

On the Safety of the Bataan Nuclear Power Plant

Introduction

Cutting to the chase: the Napot Point, Morong Bataan site has an unacceptably high risk of serious damage from earthquakes, volcanism, or both.

That risk is magnified by what Hon. Cong. Roilo Golez has characterized as a national lack of a “culture of safety that is observed in Japan, the United States and Western Europe.”

That lack has been vigorously exhibited ever since the plant was planned.

The latest expression of that lack of a culture of safety is the very bill that is before you. By “**MANDATING THE IMMEDIATE REHABILITATION, COMMISSIONING AND COMMERCIAL OPERATION OF THE BATAAN NUCLEAR POWER PLANT**”, this bill assumes that the site is safe, ignoring or misrepresenting much geological evidence that it is not.

Since January 12, 2009, technicians from the Korea Electric Power Corp. (Kepco) have been studying the plant itself. The only attention paid to the natural hazards in the area is in the Explanatory Note of the original House Bill 4631 of Hon. Congressman Mark Cojuangco. I will show that this evaluation is seriously in error. By mid January, the Philippine Institute of Volcanology and Seismology (Phivolcs) had not yet been directed to re-evaluate the geologic hazards of the site. This, despite the fact that more than twenty additional years of seismologic data had accumulated, and that enormous strides had been made in satellite-borne remote-sensing volcanologic technology.

In the 1970's, “volcaniclastic sedimentology” -- the scientific study of how volcanic explosion debris is produced, transported and deposited -- had not yet even been formalized. It was only in 1991 that the major international monograph *Sedimentation in Volcanic Settings* was published. (That monograph included one of the earliest formal uses of the term *lahar*, in an article on Mt. Mayon co-authored by Dr. Tevfik Arguden and myself. Lahars were still to be recognized by the Filipino public in 1991.)

Recognition of the dangers that earthquakes posed to the BNPP were recognized very early, but apparently were ignored as construction proceeded.

The 12 January 1977 Hernandez-Santos Report

On 12 January 1977, shortly after construction had already started on the BNPP, Nuclear Technologist III Elmer C. Hernandez and Senior Nuclear Technologist Gabriel Santos, Jr. submitted an 8-page “Report on the evaluation of the geological and seismological studies made on the Philippine Nuclear Power Plant – I Site”. Excerpts from that report are alarming. Commenting on previous Napocor site studies:

“1. The proposed site ... is very near the Manila Trench – Luzon Trough tectonic structures.

“2. The proposed site is literally bracketed by significant and very strong (high magnitude) historical earthquakes...within a 100 kilometer radius. In fact...one ... occurred (1970) within 1-2 km of the proposed site itself in Napot Point.

“3. The probability of an epicenter of an earthquake occurring at the site is unacceptably very high. Covering a span of 74 years, 49 significant earthquakes occurred in the above area, one of which one occurred within 1-2 kilometers of the proposed site itself. ...”

“4. Known significant and major earthquakes with magnitudes greater than 8 were apparently overlooked and not considered in the computation of the shutdown earthquake design basis. ... [These] should be of such value that will not seriously affect the safety of the plant to the extent that Part 100 of the USAEC Regulatory Guide could be exceeded.

“5. Earth satellite data... suggest the presence of a lineament in the site itself. Ground magnetometer data... appear to substantiate the existence of a probable fault at the proposed plant location.”

The Hernandez-Santos report concluded: “... The above review has revealed the high risk potential for the protection of health and safety of the public if the proposed site is accepted. High probability earth motions associated with earthquakes due to the Manila Trench – West Luzon Trough displacements and presence of a probable fault in the plant location itself may lend to structural failures causing the release of radioactive materials from the nuclear power plant or may cause extensive damage to the plant.”

But the construction continued.

The 25 January 1979 Sonido Memorandum

Nevertheless, the Philippine Atomic Energy Commission must have been concerned enough to ask Prof. Ernesto Sonido of the UP-Diliman Department of Geology and Geography to investigate the site further. On 25 January 1979 he submitted to PAEC a memorandum: “Observations on a field inspection of the trenches constructed by NPC to answer PAEC Question No. 2 entitled ‘Confirming the absence of shore faults south of Napot Point, Morong, Bataan’”.

