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The Manila Observatory: Cradle of early Philippine geophysics

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For 17th and 18th century Westerners, the gateway to Asia was through the Philippines. On its shores, Spanish galleons unloaded gold and silver from the New World to trade for spices, silk, abaca, and other products from Asian countries that remained closed to them. The Philippines, under Spanish colonial rule since the 16th century, was more accessible and served as a staging area to the mainland. The capital city, Manila, eventually became the de facto colonial trading center in Asia during this period.

The growing trading needs of the Asiatic region and its concomitant economic growth brought about the idea of a research institution that would provide scientific meteorological charts. Thus, the Manila Observatory started meteorological and geophysical studies in 1865, serving the Philippines as well as Southeast Asia.

The Manila Observatory (MO) was established as a private research institution, serving the science apostolate of the Society of Jesus (Jesuit). With its initial successful venture into meteorology, particularly in the systematic observation of the weather, the institute gained support and recognition. Typhoon warnings became part of its technical service to the public in 1879, and the observatory's investigation of a series of earthquakes in 1880 boosted its reputation internationally. In 1884, a royal decree from the Spanish Crown formally recognized MO as the official Philippine institution for weather forecasting, and a network of secondary stations in various parts of the country was established for this purpose.

With merchant shipping in mind, in 1885, MO began its time service and tidal studies which would greatly benefit navigation. Two years later, MO established a section devoted to the study of terrestrial magnetism in the Philippines and later one specializing in seismology. Finally, an astronomical section was completed in 1899.

In view of the MO's past performance, in 1901, the succeeding American colonial government made it the official Philippine Weather Bureau. As such, for the next 40 years, the observatory maintained a high profile in international expositions and scientific conferences. Accurate typhoon forecasting and scientific work in meteorology, geomagnetism, and astronomy gained an international reputation.

But World War II brought an end to the long and prolific history of the observatory, which was destroyed during the Battle of Manila in 1945. The new Philippine government established a separate Weather Bureau Office under government control which assumed the MO's previous meteorological functions.

However, the Jesuit observatory was to begin a second era in 1951, when it resumed operations in Baguio City. Postwar activities were confined to seismology, astronomy, and the study of sun-earth relations. In 1962, the principal station was transferred to its present site within the campus of the Ateneo de Manila University in Loyola Heights, Metro Manila (Figure 1a, b). This new location facilitated the MO's expansion and interaction with academic, government, and private organizations at home and abroad.

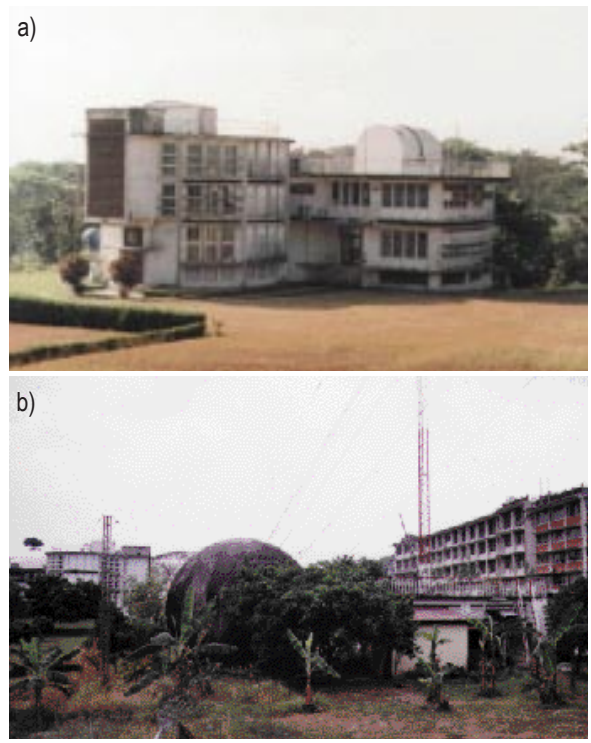

Figure 1. Some of the installations of the Manila Observatory: (a) Building where the spectroheliograph and LIDAR system operate, and (b) Optics and Ionosphere divisions instruments in the foreground; on the right, the building that houses the administration offices, technical library, and support research labs.

In fact, MO played a role in supporting the United States' space program in the 1960s. With funding from NASA, the observatory's Optics Division upgraded its instruments to improve monitoring of the sun's activities, especially solar flares, which are known to knock out satellites, disrupt communications, and pose a serious threat to astronauts in orbit. Because of its strategic location, MO became part of NASA's 24-hour surveillance network to study solar activities and sunspot cycles.

