John K Warren, Ph D, Technical Director SaltWork Consultants Pte Lte (ABN 068 889 127) Kingston Park, Adelaide, Australia 5049 (www.saltworkconsultants.com)

The professional career of Dr. Warren spans more than 30 years, of which a total of 20 years are in academia. Dr. Warren currently is Technical Director of Saltwork Consultants, Adelaide Australia and holds a Professorial position in the International Master Program in Petroleum Geoscience at Chulalongkorn University, Thailand, and. Previously he held the Shell Professorial Chair in Carbonate Studies at Sultan Qaboos University, Muscat, Sultanate of Oman. Before this, he was a faculty member in the Department of Petroleum Geosciences at Universiti Brunei (1998-2006) and Professor of Petroleum Geology at Curtin University, Perth, Western Australia (1993-1995). He specializes in Wireline Analysis, Carbonate and Evaporite Reservoir Systems, Production Geology and Reservoir Characterization.

Throughout his career he has worked as an industrial consultant dealing with diagenesis-related issues in reservoir and wireline studies as part of exploration programs conducted by ADNOC, ADCO, Asia-Pacific Potash, BHP Minerals, BHP Petroleum, Chevron, Esso-Mobil, Fortescue Metals, Homestake, Pasminco, PTTEP, Santos Indonesia, Santos Australia, Statoil-Hydro, Schlumberger, Saudi-Aramco, Shell International, Texaco, the World Bank, Geological Survey of The Northern Territory, Geological Survey of South Australia, Geological Survey of Australia and others. He has also served as a technical advisor for the AAPG, BBC, IHRDC, and New World Horizons.

He was chosen as the annual keynote speaker for PESA (Petroleum Exploration Society of Australia) and was the keynote speaker at the IAS meeting in Brazil in 2003, the keynote speaker in the SEPM conference in Aachen in 2004 and has recently ran industry-funded short courses in applied aspects of Carbonate and Evaporite Sedimentology at the Colorado School of Mines and in 2008, in Exxon Mobil Research in Houston, and in 2010-11 for Statoil-Hydro in Norway and PDO in Muscat, in 2014 for Nexen in Calgary, and will be running courses in Adelaide, India and Brazil in 2018. He is currently a retained consultant to PTTEP dealing with carbonate reservoir issues, as well as having recently been a consultant to Exxon Mobil and Statoil dealing with reservoir quality issues in the Middle East and the South Atlantic Salt Basins. He is currently a consultant to Santos Adelaide, looking at the Amadeus Basin, and to Fortescue Metals evaluating potash and lithium brine prospects in Australia and South America.

Dr. Warren has written four books in his area of expertise (evaporite and carbonate geosystems). The first edition of his most recent evaporite book (published by Springer, 2006) was chosen by the American University Association of University Librarians as one of the "Outstanding Academic Titles for 2006". His fourth book on the same subject area was published via Springer in late 2016. This is an updated and expanded version of the previous book and is now an all color edition that is more than 1800 pages in length.

He has contributed chapters on economic aspects of sedimentology in a number of other books and has published more than 60 scientific articles in major refereed journals including: American Association of Petroleum Geologists Bulletin, APEA Journal, Australian Journal of Earth Sciences, Journal of Sedimentary Petrology, Geochimica Cosmochimica Acta, Geotimes, PESA Journal, Sedimentary Geology and Sedimentology. His published and presented material has been chosen for special mentions by SEPM, AAPG, and PESA. He has received teaching awards from the University of Texas and Adelaide University. At various times in his career, he has been selected for guest lectureships to the oil Industry by Nordic Council of Ministers, by PESA, and the AAPG. He has worked extensively and successfully in various cultures including the Americas, Europe, the Middle East, Oceania and Southeast Asia.

