References

[1] Aarnes, J. E. 2004. On the use of a mixed multiscale finite element method for greater flexibility and increased speed or improved accuracy in reservoir simulation. *Multiscale Model. Simul.*, **2**(3), 421–439. doi:10.1137/030600655.

[2] Aarnes, J. E., Gimse, T., and Lie, K.-A. 2007b. An introduction to the numerics of flow in porous media using Matlab. In Hasle, G., Lie, K.-A., and Quak, E. (eds), *Geometrical Modeling, Numerical Simulation and Optimisation: Industrial Mathematics at SINTEF*. Berlin, Heidelberg, New York: Springer-Verlag, pp. 265–306.

[3] Aarnes, J. E., Hauge, V. L., and Efendiev, Y. 2007a. Coarsening of three-dimensional structured and unstructured grids for subsurface flow. *Adv. Water Resour.*, **30**(11), 2177–2193. doi:10.1016/j.advwatres.2007.04.007.

[4] Aarnes, J. E., Kippe, V., and Lie, K.-A. 2005. Mixed multiscale finite elements and streamline methods for reservoir simulation of large geomodels. *Adv. Water Resour.*, **28**(3), 257–271. doi:10.1016/j.advwatres.2004.10.007.

[5] Aarnes, J. E., Krogstad, S., and Lie, K.-A. 2006. A hierarchical multiscale method for two-phase flow based upon mixed finite elements and nonuniform coarse grids. *Multiscale Model. Simul.*, **5**(2), 337–363. doi:10.1137/050634566.

[6] Aarnes, J. E., Krogstad, S., and Lie, K.-A. 2008. Multiscale mixed/mimetic methods on corner-point grids. *Comput. Geosci.*, **12**(3), 297–315. doi:10.1007/s10596-007-9072-8.

[7] Aavatsmark, I. 2002. An introduction to multipoint flux approximations for quadrilateral grids. *Comput. Geosci.*, **6**, 405–432. doi:10.1023/A:1021291114475.

[8] Aavatsmark, I. 2007. Interpretation of a two-point flux stencil for skew parallelogram grids. *Comput. Geosci.*, **11**(3), 199–206. doi:10.1007/s10596-007-9042-1.

[9] Aavatsmark, I., Barkve, T., Bøe, Ø., and Mannseth, T. 1994. Discretization on non-orthogonal, curvilinear grids for multi-phase flow. In: *ECMOR IV – 4th European Conference on the Mathematics of Oil Recovery*. doi:0.3997/2214-4609.201411179.

[10] Aavatsmark, I., Eigestad, G. T., and Klausen, R. A. 2006. Numerical convergence of the MPFA O-method for general quadrilateral grids in two and three dimensions. In: Arnold, D. N., Bochev, P. B., Lehoucq, R. B., Nicolaides, R. A., and Shashkov, M. (eds), *Compatible Spatial Discretizations*. New York: Springer.

[11] Aavatsmark, I., Eigestad, G. T., Klausen, R. A., Wheeler, M. F., and Yotov, I. 2007. Convergence of a symmetric MPFA method on quadrilateral grids. *Comput. Geosci.*, **11**(4), 333–345. doi:10.1007/s10596-007-9056-8.

[12] Aavatsmark, I., Eigestad, G. T., Mallison, B. T., and Nordbotten, J. M. 2008. A compact multipoint flux approximation method with improved robustness. *Numer. Meth. Partial Diff. Eqs.*, **24**(5), 1329–1360. doi:10.1002/num.20320.

[13] Aavatsmark, I., and Klausen, R. 2003. Well index in reservoir simulation for slanted and slightly curved wells in 3D grids. *SPE J.*, **8**(01), 41–48. doi:10.2118/75275-PA.

[14] Abou-Kassem, J. H., Farouq-Ali, S. M., and Islam, M. R. 2006. *Petroleum Reservoir Simulations: A Basic Approach*. Houston: Gulf Publishing Company.

[15] AGMG. 2012. *Iterative solution with AGgregation-based algebraic MultiGrid*. http://agmg.eu. [Online; accessed July 11, 2018].

[16] Allen III, M. B., Behie, G. A., and Trangenstein, J. A. 1988. *Multiphase Flow in Porous Media: Mechanics, Mathematics, and Numerics*. New York: Springer-Verlag.

[17] Alpak, F. O., Pal, M., and Lie, K.-A. 2012. A multiscale method for modeling flow in stratigraphically complex reservoirs. *SPE J.*, **17**(4), 1056–1070. doi:10.2118/140403-PA.

[18] Alvestad, J., Holing, K., Christoffersen, K., and Stava, O. 1994. Interactive modelling of multiphase inflow performance of horizontal and highly deviated wells. In: *European Petroleum Computer Conference*. Society of Petroleum Engineers. doi:10.2118/27577-MS.

[19] Andersen, O. 2017. *Simplified models for numerical simulation of geological CO_2 storage*. PhD. thesis, University of Bergen. url: http://hdl.handle.net/1956/15477.

[20] Andersen, O., Gasda, S. E., and Nilsen, H. M. 2015. Vertically averaged equations with variable density for CO_2 flow in porous media. *Transp. Porous Media*, **107**(1), 95–127. doi:10.1007/s11242-014-0427-z.

[21] Andersen, O., Lie, K.-A., and Nilsen, H. M. 2016. An open-source toolchain for simulation and optimization of aquifer-wide CO2 storage. *Energy Procedia*, **86**(Jan.), 324–333. doi:10.1016/j.egypro.2016.01.033.

[22] Andersen, O., Nilsen, H. M., and Raynaud, X., 2017a. Coupled geomechanics and flow simulation on corner-point and polyhedral grids. In: *SPE Reservoir Simulation Conference*. doi:10.2118/182690-MS.

[23] Andersen, O., Nilsen, H. M., and Raynaud, X. 2017b. Virtual element method for geomechanical simulations of reservoir models. *Comput. Geosci.*, **21**(5–6), 877–893. doi:10.1007/s10596-017-9636-1.

[24] Appleyard, J. R., and Cheshire, I. M. 1983. Nested factorization. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/12264-MS.

[25] Arbogast, T., Cowsar, L. C., Wheeler, M. F., and Yotov, I. 2000. Mixed finite element methods on nonmatching multiblock grids. *SIAM J. Num. Anal.*, **37**(4), 1295–1315. doi:10.1137/S0036142996308447.

[26] Arbogast, T., Dawson, C. N., Keenan, P. T., Wheeler, M. F., and Yotov, I. 1998. Enhanced cell-centered finite differences for elliptic equations on general geometry. *SIAM J. Sci. Comp.*, **19**(2), 404–425. doi:10.1137/S1064827594264545.

[27] Ates, H., Bahar, A., El-Abd, S., et al. 2005. Ranking and upscaling of geostatistical reservoir models using streamline simulation: A field case study. *SPE Res. Eval. Eng.*, **8**(1), 22–32. doi:10.2118/81497-PA.

[28] Aziz, K., and Settari, A. 1979. *Petroleum Reservoir Simulation*. London, New York: Elsevier Applied Science Publishers.

[29] Baker, L. E. 1988. Three-phase relative permeability correlations. In: *SPE Enhanced Oil Recovery Symposium*. doi:10.2118/17369-MS.

[30] Bao, K., Lie, K.-A., Møyner, O., and Liu, M. 2017. Fully implicit simulation of polymer flooding with MRST. *Comput. Geosci.*, **21**(5–6), 1219–1244. doi:10.1007/s10596-017-9624-5.

[31] Barker, J., and Thibeau, S. 1997. A critical review of the use of pseudorelative permeabilities for upscaling. *SPE Reservoir Engineering*, **12**(2), 138–143. doi:10.2118/35491-PA.

[32] Batycky, R. P., Thieles, M. R., Baker, R. O., and Chugh, S. H. 2008. Revisiting reservoir flood-surveillance methods using streamlines. *SPE Res. Eval. Eng.*, **11**(2), 387–394. doi:10.2118/95402-PA.

[33] Baxendale, D., Rasmussen, A., Rustad, A. B., et al. 2018. *Open porous media: Flow documentation manual*. 2018-10 Rev-2 edn. http://opm-project.org.

[34] Bear, J. 1988. *Dynamics of Fluids in Porous Media*. Mineola, NY: Dover.

[35] Bear, J. 2007. *Hydraulics of Groundwater*. Mineola, NY: Dover.

[36] Bear, J., and Bachmat, Y. 1990. *Introduction to Modeling of Transport Phenomena in Porous Media*. Dordrecht: Springer.

[37] Begg, S. H., Carter, R. R., and Dranfield, P. 1989. Assigning effective values to simulator gridblock parameters for heterogeneous reservoirs. *SPE Res. Eng.*, **4**(4), 455–463. doi:10.2118/16754-PA.

[38] Beirão da Veiga, L., Brezzi, F., Cangiani, A., et al. 2013. Basic principles of virtual element methods. *Math. Mod. Meth. Appl. Sci.*, **23**(01), 199–214. doi:10.1142/S0218202512500492.

