CEP

CONSULTING ENGINEERS PARTNERSHIP LTD

CONCEPT
DAYRELLS ROAD
CHRIST CHURCH
BARBADOS, W I
TEL (809) 426 5930
FAX (809) 426 5935
P O BOX 715, BRIDGETOWN

DIRECTORS

TONY GIBBS, BSc, DCT (Leeds) FICE, FIStructE, MASCE MConsE *
A E HUTCHINSON, BEng, MASc MICE MIStructE, MIPT, MCSCE *
P T SOBERS, MSc, DIC, MICE MIStructE, MASCE *
A C T FARRELL, MSc FICE, FIStructE

CONSULTANTS

D E KEY, PhD BSc, FICE FIStructE MASCE
K M JOHNSON, OBE, BSc, FICE FIWEM *
H E BROWNE, BSc(Eng) MSc MS, MICE *

Our Ref: **CEP/20185**

1993-07-28

Pan American Health Organisation
Dayrell's Road
Christ Church
BARBADOS

Attention: Dr Jean-Luc Poncelet

Dear Sirs,

Re: La Soufriere and Vieux Fort Hospital, St. Lucia

In accordance with your instructions I have examined the existing premises and the preliminary plans of the proposed Private Ward. I have also held discussions with staff of the Architectural Department (CPU) who are responsible for the design of the proposed ward.

If the existing premises are retrofitted and the Private Ward designs amended in accordance with the general guidance in my report, the Hospital should perform satisfactorily in future hazardous events - earthquakes, hurricanes, torrential rains.

I wish to acknowledge the assistance of Mr Leon of CPU, Dr Sterling Mungal of the Ministry of Health and Dr Poncelet of PAHO in the preparation of my report, which follows.

Yours faithfully,

Tony Gibbs

CONTENTS Page

1.0 INTRODUCTION

The Government of St Lucia is currently preparing plans to add a Private Ward to the existing District Hospital for La Soufriere and Vieux Fort, which is located at La Soufriere. The Pan American Health Organisation, through Dr Jean-Luc Poncelet, has funded a vulnerability analysis of the existing premises and the designs of the proposed works with a view to reducing the risk of damage to the facilities in the event of the natural hazards of earthquakes, hurricanes and torrential rains. To this end the services of Mr Tony Gibbs of Consulting Engineers Partnership Ltd were contracted to:

"1. Make a rough estimation of structural conditions of these buildings in relation to disaster resistance.

"2. Make general cost effective recommendations that could be implemented by the St Lucia Government."

2.0 HAZARDS

2.1 Earthquakes

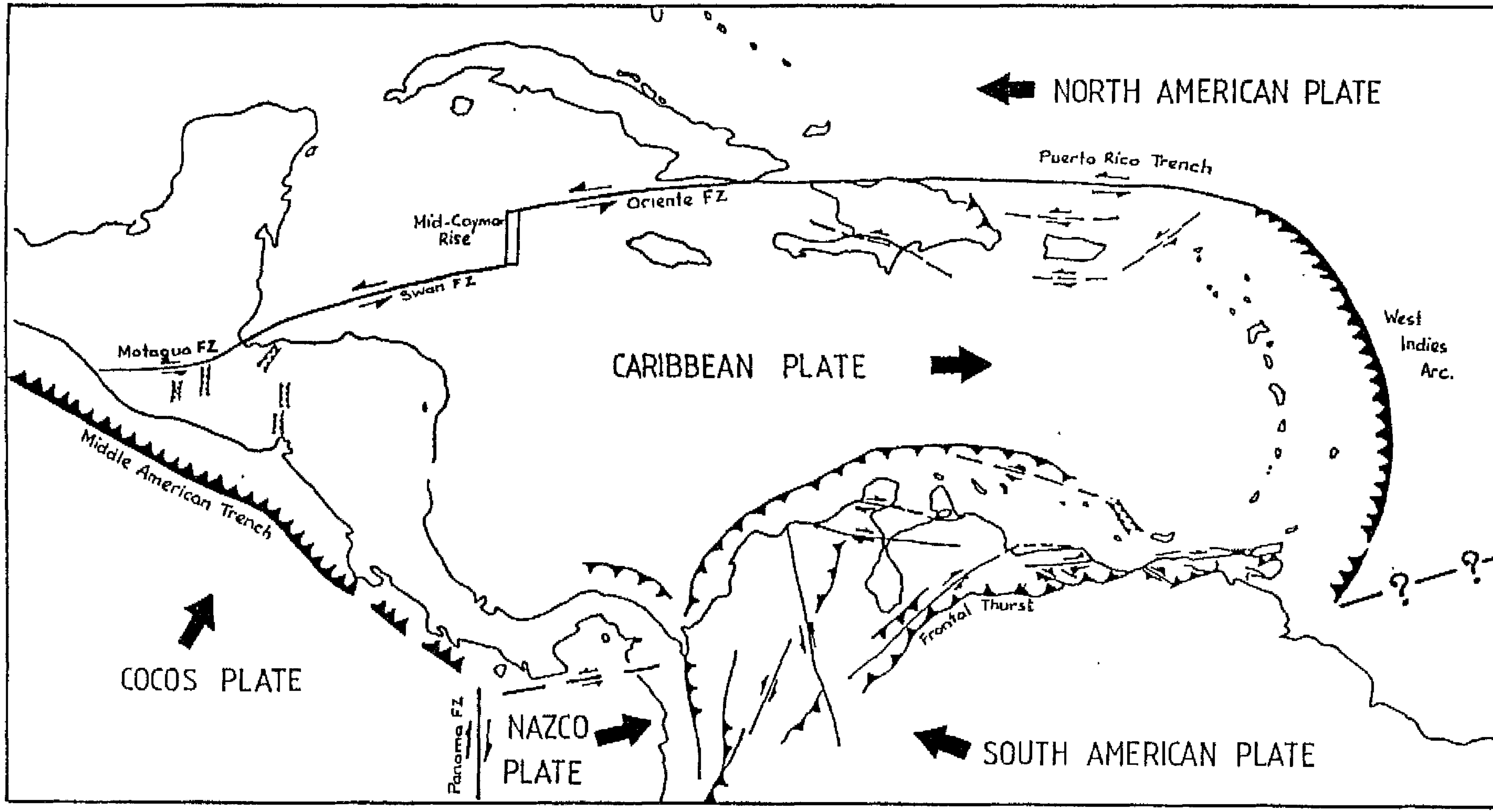
Seismic events in the Eastern Caribbean, where St Lucia is located, are principally associated with a subduction zone at the junction of the Caribbean Plate and the Americas Plate. The Caribbean Plate is moving eastwards relative to the Americas Plate at a rate of about 20mm per year. The Americas Plate dips from east to west beneath the Caribbean Plate along a north-south line approximately 150km east of St Lucia. This leads to a moderate level of inter-plate seismicity in the vicinity of St Lucia. The maximum historical intensities of earthquakes in St Lucia as reported by Dr John Shepherd (formerly of the Seismic Research Unit, UWI, Trinidad) are VII and VIII on the Modified Mercalli Scale. The Caribbean Uniform Building Code (CUBiC) recommends a Z-factor of 0.75 for St Lucia. However, a 1983 study by Faccioli, Taylor and Shepherd recommends a Z-factor of 0.5 and a design ground acceleration of less than or equal to 0.1g. This places St Lucia somewhere between zones 2 and 3 of the UBC and (old) SEAOC codes of the USA. In other words, the level of seismicity in St Lucia is moderate but sufficiently important not to be ignored.

