

South African Research on volcanic and related rocks and mantle-derived materials: 2003-2006

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South Africa has no formal organizational or research structures dedicated to the principle aims of International Association of Volcanology and Chemistry of Earth's Interior (IAVCEI) and over the period of the review there were no national research programmes which advance the main thrusts of IAVCEI. The association has a system of personal membership and the number of IAVCEI members in South Africa has not generally exceeded half a dozen over the period under review, although the potential membership is much greater as there are many scientists carrying out research on volcanic and intrusive rocks as well as mantle materials. These researchers are largely based at universities, the Council for Geoscience, as well as some mining and exploration companies, particularly those with interests in mineralization associated with the Bushveld Complex as well as diamondiferous kimberlite. Over the period of review the research of small informal groups and individuals has produced a substantial number of papers in igneous rocks and mantle materials. These outputs can be conveniently grouped as follows.

Archaean Greenstones and Granitoids and Proterozoic Igneous suites.

There is a steady output of research in these areas particularly in Archaean suites with interest in both the ultramafic-mafic komatiitic rocks as well as granitoids. Of note is the description of a new class of komatiite characterized by high silica and ultra depletion in incompatible elements.

Bushveld Complex

The Bushveld Complex one of the world's largest layered igneous complexes is host to giant ore deposits of Cr, PGE, and V. This mineralization ensures a steady output of research directed towards unravelling the emplacement and evolution of the complex and associated intrusive and volcanic rocks. Much of the research is effort emanates from the Department of Geosciences at the University of Witwatersrand where a specialised Bushveld Complex Research Group is directed by Prof Grant Cawthorn.

Mesozoic Flood Volcanism

Southern Africa is host to two large Mesozoic flood volcanic provinces - the early Jurassic Karoo Province and the early Cretaceous Etendeka Province along the Atlantic seaboard of South Africa and Namibia. Both of these feature in the research outputs. There has been a renewed interest in detailed dating in the Karoo, largely by foreign-based scientists with South African collaboration. Mineralization in Karoo intrusions has also received attention. In the Etendeka comprehensive petrogenetic models arising from decades of research have also been published.

Kimberlite and Mantle Materials

Southern Africa with its abundant diamondiferous kimberlite bodies has long been a focus of research into the nature of kimberlite as well as mantle materials contained within kimberlite. South African based scientists continue to feature prominently in kimberlite and mantle research. In recent years the Kaapvaal Craton Project as well as the 8th International Kimberlite Conference which was held in Canada in 2003 provided the impetus for publication, during the period under review, of special issues of the South African Journal of Geology (Kaapvaal Craton Project) and Lithos (Kimberlite Conference). The two special volumes of Lithos were named the Hawthorne and Clement volumes in honour of two South African geoscientists who made significant contributions to kimberlite volcanology and petrology. There is currently a renewed interest in kimberlite volcanology and emplacement as well as the chemical characterization of kimberlite liquid. With regard to the latter, significant contributions have been made by A.P. Le Roex and co-workers at the University of Cape Town. However, kimberlite remains the richest source of samples from the otherwise inaccessible interior of Earth and publications on these still dominate the research outputs.

The principle behind the compilation of publications list below is that the research output should be authored or co-authored by South African-based geoscientists at the time of publication. Some of this research has been done outside national boundaries. Likewise there is a considerable amount of published research on South African rocks from foreign research groups without South African involvement. Such outputs have not been included. Also not included are conference presentations and abstract volumes. The publications cover the period 2003-2006 and this has raised another problem in that on-line publication may precede paper publication by several months. A decision was made to use the paper publication date as a basis for compiling the list. In addition I have attempted to include only those publications which address the direct interests of IAVCEI. As these are broad, a decision regarding relevance is sometimes difficult to make. Nevertheless the papers listed below, the majority in top quality international journals, attest to a significant contribution by South African scientists to IAVCEI.

ARCHAEAN MAGMATISM

Anhaeusser C. R. (2004). Palaeoarchaeon to Mesoproterozoic (c. 3500-1000 Ma) ultramafic and mafic intrusions of the Kaapvaal Craton and neighbouring metamorphic belts: a review. *Inform. Circ. Econ. Geol. Res. Inst., Univ. Witwatersrand, Johannesburg*, **384**, 63 pp.

Anhaeusser C. R. and Poujol M. (2004). Petrological, geochemical and U-Pb isotopic studies of Archaean granitoid rocks of the Makoppa Dome, northwest Limpopo Province, South Africa. *S. Afr. J. Geol.*, **107**, 521-544.

