

May 20, 1999

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD PANEL

Before Administrative Judge Peter B. Bloch

In the Matter of)

HYDRO RESOURCES, INC.)

2929 Coors Road Suite 101)

Albuquerque, NM 87120)

Docket No. 40-8968-ML

ASLBP No. 95-706-01-ML

RESPONSE AFFIDAVIT OF DR. SPENCER G. LUCAS

I, Spencer G. Lucas, being duly sworn, make the following statement in response to Hydro Resources, Inc.'s Reply to April 21, 1999 Memorandum and Order (Questions) (May 11, 1999) and to the Affidavit of Craig S. Bartels ("Bartels Affidavit"), attached thereto, with respect to Questions 2 and 8:

1. My name is Spencer G. Lucas. I obtained a Ph.D. in geology from Yale University in 1984. I am currently the Curator of Paleontology and Geology at the New Mexico Museum of Natural History, a position that I have held since 1988. In addition, I have served as an Adjunct Professor of Geology at the University of New Mexico since 1988.
2. I have extensive knowledge of the geology for which Hydro Resources, Inc. ("HRI") proposes the Crownpoint Uranium Project. The Westwater Canyon Member Aquifer in the Morrison Formation was deposited in Late Jurassic time. I began to conduct field studies of Jurassic strata in New Mexico in 1983. In 1988, this research program expanded to a regional study of Jurassic stratigraphy.

paleontology and sedimentation in the Four Corners states. As a result of my research, I co-led three field conferences of the New Mexico Geological Society (in 1985, 1989 and 1997) in which a major focus was the Jurassic rocks. I have published several dozen articles and abstracts on Jurassic strata in New Mexico, which encompass a major re-interpretation of Middle-Late Jurassic stratigraphy, deposition and paleogeography in the American Southwest. Further details of my professional qualifications are set forth in my curriculum vitae, which is attached as Exhibit A, and in my scientific bibliography, which is attached as Exhibit B.

3. In preparation of this affidavit I reviewed the following materials:

-Intervenors' Amended Written Presentation in Opposition to Hydro Resources, Inc.'s Application for a Materials License with Respect to: Groundwater Protection and Exhibits (January 18, 1999);

-Hydro Resources, Inc.'s Response to Intervenors' Brief in Opposition to Hydro Resources, Inc.'s Application for a Materials License with Respect to Groundwater Issues, Lichnovsky Affidavit (February 19, 1999);

-The Presiding Officer's April 21, 1999 Memorandum and Order (Questions);

-Hydro Resources, Inc.'s Reply to April 21, 1999 Memorandum and Order (Questions) (May 11, 1999) and the attached Affidavit of Craig S. Bartels;

-Campbell, C. V., 1976, Reservoir geometry of a fluvial sheet sandstone: American Association of Petroleum Geologists Bulletin, v. 60, p. 1009-1020;

-Cowan, E. J. 1991. The large-scale architecture of the fluvial Westwater Canyon Member, Morrison Formation (Upper Jurassic), San Juan Basin, New Mexico: SEPM Concepts in Sedimentology and Paleontology 3, p. 80-93;

-Walker, R. G., 1992, Facies, facies models and modern stratigraphic concepts; in Walker, R. G. and James, N. P., eds., Facies models: Geological Association of Canada, St. John's, Newfoundland, p. 1-14.

4. Question 2 of the April 21, 1999 Order asks:

Based on local geology, what assurance is there concerning the likelihood of the existence of shears, fractures, and joints that could transmit appreciable quantities of water above or below the Westwater aquifer? How much greater assurance may reasonably be anticipated prior to commencing ISL operations at Churchrock Section 8? What environmental costs may reasonably be expected to result from foreseeable difficulties at Churchrock Section 8?

Michael G. Wallace responds to HRI's Response to this question in his affidavit.

The following comments are intended to supplement his response.

