Geochemical mineral exploration: should we use enrichment factors?

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The concept of enrichment factors (EF) has been introduced about four decades ago as a means of speculating on the origin of elements in the atmosphere of remote regions [1, 2, 3, 4]. The general formula for estimating EFs is: $EF_{crust}El = ([El]_{sample}/[X]_{sample}) / ([El]_{crust}/[X]_{crust})$ where El is an element under consideration, X is a reference element, the square brackets indicate element concentration, and the subscripts "crust" or "sample" refer to the medium from which element concentration was measured. The application of EFs has subsequently been extended to a variety of earth materials to discern between natural and anthropogenic sources for elements. However, Reimann and De Caritat [5, 6] concluded that this extended usage of EFs is "at odds with the original concept" and they recommended that such indiscriminate use of EFs should be avoided.

In the geochemical mineral exploration literature in the last decade or so, there are some extended applications of EFs to geochemical mineral exploration [7, 8, 9, 10, 11, 12, 13]. In this contribution, using the same soil geochemical data used by Sadeghi *et al*. [14] and Carranza *et al*. [15], it is shown through statistical and spatial analyses that using EFs is no better than using logratio-transformed data in geochemical anomaly mapping for mineral exploration. Thus, following Reimann and De Caritat [5, 6] and this present study, it is also recommended that the extended use of EFs to geochemical mineral exploration should be avoided.

[1] Chester & Stoner (1973) *Nature* **245**, 27-28. [2] Peirson *et al*. (1974) *Nature* **251**, 675-679. [3] Zoller *et al*. (1974) *Science* **183**, 199-201. [4] Duce *et al*. (1975) *Science* **187**, 59-61. [5] Reimann & De Caritat (2000) *Env Sci Tech* **34**, 5084-5091. [6] Reimann & De Caritat (2005) *Sci Total Env* **337**, 91-107. [7] Chandrajith *et al*. (2001) *Appl Geochem* **16**, 339-350. [8] El-Makky & Sediek (2012) *Nat Resour Res* **21**, 95-115. [9] Gong *et al*. (2013) *J Geochem Explor* **128**, 14-24. [10] Yaylali-Abanuz (2013) *J Geochem Explor* **132**, 63-74. [11] Liu *et al*. (2014) *J Geochem Explor* **139**, 152-159. [12] Wang *et al*. (2013) *J Geochem Explor* **124**, 40-58. [13] Hosseini-Dinani *et al*. (2015) *J of Geochem Explor* **156**, 114-130. [14] Sadeghi *et al*. (2015) *J Geochem Explor* **154**, 180-193. [15] Carranza *et al*. (2015) *Ore Geol Rev* **71**, 703-718.