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Volcanic eruption events as revealed by the geochemistry of pumice in the Upper Holocene deposits of Taiwan

Mei-Fei Chu[1], Neng-Ti Yu[2], Jiun-Yee Yen[3], I-Chin Yen[4], Hao-Yang Lee[5]

[1] Department of Geosciences, National Taiwan University, Taiwan; mfchu@ntu.edu.tw
[2] Center for General Education, National Tsing Hua University, Taiwan
[3] Department of Natural Resources and Environmental Studies, National Dong Hwa University, Taiwan
[4] Graduate Institute of Applied Geology, National Central University, Taiwan
[5] Institute of Earth Sciences, Academia Sinica, Taiwan

Pumice in the backshore sandy deposits also has the potential to be used in tephrochronology as an archive of Holocene volcanic activity, similar to the application of volcanic ash recorded in marine cores. In the Taiwan area, pumices were widely embedded in the Upper Holocene backshore colluvium. In this study, their bulk compositions of major and, more specifically, trace elements were measured in order to trace the provenance of the pumice as well as the corresponding eruptive events of intermediate-acid volcanoes in the western Pacific.

Based on the internal color, 65 pumice pebbles were classified into three groups: black (B), white (W), and gray or brown (G). With regard to the concentrations of major elements, B pumice can be distinguished from W pumice by four characteristics. These are as follows: (1) an intermediate silicate content (B: 56.2-60.6 wt%; W: acid or 65.2-75.5 wt%), (2) a higher K_2O content (B: >4.0 wt%, i.e. alkaline; W: <2.0 wt%, i.e. low-K to medium-K calc-alkaline), (3) a higher Al_2O_3 content (B: >16 wt%; W: <16 wt%), and (4) a higher P_2O_5 content (B: >0.3 wt%; W: <0.3 wt%). The data for G pumice fall between the two types of pumice.

All pumice samples exhibit trace element geochemical signatures indicative of arc-related magmatism, including enrichments in large ion lithophile elements (LILE) and light rare earth elements (LREE), and depletions in Ti, Nb, and Ta (TNT). Their incompatible-element distribution patterns show higher potential as the provenance tracers and can be categorized into two main types. Type I is exclusively observed in the B- and G-pumices, while samples exhibiting Type II patterns encompass all W pumices, a few B pumices, and some G pumices. Type I displays higher abundances in most highly incompatible elements than Type II, including most LILE (but not Cs), Th, U, Pb, TNT, and LREE (e.g., Type I: Th_N>100; Type II: Th_N <100). Two and six sub-types of Type I and Type II, respectively (Type IA-B and Type IIA-F), have been identified, based on the notable variations in the concentrations of incompatible elements, including Ba, Th, Nb, Sr, and P.

The eight patterns proposed here are intended to correspond to eight eruptive events of active volcanoes in the vicinity of Taiwan. The petrological and geochemical characteristics of the pumices enable the classification of Type I pumices as originating from the southern Bonin arc. The 1986 eruption of the Fukutoku-Oka-no-Ba submarine volcano represents the Type IA. Type II pumices are predominantly sourced from the western Pacific. The Type IIA is identified with the 1924 eruption of the Submarine Volcano NNE of Iriomotejima.

Keywords: backshore deposits, pumice, geochemistry, volcanic eruption, tephrochronology