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INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
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Second Workshop on Non-Linear Dynamics
and Earthquake Prediction

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Fractal Character of Earthquakes

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Fi
1

FRACTAL CHARACTER OF EARTHQUAKES

N = number of earthquakes with magnitude greater than m and moment greater than M

r = radius of break

$$\log N = -bm + a$$

$$\log M = cm + d$$

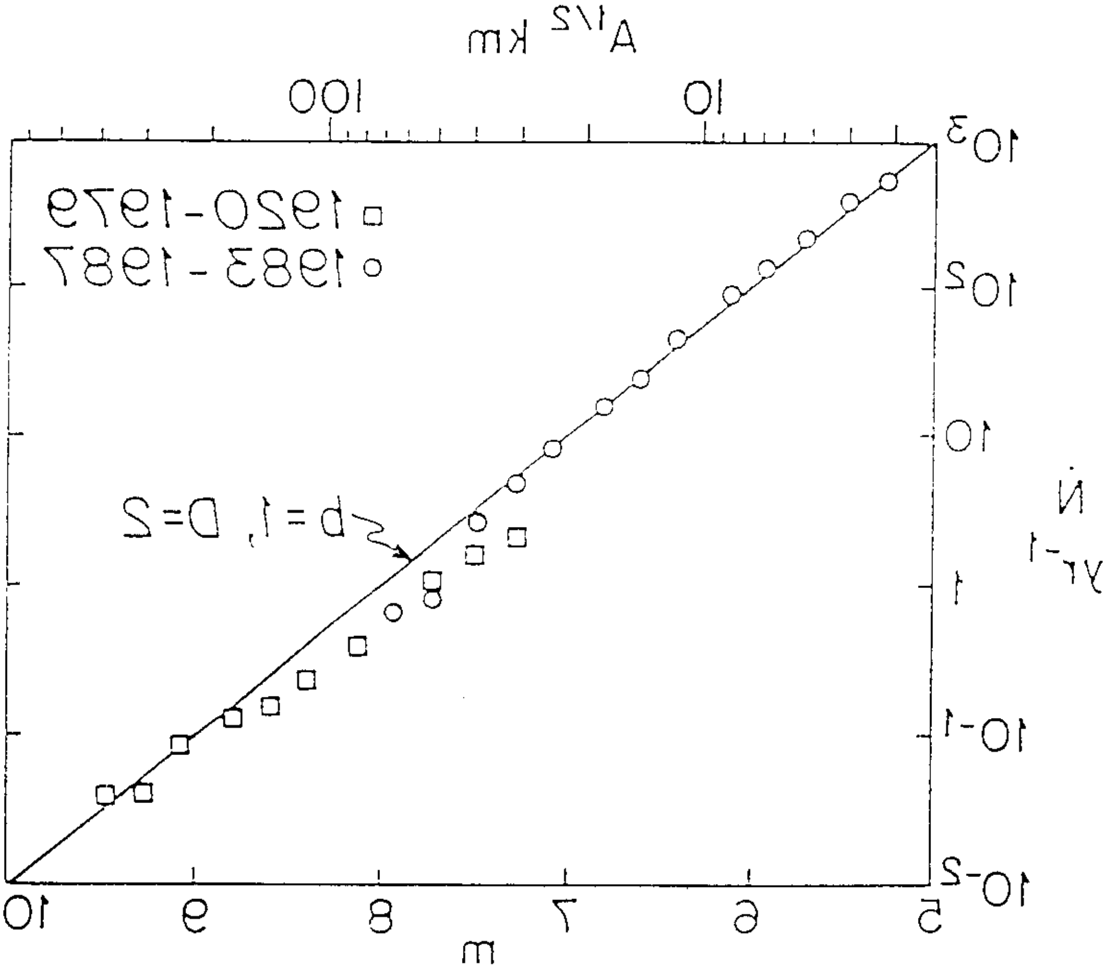
$$M = \alpha r^3$$

$$\log N = -\frac{3b}{c} \log r + \beta$$

$$N \sim r^{-3b/c} \sim r^{-D}$$

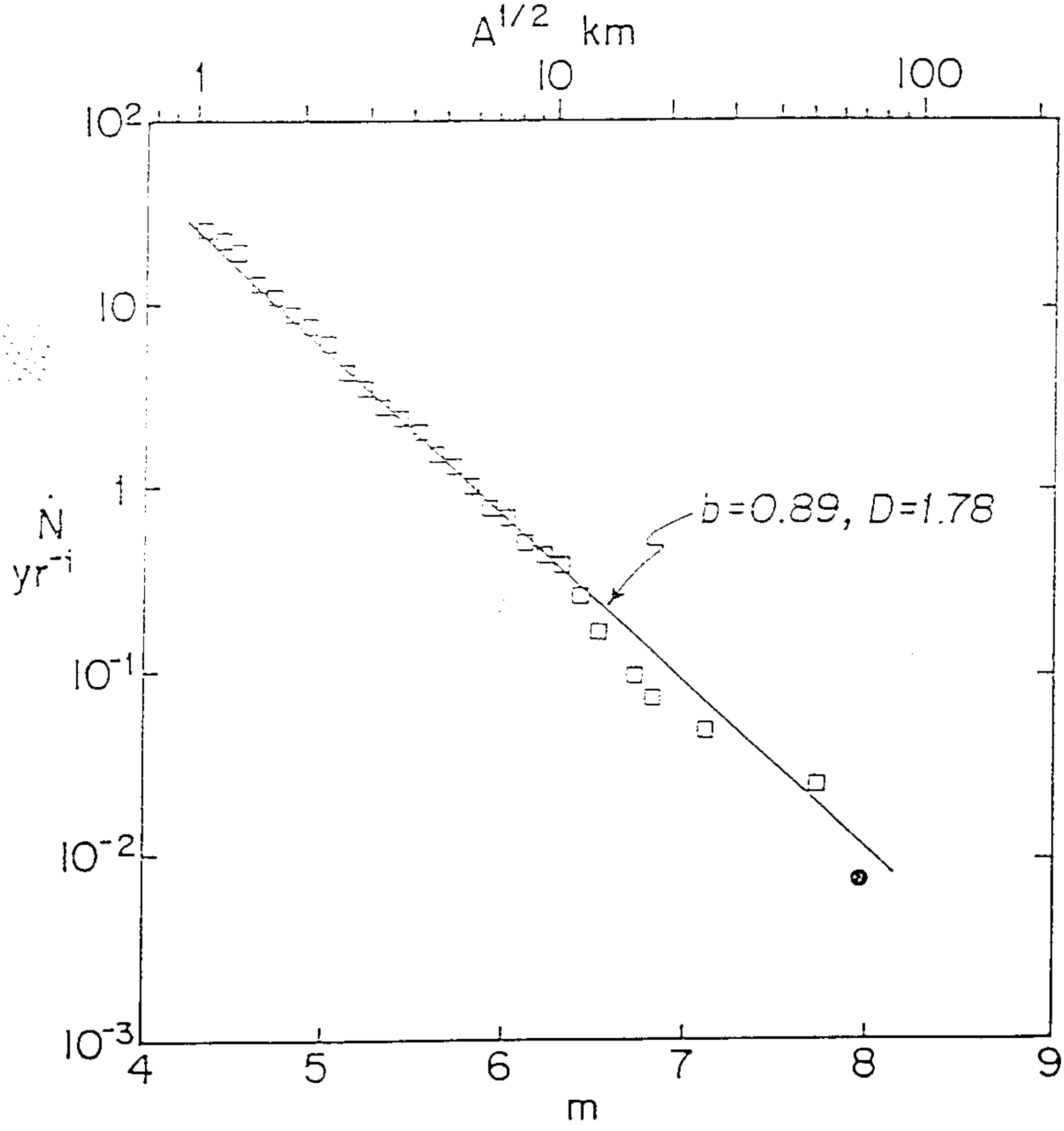
$$D = \frac{3b}{c}$$

$$c = 1.5, \quad b = 0.85 \quad \Rightarrow \quad D = 1.7$$



$A^{1/2}$ km
100
10
10^3
10^2
10
1
10^{-1}
10^{-2}
$\dot{N}$
yr^{-1}
1920-1979
1983-1987
b = 1, D = 2
10
9
8
7
6
5
m

Fig 3 b



FE
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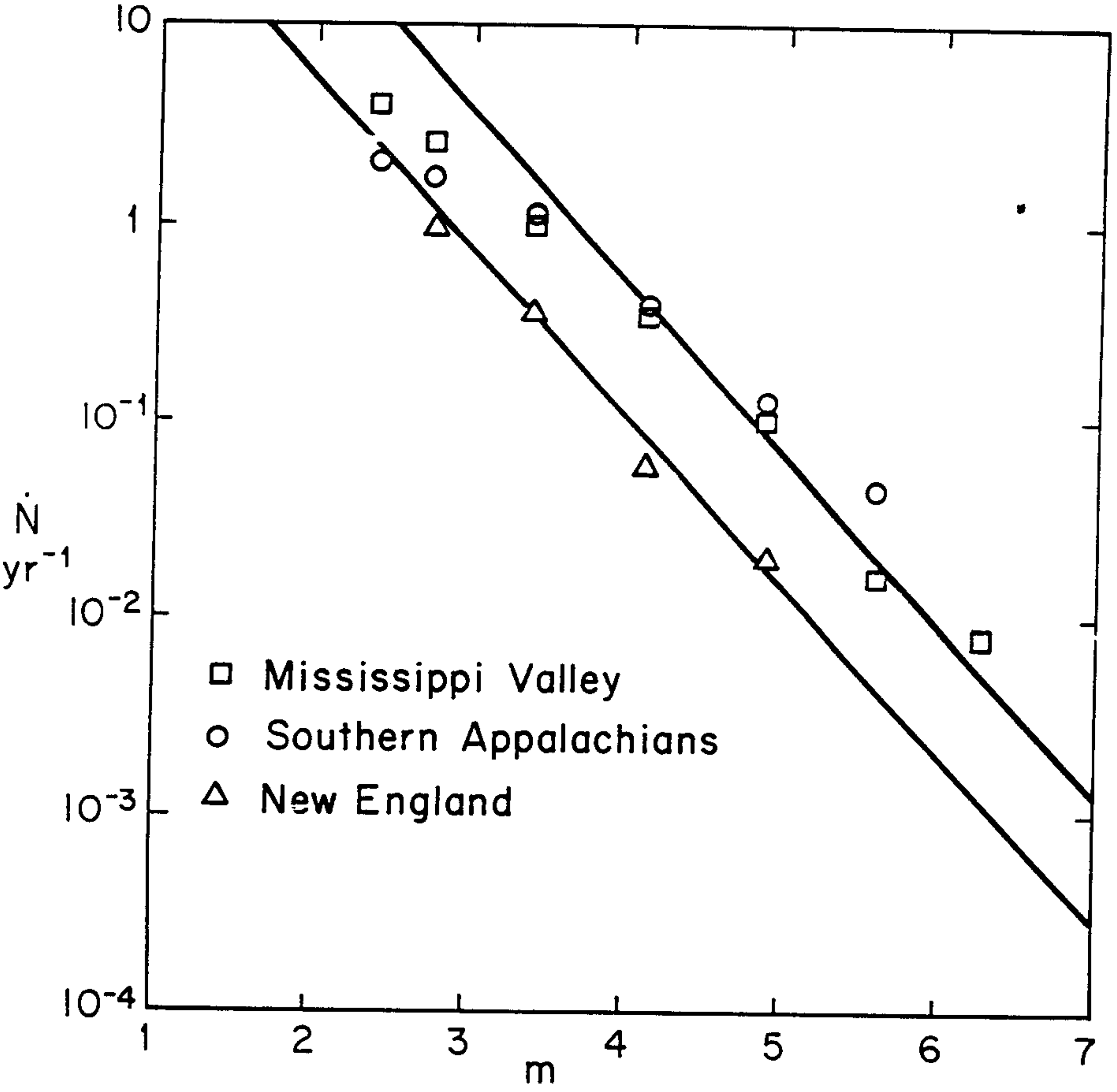
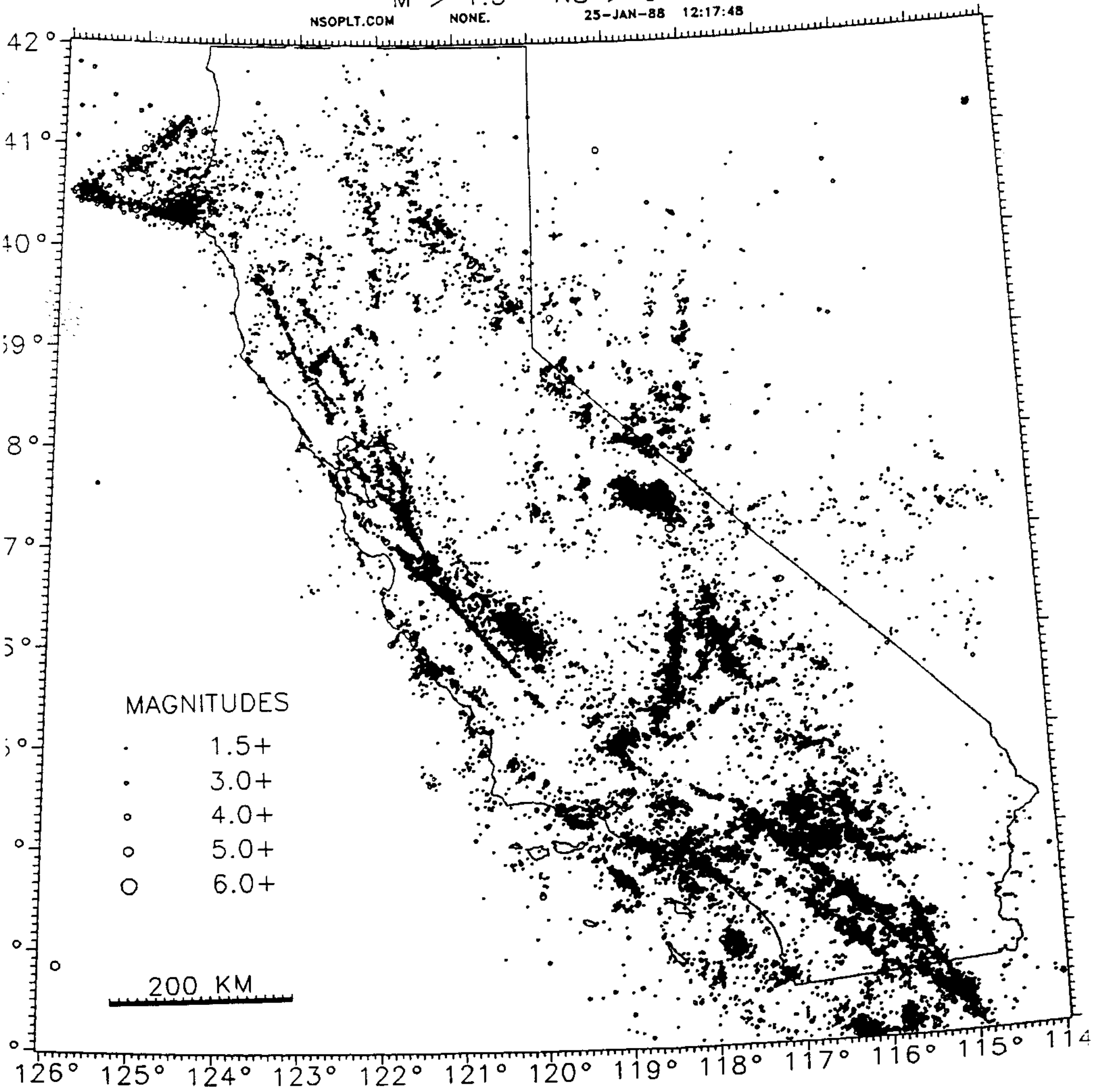

