ABSTRACT

Poás Volcano, located in central Costa Rica, is an active volcano with an eruptive history extending more than 1 ma. Several episodes of volcanism have occured during this period. The most recent eruptive history of the volcano is detailed here on the basis of field mapping of the summit area. This history begins with caldera formation, followed by composite cone construction, faulting and flank subsidence, flank fissure eruption, and multiple crater collapse.

Chemical analyses of lavas of known stratigraphic position indicate that temporal magmatic variation at Poás, for a time period spanning more than 10,000 years, consists of two nearly identical co-magmatic cycles seperated by flank and summit eruptions of a seperate and distinct magma batch. The two cycles progress from felsic lava to mafic lava with time. The cycles appear to represent a zoned magma chamber sequence developed by crystal fractionation. The break between the two cycles correlates with a shift in the active eruptive center at the summit and a period of uncommon flank eruptive activity. Lavas erupted during this time define a distinctly different magma batch unusually rich in K2O, P2O5, TiO2, and Ba. The chemical composition of the most recently erupted lava from Poás indicates that the volcano is in the last half of the present cycle.

front (N60W). The Alajeula fault scarp at the base of the southern flank of Poas, is a good example of a structural bounding fault in this region.

Poas Volcano rises 1300 meters from its base at 1400 meters above sea level and encompasses a volume of about 100 cubic kilometers. Relative to other Central American volcanoes, Poás and the other Cordillera Central volcanoes are mor massive and have higher summit elevations. In part the high summit elevations of the Cordillera Central are due to their position overlying a massive volcanic pile of welded and non-welded ignimbrites and lava flows. Saenz (1982) has reported a radiometric age of 0.98 m.y. for an ignimbrite that crops out at the base of Poas. In essence, the present day Cordillera Central volcanoes are superimposed on a proto-Cordillera Central volcanic massif.

In form, Poas has a rounded dome-like shape despite its explosive nature. This shape is probably due to repeated decapitation of the volcáno during caldera forming events in its long history. The flanks slope gently in all directions except to the north, where higher rainfall rates have caused deep erosion on that side of the volcano. The south and west flanks are heavily populated and support sugar cane and coffee crops, and dairy farms. A national park, covering 5,000 hectares, occupies the summit of the volcano.

SCOPE AND PURPOSE OF THIS STUDY

Detailed field mapping of the main crater and summit area, carried out from January through March of 1983, permitted stratigraphic correlation and ordering of pyroclastic deposits and lava flows exposed in the main crater walls and the summit region. From this compound stratigraphic section, a portion of the volcano's eruptive history could be determined and trends in magma composition and volcanic activity identified. Outcrop found at the summit of the volcano represents a discontinuous record of on the order of 10,000 years of volcanic activity. This period of time is only a fraction of the entire eruptive history of Poás. Quantification of the most recent compositional trends exhibited by the volcano provides another example of the variety of petrogenetic processes at convergent plate margin volcanoes. Furthermore, it provides a necessary framework for interpreting future activity at Poás. All constraints in future eruptive activity are vital because of the large population that inhabits the flanks of Poás.

Poás has extensive outcrop at the summit, which is easily reached via a paved road. Unfortunately, the geology of the flanks is poorly exposed and will require much further study in order to completely describe the geology at Poás.

PREVIOUS WORK

There are many eye-witness accounts of eruptive activity at Poás, some in newspapers, others in letters from explorers to governing officials. Vargas (1979) has compiled an anthology containing many such obscure reports of Poás activity. Actual geologic research on the volcano began with Williams' (1952) study of Plio-Pleistocene ignimbrites exposed in the Meseta Central graben south of the Cordillera Central. This study is the first specific description of the geology at Poás. Gravimetric studies were conducted by De La Cruz and Mena (1976) and Thorpe et. al.

(1980). Allegre and Condomines (1976) used 230Th/232Th ratios to infer that the magma source for Poás samples formed 50,000 years ago, but the details about the samples used in that study were not published.

HISTORIC ACTIVITY AT POAS

During historic time, Poás has been in a state of nearly continuous mild activity., The first record of eruptive activity at Poás dates back to 1828. Until the early twentieth century, reports of activity at Poás are restricted to infrequent observations by explorers. Since that time , most of the significant volcanic activity has been recorded. Since the formation of the national park at the summit in 1971, park personnel have occupied the summit on a 24 hour basis.

Eruptive activity at Poás consists primarily of geyser-like phreatic eruptions generally through a shallow crater lake. In addition, powerful vulcanian blasts and milder strombolian activity, as well as a lava flow have occurred in historic time. The 1953-55 eruptive phase featured all of these types of eruptive activity. The result of this eruption was the creation of a 25 meter high intra-crater cone and an adjacent pit crater. One third of the intra-crater cone collapsed into the pit crater upon its formation. A hot, acid lake (40-60C,pH=0.1) presently occupies the pit crater, although it has been vaporized or ejected during periods of intense activity.

A unique feature of Poás volcanic activity has been the occurrence of several pyroclastic sulfur eruptions. The pyroclastic sulfur particles and their origin are discussed in Francis et. al. (1980) and Bennett and Raccichini (1978).

Non-eruptive activity at Poás consists of quiet degassing from fumaroles on the east and north sides of the intra-crater cone. Since 1981, when Poás last erupted, fumarole temperatures have consistently exceeded 700C. SO_2 output from these fumaroles is about 600 tons/day (Stoiber, pers. comm.). Incandescance can seen in many of the individual fumarolic vents.

MAJOR STRUCTURES OF THE VOLCANO

Volcanic structures and features found on the flanks and summit of Poás indicate that the volcano has had a long and complex eruptive history prior to 40,000 years ago. The largest of these volcanic features are two calderas, one nested within the other. These structures are not well preserved and can only be identified by topographic breaks in the slopes of the volcano (fig. 2). The larger of the two calderas is 6 km in diameter. The inner caldera is elliptical with a N-S major axis of 4 km. These calderas have been in-filled by later Poás volcanics and have served as physical barriers between summit volcanism and deposition on the flanks.

The geology of the flanks of Poás is dominated by a thick lapilli tuff sequence that has been carbon dated as greater than 40,000 years old (Prosser,1983).This thick non-welded ignimbrite deposit, herein referred to as the Poás lapilli tuff, is overlain by only a thin veneer of later airfall deposits. The lapilli tuff appears to be the product of the later of the two caldera-forming eruptions. The negligible overlying airfall deposits indicate that the caldera walls restricted deposition of later volcanic products to the summit. The stratigraphy exposed in the summit region, therefore, begins with this lapilli tuff

On the summit of Poás there are several large volcanic structures. The largest and oldest of these post-caldera features is Von Frantzius cone. It is a highly eroded, composite cone. This cone has a south facing breached crater and represents the highest point on the volcano. Two km south of Von Frantzius cone is a smaller, younger composite cone called Botos Cone. Botos Cone contains a clear, cold water lake, which is utilized as a source of fresh water for the national park complex. Carbonized wood collected from Botos cone yielded an age of 7,540±100 years. Field mapping of Botos cone lava flows suggests that Botos Cone volcanism ceased shortly after this time. Situated between the two composite cones is the Main Crater of Poás, the site of all historic activity. The outer rim of the Main Crater is 0.8 km in diameter and encloses two smaller, nested craters. All are collapse craters, with the innermost pit crater being the site of the hot, acid lake.

