Finding peaks in geochemical data sets

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Histograms of many geochemical data sets contain peaks, and these peaks can have physical significance. A notable example is the peaks in the distribution of crustal ages obtained from a worldwide compilation of U-Pb zircon data [1]. The three main peaks at “magic ages” of 1.2 Ga, 1.9 Ga, and 2.7 Ga have been associated with major pulses in continental growth. More recently, using a compliation of helium isotopic data [2], it has been suggested that the histograms of $^4He/^3He$ ratios of ocean island basalts are also peaked, and that these peaks can be related to the crustal peaks [3]. Such a relationship would provide an important link between mantle depletion and crustal formation.

These observations raise some important general statistical questions that are relevant for any compliation of geochemical data: How can we tell if a peak in a histogram is really there? How can we separate real peaks from peaks that arise as artifacts of the sampling process? Statistical methods for addressing these questions will be described, with a particular focus on the problem of bandwidth selection in kernel density estimation, and a method for identifying significant features known as SiZer [4]. These techniques have been used to re-assess the helium-continental crust correlation, which it seems may not be supported by the current data.

[1] Condie K.C. (1998) *Earth Planet. Sci. Lett*. **163,** 97-108. [2] Abedini A.A. *et al.* (2006) *USGS-NoGaDat* http,//pubs.usgs.gov/ds/2006/202 [3] Parman S.W. (2007) *Nature* **446,** 900-903. [4] Chaudhuri P. & Marron J.S. (1999) *J. Amer. Stat. Assoc*. **94,** 807–823.

Precise U-Th-Pb geochronology of carbonatites and mantle perturbations

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Found on every continent, carbonatites range in age from the Archean through to the Recent, and hense can provide important insights into the terrestrial evolution (Bell *et al*. 1982; Bell and Blenkinsop, 1987; Kwon *et al.* 1989; Bizzaro *et al.* 2002). Carbonatite magmatism repeatedly occurred in relatively restricted areas of several cratons, and the distinct age groupings were linked to different geological events (Kukharenko, 1967; Vartiainen & Woolley, 1974; Doig, 1970; Larsen et al. 1983; Nielsen, 1985; Dahlgren, 1994; Belyaev et al. 1976; Bell, 2001). Of the known 500 or so carbonatites, however, few have been precisely dated.

Here we present new precise U-Pb, Th-Pb and Pb-Pb ages from several carbonatite complexes from Canada, Russia, and Finland which can be used to establish important reference points in defining mantle perturbations. Events at 2617 Ma and 586 Ma are now firmly established for the Baltic Shield, while several distinct events of 2680 Ma, and between 1897 - 1083 Ma are documented for the Canadian Shield. Other, less well defined, events in Canada include magmatism at 568 Ma from Manitou Islands and an event at 357 Ma from the Canadian Cordillera. East European Craton events also include carbonatitic magmatism at 2074 Ma, 1963 Ma, 1792 Ma and between 386 and 377 Ma. Most of these events can be correlated with extensive mafic magmatism generally considered to be the result of plume activity and associated continental fragmentation. Selected ages from carbonatite complexes are presented in the table below.

Complex	Age ±2σ Ma	Method
Siilinjarvi	2617.4 ± 9.6	U-Pb zircon
Cargill	1896.8 ± 1.4	U-Pb baddeleyite
Goldray	1886.0 ± 0.9	U-Pb zircon
Tiksheozero	1959 ± 16	U-Pb zircon
Chernigovka	2074.4 ± 6.3	U-Pb zircon
Firesand River	1142 ± 23	U-Pb kimzeyite
Valentine	1114.7 ± 1.1	U-Pb baddeleyite
Manitou Islands	568 ± 24	Pb-Pb isochron zircon
Turiy Peninsula	377.0 ± 3.7	206Pb*/238U baddeleyite
Kandaguba	385.6 ± 3.1	Th-Pb isochron calcite-apatite
Seblyavr	382.3 ± 5.3	Th-Pb isochron carbonates