Figures 1, 2 and 3 (at the end of this sub-section) show the tectonic setting of the Caribbean, the main physical features of the Eastern Caribbean and a cross section through the island arc.

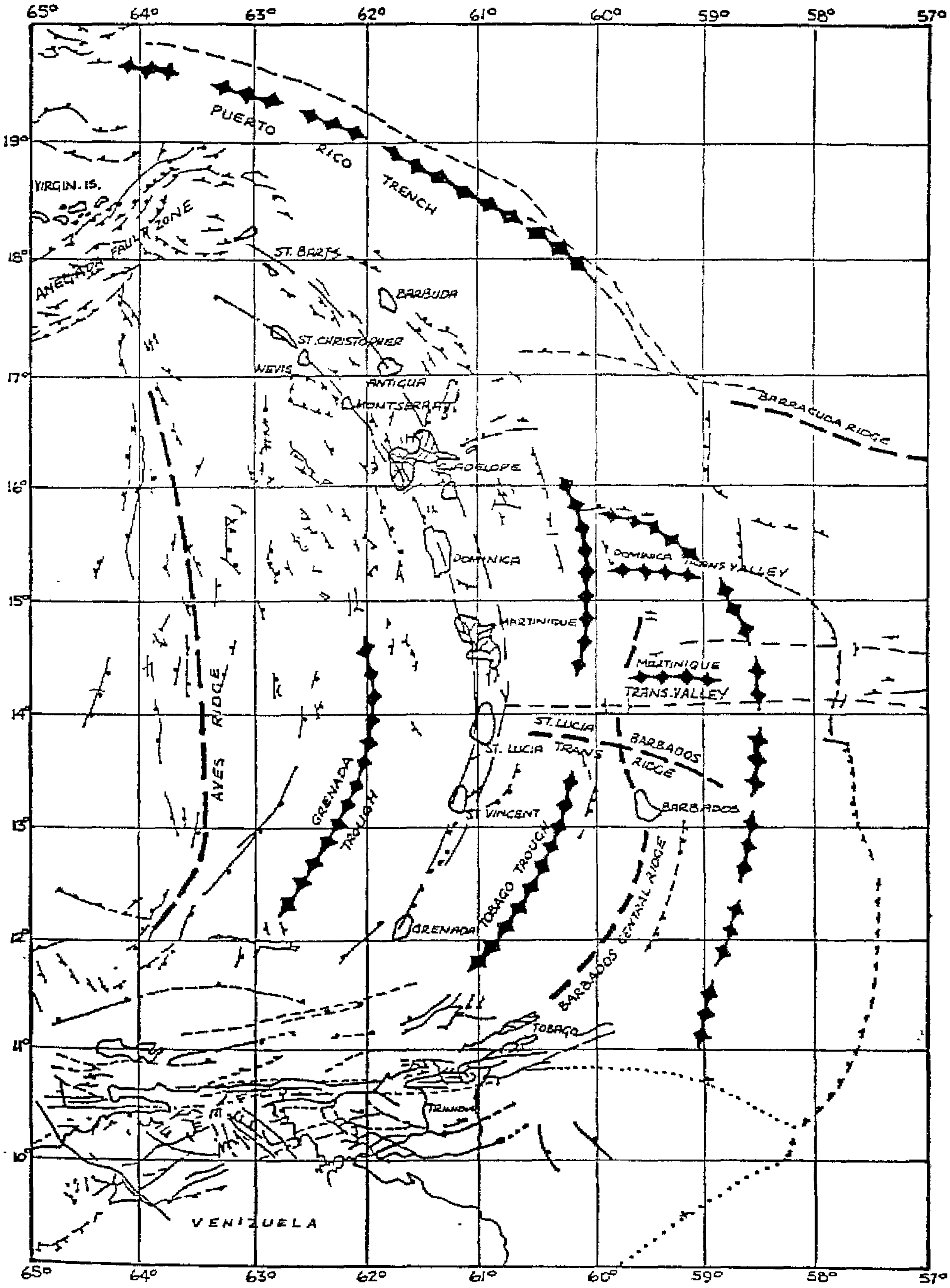
The two most recent earthquakes to have caused significant damage in St Lucia are:

