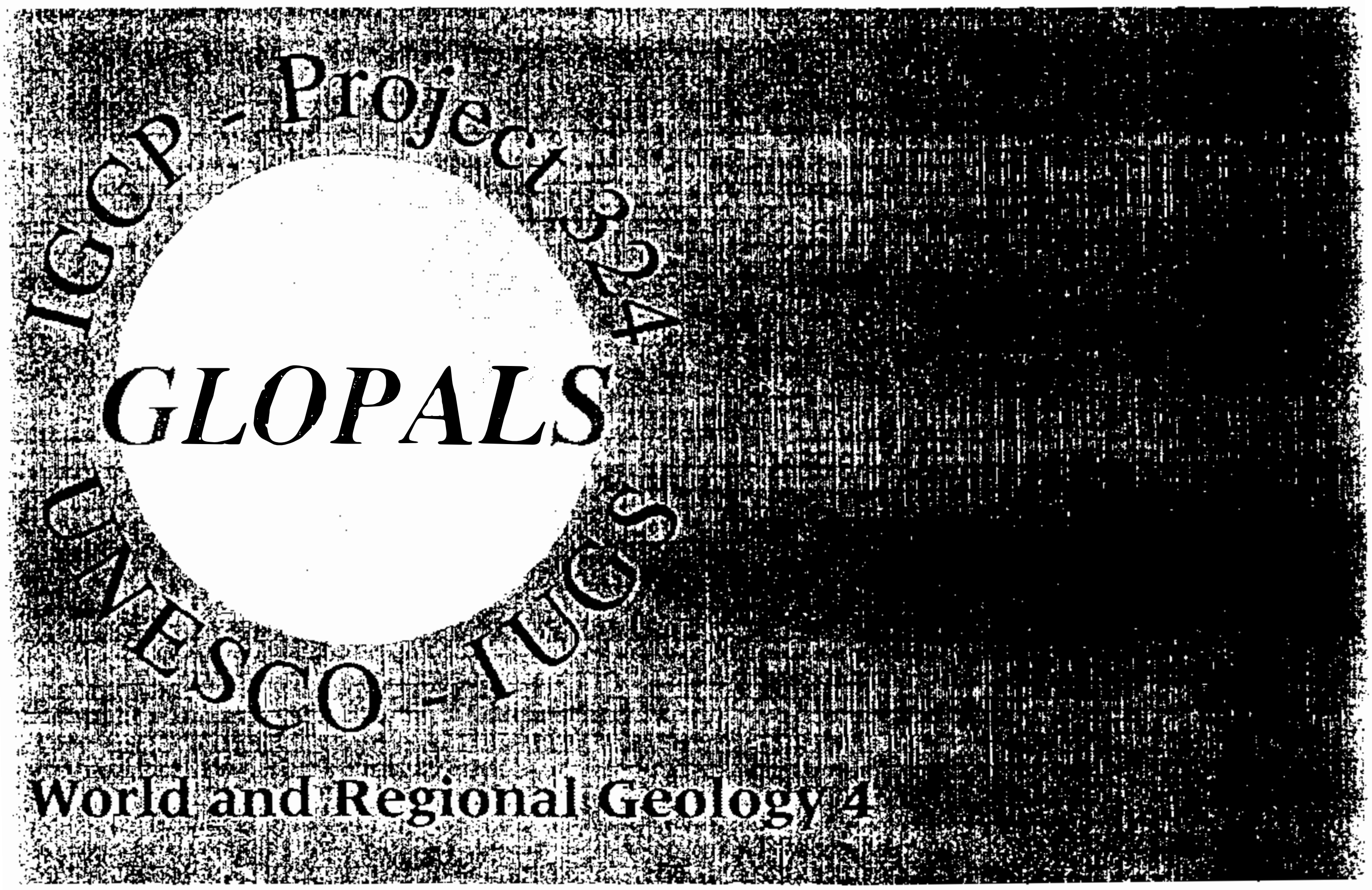
Global Geological Record of Lake Basins

VOLUME 1

Edited by

E. GIERLOWSKI-KORDESCH & K. KELTS



CAMBRIDGE UNIVERSITY PRESS

Global Geological Record of Lake Basins
Volume 1

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CAMBRIDGE
UNIVERSITY PRESS

Published by the Press Syndicate of the University of Cambridge
The Pitt Building, Trumpington Street, Cambridge CB2 1RP
40 West 20th Street, New York, NY 10011-4211, USA
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

