Annales de la Société géologique de Belgique, T. 109 - 1986, pp. 357-361 Mai 1987

UPPER CRETACEOUS BIOSTRATIGRAPHY THE KEY TO THE UNDERSTANDING OF INVERSION TECTONICS IN NW-GERMANY[1]

by

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(3 figures)

RESUME.- La tectonique d'inversion complexe du Crétacé supérieur dans le NW de l'Allemagne a été révélée grâce à une analyse précise des séquences crayeuses apparemment «uniformes» par des méthodes biostratigraphiques, lithostratigraphiques et géophysiques (logs de sondage pétrophysiques et exploration sismique).

ABSTRACT.- The complex Late Cretaceous inversion tectonics in NW-Germany have been unraveled thanks to careful analysis of the seemingly «uniform» Chalk sequences by biostratigraphical, lithostatigraphical and geophysical (petrophysical borehole logs and seismic exploration) methods.

For structural geologists working in NW-Europe the Chalk seems to be - if you follow their publications - something whitish and dull, that you should penetrate as fast as you can and in sections stipple or hatch in a uniform manner.

When in the nineteen-seventies the Deep Geology team of the «Bundesanstalt für Geowissenschaften und Rohstoffe» (Hannover, FRG) planned a structural analysis of NW-Germany and the German North Sea, we knew very well, that one of the major structural revolutions in NW-Europe took place in Late Cretaceous times and that we needed a detailed knowledge of Late Cretaceous bio- and lithostratigraphy and paleogeography in order to unravel the structural framework.

BIOSTRATIGRAPHICAL AND LITHOSTRATIGRAPHICAL CORRELATION

A group of litho- and biostratigraphers set to work. Wilhelm Koch (1977) made a microbiostratigraphical zonation, well-checked with macrobiostratigraphical data from quarries and shafts. On the base of this microbiostratigraphical system some 500 core samples from boreholes have been reinvestigated and dated. The position of all these core samples within the lithostratigraphic column became clear, when they were transferred into a standard log typical for northern Lower Saxony by means of log-correlation. That way the succession of core samples projected into one standard log could be regarded as an equivalent to a fully cored Upper Cretaceous sequence. The peaks in the resistivity and self-potential standard log served to define the biostratigraphic boundaries of the foraminifer range zones within the lithostratigraphical column.

1 *Paper presented on 17 January 1986 at special meeting in honour of Ing. P.J. Felder wo received the Medaille André Dumont 1985. Paper published with the gratefully acknowledged financial support of Continental Netherlands Oil Company (Leidschendam, the Netherlands). Revised manuscript received on 25 September 1986.*