[39] Beirão da Veiga, L., Brezzi, F., Marini, L. D., and Russo, A. 2014. The hitchhiker's guide to the virtual element method. *Math. Mod. Meth. Appl. Sci.*, **24**(08), 1541–1573. doi:10.1142/S021820251440003X.

[40] Beirao da Veiga, L., Lipnikov, K., and Manzini, G. 2014. *The Mimetic Finite Difference Method for Elliptic Problems*. New York: Springer.

[41] Benesoussan, A., Lions, J.-L., and Papanicolaou, G. 1978. *Asymptotic Analysis for Periodic Structures*. Amsterdam: Elsevier Science Publishers.

[42] Berge, R. L. 2016. *Unstructured PEBI grids adapting to geological feautres in subsurface reservoirs*. M.Sc. thesis, Norwegian University of Science and Technology. http://hdl.handle.net/11250/2411565.

[43] Bischof, C. H., Bücker, H. M., Lang, B., Rasch, A., and Vehreschild, A. 2002. Combining source transformation and operator overloading techniques to compute derivatives for MATLAB programs. *Proceedings of the Second IEEE International Workshop on Source Code Analysis and Manipulation (SCAM 2002)*. Los Alamitos, CA, pp. 65–72 doi:10.1109/SCAM.2002.1134106.

[44] Blunt, M. J. 2017. *Multiphase Flow in Permeable Media: A Pore-Scale Perspective*. Cambridge: Cambridge University Press.

[45] Braess, D. 1997. *Finite Elements: Theory, Fast Solvers, and Applications in Solid Mechanics*. Cambridge: Cambridge University Press.

[46] Branets, L., Ghai, S. S., Lyons, S. L., and Wu, X.-H. 2009a. Efficient and accurate reservoir modeling using adaptive gridding with global scale up. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/118946-MS.

[47] Branets, L. V., Ghai, S. S., Lyons, S. L., and Wu, X.-H. 2009b. Challenges and technologies in reservoir modeling. *Commun. Comput. Phys.*, **6**(1), 1–23.

[48] Branets, L., Kubyak, V., Kartasheva, E., Shmyrov, L., and Kandybor, D. 2015. Capturing geologic complexity in simulation grid. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/173270-MS.

[49] Brenier, Y., and Jaffré, J. 1991. Upstream differencing for multiphase flow in reservoir simulation. *SIAM J. Numer. Anal.*, **28**(3), 685–696. doi:10.1137/0728036.

[50] Brenner, S. C., and Scott, L. R. 2007. *The Mathematical Theory of Finite Element Methods*. 3rd edn. New York: Springer-Verlag.

[51] Brewer, M., Camilleri, D., Ward, S., and Wong, T. 2015. Generation of hybrid grids for simulation of complex, unstructured reservoirs by a simulator with MPFA. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/173191-MS.

[52] Brezzi, F., Lipnikov, K., and Simoncini, V. 2005. A family of mimetic finite difference methods on polygonial and polyhedral meshes. *Math. Models Methods Appl. Sci.*, **15**, 1533–1553. doi:10.1142/S0218202505000832.

[53] Brezzi, F., and Fortin, M. 1991. *Mixed and Hybrid Finite Element Methods*. New York: Springer-Verlag.

[54] Brooks, R. H., and Corey, A. T. 1966. Properties of porous media affecting fluid flow. *J. Irrigation Drainage Div.*, **92**(2), 61–90.

[55] Buckingham, E. 1907. *Studies on the Movement of Soil Moisture*. Bulletin, no. 38. United States. Bureau of Soils. https://archive.org/details/studiesonmovemen38buck.

[56] Buckley, S. E., and Leverett, M. C. 1942. Mechanism of fluid displacement in sands. *Trans. AIME*, **146**(01), 107–116. doi:10.2118/942107-G.

[57] Caers, J. 2005. *Petroleum Geostatistics*. Richardson, TX: Society of Petroleum Engineers.

[58] Cao, H. 2002. *Development of techniques for general purpose simulators*. PhD. thesis, Stanford University.

[59] Castellini, A., Edwards, M. G., and Durlofsky, L. J. 2000. Flow based modules for grid generation in two and three dimensions. In: *ECMOR VII – 7th European Conference on the Mathematics of Oil Recovery*. doi:10.3997/2214-4609.201406120.

[60] Cayuga Research. *ADMAT*. www.cayugaresearch.com/admat.html. [Online; accessed Jul 11, 2018].

[61] Chavent, G., and Jaffré, J. 1982. *Mathematical Models and Finite Elements for Reservoir Simulation*. Amsterdam: North Holland.

[62] Chavent, G., and Jaffré, J. 1986. *Mathematical Models and Finite Elements for Reservoir Simulation: Single Phase, Multiphase and Multicomponent Flows through Porous Media*. Amsterdam: Elsevier.

[63] Chen, Y., and Durlofsky, L. J. 2006. Adaptive local-global upscaling for general flow scenarios in heterogeneous formations. *Transport Porous Media*, **62**, 157–182. doi:10.1007/s11242-005-0619-7.

[64] Chen, Y., Durlofsky, L. J., Gerritsen, M., and Wen, X. H. 2003. A coupled local-global upscaling approach for simulating flow in highly heterogeneous formations. *Adv. Water Resour.*, **26**(10), 1041–1060. doi:10.1016/S0309-1708(03)00101-5.

[65] Chen, Z. 2000. Formulations and numerical methods of the black oil model in porous media. *SIAM J. Numer. Anal.*, **38**(2), 489–514. doi:10.1137/S0036142999304263.

[66] Chen, Z. 2007. *Reservoir Simulation: Mathematical Techniques in Oil Recovery*. Philadelphia: Society for Industrial and Applied Mathematics.

[67] Chen, Z., and Ewing, R. E. 1997. Comparison of various formulations of three-phase flow in porous media. *J. Comput. Phys.*, **132**(2), 362–373. doi:10.1006/jcph.1996.5641.

[68] Chen, Z., and Hou, T. Y. 2003. A mixed multiscale finite element method for elliptic problems with oscillating coefficients. *Math. Comp.*, **72**, 541–576. doi:10.1090/S0025-5718-02-01441-2.

[69] Chen, Z., Huan, G., and Ma, Y. 2006. *Computational Methods for Multiphase Flows in Porous Media*. Philadelphia: Society of Industrial and Applied Mathematics. doi:10.1137/1.9780898718942.

[70] Christie, M. A. 1996. Upscaling for reservoir simulation. *J. Pet. Tech.*, **48**(11), 1004–1010. doi:10.2118/37324-MS.

[71] Christie, M. A., and Blunt, M. J. 2001. Tenth SPE comparative solution project: A comparison of upscaling techniques. *SPE Reservoir Eval. Eng.*, **4**, 308–317. doi:10.2118/72469-PA.

[72] Cirpka, O. A., Frind, E. O., and Helmig, R. 1999. Streamline-oriented grid generation for transport modelling in two-dimensional domains including wells. *Adv. Water Resour.*, **22**(7), 697–710. doi:10.1016/S0309-1708(98)00050-5.

[73] Coats, K. H. 2000. A note on IMPES and some IMPES-based simulation models. *SPE J.*, **05**(03), 245–251. doi:10.2118/65092-PA.

[74] Cordes, C., and Kinzelbach, W. 1992. Continous groundwater velocity fields and path lines in linear, bilinear, and trilinear finite elements. *Water Resour. Res.*, **28**(11), 2903–2911. doi:10.1029/92WR01686.

[75] Courant, R., Friedrichs, K., and Lewy, H. 1928. Über die partiellen Differenzengleichungen der mathematischen Physik. *Math. Ann.*, **100**(1), 32–74. doi:10.1007/BF01448839.

[76] Dafermos, C. M. 2010. *Hyperbolic Conservation Laws in Continuum Physics*. Berlin, Heidelberg: Springer.

[77] Darcy, H. P. G. 1856. *Les Fontaines Publiques de la Ville de Dijon*. Paris: Dalmont.

[78] Datta-Gupta, A., and King, M. J. 1995. A semianalytic approach to tracer flow modeling in heterogeneous permeable media. *Adv. Water Resour.*, **18**, 9–24. doi:10.1016/0309-1708(94)00021-V.

[79] Datta-Gupta, A., and King, M. J. 2007. *Streamline Simulation: Theory and Practice*. Richardson, TX: Society of Petroleum Engineers.

[80] DeBaun, D., et al. 2005. An extensible architecture for next generation scalable parallel reservoir simulation. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/93274-MS.

[81] Demidov, D. 2017 (Oct.). amgcl-sdd-scaling. https://zenodo.org/record/1002948#.XE_CAFxKiUk.

[82] Deutsch, C. V., and Journel, A. G. 1998. *GSLIB: Geostatistical Software Library and User's Guide*. 2nd edn. New York: Oxford University Press.

[83] Ding, X. Y., and Fung, L. S. K. 2015. An unstructured gridding method for simulating faulted reservoirs populated with complex wells. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/173243-MS.

[84] Dogru, A. H., Fung, L. S.-K., Middya, U., Al-Shaalan, T., and Pita, J. A. 2009. A next-generation parallel reservoir simulator for giant reservoirs. In: *SPE/EAGE Reservoir Characterization & Simulation Conference*. doi:10.2118/119272-MS.

