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CARBONATE FACIES OF THE SANTA LUCÍA FORMATION (EMSIAN-COUVINIAN) IN LEÓN AND ASTURIAS, SPAIN

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ABSTRACT

Three lithofacies are distinguished in the Santa Lucía Formation: grainstone facies, packstone facies and birdseye facies. The lithofacies pattern suggests three depositional environments. An area of wave and current action (grainstone facies), a quiet and sometimes restricted lagoon protected by the extensive shallowness of the entire platform (packstone facies) and an intertidal to supratidal part (birdseye facies).

INTRODUCTION

The pre-Carboniferous stratigraphic subdivisions in the southern slope of the Cantabrian Mountains were mainly defined by C o m t e (1959). The "Calcaires de Santa Lucía" were introduced as a distinct formation with its type section along the river Bernesga near the village of Santa Lucía. Comte considered the formation in the type locality to be of Upper Emsian to Lower Couvinian age. The Santa Lucía Formation could easily be recognized in a geological survey, by the University of Leiden under the supervision of Prof.Dr. L.U. d e S i t t e r (1962, provisional map) in the province León, resulting in a series of detailed maps by R u p k e (1965), E v e r s (1967), v a n S t a a l d u i n e n (1965) and v a n d e n B o s c h (1969). In Asturias the formation was featured on maps by J u l i v e r t et al. (1968) and M a r c o s (1968) of the University of Oviedo. A general outcrop map of the Santa Lucía Formation according to the above-mentioned authors is provided in fig. 1. For the northwestern part detailed maps are not yet available; a number of data were derived from A l m e l a et al. (1956) and P o l l (1963). S m i t s (1965) introduced the name Caldas Formation for the Santa Lucía Formation near Caldas de Luna, because of the diversive character and the high argillaceous content of some of the carbonates.

A first attempt to understand the paleogeography in the area was made by v a n A d r i c h e m B o o g a e r t (1967) and by B r o u w e r (1967). The present authors are engaged in a more detailed study of the Santa Lucía Formation for their Ph.D. theses, as part of a stratigraphic research programme of the Cantabrian Devonian under the general supervison of Prof.Dr. A. Brouwer (Univ. of Leiden).

MAIN ROCK TYPES AND THEIR REGIONAL DISTRIBUTION

Almost all the rock types in Dunham's classification (1962) could be distinguished in the Santa Lucía limestones. The most important are:

Grainstones, mainly bioclastic. The bioclasts consist of parts of Bryozoa, crinoids, brachiopods, corals, stromatoporoids, ostracods and trilobites. Some quartz grains occur locally. Generally thick-bedded grainstones can be observed, resistent to erosion and sometimes containing erosional bottom structures.

