DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
KAGAWARAN NG KAPALIGIRAN AT LIKAS YAMAN

BAGONG PILIPINAS

MEMORANDUM

TO/FOR : **The Undersecretary**
Field Operations - Luzon, Visayas, and Environment

The Director
Mines and Geosciences Bureau
Environmental Management Bureau

The OIC Director
Policy and Planning Service

FROM : **The Undersecretary**
Policy, Planning and International Affairs

SUBJECT: **DIRECTIVES OF THE SECRETARY DURING EXECOM MEETING NO. 2024-07 HELD ON 20 FEBRUARY 2024 REGARDING THE UPDATE ON THE KARST STUDY IN RELATION TO THE MORATORIUM LIFTING OF ECC IN BORACAY**

DATE : MAR 0 1 2024

In the discussion of the agenda regarding the Update on the Karst Study in relation to the Moratorium lifting of ECC in Boracay, during Executive Committee Meeting No. 2024-07 held on 20 February 2024, the Secretary instructed the following:

1. Make Engineering Geological and Geohazard Assessment (EGGA) a precondition in the issuance of ECC. The EGGA Report must be reviewed by the MGB and EMB
2. PENRO and CENRO/MENRO to be included in the Levelling Off Meeting with the Aklan LGU to be held in the 1st week of March 2024.
3. Explore possible collaboration with the DPWH regarding the engineering solutions specifically on guidance to building codes and possible public infrastructure. These interventions can be introduced to sustainably manage the ecotourism sites.
4. On the first slide of the presentation on the Integrated Geologic, Geophysical, and Coastal Vulnerability Assessment of Boracay Island, under the Conclusion and Recommendations (Slide No. 29), interchange the positions of bullet one which focuses on the recommendation of minimizing sinkhole risks in Boracay's karts areas through cost-effective drainage control and bullet two which underlines EGGA as a precondition and an additional requirement of the Environmental Impact Assessment (EIA) process prior to the issuance of the Environmental Compliance Certificate (ECC).

5. Explore a possible collaboration with LGU (Governor and Mayor), MPDO, PPDO, MENRO, CENRO on coming up with a comprehensive plan for areas that are sensitive to specific environmental conditions.
6. Summarize and list down issues and possible interventions to be presented to LGUs (Governor and Mayor), MENRO, CENRO, DOT, and other concerned offices/agencies.

Relative thereto, please submit report of compliance to the above-cited directives to the Office of the Chief of Staff via email to osec@denr.gov.ph, copy furnished ouppia@denr.gov.ph, and policy@denr.gov.ph.

ATTY. JONAS R. LEONES

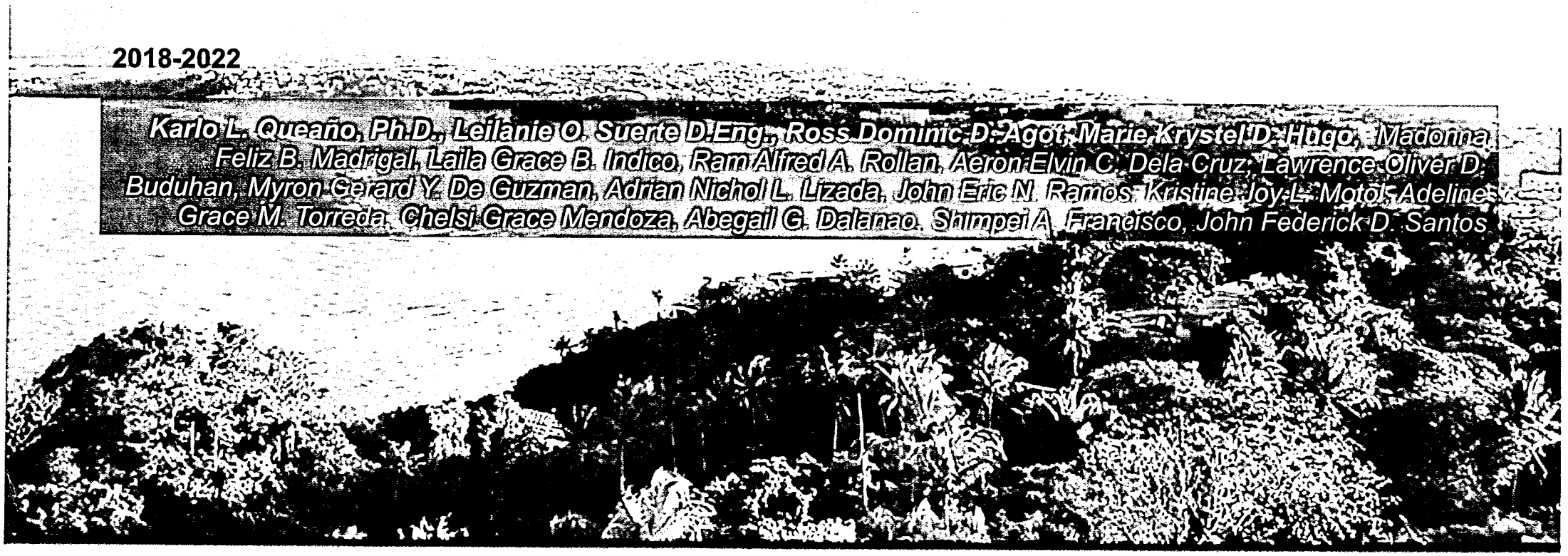
MEMO NO. 2024 - 204

MINES AND GEOSCIENCES BUREAU

Integrated Geologic, Geophysical, and Coastal Vulnerability Assessment of Boracay Island

2018-2022

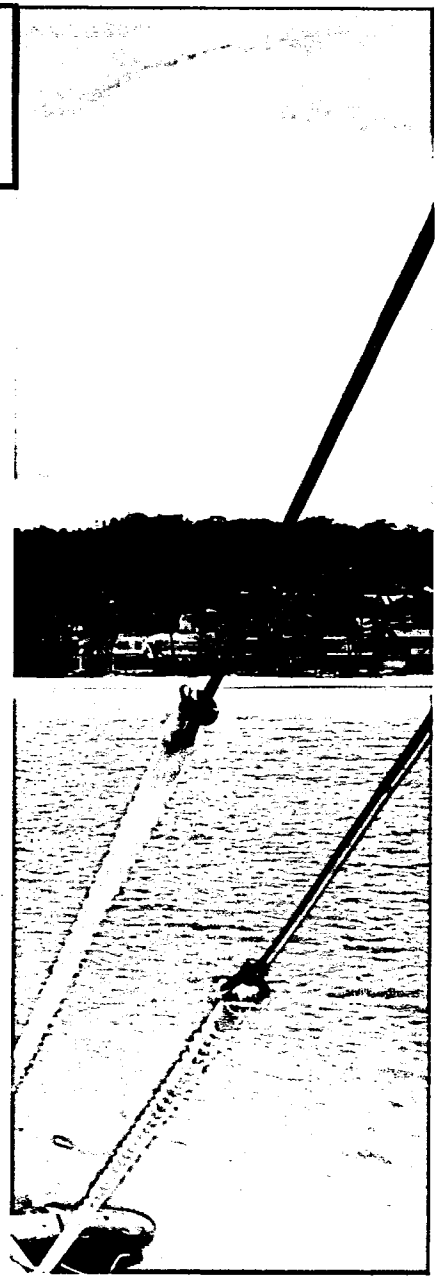
Karlo L. Queaño, Ph.D., Leilanie O. Suerte D.Eng., Ross Dominic D. Agot, Marie Krystel D. Hugo, Madonna Feliz B. Madrigal, Laila Grace B. Indico, Ram Alfred A. Rollan, Aeron Elvin C. Dela Cruz, Lawrence Oliver D. Buduhan, Myron Gerard Y. De Guzman, Adrian Nichol L. Lizada, John Eric N. Ramos, Kristine Joy L. Motol, Adeline Grace M. Torreda, Chelsi Grace Mendoza, Abegail G. Dalanao, Shimpei A. Francisco, John Federick D. Santos

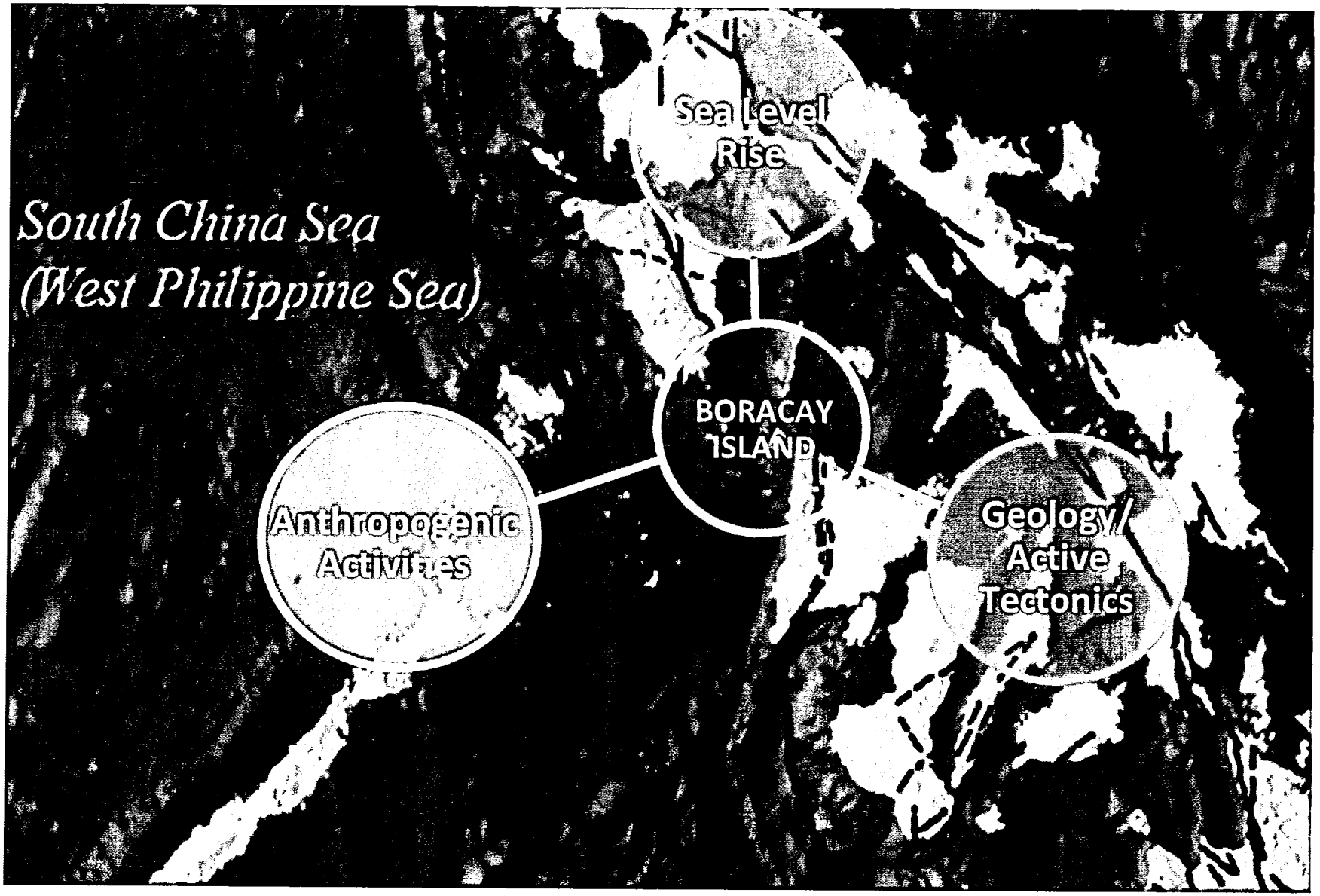


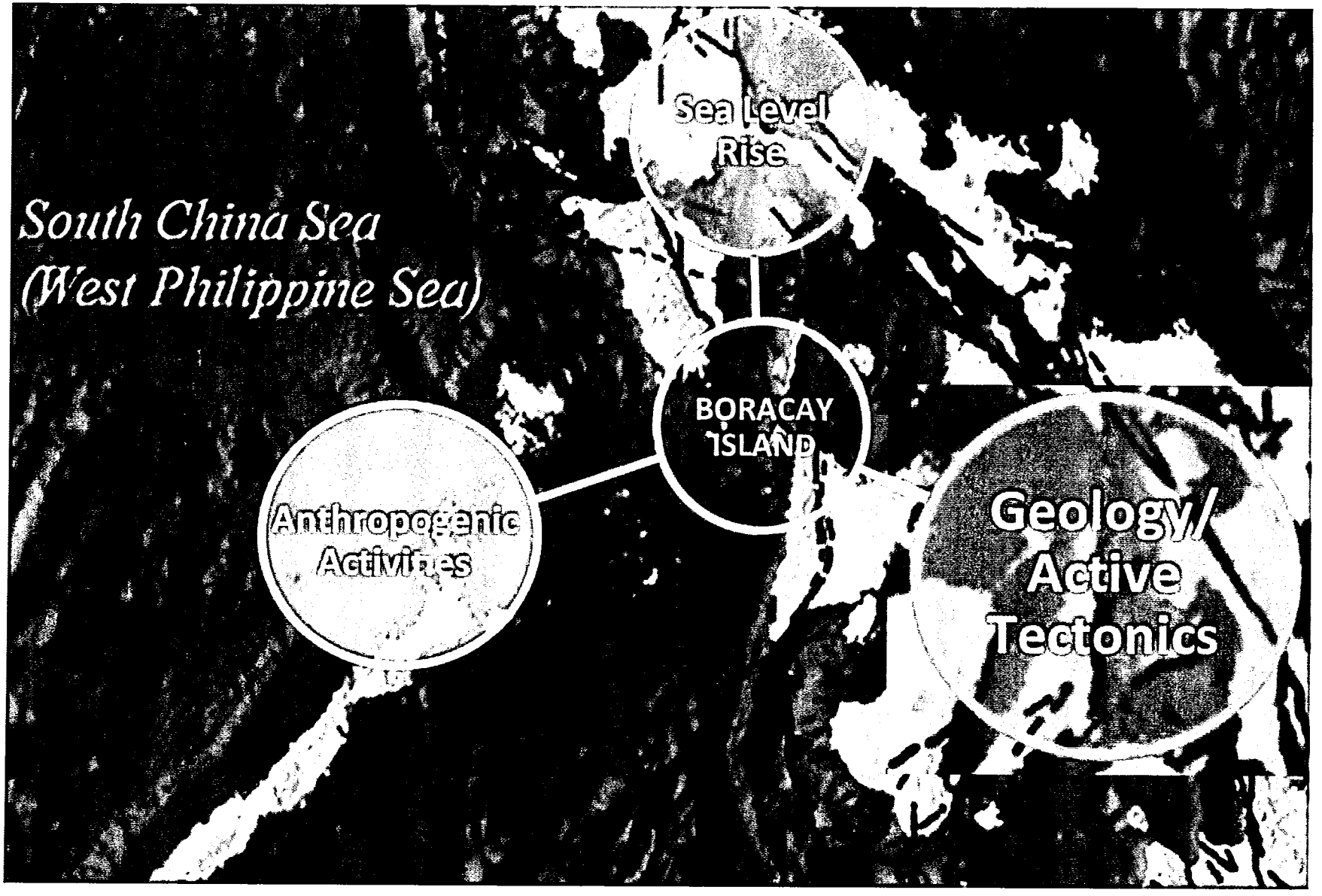
OBJECTIVES

The comprehensive study in Boracay Island aims to:

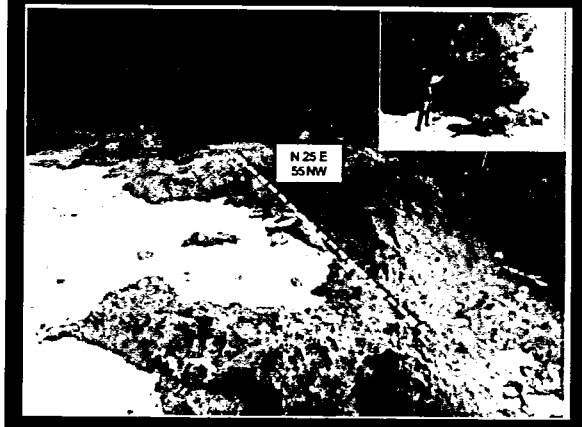
1. **Provide baseline information** and understanding of the island's geological features;
2. **Offer insights into the subsurface layers** through geophysical surveys;
3. **Identify hazard areas and generate hazard maps** based on the baseline information and geophysical surveys; and
4. **Evaluate the coastal (physical) vulnerability** of the Island.

