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## Chapter 9

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## Chapter 10

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## Chapter 11

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ed by the Canadian LITHOPROBE program in 1994; **Figure 15.5:** Data recorded by the Canadian LITHOPROBE program; **Figure 15.6:** Data recorded by the Canadian LITHOPROBE program; **Figure 15.7:** Data recorded by the Canadian LITHOPROBE program

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**Figure 16.4 a-b:** Based on a concept from D. P. McKenzie, 1978; **Figure 16.4 c:** From P.A. Ziegler, 1982, *Philosophical Transactions of the Royal Society*, London, pp. 13-143; **Figure 16.6:** Adapted from B. Wernicke and B. C. Burchfiel, 1982, *Journal of Structural Geology*, v. 4, p. 105-115, Fig. 7, p. 107. Reprinted with permission from Elsevier; **Figure 16.8:** Modified from A. D. Gibbs, 1984, Structural evolution of extensional basin margins, *Journal of the Geological Society of London*, v. 141, p. 609-620, Fig. 5, p. 611; Fig. 9, p. 614; **Figure 16.10:** From G. S. Lister, M. A. Etheridge, and P. A. Symmonds, 1986, *Geology*, v. 14, p. 246-250, Fig. 3; **Figure 16.11 a:** From P. A. Ziegler, 1982; *Philosophical Transactions of the Royal Society*, London, v. A305, p. 113-143, Fig. 11, p. 131; **Figure 16.11 b:** From W. Bosworth, 1994, *Geologische Rundschau*, v. 83, p. 671-688, Fig. 10, p. 684. Reprinted with permission from Springer-Verlog; **Figure 16.12:** J. H. Stewart, 1978, *Geological Society of America Memoir* 152, p. 1-31, Fig. 1.1, with data added from P.J. Coney, 1980, *Geological Society of America Memoir* 153, p. 7-31; **Figure 16.13 a-d:** After G. S. Lister and G. A. Davis, 1989, *Journal of Structural Geology*, v. 11, p. 65-94, Fig. 20. Reprinted with permission from Elsevier; **Figure 16.14:** Adapted from B. R. Rosendahl, 1987, *Annual Review of Earth and Planetary Science Letters*, v. 15, p. 445-503, Fig. 3. Used with permission by Annual Reviews; **Figure 16.15 b:** Modified from C. J. Ebinger, 1989, *Tectonics*, v. 8, p. 117-133, Fig. 4, p. 121; **Figure 16.15 c:** From A.W. Bally and S. Snelson, 1980, *Canadian Society of Petroleum Geologists Memoir* 6, p. 9-75, Fig. 34, p. 66; **Figure 16.16:** After W. Bosworth, 1994, *Geologische Rundschau*, 83, 671-688, Fig. 10, p. 684. Reprinted with permission from Springer-Verlog; **Figure 16.17 b:** Modified from D. R. McClay and M. J. White, 1995, *Marine and Petroleum Geology*, 12, 137-151, Fig. 1a; **Figure 16.21 a:** Based on data From W. W. Arwood, *The Physiographic Provinces of North America*, 1940, Ginn and Co.; **Figure 16.21 b:** Based on data From T. H. Dixon et al., 1989; **Figure 16.24:** Data from A. Cox and R. B. Hart, 1986, *Plate Tectonics. How It Works*. Blackwell Scientific Publications, Oxford; **Figure 16.26 a, c:** Modified from G. Davis and S. J. Reynolds, *Structural Geology*, John Wiley and Sons, New York; **Figure 16.26 b:** Modified from K. C. MacDonald, 1982, *Annual Review of Earth and Planetary Science Letters*, v. 10, p. 155-190. Used with permission by Annual Reviews; **Figure 16.26 d:** Open University Course

Team, 1989, *The Ocean Basins: Their Structure and Evolution*. Pergamon Press, Oxford, Fig. 4.15. Reprinted with permission from Elsevier; **Figure 16.27**: Modified from R. Twiss and E. Moores, 1992, *Tectonics*, W. H. Freeman, New York, Fig. 5.14. © 1992 by W. H. Freeman and Company. Used with permission; **Figure 16.28**: Inset from A. W. Erxleben and G. Carnahan, 1983, *American Association of Petroleum Geologists Studies in Geology Series*, no. 15, v. II, Seismic Expression of Structural Styles: A Picture and Work Atlas, ed. A. W. Bally (1983). Slick ranch area, Starr County, Texas by A. W. Erxleben and G. Carnahan, p. 2.3.1-22—2.3.2-27, Fig. Detached Sediments in Extensional Provinces/Growth Faults (p. 2.3.1-23). AAPG©1983, reprinted by permission of the AAPG whose permission is required for further use