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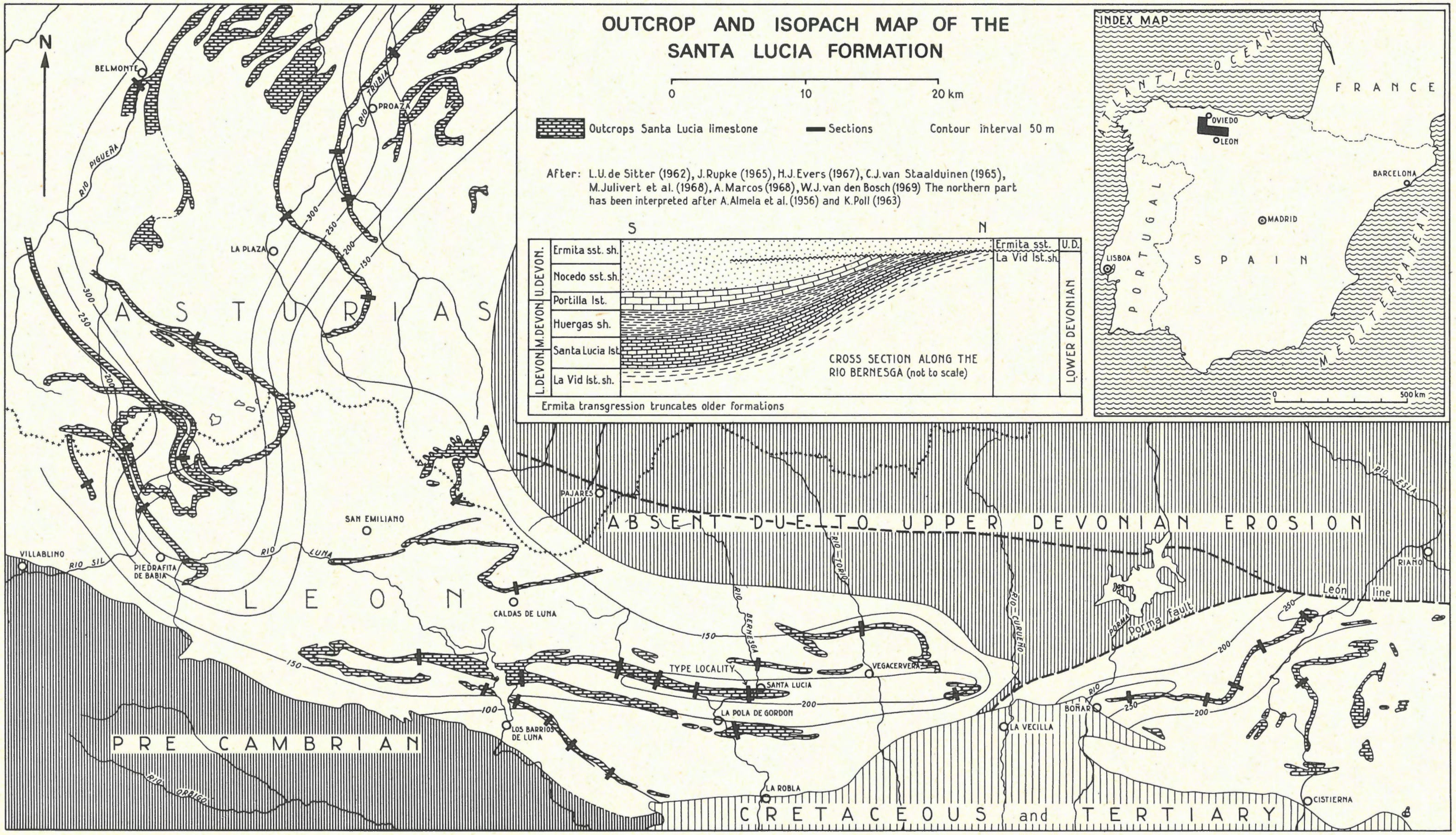
OUTCROP AND ISOPACH MAP OF THE
SANTA LUCIA FORMATION
0
10
20 km
Outcrops Santa Lucia limestone
Sections
Contour interval 50 m
After: L.U. de Sitter (1962), J. Rupke (1965), H.J. Evers (1967), C.J. van Staalduinen (1965), M. Julivert et al. (1968), A. Marcos (1968), W.J. van den Bosch (1969) The northern part has been interpreted after A. Almela et al. (1956) and K. Poll (1963)
S
N
L. DEVON.
M. DEVON.
U. DEVON.
Ermita sst. sh.
Nocedo sst. sh.
Portilla lst.
Huergas sh.
Santa Lucia lst.
La Vid lst. sh.
Ermita sst.
La Vid lst. sh.
U.D.
LOWER DEVONIAN
CROSS SECTION ALONG THE
RIO BERNESGA (not to scale)
Ermita transgression truncates older formations
INDEX MAP
ATLANTIC OCEAN
FRANCE
OVIEDO
LEON
BARCELONA
PORTUGAL
MADRID
LISBOA
SPAIN
MEDITERRANEAN
0
500 km
N
BELMONTE
PROAZA
RIO TRUBIA
RIO PIGUEÑA
LA PLAZA
ASTURIAS
SAN EMILIANO
PAJARES
VILLABLINO
RIO SIL
PIEDRAFITA DE BABIA
RIO LUNA
LEON
CALDAS DE LUNA
ABSENT DUE TO UPPER DEVONIAN EROSION
RIO ESLA
RIAÑO
León line
Porma fault
RIO PORMA
RIO CURUEÑO
RIO TORIO
RIO BERNESGA
TYPE LOCALITY
SANTA LUCIA
VEGACERVERA
LA POLA DE GORDON
LOS BARRIOS DE LUNA
LA VECILLA
BOÑAR
RIO
PRE CAMBRIAN
RIO ORBIGO
LA ROBLA
CISTIERNA
CRETACEOUS and TERTIARY
300
250
200
150
100

Fig. 1

Bioclastic packstones. The bioclasts are the same as in the grainstones and often unrecognisable due to bioturbation. The packstones are thinner bedded than the grainstones, often showing a nodular appearance. Sometimes the bioclasts are silicified and occur together with chert nodules.