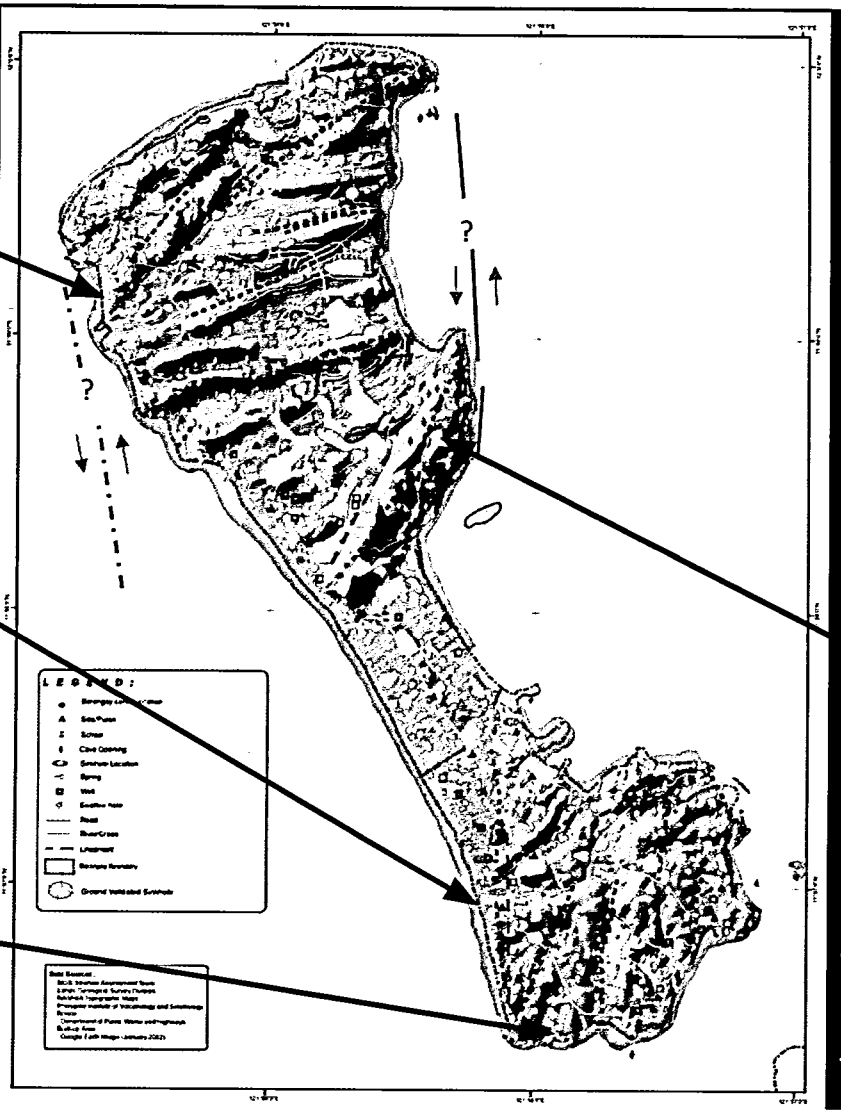



South China Sea
(West Philippine Sea)
Sea Level Rise
BORACAY ISLAND
Anthropogenic Activities
Geology / Active Tectonics

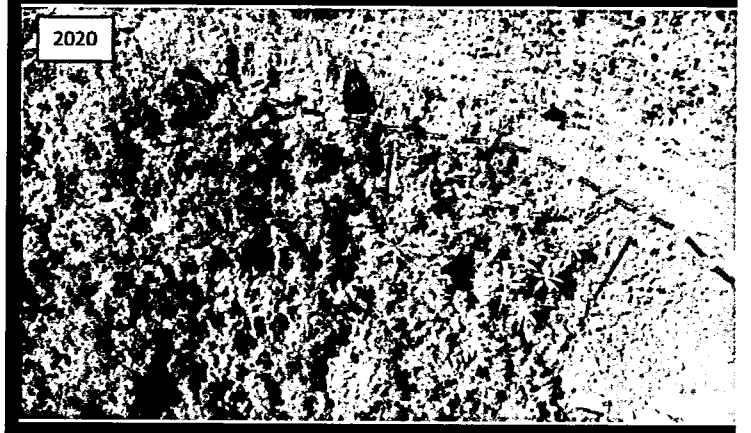

South China Sea
(West Philippine Sea)
Sea Level Rise
BORACAY ISLAND
Anthropogenic Activities
Geology/ Active Tectonics

GEOLOGY OF BORACAY ISLAND AND ITS RELATIONSHIP TO KARST DEVELOPMENT

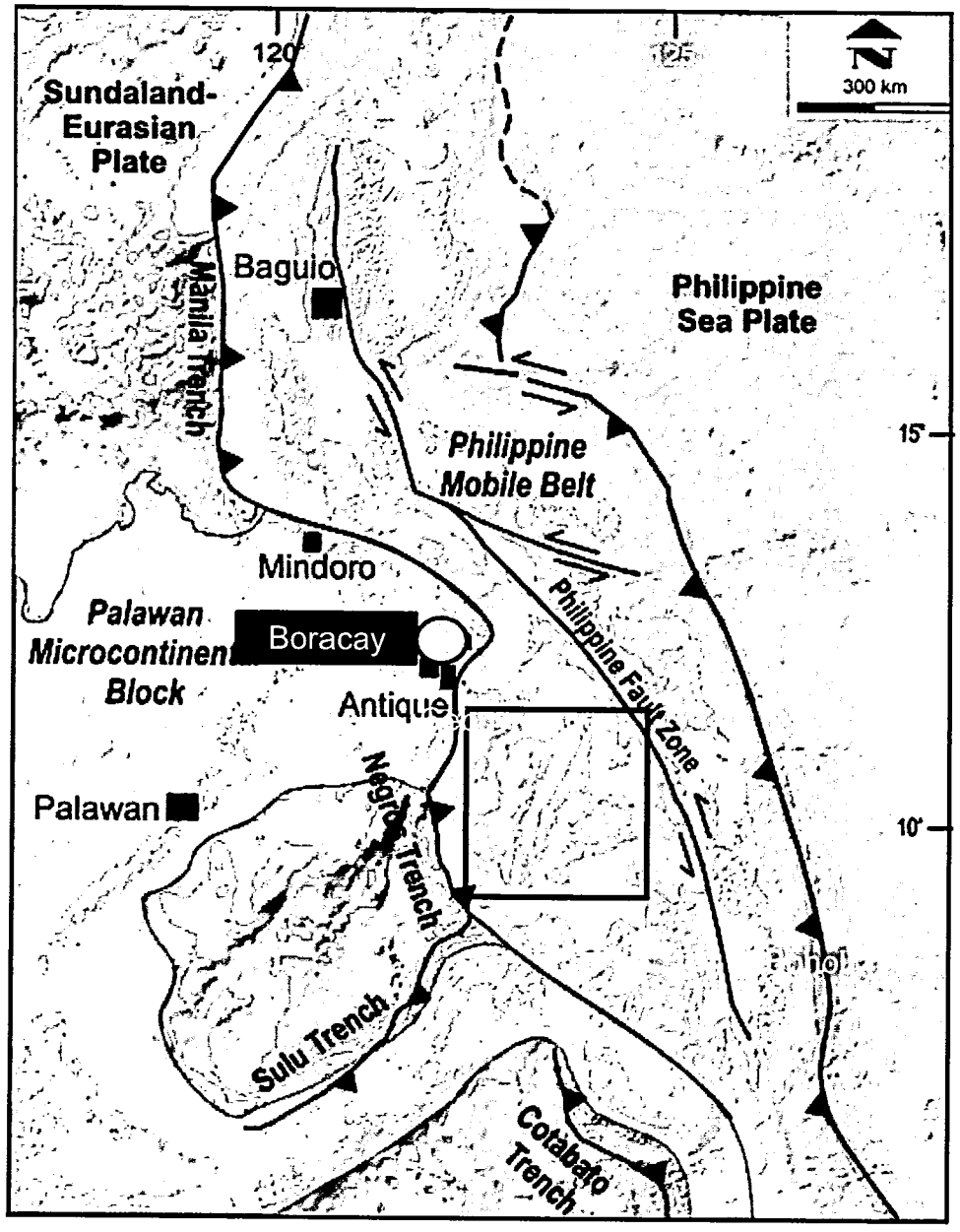


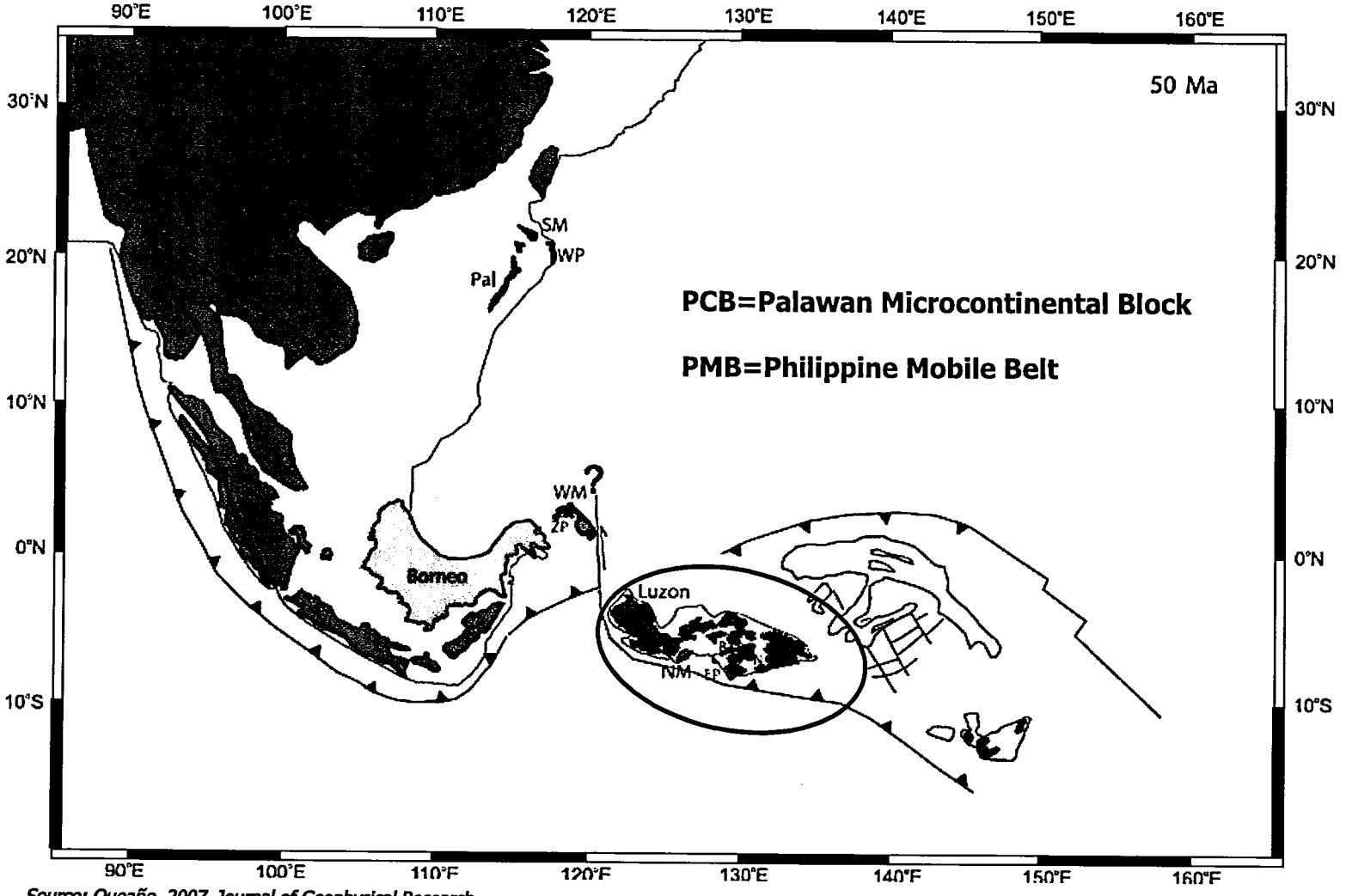


- Pliocene Sta. Cruz Formation
- Generally of coraline and fossiliferous limestone fragments; bedded
- Numerous solutional cavities
- Uplift of coral reefs relate to active tectonics

