Depositional systems and cyclicity in the intracratonic Early Jurassic basin in Poland

Anna FELDMAN-OLSZEWSKA
Zakład Geologii Regionalnej i Naftowej, Państwowy Instytut Geologiczny, Rakowiecka 4, 00-975 Warszawa, Poland
(Received: 24.10.1997)

A number of depositional systems and sub-systems have been recognized within the Lower Jurassic clastic deposits of the Polish Lowlands. These are: fluvial, deltaic, swampy (with swampy-lacustrine and swampy-lagoonal sub-systems) and siliciclastic shelf system (with shallower and deeper shelf sub-systems — the former includes brackish shelf facies). On the basis of their vertical succession and lateral changes, the Lower Jurassic sediments have been subdivided into five transgressive-regressive cycles. The lowermost deposits are included into the regressive phase of the last Triassic cycle. These cycles have been compared with the eustatic curves of B. U. Haq et al. (1988) and A. Hallam (1988).

INTRODUCTION

The analysis of depositional systems has been conducted on a basis of boreholes situated in the Mid-Polish Trough and along its margins (Fig. 1). Boreholes which provide the best geological material are shown as both correlations: Gorzów Wlkp. IG 1, Chabowo 2, Mechowo IG 1, Ustronie IG 1, Jamno IG 1 (Pomeranian line — Fig. 2) and Koło IG 4, Podłęże PIG 2, Krośniewice IG 1, Gostynin IG 1/1a, Bartoszyce IG 1 (central line — Fig. 3), and individual borehole sections (Figs. 4–7). A sedimentological profile of borehole Mechowo IG 1 has been compiled by G. Pienkowski (1997). The above-mentioned boreholes are entirely or almost entirely cored and they have a legible wireline log record. Depositional systems and transgressive-regressive cycles are shown in the sections and correlations.


It must be stressed that in northwestern Poland and the Holy Cross Mts. margins there are entirely cored boreholes with comparatively abundant fossils and — in the latter area — exposures allowing detailed sedimentological analysis to be made, contrary to the central part of the Mid-Polish Trough with the greatest thickness of the Lower Jurassic deposits where well logs are supported by 2–5 m long cores taken every 50 or 100 m.

In the central region, depositional systems have been distinguished basing upon both the analysis of now available cores and detailed correlations of well logs along the Mid-Polish Trough from Pomerania to the Holy Cross Mts.
Fig. 1. The Lower Jurassic primary thickness map after Z. Deczkowski, M. Franczyk (1988) modified by A. Feldman-Olszewska

1 — restored isopachs; maximum extent of basin: 2 — Hettangian–Early Sinemurian, 3 — Late Sinemurian–Early Bathonian, 4 — Toarcian; 5 — synsedimentary grabens; 6 — synsedimentary faults; 7 — elevations; 8 — extent of the Middle Jurassic basin; 9 — interpreted borehole sections: B — Bartoszyce IG 1, Ch — Chabowo 2, GY — Gorzów Wlkp. IG 1, G — Goszyń IG 1/A, J — Jamno IG 1, K — Koło IG 4, Kr — Krośniewice IG 1, M — Mechowo IG 1, P — Podębiece IG 1, U — Ustronie IG 1, BD — Bydgoszcz Depression, BM — Bohemian Massif, CL — Cracow Land, EEP — East European Platform, HCM — Holy Cross Mts., K — Kujawy region, KChG — Koszalin–Chojnice Graben, KD — Kutno Depression, KKG — Kalej–Kamienska Graben, LL — Lublin Land, LPG — Laska–Poznań Graben, MPT — Mid-Polish Trough, P — Pomerania, PJ — Polish Jura, WR — Wielkopolska Ridge, ZBG — Żuromin–Bieżun Graben

1 — palaeoizopachyty; m a ks y mal n e z a się gi  b a s e n ó w : 2 — hetangu–synemuru dolnego, 3 — synemuru górmenego–piensbachu, 4 — t oursa; 5 — rowy synsedymen tensyon; 6 — uskok synsedymen tension; 7 — e lewace; 8 — zasięg basenu środkowojurajskiego; 9 — interpretowane profile otworów wiertniczych — patrz tekst angielski; BD — depresja Bydgoszczy, BM — Masyw Czeski, CL — ląd Krakowa, EEP — platforma wschodnioeuropejska, HCM — Góry Świętokrzyskie, K — Kujawy, KChG — rów Koszalina–Chojnic, KD — depresja Kutna, KKG — rów Kalej–Kamienska, LL — ląd lubelski, LPG — rów Laski–Poznań, MPT — brzuda środkopolska, P — Pomorze, PJ — Jura Polska, WR — garb wielkopolski, ZBG — rów Żuromina–Bieżunia

