STUDIES OF MAFIC INTRUSIVES IN THE VREDEFORT IMPACT STRUCTURE, SOUTH AFRICA: IMPLICATIONS FOR CRATON WIDE IGNEOUS ACTIVITY AT 1.1 Ga AGO. G.Q.J. Pybus[1], W.U. Reimold[1], and C.B. Smith[2], [1]Econ. Geol. Res. Unit at the Dept. of Geology, [2]Isotope Div., BPI Geophysics, Univ. of the Witwatersrand, P.O. Wits 2050, Johannesburg, R.S.A..

We investigated the different populations and generations of the mafic intrusives abundant in the region of the Vredefort impact structure. A 100-m-thick gabbroic intrusion was recognized throughout the dome and dated at 1054 Ma. Recognition of this magmatic event has strong implications for the tectonomagmatic history of the whole of the Kaapvaal Craton and for the interpretation of thermochronological data from the Vredefort dome itself and from the surrounding Witwatersrand basin.

The Vredefort structure, 120 km southwest of Johannesburg, has long attracted attention because of the controversy about its origin by either internal or external processes [1] and its position in the centre of the economically important Witwatersrand basin. The genetic controversy has recently been resolved when new, definitive evidence in favour of impact was discovered [2,3]. However, this does not mean that Vredefort research has become obsolete. With an estimated diameter of 180-300 km [4] this structure is one of the three largest recognised terrestrial impact structures and clearly warrants further multidisciplinary study. Furthermore, it has been suggested [5] that the formation of the Vredefort dome had significant effects on the whole Witwatersrand basin and its gold mineralization. Our group continues with structural mapping of the dome and has begun a comprehensive mineralogical, chemical and isotopic study of the numerous mafic intrusives occurring in core and collar of the dome. The main objectives for this project are to identify the different populations and generations of intrusives in order to contribute to the general understanding of the tectonomagmatic history of this region, to investigate the thermal effects of these various magmatic events in the region of the Witwatersrand basin, and to investigate the possibility that the results of discrimination analysis could be of use to the mining and exploration activities in the Witwatersrand basin.

Five types of mafic intrusives were previously identified in the region of the dome: (1) primitive mafic-ultramafic meta-intrusives, (2) relatively old epi-diorites, (3) unmetamorphosed gabbros and diorites, (4) evolved high Fe-Ti diorites, and (5) Karoo dolerites [6-8]. With the exception of the Karoo dolerites, these types are transected by pseudotachylite. A sixth group, which is also not cut by pseudotachylite, but displays a chemical composition very similar to that of the high Fe-Ti group of [7], has now been identified. Correlation and classification of the various types of intrusives is achieved by petrographic study and whole rock chemical analysis (Table 1). The new rock type occurs in the Anna's Rust Sheet (ARS), the Vredefort Mafic Complex (VMC), and on the farms Hester 98 (H) and Oceaan 99 (O) and adjoining farms (Fig. 1). In addition, this material was detected in an 80 m thick section of a borehole into the Inlandsee pan and was intersected in several boreholes into the southwestern collar of the dome. It appears likely that an intrusive reported from another borehole in the vicinity of the Inlandsee [9] also represents this type. It was established that the ARS, VMC and borehole occurrences from Inlandsee and environs are approximately horizontally oriented.

Previous attempts at establishing a chronological framework for the formation of the mafic intrusives in the Vredefort area have been limited to correlations of specific rock types with regional magmatic events, such as the 2.7 Ga Ventersdorp, 2.065 Ga Bushveld and the 170-180 Ma Karoo events, on the basis of field and petrographic observations [6,10]. Palaeomagnetic work [11] on the ARS and several other small bodies in the Vredefort dome indicated similar pole positions to the Umkondo Dyke Swarm (1080 +140/-25 Ma) in Zimbabwe and to some of the post-Waterberg diabases [12]. We carried out Rb-Sr dating on whole rock and mineral samples from the ARS and the VMC (Table 2). For four biotite fractions and two plagioclase separates an errorchron was obtained corresponding to an age of 1054 +- 13 Ma (I_{Sr} = 0.7052 -+ 0.0002), cf. Fig. 2. The fact that whole rock and pyroxene data fall off the regression line can be explained by alteration effects. These results confirm a temporal relationship between Group 6 Vredefort and Umkondo Dyke intrusives and implies Kaapvaal and Zimbabwe craton-wide igneous activity around 1100 Ma ago which is coincident with the collisional tectonics in the Namaqua-Natal thrust belt at the southern/southwestern margin of the Kaapvaal Craton. Other evidence for this event was provided by workers on alkaline rocks that established widespread alkaline magmatism in the central part of the Kaapvaal Craton between 1100 and 1300 Ma ago [e.g.,13]. In the context of late thermal events in the region of the Vredefort dome [14-16], it needs to be evaluated whether the dome-wide gabbro sheet could have caused effective thermal overprinting at that time. Trieloff et. al. [17] have recently noted minor resetting of argon isotopic systematics of 2 Ga old pseudotachylites from the northern and northwestern parts of the Witwatersrand basin during the time interval 1200-1600 Ma, and the U-Xe results from Witwatersrand uraninites of Meshik et. al. [18] also indicate thermal/hydrothermal (?) activity around this time.

