Regional Studies of the Potwar Plateau Area, Northern Pakistan

Edited by Peter D. Warwick and Bruce R. Wardlaw

Prepared in cooperation with the
Geological Survey of Pakistan,
under the auspices of the
U.S. Agency for International Development,
U.S. Department of State, and the
Government of Pakistan

This volume is published as chapters A through I.
The chapters are also available separately on the World Wide Web.

Bulletin 2078

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia: 2007

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod
Telephone: 1–888–ASK–USGS

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1–888–ASK–USGS

Suggested citations:

Warwick, P.D., and Wardlaw, B.R., eds., 2007, Regional studies of the Potwar Plateau area, northern Pakistan: U.S. Geological Survey Bulletin 2078–A–I, chapters are separately paged, 5 oversize plates in pocket. (Also available online.)

Edwards, L.E., 2007, Paleocene and Eocene dinocysts from the Salt Range, Punjab, northern Pakistan, chap. C *of* Warwick, P.D., and Wardlaw, B.R., eds., Regional studies of the Potwar Plateau area, northern Pakistan: U.S. Geological Survey Bulletin 2078, p. C1–C10, fossil pls. C1, C2. (Also available online.)

Library of Congress Cataloging-in-Publication Data

Regional studies of the Potwar Plateau area, northern Pakistan / edited by Peter D. Warwick and Bruce R. Wardlaw.
p. cm. — (U.S. Geological Survey bulletin ; 2078)
"Prepared in cooperation with the Geological Survey of Pakistan, under the auspices of the U.S. Agency for International Development, U.S. Department of State, and the Government of Pakistan."
Includes bibliographical references.
1. Geology—Pakistan—Potwar Plateau Region. 2. Paleontology—Pakistan—Potwar Plateau Region. I. Warwick, Peter D. II. Wardlaw, Bruce R. III. Geological Survey of Pakistan. IV. Series.
QE75.B9 no. 2078
[QE295.4]
557.3 s—dc20
[555.491]

95–9726
CIP

ISBN 978–1–411–32093–2

Editors' Preface

By Peter D. Warwick and Bruce R. Wardlaw, U.S. Geological Survey

The papers in this volume are products of a cooperative program between the Geological Survey of Pakistan (GSP) and the U.S. Geological Survey (USGS), sponsored by the Government of Pakistan and the U.S. Agency for International Development. The focus of the program, the Coal Resources Exploration and Assessment Program (COALREAP), was to explore and assess Pakistan's indigenous coal resources. As part of COALREAP, GSP and USGS geologists conducted regional geologic studies from 1988 to 1991 of the coal-bearing areas in the Potwar region of northern Pakistan. These studies are called the Potwar Regional Framework Assessment Project. An overview of the project study area is presented in chapter A by Peter Warwick, who served as the project chief and the resident logistical support for most of the program.

The group of paleontology papers (chaps. B–E) stems from a desire to provide a stratigraphic, biostratigraphic, and paleoenvironmental framework for the coal deposits in the Potwar Plateau area in an efficient and cost-effective way. To this end, a reference section was selected from which to obtain faunal and floral analyses. The composite sections at Nammal Pass and Nammal Dam (figs. 1 and 2) served as the basis for this regional reference. Various biotic components were analyzed from samples from several other sections in the area and compared with the reference section. Spores and pollen (chap. D) from carbonaceous shales and borehole samples and ostracodes from both surface and subsurface samples appear plentiful enough to provide regional correlation with the reference section. The ostracode studies were not completed at the time this volume was assembled. Planktic foraminifers (chap. E) and nannofossils (chap. B) are sparse or badly recrystallized in most of the sections. Dinocysts (chap. C) seem to be more common than planktic foraminifers and nannofossils but are typically poorly preserved and were not investigated in every section.

The regional stratigraphic framework in which coal-bearing beds occur was investigated. The compilation of the paleontologic data and the general stratigraphic framework of the Paleocene and lower Eocene rocks in the Potwar area are presented in chapter F.

A pilot study for environmental geology in Pakistan (chap. G) was undertaken in the capital city area of Islamabad-Rawalpindi (fig. 1), which is on the northern edge of the Potwar Plateau.

