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T H E W A R M W A T E R S P H E R E

O F T H E

N O R T H E A S T A T L A N T I C

- A Miscellany -

by

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FOREWORD

The Kiel "Warmwassersphäre" research programme, supported by the German Research Society (DFG) contract SFB 133, has focussed on the North East Atlantic Ocean since its start in 1980. The heat flux from this region of the ocean feeds the westerly winds, maintaining the mild winter climate of NW Europe. The aim of the Kiel "Warmwassersphäre" research programme is to improve understanding of the physical processes that contribute to that heat source.

The North East Atlantic is one of the best observed regions of the World Ocean, and the oceanographic literature contains many maps illustrating features of the surface, mixed layer and pycnocline that are relevant to our quest. This miscellany contains a collection of such maps, redrawn on a standard base chart to facilitate comparison. The selection represents highlights from past investigations of the North East Atlantic Warmwater-sphere; the historical background to our own research. Some well-known maps (notably A. Bunker's surface fluxes) have been omitted because they are being reworked as part of our research programme and will be published elsewhere in greater detail. I would welcome suggestions for additional source material for inclusion in future editions.

It is a pleasure to acknowledge the expertise of the head of the cartography group in the Kiel Institut für Meereskunde, Herr A. Eisele, who designed the base chart and drew it and the overlay distributions.

John Woods
Kiel, 8 June 1984

Foreword to the second edition

This second edition contains new charts of (f/H), potential vorticity on isopycnals and annual displacement of particles.

John Woods
Kiel, 1 July 1987

VORWORT

Das Kieler Forschungsprogramm "Warmwassersphäre" des Sonderforschungsbereiches 133, das von der Deutschen Forschungsgemeinschaft finanziert wird, hat sich seit seinem Beginn im Jahre 1980 auf den nordöstlichen Teil des Atlantischen Ozeans konzentriert. Der Wärmefluß aus dieser Region des Ozeans trägt zum milden Winterklima in Nordwesteuropa bei, indem die Wärme an die westlichen Winde abgegeben wird. Ziel des Kieler Forschungsprogramms "Warmwassersphäre" ist es, die physikalischen Prozesse, die zu jener Wärmequelle beitragen, besser zu verstehen.

Der Nordostatlantik ist eines der am besten beobachteten Gebiete des Weltozeans, und die ozeanographische Literatur enthält viele Karten, die die Besonderheiten der Oberfläche, der durchmischten Schicht und der Pycnocline illustrieren, die für unsere Forschungen relevant sind. Dieser Sammelband enthält eine Anzahl solcher Karten, die auf einer Standardgrundkarte neu entworfen wurden, um den Vergleich zu erleichtern. Die Auswahl der Karten repräsentiert die wichtigsten früheren Forschungen der Warmwassersphäre des Nordostatlantiks; der historische Hintergrund für unsere Untersuchungen. Einige allgemein bekannte Karten (wie die erwähnenswerte Karte der Oberflächenströmung von Bunker) wurden weggelassen, weil sie als ein Teil unseres Forschungsprogramms neu bearbeitet und in größerer Ausführlichkeit an anderer Stelle veröffentlicht werden sollen. Hinweise auf weiteres Quellenmaterial, das für spätere Auflagen mitberücksichtigt werden kann, nehme ich gern entgegen.

Es ist mir eine besondere Freude, das fachmännische Geschick des leitenden Kartographen im Institut für Meereskunde, Herrn Eisele, anzuerkennen, der die Grundkarte gestaltete und sie und die Overlay-Einteilungen zeichnete.

John Woods
Kiel, 8. Juni 1984

Vorwort zur zweiten Auflage

Diese zweite Auflage enthält neue Karten von (f/H), potentieller Vorticity auf Isopyknen und jährlicher Teilchenversetzung.

John Woods
Kiel, 1. Juli 1987

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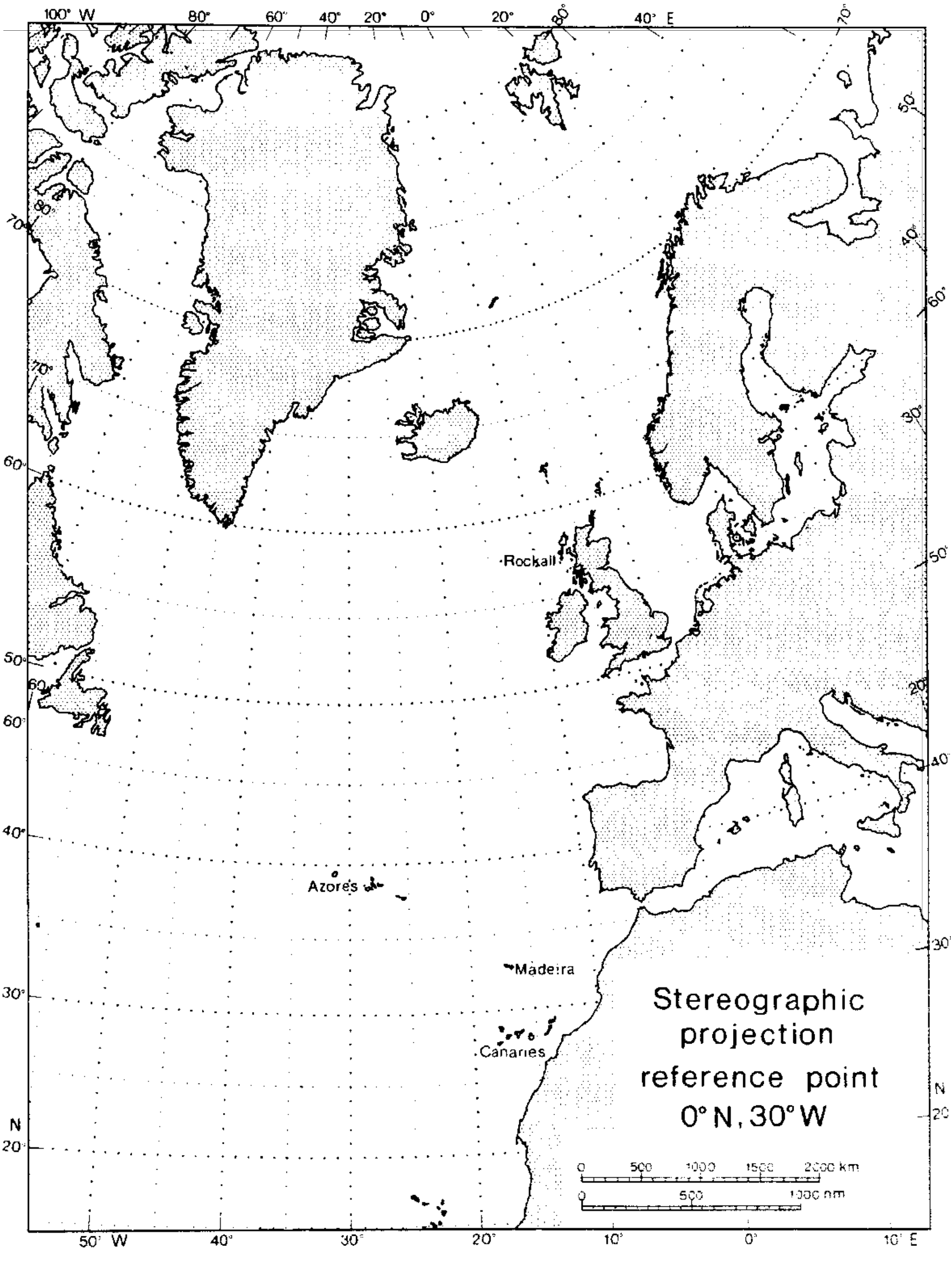

Fig. 1 The North East Atlantic in stereographic projection.

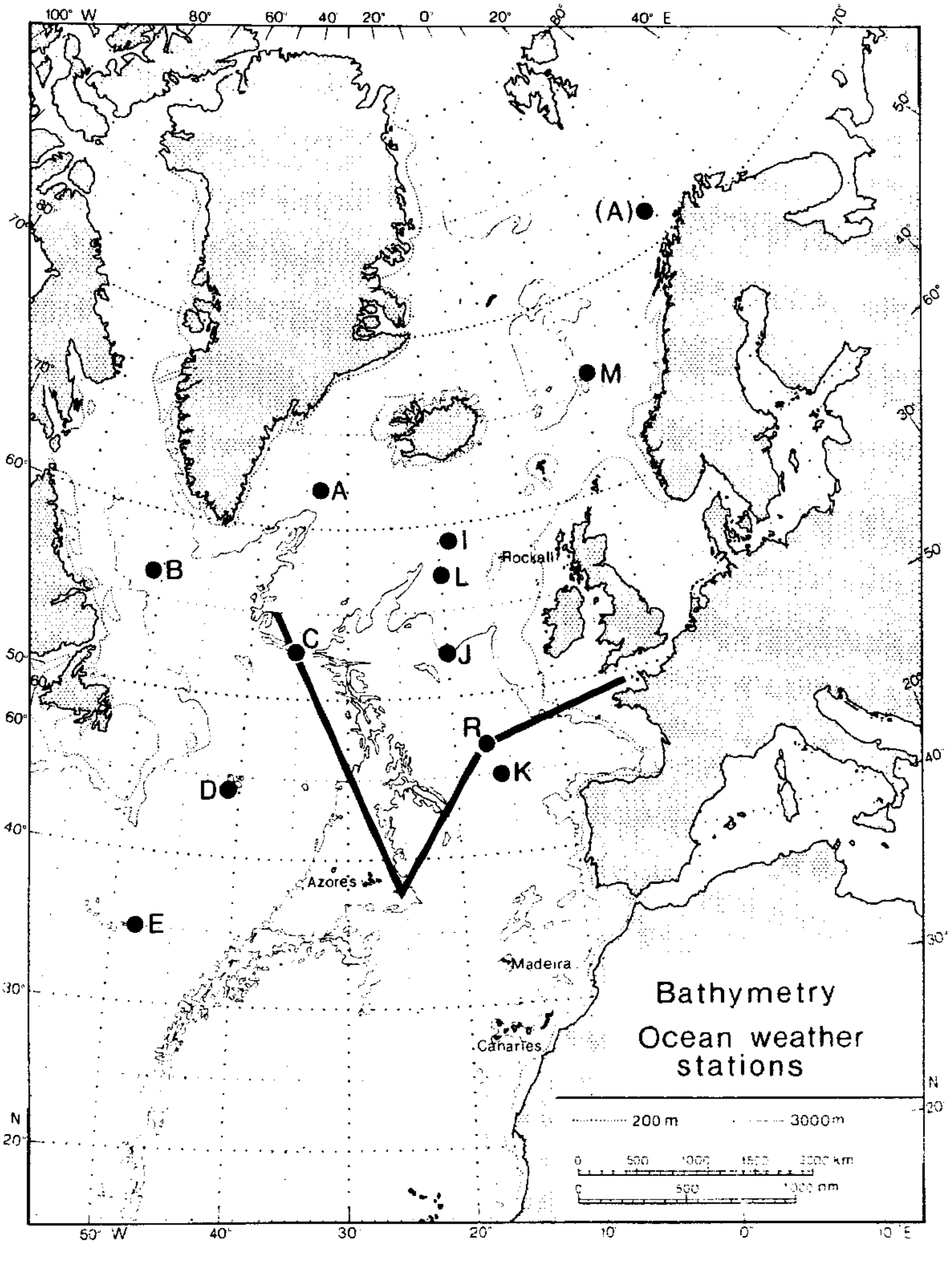

Fig. 2 Bathymetry, Ocean Weather Stations,
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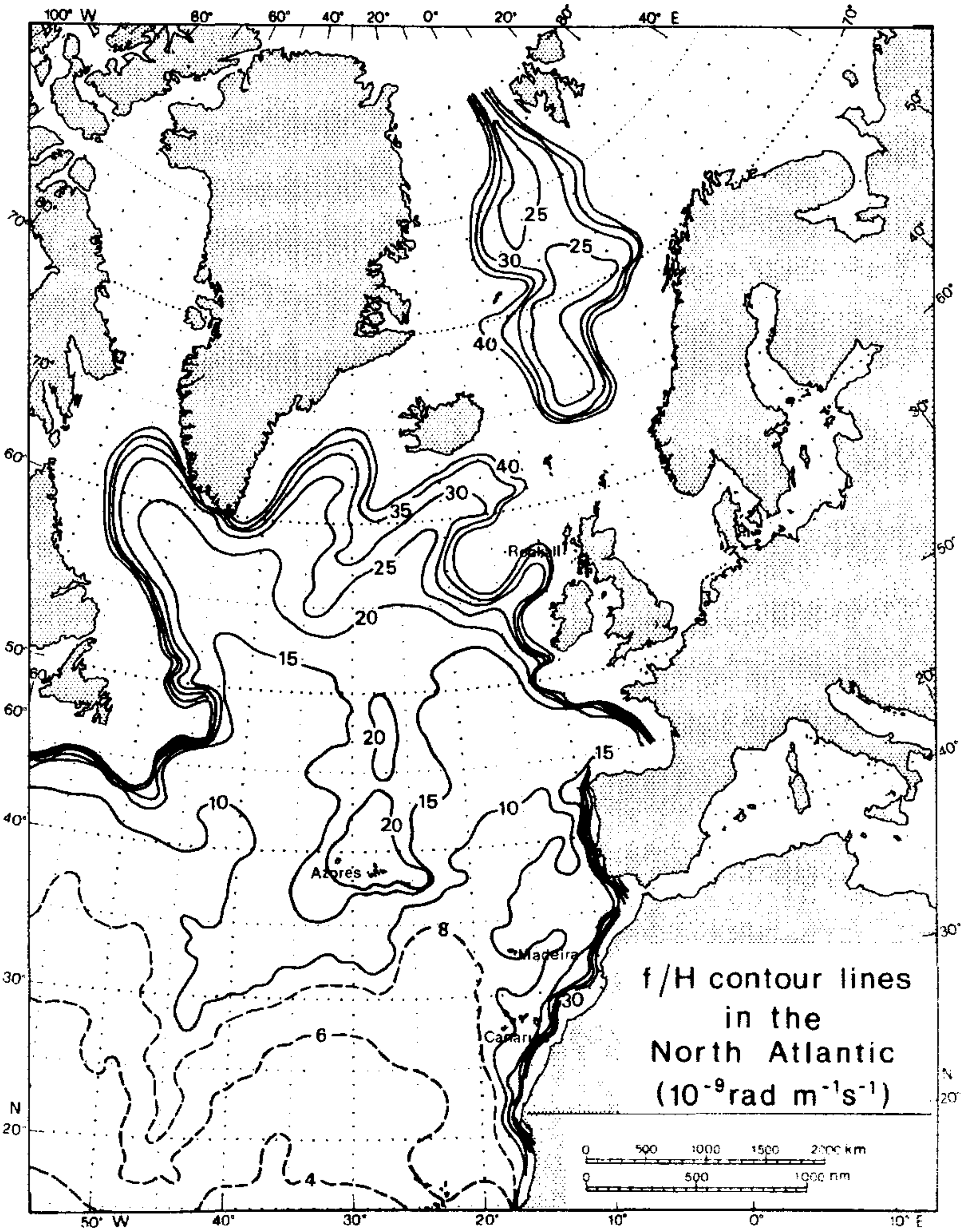
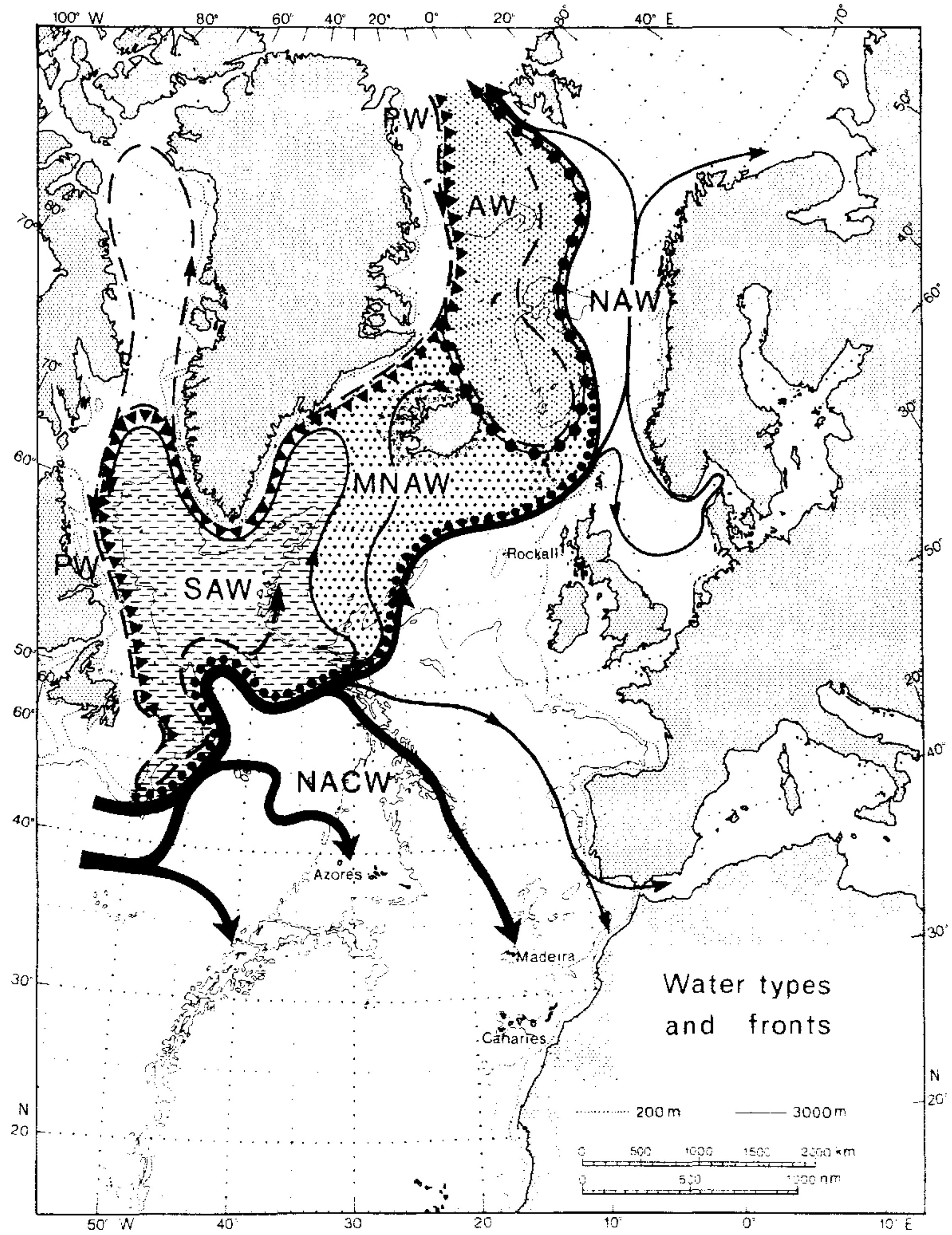


Fig. 3 Contours of (f/H) (based on a 1° square mean bathymetry of the GFDL, Princeton, 1982).



