PALEOGENE CALCAREOUS NANNOFOSSIL CHRONOSTRATIGRAPHY AT "CB" WELL, SOUTH MAKASSAR BASIN

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Abstract. "CB" well is located in the South Makassar Basin, where the lithological unit comprises of the Balangbaru and the Toraja Formation. The Paleogene calcareous nannofossils biostratigraphy of this area has not been studied yet and the chronostratigraphic framework is still arguable, So in this study, we discuss the detailed bio-chronostratigraphy of the South Makassar Basin, using calcareous nannofossil biostratigraphy. This study aims to identify the calcareous nannofossils assemblages, determine the age, calculate the sedimentation rate, and reconstruct Paleogene chronostratigraphy in the "CB" well in The South Makassar basin. This study analyzed high-resolution calcareous nannofossils of the well "CB" from a depth of 9 to 2288 m. The cutting samples and a few core samples were used for the biostratigraphic analysis and were processed using the smear slide method. There are 53 species of calcareous nannofossils belonging to 21 genera identified in the "CB" well. Three calcareous nannofossils genera which dominate the assemblages are *Cyclicargolithus, Reticulofenestra*, and *Sphenolithus*. The age of the lithological units are assigned to Maastrichtian Stage of Late Cretaceous and NP16-NP23 of middle Eocene to middle Oligocene. Unconformities detected in two horizons are correlated to the timing of well-known global climatic events such as "K/Pg Meteor impact", "the Late Paleocene Thermal Maximum" (66 to 55Ma) and "Oi-1 glaciation" (34 to 32Ma). This result reveals that the occurrence of unconformities of "CB" well in the South Makassar Basin is significantly related to eustatic changes caused by global climatic events. The implications of this study include that it could be a novel contribution to hydrocarbon exploration in Indonesia, as well as an important reference for further biostratigraphic studies in the South Makassar Basin.

INTRODUCTION

Indonesia is an archipelagic country that has very abundant natural resources. Currently, Indonesia has a gas production level of 6 Billion Standard Cubic Feet per Day (BSCFD) (Menteri ESDM, 2021) and Natural gas reserves of 62.4 Trillion Cubic Feet have been proven. Therefore, Indonesia continues to look for exploration wells in various basins with hydrocarbon prospect. One of the sedimentation basins with indications of hydrocarbons potential in Indonesia is the South Makassar Basin which is part of the edge of the Sunda mainland (Kalimantan) and then separated due to the expansion of the Makassar Strait during the Eocene (Katili, 1978; Situmorang, 1982; Sikumbang, 1990).

Previously, this area had been studied mainly regarding the petroleum system, some of the biostratigraphy that had been previously studied was based on data large foraminifera and small foraminifera, but there were still many biostratigraphic and chronostratigraphic framework is still arguable in this area. The Paleogene calcareous nannofossils biostratigraphy of this area has not been studied yet, although previously data there was research in this area by A. Bakry (1994) but the resulting geological age was not detailed and no analysis was carried out at any depth. The regional geology this area have been published in research reports but there are some lithostratigraphies still confusing, especially the name of "Formation" that will be used in this research which was not identified in previous

research. This is a problem that must be corrected by providing an explanation of the formation on each lithostratigraphy. For this reason, we tentatively use the name of "Formation" in this study according to regional stratigraphy by Lemigas (2006), and then some of the unconformities found in this research will be clarified by providing an unconformity symbol on the lithostratigraphy. Some of these problems have greatly influenced research about the reconstruction of the oil system in the basin. No recent publication has been found that examines chronostratigraphy and biostratigraphy based on calcareous nannofossils in this basin. In a previous report, there was stratigraphy located in the South Makassar basin but there was no unconformity zone (Lemigas, 2006).

The South Makassar Basin is situated on the eastern margin of the stable Sundaland craton and is located offshore of South Sulawesi province. There are 2 distinctive trends are recognized NNW – SSE and N – S (Fig.1) (Pertamina BPPKA, 1996), this structure is interpreted as the result of back arc expansion due to subduction of the eastern part, which is represented by the Toraja Formation as syn-rift deposits. The sediments of the basin are composed of the Late Cretaceous to Paleogene Series. The Late Cretaceous is composed of the Balangbaru Formations which consist of Siltstone, Sandstone and Claystone. The Paleogene Series, which are characterized by Claystone, Limestone and Coal, are Toraja Formation (Fig.2). We studied in detailed the Paleogene calcareous nannofossil biostratigraphy of the exploration well located in South Makassar Basin, Indonesia. Based on calcareous nannofossil biostratigraphy, we determine the characteristics of calcareous nannofossils Paleogene age in detail, identified the sedimentation rate and detected unconformities, and determine the chronostratigraphy of well "CB". From these problem, we clarify the unconformities and global climatic events. Finally, we summarize the geology framework and chronostratigraphy of the South Makassar Basin.

