

International Telecommunication Union

ITU-R
Radiocommunication Sector of ITU

Recommendation ITU-R P.832-3
(02/2012)

World atlas of ground conductivities

P Series
Radiowave propagation



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Foreword

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The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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Series of ITU-R Recommendations

(Also available online at <http://www.itu.int/publ/R-REC/en>)

Series	Title
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
BT	Broadcasting service (television)
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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RECOMMENDATION ITU-R P.832-3

World atlas of ground conductivities

(1992-1997-1999-2012)

The ITU Radiocommunication Assembly,

considering

- a) that for ground-wave field strength prediction, it is essential to know the electrical characteristics of the ground along the path. In cases involving coordination between administrations, it is therefore often necessary to know the ground characteristics existing outside national boundaries;
- b) that the most important electrical characteristic of the earth for frequencies below 3 MHz is the conductivity;
- c) that there is a need for suitable conductivity charts when planning all types of radiocommunication, including navigational services, in the VLF, LF and MF bands;
- d) that conductivity maps are not yet available from all administrations;
- e) that long range navigation systems use the phase information of the ground wave, paths often cross several countries, and that it is important to have reliable conductivity information along the whole path;
- f) that it is of importance to keep accurate information on secondary phase conditions, which again depend on conductivity,

recommends

- 1** that the information contained in Annex 1, which is a World Atlas of Ground Conductivities, be used to obtain the best estimate of conductivity for planning purposes;
- 2** that in presenting new or revised conductivity maps for updating the Atlas, standard values be used as indicated in Table 1.

Annex 1**World Atlas of Ground Conductivities****1 Introduction**

This Annex gives information about the ground conductivities in various areas of the world, in the form of a World Atlas of Ground Conductivities. This information is intended to be used for field-strength predictions in connection with the ground-wave propagation curves contained in Recommendation ITU-R P.368.

2 Preparation of conductivity maps

In its work on the World Atlas, the ITU-R needs information from every administration. Conductivity maps have been presented in different ways, but in future it would be helpful if they were presented with the same standard set of values of conductivity as indicated in Recommendation ITU-R P.368 and as shown in Table 1.

TABLE 1
Standard values and ranges of ground conductivity
for the presentation of the maps

Standard values (S/m)	Limiting values of the range (S/m)	
	Upper limit	Lower limit
5	7	3
3×10^{-2}	5.5×10^{-2}	1.7×10^{-2}
10^{-2}	1.7×10^{-2}	5.5×10^{-3}
3×10^{-3}	5.5×10^{-3}	1.7×10^{-3}
10^{-3}	1.7×10^{-3}	5.5×10^{-4}
3×10^{-4}	5.5×10^{-4}	1.7×10^{-4}
10^{-4}	1.7×10^{-4}	5.5×10^{-5}
3×10^{-5}	5.5×10^{-5}	1.7×10^{-5}
10^{-5}	1.7×10^{-5}	5.5×10^{-6}

3 The Atlas

The contents of the Atlas are as follows:

Figs. 1-6: VLF conductivity maps

Figs. 7-43: MF conductivity maps

3.1 The conductivity maps for the VLF part of the spectrum (Figs. 1 to 6) give values of effective ground conductivity in mS/m and are subject to the following conditions:

- they are limited in application to frequencies up to 30 kHz,
- they contain no allowance for seasonal variations,
- they have been calculated from physiographical and geological data used to define boundaries of the land areas of given conductivity, together with actual conductivity data derived from measurements,
- they represent effective ground conductivities (the effect of terrain is included in the values),
- as it seems likely that seasonal variations will become more important with increasing frequency (as the penetration depth decreases), maps for higher frequencies may need to be presented in such a way that the annual variations are shown. However, data recorded by the Administration of India indicate that at frequencies as high as 1 MHz seasonal variations in the tropics have a negligible influence on propagation.

3.2 The maps for MF, Figs. 7 to 42 and Table 2, give the effective ground conductivities in mS/m. (The maps are standardized to 1 MHz.) These maps are based on measurements and other relevant information provided by the various countries. They contain no allowance for seasonal variations.

3.3 For those areas for which results of conductivity measurements are not available, provisional information for MF use is shown in Fig. 43. It is expected that this information will be superseded by later editions of the World Atlas to be published by the ITU.

3.4 The conductivities on the MF maps are shown as presented by administrations. For those countries not represented in the Atlas, no information has been made available.

4 Future revision of the Atlas

4.1 Administrations are asked to check and, if necessary, revise the information given in this Atlas.

4.2 Administrations are asked to adjust areas of given conductivity so that each conductivity is one of the standard values given in Table 1.

4.3 It is recognized that because of the use of different methods for measuring ground conductivity, discontinuities will occur at the borders between countries. However, administrations are requested to resolve these problems bilaterally.

MAPS OF GROUND CONDUCTIVITY

VLf maps

Fig. 1 Africa

Fig. 2 Asia

Fig. 3 North America

Fig. 4 South America

Fig. 5 Australia

Fig. 6 Europe

MF maps

Fig. 7 Germany (Federal Republic of) – Western part

Fig. 8 Austria

Fig. 9 Belgium

Fig. 10 Denmark

Fig. 11 Spain

Fig. 12 Finland

Fig. 13 Greece

Fig. 14 Republic of Hungary

Fig. 15 Italy

- Fig. 16 Norway
- Fig. 17 Netherlands (Kingdom of the)
- Fig. 18 Portugal
- Fig. 19 Germany (Federal Republic of) – Eastern part
- Fig. 20 United Kingdom of Great Britain and Northern Ireland
- Fig. 21 Sweden
- Fig. 22 Armenia (Republic of), Azerbaijani Republic, Belarus (Republic of), Estonia (Republic of), Georgia, Kazakhstan (Republic of), Latvia (Republic of), Lithuania (Republic of), Moldova (Republic of), Uzbekistan (Republic of), Kyrgyz Republic, Russian Federation, Tajikistan (Republic of), Turkmenistan, Ukraine
- Fig. 23 Bosnia and Herzegovina (Republic of), Croatia (Republic of), The Former Yugoslav Republic of Macedonia, Slovenia (Republic of) and Yugoslavia (Federal Republic of)
- Fig. 24 Bangladesh (People's Republic of)
- Fig. 25 Korea (Republic of)
- Fig. 26 India (Republic of)
- Fig. 27 Iran (Islamic Republic of)
- Fig. 28 Israel (State of)
- Fig. 29 Japan
- Fig. 30 Jordan (Hashemite Kingdom of)
- Fig. 31 Thailand
- Fig. 32 Lesotho (Kingdom of), South Africa (Republic of), Swaziland (Kingdom of)
- Fig. 33 Botswana (Republic of)
- Fig. 34 Namibia (Republic of)
- Fig. 35 North America (excluding Canada)
- Fig. 35a Alaska (United States of America)
- Fig. 36 Central America
- Fig. 37 Canada
- Fig. 38 South America
- Fig. 39 Australia
- Fig. 40 New Zealand
- Fig. 41 China (People's Republic of)
- Fig. 42 Nigeria (Federal Republic of)
- Fig. 43 Provisional MF conductivity map for land areas

NOTE 1 – The denomination of a country or of a territory on these maps, as well as the tracing of any borders, do not imply, on the part of the ITU, any position with respect to the political status of such a country or territory, or official recognition of these borders.