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**Figure 17.5 a**: From D. L. Turcotte et al., 1978, *Tectonophysics*, v. 47, p. 193-205, Fig. 5. Reprinted with permission from Elsevier; **Figure 17.6 a**: Modified from E. R. Oxburgh and D. L. Turcotte, 1970, *Geological Society of America Bulletin*, 81, 1665-1688, Fig. 3; **Figure 17.6 b-c**: Modified from K. C. Condie, 1989, *Plate Tectonics and Crustal Evolution*, 3d ed., Pergamon Press, Oxford, Fig. 6.9, p. 108. Reprinted with permission from Elsevier; **Figure 17.7**: Modified from Schubert et al., 1975, *Geophysical Journal of the Royal Astronomical Society*, 42, p. 705-735, Fig. 11; **Figure 17.9**: Modified from L. Kellogg, 1999, *Science*, v. 283, Fig. 1, p. 1882; **Figure 17.12 b**: From G. F. Moore et al., 1991, *Proceedings of the Ocean Drilling Program, Initial Reports*, v. 131, p. 15-23, Fig. 5; **Figure 17.19**: Adapted from A. Nur and Z. Ben-Avraham, 1982, *Journal of Geophysical Research*, v. 87, 3644-3661, Fig. 1, p. 3649. Copyright 1982 American Geophysical Union. Modified by permission of American Geophysical Union; **Figure 17.23 a**: Modified from J. F. Dewey et al., 1986. In M. P. Coward and A. C. Ries (eds.), *Collision tectonics*, *Geological Society of London Special Publication* 19, 3-36, Fig. 4A, p. 8; **Figure 17.26 a-b**: From P. Tapponnier et al., 1982, *Geology*, 10, 611-616, Fig. 1, p. 612; Fig. 3, p. 615; **Figure 17.26 c**: From P. Tapponnier and P. Molnar, 1976; *Nature*, 264:319-324, Fig. 2a, p. 321. Reprinted with permission from Nature Publishing Group; **Figure 17.29 a**: Based on a concept from R. D. Hatcher and R. T. Williams, 1986, *Geological Society of America Bulletin*, 97, 975-985, Fig. 1, p. 976-977; **Figure 17.29 b**: Based on P. Coney, D. L. Jones, and J. W. H. Monger, 1980, *Nature*, 288, 329-333, Fig. 1, p. 330. Reprinted with permission from Nature Publishing Group; **Figure 17.30 a-b**: Adapted from Willett, Beaumont, and Fullsack, 1992, *Geology*, v. 21, no. 4, p. 371-374, Fig. 4