Banerjee N.R., Furnes H., Muehlenbachs K., Hubert Staudigel H., and De Wit M. (2006). Preservation of 3.4–3.5 Ga microbial biomarkers in pillow lavas and hyaloclastites from the Barberton Greenstone Belt, South Africa. *Earth Planet. Sci. Lett.*, **241**, 707-722.

Clemens J.D., Yearron L.M., and Stevens G. (2006). Barberton (South Africa) TTG magmas: Geochemical and experimental constraints on source-rock petrology, pressure of

formation and tectonic setting. *Precambrian Res.*, **151**,53-78.

Hart R.J. McDonald I., Tredoux M., De Wit M.J., Carlson R.W., Andreoli M., Moser D.E and Ashwal L.D. (2004). New PGE and Re/Os-isotope data from the lower crustal sections of the Vredefort Dome and a reinterpretation of its “crust on edge” profile. *S. Afr. J. Geol.*, **107**, 173-184.

Lana C., Gibson R.L., Reimold W.U. and Minnitt R.C.A. (2003). Geology and geochemistry of a granite-greenstone association in the southeastern Vredefort dome, South Africa. *S. Afr. J. Geol.*, **106**, 291-314.

Maier W.D. (2003). The potential for magmatic sulfide ores in South African komatiites: a review. *S. Afr. J. Geol.*, **106**, 35-40.

Maier W.D., Roelofse F., and Barnes S-J. (2003). The Concentration of the Platinum-Group Elements in South African Komatiites: Implications for Mantle Sources, Melting Regime and PGE Fractionation during Crystallization. *J. Petrol.*, **44**, 1787-1804.

Martin H., Smithies R.H., Rapp R., Moyen J.-F. and Champion, D. (2005). An overview of adakite, TTG and sanukitoid: relationships and some implications for crustal evolution. *Lithos*, **79**,1-24.

Parman S.W. Grove T.L., Dann J.C. and De Wit M. (2004). A subduction origin for komatiites and cratonic lithospheric mantle. *S. Afr. J. Geol.*, **107**, 107-118.

Poujol M., Robb L. J.,Anhaeusser C.R. and Gericke B. (2003). A review of the geochronological constraints on the evolution of the Kaapvaal Craton, South Africa. *Precambrian Res.*, **127**, 181-213.

Poujol M., Kiefer R., Robb L. J., Anhaeusser, C. R. and Armstrong R. A. (2005). New U-Pb data on zircons from the Amalia greenstone belt Southern Africa: insights into the Neoproterozoic evolution of the Kaapvaal Craton. *S. Afr. J. Geol.*, **108**, 317-332

Steenfelt A., Garde A.A., and Moyen J.-F. (2005). Mantle wedge involvement in the petrogenesis of Archaean grey gneisses in West Greenland. *Lithos*, **79**, 207-228.

Wilson A.H (2003) A new class of silica enriched, highly depleted komatiites in the southern Kaapvaal Craton, South Africa. *Precambrian Res.*, **127**, 125-141.

Wilson A.H., Shirey S.B., Carlson R.W. (2003) Archaean ultra-depleted komatiites formed by hydrous melting of cratonic mantle. *Nature*, **423**, 858-861.

PROTEROZOIC SUITES

De Waal S.A. Xu Z., Li C. and Mouri H. (2004). Emplacement of viscous mushes in the Jinchuan ultramafic intrusion, western China. *Canadian Mineralogist*, **42**, 371-392.

De Waal S.B., Graham I.T. and Armstrong R.A. (2006) The Lindeques Drift and Heidelberg intrusions and the Roodekraal complex, Vredefort, South Africa: comagmatic plutonic and volcanic products of a 2055 Ma ferrobaltic magma. *S. Afr. J. Geol.*, **109**, 279-300.

McMillan A., Harris N.B.W., Holness M., Ashwal L.D., Kelly, S. and Rabeloson R. (2003) A granite-gabbro complex from Madagascar: constraints on melting of the lower crust. *Contrib. Mineral. Petrol.*, **145**, 585-599.

Pandit M.K., Carter L.M., Ashwal L.D., Tucker R.D., Torsvik T.H., Jamtveit B. and Bhushan S.K. (2003). Age, petrogenesis and significance of Early Neoproterozoic granitoids and related rocks from the Sendra area, Aravalli Craton, NW India. *J. Asian Earth Sci.*, **22**, 363-381.