10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
$\dot{N}$
yr^{-1}
1
2
3
4
5
6
7
m
Mississippi Valley
Southern Appalachians
New England

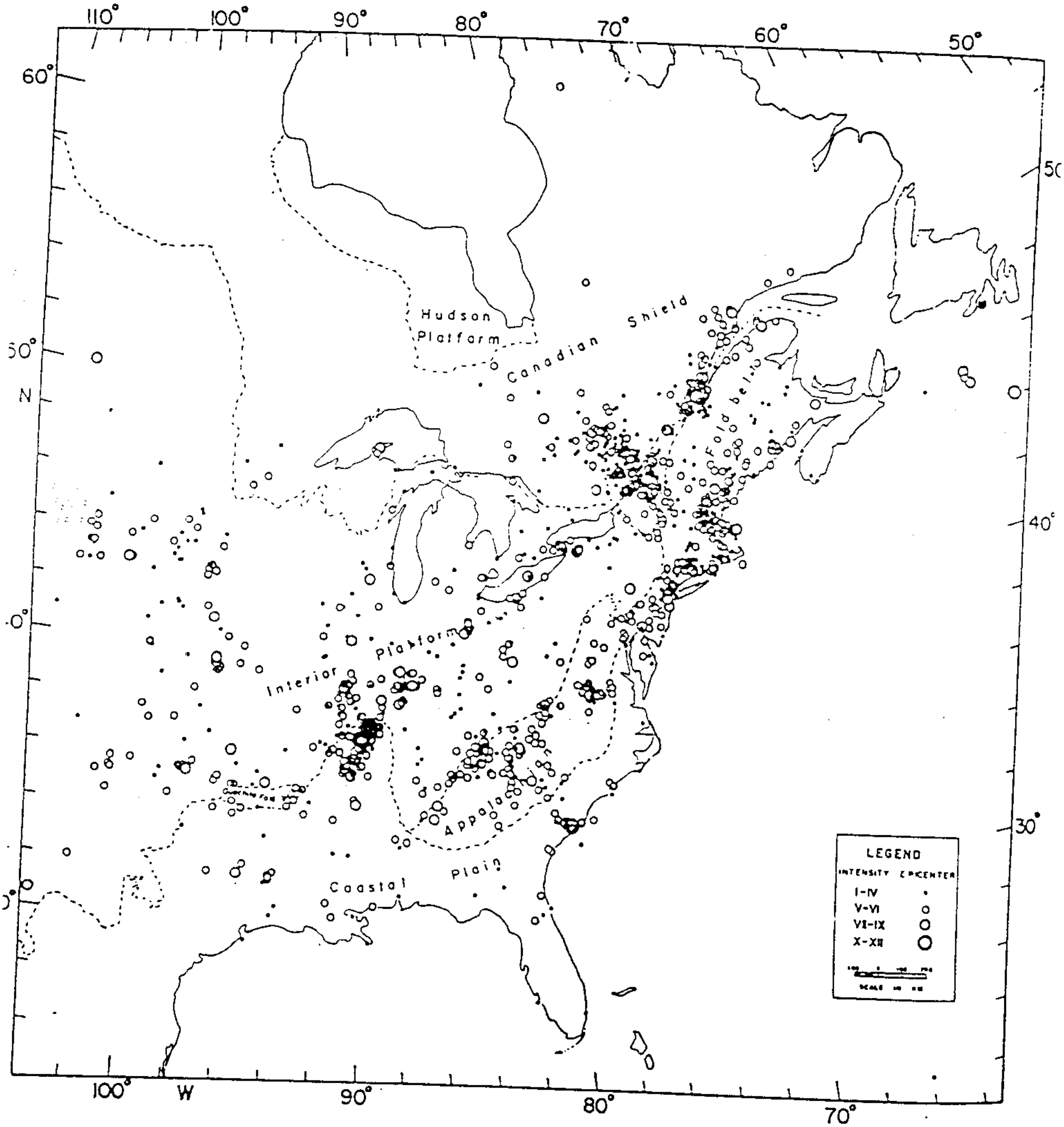
E6 [redacted]