Biostratigraphy is a branch of geology that discusses sequences, relationships and events or the history of rocks based on the fossils contain. Determination of biozonation is based on the interval zone, namely the "first"occurance datum (FO) which is the lower age boundary or first appearance of a nannofossil taxon and the "last" occurrence (LO) which is the upper age boundary or last appearance of a nannofossil taxon (SSI, 1999). Nannofossil are very small calcite plates (<25 microns) originating from single-celled algae with photosynthetic pigments and belong to the *Chrysophyta* division, class *Coccolithophyceae* (Gartner, 1981; Perch-Nielsen, 1985). A single nannofosil is called a *Coccosphere.* Nannofossil are one of the best groups of microfossils used in paleoenvironment reconstruction, stratigraphy and can be used in the petroleum industry to determine the relative age of the rock and correlation of lithofacies identified in gas and oil wells.

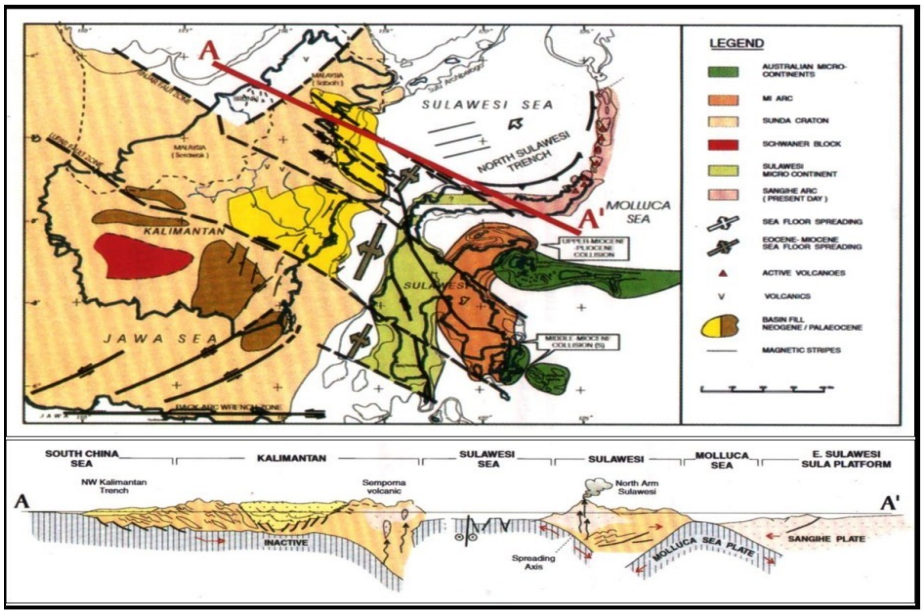

FIGURE 1. Main Tectonic Elements of Sulawesi (Pertamina BPPKA, 1996)

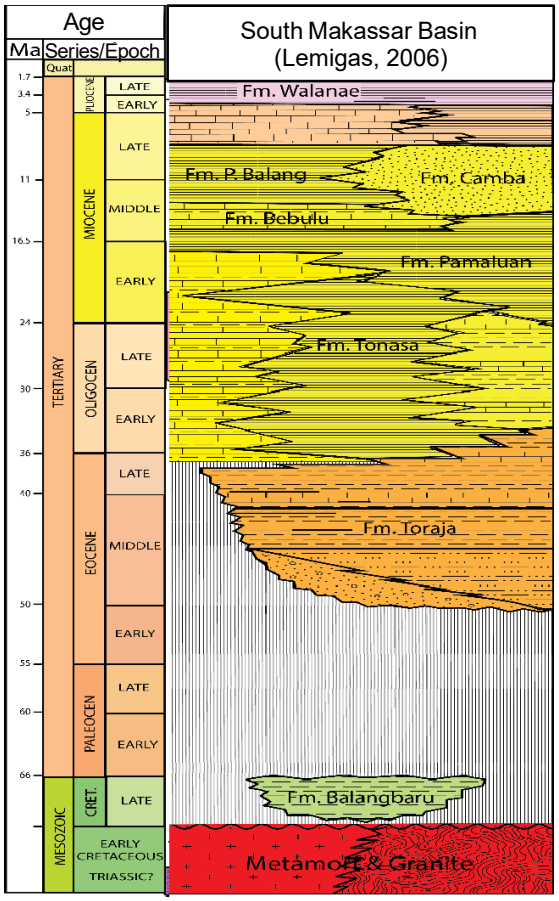

FIGURE 2. Stratigraphy of the South Makassar Basin (Lemigas, 2006) with modification