5. HRI claims (citing the FEIS) that the mine zone in the Westwater is confined by good aquitards, with good overlying clays and underlying shale. HRI Response at 8. Specifically, HRI claims that there is little risk of excursion into the underlying Cow Springs aquifer because of the thickness of the Recapture shale. HRI Response at 10. I concur with the January 11, 1999, testimony of Mr. Wallace that the Recapture Shale is not a confining layer in this region because the Recapture is a fluvial deposit in the southern part of the San Juan Basin. The nomenclature used in this instance is misleading and outdated.
6. The rock section immediately below the Westwater Canyon Member is not shale – it is a mixture of sandstone, siltstone and thin gypsum beds that overlie the gypsum beds of the upper Todilto Formation. These gypsum beds regionally are known to be very ductile and soluble. Thus, they are easily deformed or dissolved, and this produces numerous fractures in the subsurface and at the surface. These fractures are well documented because they are conduits for groundwater flow and also sometimes serve as the loci of uranium mineralization.
7. Mr. Bartels refers to the overlying layers at Church Rock as the Poison Canyon and Dakota formations. Bartels Affidavit at 9. In fact, the Poison Canyon is the

designation of an ore horizon in the Ambrosia Lake/Laguna region of New Mexico. The overlying layers at Church Rock about the Westwater are the Brushy Basin B sand and the Dakota formations. This is a remarkable error, which undermines confidence in HRI's ability to understand the details of geologic conditions in Church Rock.

8. Question 8 of the April 21, 1999 Order asks:

Intervenors Groundwater Exhibit L quotes Cowan (1991), who states that near Church Rock, channelways "15-30 m. thick" occur "which would affect fluid flow." SRIC/ENDAUM will please promptly provide a reference for the citation so that we may discover whether Cowan says anything about the width of these channelways.

9. The citation is correct in that the Cowan study identifies channelways within the channel system which conduct fluid flow along channel boundaries. HRI's attorney criticizes the Cowan study as "mostly a two dimensional study..." that is "based on a very small portion of the Westwater Canyon Member." HRI Response at 41. These criticisms are unfounded. HRI's statement that "Cowan's description of the Westwater Canyon as made up of coalesced sand sheets precludes the existence of confined elongated channels" is also a misreading of the article. HRI Response at 41.
10. Cowan is a state-of-the-art scientific study designed to reconstruct the fluvial architecture of the Westwater Canyon Member of the Morrison Formation in west-central New Mexico. In a sedimentological study such as that of Cowan, an architectural element is defined as a "morphological subdivision of a particular depositional system that emphasizes the three dimensional geometry of the facies

[rock environment] associations" (Walker, 1992, p. 2, 5). In other words, the term architecture is used by sedimentologists to mean the three dimensional geometry of a rock body formed in a particular environment. Indeed, both the text and the illustrations of Cowan's article (see especially his figure 18, Exhibit C) make it clear that the goal is to reconstruct, in three dimensions, the fluvial system which deposited the Westwater Canyon Member.

11. Therefore, HRI's statement that Cowan's article "is mostly a two-dimensional study..." is misleading.
12. Cowan (1991) re-evaluates an important study of Westwater Canyon Member deposition by Campbell (1976), who concluded that deposition took place in channel systems 1.6 to 34 km wide by a braided river system composed of many smaller channels with widths of 30 to 366 m. Cowan argues that the channel systems identified by Campbell are not primary depositional features, but instead are "post-depositional aquifer conduits, or permeability-pathway components" (p. 80). Cowan concludes that Westwater Canyon deposition was in channel belts one to several km wide composed of numerous, smaller channels. Cowan's article thus well documents the lithologic heterogeneity of the Westwater Canyon Member at the scale of the small channels (which are associated with lenticular bar and overbank deposits) and the continuity of long, nearly linear channel belts. A modern analogy is the depositional development of the Rio Grande and upper-middle reaches of the Mississippi Rivers, as they change course and sediments accumulate, forming sandbars. Therefore, the statement of HRI's attorney that "Cowan's description of the Westwater Canyon as made up of coalesced sand

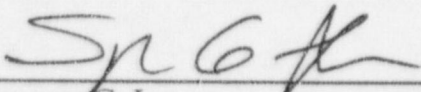
sheets precludes the existence of confined elongated channels" is a misreading of the article.

