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CLIMATIC OSCILLATIONS DEPICTED AND PREDICTED BY ISOTOPE ANALYSES OF A GREENLAND ICE CORE

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The Arctic has cooled off considerably since the climatic optimum in the 1930'es (1). One result of the cooling is more frequent occurrence of sea ice in northern waters, for instance off the northern coast of Iceland (2). The increasing importance of Arctic waters makes a climatic prognosis an urgent need. No long-term climatic records exist, however, and information about past climatic conditions must therefore be looked for indirectly.

One of the most promising sources seems to be the ice that is continuously deposited on the Greenland ice cap. The isotopic composition of snow depends mainly upon the temperature of formation (3). Therefore, a climatic record can be obtained by measuring the relative oxygen-18 concentration, δ , in samples of a vertical ice core drilled at a location, where only slight or no melting occurs. An ice core became available for such climatic studies, when the U.S. Army C.R.R.E.L. in 1966 recovered a 1400 meters long surface-to-bottom core at Camp Century, 225 km East of Thule (4).

The ice core contains too little ice to allow a dating by radioactive methods. In stead, an age versus depth relationship was established theoretically by considering the simple ice flow pattern in the accumulation area (5). This preliminary time scale was later corrected by a Fourier spectrum method assuming that observed periods of persistant climatic oscillations have remained constant in time (6). Plotted on the corrected time scale the values gave a detailed climatic record, in which all of the pronounced climatic events, known from other independent studies, were recognized in an

interval of more than 70,000 years (6).

Of special interest is the top 273 meters of the core spanning the last 790 years. This is the only part of the core, within the last 10,000 years, which is completely continuous and suitable for detailed climatic studies. A continuous δ-record for this part of the core based on 10 to 15 years samples has been published previously (7). Since then, 1 year samples covering the same 790 years have been measured. The two full curves in Fig. 1 show the 10 years (left) and 30 years (mid section) running mean δ values. The records depict known climatic events, such as the cold period of the "Little Ice Age" between 1500 and 1700 A.D. and the climatic optimum in the 1930'es.

In order to detect possible periodicities in the δ record a power spectrum was calculated using the Fourier integral of the entire record. The results are shown in Fig. 2. The three dominant peaks indicate a strong tendency of the data to oscillate with periods of 449, 177 and 77 years. The Fourier integral gives also the phases and the amplitudes of the corresponding harmonic oscillations, the sum of which is shown to the right in Fig. 1. Combining the eight harmonics corresponding to the peaks set off in black in Fig. 2 leads to the dashed curve in the mid section of Fig. 1. The dashed curves depict the main characteristics of the δ curve to various degrees of detail.

Extensions of the synthetized curves outside the measured interval (1180 to 1870 A.D.) suggest that the δ values were generally above normal in the warm period (8) of the Norsemen settling in Greenland (11'th century), and that the δ values will remain generally below normal for the coming more than 100 years.

If using the latter suggestion as a climatic prognosis, one should bear in mind that (i) possible human impact on the climatic has been neglected, (ii) the details of the δ curve may be representative only for northern Greenland, (iii) no oscillations with periods shorter than 29 years have been considered, and (iv) longer series of detailed δ measurements are desirable for checking the persistance of the basic harmonics.

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Legend to the figures

Fig. 1 : Full curves : Relative oxygen-18 concentrations (δ) in annual samples of ice deposited at Camp Century, Northwest Greenland, since 1180 A.D., averaged to 10 (left) and 30 years running means (mid section).

Dashed curves : Syntheses of 3 (right) and 8 (mid section) harmonic components of the δ record with extensions backwards in time (bottom) and into the future (top).

Fig. 2 : Fourier power spectrum of δ oscillations. The 8 peaks set off in black correspond to the harmonic components used for the (dashed) synthesis in the mid section of Fig. 1.

