



Geology of the Zuni Plateau



Editors:

Spencer G. Lucas
Steven C. Semken
William R. Berglof
Dana S. Ulmer-Scholle



**New Mexico Geological Society
Fifty-fourth Annual Field Conference
September 24-27, 2003**

CONTENTS

Dedication.....	vi
President's Message.....	vii
Editors' Message.....	viii
Committees.....	ix
Field Conference Schedule and Credits.....	x

ROAD LOGS

First-day road log, from Gallup to Gamerco, Yah-Ta-Hey, Window Rock, Fort Defiance, Navajo, Todilto Park, Crystal, Narbona Pass, Sheep Springs, Tohatchi and Gallup.....	
..... <i>S.G. Lucas, S.C. Semken, A.B. Heckert, W.R. Berglof, G. Hoffman, B.S. Kues, L.S. Crumpler and J.C. Aubele</i>	1

Minipapers:

The Laramide Defiance uplift.....	<i>S.M. Cather</i>	6
No dextral offset of Jurassic strata across the Defiance monocline.....	<i>S.G. Lucas</i>	7
Lectostratotype section of the Jurassic Todilto Formation, western New Mexico.....	<i>S.G. Lucas, A.B. Heckert and W.R. Berglof</i>	15
Green Knobs ultramafic diatreme and carbon dioxide sequestration investigations.....	<i>F. Goff</i>	16
The age of the Chuska Sandstone.....	<i>S.G. Lucas</i>	19
Julian Sears and Cretaceous transgressive-regressive deposition.....	<i>S.G. Lucas</i>	33

Second-day road log, from Gallup to Fort Wingate, Sixmile Canyon, Ciniza, Red Rock Park, Church Rock, White Mesa, Thoreau and Grants.....	
..... <i>S.G. Lucas, A.B. Heckert, W.R. Berglof, B.S. Kues, L.S. Crumpler, J.C. Aubele, V.T. McLemore, D.E. Owen and S.C. Semken</i>	35

Minipapers:

From Bear Spring to Fort Wingate.....	<i>A.B. Heckert, B.S. Kues and S.C. Semken</i>	37
The Upper Triassic Sonsela Member of the Petrified Forest Formation in the Zuni Mountains.....	<i>A.B. Heckert and S.G. Lucas</i>	44
The Upper Triassic Perea Sandstone Bed (Petrified Forest Formation, Painted Desert Member) in the Zuni Mountains.....	<i>A.B. Heckert and S.G. Lucas</i>	50
Deposition of the Upper Triassic Owl Rock Formation, west-central New Mexico.....	<i>S.G. Lucas and A.B. Heckert</i>	52
Red Rock Park.....	<i>V.T. McLemore</i>	54
Clarence Dutton.....	<i>S.G. Lucas</i>	57
Bluewater Lake State Park.....	<i>V.T. McLemore</i>	63

Third-day road log, from Grants to Milan, Homestake Mining Company, Dos Lomas, Haystack Mountain and El Tintero.....	
..... <i>S.G. Lucas, A.B. Heckert, W.R. Berglof, L.S. Crumpler, J.C. Aubele, B.S. Kues and V.T. McLemore</i>	69

Minipapers:

Mineral resources of East Grants Ridge.....	<i>V.T. McLemore and J.M. Barker</i>	70
Homestake Mill.....	<i>V.T. McLemore</i>	75
The Mount Taylor volcanic field.....	<i>L.S. Crumpler</i>	75

Supplemental road log 1, from Grants to eastern margin of El Malpais, Sandstone Bluffs Overlook, and McCarty's lava flow.....	<i>L.S. Crumpler, J.C. Aubele, S.G. Lucas and A.B. Heckert</i>	85
Supplemental road log 2, Lobo Canyon, from Grants to San Mateo to Milan.....	<i>P.B. Jackson Paul and V.T. McLemore</i>	92
Road log references.....		95

ARTICLES

Thesaurus

A Navajo-English thesaurus of geological terms.....	<i>A. Blackhorse, S. Semken and P. Charley</i>	103
---	--	-----

