COURS INTENSIF EUROPEEN
19-22 MAI 1992

EUROPEAN INTENSIVE COURSE
19-22 MAY 1992

Prévention des risques d'érosion et de submersion littoraux: la connaissance du risque, les études d'impact en vue des travaux de protection

Prevention of coastal erosion and submersion risks: knowledge of the risk, impact studies with a view to protection works

----

Organisé par le Centre Européen sur les Risques Géomorphologiques
Organised by the European Centre on Geomorphological Hazards

Sous la Direction de
Directed by

Professeur Jean-Claude FLAGEOLLET

Avec le Concours de
With the support of

- Conseil de l'Europe: Accord Partiel Ouvert Risques Majeurs
- Ministère de l'Environnement: Délégation aux Risques Majeurs
- Direction Régionale à l'Environnement, Basse- Normandie
- Direction Départementale de l'Equipement du Calvados
- Université de Caen: Laboratoire de Géologie marine

THE BESSIN CLIFFS

O. MAQUAIRE, Centre Expérimental du Bâtiment et des Travaux Publics
Laboratoire de Tours

The Bessin cliffs in Normandy consist of a succession of calcareous and marly formations. These formations are affected by large-scale tectonic fracturing (Hachettes fault, anticline bulge, etc...).
These tectonic deformations result in great variability of the lithological profile and, in particular, the relative thicknesses between the Bessin limestones and Port marls (Fig.1).

This variability largely accounts for the diversity, in terms of both form and volume, of the many terrain movements observed, which may be :
- overhang collapses;
- small circular slides;
- major slides of the planar type with collapse at the rear;
- slides due to flowage of marls at the toe.

The Porifera limestones countain extensive confined groundwater, particulary in the Port en Bessin area, where it circulates via a well-developed karstic network (Fig.2).
This network is connected with the disappearance of the Auge 3km south of Port en Bessin, whose waters re-emerge in the port and for 1.7 km along the coast as far as Goulette de Vary, in three main zones.

THE LANDSLIDE OF LE BOUFFAY AND THE PROBLEMS INVOLVED IN INTERPRETING IT

On 5 August 1981, a major landslide, with collapse of the plateau at the rear and compression of the tidal flat in front, propelled into motion 1.5 million tonnes of terrain in the space of few minutes (Fig.3).

The horizontal displacement was 20 metres. At the rear, vertical displacement due to collapse of the plateau in normal faults was as much as 25 metres. In front, the marls were affected by various compressive deformations, overlapping flat shearing strains and folds, which raised the foreshore in places by as much as 7 to 8 metres (Fig.4) .

The kinematics of the slide made it possible to develop models for stability calculations and test their validity a posteriori.
The two caculation models used produced very similar results (Fig.5) :