Education

Ph.D. 1981 Flinders University, South Australia, School of Earth Sciences – Carbonate Sedimentology
B.Sc. Hon. 1st Class 1975 Flinders University, South Australia, School of Earth Sciences – Marine Geology
B.Sc. 1972 University of Adelaide - Majors in Geology and Palaeontology

Research Interests

Applied evaporite sedimentology

Evaporite sedimentology

Economic geology of evaporite geosystems

Potash and lithium resources in saline settings

Evaporite-related geohazards

Evaporites as source rocks

Use of image logs and seismic in defining reservoir quality in evaporite-sealed and halokinetic systems

Quaternary arid zone carbonates

Arabian Gulf coastlines, Australia and elsewhere Current projects in eastern Saudi Arabia and Australia

Carbonate reservoir characterization

Core-calibrated wireline studies of evaporite-plugged and leached/dolomitised carbonate reservoirs with a view to predicatively mapping and understanding porosity and permeability distributions with a prime focus in carbonate reservoirs in the Precambrian, Permian, Jurassic and Miocene petroleum systems of the Middle East

Core to wireline calibration of carbonates, especially dolomitised karst systems as in the Miocene gas reservoirs of Vietnam and Indonesia

Modern dolomite deposition in sabkhas of the Coorong and the Middle East Development of non-actualistic models for greenhouse platform carbonates Facies and porosity degradation in modern and ancient carbonate reefs

Training and Research Fields

Primary –Wireline Analysis, Carbonate and Evaporite Sedimentology, Petroleum Geology, Secondary – Presentation Skills for Business Professionals

Employment

August 2014-Present – Technical Director, Saltwork Consultants Pte Ltd, Adelaide, Australia (<u>www.saltworkconsultants.com</u>)

Aug 2009-Present – Full Professor in the International Master Program in Petroleum Geosciences at Chulalongkorn University, Bangkok Thailand (<u>www.cupetrogeoscience.com</u>)

2007-2008 - Shell Chair in Carbonate Studies, Oil and Gas Research Centre, Sultan Qaboos University, Sultanate of Oman

1998-2006 - Contracted Professor, Reservoir Studies, Department Petroleum Geoscience, University Brunei Darussalam, Bandar

1995-2009 - Executive Director, JK Resources Pty. Ltd., Adelaide, Australia.

1992-1995- Professor of Petroleum Geology, School of Applied Geology, Curtin University, Perth, Western Australia.

1989-1992 - Principal Petroleum Geologist, National Centre Petroleum Geology and Geophysics (NCPGG), University of Adelaide, Australia.

1982-1988 - Asst. Professor, Dept Geological Science, University Texas at Austin. USA

<u>Academic courses offered (</u>commercial course can be viewed on <u>www.saltwork</u>consultants.com)

Graduate – Wireline Analysis, Reservoir Sedimentology, Production Geology and Reservoir Characterization.

Undergraduate – In academic positions prior to current appointment he was involved in teaching aspects of undergraduate courses in Physical Geology, Historical Geology, Field Geology, Environmental Geology, Hydrogeology, Petroleum Geology, Carbonate Sedimentology, Clastic Sedimentology.

Thesis/Dissertation Supervision

Supervised a total of 74 M.Sc. theses and 8 Ph.D. dissertations.

Computer Literacy

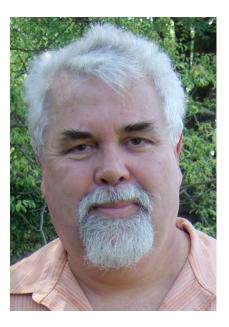
Operating systems – All geological software under Windows and OSX, as well as Unix familiarity

Research and teaching – WellCad, Interactive Petrophysyics, MapInfo, Petrel and various Geoframe geological and petrophysical packages

Interactive Petrophysics and WellCad are software packages forming the main training tools and research tools in wireline analysis in the postgraduate unit under Professor Warren's supervision at SQU

<u>Personal</u>

Australian citizen, Born 12th August, 1951 Married (17 January 1972), 2 adult children Excellent health



LIST OF PUBLICATIONS

Four books, numerous papers and abstracts in different national and international journals. The appended publication list does not include numerous technical reports prepared in his role as a consultant to the hydrocarbon and minerals industries.

Воокѕ

Warren, J. K., 2016, Evaporites: A compendium (ISBN 978-3-319-13511-3): Berlin, Springer, 1854 p.

Warren, J. K., 2006, Evaporites: Sediments, Resources and Hydrocarbons: Berlin, Springer, 1036 p.