13. What HRI fails to appreciate is that at a "small scale" (channel widths of tens to hundreds of meters), the Westwater Canyon is a three-dimensionally very complex amalgamation of many coalesced channel, bar and overbank deposits. But, at a "large scale" (widths of hundreds of meters to a few kms) the Westwater Canyon Member consists of long, discrete channel belts, just like those produced by modern braided rivers. Thus, at the small scale the Westwater Canyon is lithologically heterogeneous, consisting of numerous, interlaced ribbon-like sandstone bodies and lenses of conglomerate and mudrock, but only at the large scale can each channel belt be superficially characterized as sandstone, because the majority of the deposit is sandstone.
14. Cowan's article can be used to conclude there must be at least two levels of permeability/porosity in the Westwater Canyon Member: (1) the small scale (averaging 30 meters (100 feet)) of complex conduits; and (2) large scale conduits that correspond to the channel belts. There must also be a third scale of permeability as well according to Cowan, at the scale of Campbell's (1976) channel systems, which is up to 34 km in width. With these superimposed levels (scales) of permeability/porosity, small channel effects greatly complicate the understanding of groundwater flow in the larger channels.
15. HRI also attempts to dismiss the significance of Cowan's study by stating it is "based on a very small portion of the Westwater Canyon Member." However, Cowan's study is placed in a basinal context and examines in detail an outcrop

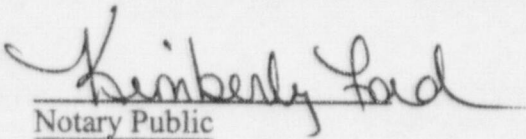
belt characteristic of the Westwater Canyon Member. This is standard sedimentological procedure, and there is no reason to believe that Cowan's conclusions do not apply to the Westwater Canyon throughout its depositional extent. Indeed, Cowan's study area is just east of Gallup near Red Rock State Park, only a few miles west of Church Rock. Any competent geologist would readily extend Cowan's conclusions into the Church Rock area, given the vast scale of the Westwater Canyon Member river system.

AFFIRMATION

I declare on this 20th day of May, 1999, at Albuquerque, New Mexico,
under penalty of perjury that the foregoing is true and correct to the best of my
knowledge, and the opinions expressed herein are based on my best professional
judgment.


Spencer G. Lucas

Sworn and subscribed before me, the undersigned, a Notary Public in and for
the State of New Mexico, on this 20th day of May, 1999.


Notary Public

My Commission expires on:

10-22-2002.

CURRICULUM VITAE

NAME

Spencer George Lucas
Born April 25, 1955
Minneapolis, Minnesota
U.S. Citizen

ADDRESS

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EDUCATION

1976 - B.A. (summa cum laude and with honors)
University of New Mexico (Anthropology)
1979 - M.S. Yale University (Geology)
1979 - M. Phil. Yale University (Geology)
1984 - Ph.D. Yale University (Geology)

EMPLOYMENT

1988 - present Curator of Paleontology and Geology,
New Mexico Museum of Natural History
1989 - 1991 Chairman, Science Department, New
Mexico Museum of Natural History.
1988 - present Adjunct Associate Professor of
Geology, University of New Mexico.
1984 - 1988 Curator and Adjunct Assistant Professor of
Geology, University of New Mexico.
1982-1983 Geologist, Esca-Tech Corporation, Albuquerque,
New Mexico

PROFESSIONAL ORGANIZATIONS

Albuquerque Geological Society (Vice President, 1990)
New Mexico Geological Society (Managing Editor, 1987-
1990; General Chairman, Annual Fall Field Conferences,
1985, 1987, 1992); elected Honorary Member, 1994
New Mexico Academy of Science (Life Member; President
elect, 1991, President, 1992, Past-President, 1993)
Paleontological Society (President, Rocky Mountain
Section, 1991)
Society of Vertebrate Paleontology (Member, Government
Liaison Committee, 1989-1994)

EXHIBIT

A

Voting member, **Subcommission on Triassic Stratigraphy**, International Union of Geological Sciences (1990-present)

GRANTS, AWARDS AND FELLOWSHIPS

1976 - Sigma XI Grant-in-Aid-of-Research "Studies of Early Tertiary Vertebrate Fossils" [\$150].

1977 - Yale University Graduate Fellowship.

1978 - Sigma XI Grant-in-Aid-Research "Taphonomy of Drought" [\$300]; James Dwight Dana Fellowship in Geology, Yale University.

1979 - National Science Foundation Doctoral Dissertation Improvement Grant DEB-7919681: "Species-level evolution of *Coryphodon* " [\$6,000]; Alan Bateman Fellowship in Geology, Yale University.