FIGURE 1
Africa

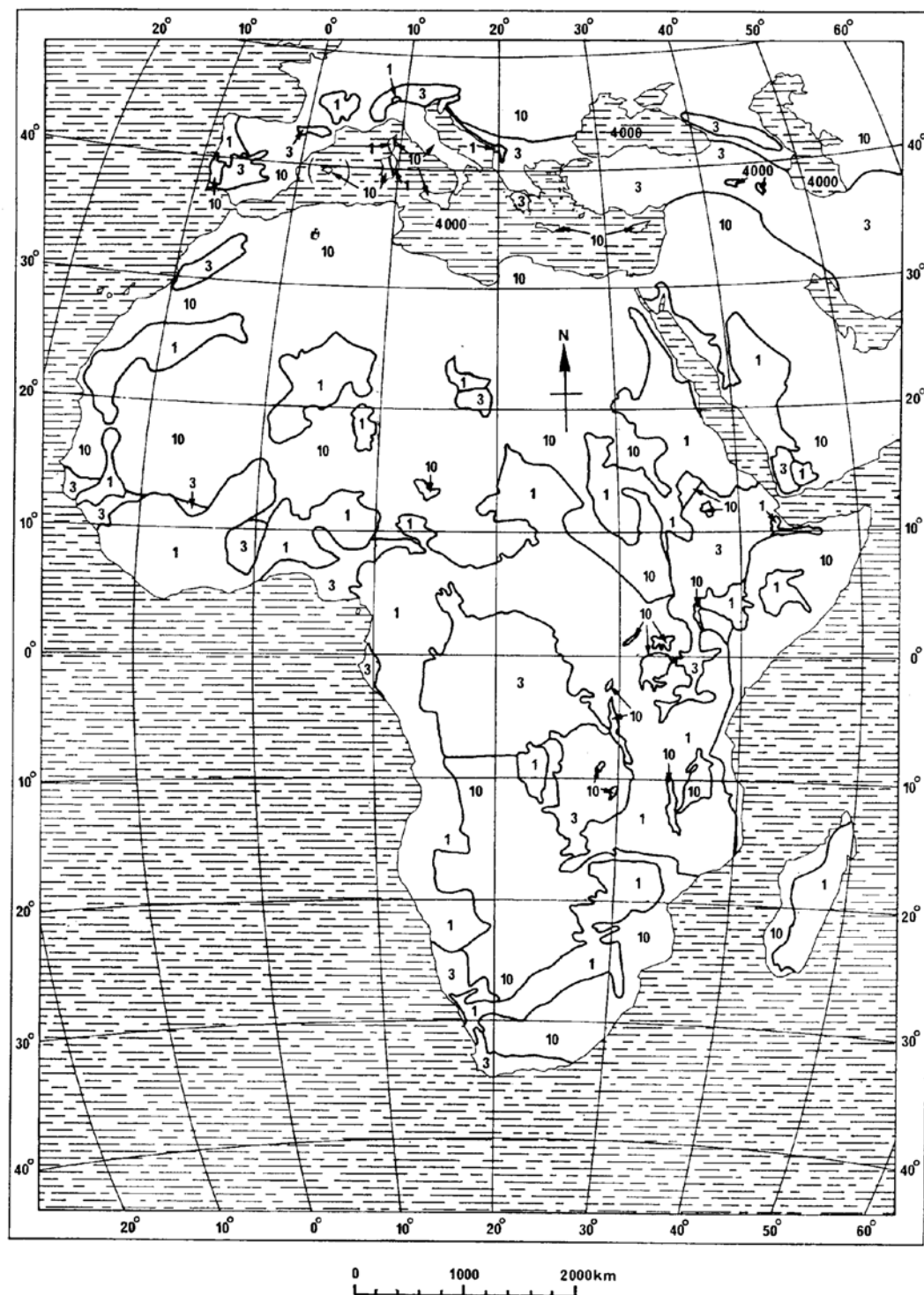


FIGURE 2

Asia

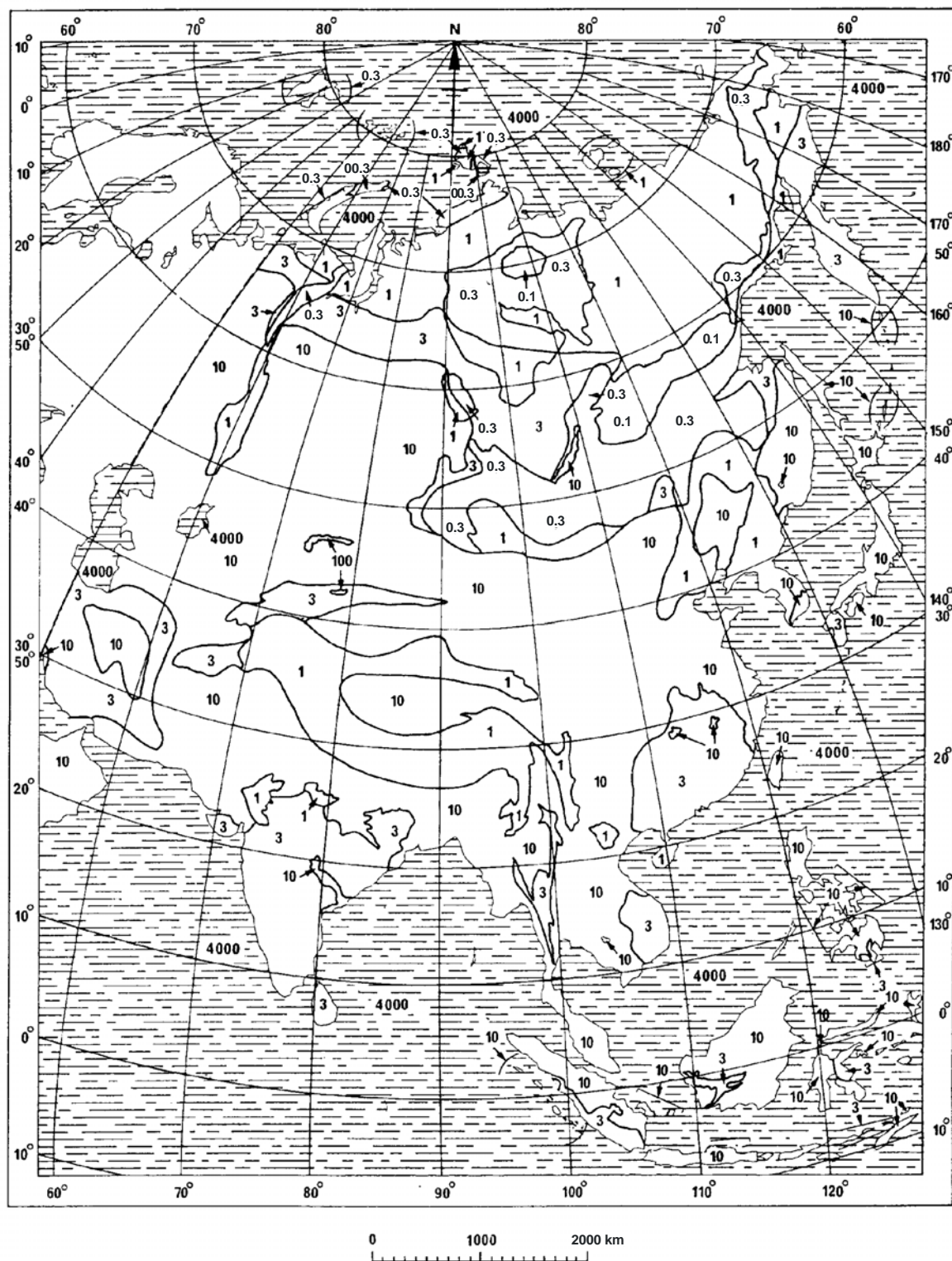


FIGURE 3
North America

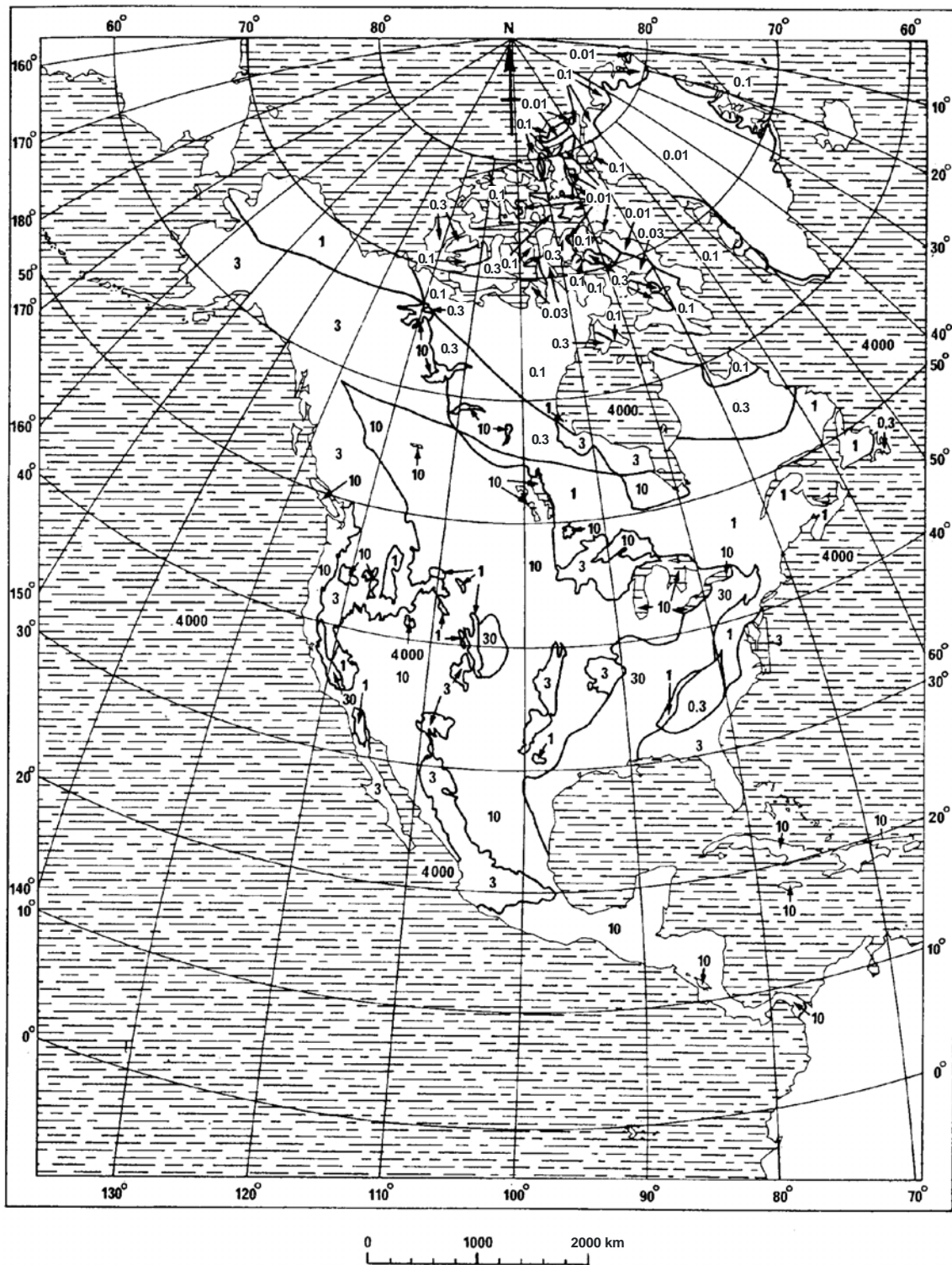


FIGURE 4
South America

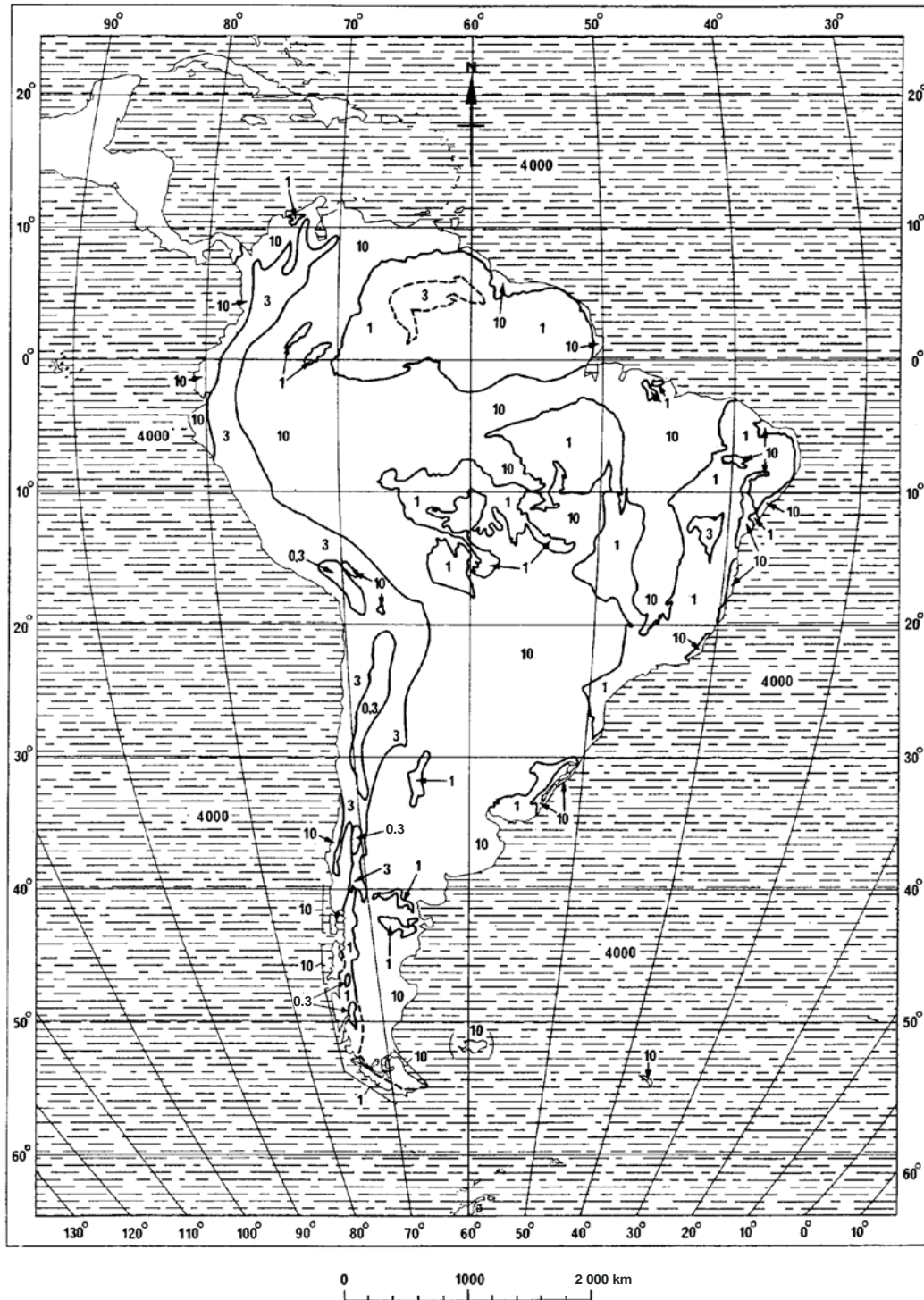
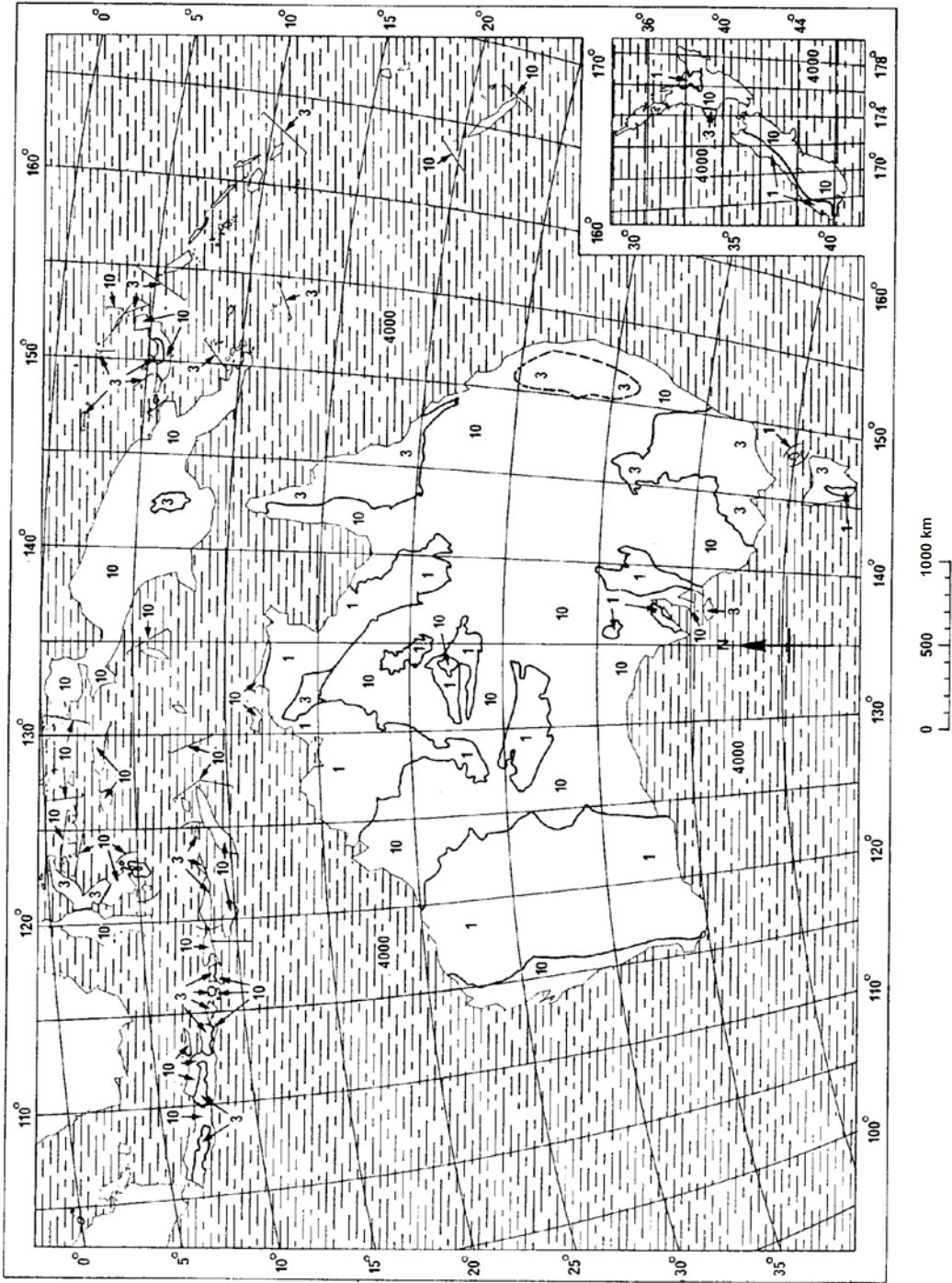


FIGURE 5
Australia



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FIGURE 6

Europe

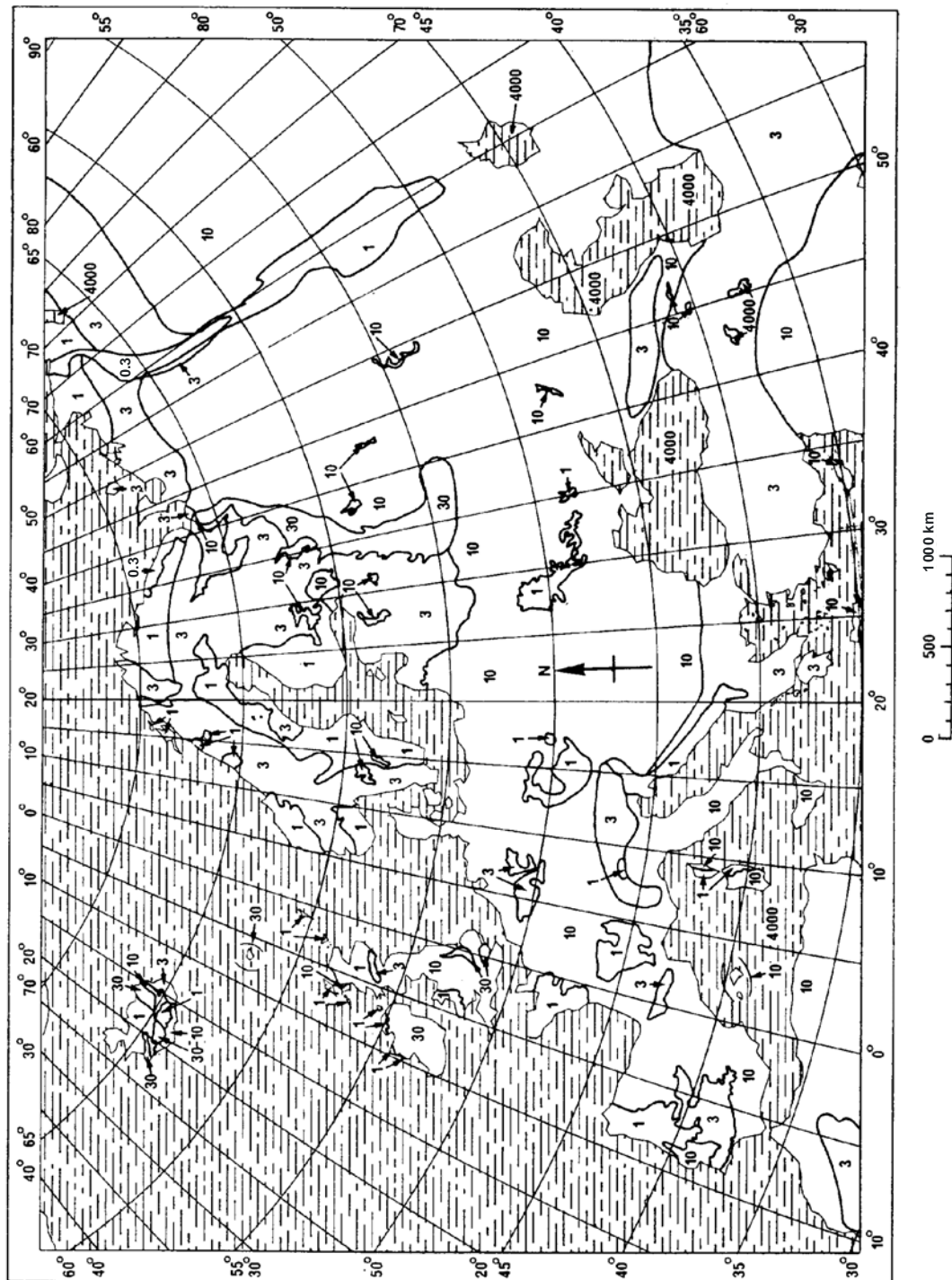
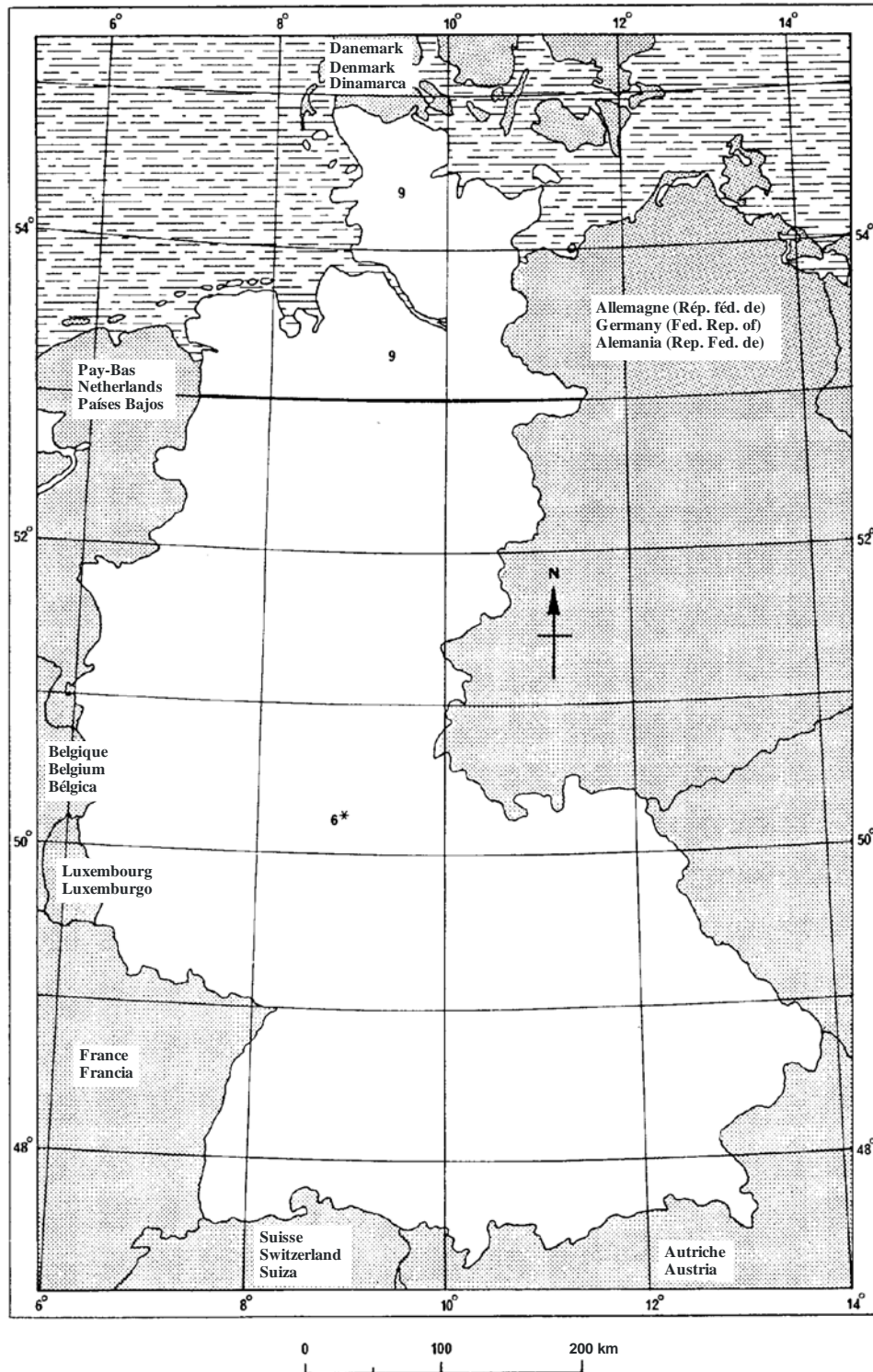


FIGURE 7
Germany (Federal Republic of) – Western part



* In particularly mountainous regions, well below 1mS/m.

