Report for 2003GU18B: Inventory and Evaluation of Karst Features Relating to Past and Present Groundwater Flow on Rota, Commonwealth of the Northern Mariana Islands (CNMI), in Terms of the Carbonate Island Karst Model

There are no reported publications resulting from this project.

Report Follows

PROJECT SYNOPSIS REPORT

Project Title: Inventory of Karst Features Relating to Past and Present Groundwater Flow in Rota CNMI, in terms of the Carbonate Island Karst Model.

Problem and Research Objectives

On uplifted limestone-covered islands, such as Rota, which rely on their limestone aquifers for most of their potable water, the karst features that develop in the limestone are important entry points, transport routes, and discharge points for groundwater. Understanding the relative sizes, distribution, and inter-relationships between the sinkholes, caves, and karst springs and seeps that control water entry and movement through the aquifer is therefore fundamental to formulating appropriate aquifer management practices to support sustainable economic development.

Rota is about 12 miles (20 km) long and 5 miles (8 km) wide at the widest point, and supports a population of about 2500. The entire island surface is covered by uplifted limestone, except for the 2.5-mile (4 km) scarp along the southernmost flank of the island, where the volcanic core is exposed. Currently, almost all of the island's potable water is produced from springs that emerge along the face of the scarp at the contact between the limestone and the underlying volcaniclastic basement. Protecting the watersheds that supply these springs must be given high priority to maintain water quality.

Future aquifer development will require a better understanding of the occurrence of water in the rest of the aquifer. Effective aquifer management and future development requires a more detailed understanding of the aquifer, specifically, the processes and pathways by which fresh water enters and is stored and transported through it. Experience on similar but more developed islands, such has Guam, has shown that his type of information will be needed in increasing detail by hydrogeologists, engineers, and planners to support reliable determinations of what types of extraction techniques are most appropriate, what levels of production are sustainable, and what sorts of land use and regulatory strategies are necessary or appropriate for protecting water quality.

The central objective of this study was to make a comprehensive survey of the island's major karst features, examine their relationships to the fundamental geologic units and hydrologic conditions (*e.g.*, past sea levels), and lay the groundwork for composing a systematic conceptual model of the island's aquifer units in terms of the Carbonate Island Karst Model. The project also provided the necessary reconnaissance of the island from which more detailed subsequent studies, such as the one recently concluded on Guam, may be successfully undertaken under separate funding.

Specific objectives of the project included the following: (1) Prepare maps of the key features of the karst drainage systems, to include fields of closed depressions, stream insurgences (groundwater entry points) and resurgences (groundwater exit points), and coastal springs and seeps. (2) Prepare preliminary maps of the limestone units in terms of

their field characteristics and recognizable or inferred hydrogeologic attributes, showing relationships to cave systems and coastal discharge features, and boundaries of inferred groundwater drainage basins. (3) Identify and survey selected major caves, and prepare maps of representative caves.

Methodology

The study employed the classical methods of geological field investigation, including an exhaustive search and analysis of the previous work and existing literature, and exploration and mapping of selected features above ground and underground. WERI has robust GIS capabilities and access to digital elevation models, which were employed to produce state-of-the-art maps. Field investigations were coordinated with the USGS office in Saipan and the CNMI Department of Environmental Quality and Department of Historical Preservation. Both provided assistance in helping the field team to gain access where needed.

Most of the fieldwork took place during May-June 2003, when weather and sea-level conditions are most conducive to success. The principal investigator, Dr. Jenson, retained Dr. John Mylroie to join the field team for approximately 10 days of fieldwork on Rota. Mr. Robert Carruth, USGS hydrogeologist at the USGS Saipan Field Station, collaborated with the field team.

Dr. Jenson also employed and supervised a graduate research assistant to participate in fieldwork and conduct an exhaustive literature and data search. The search assembled not only the historical scientific and engineering publications related to the island, but also numerous drilling logs, aquifer test results, planning documents, environmental studies and meteorological data related to the island as well. Many such documents were found archived at the University of Guam's Micronesian Area Research Center. Much unpublished data were located in the field offices of the USGS and Commonwealth Utility Corporation on Saipan and Rota. All of this data was catalogued and put into a database to support the maps and diagrams that were produced from the field study. The reports and maps produced from the project were a result of synthesis of the analysis of existing work and the fieldwork undertaken during the summer of 2003.

Principal Findings and Significance

The immediate results of the study were a set of maps of the karst features of the island and a report describing their relationships to one another along with the implications for groundwater management. The first major benefit of these results was a more detailed and specific understanding of hydrologic processes that govern the catchment, storage, transport, and discharge of water from Rota's aquifer. Such understanding will directly support water resource development and management by providing basic information about the response of the aquifer to recharge and

contamination and thus the vulnerability of the aquifer and its coastal discharge zones to contamination.

Second, the results of this work will support continuing development of the Carbonate Island Karst Model (CIKM), a general conceptual model of carbonate island karst that has recently been refined to include results from observations on Guam. The CIKM is currently being applied to Saipan and Tinian. Incorporating observations from Rota into the CIKM has helped to further refine the conceptual model itself. In particular, Rota is unique in that while it is relatively small and compact, it is also a composite island, *i.e*., one on which the volcanic basement is exposed at the surface. The CIKM predicts that for small islands, their relatively large perimeter-to-surface catchment ratio likely precludes the development of significant conduit transport and discharge. On the other hand, it also predicts that composite islands should tend to exhibit stream caves along the basement contact, reflecting pathways established at former as well as present sea levels. Because Rota possesses a spectacular set of caves apparently fed by water that accumulates on the flank of the volcanic core and is thence concentrated in pathways that converge on flowing caves, observations on Rota have provided important new insights that will help to refine the CIKM.

The more complete and accurate conceptual model will provide hydrologists working on other uplifted carbonate islands with a means for more reliable estimates of sustainable yield and more accurate predictions of aquifer response to proposed land-use or regulatory strategies.