PALAEOTECTONIC AND PALAEOGEOGRAPHIC ELEMENTS OF THE EARLY JURASSIC BASIN

The main palaeotectonic element of the Early Jurassic basin is the Mid-Polish Trough existing during the whole epoch (Fig. 1). It is characterized by the complete lithological-stratigraphical sequence reaching over 1200 m in thickness in the Bydgoszcz Depression and over 1300 m in the Kutno Depression. In the Pomeranian region the trough is
Depositional systems and cyclicity in intracratonic... 477

bounded from the south-west by a series of the Laska-Poznań synsedimentary grabens, and from the north-east by a series of Koszalin-Chojnice synsedimentary grabens. In the central region, the trough is sharply separated in the south-west from the Wielkopolska Ridge by presumably extensional half-graben systems. In this part of the trough there is a dramatic increase in thicknesses and in the Wielkopolska Ridge area a sedimentary gap spanning presumably Hettangian and Sinemurian times and locally erosional gap comprising the Upper or whole Toarcian is recorded (R. Dadlez, M. Franczyk, 1976). North-east of the central region, the Mid-Polish Trough passes more gradually into the East European Platform. In this part of the basin, at the contact between the above-mentioned tectonic units, there are also several minor synsedimentary grabens and horsts (Żuromin-Bieżuń Graben, Płońsk zone, Nasielsk-Dębe Graben, Kompina-Różycze zone) not linked with one another. Apart from the listed tectonic elements, the Kaleje-Kamieńsk Graben bordering the Wielkopolska Ridge from the south-west must be mentioned.

The Early Jurassic basin was surrounded by land areas subjected to denudation: marginal parts of the East European Craton from the north-east, Bohemian Massif from the south-west and Cracow Land from the south. It is also likely that, at least during the Hettangian, the Cracow and Lublin areas were joined together.

Salt tectonics considerably influenced the sedimentation and evolution of the Early Jurassic basin. It resulted in the formation of locally elevated zones and related to them down-
DEPOSITIONAL SYSTEMS

The following depositional systems have been recognized within the Lower Jurassic sequence in the Polish Lowlands:

1. fluvial system:
   - braided river sub-system,
   - meandering river sub-system;
2. swampy system:
   - swampy-lacustrine sub-system,
   - swampy-lagoonal sub-system;
3. deltaic system;
4. siliciclastic shelf system:
   - shallower siliciclastic shelf sub-system,
   - brackish shelf facies,
   - deeper siliciclastic shelf sub-system.

Spatial relationships between the sub-systems and systems within each cycle are shown in Table 1 and Figure 8.

Such zones were located south of grabens and faults which bordered the Mid-Polish Trough. These are elevations situated south of the Laska-Poznań Graben as well as in the Wielkopolska Ridge area (Z. Deczkowski, M. Franczyk, 1988). In the central part of the Mid-Polish Trough (Kujawy region), synsedimentary growth of salt pillows also took place.
Table 1


