GEOL 415 Assignment 2

1. In order to assess which method to use out of the three (Rb-Sr, Sm-Nd or U—Pb), it is necessary to specify what period of Earth history they are investigating and in fact what type of rock i.e. igneous, sedimentary or metamorphic. In the case of the Archaean period, this lasted from 4.0 Ga to 2.5 Ga ago which actually translates to 4,000 – 2,500 million years ago.

   Further specifying the type of rock, in our case metamorphic, the Rb-Sr isotope system would not be as good a candidate when compared to the other dating methods. This is because during metamorphism, a closed system condition is violated so an accurate age is difficult to assess. When using the Rb-Sr dating method, samples should be altered as little possible since alteration is a major problem in many Archaean terrains, Nisbet (1987) writes.

   In addition, studies from Bridgewater and Collerson (1977) and Schiotte (1985) have shown that the Rb-Sr method may have problems dating very old rocks. Since the Archaean period started 4 billion years ago as previously mentioned, this would not qualify as a good candidate for those older rocks, especially older metamorphic rocks that undergo alteration.

   The Sm-Nd technique has the same basic form as the Rb-Sr isochron equation. However, it is more resistant to alteration and qualifies as a better dating method for Archaean metamorphic rocks. Studies have shown a comparison between the Rb-Sr and Sm-Nd methods (Hamilton 1977) where the heavy alteration of the rock unit gave inaccurate results via Rb-Sr yet Sm-Nd proved to be more resilient.

   However, the drawback of Sm-Nd technique is the incompatibility which refers to “the degree to which an element will tend to concentrate in the liquid phase of a partial melt rather than becoming part of newly-forming crystals or remaining in melting crystals” (Athabasca GEOL 415 unit 2 lesson 5 notes). Notice though that even with incompatibility, this does not necessarily mean that meaningful age results can or cannot be determined as long as it occurs before the system closes.

Lastly, the U-Pb method is one of the most powerful methods of dating and in general, it is a precise tool in Archaean stratigraphy. It is a more accurate form of the Rb-Sr method in that it produces better ages though it suffers from a similar problem. If a major fluid movement through the rock does not occur and if the system has remained chemically closed throughout its history, then this technique is valid. However, in the case of a metamorphic rock, this may not always hold true. Alteration is a definite issue when it comes to metamorphic rocks regardless of whichever age period. As such, it all depends on what type of specific metamorphosis has occurred and how the composition had changed of the rock unit (whether or not there was recrystallization vs fluid movement vs temperature change etc).

2. The two equations shown refer to the 'burning' of hydrogen in extremely different ways. Hydrogen 'burning' in stars, the first equation, refers to the fusion of hydrogen nuclei to form helium. This process refers to how the Sun, for example, generates energy and is self sustainable for millions of years given the immense gravity and heat. Essentially what is occurring is the combining (i.e. fusion) of hydrogen under extreme heat to form helium along with emitted energy. The energy emitted is great magnitudes higher than the second combustion equation that is common on Earth.

   On Earth, hydrogen can react with oxygen to form water along with heat energy. The energy formed, like previously mentioned, is much, much lower than fusion. This is also a 'one way' reaction that stops after occurring and does not retrigger itself. Whereas the fusion reaction is a self sustaining chain reaction that keeps itself going due to the nature of the products it produces which eventually causes to repeat itself via self collapse and reheat cycles. This type of sophistication is not seen in a combustion reaction of hydrogen into water. Fusion reactors on Earth that attempt to replicate star fusion are a current area of research. These reactors would be more comparable than a simple combustion reaction in which they attempt to replicate fusion of the Sun, though the required energy for them is greater than the net output and so are currently unviable.

3. The abundances of elements, specifically Li, Be and B, can be partially explained via analyzing their Z and N values (proton and neutron). This phenomena is known as the Oddo-Harkins rule. Be has an even amount of protons yet an odd number of neutrons and so is much less abundant than a

more 'unstable' element. With regards to Li and B, both of these elements have odd numbered protons but even number neutrons. Both of these elements are not very radioactive and so are not very abundant in stellar composition study.

With regards to the table provided going over nucleosynthesis reactions, it is shown that reactions involving Be, B and Li only account for 15% of the initial solar interior reactions. There is also no additional Be, B or Li generated as products from those reactions, only He. This also contributes to the fact that the abundances of Be, B and Li are lower in quantity.

Some additional interpretations of cosmic abundances from an external paper[1] point to the depletion of Li during pre main sequence stellar evolution, being quickly destroyed by alpha reactions. This is also the case with Be though during the main sequence rather than pre sequence. This ideas along with the odd/even pairings of proton/neutron configurations can explain the low abundances of Be, B and Li in stellar composition.

4. Although both of these descriptions refer to stellar nucleosynthesis, the simplified version in the course notes applies to a star that is existing in early history of the universe. This is because it starts with describing how stars begin by burning hydrogen to form helium initially. They then go through the chain process as described in the course notes and so that is describing the early inception of a star that is beginning to do that process and will eventually continue to do so to reach hydrostatic state.

   In Meyer and Zinner 2006, however, the full table describes a star that is already in hydrostatic state. In a hydrostatic phase, stars are at a equilibrium. There is a balance between thermal pressure and weight of the material above pressing inward i.e. gravity compression balanced by pressure outward. Since the paper describes a star in the hydrostatic phase, this refers to a star in recent history such as our Sun that is currently in hydrostatic state.

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[1] http://articles.adsabs.harvard.edu/cgi-bin/nph-iarticle_query?bibcode=1976PASP...88..353B&db_key=AST&page_ind=11&plate_select=NO&data_type=GIF&type=SCREEN_GIF&classic=YES