▼▼▼▼▼ POLAR FRONT ●●●● ARCTIC FRONT

••••••• SUBARCTIC FRONT

PW = Polar Waters
AW = Arctic Waters
SAW = Subarctic Waters
NAW = North Atlantic Waters
NACW = North Atlantic Central Waters
MNAW = Modified North Atlantic Waters

Fig. 4 Nomenclature of water types and fronts proposed by J. Meincke 1984

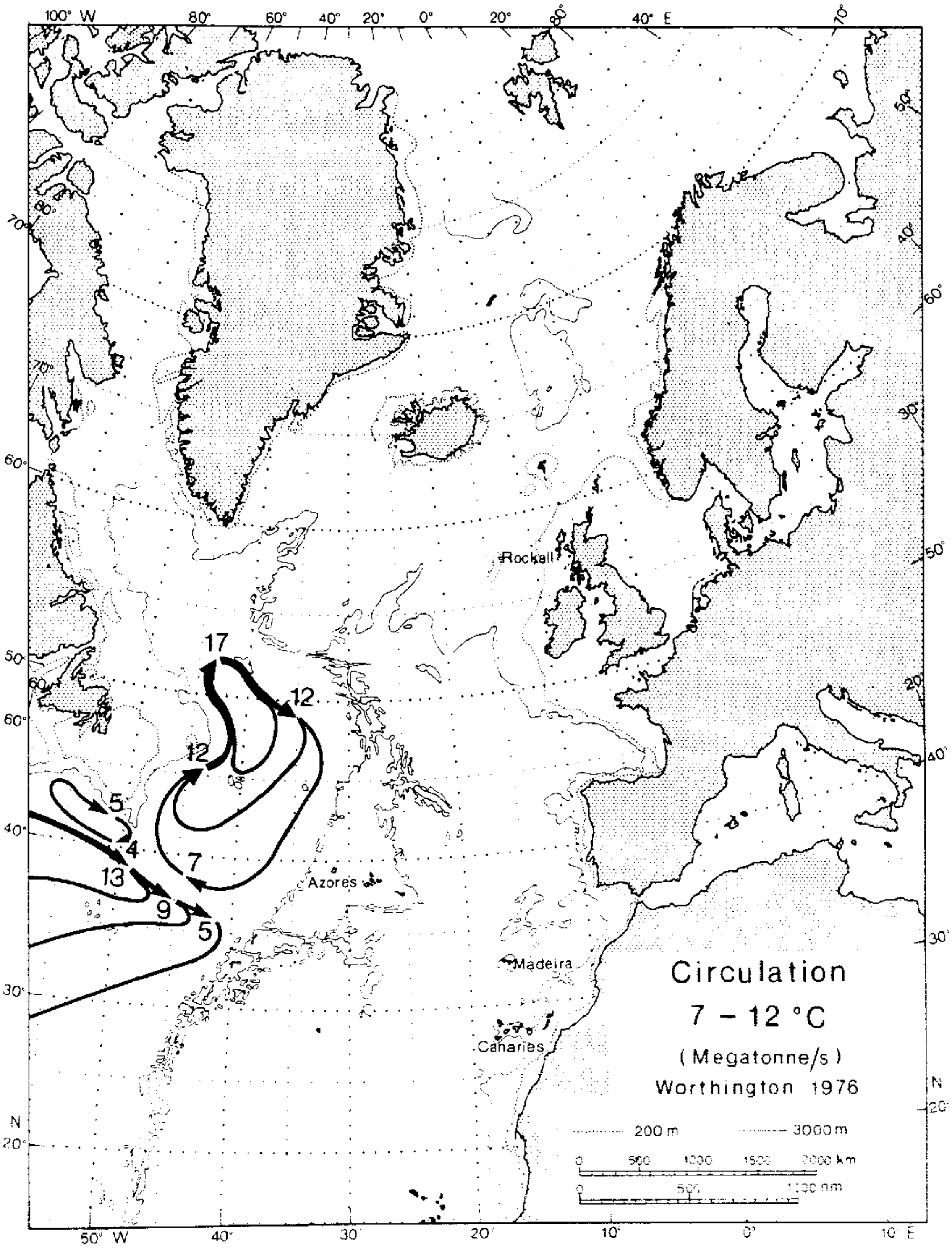
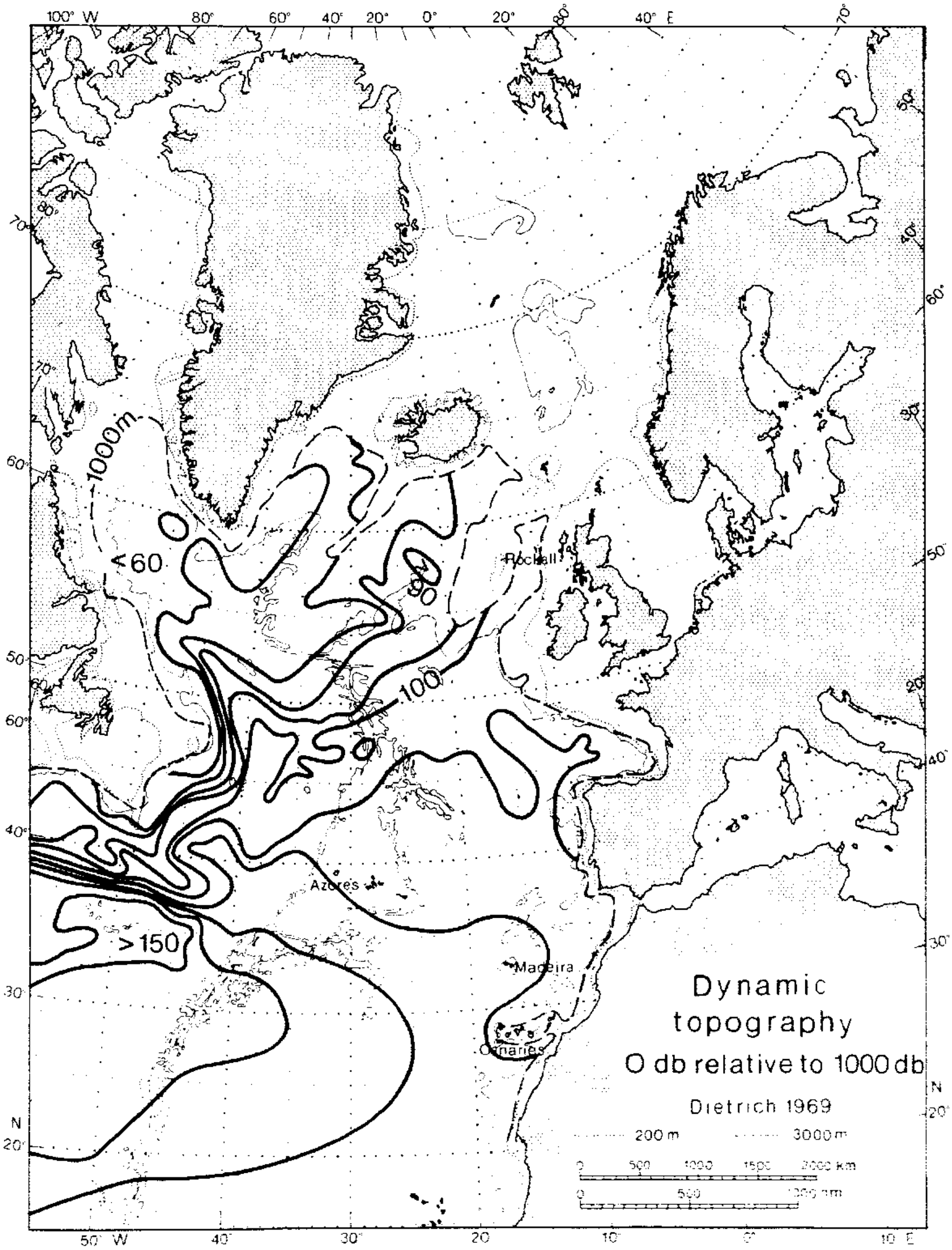


Fig. 5 Circulation (megatonne/second) between 7°C and 12°C isotherms according to L.V. Worthington (1976).



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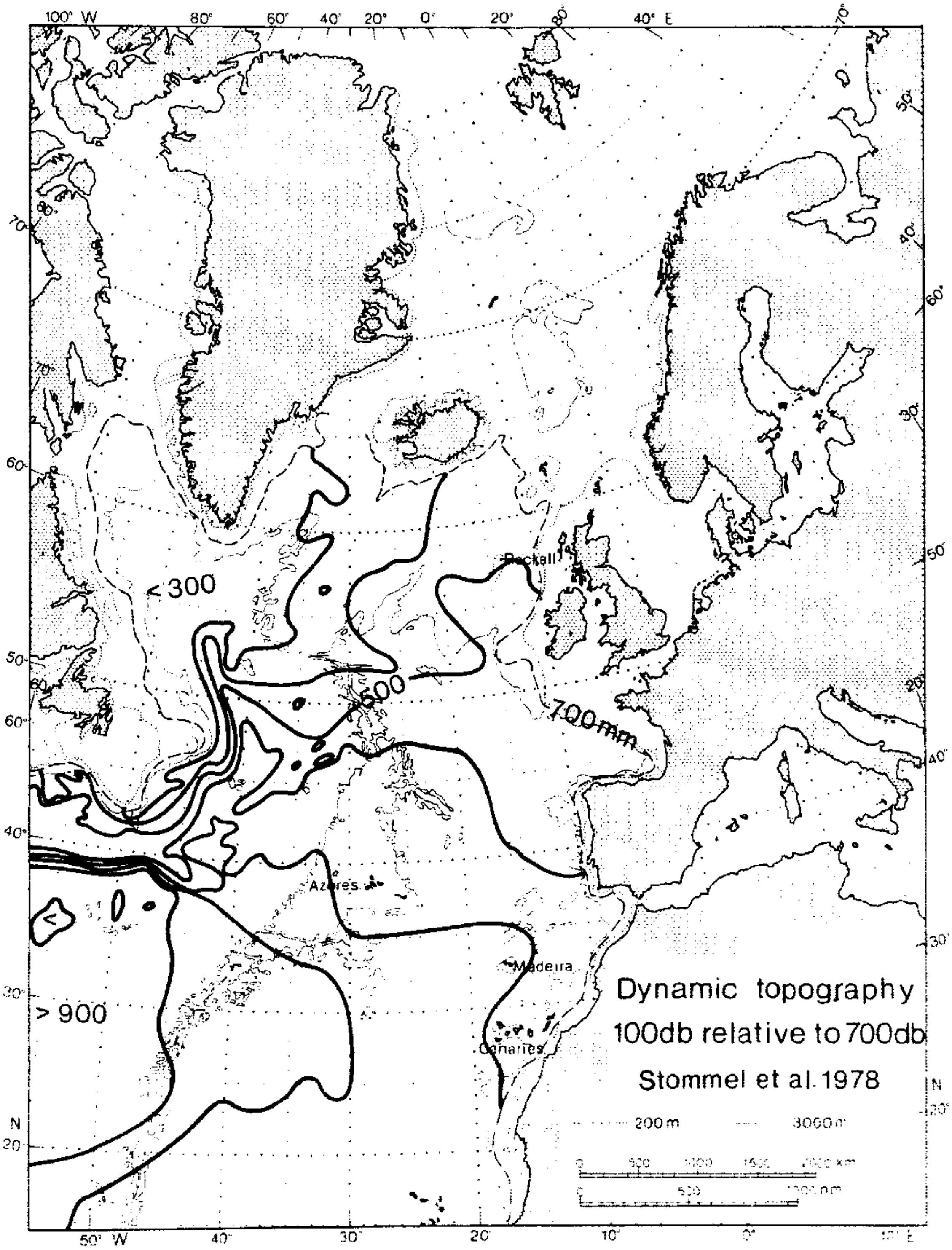


Fig. 7 Dynamic topography of the 100 decibar surface relative to 700 decibars, calculated by the dynamic method using data selected from the World Data Centre (from H. Stommel, P. Niiler & D. Anati 1978).

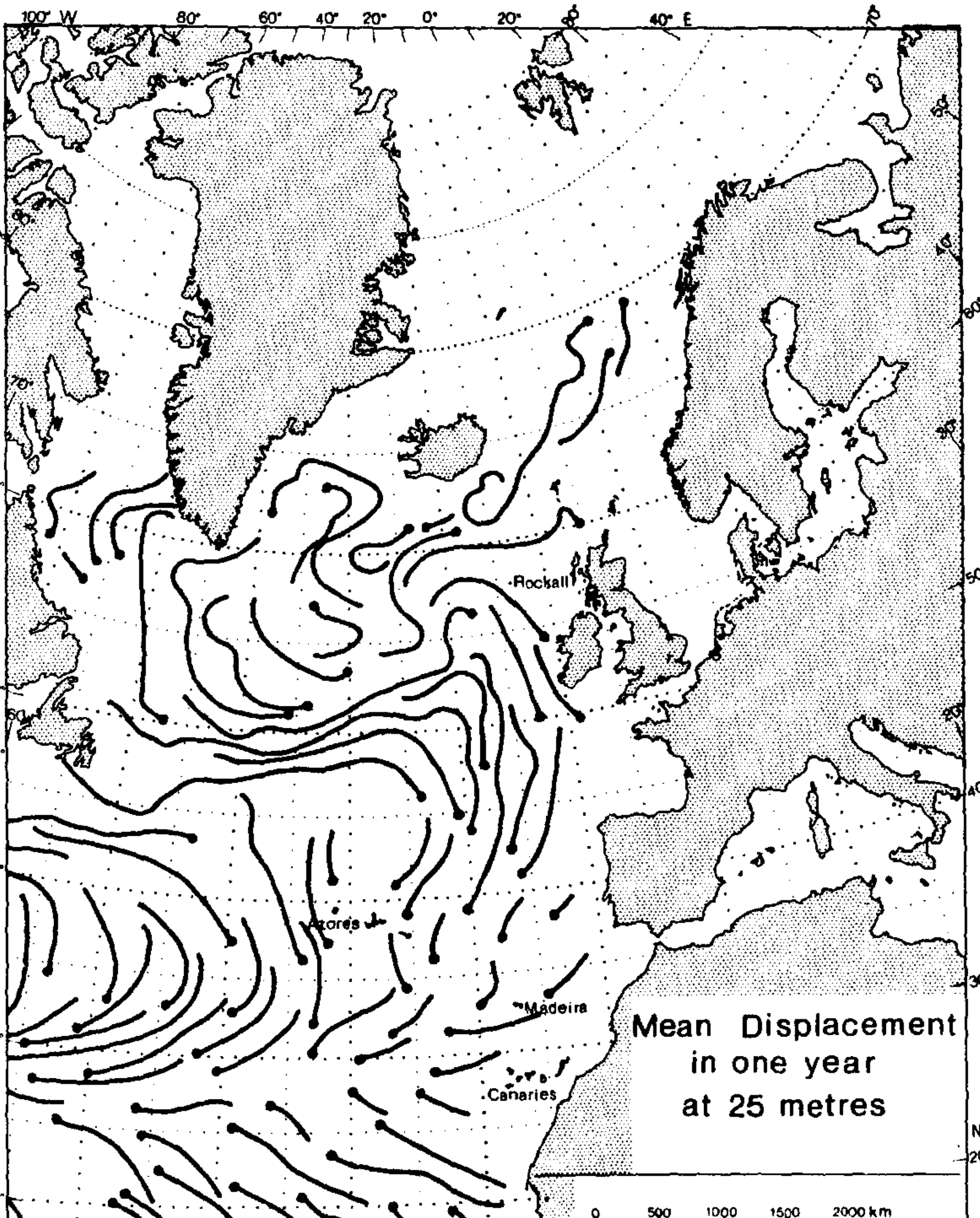
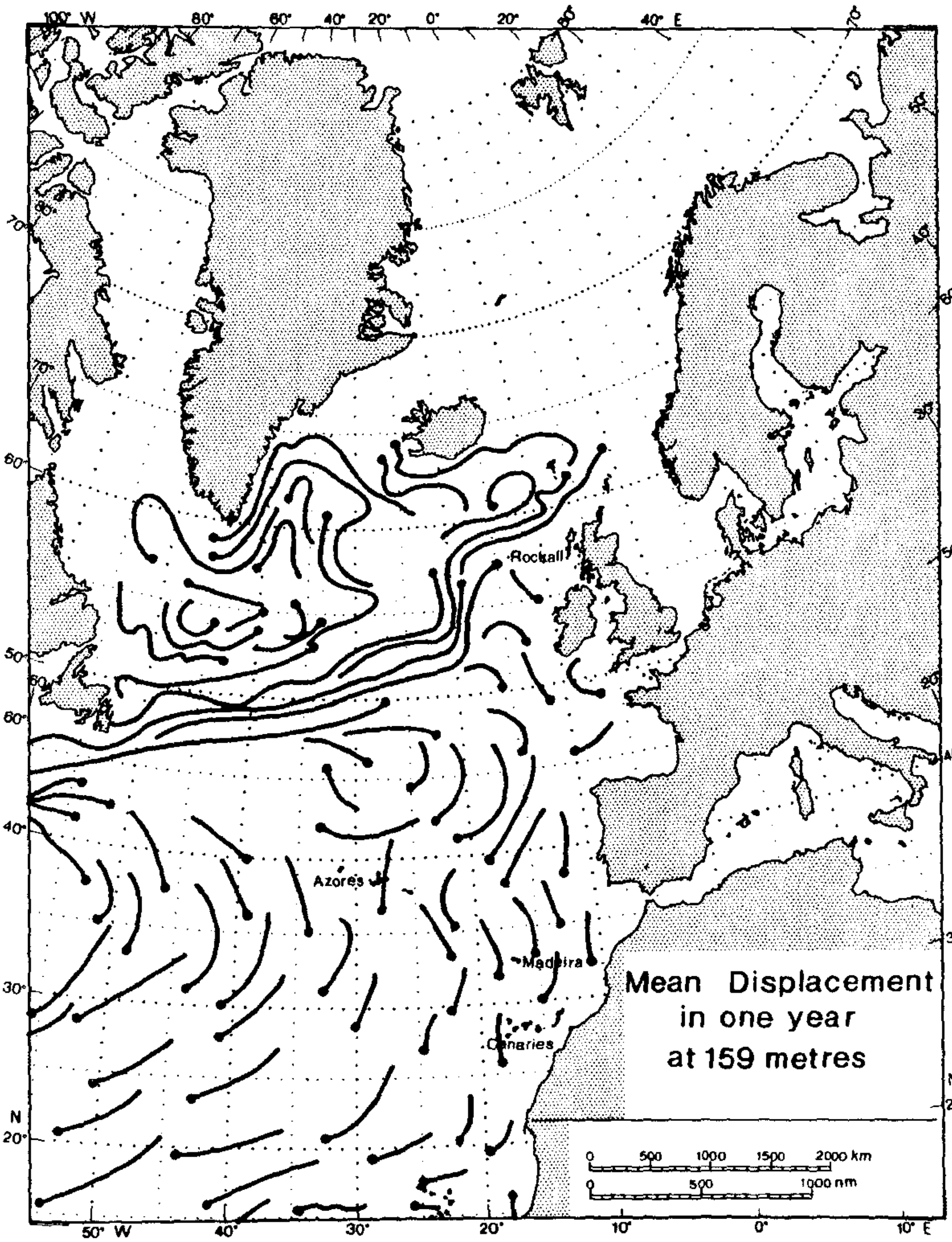


Fig. 8 Mean displacement in one year at a depth of 25 metres
(from J.L. Sarmiento and K. Bryan 1982).