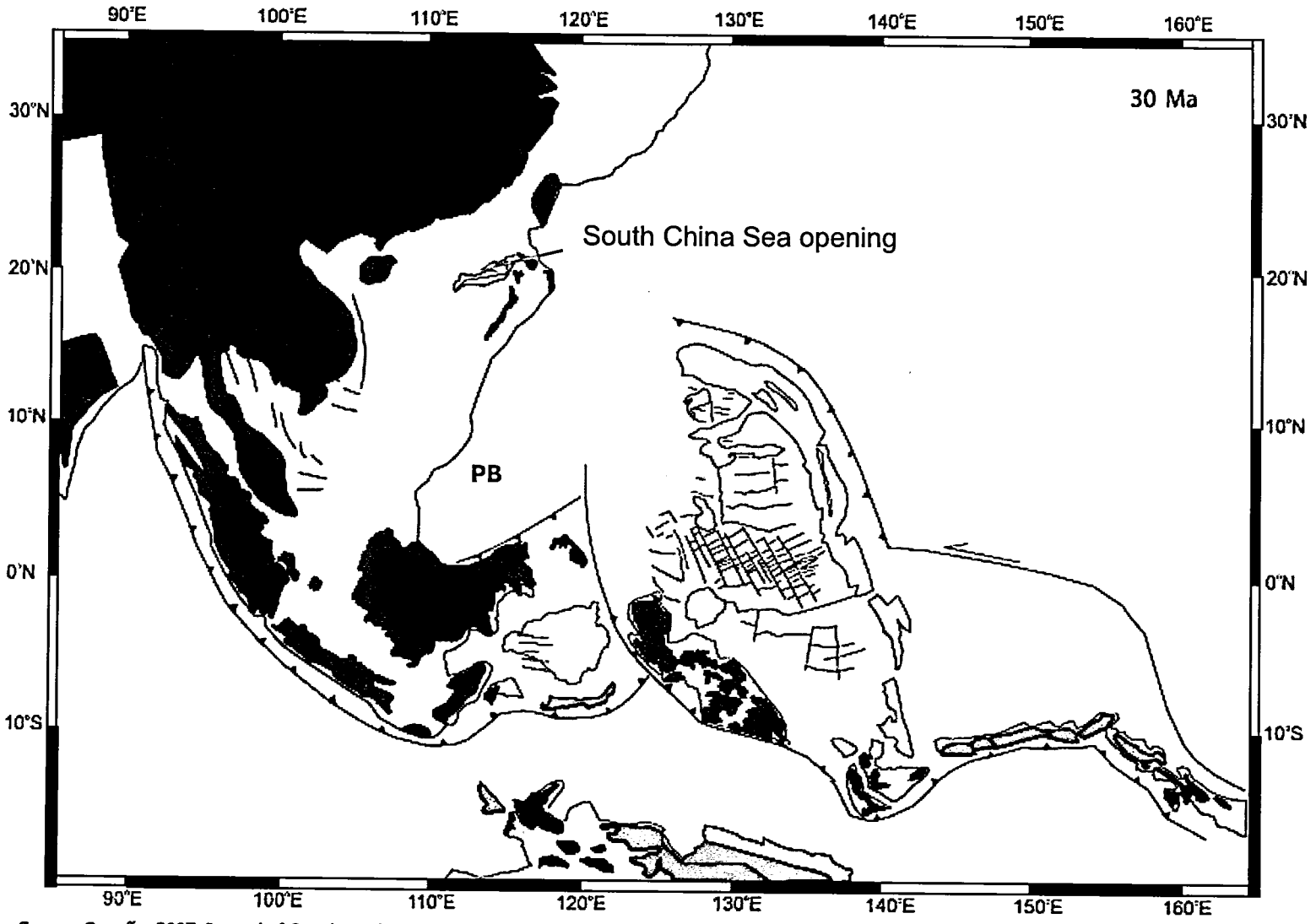


Active deformation in Central Visayas

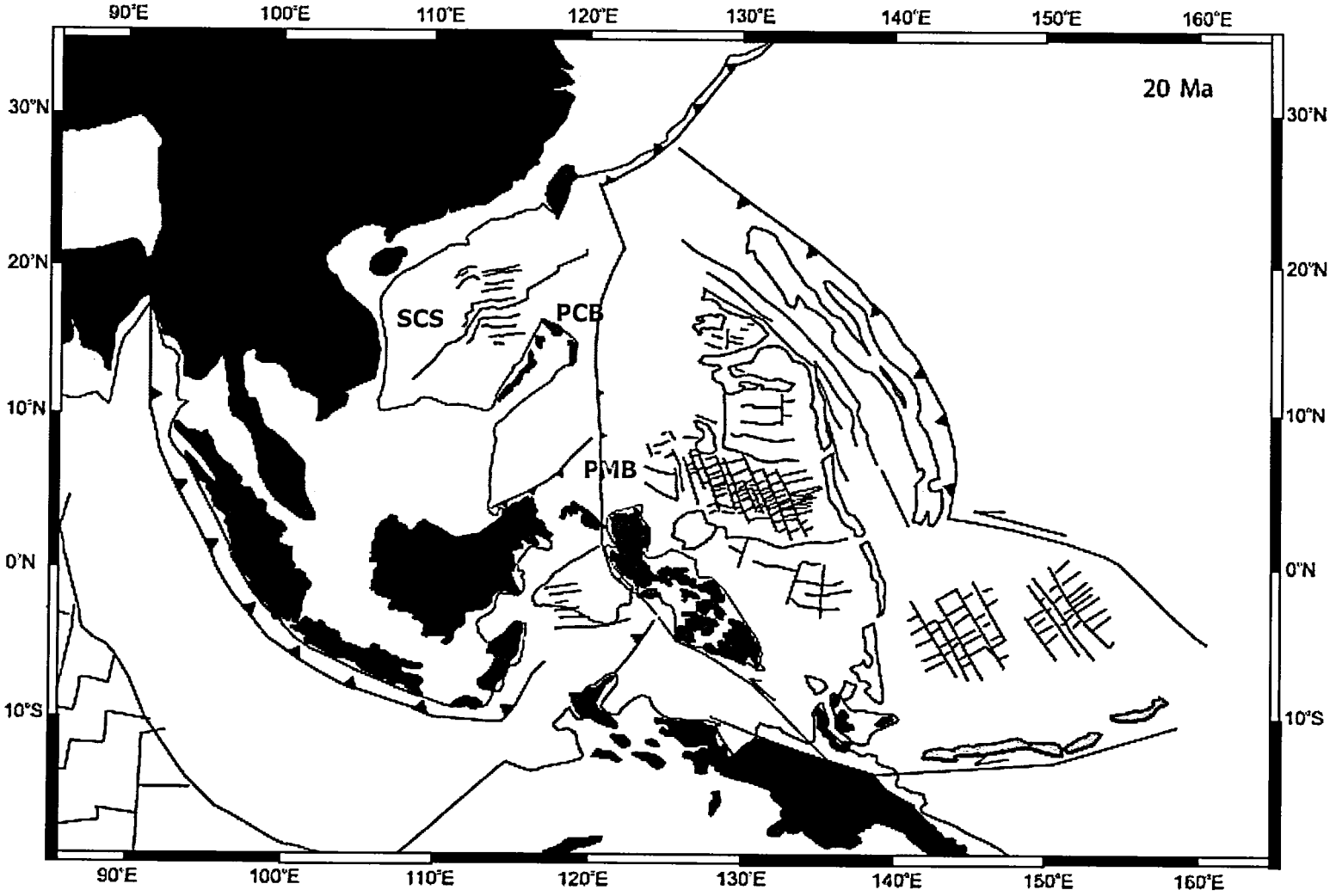




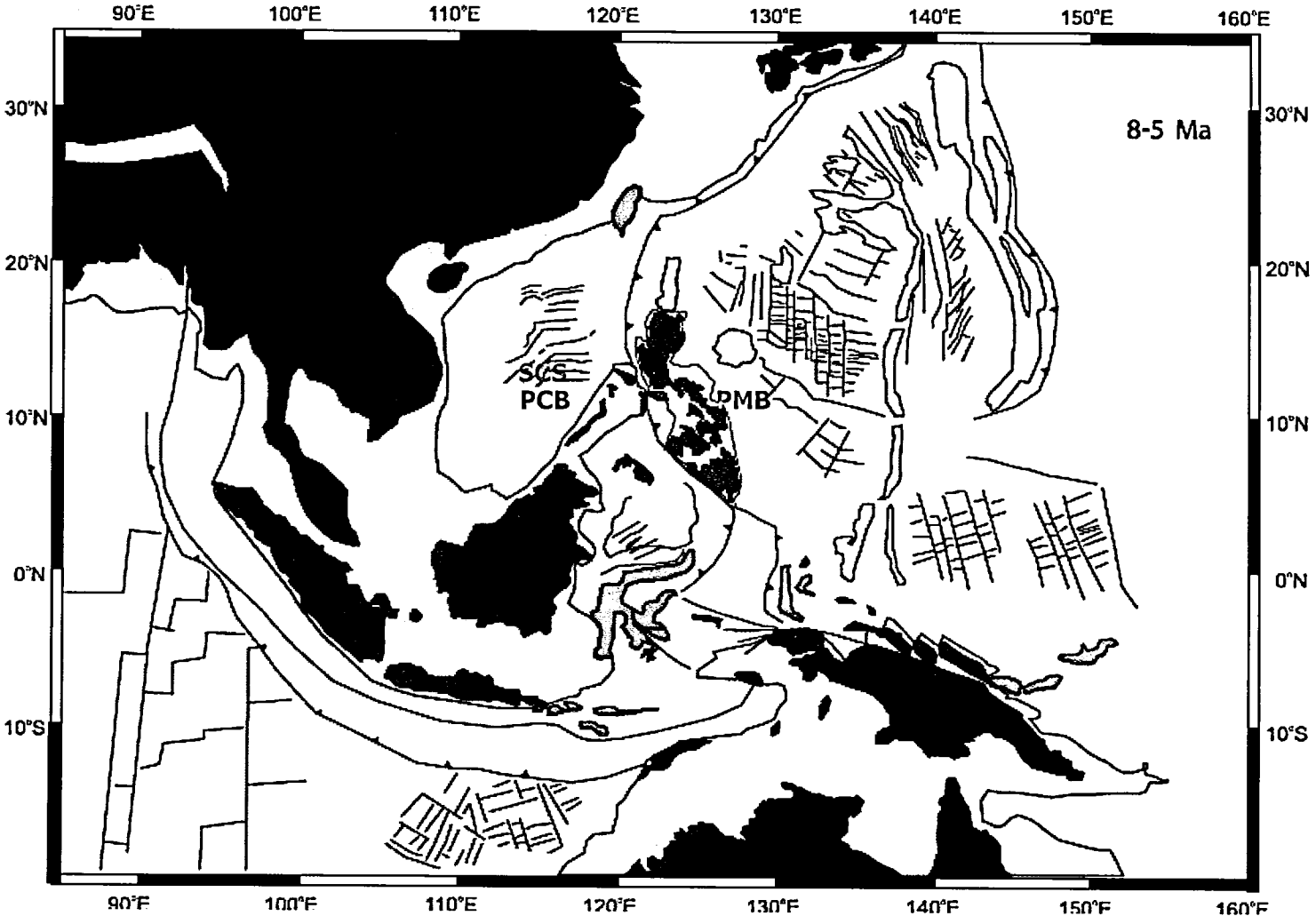
Source: Queaño, 2007. Journal of Geophysical Research



Source: Queaño, 2007. Journal of Geophysical Research

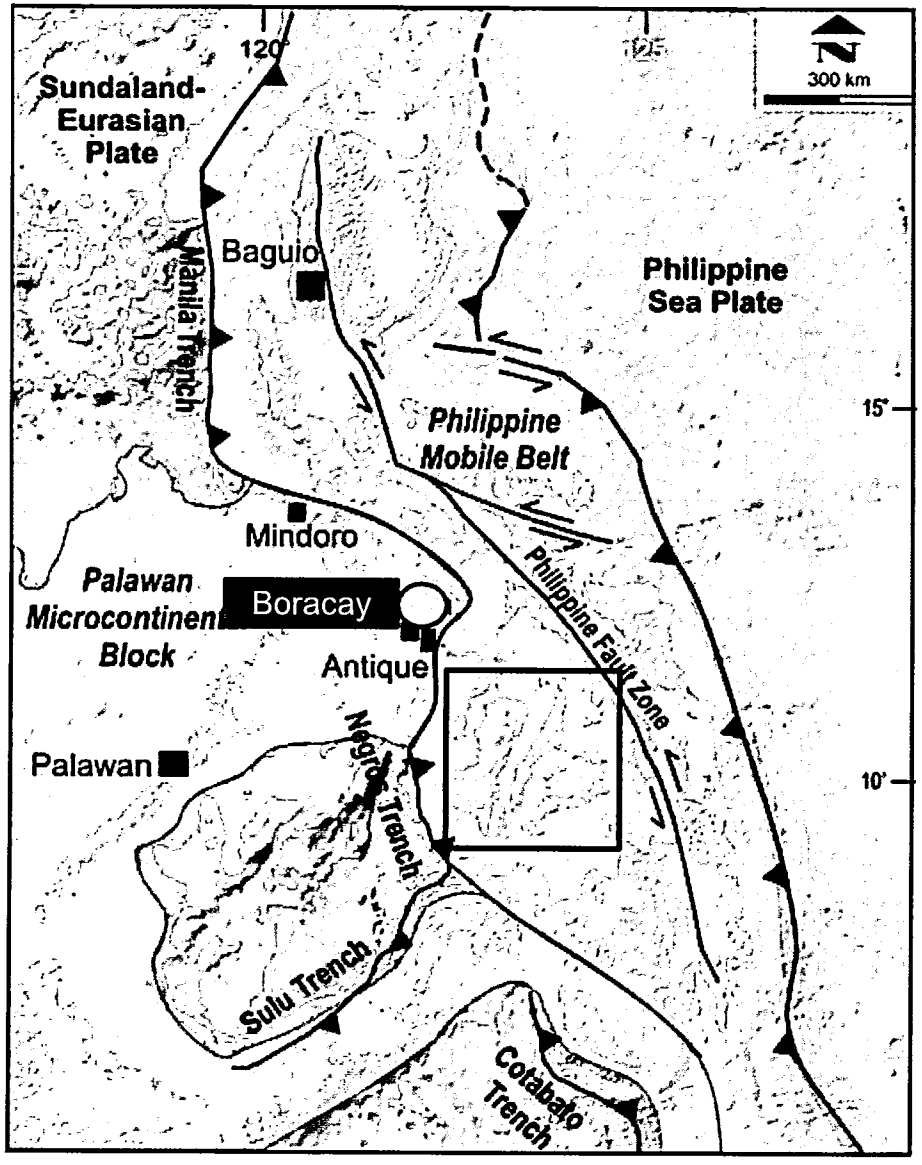


Source: Queaño, 2007. Journal of Geophysical Research

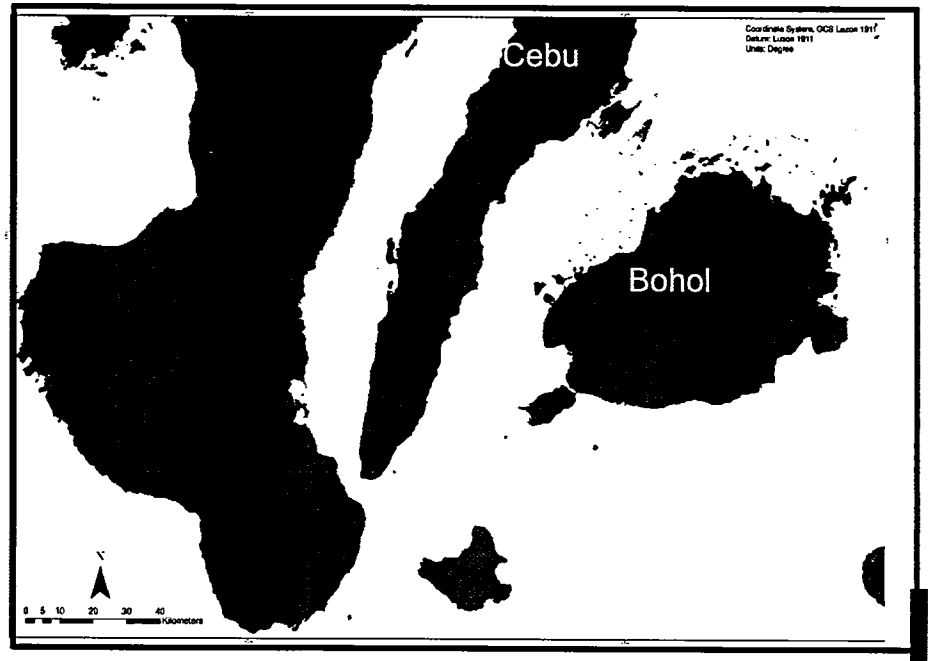


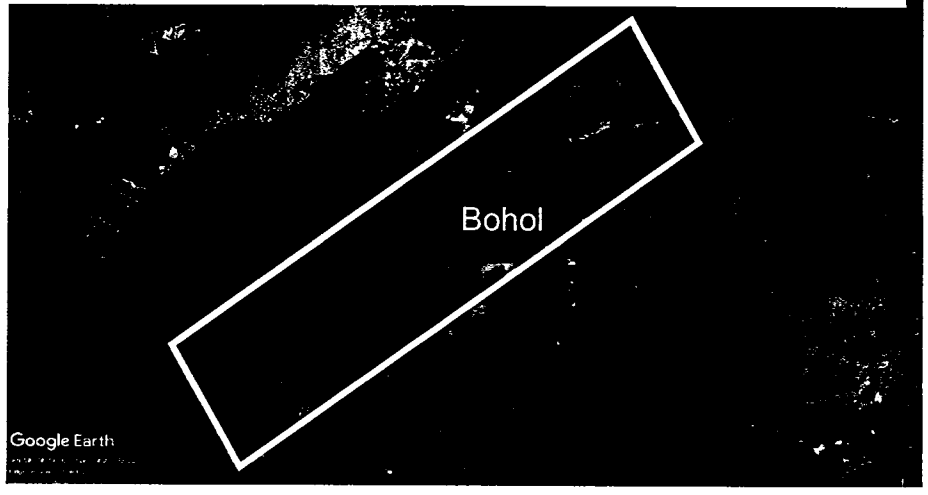
Source: Queaño, 2007. Journal of Geophysical Research

