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Modeling of pyroclastic flows of Colima Volcano, Mexico: implications for hazard assessment

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Abstract

The 18–24 January 1913 eruption of Colima Volcano consisted of three eruptive phases that produced a complex sequence of tephra fall, pyroclastic surges and pyroclastic flows, with a total volume of 1.1 km^3 (0.31 km^3 DRE). Among these events, the pyroclastic flows are most interesting because their generation mechanisms changed with time. They started with gravitanional dome collapse (block-and-ash flow deposits, Merapi-type), changed to dome collapse triggered by a Vulcanian explosion (block-and-ash flow deposits, Soufrière-type), then ended with the partial collapse of a Plinian column (ash-flow deposits rich in pumice or scoria,). The best exposures of these deposits occur in the southern gullies of the volcano where Heim Coefficients (H/L) were obtained for the various types of flows. Average H/L values of these deposits varied from 0.40 for the Merapi-type (similar to the block-and-ash flow deposits produced during the 1991 and 1994 eruptions), 0.26 for the Soufrière-type events, and 0.17–0.26 for the column collapse ash flows. Additionally, the information of 1991, 1994 and 1998–1999 pyroclastic flow events was used to delimit hazard zones. In order to reconstruct the paths, velocities, and extents of the 20th Century pyroclastic flows, a series of computer simulations were conducted using the program FLOW3D with appropriate Heim coefficients and apparent viscosities. The model results provide a basis for estimating the areas and levels of hazard that could be associated with the next probable worst-case scenario eruption of the volcano. Three areas were traced according to the degree of hazard and pyroclastic flow type recurrence through time. Zone 1 has the largest probability to be reached by short runout (<5 km) Merapi and Soufrière pyroclastic flows, that have occurred every 3 years during the last decade. Zone 2 might be affected by Soufrière-type pyroclastic flows (~9 km long) similar to those produced during phase II of the 1913 eruption. Zone 3 will only be affected by pyroclastic flows (~15 km long) formed by the collapse of a Plinian eruptive column, like that of the 1913 climactic eruption. Today, an eruption of the same magnitude as that of 1913 would affect about 15,000 inhabitants of small villages, ranches and towns located within 15 km south of the volcano. Such towns

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include Yerbabuena, and Becerrera in the State of Colima, and Tonila, San Marcos, Cofradia, and Juan Barragán in the State of Jalisco.

Keywords: hazard zonation; pyroclastic flows; Volcán de Colima; Mexico

1. Introduction

Colima Volcano lies in the western part of the Trans-Mexican Volcanic Belt (TMVB), a calc-alkaline continental arc that runs across the central part of Mexico. The western TMVB is widely accepted to be the result of subduction of the Cocos and Rivera Plates beneath the North American plate (Fig. 1A). The western TMVB consists of three regional structures: the Colima Graben, the Zacoalco right-lateral fault zone, and the Chapala Graben (CZC) (Luhr et al., 1985). The Colima graben is the southern arm of the CZC triple junction system. It is bordered by N–S normal faults running from the junction with the Chapala and Zacoalco grabens to the north and by the Pacific Ocean coast to the south (Fig. 1B). It is

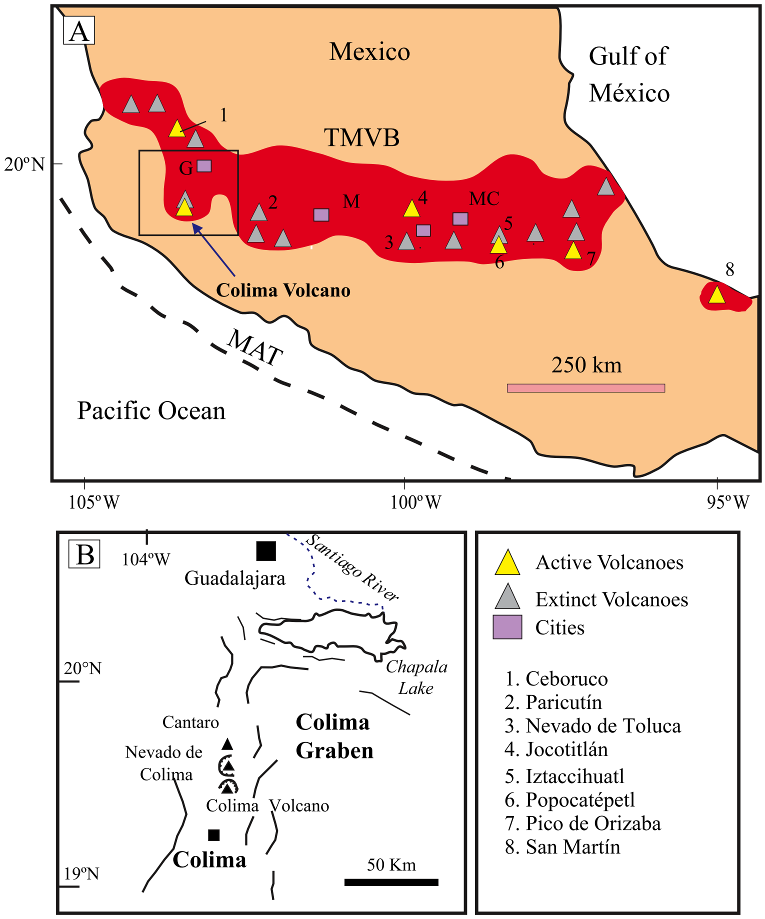

Fig. 1. (A) Location of Volcán de Colima in the western portion of the Trans-Mexican Volcanic Belt. Abbreviations are: MC=Mexico City, T=Toluca, G=Guadalajara, M=Morelia, TMVB=Trans-Mexican Volcanic Belt, and MAT=Middle American Trench. (B) Sketch map of the Colima Graben showing the location of the Cantaro, Nevado de Colima, and Colima volcanoes.