Precambrian Geology and Tectonics

Proterozoic evolution of the Zuni Mountains, western New Mexico: Relationship to the Jemez lineament and implications for a complex cooling history.....	<i>D. Strickland, M.T. Heizler, J. Selverstone and K.E. Karlstrom</i>	109
Polypphase Laramide tectonism and sedimentation in the San Juan Basin, New Mexico.....	<i>S.M. Cather</i>	119

<i>Volcanology</i>	
Black rocks protruding up: The Navajo volcanic field	S. Semken 133
Geology and petrogenesis of very unusual silicate veins at El Porticito vent, Catron County, New Mexico	R.R. Horning, N. W. Dunbar, W.S. Baldrige and P.R. Kyle 139
Natural scoria cone half-section, East Grants Ridge: A test of basalt pyroclastic eruption models.....	L.S. Crumpler 155
<i>Economic Geology</i>	
Uranium resources in the San Juan Basin, New Mexico	V.T. McLemore and W.L. Chenoweth 165
Economic geology of the Todilto Formation	W.R. Berglof and V.T. McLemore 179
<i>Hydrogeology</i>	
Hydrostratigraphy, hydrodynamics, and hydrochemistry—geologic controls of ground-water phenomena in the San Juan Basin	W.J. Stone 191
Late Holocene behavior of small drainage basins on the Colorado Plateau: Influences of lithology, basin form, and climate change	A. Tillery, P Fawcett, L. McFadden, L. Scuderi and J. McAuliffe 197
<i>Stratigraphy, sedimentology and paleontology</i>	
Clarence Dutton's stratigraphy of west-central New Mexico	S.G. Lucas 209
Upper Pennsylvanian strata in the Zuni Mountains, west-central New Mexico	K. Krainer, S.G. Lucas, and B. S. Kues 219
Lower Permian terrestrial paleoclimatic indicators in New Mexico and their comparison to paleoclimate models...G.H. Mack	231
Tetrapod footprints from the Middle Triassic (Perovkan-early Anisian) Moenkopi Formation, west-central New Mexico....	S.G. Lucas, A.B. Heckert and A.P. Hunt 241
Triassic stratigraphy in the Zuni Mountains, west-central New Mexico	A. B. Heckert, and S. G. Lucas 245
Possible tectonic controls on Late Triassic sedimentation in the Chinle basin, Colorado Plateau	L.H. Tanner 263
Pedogenic features of the Chinle Group, Four Corners region: Evidence of Late Triassic aridification	L.H. Tanner 269
Stratigraphy and paleontology of the lower Chinle Group (Adamanian: latest Carnian) in the vicinity of St. Johns, Arizona	A.B. Heckert and S.G. Lucas 281
Jurassic stratigraphy in west-central New Mexico	S.G. Lucas and A.B. Heckert 289
The Middle Jurassic Entrada Sandstone in northeastern Arizona and adjacent areas	R.B. O'Sullivan 303
An Upper Jurassic theropod dinosaur from the section 19 mine, Morrison Formation, Grants uranium district	A.B. Heckert, J.A. Spielmann, S.G. Lucas, R. Altenberg and D.M. Russell 309
Geology and paleontology of the Upper Jurassic (Morrison Formation: Brushy Basin Member) Peterson quarry, central New Mexico	A.B. Heckert, K.E. Zeigler, S.C. Lucas, J.A. Spielmann, P.M. Hester, R.E. Peterson, R.E. Peterson, and N.V.D. D'Andrea 315
Stratigraphy of the Dakota Sandstone and intertongued Mancos Shale along the southern flank of the San Juan Basin, west-central New Mexico.....	D.E. Owen and D.E. Owen, Jr. 325
Exceptionally preserved invertebrate fauna from the Upper Cretaceous Paguate Member of the Dakota Formation, Rio Puerco Valley, New Mexico.....	P.L. Scale and S.G. Lucas 331
Turonian ammonites from the Upper Cretaceous D-Cross Member of the Mancos Shale, Cebollita Mesa, Cibola County, New Mexico	P.L. Sealer and S.G. Lucas 339
Cretaceous invertebrate and selachian fossil assemblage from the Juana Lopez Member of the Mancos Shale near Herrera, west-central New Mexico.....	S.G. Lucas and S.C. Johnson 347
Selachian fauna from the Upper Cretaceous Dalton Sandstone, middle Rio Puerco Valley, New Mexico.....	S.C. Johnson and S.G. Lucas 353
Stratigraphy, age and correlation of the Upper Cretaceous Tohatchi Formation, western New Mexico	S.G. Lucas, D.R. Braman and J.A. Spielmann 359
The Kirtlandian, a new land-vertebrate "age" for the Late Cretaceous of western North America.R.M. Sullivan and S.G. Lucas	369
A new hadrosaur track from the Upper Cretaceous Fruitland Formation of northwestern New Mexico	A.P. Hunt and S.G. Lucas 379
Origin and stratigraphy of historic dinosaur quarries in the Upper Cretaceous Fruitland Formation of the Fossil Forest Research Natural Area, northwestern New Mexico	A.P. Hunt and S.G. Lucas 383
Stratigraphy of the Paleogene Chuska Sandstone, New Mexico-Arizona	S.G. Lucas and S.M. Cather 389
Genetic stratigraphy, provenance, and new age constraints for the Chuska Sandstone (upper Eocene-lower Oligocene), New Mexico-Arizona	S.M. Cather, L. Peters, N. W Dunbar and W.C. McIntosh 397
Pleistocene mammals from Zuni Pueblo, west-central New Mexico	S.G. Lucas and G.S. Morgan 413
Stratigraphy and paleontology of Trapped Rock Draw mastodont site, Zuni, New Mexico	P.G. Drakos, S.G. Lucas, G.S. Morgan and S.L. Reneau 419