Selected minerals and industrial commodities were evaluated in the Potwar Plateau area, as described in chapter H. Clay mineral resources were also evaluated, but the results are not presented in this volume. Finally, the coal-bearing Paleocene Patala Formation, which makes up the bulk of the Salt Range coal field, was carefully examined. Chapter I describes its character and distribution.

Update in 2007.—Although this Bulletin 2078 is being released in 2007, the writing and technical reviews were completed in 1993, and the chapters reflect the work done until that time. During the long production process for the Bulletin, which ultimately resulted in the oversize plates being digitized, the scientific content of the chapters was not changed, and most reports published since 1993 were not cited. A change in the age of the Patala Formation is discussed below, but the age discussions and illustrations in the chapters were not updated.

This manuscript was completed before the international agreement on the placement of the Paleocene-Eocene boundary occurred (ratified in 2003, according to Gradstein and others, 2004, p. 30). The boundary is now accepted to correlate with the base of the major negative carbon isotope excursion and is somewhat below the base of calcareous nannoplankton Zone NP 10 and thus is within the uppermost part of Zone NP 9. According to Bybell's studies in the U.S. Gulf of Mexico and Atlantic Coastal Plains, the calcareous nannofossil species *Transversopontis pulcher s.1.* first appears just below the Paleocene-Eocene boundary, and the last consistent occurrences of *Toweius eminens* var. *tovae* and *Scapholithus apertus* are very near the boundary (Laurel M. Bybell, USGS, written commun., 2006). The carbon isotope excursion correlates with the worldwide acme of the dinoflagellate genus *Apectodinium* (Crouch and others, 2001) and with the range base of the species *Apectodinium augustum* (Powell and Brinkhuis *in* Luterbacher and others, 2004, p. 396).

For the purposes of this Bulletin, the upper part of the Patala Formation must now be placed within the Eocene, rather than in the Paleocene. At the Nammal Dam location, the Patala Formation sample from 411 feet contains the lowest occurrence of the dinoflagellate *Apectodinium augustum* and the lowest occurrence of the calcareous nannofossil *Transversopontis pulcher s.1.* The sample from 409 feet does not contain these two species. Therefore, the Paleocene-Eocene boundary can be assumed to occur between 409 feet and 411 feet.

References Cited

Crouch, E.M., Heilmann-Clausen, Claus, Brinkhuis, Henk, Morgans, H.E.G., Rogers, K.M., Egger, Hans, and Schmitz, Birger, 2001, Global dinoflagellate event associated with the late Paleocene thermal maximum: Geology, v. 29, no. 4, p. 315–318.

Gradstein, F.M., Ogg, J.G., and Smith, A.G., 2004, Chronostratigraphy; Linking time and rock, *in* Gradstein, F.M., Ogg, J.G., and Smith, A.G., eds., A geologic time scale 2004: New York, Cambridge University Press, p. 20–46.

Luterbacher, H.P., Ali, J.R., Brinkhuis, Henk, Gradstein, F.M., Hooker, J.J., Monechi, Simonetta, Ogg, J.G., Powell, A.J., Röhl, U., and Sanfilippo, Annika, 2004, The Paleogene Period, *in* Gradstein, F.M., Ogg, J.G., and Smith, A.G., eds., A geologic time scale 2004: New York, Cambridge University Press, p. 384–408.