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**Figure 18.5 b**: Seismic data courtesy of the PGS-IDSIL partnership and the Nigerian Department of Petroleum Resources; **Figure 18.7 a-c**: Adapted from J. Suppe, 1985, *Principles of Structural Geology*, Prentice-Hall, Englewood Cliffs, NJ, Fig. 9-42; **Figure 18.10**: Adapted from R. Twiss & E. Moores, 1992, *Tectonics*, W. H. Freeman, New York, Fig. 6.4. © 1992 by W.H. Freeman and Company. Used with permission; **Figure 18.11 c**: Adapted from F. Royse, Jr., 1993, in A.W. Snoko et al. (eds.), *Geology of Wyoming: Geological Survey of Wyoming memoir* 5, p. 272-311, Map sheet 1; **Figure 18.12 a**: Modified from S. Mitra, 1986, Duplex structures and imbricate thrust systems: Geometry, structural position, and hydrocarbon potential, *American Association of Petroleum Geologists Bulletin*, v. 70/9, p. 1087-1112; Fig. 7 (p. 1095). AAPG©1986, modified by permission of the AAPG whose permission is required for further use; **Figure 18.13a**: Modified from S. Boyer and D. Elliott, 1982, Thrust Systems, *American Association of Petroleum Geologists Bulletin*, v. 66, p. 1196-1230, Fig. 19. AAPG © 1982, modified by permission of the AAPG whose permission is required for further use; **Figure 18.15**: Simplified from J.G. Ramsay & M.I. Huber, 1983, *The Techniques of Modern Structural Geology*, v. 1: *Strain Analysis*, Academic Press, London, Fig. 11.10, p. 205. Reprinted with permission from Elsevier; **Figure 18.16 b**: S. Mitra, 1986, Duplex structures and imbricate thrust systems: Geometry, structural position, and hydrocarbon potential, *American Association of Petroleum Geologists Bulletin*, v. 70/9, p. 1087-1112; Fig. 10 (foldout). AAPG©1986, reprinted by permission of the AAPG whose permission is required for further use; **Figure 18.17 b**: Modified from B. Willis, 1923, *Geologic Structures*, McGraw-Hill Book Company, New York, Fig. 60; **Figure 18.18 a**: Modified from J. Suppe, 1983, Geometry and kinematics of fault-bend folding, *American Journal of Science*, v. 283, p. 684-721, Fig. 3; **Figure 18.19**: M. S. Wilkerson, D. A. Medwedeff, S. Marshak, 1991, Geometrical modeling of fault-related folds: a pseudo-three-dimensional approach, *Journal of Structural Geology*, v. 13, p. 801-812, Fig. 1. Reprinted with permission from Elsevier; **Figure 18.20 a**: J. Suppe and D. Medwedeff, 1990, Geometry and kinematics of fault-propagation folding, *Ecolgae Geologicae Helveticae*, v. 83, p. 409-454, Fig. 6; **Figure 18.21**: Adapted From Zehnder and Allrendinger, *Journal of Structural Geology*, 2000;22:1099-1014, based on a concept by Erslev, 1991; **Figure 18.22**: Adapted from H. P. Laubscher, 1961, *Ecolgae Geologicae Helveticae*, v. 54, Fig. 3, p. 233; **Figure 18.24**: Modified from Dahlstrom, 1970, *Bulletin of Canadian Petroleum Geology*, v. 18, p. 332-406l, Fig. 26; **Figure 18.25 b**: D. Elliott, 1976, The energy balance and deformation mechanisms of

thrust sheets, *Philosophical Transactions of the Royal Society*, London, v. A283, p. 289-312, Fig. 4; **Figure 18.28 a-b**: S. Boyer and D. Elliott, 1982, Thrust systems, *American Association of Petroleum Geologists Bulletin*, v. 66/9, p. 1196-1230, Fig. 17 (p.1206), Fig. 19 (p.1208). AAPG©1982, reprinted by permission of the AAPG whose permission is required for further use; **Figure 18.31 a-c**: Adapted from K. Dejong and R. Scholten, 1973, *Gravity and Tectonics*, John Wiley & Sons, New York, Fig. 1, p. xii