1) model of a non-circular slide with a low curve radius at the base

2) model developed according to the classical method of thrust at the rear,

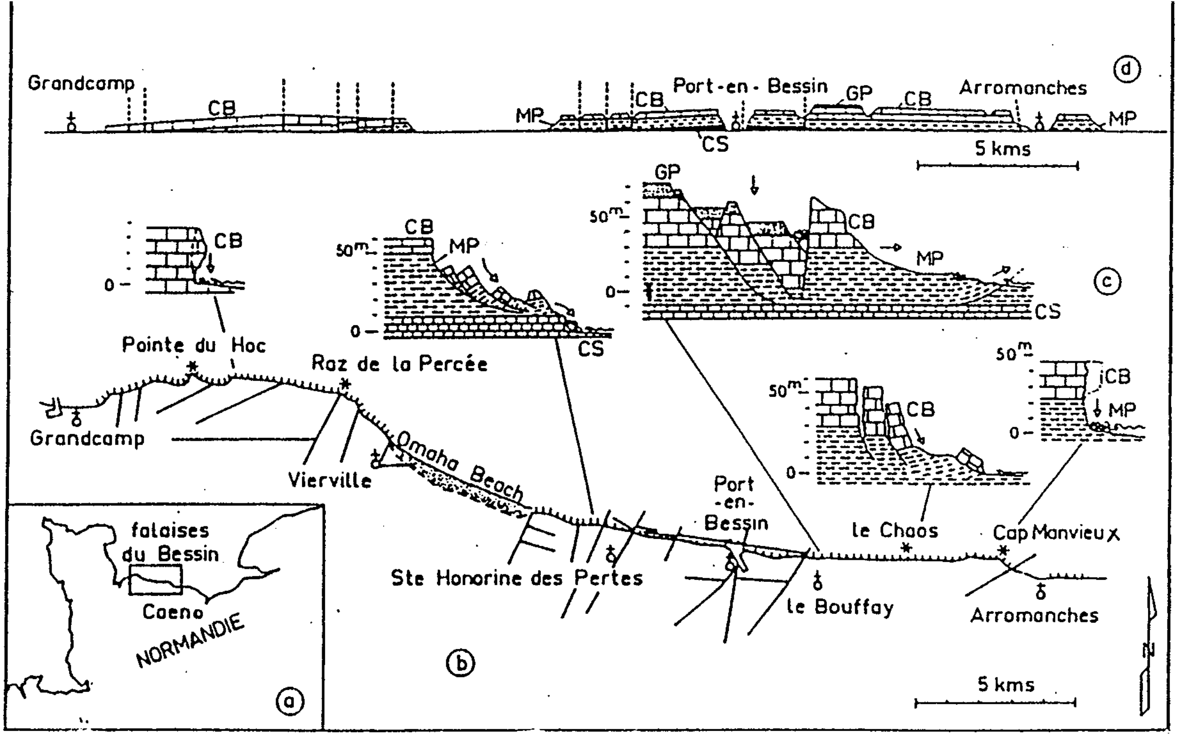


Fig.1 Location and geomorphology of the cliffs in the Bessin Area
1a. Location of the Bessin Cliffs
1b. Simplified map: location of the cliffs and of the main faults
1c. Morphology of the main types of terrain movements affecting the lithological succession of the Bessin cliffs; CS = Porifera limestone; MP = Portmarls; CB = Bessin limestone; GP = Le Planet sandstone
1d. Schematic profile of the Bessin cliffs, parallel to the coast line showing variations of the lithological profile.