METHOD

The "CB" well located in the Tanakeke Island which is off the coast of South Sulawesi. This research used primary data, namely drill cuttings samples and few core samples from the "CB" well and secondary data namely summary log data (lithology). The research well reached a depth of 2288 m and 100 samples were prepared using the smear slides method starting from a depth of 9 to 2288 meters. The samples are collected about a 18 m interval. The cutting samples and few core samples are used for the preparation of calcareous nannofossil. The preparations were carried out at the Sedimentology laboratory, Faculty of Earth and Energy Technology, Universitas Trisakti. A little bit of cutting samples from studied wells are picked up and crushed for making powder using hammer. A small amount of sample powder is placed on the cover glass. A little amount of water is dropped on the powder and spread over the cover glass using the toothpick. After dry on the hot plate, drop the mounting adhesive on the sliding glass and put the cover glass. Put the preparation into the ultraviolet lightbox for about fifteen minutes, then complete.

After preparation, the nannofossil samples were analyzed using a polarizing microscope with 1500x magnification. This observation used the transect method. That is, counting the nannofossil species found from top to bottom in one pass and counting 100 specimens of nannofossil were counted which were identified as 20 microns wide in one point of view (POV). The biostratigraphic method used is determining biostratigraphic zoning based on the Interval zone. In this study divide the nannofossil zones become four NP zones. Nannofossil biostratigraphy and datum used in this study are shown in Fig.3. Nannofossil datum indicated by 1 to 7 in Fig.3 is useful for determination of the geological age in this area. Based on the characteristics, we carefully checked and identified the horizon of nannofossil datum in the sequences for detecting the unconformities in this study.