Apparently, NPC had cut trenches through a postulated fault and reported no evidence of faulting in them “without considering the difficulty of detecting faults in thick overburden and easily ‘healable’ rocks exposed in the trenches.”

Dr. Sonido remarked on numerous mistakes by NPC, including a 90° error in the given direction of a trench. He also remarks several times that much field information had already been destroyed or obscured by the ongoing construction.

Nevertheless, Dr. Sonido and Mr. John Palmer, who was the groundwater consultant of the contractor firm Ebasco, agreed on site that “the postulated fault is a fault zone with a width equal to the width of [a] river [south of Napot Point?] and that the existing river is along the fault...” Numerous seepages along fractures in otherwise impermeable rocks, and variable depths of a ‘tuff’ horizon in more than 30 boreholes at the plant site “...suggest that the area had been tectonically active...”.

The 1992 Torres report

While he was still at Phivolcs, Dr. Ronnie Torres, a foremost expert regarding pyroclastic flows who is now at the University of Hawaii, warned of volcanism and faulting at the site in a 1992 report, “The vulnerability of PNPP site to the hazards of Natib volcano” (PHIVOLCS *Observer* Vol. 8 No. 3: 1-4).

Quoting Dr. Torres: “Natib volcano does not erupt very often *but could still erupt.*” As a rough rule of thumb, the longer a volcano is in repose, the more time it has to store eruptive energy, and thus, the stronger the eventual eruption.

The Sonido-Umbal 2000 Report to the Subic Bay Metropolitan Authority

Dr. Ernesto Sonido collaborated with Mr. Jesse Umbal to submit in 2000 an exhaustive, 38-page analysis for SBMA of the geology and geohazards of the Subic Bay area. Jess Umbal is one of the brightest, most competent volcanologists and geologists I know. Working with me during the Pinatubo eruption, he earned his Masters degree at the University of Illinois in 1993. Dr. Sonido is not a volcanologist, so we can assume that Umbal wrote those aspects in the report, which adjudged Natib as “potentially active”.

It is important to recognize that Natib, like Pinatubo, is a “caldera-forming” volcano (Figure 1). Volcanoes of that type characteristically have very powerful eruptions separated by long repose periods. The report documented two Natib eruptions that formed large calderas, one with a diameter more than twice as big as that of the new caldera on Mt. Pinatubo.

Sonido and Umbal also studied the system of faults exposed on land in the larger region. They estimated the recurrence period for earthquakes of Magnitude 6.4 to 7.0 at 22 years; of Magnitude 7.0 to 7.3 at 59 years; and of Magnitude 7.3 to 8.2 at 157 years.

The Cabato et al. 2005 article

Hon. Congressman Mark Cojuangco’s Explanatory Note to his Bill cites our work as certifying the safety of the site:

“Top geologists have evaluated Bataan and, with the exception of Mt. Natib which is a dormant volcano whose last eruption was estimated to have been between 11.3 to 18 thousand years ago (Cabato et al. 2005) and which is ten kilometers (10 km) from the BNPP, could find no anomalies in locating the plant there.”