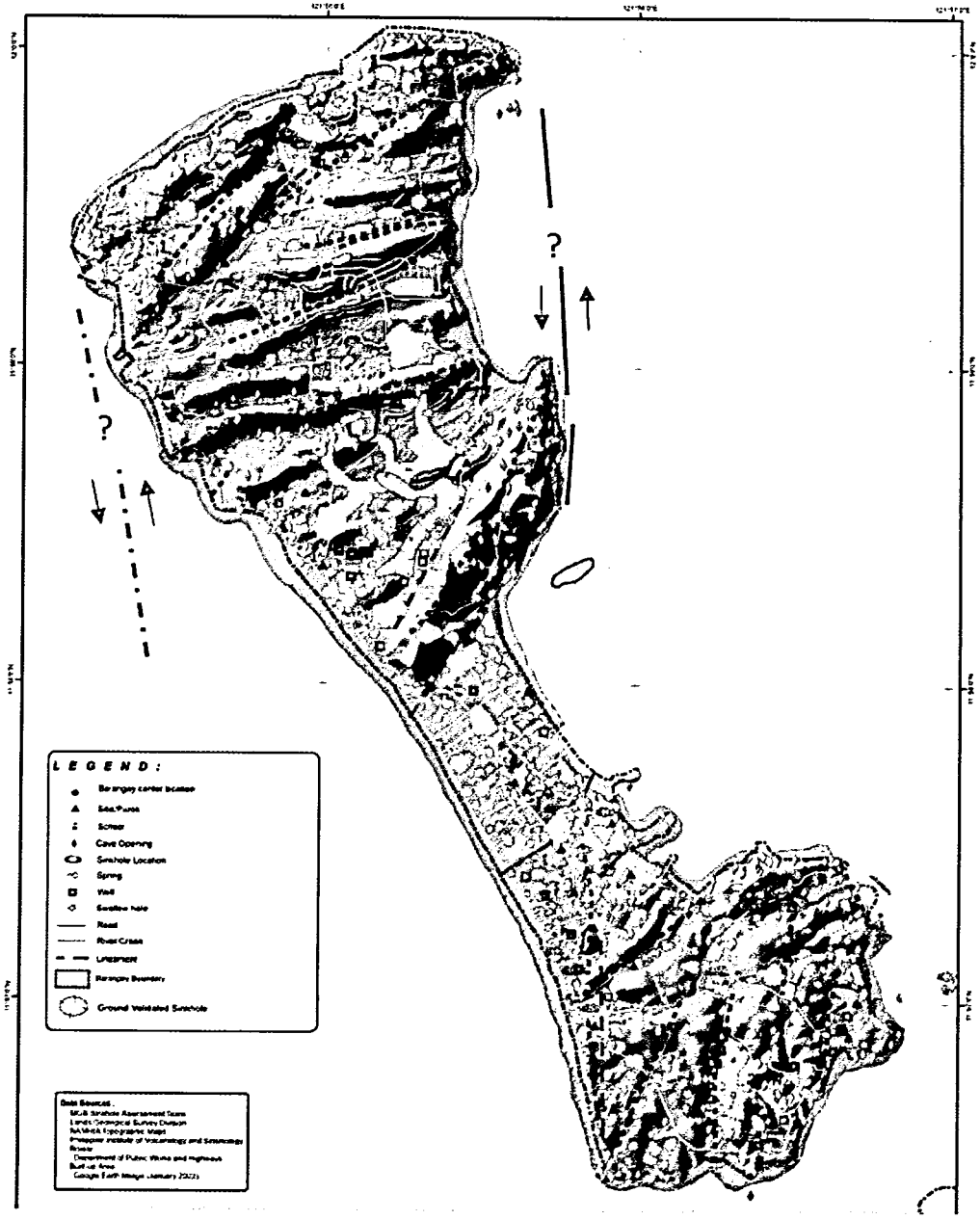
Active deformation in Central Visayas

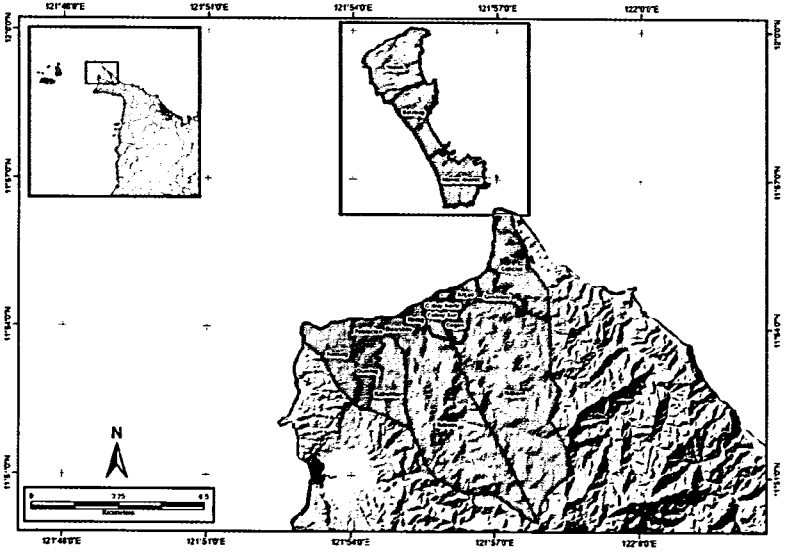


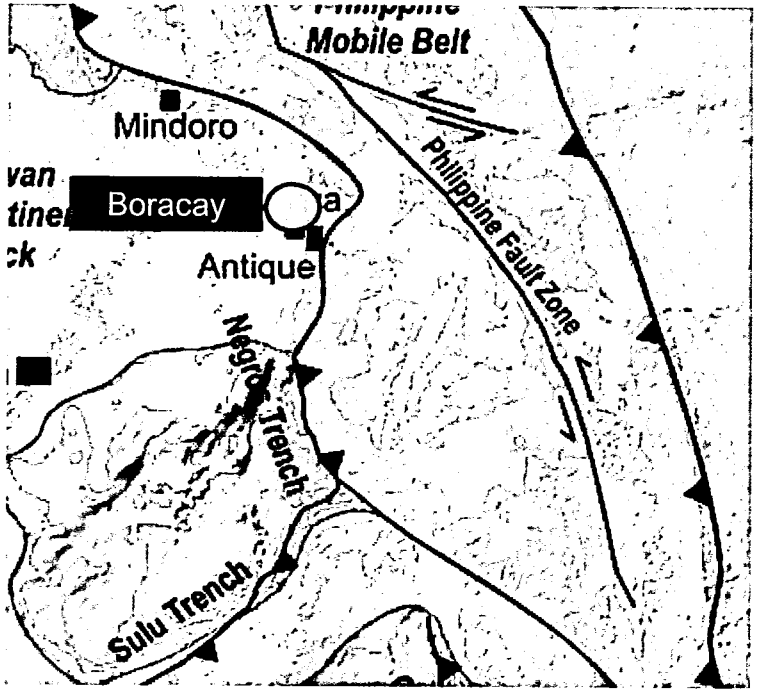
Clockwise rotation for Negros, Cebu and Bohol following collision; Boracay falls outside but near to the collision





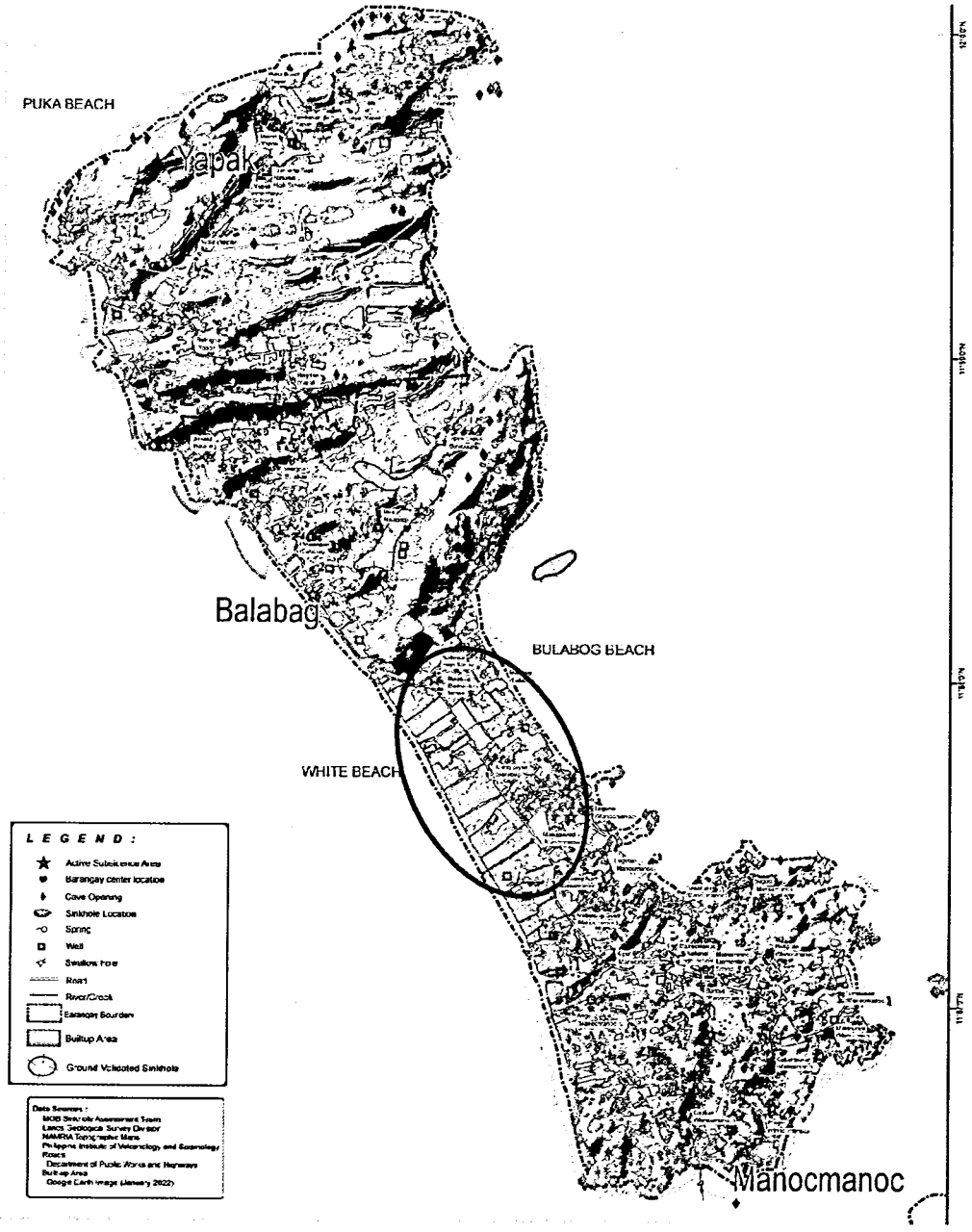






Folding in NW and vertical uplift of young coralline limestone in the SE part of Boracay

Style of deformation influences the distribution of sinkholes

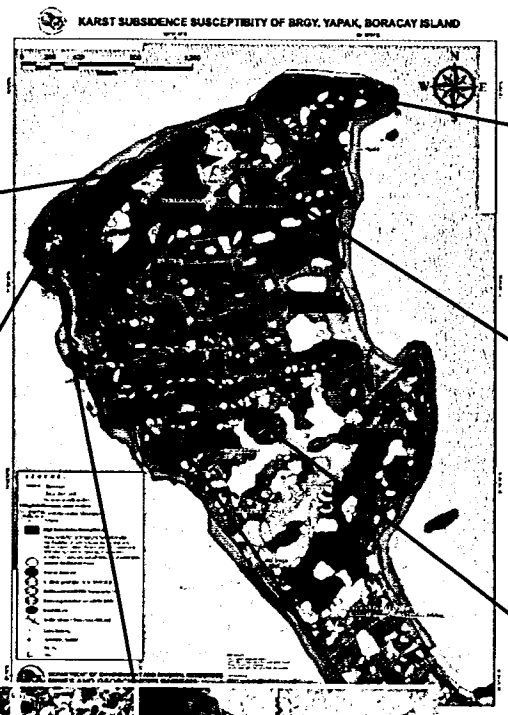


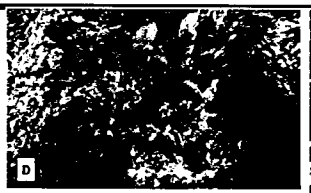
Collapsed section? Reactivation of the dissolution process

SINKHOLES AND CAVE OPENINGS IN BORACAY ISLAND

Dissolution and cover subsidence sinkholes were identified within Wetland No. 1. Its aperture ranges from 3 meters to about 15 meters. The lower right picture shows the water-filled extent of Wetland No. 1 Surrounding and within

The solution sinkhole at the center of Shangrila was developed into a fish pond. It was reported by the manager. Tilapia are found in the pond. Nauclea is a native tree. It is located in the opening



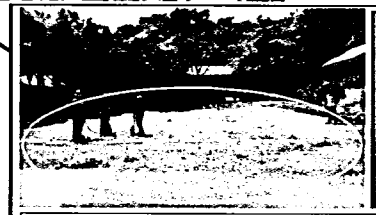


D

E

F

2. A taller opening of the Crystal Cave
E. A small opening identified as a karst window inside Tirol property.
F. Crystal Cave

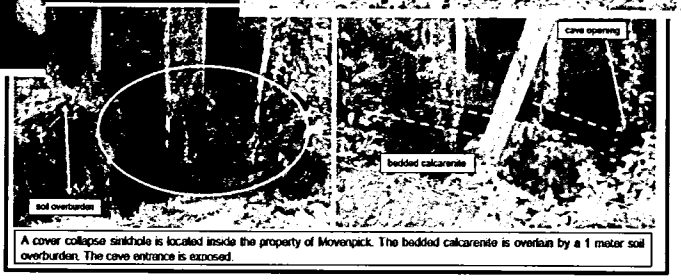


A cover subsidence sinkhole was identified at the open field of Lamberto Tirol National High School. Staircase cracks were noted at the Yapak Elementary School.

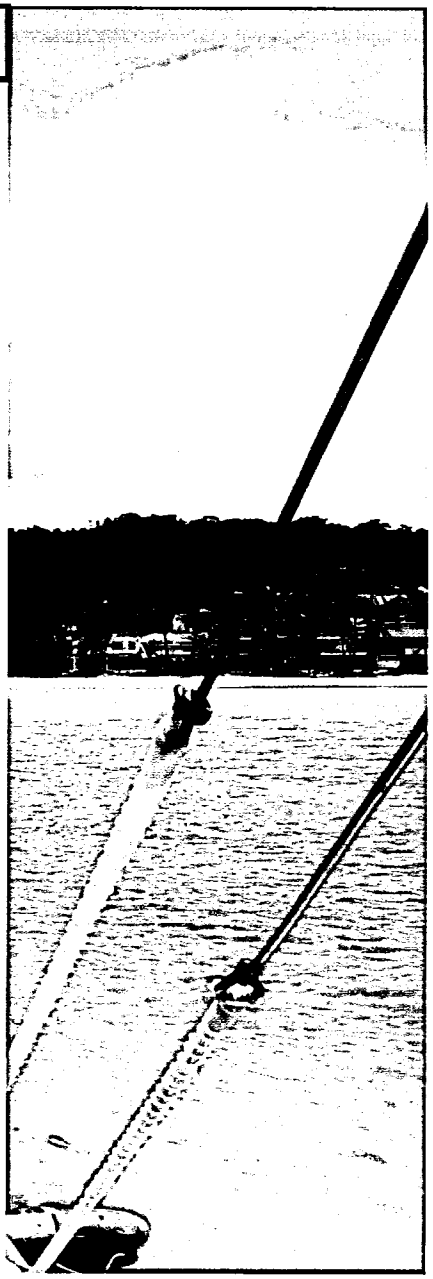
D

A

B

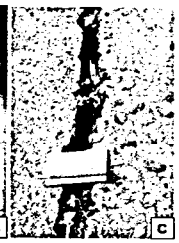


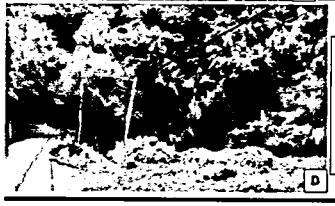
A cover collapse sinkhole is located inside the property of Movenpick. The bedded calcarenite is overlain by a 1 meter soil overburden. The cave entrance is exposed.