Bioclastic wackestones. The bioclasts consist mainly of parts of, or complete, solitary Rugosa, Thamnopora, Aulopora, ostracods and distinct Bryozoa. The wackestones are thinly bedded and have a dark grey or black appearance.

Mudstones often show a very characteristic lamination sometimes like stromatolites. In some places the mudstones are slightly dolomitised.

Boundstones. Due to the scale factors this rock type is very difficult to recognize. A boundstone of interconnected skeletal matter of stromatoporoids and corals can only be seen on large surfaces polished by erosion, in the exposure and not in thin sections. In some locations in the Santa Lucía Formation these surfaces are present where clearly interconnected corals and stromatoporoids can be observed, growing *in situ* and forming beds a few metres in thickness. Laminations contrary to gravity seldom occur. The flat type laminated mudstones are not considered as boundstones, as it is uncertain whether these are algal bound or not.

Birdseye limestones (Ham, 1952). These are mudstones often pelleted with peculiar sparite vugs orientated parallel or at random. The mud generally contains many calcispheres.

Argillaceous limestones in this formation are mudstones with a high content of quartz silt and clay particles (10-50%).

The areal distribution of several rock types distinguished is shown in the lithofacies map (fig. 2). Only three components of the carbonates are considered and featured: grains, mud and birdseye structures. A grain-mud ratio map (Krumbein & Sloss, 1963) could be constructed with the occurrence of birdseye structures superimposed upon it. Three areas can be distinguished on the map: one predominantly with grains (mainly grainstones with some intercalated packstones), one with equal quantities of grains and mud (mainly packstones with some intercalated grainstones, wackestones and mudstones) and another predominantly with mud and birdseye structures (birdseye limestones alternating with luminated mudstones, argillaceous mudstones and some packstones and wackestones). The occurrence of argillaceous influxes is indicated separately by the hatched area.

In the central part of the map the Santa Lucía Formation has suffered erosion prior to the Upper Devonian transgression. The gransgressive Ermita Formation, sandstones and shales, cuts deeper into the stratigraphic sequence from south to north causing a very slight angular unconformity with Lower Paleozoic strata as may be seen in fig. 1.

The thickness of the Santa Lucía Formation changes considerably over the area. The isopachs are shown in fig. 1.

CARBONATE FACIES

Apparently the significant distribution of the rock types distinguished represents the various depositional environments. From the lithofacies map three important facies can be derived, named after their diagnostic rock types: grainstone facies, packstone facies and birdseye facies.

Environmental interpretation

Grainstone facies. Clean-washed bioclasts without any mud indicate turbulent conditions of deposition. The fossils are exclusively marine. Sometimes cross-stratification and erosive bottom structures can be observed, suggesting current action.

Packstone facies. The mud has not been winnowed out as in the grainstones, consequently quiet conditions must have prevailed. Rocks occurring in this facies are often bituminous with chert nodules and silicified fossils. This may even suggest a somewhat restricted environment, although bioturbation and traces of scavenging activities can often be observed. Boundstones are included in the packstone facies, because, if present, they always occur in a sequence of packstones and other mud-supported carbonates. Together with the boundstones the packstone facies is rather similar to the shelf lagoon or backreef facies of the Devonian reef complex in the Canning Basin of Western Australia (Playford and Lowry, 1966). It is a remarkable feature that the tickest part of the formation generally coincides with the predominance of the packstone facies (compare fig. 1 and 2).