Another feature on Poás is a line of N-S oriented cinder cones located on the south flank near the town of Sabana Redonda. These cones are relatively recent features and may have been active simultaneously with late Botos Cone volcanism (see discussion below). The west flank of Poás is dominated by a large graben extending from Botos Cone to the base of the volcano. The axis of the graben strikes N60W, parallel to the larger tectonic Meseta Central structural depression south of Poás. Subsidence of the west flank graben probably occurred along re-activated tectonic faults originally associated with formation of the Meseta Central. The graben is bounded on the south by the 400 meter Rio Desague fault scarp, and on the north by a series of smaller step faults. Lava flows are well exposed in the upper 200 meters of the Rio Desague fault scarp.

North of Poás are several volcanic edifices that deserve mention because together with Poás itself, they form a well defined N-S lineation of eruptive centers (figure 3). At the base of the northern flank of Poás is Cerro Congo Cone, a parasitic, composite cone. Three km north of Cerro Congo is Laguna Hule Caldera, which is 2 km in diameter and contains a crater lake as well as an intra-crater cone. Six km further north is Laguna Rio Cuarto, an ancient maar.

Stoiber and Carr (1973) have noted the N-S alignment of volcanic features throughout the length of the Central American volcanic arc. They consider the common N-S alignment of vents to represent the axis of maximum horizontal compression in the volcanic belt. Nakamura (1977) found that volcanic vents at polygenetic volcanoes such as Poás are commonly aligned normal to the direction of maximum horizontal compression generated along the associated subduction zone. However, in Central America the axis of maximum horizontal compression in the subduction zone, as defined by focal mechanisms (Molnar and Sykes, 1969), is N30E and not N-S. The reason for the discrepancy between the stress field in the subduction zone and the stress field in the volcanic belt is not clear.

In addition to controlling the trend of volcanic vents at Poás, structural features on the volcano also appear to control the specific location of vents. For example, the Von Frantzius cone is located at the intersection of the N-S lineament with the extrapolated trace of caldera bounding faults of the inner caldera. Also, the intersection of the graben forming normal faults seen on the west flank appear to structurally control the locations of both Botos Cone and the Main Crater. The cinder cones at Sabana Redonda on the south flank are not located at the junction of conjugate structural features. Nonetheless, spatial volcanism at Poás is a function of regional and local structural features and their points of intersection. In turn, the structural features, in large part, reflect the effects of tectonic forces on the region.

SUMMIT GEOLOGY

Lava flows and airfall tephras that are exposed in the Rio Desague fault scarp and in the walls of the Main Crater represent a nearly complete record of volcanic activity at Poas for a period covering at least the last ten thousand years. All of this activity postdates the eruption of the lapilli tuff which blankets the southern flank of the volcano. Although lava flows are normally well exposed tephras are generally very poorly preserved, often having been weathered to mud and clay. The stratigraphy exposed in the Rio Desague fault scarp is comprised of approximately equal volumes of lava flows and pyroclastic material. On the other hand, younger stratigraphy exposed in the Main Crater consists of three to four, times more pyroclastic material than lava flows. This shift in eruptive style over time may be attributed to the temporal change in magma composition. The high volume ratio of pyroclastics to lavas in the Main Crater stratigraphy is consistent with observations of historic eruptive activity which are of dominantly explosive nature at Poás.

From oldest to youngest, the stratigraphic section exposed in the Rio Desague fault scarp is made up of thin, flat lying andesitic lava flows interbedded with thin, occasionally bedded airfall tephras. At the base of the section is a thick tephra unit of unknown character, possibly the same Poás lapilli tuff found on the flanks. Access to outcrops of this tephra is made extremely hazardous by the canyon created as a result of down cutting of the Rio Desague. Elongate vessicle azimuths in lava flows and geographic location of volcanics exposed in the fault scarp indicate that the source vent was Botos Cone. The lack of post-Poás lapilli tuff lava flows on the flanks of the volcano, and the flat lying atitudes of the early Botos Cone lavas exposed in the fault scarp can be interpreted as evidence that caldera walls restricted the distribution of volcanic products to the summit of the volcano. Therefore, Botos Cone volcanism served primarily to in-fill the existing inner caldera.

Botos Cone volcanism both pre-dates and post-dates movement along the Rio Desague fault. Aside from Botos Cone volcanics exposed in the fault scarp, there are also Botos Cone lava flows that mantle the fault scarp and are well exposed in the south main crater wall stratigraphy. Of the flows that mantle the scarp, three were sampled for petrologic study (samples 6,7 and 8, table 1). Five samples from flows exposed in the scarp were also collected and analyzed (samples 1 through 5, table 1). Carbonized wood fragments found between scarp mantling Botos Cone flows yielded a radiocarbon age of 7,540+100 years (Prosser, 1983). Cessation of Botos Cone volcanism followed soon after deposition of the carbon bearing tephra.

The volcanostratigraphy associated with Main Crater volcanism is very well exposed in the near vertical walls of the Main Crater, although 1953-55 tephra mantles and obscures stratigraphy near the crater floor. The geology of the Main

Crater is given in figure 4. Thick deposits of poorly sorted tephra are punctuated with lava flows ranging in composition from dacite to andesite. The Main Crater tephras are characterized by their chaotic mixture of unsorted lapilli, bombs, blocks and ashy matrix. Individual tephra units may exhibit bedding and normal sorting, and range in thickness from 0.5 to 15 meters. These pyroclastic units are remarkably uniform in appearance and indicate that the eruptive style at Poás, small to moderate sized phreatic, phreatomagmatic, and vulcanian eruptions, was consistent over a long span of eruptions. This is also the present pattern of activity at Poas. A distinctive red (Fe oxidized) pyroclastic unit of well sorted, bedded, vessiculated, juvenile lapilli crops out at the top of the southwest rim of the crater. The stratigraphic position and unique character of this deposit suggests that it was erupted just prior to collapse of the Main Crater, and may in fact be the result of the crater forming eruption. This unit reaches five meters in thickness in the west Main Crater wall (see sample 12 table 1).

Three lava flows are contained within the Main crater tephra and are exposed in the walls of the Main Crater (samples 9 through 11, table 1). All three flows crop out in the north and northwest crater walls. Older Botos cone flows appear to have created physical barriers to flow to the west and east and the Rio Desague fault scarp blocked flow to the south. Each of these flows exhibit well developed sheet and cooling joints, as well as rubbly flow tops and bottoms. The latter two flows are seperated by less than one meter of rubble or tephra. Nonetheless the Main crater stratigraphy is dominated by pyroclastic deposits. Therefore, in the past, as is true historically, Poás volcanism was primarily explosive.