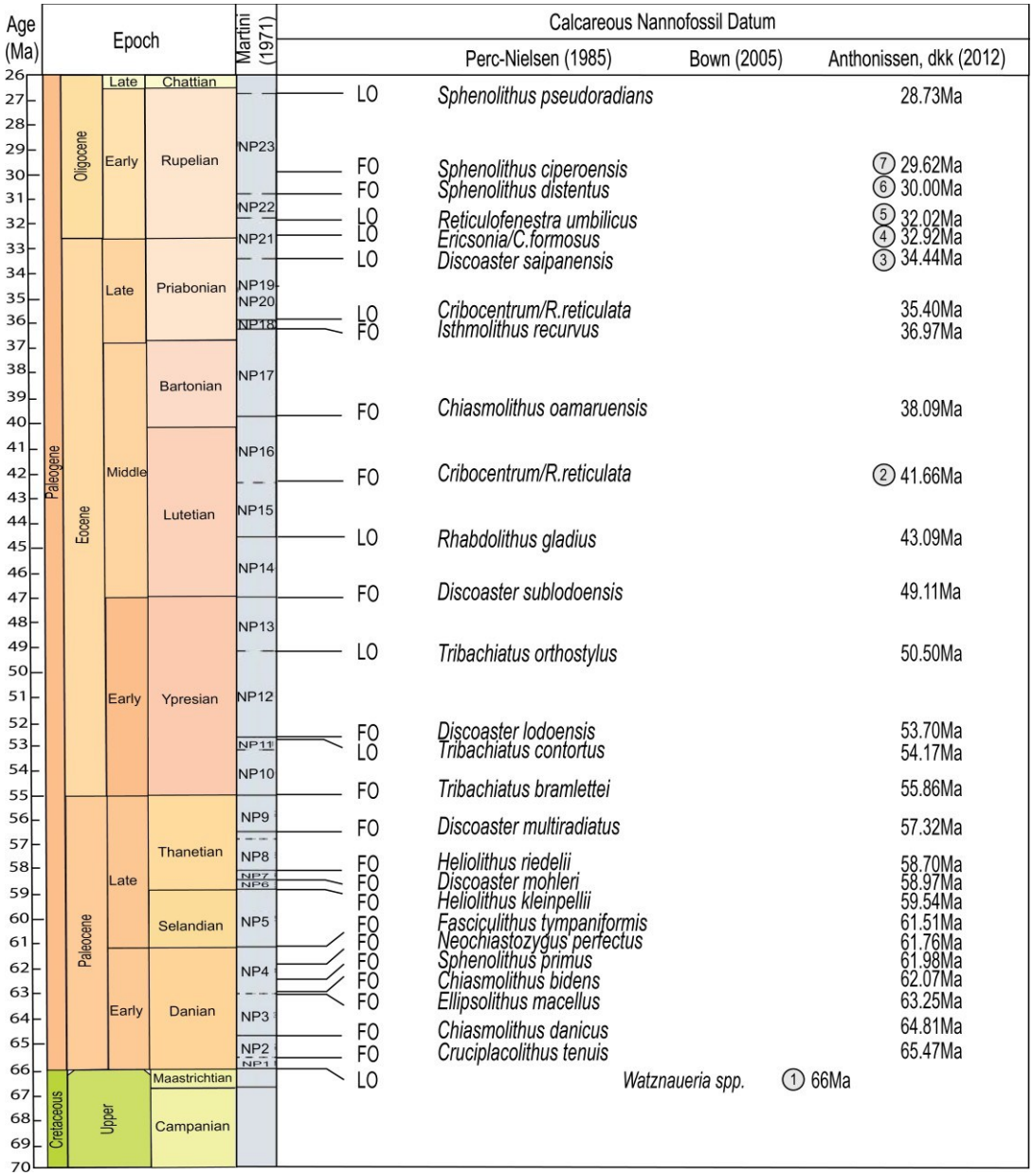

FIGURE 3. Upper Cretaceous to Late Oligocene Calcareous Nannofossil datum used in this study.

RESULT AND DISCUSSION

Lithostratigraphy

The lithology of the "CB" well is characterized by claystone, sandstone, siltsone, limestone, tuff and coal. In the "CB" well there are two formations, namely the Balangbaru and Toraja Formation. In the Balangbaru formation there are four lithologies, namely siltstone, sandstone, tuff and claystone. Then, in the Toraja formation there are four lithologies, namely siltstone, claystone, coal and limestone.