First published 1994

Printed in Great Britain at the University Press, Cambridge

A catalogue record for this book is available from the British Library

Library of Congress cataloguing in publication data

Gierlowski-Kordesch, E. (Elizabeth)
Global geological record of lake basins / E. Gierlowski-Kordesch
and K. Kelts. vol. 1
p. cm.
ISBN 0-521-41452-0
1. Paleolimnology. 2. Sedimentary basins. I. Kelts, K. (Kerry)
II. Title.
QE39.5.P3G54 1994
551.48'2–dc20 93-28336 CIP

ISBN 0 521 41452 0 hardback

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Cenozoic lacustrine deposits in the Duero Basin (Spain)

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Introduction

The Ducro Basin lies in the northwestern Iberian Peninsula with a surface extent of 55,000 km^2. It rests upon Pre-Mesozoic metasedimentary and granitic rocks of the Hesperic Massif (along the western, southern and northwestern borders) and Mesozoic sedimentary rocks (along the eastern and northeastern borders). Uplift of the proto-Central System during the Paleocene started the differentiation of the Duero Basin (Portero & Aznar, 1984). During the Eocene, a northwest–southeast compression increased the uplift and generated the Central System (Béjar, Gredos & Guadarrama Ranges, Fig. 1) that separated Duero Basin from the Tajo (Madrid) Basin. Most of the sedimentary fill of the Duero Basin consists of terrestrial deposits, however, a connection with the open sea existed to the north and northeast. During the Late Eocene and Oligocene, rapid uplift of the northern and northeastern margins of the Duero Basin and the complete establishment of the Central System (along the southern border) occurred. These major changes of paleogeography triggered rapid erosion of uplifted source areas and a large input of conglomerates to the basin. The largest rates of subsidence and accumulation of sediment are along the northern and castern margins of the basin; the western and southern borders record much smaller volumes (Fig. 1A).

Paleogene sedimentary rocks crop out only along the margins of the Duero Basin (Fig. 1A), which are interpreted as alluvial-fan and proximal fluvial facies. Distal fluvial and lacustrine facies occur in the central parts of the basin as shown by drill cores (Compañia General de Sondeos, 1985). On the other hand, large outcrops of Neogene deposits in the basin represent various types of facies: alluvial-fan (northern and eastern borders), fluviatile (western border and toward basin center), and fluvio-lacustrine and lacustrine (central sector). The Neogene sedimentary record is limited in the south of the basin (Fig. 1A) because of large-scale erosion.

The Tertiary lacustrine deposits are arranged into two groups based on paleogeography: marginal lacustrine and central lacustrine systems. Marginal lacustrine systems include ephemeral marches or very shallow lakes and ponds related to alluvial-fan or low-sinuosity fluvial systems (Fig. 2A and B). Central lacustrine systems contain more stable, perennial lakes located in the basin center, preferentially aligned along the axis of maximum subsidence (Fig. 1A). These lakes developed at the distal part of fluvial systems, but in areas of high subsidence rates they may have been associated with alluvial fans as well.

Marginal lacustrine deposits

These deposits are lenticular units (0.2 to 10 m thick, several km long) exhibiting many features indicative of subaerial exposure, such as pedogenic textures, brecciation, and carbonate crusts (Fig. 2A and B). They interbed and are associated laterally with conglomerates, sandstones and mudstones, interpreted as alluvial sediments. Three facies associations based upon lithology are recognized: (1) Interbedded carbonate mudstones or marlstones (0.2 to 0.5 cm thick) and ripple cross-laminated sandstones (10 to 20 cm thick) (Fig. 2C, left) with *Chelonia*, crocodylia and fish remains (Jiménez, 1977), interpreted as floodplains of low-sinuosity river systems (Corrochano, 1977; Martin-Serrano, 1988) mostly along the western edge of the basin (Fig. 2A and B) and fed by granitic source areas. (2) Carbonate layers (marlstones or calcareous marlstones) passing upward into brecciated and cdaphized limestones (Fig. 2C, right) with ostracods, charophytes, and gastropods, occurring at the front, or between lobes, of alluvial fans (Armenteros, 1986; Alonso Gavilán *et al.*, 1987), mostly along the southern and southeastern edges of the basin and fed by Paleozoic and Mesozoic siliciclastic and carbonate source areas. (3) Alternations of laminated carbonate-siliciclastic mudstones on a em to dm scale, with abundant remains of palynomorphs or dolostones and gypsum (Fig. 2D), interpreted as lacustrine deposits (marshes/ponds), occupying a position distal to the fan systems (Garcia Talcgón & Alonso Gavilán, 1989) along the northern edgc of the basin with source areas containing Mesozoic carbonate and gypsiferous rocks.