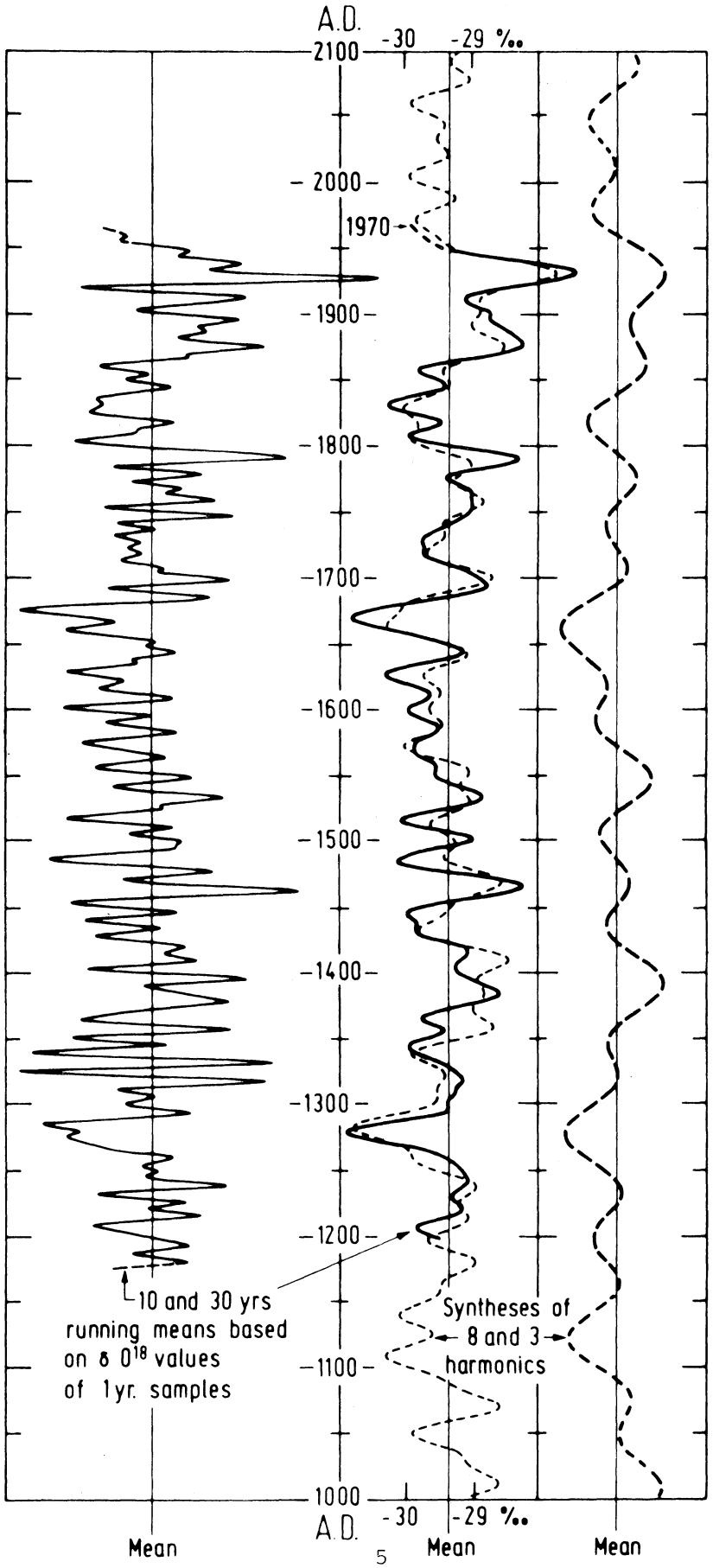
A.D.
-30
-29 ‰
2100
2000
1970
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
A.D.
-30
-29 ‰
10 and 30 yrs
running means based
on δ O18 values
of 1yr. samples
Syntheses of
8 and 3
harmonics
Mean
Mean
Mean