<table>
<thead>
<tr>
<th>CYCLES</th>
<th>DEPOSITIONAL SYSTEM</th>
<th>CHRONOSTRATIGRAPHY</th>
<th>LITHOSTRATIGRAPHY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Western Poland</td>
</tr>
<tr>
<td>J2-I</td>
<td>fluvial</td>
<td>Toarcian</td>
<td>Upper Kamięt Beds</td>
</tr>
<tr>
<td></td>
<td>lagoonal</td>
<td></td>
<td>Borucice Beds</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Margins of the Holy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cross Mts.</td>
</tr>
<tr>
<td></td>
<td>brackish shelf facies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J1-IV</td>
<td>fluvial</td>
<td>Pliensbachian</td>
<td>Upper Komorów Beds</td>
</tr>
<tr>
<td></td>
<td>fluvial</td>
<td></td>
<td>Upper Sławęcin Beds</td>
</tr>
<tr>
<td></td>
<td>deltaic</td>
<td></td>
<td>Drzewica Formation</td>
</tr>
<tr>
<td></td>
<td>shallower siliciclastic shelf</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>deeper siliciclastic shelf</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>shallower siliciclastic shelf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J1-III</td>
<td>fluvial</td>
<td>Sinemurian</td>
<td>Upper Radowo Beds</td>
</tr>
<tr>
<td></td>
<td>deltaic</td>
<td></td>
<td>Main Sławęcin Beds</td>
</tr>
<tr>
<td></td>
<td>shallower siliciclastic shelf</td>
<td></td>
<td>Koszorów + Ostrowiec Formations</td>
</tr>
<tr>
<td>J1-II</td>
<td>fluvial</td>
<td></td>
<td>Upper Mechowo Beds</td>
</tr>
<tr>
<td></td>
<td>shallower siliciclastic shelf</td>
<td></td>
<td>Ore-Bearing Formation</td>
</tr>
<tr>
<td></td>
<td>swampy-lacustrine</td>
<td></td>
<td>Skłoby Formation</td>
</tr>
<tr>
<td>J1-I</td>
<td>fluvial</td>
<td>Hettangian</td>
<td>Upper Mechowo Beds</td>
</tr>
<tr>
<td></td>
<td>shallower siliciclastic shelf</td>
<td></td>
<td>Ksawerów Beds</td>
</tr>
<tr>
<td></td>
<td>swampy-lacustrine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T4-III</td>
<td>fluvial</td>
<td></td>
<td>Lower Mechowo Beds</td>
</tr>
<tr>
<td></td>
<td>fluvial</td>
<td></td>
<td>Upper Klodawa Beds</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Zagaj Formation</td>
</tr>
</tbody>
</table>

FLUVIAL SYSTEM

Braided river sub-system — packages of sandstones, gravels and quartz conglomerates, up to twenty metres thick, with large-scale cross bedding. These deposits have been recognized in the marginal parts of the basin (the Polish Jura, Holy Cross Mts. margin — lower part of the Zagaj Formation) (G. Pieńkowski, 1983, 1988) where they overlie an erosional surface marking a gap which comprises the uppermost Rhaetian and perhaps even the lowermost Liassic (G. Pieńkowski, 1997)

Meandering river sub-system — light grey, fine-, medium- and vari-grained sandstones. They are characterized by the presence of either sandy members only (channel deposits) or normal cycles (channel deposits overlain by alluvial plain). The sandstones show trough bedding, planar bedding or they are massive with rare clayey flaser laminae enriched in coalified plant detritus. They are also characterized by the low grade of textural maturity, the presence of erosional surfaces covered by gravel horizons and occurrence of abundant coalified plant detritus as well as large plant fragments. Rhizoids, forming ancient soil horizons have also been found. Meandering river deposits represent regressive phases of sedimentary cycles. They occur below the first Early Jurassic transgression over the whole Mid-Polish Trough and in the marginal zones (East European Platform — Olzyszn Beds and Borucice Beds), and they terminate transgressive-regressive cycles J1-III, J1-IV and J2-1 (in Pomerania they comprise the upper part of the Radowo Beds, Komorów Beds and Kamięt Beds; in the central area — the middle part of the Main Sławęcin Beds, the upper part of the Upper Sławęcin Beds and the Borucice Beds; in the Holy Cross Mts. margin — the lowermost part of the Ostrowiec Formation, part of the Drzewica Formation and the Borucice Formation). In the Polish Jura, meandering river deposits constitute the Blanowice and Łysiec Beds.

SWAMPY SYSTEM

Swampy-lacustrine sub-system — dark grey and grey-olive muddy deposits with frequent lenticular or wavy lamination. They are also rich in coalified plants, rhizoid horizons
and coal intercalations. Rare fresh-water fauna and ichnofauna have been recorded. As a thick complex, these sediments occur only in the southeastern part of the Mid-Polish Trough forming the Zagaje Formation (120 m in thickness) and in the Polish Jura where they compose a part of the Coal Beds (G. Piekfowski, 1988). In Central and Western Poland, swampylacustrine deposits are present only in the Hettangian (upper part of the Upper Kłodawa Beds, lower part of the Ksawerów Beds, upper part of the Mechowo Beds).