19th March 1953	Richter magnitude 7.5, Modified Mercalli intensity VII in St Lucia;
16th February 1906 -	Richter magnitude 7.0, Modified Mercalli intensity VII-VIII in St Lucia. An isoseismic map of that event is reproduced in figure 4c (at the end of this sub-section).

The catastrophic Guadeloupe earthquake of 8th February 1843 produced a Mercalli-Sieberg-Cancani intensity of VII in St Lucia. An isoseismic map of that event is reproduced in figure 4b (at the end of this sub-section). Other isoseismic maps (figures 4a and 4d) are presented for the events of 11th January 1839 (Richter M=7.5-7.8, MSC=VIII) and 21st May 1946 (Richter M=7.0, MSC=VII).

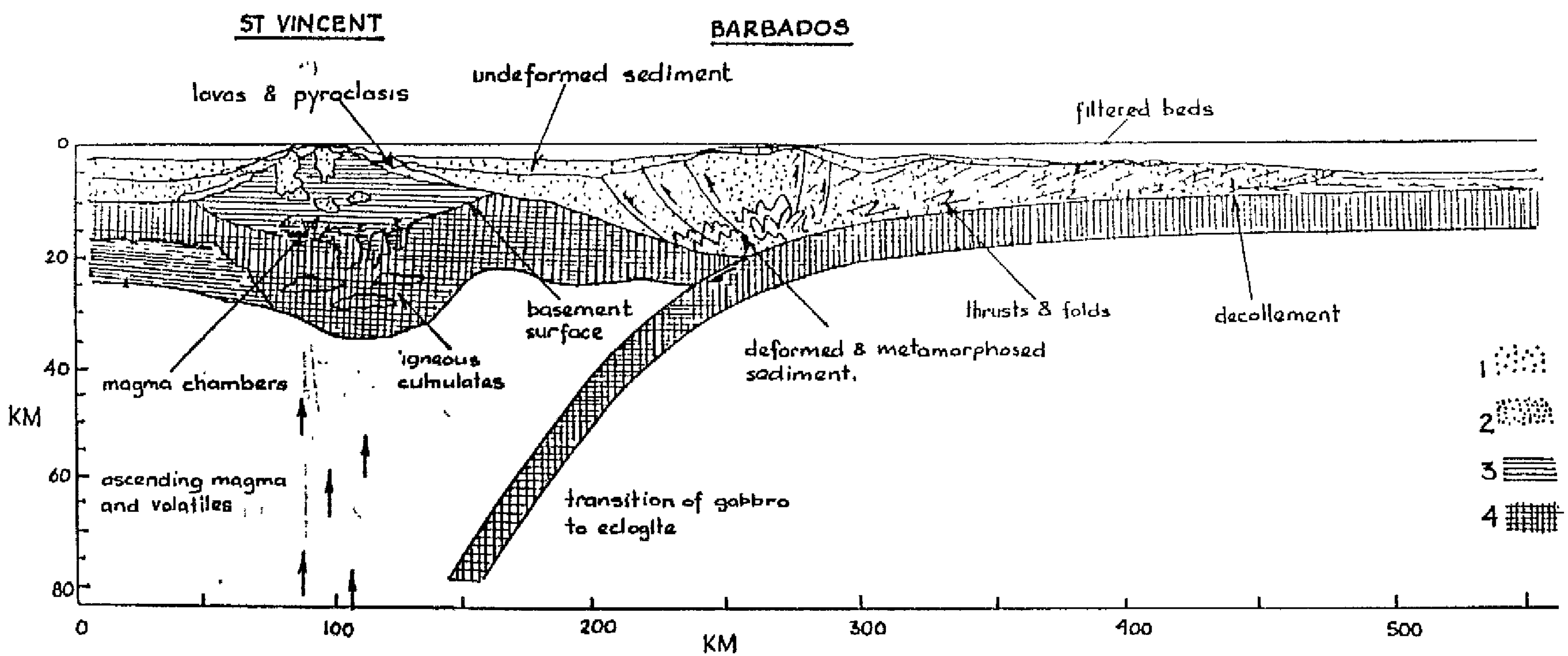


Tectonic Setting of the Caribbean
(after Molnar and Sykes, 1969)
Figure 1



Main Features of Eastern Caribbean
(based on compilation by JE Case and TA Holcomb USNOO
and from Peter and Westbrook, 1976)

Figure 2



Diagrammatic cross-section of the Eastern Caribbean island arc illustrating the structure and the processes acting on it. 1. Undeformed sediment. 2. Deformed and/or consolidated sediment. 3. Igneous crust produced by the volcanic arc. 4. Main oceanic crustal layer and lower crust of arc. Vertical exaggeration 2:1.

