FURTHER $^{40}$Ar-$^{39}$Ar STEPHANEATING DATING OF FAULT ROCKS AND METAMORPHIC MINERALS FROM THE VREDEFORT DOME AND WITWATERSRAND BASIN; 1W.U. Reimold, 1R.L. Gibson, and 2P.W. Layer, 1Department of Geology, Univ. of the Witwatersrand, Private Bag 3, P.O. Wits 2050, Johannesburg, R.S.A. (E-mail, W.U.R.: 065wur@cosmos.wits.ac.za), 2Geophysical Institute, University of Alaska, Fairbanks, Alaska 99775-7320, U.S.A.

Summary: $^{40}$Ar-$^{39}$Ar stepheating dating results for a number of fault rocks (cataclasite, mylonite) from the southwestern part of the Witwatersrand Basin, of pseudotachylitic breccias and their host rocks from the collar of the Vredefort Dome, and mineral separates (biotite, amphibole, plagioclase) from various Vredefort core and collar rocks strongly support an age of ca. 2025 Ma for the Vredefort impact event. The granitoid basement of the Dome must be older than 3.1 Ga and was subjected to a first, pervasive, metamorphic event at about 3.08 Ga ago. A strong Kibaran event, associated with magmatic, tectonic, and hydrothermal activity, has been recognized between about 1 and 1.3 Ga, and, like the Vredefort event at 2025 Ma, influenced the Witwatersrand ore deposits to a significant degree.

Background: In the past 5 years, our group has undertaken thermochronological analysis of different fault rock types, as well as of metamorphic and hydrothermally grown authigenic minerals from the Vredefort Dome and the surrounding Witwatersrand Basin. Objectives for this work were (1) to date the Vredefort impact event through dating of pseudotachylitic breccia; (2) to test the hypothesis that several generations of such breccias occurred in this region; (3) to date the metamorphic events that affected the Vredefort Dome and the wider Witwatersrand Basin, and (4) to test the possibility of a relationship of this metamorphism to the emplacement of the Bushveld Complex at ca. 2.05 Ga ago. Earlier results on fault rocks and metamorphic minerals were discussed by [1-3]. Laser Ar probe dating results on Vredefort pseudotachylitic breccias [4] confirmed that most of these breccias from the Vredefort Dome were formed at about $2018 \pm 14$ Ma, but also revealed the presence of at least one occurrence of about 1.6 Ga old breccia. Trieloff et al. [1] showed that Witwatersrand breccias can also be related to the ca. 2.02 Ga event. Reimold et al. [5] presented U-Xe fission ages for uraninites from different parts of the Witwatersrand Basin and obtained evidence for strong resetting around 1-1.3 Ga ago.

Results: Here we can report $^{40}$Ar-$^{39}$Ar stepheating results from fault rock samples from Joel Gold Mine (JGE) in the Welkom goldfield [6] and from the western part of the collar of the Vredefort Dome, as well as for a suite of metamorphic minerals from core and collar rocks of the Dome. A complex age spectrum with ages between 1900 and 2090 Ma was obtained for a JGE cataclasite, as well as for a suite of metamorphic minerals from core and collar rocks of the Dome. The integrated age for this sample is $2050 \pm 7$ Ma, but it was strongly overprinted in post-2 Ga times. A JGE mylonite yielded an excellent plateau spectrum with 80% of the released gas corresponding to an age plateau at $2038 \pm 5$ Ma, and a JGE ultracataclasite ages between 1200 and 1750 Ma (integrated age: $1478 \pm 23$ Ma), indicating strong overprinting around 1.2 Ga ago.