1980 - James Dwight Dana Fellowship in Geology, Yale University

1982 - Swedish National Science Foundation Grant for Study of fossil vertebrates from China housed in the Paleontologiska Institution, Uppsala University, Sweden [\$3,000]; Philip M. Orville Prize for outstanding research by a graduate student in geology, Yale University; Contract YA-553-CTI-129 from U.S. Bureau of Land Management for Paleontological Resource Inventory of White River Resource Area, northwestern Colorado [\$150,000].

1984 - University of New Mexico Foundation for renovation of UNM Geology Museum (with R.C. Ewing and B.S. Kues) [\$15,000]; New Mexico Natural Resources Department for preparation of museum exhibit for Elephant Butte State Park, New Mexico [\$1,000].

1989 - *Coelophysis* Society Research Award, New Mexico Museum of Natural History.

1989 - 1991 - Petrified Forest Museum Association (with K.K. Kietzke) for studies of late Triassic microfossils [\$3,500].

1991 - Petrified Forest Museum Association (with A. P. Hunt) for studies of Late Triassic amphibians [\$1,000]

1991-1993 - National Geographic Society (with A. P. Hunt) to study Upper Triassic stratigraphy and paleontology in Wyoming-Idaho [\$10,000].

1992-1994 - National Geographic Society (with F. S. Szalay) to study early Cenozoic mammals of Soviet Central Asia [\$20,000].

1992-1993 - Petrified Forest Museum Association, to support the Nonmarine Triassic Symposium [\$10,000].

1994 - BLM Contract to study Early Permian footprints [\$65,000]; CONACYT grant to study Triassic-Jurassic of northern Mexico [\$60,000].

1995 - National Geographic Society (with R. J. Emry) to study early Cenozoic stratigraphy and biostratigraphy of the Zaysan basin, Kazakhstan [\$43,000]; Petrified Forest Museum Association to study Triassic stratigraphy [\$2,000]; Dinosaur Society to study Cretaceous dinosaurs of Kazakhstan [\$4,000]

TEACHING EXPERIENCE

1983-1995 University of New Mexico, Departments of Geology and Anthropology: taught Geology 101 (Physical Geology), 102 (Historical Geology), 210 (Earth Environment), 211 (Dinosaurs), 520 (Vertebrate Paleontology), 540 (Advanced Stratigraphy/ Sedimentology), Geology 470/Anthro 470 (Paleontological field techniques), Anthro 450 (Primate evolution).

I have served on 6 M.S. thesis committees (3 as co-advisor) and 4 Ph.D. committees (4 as co-advisor) and teach Geology 211 as an adjunct faculty member.

Spencer G. Lucas

Scientific Bibliography

AUTHORED BOOKS

1993

Dinosaurs of New Mexico. Albuquerque, New Mexico Academy of Science [New Mexico Journal of Science, v. 32], 130 pp.

1994

Dinosaurs the Textbook. Dubuque, Wm. C. Brown Publishers, 290 pp.

Instructor's Manual to Accompany Dinosaurs the Textbook. Dubuque, Wm. C. Brown Publishers, 73 pp.

1997

Dinosaurs: The Textbook. Second edition. DuBuque, Wm. C. Brown Publishers, 292 pp.

Instructor's Manual. Dinosaurs: The Textbook. Second Edition. DuBuque, Wm. C. Brown Publishers, 74 pp.

EDITED BOOKS

1981

Advances in San Juan Basin Paleontology. Albuquerque, University of New Mexico Press, 393 pp. (edited by S.G. Lucas, J.K. Rigby, Jr., and B.S. Kues).

1985

Santa Rosa — Tucumcari region [New Mexico Geological Society, Guidebook, 36th Annual Field Conference]. Socorro, New Mexico Geological Society, 344 pp. (edited by S.G. Lucas and J. Zidek).

Studies of Chinese Fossil Vertebrates. Bulletin of the Geological Institutions of the University of Uppsala, New Series, 11, 150 pp. (edited by S.G. Lucas and N.J. Mateer).

1987

Northeastern New Mexico [New Mexico Geological Society, Guidebook, 38th Field Conference]. Socorro, New Mexico Geological Society, 354 pp. (edited by S.G. Lucas and A.P. Hunt).

EXHIBIT

B

1988

Cretaceous and Laramide Tectonic Evolution of Southwestern New Mexico [New Mexico Geological Society, Guidebook, 39th Annual Field Conference]. Socorro, New Mexico Geological Society, 216 pp. (edited by G.H. Mack, T.F. Lawton and S.G. Lucas).