An interesting observation to note is the occurence of native sulfur veins exposed in the north wall, approximately two-thirds of the way from the floor to the rim of the crater. These veins are locally upto 40 cm thick and crosscut the Main crater tephras. Very similar, but thinner, veins can be seen crosscutting later intra-crater lacustrine beds. The north crater wall sulfur veins represent fumarole feeder pipes to the now absent summit volcanic vent prior to crater collapse. Active fumaroles beneath the present crater lake are in the process of forming more such sulfur veins. When the lake level is low, sulfur tubes on the shores of the lake project upto 20 cm above the thixotropic lake bottom sediments. It would seem that during hiatuses in the deposition of the early main crater stratigraphy that Poás degassed in a manner very similar to that seen today.

Post-crater collapse deposits are primarily pyroclastic, but also include two lava flows and lacustrine volcanoclastic sediments. In addition, since the initial crater collapse, two smaller collapses have occurred within the Main Crater. At the base of the post-crater collapse stratigraphic section is a thick, chaotic, unsorted tephra overlain by well bedded lacustrine sediments and lake deposited ash and tephra. The lakebeds are best exhibited in the eastern portion of the crater and show soft sediment deformation structures and bomb sags. The beds, in many cases, are very thin and continuous. The lake sediments are altered to clay,and alunite, and include fine grained disseminated green sulfur, as well as thin cross cutting sulfur veins. The lacustrine sediments represent a quiessent period in the volcano's history, punctuated by infrequent, mildly explosive eruptions.

This quiessent period appears to have occured just after the initial crater collapse.

Overlying, and deforming, the lake sediments and volcaniclastics is a 30 meter thick andesitic lava flow. The cooling and sheet joints, and rubbly sections in the central portion of this flow indicate that the flow ramped over itself as it became restricted by the walls of the crater. Shortly after extrusion of this flow a second crater collapse, approximately one third the volume of the first initial crater, gave the Main Crater its present dimensions. The development of an intra-crater cinder cone, lava flow, and pit crater were the result of the 1953-55 eruptive activity described earlier.

PETROGRAPHY

Poás lavas are gray to black, pilotaxitic, and contain phenocrysts of plagioclase, augite, hypersthene, and opaque iron oxides. No olivine was seen in hand sample or thin section, although possible pyroxene pseudomorphs after olivine were seen in thin section. Groundmass of Poás lavas generally consists of plagioclase, with lesser amounts of augite hypersthene, and glass also present. In addition, some samples also contained small glomeroporhpyritic clusters of plagioclase. Large 20 cm diameter bombs made up entirely of phenocryst phases were also found at the Sabana Redonda cinder cones. These glomeroporhpyritic clusters are believed to be inclusions of cumulate phases fractionated during cooling of the parent magma.

Plagioclase phenocryst compositions, determined by optical methods, vary from bytownite through andesine, but are most commonly labradorite or andesine. Plagioclase phenocrysts commonly exhibit strong oscillatory zoning and contain inclusions of other mineral phases, groundmass, and glass. In all samples, opaque iron oxides could be found that were wholly or partially enclosed by pyroxene.

TEMPORAL CHEMICAL VARIATION

The chemical compositions of 17 Poás lavas are given in table 1. Of these samples, 16 are from the summit area and Main Crater walls. The stratigraphic position of each of the summit lavas has been determined using field observations. The summit samples have been given numbers denoting their stratigraphic position in table 1, ascending from oldest to youngest, and these numbers will be used to refer to samples in the text. Samples 1 through 5 are from the flat-lying flows exposed in the Rio Desague fault scarp on the west summit flank of the volcano. These flows are the caldera filling flows erupted from a vent in the vicinity of the present Botos Cone, or Botos Cone itself and are referred to as early Botos Cone lavas in table 1. Samples 6 through 8 are steeply dipping flows that were erupted from Botos Cone and flowed down the already formed Rio Desague fault scarp (late Botos Cone lavas in table 1). A time interval, sufficient to allow up to 300 meters of vertical movement along the fault, seperates these two sets of flows. Samples 9 through 12 were collected from lava flows exposed in the Main Crater walls. Samples 12 and 14 are the only samples not taken from lava flows, but instead from juvenile pyroclastic units.

Figure 5 shows Harker diagrams of the Poás lava analyses presented herein. Overall, the major oxides exhibit smooth variation indicating consistent and uniform fractionation of the parent magma. However, three samples stand out as markedly different from the rest. Samples 7, 8, the last flows from Botos Cone, and PO83-56, from the flank cinder cones at Sabana Redonda, have high K2O, TiO2, and P2O5 contents. In addition, samples 7 and 8 have abnormally high Ba/SiO2 ratios relative to the other analyses. Analysis for barium is not available for sample PO83-56. The unique compositional character of these three lavas suggests that they are genetically related and distinctly seperates them from the other summit lavas. It would appear that the late stages of summit volcanism at Botos Cone was accompanied by the flank rift eruption that produced the Sabana Redonda cinder cones. Another implication of the petrologic similarities of the last Botos cone lavas and the flank cinder cone lava is that a time constraint can be placed on when the cinder cones were formed, about 7,540 years ago using the radiometric age given for the carbon sample found stratigraphically between flows 6 and 8 in the south Main Crater wall.

Figure 6 graphically depicts major oxide and minor element variation of the 14 summit sampled with respect to their stratigraphic position. Although the samples are equally spaced in the diagrams of figure 6, it should be remembered that the time interval between each sample is not constant. In particular, there is probably a long time interval between samples 5 and 6 during which there was over 300 meters of vertical movement along the Rio Desague fault. Two distinct co-magmatic, felsic to mafic trends can be readily seen in the diagrams of figure 6. The first cycle (squares) extends from sample 1 through sample 8, and the present co-magmatic cycle (triangles) begins with sample 9. Newhall (1979), in a similar study of temporal chemical variation in lavas of Mayon Volcano, refers to chemical variation over the span of several eruptions as medium term variation. The limited number of samples analyzed as part of this study permit examination of medium term temporal magmatic variation, but does not allow further extrapolation of the data in order to define long term temporal variation trends. The time span covered by each of the co-magmatic cycles described in this study is believed to be on the order of between 10,000 and 100,000 years.

The felsic to mafic compositional trends found at Poás add to the variety of temporal magmatic variations found at other Central American volcanoes. Several volcanoes experienced mafic to felsic temporal magmatic variations over medium to long term periods (Santa María, Rose et al., 1977; Boqueron, Fairbrothers et al., 1978; Izalco, Woodruff et al., 1979). Izalco volcano (Carr and Pontier, 1981) has experienced a crude felsic to mafic temporal variation, which, in detail, is related to progressively shorter repose intervals. The summit crater of Santa Ana volcano exposes a short sequence of lavas that may represent an inverted magma chamber, with a graded silicic top and a uniform mafic bottom. Upon eruption this stratigraphy was inverted, giving a short term felsic to mafic trend. In regard to long term variation, Poas also does not fit the description of a basalt cored andesitic island arc volcanoes envisioned by McBirney (1976). In fact, Poás is built up on a base of silicic ignimbrites and mantled by basaltic and andesitic flows and tephras. However, the very long history of volcanism, and complexity of the eruptive history at Poas probably masks the true nature of long term magmatic variation at Poas. It is very probable that the silicic ignimbrites that form the base of Poás were erupted during an earlier epoch of volcanism at Poás, unrelated to more recent volcanism.