Central lacustrine deposits

Occuring in areas of maximum subsidence (Fig. 1A), five sedimentary cycles (N-1 to N-5) can be distinguished bounded by

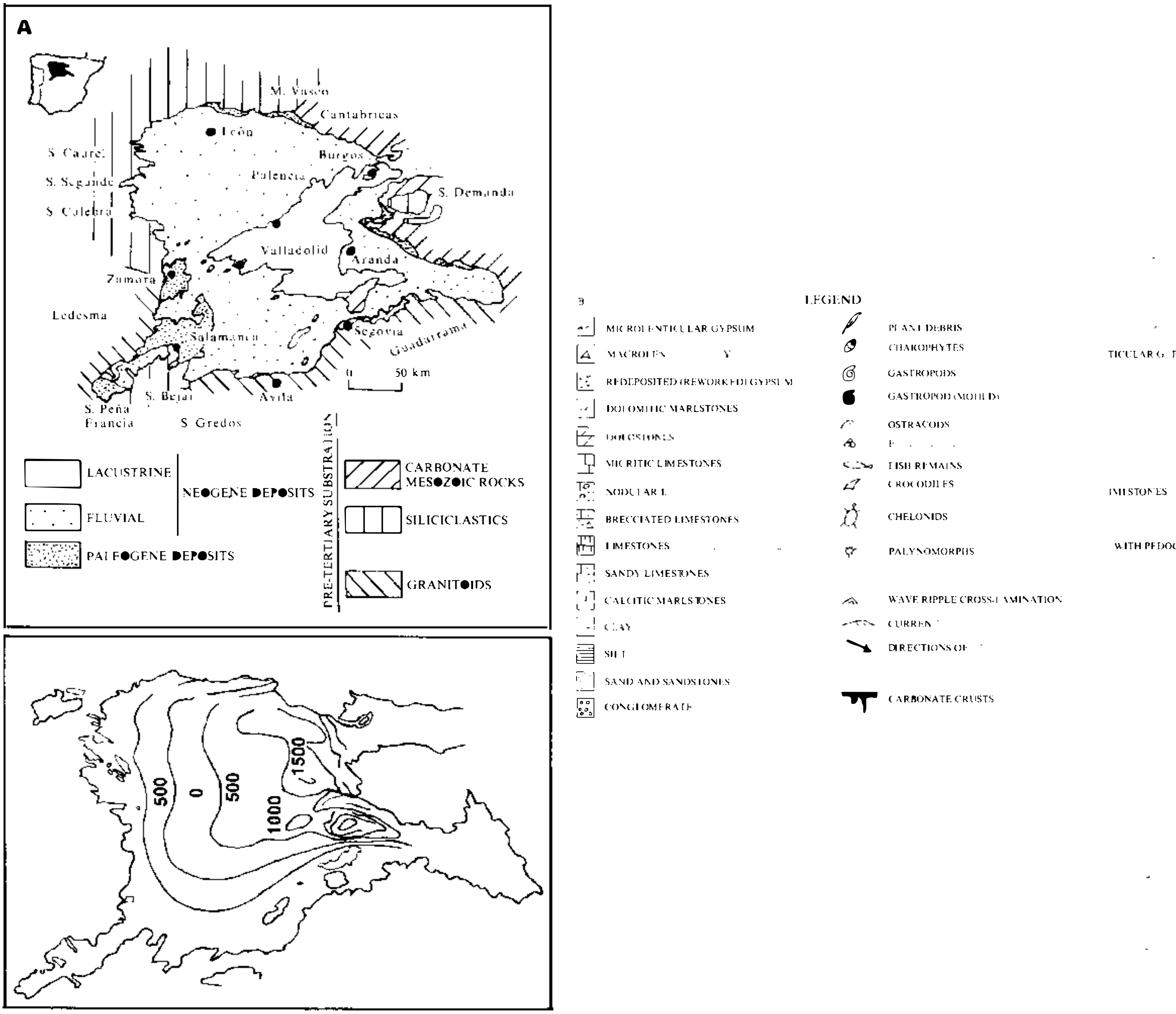

Fig. 1. (A) The Duero Basin and isobath map of the base of the Tertiary (from Compañia General de Sondeos, 1985). Datum, present sea level. (B) Legend for Figs 1–6.

