TOWARD A RISK ASSESSMENT OF THE SANTORINI-AMORGOS VOLCANIC COMPLEX

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Abstract

The Santorini-Amorgos Volcanic Complex has been investigated in spring 2006 by means of profiling geophysical data. More than 1500 km of multichannel seismic and magnetic data as well as 2500 km of gravity data have been collected. The data allow the identification of active tectonics; the budgeting of pyroclastic deposits around Santorini and the Columbo volcano as well as in the SAZ; the interpretation of individual eruption events of the Columbo and Santorini volcanoes; and the detection of fluid migration paths and reservoirs associated with magmatic intrusions.

Keywords : Aegean Sea, Volcanology, Seismics.

Active tectonic processes along the African-Eurasian collision zone are associated with catastrophic events including earthquakes, major volcanic eruptions, and tsunamis. Understanding how these processes can affect the eastern Mediterranean is of increasing scientific and public interest. The region includes a frequently crossed international sea traffic corridor and dense population centers. Furthermore, most of the small volcanic islands in the Aegean are major tourist attractions that contribute significantly to the wealth of this region. One of these Aegean islands is Santorini, which is a major explosive volcano and possibly one of the most dangerous volcanoes in Europe. During the past 150 million years, Santorini has had 12 major eruptions, and several of them ejected large columns of ash and debris high into the atmosphere. It is widely believed that the eruption of Santorini about 3600 years before present (B.P.) destroyed the Minoan civilization of Crete. In addition to the volcanic island, there are several submarine volcanic seamounts in the Aegean Sea. One of them, the Columbo seamount, is about eight kilometers northeast of Santorini, and recently has attracted attention due to the high earthquake activity of the Hellenic subduction zone. This activity is concentrated in an area northeast of Santorini, within the so-called Santorini-Amorgos zone.

According to previous findings, the Santorini-Amorgos zone (SAZ) marks a major structural boundary in a dextral transtensional regime that subdivides the Hellenic volcanic arc into a seismically and volcanically quiet western and an active eastern part. The highest earthquake activity has been observed beneath the submarine Columbo volcano and northeast of it along the Santorini-Amorgos Ridge, which terminates south of the island of Amorgos [1].

The activity close to the Columbo seamount is considered to be linked directly to a magma reservoir and to be influenced by the migration of magma and fluids toward the surface. Earthquakes northeast of the volcano also may result from magma and associated fluid migration toward the surface, according to some suggestions. The Santorini-Columbo volcanic complex includes one caldera at Santorini and one crater at Columbo. The caldera of Santorini is formed by four deep basins (from 290 to 390 meters deep). The Columbo volcano has a well-defined crater with a single basin (depth 500 meters). Until now, only a single underwater eruption has been reported for the Columbo volcano in 1650 A.D. [2]. However, evidence for previously undiscovered activity in Colombo's was expected on the seafloor surrounding the seamount.

The general scientific objectives of the already completed first phase of the so-called Inspecting Columbo project included the investigation of shallow expressions of deep-rooted tectonic or magmatic intrusions, which may result in active faulting or fluid migration, respectively [3]. During the research cruise, the Santorini-Columbo complex as well as the SAZ were mapped in detail by means of multichannel reflection seismics as well as magnetic (1500 kilometers each) and gravity (2500 kilometers) profiling. For the active seismics, a bubble free airgun with about 100-hertz main frequency served as the seismic source. In the sediment basins, the signal penetrated to a depth of more than one kilometer beneath the seafloor. Data were received by two seismic sensor cables (streamers) of 600- and 150-meter length, respectively. The seismic data will help with (1) the identificationof active tectonics; (2) the budgeting of pyroclastic deposits around Santoriniand the Columbo volcano as well as in the SAZ; (3) the interpretation ofindividual eruption events of the Columbo and Santorini volcanoes; and (4) the detection of fluid migration paths and reservoirs associated with magmatic intrusions. The gravity and magnetic data will help to correlate shallow tectonic signals with deeper magmatic intrusions, and therefore determine the distinction between main faults above an intrusion or side branches.

Seismic cross-sections of the Santorini-Amorgos Ridge where the earthquake activity is highest indicate that its sediment cover is highly and actively faulted. The presence of magnetic anomalies at the ridge's southeastern escarpment suggests that the earthquake activity and the active faulting are caused by magmatic processes. Initial modeling results suggest that the magnetic source body, such as a magma chamber, lies at a depth of five kilometers. This is consistent with previously published epicenter depths of a few kilometers. Seismic lines across the Columbo volcano elucidate the primary building blocks of the volcano. Two cone-like volcanoclastic deposits show that the Columbo volcano evolved from atleast two eruptions. A bright spot about 200 meters beneath the calderaprovides evidence for gassy and/or fluid charged sediments. The strong magneticanomaly (450 nanoteslas) above the caldera can be assumed to be caused by a magma chamber beneath the caldera. In addition, a depth for the magnetic body has been estimated at five kilometers. Southeast of the volcano, along theso-called Kameni line, an elongated dike intrusion, named the Poseidon Ridge, has been discovered about 100 meters beneath the seafloor. The ridge, six kilometers wide and more than 10 kilometers long, is characterized by a small magnetic anomaly of about 40 nanoteslas. An active extensional fault can be seen on the seafloor. A second extensional fault lineament is present northwestof Columbo, where initial faults already pierce the seafloor. Both of these examples prove that the Santorini-Amorgos zone is tectonically active and deserves constant monitoring.

References

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