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Thermal evolution of the Stolzburg Block, Barberton granitoid-greenstone terrain, South Africa: Implications for Paleoarchean tectonic processes

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ABSTRACT

The thermal state of the crust controls its rheology and is therefore an important variable in understanding Archean tectonic processes. Thermochronology is a useful tool to track the long-term thermal evolution of the crust, and U-Pb in apatite, with an effective closing temperature for volume diffusion of Pb of ca. 400–550 °C, is useful in constraining the temperature-time history of igneous and metamorphic rocks, when apatite contains sufficient U. The Paleo- and Mesoarchean represent time periods in Earth's history where there is little certainty about the geodynamic processes that controlled the movement of crustal blocks. In this study on the Paleoarchean Stolzburg Block of the Barberton Granitoid Greenstone Terrain (BGGT), South Africa, we report new U-Pb apatite and zircon ages, as well as Lu-Hf zircon data for several TTG plutons that are considered to represent the type of felsic crust that formed the nucleus of the proto-Kaapvaal craton. Zircons from the Stolzburg, Theespruit and Weergevonden plutons provide apparent crystallization ages of ca. 3451 Ma in agreement with earlier studies. Felsic dykes concentrated in the deformed margins of the Stolzburg and Theespruit plutons yielded zircon crystallization ages of ca. 3215 Ma, postdating the main 3230–3225 Ma accretionary event in the belt. Zircon εHf_t values were determined to be +1.2 to −0.8. in the 3450 Ma plutons and +0.4 to −2.0 in the 3215 Ma dykes. U-Pb apatite thermochronology for the plutons shows igneous ages of ca. 3445 Ma, but also and multiple subsequent events of apatite growth or recrystallization at ca. 3210, 3105 and 2820 Ma. The preservation of this range of apatite dates indicates that no post-emplacement heating of the granitoids above ca. 600 °C has occurred. The Hf isotopic data show that the ca. 3.2 Ga dykes are less evolved than their host TTG plutons and are not produced by melt extraction following anatexis of the latter or their equivalents. Collectively, this evidence demonstrates that the Stolzburg, Theespruit and Weergevonden plutons have not undergone anatexis and have not been mobilized as anatectic domes at ca. 3.2 Ga, as proposed by some tectonic models

1. Introduction

The nature of the geodynamic processes that shaped the first stable continental nuclei to emerge in the Paleoarchean is poorly constrained. This is due to both the scarcity of well-preserved Archean sequences and the fact that the typically greenschist- to amphibolite-facies grades of metamorphism that characterize most Archean volcanosedimentary successions are not specific to any particular tectonic context. The debate has traditionally revolved around a dichotomy between uniformitarian and static lid models, which, as discussed below, has not been particularly useful in advancing knowledge of Archean geodynamics. For example, it has been suggested that plate tectonics functioned since Paleoarchean times, that some greenstone successions from this era represent ophiolite complexes (de Wit, 2004; de Wit et al., 1987; Furnes et al., 2015, 2009, 2007; Grosch and Slama, 2017), that some trondhjemites and tonalites represent magmas that were formed as a consequence of Archean subduction processes (De Ronde and Kamo, 2000; de Wit et al., 2011; Kisters et al., 2003; Laurie et al., 2013; Martin, 1999, 1986; Martin and Moyen, 2002; Moyen et al., 2006) and that garnet-amphibolites from this era may represent the Archean equivalents of blueschists (Moyen et al., 2006; Palin and Dyck, 2018; Palin and White, 2016). On the other hand, non-uniformitarian models propose vertical

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