The felsic to mafic trend in each of the Poás co-magmatic cycles shown in diagrams of figure 6 can be explained in terms of repeated similar fractionation of a common parent magma, with the exception of samples 7 and 8. Note in the Harker diagrams of figure 5 that there is no distinct differences between the two cycles. Only lavas 7 and 8, erupted in the interval between the two cycles, and PO83-56, erupted during simultaneous(?) flank volcanism fall off the normal Poás trend. Initial eruptions in each co-magmatic cycle derive magma from the uppermost portion of the magma chamber which has been compositionally zoned by crystal fractionation of plagioclase and pyroxenes. As the co-magmatic cycle progresses, magma is derived from deeper within the chamber causing eruption of more mafic, fractionated lavas as the chamber is emptied. Additionally the Main Crater cycle can be sub-divided into two subordinate felsic to mafic cycles. This suggests an open fractionation system exists in the present co-magmatic cycle. The long time interval occupied by each of the co-magmatic cycles would indicate the existence of a large, slowly cooling magma chamber deep within the earth's crust. Thorpe et al. (1981), based on modeling of gravity data taken across the summit of Poás, favor the existence of a magma chamber at lower crustal levels rather than at a shallow level beneath the volcano.

The transition from the first co-magmatic cycle occurs at a very significant point in the evolution of the summit of Poás. All of the first cycle lavas were erupted from Botos Cone or a vent near the present site of Botos Cone. On the other hand, all of the second cycle lavas were erupted from the present Main Crater vent. Therefore, the transition from the first cycle to the second cycle was marked by a change in the location of the active vent. The change of vent location could have been brought about by alteration in the plumbing of the volcano by forceful injection of a new batch of magma. Furthermore, the Main Crater attained its present dimensions during a large scale collapse following the eruption of tephra from which sample 12 was collected. This eruption also appears to signal the beginning of a new, subordinate cycle, possibly begun as a result of addition of new magma to the existing magma body. Progressive emptying of the magma chamber and magma withdrawal from the active conduit may be the cause of the two crater collapses since that time. The chemical composition of the 1953-55 lava indicates that the present co-magmatic cycle is approaching its conclusion. In terms of the geologic history of the summit, movement along the Rio Desague fault and creation of the west flank graben may be correlated with the end of the first co-magmatic cycle. Movement along the fault occured shortly before the end of the first co-magmatic cycle, much the same as the Main Crater has collapsed near the end of the present co-magmatic cycle.

The final two sampled lavas erupted from Botos Cone and the sample from the Sabana Redonda cinder cones are distinctly different. The chemical compositions of these lavas are not consistent with the fractionation pattern of the two cycles. Therefore, it is likely that at the end of the first cycle the Botos vent was used by magma from a different batch and possibly a different magma chamber. Since the Sabana Redonda cinder cones on the south flank of Poás are composed of this distinctive magma it is possible that the Sabana Redonda cinder cones formed at about the same time as these last flows were being extruded from Botos Cone. Flank volcanism along a N-S oriented rift is a marked departure in the style of volcanism at Poás and the nature of Poás volcanism may have been influenced by the injection of the second pulse of magma along N-S oriented dikes. Other volcanoes in the Cordillera Central also exhibit cinder cones along flank fissures.

CONCLUSION

The combination of the interpreted geologic history and the stratigraphically ordered chemical data from the summit of Poás presents a clear, comprehensive picture of the evolution of the summit region. This study has shown that there is a definite correlation between the chemical composition of Poás lavas and major geological events at the summit. Although the actual mechanics of how the two are related has not been clearly determined, what is known can be used to assess the implications of future activity at Poás. In this regard, the results of this study suggest that Poás lavas with greater than about 62% silica should be viewed as a warning sign for potentially hazardous activity at Poás. In the geologic record, lavas with high silica contents have signalled the beginning of a new co-magmatic cycle, and also been associated with large scale collapse of the Main Crater. In addition, if lava compositions fall below about 51% then the end of a co-magmatic cycle is imminent and a change in the location of the active vent may occur. This information, combined with present day monitoring of the volcano (seismic, radon, deformation, fumarolic gas geochemistry) will allow a better assessment of the volcanic hazard presented by Poás to the national park and the surrounding populace.

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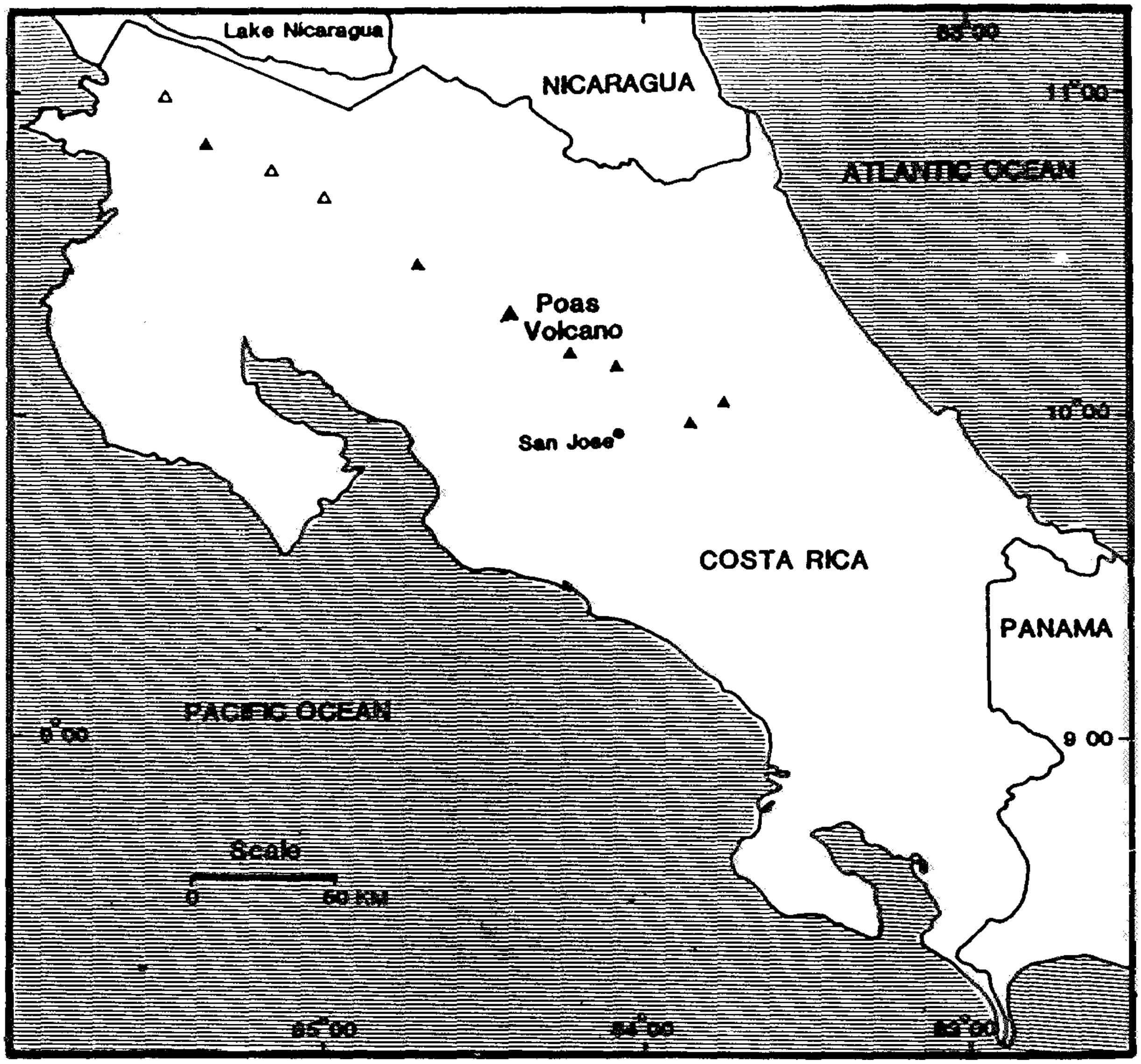