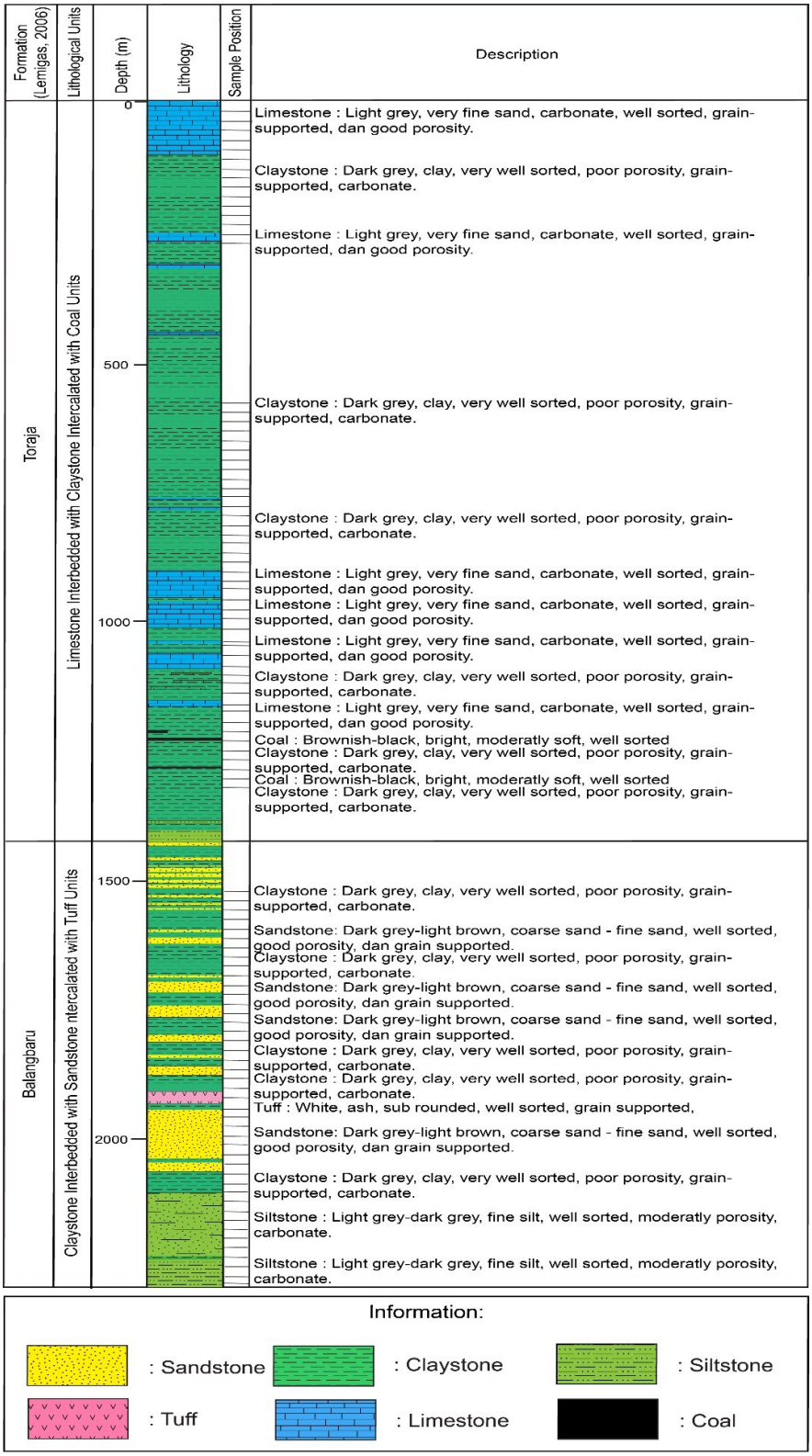

FIGURE 4. Lithology column of "CB“ well research area.

Calcareous Nannofossil Biostratigraphy

Calcareous nannofossil in "CB" well are very abundant occur but they are very rare to barren at some specimens. Then, preservation of nannofossil in this study is moderate to well throughout the section and some specimens are poor. There are 53 species of calcareous nannofossils belonging to 21 genera identified in this well. In general, three calcareous nannofossils genera which dominate the assemblages are *Cyclicargolithus, Reticulofenestra,* and *Sphenolithus*. The datums found in this well are the Last occurance of *Watznaueria* spp at a depth of 1820 m, the Last occurance of *Reticulofenestra reticulata* at a depth of 1164 m, the Last occurance of *Discoaster saipanensis* at a depth of 210 m, the Last occurance of *Coccolithus formosus* at a depth of 174 m and *Reticulofenestra umbilicus* at a same depth. Then, the First occurance of *Sphenolithus distentus* at a depth of 64 m and First occurance of *Sphenolithus ciperoensis* at a depth of 46 m. Based on the analysis of biostratigraphy in this well, we get the age of the lithological unit are assigned to Maastrichian stage of Late Cretaceous and NP16 – NP23 of middle Eocene to middle Oligocene.