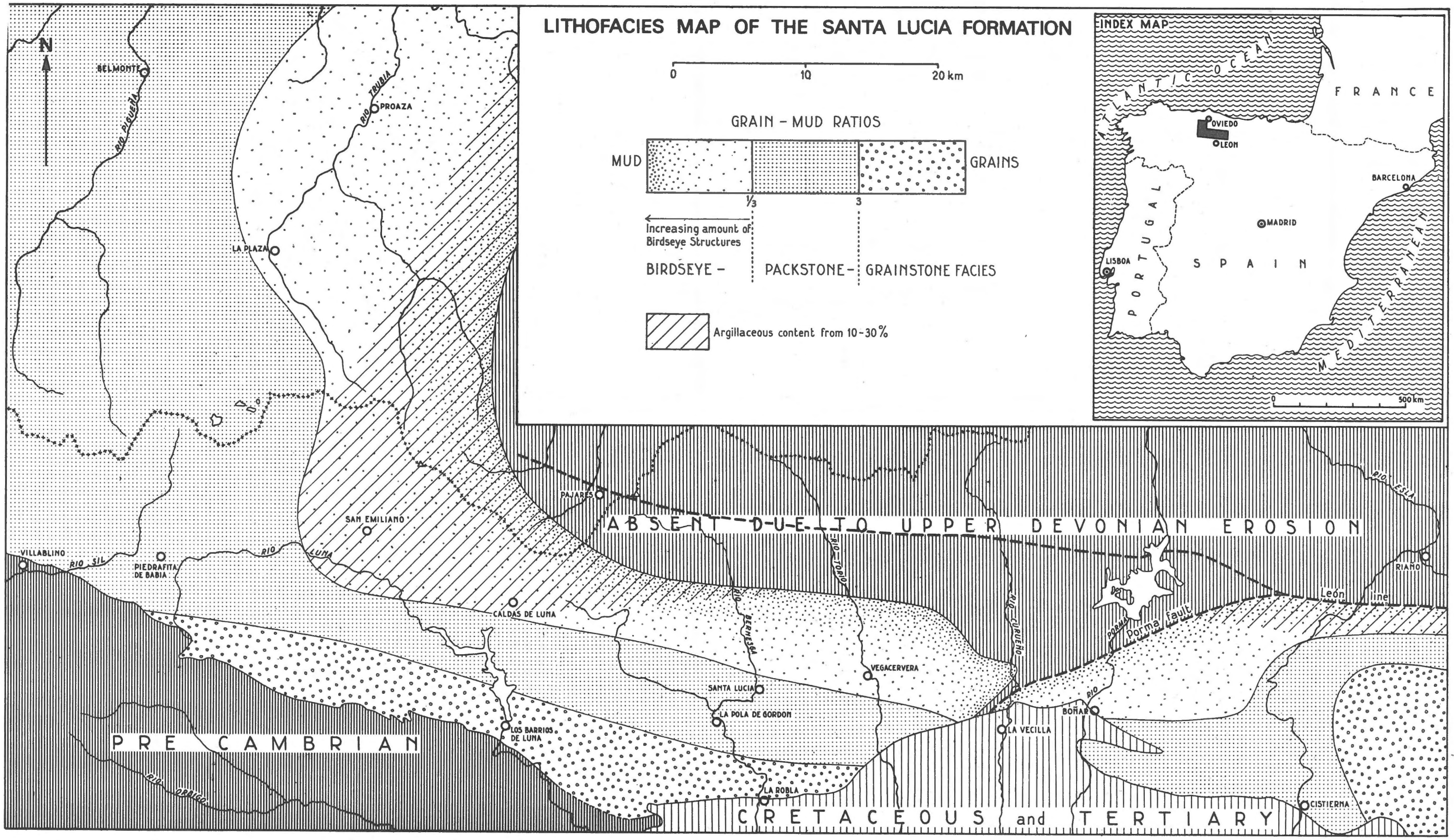
LITHOFACIES MAP OF THE SANTA LUCIA FORMATION
0
10
20 km
GRAIN - MUD RATIOS
MUD
GRAINS
1/3
3
Increasing amount of Birdseye Structures
BIRDSEYE -
PACKSTONE -
GRAINSTONE FACIES
Argillaceous content from 10-30%
INDEX MAP
FRANCE
OVIEDO
LEON
BARCELONA
MADRID
LISBOA
SPAIN
PORTUGAL
500 km
N
BELMONTE
RIO PIGUEÑA
PROAZA
RIO TRUBIA
LA PLAZA
SAN EMILIANO
PAJARES
ABSENT DUE TO UPPER DEVONIAN EROSION
RIO ESLA
RIAÑO
León line
Porma fault
VILLABLINO
RIO SIL
PIEDRAFITA DE BABIA
RIO LUNA
CALDAS DE LUNA
RIO BERNESGA
RIO TORIO
RIO CURUEÑO
VEGACERVERA
SANTA LUCIA
LA POLA DE GORDON
LA VECILLA
BOÑAR
RIO PORMA
LOS BARRIOS DE LUNA
PRE CAMBRIAN
RIO ORBIGO
LA ROBLA
CISTIERNA
CRETACEOUS and TERTIARY