Swampy-laginal sub-system — dark grey muddy deposits, up to 30 m thick, rich in plant remains, rhizoids, desiccation-syneresis cracks and coal horizons separating deposits with brackish bivalves, agglutinated foraminifers, feeding traces, sideritic and pyritic concretions. They usually show no sedimentary structures. Lenticular lamination can sometimes be observed. These sediments form the ore-bearing horizons in the Holy Cross Mts. margin, mark the onset of the 1st and 5th transgression in Pomerania (upper part of the Lower Mechowo Beds and uppermost part of the Komo­rów Beds in borehole Mechowo IG 1) and the beginning of the regressive phase of cycle J2-I (upper part of the Ciechos­ cinek Beds in the central region and upper part of the Gryfic Beds in the Pomeranian region of the Mid-Polish Trough).

DELTAIC SYSTEM

This system is represented by sandy and muddy deposits arranged in coarsening upward cycles of clastic sequences succeeded in the upper part by fining upward cycles reflecting the transition from fine-grained (muddy) prodelta deposits through coarser-grained sandy delta front sediments, again into finer-grained muddy delta plain sediments. Muscovite, abundant coalified plant detritus, kaolinite, sideritic concretions and pyrite are present here. It seems that Early Jurassic deltas were of river-dominant character and they were prograding into a shallow-marine basin of low salinity or into bays and lagoons.

Deltaic deposits have been recognized within the Skłoby Formation, in sandstones between ore-bearing horizons of the Ore-Bearing Formation and within the Ostrowiec and Drze­wica Formations of the Holy Cross Mts. margin (G. Piekfowski, 1997). They also occur within the "Łysiec Beds" of the Polish Jura (G. Piekfowski, 1988) as well as in Pomerania within the Lower and Middle Mechowo, Radowo and Komo­rów Beds (G. Piekfowski, 1997) overlying shallow siliciclastic shelf deposits. It is probable that the lower part of the Main Ślawęcin Beds resting in the central region upon shallow-marine deposits of the Ksawerów Beds may also represent deltaic environment. Deltaic deposits are usually overlain by fluvial sediments, sometimes (e.g. in the Mechowo Beds) by shallow siliciclastic shelf deposits.

SILICICLASTIC SHELF SYSTEM

Shallower siliciclastic shelf sub-system — sandy or sandy-heterolithic complexes, several tens of metres thick. The sandstones are most frequently fine- to medium-grained of high maturity with dolomitic and calcareous intercalations. They show tabular, hummocky or low-angle cross bedding and planar bedding. Heteroliths are wavy, flaser and lenticular bedded. One of the most characteristic features here is also the presence of trace fossils, among others Diplocraterion ichnos. Shallow shelf deposits occasionally contain pebbles, mud clasts, Fe-oolites, feeding structures, resting traces of bivalves and in the Pomeranian region also scarce aggluti­nated foraminifers and brackish bivalves (J. Kopik, 1964; W. Karaszewski, 1962; G. Piekfowski, 1983).

These sediments were deposited in a shallow, vast, frequently of lowered salinity, within the upper offshore (heteroliths), shoreface and foreshore (barriers and beaches — sandstones) zones above storm wave-base. Shallow shelf deposits mark the onset of transgressive-regressive cycles J1-I, J1-II and J1-III, and appear within the highstand systems tract of cycle J1-IV. In the Pomeranian region they occur within the Mechowo Beds, lower part of the Radowo Beds and the upper part of the Łobez Beds; in the central region they compose the middle and upper part of the Ksawerów Beds, lower and middle part of the Main Ślawęcin Beds and lower part of the Upper Ślawęcin Beds. In the Holy Cross region they have been recognized within the Skłoby Forma-
Fig. 5. Lower Jurassic depositional systems and cyclicity in the Mechowo IG 1 borehole section; sedimentological section after G. Pieńkowski (1997)
For explanations see Fig. 4
Systemy depozycyjne i cykllicznosc w jurze dolnej w otworze Mechowo IG 1; profil sedimentologiczny według G. Pieńkowskiego (1997)
Objaśnienia na fig. 4
Fig. 6. Lower Jurassic depositional systems and cyclicity in the Krośniewice IG 1 borehole section
For explanations see Fig. 4
Systemy depozycyjne i cykliczność w jurze dolnej w otworze Krośniewice IG 1
Objaśnienia na fig. 4
tion, lower part of the Ostrowiec Formation and lower part of the Drzewica Formation. Barrier and beach deposits are also represented between the ore-bearing horizons of the Ore-Bearing Formation (G. Pienkowski, 1983, 1997). Shallow shelf heteroliths with marine bivalves have also been recorded from the Sub-Coal Beds in the Polish Jura (G. Pienkowski, 1988).