Figure 1 - Location map for Poás Volcano

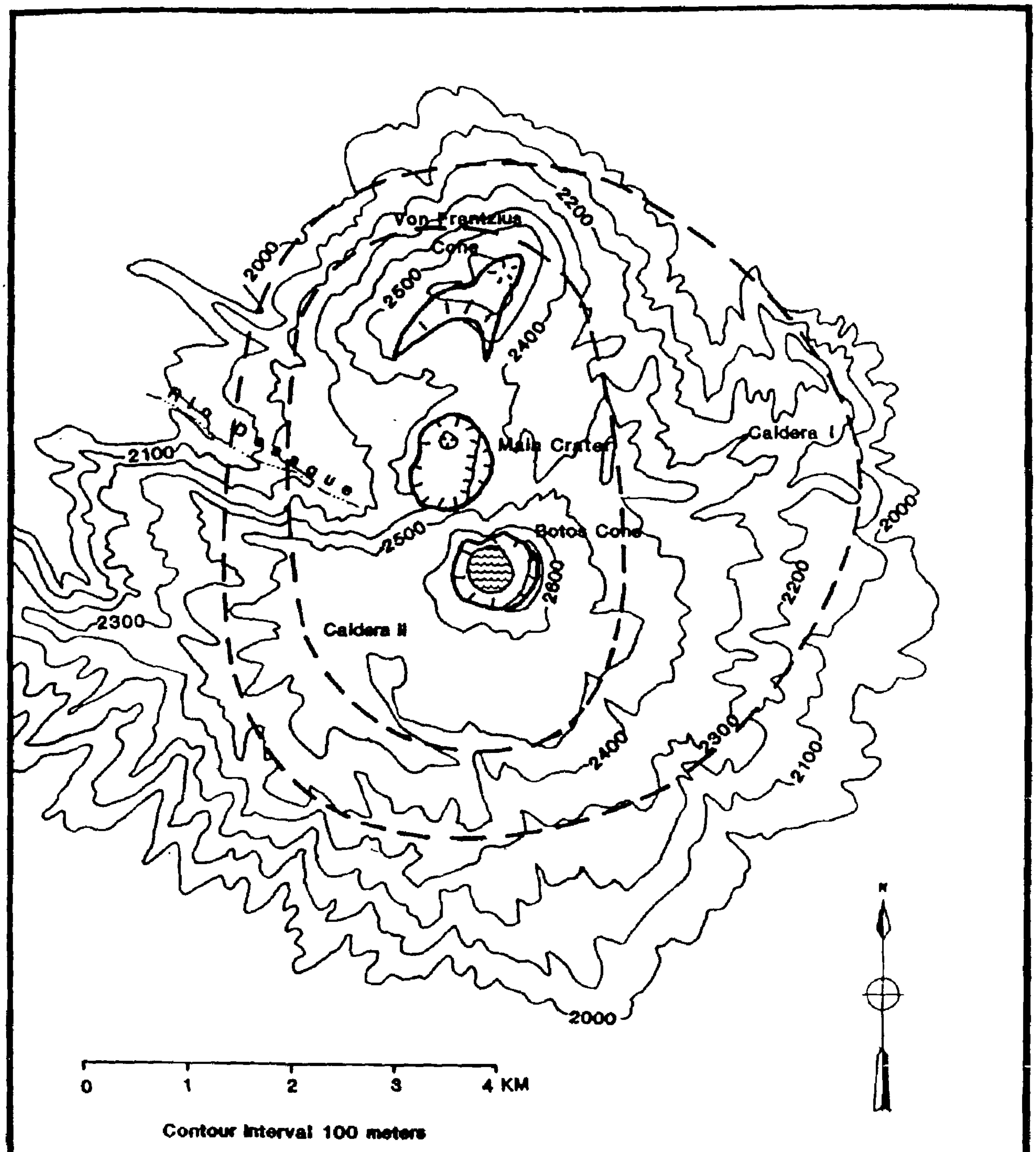

Figure 2 - Map showing the topographic expression of two ancient calderas on Poás Volcano.

