper No. OMC-2017-742, 1-8, ISBN:978889404300.
2. Perulero Serrano, R., L. Guadagnini, M. Giudici, A. Guadagnini, and M. Riva (2012), Application of the Truncated Plurigaussian Method to delineate hydrofacies distribution in heterogeneous aquifers, *XIX International Conference on Water Resources*, CMWR 2012, A.J. Valocchi (Ed), proceedings on CD-ROM, University of Illinois at Urbana-Champaign, 952-959.
3. Tóth, B., A. Makó, L. Guadagnini, A. Azzellino, and A. Guadagnini (2008), Grouping of soils according to their soil water retention characteristics, *International Conference on Calibration and Reliability in groundwater modelling*, ModelCARE 2007, IAHS Publ. 320, 154-159, ISSN 0144-7815.
4. Tóth, B., A. Makó, L. Guadagnini, and A. Guadagnini (2008), Factor analysis of Hungarian hydrophysical data to predict soil water retention characteristics, VII. Alps-Adria Scientific Workshop, Cereal Research Communications, Vol. 36(Suppl.), 411-414.
5. Riva, M., L. Guadagnini, A. Guadagnini, E. Martac, and T. Ptak (2006), A composite medium approach for probabilistic modelling of contaminant travel time distribution to a pumping well in a heterogeneous aquifer, in *Proc. of the 5th International Conference on Calibration and Reliability in groundwater modelling*, ModelCARE05, The Hague, June 2005, IAHS Publ. 304, 227-233, ISSN 0144-7815, ISBN 1-901502-58-9.
6. Riva, M., L. Guadagnini, E. Martac, and T. Ptak (2005), Stochastic modelling of well head protection zones in highly heterogeneous aquifers, in Bringing Groundwater Quality Research to the Watershed Scale (Proceedings of GQ2004, the 4th International Groundwater Quality Conference, Waterloo, Canada, July 2004). IAHS Publ. 297, 2005: 449-457. Pubblicato a Waterloo, Canada, 2005
7. Guadagnini, L., A. Guadagnini, and D.M. Tartakovsky (2004), A geostatistical model for distribution of facies in highly heterogeneous aquifers, in Proc. of the Fourth European Conference on Geostatistics for Environmental Applications – geoENV IV, 211-222, Barcellona, Spagna, Kluwer Academic Publishers. Pubblicato in The Netherlands, 2004. ISBN: 1-4020-2114-3
8. Martac, E., L. Guadagnini, M. Riva, and T. Ptak (2003), Multivariate geostatistical parameterization approach for 3D transient stochastic modeling of wellhead protection zones in a highly heterogeneous aquifer, in Proc. of Modflow and More 2003 - Understanding through Modelling, 686-690. Poeter Zheng, Hill Doherty Editors - International Ground Water Modeling Center (IGWMC). Pubblicato a Golden, Colorado, Stati Uniti d'America, 2003
9. Guadagnini, L., A. Guadagnini, and D.M. Tartakovsky (2004), A geostatistical model for distribution of facies in highly heterogeneous aquifers, in *Proc. of the 4th European Conference on Geostatistics for Environmental Applications (geoENV-2002)*, 211-222.
10. Tartakovsky, D.M., A. Guadagnini, L. Guadagnini, and S. Franzetti (2003), Apparent conductivity of random composite formations, in *Proc. of the XXIX IAHR Congress*, Maksimovic C. and Kaleris V. (Eds.), Theme B, 691-697, ISBN: 960-243-594-1.
11. Guadagnini, A., L. Guadagnini, D.M. Tartakovsky, and C.L. Winter (2003), Solution of moment equations of groundwater flow in random composite layered aquifers, in *Proc. of the International Conference Calibration and Reliability in Groundwater Modelling: a Few Steps Closer to Reality*

(MODELCARE'2002), IAHS Publication No. 277, Kovar, K.- Hrkal, Z. (Eds.), 108-114.

12. Guadagnini, L., M. Farina, and M. Simoni (2003), Geostatistical modelling of a heterogeneous alluvial aquifer by indicator variables, in Calibration and reliability in groundwater modelling: a few steps closer to reality - Proceedings of the ModelCARE'2002 Conference, 115-121, Prague, 2002. Kovar, K.- Hrkal, Z. Editors. IAHS Publ. no. 277, IAHS Press, Pubblicato a Wallingford – Oxfordshire, UK, 2003. ISBN: 1-901502-07-4.
13. Tartakovsky, D. M., A. Guadagnini, and L. Guadagnini (1999), Stochastic averaging and estimate of effective (upscaled) conductivity and transmissivity, Proc. of IAMG'99, The Fifth Annual Conference of the International Association for Mathematical Geology (IAMG99), Trondheim, Norway, August 6-11, Vol. II, 755-760. S.J. Lippard, A. N☆ss, R. Sinding-Larsen Editors. Pubblicato a Trondheim, Norvegia, 1999
14. Guadagnini, A., L. Guadagnini, and D.M.Tartakovsky (1999), Prediction of steady state flow in randomly heterogeneous formations by conditional nonlocal finite elements, Proc. of the Second European Conference on Geostatistics for Environmental Applications - geoENVII, 271-282, Valencia, Spain, 1998. J. Gòmez-Hernandez, A. Soares and R. Froidevaux Editors. Kluwer Academic Publishers. Pubblicato in The Netherlands, 1999. ISBN: 0-7923-5783-3
15. Guadagnini, L., and S. Morandi (1998), Applicability of multivariate statistical data analysis techniques to investigate ground water pollutant sources, Proc. of IAMG'98, The Fourth Annual Conference of the International Association for Mathematical Geology, 439-444, Ischia Island, Italy, 5-9 October 1998. A. Buccianti, G. Nardi and R. Potenza Editors. De Frede Ed., Napoli, 1998.
16. Guadagnini, L. (1997), Spatial correlations of hydrochemical parameters, Proc. of the First European Conference on Geostatistics for Environmental Applications - geoENVI, 223-234, Lisbon, 20-22 Novembre 1996. A. Soares, J. Gòmez-Hernandez and R. Froidevaux Editors. Kluwer Academic Publishers. Pubblicato in The Netherlands, 1997. ISBN: 0-7923-4590-8.