[85] Dogru, A. H., Fung, L. S. K., Middya, U., et al. 2011. New frontiers in large scale reservoir simulation. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/142297-MS.

[86] Douglas Jr., J., Peaceman, D. W., and Rachford Jr., H. H. 1959. A method for calculating multi-dimensional immiscible displacement. *Petrol. Trans. AIME*, **216**, 297–308.

[87] Duarte, A. C. 2016. *Contributions to production optimization of oil reservoirs*. PhD. thesis, Norwegian University of Science and Technology. http://hdl.handle.net/11250/2383090.

[88] Duff, I. S. 2004. MA57–A code for the solution of sparse symmetric definite and indefinite systems. *ACM Trans. Math. Softw.*, **30**(2), 118–144. doi:10.1145/992200.992202.

[89] Duff, I. S., and Reid, J. K. 1983. The multifrontal solution of indefinite sparse symmetric linear. *ACM Trans. Math. Software*, **9**(3), 302–325. doi:10.1145/356044.356047.

[90] Durlofsky, L. J. 1991. Numerical calculations of equivalent gridblock permeability tensors for heterogeneous porous media. *Water Resour. Res.*, **27**(5), 699–708. doi:10.1029/91WR00107.

[91] Durlofsky, L. J. 2003. *Upscaling of Geocellular Models for Reservoir Flow Simulation: A Review of Recent Progress*. Presented at 7th International Forum on Reservoir Simulation Bühl/Baden-Baden, Germany, June 23–27, 2003.

[92] Durlofsky, L. J. 2005. *Upscaling and Gridding of Fine Scale Geological Models for Flow Simulation*. Presented at 8th International Forum on Reservoir Simulation Iles Borromees, Stresa, Italy, June 20–24, 2005.

[93] Durlofsky, L. J., Jones, R. C., and Milliken, W. J. 1997. A nonuniform coarsening approach for the scale-up of displacement processes in heterogeneous porous media. *Adv. Water Resour.*, **20**(5-6), 335–347. doi:10.1016/S0309-1708(96)00053-X.

[94] Edwards, M. G., and Rogers, C. F. 1994. A flux continuous scheme for the full tensor pressure equation. In: *ECMOR IV – 4th European Conference on the Mathematics of Oil Recovery*. doi:10.3997/2214-4609.201411178.

[95] Efendiev, Y., and Hou, T. Y. 2009. *Multiscale Finite Element Methods: Theory and Applications*. New York: Springer-Verlag.

[96] Eigestad, G. T., and Klausen, R. A. 2005. On the convergence of the multi-point flux approximation o-method: Numerical experiments for discontinuous permeability. *Num. Meth. Partial Diff. Eqs.*, **21**(6), 1079–1098. doi:10.1002/num.20079.

[97] Eigestad, G., Dahle, H., Hellevang, B., Riis, F., Johansen, W., and Øian, E. 2009. Geological modeling and simulation of CO2 injection in the Johansen formation. *Comput. Geosci.*, **13**(4), 435–450. doi:10.1007/s10596-009-9153-y.

[98] Eikemo, B., Lie, K.-A., Dahle, H. K., and Eigestad, G. T. 2009. Discontinuous Galerkin methods for transport in advective transport in single-continuum models of fractured media. *Adv. Water Resour.*, **32**(4), 493–506. doi:10.1016/j.advwatres.2008.12.010.

[99] Ertekin, T., Abou-Kassem, J. H., and King, G. R. 2001. *Basic Applied Reservoir Simulation*. Richardson, TX: Society of Petroleum Engineers.

[100] Evazi, M., and Mahani, H. 2010a. Generation of Voronoi grid based on vorticity for coarse-scale modeling of flow in heterogeneous formations. *Transp. Porous Media*, **83**(3). doi:10.1007/s11242-009-9458-2.

[101] Evazi, M., and Mahani, H. 2010b. Unstructured-coarse-grid generation using background-grid approach. *SPE J.*, **15**(2), 326–340. doi:10.2118/120170-PA.

[102] Ewing, R. E., Lazarov, R. D., Lyons, S. L., Papavassiliou, D. V., Pasciak, J., and Qin, G. 1999. Numerical well model for non-Darcy flow through isotropic porous media. *Comput. Geosci.*, **3**(3-4), 185–204. doi:10.1023/A:1011543412675.

[103] Eymard, R., Gallouët, T., and Herbin, R. 1999. Convergence of finite volume schemes for semilinear convection diffusion equations. *Numer. Math.*, **82**(1), 91–116. doi:10.1007/s002110050412.

[104] Eymard, R., Gallouët, T., and Herbin, R. 2001. Finite volume approximation of elliptic problems and convergence of an approximate gradient. *App. Numer. Math.*, **37**(1-2), 31–53. doi:10.1016/S0168-9274(00)00024-6.

[105] Eymard, R., Guichard, C., and Herbin, R. 2012a. Small-stencil 3D schemes for diffusive flows in porous media. *ESAIM: Math. Model. Numer. Anal.*, **46**(2), 265–290. doi:10.1051/m2an/2011040.

[106] Eymard, R., Guichard, C., Herbin, R., and Masson, R. 2012b. Vertex-centred discretization of multiphase compositional Darcy flows on general meshes. *Comput. Geosci.*, **16**(4), 987–1005. doi:10.1007/s10596-012-9299-x.

[107] Fanchi, J. R. 2005. *Principles of Applied Reservoir Simulation*. Houston, TX: Gulf Professional Publishing.

[108] Farmer, C. L. 2002. Upscaling: A review. *Int. J. Numer. Meth. Fluids*, **40**(1–2), 63–78. doi:10.1002/fld.267.

[109] Fayers, F. J., and Matthews, J. D. 1984. Evaluation of normalized Stone's methods for estimating three-phase relative permeabilities. *SPE J.*, **24**(2), 224–232. doi:10.2118/11277-PA.

[110] Fink, M. 2007. *Automatic Differentiation for Matlab*. MATLAB Central. https://tinyurl.com/ycvp6n8a. [Online; accessed July 11, 2018].

[111] Floris, F. J. T., Bush, M. D., Cuypers, M., Roggero, F., and Syversveen, A. R. 2001. Methods for quantifying the uncertainty of production forecasts: a comparative study. *Petroleum Geoscience*, **7**(S), S87–S96. doi:10.1144/petgeo.7.S.S87.

[112] Forth, S. A. 2006. An efficient overloaded implementation of forward mode automatic differentiation in MATLAB. *ACM Trans. Math. Software*, **32**(2), 195–222. doi:10.1145/1141885.1141888.

[113] Fung, L. S. K., Ding, X. Y., and Dogru, A. H. 2014. Unconstrained Voronoi grids for densely spaced complex wells in full-field reservoir simulation. *SPE J.*, **19**(5), 803–815. doi:10.2118/163648-PA.

[114] Gain, A. L., Talischi, C., and Paulino, G. H. 2014. On the virtual element method for three-dimensional linear elasticity problems on arbitrary polyhedral meshes. *Comput. Meth. App. Mech. Engng.*, **282**, 132–160. doi:10.1016/j.cma.2014.05.005.

[115] Gao, M. 2014. *Reservoir and Surface Facilities Coupled through Partially and Fully Implicit Approaches*. M.Sc. thesis, Texas A & M University. http://hdl.handle.net/1969.1/154076.

[116] Garcia, M. H., Journel, A. G., and Aziz, K. 1992. Automatic grid generation for modeling reservoir heterogeneities. *SPE Reservoir Eng.*, **7**(6), 278–284. doi:10.2118/21471-PA.

[117] Gerritsen, M., and Lambers, J. V. 2008. Integration of local-global upscaling and grid adaptivity for simulation of subsurface flow in heterogeneous formations. *Comput. Geosci.*, **12**(2), 193–208. doi:10.1007/s10596-007-9078-2.

[118] Godunov, S. K. 1959. A difference method for numerical calculation of discontinuous solutions of the equations of hydrodynamics. *Mat. Sb. (N.S.)*, **47 (89)**, 271–306.

[119] Gries, S., Stüben, K., Brown, G. L., Chen, D., and Collins, D. A. 2014. Preconditioning for efficiently applying algebraic multigrid in fully implicit reservoir simulations. *SPE J.*, **19**(04), 726–736. doi:10.2118/163608-PA.

[120] Guérillot, D., Rudkiewicz, J. L., Ravenne, C., Renard, D., and Galli, A. 1990. An integrated model for computer aided reservoir description: From outcrop study to fluid flow simulations. *Oil Gas Sci. Technol.*, **45**(1), 71–77. doi:10.2516/ogst:1990005.

[121] Gunasekera, D., Cox, J., and Lindsey, P. 1997. The generation and application of K-orthogonal grid systems. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/37998-MS.

[122] Hægland, H., Dahle, H. K., Lie, K.-A., and Eigestad, G. T. 2006. Adaptive streamline tracing for streamline simulation on irregular grids. In: Binning, P. J., Engesgaard, P. K., Dahle, H. K., Pinder, G. F., and Gray, W. G. (eds), *XVI International Conference on Computational Methods in Water Resources*. http://proceedings.cmwr-xvi.org/.