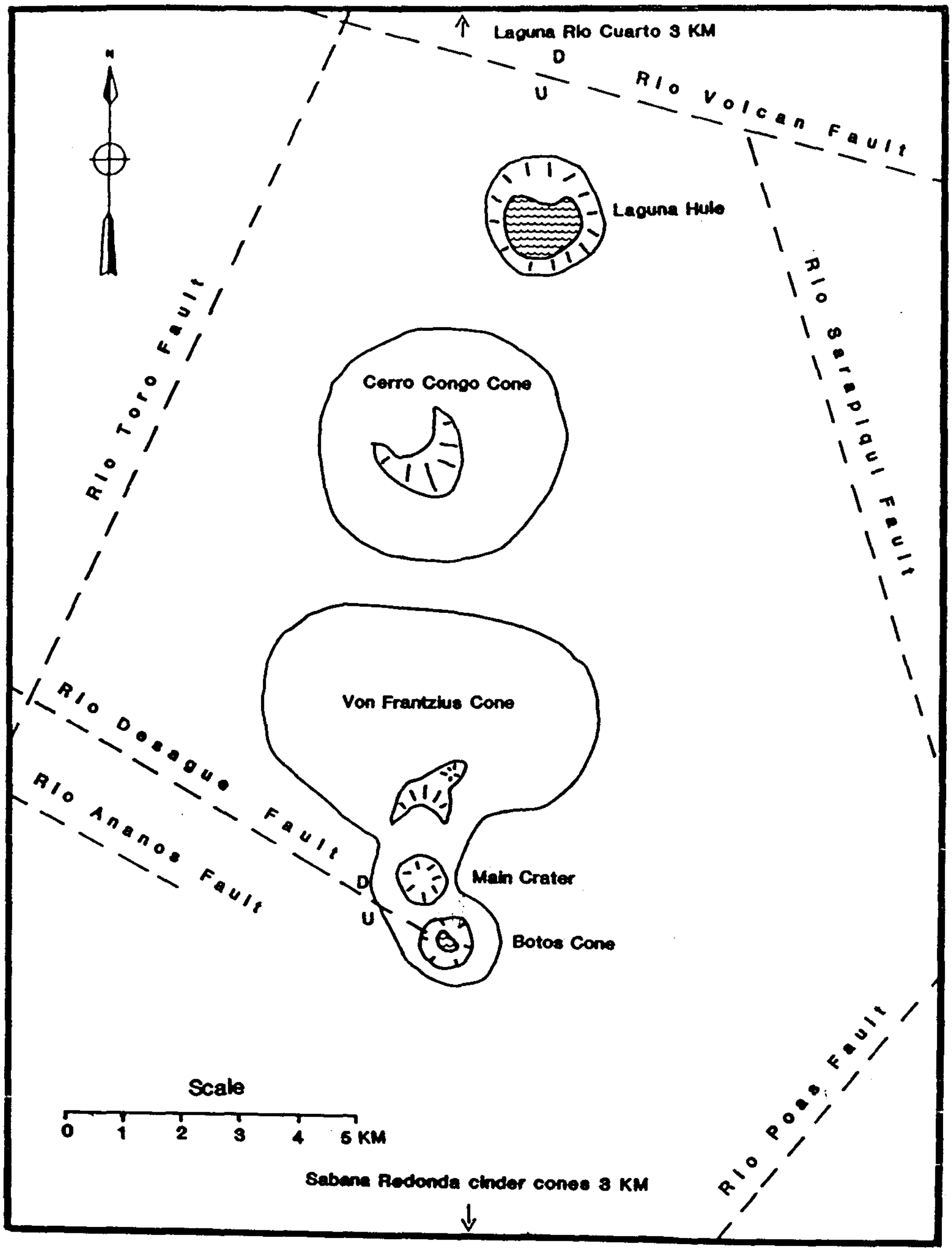

Figure 3 - Diagram showing structural features associated with Poás Volcano. Note the north-south alignment of volcanic edifices.

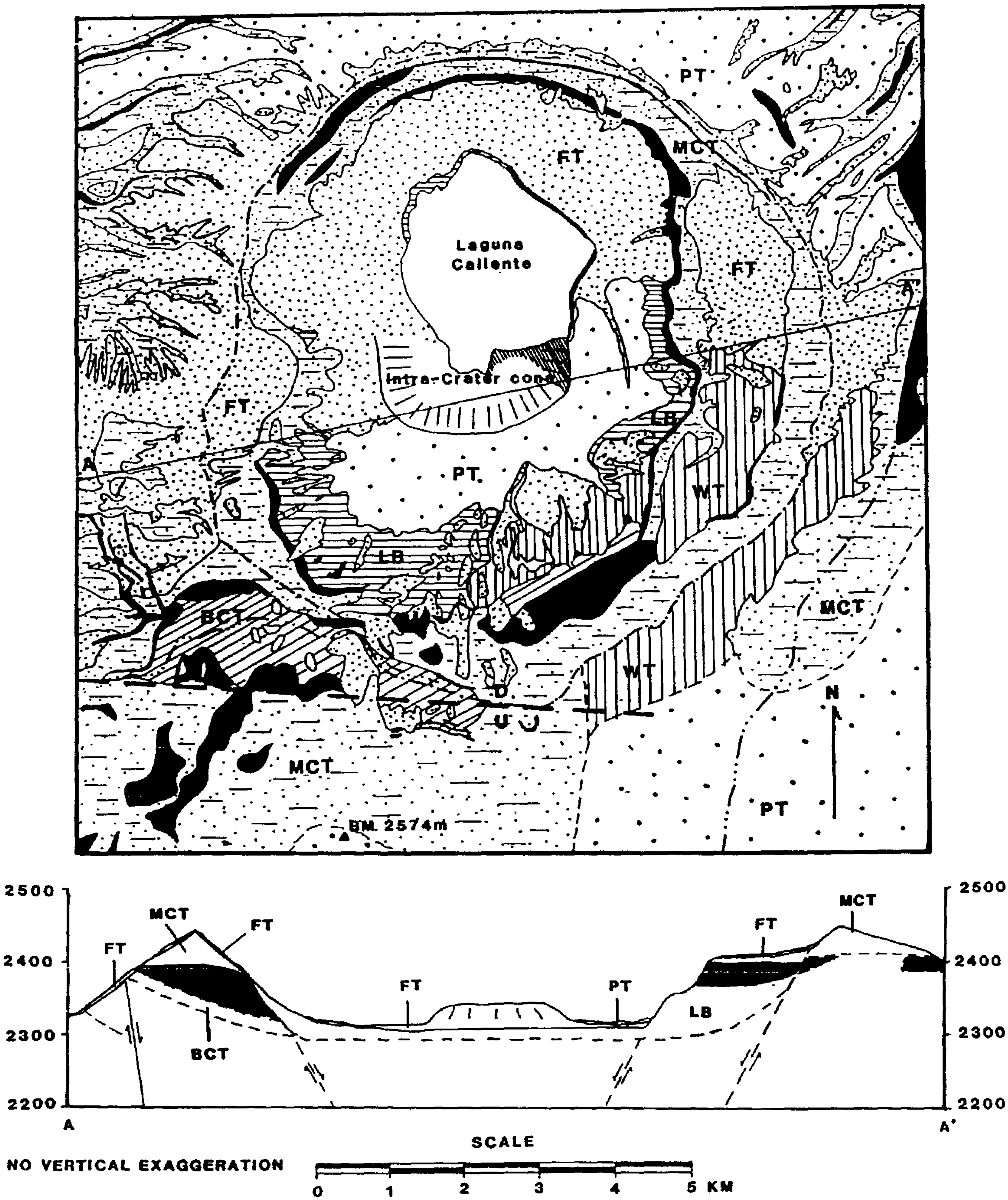

Figure 4 - Geologic map of the Main Crater, Poás Volcano.

Figure 4 continued - Map unit descriptions

PT	Post-1955 phreatic tephra containing pyroclastic sulfur
PT	Black 1953-55 juvenile tephra
WT	Distinctive white phreatic tephra consisting of altered fragments
LB	Well bedded lacustrine volcanoclastic sediments and unbedded pyroclastic material deposited in lake.
MCT	Undifferentiated Main Crater tephras
BCT	Distinctive Botos Cone tephra that may appear hydrothermally altered, and that contains carbonized wood fragments