Brackish shelf facies — grey-green muddy and heterolithic deposits. They are parallelly or lenticularly laminated, with lenticular bedding. Claystones are locally non-laminated. They are occasionally interbedded with sandy layers showing features of tempestites. Coagulated plant detritus, muscovite, siderites, estheria and agglutinated foraminifers have been recorded from these deposits. In the Polish Jura, Diplocraterion ichnosp., a trace fossil characteristic of the middle shoreface zone, has been found. These deposits, representing the lower part of the Gryfice Beds and Ciechocinek Beds (so-called Green Series), are common over the whole area of the Polish Lowlands reaching up to 50–60 m in thickness. Only in northeastern Poland they are more sandy. Muddy sediments are locally light grey and do not exceed 40 m in thickness there (R. Dadlez, 1964, 1973). Clastic brackish basin deposits compose the lower, transgressive part of the Early Jurassic transgressive-regressive cycle J2-I.

Deeper siliciclastic shelf sub-system — 20–60 m thick complex of dark grey mudstones with either lenticular bedding and lamination or completely structureless. They contain marine fauna of ammonites (in the Lobez Beds only), agglutinated and calcareous foraminifers, bivalves and trace fossils. These deposits appear in the Early Jurassic only within the transgressive systems tract of cycle J1-IV, composing the Lobez Beds in Pomerania and, most likely, the uppermost part of the Main Święcin Beds in the central region, as well as the upper part (muddy) of the Gielniów Formation in the Holy Cross Mts. margin.

### TRANSGRESSIVE-REGRESSIVE CYCLES

Five 3rd-order transgressive-regressive cycles (1–10 Ma long each) can be recognized in the Lower Jurassic of the Polish Lowlands (Tab. 1, Fig. 8).

**T4-III.** The Lower Jurassic sequence begins with fluvial and swampy deposits representing the regressive phase of the last Triassic cycle. In the lithostratigraphical subdivision in Poland they are correlated with the lower part of the Lower Mechowo Beds of Pomerania (Fig. 5), Upper Kłodawa Beds and the lower part of the Ksawerów Beds in the central region (Fig. 6) and also Zagaje Formation of the Holy Cross Mts. margin (Tab. 1). Basing upon the megaspore Nathorstisporites hopliticus Jung (Mechowo IG 1 — T. Marcinkiewicz, 1964; Gorzów Wlkp. IG 1 — T. Marcinkiewicz, 1971; Konary IG 1 — T. Marcinkiewicz, unpublished) and the miospores Araritisporites minimus Schulz (Opocno PIG 2 — A. Fijałkowska, unpublished), Pinus pollenites minimus (Couper) (Ostałów PIG 2 — A. Fijałkowska, unpublished), Lycostrobus scotii Nathorst (Gorzów Wlkp. IG 1) they may...
be asssumed to be Hettangian in age. Because the overlying marine deposits are correlated with a transgression which took place in the planorbis Zone, so the described sediments must correspond to the lowest zone comprising the Lower Hettangian. It is possible that, moving towards the Holy Cross Mts. margin, the studied deposits comprise larger and larger part of the planorbis Zone and perhaps even the lower part of the liasicus Zone, since it seems that the first Liassic transgression was diachronous in the Polish Lowlands. The upper part of cycle T4-III corresponds to the shelf margin wedge systems tract (SMW) in the eustatic curve of B. U. Haq et al. (1988) (Fig. 9).

JI-I. This cycle comprises the whole remaining part of the Hettangian and earliest Sinemurian. Its transgressive phase is represented by shallower shelf siliciclastic deposits overlain by deltaic sediments followed by fluvial (e.g. borehole Krośniewice IG 1 — Fig. 6; Gorzów Wlkp. IG 1 — Fig. 4) or swampy ones (Mechowo IG 1 — Fig. 5). This cycle corresponds to the upper part of the Lower Mechowo Beds, Middle Mechowo Beds, and the lower part of the Upper Mechowo Beds in Pomerania, Ksawerów Beds and the lowest part of the Main Sławęcin Beds in the central region, most of the Liwiec Beds in the eastern Warsaw Trough, the Słkoby Formation and the lower part of the Ore-Bearing Formation in the Holy Cross Mts. margin (Tab. 1).