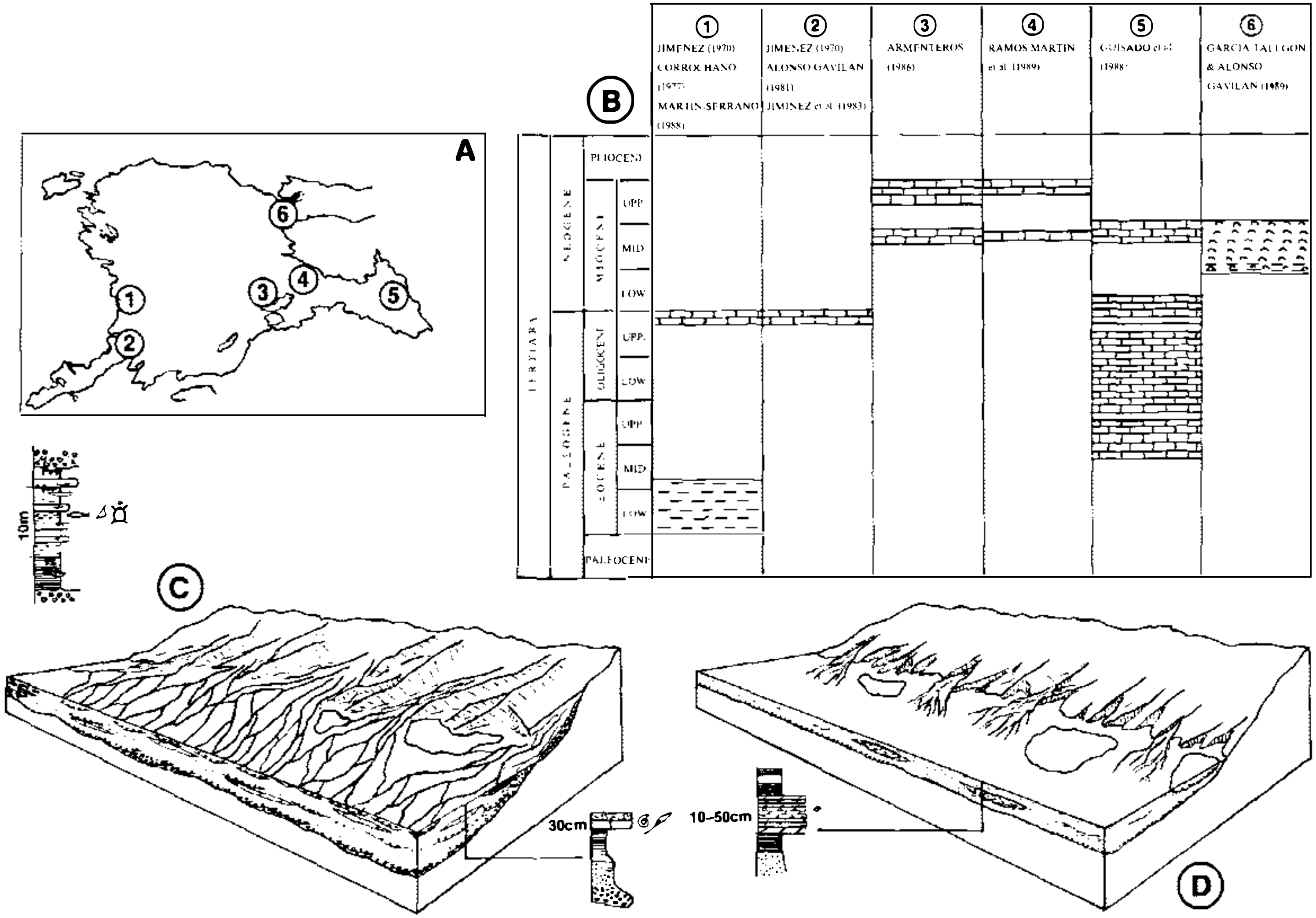

Fig. 2. (A) Location map of the marginal lacustrine deposits. (B) Temporal distribution of the marginal lacustrine deposits. (C) Conceptual models of carbonate ephemeral (modified from Dabrio *et al.*, 1989) and siliciclastic (Martin-Serrano, 1988) lakes. (D) Conceptual model of saline (gypsiferous) ephemeral lakes (modified from García Talegón and Alonso Gavilán, 1989).