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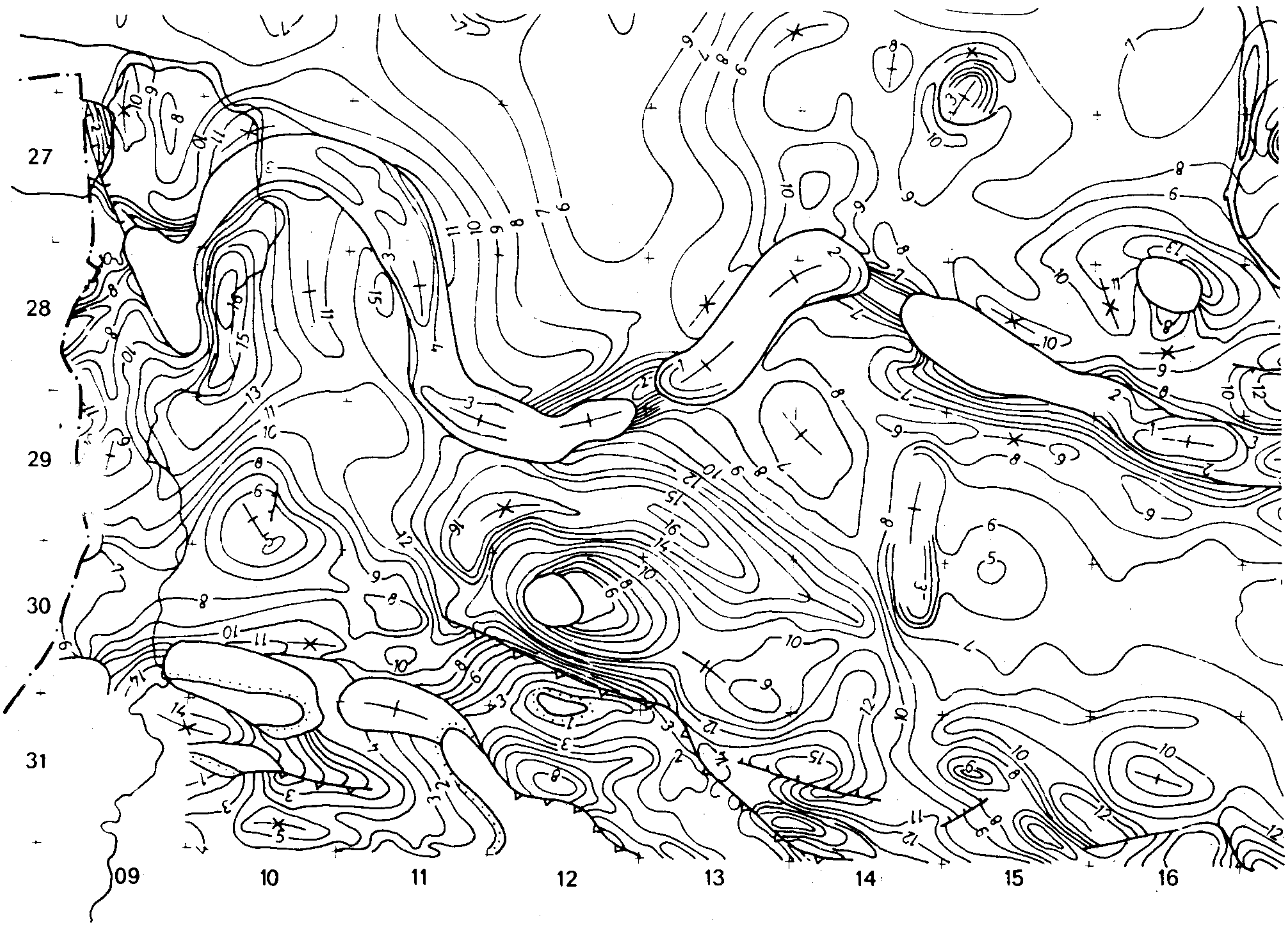


Fig. 1.- Residual thicknesses (in 100 m) of the Upper Cretaceous between the rivers Lower Weser and Lower Ems (after Baldschuhn & Jaritz, unpublished).

In this way Baldschuhn & Jaritz (1977) could correlate also distant wireline logs peak by peak, because the facies changes in the NW-German Chalk are not very important. On that basis most of the boreholes in NW-Germany have been subdivided and correlated according to the microbiostratigraphical range zones. This was cross-checked by biostratigraphical redetermination of samples not used previously for the establishment of the lithostratigraphic standard subdivision. In all these boreholes the main stage boundaries could be defined in the logs within a range of 2 to 5 m.

INTERPRETED SEISMIC SECTIONS, ISOPACH MAPS

Borehole velocity measurements enabled us to identify seismic markers within the Chalk sequence in reflexion seismic sections, and thus the thickness of the different stages and substages of the NW-German Chalk could be determined not only at the borehole but over the entire area. The high complexity of the deposition processes in the «uniform» Chalk became revealed - onlap of higher Chalk stages at the flancs of structures, angular unconformities within the Chalk sequence, non-continuous subsidence and the small-scale differentiation of the entire basin into local swells and sinks.

The thickness variation of the different Upper Cretaceous stages (fig. 1) is caused in the northern part of NW-Germany, called the Pompeckj Block, mainly by halokinetic movements of salt structures. In the central part along the border zone of the Lower Saxony block they generally are caused by inversion movements. The syngenetic history of these inversion structures can be revealed simply by studying the thickness variations of the Chalk stages in seismic sections with identified markers.

