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Hydrogeological Conceptual Model of Groundwater from Carbonate Aquifers Using Environmental Isotopes (^{18}O, ^{2}H) and Chemical Tracers: A Case Study in Southern Latium Region, Central Italy

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ABSTRACT
The present work provides hydrochemical and stable isotope data and their interpretations for 54 springs and 20 wells, monitored from 2002 to 2006, in the Southern Latium region of Central Italy to identify flow paths, recharge areas and hydrochemical processes governing the evolution of groundwater in this region. The hydrogeological conceptual model of the carbonate aquifers of southern Latium was based on environmental isotopic and hydrochemical investigation techniques to characterize and model these aquifer systems with the aim of achieving proper management and protection of these important resources. Most of the spring samples, issuing from Lepini, Ausoni and Aurunci Mts., are characterized as Ca-Mg-HCO_3 water type, however, some samples show a composition of Na-Cl and mixed Ca-Na-HCO_3-Cl waters. Groundwater samples from Pontina Plain are mostly characterized by Na-Cl and Ca-Cl type waters. Geochemical modeling and saturation index computation of the Lepini, Ausoni Aurunci springs and Pontina Plain wells shows an interaction with carbonate rocks. Most of the spring and well water samples were saturated with respect to calcite and dolomite, however all sampled waters were undersaturated with respect to gypsum and halite. The relationship between $\delta^{18}O$ and $\delta^{2}H$, for spring and well water samples, shows shifts of both the slope and the deuterium excess when compared to the world meteoric (WMWL) and central Italy meteoric (CIMWL) water lines. The deviation of data points from the meteoric lines can be attributed to evaporation both during the falling of the rain and by run-off on the ground surface before infiltration. Most springs and wells have a deuterium excess above 10 ‰ suggesting the precipitation in the groundwater comes from the Mediterranean sector. On the basis of local isotopic gradients, in combination with topographic and geologic criteria, four recharge areas were identified in the Aurunci Mountains. In Pontina Plain, the elevations of the recharging areas suggest that the Lepini carbonate aquifers are feeding them.

KEYWORDS
Carbonate Aquifers; Recharge Areas; Hydrogeochemical Modeling; Groundwater Flow; Stable Isotopes

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References

[1] D. Chapman, "Water Quality Assessment; A Guide to the Use of Biota, Sediments and Water in Environmental Monitoring," Chapman & Hall, University Press, Cambridge, 1992.

[2] S. S. D. Foster, A. R. Lawrence and B. L. Morris, "Gro- undwater in Urban Development: Assessing Management Needs and Formulating Policy Strategies," World Bank Technical Paper, Washington DC, 1997.

[3] I. D. Clark and P. Fritz, "Environmental Isotopes in Hydrogeology," CRC Press/Lewis Publishers, Boca Raton, 1997.

[4] P. G. Cook and A. L. Herczeg, "Environmental Tracers in Subsurface Hydrology," Kluwer Academic

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[5] P. Fritz and J. Ch. Fontes, "Handbook of Environmental Isotope Geochemistry," The Terrestrial Environment A, Elsevier, Amsterdam, Vol. 1, 1980.

[6] W. G. Mook, "Environmental Isotopes in the Hydrological Cycle," Principles and Applications, IHP-V, Technical Documents in Hydrology 1, Vol. IV, No. 39, UNESCO, Paris, 2000.

[7] J. L. Terwey, "Challenges in African Hydrology and Water Resources," Proceedings of the Harare Symposium, July 1984, IAHS Publication No. 144.

[8] H. Azzaz, M. Cherchali, M. Meddi, B. Houha, J. M. Puig and A. Achachi, "The Use of Environmental Isotopic and Hydrochemical Tracers to Characterize the Functioning of Karst Systems in the Tlemcen Moutains, Nor- thwest Algeria," Hydrogeology Journal, Vol. 16, No. 3, 2008, pp. 531-546. doi:10.1007/s10040-007-0235-4

[9] G. M. Zuppi and E. Sacchi, "Dynamic Processes in the Venice Region Outlined by Environmental Isotopes," In: P. Krumbergel, Eds., Isotopes in Environmental and Health Studies, Vol. 40, No. 1, 2004, pp. 35-44.