[123] Hales, H. B. 1996. A method for creating 2-d orthogonal grids which conform to irregular shapes. *SPE J*, **1**(2), 115–124. doi:10.2118/35273-PA.

[124] Hauge, V. L. 2010. *Multiscale methods and flow-based gridding for flow and transport in porous media*. PhD. thesis, Norwegian University of Science and Technology. http://hdl.handle.net/11250/258800.

[125] Hauge, V. L., Lie, K.-A., and Natvig, J. R. 2012. Flow-based coarsening for multiscale simulation of transport in porous media. *Comput. Geosci.*, **16**(2), 391–408. doi:10.1007/s10596-011-9230-x.

[126] He, C., and Durlofsky, L. J. 2006. Structured flow-based gridding and upscaling for modeling subsurface flow. *Adv. Water Resour.*, **29**(12), 1876–1892. doi:10.1016/j.advwatres.2005.12.012.

[127] He, Z., Parikh, H., Datta-Gupta, A., Perez, J., and Pham, T. 2004. Identifying reservoir compartmentalization and flow barriers from primary production using streamline diffusive time of flight. *SPE J.*, **7**(3), 238–247. doi:10.2118/88802-PA.

[128] Heinemann, Z. E., Brand, C. W., and Munka, M. 1991. Modeling reservoir geometry with irregular grids. *SPE Res. Eng.*, **6**(2), 225–232. doi:10.2118/18412-PA.

[129] Helmig, R. 1997. *Multiphase Flow and Transport Processes in the Subsurface: A Contribution to the Modeling of Hydrosystems*. Berlin, Heidelberg: Springer.

[130] Hilden, S. T., Møyner, O., Lie, K.-A., and Bao, K. 2016. Multiscale simulation of polymer flooding with shear effects. *Transp. Porous Media*, **113**(1), 111–135. doi:10.1007/s11242-016-0682-2.

[131] Hilden, S. T. 2016. *Upscaling of water-flooding scenarios and modeling of polymer flow*. PhD. thesis, Norwegian University of Science and Technology. http://hdl.handle.net/11250/2388331.

[132] Hilden, S. T., Lie, K.-A., and Raynaud, X. 2014. Steady state upscaling of polymer flooding. In: *ECMOR XIV – 14th European Conference on the Mathematics of Oil Recovery*. doi:10.3997/2214-4609.20141802.

[133] Holden, L., and Nielsen, B. F. 2000. Global upscaling of permeability in heterogeneous reservoirs; the output least squares (OLS) method. *Trans. Porous Media*, **40**(2), 115–143. doi:10.1023/A:1006657515753.

[134] Holden, H., and Risebro, N. H. 2002. *Front Tracking for Hyperbolic Conservation Laws*. New York: Springer-Verlag.

[135] Hornung, U. 1997. *Homogenization and Porous Media*. New York: Springer-Verlag.

[136] Hoteit, H., and Firoozabadi, A. 2008. Numerical modeling of two-phase flow in heterogeneous permeable media with different capillarity pressures. *Adv. Water Resour.*, **31**(1), 56–73. doi:10.1016/j.advwatres.2007.06.006.

[137] Hubbert, M. K. 1956. Darcy's law and the field equations of the flow of underground fluids. *Petrol. Trans., AIME*, **207**, 22–239.

[138] Hui, M.-H. R., Karimi-Fard, M., Mallison, B., and Durlofsky, L. J. 2018. A general modeling framework for simulating complex recovery processes in fractured reservoirs at different resolutions. *SPE J.*, **22**(1), 20–29. doi:10.2118/182621-MS.

[139] Huseby, O., Sagen, J., and Dugstad, Ø. 2012. Single well chemical tracer tests – Fast and accurate simulations. In: *SPE EOR Conference at Oil and Gas West Asia*. doi:10.2118/155608-MS.

[140] Idrobo, E. A., Choudhary, M. K., and Datta-Gupta, A. 2000. Swept volume calculations and ranking of geostatistical reservoir models using streamline simulation. In: *SPE/AAPG Western Regional Meeting*. doi:10.2118/62557-MS.

[141] Iemcholvilert, S. 2013. *A Research on production optimization of coupled surface and subsurface model*. M.Sc. thesis, Texas A & M University. http://hdl.handle.net/1969.1/151189.

[142] Islam, M. R., Hossain, M. E., Moussavizadegan, S. H., Mustafiz, S., and Abou-Kassem, J. H. 2016. *Advanced Petroleum Reservoir Simulation: Towards Developing Reservoir Emulators*. John Wiley & Sons, Inc. doi:10.1002/9781119038573.

[143] Islam, M. R., Mousavizadegan, S. H., Mustafiz, S., and Abou-Kassem, J. H. 2010. *Advanced Petroleum Reservoir Simulations*. Hoboken, NJ: John Wiley & Sons, Inc.

[144] Izgec, O., Sayarpour, M., and Shook, G. M. 2011. Maximizing volumetric sweep efficiency in waterfloods with hydrocarbon f-ϕ curves. *J. Petrol. Sci. Eng.*, **78**(1), 54–64. doi:10.1016/j.petrol.2011.05.003.

[145] Jansen, J. D. 2017. *Nodal Analysis of Oil and Gas Wells-System Modeling and Numerical Implementation*. Richardson, TX: Society of Petroleum Engineers.

[146] Jenny, P., Lee, S. H., and Tchelepi, H. A. 2003. Multi-scale finite-volume method for elliptic problems in subsurface flow simulation. *J. Comput. Phys.*, **187**, 47–67. doi:10.1016/S0021-9991(03)00075-5.

[147] Jenny, P., Tchelepi, H. A., and Lee, S. H. 2009. Unconditionally convergent nonlinear solver for hyperbolic conservation laws with S-shaped flux functions. *J. Comput. Phys.*, **228**(20), 7497–7512. doi:10.1016/j.jcp.2009.06.032.

[148] Jenny, P., Wolfsteiner, C., Lee, S. H., and Durlofsky, L. J. 2002. Modeling flow in geometrically complex reservoirs using hexahedral multiblock grids. *SPE J.*, **7**(2). doi:10.2118/78673-PA.

[149] Jikov, V. V., Kozlov, S. M., and Oleinik, O. A. 1994. *Homogenization of Differential Operators and Integral Functionals*. New York: Springer-Verlag.

[150] Jimenez, E., Sabir, K., Datta-Gupta, A., and King, M. J. 2007. Spatial error and convergence in streamline simulation. *SPE J.*, **10**(3), 221–232. doi:10.2118/92873-MS.

[151] Journel, A. G., Deutsch, C. V., and Desbarats, A. J. 1986. Power averaging for block effective permeability. In: *SPE California Regional Meeting*. doi:10.2118/15128-MS.

[152] Karimi-Fard, M., and Durlofsky, L. J. 2012. Accurate resolution of near-well effects in upscaled models using flow-based unstructured local grid refinement. *SPE J.*, **17**(4), 1084–1095. doi:10.2118/141675-PA.

[153] Karimi-Fard, M., and Durlofsky, L. J. 2016. A general gridding, discretization, and coarsening methodology for modeling flow in porous formations with discrete geological features. *Adv. Water Resour.*, **96**(Supplement C), 354–372. doi:10.1016/j.advwatres.2016.07.019.

[154] Karypis, G., and Kumar, V. 1998. A fast and high quality multilevel scheme for partitioning irregular graphs. *SIAM J. Sci. Comp.*, **20**(1), 359–392. doi:10.1137/S1064827595287997.

[155] Keilegavlen, E., Kozdon, J. E., and Mallison, B. T. 2012. Multidimensional upstream weighting for multiphase transport on general grids. *Comput. Geosci.*, **16**, 1021–1042. doi:10.1007/s10596-012-9301-7.

[156] Keilegavlen, E., and Nordbotten, J. M. 2017. Finite volume methods for elasticity with weak symmetry. *Int. J. Numer. Meth. Eng.*, **112**(8), 939–962. doi:10.1002/nme.5538.

[157] Keilegavlen, E., Nordbotten, J. M., and Aavatsmark, I. 2009. Sufficient criteria are necessary for monotone control volume methods. *Appl. Math. Letters*, **22**(8), 1178–1180. doi:10.1016/j.aml.2009.01.048.

[158] Kenyon, D. 1987. Third SPE comparative solution project: Gas cycling of retrograde condensate reservoirs. *J. Petrol. Tech.*, **39**(08), 981–997. doi:10.2118/12278-PA.

[159] Killough, J. E. 1995. Ninth SPE comparative solution project: A reexamination of black-oil simulation. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/29110-MS.

[160] King, M. J. 2007. Recent advances in upgridding. *Oil Gas Sci. Technol. – Rev. IFP*, **62**(2), 195–205. doi:10.2516/ogst:2007017.

[161] King, M. J., and Mansfield, M. 1999. Flow simulation of geologic models. *SPE Res. Eval. Eng.*, **2**(4), 351–367. doi:10.2118/57469-PA.

[162] King, M. J., Burn, K. S., Muralidharan, P. W. V., et al. 2006. Optimal coarsening of 3D reservoir models for flow simulation. *SPE Reserv. Eval. Eng.*, **9**(4), 317–334. doi:10.2118/95759-PA.