1989

Dawn of The Age of Dinosaurs in The American Southwest. Albuquerque, New Mexico Museum of Natural History, 414 pp. (edited by S.G. Lucas and A.P. Hunt).

Energy Frontiers in the Rockies. Albuquerque, Albuquerque Geological Society, 168 pp. (edited by J.C. Lorenz and S.G. Lucas).

Southeastern Colorado Plateau [New Mexico Geological Society, Guidebook, 40th Field Conference]. Socorro, New Mexico Geological Society, 346 pp. (edited by O.J. Anderson, S.G. Lucas, D.W. Love and S.M. Cather).

1990

Tectonic Development of the Southern Sangre de Cristo Mountains, New Mexico. [New Mexico Geological Society, Guidebook, 41st Field Conference]. Socorro, New Mexico Geological Society, 450 pp. (edited by P.W. Bauer, S.G. Lucas, C.K. Mawer and W.C. McIntosh).

1991

Geology of the Sierra Blanca, Sacramento and Capitan Ranges, New Mexico [New Mexico Geological Society, Guidebook, 42nd Field Conference]. Socorro, New Mexico Geological Society, 361 pp. (edited by J.M. Barker, B.S. Kues, G.S. Austin and S.G. Lucas).

1992

San Juan Basin IV [New Mexico Geological Society, Guidebook, 43rd Field Conference]. Socorro, New Mexico Geological Society, 412 pp. (edited by S.G. Lucas, B.S. Kues, T.E. Williamson and A.P. Hunt).

1993

Vertebrate paleontology in New Mexico: New Mexico Museum of Natural History and Science, Bulletin 2, 338 pp. (edited by S. G. Lucas and J. Zidek).

The Nonmarine Triassic: New Mexico Museum of Natural History and Science, Bulletin 3, 544 pp. (edited by S. G. Lucas and M. Morales).

1995

Early Permian footprints and facies: New Mexico Museum of Natural History and Science, Bulletin 6, 301 pp. (edited by S. G. Lucas and A. B. Heckert).

1997

Yin, Late Palaeozoic and early Mesozoic circum-Pacific events and their global correlation. Cambridge, Cambridge University Press, 245 pp. (Edited by J. M. Dickins, Z. Yang, H. S. G. Lucas and S. K. Acharyya).

Mesozoic Geology and Paleontology of the Colorado Plateau [New Mexico Geological Society Guidebook 48]: Socorro, New Mexico Geological Society (edited by O. J. Anderson, B. S. Kues and S. G. Lucas), 288 pp.

New Mexico's Fossil Record 1: New Mexico Museum of Natural History and Science Bulletin 11, 143 pp. (edited by S. G. Lucas, J. W. Estep, T. E. Williamson and G. S. Morgan).

Late Paleozoic and early Mesozoic circum-Pacific events: Biostratigraphy, tectonics and ore deposits of Primorye (Far East Russia): *Mémoires de Géologie* (Lausanne), no. 30, 202 pp. (edited by A. Baud, I. Popova, J. M. Dickins, S. G. Lucas and Y. Zakharov).

1998

Permian stratigraphy and paleontology of the Robledo Mountains, New Mexico: New Mexico Museum of Natural History and Science Bulletin 12, 98 pp. (edited by S. G. Lucas, J. W. Estep and J. M. Hoffer).

Lower and Middle Cretaceous Terrestrial Ecosystems: New Mexico Museum of Natural History and Science Bulletin 14, 330 pp. (edited by S. G. Lucas, J. I. Kirkland and J. W. Estep).

The Permian-Triassic boundary and global Triassic correlations: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 143, p. 195-384 (edited by S. G. Lucas and H. Yin).

Late Paleocene-early Eocene climatic and biotic events in the marine and terrestrial records. New York: Columbia University Press, 513 pp. (edited by M-P. Aubry, S. G. Lucas and W. A. Berggren).

ARTICLES IN SCIENTIFIC JOURNALS

1979

Comment on "Biostratigraphy and magnetostratigraphy of Paleocene terrestrial deposits, San Juan Basin, New Mexico." *Geology*, v. 7, p. 323-327 (S.G. Lucas and J.K. Rigby, Jr.).

Comment on "Geologic implications of the relationship between mammalian faunal similarity and geographic distance." *Geology*, v. 7, p. 327-328 (S.G. Lucas and S.M. Raza).