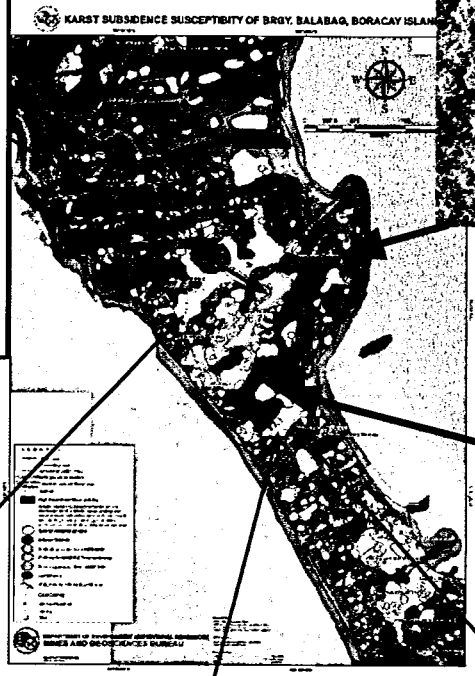
Brgy. Yapak

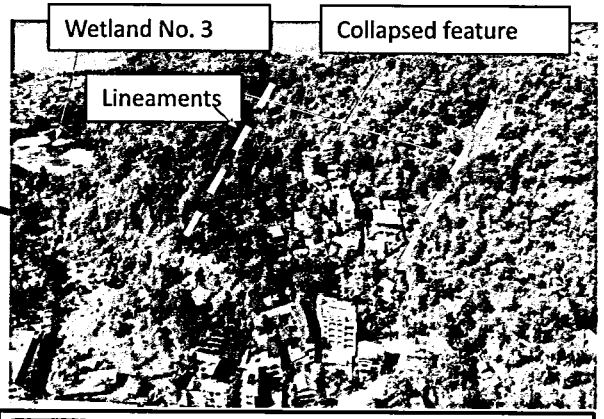
SINKHOLES AND CAVE OPENINGS IN BORACAY ISLAND

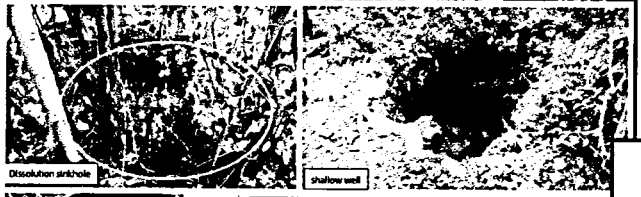




A. A solution sinkhole was identified which is part of Wetland No. 2. It is situated adjacent to the entrance of the Dark Side of Paradise Cave. Piles of garbage were retrieved by paid workers from this sinkhole.
B. It is observed that this portion of Laxus Ibeus road is gradually subsiding as manifested by the tension cracks.
C. A vertical displacement of about 1 inch was noted while a horizontal separation of about 2 inches is evident.
D. Electric posts are already leaning towards the sinkhole.





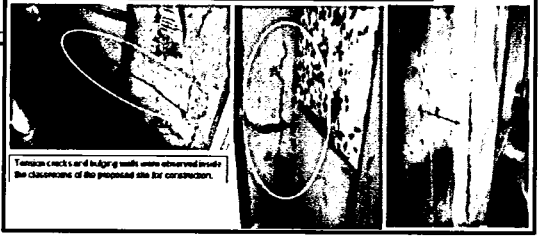


A cover subsidence sinkhole covered with small shrubs, vines and grasses is adjacent to Las Brisas Resort. A septic tank is situated within the sinkhole.

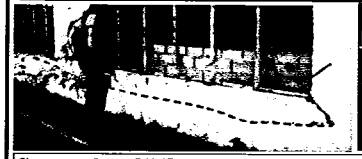
One of the sinkholes is a dissolution type with a diameter of about 2 meters. This is where floodwaters is pumped by Las Brisas.

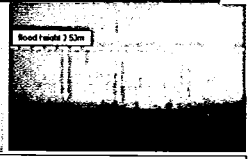
Two shallow wells are found where residents utilize the water for bathing.

A cover subsidence sinkhole at the east end of Balabag Elementary School



Tension cracks and bulging walls were observed inside the classrooms of the proposed site for construction.

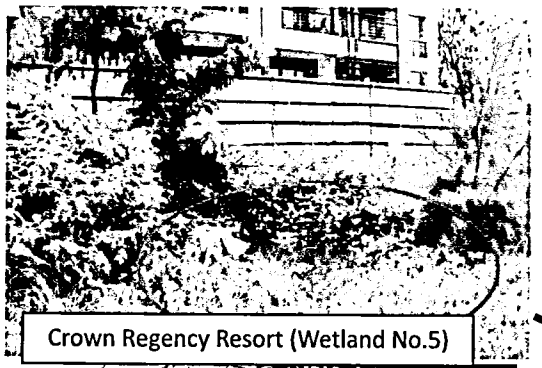




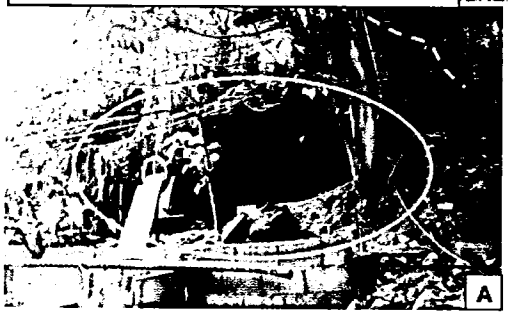
Classrooms and the open field of Boracay National High School is frequently flooded during inclement weather. The open field has been filled up with large amounts of soil with the purpose of preventing continuous ground subsidence. However subsidence is still prominent as manifested by the tension cracks on the concrete path walks and walls as well as bulging walls. A small depression within the floor and wall was noted.

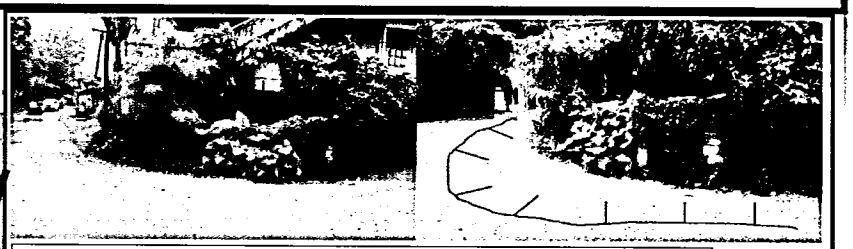
Brgy. Balabag

SINKHOLES AND CAVE OPENINGS IN BORACAY ISLAND



Crown Regency Resort (Wetland No.5)





Ground validated cover subsidence sinkhole from LIDAR and threshold data. A 3-floor building with several apartment units is built on the sinkhole. Soil materials are slowly sagging exposing the foundation of the building. Rainwater from the road and the surrounding areas pools the base of the building. Vegetation such as *gabi* indicates that the area is usually water-laden. It is also observed that the road is slightly tilted towards the building.

(Upper left photo) Cover subsidence sinkhole located at Bunbo 3 area of Lcoure Rosorts World property. *(Upper right photo)* Note the growth of coconut trees are slanted though they are in a flat area. *(Lower photos)* Cracks all over the floor of the house are observed. Moreover, the floor bulges at the center of the house.

Behind some houses are cave openings. Some have been exposed during construction of houses. The cave (pointed by yellow arrow) has a height of about 20 feet, according to a resident in Sitio Cagbao Bubos.

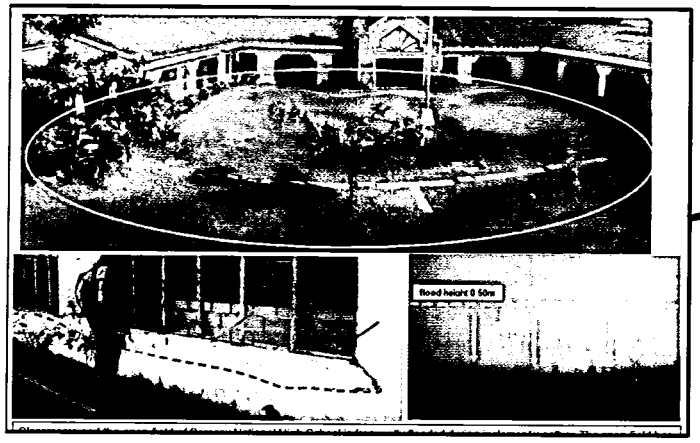
Brgy. Manoc-Manoc

GEOPHYSICAL SURVEY

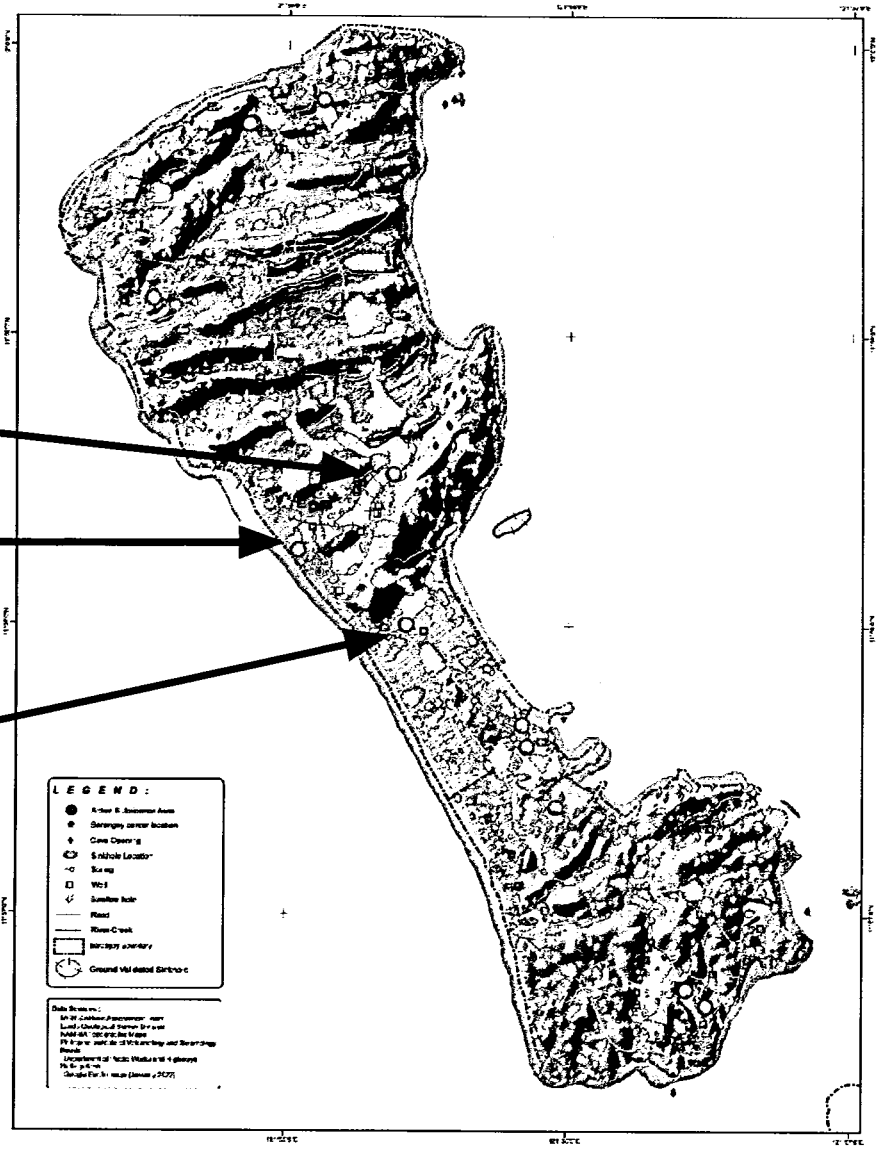
Ground Penetrating Radar

1D/2D Electrical Resistivity Survey

OBSERVED ACTIVE SUBSIDENCE IN BORACAY ISLAND

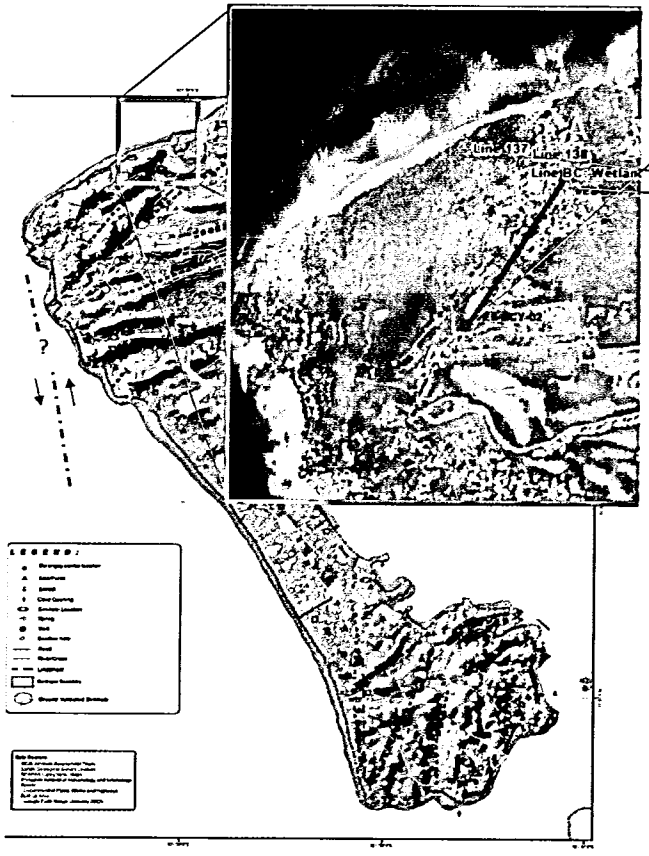


AREAS WITH OBSERVED ACTIVE
SUBSIDENCE IN BORACAY ISLAND, MALAY, AKLAN

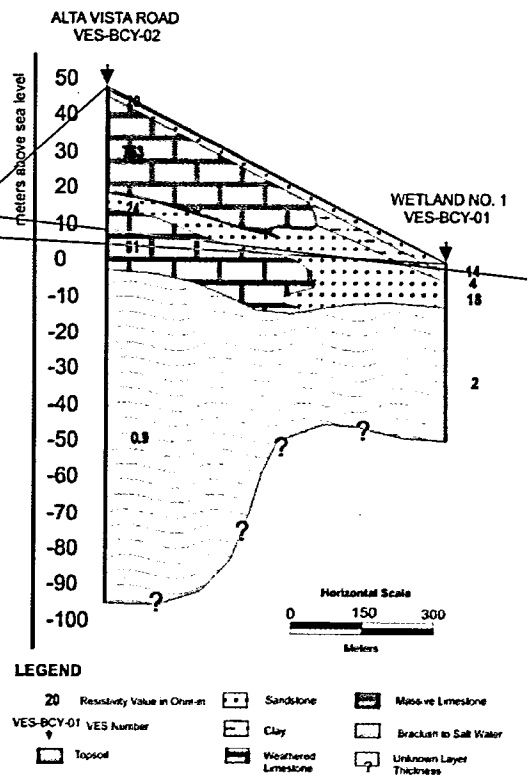


GEOPHYSICAL SURVEY

Barangay Yapak Near Wetland No. 1



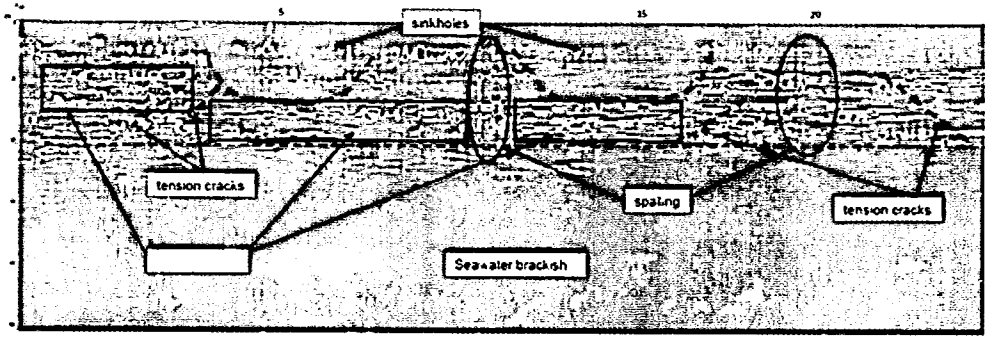
YAPAK, BORACAY ISLAND, AKLAN



RESISTIVITY PROFILE A-A'