G. Pieńkowski (1991, 1997) correlates the transgression of cycle JI-I with the worldwide transgression of the planorbis Zone suggesting that this transgression was synchronous over the whole Polish Lowlands area. Analysing the correlations of wireline logs in many boreholes located along the Mid-Polish Trough (Mechowo IG 1, Piaski IG 1, Rzeko 1, Czaplinek IG 1, Złotów 2, Pila IG 1, Zabartowo 1, Bydgoszcz IG 1, Konary IG 1, Byczyna 1, Brześć Kujawski IG 1, Krośniewice IG 1, Zgierz IG 1, Jeżów IG 1, Rawa Mazowiecka 1, Studzianna IG 2, Opoczno PIG 2 and Ostałów PIG 2) the author has come to a conclusion that this transgression is diachronous and its beginning in the Holy Cross Mts. margin (bottom of the Słkoby Formation) should be correlated with the lowermost part of the Middle Mechowo Beds in Pomerania.

The JI-I cycle corresponds well with both B. U. Haq et al. (1988) and A. Hallam (1988) eustatic curves (Fig. 9).

JI-II. This cycle comprises the Early Sinemurian. Its transgressive phase is represented by shallower siliciclastic shelf deposits whereas the regressive one is pronounced by swampy-lagoonal (Mechowo IG 1 — Fig. 5) or deltaic and fluvial (Krośniewice IG 1 — Fig. 6) sediments.

This cycle comprises the middle and upper part of the Upper Mechowo Beds in Pomerania, lower part of the Main Sławęcin Beds in the central region, and the Ore-Bearing Formation together with the lowermost part of the Ostrowiec Formation in the Holy Cross Mts. margin (Tab. 1). G. Pieńkowski (1991, 1997) correlates this part of the Upper Mechowo Beds with the Ostrowiec Formation. The present author, however, basing upon the above-mentioned correlation along the Mid-Polish Trough is convinced that the Ore-Bearing Formation is equivalent to the Upper Mechowo Beds. This opinion is consistent with R. Dadlez’s views (1973, 1978).

Basing upon the analysis of sections in the Szczechin–Pińtrków area, it seems that the sea did not transgress this region and was limited only to the Mid-Polish Trough. The transgressive phase of this cycle is dated in its lower part by the megaspore Nathorstisporites hopliticus Jung (Mechowo IG 1 — T. Marcinkiewicz, 1964; Gorzów Wlkp. IG 1 — T. Marcinkiewicz, 1971), thus it commenced during the Early Sinemurian or earlier.

Cycle JI-II corresponds with both B. U. Haq et al. (1988) and A. Hallam (1988) eustatic curves (Fig. 9).

JI-III. This cycle represents Late Sinemurian times. Its transgressive phase consists of shallower siliciclastic shelf deposits whereas the regressive one is pronounced by deltaic and fluvial sediments (correlations — Figs. 2 and 3). This cycle comprises the upper part of the Upper Mechowo and Radowo Beds (Mechowo IG 1 — Fig. 5), most part of the Main Sławęcin Beds up to the top clayey series in the central region (Krośniewice IG 1 — Fig. 6) and the Ostrowiec Formation (Ostrowiec and Koszoróws Formations sensu W. Karaszewski, 1962).

This sedimentary cycle has poor biostratigraphical documentation. In the upper part of the Upper Mechowo Beds of borehole Gorzów Wlkp. IG 1, the megaspore Nathorstisporites hopliticus Jung (T. Marcinkiewicz, 1971) has been found. Radowo Beds of boreholes Mechowo IG 1 and Gorzów Wlkp. IG 1 have yielded Maexisporites planatus (Marcinkiewicz) Marcinkiewicz (T. Marcinkiewicz, 1964, 1971).

Cycle JI-III corresponds with both B. U. Haq et al. (1988) and A. Hallam (1988) eustatic curves (Fig. 9).

JI-IV. This cycle represents the whole Pliensbachian. It covers, for the first time, the entire area of the Polish Lowlands. It occurs in the Mid-Polish Trough, Szczechin Trough, Gorzów Block, Wielkopolska Ridge and northeastern Poland. In the areas of sedimentary continuity (Mid-Polish Trough and Szczechin–Gorzów region), the transgressive phase of this cycle is represented by mudstones of deeper siliciclastic shelf. Slow falling of sea-level during this cycle resulted in that the deeper shelf sediments are overlain by claystone-sandstone series of shallower shelf and followed by deltaic and fluvial deposits terminating this cycle. In the areas where the Early Jurassic deposition was initiated by this cycle, fluvial sediments occur.