[10] W. C. Sidle, "Environmental Isotopes for Resolution of Hydrology Problems," Environmental Monitoring and Assessment, Vol. 52, No. 3, 1998, pp. 389-410. doi:10.1023/A:1005922029958

[11] L. Serva and F. Brunamonte, "Subsidence in the Pontina Plain, Italy," Bulletin of Engineering Geology and the Environment, Vol. 66, No. 2, 2007, pp. 125-134. doi:10.1007/s10064-006-0057-y

[12] R. Salvati and I. D. Sasowsky, "Development of Cover Collapse Sinkholes in Areas of Groundwater Discharge," Journal of Hydrology, Vol. 264, No. 1, 2002, pp. 1-11. doi:10.1016/S0022-1694(02) 00062-8

[13] C. Boni, P. Bono, G. Capelli, S. Lombardi and G. M. Zuppi, "Contributo all ' Idrogeologia dell ' Italia Centrale: Analisi Critica dei Metodi di Ricerca," Memorie Società, Geologica Italiana, Vol. 35, 1986, pp. 947-956.

[14] R. Casa, M. Rossi, G. Sappa and A. Trotta, "Assessing Crop Water Demand by Remote Sensing and GIS for the Pontina Plain, Central Italy," Water Resources Management, Vol. 23, No. 9, 2009, pp. 1685-1712. doi:10.1007/s11269-008-9347-4

[15] C. Boni, P. Bono and G. Capelli, "Schema Idrogeologico dell ' Italia Centrale," Memorie Società Geologica Italiana, Vol. 36, 1986, pp. 991-1012.

[16] M. Boccaletti, M. Coli and G. Napoleone, "Nuovi Line- amenti Strutturali da Immagini Landsat e Rapporti con l ' Attività Sismica Negli Appennini," Bollettino della Società Geologica Italiana, Vol. 96, 1977, pp. 679-694.

[17] C. Boni and P. Bono, "Carta Idrogeologica del Territorio della Regione Lazio—Scala 1:250.000," Regione Lazio, Assessorato alla Programmazione, Ufficio Parchi e Riserve, Università degli Studi di Roma "La Sapienza", Roma, 1988.

[18] C. Boni, "The Relationship between the Geology and Hydrology of the Latium-Abruzzi Apennines," In: M. Parotto and A. Praturlon, Eds., Geological Summary of the central Apennines, Quaderni de "La ricerca scientifica", Vol. 90, 1975, pp. 301-311.

[19] B. Accordi, A. Biasini, C. Caputo, G. Devoto, R. Fun- iciello, G. B. La Monica, E. Lupia Palmieri, R. Matteucci and U. Pieruccini, "Geologia e Dissesti del Territorio Montano della Regione Lazio," In: Carta della Montagna, Vol. 2, Monografia Regionali No. 12 Lazio, Ministero di Agricoltura, Roma, 1976, pp. 55-101.

[20] P. Celico, "Schema Idrogeologico dell ' Appennino Car- bonatico Centro-Meridionale," Memorie e Note dell ' Istituto di Geologia Applicata, Vol. 14, 1978, pp. 1-97.

[21] C. Kendall and T. B. Coplen, "Multisample Conversion of Water to Hydrogen by Zinc for Stable Isotope Determination," Analytical Chemistry, Vol. 57, 1985, pp. 1437- 1440. doi:10.1021/ac00284a058

[22] S. Epstein and T. Mayeda, "Variation of 18O Content of Water from Natural Sources," Geochimica et Cosmochimica Acta, Vol. 4, No. 5, 1953, pp. 213-224. doi:10.1016/0016-7037(53)90051-9

[23] H. Craig, "Isotopic Variation in Meteoric Water," Science, Vol. 133, No. 3465, 1961, pp. 1702-1703. doi:10.1126/science.133.3465.1702

[24] D. L. Parkhurst and C. A. J. Appello, "User's Guide to PHREEQC (Version 2)—A Computer Program for Speciation, Batch-Reaction, One-Dimensional Transport, and Inverse Geochemical Calculations," US Geological Survey Water-Resources Investigations, Report 99-4259, 1999.

[25] X. H. Wen, Y. Q. Wu and J. Wu, "Hydrochemical Characteristics of Groundwater in the Zhangye Basin, Northwestern China," Environmental Geology, Vol. 55, No. 8, 2008, pp. 1713-1724.