Structure in Region of Barbados

(Westbrook, 1970)

Figure 3

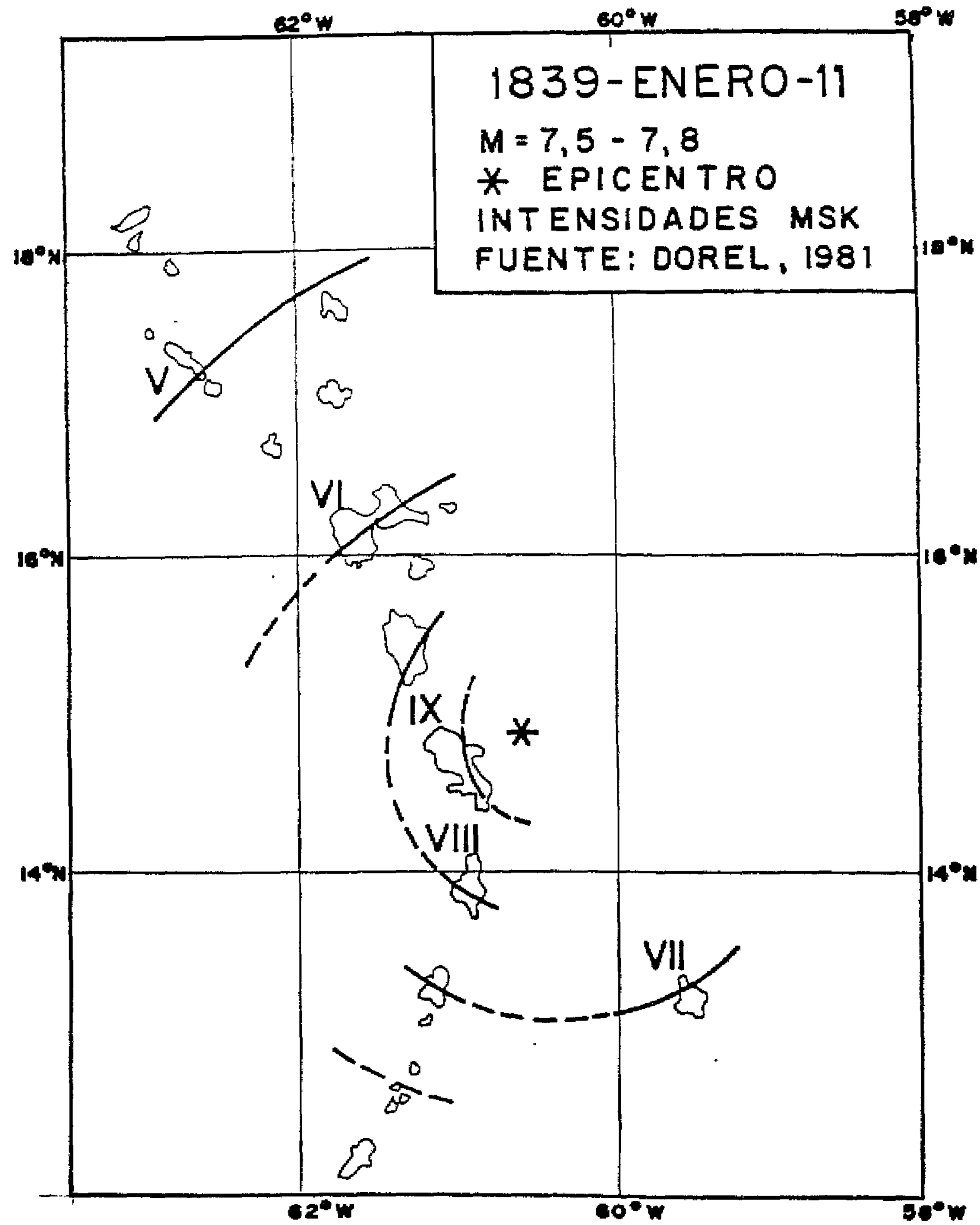

62° W
60° W
58° W
1839-ENERO-11
M = 7,5 - 7,8
✳ EPICENTRO
INTENSIDADES MSK
FUENTE: DOREL, 1981
18° N
16° N
14° N
V
VI
IX
VIII
VII
62° W
60° W
58° W