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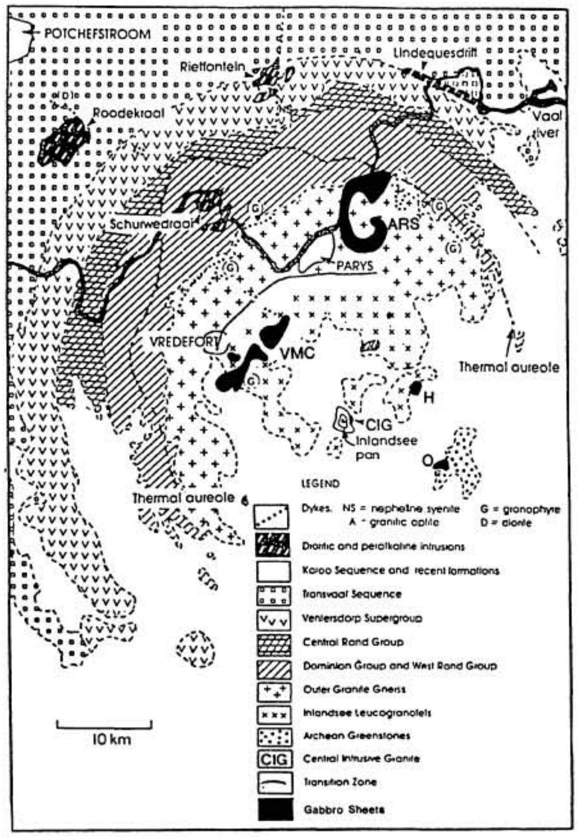

FIGURE 1 :Simplified geological map of the Vredefort Structure.

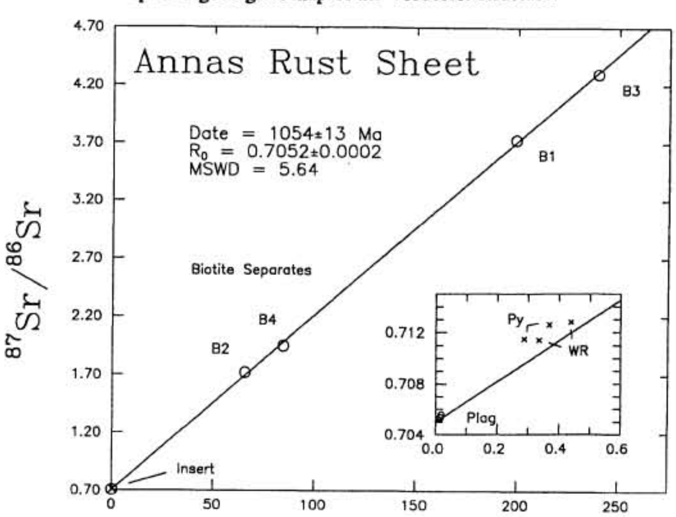

FIGURE 2 :Errorchron for the four biotite separates from an ARS sample. Regression includes two plagioclase samples, (see insert), one of which is from the VMC (sample UP16). The insert shows the offset of the pyroxene and whole rock samples not included in the regression. (B=Biotite, Py=pyroxene, WR=whole rock, Plag=plagioclase).

Sample	Weight (g)	Rb (ppm)	Sr (ppm)	$^{87}Sr/^{86}Sr$	$^{87}Rb/^{86}Sr$
GP18-WR	0.06501	25.40	167.7	0.71280	0.4383
GP18-PL	0.00543	1.744	297.2	0.70558	0.0170
GP18-PY	0.03828	1.520	11.97	0.71260	0.3675
GP18-B1	0.00511	377.1	7.093	3.72689	199.20
GP18-B2	0.00943	100.4	4.868	1.71801	65.564
GP18-B3	0.00291	405.8	6.624	4.29976	239.49
GP18-B4	0.00246	143.4	5.504	1.94616	84.479
UP16-PY	0.02902	1.206	12.16	0.71148	0.2870
UP16-PL	0.00316	1.574	315.6	0.70537	0.144
UP16-WR	0.06438	20.25	174.7	0.71142	0.3354

TABLE 2. Analytical results of Rb-Sr isotopic analysis from samples UP16 and GP18. (WR = whole rock, PY = pyroxene, PL = plagioclase, B(1-4) = biotite). All data blank corrected, Rb Blank = 2ng; Sr Blank = 2.5ng.

	ARS	VMC	HESTER	OCEAAN
SiO_2	51.0	51.3	49.9	50.8
TiO_2	1.49	1.32	1.46	1.43
Al_2O_3	14.8	15.2	15.8	15.2
Fe_2O_3[2]	13.4	12.7	13.1	13.3
FeO	na	na	na	na
MnO	0.20	0.19	0.19	0.19
MgO	6.53	6.88	6.46	6.60
CaO	9.77	10.2	9.87	9.77
Na_2O	2.08	1.78	1.81	2.15
K_2O	0.72	0.60	0.65	0.66
P_2O_5	0.16	0.14	0.17	0.15
LOI	0.14	0.24	0.37	0.23
Total	100	100	99.7	100
Ba	223	200	206	211
Rb	41	31	38	41
Sr	170	178	176	178
Y	29	26	29	29
Zr	123	107	118	115
Nb	8	8	8	8
V	300	313	253	284
Cr	133	165	251	141
Co	44	40	41	45
Ni	93	95	107	104
Cu	109	98	109	106
Zn	122	114	124	105
N[1]	29	3	4	2

TABLE 1. Whole rock chemical compositions for the four localities in Figure 1.
[1] - Number of samples; [2] - Total Fe as Fe_2O_3,
na - not analysed.