DEDICATION

With great pleasure, I dedicate this book to one of the foremost students of the geology of west-central New Mexico, Orin .1. Anderson. Born in 1938 in Bakersfield, California, the key years of Orin's youth were spent on the family farm in North Dakota. Orin received a bachelor's degree in geology from the University of North Dakota in 1961, and then was employed as a geologist by the U. S. Bureau of Reclamation in Billings, Montana. His work focused on geological investigations of proposed dam and reservoir sites, power transmission corridors and irrigation facilities. Orin soon moved to Minneapolis-St. Paul, where he first spent two years working for Soil Exploration Company, mostly involved in drilling for foundations at proposed construction sites. He then worked for Litton Industries as a soil mineralogist and microbiologist. Further employment followed at the Limnological Research Center of the University of Minnesota, working on lake sediments and water geochemistry.

In 1970, Orin returned to school at the University of New Mexico, where he completed a masters degree in geology in 1973 (thesis topic: "Geology of the Seistan basin, southwestern Afghanistan"). He then took a position as a staff geologist in the Office of the State Geologist in Santa Fe, New Mexico. Here, Orin worked as an economic geologist focused on coal and uranium resources. In 1979, Orin moved to Socorro to the New Mexico Bureau of Mines and Mineral Resources, where he remained for 19 years until his retirement in 1998. Orin began work at the Bureau as a coal geologist, primarily evaluating coal resources and mapping coal-bearing strata in west-central New Mexico. He advanced to the position of Senior Geologist, and



Orin Anderson measuring a stratigraphic section in the Morrison Formation at Placitas, New Mexico in 2000.

from 1989 to 1995, devoted most of his effort to compiling a new, 1:500,000 scale geologic map of the state of New Mexico.

During his nearly two decades at the Bureau, Orin mapped (mostly singlehanded) the geology of fifteen 7.5-minute quadrangles in west-central New Mexico, from Zuni Salt Lake on the south, to Fort Wingate on the north. He also mapped the geology of the Fence Lake 1:100,000 sheet, and several of the quadrangles he mapped were combined for publication as the Atarque Lake 1:50,000 sheet. When Orin retired, much more mapping in west-central New Mexico was completed or underway.

But, beyond the coal geology and the geologic mapping, Orin Anderson solved major problems of the regional stratigraphy of west-central New Mexico, especially with regard to the Jurassic rocks. In particular, in two articles published in 1983, Orin redefined Dutton's 1885 term Zuni Sandstone and deftly solved a problem of Jurassic regional stratigraphy that had persisted for nearly a century.