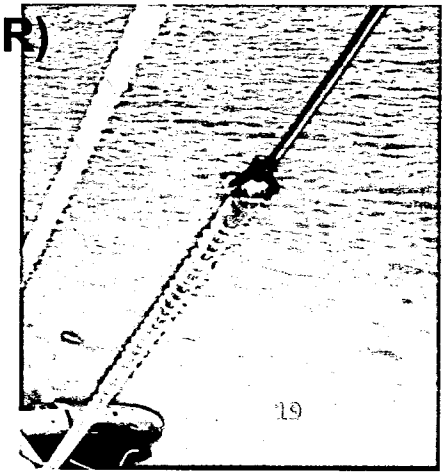
(ER – 1D)

GPR RADARGRAM IN WETLAND 1
LINE BC: ALONG PUKA BEACH ROAD
N11 59 44.4 E121 54 51.8 – N11 59 45.1 E121 54 52.1



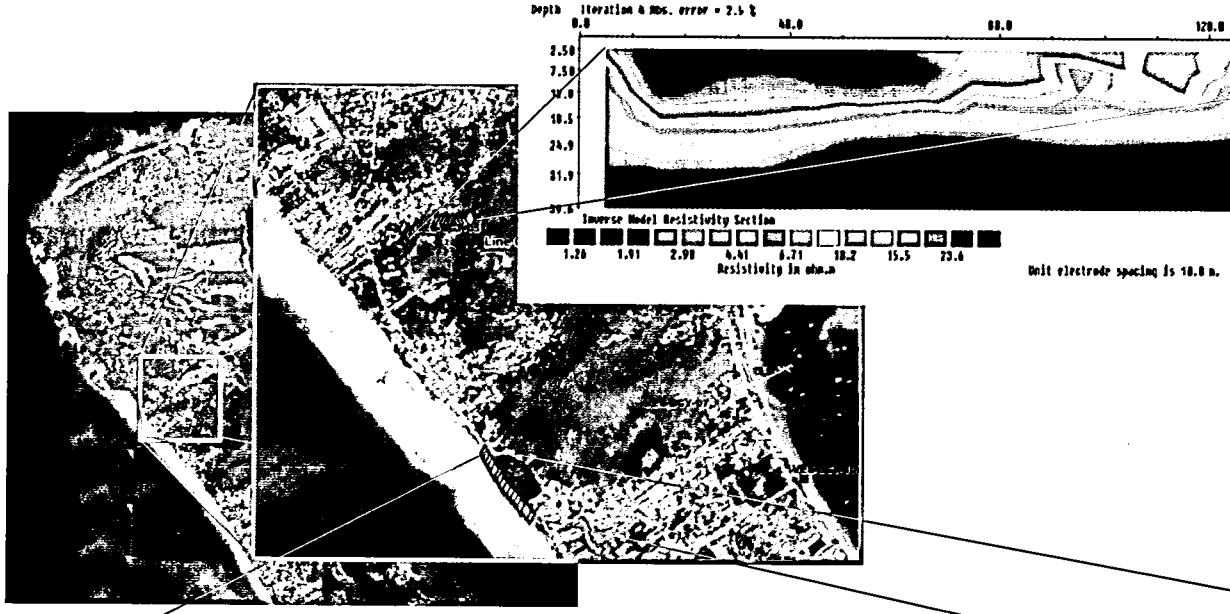
Maximum Depth of Penetration: 25 m
Dielectric Constant: 8 for Limestone
Lithology: Limestone

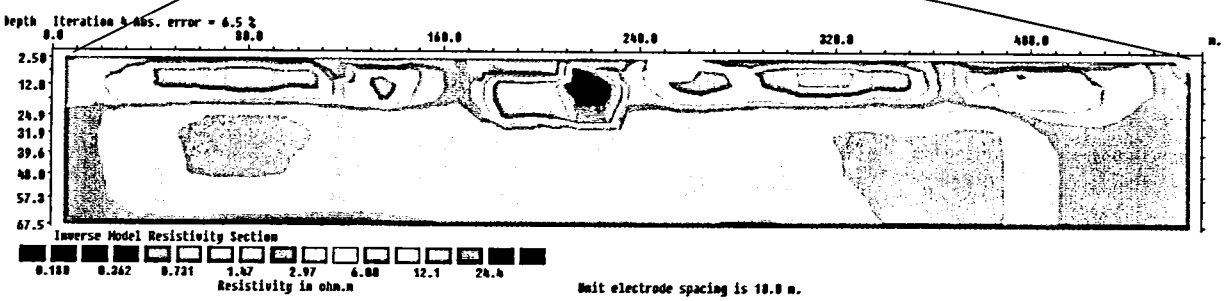
(GPR)



GEOPHYSICAL SURVEY

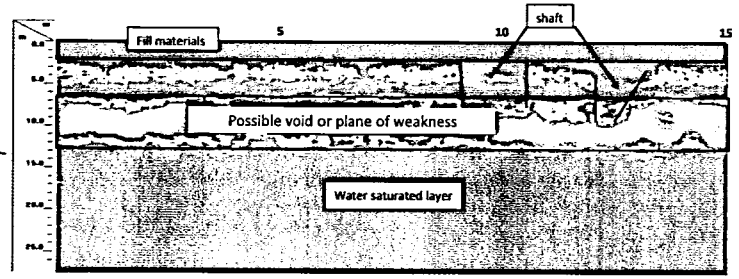
Front of Elizalde's Guesthouse, White Beach, Barangay Balabag





(ER – 2D)

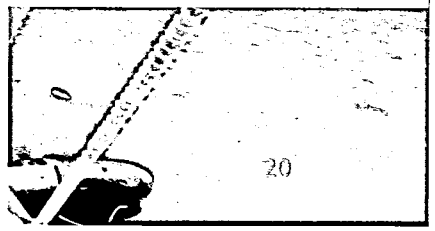
GPR RADARGRAM ALONG THE ROAD IN FRONT OF ELIZALDE PROPERTY
LINE 006 (CD): N11 58 3.5 E121 55 12.9 - N11 58 3.3 E121 55 13.4

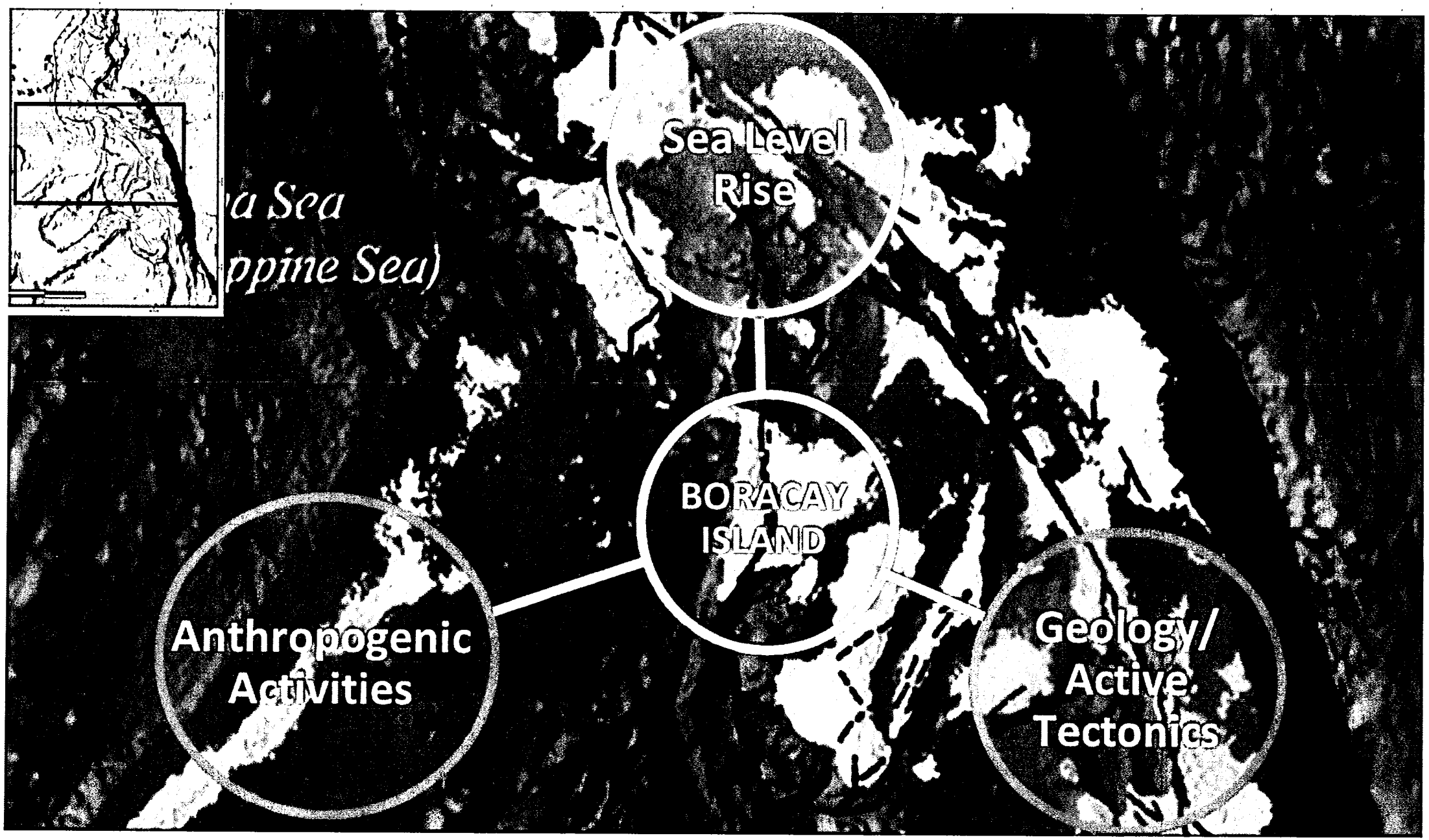


Maximum Depth of Penetration: 25 m
Dielectric Constant: 8

Lithology: Limestone

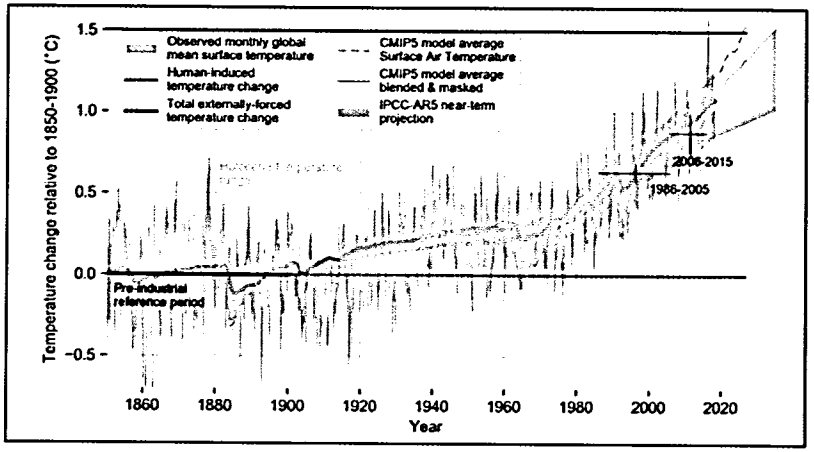
(GPR)



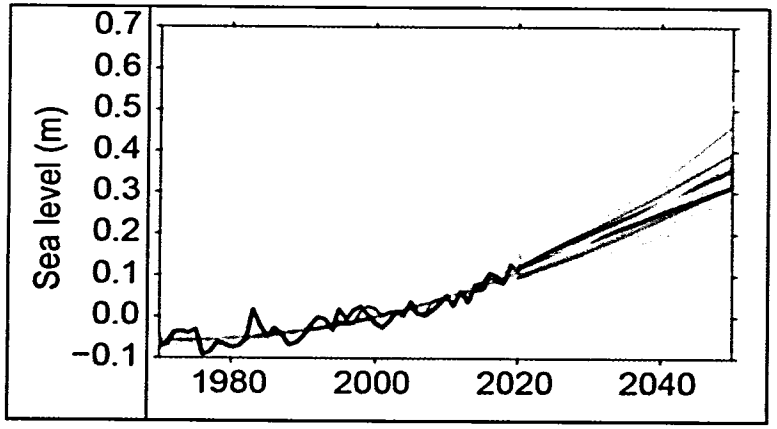

Sea Level Rise
BORACAY ISLAND
Anthropogenic Activities
Geology/ Active Tectonics

Sea level trend

Globally: 3.4 mm/yr (since the 1993-present; satellite)



Southeast Asia: 2x faster



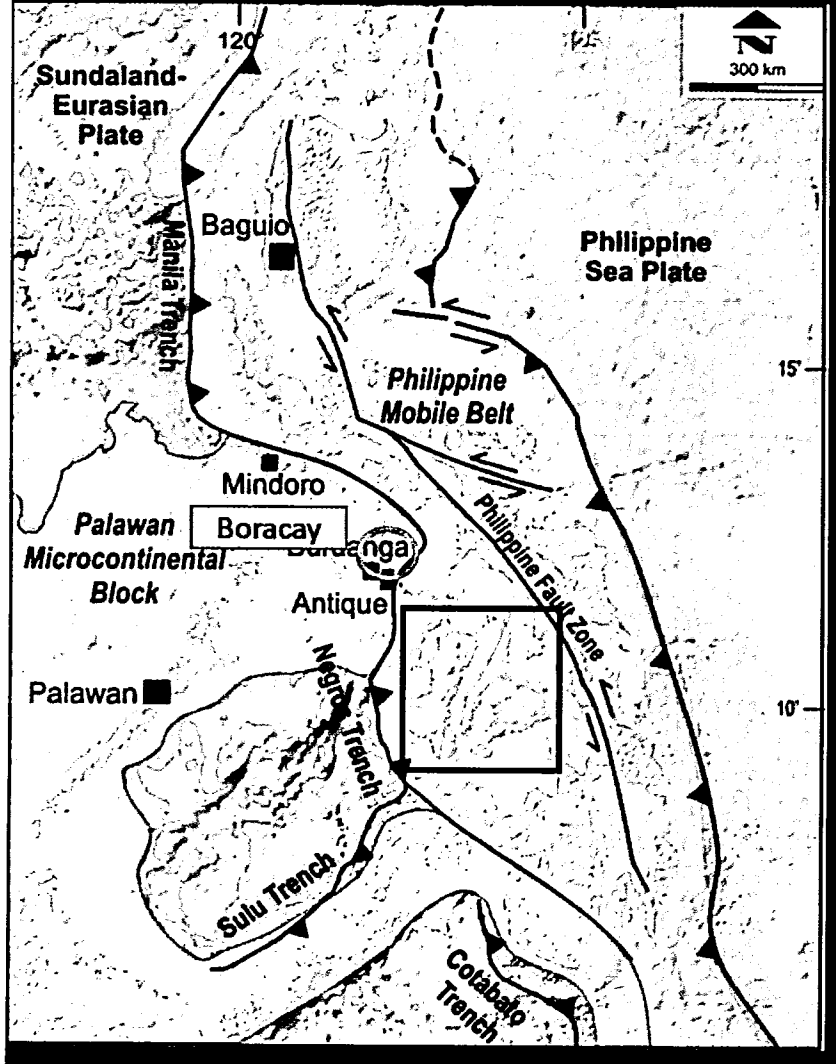
Intergovernmental Panel on Climate Change (IPCC) 2022 Sea Level Rise Technical Report