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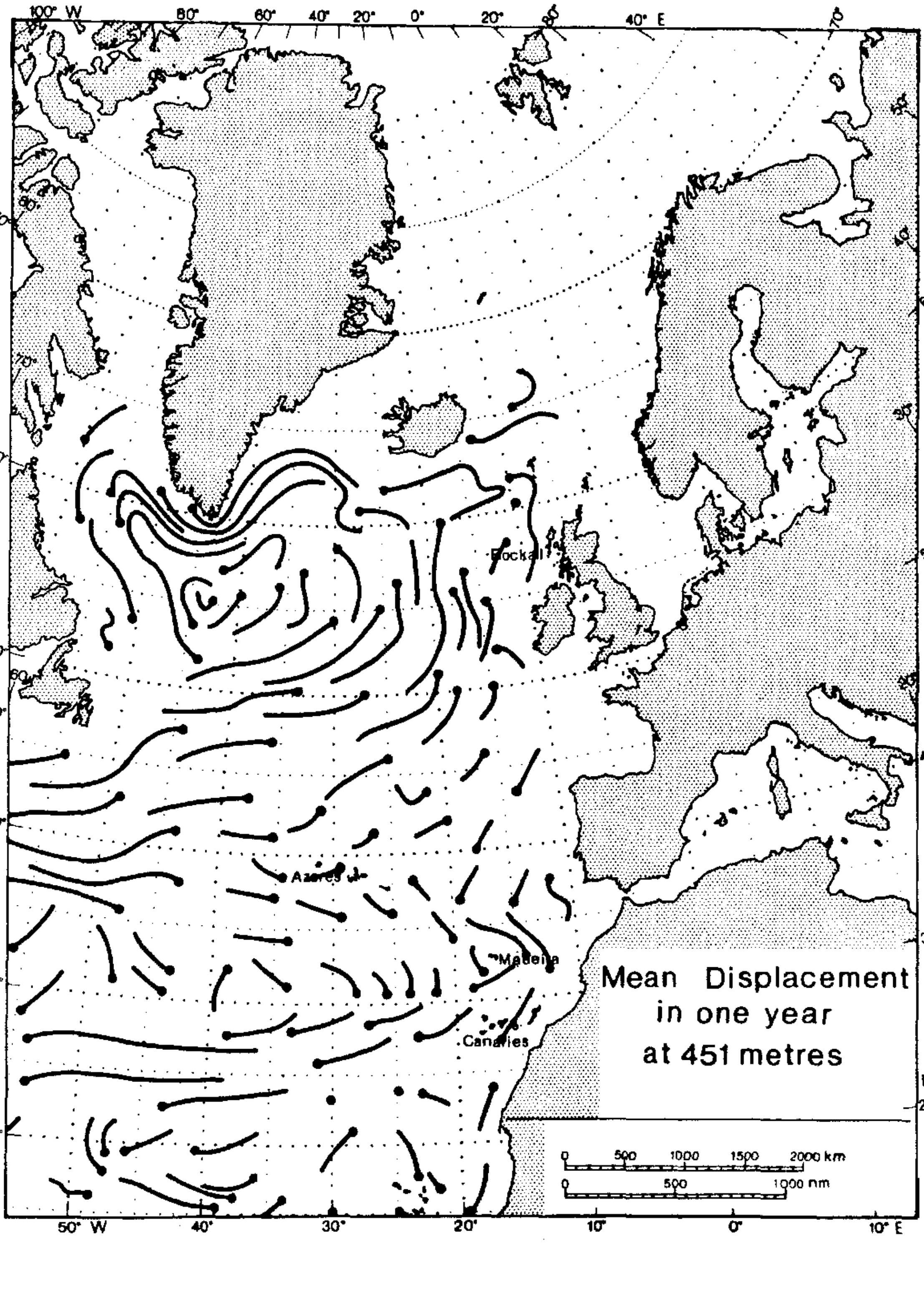

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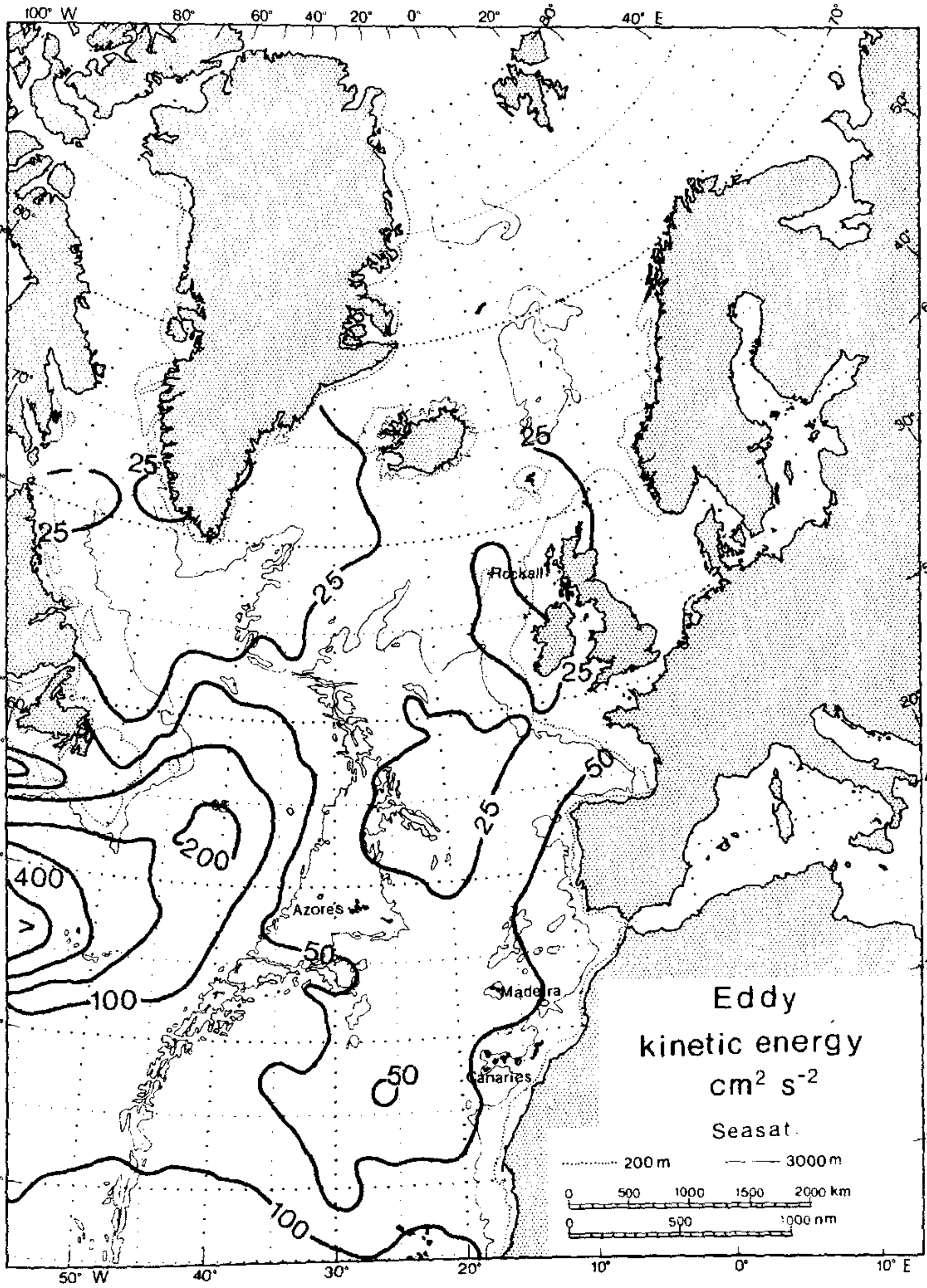
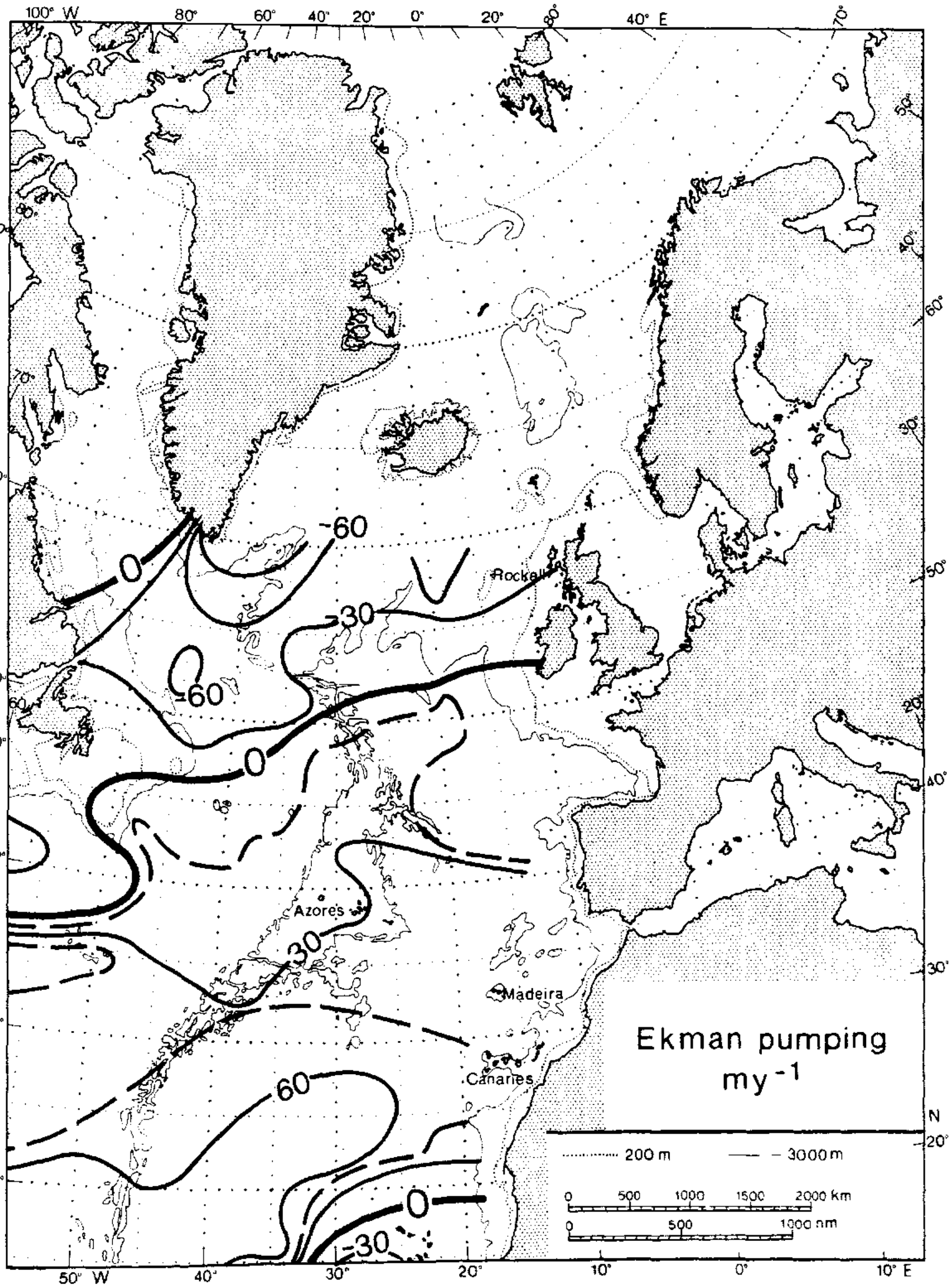


Fig. 11 Geostrophic eddy kinetic energy calculated from Seasat altimeter data (from R.E. Cheney, J.G. Marsh & B.D. Beckley 1983)



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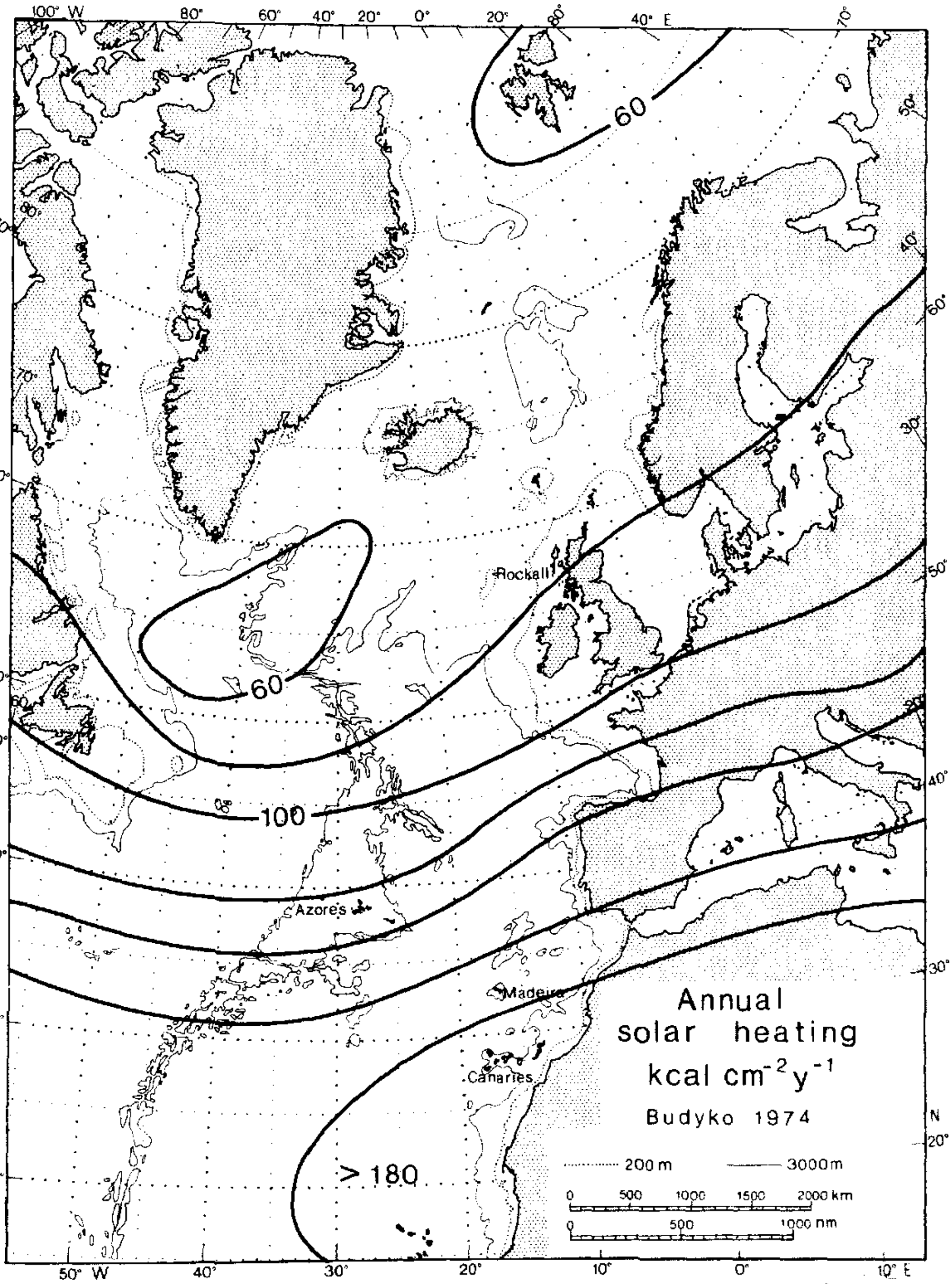


Fig. 13 Annual mean solar heating (from M.I. Budyko 1974).

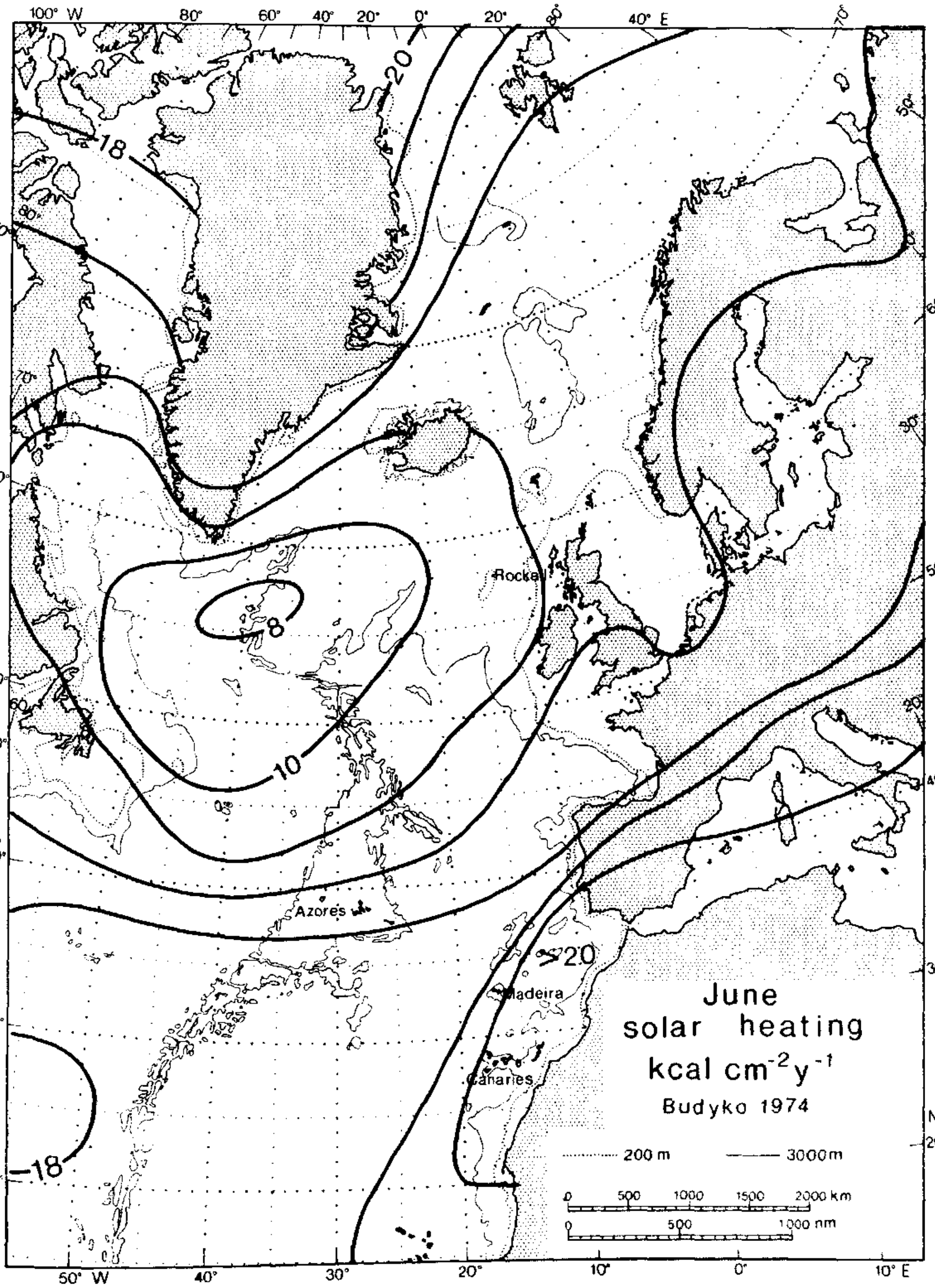


Fig. 4 June mean solar heating (from M.I. Budyko 1974).