CALIF–NEV QUAKES 1980–1986 *Hill et al (1989)*

M > 1.5 NS > 6

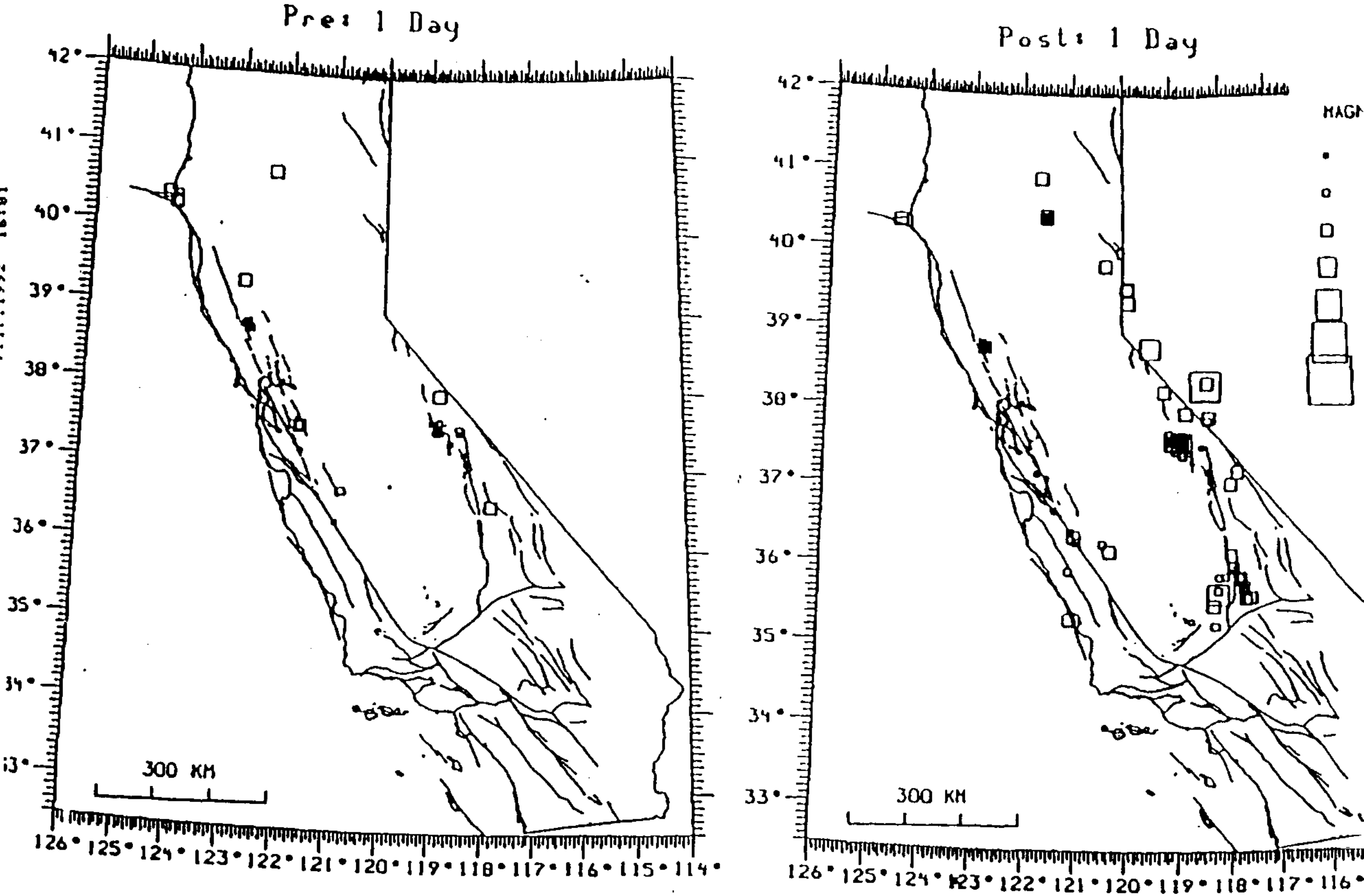


E5


110°
100°
90°
80°
70°
60°
50°
60°
50°
N
40°
30°
W
Hudson
Platform
Canadian Shield
Interior Platform
Coastal Plain
LEGEND
INTENSITY EPICENTER
I-IV
V-VI
VII-IX
X-XII