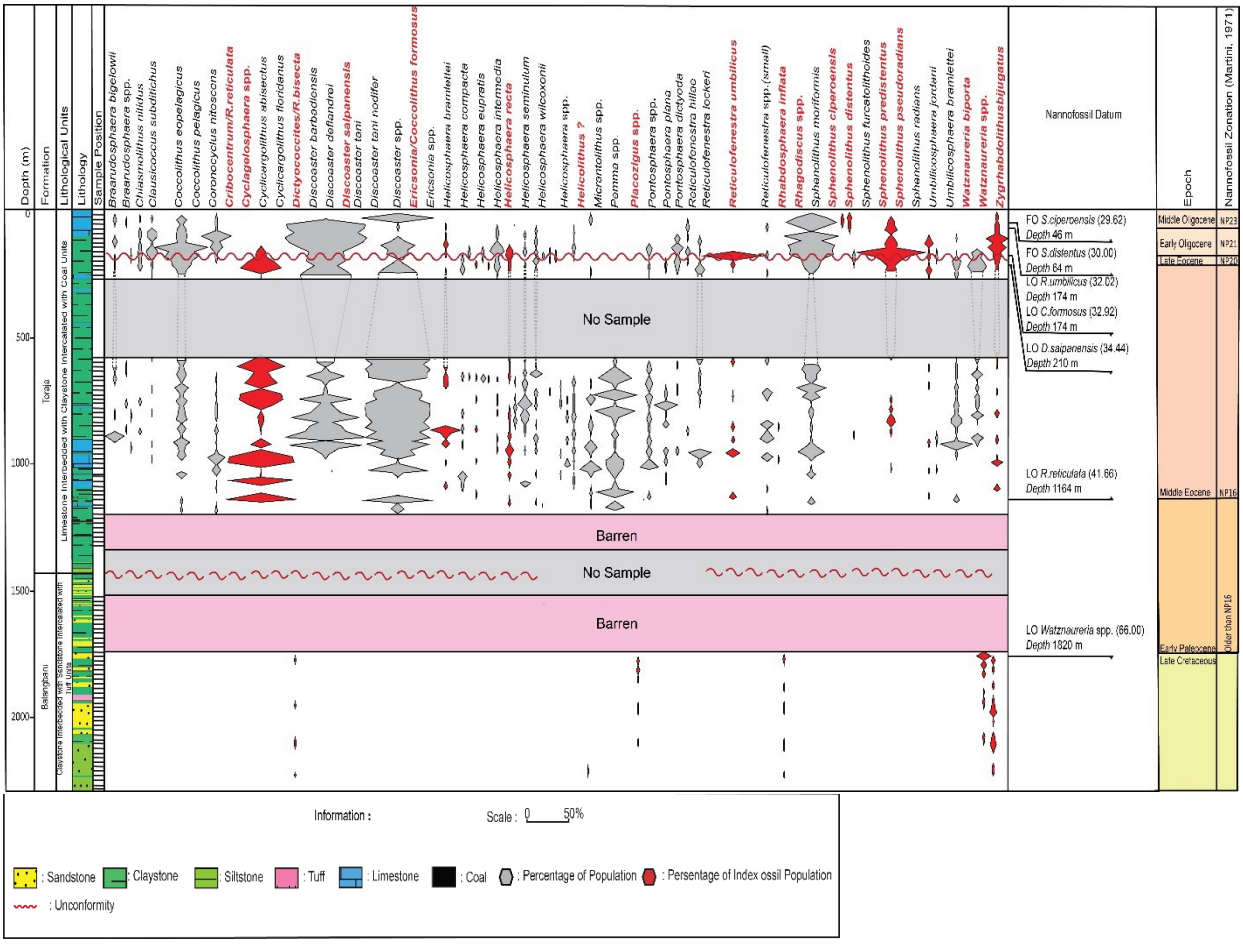

FIGURE 5. Butterfly chart of "CB" well.

Unconformity and Sedimentation Rates

1) Unconformities

Based on calcareous nannofossil biostratigraphy, two unconformities are detected in the "CB" well around the 1400 m depths, between 66Ma and 41.66Ma. Then, between 34.44Ma and 32.02Ma in 174 m. The unconformity occurred because two datums were found simultaneously at the same depth and at adjacent depths, so it is estimated that a time gap (hiatus) or unconformity occurred in the Late Cretaceous – Early Paleocene boundary and in the Late Eocene – Early Oligocene boundary. So that, sediment deposition did not occur at that age.

2) Sedimentation rate

Sedimentation rate in this study are discussed based on thickness, this well is assumed to be at the top of an anticline based on summary log data with vertical well depth determination (TVDSS). The rate is 13.45cm/Kyr to 3.61cm/Kyr.