FIGURE 8

Austria

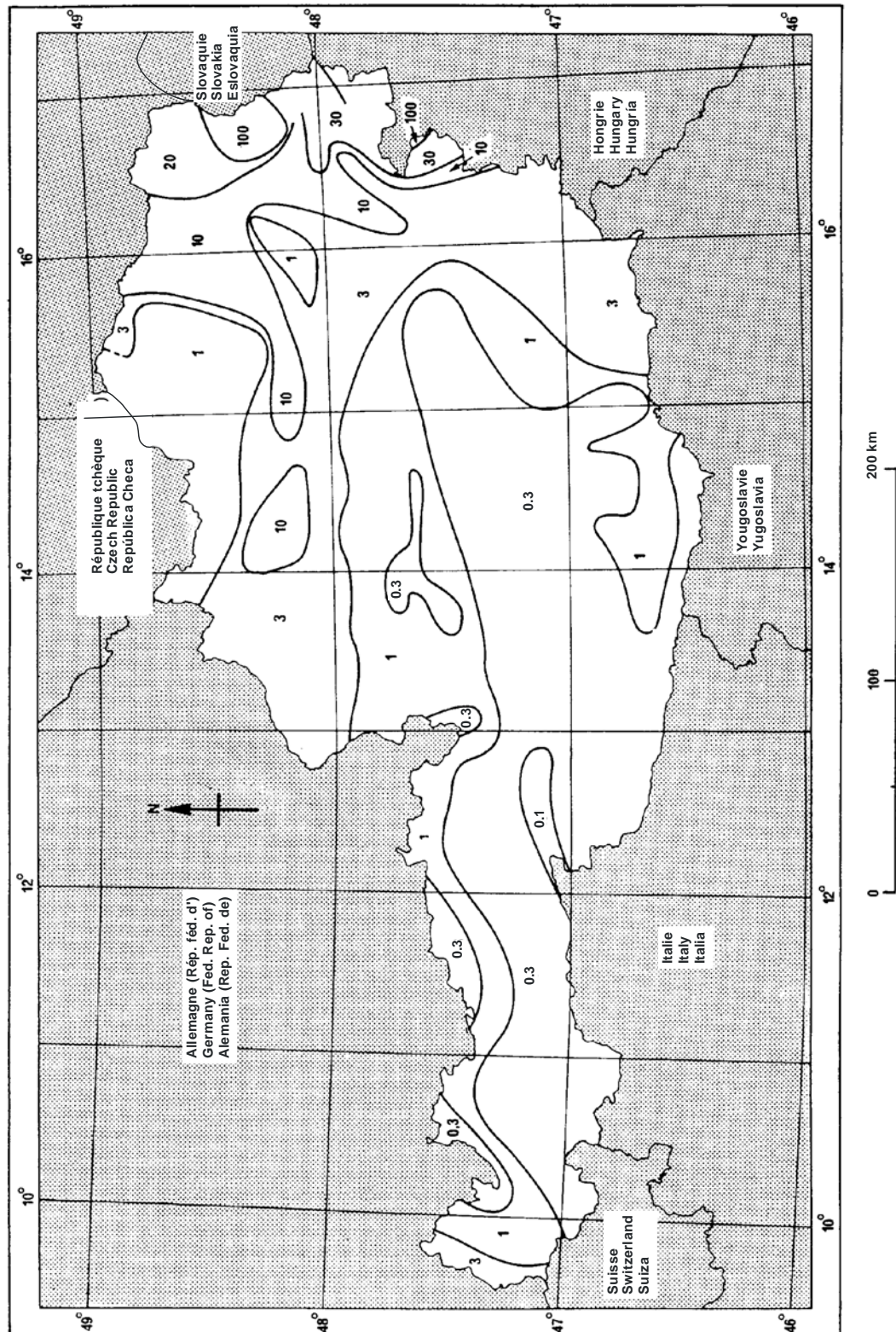


FIGURE 9
Belgium

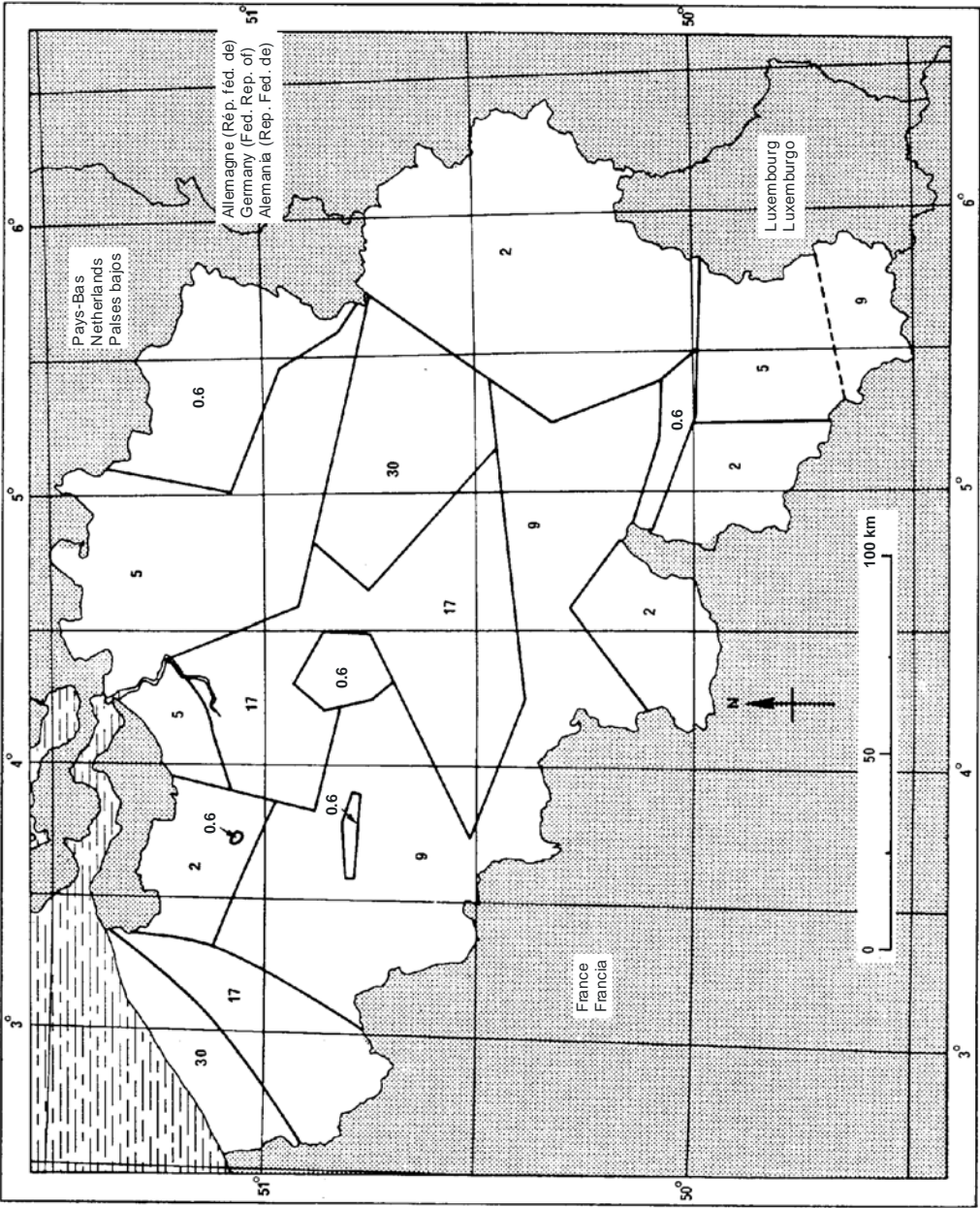


FIGURE 10
Denmark

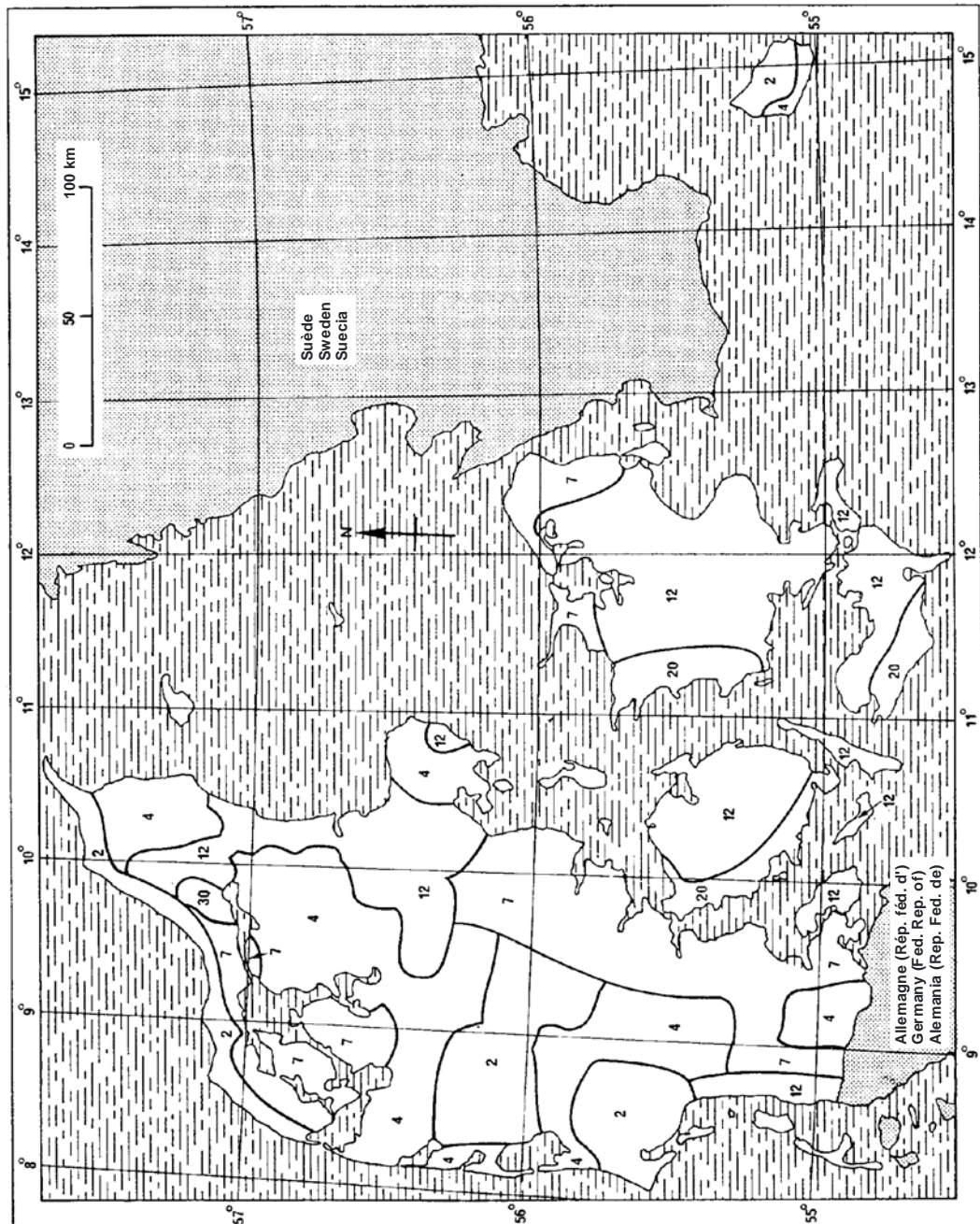
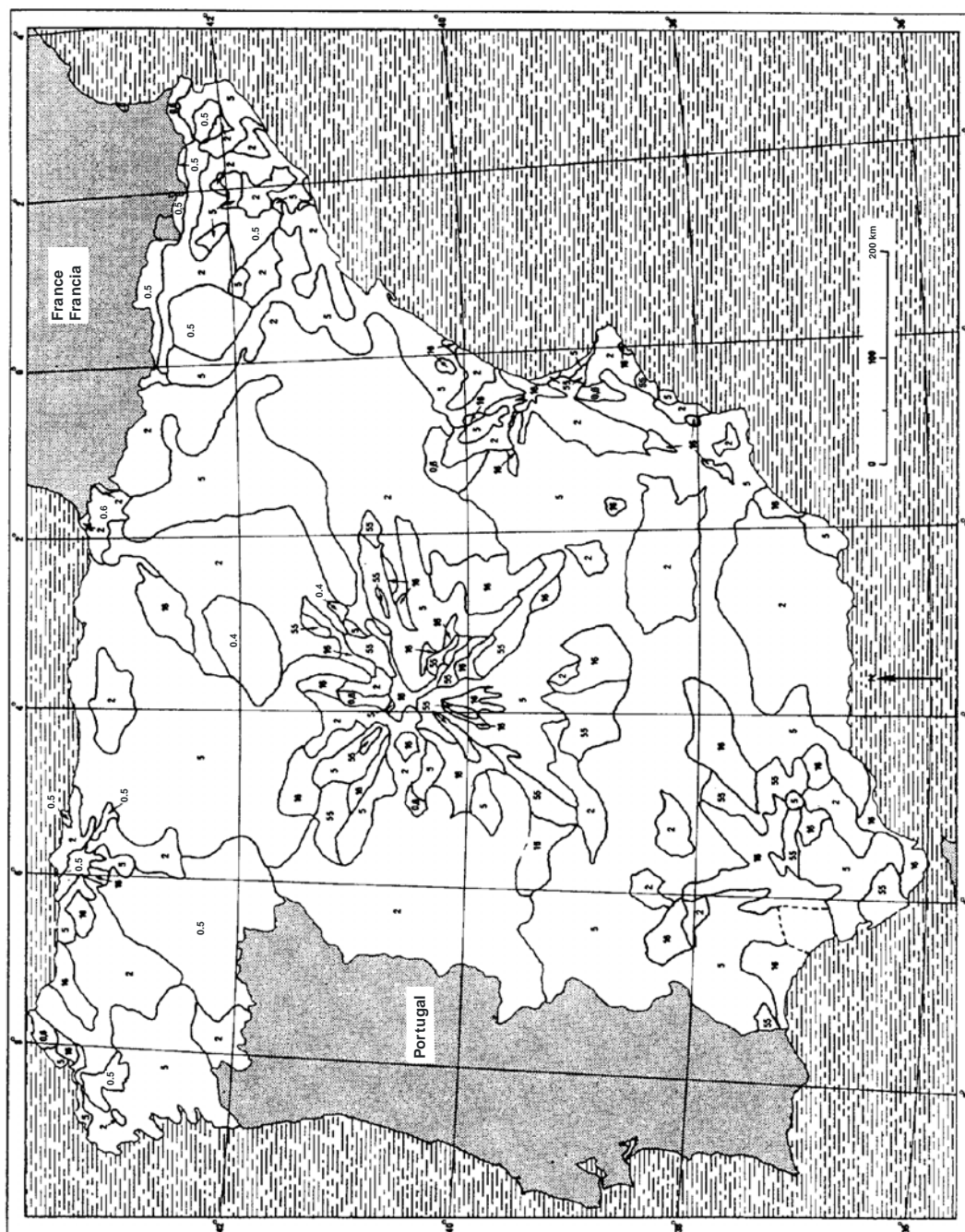


FIGURE 11

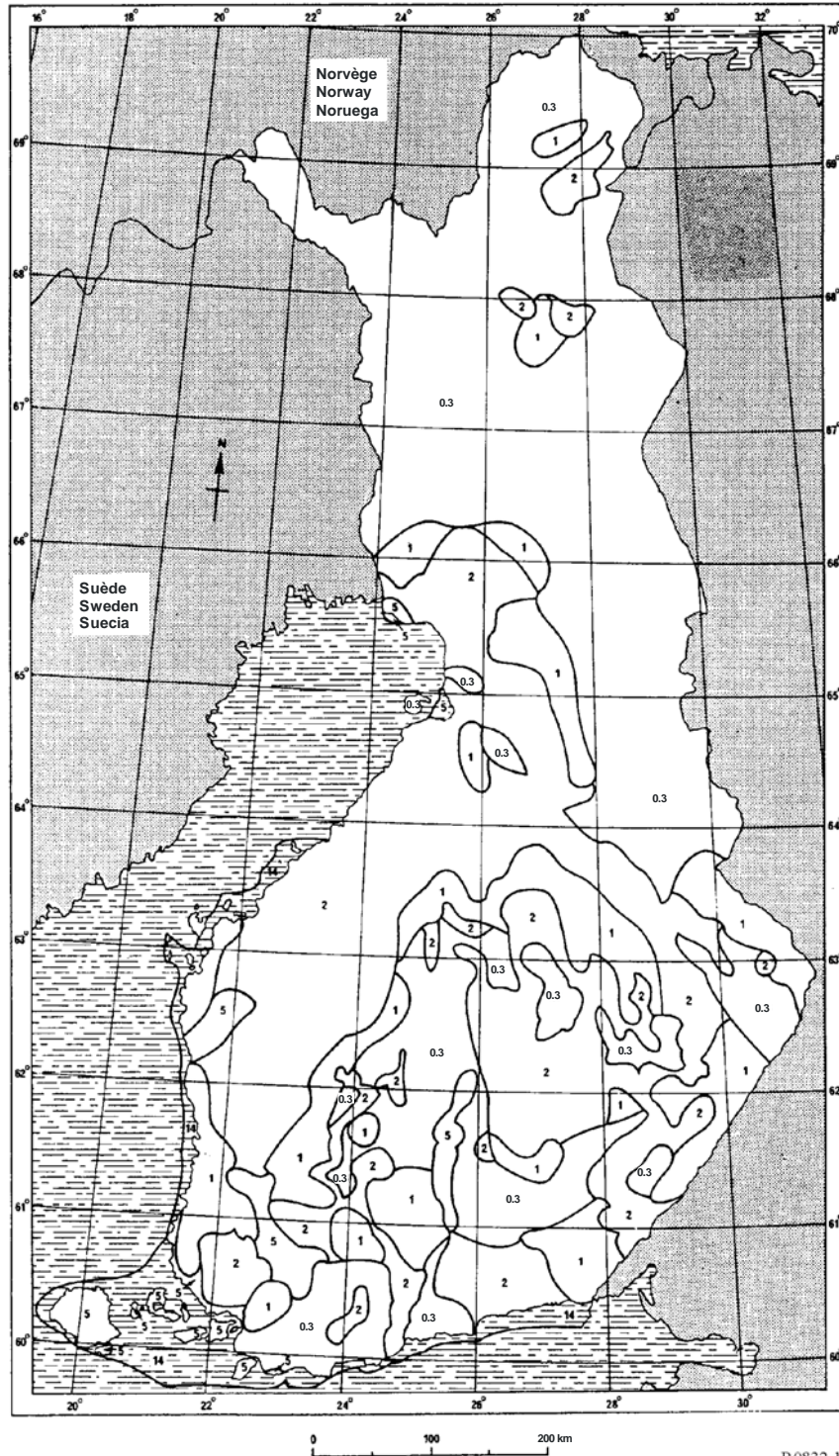
Spain



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FIGURE 12

Finland



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FIGURE 13
Greece

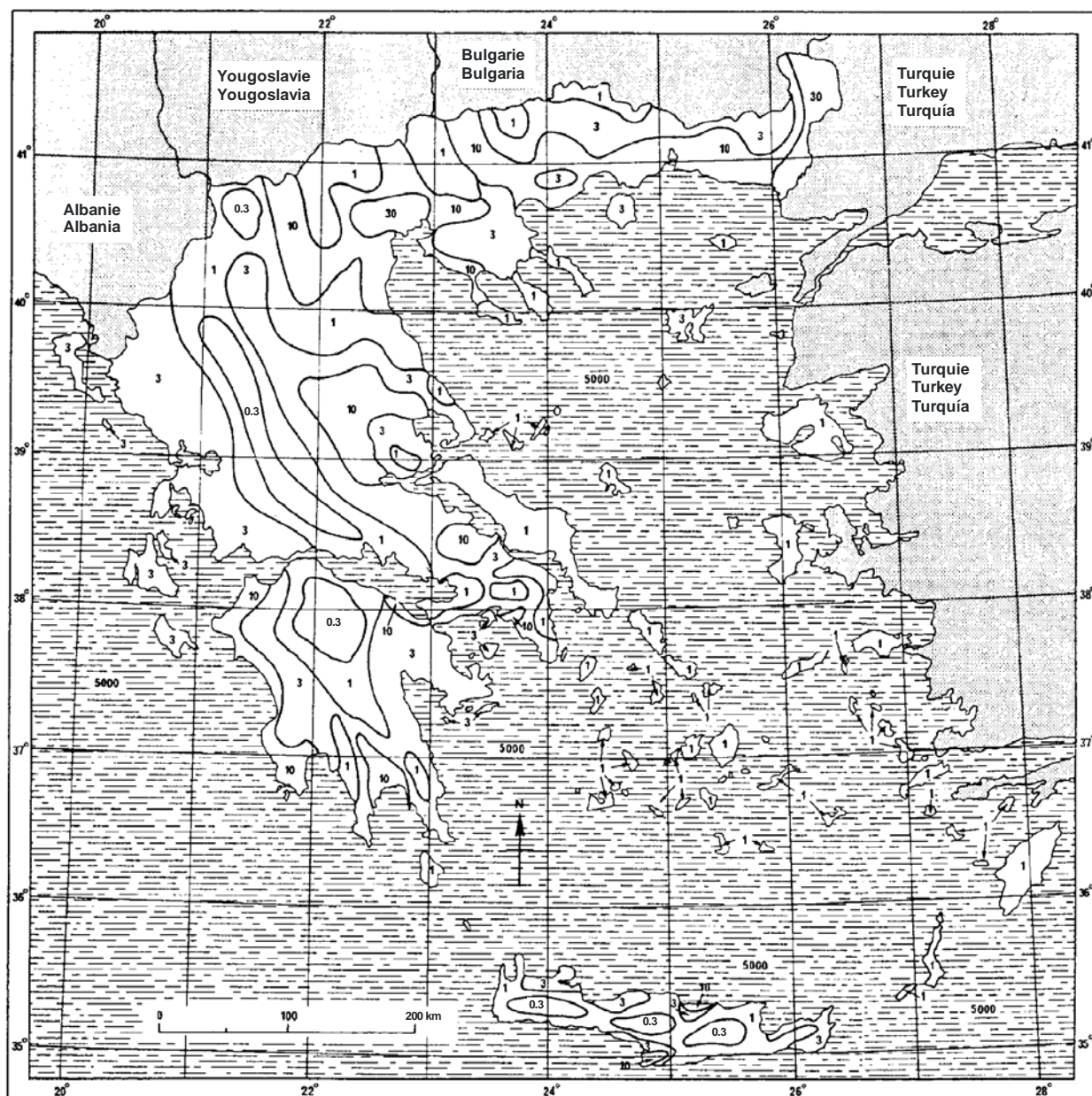
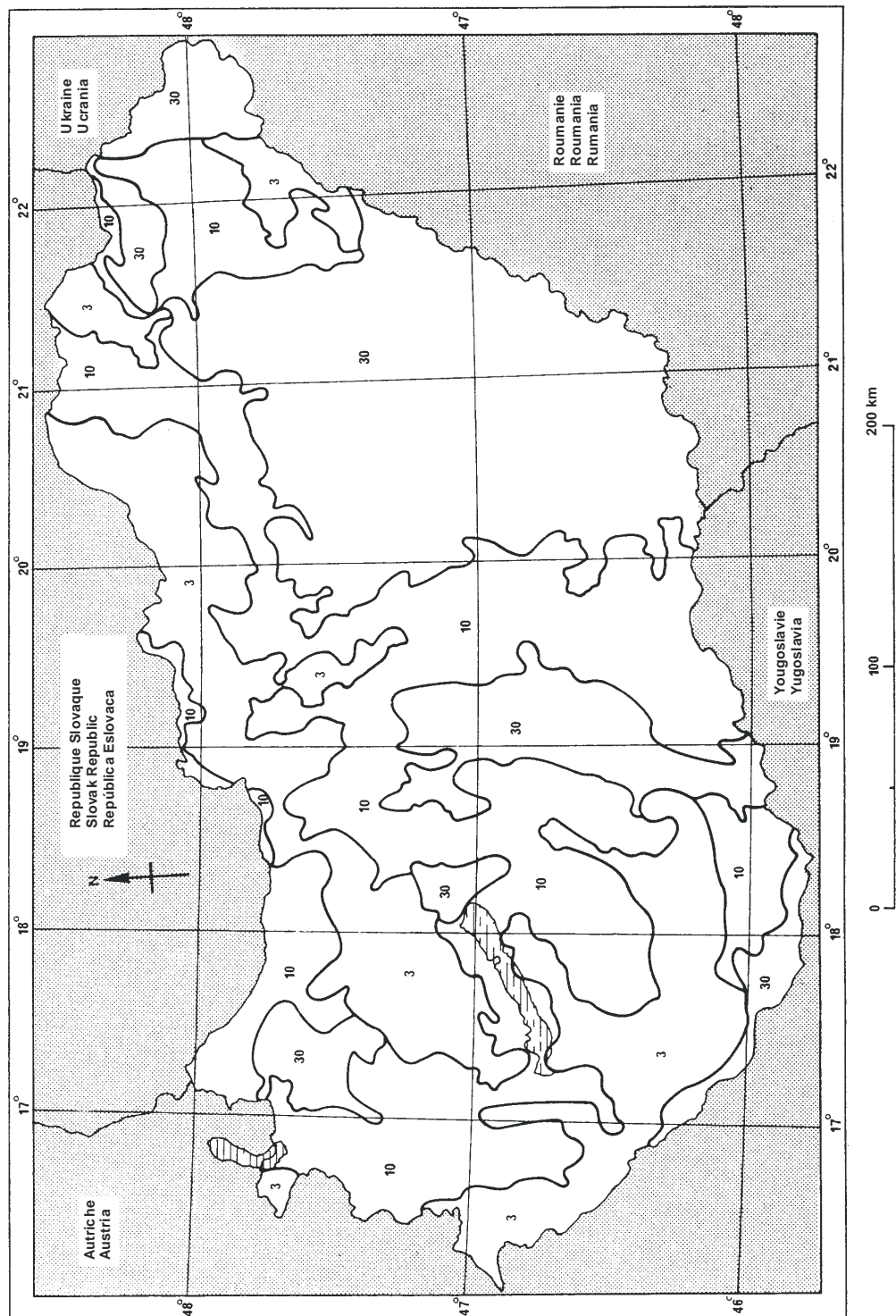


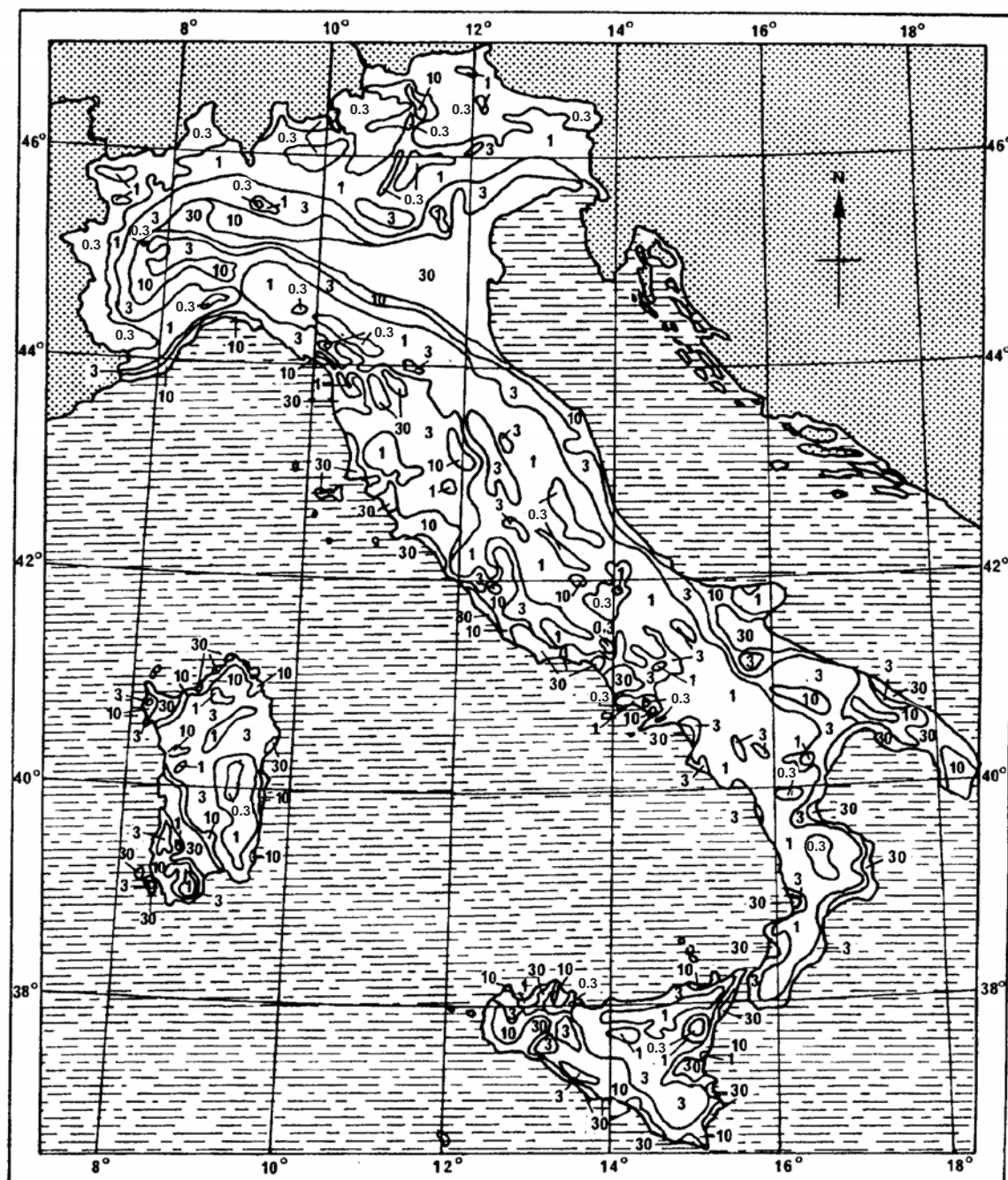
FIGURE 14
Hungary (Republic of)