I should also point out that Orin did yeoman service to the New Mexico Geological Society over many years. He served on the Society's Executive Committee, especially in publication sales. He co-organized two field conferences, in west-central New Mexico (1989) and in the Four Corners (1997), and he helped with many others. The Society elected him an Honorary Member in 1987.

I began to work with Orin in 1988 on that west-central New Mexico field conference. That conference ended at Dowa Yalannê, the sacred mountain of the Zuni people, and the type section of Dutton's Zuni Sandstone. Something was very wrong with how the U. S. Geological Survey interpreted the Jurassic strata on that sacred mountain, Orin and I realized it, and we set out to re-evaluate the Jurassic section on the southern Colorado Plateau. We spent the next decade working on various problems of Mesozoic (mostly Jurassic) stratigraphy in Utah, Arizona, Colorado, New Mexico and West Texas. What came out of it was a revised Jurassic regional stratigraphy and the new interpretations of Jurassic depositional history and paleogeography that the stratigraphy supports. Orin's firm grasp of basic stratigraphic principles, his willingness to question anything in print, his no nonsense approach to lithostratigraphy and his tirelessness on the outcrop were central to the work. I learned much from Orin, and I learned much about him, particularly the meaning of the phrase "you can tell a Swede, but you can't tell him much."

Orin's contributions to the geology of west-central New Mexico thus stand out as both extensive and incisive. In my mind, he joins that short list of the great students of the geology of west-central New Mexico, which now includes Clarence Dutton, Julyan D. Sears, Charles Maxwell and Orin Anderson.

Spencer G. Lucas

PRESIDENT'S MESSAGE

Welcome to the 54th annual Fall Field Conference of the New Mexico Geological Society. This year's conference marks our eighth venture into neighboring Arizona. The first day will find us in the Navajo Nation heartland, very near the area covered by the 18' fall field conference in 1967. This year, with kind permission from the Navajo Nation, we will travel ground never before visited by the Society through Todilto Park and Narbona Pass. On the second day the conference moves its headquarters from Gallup to Grants, taking in the sights and geology of the red rock country. And, on the last day, among other sights, we will view remains of the once-prosperous Grants uranium belt.

Once again Spencer Lucas steps into the breach and serves the Society as your conference co-chair and guidebook editor along with first-timers Bill Berglof and Steven Semken. The road logs you will be following are also the handiwork of Andy Heckert, Barry Kues, Virginia McLemore, Larry Crumpler, Jayne Aubele, Gretchen Hoffman and Don Owen. Fall field conferences do not happen as effortlessly or as spontaneously as they seem, so please take the time to express your appreciation to these individuals. Dana Ulmer-Scholle is once again the Managing Editor of an entirely digital guidebook. The conversion from the days of pencil and Mylar to those of software and electronic data transfer was not always an easy process. We owe a tremendous thank you to Dana for completing this transformation.

The 2003 NMGS Spring Meeting was dedicated to cave and karst geology and included a keynote address by Louise Hose, Director of the newly opened Cave and Karst Research Institute in Carlsbad. The cave and karst theme contributed to a very successful meeting this Spring, and our thanks go to Bill Raatz (General Chair), Penny Boston (Technical Chair) and Sean Connell (Registration Chair).

While the support of the New Mexico Bureau of Geology and Mineral Resources (Bureau) has been appreciated and recognized in this column before, I don't think the Society as a whole recognizes the extent and value of the Society's relationship with the Bureau. The Bureau provides a central location from which the Society operates. This support includes providing staff to maintain NMGS publication sales, membership and registrations for the Spring and Fall meetings. This relationship is beneficial to both sides in that it promotes the knowledge of geology throughout the State. At Society meetings, the publications and work of the Bureau are promoted and acknowledged. In turn, the Bureau promotes Society publications at meetings where Bureau publications are displayed. The State of New Mexico itself benefits from this relationship because it provides a basis for a robust professional organization, one of the largest, and the best geological society in this country. The NMGS Executive Committee has developed a memorandum of understanding with the Bureau, signed in April of this year, to memorialize this relationship.

