Progress in detrital garnet Sm-Nd geochronology: the second point on the isochron

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Detrital minerals in the sedimentary record provide valuable information about the tectonic evolution of the Earth. Detrital garnets also preserve a chemical record of tectonometamorphic processes, conditions and provenance [1] that may not necessarily be recorded by other commonly dated detrital minerals. Detrital garnets could therefore form a valuable and complimentary tool in detrital analysis of ancient tectonic processes and provenance. Here, we describe recent advances beyond previous attempts to date detrital garnets [2,3] and illuminate the current possibilities and limitations.

Two challenges must be overcome. First, is the sample size limitation which is solved through use of NdO^+ TIMS analysis with Ta_2O_5 activator [3,4]. This small sample capability provides an opportunity for geochronology on single >500 um grains or equivalent multi-grain separates. Second, a detrital garnet grain is no longer associated with the parent rock from which it crystallized. Thus there is no obvious second point to constrain an isochron. Here, detrital garnets may be crushed and treated with acids (including HF) to partially dissolve and analyze mineral inclusions which should in most cases adequately represent the original garnet host assemblage. But, well established methods for conventional garnet geochronology demonstrate that the garnet's inclusions often fall off the garnet-matrix isochron [5], and thus these inclusions are typically removed and discarded. Fortunately, in the detrital garnet application, the magnitude of the "age effect" related to the use of inclusions as the second point on the isochron (rather than the matrix) is small; generally less than a few million years which is an acceptable tolerance for most detrital geochronologic studies. Only if inherited zircons, which themselves can have high Sm/Nd ratios, represent a dominant part of the inclusion population could the detrital garnet age be skewed more significantly.

Test garnets extracted from New England (USA) sediments have been dated with this approach, yielding Acadian ages (as expected) with age uncertainty as low as ±4 Myrs on single grains as small as 3mg (or about 1.5mm diameter). $^{147}Sm/^{144}Nd$ ratios as high as 2.4 in cleansed garnet reflect success in separating inclusions from garnet via partial dissolution. Our data show a correlation with apparent isochron age and spread in $^{147}Sm/^{144}Nd$. The larger the spread between the two points in the isochron, the younger and more accurate the age. With our test samples, we have found that $^{147}Sm/^{144}Nd$ spread greater than 0.5 is necessary to produce accurate ages. Samples which yield less spread are too old, reflecting incomplete separation of garnet from inherited inclusions.

[1] Hutchinson AR & Oliver GJH 1998. J. Geol. Soc. Lond. 155, 541-550; [2] Oliver GJH et al. 2000. Geology, 28, 459-462; [3] Baxter EF et al. 2010. Goldschmidt; [4] Harvey J & Baxter EF 2009. Chem. Geol. 258, 251-257; [5] Pollington AD & Baxter EF 2011. Chem. Geol. 281, 270-282.

Hydrochemical and multiple isotopic approach to delineate the contamination of urban groundwater in Ulaanbaatar, Mongolia

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In Ulaanbaatar City (UB), Mongolia, significant population growth (currently, ~1.2 million) and rapid industrialization over the last two decades resulted in diverse environmental problems including a shortage and contamination of the water supply. Municipal water supply in UB depends on groundwater withdrawn from an alluvial aquifer located along the Tuul River. There are also many private wells completed in variable depths. Groundwater in UB has become increasingly polluted because of a deficient municipal sewer system, illegal waste dumping, air and soil pollution, and deforestation of surrounding areas. To our knowledge, there is no detailed survey that has assessed the status of groundwater quality in UB. Therefore, we have performed a hydrogeochemical survey including hydrochemical and multiple isotopic (i.e., $\delta^{13}C$ of dissolved inorganic carbon, $\delta^{15}N$ and $\delta^{18}O$ of nitrate, and $\delta^{34}S$ and $\delta^{18}O$ of sulfate) measurements on 45 groundwater, 4 surface water and 2 spring water samples collected in July 2011. The obtained data were interpreted in relation to land use patterns, which include the urban center, peripheral residential areas with dense traditional homes, grasslands, and forests.

Our results show the occurrence of three major hydrochemical types: 1) $Ca\text{-}HCO_3$ type, 2) $Ca(\text{-}Na)\text{-}HCO_3\text{-}Cl(\text{-}NO_3)$ type, and 3) $Ca\text{-}Na\text{-}HCO_3$ type. The spatial distribution of different water types is controlled by land use. Types 1 and 3 occur under forest and grassland areas and are representative of unpolluted or less-contaminated groundwater. On the other hand, type 2 occurs predominantly in urbanized areas and shows progressive enrichments of groundwater with $Cl+NO_3$ (and NO_2)+SO_4 with increasing TDS, due to anthropogenic impact from latrines and domestic sewage. Nitrate contamination especially in the city center and peripheral residential areas is pervasive and severe resulting in NO_3^- concentrations of up to ~290 mg/L. The $\delta^{15}N$ and $\delta^{18}O$ values of nitrate suggest that in the city center and peripheral residential areas, latrines and domestic sewage are major sources of the severe nitrate contamination. Therefore, better management of latrines and sewage systems is urgently needed in UB. Our study also shows that groundwater contamination in UB is linked to the progressive population growth and city expansion.