Geochemical and isotopic constraints on the origin of mafic volcanism in central Mexico

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On the basis of a regional geochemical and isotopic study I propose a complex origin of mafic volcanism in the Mexican Volcanic Belt. In addition to the subduction, rifting and faulting are responsible for the origin of mafic magmas in central Mexico. This demonstrates the importance of processes other than subduction in a modern continental arc.

Introduction

Miocene to Recent volcanism in central Mexico is wide-spread mainly in two volcanic provinces (Fig. 1); basaltic to rhyolitic volcanism in east-west trending Mexican Volcanic Belt (MVB) from the Pacific to the Gulf of Mexico and dominantly mafic volcanism in Los Tuxtlas Volcanic Field (LTVF), presumably a part of Eastern Alkaline Province. The origin of these volcanic provinces and their interrelationship are controversial. Widely varying models have been proposed for the MVB (abundant literature does indeed exist at present), among which the most cited are related to the subduction of Cocos and Rivera plates. The distance of the volcanic front of the MVB from the trench (MAT, Fig. 1) varies from ~160 km in the west to ~450 km in the easternmost Veracruz area. The LTVF and the El Chichón volcano are situated about 380 km and 320 km respectively from the MAT. A systematic study of mafic volcanism should prove helpful in deciphering the origin of these volcanic provinces.

Data base

I have compiled the available (new as well as published; citation to the vast literature is not possible here because of space limitation) geochemical and radiogenic isotopic data on a total of 230 samples of mafic magmas (215 samples from the MVB, 14 from the LTVF and 1 from El Chichón volcano). These samples are about equally distributed as hy-normative and ne-normative magmas in the MVB, whereas ne-

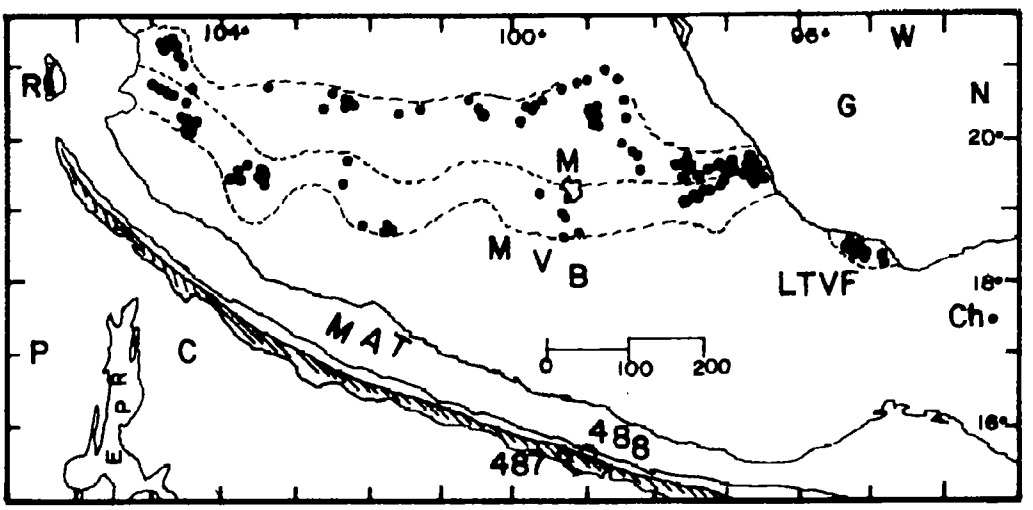

FIG. 1. Distribution of mafic volcanism in the Mexican Volcanic Belt (MVB) and the Los Tuxtlas Volcanic Field (LTVF) in central Mexico. MAT = Middle America Trench; EPR = East Pacific Rise; C = Cocos plate; R = Rivera plate; P = Pacific plate; M = Mexico City; G = Gulf of Mexico; Ch = El Chichón volcano. Locations of IPOD-DSDP Sites 487 and 488 are also shown.

normative magmas dominate the LTVF. From a subset of 119 samples with a high mg-number (> 63), I selected 29 Pliocene to Recent mafic magmas, with available Sr, Nd or Pb isotopic data, for a detailed examination.

In order to constrain the models of magma genesis in the MVB, I have also analyzed for the same chemical and isotopic parameters, a series of sediments and underlying basaltic rocks from Sites 487 and 488 of the IPOD-DSDP drilled in the MAT off Acapulco. These data have direct implications for subduction models for the eastern part of the MVB, particularly the region of Sierra de Chichinautzin situated south and southeast of Mexico City.

Results and discussion

These selected samples are classified as basalt (15 samples), tephrite/basanite (4), phono-tephrite (2), trachybasalt (3), basaltic trachy-andesite (4), and basaltic andesite (1). They show a wide range of K_2O enrichment varying from tholeiitic and calc-alkaline to shoshonitic series. In chondrite-normalized *REE* plots, all samples are *LREE*-enriched with negligible Eu and Ce anomalies. Their $^{87}Sr/^{86}Sr$ ratios range from 0.70324 to 0.70456, $^{143}Nd/^{144}Nd$ 0.51265 to 0.51296, $^{206}Pb/^{204}Pb$ 18.58–19.00, $^{207}Pb/^{204}Pb$ 15.56–15.63, and $^{208}Pb/^{204}Pb$ 38.23–38.74.

On multi-element N-Morb and primitive mantle normalized plots, only the samples situated close to the trench in the western part of the MVB (Luhr *et al.*, 1989) show a large negative Nb anomaly ([Nb/Nb*] ~ 0.1–0.2). Perhaps the most interesting result is that all samples (hy-normative mafic magmas) from the Sierra de Chichinautzin (eastern MVB) show a very small negative Nb anomaly or none ([Nb/Nb*] ~ 0.6–1). It requires an ocean island type mantle source region in the southern part of Mexico City (Verma, manuscript in preparation). This type of source has also been proposed for alkaline magmas in the northwestern part of the MVB (Verma and Nelson, 1989).

The geochemical and isotopic data for basalts and sediments from the Cocos plate near the MAT limit the contribution of sediments to less than about 1% in the source region of the MVB. In fact, no simple models of slab melting can by themselves explain the isotopic and trace element characteristics of the MVB mafic magmas.

The evidence taken together points to a rather complex model in which the mantle source region is geochemically and isotopically different throughout the MVB. The belt is a consequence of rifting and faulting in addition to the subduction related processes. The actual contribution and relative importance of these different tectonic regimes varies from one place to the other and can be evaluated through detailed geological, geochemical and geophysical studies.

Acknowledgements

I am grateful to Al Hofmann for the use of experimental facilities at the MPI and the AvH Foundation for support during my stay in Germany. I also thank J.F.W. Negendank and J.F. Luhr for kindly providing one sample from El Chichón volcano and two samples from El Jorullo volcano respectively.

References

Luhr, J. F., Allan, J. F., Carmichael, I. S. E., Nelson, S. A. and Hasenaka, T. (1989) *J. Geophys. Res.*, **84**, 4515–30.

Verma, S. P. and Nelson, S. A. (1989) *J. Geophys. Res.*, **84**, 4531–44.