Warren, J. K., 1999, Evaporites: Their evolution and economics, Blackwell Scientific, Oxford, UK, 438 p.

Warren, J. K., 1989, Evaporite Sedimentology: Importance in Hydrocarbon Accumulations. Prentice Hall Advanced Reference Series, Englewood Cliffs, 285 p.

CHAPTERS IN BOOKS

Warren, J., 2017, Evaporites, *in* W. M. White, ed., Encyclopedia of Geochemistry: A Comprehensive Reference Source on the Chemistry of the Earth: Cham, Springer International Publishing, p. 1-8.

Warren, J. K., 2017, Halide Minerals, in W. M. White, ed., Encyclopedia of Geochemistry, Springer International.

Warren, J. K., 2001, Evaporites: In, McGraw Hill Encyclopedia of Science and Technology, 9th Edition. New York

Warren J. K., 1994, Holocene Coorong Lakes, South Australia. In E. Gierlowski-Kordesch & K. Kelts (eds), Global Geological Record of Lake Basins, Cambridge University Press, p. 387-394.

Warren J. K., 1991, Sulphate-dominated sea marginal and platform evaporative settings: In, Melvin, J. (ed) Evaporites, Petroleum and Mineral Resources Elsevier Developments in Sedimentology No. 50, p. 69 - 187.

Kendall, G. C. St. C., and <u>Warren, J. K.</u>, 1989, Sabkha and subaqueous evaporites; A review; In; Evaporites and Hydrocarbons, B. C. Schreiber (ed) Columbia Univ. Press. 475 p.

ARTICLES IN REFEREED JOURNALS

Warren, J. K., 2017, Salt usually seals, but sometimes leaks: Implications for mine and cavern stabilities in the short and long term: Earth-Science Reviews, v. 165, p. 302-341.

Gindre-Chanu, L., <u>J. K. Warren</u>, C. Puigdefabregas, I. R. Sharp, D. C. P. Peacock, R. Swart, R. Poulsen, H. Ferreira, and L. Henrique, 2015, Diagenetic evolution of Aptian evaporites in the Namibe Basin (south-west Angola): Sedimentology, v. 62, p. 204-233.

Richards, L., R. C. King, A. S. Collins, M. Sayab, M. A. Khan, M. Haneef, C. K. Morley, and J. Warren, 2015, Macrostructures vs microstructures in evaporite detachments: An example from the Salt Range, Pakistan: Journal of Asia Earth Sciences, v. 113, p. 922-934.

Warren, J. K., 2014, Section 13.22 - Geochemistry of Evaporite Ores in an Earth-Scale Climatic and Tectonic Framework, in H. D. Holland, and K. K. Turekian, eds., Treatise on Geochemistry (Second Edition): Oxford, Elsevier, p. 569-593.

Warren, J. K., C. Morley, T. Charoentitirat, I. Cartwright, P. Ampaiwan, P. Khositchaisri, M. Mirzaloo, and J. Yingyuen, 2014, Structural and fluid evolution of Saraburi Group sedimentary carbonates, central Thailand: A tectonically driven fluid system: Marine and Petroleum Geology, v. 55, p. 100-121.

Morley, C. K., <u>J. K. Warren</u>, M. Tingay, P. Boonyasaknanon, and A. Julapour, 2014, Comparison of modern fluid distribution, pressure and flow in sediments associated with anticlines growing in deepwater (Brunei) and continental environments (Iran): Marine and Petroleum Geology, v. 51, p. 210-229.

Schofield, N., I. Alsop, <u>I. K. Warren</u>, J. R. Underhill, R. Lehné, W. Beer, and V. Lukas, 2014, Mobilizing salt: Magma-salt interactions: Geology. DOI 10.1130/G35406.1

Mansyur, M., J. K. Warren, I. Cartwright, and Y. L. Cheong, 2013, Dolomitisation and its relation to fracture porosity evolution: A case study in Permian Ratburi carbonate outcrop in the Sibumasu Domanin, Krabi, Southern Pensinsular Thailand: Proceedings of the 2013 IPA Annual Convention, 15-17 May, 2013, v. IPA13-G-016.