Current research. The upgraded observatory has four divisions — Seismic, Optics, Ionosphere, and Environmental Research — all headed by Jesuit scientific scholars.

Seismic: This department operates the country's seismograph stations to record earthquakes. With this information, seismic hazards are better understood and risk analysis is fine-tuned to help establish and improve building codes. The study of regional tectonics from earthquake occurrences helps to continuously upgrade the seismo-

tectonic map of the Philippines. The division has begun to pursue crustal deformation studies using space-based geodetic techniques. Scientists from the Jet Propulsion Laboratories (JPL) expressed their interest in setting up a GPS receiving station within MO grounds that will be part of a worldwide net of observation points. Once this project is under way, related applications of remote sensing (RS) and geographic information systems (GIS) — seismic hazard extraction, detection, mapping, and monitoring — will be explored.

Optics: Four laboratories form the Optics Division: Spectroscopy, LIDAR, Pollution Monitoring, and Vacuum and Thin Films. The first three labs are mainly dedicated to air pollution monitoring, while the vacuum facility, when fully developed, will provide support to this division.

The spectroheliograph was originally designed to monitor sunspot cycles and solar activities. The instrument, however, is undergoing rehabilitation in optical design for conversion into a system for measuring atmospheric pollution. A proposal to convert the spectroheliograph into a monitoring system in the differential optical absorption spectroscopy (DOAS) mode has been fielded with different agencies worldwide and awaits response from funding agencies. This DOAS-type instrument uses ultraviolet and visible light to probe the atmosphere.

The LIDAR (light detection and ranging) system operates at the second harmonic node (532 nm) of an Nd:YAG laser transmitter. The system is capable of detecting and imaging the presence of suspended aerosol and dust particles in the atmosphere. Optical properties of these suspended particles can be calculated from the backscatter intensity. Cloud base and top can also be determined. This system has been in operation since January 1996.

Ionosphere: Four times each hour, the ionosphere is probed by a transmitter having a sweep frequency from 17 to 70 MHz. Signals transmitted across the equator from MO and received by several stations reveal the changing characteristics of the equatorial ionosphere. This is a cooperative

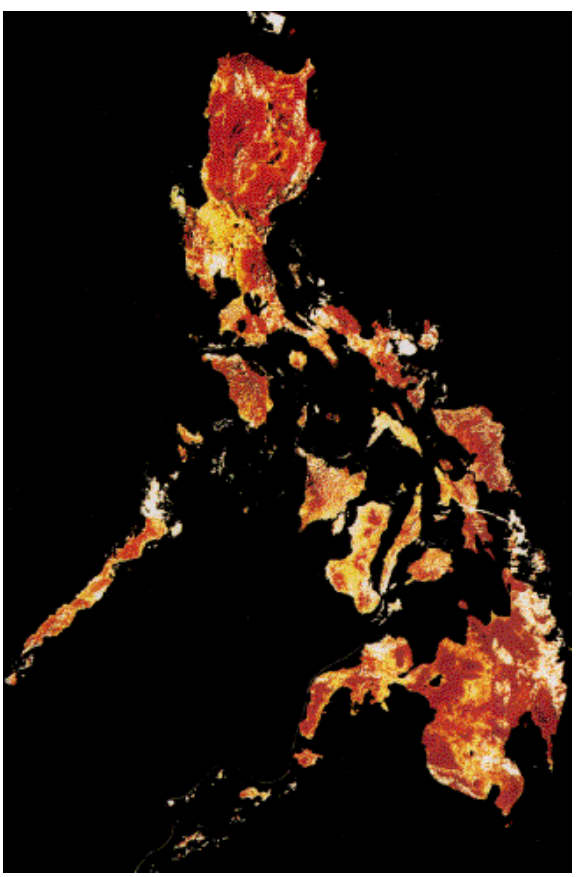

Figure 2. Landsat mosaic profile of the Philippine Islands suggests the fragmented nature of the country's geology.