Fig. 2

Birdseye facies. According to S h i n n (1968) birdseye structures of the type occurring in the Santa Lucía Formation indicate sedimentation in an intertidal or even supratidal environment. Laminated limestones in this facies are very similar to those considered as algal laminated by D a v i e s (1970) or as planar stromatolites formed under tidal and supratidal conditions by L o g a n et al. (1964). The polygonal structures which can often be observed on surfaces of strata in this facies may be compared with dessiccation cracks and/or algal mats as described by I l l i n g et al. (1965) in the Persian Gulf.

CONCLUDING REMARKS

Sedimentation model

A synthesis of the lithofacies map and the environmental interpretation gives a sedimentation model of the Santa Lucía Formation (fig. 3) and an impression of the geographical conditions prevailing during the transition from Lower to Middle Devonian times in the Cantabrian Mountains. We obtain the following picture: from open marine conditions at the outer edge of the area, where the waves of the open sea break via a lagoon protected by the extensive shallowness of the platform, to the tidal and supratidal region of the inner part of the area, where even land may have been present (compare with the models of D o o g e, 1966, and of R o e h l, 1967).

Tectonics

When looking at the lithofacies map we must bear in mind that tectonic activities in Hercynian times have somewhat altered the picture. The present situation is not equal to that at the time of deposition. E v e r s (1967) calculated that the tectonic shortening of the southern slope of the Cantabrian Mountains was about 50%, which means that the original width of the Santa Lucía sedimentation area was twice the present width. This may be even more important in the eastern part of the area, where the Esla nappe (R u p k e, 1965) plays a considerable role.

The Caldas Formation

When S m i t s (1965) introduced the Caldas Formation as a new lithostratigraphic unit laterally equivalent to the Santa Lucía Formation, the areal distribution of the Santa Lucía limestone types was not yet known. At the moment a complete picture is avilable of the various lithofacies in the formation and it is evident that the "Caldas facies" (similar to the argillaceous birdseye facies) can be widely correlated over the entire area, and also to places where initially Santa Lucía was mapped. Consequently, there is no longer any need to maintain the Caldas Formation as a distinct lithostratigraphic unit.

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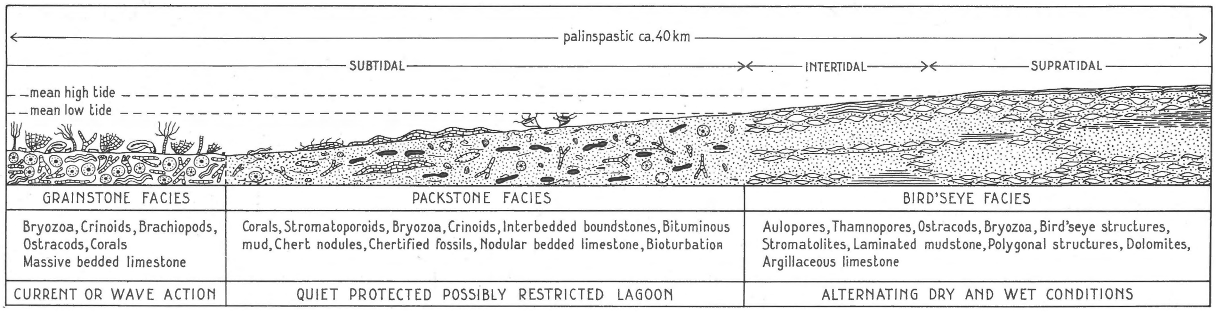

Fig. 3
Sedimentation model.