Papers in Proceedings of National Conferences

1. Guadagnini, L., A. Molinari, M. Marcaccio, and A. Guadagnini (2018), Lo stato di qualità ambientale degli acquiferi potenzialmente utilizzabili a scopo idropotabile, Proc. Del Convegno Tecniche per la difesa del suolo e dall'inquinamento, Guardia Piemontese Terme (Cs), June 20-23 2018.
2. Marcaccio, M., A. Molinari, L. Guadagnini, A. Guadagnini, A. Palumbo, and I. Pellegrino (2012), Valori di fondo naturale e valori soglia di specie chimiche potenzialmente contaminanti per l'individuazione dello stato chimico delle acque sotterranee dell'Emilia-Romagna, Proc. del Convegno Le direttive sulle acque (2000/60/EC) e sulle acque sotterranee (2006/18): implementazione, innovazione e prospettive future, *Ecomondo 2012*, L. Morselli Ed., Maggioli Editore, 977-981.
3. Bianchi Janetti, E., L. Guadagnini, M. Riva, E. Larcan, and A. Guadagnini (2011), Geostatistical characterization of a regional-scale sedimentary aquifer, Proc. of XX Congresso dell'Associazione Italiana di Meccanica Teorica e Applicata, Bologna 12-15 September 2011, F. Ubertini, E. Viola, S. de Miranda, G. Castellazzi (Eds.), ISBN 978-88-906340-1-7 (online), 1-10.
4. Guadagnini, A., M. Riva, and L. Guadagnini (2010), Modeling dissolution experiments and heavy metals competition in porous media, *Mem. Descr. Carta Geol. d'It.*, XC, Atti del Secondo Workshop Nazionale "L'approccio multidisciplinare allo studio degli acquiferi porosi", VII Forum italiano di Scienze della Terra - Geoitalia 2009, Rimini, 9-11 settembre 2009, 121-132.121-132.
5. Riva, M., L. Guadagnini, and A. Guadagnini (2010), Prove di campo con traccianti: effetto dell'incertezza nella caratterizzazione litologica e nella distribuzione delle proprietà idrauliche, in *Atti del XXXII Convegno di Idraulica e Costruzioni Idrauliche*, Walter Farina Ed., 248 (full paper on CD-ROM).
6. Guadagnini, L., M. Riva, and S. Franzetti S. (2004), Perimetrazione di zone di cattura probabilistiche in un acquifero eterogeneo, Atti del XXIX Convegno di Idraulica e Costruzioni Idrauliche, Trento 7-10 settembre 2004 – Vol 2, 603-610, Trento. Ed. Bios, Cosenza, 2004, ISBN: 88-7740-382-9, 2004
7. Guadagnini, L., M. Farina, S. Frontini, and M. Simoni (2002), La funzione degli acquitardi per la determinazione della vulnerabilità idrogeologica – contributo geostatistico e stocastico, Atti del terzo seminario sulla cartografia geologica (a cura di P. Barchesi, A. Angelelli, S. Forni), 133-135, Bologna 26-27 febbraio 2002. Servizio Geologico Sismico e dei Suoli Regione Emilia-Romagna. Stampa Labanti, Bologna
8. Guadagnini, L. (2001), Analisi della correlazione spaziale di proprietà di un acquifero naturale, Atti del VI Workshop Informatica Applicata alle Scienze della Terra (GIAST), 163-180, Sansepolcro (Ar), 14-16 Settembre 1999. De Frede Ed., Napoli, 2001. (Edito in Italia, a Napoli, 2001).

9. Guadagnini, L. (2000), L'impiego di metodi geostatistici per la ricostruzione degli inquinamenti delle acque sotterranee", Atti del 51° Corso di Aggiornamento in Ingegneria Sanitaria-Ambientale "Siti Contaminati: Indagini, Analisi di Rischio e Tecniche di Bonifica, 249-281. Milano, 26-30 Giugno 2000. Edito da: Dipartimento di I.I.A.R – Politecnico di Milano, Milano, 2000.
10. Alberti, L. and L.Guadagnini (1999), Analisi e valutazione degli inquinamenti determinati dagli scambi idrici tra fiumi e falda, Atti del 3° Convegno Nazionale sulla Protezione e Gestione delle Acque Sotterranee per il III Millennio, 2.53-2.64. Parma, 13-15 ottobre 1999. Pitagora Ed. Bologna, 1999.