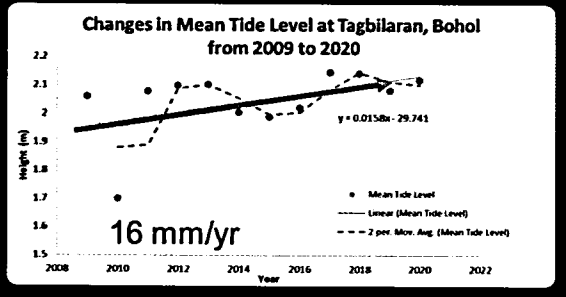
Philippines and vicinity: As much as 3x of the global average sea level rise rate

(International Development Research Centre (IDRC), 2015)

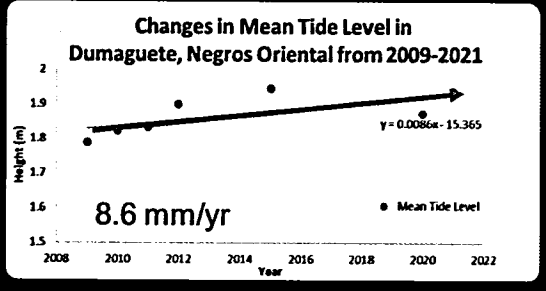
- **Sea level has risen by as much as 5.7-7.0 mm/yr over the Philippine Sea**

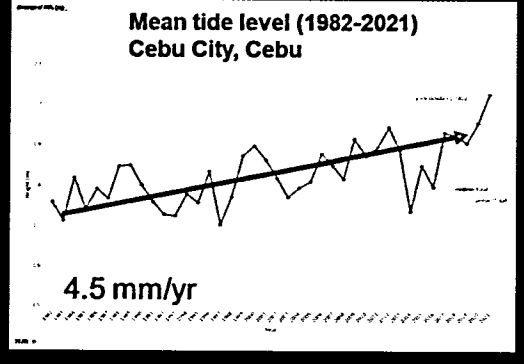
COASTAL HAZARD ASSESSMENT

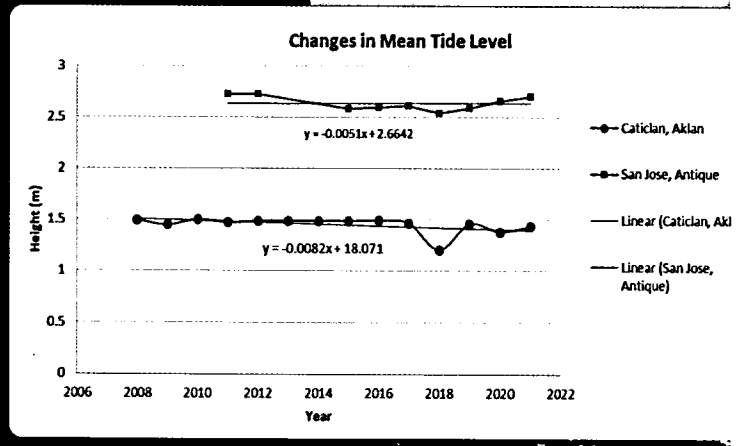


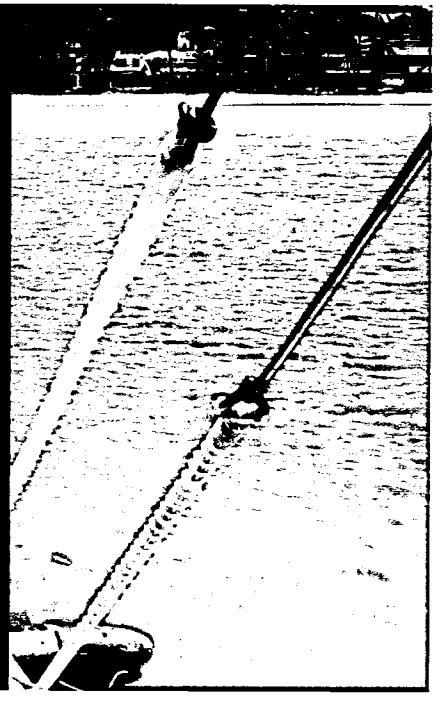


Isostatic rebound after 2013 Bohol earthquake



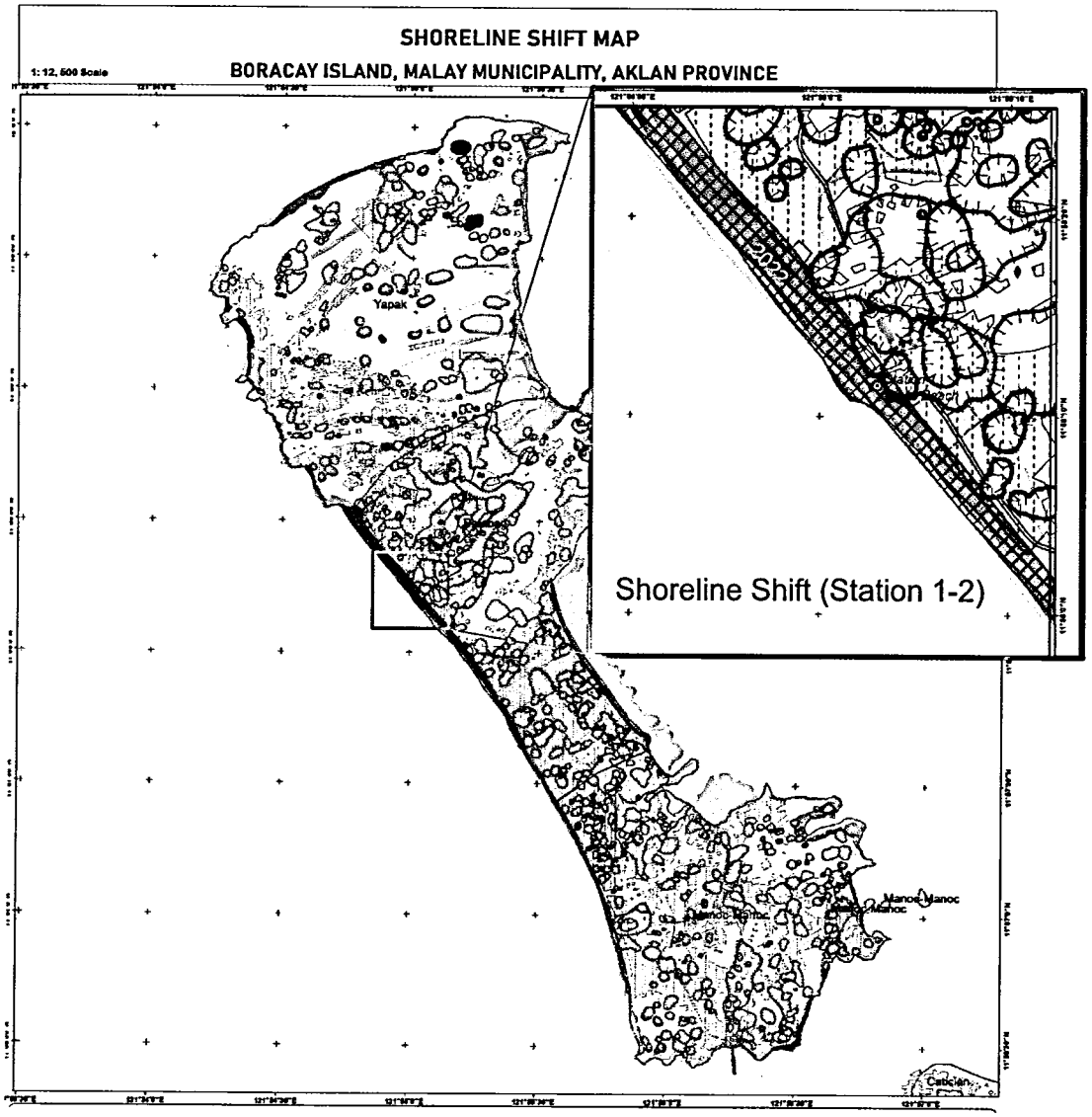


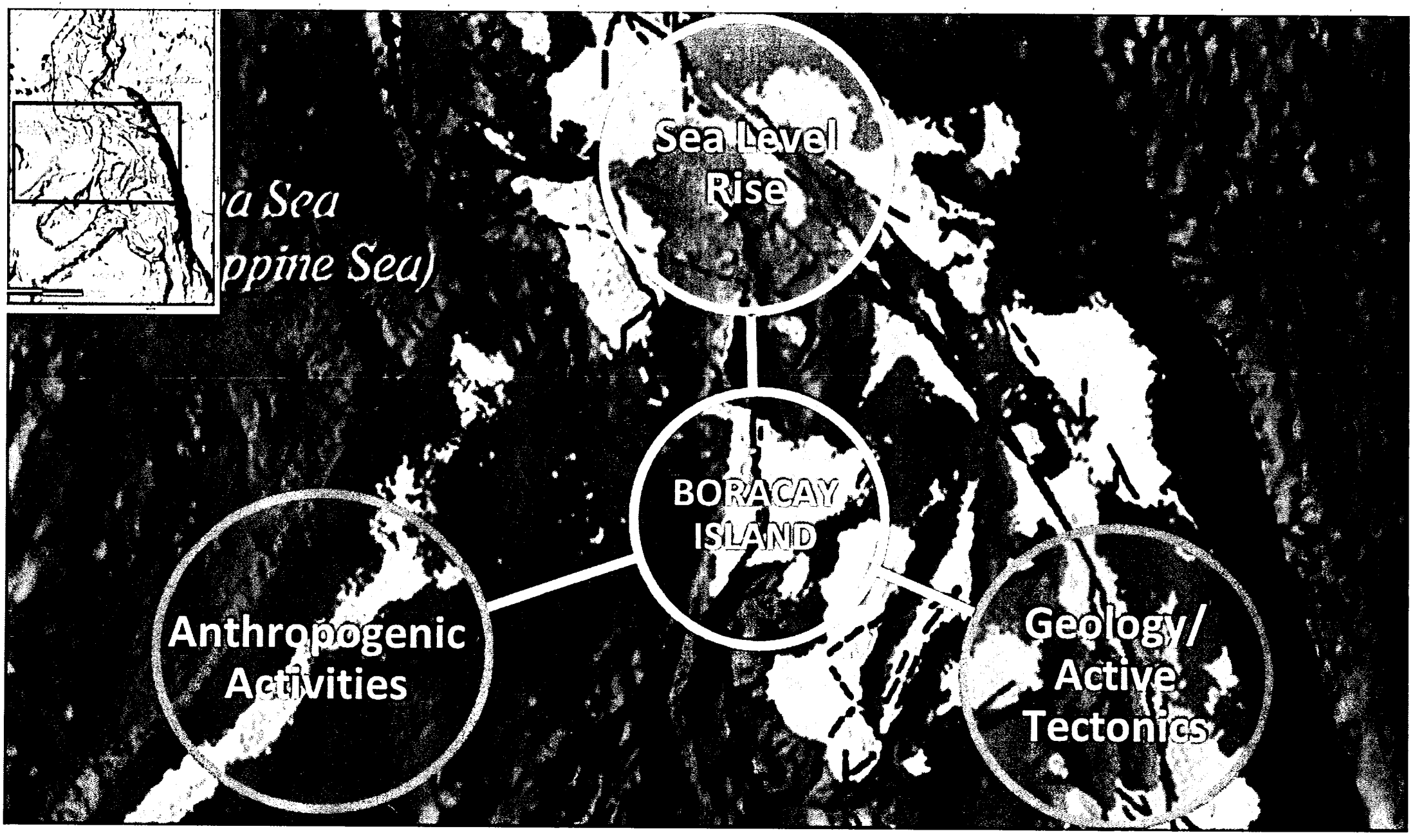




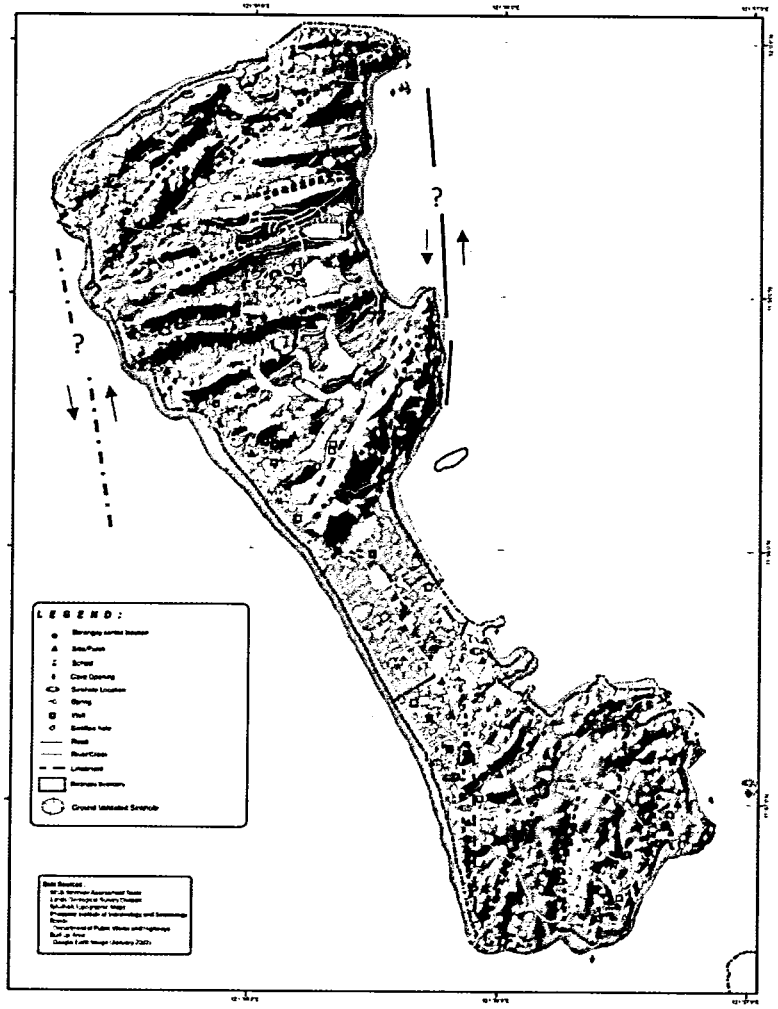
Data Source: NAMRIA

COASTAL HAZARD ASSESSMENT




Sea Level Rise
BORACAY ISLAND
Anthropogenic Activities
Geology/ Active Tectonics

COASTAL HAZARD ASSESSMENT



GMA NEWS ONLINE
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NEWS

Filtered By Topstories

Boracay implements stricter penalties against sand thieves

By AMANDA LAGO, GMA News

Published August 29, 2012 8:20

INQUIRER.NET

Gov't work crews demolish illegal structures in Boracay resort

MUNICIPAL ORDINANCENO. 310
Series of 2012

AN ORDINANCE AMENDING MUNICIPAL ORDINANCE NO.141, SERIES OF 2001 (*AN ORDINANCE BANNING THE EXTRACTION AND COLLECTION OF WHITE SANDSAND PEBBLES IN THE BEACHES OF BORACAY ISLAND*).