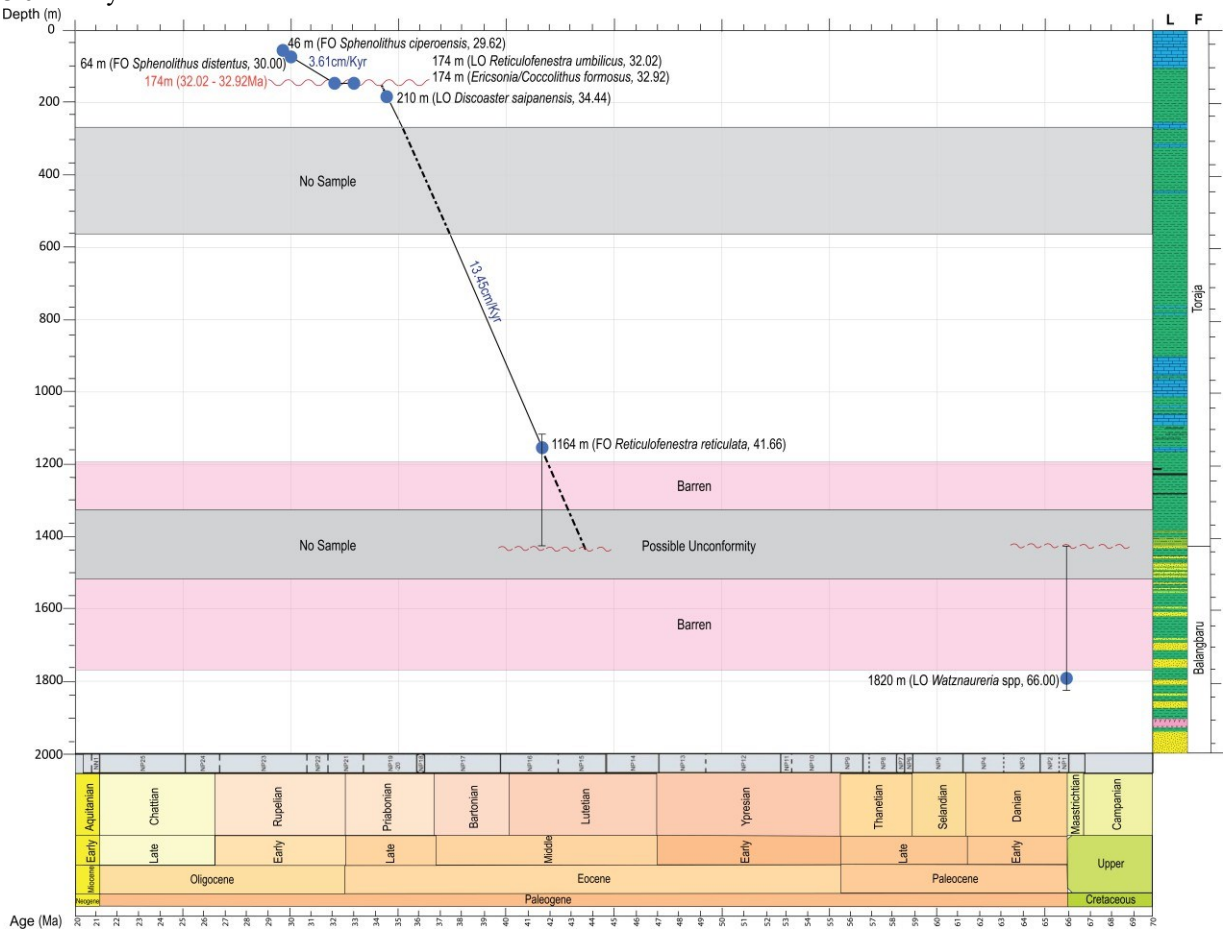

FIGURE 6. Unconformities and Sedimentation Rate of "CB" Well.

Chronostratigraphy

Unconformities detected in two horizons are correlated to the timing of well-known global climatic events. There are, "K/Pg Meteor impact", "the Late Paleoene Thermal Maximum", and 'Oi-1 Glaciation". There was a change in the climate to become hot which is thought to be the K/Pg meteor impact and the sea level graph was decreasing (regression). Then, there was an unconformity in the Early Paleocene – Late Paleocene age due to a gap in geological time where no deposition occurred at that time. Then, the global geological event that occurred was the Late Paleocene Thermal Maximum, the global sea level graph rose and was interpreted as the tectonic phase at that time was Syn-rift. There was deposition again in the Early Eocene and a global geological event that occurred E.Eocene Climatic Optimum. Then, the global sea level graph dropped and the temperature slowly fell. Then, the sea level graph was decreasing (regression) and the Small Ephemeral Ice-sheets appear at the Late Eocene age. Then, an unconformity occurred whichs was found fossil datums at the same depth. Then the global geological event that occurred was the Oi-1 Glaciation at the Late Eocene – Early Oligocene boundary and then the sea level graph was decreasing (regression), the local tectonic phase that occurred at that time was interpreted as Post-rift. Then, deposition occurred again in the Middle Oligocene (30 to 29.62 Ma).