6

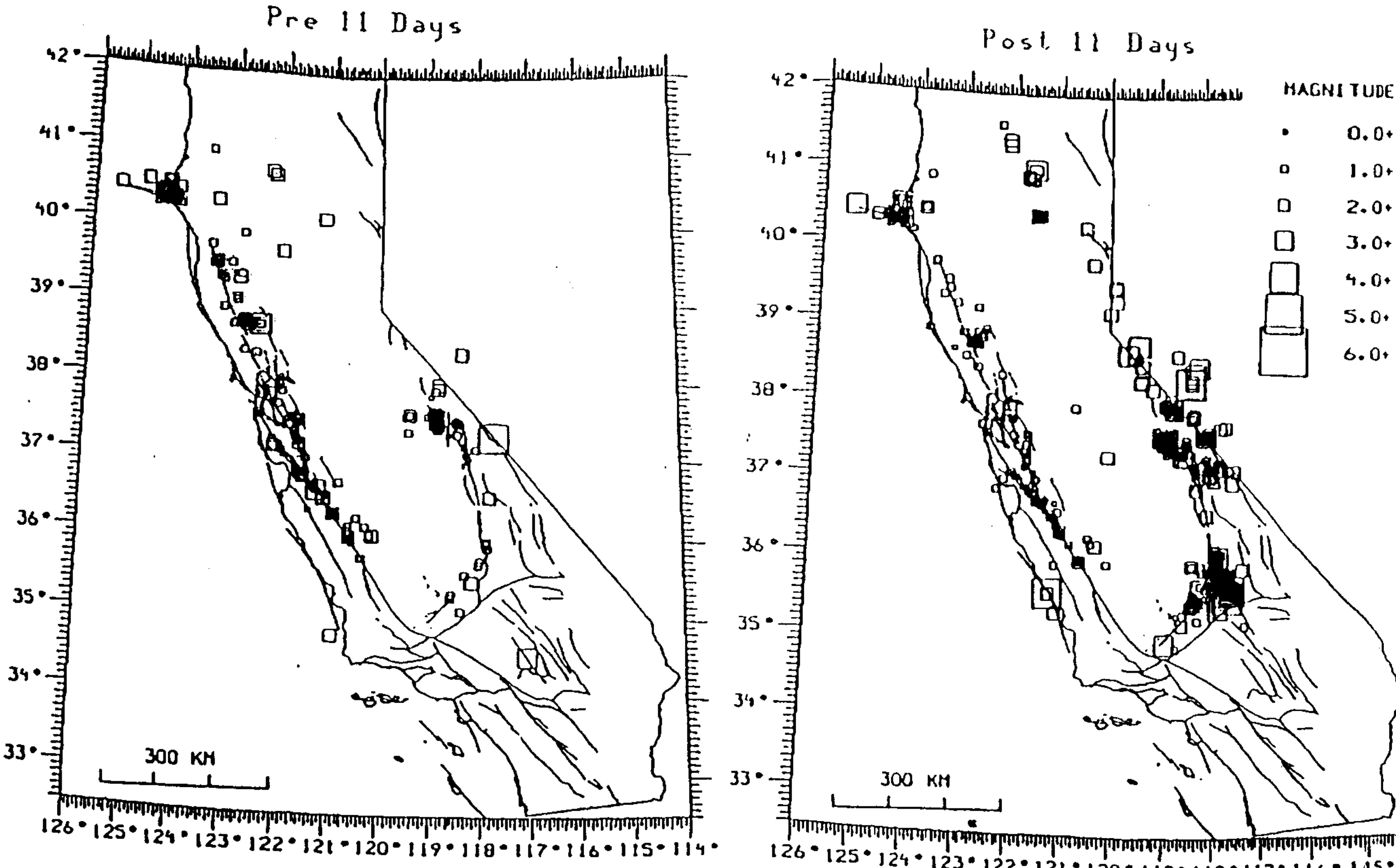
Fig. 2 Northern California Network



Reasenberg & H

Fig. 3

NORTHERN CALIFORNIA NET



Reasenberg & Hill

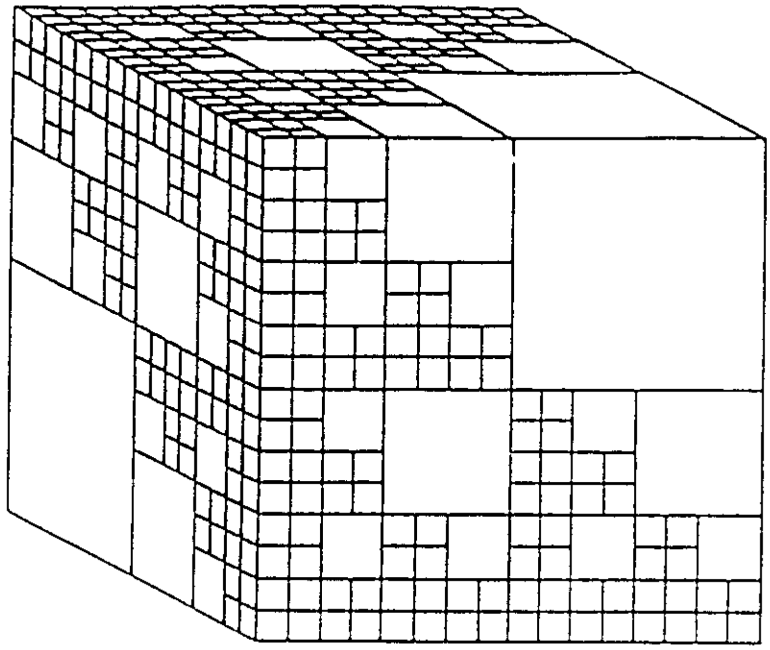


Figure 3.3. Illustration of a fractal model for fragmentation. Two diagonally opposite cubes are retained at each scale. With $r_1 = h/2$, $N_1 = 2$ and $r_2 = h/4$, $N_2 = 12$ we have $D = \ln 6/\ln 2 = 2.5850$.

