Paper Number: 3353

Secular Au and PGE Sequestration in the Kaapvaal Cratonic Crust, South Africa

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The Kaapvaal Craton in South Africa is unique amongst Archaean cratons worldwide because of its anomalous gold (Au) deposits, the world's largest deposits of platinum group elements (PGE) and other economically viable minerals. The genesis of these deposits has been widely researched, though this has not led to a general agreement on the craton's metallogeny yet. The underlying hypothesis of this study is the assumption that the exceptional concentrations of Au and PGE in the Kaapvaal Craton are not coincidental but have a common geological cause that must be ultimately sought in an anomalous chemistry of the source regions in the mantle from which the Kaapvaal crust emanated. Shales have been used in this study with the aim to search for clues on secular variations in Au and PGE sequestration from the mantle into the Kaapvaal cratonic crust.

In addition to a wealth of historic geochemical data on Witwatersrand shales, new data were obtained on a total of 134 fresh drill core and underground shale samples collected from different Kaapvaal cratonic cover sequences (Barberton, Witwatersrand and Transvaal Supergroups). Their mineralogy was assessed by XRD, major element and trace element concentrations obtained by respectively XRF and LA-ICP-MS, whereas Au and PGE contents were determined using ICP-MS following nickel sulphide collection fire assay.

The results indicate that the various shale units are compositionally highly variable, both laterally within and vertically across stratigraphic units. Even those samples that had experienced the least amount of post-depositional alteration are characterised by high chemical index of alteration, chemical index of weathering and index of compositional variability, all of which suggest that the source areas were lithologically complex and subjected to intense chemical weathering. Sequentially, the Barberton Supergroup shales consist mainly of quartz-chlorite-illite-albite-dolomite-monazite-siderite-rutile-zircon-sulphides and are rich in Cr and Ni with anomalously high Au contents and depletion in PGE relative to Average Archaean crust. Regionally persistent Witwatersrand Supergroup shales are composed of quartz-magnetite-amphibole-chlorite-siderite-ankerite-hematite-muscovite-pyrophllite-biotite and characterised by high Cr, Co and Ni with significantly higher Au-Pd enrichments and depletion in Pt and Ru. Shales from the Transvaal Supergroup, including the Black Reef Formation at its base, are characterised by significant amounts of carbon. They are depleted in Au and PGE, except for the Black Reef Formation, which is enriched in Pd and Pt. The variation in Pd and Pt in these shales is most likely related to decoupling of the two elements in the continental crust, which by implication indicates different primary concentration mechanism in the sedimentary environment. The discrete secular sequestration of Au shows that the distribution in the continental crust is independent of sediment provenance. The Au and PGE may ultimately originate from a geochemically anomalous mantle domain from which the Kaapvaal crust was sourced in the course of its Archaean evolution. This anomalous mantle could either be a remnant of a domain that had experienced incomplete core-mantle

differentiation in the early stages of the planet's history or it reflects a domain that was marked by extra-terrestrial addition during the early heavy meteoroid-bombardment stage. In either case, elevated contents of highly siderophile elements would be expected. Such a mantle domain enriched in highly siderophile elements could have been the source region for the melts that eventually led to the crystallisation of the source rocks for the Witwatersrand gold as well as, at a later stage, for the Bushveld Igneous Complex.