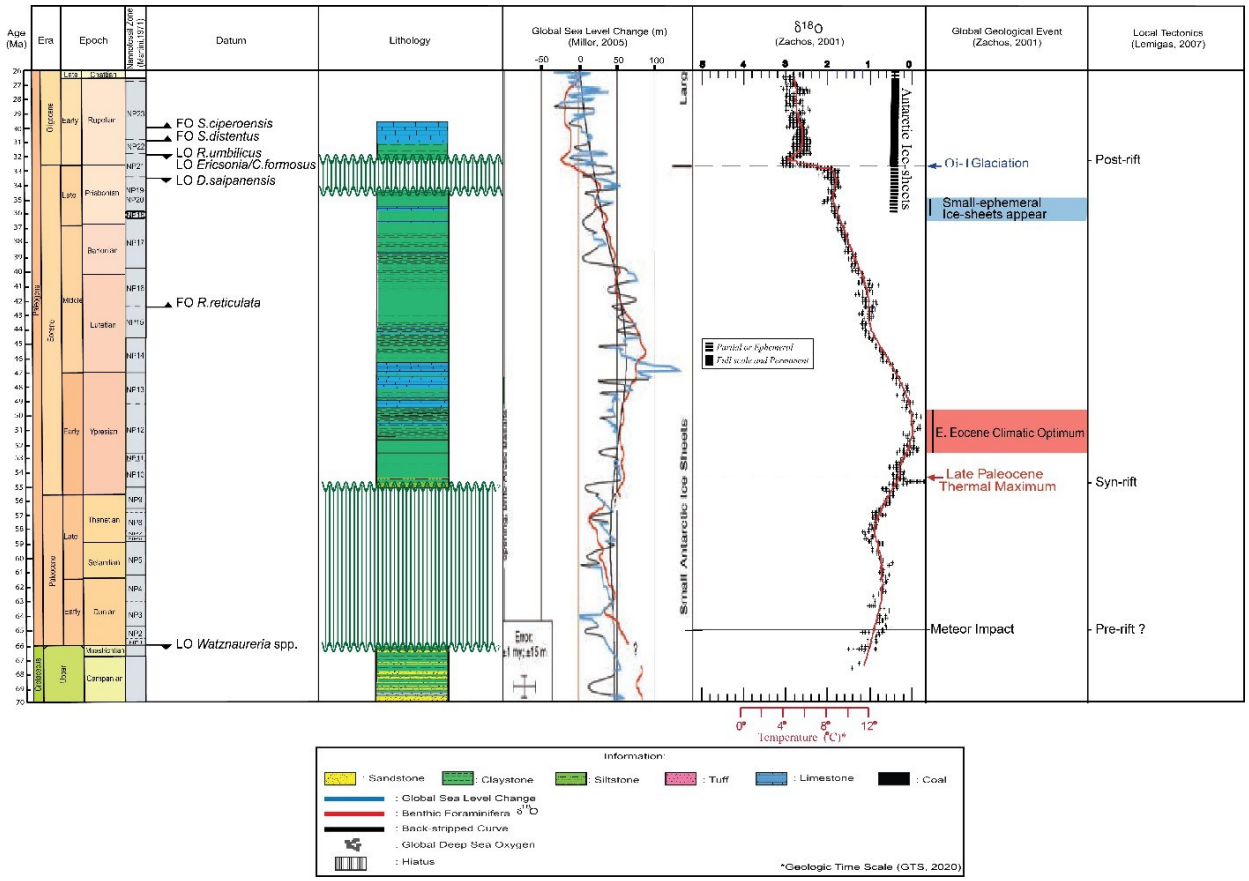

FIGURE 7. Chronostratigraphy of the "CB" well with global sea level changes, global geological events and local tectonics.

CONCLUSION

Based on the results obtained in this research, it can be concluded as follows, we succeeded in identifying 21 genera and 53 species of nannofossil in the “CB” well. In general, nannofossil are dominated by the genera *Cyclicargolithus, Reticulofenestra,* and *Sphenolithus.* Based on the analysis of biostratigraphy in this well, we get the age of the lithological unit are assigned to Maastrichian stage of Late Cretaceous and NP16 – NP23 of middle Eocene to middle Oligocene. Two unconformities are detected in this well, it is estimated that a time gap (hiatus) or unconformity occurred in the Late Cretaceous – Early Paleocene boundary and in the Late Eocene – Early Oligocene boundary. Unconformities detected in two horizons are correlated to the timing of well-known global geological events in the chronostratigraphic chart. There are, “K/Pg Meteor impact” in Late Cretaceous age (66Ma), “the Late Paleoene Thermal Maximum” in Late Paleocene age (55Ma) , and “Oi-1 Glaciation” in Early Oligocene age (32Ma).

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