LEGEND

Lava flow outcrop

Fault

Stream

Main Crater rim

Fumarole bank

Cone

TABLE 1

Chemical analyses of Poás lavas

	[--------EARLY BOTOS CONE--------]					[--LATE BOTOS CONE-]			[--------------MAIN CRATER--------------]						Sabana Redon-da**	Botos Cone	Von Frant-zius
strat #	1	2	3	4	5	6	7	8	9	10	11	12	13	14			
samp #	P08393	P08394	P08395	P08396	P08397	P08310	P08340	P08317	P08309	P08369	P08308	P08312	P08305	P08398	P08356	P08319	P08349
SiO2	57.55	57.98	54.88	56.18	51.47	50.48	52.52	49.10	64.57	57.13	53.9[illegible]	61.54	57.14	54.63	56.50	59.55	54.57
TiO2	0.72	0.70	0.73	0.73	0.83	0.77	1.03	1.05	0.50	0.62	0.75	0.58	0.69	0.80	0.94	0.69	0.84
Al2O3	16.79	16.44	16.71	16.80	18.32	17.41	16.89	15.52	15.80	16.75	17.38	16.37	17.05	18.18	15.90	18.29	18.89
FeO	7.72	7.12	7.61	8.02	10.09	10.05	9.80	9.47	4.64	7.40	9.21	5.60	7.71	8.70	10.30	5.60	6.97
MnO	0.14	0.13	0.15	0.16	0.18	0.18	0.18	0.15	0.10	0.16	0.14	0.13	0.14	0.15	0.17	0.12	0.13
MgO	3.35	3.21	3.47	3.63	5.59	5.01	4.44	7.11	1.67	3.13	4.20	2.38	3.42	4.78	3.04	2.25	2.69
CaO	6.94	6.63	6.61	7.13	10.22	9.98	9.03	9.44	4.38	7.36	7.99	5.35	7.53	9.21	6.56	6.61	7.51
Na2O	3.28	3.22	2.91	3.15	2.56	2.25	2.81	2.46	3.37	3.04	2.75	2.94	2.92	2.99	3.25	3.39	3.21
K2O	1.66	1.75	1.44	1.55	0.85	0.85	1.46	1.52	2.57	1.62	1.20	2.00	1.65	1.04	2.30	2.11	1.43
P2O5	0.17	0.18	0.16	0.19	0.16	0.14	0.27	0.42	0.16	0.16	0.16	0.18	0.17	0.13	0.25	0.24	0.18
TOTAL	98.32	97.36	94.67	97.54	100.27	97.12	98.43	96.24	97.76	97.37	97.76	97.07	98.42	100.61	99.21	98.85	96.42
TRACE ELEMENTS (ppm)																	
Rb	37	26	13	24	26	8	31	33	71	37	18	61	50	27	70	64	40
Ba	767	829	728	768	439	487	619	708	976	685	561	814	698	468	---	794	628
Sr	474	490	471	519	553	577	622	738	428	566	598	525	542	565	500	525	584
V	190	199	192	227	292	287	326	240	90	179	246	116	213	269	---	142	220
Cr	32	32	33	45	37	51	27	221	33	27	34	7	28	27	50	12	25
Ni	12	15	10	21	21	22	16	112	10	12	13	9	15	14	---	3	30
Zr	118	145	114	133	80	97	102	146	177	120	110	126	149	94	190	150	111
Sc	23	23	23	26	31	32	34	28	11	19	24	13	23	28	---	16	23
Cu	67	98	83	91	113	160	118	51	79	111	110	56	100	121	---	67	102

** Analyzed by x-ray fluorescence

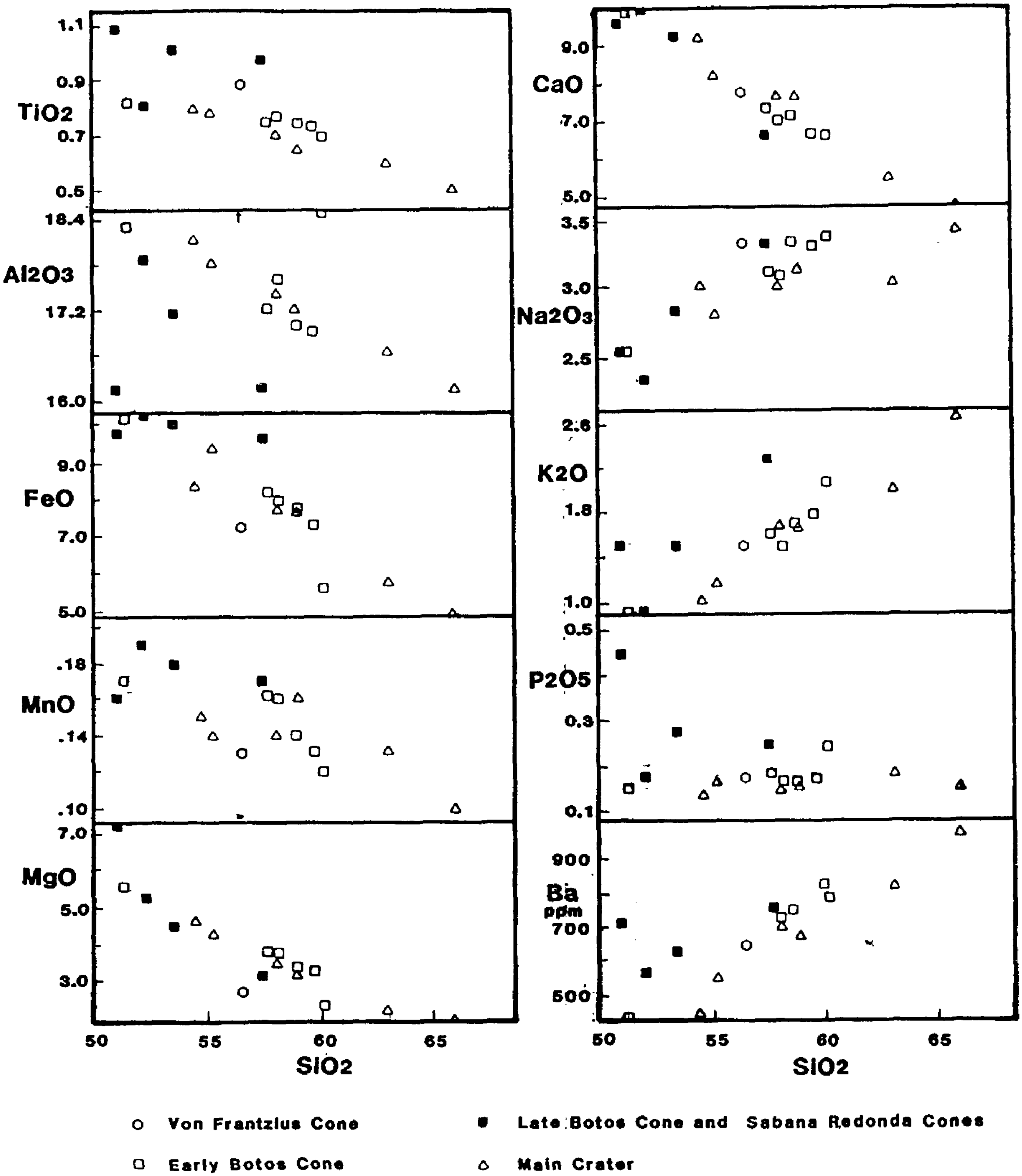

Figure 5 - Harker diagrams for analyses given in table 1. Symbols denote the source vent of sample.