The transgressive phase is represented by the Łobez Beds in Pomerania, the uppermost part of the Main Sławęcin Beds in the central region (claystone complex at their top) and the Gielniów Formation in the northern margin of the Holy Cross
Ms. The regressive phase is represented by the Komorów and Upper Ślawęcin Beds and Drzewica Formation (Tab. 1). In northeastern Poland this cycle consists of the Olsztyn Beds (Bartoszyce IG 1 — Fig. 7).

In the western part of the Polish sedimentary basin this cycle is very well documented by fossils. Early Pliensbachian ammonites characteristic of the jamesoni Zone (R. Dadlez, J. Kopik, 1972) and documenting the transgressive phase have been recorded from the Łobez Beds. Within this zone, the jamesoni Subzone is also documented in borehole Mechowo IG 1 by the appearance of the ammonite Uptonia sp. juv. (cf. distincta Tutcher et Trueman) (J. Kopik, 1964; R. Dadlez, J. Kopik, 1972). It is likely that the transgression reached the territory of Poland as early as during the polymorphus Zone because it seems that Hypoxynoticeras sphenonotum (Monke) found in borehole Golancz and poorly preserved, problematic Peripleuroceras sp. described from borehole Kamięń Pomorski IG 1, come from this zone (R. Dadlez, J. Kopik, 1972). The transgressive phase continued here also during the ibex Zone which is evidenced by the appearance of index ammonites in boreholes Rokita IG 1, Mechowo IG 1, Świnoujście 1 and Kamięń Pomorski IG 1.

In Western Poland, the margaritatus Zone (Chabowo 2 — J. Kopik, unpublished) and spinatum Zone (Wolin IG 1) are also documented by ammonites. Between these two well documented shaly parts of the Pliensbachian section (jamesoni-ibex and margaritatus-spinatum Zones) there are sandstones probably representing the davoei Zone but lacking any index fossils so far. Therefore, it is likely that in the extreme west of the Polish Lowlands, two sedimentary cycles instead of one should be distinguished in the Pliensbachian. Insufficient data and lack of sedimentological studies of this zone do not allow drawing such conclusions yet.

Other regions of Polish Lowlands have much worse age documentation. They were dated based on megaspores which ranges point to the Upper Sinemurian and Pliensbachian together.

In the Warsaw Trough, the Pliensbachian is documented by megaspores described by T. Marcinkiewicz. These are: Horstisporites planatus (Marcinkiewicz) Marcinkiewicz (= Maexisporites planatus (Marcinkiewicz) Marcinkiewicz); H. harrisi (Murray) Potonie; Minerisporites institus Marcinkiewicz; Bacutriletes spicatus (Marcinkiewicz) Marcinkiewicz (M. Franczyk, 1983).

In Kujawy region only in Jezów IG 1 borehole was found 1 specimen of B. spicatus (Marcinkiewicz) Marcinkiewicz.

In northeastern Poland the following megaspores have been described from fluvial deposits: H. harrisi (Murray) (= Erlansonisporites reticulatus); H. planatus (Marcinkiewicz) Marcinkiewicz; H. harrisi (Murray) (= E. reticulatus) (Bartoszyce IG 1 — R. Dadlez, 1974) and B. spicatus (Marcinkiewicz) Marcinkiewicz (Elk IG 1 — R. Dadlez, 1968).
Cyclicity of the Polish Lowlands

B.U. Haq et al. (1988)

A. Hallam (1988)

Fig. 9. Transgressive-regressive cycles in Central Poland compared with eustatic curve of B. U. Haq et al. (1988) and with eustatic curve of A. Hallam (1988)


Cycle J1-JV is subdivided into several 3rd-order cycles in the curve of B. U. Haq et al. (1988). The A. Hallam curve (1988), in which only two transgressive-regressive cycles are shown in the Pliensbachian, is more suitable for comparison with the Polish Lowlands (Fig. 9). As it was suggested above, both these transgressions separated by a regression in the davoei Zone will possibly be recognized in the extreme western part of Poland.

J2-I. This cycle is correlated with the Toarcian. Its geographical extent is almost equal to the previous one. Its transgressive phase is marked over the whole Polish Lowlands by grey and green mudstones representing brackish basin facies. Only in Pomeranian region it begins with swampy-lagoonal deposits followed by brackish facies. The regressive phase is pronounced by swampy-lagoonal deposits passing upwards into a thick (over 200 m in the Kutno Depression) fluvial complex.