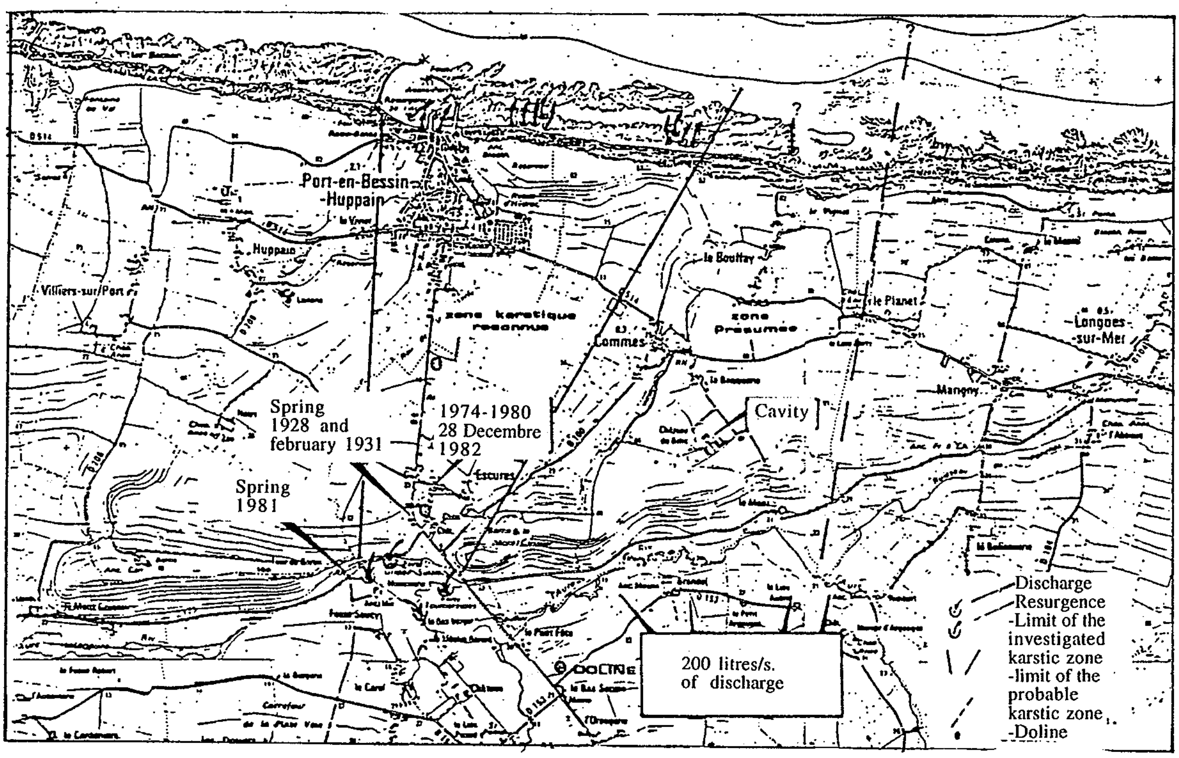


Fig2 Karstic phenomena and their consequences in the Port en Bessin area

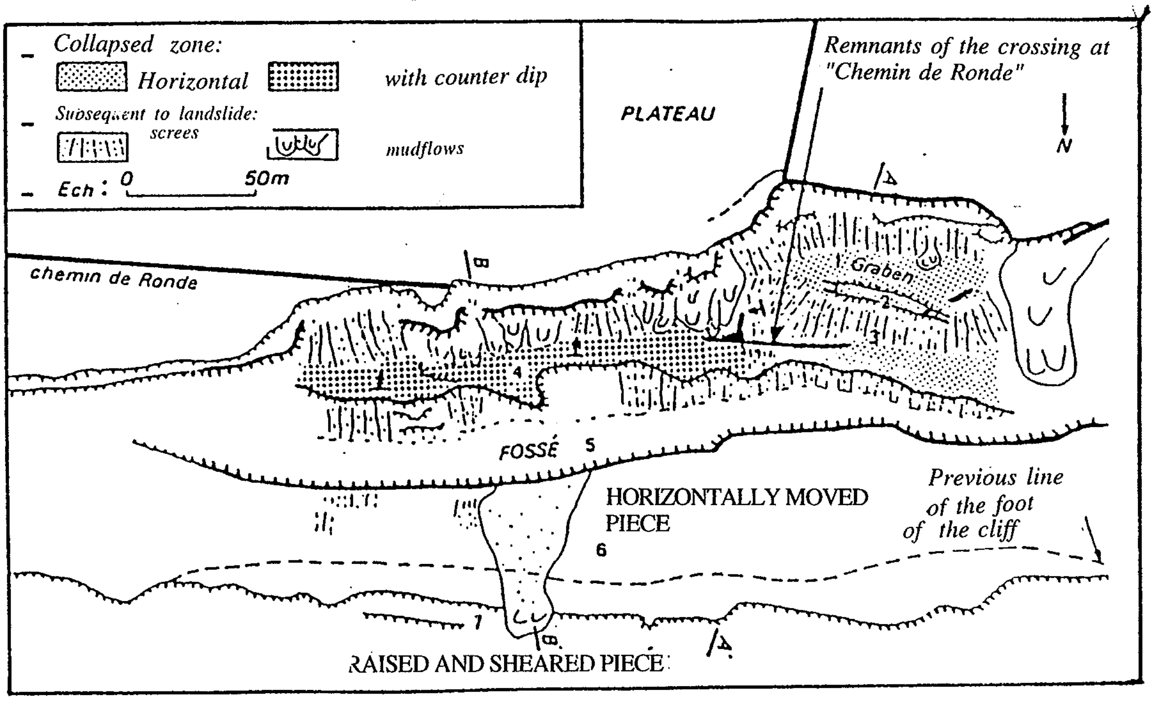
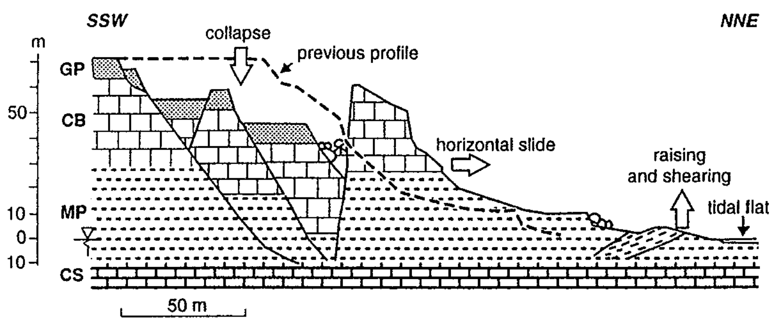


Fig.3 Morphology of the Le Bouffay landslide



O. Maquaire . P. Gigot (France)

Fig. 4 Geological and geomorphological profile of the cliff of " Le Bouffay" (Bessin)