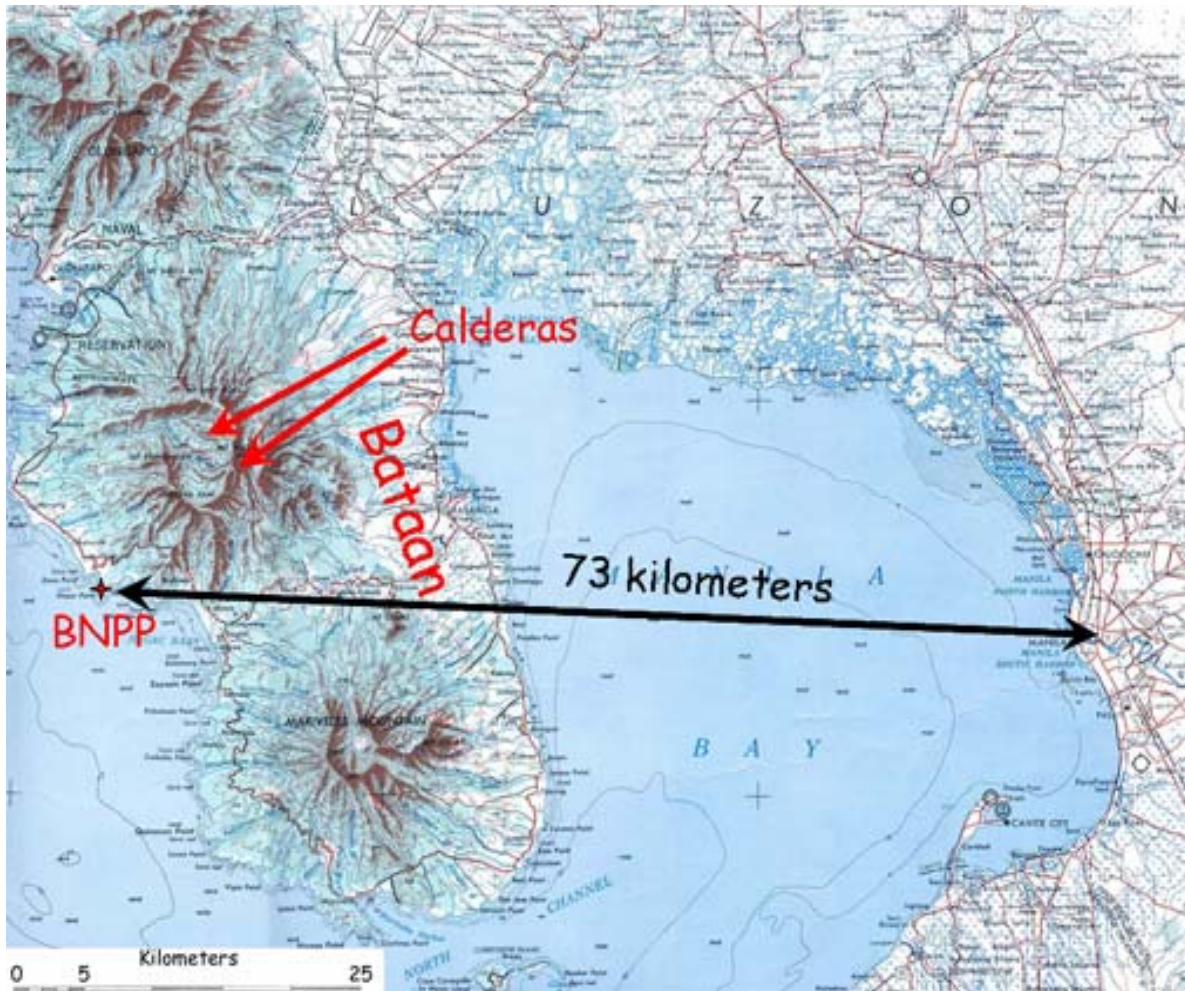


FIGURE 1. Mt. Natib, the Bataan penionsula, and Manila Bay.

The full title of that report, published after rigorous review in an international scientific journal, is “Cabato, M. E. J. A., Rodolfo, K. S., and Siringan, F. P. (2005). History of sedimentary infilling and faulting in Subic Bay, Philippines revealed in high-resolution seismic reflection profiles: *Journal of Asian Earth Science* Vol. 25: 849-858.

That work took several years of gathering 125 kilometers of seismic reflection data **cris**-crossing Subic Bay, analyzing it, and preparing the manuscript, which underwent rigorous scrutiny by our geological peers abroad.

My first comment about Congressman Cojuangco’s quoted comment is: The BNPP is *not* 10 kilometers away from Natib, it is *on* Natib, which constitutes more than the entire northern half of the Bataan peninsula (Figure 1).

Second, Drs. Cabato and Siringan and I did *not* estimate the age of Mt. Natib’s last eruption in our paper. This is what we wrote:

“A breach in the caldera of Mt. Natib is the most likely source of a presumed pyroclastic deposit in the eastern bay that is associated with sediments about 11.3–18 ka [11,300 to 18,000 years ago], indicating that a Natib eruption occurred much more recently than previously documented for this volcano.”

The objective of our research had been to study the geologic history of Subic Bay. As is common in science, we discovered facts beyond that objective. By accident, we found evidence of a Natib eruption much younger than the 27,000 year old one previously recognized. To determine the latest activity of Natib would require a systematic study of the volcano. If we could cut the age of the youngest recognized eruption in half purely by accident, what are the chances of finding an even younger eruption?