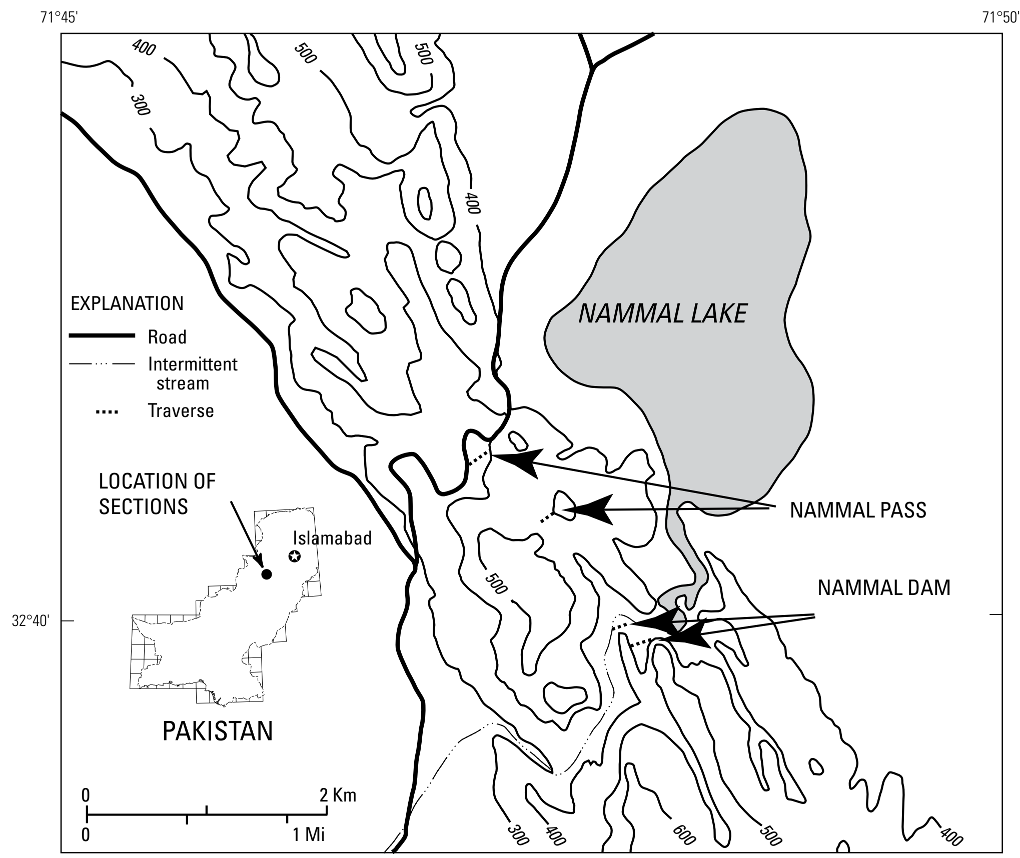

Figure 1. Location of traverses of measured section at Nammal Pass and Nammal Dam. Contour interval is 100 meters. Map portion taken from Survey of Pakistan topographic map 38 P/14 (1987, scale 1:50,000).