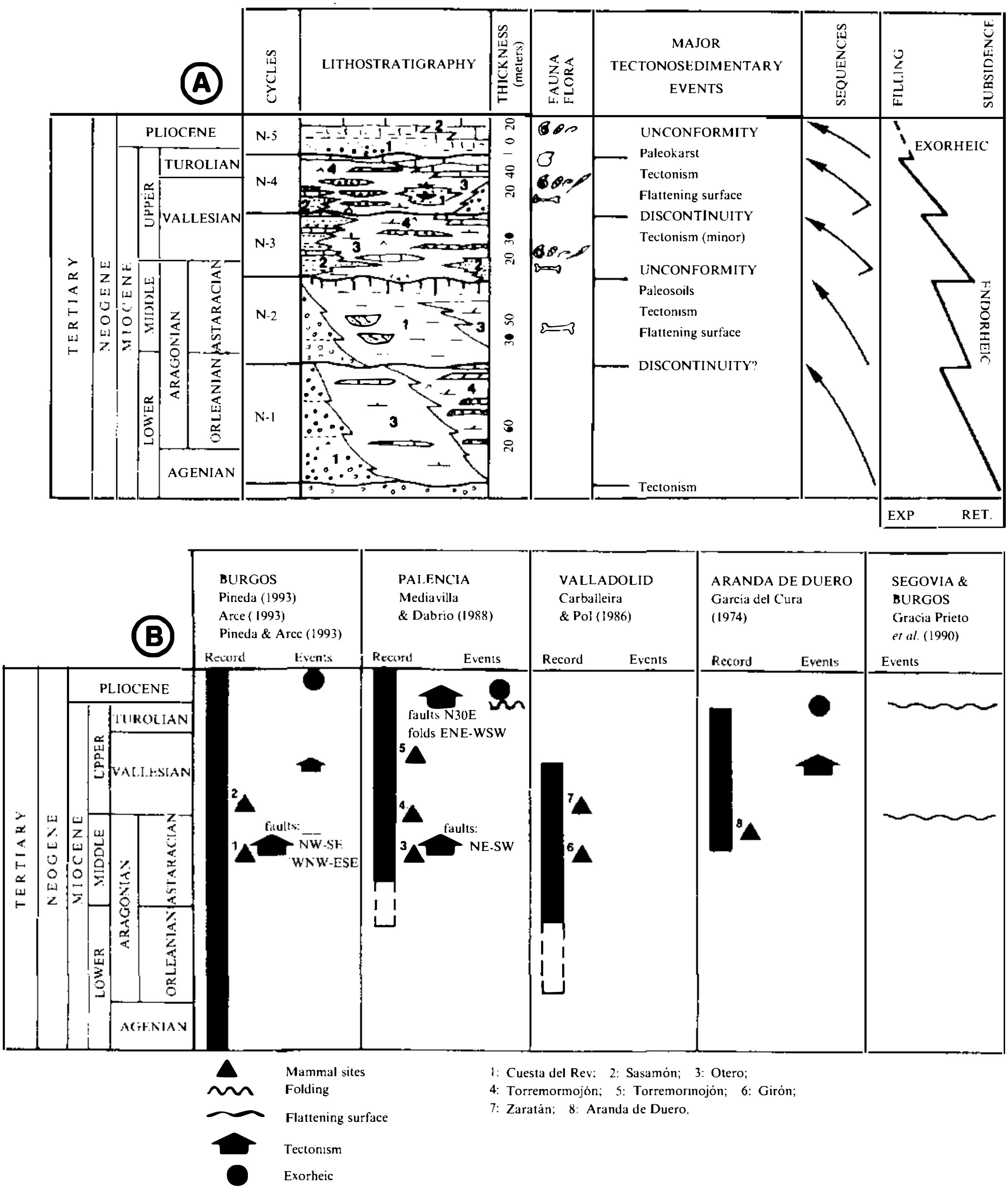

Fig. 3. (A) Generalized stratigraphic section of the Neogene central lake deposits of the Duero Basin. (B) Neogene stratigraphic successions and recorded events in various areas of the Duero Basin. Key: (1) alluvial; (2) fluvio-lacustrine; (3) carbonate lacustrine; (4) saline lacustrine. (Exp.) expansion; (Ret.) regression. Flattening surface = unconformity.