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Warren, J. K., 2011, Evaporitic source rocks: mesohaline responses to cycles of "famine or feast" in layered brines, Doug Shearman Memorial Volume, (Wiley-Blackwell) IAS Special Publication Number 43, p. 315-392.

Warren, J. K., A. Cheung, and I. Cartwright, 2011, Organic Geochemical, Isotopic and Seismic Indicators of Fluid Flow in Pressurized Growth Anticlines and Mud Volcanoes in Modern Deepwater Slope and Rise Sediments of Offshore Brunei Darussalam; Implications for hydrocarbon exploration in other mud and salt diapir provinces (Chapter 10), in L. J. Wood, ed., Shale Tectonics, v. 93: Tulsa OK, AAPG Memoir 93 (Proceedings of Hedberg Conference), p. 163-196.

Kukla, P., J. Urai, <u>J. K. Warren</u>, L. Reuning, S. Becker, J. Schoenherr, M. Mohr, H. van Gent, S. Abe, S. Li, Desbois, G. Zsolt Schléder, and M. de Keijzer, 2011, An Integrated, Multi-scale Approach to Salt Dynamics and Internal Dynamics of Salt Structures: AAPG Search and Discovery Article #40703 (2011).

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extensional intracontinental setting (Late Triassic of northwestern Germany): Geology, v. 35, p. 963-966.

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Warren, J. K., 1992, Oil in Carbonates: An Australian Perspective. PESA Journal v. 20, p. 48 - 57.

Cathro, D., <u>Warren, J. K.</u> and Williams, G. E., 1992, Halite saltern in the Canning Basin, Northwest Australia: A sedimentological analysis of drill core from the Ordovician-Silurian Mallowa Salt: Sedimentology, v 39 p. 983 - 1002.

Hussain, M. and <u>Warren, J. K.</u>, 1991, Source rock potential of shallow water evaporites: An investigation in Holocene-Pleistocene Salt Flat sabkha (playa), West Texas-New Mexico. Carbonates and Evaporites, v. 6, p. 217 - 223.

Warren, J. K., 1990a, Sedimentology and mineralogy of dolomitic Coorong Lakes, South Australia: Journal of Sedimentary Petrology, v. 60, p. 843 - 858.

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Gaughan, C. J. & <u>Warren, J. K.</u>, 1990, Lower Cambrian Relief Sandstone, Eastern Officer Basin, South Australia: An example of secondary porosity development: APEA Journal 1990, p. 184 - 194.

Rosen, M. R. and <u>Warren, J. K.</u>, 1990, The origin and significance of groundwater seepage gypsum from Bristol Dry Lake, California, USA: Sedimentology, v. 37, p. 983 -996.

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Elliott, L. A., and <u>Warren, J. K.</u>, 1989, Stratigraphy and depositional environment of Lower San Andres Formation in subsurface and equivalent outcrops: Chaves, Lincoln, and Roosevelt Counties, New Mexico: American Association of Petroleum Geologists Bulletin, v. 73, p. 1307 - 1325.

Hussain and <u>Warren, J. K.</u>, 1989, Dolomitization in a sulphate-rich environment: Modern example from Salt Flat Sabkha (dried playa lake) in West Texas-New Mexico: Carbonates and Evaporites, v. 3, p. 165 - 173.

Hussain M., and <u>Warren, J. K.</u>, 1989, Nodular and enterolithic gypsum: the "sabkha-tization" of Salt Flat playa, West Texas. Sedimentary Geology, 64, p. 13 - 24.

Parsley, M. J., and <u>Warren, J. K.</u>, 1989, Characterization of an Upper Guadalupian barrier-island complex from the Middle and Upper Tansill Formation (Permian), east Dark Canyon, New Mexico: In, Harris P. M. and Grover, G. A. (eds.), Subsurface and outcrop examination of the Capitan shelf Margin, Northern Delaware Basin, SEPM core workshop No. 13, 279-286.

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Hussain, M., Rohr, D. M., and <u>Warren, J. K.,</u> 1988, Depositional environments and facies in a Quaternary continental sabkha, west Texas: In Reid, S. T., Bass, R. O., and Welch, P. (eds) Guadalupe Mountains revisited, Texas and New Mexico, West Texas Geological Society Publ. 88-84, P. 177 - 185.

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