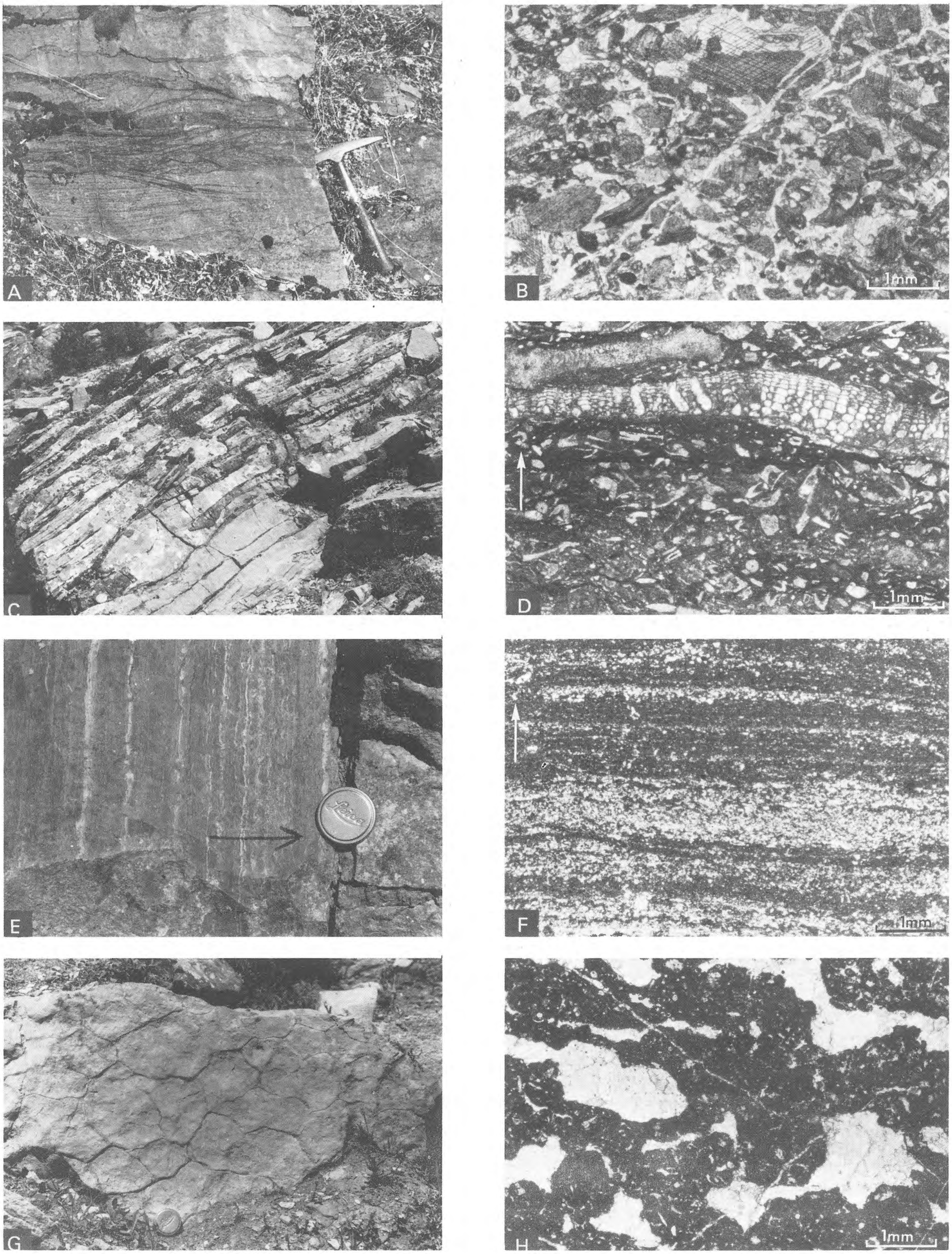
A
B
1mm
C
D
1mm
E
F
1mm
G
H
1mm

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Fig. 4.
A. Cross-stratification in iron-rich bioclastic grainstone. Grainstone facies. Aguasalio section. – B. Bioclastic grainstone. Bioclasts consist mainly of crinoids and bryozoans. Grainstone facies. Beberino section. – C. Bioclastic packstone with interbedded chert. Packstone facies. Aviados section. – D. Bioclastic packstone with stromatoporoid in growing position. Packstone facies. La Cueta section. – E. Laminated mudstone probably of algal origin. Arrow indicates top. Birdseye facies. Felmín section. – F. Laminated mudstone. Birdseye facies. Cubilla section. – G. Polygonal structures of dessiccation and/or algal origin. Birdseye facies. Caldas section. – H. Birdseye limestone with calcispheres. Birdseye facies. La Plaza section. (B, D, F, and H with crossed nicols).