International Conference on Geology, Geotechnology and Mineral Resources of Indochina (Geo-Indo '95)
22 -25 November 1995, Khon Kaen, Thailand

A Late Pliocene Ko Kha - Sop Prap and Nam Cho Basaltic Eruption, Northern Thailand: Evidences from Geology and $^{40}Ar/^{39}Ar$ Geochronology

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Abstract

Basalts of the Nam Cho and the Ko Kha - Sop Prap areas in Lampang province, northern Thailand, were systematically mapped. Five major flow layers and one major layer are recognized in the Sop Prap - Ko Kha and the Nam Cho areas, respectively. Field evidences indicate that basalts of both suites overlie Triassic marine clastics and unconsolidated Quaternary gravels. Geochronological results from whole-rock samples by $^{40}Ar/^{39}Ar$ approach reveal that both basaltic suites may have occurred during 2 to 3 Ma (or late Pliocene). The Nam Cho suite may be regarded as gem - bearing and the Sop Prap suite are gem - barren. Geochemical studies indicate that both basaltic suites may have formed by partial melting of primary magma within the continental plate, however, the Nam Cho suite may have taken place in the deeper upper mantle source region.

Introduction

Nam Cho (northern) and Ko Kha - Sop Prap (southern) basaltic suites (Sutthirat, 1995) in southern Lampang province occur in the roughly N-S trending Cenozoic basin of northern Thailand (Fig. 1.1). Gemstones (especially sapphire) in this area were first systematically explored in detail by Gemstone Exploration Section, Economic Geology Division, Department of Mineral Resources. Field evidences advocate that the basalts are regarded to be spatially and perhaps temporally associated with basaltic rocks of these two suites. Fig. 1.2 illustrates sample locations for chemical and petrographic analyse sand for geochronological study.

Nam Cho Suite

Geology

The Nam Cho basalts extruded Permo-Triassic volcanic/volcaniclastic rocks and covered parts of Cenozoic sediments. It exposed as thin reddish brown vesicular (top) and black dense (bottom) layers of distinct volcanic flows, overlying hill slopes of the Phra That Formation of the Lampang Group (or Triassic marine clastics; Piyasin, 1971) from east to west and northwest. Ultramafic nodules of spinel lherzolite and magacrysts of olivine, pyroxene, and spinel, are invariably found in the Nam Cho basalts.

Geochronology

This basaltic suite is geochemically classified as high alkaline basalt (see Figs.2 and 3) which confirms fairly well with petrographic investigation. New data on $^{40}Ar/^{39}Ar$ geochronology depict that the whole - rock basalt exhibits a good plateau age of 2.02 $\pm$ 0.10 Ma (Fig. 4) for a sample of this basaltic suite. Details of geochronological method and procedure can be found in Charusiri (1989) and will not be specified herein.

Ko Kha - Sop Prap Suite

Geology

The Ko Kha-Sop Prap suite which occupies majority of the study area, is also mainly encompassed by Permo-Triassic volcanic/volcaniclastic rocks, and Quaternary sediments. Volcanic eject including bombs and scoriaceous spatter materials can be observed nearby the volcanic crater, where at least 5 volcanic flow layers with the total thickness of about 20 m are well exposed. All the flows bear similarity in texture and mineralogy. The rocks are conclusively

