Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 441

A Novel Radiometric Dating Technique

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A new radiometric dating technique using the decay of ^{130}Te to ^{130}Xe (half-life ~ 8x10^{20} years) has been developed, and shown to be capable of directly dating hydrothermal mineralisation (Gilmour et al., 1999). Neutron irradiation of a tellurium bearing sample converts ^{130}Te to ^{131}Xe, allowing a subsequent step-heating experiment analogous to Ar-Ar dating to be performed. With sufficient sensitivity, such as that obtained using the unique RELAX resonance ionisation instrument at Manchester (Gilmour et al., 1994), samples smaller than 1 mg may be used making widespread application of the technique practical. Because of the uncertainty in the half-life of ^{130}Te, and the novelty of the technique, we initially chose samples from three well-studied areas: Clogau (Wales), Carrock Mine (Cumbria) and Kalgoorlie (Yilgarn block, Australia). Accurate tellurium fluence monitors from the two irradiations have not yet been analysed, so ages have been calculated on the assumption that the telluride from Clogau (with a well defined Xe-Xe isochron) has an age of 405 Ma (derived from K-Ar dating (Shepherd and Bottrell, 1993)).

Figure 1 shows data from three grains of $AuTe_2$ from a location in the Kalgoorlie gold deposit. $^{132}Xe_T$ denotes the trapped atmospheric xenon component, ^{131}Xe* denotes the excess of the artificially induced isotope (from ^{130}Te) over atmospheric composition. The correlation of ^{130}Xe with $^{131}Xe^*$ is a result of the in situ decay of ^{130}Te. The derived age of 2553±75 Ma is consistent with previous work dating the gold-bearing veins to 2600-2700 Ma. Samples from two other locations within the Kalgoorlie deposit gave results that are harder to interpret. Another sample of $AuTe_2$ gave a well-defined but considerably later age of 1897±58 Ma suggesting that some regions of the deposit either formed later, or have been reset by heating. A sample of goldfieldite ($Cu_{10}Fe_2(Sb,Te)_4S_{13}$) may have been reset within the last 90 Ma, or this more complex mineral does not effectively retain Xe.

One sample from the Carrock tungsten mine has been analysed so far, and although data reduction was complicated by the apparent presence of a strongly mass-fractionated atmospheric component, an age of 312±50 Ma was obtained. The tungsten deposit is in the form of wolframite-scheelite-sulfide veins on the margin of the Skiddaw granite (400 Ma). A nearby greisen has been dated to 387 Ma (Shepherd et al, 1976), but there are also veins formed in later hydrothermal events, and one of these may be responsible for the apparent telluride age.

These early results, together with estimated neutron fluences, support some previous estimates of the half-life of ^{130}Te (Takoaka et al., 1996; Manuel, 1991) and demonstrate the utility of Xe-Xe dating of tellurium-bearing minerals. Future work will improve the accuracy with which the ^{130}Te half-life is known by applying the Xe-Xe technique to tellurides with a variety of known ages, and selection of samples with varying post-formation histories will enable us to develop a better understanding of how different geological events affect Xe-Xe ages.

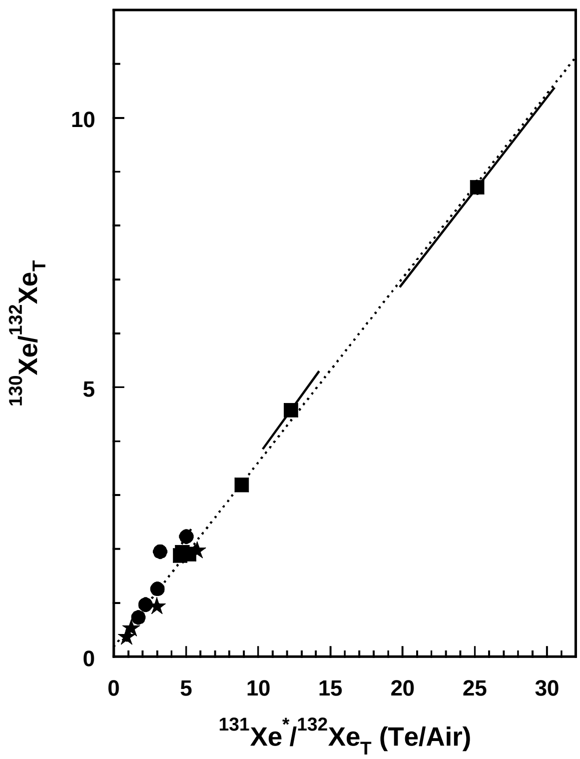

Figure 1:Xe-Xe data for a neutron irradiated telluride from Kalgoorlie, showing a mixing line between air and a tellurium-derived component. The gradient is related to the age of the sample.

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