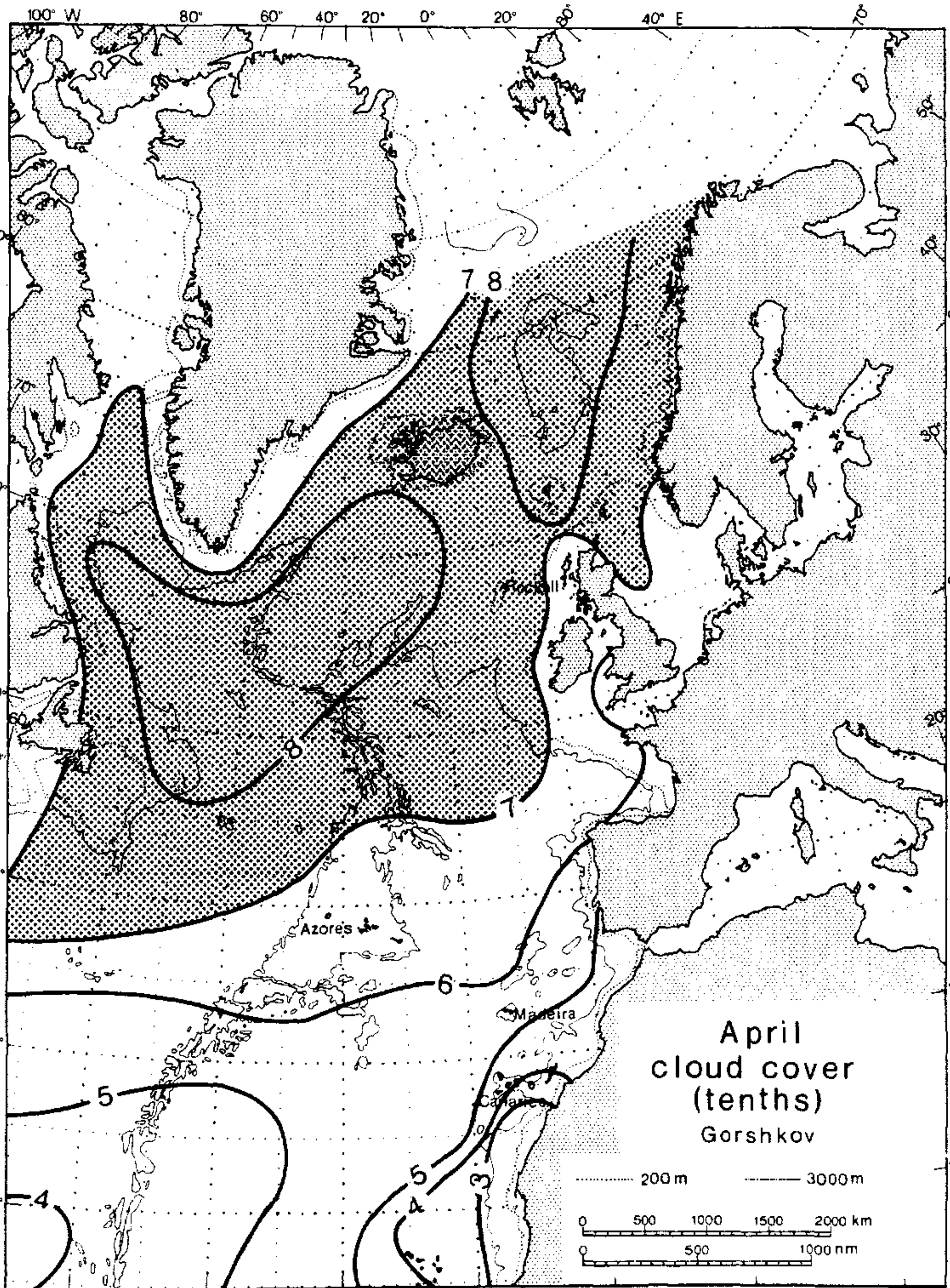


Fig. 15 April mean cloud cover (from S.G. Gorshkov 1978).

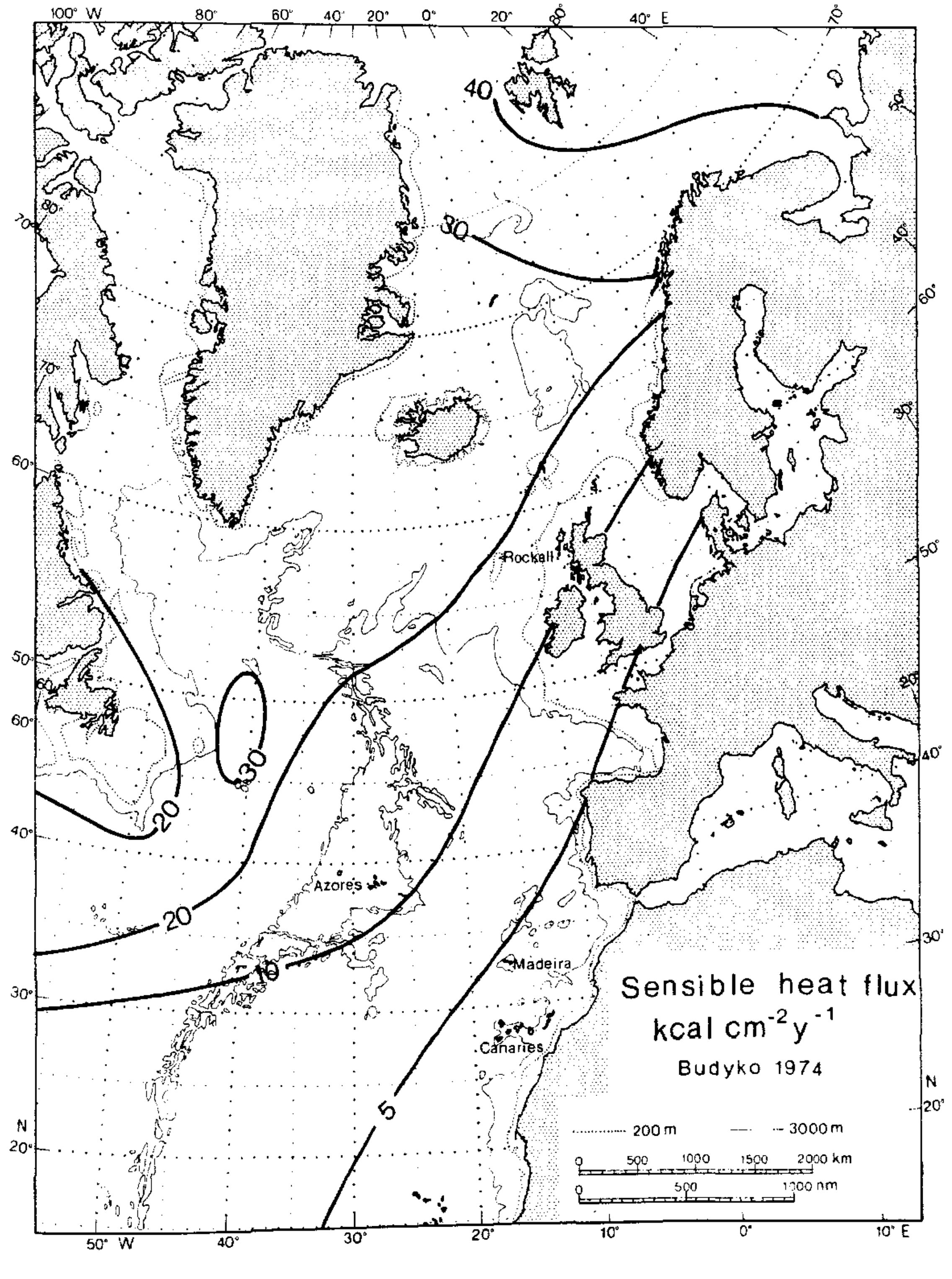


Fig. 16 Annual mean sensible heat flux (from M.I. Budyko 1974).

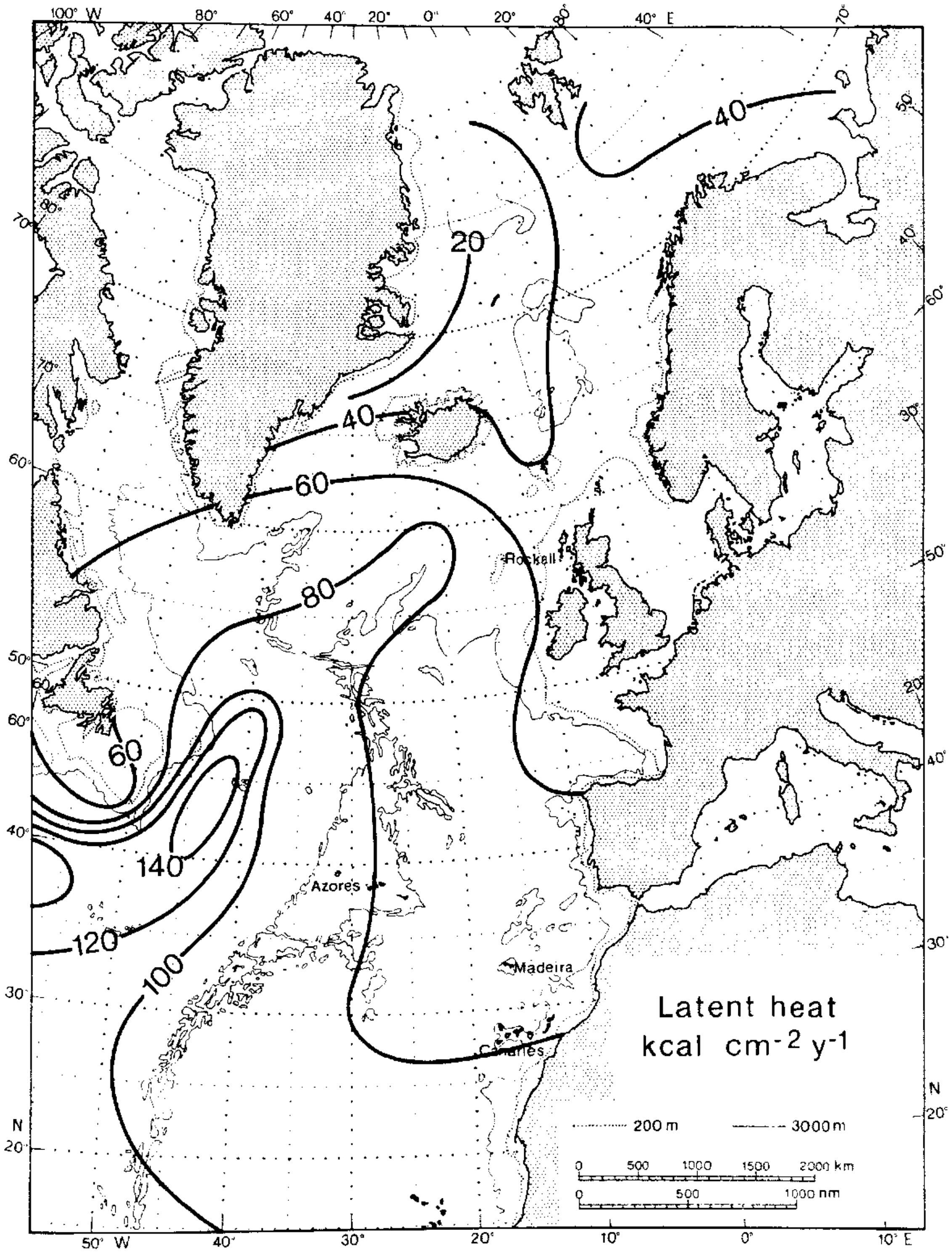
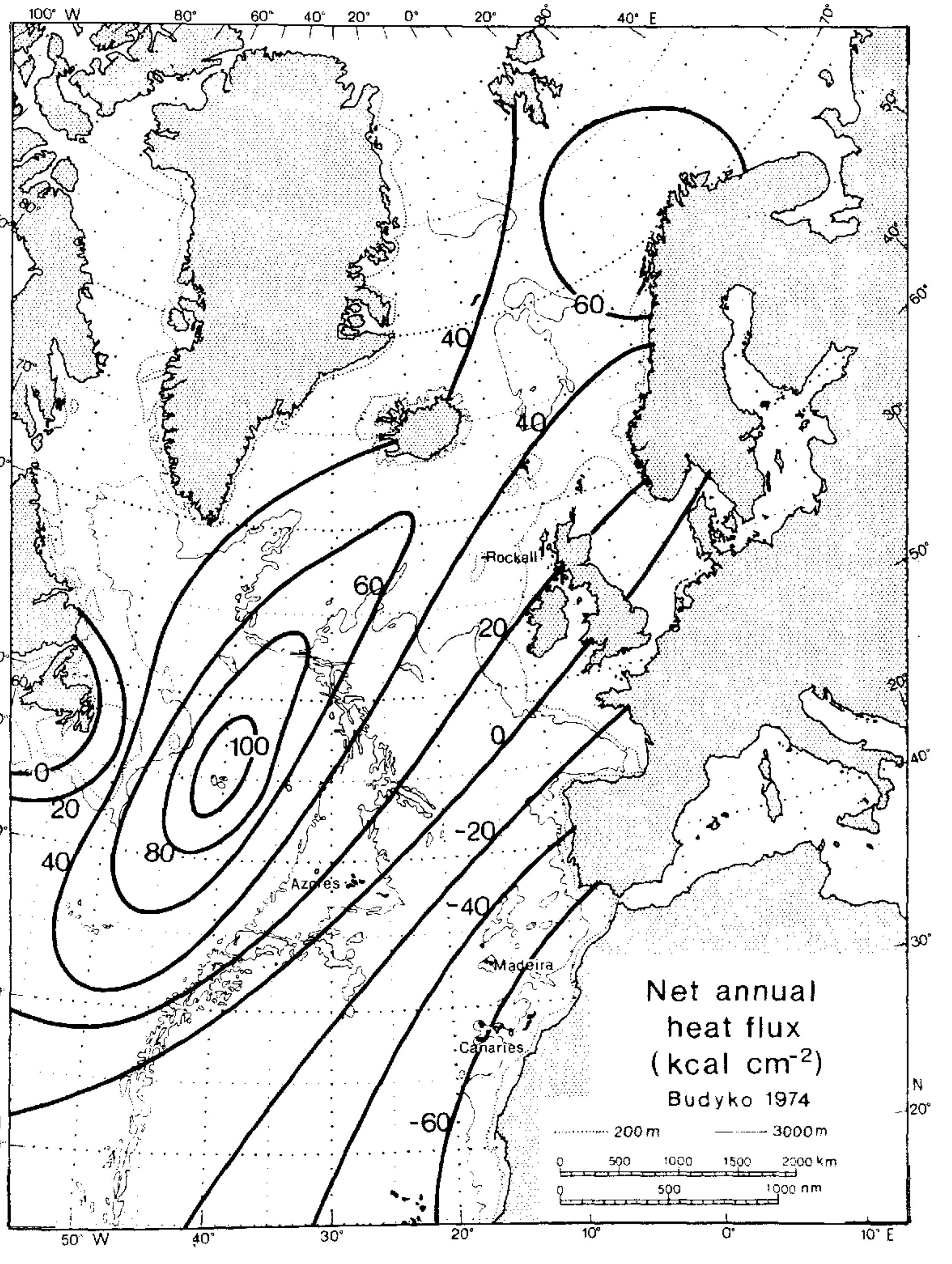


Fig. 17 Annual mean latent heat flux (from M.I. Budyko 1974).



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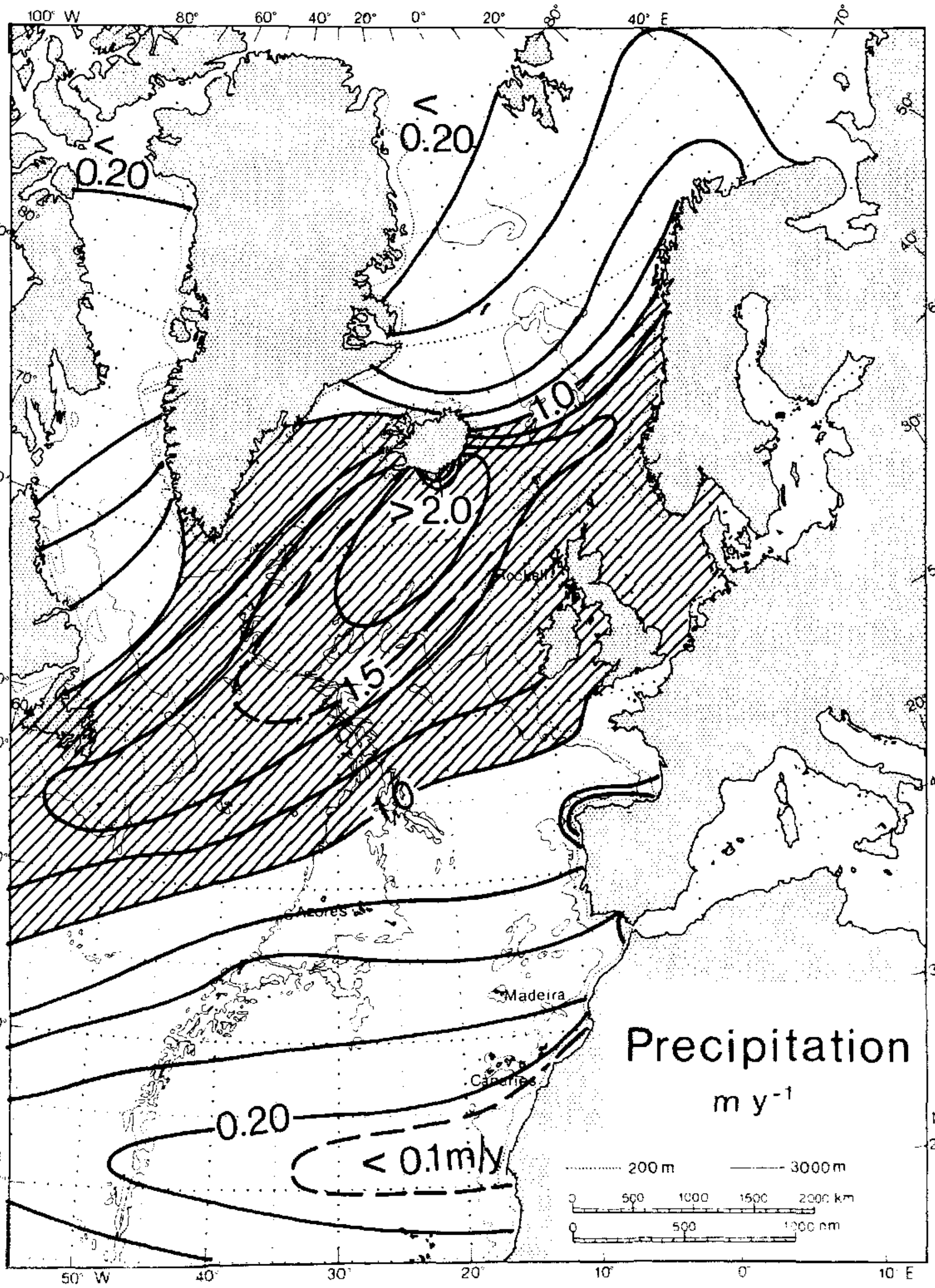


Fig. 19 Annual mean precipitation (from A. Baumgartner & E. Reichel 1975).