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**Figure 19.1 a**: Modified from J. C. Crowell, 1987, in *Episodes* v. 10, p. 278-282, Fig. 1, p. 279; **Figure 19.1 b**: Modified from J. C. Crowell, 1979, *Journal of the Geological Society of London*, v. 136, p. 293-302, Fig. 2, p. 295; **Figure 19.2 a**: After G. W. Grindley, 1974. New Zealand; in A.M. Spencer (ed.) *Geological Society of London Special Publication*, v. 4, p. 387-416, Fig. 1, p. 388; **Figure 19.2 b**: Modified from Z. Garfunkel, 1981, *Tectonophysics*, v. 80, p. 81-108, Fig. 1, p. 82. Reprinted with permission from Elsevier; **Figure 19.8 a-b**: Modified from R. Twiss & E. Moores, 1992, *Tectonics*, W. H. Freeman, New York, Fig. 7.10, p. 121. © 1992 by W. H. Freeman and Company. Used with permission; **Figure 19.10**: Modified From Goddard Space Flight Center, 1976; **Figure 19.14 d**: From R. E. Wilcox, T. P. Harding, and D. R. Seely, 1973, *American Association of Petroleum Geologists Bulletin*, v. 57/1, Basic wrench tectonics, pp. 74-96, Fig. 8, p. 84 AAPG©1973; **Figure 19.16 a-c**: Modified from M.R. Nelson and C. H. Jones, 1987, *Tectonics*, v. 6, p. 13-33, Fig. 6. Copyright 1987 American Geophysical Union. Modified by permission of American Geophysical Union; **Figure 19.19 a**: From T.P. Harding and J.D. Lowell, 1979, *American Association of Petroleum Geologists Bulletin*, v. 63/7, Structural styles, their plate-tectonic habitats . . . , p. 1016-1058, Fig. 6 (p. 1025). AAPG©1979, reprinted by permission of the AAPG whose permission is required for further use; **Figure 19.21**: From Woodcock and Fischer, 1986; **Figure 19.23**: Modified from P. Tapponnier et al., 1982, *Geology*, v. 10, p. 611-616, Fig. 1, p. 612; **Figure 19.24 b**: See Dewey J. F. et al, in *Geological Society of London Special Publication 9*, 1974:11; **Figure 19.26 a**: Modified from S. Mitra, 1988, *Geological Society of America Bulletin*, v. 100, p. 72-95, Fig. 1, p. 72; **Figure 19.27**: Modified from S. Marshak, 1988, *Tectonics*, v. 7, p. 73-86, Fig. 15, p. 83. Copyright 1988 American Geophysical Union. Modified by permission of American Geophysical Union; **Figure 19.28**: From B. C. Burchfiel and G. A. Davis, 1973, *Geological Society of America Bulletin*, v. 84, p. 1407-1422, Fig. 4, p. 1417; **Figure 19.29**: from I. Barany and J. A. Karson, 1989, *Geological Society of America Bulletin*, v. 101, p. 204-220, Fig. 2, p. 205

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**Figure 20.1**: NGDC; **Figure 20.2**: Modified from Burchfiel, *Scientific American*, September, 1983, Fig. 2; **Figure 20.3**: Modified from Hatcher and Williams, *Geological Society of America Bulletin*, 1986

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**Figure 21.1.2**: Modified after Froitzheim et al., 1996; **Figure 21.1.3**: Profile modified after Schmid and Kissling, 2000; **Figure 21.1.4 b**: Profile modified after Schmid and Kissling, 2000; **Figure 21.1.5 c**: Profile modified after Schmid and Kissling, 2000

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**Figure 22.1.1**: From a map compiled by T. Simkin et al., *This Dynamic Planet, World Map of Volcanoes, Earthquakes, and Plate Tectonics*, U.S.G.S., 1989, Map Distribution Box 25286 Federal Center Denver CO 80225; **Figure 22.1.2**: From Balley et al., North America; Plate-tectonic setting and tectonic elements. *Dec N. Am. Geol.*, vol. A., Fig. 1; **Figure 22.1.3**: Modified from Engebretson et al., 1985; **Figure 22.1.4 a**: After Miller and Gans, 1989; **Figure 22.1.4 b**: After Gans et al., 1989; **Figure 22.1.5**: Modified and simplified after Burchfiel et al., 1992; **Figure 22.1.6**: Based on Bennet et al., from Unavco Poster (NSF-NASA), 1999; **Figure 22.2.1**: After Willett et al., 1993; **Figure 22.2.2**: Malavieille, 1984; **Figure 22.2.4 a**: After Brandon, 1998 and Stewart and Brandon, 2003; **Figure 22.2.4 b**: After Escher and Beaumont, 1997; **Figure 22.2.5**: From Pazzaglia and Brandon, 2001; **Figure 22.2.6**: After Clowes et al., 1987; **Figure 22.5.3**: Modified From Pickering et al., 1988; **Figure 22.7.1**: From S. Marshak, *Earth: Portrait of a Planet*, 2001, W. W. Norton & Company, New York, Fig. 11.34; **Figure 22.7.4**: Adapted from S. Marshak and T. Paulsen, 1996, *Geology*, v. 24, p. 151-154; **Figure 22.7.7**: Adapted from J. H. McBride and W. J. Nelson, 1999, *Tectonophysics*, v. 305, p. 275-286, Fig. 11, p. 268. Reprinted with permission from Elsevier; and S. Marshak et al., 2003, *Geological Society of London Special Publication 210*, p. 159-184, Fig. 4, p. 164; **Figure 22.7.8**: From J. P. Craddock et al., *Tectonics*, 1993, v. 12, p. 257-264, Fig. 2, p. 260. Copyright 1993 American Geophysical Union. Reproduced by permission of American Geophysical Union