Figure 4a

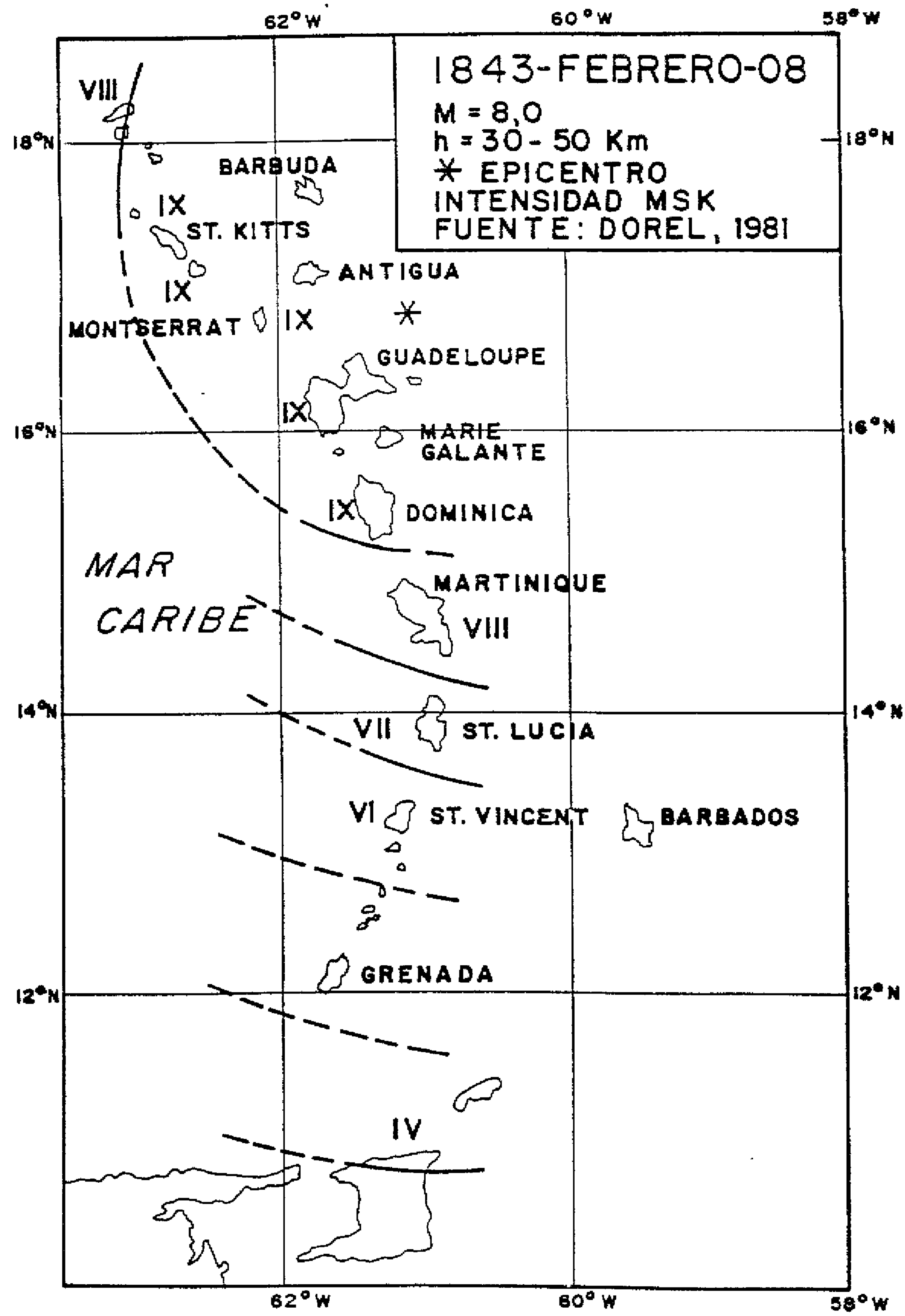

62° W
60° W
58° W
1843-FEBRERO-08
M = 8,0
h = 30 - 50 Km
✳ EPICENTRO
INTENSIDAD MSK
FUENTE: DOREL, 1981
18°N
16°N
14°N
12°N
VIII
BARBUDA
IX
ST. KITTS
IX
ANTIGUA
MONTSERRAT
IX
GUADELOUPE
IX
MARIE
GALANTE
IX
DOMINICA
MAR
CARIBE
MARTINIQUE
VIII
VII
ST. LUCIA
VI
ST. VINCENT
BARBADOS
GRENADA
IV