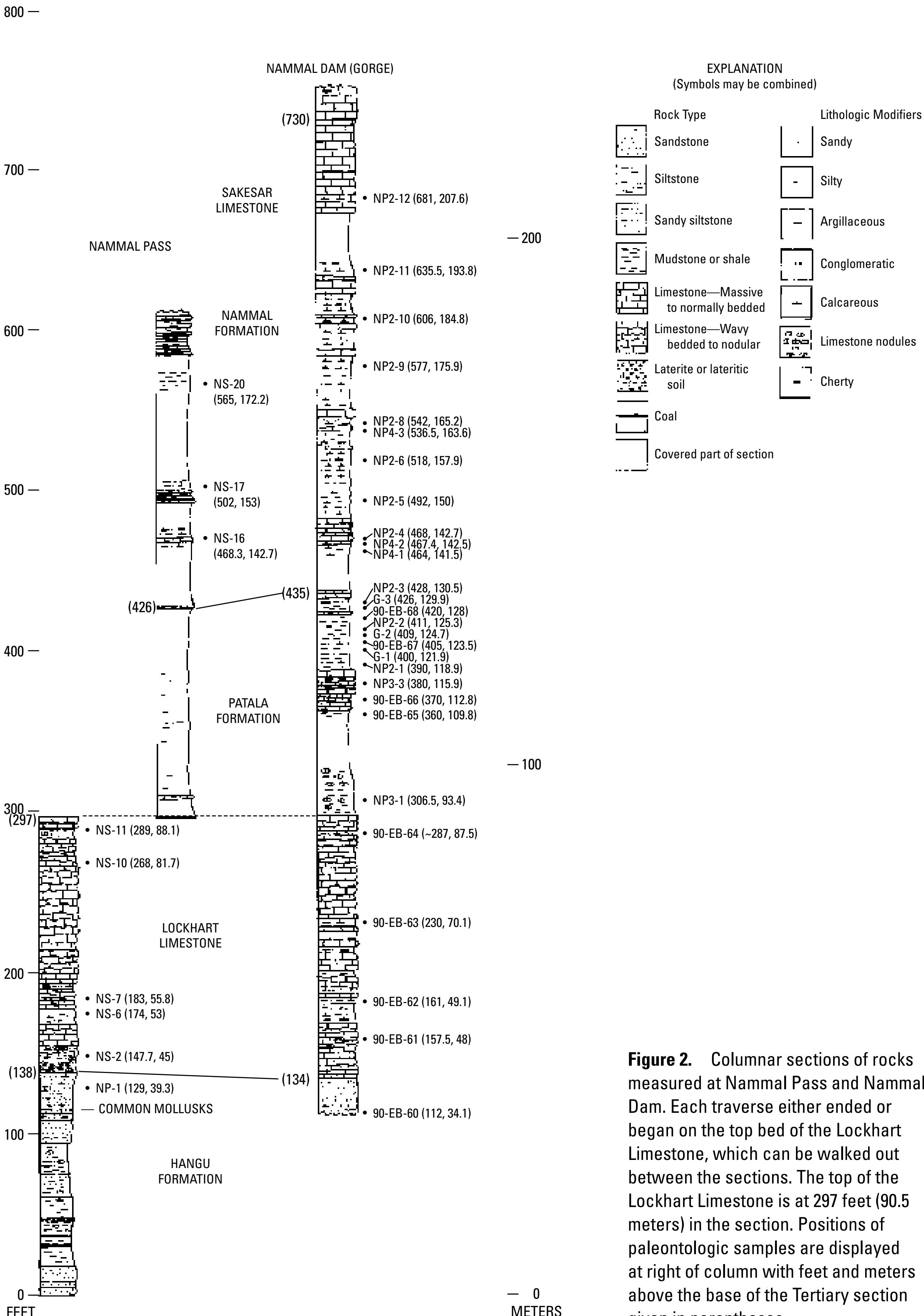

Figure 2. Columnar sections of rocks measured at Nammal Pass and Nammal Dam. Each traverse either ended or began on the top bed of the Lockhart Limestone, which can be walked out between the sections. The top of the Lockhart Limestone is at 297 feet (90.5 meters) in the section. Positions of paleontologic samples are displayed at right of column with feet and meters above the base of the Tertiary section given in parentheses.

Contents

[Letters designate the chapters]

Conversion Factors

Various units used in chapters A–I are listed in the first column below.

Multiply	By	To obtain
Length		
micrometer (µm)	0.00003937	inch
millimeter (mm)	0.03937	inch
centimeter (cm)	0.3937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
foot (ft)	0.3048	meter
Area		
square centimeter (cm^2)	0.1550	square inch
square meter (m^2)	10.76	square foot
hectare (ha)	2.471	acre
square kilometer (km^2)	0.3861	square mile
Mass		
kilogram (kg)	2.205	pound avoirdupois
metric ton (1,000 kg)	1.102	ton (2,000 pounds)
ton (2,000 pounds)	0.9072	metric ton (1,000 kg)
Density		
gram per cubic centimeter (g/cm^3)	0.03613	pound per cubic inch
Compressive strength		
kilogram per square centimeter (kg/cm^2)	14.22	pound-force per square inch
Heat per unit mass		
British thermal unit per pound (Btu/lb)	2.326	kilojoule per kilogram

Temperature.—To convert temperatures from degrees Celsius (°C) to degrees Fahrenheit (°F), use the following equation:

$$°F = (1.8 \times °C) + 32$$

Age designations.—The age of a geologic event or the age of an epoch boundary is expressed as ka (kilo-annum, thousands of years ago) or Ma (mega-annum, millions of years ago). Intervals of time are expressed as m.y. (million years duration). Some examples follow. The unconformity was dated at 1.9±4 Ma. During the last 1.5 m.y., erosion dominated. Thermoluminescence ages of the loess are greater than 170 ka.