Like last year, the Society continues to be financially healthy despite the financial market plunge and its affect on our scholarship fund investments. The CPA firm of Beckham and Penner, P.C., now manages the accounts of the Society. The assets of the Society, including scholarship fund accounts, publications inventory, our investment in the Bureau's publication storage building, and our checking account, now top \$1 million. It occurs to me that NMGS is no longer your father's professional society. Managing a million-dollar corporation requires careful and thoughtful planning. The total assets of the Society (as they always have been) are exposed to certain risks and liabilities. This exposure has become

more meaningful as the value has increased. The non-profit status of NMGS, Inc. is in serious jeopardy due to the growth of the Pipkin scholarship account, and the total value of the assets exceeds the amount of protection provided by any reasonably affordable liability insurance policy. The NMGS Executive Committee is considering a major organizational change to address these concerns and to assure that the Society's scholarship accounts are preserved and protected. As this guidebook goes to print, the Executive Committee is seeking professional legal advice as to the wisdom of forming a NMGS Foundation separate and distinct from NMGS, Inc. The thought is to move the growing scholarship accounts into the Foundation. Within this foundation the scholarship accounts would be protected from the normal liabilities of NMGS, Inc. They would be allowed to grow until they become self-sustaining. At the current rate of growth, we expect that could occur in as little as five years. The plan is for the scholarship accounts to become permanently endowed, assuring scholarship awards and subsidies in perpetuity. Some of our sister societies around the country have been using this process with great success for some time. Quite possibly, by the time you are reading this during the 2003 Fall Field Conference, the NMGS membership will have been part of a decision to take this momentous step. I wish to express appreciation to Brian Brister, NMGS Treasurer this year, acknowledging the work he has done in evaluating the productive capability of the Pipkin oil and gas leases and performing the economic analysis that has led to these conclusions.

This year we plan to award \$39,450 in scholarships, fellowships and research grants to both graduate and undergraduate students in New Mexico—a 40% increase over previous years! The overriding royalty in five oil and gas leases in the San Juan Basin, gifted to the Society by Lucille Pipkin, will allow us once again to award a full-year tuition scholarship to a deserving senior at each of the four New Mexico universities offering geosciences degrees. The Pipkin scholarship fund also provides free NMGS memberships to New Mexico undergraduate students and discounts on our publications. The Society enjoys the enviable position of being able to increase scholarship awards while growing the corpus of the scholarship accounts through operating surpluses, the Pipkin royalties, and investment strategies.

The 2004 Fall Field Conference heads to the Taos region and is being organized by Paul Bauer. The 2005 Fall Field Conference will find us in the San Mateo Mountains. It has been 23 years since I attended my first NMGS Fall Field Conference, missing only two conferences in all that time. Like my predecessors, I remain impressed by the participation and commitment of New Mexico geologists to maintaining the quality of our field trips and our Society. I encourage you not only to become more involved with NMGS, but to consider volunteering to be an officer and member of the Executive Committee as well. Borrowing from the words of our Treasurer, the favorable financial condition and quality of the New Mexico Geological Society has resulted from more than 50 years of member sweat-equity. The Society cannot maintain these achievements without your participation.

This year's conference will provide an opportunity to see and appreciate an area of New Mexico and Arizona which has not been visited by the Society in many years. I hope you enjoy the trip and have a great time.

EDITOR'S MESSAGE

In the summer of 1884, Clarence Dutton (1841-1912), working for a young U. S. Geological Survey, spent two months in west-central New Mexico doing geological field work to produce a map and report on the geology of what he termed the "Zuni Plateau." This area covered approximately 7700 square miles and extended from the Rio Puerco on the east to the Arizona-New Mexico border on the west, and from Zuni Pueblo on the south to the southern end of the Chuska Mountains on the north. Dutton's report stands as a remarkable classic of New Mexico geology. Its mapping, stratigraphy and volcanology provided a solid basis for all subsequent geologic studies in the region.