[26] A. M. Piper, "A Graphic Procedure in the Geochemical Interpretation of Water-Analyses," Transactions of the American Geophysical Union, Vol. 25, 1944, pp. 914- 923.

[27] B. F. Jones, A. Vengosh, E. Rosenthal and Y. Yechieli, "Geochemical Investigations," In: J. Bear, A. H. D. Cheng, S. Sorek, D. Ouazar and I. Herrera, Eds., Seawater Intrusion in Coastal Aquifers—Concepts, Methods and Practises, Kluwer Academic Publishers, Dordrecht, 1999, pp. 51-72.

[28] G. Ghiglieri, G. Oggiano, D. Fidelibus, G. Barbieri, A. Vernier and A. Tamiru, "Hydrogeology of the Nurra Region, Sardinia (Italy): Basement-Cover Influences on Groundwater Occurrence and Hydrogeochemistry," Hy- drogeology Journal, Vol. 17, No. 2, 2009, pp. 447-466. doi:10.1007/s10040-008-0369

[29] C. A. J. Appelo and D. Postma, "Geochemistry, Groundwater and Pollution," 2nd Edition, Balkema, Rotterdam, 2005, pp. 241-309. doi:10.1201/9781439833544.ch6

[30] W. Stumm and J. J. Morgan, "Chemical Equilibria and Rates in Natural Waters," John Wiley and Sons, New York, 1996.

[31] D. Langmuir, "Geochemistry of Some Carbonate Ground Waters in Central Pennsylvania," Geochimica et Cosmochimica Acta, Vol. 35, No. 10, 1971, pp. 1023-1045. doi:10.1016/0016-7037(71)90019-6

[32] I. J. Fairchild, A. Borsato, A. F. Tooth, S. Frisia, C. J. Hawkesworth, Y. M. Huang, F. McDermott and B. Spiro, "Controls on Trace Element (Sr-Mg) Compositions of Carbonate Cave Waters: Implications for Speleothem Climatic Records," Chemical Geology, Vol. 166, 2000, pp. 255-269. doi:10.1016/S0009-2541(99)00216-8

[33] W. B. White, "Geomorphology and Hydrology of Karst Terrains," Oxford University Press, New York, 1988.

[34] C. D. Palmer and J. A. Cherry, "Geochemical Evolution of Groundwater in Sequences of Sedimentary Rocks," Journal of Hydrology, Vol. 75, No. 2, 1984, pp. 27-65. doi:10.1016/0022-1694(84)90045-3

[35] J. S. Herman and W. B. White, "Dissolution Kinetics of Dolomite: Effects of Lithology and Fluid Flow Velocity," Geochimica et Cosmochimica Acta, Vol. 49, 1985, pp. 2017-2026. doi:10.1016/0016-7037(85)90060-2

[36] W. McLean, J. Jankowski and N. Lavitt, "Groundwater Quality and Sustainability in an Alluvial Aquifer, Australia," In: O. Sililom, et al., Eds., Groundwater past Achi- evements and Future Challenges, A Balkema, Rotterdam, 2000, pp. 567-573.

[37] M. Meybeck, "Global Chemical Weathering of Surficial Rocks Estimated from River Dissolved Loads," American Journal of Science, Vol. 287, 1987, pp. 401-428. doi:10.2475/ajs.287.5.401

[38] Y. Fakir, M. El Mernissi, T. Kreuser and B. Berjami, "Natural Tracer Approach to Characterize Groundwater in the Coastal Sahel of Oualidia (Morocco)," Environmental Geology, Vol. 43, 2002, pp. 197-202. doi:10.1007/s00254-002-0644-6

[39] D. C. Andreasen and W. B. Fleck, "Use of Bromide: Chloride Ratios to Differentiate Potential Sources of Chloride in a Shallow, Unconfined Aquifer Affected by Brackish-Water Intrusion," Hydrogeoly Journal, Vol. 5, No. 2, 1997, pp. 17-26. doi:10.1007/s100400050104

[40] E. Randolph McFarland and T. Scott Bruce, "Distribution, Origin, and Resource-Management Implications of Gro- und-Water Salinity along the Western Margin of the Chesapeake Bay Impact Structure in Eastern Virginia," Studies of the Chesapeake Bay Impact Structure—The USGS-NASA