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FIGURE 15

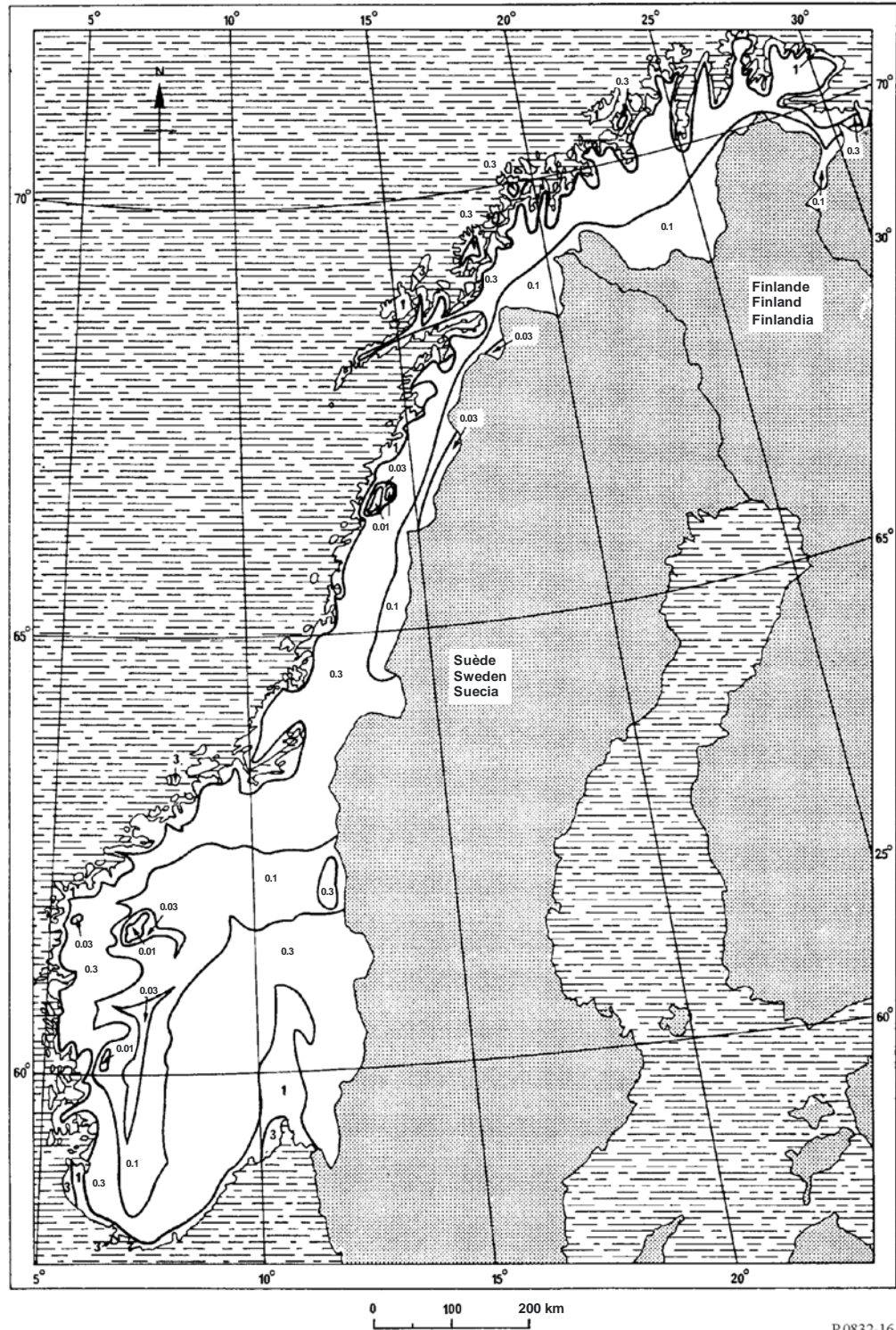
Italy



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FIGURE 16

Norway



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FIGURE 17
Netherlands (Kingdom of the)

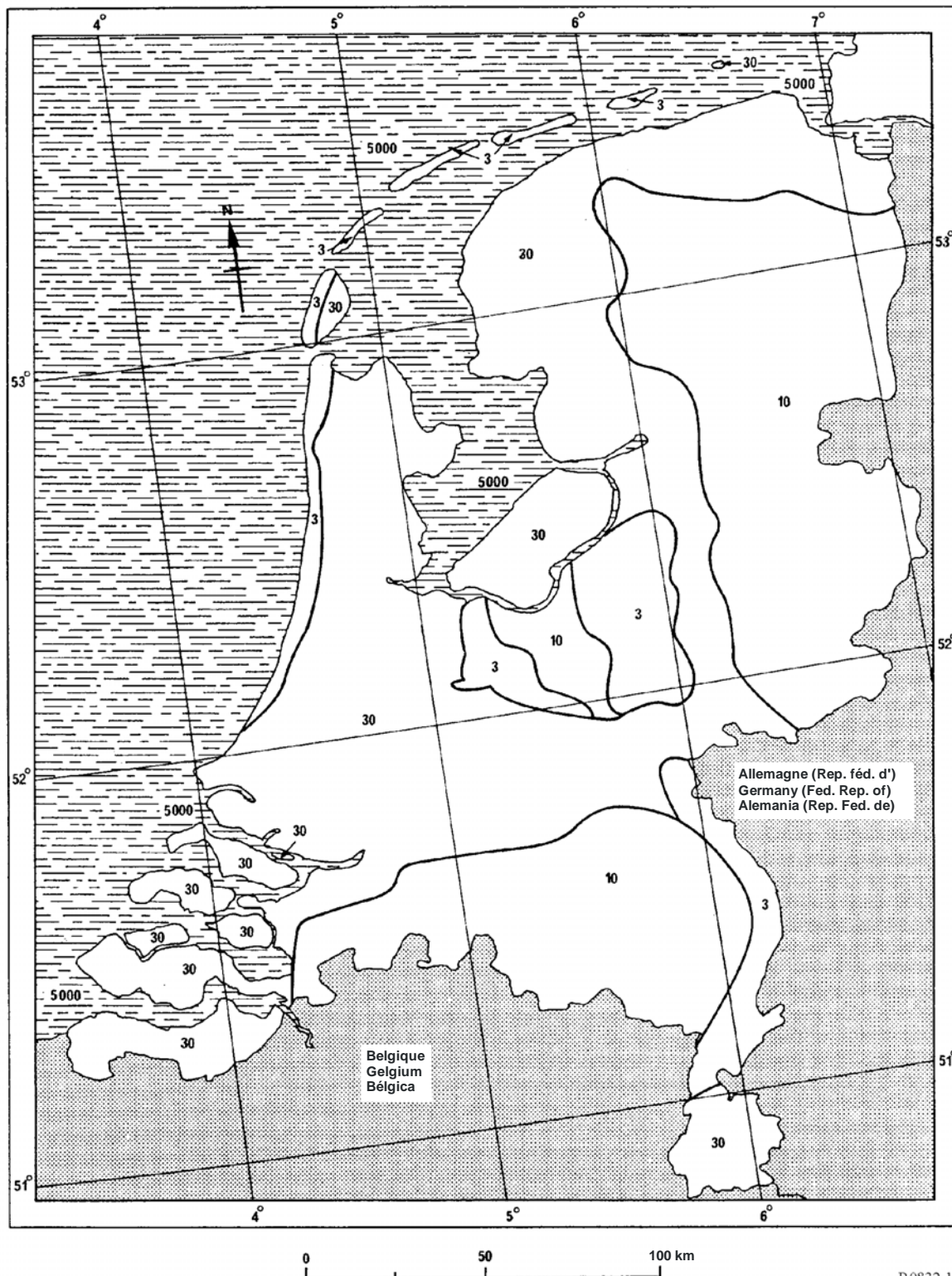
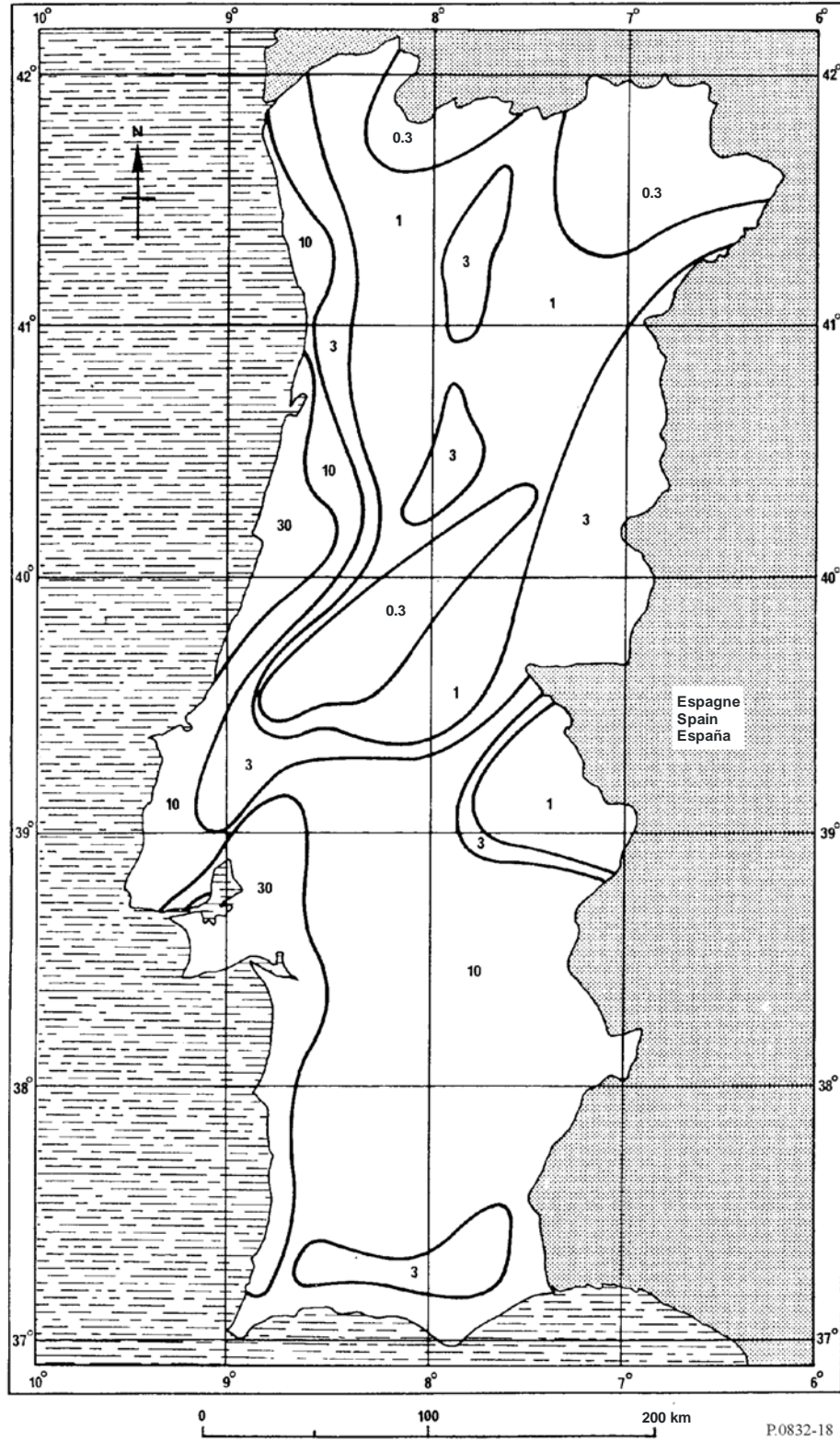
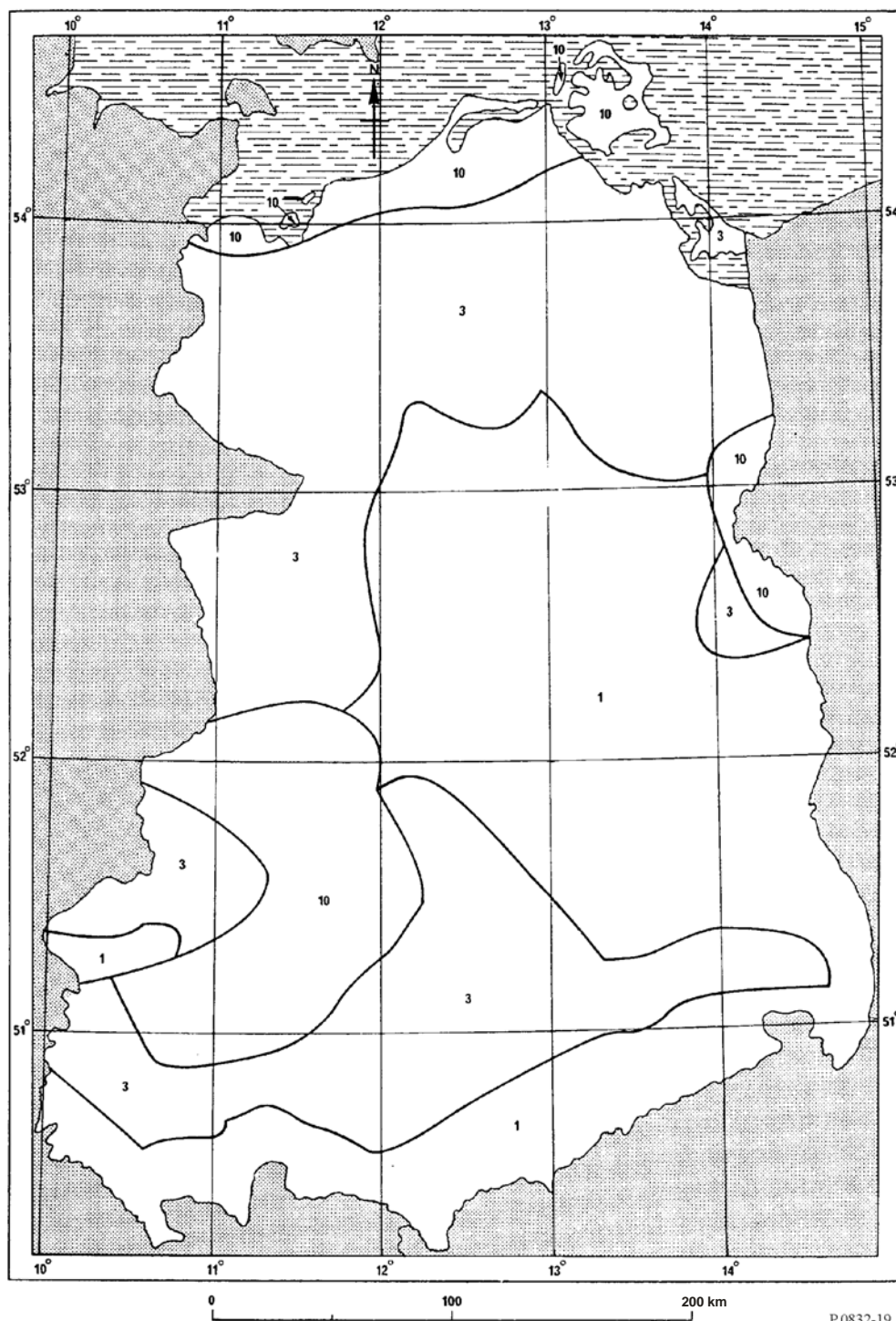


FIGURE 18
Portugal



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FIGURE 19
Germany (Federal Republic of) – Eastern part



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FIGURE 21

Sweden

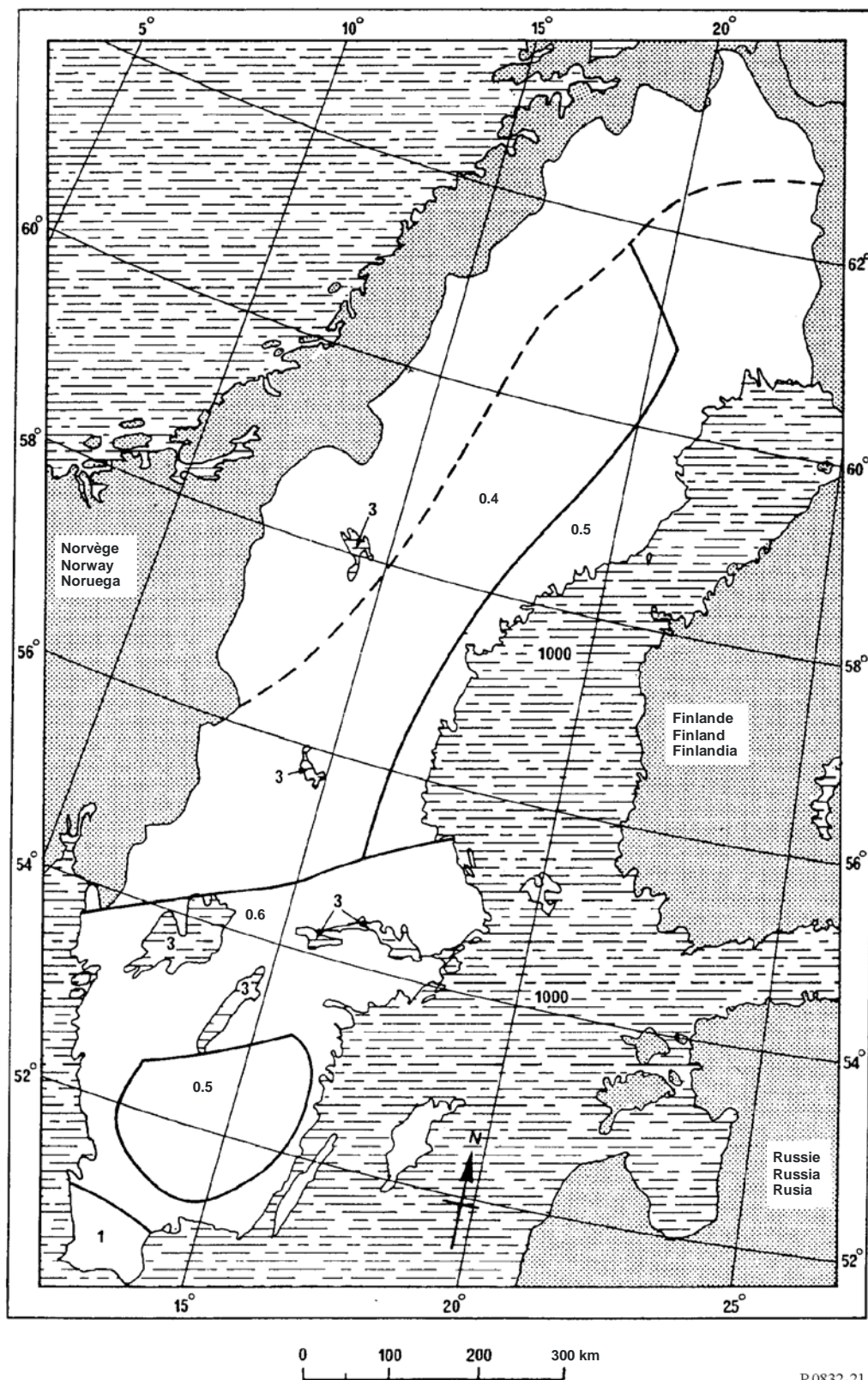
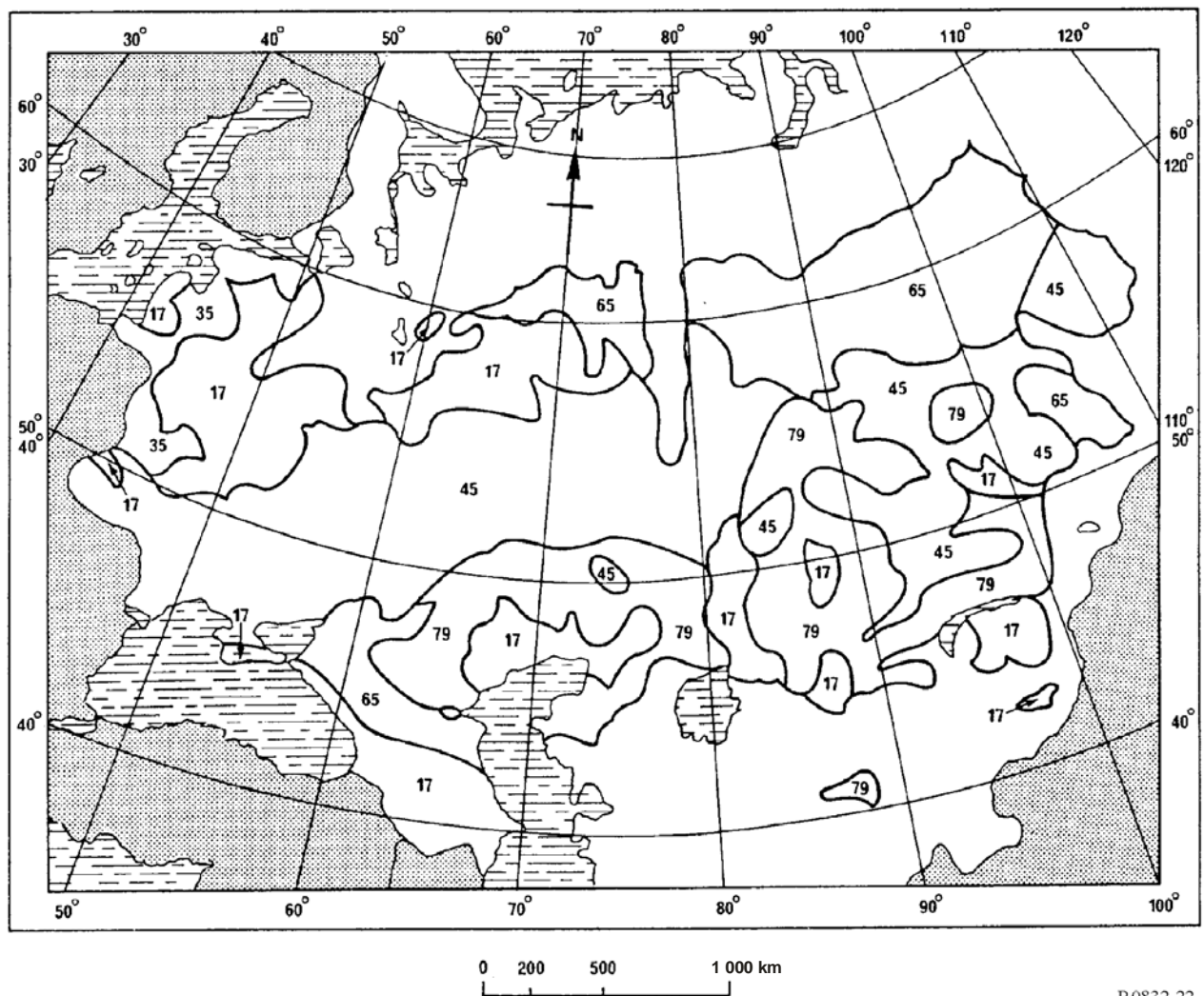


