BIOSTRATIGRAPHY

The surface and well sections mentioned in the present report add up to a length of 174 km.

From slightly over 41 km of section almost 2,900 sediment samples have been investigated palaeontologically, giving a coverage of one sample for each 14 m of section.

Although occasional palaeontological studies date form as early as 1922 (VAN DER VLERK), a systematic investigation was not undertaken until October 1935.

Ten standard sections were thoroughly studied, viz. Ngrayong and Nganget (1936), Kawengan, Tawun, Kedewan N., Pegat and Ledok (1937), Mahindu and Mundu-Kedinding (1938) and Konang (1940).

The results obtained from the sections Plantungan and Pati-Candi (1941) were unfortunately lost during the second world war.

From these detailed and thoroughly executed investigations the following “Palaeontological zonation East Java” valid for the Kening area gradually emerged:

- **Zone 1**
- **Zone 2** “Rotalia-rijke lagen”
- “Fossiel-arm traject”
- “toplagen zone 4”
- **Zone 3** “Goborotalia 3 lagen”
- **Zone 4** “Bolivina-rijke lagen”
- **Zone 5** “C-G-V-lagen”
- **Zone 7** (with subzones 7a, b, and c)
- **Zone 8** (with subzones 8a, b, c, and d)
- **Zone 9, 10, 11 and 12** (in Tawun only)

Just before the war the same zones were extended to the Surabaya area (WAIBEL, 1941).

A renewed exploration effort in 1949 led to micropalaeontological investigations of material from the Jawa Sea, Madura, Tuban, South Rembang Hills and the exploration wells Pulungan, Gunung Anjar, Kawengan E-90, Gogor, and Pegat.

In order to facilitate comparison with older reports the old “Palaeontological zonation East Java” is indicated on encls. 8-27.

Because the above zonal subdivision is partly time bound and partly dependent on environmental criteria, difficulties were encountered with correlations in the basinward direction, where the larger foraminifera are practically absent.

For this reason a study of pelagic foraminifera was started in 1955, although in the meantime the old zonal subdivision was extended by zones 13-17 for the Tuban area (MUHAR, 1956a).
Text fig. 4 – zonation based on larger foraminifera. Letter classification of the Tertiary after VAN DER VLERK & UMBGROVE, 1927, and LEUPOLD & VAN DER VLERK, 1931, slightly modified.
Text fig. 5. Verticale verspreiding pelagische foraminiferen indonesië (voorlopige tabel)
a. Time-stratigraphic units

The classical tools for time-stratigraphic zonation in Indonesia are the larger foraminifera. A slightly modified version of VAN DER VLERK’s letter classification was generally used in East Java and Madura. The main determinations of this zonations are shown in text figure 4.

The boundary between f2 and f3 is placed at the highest occurrence of *Miogypsina*. This may not be valid for the whole Indo-Pacific region, because it is as yet uncertain whether this boundary may not be facies-bound after all (compare HAAK, The Hague,EP-25943). The boundary has so far been helpful for local use, as the pelagic faunas above and below it indicate a different age.

The larger foram-bearing intervals permitting a zonation within this letter classification are indicated on encls. 8-27 in a separate column.

East Java is a prolific region for both pelagic and larger foraminifera. In marine sediments lacking the latter group, pelagic foraminifera usually abound. Unfortunately, only pelagic components of the post-war sections could be studied. For the pre-war ones, we had to rely upon the distribution charts, as the material had been lost. Gradually, however, a pelagic zonation emerged that proved to be useful for the whole area (text figure 5).

This zonation can still be improved upon, particularly if the flood of literature published on this subject during the last decade is consulted. Those intervals from which sample material contained a determinable pelagic fauna are mentioned on encls. 8-27.

One of the main results obtained from the study of the pelagics is that the KMM in the South Rembang Hills, although lithologically equivalent, appeared to be younger than the KMM from Central Rembang.

b. Environmental interpretation

At the time this study was interrupted, the interpretation of the environment of deposition indicated by the fossil benthic foraminiferal faunas could only be realized by a comparative study of the distribution of Recent faunas. At that time this was a time-consuming task, in view of the amount of literature on the subject and the absence of a usable library in Surabaya.