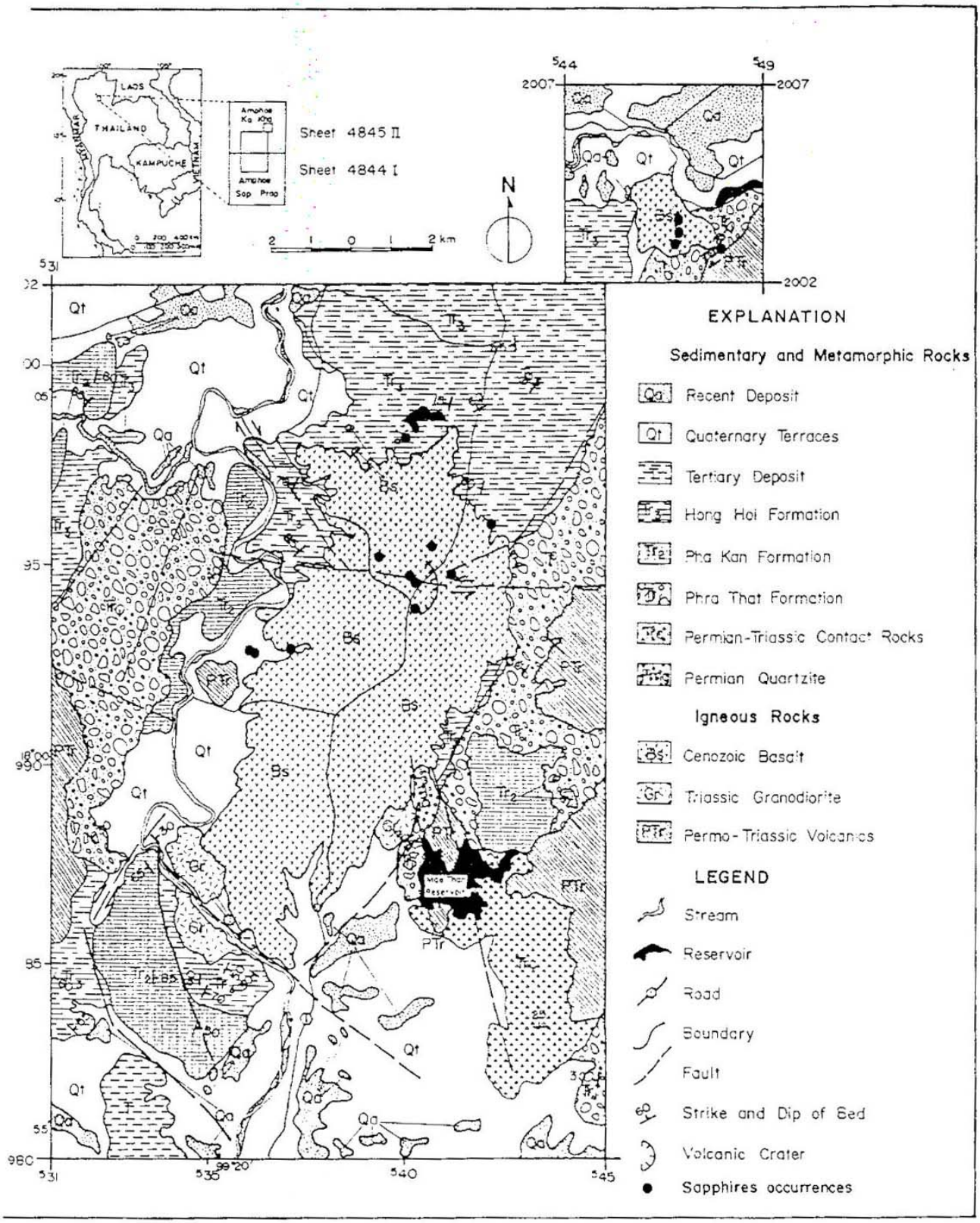

Figure1.1 Geologic map of the Nam Cho (upper) and the Sop Prab (lower) areas showing aerial extent of basalts in southern Lampang (modified after Sutthirat, 1995).