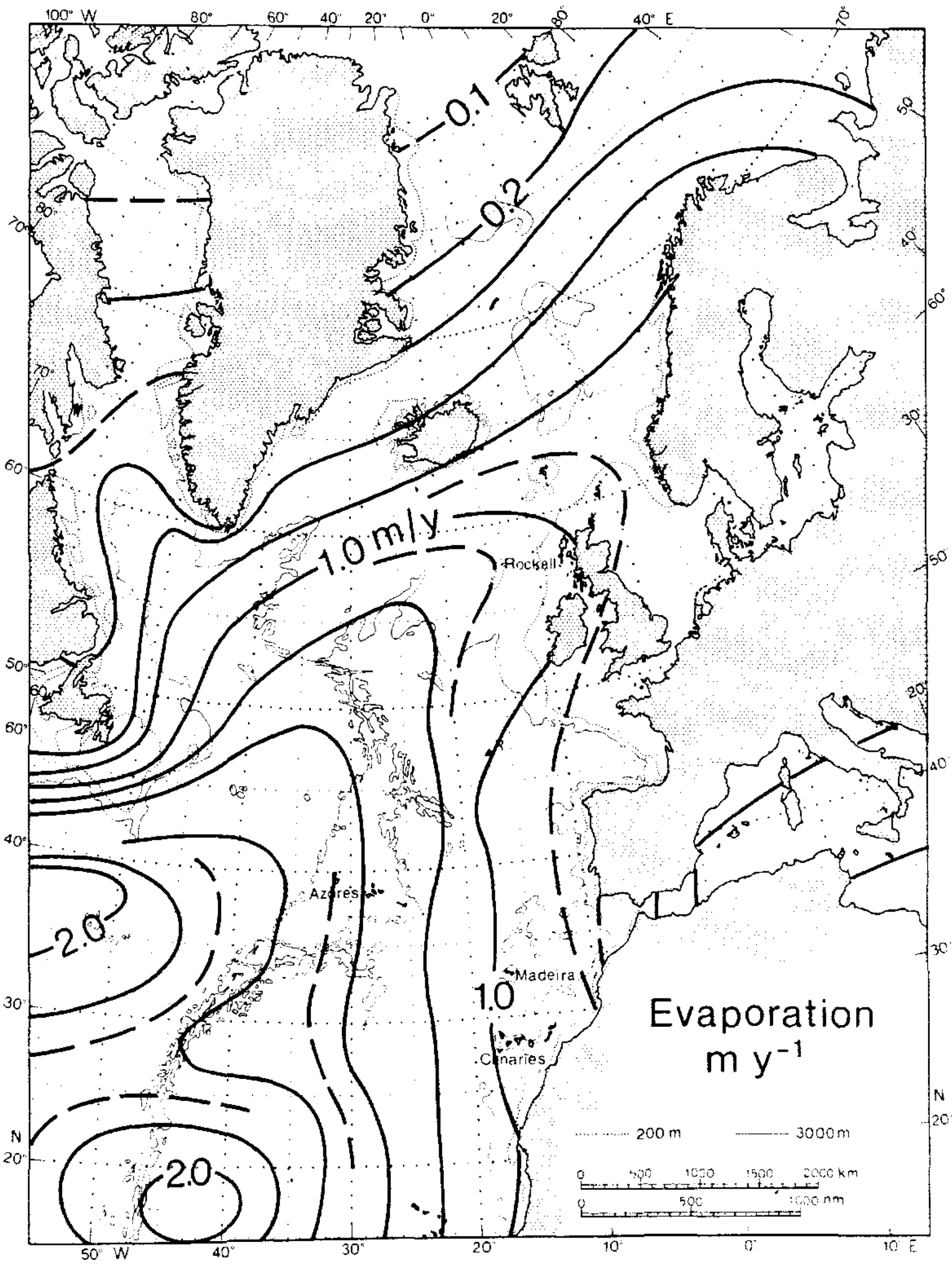
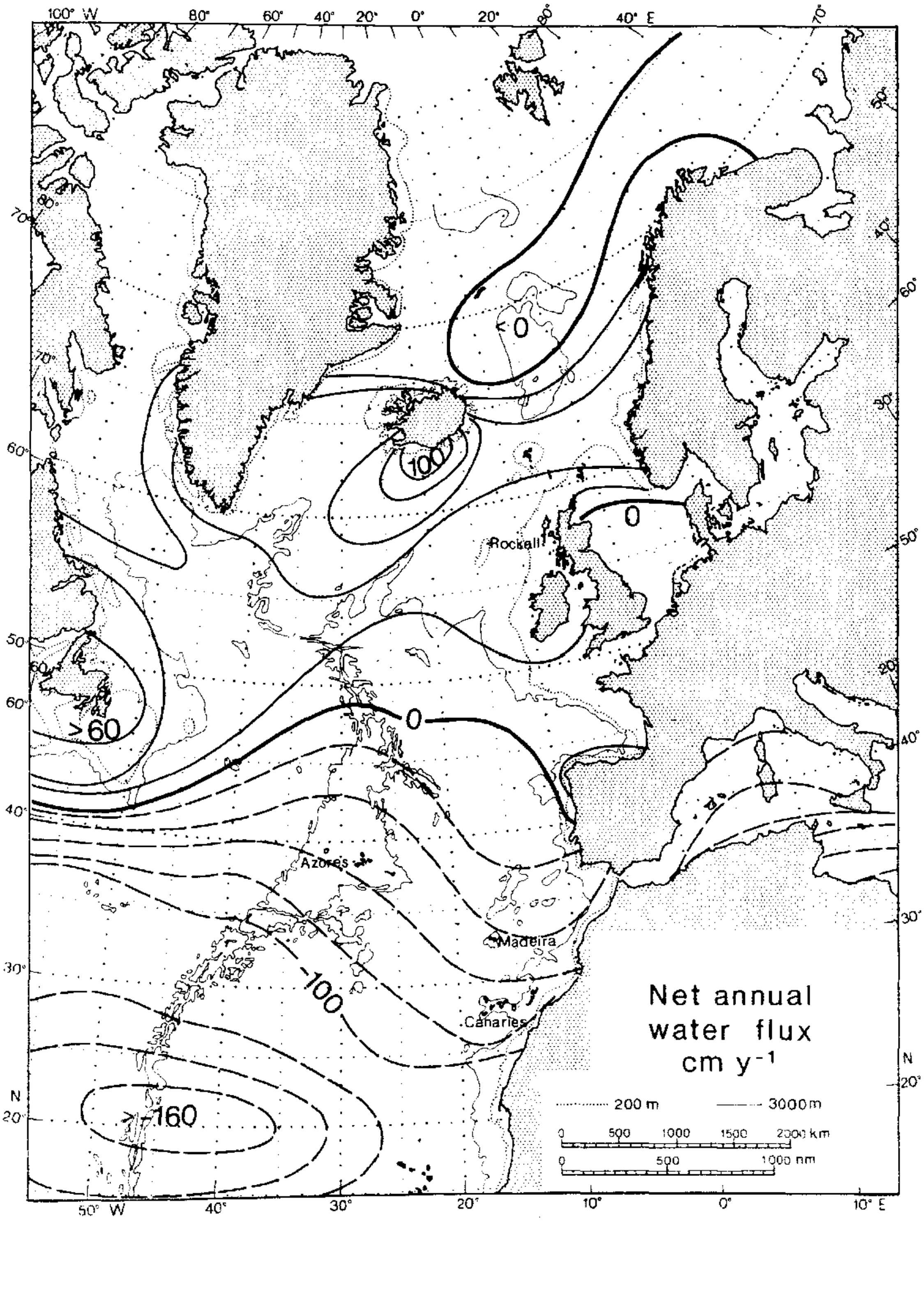


Fig. 20 Annual mean evaporation (from A. Baumgartner & E. Reichel 1975).



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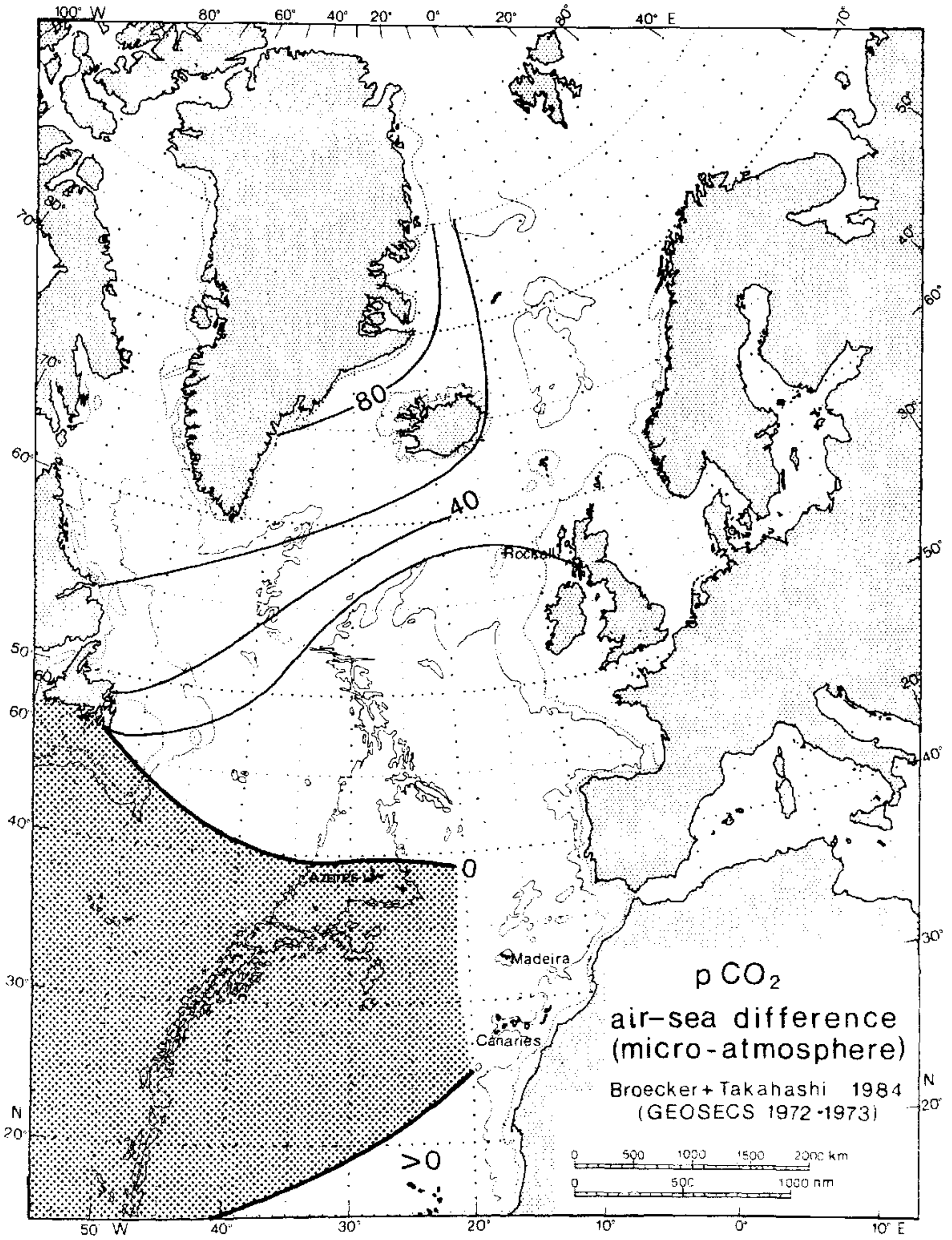


Fig. 22 Carbon-dioxide partial pressure difference between the ocean and the atmosphere during summer, based on GEOSEKS data 1972-1973 (from W.S. Broecker & T. Takahashi 1984).

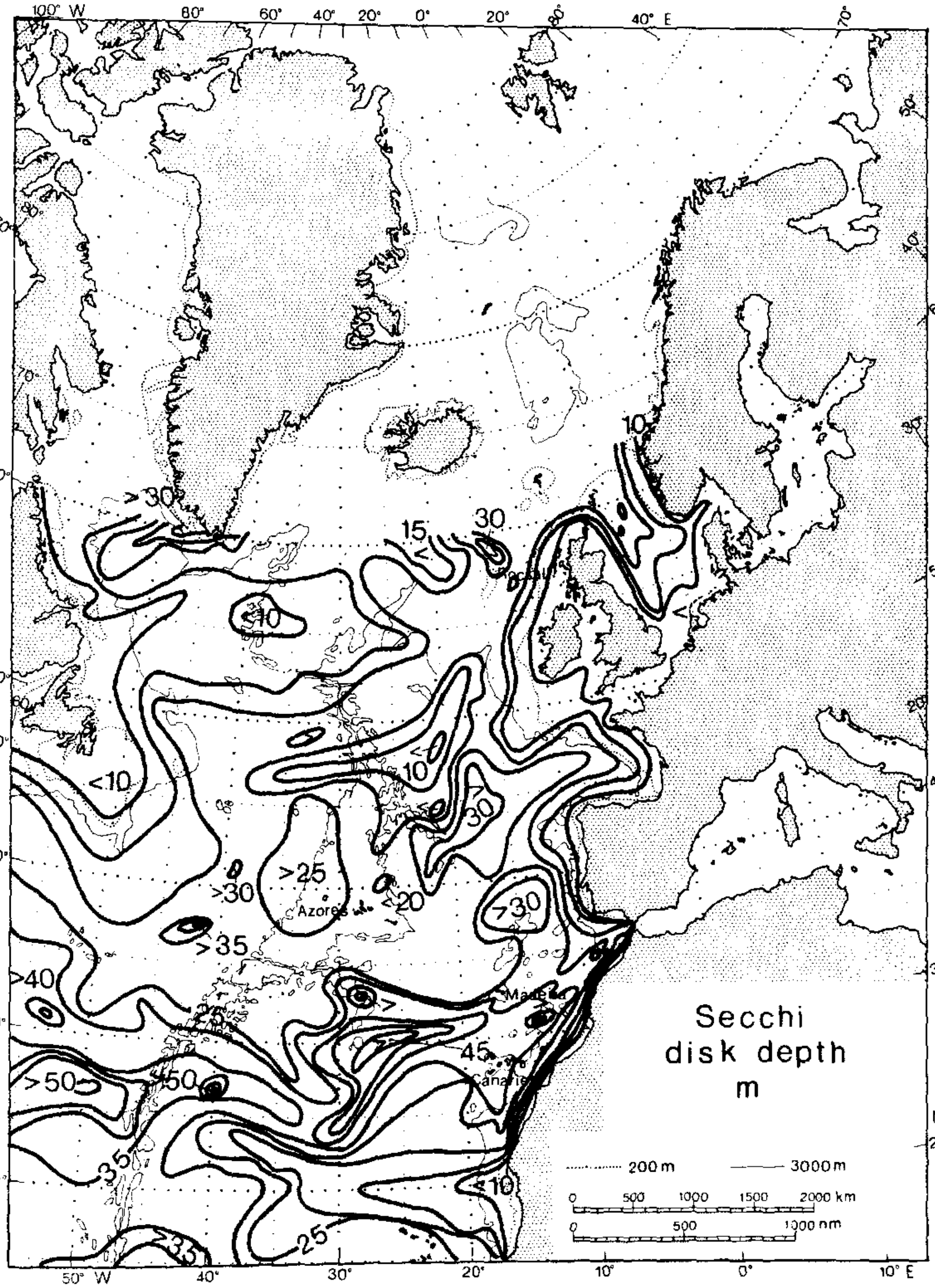


Fig 23 Secchi disk depth. The equivalent Jerlov optical water types are as follows: I (50 m), IA (40 m), IB (33 m), II (23 m) and III (13 m) (from R.R. Dickson 1972)

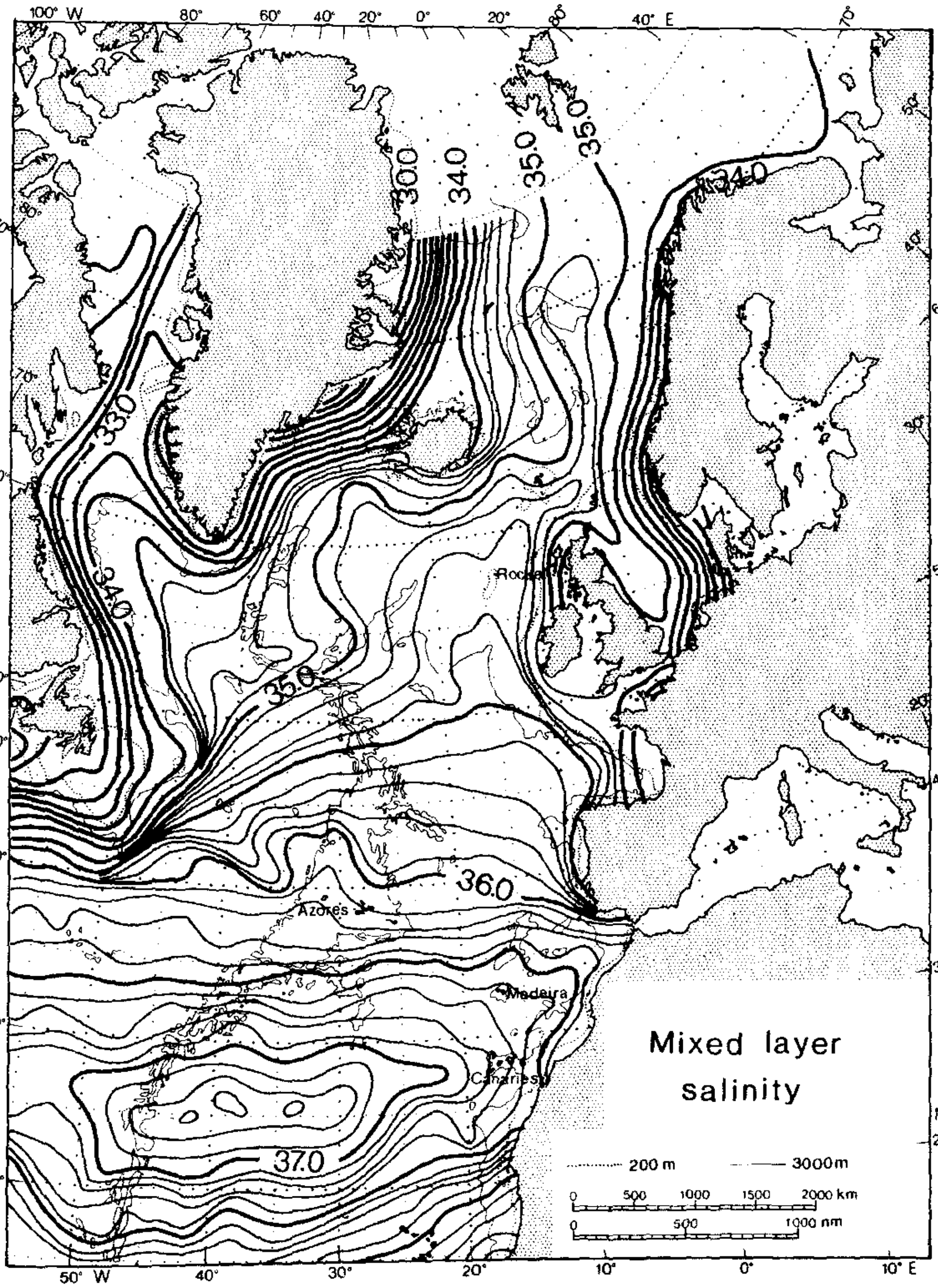
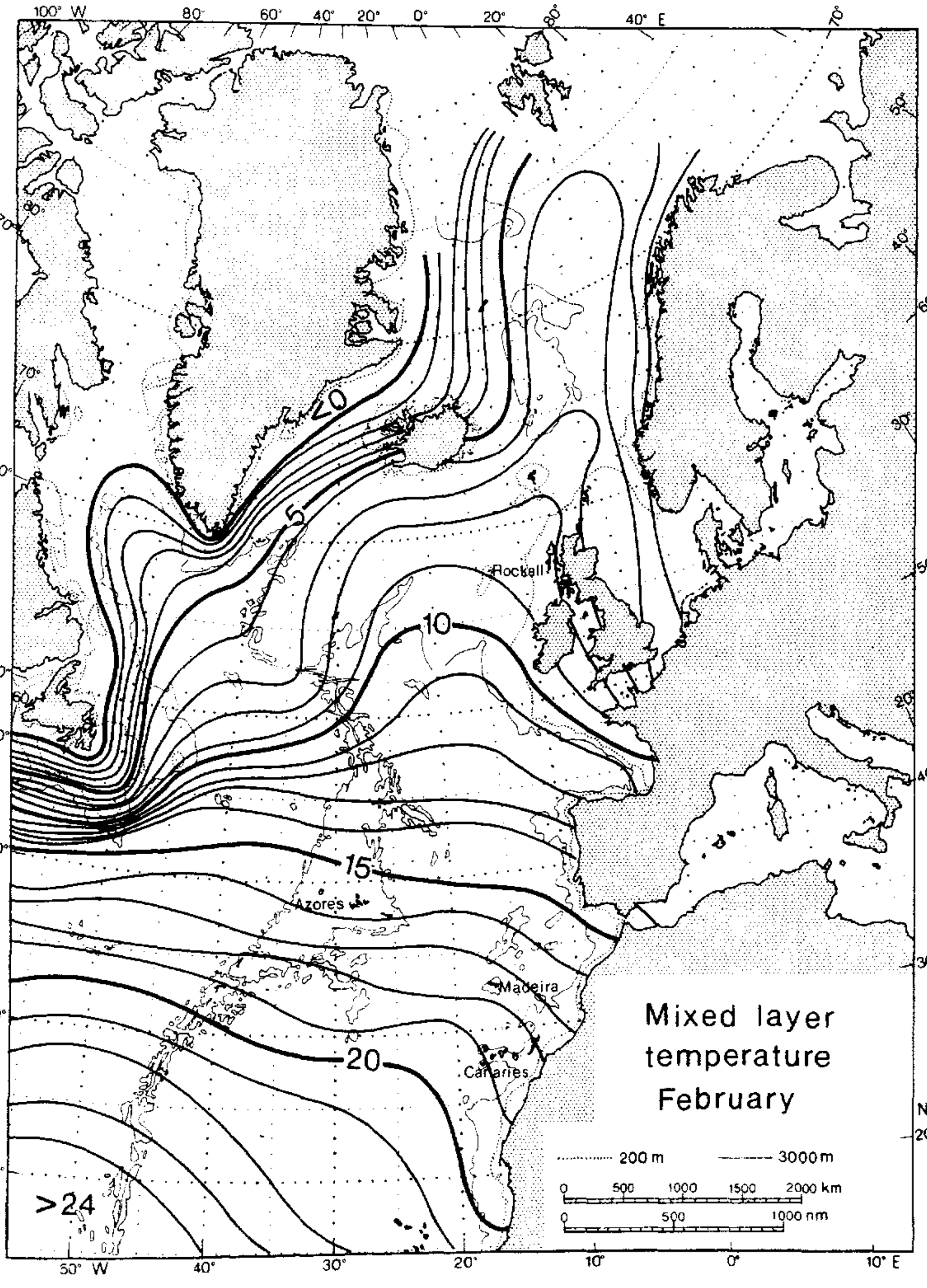