Two specimens of pseudotachylitic breccia and their sericite-rich quartzitic host rocks (courtesy AAPS Pty. Ltd.) from a drillcore into Central Rand Group strata (western collar) were analysed. Pseudotachylitic breccia QE901p yielded a spectrum with a badly defined 'plateau' feature around 2050 Ma and a drop-off to ages as low as 1100 and 550 Ma at low temperature steps. Pseudotachylitic breccia QE903p has also been disturbed since formation, but the partial plateau and integrated ages of $2025 \pm 5$ and $2023 \pm 6$ Ma, respectively, are indistinguishable from the U-Pb single zircon age of $2025 \pm 5$ Ma obtained by Kamo et al. [6] for zircon from a pseudotachylitic breccia from the center of the Vredefort Dome. The sericitic host rocks to these samples were analysed to test how muscovite ages, in comparison to ages for other, more or less retentive, minerals from Vredefort rocks compared against our earlier Argon stepheating results. Both quartzite samples yielded excellent
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Age plateaus corresponding to ages of 2029±7 and 2029±5 Ma, respectively (with only minor indications of post-2 Ga overprinting).

Several other mineral separates from Vredefort collar rocks were analysed: An amphibole separate from a BIF unit in the Hospital Hill Subgroup provided two partial 'plateau' features at high temperature (3100±10 Ma) and intermediate temperature 2485-2840 Ma) steps, and at lowest temperature steps further Ar loss at or below 1.5 Ga is indicated. Analysis of two biotite separates from Government Reef metapelites Reef metapelites resulted in rather good age plateaux corresponding to average ages of 2034±4 Ma (a slight buckle causes a slight shift to a somewhat too high age) and 2032±4 Ma (some minor Ar loss since 1.7 Ga ago).

Mineral separates from a granulite-facies charnockitic gneiss from the Steynskraal Metamorphic Zone [7] were also analysed: A plagioclase sample gave a typical saddle shape spectrum with a saddle age of 1987±4 Ma and ages for high and low temperature steps in excess of 2.6 Ga. For the biotite separate a well-defined plateau age of 2026±4 Ma was obtained (a 2-step hump with somewhat higher ages indicates that this age likely represents a resetting age for this mineral). The amphibole age spectrum consists of a central flat age plateau corresponding to an average age of 2817±5 Ma and low and high T drop-offs to 2.3-2.5 Ga ages.

Conclusions: Against the full chronological data base now available for the region of the Witwatersrand Basin, a number of conclusions can be drawn: From the U-Pb single zircon data of [6] and our amphibole Argon dating results it is clear that the granitoid basement to the Vredefort Dome is older than 3.1 Ga and underwent a first phase of metamorphism at about 3.08 Ga ago. For several other amphibole separates ages between 2.9 and 2.6 Ga were recorded, which could be the result of partial resetting or of a hypothetical event at 2.8 Ga already proposed by [8]. For the Witwatersrand basin, a significant hydrothermal event at about 2.5 Ga has been proposed [e.g., 9], but our data base does not provide supportive evidence for this. The next established event in the chronological history of the Vredefort Dome occurred at 2.15-2.2 Ga, when the alkali granitic intrusions into the collar of the Vredefort Dome occurred. This time is also favoured by some Witwatersrand workers to correspond to a strong phase of hydrothermal activity that affected the Witwatersrand ore resources.

Only a small number of data are available that concur with the 2.05 Ga age for the Bushveld Complex. In contrast, the overwhelming proportion of our data is restricted to a narrow timespan between 2.02 and 2.03 Ga, coincident with the U-Pb single zircon age of Kamo et al., believed to pinpoint the time of the Vredefort impact event. Hardly any data fall into the period from 1.8 to 2.0 Ga, which is significant, as this fact strongly delimits the period of Vredefort-related metamorphism and/or hydrothermal activity [see also 1]. Finally a number of results in the period 1.3-1.8 Ga can be related to partial resetting due to the well-defined event at 1 - 1.25 Ga ago. Tectonic, magmatic, and hydrothermal activity at this, so-called Kibaran, time has been presented recently by a number of workers.

Because of the strong thermal (and hydrothermal?) activity associated with the 2025 Ma event it has not been possible to detect evidence supporting the postulated 2.2 and 2.5 Ga events by means of the 40Ar-39Ar stepheating technique. However, it has been possible in these studies to separate the Bushveld and Vredefort events and to demonstrate the strong effects of the Vredefort impact event and the Kibaran event in the whole region of the Witwatersrand Basin.