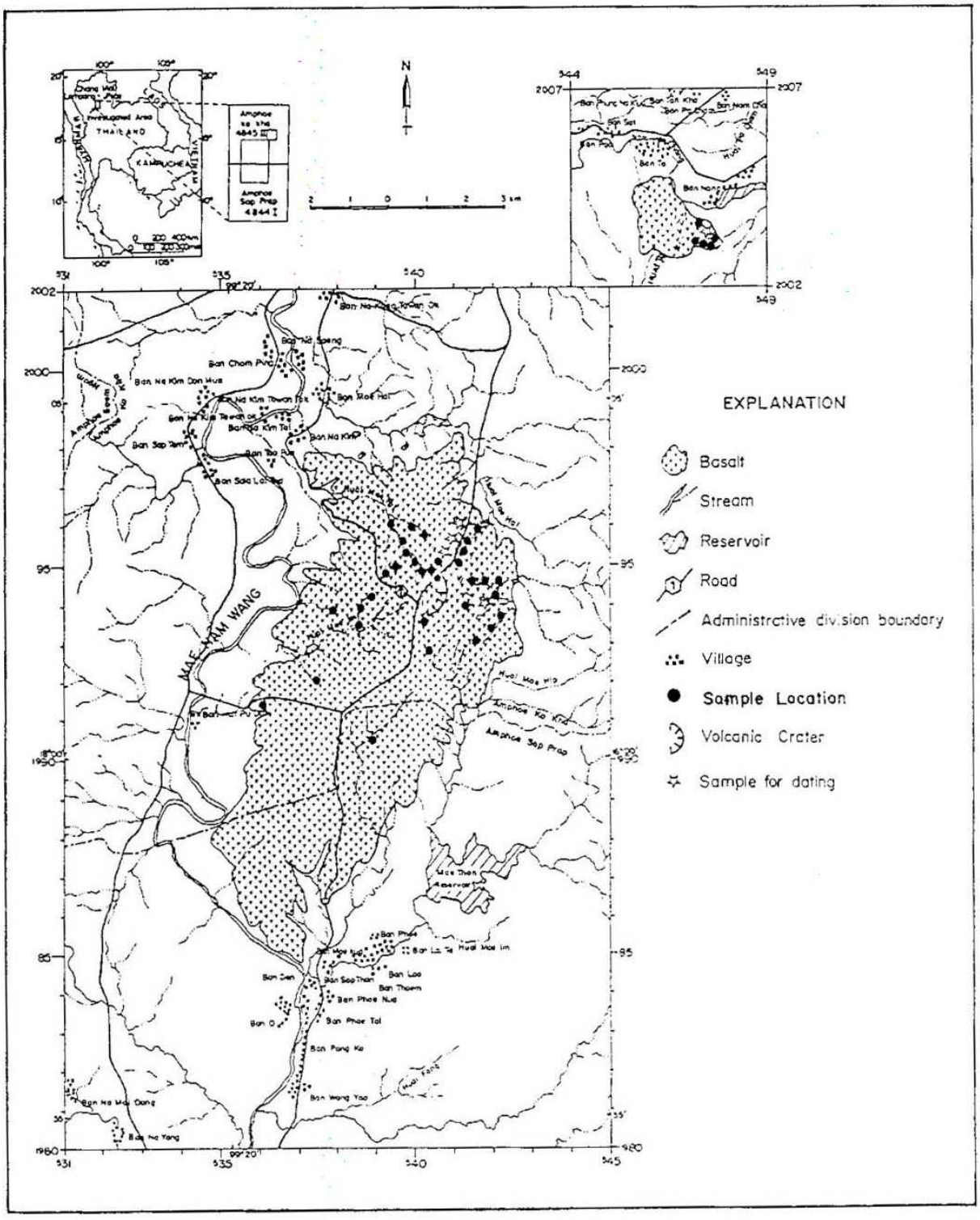

Figure 1.2 Map showing the aerial extent of basalts and location of basalt samples in the study area.