[163] King, M. J., MacDonald, D. G., Todd, S. P., and Leung, H. 1998. Application of novel upscaling approaches to the Magnus and Andrew reservoirs. In: *European Petroleum Conference*. doi:10.2118/50643-MS.

[164] King, M. J., and Datta-Gupta, A. 1998. Streamline simulation: A current perspective. *In Situ*, **22**(1), 91–140.

[165] Kippe, V., Aarnes, J. E., and Lie, K.-A. 2008. A comparison of multiscale methods for elliptic problems in porous media flow. *Comput. Geosci.*, **12**(3), 377–398. doi:10.1007/s10596-007-9074-6.

[166] Klausen, R. A., Rasmussen, A. F., and Stephansen, A. 2012. Velocity interpolation and streamline tracing on irregular geometries. *Comput. Geosci.*, **16**, 261–276. doi:10.1007/s10596-011-9256-0.

[167] Klausen, R. A., and Winther, R. 2006. Robust convergence of multi point flux approximation on rough grids. *Numer. Math.*, **104**(3), 317–337. doi:10.1007/s00211-006-0023-4.

[168] Klemetsdal, Ø. S. 2016. *The virtual element method as a common framework for finite element and finite difference methods – numerical and theoretical analysis*. M.Sc. thesis, Norwegian University of Science and Technology. http://hdl.handle.net/11250/2405996.

[169] Klemetsdal, Ø. S., Berge, R. L., Lie, K.-A., Nilsen, H. M., and Møyner, O. 2017. Unstructured gridding and consistent discretizations for reservoirs with faults and complex wells. In: *SPE Reservoir Simulation Conference*. doi:10.2118/182679-MS.

[170] Krogstad, S., Lie, K.-A., Møyner, O., Nilsen, H. M., Raynaud, X., and Skaflestad, B. 2015. MRST-AD – An open-source framework for rapid prototyping and evaluation of reservoir simulation problems. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/173317-MS.

[171] Krogstad, S., Lie, K.-A., Nilsen, H. M., Berg, C. F., and Kippe, V. 2017. Efficient flow diagnostics proxies for polymer flooding. *Comput. Geosci.*, **21**(5-6), 1203–1218. doi:10.1007/s10596-017-9681-9.

[172] Krogstad, S., Raynaud, X., and Nilsen, H. M. 2016. Reservoir management optimization using well-specific upscaling and control switching. *Comput. Geosci.*, **20**(3), 695–706. doi:10.1007/s10596-015-9497-4.

[173] Kružkov, S. N. 1970. First order quasilinear equations in several independent variables. *Mathematics of the USSR-Sbornik*, **10**(2), 217. doi:10.1070/SM1970v010n02ABEH002156.

[174] Kurganov, A., Noelle, S., and Petrova, G. 2001. Semidiscrete central-upwind schemes for hyperbolic conservation laws and Hamilton–Jacobi equations. *SIAM J. Sci. Comp.*, **23**(3), 707–740. doi:10.1137/S1064827500373413.

[175] Kwok, F., and Tchelepi, H. 2007. Potential-based reduced Newton algorithm for nonlinear multiphase flow in porous media. *J. Comput. Phys.*, **227**(1), 706–727. doi:10.1016/j.jcp.2007.08.012.

[176] Lake, L. W. 1989. *Enhanced Oil Recovery*. Upper Saddle River, NJ: Prentice-Hall.

[177] Lake, L. W. (ed). 2007. *Petroleum Engineering Handbook*. Richardson, TX: Society of Petroleum Engineers.

[178] Lax, P., and Wendroff, B. 1960. Systems of conservation laws. *Comm. Pure Appl. Math.*, **13**(2), 217–237. doi:10.1002/cpa.3160130205.

[179] Le Potier, C. 2009. A nonlinear finite volume scheme satisfying maximum and minimum principles for diffusion operators. *Int. J. Finite Vol.*, **6**(2), 1–20.

[180] Lee, S. H., Jenny, P., and Tchelepi, H. A. 2002. A finite-volume method with hexahedral multiblock grids for modeling flow in porous media. *Comput. Geosci.*, **6**(3-4), 353–379. doi:10.1023/A:1021287013566.

[181] Leeuwenburgh, O., and Arts, R. 2014. Distance parameterization for efficient seismic history matching with the ensemble Kalman Filter. *Comput. Geosci.*, **18**(3–4), 535–548. doi:10.1007/s10596-014-9434-y.

[182] Leeuwenburgh, O., Peters, E., and Wilschut, F. 2011. Towards an integrated workflow for structural reservoir model updating and history matching. In: *SPE EUROPEC/EAGE Annual Conference and Exhibition*. doi:10.2118/143576-MS.

[183] LeVeque, R. J. 2002. *Finite Volume Methods for Hyperbolic Problems*. Cambridge: Cambridge University Press.

[184] Leverett, M. C. 1941. Capillary behavior in porous solids. *Trans. AIME*, **142**, 159–172. doi:10.2118/941152-G.

[185] Li, X., and Zhang, D. 2014. A backward automatic differentiation framework for reservoir simulation. *Comput. Geosci.*, **18**(6), 1009–1022. doi:10.1007/s10596-014-9441-z.

[186] Lie, K.-A. 2018. On Holden's seven guidelines for scientific computing and development of open-source community software. In: Gesztesy, F., et al. (eds), *Non-Linear Partial Differential Equations, Mathematical Physics, and Stochastic Analysis: The Helge Holden Anniversary Volume*. European Mathematical Society Publishing House. pp. 389–422.

[187] Lie, K.-A., Kedia, K., Skaflestad, B., et al. 2017a. A general non-uniform coarsening and upscaling framework for reduced-order modeling. In: *SPE Reservoir Simulation Conference*. doi:10.2118/182681-MS.

[188] Lie, K.-A. 2015a. *JOLT 1: Introduction to MRST*. SINTEF ICT / ICME, Stanford University. www.sintef.no/mrst-jolts.

[189] Lie, K.-A. 2015b. *JOLT 2: Grids and petrophysical data*. SINTEF ICT / ICME, Stanford University. www.sintef.no/mrst-jolts.

[190] Lie, K.-A., Mykkeltvedt, T. S., and Møyner, O. 2018. Fully implicit WENO schemes on stratigraphic and fully unstructured grids. In: *ECMOR XVI – 16th European Conference on the Mathematics of Oil Recovery*.

[191] Lie, K.-A., Møyner, O., and Natvig, J. R. 2017a. Use of multiple multiscale operators to accelerate simulation of complex geomodels. *SPE J.*, **22**(6), 1929–1945. doi:10.2118/182701-PA.

[192] Lie, K.-A., Krogstad, S., Ligaarden, I. S., et al. 2012b. Open-source MATLAB implementation of consistent discretisations on complex grids. *Comput. Geosci.*, **16**, 297–322. doi:10.1007/s10596-011-9244-4.

[193] Lie, K.-A., Nilsen, H. M., Andersen, O., and Møyner, O. 2016. A simulation workflow for large-scale CO_2 storage in the Norwegian North Sea. *Comput. Geosci.*, **20**(3), 607–622. doi:10.1007/s10596-015-9487-6.

[194] Lie, K.-A., Natvig, J. R., Krogstad, S., Yang, Y., and Wu, X.-H. 2014. Grid adaptation for the Dirichlet–Neumann representation method and the multiscale mixed finite-element method. *Comput. Geosci.*, **18**(3), 357–372. doi:10.1007/s10596-013-9397-4.

[195] Lie, K.-A., Møyner, O., Natvig, J. R., et al. 2017b. Successful application of multiscale methods in a real reservoir simulator environment. *Comput. Geosci.*, **21**(5-6), 981–998. doi:10.1007/s10596-017-9627-2.

[196] Lie, K.-A., Natvig, J. R., and Nilsen, H. M. 2012a. Discussion of dynamics and operator splitting techniques for two-phase flow with gravity. *Int. J. Numer. Anal. Mod.*, **9**(3), 684–700.

[197] Ligaarden, I. S. 2008. *Well models for mimetic finite difference methods and improved representation of wells in multiscale methods*. M.Sc. thesis, University of Oslo. http://urn.nb.no/URN:NBN:no-19435.

[198] Lipnikov, K., Shashkov, M., Svyatskiy, D., and Vassilevski, Y. 2007. Monotone finite volume schemes for diffusion equations on unstructured triangular and shape-regular polygonal meshes. *J. Comput. Phys.*, **227**(1), 492–512. doi:10.1016/j.jcp.2007.08.008.

[199] Lipnikov, K., Shashkov, M., and Yotov, I. 2009. Local flux mimetic finite difference methods. *Numer. Math.*, **112**(1), 115–152. doi:10.1007/s00211-008-0203-5.

[200] Lunati, I., and Lee, S. H. 2009. An operator formulation of the multiscale finite-volume method with correction function. *Multiscale Model. Simul.*, **8**(1), 96–109. doi:10.1137/080742117.

[201] Mahani, H., Muggeridge, A. H., and Ashjari, M. A. 2009. Vorticity as a measure of heterogeneity for improving coarse grid generation. *Petrol. Geosci.*, **15**(1), 91–102. doi:10.1144/1354-079309-802.