WHEREAS, Article 2, Section 16 of the Constitution provides that the State shall protect and advanc
balanced and healthful ecology in ac
of nature;

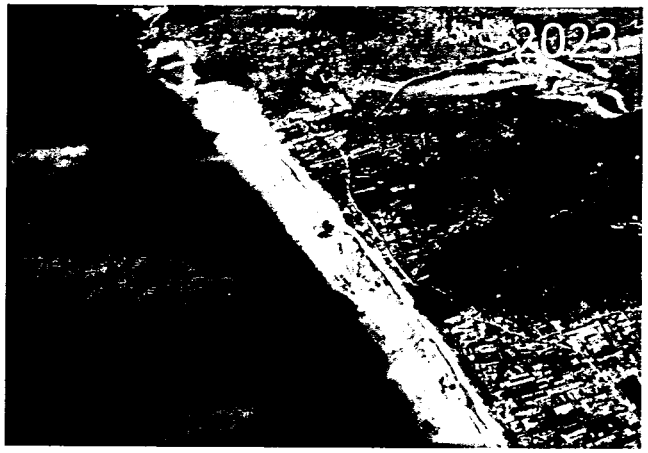
philstar

Illegal structures demolished along Boracay shoreline

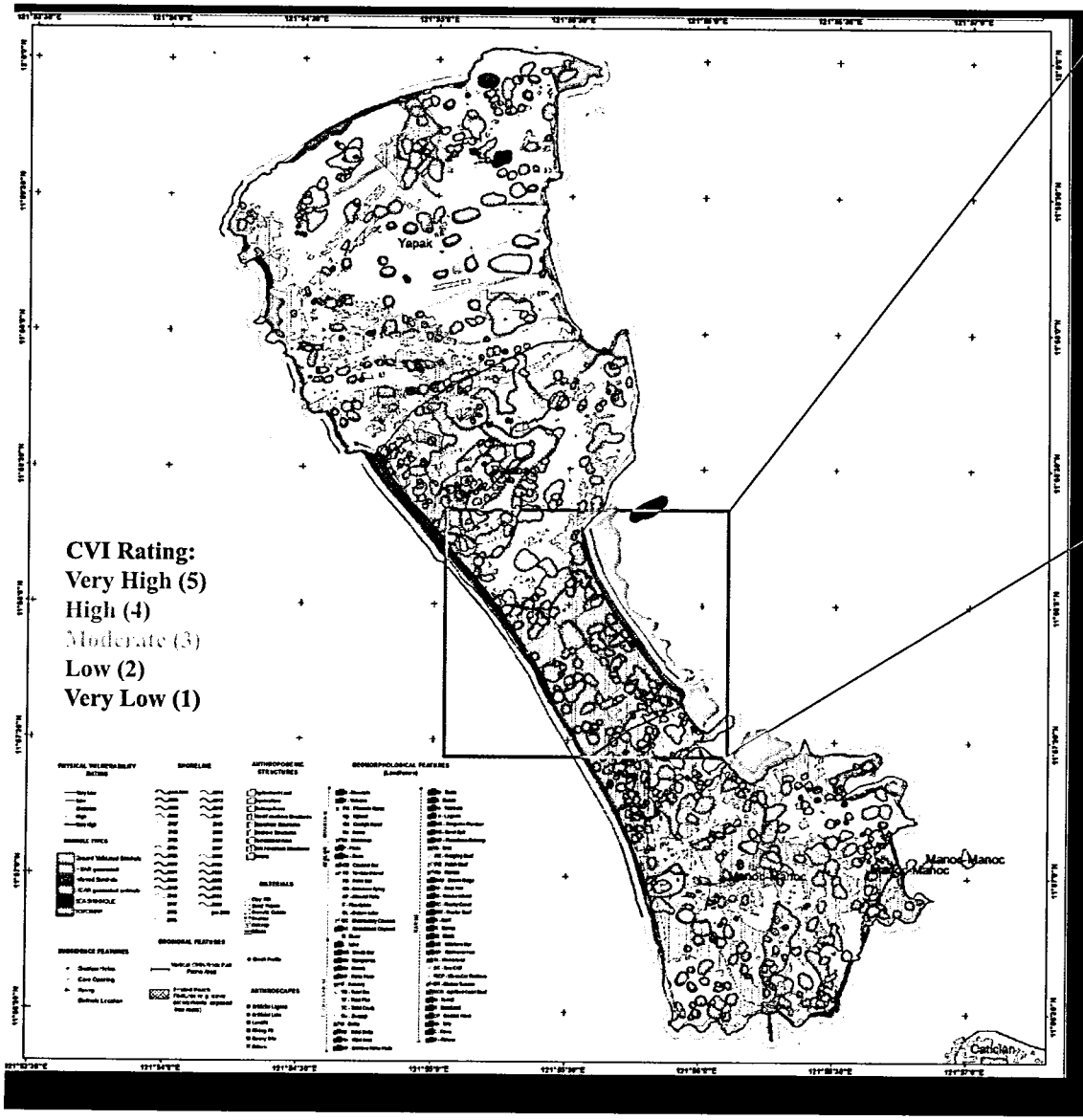
- Delon Porcalla -

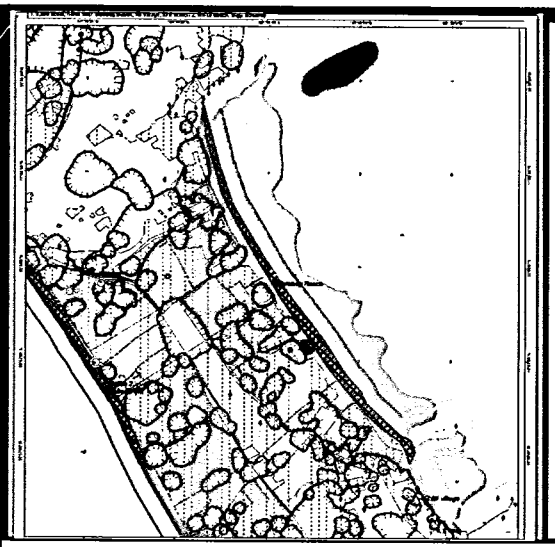
October 22, 2006 | 12:00am


Source: Deparis and del Cam



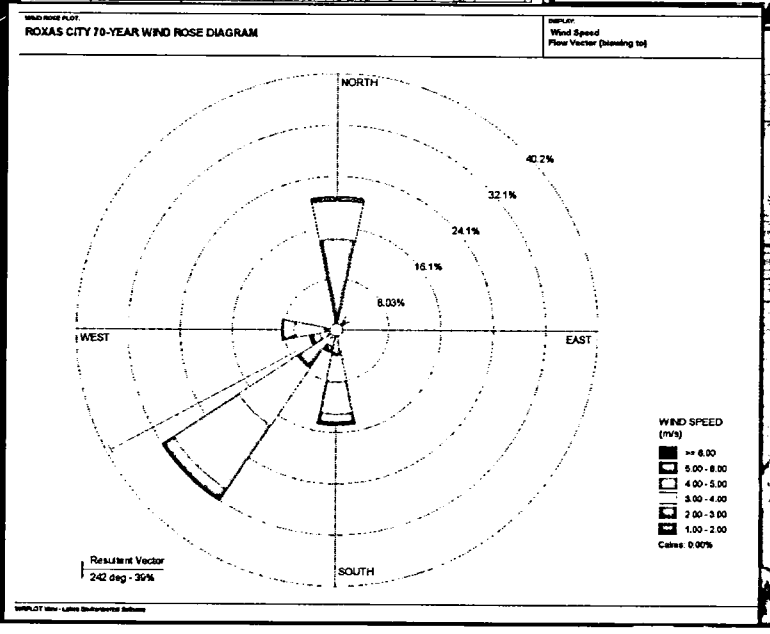
COASTAL HAZARD ASSESSMENT

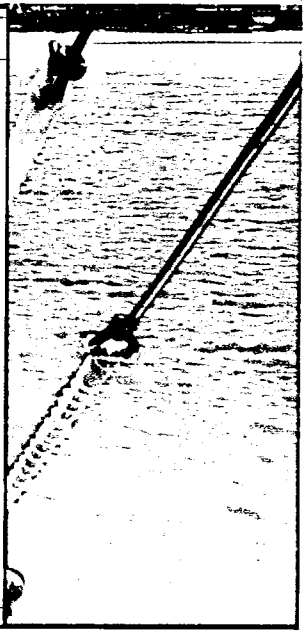




CVI Physical Parameters:

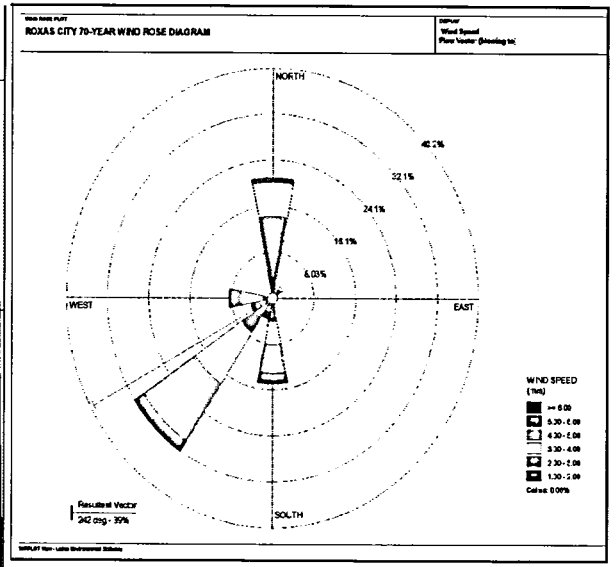
- *Shoreline Change*
- *Geology and Geomorphology*
- *Coastal Alignment*
- *Coastal Slope*
- *Human Activities*
- *Natural Buffers*
- *Mean Tidal Range*



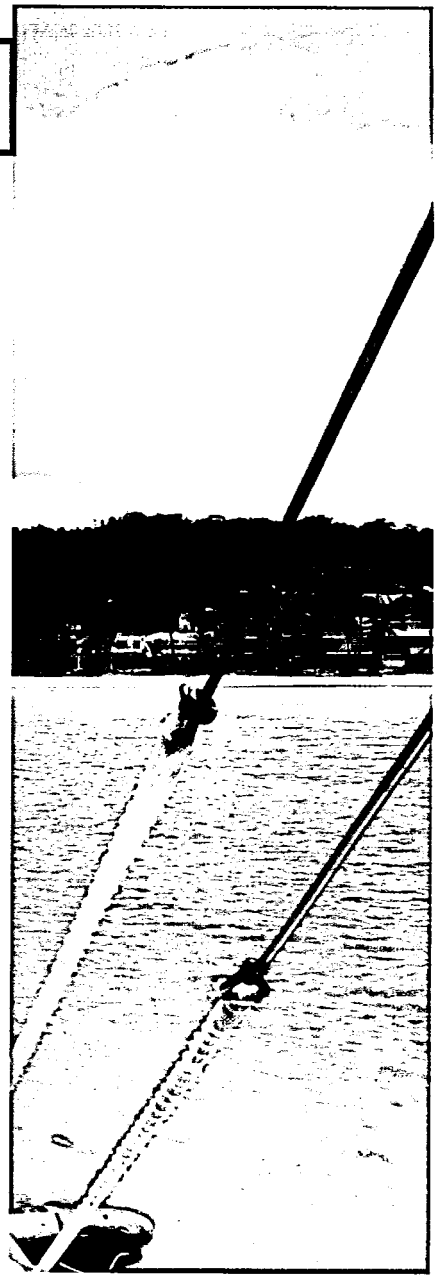


Bathymetry


12° 0' 0" N
11° 58' 48" N
11° 57' 36" N
11° 56' 24" N
121° 52' 48" E
121° 54' 0" E
121° 55' 12" E
121° 56' 24" E
121° 57' 36" E
121° 58' 48" E
Depth (m
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80
3 km
Google Earth


ROXAS CITY 70-YEAR WIND ROSE DIAGRAM
NORTH
EAST
SOUTH
WEST
WIND SPEED

CONCLUSION AND RECOMMENDATIONS



- Sinkholes are the primary karst features in Boracay. Therefore, the most cost-effective way to reduce sinkhole risks is by **controlling drainage.** This involves preventing any new water inputs into the soil profile. Such inputs are typically caused by increased runoff from concrete or asphalt surfaces, poorly located soak ways, broken drains and pipelines, unmanaged storm water, or the removal of topsoil.

- Prior to any construction of major infrastructures requiring ECC in all portions of Boracay island, an Engineering Geological and Geohazards Assessment (EGGA) should required to be undertaken by the proponent by the EMB, per DENR AO2000-28 and MC2000-33. The corresponding report (EGGAR) should be submitted and thoroughly reviewed by the MGB. As a note, the EGGA is an additional requirement of the EIA process **BEFORE the issuance of the environmental compliance certificate (ECC) or any infrastructure development. It should not be a** post-ECC conditionality.

CONCLUSION AND RECOMMENDATIONS

- In the EGGA report (EGGAR), the project proponent should be able to document in detail the geological hazards (i.e., future climate-change effects such as sea-level rise) based on scientific principles and methods. This should also detail the condition of the subsurface using borehole data. **The EGGAR should be very clear and specific about the measures (both structural and non-structural) that need to be implemented in order to mitigate geohazards and at the same time, avoid any untoward incident that could affect neighbouring areas**. The EGGAR is reviewed by the Mines and Geosciences Bureau (Central and/or Regional). Coastal projects are reviewed by the MGSD-MGB (CO).

- Land developers and managers should make a **concerted/coordinated effort with the LGU to ensure proper management of groundwater resources**. This include avoidance of excessive withdrawal of groundwater that would lead to enhanced ground subsidence and attendant increase in relative sea-level and associated hazards (e.g., saltwater intrusion). Given that Boracay is a highly populated small island with limited groundwater resources and prone to ground subsidence, **tapping of groundwater is not recommended.**

CONCLUSION AND RECOMMENDATIONS

- It is essential to **educate all stakeholders and the general population about the intricate relationships among beach processes of erosion and sediment transport; pollution dispersion patterns; the role of natural buffers (coral reefs and coastal vegetation), and anthropogenic activities in marine, coastal and terrestrial areas**. To effectively implement and adhere to coastal erosion and proper land development and management guidelines, it is vital to address any misconceptions through a sustained information and education campaign (IEC) to be conducted by the local government, alongside various agencies of the DENR and other relevant agencies.

- The **LGU should ensure the protection and enhancement of natural buffers, including coral reefs, seagrasses, and mangroves**. The LGU should strictly adhere to and implement existing laws related to the preservation of these critical natural buffers.

CONCLUSION AND RECOMMENDATIONS

- As net coastal erosion affects Boracay, implementing a **setback zone of at least 25 meters plus 5 meters from the highest high tide** is recommended (e.g., for future developments) in the beaches/coastal plain in consideration of potential climate change effects, such as relative sea level rise and ground subsidence. It should be noted that some areas within Boracay show indications of subsidence related to the dissolution features such as sinkholes and caverns.

- **Coastal developments in cliff-bounded areas should be avoided** due to the risk of slope failures (e.g., rock slides or rock falls). Further, constructing at the cliff's edge, especially in the presence of a wave notch at the cliff base, should be discouraged, as these areas are highly susceptible to slope failure. Depending on the type of infrastructures and the result of the geotechnical test of the subsurface, an easement from the cliff edge should be established. At least 20-meter easement from the edge of the cliff is often recommended, subject to change with the result of the engineering/geotechnical results.

CONCLUSION AND RECOMMENDATIONS

- Given Boracay's limited land area and relatively subdued or rolling landscape, which limits sediment sources for coastal replenishment, it is imperative for the Local Government Unit (LGU) and coastal managers to **ensure that any construction along the coast does not disrupt natural sediment processes**.

- **The hauling of beach sands, for building structures; covering exposed tree roots and/or for recreational purposes such as building sandcastles should be strictly prohibited** due to the environmental sensitivity of karstic terrains and the limited sediments available for beach nourishment. This activity is prohibited under BP 265.

- The LGUs, with the active participation of communities should make an effort to **revegetate coastal areas affected by previous storms or subjected to cutting or burning.** The vegetation serves as windbreaks and help stabilize soils and beach sediments.

MINES AND GEOSCIENCES BUREAU

THANK YOU!

Lands and Marine Geological Survey Division MGB Central Office and Geosciences Division
MGB Regional Office No. VI