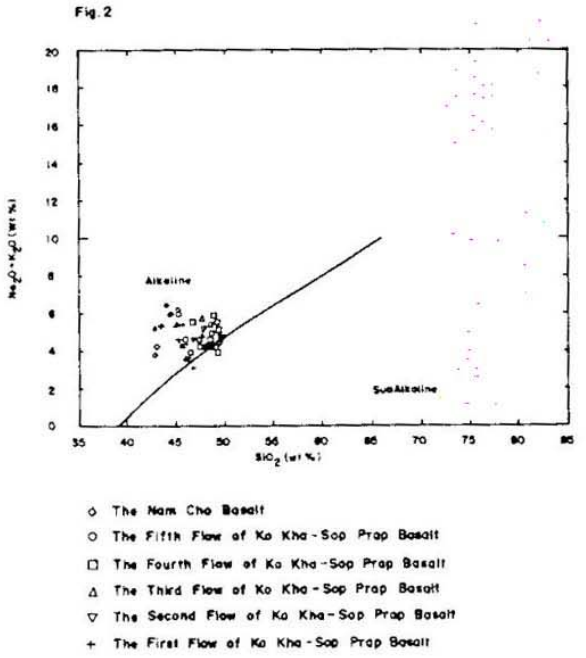

Figure 2. Total alkaline- SiO_2 plot (TAS) with line separating fields of alkaline and subalkaline magma series (Irvine and Baragar, 1971).

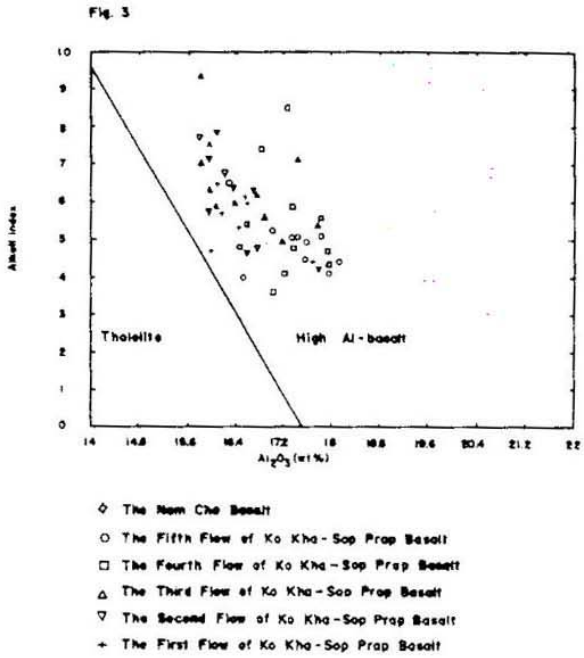

Figure 3. Plot of Alkali index (A.I.) versus wt% Al_2O_3 of the Nam Cho and the Ko Kha - Sop Prab basalts (fields from Middlemost, 1975).

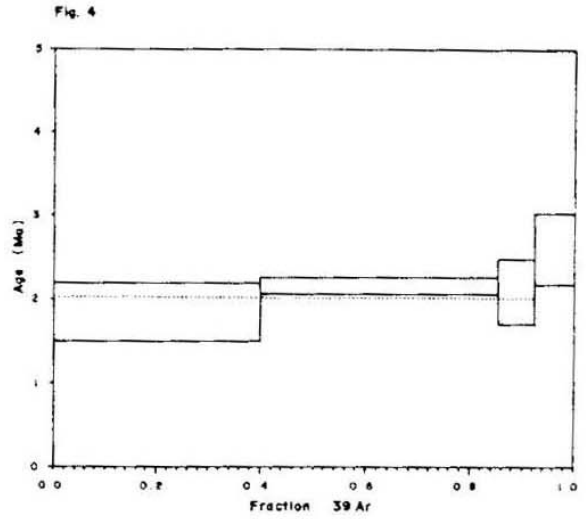

Figure 4. $^{40}Ar/^{39}Ar$ age spectrum of a whole-rock basalt from the Nam Cho suite, southern Lampang, showing more than 90% of plateau age at about 2.02 Ma.