Prevec S.A, and Baadsgaard H. (2005). Evolution of Palaeoproterozoic mafic intrusions located within the thermal aureole of the Sudbury Igneous Complex, Canada: Isotopic, geochronological and geochemical evidence. *Geochim. Cosmochim. Acta*, **69**, 3653-3669

BUSHVELD COMPLEX

Arndt N., Jenner G., Ohnenstetter M., Deloule E. and Wilson, A.H. (2005) Trace elements in the merensky Reef and adjacent norites, Bushveld Complex, South Africa. *Mineralium Deposita*, **40**, 550-575.

Ashwal L.D., Webb S.J. Knoper M.W.(2005). Magmatic stratigraphy in the Bushveld Northern Lobe: continuous geophysical and mineralogical data from the 2950m Bellevue drillcore. *S. Afr. J. Geol.*, **108**, 199-232.

Baillie R.H. and Robb L.J.(2004). Polymetallic mineralization in the granites of the Bushveld Complex - examples from the central southeastern lobe. *S. Afr. J. Geol.*, **107**, 633-652.

Barnes S.-J., Maier W.D. and Ashwal L.D. (2004). Platinum-group element distribution in the Main Zone and in the Upper Zone of the Northern Limb of the Bushveld Complex. *Chem. Geol.*, **208**, 293-317.

Boorman S., Boudreau A. and Kruger F.J. (2004). The Lower Zone-Critical Zone transition in the Bushveld Complex: a quantitative textural study. *J. Petrol.*, **45**, 1209-1235.

Boorman S.L., McGuire J.B. Boudreau A.E. and Kruger F.J. (2003). Fluid overpressure in layered intrusions: formation of a breccia pipe in the eastern Bushveld Complex, republic of South Africa. *Mineralium Deposita*, **38**, 356-369.

Cawthorn R.G. (2003). Genesis of magmatic oxide deposits — a view from the Bushveld Complex. *Norges Geologiske Undersokelse, Spec. Publ.* **9**, 11-20.

Cawthorn R.G. and Spies, L. (2003). Plagioclase-rich cyclic units in the Bushveld Complex. *Contrib. Mineral. Petrol.*, **145**, 47-60.

Cawthorn R.G. and Kruger F.J. (2004). Petrology and Ni-Cu-PGE potential of the Insizwa lobe, Mount Ayliff Intrusion, South Africa. *Canadian Mineralogist*, **42**, 303-324.

Cawthorn R.G. (2005). Contrasting sulphide contents of the Bushveld and Sudbury Igneous Complexes. *Mineralium Deposita*, **40**, 1-12.

Cawthorn, R.G. (2005). Pressure fluctuations and the formation of the PGE-rich Merensky and chromitite reefs, Bushveld Complex. *Mineralium Deposita*, **40**, 231-235.

Cawthorn R.G. (2005). Stratiform PGE deposits in layered intrusions. *Mineralogical Association of Canada, Short Course Volume*, **35**, 57-73.

Cawthorn R.G., Barnes S.J., Ballhaus C. and Malitch K.N. (2005). Platinum-group element, chromium, and vanadium deposits in mafic and ultramafic rocks. *Econ. Geol.*, **100**, 215-249.

Gerya T.V., Uken R., Reinhardt J., Watkeys M.K., Maresch W.V. and Clarke B.M. (2003). Cold fingers in a hot magma: country rock diapirs triggered by the Bushveld layered intrusion, South Africa. *Geology*, **31**, 753-756

Harris C., Pronost J.J.M., Ashwal L.D. and Cawthorn R.G. (2005) Oxygen and hydrogen isotope stratigraphy of the Rustenburg Layered Suite, Bushveld Complex: Constraints on crustal contamination. *J. Petrol.*, **46**, 579-602

Harris N., McMillan A., Holness M., Uken R., Watkeys M.K., Rogers N. and Fallick A. (2003). Melt generation and fluid flow in the thermal aureole of the Bushveld Complex. *J. Petrol.*, **44**, 1031-1054.

Johnson T.E., Gibson R.L., Brown M., Buick I.S., and Ian Cartwright I. (2003). Partial Melting of Metapelitic Rocks Beneath the Bushveld Complex, South Africa. *J. Petrol.*, **44**, 789-813

Kinnaird J.A., Kruger F.J. and Cawthorn R.G. (2004). Rb-Sr and Nd-Sm isotopes in fluorite related to the granites of the Bushveld Complex. *S. Afr. J. Geol.*, **107**, 413-430.