FIG. 1

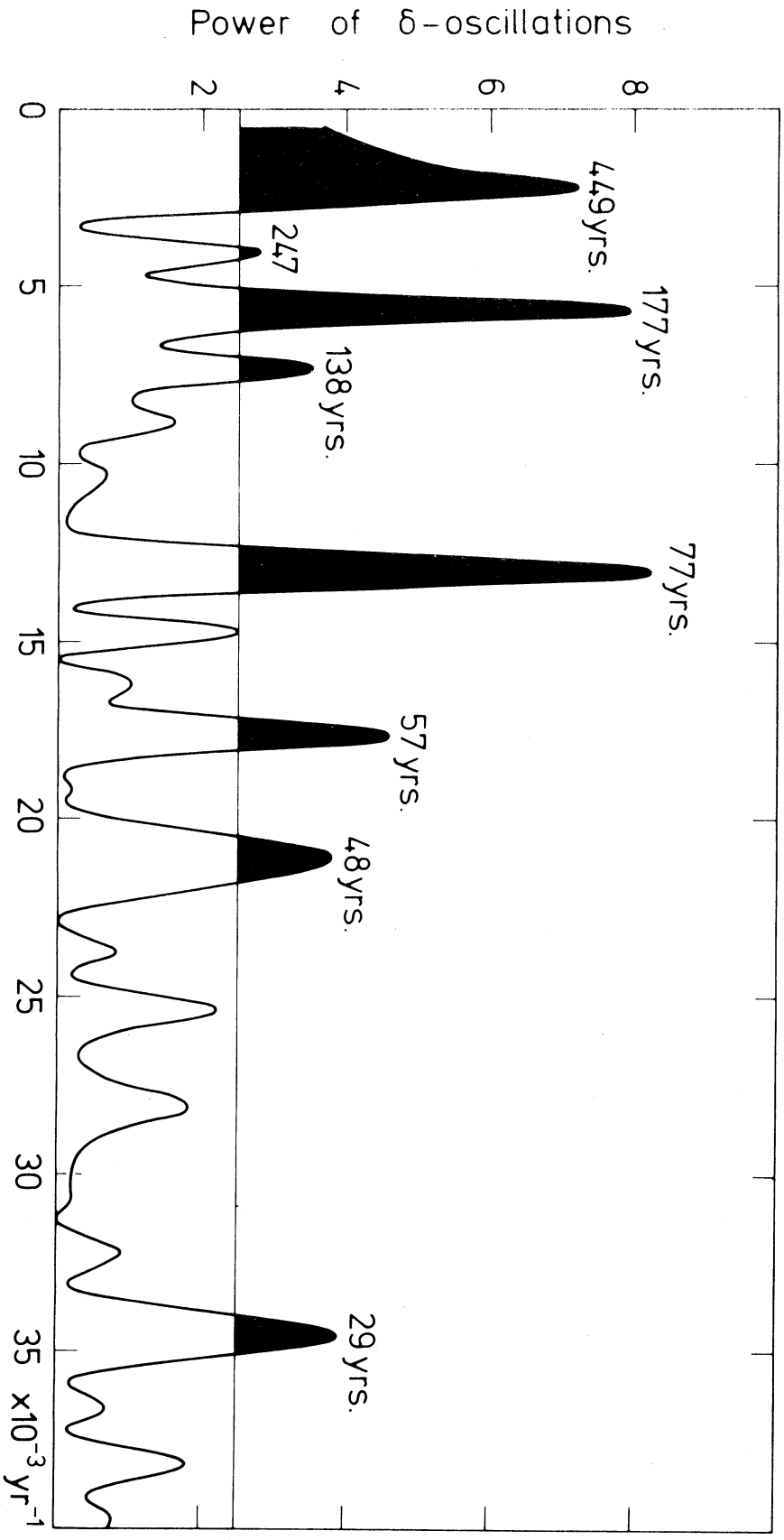
Power of δ-oscillations
2
4
6
8
0
5
10
15
20
25
30
35 ×10⁻³ yr⁻¹
449yrs.
247
177yrs.
138yrs.
77yrs.
57yrs.
48yrs.
29yrs.

FIG. 2