[202] Mallison, B., Sword, C., Viard, T., Milliken, W., and Cheng, A. 2014. Unstructured cut-cell grids for modeling complex reservoirs. *SPE J.*, **19**(2), 340–352. doi:10.2118/163642-PA.

[203] Manzocchi, T., et al. 2008. Sensitivity of the impact of geological uncertainty on production from faulted and unfaulted shallow-marine oil reservoirs: Objectives and methods. *Petrol. Geosci.*, **14**(1), 3–15. doi:10.1144/1354-079307-790.

[204] Matringe, S. F., and Gerritsen, M. G. 2004. On accurate tracing of streamlines. In: *SPE Annual Technical Conference and Exhibition*. doi:10.2118/89920-MS.

[205] Matringe, S. F., Juanes, R., and Tchelepi, H. A. 2007. Streamline tracing on general triangular or quadrilateral grids. *SPE J.*, **12**(2), 217–233. doi:10.2118/96411-MS.

[206] Mattax, C. C., and Dalton, R. L. (eds). 1990. *Reservoir Simulation*. Society of Petroleum Engineers.

[207] McCain, Jr., W. D. 1990. *The Properties of Petroleum Fluids*. 2nd edn. Tulsa, OK: PennWell Books.

[208] McIlhagga, W. 2010. *Automatic Differentiation with Matlab Objects*. MATLAB Central. https://tinyurl.com/yavlcra4. [Online; accessed July 11, 2018].

[209] Merland, R., Caumon, G., Lévy, B., and Collon-Drouaillet, P. 2014. Voronoi grids conforming to 3d structural features. *Comput. Geosci.*, **18**(3-4), 373–383. doi:10.1007/s10596-014-9408-0.

[210] Mlacnik, M. J., Durlofsky, L. J., and Heinemann, Z. E. 2006. Sequentially adapted flow-based PEBI grids for reservoir simulation. *SPE J.*, **11**(3), 317–327. doi:10.2118/90009-PA.

[211] Møyner, O. 2012. *Multiscale finite-volume methods on unstructured grids*. M.Sc. thesis, Norwegian University of Science and Technology. http://hdl.handle.net/11250/259015.

[212] Møyner, O. 2016. *Next generation multiscale methods for reservoir simulation*. PhD. thesis, Norwegian University of Science and Technology. http://hdl.handle.net/11250/2431831.

[213] Møyner, O. 2017. Nonlinear solver for three-phase transport problems based on approximate trust regions. *Comput. Geosci.*, **21**(5-6), 999–1021. doi:10.1007/s10596-017-9660-1.

[214] Møyner, O., and Lie, K.-A. 2014. The multiscale finite-volume method on stratigraphic grids. *SPE J.*, **19**(5), 816–831. doi:10.2118/163649-PA.

[215] Møyner, O., and Lie, K.-A. 2016a. A multiscale restriction-smoothed basis method for compressible black-oil models. *SPE J.*, **21**(06), 2079–2096. doi:10.2118/173265-PA.

[216] Møyner, O., and Lie, K.-A. 2016b. A multiscale restriction-smoothed basis method for high contrast porous media represented on unstructured grids. *J. Comput. Phys.*, **304**, 46–71. doi:10.1016/j.jcp.2015.10.010.

[217] Møyner, O., and Tchelepi, H. A. 2017. A multiscale restriction-smoothed basis method for compositional models. In: *SPE Reservoir Simulation Conference*. doi:10.2118/182679-MS.

[218] Møyner, O., Krogstad, S., and Lie, K.-A. 2014. The application of flow diagnostics for reservoir management. *SPE J.*, **20**(2), 306–323. doi:10.2118/171557-PA.

[219] Muskat, M., and Wyckoff, R. D. 1937. *The Flow of Homogeneous Fluids through Porous Media*. Vol. 12. New York: McGraw-Hill.

[220] Natvig, J. R., and Lie, K.-A. 2008. Fast computation of multiphase flow in porous media by implicit discontinuous Galerkin schemes with optimal ordering of elements. *J. Comput. Phys.*, **227**(24), 10108–10124. doi:10.1016/j.jcp.2008.08.024.

[221] Natvig, J. R., Lie, K.-A., Eikemo, B., and Berre, I. 2007. An efficient discontinuous Galerkin method for advective transport in porous media. *Adv. Water Resour.*, **30**(12), 2424–2438. doi:10.1016/j.advwatres.2007.05.015.

[222] Natvig, J. R., Skaflestad, B., Bratvedt, F., et al. 2011. Multiscale mimetic solvers for efficient streamline simulation of fractured reservoirs. *SPE J.*, **16**(4), 880–888. doi:10.2018/119132-PA.

[223] Neidinger, R. 2010. Introduction to automatic differentiation and MATLAB object-oriented programming. *SIAM Review*, **52**(3), 545–563. doi:10.1137/080743627.

[224] Nessyahu, H., and Tadmor, E. 1990. Nonoscillatory central differencing for hyperbolic conservation laws. *J. Comput. Phys.*, **87**(2), 408–463. doi:10.1016/0021-9991(90)90260-8.

[225] Nielsen, B. F., and Tveito, A. 1998. An upscaling method for one-phase flow in heterogeneous reservoirs; A Weighted Output Least Squares (WOLS) approach. *Comput. Geosci.*, **2**, 92–123. doi:0.1023/A:1011541917701.

[226] Nikitin, K., Terekhov, K., and Vassilevski, Y. 2014. A monotone nonlinear finite volume method for diffusion equations and multiphase flows. *Comput. Geos.*, **18**(3-4), 311–324. doi:10.1007/s10596-013-9387-6.

[227] Nilsen, H. M., Lie, K.-A., and Andersen, O. 2016b. Robust simulation of sharp-interface models for fast estimation of CO_2 trapping capacity. *Comput. Geosci.*, **20**(1), 93–113. doi:10.1007/s10596-015-9549-9.

[228] Nilsen, H. M., Lie, K.-A., and Andersen, O. 2016a. Fully implicit simulation of vertical-equilibrium models with hysteresis and capillary fringe. *Comput. Geosci.*, **20**(1), 49–67. doi:10.1007/s10596-015-9547-y.

[229] Nilsen, H. M., Nordbotten, J. M., and Raynaud, X. 2018. Comparison between cell-centered and nodal based discretization schemes for linear elasticity. *Comput. Geosci.*, **22**(1), 233–260. doi:10.1007/s10596-017-9687-3.

[230] Nilsen, H. M., Lie, K.-A., Møyner, O., and Andersen, O. 2015b. Spill-point analysis and structural trapping capacity in saline aquifers using MRST-co2lab. *Comput. Geosci.*, **75**, 33–43. doi:10.1016/j.cageo.2014.11.002.

[231] Nilsen, H. M., Lie, K.-A., and Natvig, J. R. 2012. Accurate modelling of faults by multipoint, mimetic, and mixed methods. *SPE J.*, **17**(2), 568–579. doi:10.2118/149690-PA.

[232] Nilsen, H. M., Lie, K.-A., and Andersen, O. 2015a. Analysis of CO_2 trapping capacities and long-term migration for geological formations in the Norwegian North Sea using MRST-co2lab. *Comput. Geosci.*, **79**, 15–26. doi:10.1016/j.cageo.2015.03.001.

[233] Nordbotten, J. M. 2016. Stable cell-centered finite volume discretization for biot equations. *SIAM J. Numer. Anal.*, **54**(2), 942–968. doi:10.1137/15M1014280.

[234] Nordbotten, J. M., and Eigestad, G. T. 2005. Discretization on quadrilateral grids with improved monotonicity properties. *J. Comput. Phys.*, **203**(2), 744–760. doi:10.1016/j.jcp.2004.10.002.

[235] Nordbotten, J. M., Aavatsmark, I., and Eigestad, G. T. 2007b. Monotonicity of control volume methods. *Numer. Math.*, **106**(2), 255–288. doi:10.1007/s00211-006-0060-z.

[236] Nordbotten, J. M., and Aavatsmark, I. 2005. Monotonicity conditions for control volume methods on uniform parallelogram grids in homogeneous media. *Comput. Geosci.*, **9**(1), 61–72. doi:10.1007/s10596-005-5665-2.

[237] Nordbotten, J. M. 2015. Convergence of a cell-centered finite volume discretization for linear elasticity. *SIAM J. Numer. Anal.*, **53**(6), 2605–2625. doi:10.1137/140972792.

[238] Notay, Y. 2010. An aggregation-based algebraic multigrid method. *Electron. Trans. Numer. Anal.*, **37**, 123–140.

[239] Nutting, P. G. 1930. Physical analysis of oil sands. *AAPG Bulletin*, **14**(10), 1337–1349.

[240] Obi, E., Eberle, N., Fil, A., and Cao, H. 2014. Giga cell compositional simulation. In: *IPTC 2014: International Petroleum Technology Conference*. doi:10.2523/IPTC-17648-MS.

[241] Odeh, A. S. 1981. Comparison of solutions to a three-dimensional black-oil reservoir simulation problem. *J. Petrol. Techn.*, **33**(1), 13–25. doi:10.2118/9723-PA.