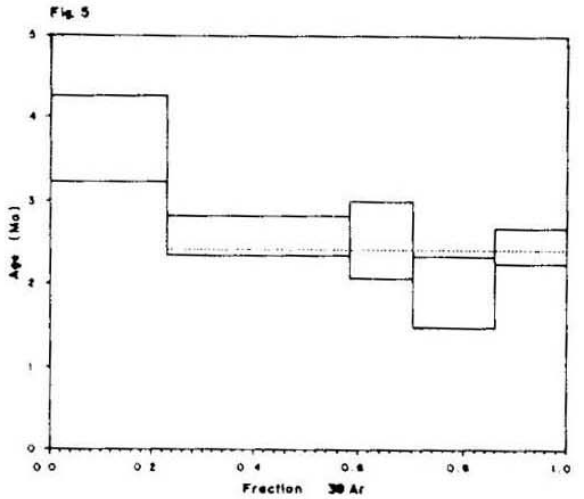

Figure 5. $^{40}Ar/^{39}Ar$ age spectrum of a whole-rock basalt of the bottommost flow layer of the Ko Kha-Sop Prap suite, showing approximately 80% of plateau age at about 2.41 Ma.

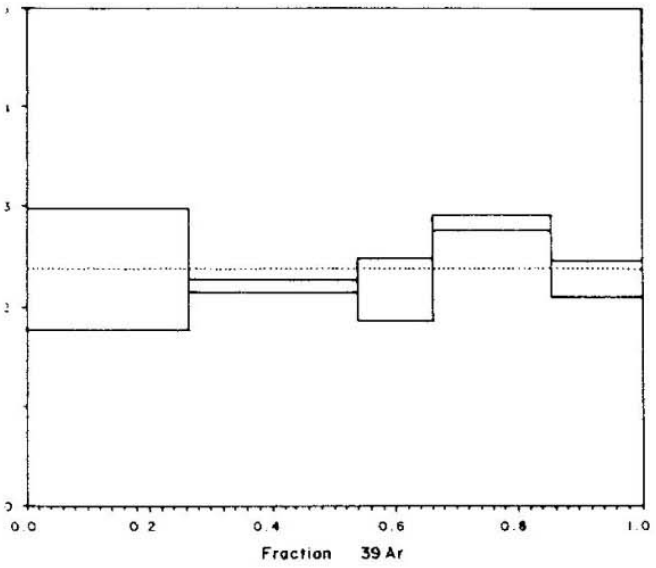

Figure 6. $^{40}Ar/^{39}Ar$ age spectrum of a whole-rock basalt of the second flow layer of the Ko Kha - Sop Prap suite, showing an integrated age datched line corresponding to a plateau age at about 2.38 Ma.

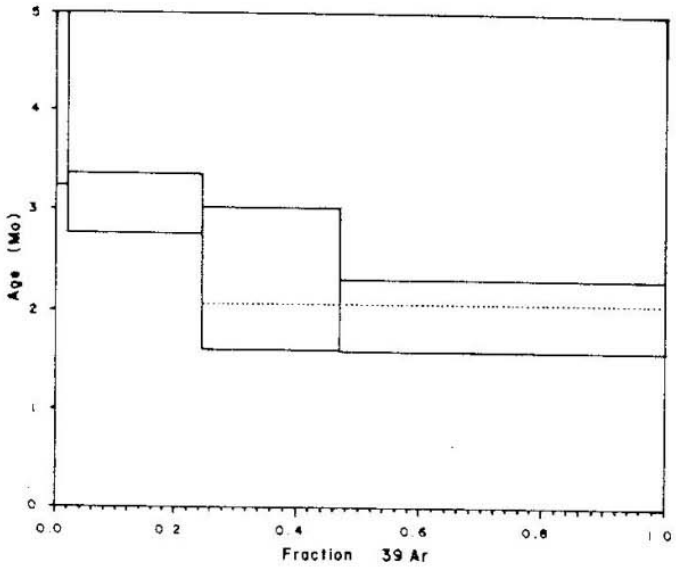

Figure 7. $^{40}Ar/^{39}Ar$ age spectrum of a whole - rock basalt of the third flow layer of the Ko Kha - Sop Prap suite, showing 85 % plateau age at about 2.36 Ma.