This cycle comprises the middle and upper part of the Gryfice and entire Kamień Beds in Pomerania (Tab. 1, Figs. 4 and 5), and Ciechocinek and Borucice Beds in Central and Eastern Poland (Tab. 1, Figs. 6 and 7).

No index fossils have been found in its transgressive deposits so far. Its age is determined in Western Poland by the appearance of the megaspores: Paxillitriletes phylicus (Murray) Hall et Nicolson (=Thomsonia phylicus), Erlansonisporites sparassis (Murray) Potonié (= E. tegimentus Marcinkiewicz), Echitriletes hispidus Marcinkiewicz, E. ex.
CONCLUSIONS

1. The Early Jurassic sedimentation took place within a shelf and intracontinental basin, alternately. During transgressive phases, largely shallow-shelf heteroliths and sandstones were deposited. Regressive phases were the periods of deltaic, fluvial and swampy sedimentation. Deeper shelf mudstones were deposited only in the transgressive phase of the Pliensbachian cycle J1-IV.

2. Stratigraphy is chiefly based upon megaspores and miospores whose stratigraphical ranges comprise several ammonite zones. Therefore, correlations with various parts of the Polish Basin and the basins of Western Europe are not fully reliable. They are additionally supported by lithostratigraphic and wireline log correlations. Index ammonite fossils enable a comparison with the standard stratigraphical division only in the Pliensbachian of the Pomeranian region.

3. Five 3rd-order transgressive-regressive cycles have been distinguished in the Polish Basin. They fairly well correspond to the cycles in both the B. U. Haq et al. curve (1988) and A. Hallam curve (1988) (Fig. 9). Only cycles J1-IV and J2-I comprise a few B. U. Haq’s cycles and two A. Hallam’s cycles each. Therefore, they may be considered 2nd-order instead of 3rd-order cycles.

Acknowledgements. The author expresses her sincere thanks to Mrs. Elżbieta Tarka and Mr. Jan Turczynowicz for computer drafts.

Translated by Krzysztof Leczyński

REFERENCES


SYSTEMY DEPOZYCJNE I ANALIZA CYKLICZNOŚCI W DOLNOJURAJSKIM BASENIE INTRAKRATONICZNYM

Streszczenie

Analizę basenową utworów jury dolnej wykonano na podstawie kilku‐
dziesięciu utworów występujących w bruzdzie siedmopolskiej oraz na jej obraże‐
zeniach (fig. 1). W przypadku dużego materiałem badanym ostatecznie zostały przedstawione na oddzielnych profilach oraz przekrojach korelowalnych i biegających poprzez trzy: Gorzów Wlkp. IG 1 (fig. 4), Chabowo 2, Mechowo IG 1 (fig. 5), Ustronie IG 1, Jarno IG 1 — linia pomorska (fig. 2) oraz Koło IG 4, Podobiece PIG 2, Królewice IG 1 (fig. 6), Gostynin IG I/la, Bartoszyce IG 1 (fig. 7) — linia centralna (fig. 3).

W pierwszym etapie badań przeanalizowano osady pod względem genetycznym, co pozwoliło wydzielić systemy depozytory: fluwialny (z podsystemami: rzek meandrujących, rzek roztopowych), deltowy, bagienny (z podsystemami: bagienno-jeziornym, bagienno-lagunowym), szelfu klastycznego (z podsystemami: szelfu płaskiego, głębokiego oraz fację szelfu brakicznego).

Na podstawie następującej pionowej i przebiegu obocznych wymienionych systemów depozytyjnych dokonano podziału utworów jury dolnej na 5 cykli transgresywno-regresywnych, a najstarsze utwory (hetang dolny) zaliczono do fazy regresywnie ostatniego cyklu triasowego (T4-III) (tab. 1).


W Polsce zachodniej cykl ten jest dobrze datowany amonitami przewodnimi poziomów jassonis i i mesoni i spinatum (R. Dąblewski, 1972; J. Kopik, dane niepublikowane). W centralnej i północno-wschodniej Polsce fauny przewodnicy nie stwierdzono, osady datowane są na podstawie przewodnich megaspory.


Osady cyklu datowane są na podstawie przewodnich megaspory.


Prezentowany model cykliczności generalnie jest zgodny z modelem opublikowanym przez G. Pietrowskiego (1997).