Long before Dutton, the lands of the Zuni Plateau sustained the indigenous peoples of the Zuni, Acoma, Laguna, and Dine (Navajo) nations. Landforms, climate, and water resources have always figured prominently in the histories, lifeways, arts and ceremonial knowledge of the Native Americans of this region. With respect and care, we will be traversing lands and viewing places many still consider to be sacred.

After Dutton, in the early twentieth century, Cretaceous coal in the Zuni Plateau brought a population explosion to the region and formed the backbone of a bustling economy in Gallup and nearby mining towns. Another U. S. Geological Survey geologist, Julian Sears (1891-1970), came to study the coal geology and with his colleagues provided the first true understanding of transgressive-regressive deposition and stratigraphy of the Cretaceous Western Interior seaway.

After the Second World War, a second mining surge occurred with the fabled discovery of uranium ore that turned Grants into a boom town. From the 1950s until the 1980s, what came to be called the Grants uranium region was the nation's most important source of uranium. Yet another perceptive U. S. Geological Survey geologist, Charles Maxwell (1923-2000) then appeared, and mapped a significant portion of the Zuni Plateau, thereby greatly improving understanding of the regional stratigraphy and volcanics.

The mining in the Zuni Plateau was of uranium and limestone products from the Jurassic strata and of coal from the Cretaceous section. This mining is a major focus of this field conference. The rocks that hosted the mines are a classic section of Mesozoic sediments exposed near the southern border of the Colorado Plateau. They, too, receive much attention in this field conference.

Additional mining, for fluorite, copper, silver, and gold, was in the Zuni Mountains just beyond the field conference route. Finally, long after the Mesozoic, two great volcanic fields pushed through and covered parts of the Zuni Plateau and surrounding regions—the Oligocene-Miocene Navajo volcanic field and the Pleistocene-Holocene Zuni-Bandera-El Malpais field. The intrusives and eruptives of both fields are also well examined by this field conference and by supplemental road log 1. The volcano Mount Taylor is visible during much of the second and third days of the field conference. Supplemental road log 2 covers part of the Pliocene Mount Taylor volcanic field, and reviews pumice and perlite mining. Thus, the conference and the guidebook pursue three major topics: Mesozoic strata, mining, and Cenozoic volcanics.

This is the fourth time that a field conference of the New Mexico Geological Society has visited at least part of the Zuni Plateau. However, the previous trips (in 1951, 1967 and 1989) followed routes that are different from those of this year's conference. In 2003, the conference is headquartered in Gallup and then moves to Grants. The road log routes cross the Chuska and Zuni Mountains and end in the Grants uranium belt. Members of the roadlogging committee worked with us to produce what we believe are detailed and instructive road logs of the conference routes. They deserve special thanks: Jayne Aubele, Larry Crumpler, Andrew Heckert, Gretchen Hoffman, Barry Kues, Virginia McLemore, and Don Owen. Dana Ulmer-Scholle's skill and good cheer as managing editor made this book possible. The Navajo Nation Minerals Department generously granted permission to conduct field studies on Navajo lands on the first day's trip. And, we also thank the following organizations and people for diverse support of the field conference and guidebook: New Mexico Museum of Natural History, U. S. Forest Service, New Mexico Bureau of Geology and Mineral Resources, WERC, a consortium for environmental education and technology development and Dine College.

Spencer G. Lucas
Steven C. Semken
William R. Berglof

COMMITTEES

2003 EXECUTIVE COMMITTEE

Gary Stephens, President	U.S. Bureau of Land Management
Jeffrey M. Amato, Vice President	New Mexico State University
Brian S. Brister, Treasurer	New Mexico Bureau of Geology & Mineral Resources
Jennifer Lindline, Secretary	New Mexico Highlands University
Maureen Wilks, Past President	New Mexico Bureau of Geology and Mineral Resources

FIELD CONFERENCE

Spencer G. Lucas	New Mexico Museum of Natural History
William R. Berglof	University of Maryland University College
Steven C. Semken	Dine College
Andrew B. Heckert	New Mexico Museum of Natural History