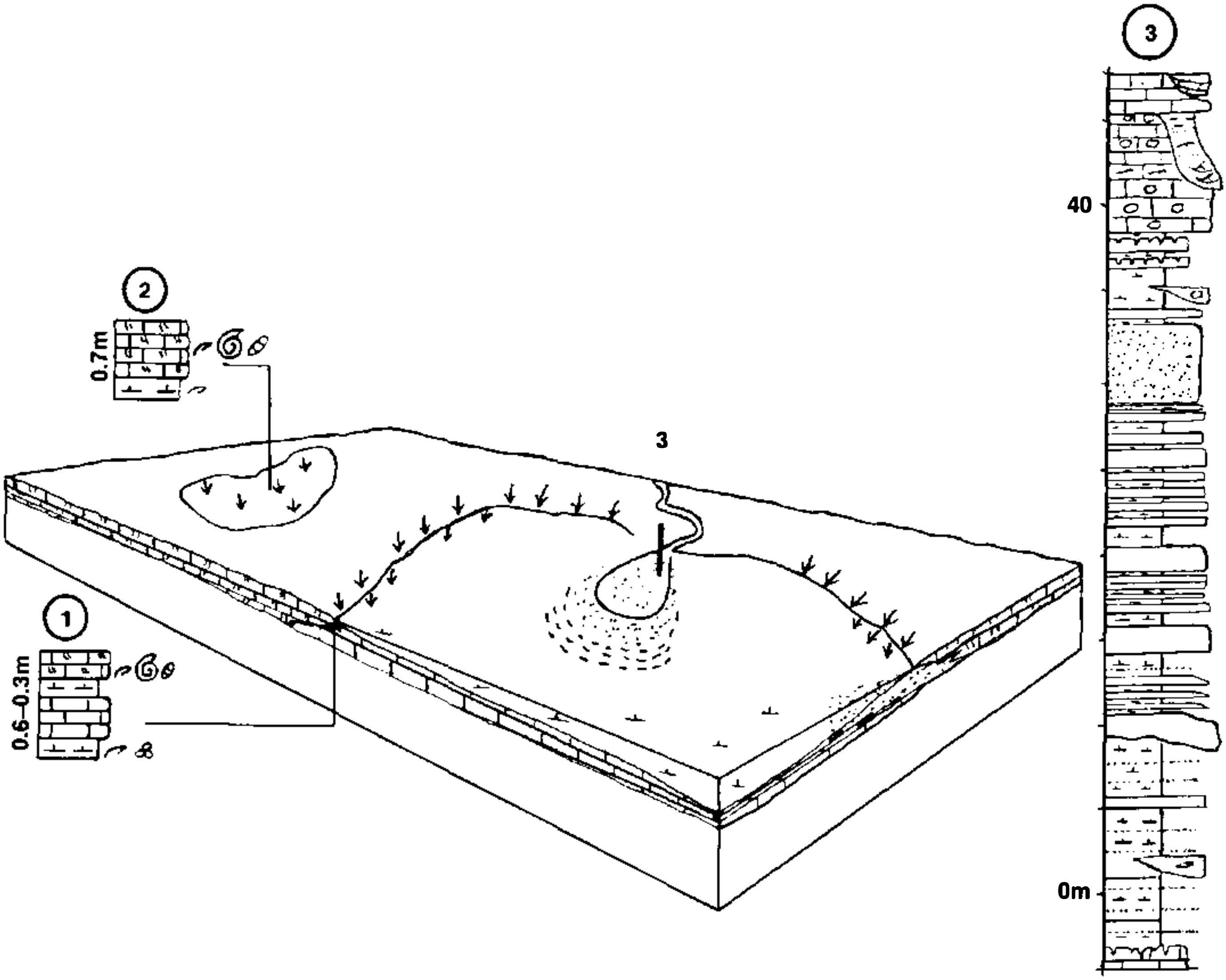

Fig. 4. Conceptual model of carbonate lakes and resulting facies associations. Key: (1) lake deposits; (2) paludal deposits; (3) deltaic deposits (modified after Mediavilla and Dabrio, 1986 and Sanchez Benavides *et al.*, 1988).

unconformities or sedimentary discontinuities (Fig. 3A, B). Each cycle contains alluvial conglomerates, sandstones and mudstones that intcrfinger with lacustrinc deposits. Lacustrine deposits of cycles N-l, N-3 and N-4 are carbonates and evaporites, whereas those of N-2 and N-5 are mostly of carbonates. These perennial lakes experienced continuous water level changes. Very low topographic gradients accounted for large shifts of the shorelines and large areas affected by alternating subaerial exposure and inundation.

A typical sedimentary sequence for carbonate lakes (Fig. 4.1) shows marlstones or biomicrites containing ostracods, charophytes, and some foraminifera that pass upwards into nodular limestones with gastropods and charophytes, topped by brecciated limestones. Paludal carbonates (Fig. 4.2) and deltaic siliciclastic green mudstones and sandstones (Sánchez Benavides *et al.*, 1988) are associated with these carbonate lakes (Fig. 4.3).

A typical sequence for gypsiferous lakes (Fig. 5) contains alternating centimeter-thick layers of dolostones, or dolomitic marlstones, and lenses of gypsum ('microlenticular') passing upwards into layers of ripple cross-laminated gypsarenites, dolomicrites with gypsum lenses, topped by recrystallized, edaphized dolostones (Fig. 5A). Mediavilla (1986–87) observed layers of turbiditic gypsum in these deposits (Fig. 5B).

The areal distribution of these two types of lakes was controlled by tectonics, sediment input to the lacustrine areas and climate (see also Mediavilla *et al.*, 1991). Tectonic events interrupted the progressive filling of the basin and expansion of the lakes (Figs. 3A & 6), generating the sedimentary cycles. Furthermore, changes in

