$^{40}Ar/^{39}Ar$ Dating of yimengite from the Turkey Well kimberlite, Australia: The oldest and the rarest

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Location and Regional Geology

During the past ten years Stockdale Prospecting Limited (SPL), the exploration arm of De Beers Consolidated Mines in Australia, has found a number of kimberlites in the Eastern Goldfields of the Yilgarn Craton (Turkey Well, Granite Creek, Red Well, Teutonic Bore, Rainbow, Wilbah, Melita - see Figure 1). The Turkey kimberlites (120°39'07"E, 28°52'33"S) were discovered in 1991 following reconnaissance sampling on the Leonora 1:250000-scale map sheet (SH51-01). The Leonora area consists of Archaean granites and gneisses, which surround and intrude elongate N-NW trending greenstones (Thom and Barnes, 1977; Kriewaldt, 1970). Together these elements comprise the Norseman-Wiluna granite-greenstone belt. The granitic magmatism occurred over the period 2.7 Ga to 2.55 Ga. Archaean calc-alkaline lamprophyre dykes (2.66 Ga) and Early Proterozoic easterly-trending dolerite and gabbro dykes (2.4 Ga) intrude the whole stratigraphic succession. The area is bounded in the west by the Ida Lineament and in the east by greenstone belts and the Keith-Kilkenny Lineament.

Exploration History and Methodology

The Leonora area was selected for a diamond exploration program because it is central to the Yilgarn Craton and contains major continental scale structures. Some drainage existed to allow for the collection of stream samples. Reconnaissance stream and later verification sampling showed the Turkey Well, Granite Creek and Red Well areas to be of particular interest, with the recovery of kimberlitic chromites. In 1991 a small outcrop of highly silicified, hypabyssal-facies macrocrystic kimberlite was found in the western side of the Turkey Well loam grid. This was the first kimberlite to be found central to the Yilgarn Craton. Detailed mapping and drilling located several small outcrops of kimberlite, which have been interpreted to represent two east-west trending dykes and a possible sill.

Petrography and Indicator Minerals

The kimberlite is extensively weathered, but appears to contain relict olivine and phlogopite macrocrysts as well as altered groundmass phlogopite and pseudomorphs after monticellite. The occurrence is classified as a hypabyssal-facies macrocrystic kimberlite. Petrographically it is a phlogopite-monticellite (?) kimberlite. Chromium-rich spinel is the main indicator mineral but rare yimengite and very rare pyrope garnet and picro-ilmenite are also present. Two small (-0.5mm +0.3mm) diamond fragments were recovered in drill samples from 20-22m depth but no micro-diamonds were recovered from 130 kg of surface macrocrystic kimberlite. Yimengite ($K[Cr,Ti,Fe,Mg]_{12}O_{19}$), a metasomatic alteration product of chromium spinel macrocrysts, is a Large Ion Lithophile Element (LILE) oxide belonging to the Magnetoplumbite mineral group (Haggerty, 1991). It is rare and is usually associated with other metasomatic minerals such as phlogopite, K-richterite, secondary diopside, Mg-chromite, lindsleyite, Mg-Cr ilmenite and Nb-Cr rutile. Yimengite has previously been reported from kimberlites in Shandong Province, China

(Dong Zhenxin et al, 1983; Peng Zhinzhong and Lu Qi, 1985) and from kimberlites in the Guaniamo district, Venezuela (Nixon and Condliffe, 1989; Nixon et al., 1992; Nixon et al., 1994). The Turkey Well yimengite grains have typical compositions with ~31wt% TiO_2, ~35wt% Cr_2O_3, 17-19wt% FeO, 3-5wt% MgO and ~4.0wt% K_2O.

Geochronology

Initial attempts to date the Turkey Well kimberlites concentrated on Rb-Sr analyses of phlogopite macrocrysts. These analyses yielded an errorchron result of 2184 ± 170 Ma, with an imprecise, low initial ratio of 0.66 ± 0.09. If an initial ratio of 0.704 is assumed, the age obtained reduces to ~2100 Ma. It was also noted that the phlogopite separates contained lower Rb concentrations than normally found in kimberlitic phlogopite, suggesting possible Rb loss. Given the imprecision of the Rb-Sr data, $^{40}Ar/^{39}Ar$ laser probe analyses were carried out on several yimengite grains recovered from the Turkey Well kimberlite. Step-heating experiments on four grains produced plateau ages of 2196 ± 19 Ma, 2198 ± 16 Ma, 2183 ± 18 Ma and 2176 ± 19 Ma, respectively (Figure 2). The weighted mean age of 2188 ± 11 Ma is consistent with the Rb-Sr data and is considered to represent a reliable estimate for the time of emplacement of the Turkey Well kimberlite.