[242] Øren, P.-E., Bakke, S., and Arntzen, O. J. 1998. Extending predictive capabilities to network models. *SPE J.*, **3**(4), 324–336. doi:10.2118/52052-PA.

[243] Pal, M., Lamine, S., Lie, K.-A., and Krogstad, S. 2015. Validation of the multi-scale mixed finite-element method. *Int. J. Numer. Meth. Fluids*, **77**(4), 206–223. doi:10.1002/fld.3978.

[244] Park, H.-Y., and Datta-Gupta, A. 2011. Reservoir management using streamline-based flood efficiency maps and application to rate optimization. In: *SPE Western North American Region Meeting*. doi:10.2118/144580-MS.

[245] Peaceman, D. W. 1983. Interpretation of well-block pressures in numerical reservoir simulation with nonsquare grid blocks and anisotropic permeability. *Soc. Petrol. Eng. J.*, **23**(3), 531–543. doi:10.2118/10528-PA.

[246] Peaceman, D. W. 1991. *Fundamentals of Numerical Reservoir Simulation*. New York, NY, USA: Elsevier Science Inc.

[247] Peaceman, D. W. 1978. Interpretation of well-block pressures in numerical reservoir simulation. *Soc. Petrol. Eng. J.*, **18**(3), 183—194. doi:10.2118/6893-PA.

[248] Persson, P.-O., and Strang, G. 2004. A simple mesh generator in MATLAB. *SIAM Review*, **46**(2), 329–345. doi:10.1137/S0036144503429121.

[249] Peters, L., Arts, R., Brouwer, G., et al. 2010. Results of the Brugge benchmark study for flooding optimization and history matching. *SPE Reser. Eval. Eng.*, **13**(03), 391–405. doi:10.2118/119094-PA.

[250] Pettersen, Ø. 2006. *Basics of Reservoir Simulation with the Eclipse Reservoir Simulator*. Lecture Notes. Department of Mathematics, University of Bergen. http://folk.uib.no/fciop/index_htm_files/ResSimNotes.pdf.

[251] Pettersen, Ø. 2012. Horizontal simulation grids as alternative to structure-based grids for thin oil-zone problems: A comparison study on a Troll segment. *Comput. Geosci.*, **16**(2), 211–230. doi:10.1007/s10596-011-9240-8.

[252] Pinder, G. F., and Gray, W. G. 2008. *Essentials of Multiphase Flow in Porous Media*. Hoboken, NJ: John Wiley & Sons.

[253] Pollock, D. W. 1988. Semi-analytical computation of path lines for finite-difference models. *Ground Water*, **26**(6), 743–750. doi:10.1111/j.1745-6584.1988.tb00425.x.

[254] Ponting, D. K. 1989. Corner point geometry in reservoir simulation. In: King, P. R. (ed), *ECMOR I – 1st European Conference on the Mathematics of Oil Recovery*. Oxford: Clarendon Press, pp. 45–65. doi:10.3997/2214-4609.201411305.

[255] Potempa, T. C. 1982. *Finite element methods for convection dominated transport problems*. PhD. thesis, Rice University. http://hdl.handle.net/1911/15714.

[256] Prevost, M., Edwards, M. G., and Blunt, M. J. 2002. Streamline tracing on curvilinear structured and unstructured grids. *SPE J.*, **7**(2), 139–148. doi:10.2118/78663-PA.

[257] Prevost, M., Lepage, F., Durlofsky, L. J., and Mallet, J.-L. 2005. Unstructured 3D gridding and upscaling for coarse modelling of geometrically complex reservoirs. *Petrol. Geosci.*, **11**(4), 339–345. doi:10.1144/1354-079304-657.

[258] Pyrcz, M. J., and Deutsch, C. V. 2014. *Geostatistical Reservoir Modeling*. Oxford: Oxford University Press.

[259] Rashid, B., Muggeridge, A., Bal, A.-L., and Williams, G. J. J. 2012a. Quantifying the impact of permeability heterogeneity on secondary-recovery performance. *SPE J.*, **17**(2), 455–468. doi:10.2118/135125-PA.

[260] Rashid, B., Bal, A.-L., Williams, G. J. J., and Muggeridge, A. H. 2012b. Using vorticity to quantify the relative importance of heterogeneity, viscosity ratio, gravity and diffusion on oil recovery. *Comput. Geosci.*, **16**(2), 409–422. doi:10.1007/s10596-012-9280-8.

[261] Rasmussen, A. F., and Lie, K.-A. 2014. Discretization of flow diagnostics on stratigraphic and unstructured grids. In: *ECMOR XIV – 14th European Conference on the Mathematics of Oil Recovery*. doi:10.3997/2214-4609.20141844.

[262] Raviart, P. A., and Thomas, J. M. 1977. A mixed finite element method for 2nd order elliptic equations. In: Galligani, I., and Magenes, E. (eds), *Mathematical Aspects of Finite Element Methods*. Berlin, Heidelberg, New York: Springer-Verlag.

[263] Renard, P., and De Marsily, G. 1997. Calculating equivalent permeability: A review. *Adv. Water Resour.*, **20**(5), 253–278. doi:10.1016/S0309-1708(96)00050-4.

[264] Richards, L. A. 1931. Capillary conduction of liquids through porous mediums. *J. App. Phys.*, **1**(5), 318–333. doi:10.1063/1.1745010.

[265] Ringrose, P., and Bentley, M. 2015. *Reservoir Model Design: A Practitioner's Guide*. New York: Springer.

[266] Samier, P. 1990. A finite element method for calculation transmissibilities in n-point difference equations using a non-diagonal permeability tensor. In: Guérillot, D. (ed), *ECMOR II – 2nd European Conference on the Mathematics of Oil Recovery*. Editions TECHNIP, pp. 121–130. doi:10.3997/2214-4609.201411106.

[267] Samier, P., and Masson, R., 2017. Implementation of a vertex-centered method inside an industrial reservoir simulator: Practical issues and comprehensive comparison with corner-point grids and perpendicular-bisector-grid models on a field case. *SPE J.*, **22**(02), 660–678. doi:10.2118/173309-PA.

[268] Sandve, T. H., Berre, I., and Nordbotten, J. M. 2012. An efficient multi-point flux approximation method for discrete fracture matrix simulations. *J. Comput. Phys.*, **231**(9), 3784–3800. doi:10.1016/j.jcp.2012.01.023.

[269] Schlumberger. 1999. *ECLIPSE 100 User Course*. Schlumberger GeoQuest.

[270] Schlumberger. 2014a. *ECLIPSE: Reference Manual*. 2014.1 edn. Schlumberger.

[271] Schlumberger. 2014b. *ECLIPSE Reservoir Simulation Software: Technical Description*. 2014.1 edn. Schlumberger.

[272] Schneider, M., Flemisch, B., and Helmig, R. 2017. Monotone nonlinear finite-volume method for nonisothermal two-phase two-component flow in porous media. *Int. J. Numer. Meth. Fluids*, **84**(6), 352–381. doi:10.1002/fld.4352.

[273] Shah, S., Møyner, O., Tene, M., Lie, K.-A., and Hajibeygi, H. 2016. The multiscale restriction smoothed basis method for fractured porous media. *J. Comput. Phys.*, **318**, 36–57. doi:10.1016/j.jcp.2016.05.001.

[274] Shahvali, M., Mallison, B., Wei, K., and Gross, H. 2012. An alternative to streamlines for flow diagnostics on structured and unstructured grids. *SPE J.*, **17**(3), 768–778. doi:10.2118/146446-PA.

[275] Shampine, L. F., Ketzscher, R., and Forth, S. A. 2005. Using AD to solve BVPs in MATLAB. *ACM Trans. Math. Software*, **31**(1), 79–94. doi:10.1145/1055531.1055535.

[276] Sheldon, J. W., Harris, C. D., and Bavly, D. 1960. A method for general reservoir behavior simulation on digital computers. In: *Fall Meeting of the Society of Petroleum Engineers of AIME*. doi:10.2118/1521-G.

[277] Shook, G. M., and Forsmann, J. H. 2005. *Tracer Interpretation Using Temporal Moments on a Spreadsheet*. Tech. rept. INL report 05-00400. Idaho National Laboratory.

[278] Shook, G., and Mitchell, K. 2009. A robust measure of heterogeneity for ranking earth models: The F-Phi curve and dynamic Lorenz coefficient. In: *SPE Annual Technical Conference and Exhibition*. doi:10.2118/124625-MS.

[279] Shubin, G. R., and Bell, J. B. 1984. An analysis of the grid orientation effect in numerical simulation of miscible displacement. *Comput. Methods Appl. Mech. Eng.*, **47**(1), 47–71. doi:10.1016/0045-7825(84)90047-1.

[280] Spillette, A. G., Hillestad, J. G., and Stone, H. L. 1973. A high-stability sequential solution approach to reservoir simulation. In: *Fall Meeting of the Society of Petroleum Engineers of AIME*. doi:542-MS.

[281] Stephansen, A. F., and Klausen, R. A. 2008. Mimetic MPFA. In: *ECMOR XI – 11th European Conference on the Mathematics of Oil Recovery*. doi:10.3997/2214-4609.20146365.