Figure 4b

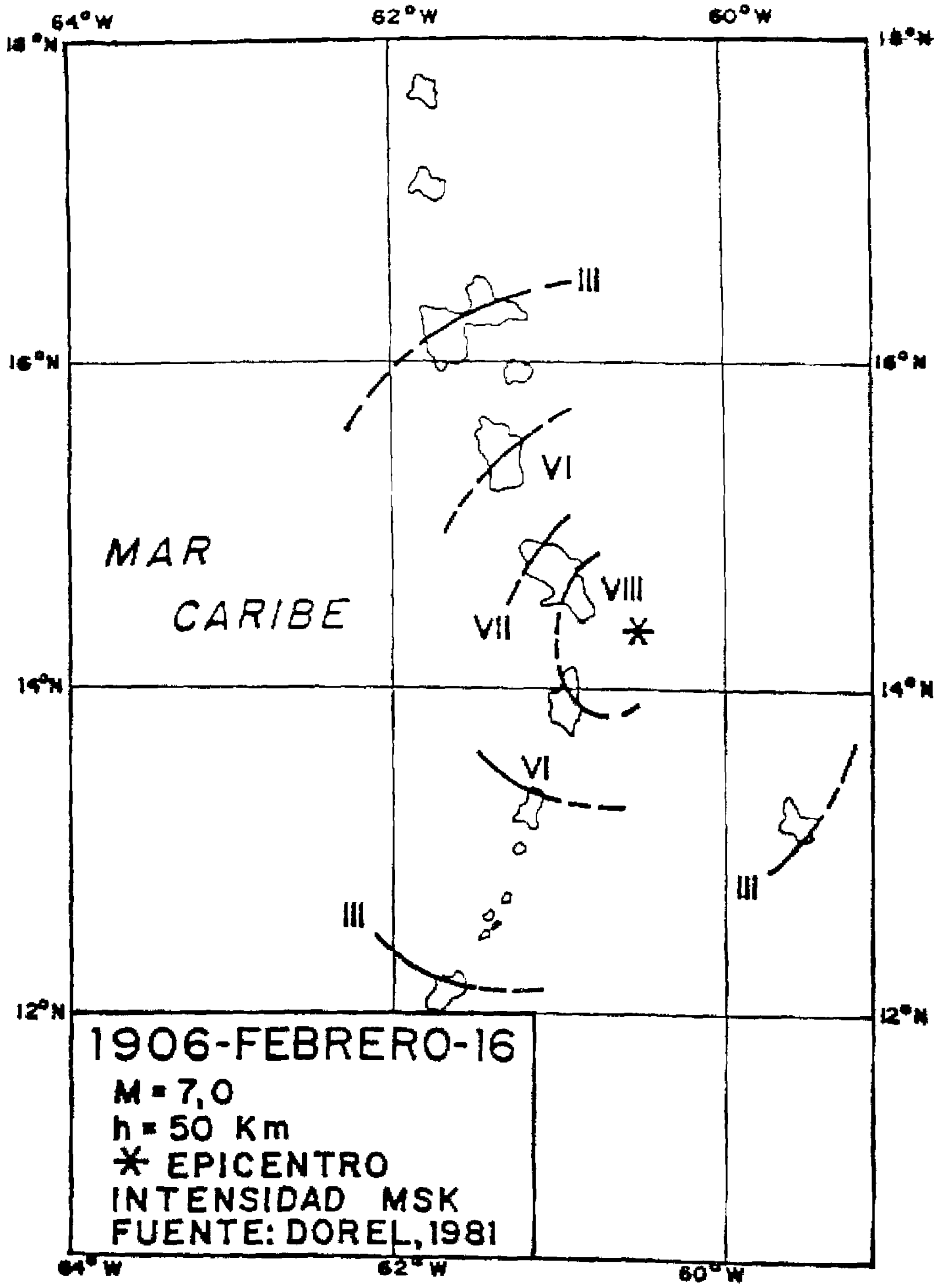
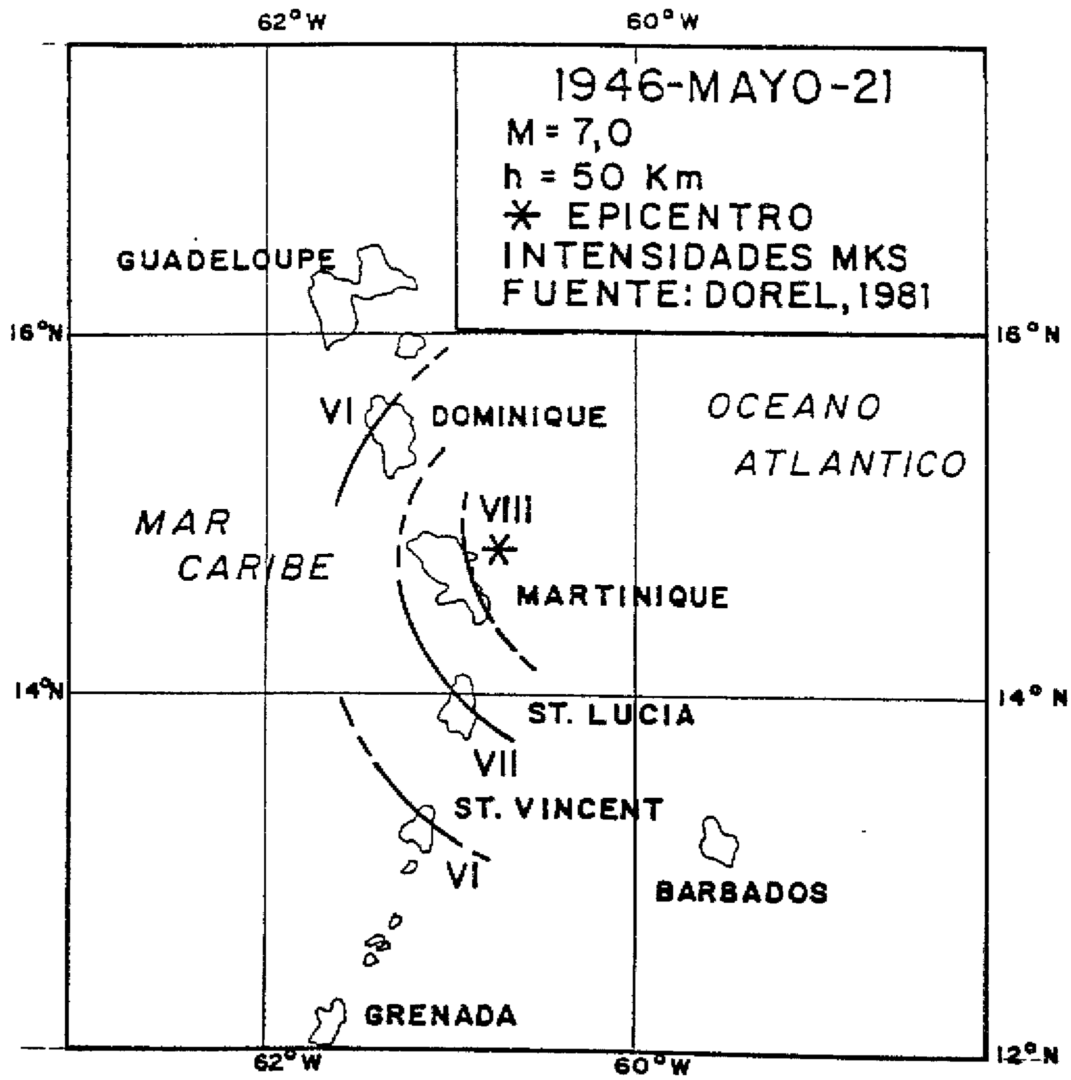

