

Weathering path diagram (WPD)

KADDERI MD. DESA

Jabatan Geologi, Universiti Kebangsaan Malaysia

Various methods of quantifying weathering have been proposed. Many based on the compositions of weathered materials (Maynard, 1992; Chittleborough, 1990; Harnois, 1988; Nesbitt and Young, 1984; Roaldset, 1972; Parker, 1970; Ruxton, 1968 and Rieche, 1943). These methods are similar in approach but differ in the value of the calculated indices. Furthermore, the calculated indices do not provide information about the state of weathering profiles, particularly profiles that have been subjected to and overprinted by later processes for example diagenesis and hydrothermal alteration. Nesbitt and Young (1989) state that the compositional trends of many igneous rocks during weathering are similar and that the trend can be calculated. Furthermore these trends can be used as a template against which the chemical history of weathering profiles can be compared, particularly ancient and buried profiles. A weathering path diagram is proposed as a weathering template where the state of weathering profiles can be evaluated. The WPD diagram is constructed based on $\log K_2O$ vs $SiO_2/(Al_2O_3+Fe_2O_3)$. The weathering path diagram has the property that all weathering paths converge to a narrow range of $SiO_2/(Al_2O_3+Fe_2O_3)$ ratios between 0.6 and 1.0. It also discriminates between two dominant weathering systems; acid and basic igneous rocks. The plot of $\log K_2O$ vs $SiO_2/(Al_2O_3+Fe_2O_3)$ is sensitive to alkali enrichment by diagenetic and hydrothermal processes or alkali leaching during the early stage of weathering; therefore the WPD is a useful tool for characterizing weathering profiles and paleosols.

The $SiO_2/(Al_2O_3+Fe_2O_3)$ ratio is generally known as the Shellmann quotient (after Schellmann, 1982). The quotient reflects slow leaching of silicate and passive enrichment of oxides and hydroxides of aluminium and

iron. It also has the effect of balancing selective removal of aluminium (lateritic environments) or iron (bauxitic environments). Silica should provide a good indicator of weathering since in tropical conditions silica loss correlates significantly with total element loss (Ruxton, 1968), and also a recent experimental work indicates that silica surfaces control the dissolution rate of silicate minerals (Brady and Walther, 1989). The choice of Fe_2O_3 (excluding FeO) is to reflect oxidising conditions associated with weathering (Price, 1992; Curtis, 1976) i.e. it is critical for profiles developed in temperate and cold climatic regions or profiles that show an early or intermediate stage of weathering. For profiles in tropical regions which are dominated mainly by gibbsite-goethite-kaolinite the use of Fe_2O_3 total values has little effect on the Shellmann quotient because in such environments almost all Fe^{2+} will be oxidised to Fe^{+3} .

The choice of K_2O as one of the axis is made because;

1. It reflects rapid alkali leaching through cation exchange at the beginning of weathering, but the rate of potassium leaching is slow when compared to other alkalis (Na, Li, Rb, Sc) (Hamzah *et al.*, 1990).
 2. It suggests diagenetic influences through reverse incorporation of K into clays such illite (Harnois, 1988), vermiculite and mica or irreversible glauconization (Courbe *et al.*, 1972).
 3. It indicates hydrothermal alteration by alkali rich fluids or sign of K-alteration and K-metasomatism (e.g. Nesbitt and Young, 1989; Alderton *et al.*, 1980); and
 4. It is not influenced by zeolitization process, a common alteration phenomena in basalts, because potassium is a rare constituent of zeolites (Gottardi and Galli, 1985).
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