Conclusions

The Turkey Well bodies are the first classical kimberlites to be found central to the Yilgarn Craton. The above geochronological data indicate that they are the oldest known kimberlites so far dated. Previously, the oldest known kimberlites were considered to be the 1.6 Ga Kuruman bodies in South Africa (Shee et al., 1989) and possibly the 1.73 Ga intrusives in Guaniamo, Venezuela (Nixon et al., 1994). This study shows that $^{40}Ar/^{39}Ar$ laser probe analyses on yimengite grains can successfully be used to date the emplacement ages of their host kimberlites.

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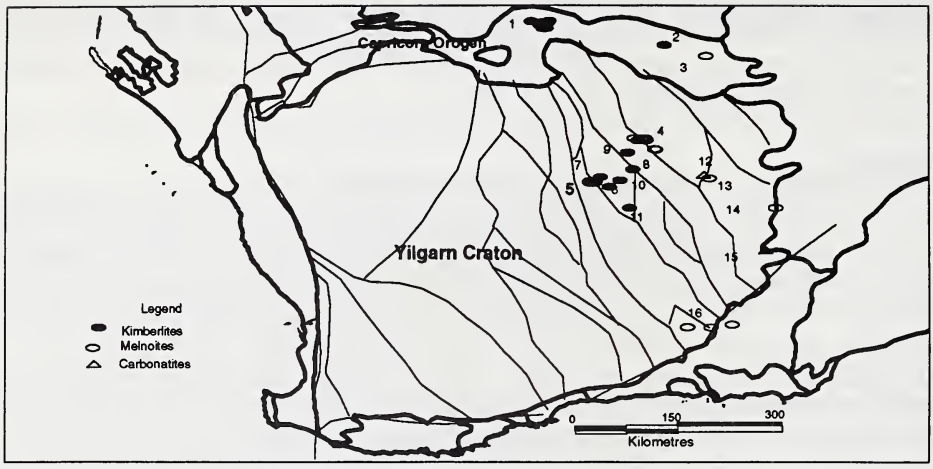

Figure 1. Locations of kimberlites and related rocks, Yilgarn Craton, Western Australia. 1 Nabberu (SPL), 2 Jewill (CRA), 3 Bulljah (WMC), 4 Melrose Akbar (WMC, SPL), **5 Turkey Well (SPL)**, 6 Granite Creek (SPL), 7 Red Well (SPL), 8 Teutonic Bore (SPL), 9 Rainbow (SPL), 10 Wilbah (SPL), 11 Melita (SPL), 12 Mt Weld, 13 Placer Pacific, 14 Lara (WMC, SPL), 15 Ponton Creek / Cundeelee, 16 Norseman (SPL).

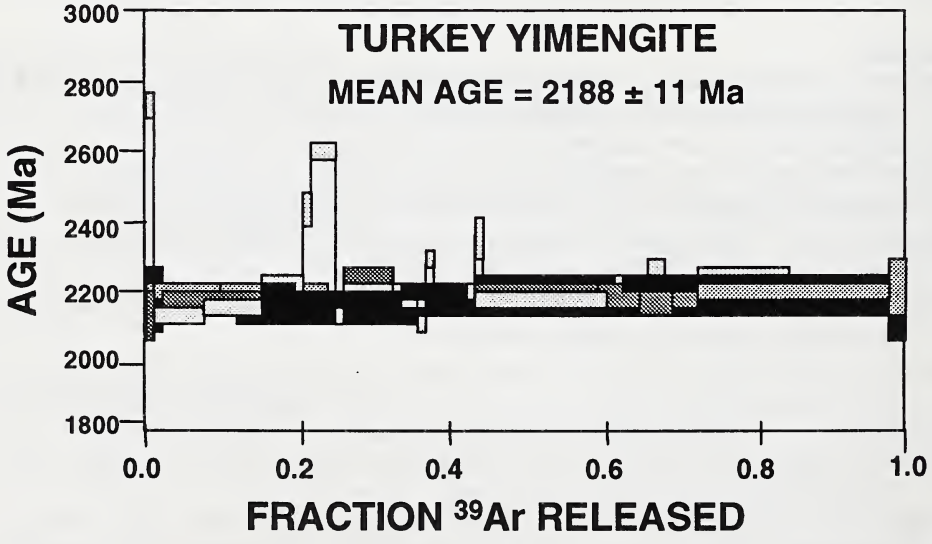

Figure 2. $^{40}Ar/^{39}Ar$ laser probe step-heating spectrum for yimengite grains from the Turkey Wells kimberlite. Each rectangle represents a single analysis or temperature step. Temperature increases from left to right. The length of each bar indicates the proportion of $^{39}Ar_K$ released in that step, while the width represents 1 σ uncertainties in the age.