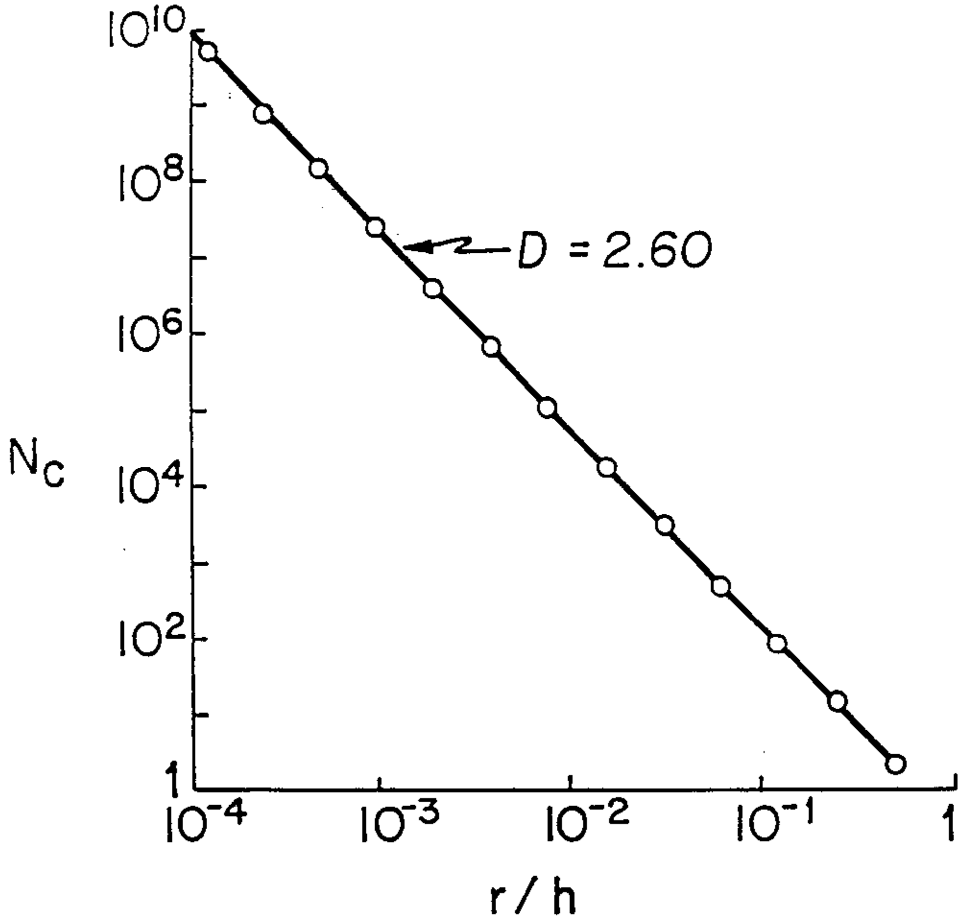
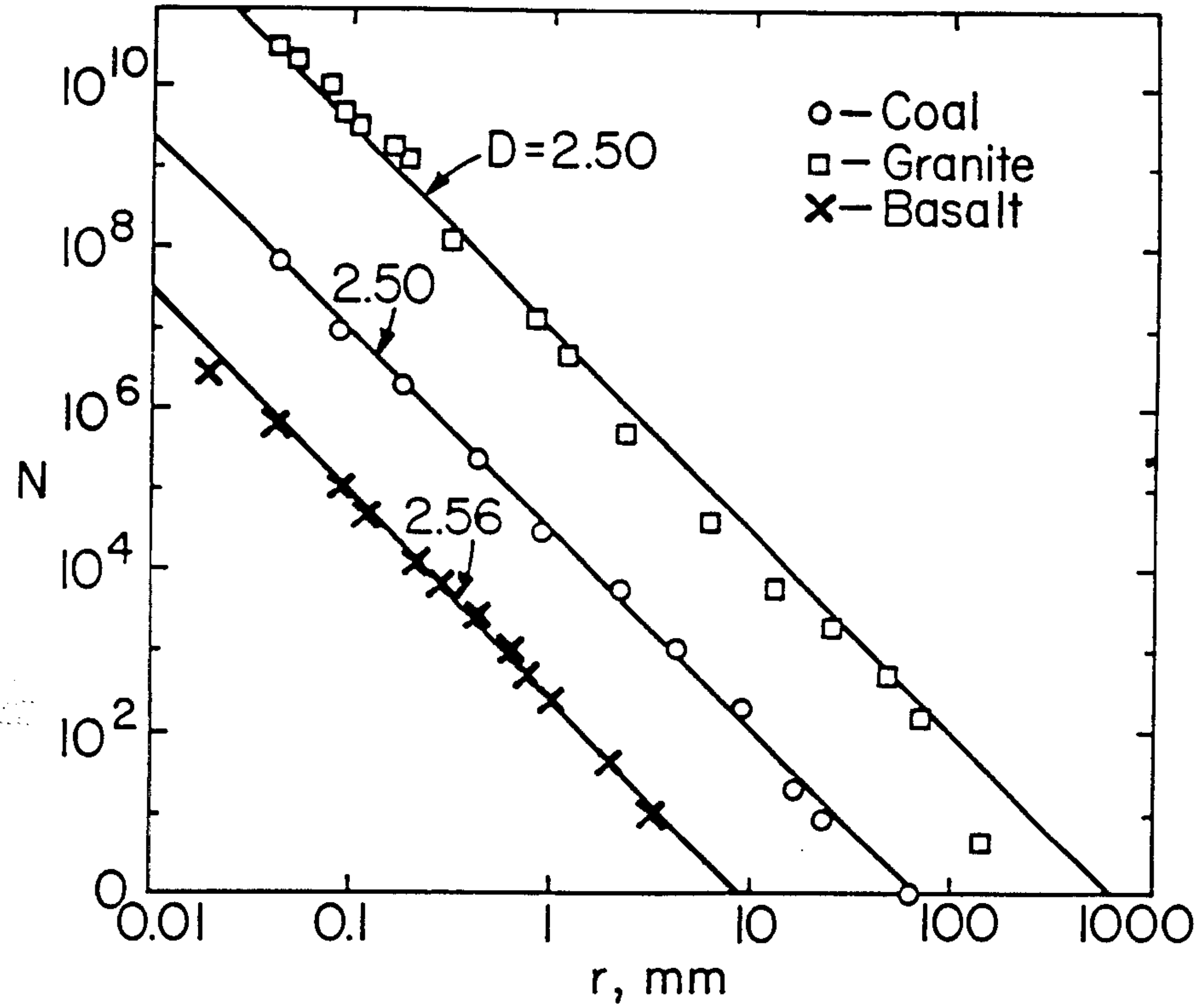


Figure 3.4. Cumulative statistics for the fragmentation model illustrated in Figure 3.3. Correlation with (2.5) gives D=2.60.



The number of fragments with radius greater than r.

(1) Broken coal (Bennett, 1936), (2) Broken granite resulting from a 61-kt underground nuclear detonation (Schoutens, 1979). (3) Imact ejecta due to a 2.6 km/s polycarbonate projectile impacting on basalt (Fujiwara et al., 1977).