But even a casual reading of our article reveals a much greater potential danger, one from earthquakes. We have documented numerous faults in Subic Bay, some very recently active, geologically speaking. Again quoting from our paper:

“...the youngest [faults] ... show that movements occurred about every 2 ky [2,000 years], most recently about 3 ka [3,000 years ago].”

This geologic evidence suggests that Subic Bay may be overdue for an episode of faulting and earthquakes.

Vertical displacements on the faults in Subic Bay are as much as 5 meters. In other words, when one of the faults is active, one side of it moves up or down vertically about 5 meters relative to the other side. We cannot say how much additional, horizontal motion would accompany the vertical drop during an earthquake, or how fast the movement would be. We also cannot say whether such movement would generate a tsunami, but this is a genuine possibility.

Lessons from the 1991 Pinatubo Eruption

We must remember what Pinatubo taught us in 1991.

First, Pinatubo was regarded as “extinct” until only a few months before the eruption.

Second, the new caldera is less than half as wide as the largest of the two Natib calderas (Figure 2), which must have been formed by an even larger eruption. Remember that the new Pinatubo caldera was formed by removing between two and three cubic kilometers of rock.

Third, caldera-forming eruptions form large “pyroclastic flows” – dense mixtures of volcanic gas and rock debris as hot as 500°C that flow down the side of the volcano at speeds of 100 kilometers per hour or more. Note that the large presumed pyroclastic flow from Mt. Natib that Cabato et al. reported easily made its way into Subic Bay. Similarly, if a large caldera formed in the future and sent pyroclastic flows southward, Napot Point would be overwhelmed.