New discoveries of fossil primates from the type Torrejonian (middle Paleocene) of New Mexico. *Folia Primatologica*, v. 32, p. 1-7 (C.B. Wood, G.C. Conroy and S.G. Lucas).

1980

Taxonomic status of *Eohyus* Marsh, 1894. Postilla [Yale Peabody Museum of Natural History], no. 182, 6 pp.

1981

Occurrence of *Pantolambda* (Mammalia; Pantodonta) in the Torrejonian *Deltatherium* "zone," San Juan Basin, New Mexico. *American Journal of Science*, v. 281, p. 187-191 (S.G. Lucas and F.M. O'Neill).

Akanthosuchus langstoni, a new crocodile from the Nacimiento Formation (Paleocene, Torrejonian) of New Mexico: *Journal of Paleontology*, v. 55, p. 340-352 (F.M. O'Neill, S.G. Lucas and B.S. Kues).

The systematics of *Forstercooperia*, a middle to late Eocene hyracodontid (Perissodactyla, Rhinocerotidae) from Asia and western North America. *Journal of Paleontology*, v. 55, p. 826-841 (S.G. Lucas, R.M. Schoch and E. Manning).

A mosasaur from the Upper Cretaceous Lewis Shale in northwestern New Mexico. *New Mexico Geology*, v. 3, p. 37-40 (S.G. Lucas and P.K. Reser).

Cope, Marsh and the type of *Lystrosaurus frontosus*, a mammal-like reptile from the Triassic of South Africa. *Discovery* [Yale Peabody Museum of Natural History], v. 15, p. 28-33 (S.G. Lucas and R.M. Schoch).

The systematics of *Stylinodon*, an Eocene taeniodont from western North America. *Journal of Vertebrate Paleontology*, v. 1, p. 175-183 (R.M. Schoch and S.G. Lucas).

New conoryctines (Mammalia; Taeniodonta) from the middle Paleocene (Torrejonian) of western North America. *Journal of Mammalogy*, v. 62, p. 683-691 (R.M. Schoch and S.G. Lucas).

The systematics of *Rhodopagus*, a late Eocene hyracodontid (Perissodactyla; Rhinocerotidae) from China. Bulletin of the Geological Institutions of the University of Uppsala, v. 9, p. 843–850 (S.G. Lucas and R.M. Schoch).

A new species of *Conoryctella* (Mammalia; Taeniodonta) from the Paleocene of the San Juan Basin, New Mexico and a revision of the genus. Postilla [Yale Peabody Museum of Natural History], no. 185, 23 pp. (R.M. Schoch and S.G. Lucas).

Basalina, a tilodont from the Eocene of Pakistan. Mitteilungen der Bayerische Staatssammlung, v. 21, p. 89–95 (S.G. Lucas and R.M. Schoch).

Cenozoic continental deposits of New Mexico: an overview. Geological Society of America Bulletin, Part I, v. 92, p. 917–932 (S.G. Lucas and R.V. Ingersoll).

The Eocene biostratigraphy of New Mexico. Geological Society of America Bulletin, Part I, v. 92, p. 951–967 (S.G. Lucas, R.M. Schoch, E. Manning and C. Tsentas).

Lexicon of Cenozoic rock-stratigraphic units of New Mexico, 1869–1980. Geological Society of America Bulletin, Part II, v. 92, p. 1807–1981 (S.G. Lucas and R.V. Ingersoll).

Annotated bibliography of the Eocene paleontology and stratigraphy of New Mexico: Geological Society of America Bulletin, Part II, v. 92, p. 2268–2307 (S.G. Lucas, R.M. Schoch, E. Manning and C. Tsentas).

1982

A middle Eocene titanothere from the Baca Formation, south-central New Mexico. Journal of Paleontology, v. 56, p. 542–545 (S.G. Lucas, D.L. Wolberg, A.P. Hunt and R.M. Schoch).

An occurrence of *Ichthyornis* in the Late Cretaceous Mancos Shale (Juana Lopez Member), northwestern New Mexico. Journal of Paleontology, v. 56, p. 545–547 (S.G. Lucas and R.M. Sullivan).

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Discussion — magnetic polarity zonation and biostratigraphy of Late Cretaceous and Paleocene continental deposits, San Juan Basin, New Mexico. American Journal of Science, v. 282, p. 920–927 (S.G. Lucas and R.M. Schoch).