FIGURE 22

Armenia (Republic of), Azerbaijani Republic, Belarus (Republic of), Estonia (Republic of), Georgia,
Kazakstan (Republic of), Latvia (Republic of), Lithuania (Republic of), Moldova (Republic of),
Uzbekistan (Republic of), Kyrgyz Republic, Russian Federation,
Tajikistan (Republic of), Turkmenistan, Ukraine



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FIGURE 23

Bosnia and Herzegovina (Republic of), Croatia (Republic of), The Former Yugoslav Republic of Macedonia,
Slovenia (Republic of) and Yugoslavia (Federal Republic of)

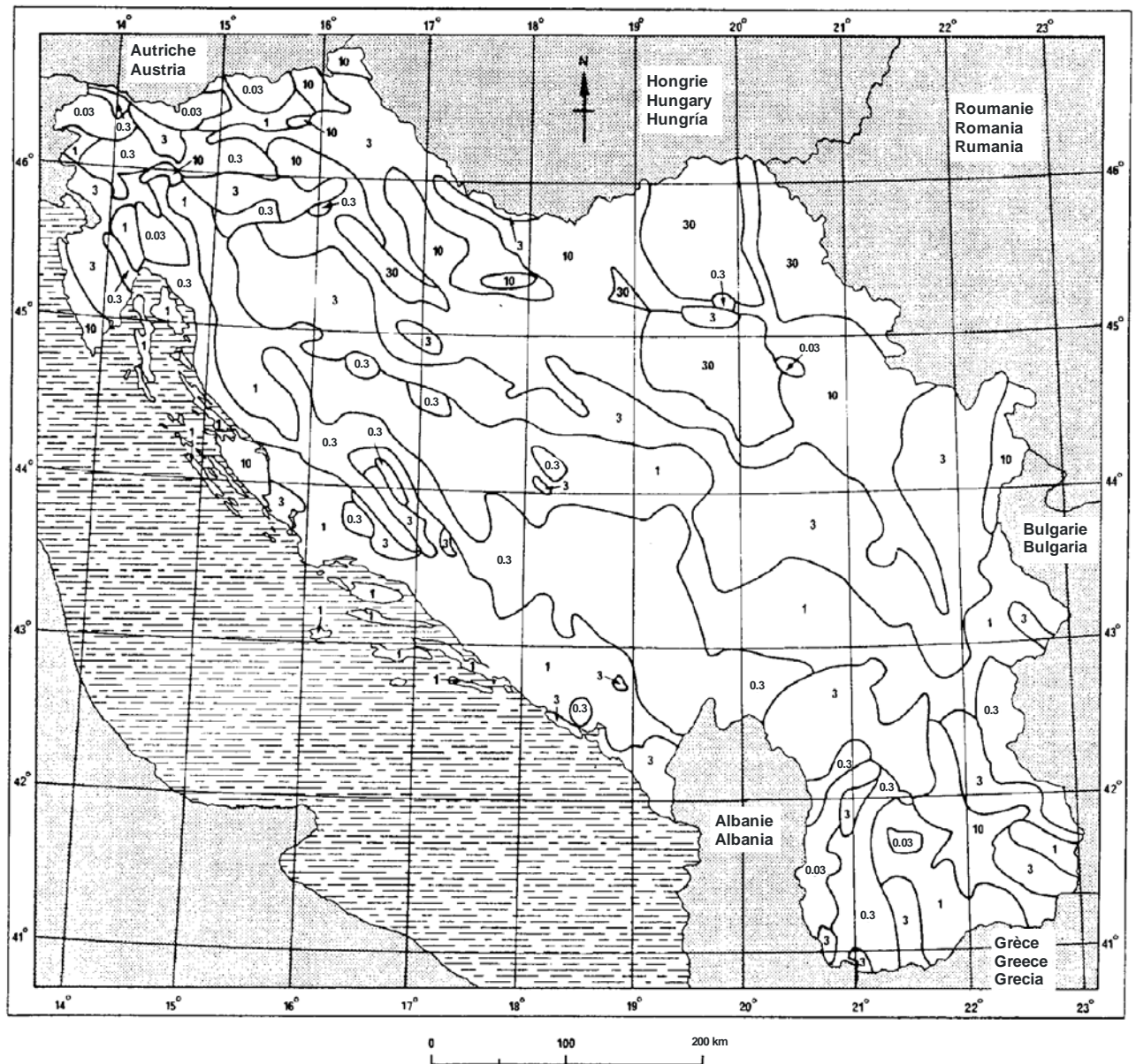


FIGURE 24
Bangladesh (People's Republic of)

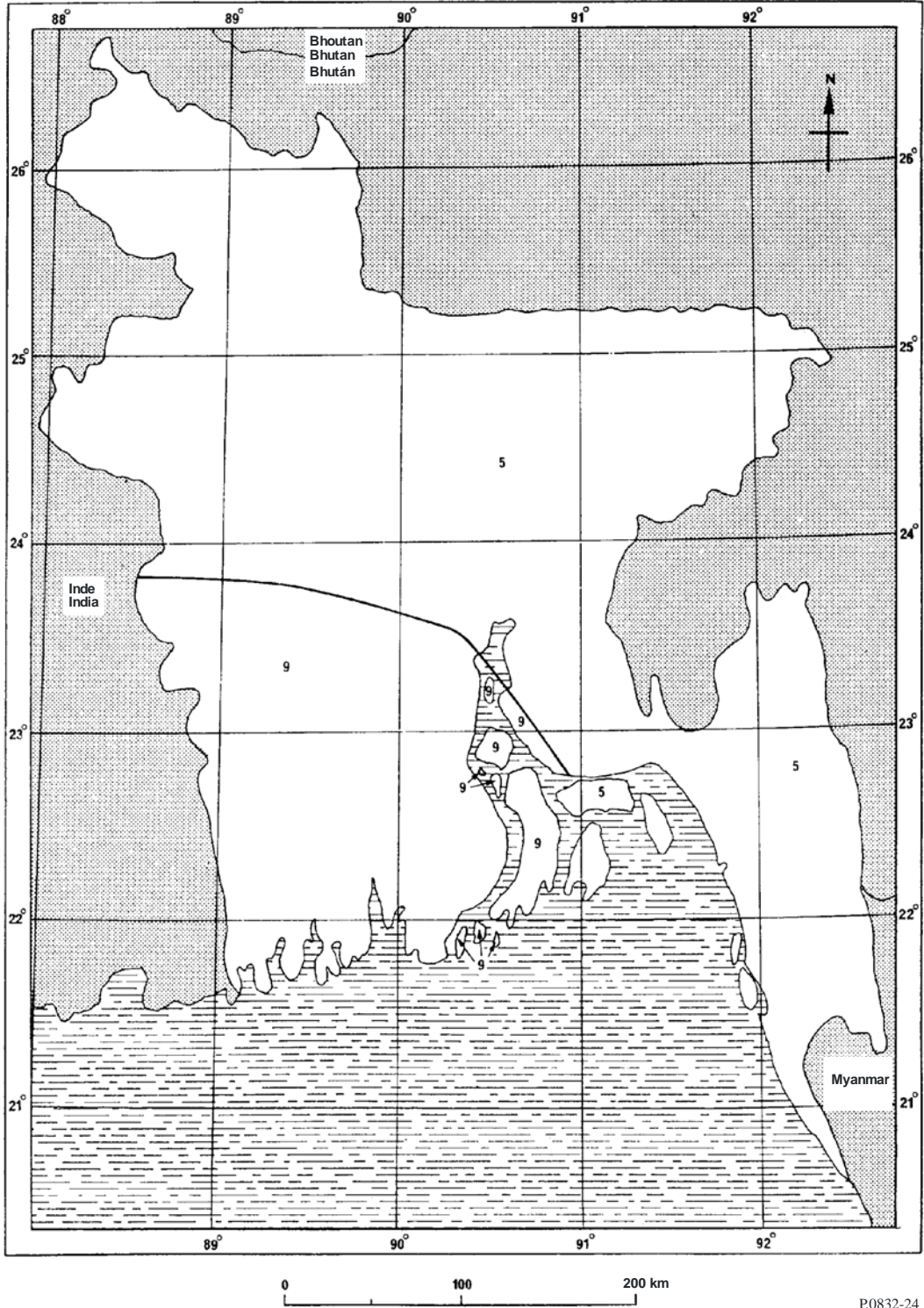


FIGURE 25
Korea (Republic of)

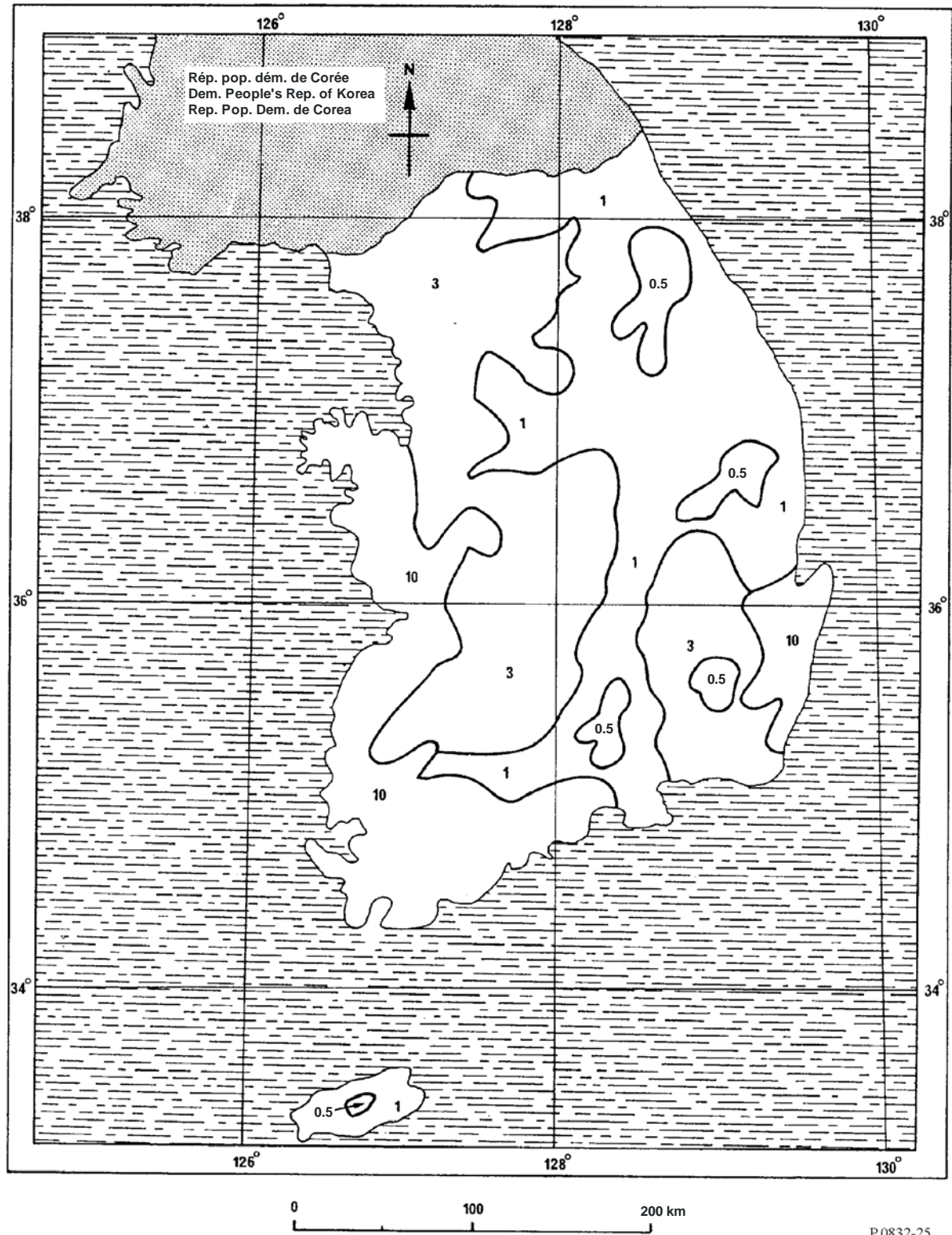


FIGURE 26
India (Republic of)

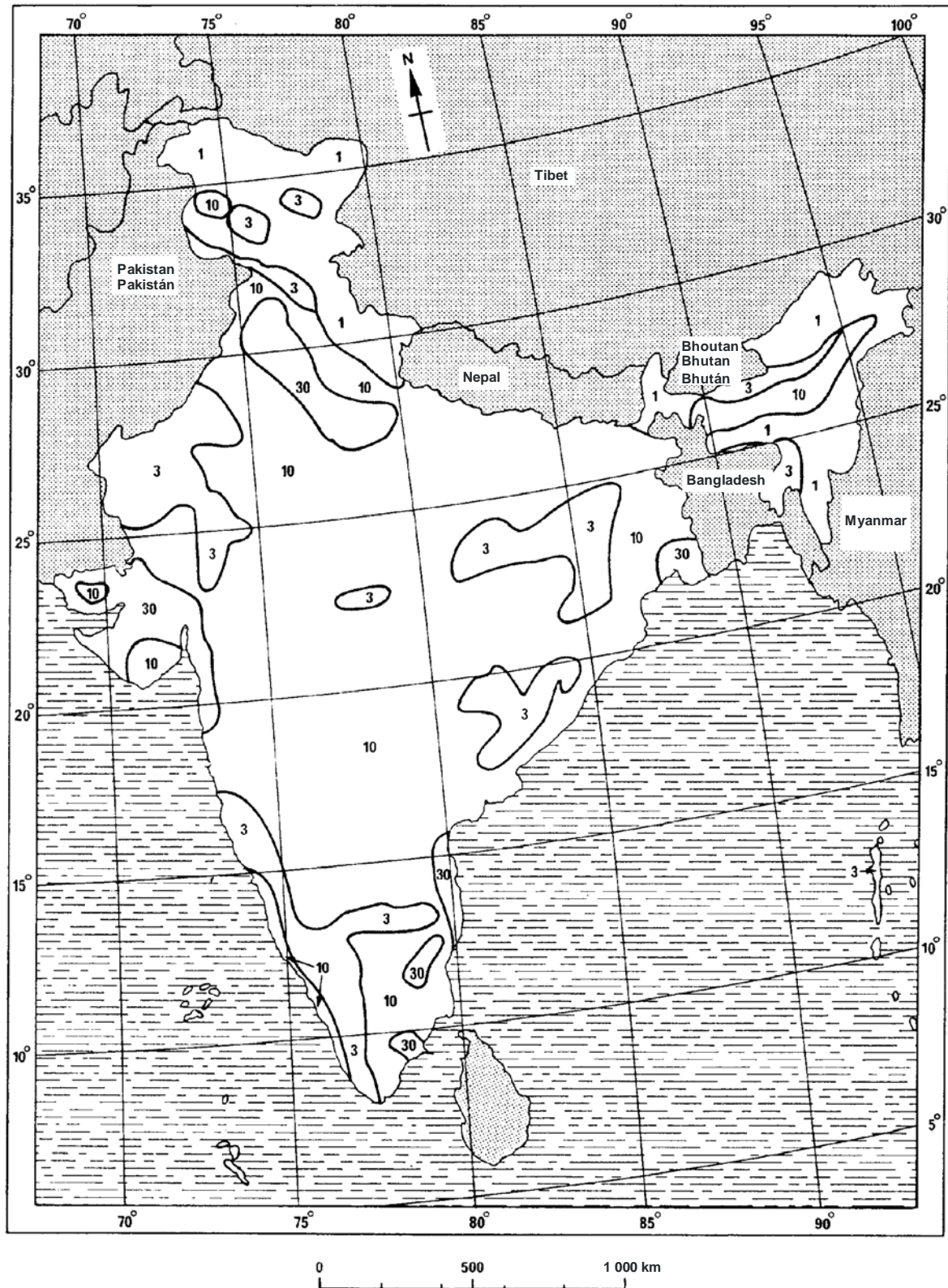


FIGURE 27

Iran (Islamic Republic of)

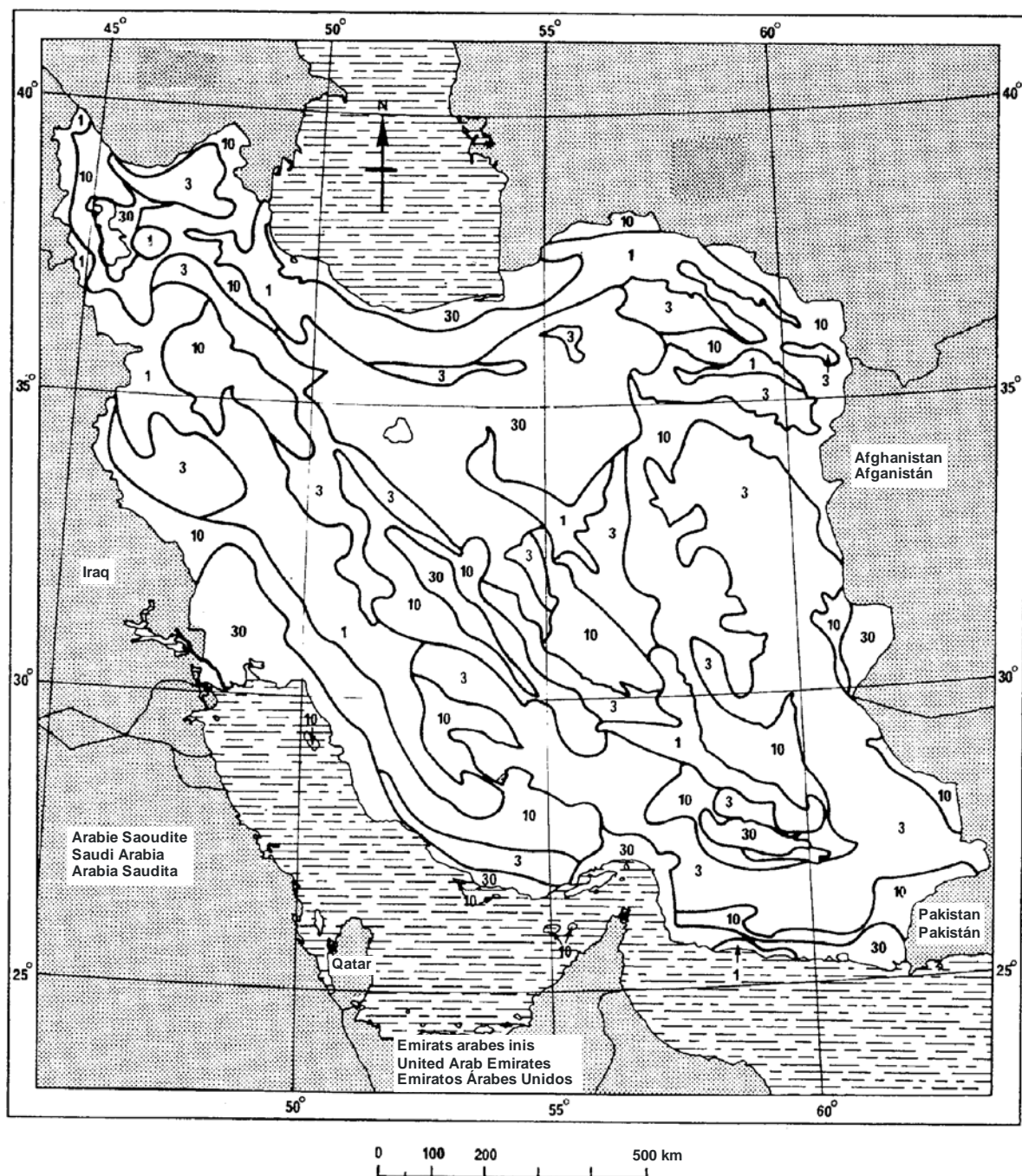


FIGURE 28
Israel (State of)