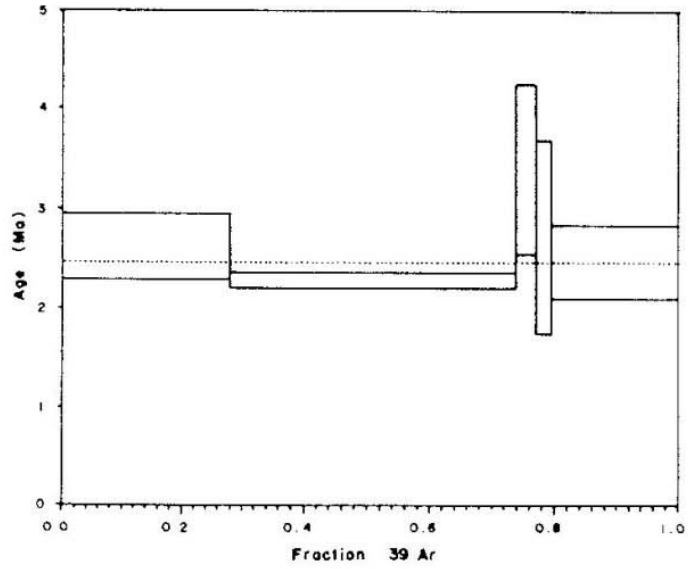

Figure 8. $^{40}Ar/^{39}Ar$ age spectrum of a whole - rock basalt of the fourth flow layer of the Ko Kha- Sop Prap suite, showing 90 % plateau age at about 2.03 Ma.

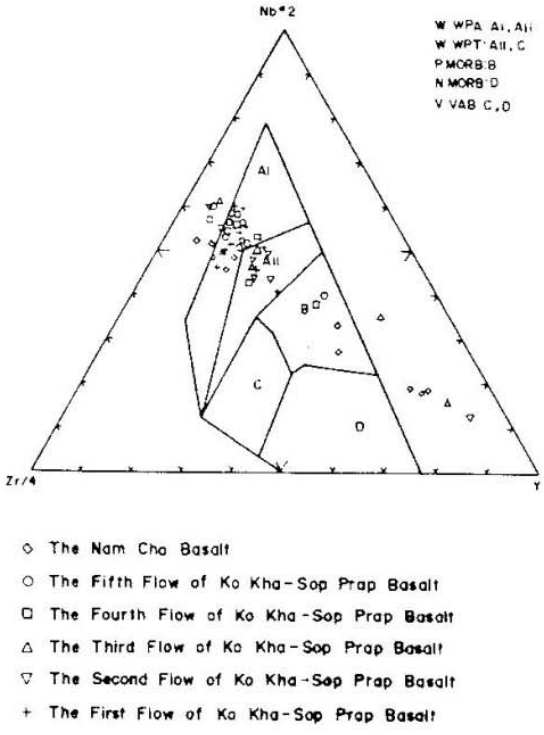

Figure 9. Ternary plot of Zr/4-Nb*2-Y of the Nam Cho and the Ko Kha - Sop Prap basalts (fields from Meschede, 1986) implying the within - plate continental basalts.

characterized by vesicular to massive microporphyritic to porphyritic, and fine - grained basalt, with olivine phenocrysts. Columnar-like jointings, partings, channel-like structures and ropy structures are frequently prominent in some parts of each flow. Average grain size is in general larger than that of the Nam Cho basalt. The Ko Kha-Sop Prap basalt is geochemically defined as alkaline olivine basalt.

Geochronology

Representative 4 fresh samples from individual flow layers, except the fifth (youngest) flow, were dated by $^{40}Ar/^{39}Ar$ method. Results of these data are shown in Figs. 5 to 8. The ages obtained included a well - defined plateau age of ca. 2.41 ± 0.17 Ma for the first flow (Fig. 5), a plateau/integrated age of ca. 2.38 ± 0.17 Ma for the second (Fig. 6), a 85% plateau age of ca. 2.36 ± 0.31 Ma for the third (Fig. 7) , and a nearly 90% plateau age of ca. 2.30 ± 0.13 Ma for the fourth (Fig. 8). However, basalts of the last flow were not dated due to an unfreshness of the sample. It is interpreted that this last basaltic flow can be possibly related to that of the Nam Cho suite in the light of gem - bearing characteristics.