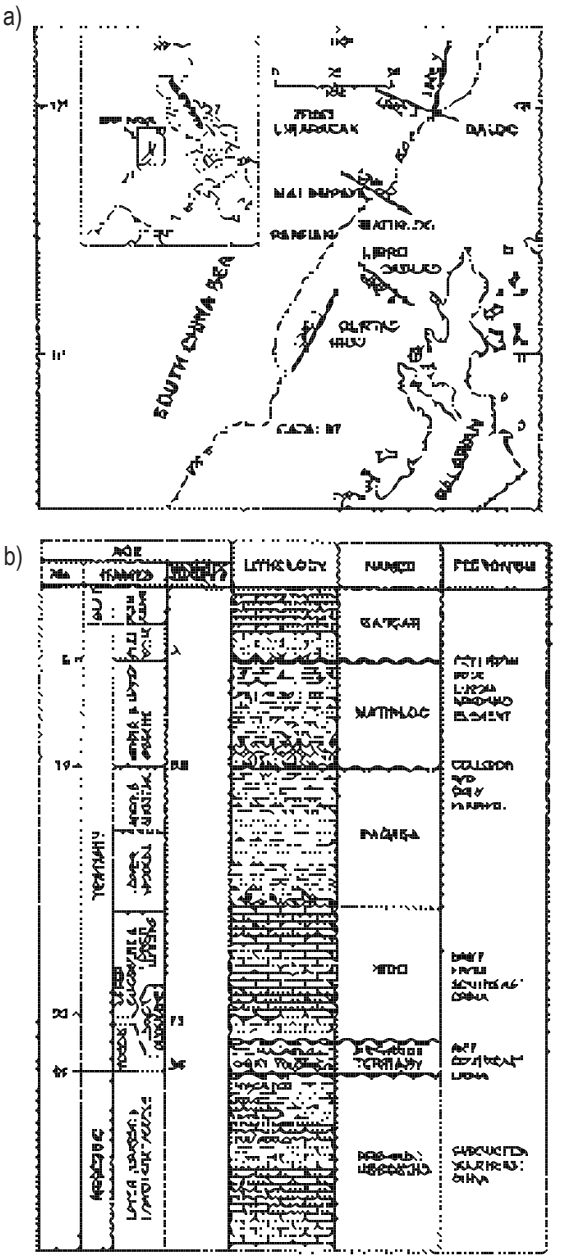

Figure 3. Most of the country's oil production comes from offshore, northwest of Palawan Island. (a) Location map and (b) tectonism and lithostratigraphic relationships for the area.

work between MO and DSTO of Australia. In addition, ionospheric tomography is being conducted via signals from a set of satellites (the precursor of the GPS system) and are simultaneously received by six stations located in several countries along the 120° East Meridian, to determine the morphology and dynamics of the equatorial anomaly.

Environmental Research: This new division provides technical assistance to government and private organizations concerned with watershed management and environmental issues through the establishment of the Community Mapping Base Station. It will become the center of expanded RS-GIS applications facilitating the mapping of rural-urban and land-use changes that are anticipated when economic and/or population growth continue to expand. There are plans, however, to spin off this division so that it can experience faster growth as an independent organization.

In response to growing concern over the environmental degradation brought about by population and industrial growth, especially in Southeast Asia, there has been strong advocacy for sustainable development through scientific and innovative processes. With cooperation and funding support from Australian, Japanese, and United States organizations, MO is rapidly expanding a much-needed central laboratory to evaluate ecosystems at all levels — from molecular to regional. The lab also provides guidance in matters of socioenvironmental planning and management.

The laboratory's study of the region's sustainable growth will entail situational, conceptual, and predictive modeling that is often founded upon real-time and real-space data such as those accessible via RS-GIS-GPS. Natural events have often demonstrated that some local occurrences — for instance, the volcanic eruption of Mount Pinatubo in June 1991 — may have global effects. Thus, it is expected that the use of geophysical techniques will be expanded toward these studies.

Exploration geophysics. Manpower and financial requirements for oil and gas exploration are, for the time being, well beyond MO's capabilities. The Philippine Islands are an especially challenging region to survey due to a fragmented geology (Figure 2) that resulted from a long and complex history of microplate tectonics. Carbonate and clastic stratigraphic hydrocarbon traps — instead of structural reservoirs — are the norm; therefore, exploration risk is high, and returns on investment are small because the typical reservoir size is probably small. Most of the country's oil production comes from offshore in the northwest sector of Palawan (Figure 3).

Petroleum exploration and production fall under the jurisdiction of the Philippine National Oil Company (PETRON), in a consortium with other major foreign oil companies. MO's geophysical research efforts are conducted at a much smaller scale and directed toward mining — one of the country's major industries — engineering, and the expanding field of environmental applications. TLE

Acknowledgments: I thank my Jesuit mentors for their lifelong commitment, dedication, and devotion to their work and for inspiring others to continually challenge themselves to be better. Special dedication is extended to my grandfathers, Don José Javier Gochioco and Robert Choachuy, for their entrepreneurial and philanthropic spirits.

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