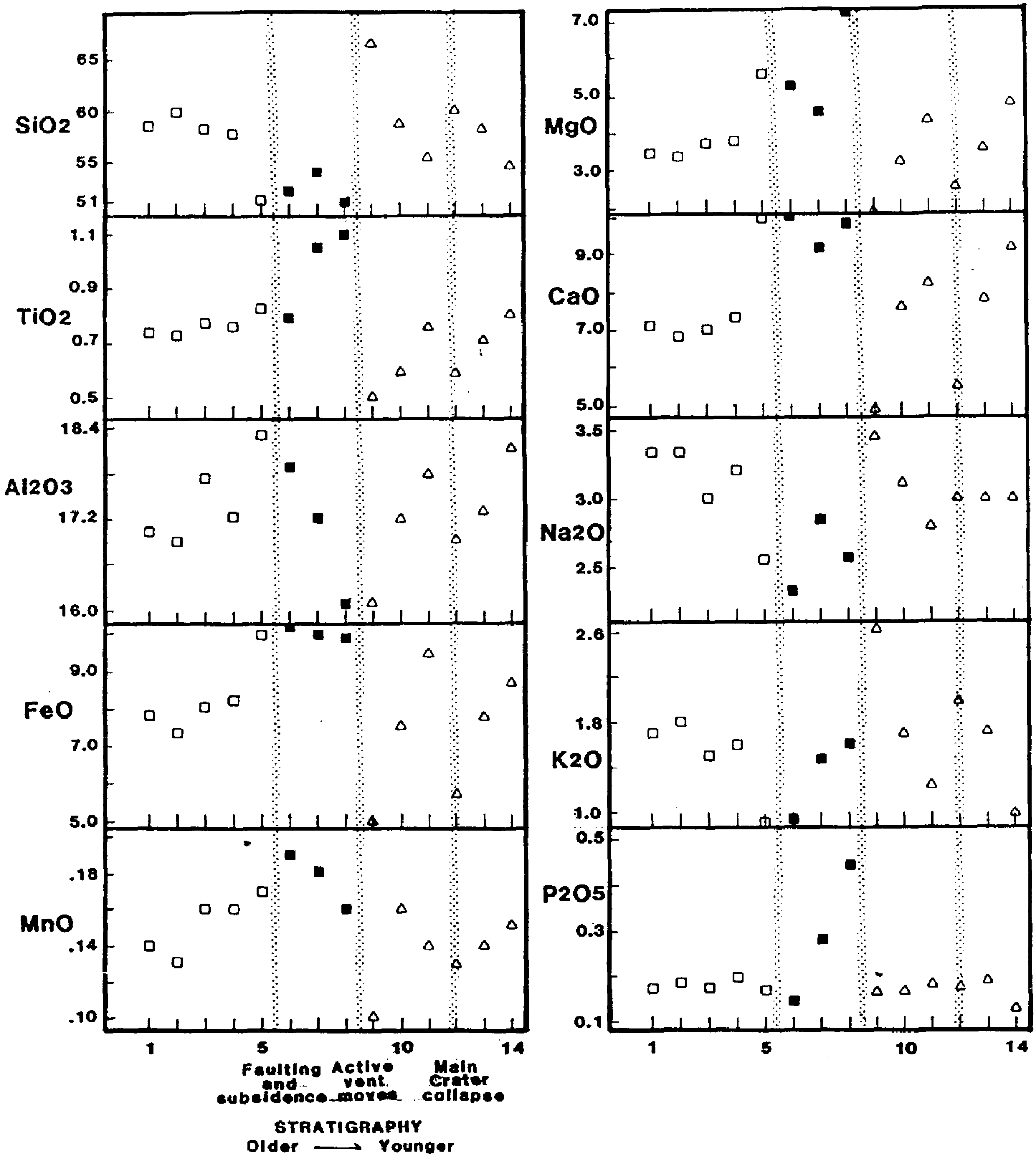

Figure 6 - Diagram showing temporal chemical variation in Poas lavas. Symbols are as for figure 5. Shaded vertical lines mark significant events in the evolution of the summit during the period represented by the chemical data.

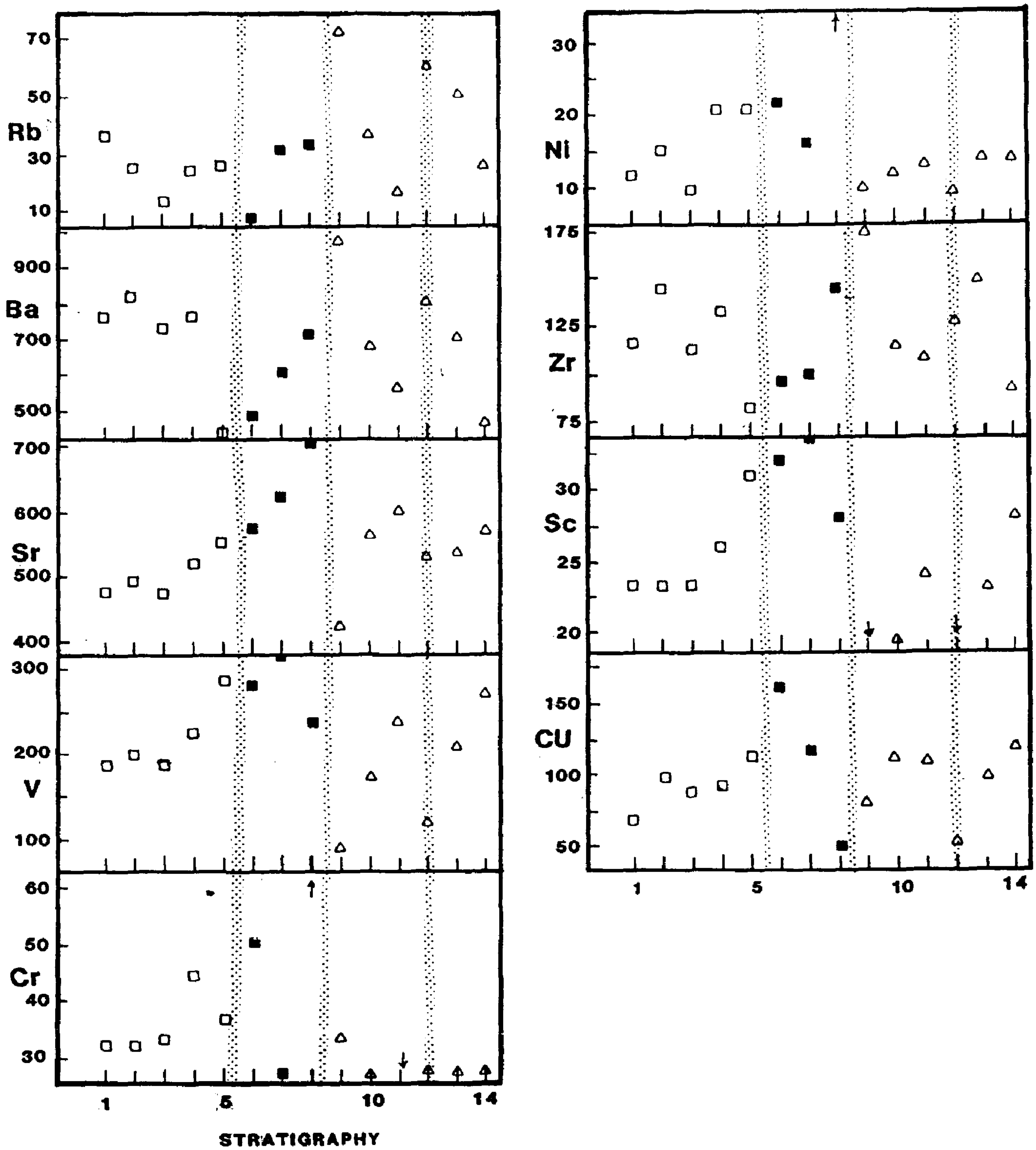

Figure 6 continued