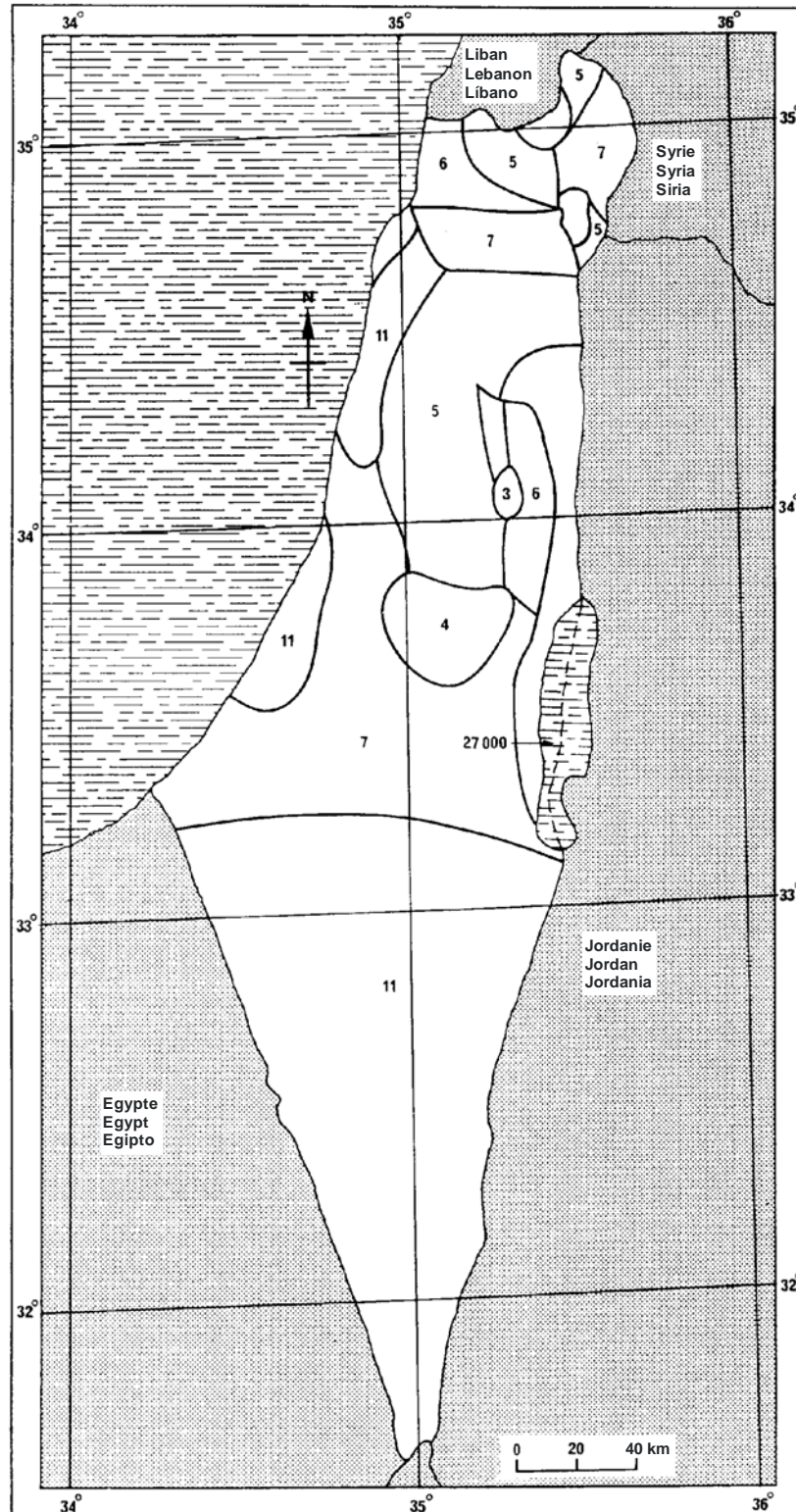
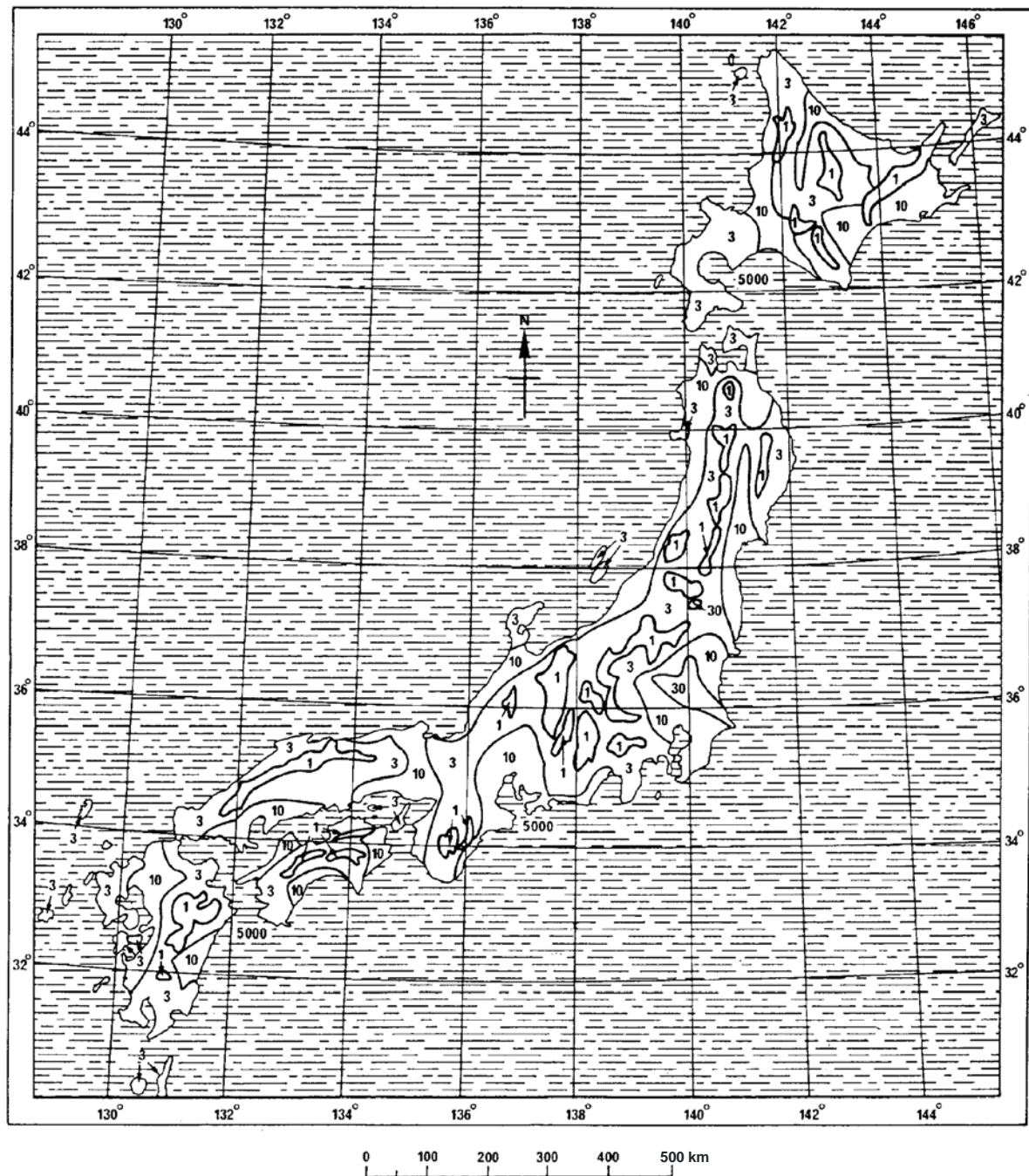


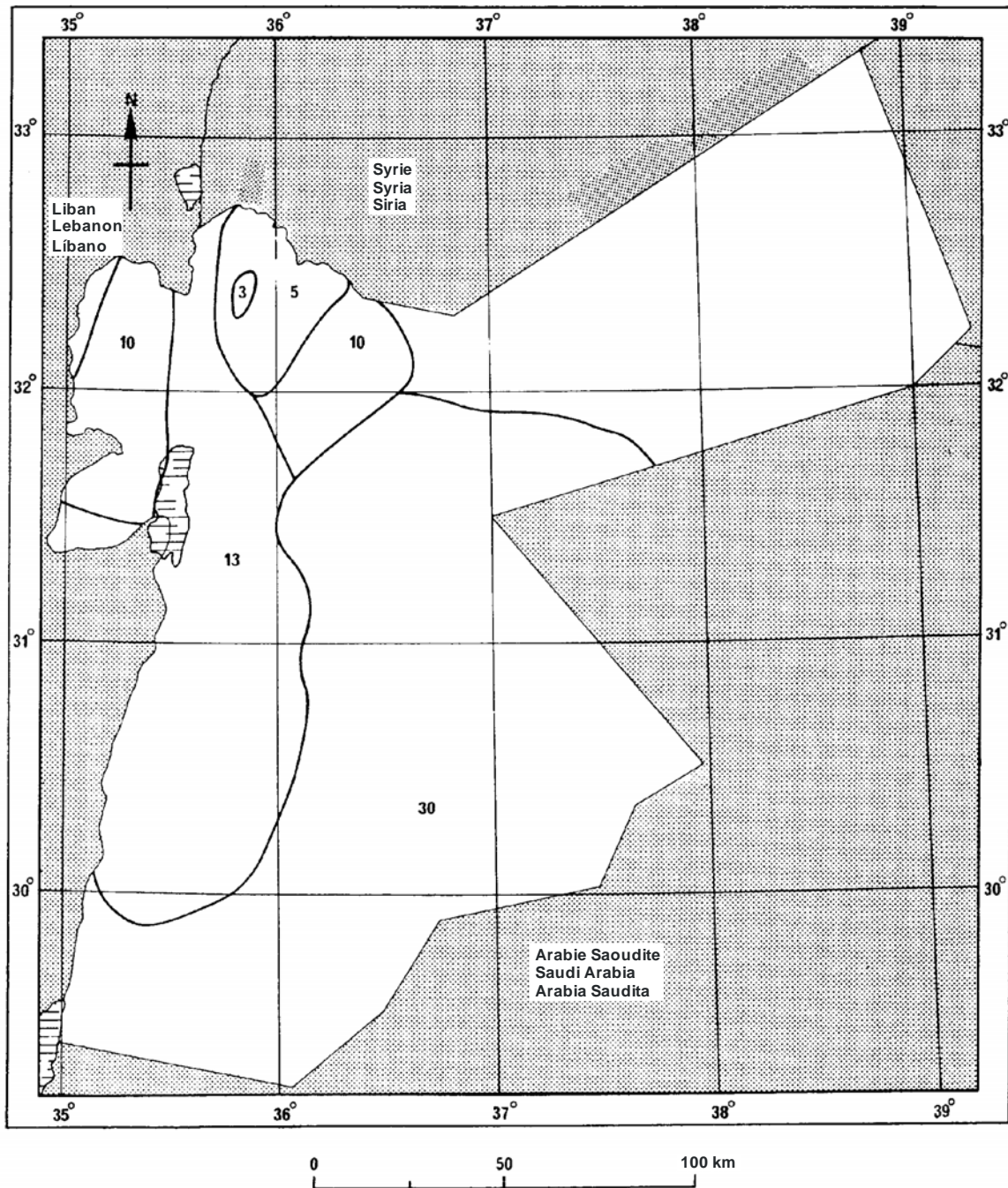
FIGURE 29

Japan



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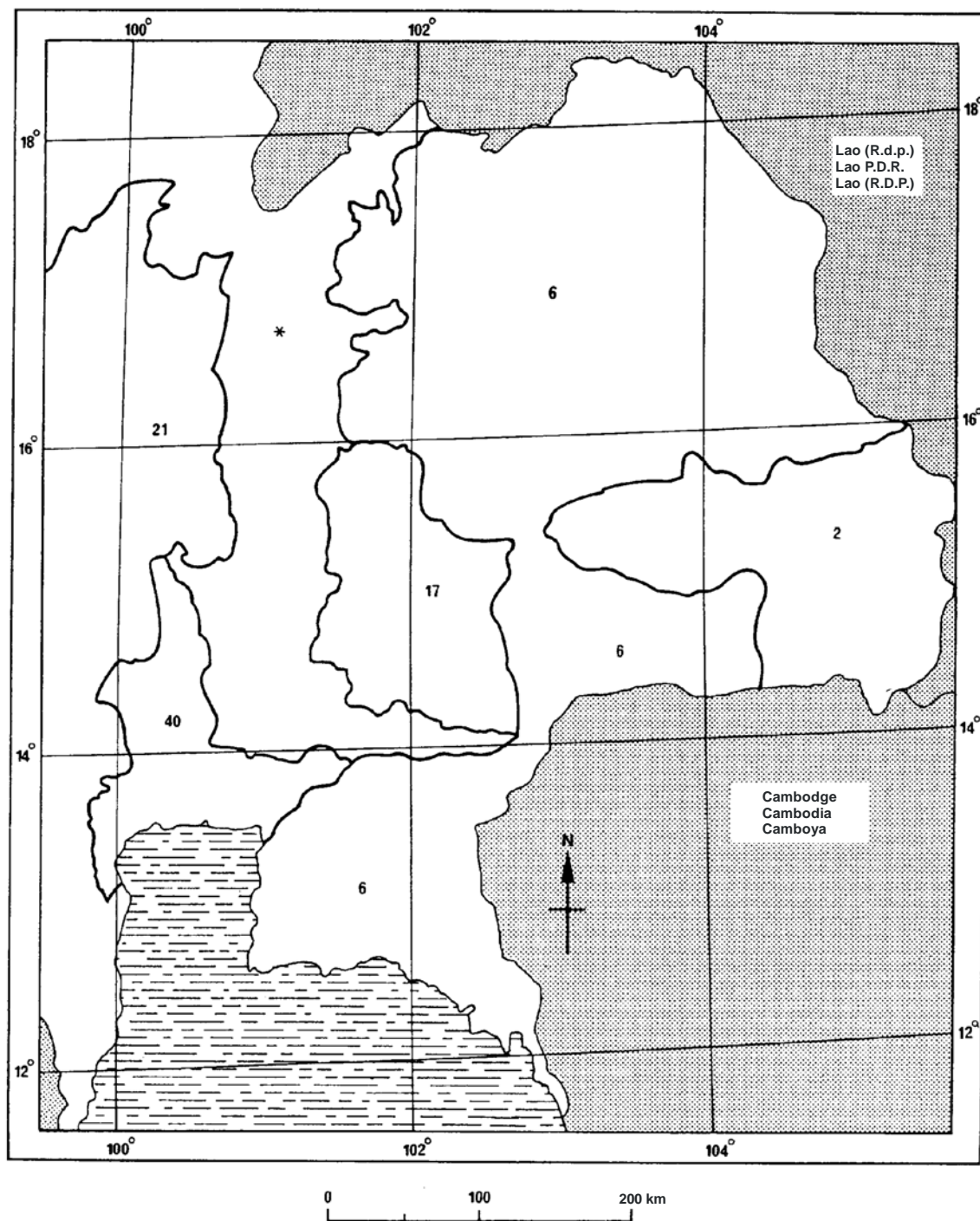
FIGURE 30
Jordan (Hashemite Kingdom of)



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FIGURE 31

Thailand



* Mountainous terrain.

FIGURE 32

Lesotho (Kingdom of), South Africa (Republic of), Swaziland (Kingdom of)

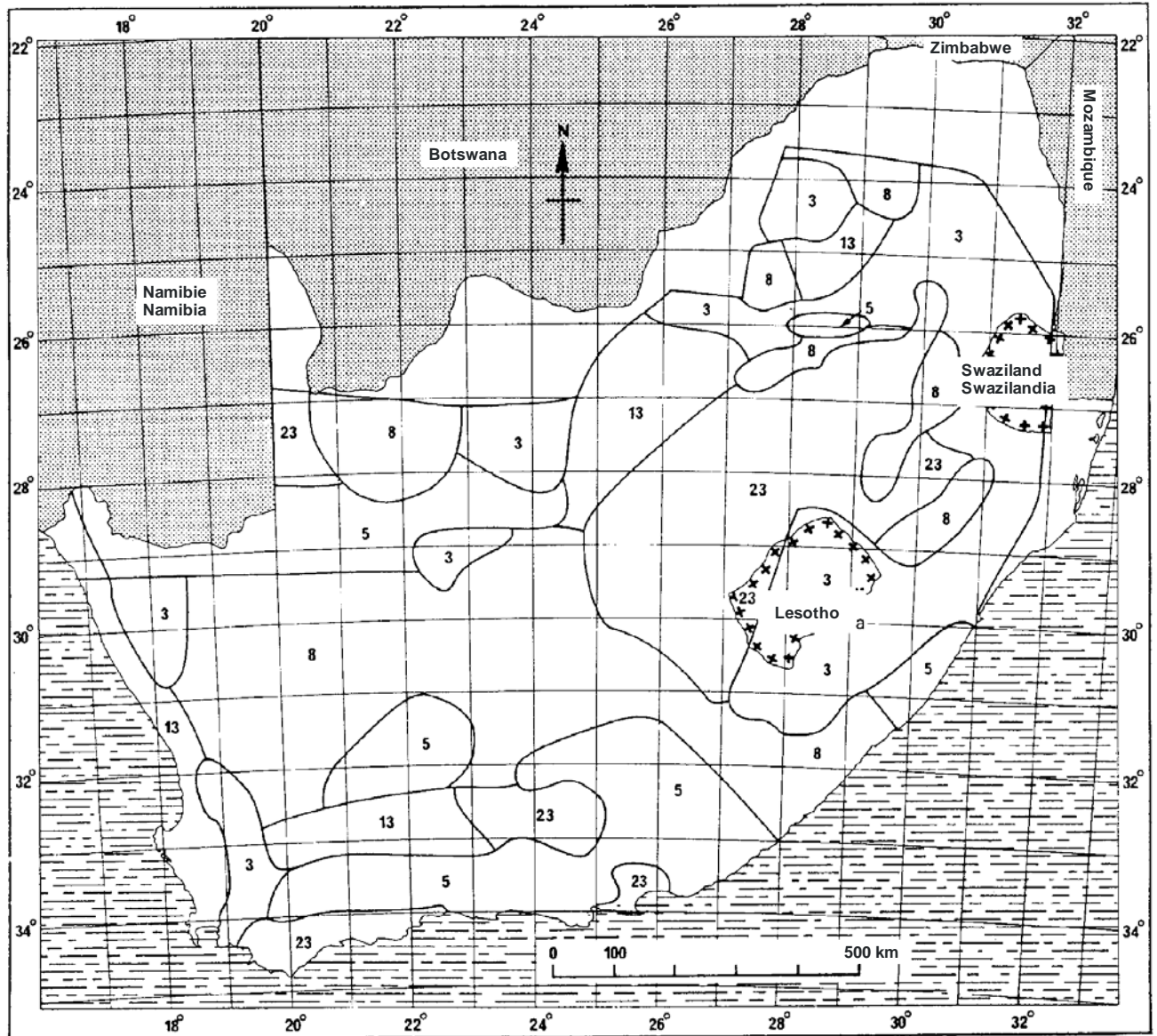


FIGURE 33
Botswana (Republic of)