[282] Stone, H. L. 1970. Probability model for estimating three-phase relative permeability. *J. Petrol. Tech.*, **22**(02), 214–218. doi:10.2118/2116-PA.

[283] Stone, H. L. 1973. Estimation of three-phase relative permeability and residual oil data. *J. Pet. Technol.*, **12**(4). doi:10.2118/73-04-06.

[284] Stone, H. L., and Garder Jr., A. O. 1961. Analysis of gas-cap or dissolved-gas drive reservoirs. *SPE J.*, **1**(02), 92–104. doi:10.2118/1518-G.

[285] Stüben, K. 2001. A review of algebraic multigrid. *J. Comput. Appl. Math.*, **128**(1), 281–309. doi:10.1016/S0377-0427(00)00516-1.

[286] Technische Universität Darmstadt. *Automatic Differentiation for Matlab (ADiMat)*. http://www.adimat.de/. [Online; accessed July 11, 2018].

[287] Thiele, M. R., and Batycky, R. P. 2003. Water injection optimization using a streamline-based workflow. In: *SPE Annual Technical Conference and Exhibition*. doi:10.2118/84080-MS.

[288] Thomas, G. W. 1981. *Principles of Hydrocarbon Reservoir Simulation*. Boston: IHRDC.

[289] Todd, M. R. and Longstaff, W. J. 1972a. The development, testing, and application of a numerical simulator for predicting miscible flood performance. *J. Petrol. Tech.*, **24**(07), 874–882. doi:10.2118/3484-PA.

[290] Todd, M. R., O'Dell, P. M., and Hirasaki, G. J. 1972b. Methods for increased accuracy in numerical reservoir simulators. *Soc. Petrol. Eng. J.*, **12**(06), 515–530. doi:10.2118/3516-PA.

[291] Tomlab Optimization Inc. *Matlab Automatic Differentiation (MAD)*. http://matlabad .com/. [Online; accessed July 11, 2018].

[292] Toor, S. M., Edwards, M. G., Dogru, A. H., and Shaalan, T. M. 2015. Boundary aligned grid generation in three dimensions and CVD-MPFA discretization. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/173313-MS.

[293] Toro, E. F. 2009. *Riemann Solvers and Numerical Methods for Fluid Dynamics: A Practical Introduction*. 3rd edn. Berlin: Springer-Verlag.

[294] Trangenstein, J. A. 2009. *Numerical solution of hyperbolic partial differential equations*. Cambridge: Cambridge University Press.

[295] Trangenstein, J. A., and Bell, J. B. 1989. Mathematical structure of the black-oil model for petroleum reservoir simulation. *SIAM J. Appl. Math.*, **49**(3), 749–783. doi:10.1137/0149044.

[296] Trottenberg, U., Oosterlee, C. W., and Schüller, A. 2000. *Multigrid*. Academic press.

[297] Ucar, E., Berre, I., and Keilegavlen, E. 2015. Simulation of slip-induced permeability enhancement accounting for multiscale fractures. In: *Fourtieth Workshop on Geothermal Reservoir Engineering*.

[298] van Genuchten, M. T. 1980. Closed-form equation for predicting the hydraulic conductivity of unsaturated soils. *Soil Science Soc. America J.*, **44**(5), 892–898. doi:10.2136/sssaj1980.03615995004400050002x.

[299] Varela, J. 2018. *Implementation of an MPFA/MPSA-FV solver for the unsaturated flow in deformable porous media*. M.Sc. thesis, University of Bergen. http://hdl.handle.net/1956/17905.

[300] Verma, A. 1999. ADMAT: Automatic differentiation in MATLAB using object oriented methods. In: Henderson, M. E., Anderson, C. R., and Lyons, S. L. (eds), *Object Oriented Methods for Interoperable Scientific and Engineering Computing: Proceedings of the 1998 SIAM Workshop*. Philadelphia: SIAM, pp. 174–183.

[301] Verma, S., and Aziz, K. 1997. A control volume scheme for flexible grids in reservoir simulation. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/37999-MS.

[302] Voskov, D. V., and Tchelepi, H. A. 2012. Comparison of nonlinear formulations for two-phase multi-component eos based simulation. *J. Petrol. Sci. Engrg.*, **82–83**(0), 101–111. doi:10.1016/j.petrol.2011.10.012.

[303] Voskov, D. V., Tchelepi, H. A., and Younis, R. 2009. General nonlinear solution strategies for multiphase multicomponent EoS based simulation. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/118996-MS.

[304] Wallis, J. R. 1983. Incomplete gaussian elimination as a preconditioning for generalized conjugate gradient acceleration. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/12265-MS.

[305] Wallis, J. R., Kendall, R. P., and Little, T. E. 1985. Constrained residual acceleration of conjugate residual methods. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/13536-MS.

[306] Wang, X., and Tchelepi, H. A. 2013. Trust-region based solver for nonlinear transport in heterogeneous porous media. *J. Comp. Phys.*, **253**, 114–137. doi:10.1016/j.jcp.2013.06.041.

[307] Watts, J. W. 1986. A compositional formulation of the pressure and saturation equations. *SPE Res. Eng.*, **1**(3), 243–252. doi:10.2118/12244-PA.

[308] Weiser, A., and Wheeler, M. F. 1988. On convergence of block-centered finite differences for elliptic problems. *SIAM J. Numer. Anal.*, **25**(2), 351–375. doi:10.1137/0725025.

[309] Welge, H. J. 1952. A simplified method for computing oil recovery by gas or water drive. *J. Petrol. Tech.*, **4**(04), 91–98. doi:10.2118/124-G.

[310] Wen, X. H., Durlofsky, L. J., and Edwards, M. G. 2003. Upscaling of channel systems in two dimensions using flow-based grids. *Transp. Porous Media*, **51**(3), 343–366. doi:10.1023/A:1022318926559.

[311] Wen, X.-H., and Gómez-Hernández, J. J. 1996. Upscaling hydraulic conductivities in heterogeneous media: An overview. *J. Hydrol.*, **183**, ix–xxxii. doi:10.1016/S0022-1694(96)80030-8.

[312] Wheeler, J. A., Wheeler, M. F., and Yotov, I. 2002. Enhanced velocity mixed finite element methods for flow in multiblock domains. *Comput. Geosci.*, **6**(3-4), 315–332. doi:10.1023/A:1021270509932.

[313] Wheeler, M. F., Arbogast, T., Bryant, S., et al. 1999. A parallel multiblock/multidomain approach for reservoir simulation. In: *SPE Reservoir Simulation Symposium*, pp. 51–61.

[314] Wheeler, M. F., and Yotov, I. 2006. A cell-centered finite difference method on quadrilaterals. In: Arnold, D. N., Bochev, P. B., Lehoucq, R. B., Nicolaides, R. A., and Shashkov, M. (eds), *Compatible Spatial Discretizations*. New York: Springer, pp. 189–207.

[315] Whitaker, S. 1986. Flow in porous media I: A theoretical derivation of Darcy's law. *Transp. Porous Media*, **1**(1), 3–25. doi:10.1007/BF01036523.

[316] Whitson, C. H., and Brulé, M. R. 2000. *Phase Behavior*. Richardson, TX: Society of Petroleum Engineers.

[317] Wiener, O. 1912. *Abhandlungen der Matematisch*. PhD. thesis, Physischen Klasse der Königlichen Sächsischen Gesellscaft der Wissenschaften.

[318] Wu, X.-H., Efendiev, Y., and Hou, T. Y. 2002. Analysis of upscaling absolute permeability. *Discrete Contin. Dyn. Syst. Ser. B*, **2**(2), 185–204. doi:10.3934/dcdsb.2002.2.185.

[319] Wu, X.-H., and Parashkevov, R. 2009. Effect of grid deviation on flow solutions. *SPE J.*, **14**(01), 67–77. doi:10.218/92868-PA.

[320] Wyckoff, R. D., Botset, H. G., Muskat, M., and Reed, D. W. 1933. The measurement of the permeability of porous media for homogeneous fluids. *Rev. Sci. Instrum.*, **4**(7), 394–405. doi:10.1063/1.1749155.

[321] Yanosik, J. L., and McCracken, T. A. 1979. A nine-point, finite-difference reservoir simulator for realistic prediction of adverse mobility ratio displacements. *Soc. Petrol. Eng. J.*, **19**(04), 253–262. doi:10.2118/5734-PA.

[322] Younis, R. 2009. *Advances in modern computational methods for nonlinear problems: A generic efficient automatic differentiation framework, and nonlinear solvers that converge all the time*. Ph.D. thesis, Stanford University.

[323] Younis, R., and Aziz, K. 2007. Parallel automatically differentiable data-types for next-generation simulator development. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/106493-MS.

[324] Zhang, P., Pickup, G. E., and Christie, M. A. 2005. A new upscaling approach for highly heterogenous reservoirs. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/93339-MS.

[325] Zhou, Y., Tchelepi, H. A., and Mallison, B. T. 2011. Automatic differentiation framework for compositional simulation on unstructured grids with multi-point discretization schemes. In: *SPE Reservoir Simulation Symposium*. doi:10.2118/141592-MS.