Fig. 24 Annual mean salinity of the mixed layer (from M.K. Robinson, R.A. Bauer & E.H. Schroeder 1979).



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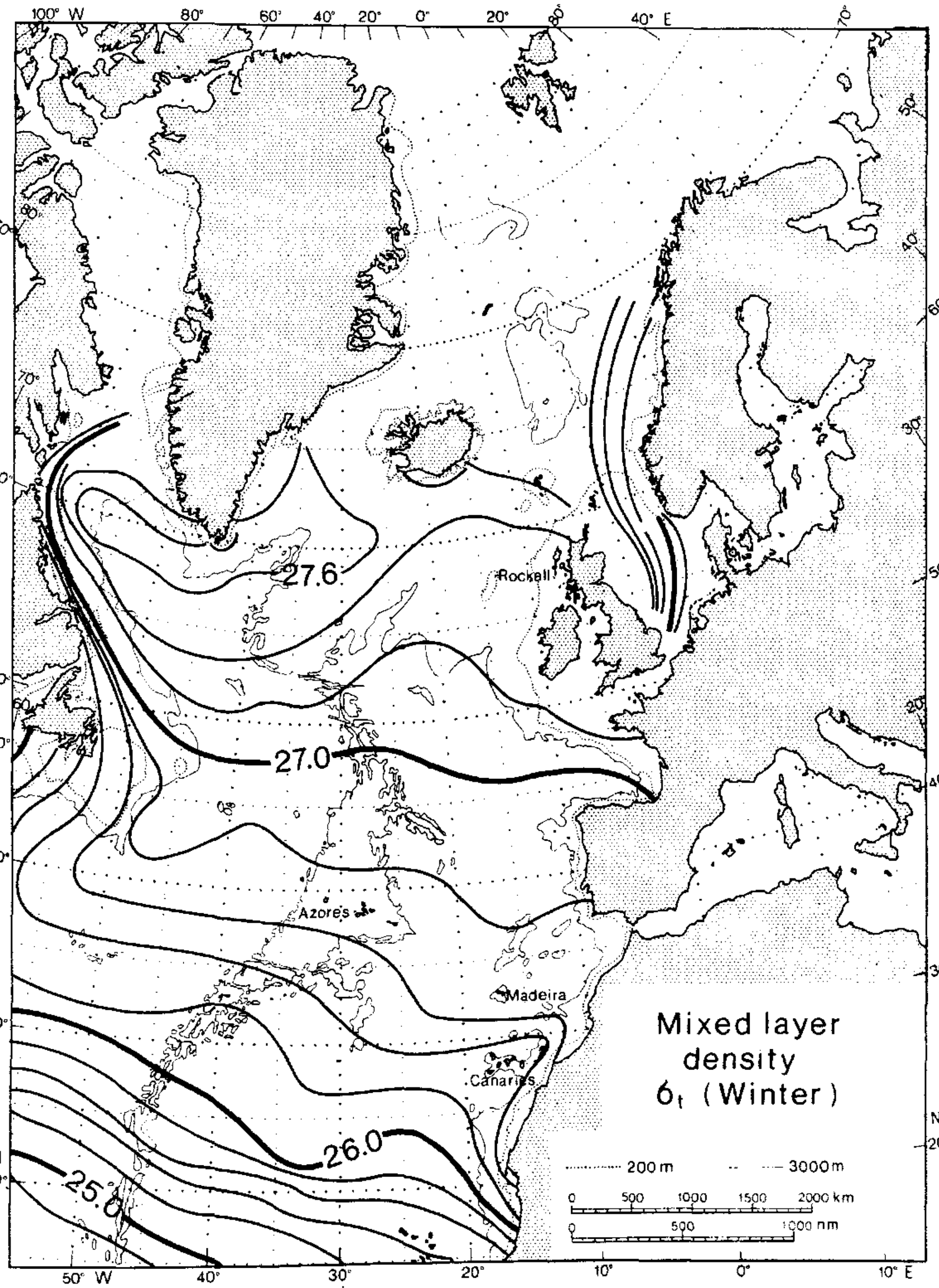

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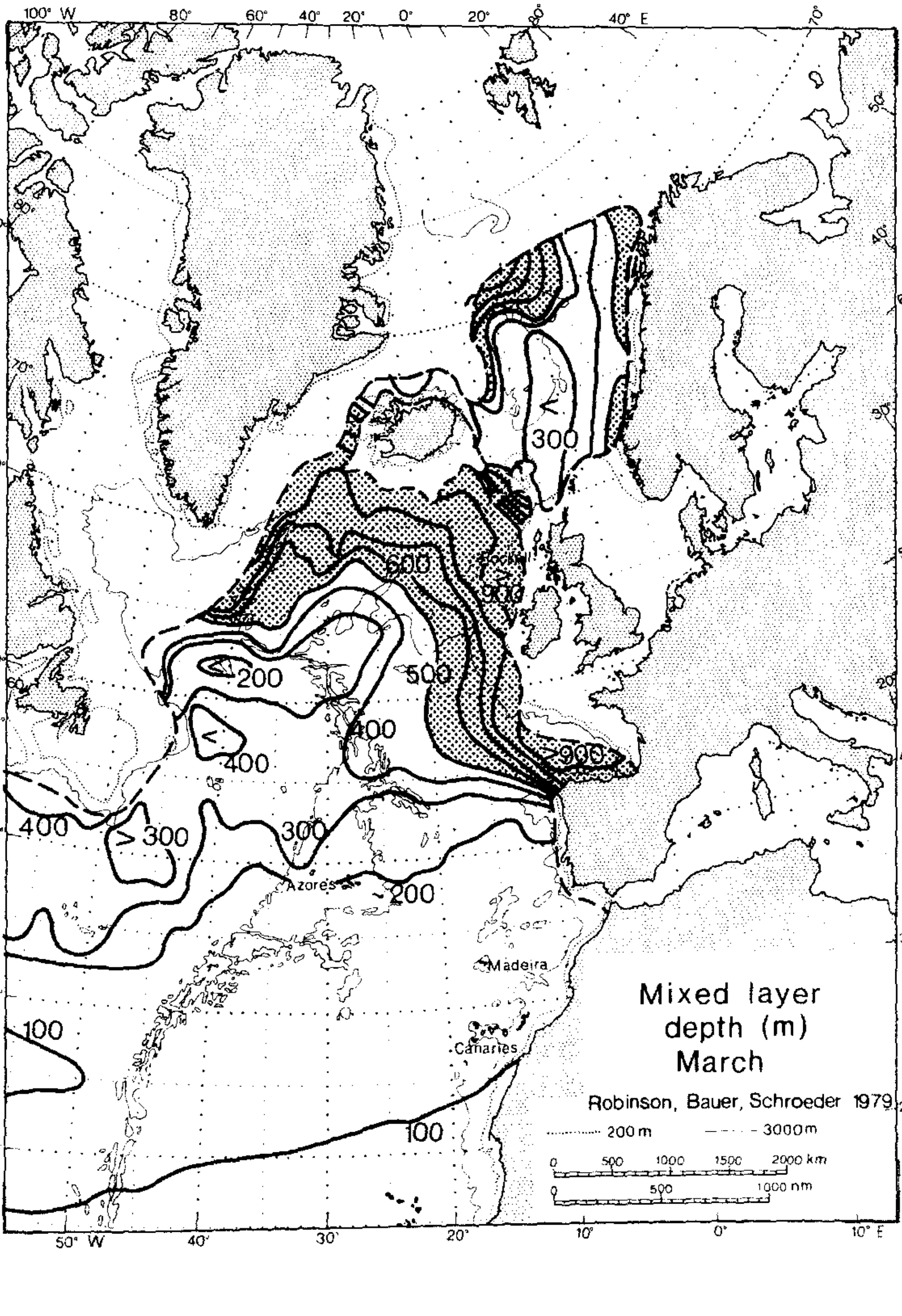

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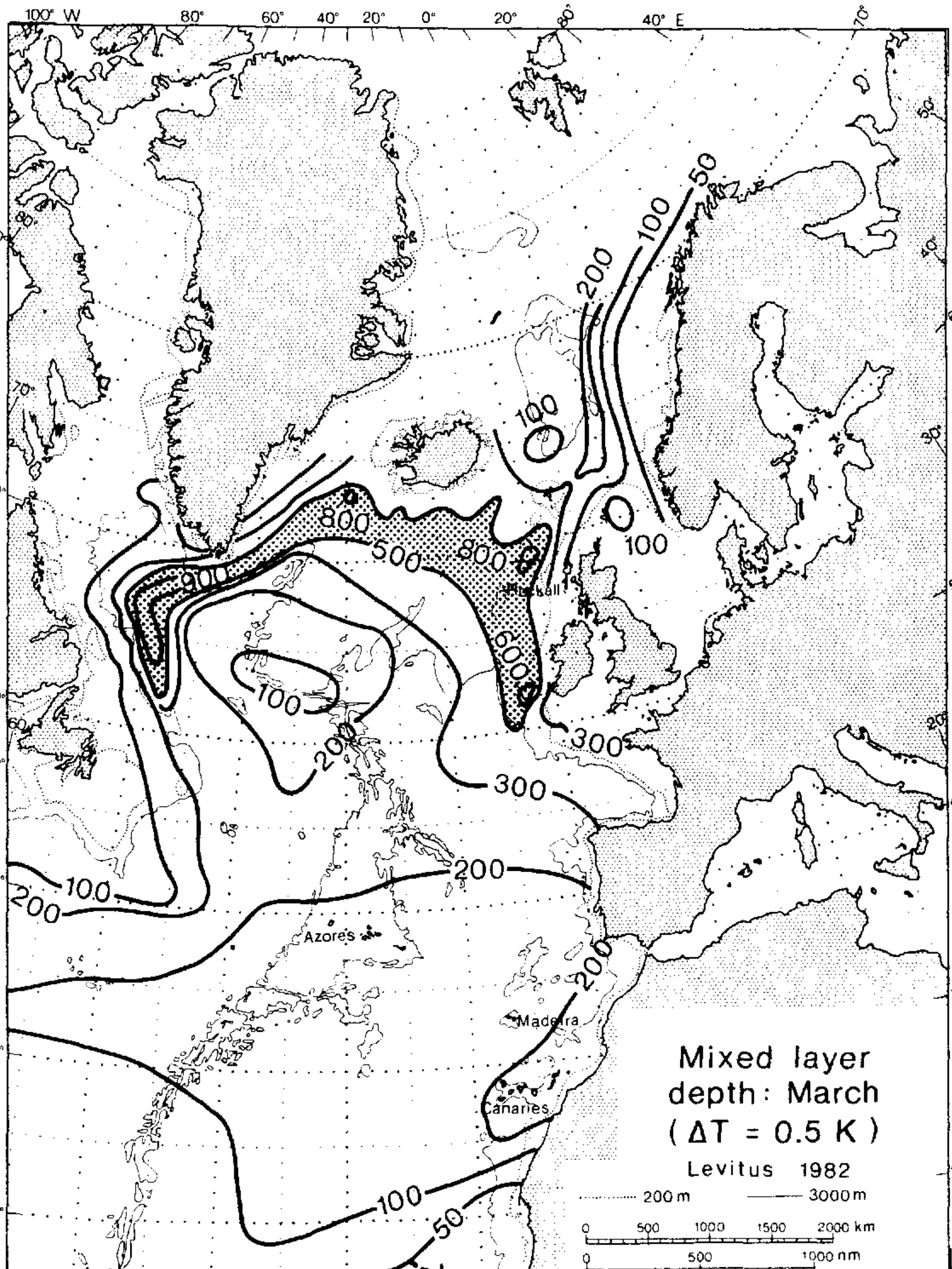

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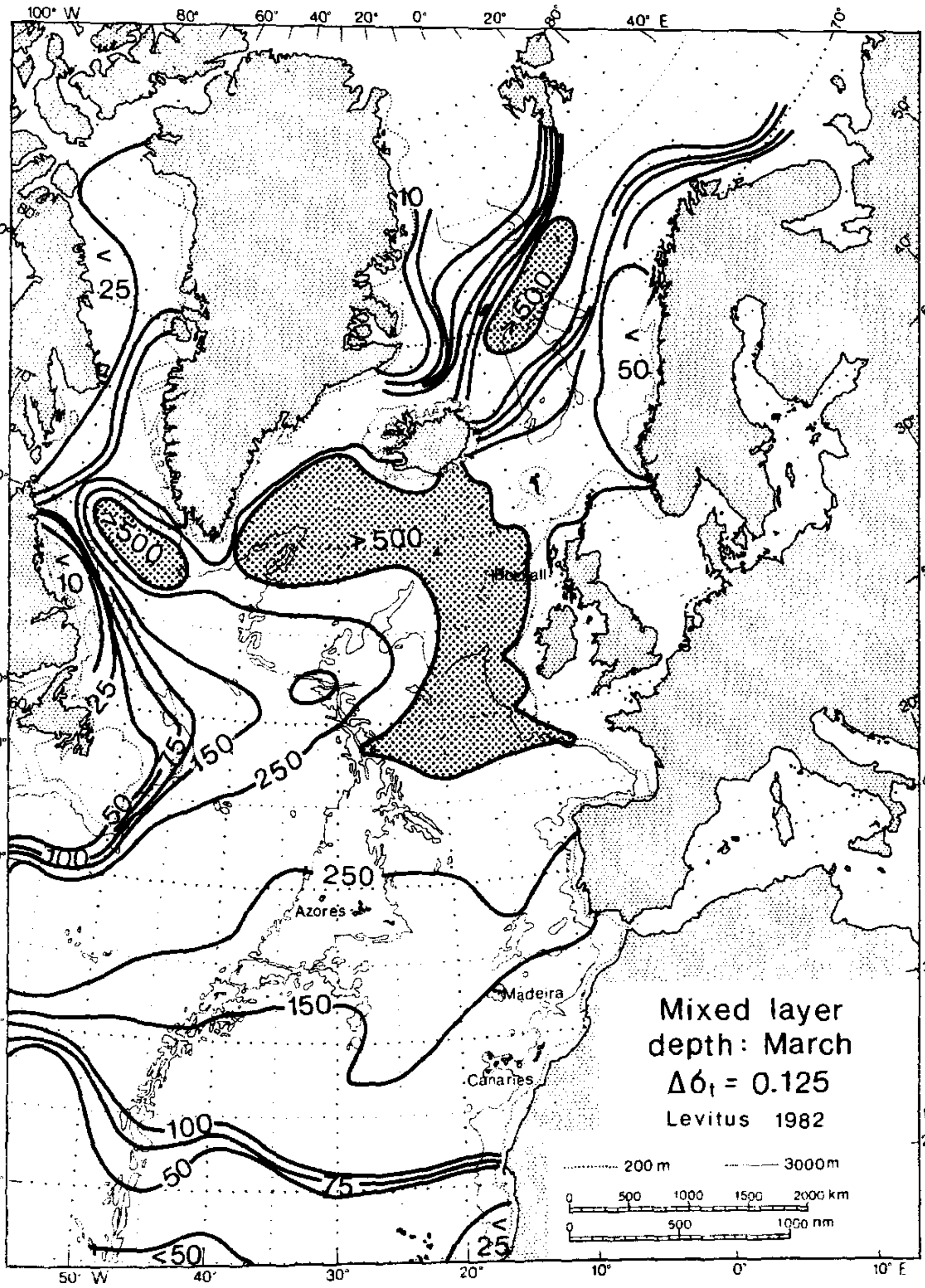