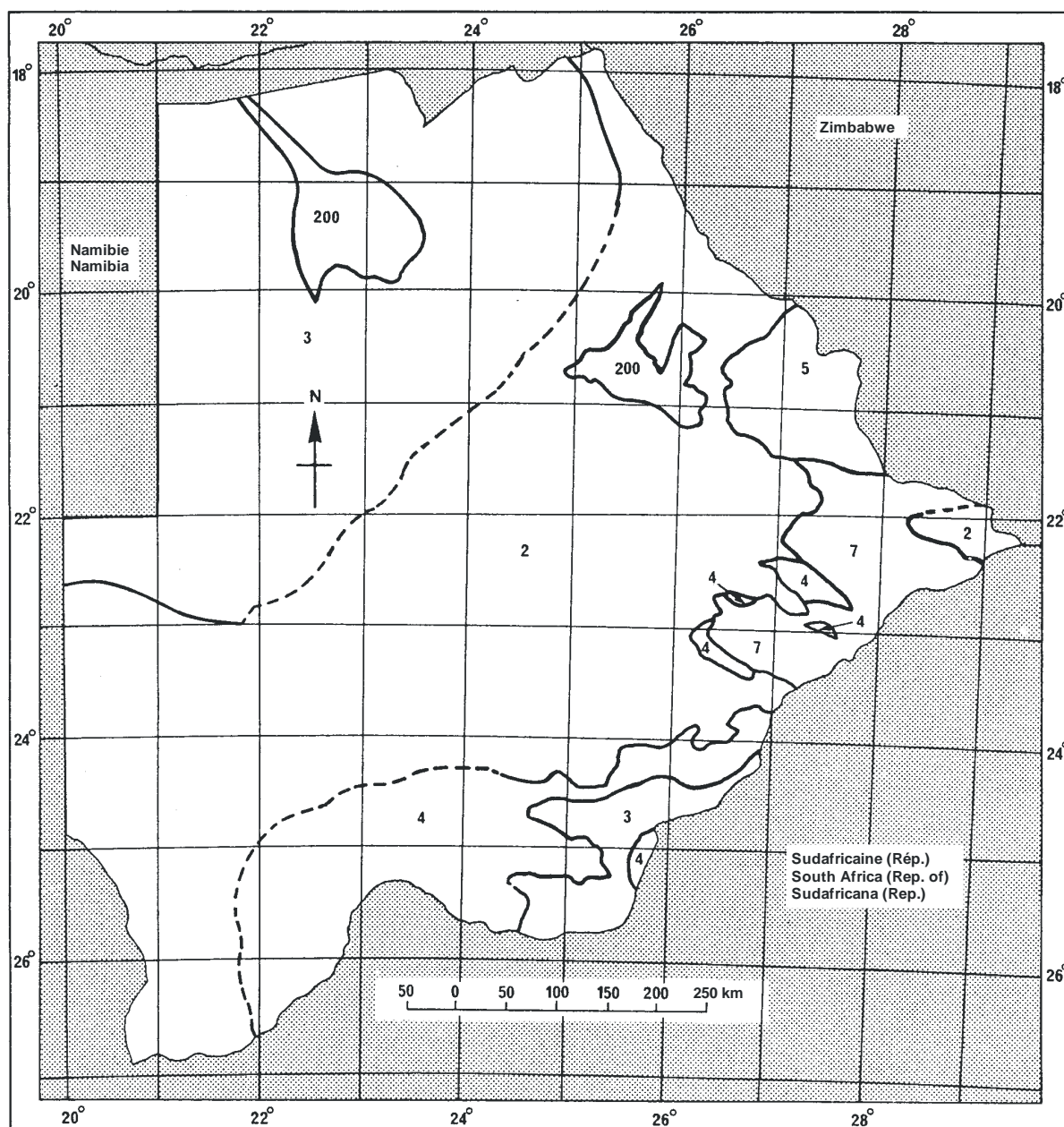
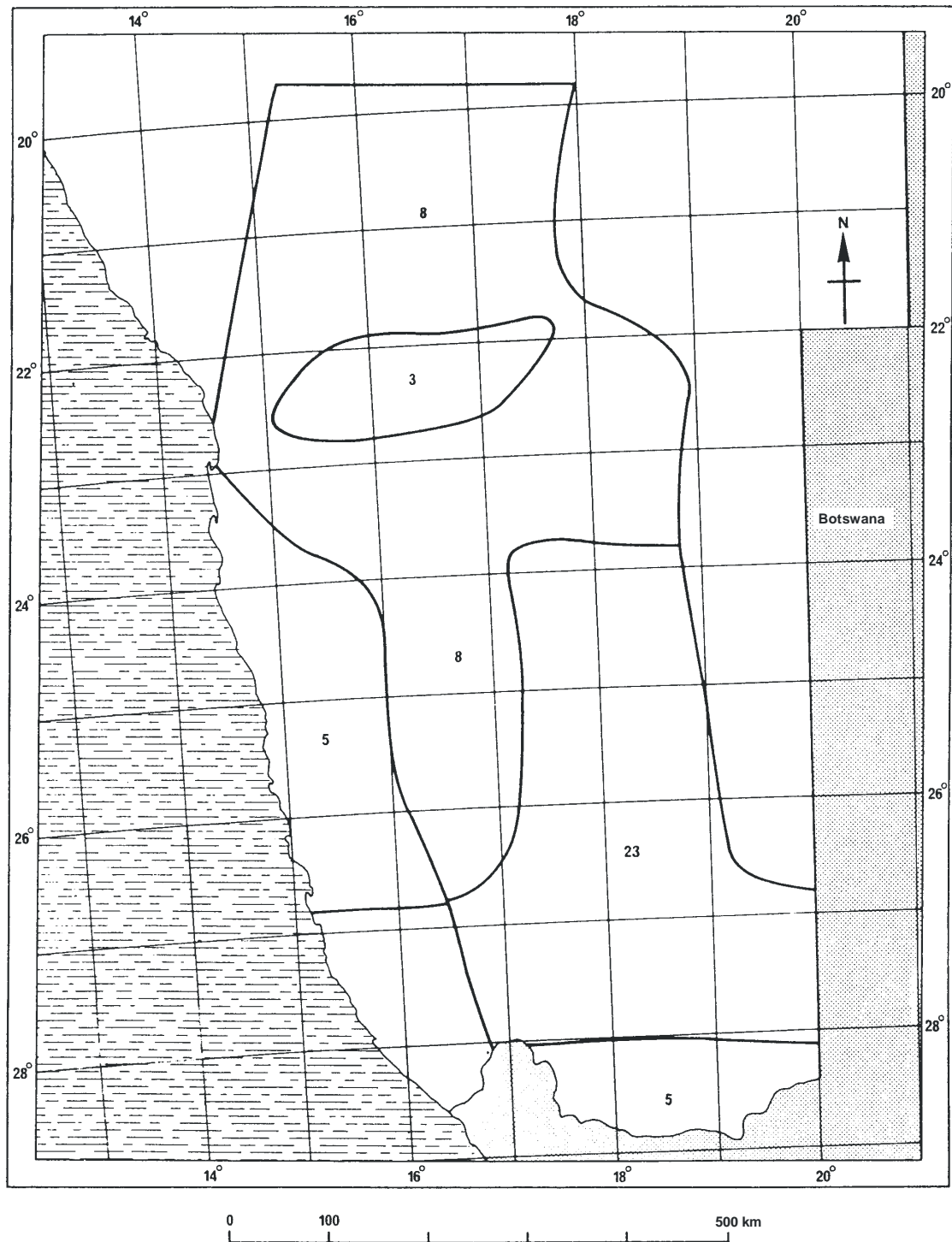
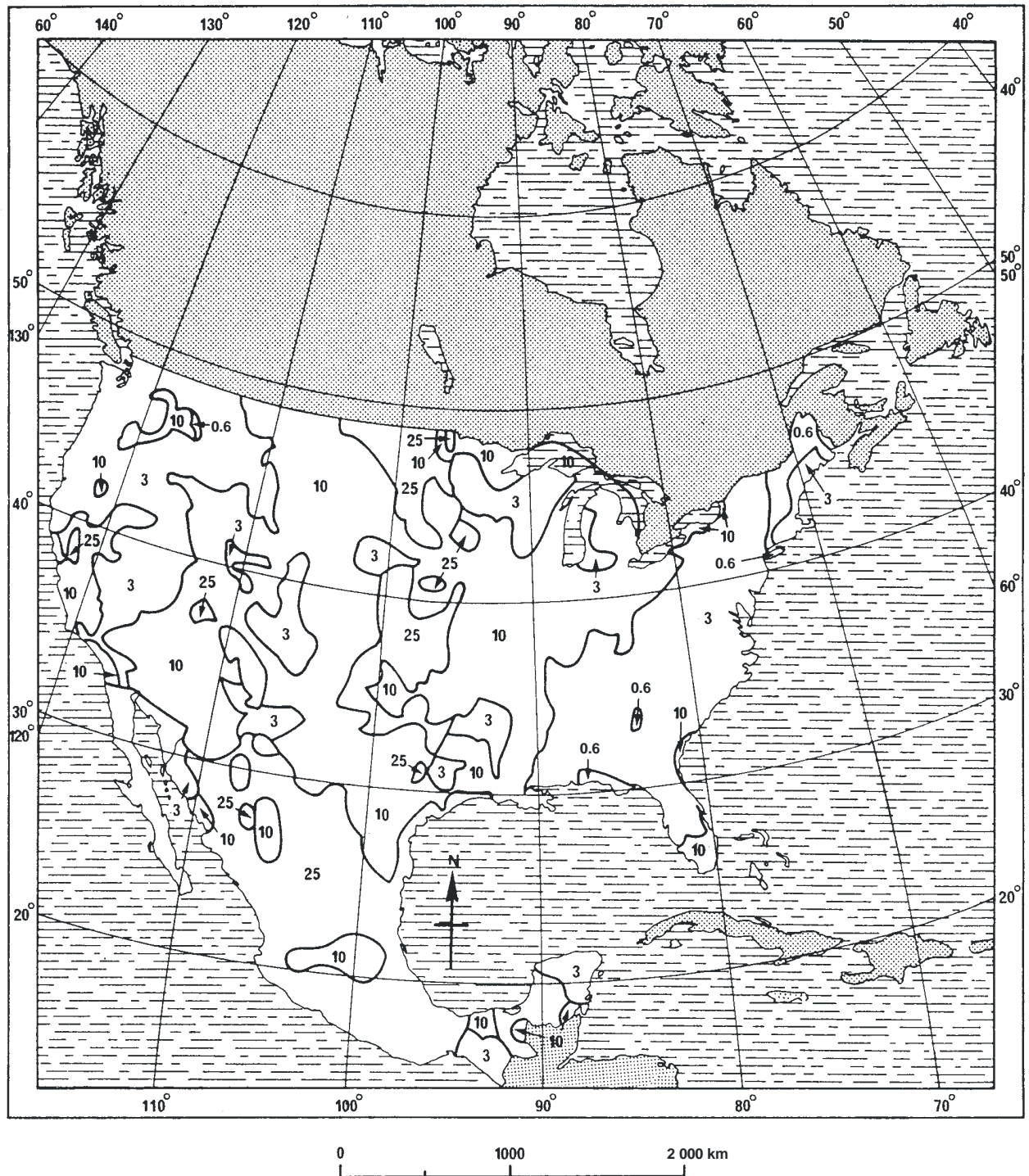


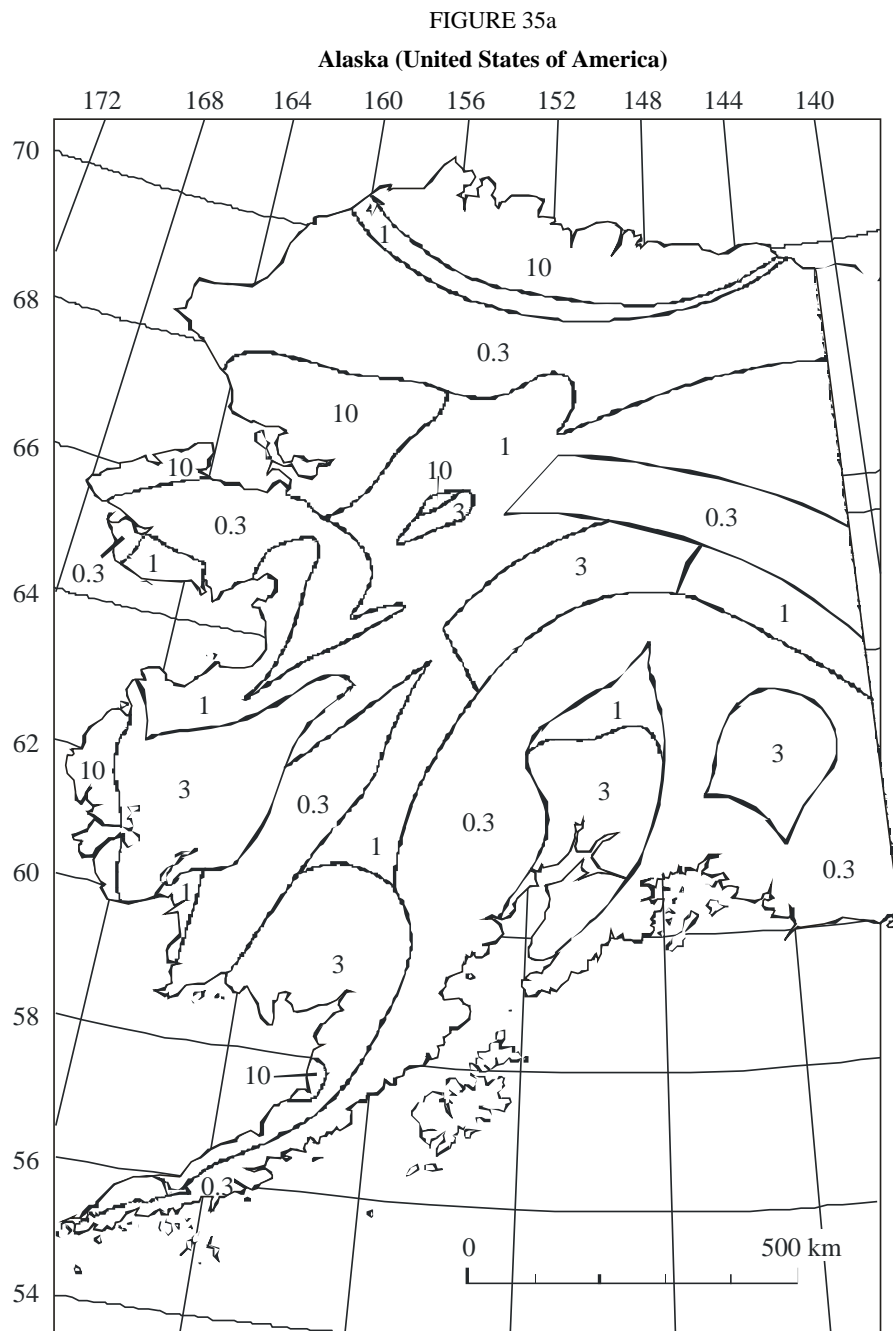
FIGURE 34
Namibia (Republic of)



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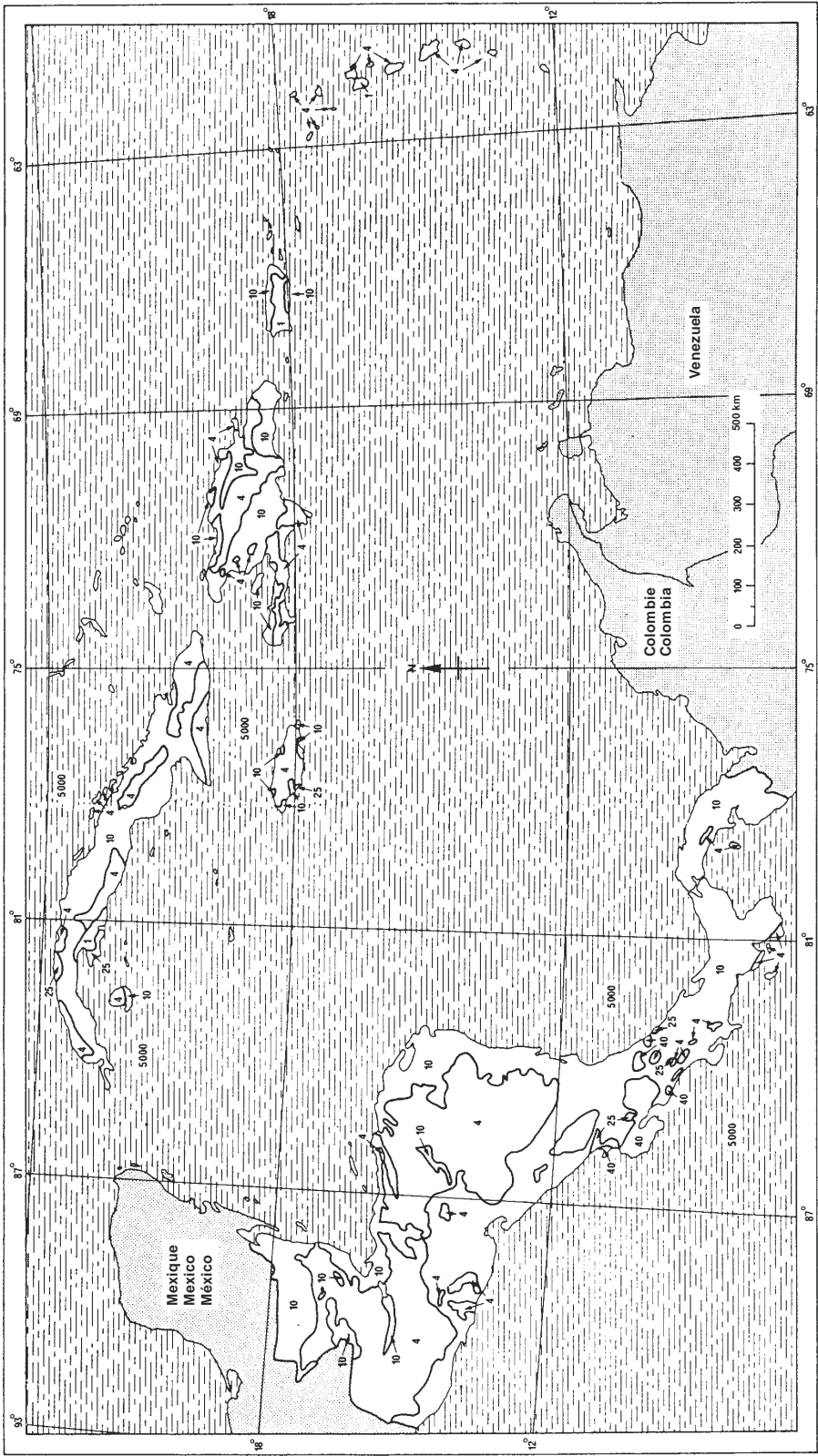
FIGURE 35
North America (excluding Canada)





Note 1 – Areas labeled 10 (mS/m) are believed to contain layered earth. This should be taken into account if the information is to be used in other frequency bands.