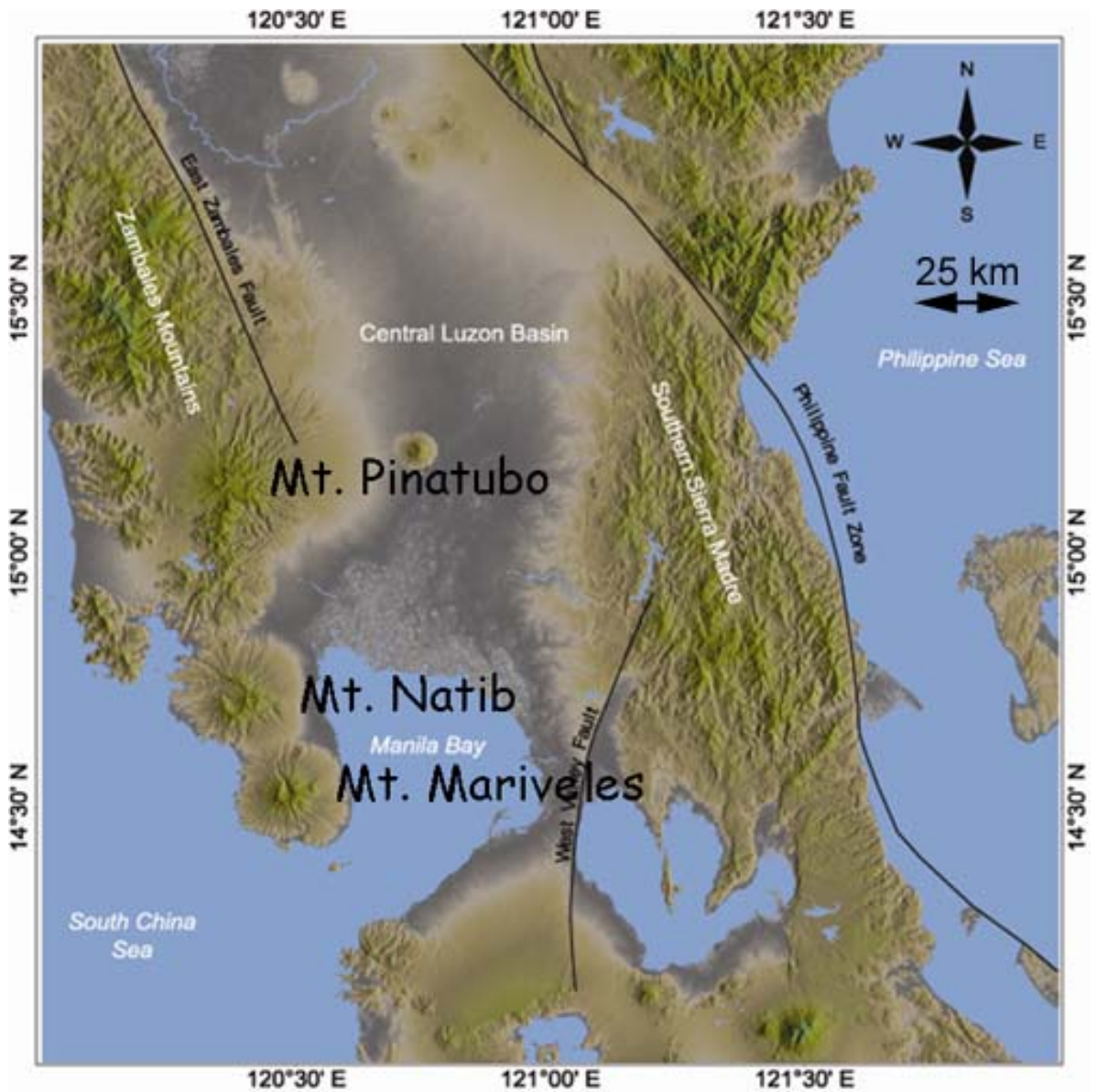


FIGURE 2. The three sister volcanoes Pinatubo, Natib and Mariveles. Note the sizes of their respective calderas.

New Earthquake Data

Since 1973, a large number of earthquakes have occurred around and even under Mt. Natib (Figure 3). We cannot say what caused them, but only two explanations are possible: either they are caused by movements on faults, or by movement of magma. Phivolcs has well trained seismologists who can evaluate each individual quake to distinguish between the two possibilities. Given the size of the population that might be at risk, that analysis is urgent.