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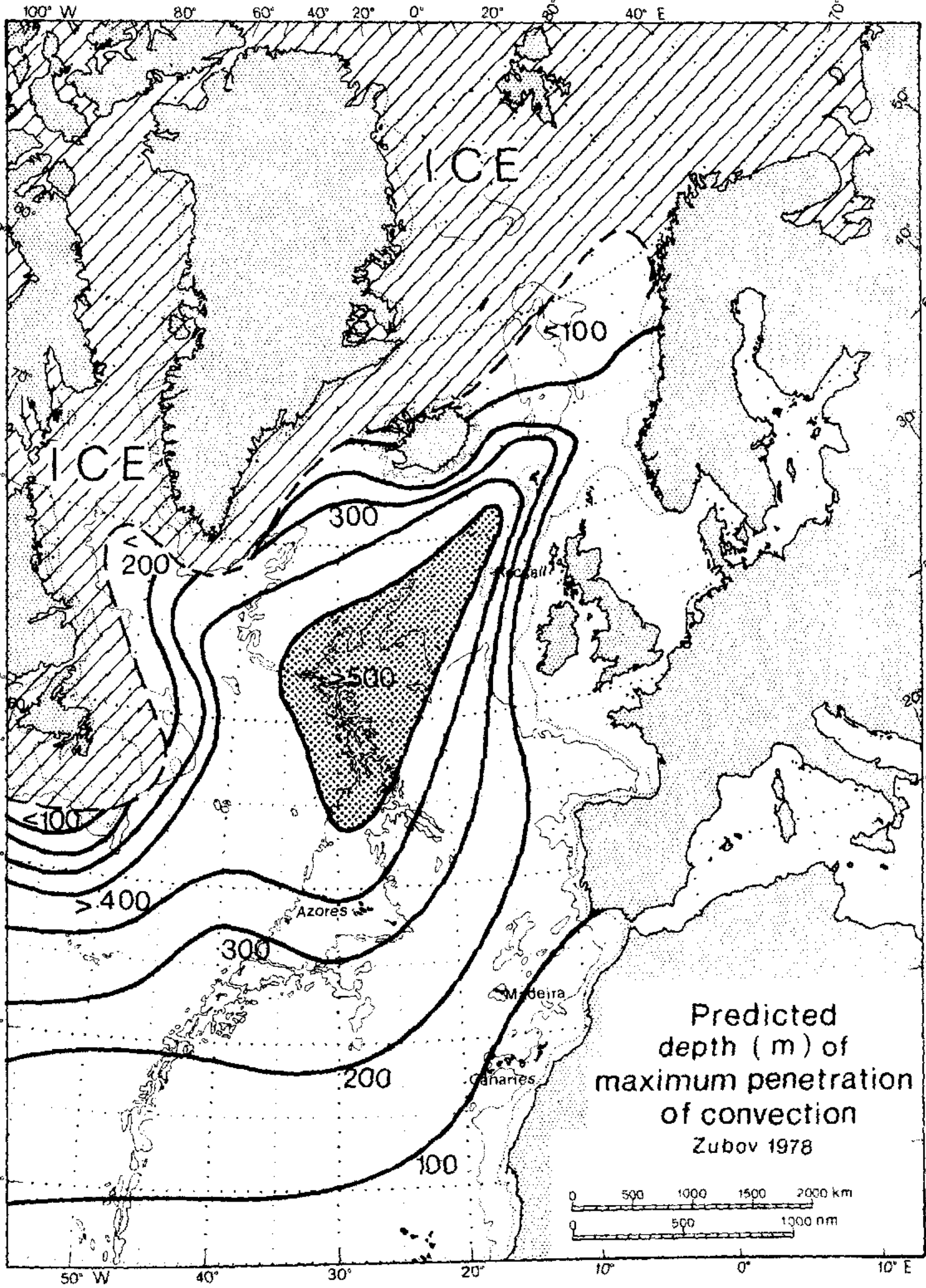

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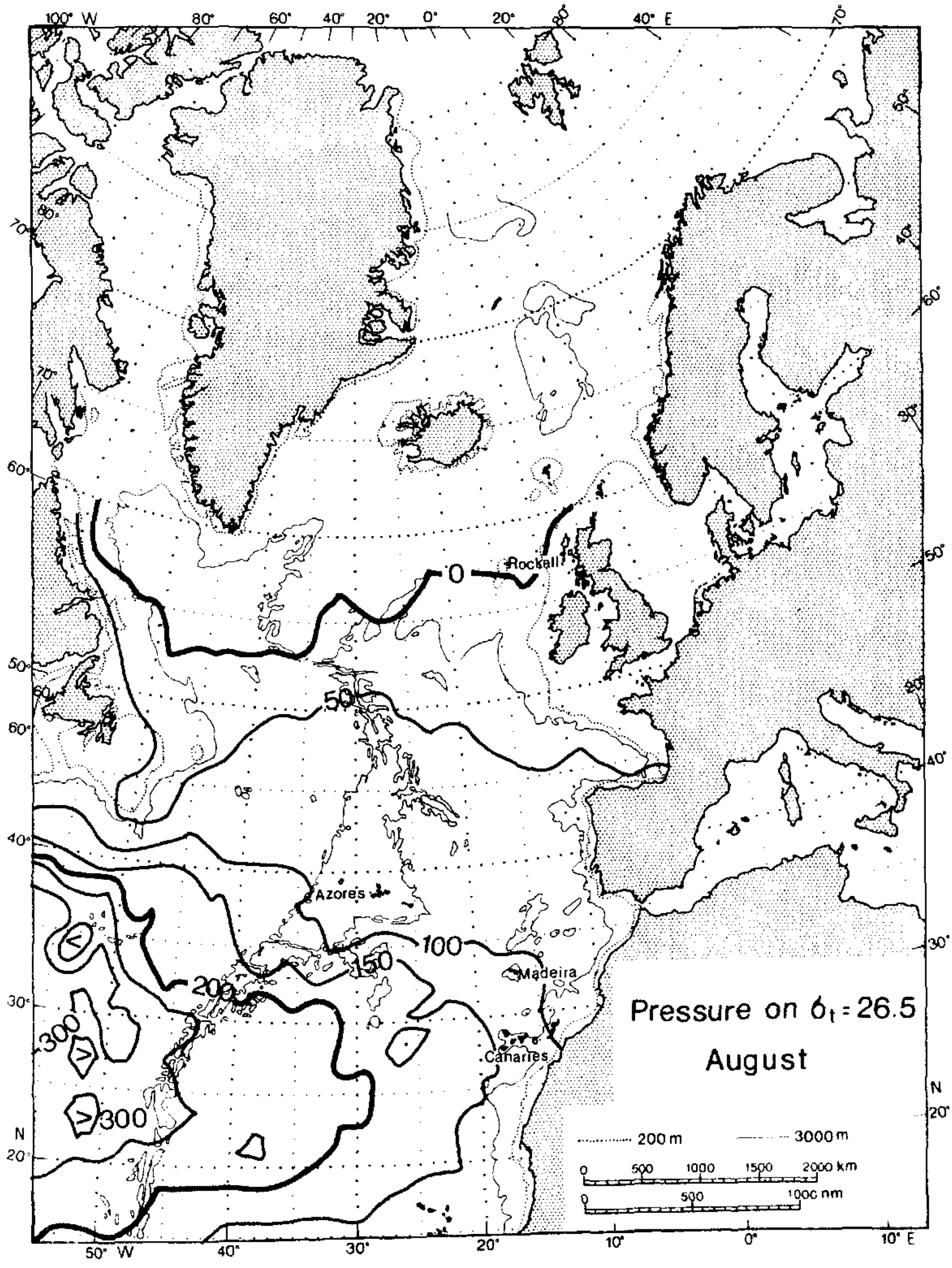


Fig. 31 August mean distribution of pressure on the isopycnic surface σ_t = 26.5 kg/m³ (from J. Bauer & J.D. Woods 1984).

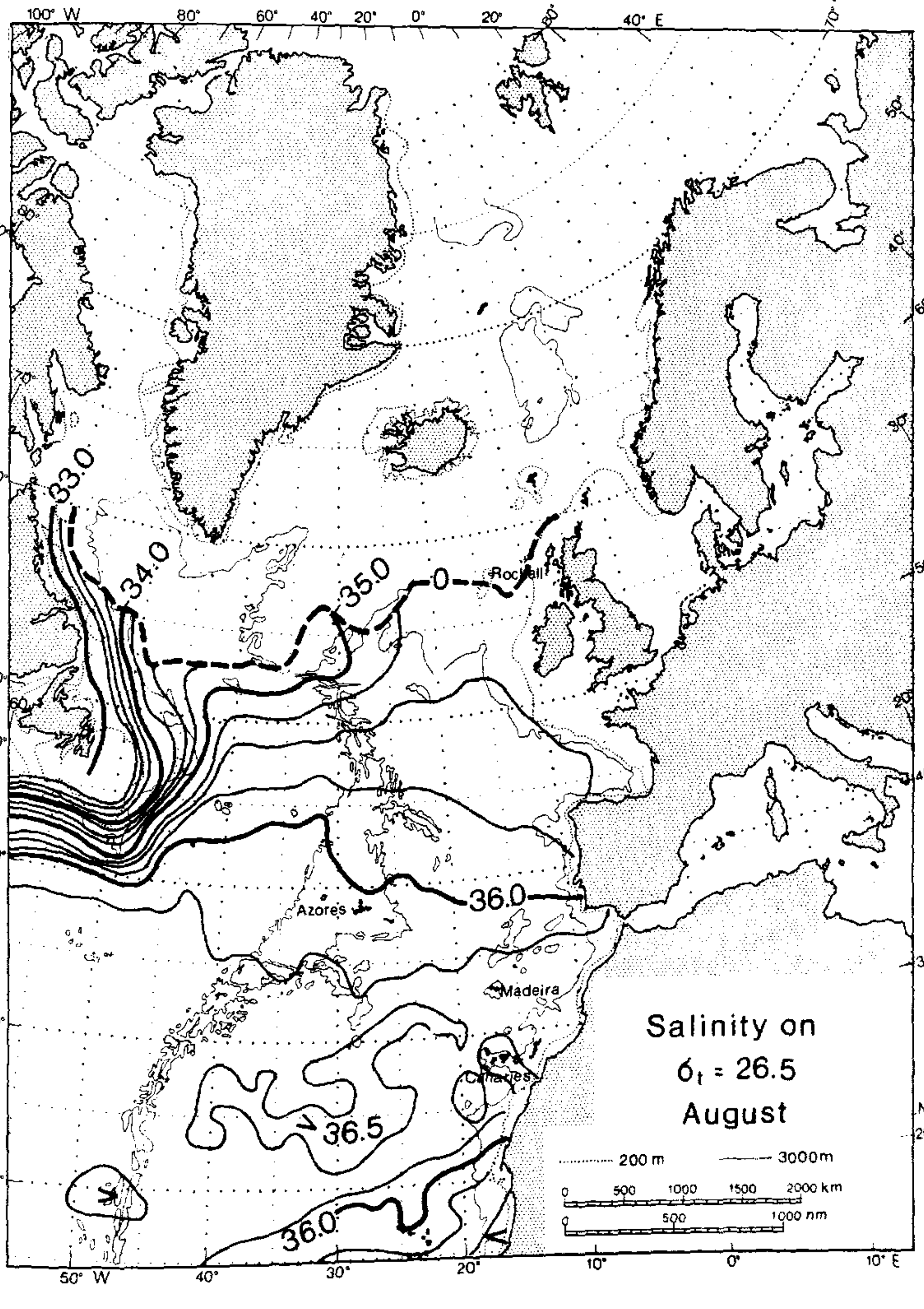


Fig. 32 August mean distribution of salinity on the isopycnic surface σ_t = 26.5 kg/m³ (from J. Bauer & J.D. Woods 1984).

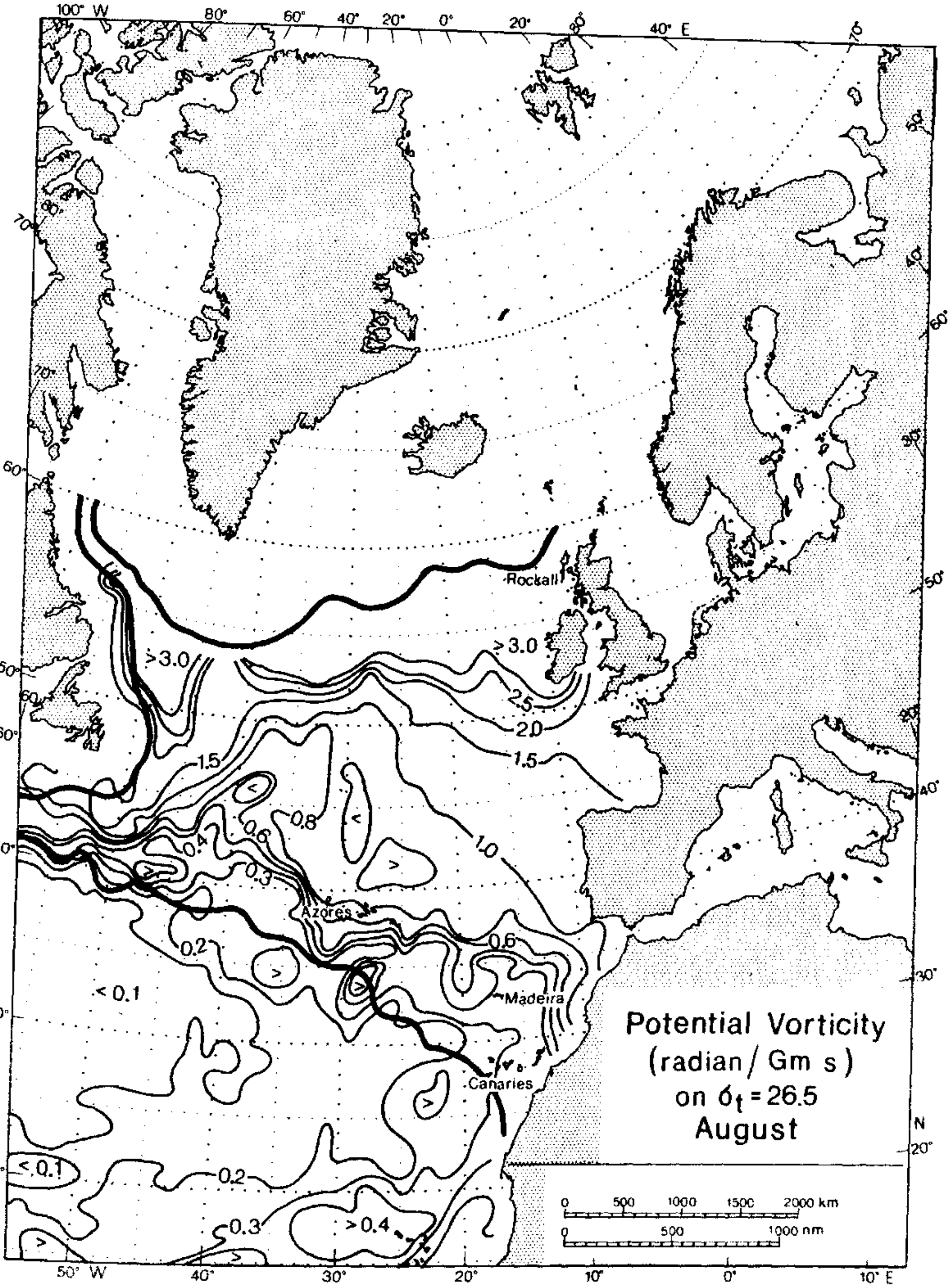
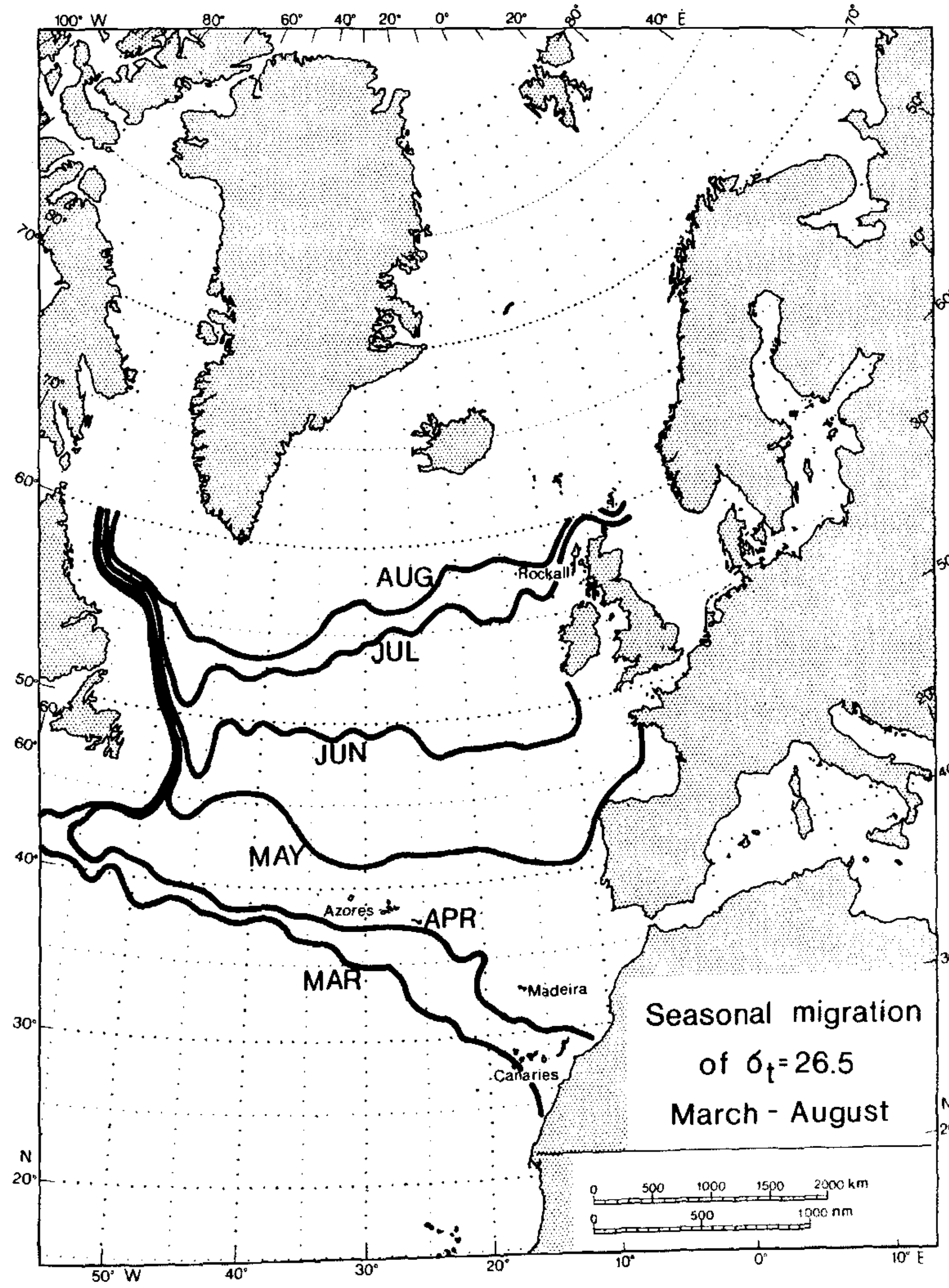


Fig. 33 August mean distribution of isopycnic potential vorticity on σ_t = 26.5 kg/m³ (from D. Stammer & J.D. Woods 1987).