THE EVOLUTION OF INVERSION STRUCTURES IN NW-GERMANY

In the northern part of the Lower Saxony Block and the southern fringe of the Pompeckj Block a

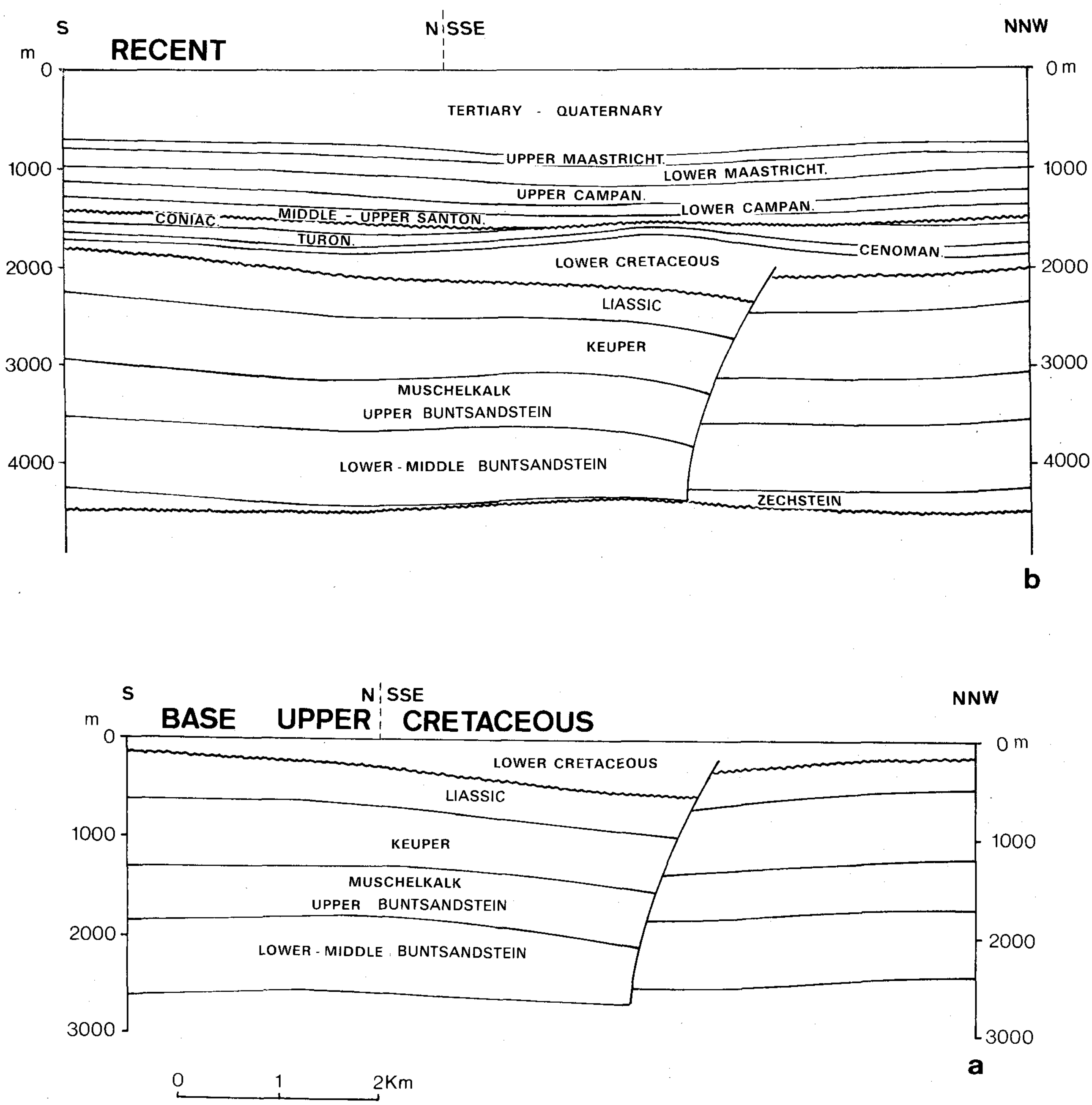
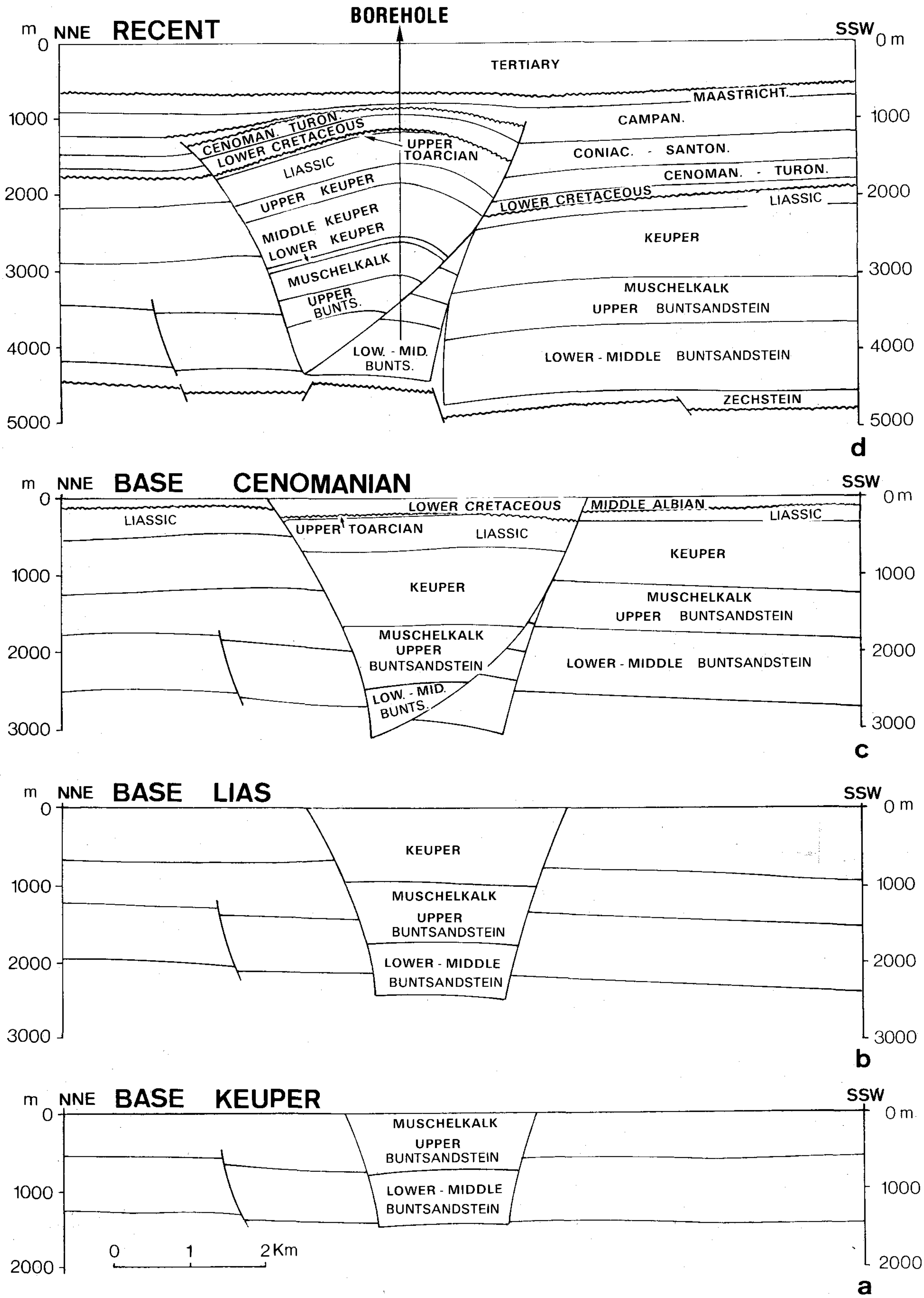