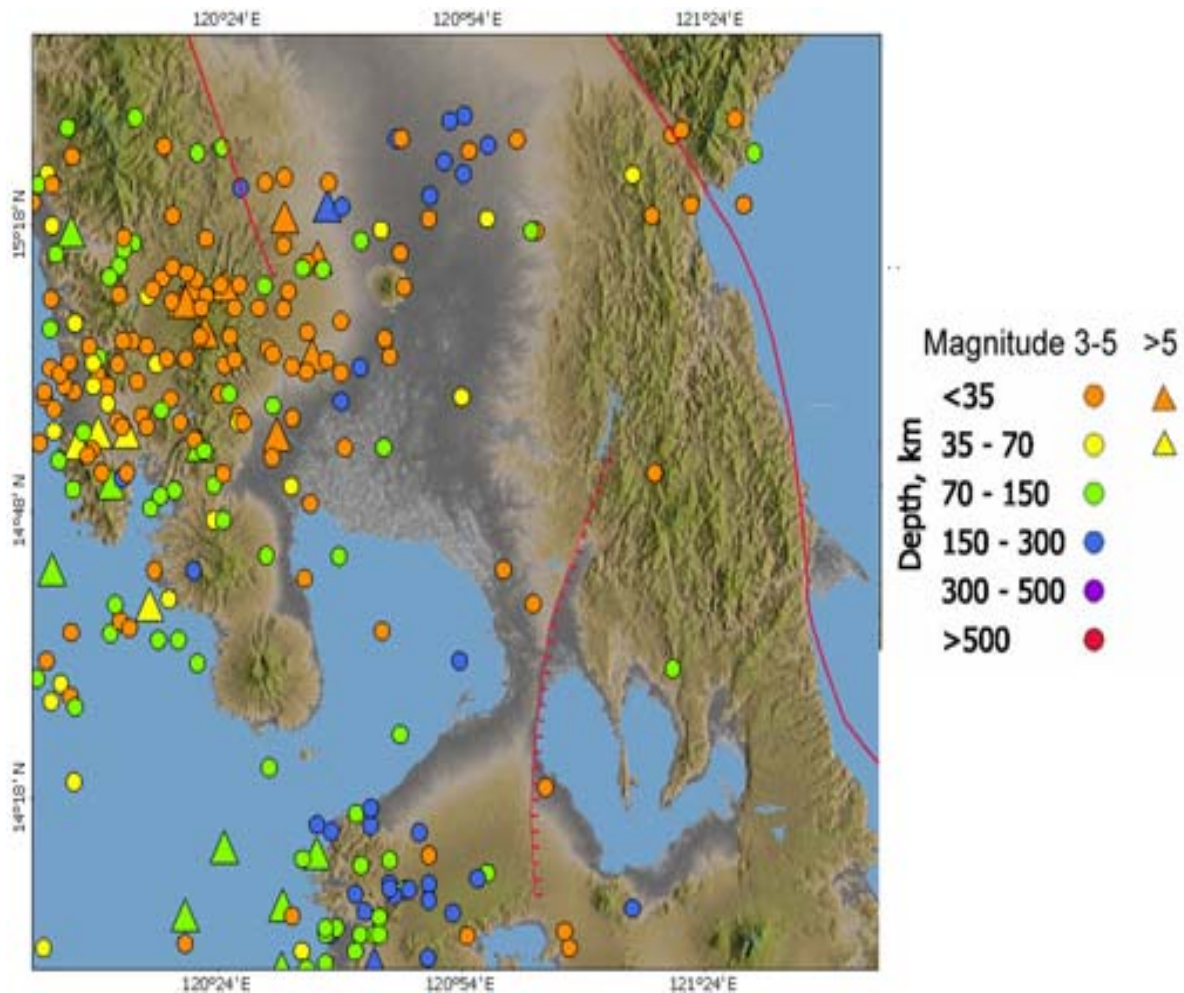


FIGURE 3. Epicenters of all earthquakes from 1973 to 2008 recorded and archived by the National Earthquake Information Center of the United States Geological Survey.

The Lubao Lineament

Since 1997, Prof. Fernando Siringan (formerly at UP-NIGS but now with the Marine Science Institute at UP-Diliman), his students and I have been studying land subsidence of coastal Bataan, Pampanga, Bulacan and Kamanava. Very early, we noticed a sharp, northeast-trending lineament in Pampanga, which we have named the Lubao Lineament after the town of that locality. It is interesting to compare Figure 5 showing the Lubao lineament with the epicenter locations in Figure 4. Again, the possibility that the lineament is a fault, and the possibility that it extends under Mt. Natib need urgently to be explored by scientists of Phivolcs and other institutions. Professor Mahar Lagmay has established genetic relationships between faults and volcanoes, including Mt. Pinatubo and the volcanoes in Bicol.