Vertebrate paleontology, stratigraphy and biostratigraphy of Eocene Galisteo Formation, north-central New Mexico. New Mexico Bureau of Mines and Mineral Resources, Circular 186, 34 pp.

Bibliography of papers published by E.D. Cope on the Paleocene of the San Juan Basin, New Mexico. New Mexico Journal of Science, v. 22, p. 52–55.

1983

The taxonomic status of *Australopithecus afarensis* Johanson in Hinrichsen 1978 (Mammalia, Primates). Haliksa'i [UNM Contributions to Anthropology], v. 2, p. 16-27 (T.R. Logan, S.G. Lucas and J.C. Sobus).

Pathologic vertebra of a Late Cretaceous mosasaur from northwestern New Mexico. New Mexico Journal of Science, v. 23, p. 28-32 (S.G. Lucas and P.K. Reser).

Endocranial cast of a Puercan (early Paleocene) crocodilian from the San Juan Basin, New Mexico. Copeia, v. 1983, p. 842-845 (G.W. Storrs, S.G. Lucas and R.M. Schoch).

Glyptosaurine lizard from Eocene Baca Formation, south-central New Mexico. New Mexico Geology, v. 5, p. 77-78 (S.G. Lucas, R.M. Sullivan and T.R. Logan).

Vertebrate paleoecology of the late Campanian (Cretaceous) Fruitland Formation, San Juan Basin, New Mexico (U.S.A.). Acta Palaeontologica Polonica, v. 28, p. 195-204 (S.G. Lucas and N.J. Mateer).

Aphelops and other Miocene vertebrates collected from the Tesuque Formation (Espanola basin, New Mexico) by the Wheeler Survey in 1873. New Mexico Journal of Science, v. 23, p. 28-36 (S.G. Lucas and R.M. Schoch).

Protitanotherium (Mammalia, Perissodactyla) from the Eocene Baca Formation, west-central New Mexico. New Mexico Journal of Science, v. 23, p. 39-47.

Comments on two species of the Eocene artiodactyl *Homacodon* and the taxonomic status of *Nanomeryx caudatus* Marsh, 1894. New Mexico Journal of Science, v. 23, p. 48-56.

1984

A new look at the discovery of "Peking Man." Haliksa'i [UNM Contributions to Anthropology], v. 3, p. 148-154 (S.G. Lucas and J.C. Sobus).

Early Paleocene vertebrates, stratigraphy and biostratigraphy, West Fork of Gallegos Canyon, San Juan Basin, New Mexico. New Mexico Geology, v. 6, p. 56-60.

Late Cretaceous (Lancian) dinosaurs from the McRae Formation, Sierra County, New Mexico. New Mexico Geology, v. 6, p. 72-77 (R.P. Lozinsky, A.P. Hunt, D.L. Wolberg and S.G. Lucas).

Choeropsis Leidy, 1852 (Artiodactyla): proposed conservation under the plenary powers. Z.N.(S.) 2407. Bulletin of Zoological Nomenclature, v. 41, p. 94-96 (R.M. Schoch and S.G. Lucas).

Pleistocene horse from the Albuquerque area, New Mexico. New Mexico Journal of Science, v. 24, p. 29-32 (S.G. Lucas and T.R. Logan).

Synopsis of the species of *Coryphodon* (Mammalia, Pantodonta). New Mexico Journal of Science, v. 24, p. 33–42.

Leptotomus (Mammalia, Rodentia) from the Eocene "Baca" Formation, south-central New Mexico. New Mexico Journal of Science, v. 24, p. 43–46.

Taxonomic status of *Titanoides simpsoni* Simons, 1860 and some observations on *Pantolambda* Cope, 1882 (Mammalia, Pantodonta). New Mexico Journal of Science, v. 24, p. 46–52.

1985

Shark vertebrae from the Upper Cretaceous Pierre Shale, northeastern New Mexico. New Mexico Bureau of Mines and Mineral Resources, Circular 195, p. 21–23 (S.G. Lucas, P.K. Reser and D.L. Wolberg).

Dinosaurs from the Upper Jurassic Morrison Formation in New Mexico. New Mexico Journal of Science, v. 25, p. 1–12 (S.G. Lucas and A.P. Hunt).

Discussion: a critique [of] chronostratigraphy. American Journal of Science, v. 285, p. 764–766.