64° W
62° W
60° W
18° N
16° N
14° N
12° N
III
VI
VII
VIII
MAR
CARIBE
VI
III
III
1906-FEBRERO-16
M = 7,0
h = 50 Km
✳ EPICENTRO
INTENSIDAD MSK
FUENTE: DOREL, 1981

Figure 4c



62° W
60° W
1946-MAYO-21
M = 7,0
h = 50 Km
* EPICENTRO
INTENSIDADES MKS
FUENTE: DOREL, 1981
GUADELOUPE
16°N
16° N
VI
DOMINIQUE
OCEANO
ATLANTICO
VIII
MAR
CARIBE
MARTINIQUE
14°N
14° N
ST. LUCIA
VII
ST. VINCENT
VI
BARBADOS
GRENADA
62° W
60° W
12° N

Figure 4d

2.2 Hurricanes

St Lucia lies in the North Atlantic Ocean, one of the six main tropical areas of the earth where hurricanes may develop every year. In its April 1991 Information Bulletin, the Caribbean Cyclone-Resistant Housing Project (UWI) states that over 4000 tropical storms have occurred in the region within the past 500 years, half of which developed into hurricanes. A general historical record of those hurricanes affecting St Lucia from the seventeenth century to 1980 is given in Table 1 (at the end of this sub-section).

Cyclones are formed when an organised system of revolving winds, clockwise in the Southern Hemisphere and anti-clockwise in the Northern Hemisphere, develop over tropical waters. The classification of a cyclone is based on the average speed of the wind near the centre of the system. In the North Atlantic they are called tropical depressions for wind speeds up to 17 metres per second (m/s). Tropical storms have wind speeds in the range 18 m/s to 32 m/s. When the wind speeds exceed 32 m/s the system is called a hurricane.

A hurricane is a low-pressure, large-scale weather system. It derives its energy from the latent heat of condensation of water vapour over warm tropical seas. In order to develop, a hurricane requires a sea temperature of at least 26°C which must be maintained for several days for the system to sustain itself. A large expanse of sea surface is required for the formation of a hurricane, about 400 kilometers (km) in diameter. A mature hurricane may have a diameter anywhere from 150 km to 1000 km with sustained wind speeds often exceeding 52 m/s near the centre with still higher gusts.

A unique feature of a hurricane is the eye. The system of revolving winds does not converge to a point, but becomes tangential to the wall of the eye at a radius of 8 to 12 km from the geometric centre of the disturbance. The eye is an area of light winds, thin cloud cover and the lowest barometric pressure. The eye provides a convenient frame of reference for the system and can be tracked with radar, aircraft or satellite. Figure 5 (at the end of this sub-section) shows the variations of wind speed and barometric pressure with distance from the eye of the hurricane.

In Figures 6 and 7 (at the end of this sub-section) are presented a probability chart and table (CCRHP-UWI) of cyclone risk in a 2-degree square (approximately 220 km x 220 km) centred on Barbados. The statistics for St Lucia are not readily available but are likely to be very similar to those for Barbados. It is estimated that the probability of a direct hit on St Lucia is about 65% of the probability of a passage through the 2-degree square as shown on figures 6 and 7.

The destructive potential of a hurricane is significant due to high wind speeds, potential torrential rains which produce flooding and occasional storm surges with heights of several metres above normal sea level.

The Saffir-Simpson scale is often used to categorize hurricanes based on wind speed and damage potential. The following five categories of hurricanes are recognized:

Category	Wind Speed m/s	mph	Damage
HC1	33 - 42	74 - 95	Minimal
HC2	43 - 49	96 - 110	Moderate
HC3	50 - 58	111 - 130	Extensive
HC4	59 - 69	131 - 155	Extreme
HC5	>69	>155	Catastrophic

The Caribbean Uniform Building Code and the BNSI/NCST/OAS/BAPE Wind Code set out the basic wind parameters for the design of buildings in St Lucia. The normal requirement is the 1-in-50-year wind, ie a wind speed which on average is not expected to be exceeded more than once in 50 years. In St Lucia this produces a basic 3-second gust wind speed of 58 m/s. This represents a category 3 hurricane. For a category 4 hurricane, a wind speed is experienced which on average is not expected to be exceeded more than once in 100 years. The 1-in-200-year wind is experienced in a category 5 hurricane.