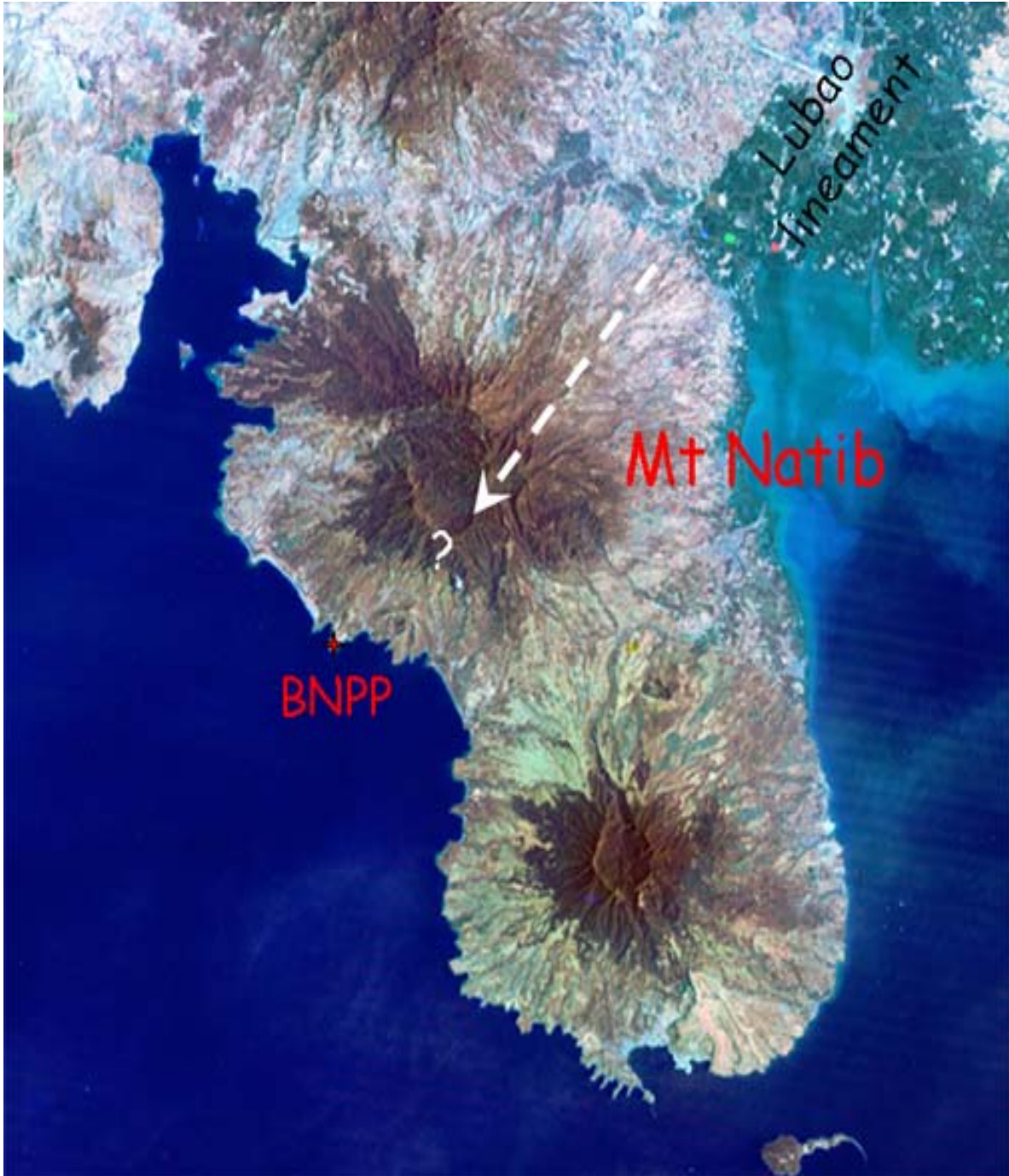


FIGURE 4. Landsat image of the Bataan Peninsula including Mt. Natib, and the Lubao lineament to the northeast. Compare with Figure 3, the map of earthquake epicenters.

Faulting, Earthquakes, and the Geographic Extent of Earthquake Damage

At a colloquium on the BNPP at the National Institute of Geological Sciences in UP Diliman on January 30, Congressman Cojuangco stated that he is unwilling to postpone

the commissioning of the BNPP any longer than it takes to determine if a fault exists directly under the reactor. Another lesson from the recent past is in order, from the Luzon earthquake of 1990.

Quoting Phivolcs: “At 16:26 local time on 16 July 1990, a surface magnitude 7.8 earthquake struck Luzon, forming a 125 km-long ground rupture that stretched from Dingalan, Aurora to Kayapa, Nueva Vizcaya, due to lateral movements along the Philippine Fault Zone and the Digdig Fault. The quake’s epicentre was close to the town of Rizal, north-east of Cabanatuan City, and caused damage across an area of around 20,000 km², stretching from north-west Manila, through central Luzon and into the Cordillera Mountains.

“The tourist destination of Baguio City was one of the worst-hit locations, with close to a thousand deaths occurring here due to building collapse, including high-rise hotels. For the first 48 hours after the quake, the city was isolated from the rest of the country due to landslides blocking transport routes.



FIGURE 5. Damage from the earthquake centered in Rizal, Nueva Ecija, in Baguio and Dagupan cities, both 100 kilometers away from the epicenter.

“Only one building in Cabanatuan City was destroyed killing 154 people and in Dagupan City, liquefaction caused buildings to sink by as much as 1 m leading to flooding across some of the regions of the city that decreased in elevation. The towns of Rizal, Laur, Bongabon, Gabaldon, Digdig, Puncan and Imugan were also badly affected. In the province of La Union, east Luzon island, 2387 families were displaced when two coastal villages sank.

Clearly, a serious earthquake anywhere near the BNPP, and not just under it, would have drastic consequences.

Why the Rush to Activate BNPP?

A mystery has arisen, centered on the following chronology:

Late January, 2008, DOE Sec. Angelo Reyes requests the International Atomic Agency (IAEA) to help assess the possibility of reopening the BNPP.

June 7, 2008: Newspapers quote (or misquote?) Sec. Reyes as saying that “a team from the International Atomic Energy Agency that inspected the power plant in Bataan months ago has reported that this could be rehabilitated in at least five years at a cost of \$800 million.” (But the IAEA denies this).