Mosasaur remains from the Lewis Shale (Upper Cretaceous), southwestern Colorado. Journal of Paleontology, v. 59, p. 1395–1406 (B.S. Kues and S.G. Lucas).

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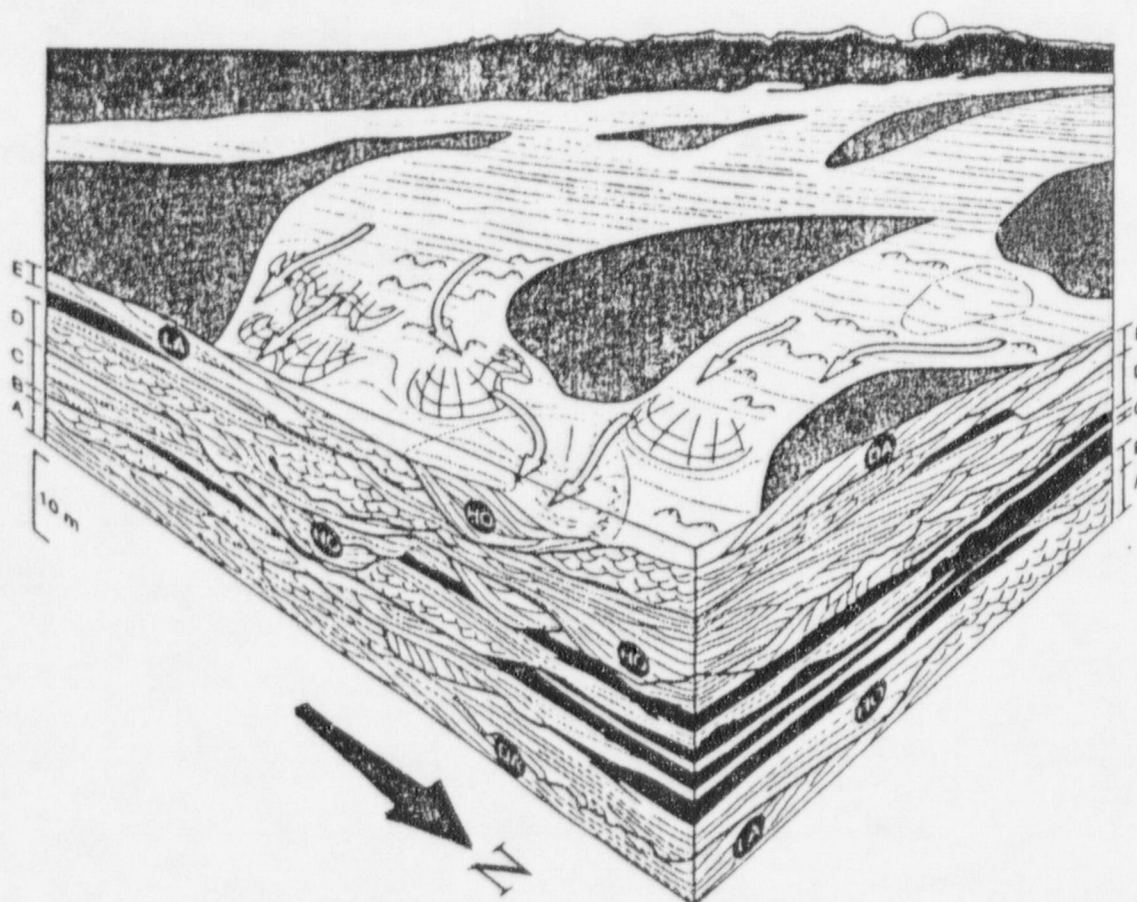


FIG. 18.--The large-scale architectural model of the Westwater Canyon Member fluvial system. The block diagram illustrates waning-stage flow, seen looking toward the southwest and the Late Jurassic magmatic arc. The sandstone units produced between each avulsive event of the channel belt are approximately 5 m thick, and are bounded by laterally-extensive fifth-order bounding surfaces. The width of the sandstone sheets is most likely >1 km. The sandstone bodies can be either single or composite channel-belt sandstones, depending on their vertical stacking, as shown by the examples of sandstone sheets A to E. The large hollows (labelled HO) within the sandstone sheets are interpreted as channel-confluence scours produced downstream of emergent channel sand bars, which in turn produce low-amplitude lateral accretion (LA) and downstream accretion (DA) deposits.