Object	Reference	Fractal Dimension D
Projectile fragmentation of gabbro with lead	Lange et al (1984)	1.44
Projectile fragmentation of gabbro with steel	Lange et al. (1984)	1.71
Meteorites (Prairie Network)	McCrosky (1968)	1.86
Artifically crushed quartz	Hartmann (1969)	1.89
Disaggregated gneiss	Hartmann (1969)	2.13
Disaggregated granite	Hartmann (1969)	2.22
FLAT TOP I (chemical explosion, 0.2 kt)	Schoutens (1979)	2.42
PILEDRIVES (nuclear explosion, 62 kt)	Schoutens (1979)	2.50
Broken coal	Bennett (1936)	2.50
Interstellar grains	Mathis (1979)	2.50
Projectile fragmentation of quartzite	Curran et al. (1977)	2.55
Projectile fragmentation of basalt	Fujiwara (1977)	2.56
Sandy clays	Hartmann (1969)	2.61
Terrace sands and gravels	Hartmann (1969)	2.82
Glacial till	Hartmann (1969)	2.88
Stony meteorites	Hawkins (1960)	3.00
Asteroids	Donnison & Sugden (1984)	3.05
Ash and pumice	Hartmann (1969)	3.54

Table 1. FRACTAL DIMENSIONS FOR A VARIETY OF FRAGMENTED OBJECTS

FE
14

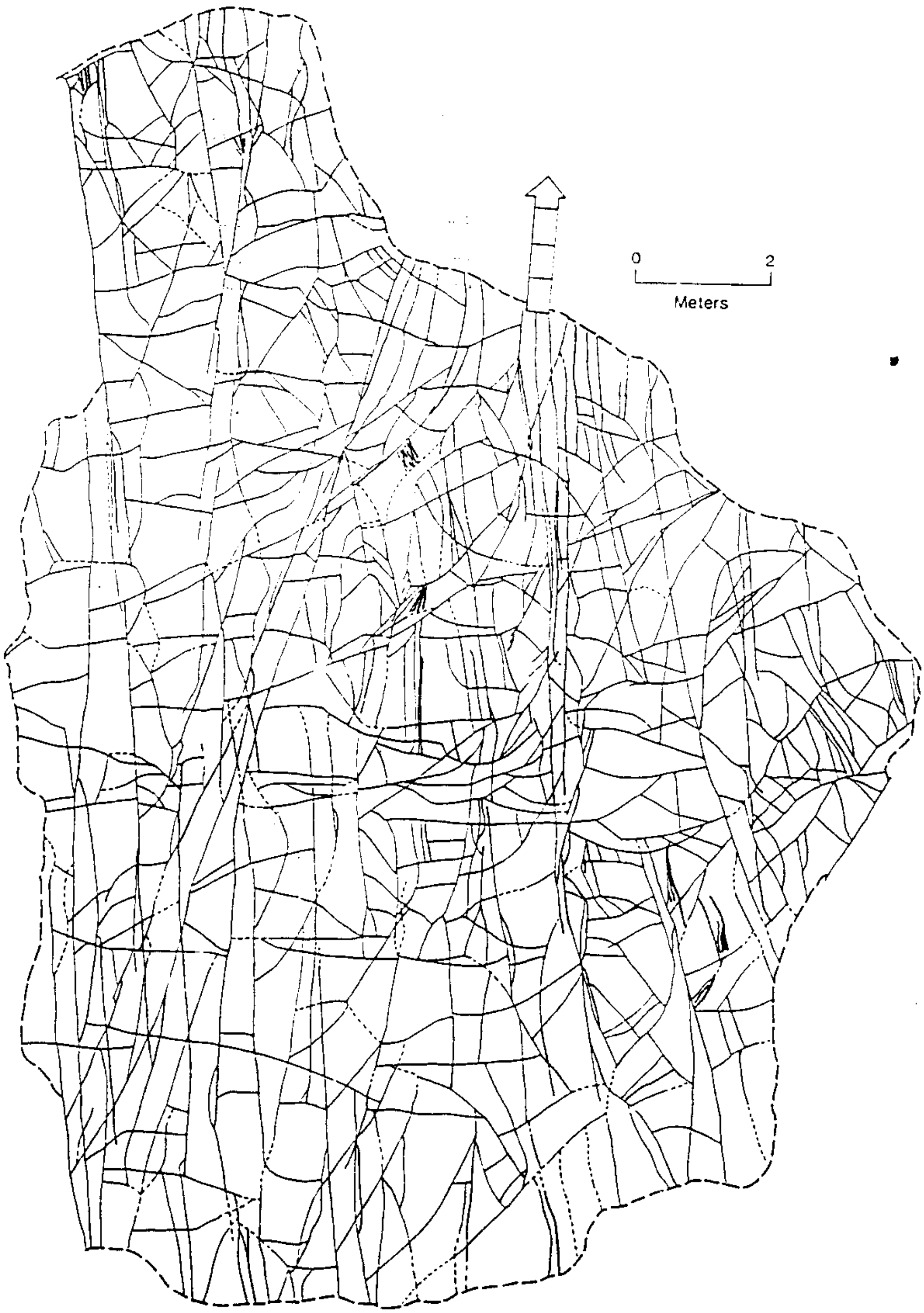
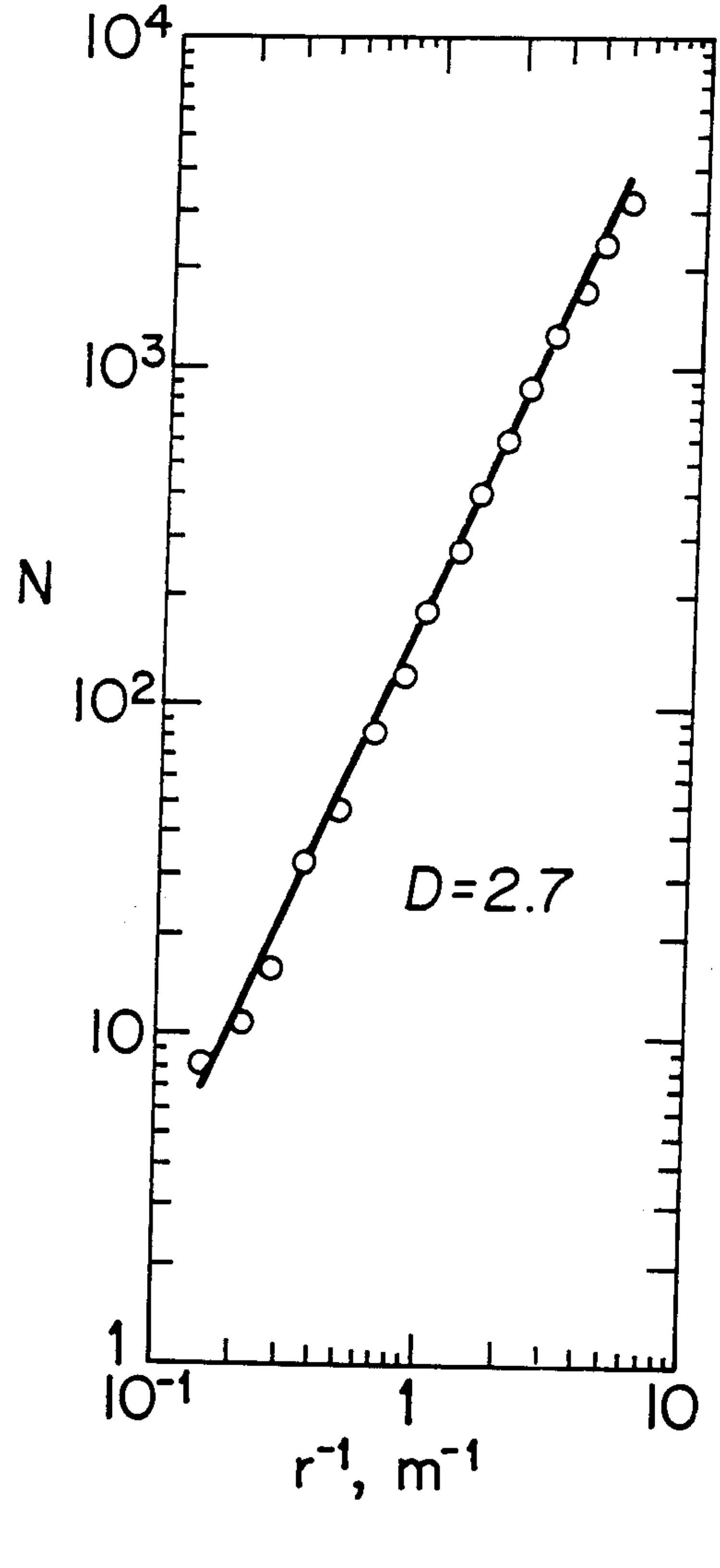