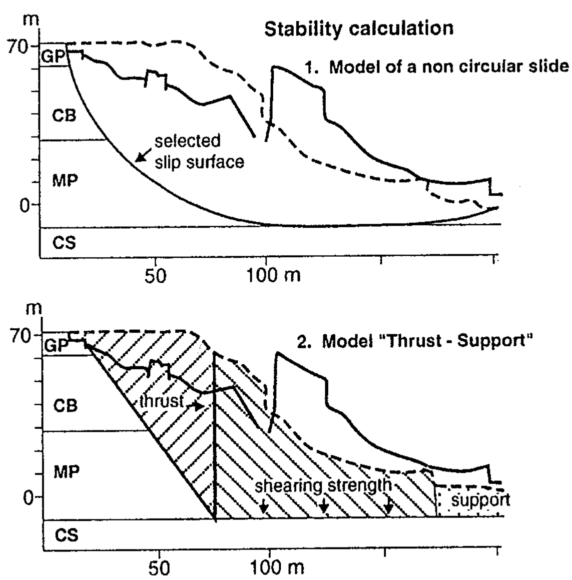
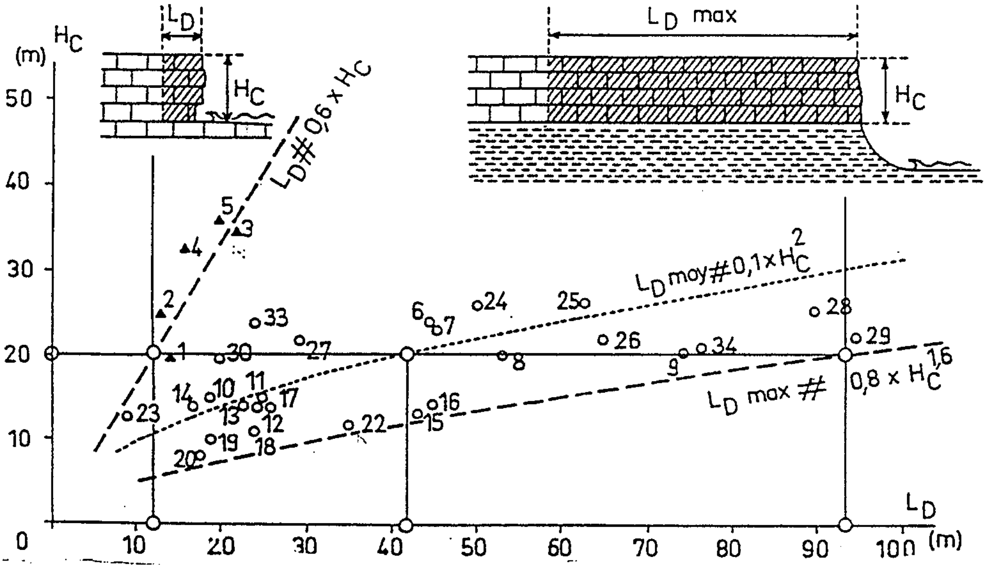


Fig. 5 The two types of tested calculation models



6 Relationship between the decompressed strip the thickness of the calcareous ledge, blished from 34 seismic measurement profiles. iles 1 to 5 : Calcareous cliff without marly tratum.Profiles 6 to 34: calcareous ledge lying marly substratum; = Width of decompressed strip.HC = Height of areous cliff or ledge. cerning a calcareous cliff without marly tratum, the decompressed width rises in a r way according to the height of the limestone that is to say LD# 0.6. Hc.

Concerning a cliff constitued by a limestone ledge overlying marls, the decompressed width is much more important because of the influence of the marly substratum on the decompression. The obtained medium value is LD max # 0.1 Hc'. Following the current evolution of the cliffs, decompression does not reach in every point the same stage of evolution and it explains the great scattering of the values of the decompressed width. For these reasons and in expectation of forecast, it is to be desired that one keeps the maximum limit of the obtained points, limit which is LD max # 0.8 HC.