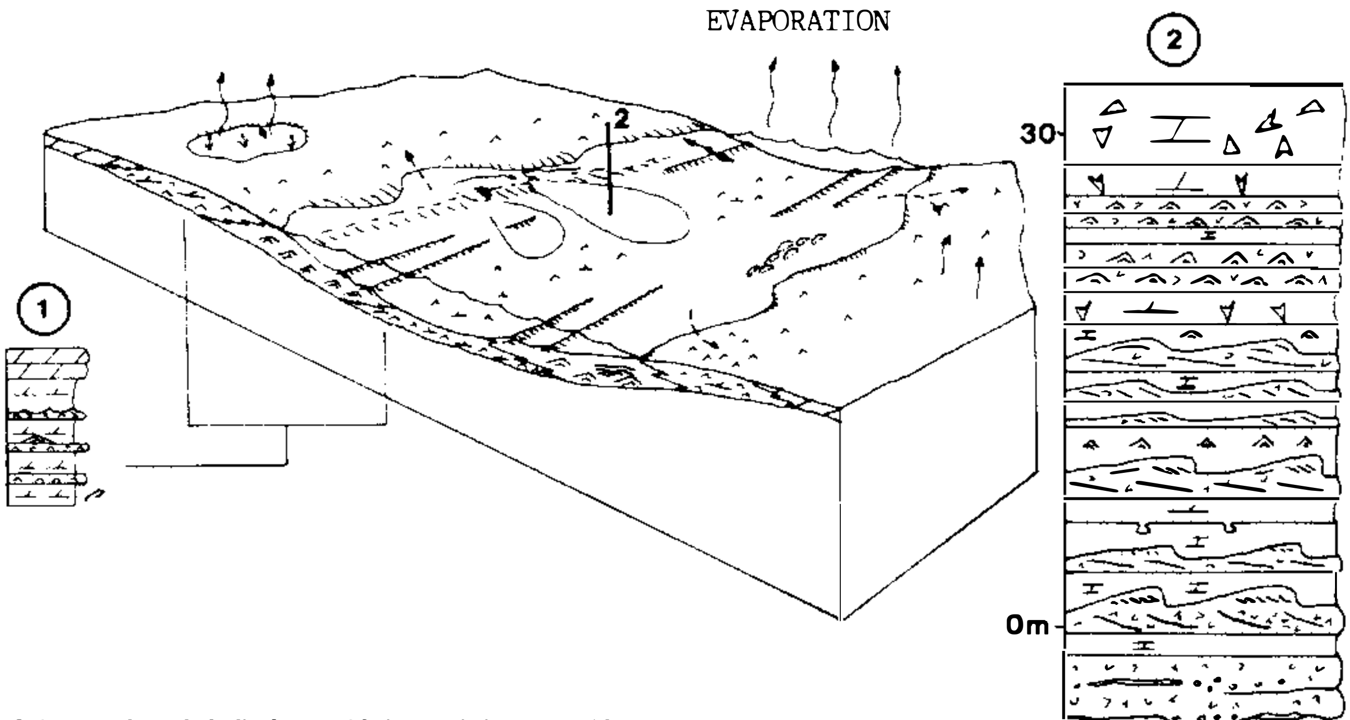

Fig. 5. Conceptual model of saline lakes and facies associations. Key: (1) lake deposits; (2) turbidites (modified after Mediavilla, 1986–87 and Mediavilla et al., 1991).

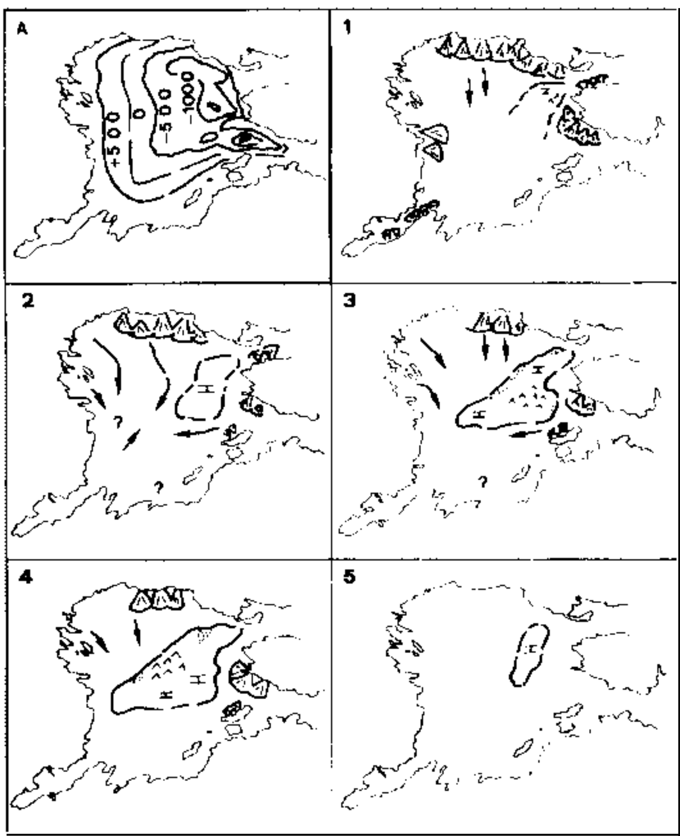

Fig. 6. Paleogeography of central lacustrine environments. (1) Agenien–Orleanian; (2) Orleanian–Astaracian; (3) Astaracian–Vallesian; (4) Vallesian–Turolian; (5) Turolian–Pliocene. (A) Isobath map.

the rate of external sediment input to the depositional system triggered shifts in lithology (Fig. 6). Climate may also have influenced depositional patterns and the transport and preservation of the gypsum. A closed hydrologic drainage is postulated for sedimentary cycles N-1 to N-4. Open drainage during cycle N-5 is evidenced by deposits of large alluvial systems.

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