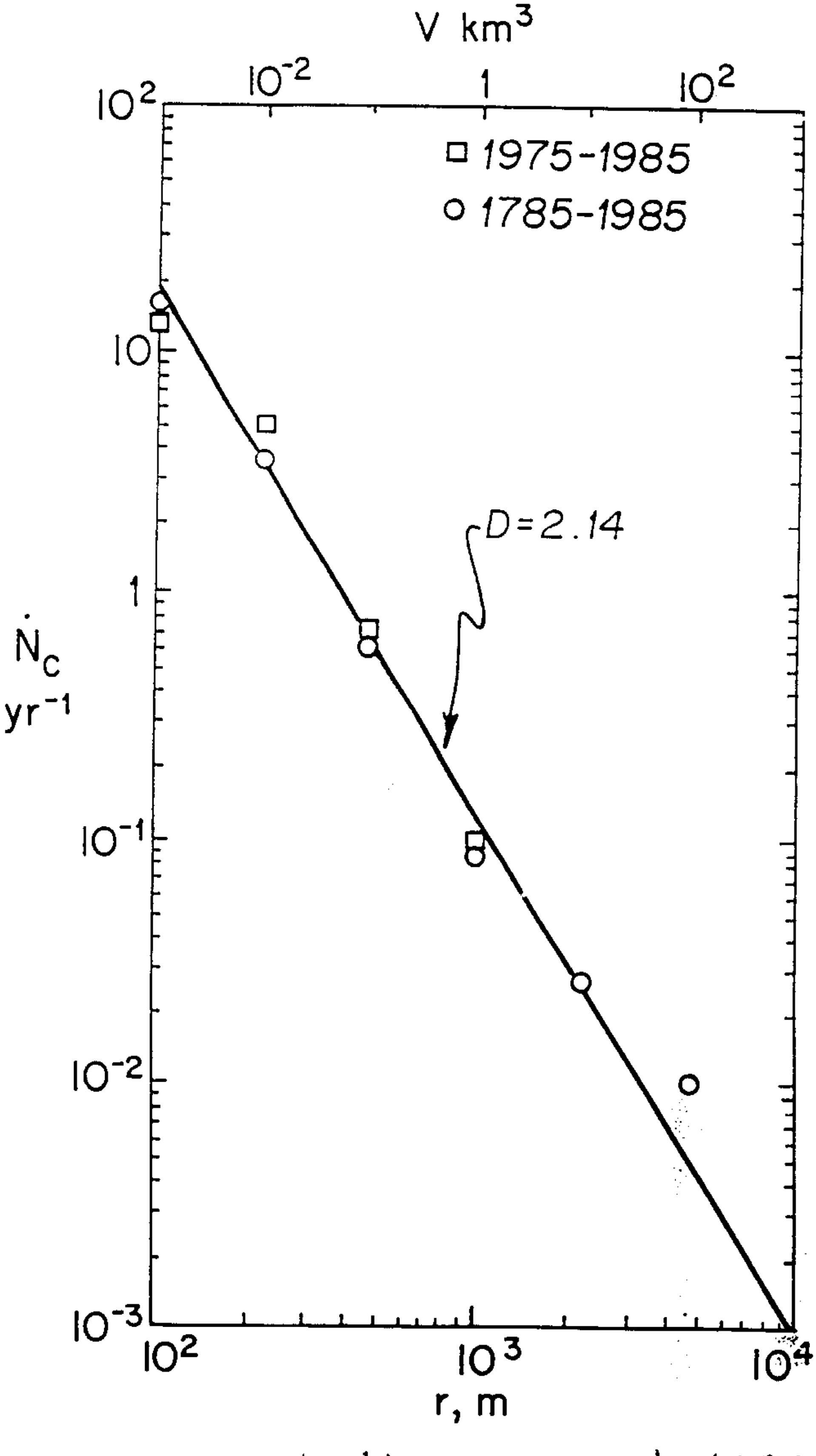
FIGURE 18. Fracture-trace map of pavement 1000, Stop 5-2, Yucca Mountain, Nevada. (Explanation shown on fig. 15) (... & Hoit, ...)

T385: 28



10^4
10^3
10^2
10
1
N
D=2.7
10^{-1}
1
10
r^{-1}, m^{-1}

E 22


V km^3
10^{-2}
1
10^2
10^2
□ 1975-1985
○ 1785-1985
10
D=2.14
1
$\dot{N}_c$
yr^{-1}
10^{-1}
10^{-2}
10^{-3}
10^2
10^3
10^4
r, m

[illegible] et al. ([illegible])