FIGURE 36
Central America



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FIGURE 37
Canada

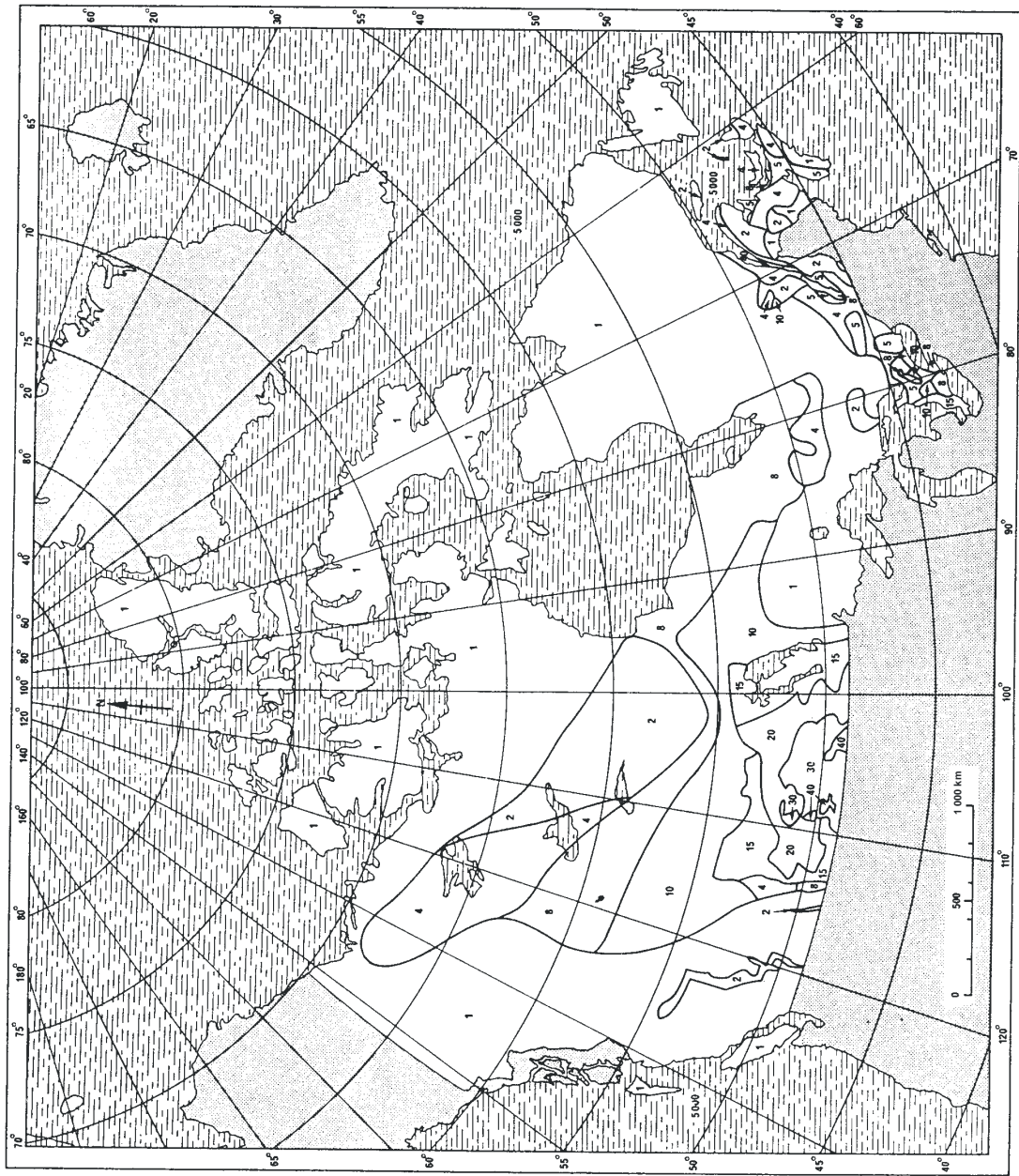


FIGURE 38
South America

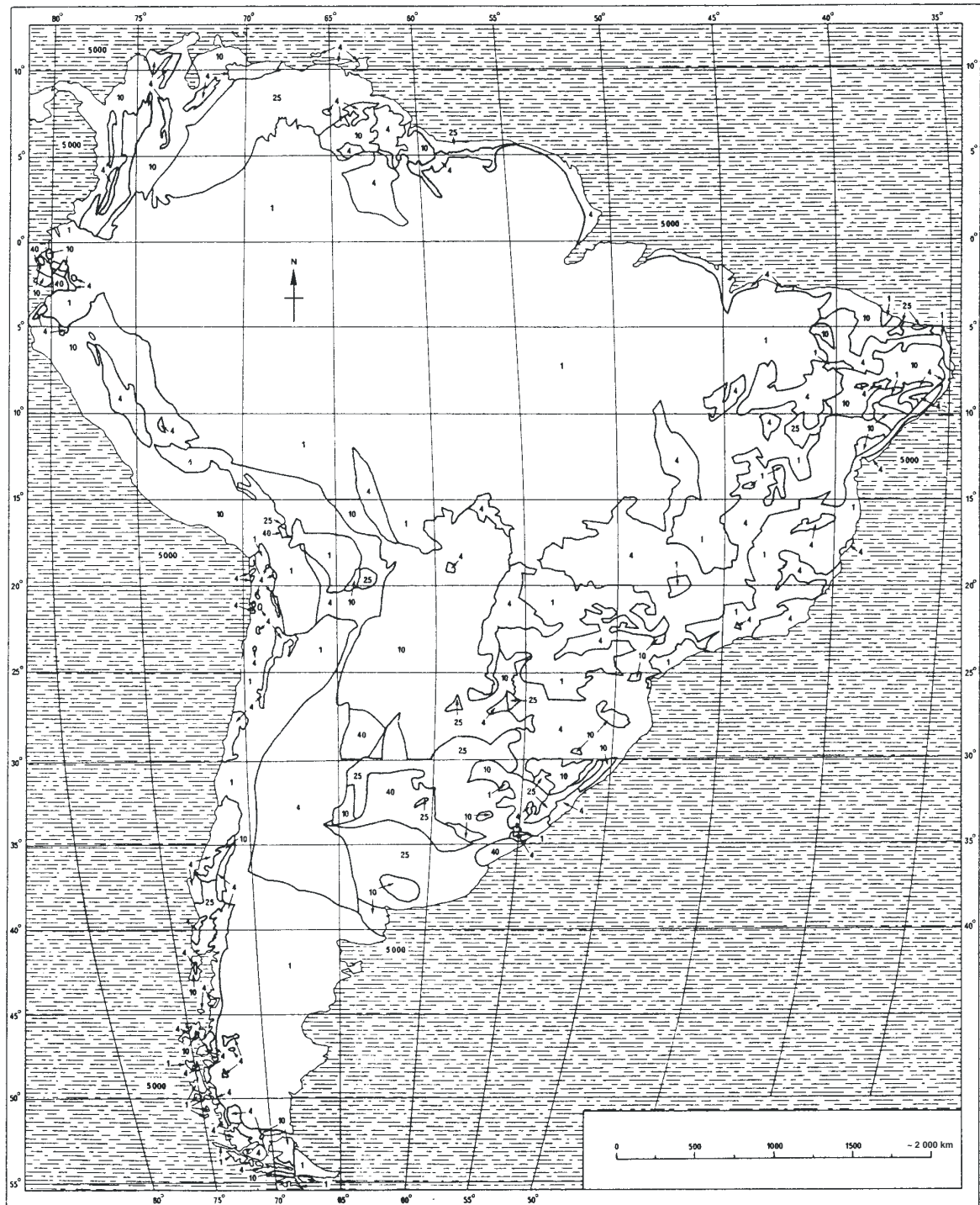


FIGURE 39
Australia

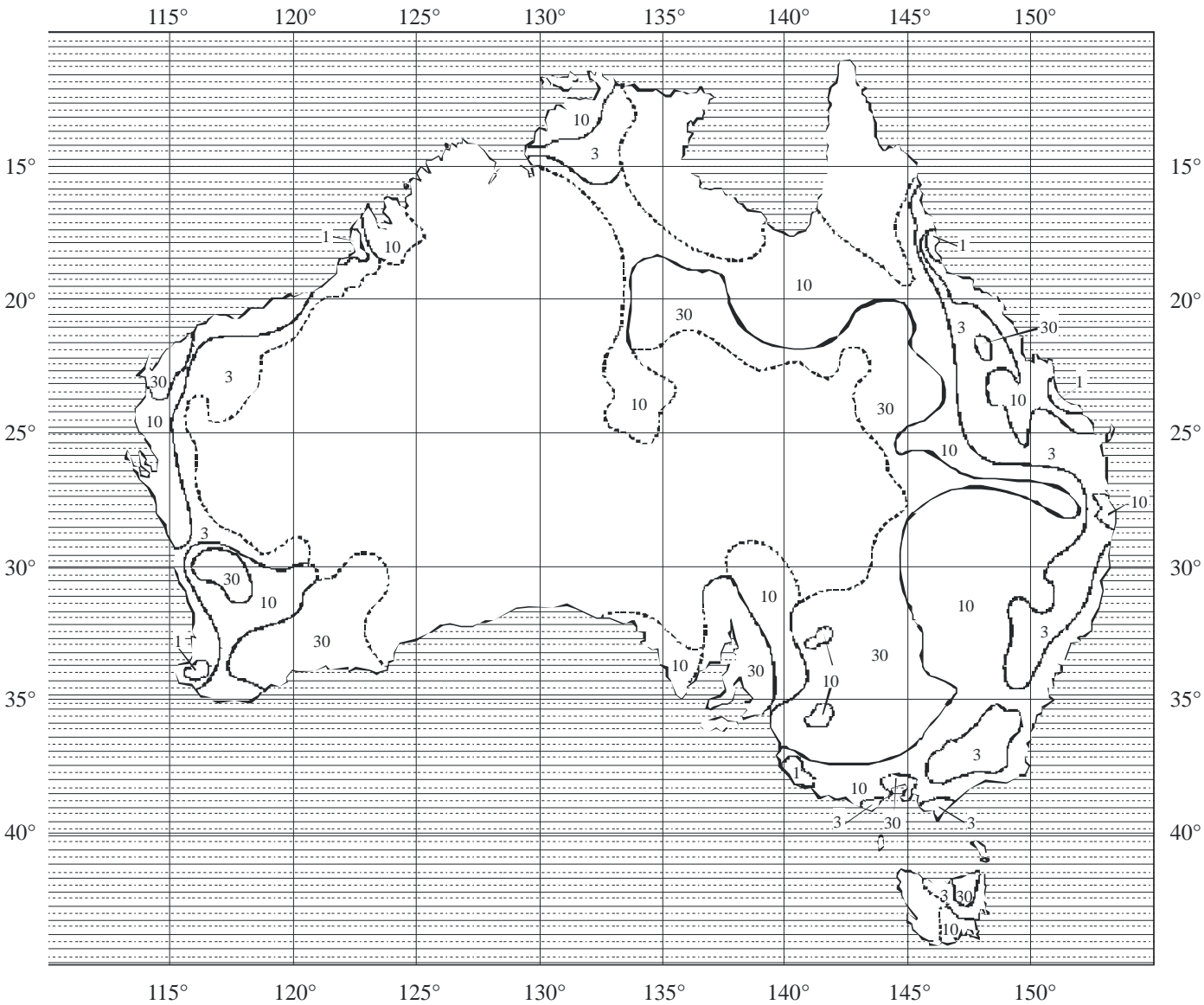


FIGURE 40
New Zealand

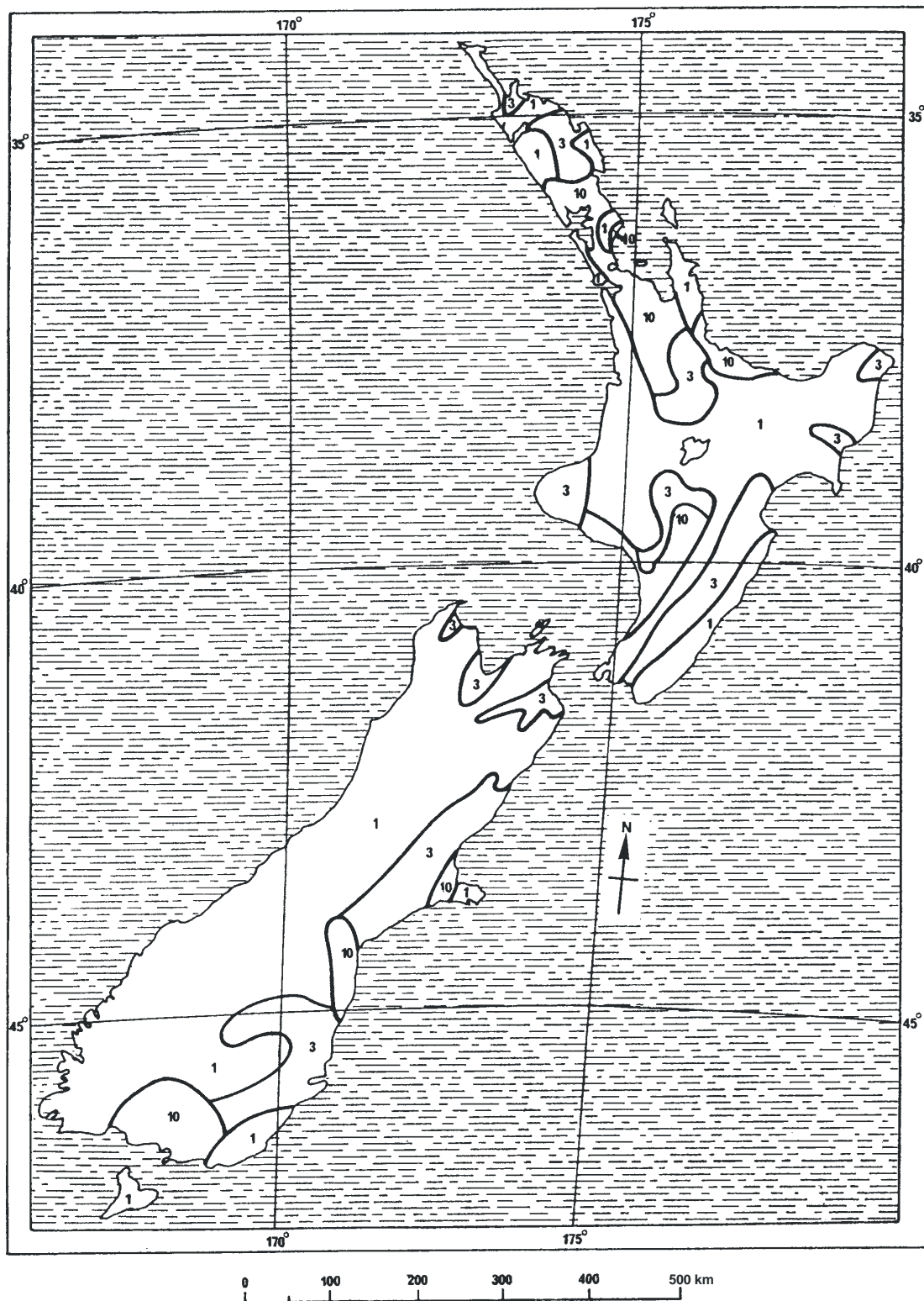
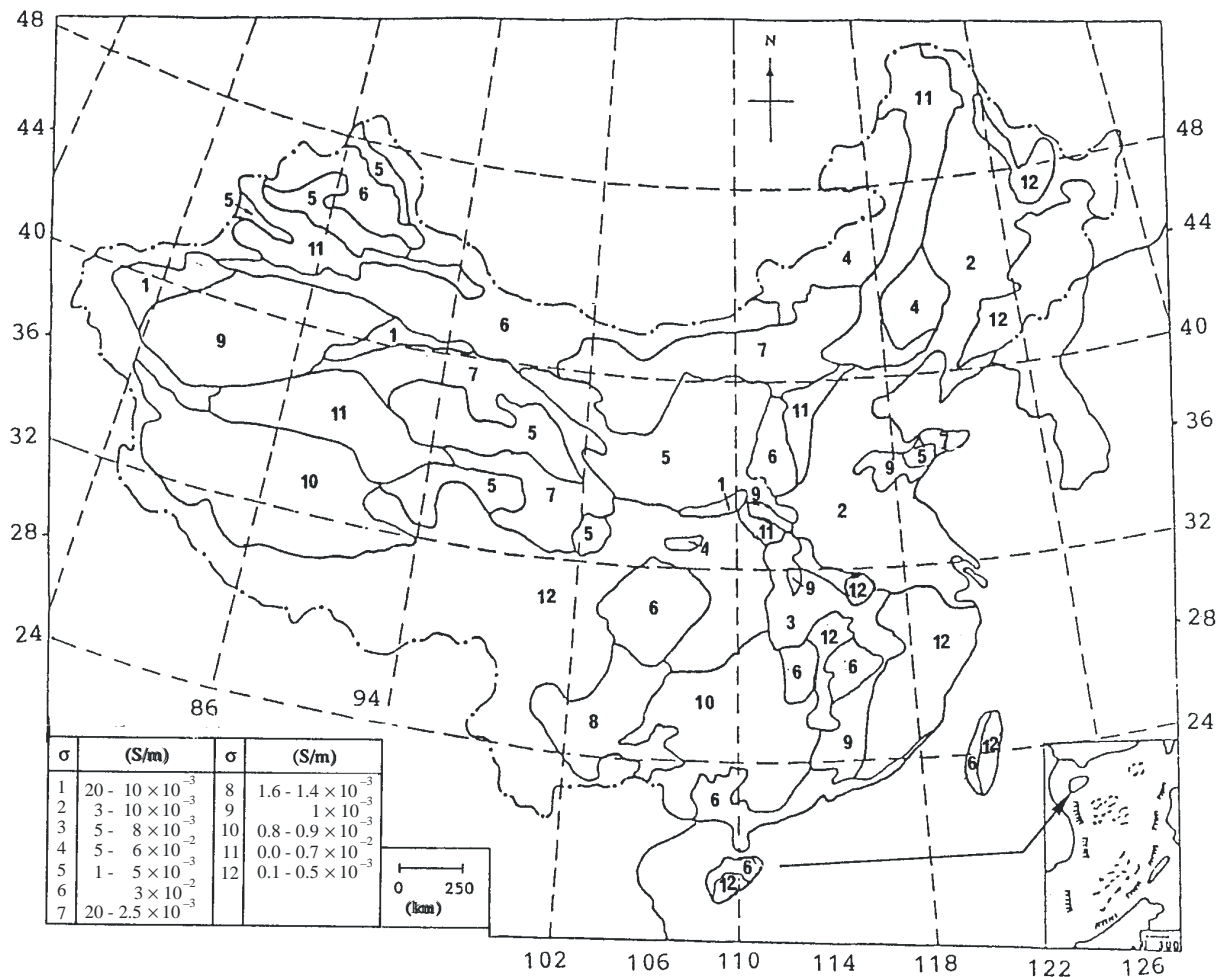
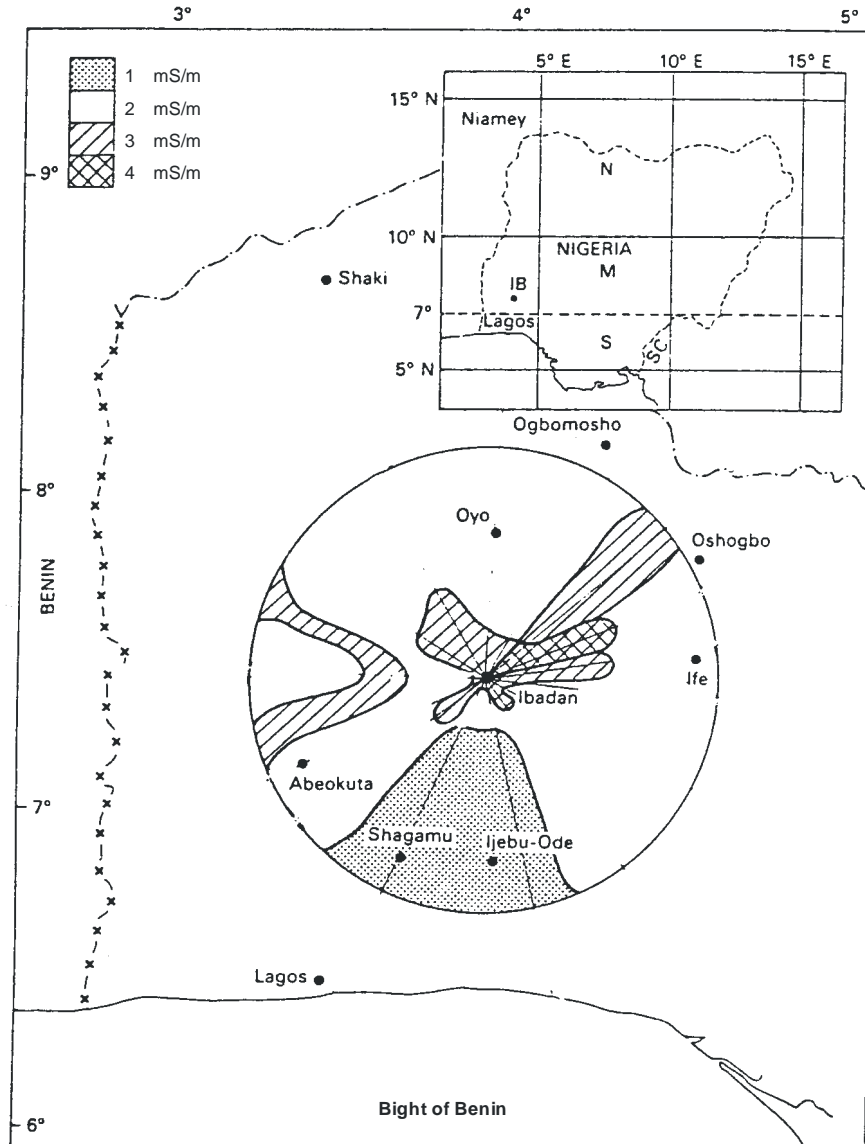


FIGURE 41
China* (People's Republic of)



* Note 1 – The conductivity map of China is based on measurements of 100 kHz signals and checked by LORAN-C signals. The values are also applicable to the MF band.

FIGURE 42
Nigeria (Federal Republic of)*



* Note 1 – The partial conductivity map of Nigeria is taken from an article in the *ITU Telecommunication Journal*, Vol. 55.II/1988.

TABLE 2
Measurement results for Afghanistan

Place of measurement	Longitude	Latitude	Frequency (kHz)	Ground conductivity (mS/m)
Kabul	69° 11'	34° 31'	660 1 280	7.5 9.0
Jalalabad	70° 27'	34° 26'	660 1 280	3.0
Gardez	69° 13'	33° 35'	660 1 280	2.0
Ghazni	68° 25'	33° 33'	660 1 280	2.5
Kandahar	65° 43'	31° 37'	840	1.0
Herat	62° 12'	34° 21'	630	1.0

FIGURE 43
Provisional MF conductivity map for land areas