Fig. 2.- Polar inversion stucture on the Pompeckj Block (after Baldschuhn, Frisch & Kockel, 1985).
Subsidence of a half-graben with northern border fault during the Lower Cretaceous
Fading out of taphrogenetic movements during Albian, Cenomanian and Turonian
Inversion of the graben and upthrusting movements of the graben border fault during the Late Coniacian to Middle Santonian
Transgression of Middle Santonian on Turonian on the crest of the structure. Further updoming during Middle and Upper Santonian
From the Lower Campanian onwards no tectonic activities except a slight downwarping of the crest of the structure.


m NNE RECENT
BOREHOLE
SSW 0 m
TERTIARY
MAASTRICHT.
CAMPAN.
CENOMAN. TURON.
LOWER CRETACEOUS
UPPER TOARCIAN
LIASSIC
CONIAC. - SANTON.
CENOMAN. - TURON.
UPPER KEUPER
LOWER CRETACEOUS
LIASSIC
MIDDLE KEUPER
LOWER KEUPER
KEUPER
MUSCHELKALK
UPPER BUNTS.
MUSCHELKALK
UPPER BUNTSANDSTEIN
LOW. - MID. BUNTS.
LOWER - MIDDLE BUNTSANDSTEIN
ZECHSTEIN
0 1000 2000 3000 4000 5000
d
m NNE BASE CENOMANIAN
SSW 0 m
LOWER CRETACEOUS
MIDDLE ALBIAN
LIASSIC
UPPER TOARCIAN
LIASSIC
LIASSIC
KEUPER
KEUPER
MUSCHELKALK
UPPER BUNTSANDSTEIN
MUSCHELKALK
UPPER BUNTSANDSTEIN
LOWER - MIDDLE BUNTSANDSTEIN
LOW. - MID. BUNTS.
0 1000 2000 3000
c
m NNE BASE LIAS
SSW 0 m
KEUPER
MUSCHELKALK
UPPER BUNTSANDSTEIN
LOWER - MIDDLE BUNTSANDSTEIN
0 1000 2000 3000
b
m NNE BASE KEUPER
SSW 0 m
MUSCHELKALK
UPPER BUNTSANDSTEIN
LOWER - MIDDLE BUNTSANDSTEIN
0 1 2 Km
0 1000 2000
a

great number of important and minor inversion structures have formed. They originated from graben or half-graben structures active from the Upper Triassic to the top of the Aptian. During the time span between Late Coniacian to Campanian all these structures inverted, that is : the graben filling was thrusted upon its shoulders, using the former border faults in a reverse sence. The former Graben center became a positive structure, foredeeps formed on the former shoulders. During the Maastrichtian the velocity of the upward movements decreased. The non-ruptual uplift sometime continued into the Paleogene. Two examples of minor inversion structures in the southern Pompeckj block (fig. 2-3) demonstrate this development. The exact datation of the inversion movements was only possible by mapping the Upper Cretaceous stage boundaries in the seismic section.

CONCLUSIONS

- Structural geologists should, if possible, always rely on a sound biostratigraphic base.
- In NW-Europe we should have a close look at the Chalk and its subdivisions. Without this we shall not be able to understand the mechanism of inversion so widespread and so characteristic for the Subhercynian revolution.
- The reconstruction of a three-dimensional picture of a sedimentary area is of vital importance. The detailed study of a few outcrops alone is not sufficient.
- Besides the ortho-biostratigraphical definition of stages we need a biostratigraphy which is based on meso- or microfossils. Ammonites and sea-urchins alone are not sufficient.

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◄ Fig. 3.- Bipolar, asymmetric inversion structure on the Pompeckj Block (after Baldschuhn, Frisch & Kockel, 1985).

Asymmetric rifting during Upper Bunter, Muschelkalk and Keuper
Deepening of the graben during the Liassic
General uplift of the Pompeckj block. Removal of Middle and Lower Jurassic except in the graben area during Upper Jurassic
Lower Cretaceous transgression, further subsidence of the graben
Quiet period of deposition from the Upper Albian to the end of the Turonian
Updoming of the graben filling, upthrusting movements along the former graben border faults during the inversion period between Coniacian and Upper Santonian
Transgression of uppermost Santonian and Campanian over the crest of the structure. Further updoming in the Lower Maastrichtian.
Gentle updoming of the crest in Upper Maastrichtian and Paleogene time.