If such an environmental interpretation of an entire area were to be undertaken at present it would only take a fraction of the time, as part of the job could be done by a computer. The procedure would be to:

i. Select from the foraminiferal distribution charts the main components present in each of the investigated samples.
ii. Determine the main components thus found by using the types from the East Java Type Collection.
iii. Look up for each determined species the appropriate species number under which it is registered in the IBM data bank at Rijswijk (if the species does not occur in Recent deposits, take the most closely related Recent deposits, take the most closely related Recent equivalent).
iv. Compile a numbered list of all samples to be interpreted, giving for each sample the species numbers of the main components present.
v. Run computer programme 36208 – which utilizes the p° values of Recent species (see Rijswijk Research Report R 1158, October 1964) – and calculate per sample the most probable environment and / or depth range indicated by the combination of main components in that sample.
vi. Plot the results on the cross-sections.
When comparing the benthic faunas of East Java and Madura with Recent ones on a more general scale, the following impression was gained:

**Marsh** faunas have thus far not been recognized in this region.

(These faunas occur widely, e.g. in E. Kalimantan, and are characterized by the following main components:

- *Haplophragmoides wilberti* ANDERSON = *Cyclammina* BP. 1, *Haplophragmoides* BP. 2, 2a, 2b
- *Miliammina fusca* (BRADY) = *Ammodiscus* BP. 3c, *Massilina* BP. 8,
- *Quinqueloculina* BP. 4a, 13, *Ammomarginulina* BP. 3.
- *Trochammina lobata* CUSHMAN = *Trochammina* BP. 1, 13, *Ammomarginulina* BP. 3
- *Trochammina macrescens* BRADY = *Trochammina* BP. 8)

**Neritic** (and possibly in part also lagoonal and estuarine) faunas commonly occur in E. Java and Madura. They are characterized by the following main components:

- *Ammonia annextens* (PARKER & JONES) = Rotalia J. 3
- *Ammonia* ex. gr. *beccarii* (LINNE) = Rotalia J. 8b, 13, 33, 33a, 34, 34a, 36, 39, 39a, 40, 43, *Calcarina* J. 3
- *Amphistegina lessonii* D’ORBIGNY = *Amphistegina* J. 1, 1a, 3, 3c, 5, 5b
- *Asterigerina carinata* D’ORBIGNY = *Asterigerina* J. 1
- *Asterorotalia pulchella* (D’ORBIGNY) = *Rotalia* J. 2, 2s, 2a, 2as, 2bs, BP. 4
- *Cancris oblonga* (WILLIAMSON) = *Cancris* J. 1, 1c
- *Cribrononion advena* (CUSHMAN) = *Elphidium* J. 2b, 6, 16, 16a
- *Eponides antillarum* (D’ORBIGNY) = *Discorbis* J. 1, 1a, 1s
- *Nummulites ammonoides* (GRONOVIUS) = *Operculina* J. 8, 9, BP, 10v
- *Pseudorotalia schroeteriana* (PARKER & JONES) = *Rotalia* J. 7, 11, 11a, BP, 28a

This group also includes the forms belonging to the Nummulitidae, Miogypsinidae and Lepidocyclinidae. Faunas with such neritic main components have their main distribution in LDT, LLK, KLK, KNZ, MF and certain intervals of the TF.

**Bathyal / abyssal** faunas are also widely distributed in this region.

They are characterized by the following main components:

- *Bulimina alazanensis* CUSHMAN = *Bulimina* J. 2b
- *Bulimina* ex. gr. *inflata* SEGUENZA = *Bulimina* J. 2a, 2d, 5
- *Chilostomella oolina* SCHWAGER = *Chilostomella* J. 1, 2, 2a
- *Cibicidoides robertsonianus* (BRADY) = *Cibicides* J. 1e, 1h
- *Cyclammina cancellata* BRADY = *Cyclammina* J. 1d, 3, 3a, 3b, 3d, 3e, 3s, 6,7
- *Eggerella bradyi* (CUSHMAN) = *Eggerella* J. 1, 1a, 3, 4
- *Gavelinopsis translucens* (PHLEGER & PARKER) = *Glomospira* J. 4
- *Glomospira charoides* (JONES & PARKER) = *Glomospira* J. 4
- *Gyroidina* ex. gr. *soldani* (D’ORBIGNY) = *Gyroidina* J. 1, 2a, 3, 3a, 3s, 4, 4b, 4c, 4d, 11a, 11b, 11c, 17
- *Hoeglundina elegans* (D’ORBIGNY) = *Epistomina* J. 1, 1s, 6
- *Karreriella bradyi* (CUSHMAN) = *Dorothia* J. 1, 2
- *Laticarinina pauperata* (PARKER & JONES) = *Laticarinina* J. 1
- *Martinottiella* ex. gr. *communis* (D’ORBIGNY) = *Clavulina* J. 1, 1a, 1b, 1c, 1as, 1s, 2d, 16
- *Melonis pompilioides* (FICHTEL & MOLL) = *Nonion* J3
Osangularia culter (PARKER & JONES) = Pulvinulinella J. 1, 3,
Planulina wuellerstorfi (SCHWAGER) = Planulina J. 1, 1b, 1s, 14, 14a
Pullenia bulloides (D’ORBIGNY) = Pullenia J. 1
Sigmoilopsis schlumbergeri SILVESTRI = Sigmoilina J. 1a, 1e, 1f

Faunas with the above forms among their main components are widely distributed in the KSZ, KMM, KWM, and TF, but also in certain parts of the KLK.

Apart from the species mentioned above there are many other determinable forms which have their own more or less restricted environment distribution.

It is therefore justified to conclude that a more detailed environmental analysis on a sample basis is quite feasible, resulting in a more complete picture of local vertical and lateral facies changes within the E. Java basin.

c. Environmental distribution of reservoir rock

In the preceding paragraph it was shown that in the sandy and limy KLK, KNZ, and in certain intervals of the TF, neritic foraminiferal faunas are present and that marly members of KF and TF are often of a bathyal-abyssal origin. This is expressed schematically and tentatively in a diagram (text fig. 6) which reviews per structure the stratigraphic intervals that are oil-bearing and those that are not. The names of those structures that yielded oil in certain intervals or else proved to be non-productive in exploration wells are shown in a block.

The producing sands seems to be confined to the predominantly neritic deposits, although the exact environmental setting of the reservoir rock is for each field still a matter of speculation, particularly for the KLK. It is for instance not possible to conclude from the available lithological data whether the sands are partly barrier sands or whether they have a different origin.

Another possibility is that the sands in the KLK are partly turbiditic, but this cannot be concluded form the lithological information either, as data on sedimentary structures are not available. This diagram also included schematically the expectations regarding those structures and stratigraphic intervals that have not been tested.

Finally, it should be mentioned that production from turbiditic sands in the marly deeper-water sequences is always a possibility.
Text-fig. 6. Diagram showing expected distribution of reservoir rock within BPM-areas. Situation as per end 1957 (no scale)
IV. CONCLUSIONS

The sediments in the younger Tertiary East Java Madura basin have been deposited in a variety of environments ranging from siliciclastic to carbonate, and from shallow neritic to bathyal, and possibly even abyssal.

The preliminary environmental interpretations suggest a shallowing towards the north, although lagoonal and marsh deposits have not been recognized as such.

Generally speaking, the sediments thicken in southerly direction, but time-stratigraphic evidence points to the absence of some sequences.

Oil-producing reservoir rocks consist of sandstones, which presumably are of neritic origin.

The abundant pelagic faunas present in the marly sediments made it possible to extend the larger foram zonation – mainly of use within neritic sediments – into the deeper marine deposits.

An environmental interpretation on a sample basis is possible, if both a type collection and a set of foraminiferal distribution charts are available.

V RECOMMENDATIONS

1. The presence of very well-exposed surface sections covering younger Tertiary deposits in a variety of environments offers the opportunity for a detailed study of time-stratigraphic zonation based both on pelagic and on larger benthic foraminifera, and the relationship between these two. Such a study would contribute towards and improvement in the worldwide zonation based on these two groups of organisms.

2. As within this region there are good examples of facies changes form carbonate to siliciclastic, and from shallow neritic to bathyal-abyssal environments, a combined sedimentological-palaeoecological study should be undertaken, of which the results will be of more than local value.

   This region moreover could be used as a test case for an environmental interpretation by computer covering a whole basin in one programme.

3. Special attention should be paid to a study of the oil sands, as they are often fossiliferous, which is often not the case in reservoir rocks of siliciclastic origin.

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