GUIDEBOOK

Spencer G. Lucas	New Mexico Museum of Natural History
William R. Berglof	University of Maryland University College
Steven C. Semken	Dine College
Dana Ulmer-Scholle, Managing Editor	New Mexico Institute of Mining & Technology

ROAD LOGS

Spencer G. Lucas, Chair	New Mexico Museum of Natural History
Andrew B. Heckert	New Mexico Museum of Natural History
Steven C. Semken	Dine College
William R. Berglof	University of Maryland University College
Barry S. Kues	University of New Mexico
Gretchen Hoffman	New Mexico Bureau of Geology and Mineral Resources
Virginia T. McLemore	New Mexico Bureau of Geology and Mineral Resources
Larry S. Crumpler	New Mexico Museum of Natural History
Jayne C. Aubele	New Mexico Museum of Natural History
Donald E. Owen	Lamar University

REGISTRATION

Theresa Lopez	New Mexico Bureau of Geology and Mineral Resources
---------------------	--

LOCAL ARRANGEMENTS

William R. Berglof	University of Maryland University College
Spencer G. Lucas	New Mexico Museum of Natural History
Steven C. Semken	Dine College

PUBLICATIONS COMMITTEE

James M. Barker, Chair	New Mexico Bureau of Geology & Mineral Resources
Richard M. Chamberlin	New Mexico Bureau of Geology & Mineral Resources

PUBLICATION SALES

Theresa Lopez	New Mexico Bureau of Geology & Mineral Resources
Susie Kyle	New Mexico Bureau of Geology & Mineral Resources

FIELD CONFERENCE SCHEDULE AND CREDITS

Wednesday, September 24, 2003 – Pre-meeting Trip and Registration Day

1:00 PM Pre-meeting Trip, El Malpais near Grants
 6:00 – 9:00 PM Registration and ice-breaker party, Best Western Inn and Suites, Gallup

Thursday, September 25, 2003 – First Day, round trip from Gallup to Narbona Pass and return

6:00 – 7:15 AM Breakfast (not provided)
 7:00 – 7:30 AM Registration, Best Western Inn and Suites, Gallup
 7:30 AM Buses leave Best Western Inn and Suites
 6:00 PM 8:00 Barbeque (provided), Red Rock State Park
 PM Return to Gallup

Friday, September 26, 2003 – Second Day, Gallup to Grants

6:00 – 7:15 AM Breakfast (not provided)
 7:00 – 7:30 AM Registration, Best Western Inn and Suites
 8:00 AM Caravan leaves Best Western Inn and Suites, Gallup
 6:00 PM Caravan arrives at Best Western Inn and Suites, Grants
 6:00 – 7:00 PM Optional visit to Grants Mining Museum (emphasis on uranium mining)
 6:00 – 7:00 PM Social hour, La Ventana Restaurant, Grants
 7:00 PM Annual Banquet (provided), La Ventana Restaurant, Grants

Saturday, September 27, 2003 – Third Day, Grants to Haystack Mountain

6:00 – 7:30 AM Breakfast (not provided)
 8:00 AM Caravan leaves Best Western Inn and Suites, Grants
 1:00 PM Field Conference ends at Haystack Mountain west of Grants

CREDITS

Front Cover: Photograph of Church Rock by Andrew Heckert

Inside Front Cover: Aerial photograph of field conference area by Mark Mansell, New Mexico
 Bureau of Geology and Mineral Resources

Title page: Geologic map of the Zuni Plateau by Clarence Dutton (1885)

Inside Back Cover: Stratigraphic chart of field conference area by Spencer G. Lucas

Logistical Assistance: Jim Barker and Gretchen Hoffman, New Mexico Bureau of Geology and Mineral
 Resources, New Mexico Museum of Natural History and Science

Photography and Figures: Spencer Lucas, Andrew Heckert, William Berglof

Formatting and Production: Dana Ulmer-Scholle

Printer: Starline Printing, Albuquerque, New Mexico

COPYRIGHT © 2003 by the New Mexico Geological Society, Inc.

The articles and roadlogs in this guidebook were prepared for the 54th annual field conference of the New Mexico Geological Society. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of the New Mexico Geological Society, Inc.