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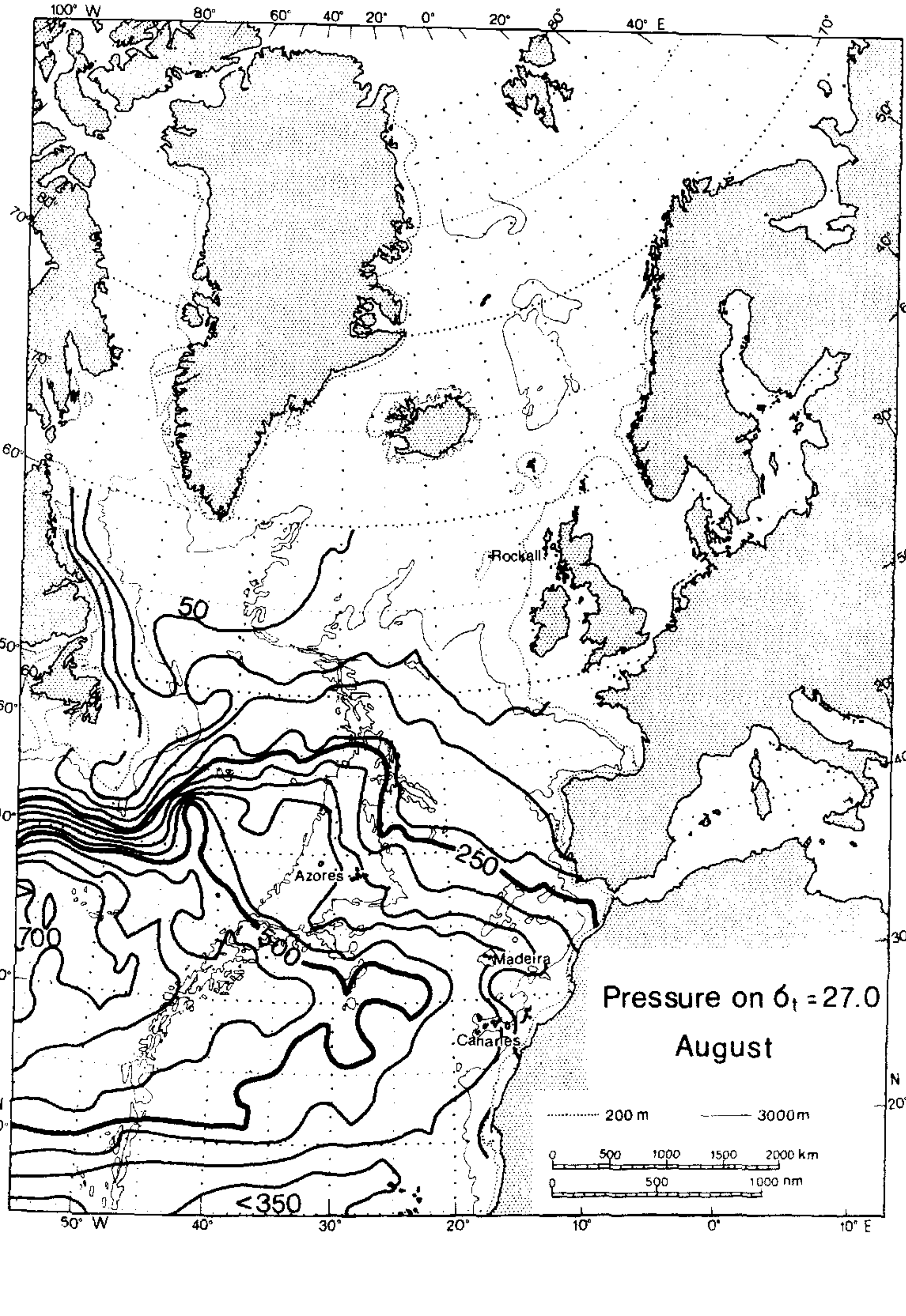

Fig. 35 August mean distribution of pressure on the isopycnic surface $\sigma_t = 27.0 \ kg/m^3$ (from J. Bauer & J.D. Woods 1984).

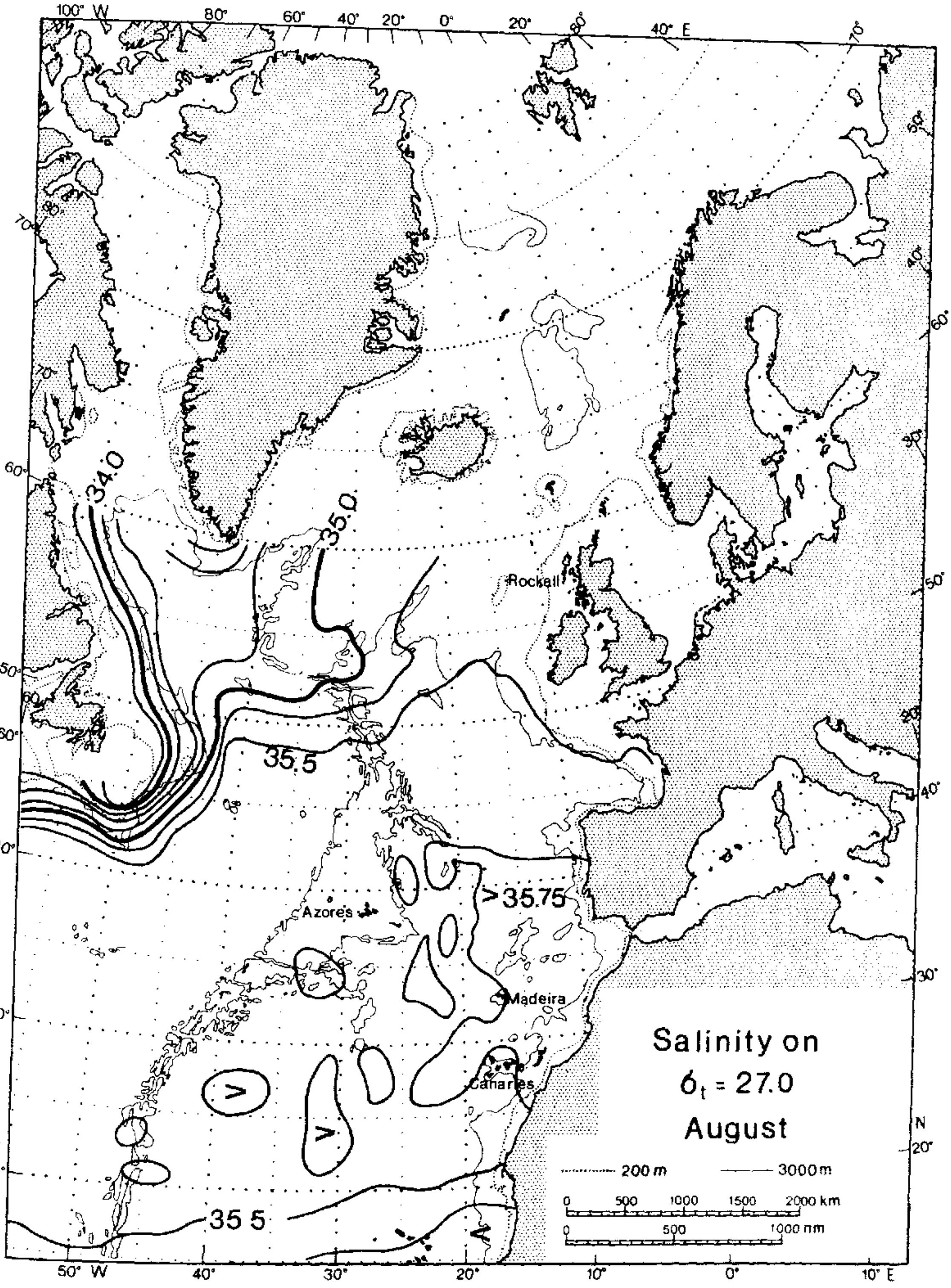

Fig. 36 August mean distribution of salinity on the isopycnic surface σ_t = 27.0 kg/m³ (from J. Bauer & J.D. Woods 1984).

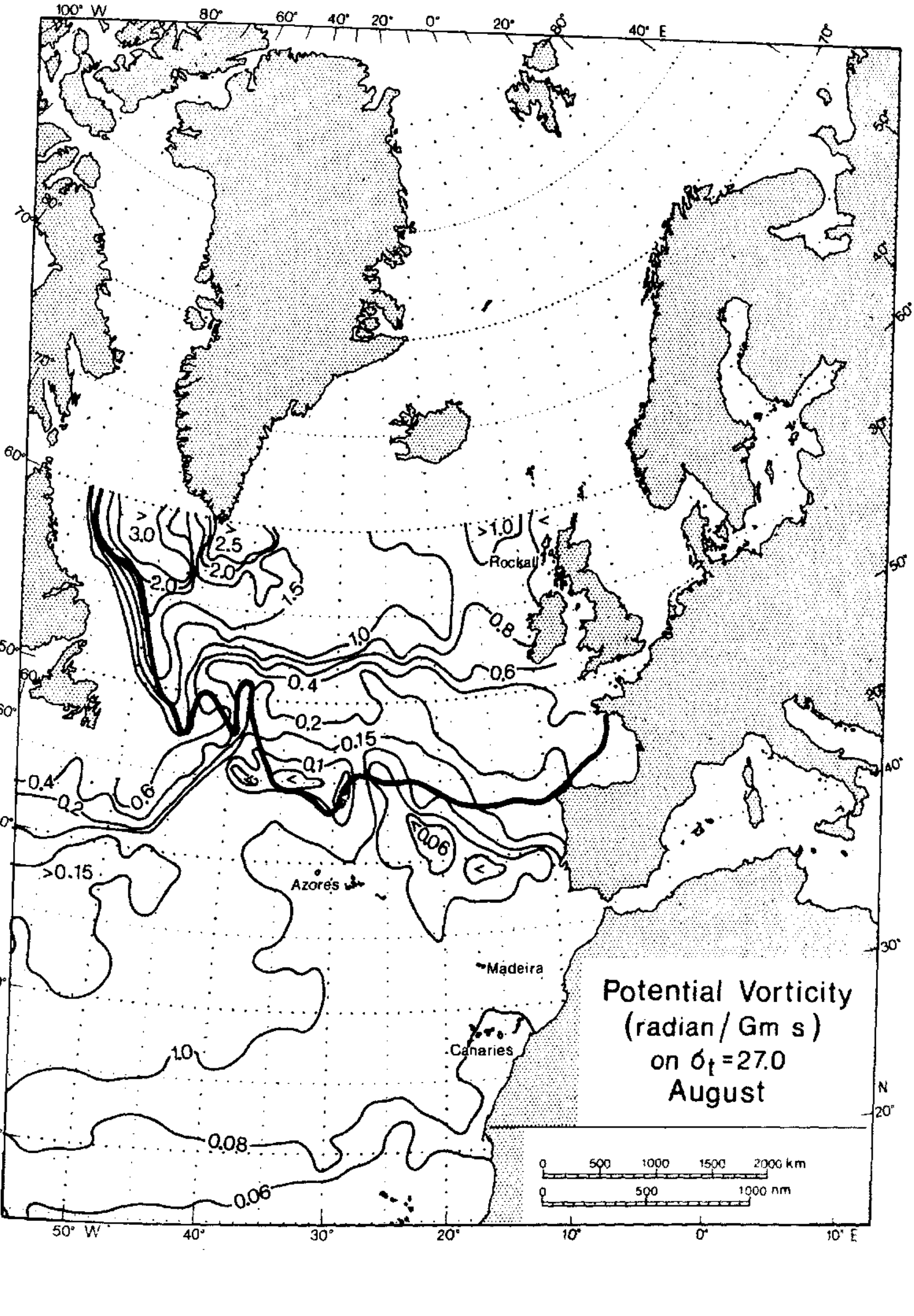

Fig. 37 August mean distribution of isopycnic potential vorticity on σ_t = 27.0 kg/m³ (from D. Stammer and J.D. Woods 1987).

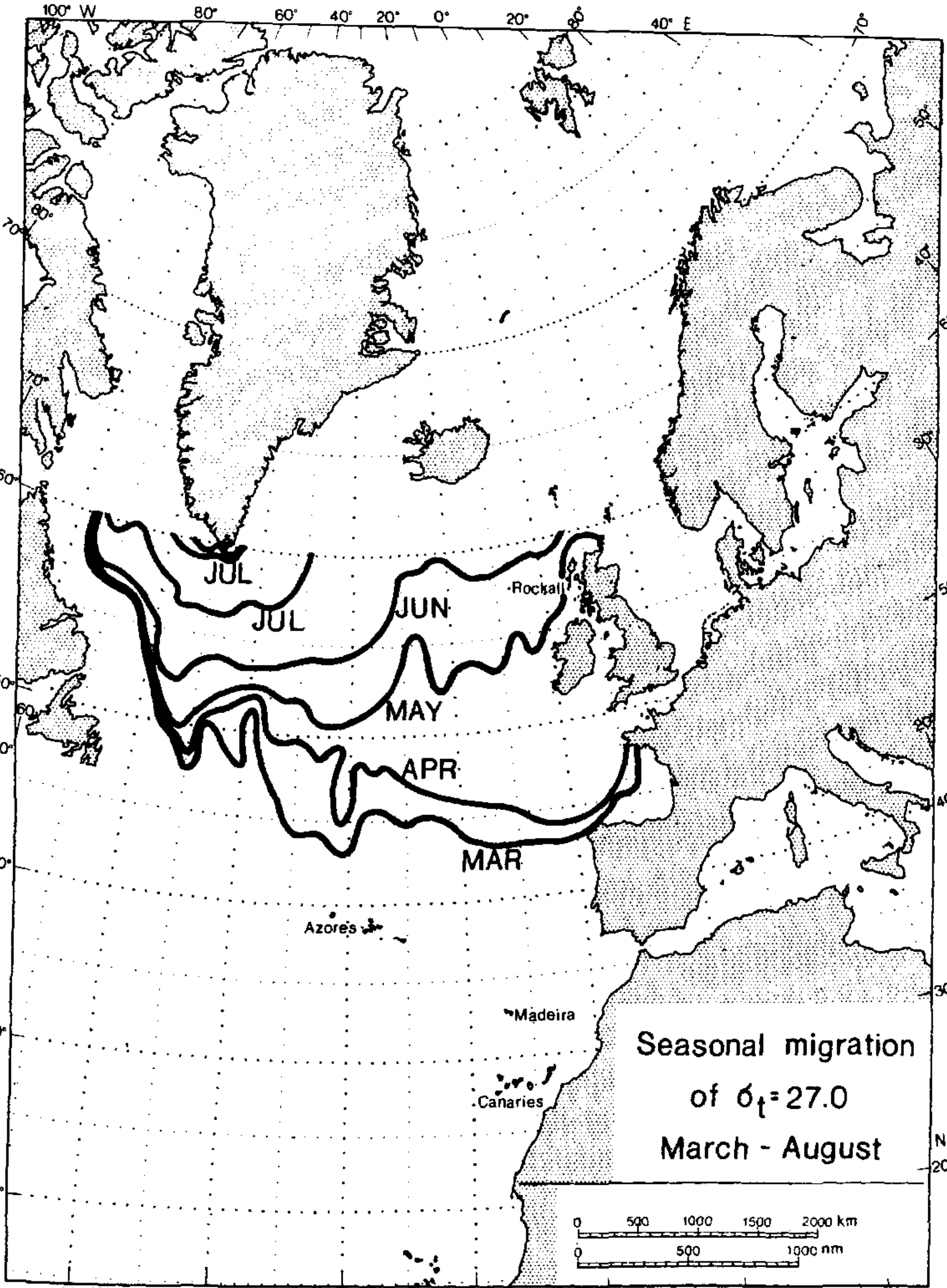

Fig. 38 Seasonal migration of the surface outcrop of the isopycnic surface σ_t = 27.0 kg/m³ (from D. Stammer & J.D. Woods 1987).

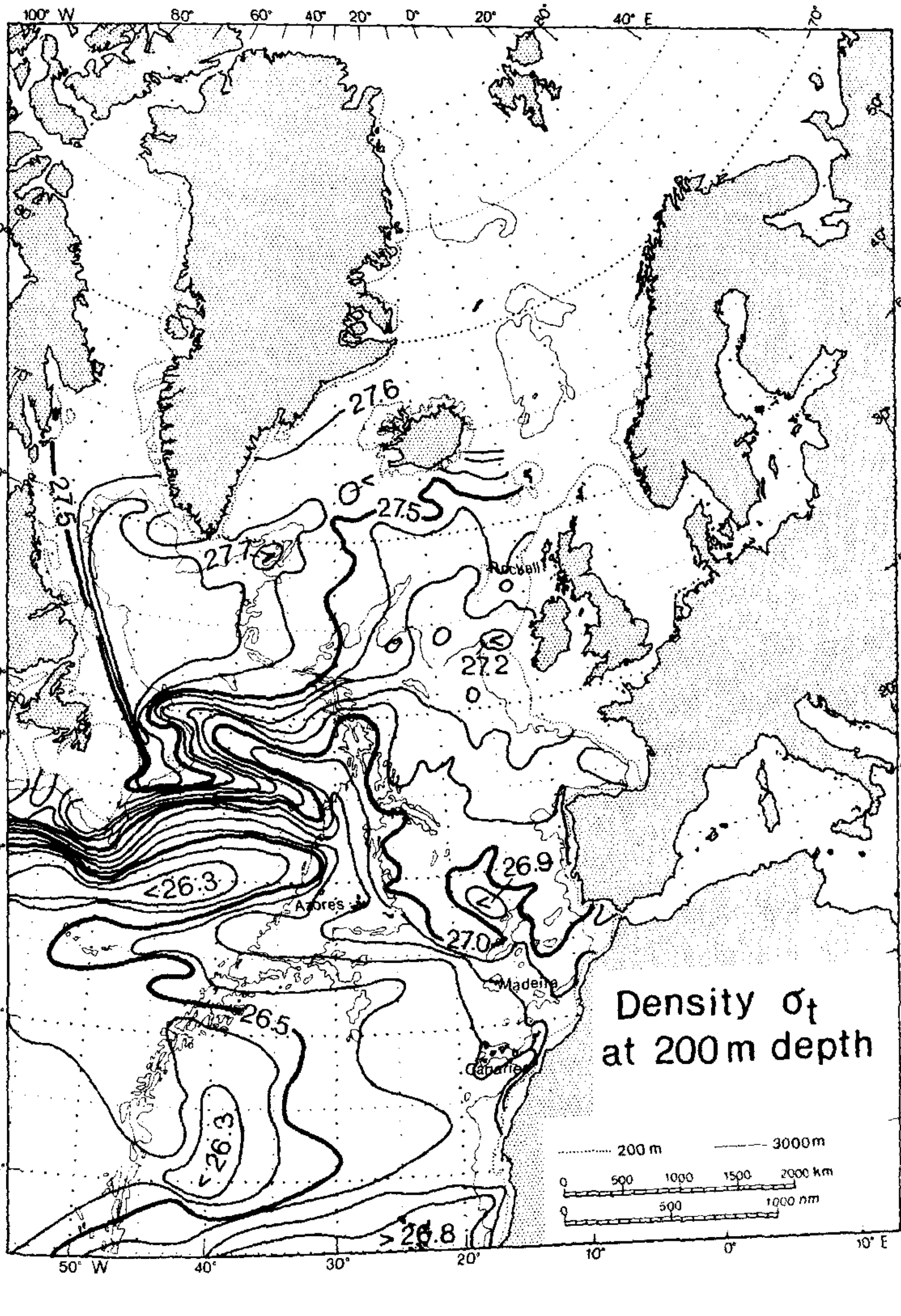

Fig. 39 Density at a depth of 200 metres (from G. Wüst 1936).