ST LUCIA

1600-1700

October 23 or 24, 1694

1700-1800

June 12-14, 1780
October 10-18, 1780 - "Great Hurricane"

1800-1900

October 23, 1817
October 21, 1818
September 21-22, 1819
October 13-15, 1819
July 9, 1837
October 6, 1841

1900-1980

September 2-5, 1951
October 30 - November 6, 1956 - heavy swells from "Greta" to west-northwest
July 10, 1960 - "Abby" - destruction most severe in memory
September 25, 1963 - "Edith" - $3,465,000 in damages
September 5-22, 1967 - "Beulah" - torrential rains; $3 million in damages
August 4, 1980 - Hurricane "Allen"

Table 1

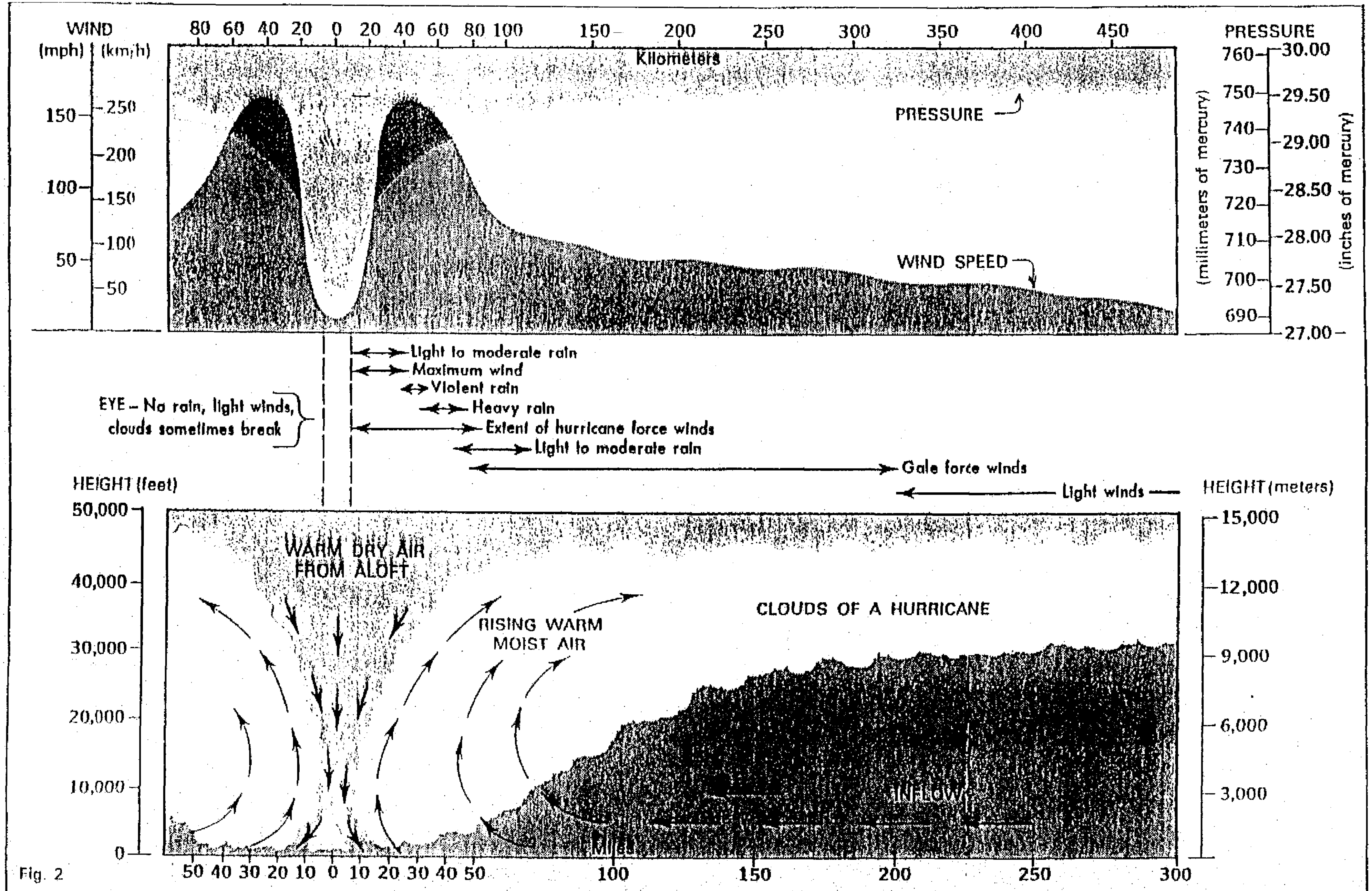


Fig. 2

upper chart shows:
Variations of Wind Speed and Barometric Pressure with distance from the eye of the hurricane

Figure 5