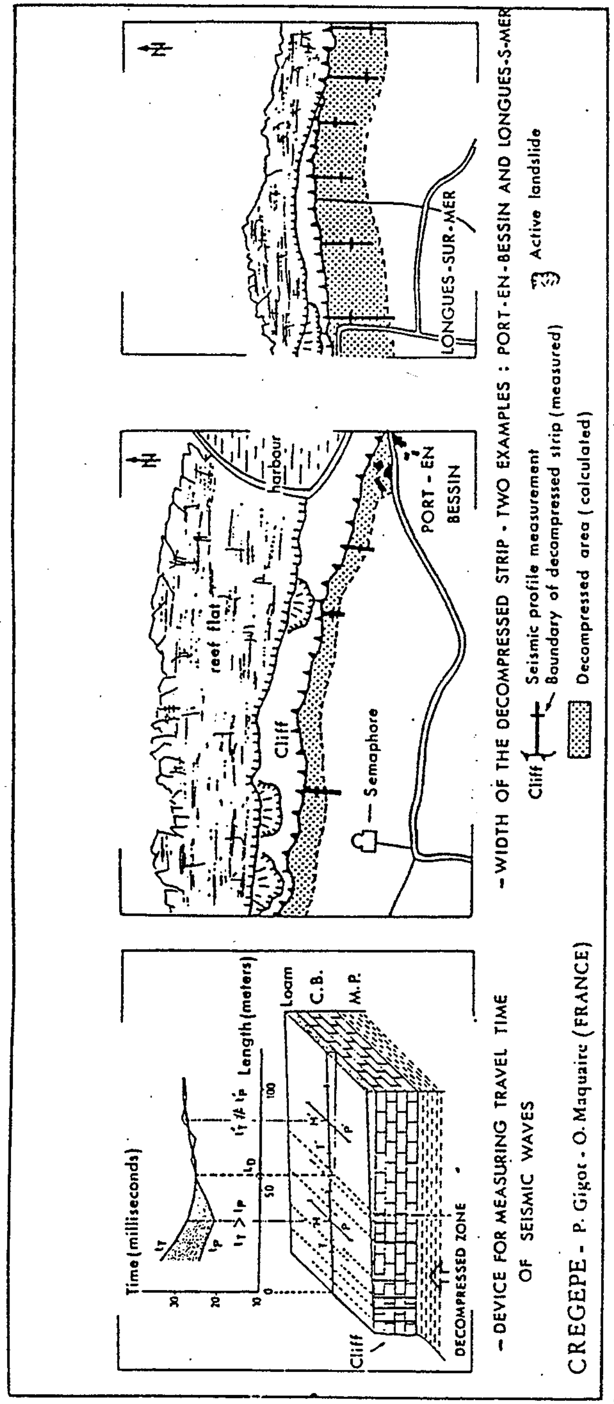


Fig.7 An exploration seismic refraction study of decompression behind the Bessin cliffs

support at the front and planar sliding in the middle.

The calculations showed that instability is achieved by taking into account characteristics close to the residual characteristics, which is surprising because the le Bouffay landslide is not the resumption of an earlier landslide.

It is therefore believed that a slow reworking (flowage) of the marls, leading to decompression of the overlying Bessin limestones, may have subtantially impaired the mechanical strength of the marls and brought it down to the level of the residual characteristics.

This phenomenon of decompression was discovered by seismic refraction, as was the width of the decompressed strip in the limestone.

ANALYSIS OF THE DECOMPRESSED WIDTH BY SEISMIC REFRACTION

Decompression may be identified by measuring the travel time of a seismic wave between two points located at ground level (Fig.6).

The wave is slowed down when it travels perpendicularly to open cracks. Parallel to the cracks, however, it travels, without encountering them, at a speed virtually identical to that which would be measured over the same, non fissured series.
The practical exercise consisted in evaluating the anisotropy of the speeds at various distances from the edge of the cliff along profiles perpendicular to it.

Comparison of the travel times parallel and transversely to the cliff shows :
- in the non-decompressed zone, virtually equal transversal and parallel shooting times;
- in the decompressed zone, considerably longer transversal shooting times.

Thirty-four profiles were made. The width of the decompressed zone varies from 10 to 95 m.
The relationship between the decompressed width and the morphology of the cliff depends on two parameters (Fig.7) :

- the presence or absence of marls at the foot of the cliff;
- the thickness of the limestone ledge.

For forecasting purposes, we think it desirable to adopt the maximum number of points obtained. By way of an example, in the case of a limestone ledge 20m thick overlying marls, one can forecast a maximum decompressed width of around 95m.

These figures clearly demonstrate the scale of the decompressed area and emphasise the great influence exerted by the presence of marls on decompression of overlying limestone.