Tectonic Settings

Details of chemical analyses are not shown herein and can be found in Sutthirat (1995). Trace element data (Figs. 9 and 10) show that both basaltic suites may have been regarded as within-plate continental basalts. In addition, according to Sutthirat (1995) based upon mineralogy, lithology, sapphire occurrences and REE result, partial melting of primary magma occurring as a result of very Late Tertiary extension tectonics (Sutthirat, 1995) may have been responsible for the occurrence of these two basaltic suites. However, the gem - bearing Nam Cho basalts may have formed at either deeper depth or higher pressure (possibly more than 20 kbar), implying an upper mantle source region.

Discussion and Conclusion

With regard to our geological studies, it is noteworthy that the characteristics of Nam Cho basalts are quite similar to those of other gem-bearing basalts in Thailand whereas those of the Ko Kha-Sop

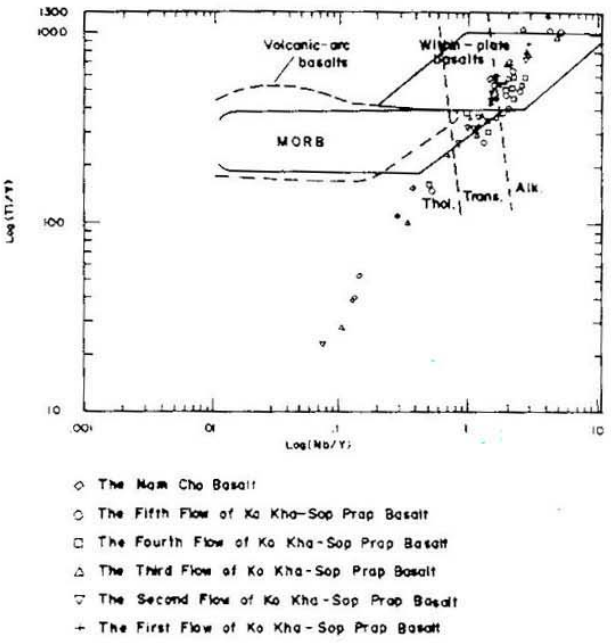

Figure 10. Variation diagram of log (Ti/Y) versus log (Nb/Y) for the Nam Cho and the Ko Kha - Sop Prap basalts (fields from Pearse, 1982).

Prap basalts are not. Our geochronological data indicate clearly than Nam Cho suite is considered to be younger than the Sop Prap - Ko Kha suite. This current geochronological information places these two basaltic suites within the fourth volcanic eruption of Thailand during Cenozoic period (Sutthirat et al., 1994). This confirms that the age of eruption of gem - bearing basalt in Thailand is late Pliocene Epoch. Our result also indicates that the ages of both basaltic suites are dissimilar to those of the gem - barren Mae Tha basaltic suites of northern Lampang province as reported by Sasada et al. (1987; 0.8±0.3 Ma and 0.6±0.2 Ma), Barr and Macdonald (1981; 0.69 - 0.95 Ma), and Sutthirat et al.(1994; 0.5±0.05 Ma). The latter suites are, therefore, believed to have formed from different and shallower mantle region. These lines of evidences also point out that the upper mantle source region are heterogeneous beneath the Lampang province.

Acknowledgements

The authors would appreciate a sincere and consistent support from Mr. Rak Hansawek, Gemstone Exploration Section Department of Mineral Resources. Thanks are also due to Department of Geology, Chulalongkorn University for some logistical

and financial support. The authors would like to express gratitude to Mr. Wattana Tuteechin, Mr. Wimon Ubolphuang, and Mr. Pracheen Tongprachum for their helps in drawing some figures and thin - section preparation.

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