July 8, 2008: Congressman Mark Cojuangco files House Bill 4631.

24 June or 12 July 2008: The IAEA reports that: “Earlier this year, the IAEA was asked by the government of the Philippines to advise on the recommended steps to follow and matters to be considered in rehabilitating Bataan Nuclear Power Plant (BNPP), a completely built pressurized water reactor that has been "mothballed" since 1986. A team of experts was deployed by the IAEA in February 2008 to counsel the Philippine government on the practicalities of revitalizing the plant.

"In the case of Bataan, the plant was completed over 20 years ago. Our mission visited the plant to gauge the current state of the plant, but our suggestion to the Philippines was simply on what steps they need to take and what needs to be considered to complete their own assessment," explained Akira Omoto, Director of the IAEA's Division of Nuclear Power and leader of the mission to the Philippines.

"The government has to assess what the new licensing requirements should be, how to modernize the two-decades old technology to current standards, and how to confirm that all aspects of the plant will function properly and safely.

“It is not the IAEA’s role to state whether the plant is usable or not, or how much it will cost to rehabilitate,” said Omoto [emphasis mine].

Does this mean that all the necessary due diligence requested by IAEA has been accomplished?

A final note: In the 1970s, the IAEA had no guidelines for assessing volcanic hazards in nuclear power plant siting.

Such guidelines only began to be established in 1993 by an international team of volcanologists, at the behest of IAEA. In 1997, IAEA published its Provisional Safety Standards Series No. 1: “Volcanoes and associated topics in relation to nuclear power plant siting”.

The protocol provided by the document clearly would take several years at least. So the Bill “MANDATING THE IMMEDIATE REHABILITATION, COMMISSIONING AND COMMERCIAL OPERATION OF THE BATAAN NUCLEAR POWER PLANT” is moot. No way can it be executed.

Final Thoughts

I never ask anyone to take my scientific pronouncements on faith, but an act “Mandating the immediate re-commissioning and commercial operation of the Bataan Nuclear Power Plant” is clearly premature. I would welcome, instead, legislation that properly funds a thorough, inter-agency evaluation of the site. The study would properly be led by Phivolcs and involve geologists of the Mines and Geosciences Bureau and the National Institute of Geological Sciences.

There are other very strong reasons why nuclear power is wrong for the Philippines.

We have no Uranium ore in the Philippines, and no hope of finding any. Reviving nuclear power here, in addition to putting many Filipinos in harm’s way, means that we would expend a huge amount of money to put ourselves at the mercies of countries that have Uranium, much as we have made ourselves utterly dependent on petroleum-exporting companies.

The very well-funded global nuclear lobby is fond of claiming that nuclear power generates no carbon dioxide to add to global warming. But much fossil fuel is spent to mine, mill and process Uranium before it reaches a reactor. Every watt of electricity generated by a nuclear plant thus indirectly makes about 30 percent as much CO₂ as a watt generated by burning fossil fuel.

The Congressman says that government will have to subsidize nuclear power here. Instead of saying “government”, he should say “the Filipino taxpayer”.

The Filipino taxpayer has already paid US\$ 2.3 billion for the plant, plus \$460 million in interest, without receiving any benefit. Now it is proposed to spend another \$1 billion to renovate it.

No less an expert on Philippine governmental corruption than President Joseph Estrada declared publicly in June 1999 that Philippine government project funds routinely lose 20% to graft and corruption.

Of course, the present administration is totally free of graft and corruption. But renovating BNPP could take at least a decade, and who can guarantee the honesty of administrations to come? After all, 20% of \$1 billion is very tempting...

Given the potential burden of reviving BNPP, the government owes it to the Filipino taxpayer to vigorously, openly, and thoroughly explore all the ramifications.

Finally, beyond the issues of the Bataan Nuclear Power Plant, the nation must concern itself with the continuing abuse of science. Dr. Cabato, like many other highly trained scientists, could well be discouraged from returning to work here. Is it any wonder that Philippine science lags behind the rest of Asia?

Testimony given on behalf of the Philippine Climate Watch Alliance
To the House Committee on Appropriations
February 2, 2009

I hereby request that this document be accepted and entered into
the Hearing transcript in support of my testimony.



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