Kinnaird J.A., Hutchinson D., Schurmann L., Nex, P.A.M. and De lange R. (2005). Petrology and mineralization of the southern Platreef: northern limb of the Bushveld Complex, South Africa. *Mineralium Deposita*, **40**, 576-597.

Kruger F.J. (2005). Filling the Bushveld complex magma chamber: lateral expansion, roof and floor interaction, magmatic unconformities and the formation of giant chromitite, PGE and Ti-V-magnetite deposits. *Mineralium Deposita*, **40**, 451-472.

Letts, S., Torsvik, T.H., Webb, S.J., Ashwal, L.D., Eide, E.A. and Chunnnett, G. (2005). Palaeomagnetism and $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology of mafic dykes from the eastern Bushveld Complex (South Africa). *Geophys. J. International*, **162**, 36-48.

Maier W.D. and Barnes S-J. (2003) Platinum-group elements in the Boulder bed, western Bushveld Complex, South Africa. *Mineralium Deposita*, **38**, 370-380.

Maier W.D., Gomwe R., Barnes S-J., Li C. and Theart H. (2004). Platinum group elements in the Uitkomst complex, South Africa. *Econ. Geol.*, **99**, 499-516.

Manyeruke T.D., Maier W.D. and Barnes S-J. (2005). Major and trace element geochemistry of the Platreef on the farm Townlands, northern Bushveld Complex. *S. Afr. J. Geol.*, **108**, 381-396.

Prevec, S.A., Ashwal, L.D. and Mkaza, M.S. (2005). Mineral disequilibrium from the Merensky pegmatoid, western Bushveld Complex, South Africa: new Sm-Nd isotopic evidence. *Contrib. Mineral. Petrol.*, **149**, 306-315.

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Seabrook C.L., Cawthorn R.G. and Kruger F.J. (2005). The Merensky Reef, Bushveld complex: mixing of minerals not mixing of magmas. *Econ Geol.*, **100**, 1191-1206.

Smith D.S. and Basson I.J. (2006). Shape and distribution analysis of Merensky Reef potholing, Northam Platinum Mine, western Bushveld Complex: implications for pothole formation and growth. *Mineralium Deposita*, **41**, 281-295.

Smith, D., Basson, I.J. and Reid, D.L. (2004). The normal reef sub-facies of the Merensky Reef at Northam platinum mine, Zwartklip facies, western Bushveld Complex. *Canadian Mineralogist*, **42**, 243-260.

Van Der Merwe J. and Cawthorn R.G. (2005). Structures at the base of the Upper Group 2 chromitite layer, Bushveld Complex, South Africa, on Karee Mine (Lonmin Platinum). *Lithos*, **83**, p. 214-228.

Webb S. J., Cawthorn R. G., Nguuri T. K., and James D. E. (2004). Gravity modeling of Bushveld Complex connectivity supported by Southern African Seismic Experiment results. *S. Afr. J. Geol.*, **107**, 207-218.

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Cawthorn R.G and Kruger F.J. (2004) Petrology and Ni-Cu-PGE potential of the Insizwa lobe, Mount Ayliff intrusion. *Canadian Mineralogist*, **42**, 303-324.

De Bruijn H. Schoch A.E., Fairwood D.S., Van Der Westhuizen W.A. (2005). The geology and petrochemistry of the Mashikiri Formation along the Olifants River Section, Kruger National Park, South Africa. *S. Afr. J. Geol.*, **108**, 173-186.

Ewart A, Marsh J.S., Milner S.C., Duncan A.R., Kamber B.S. and Armstrong R.A. (2004). Petrology and geochemistry of Early Cretaceous bimodal continental flood volcanism of NW Etendeka, Namibia. Part I: Introduction, mafic lavas and re-evaluation of mantle source components. *J. Petrol.*, **45**, 59-105.

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and low-Ti voluminous quartz latite eruptives. *J. Petrol.*, **45**, 107-138.

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Jourdan F., Féraud G., Bertrand H., Watkeys M.K., Kampunzu A.B. and Le Gall B. (2006). Basement control on dyke distribution in Large Igneous Provinces: Case study of the Karoo triple junction. *Earth Planet. Sci. Lett.*, **241**, 307-322.

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Marsh J.S., Allen P. and Fenner, N (2003). The geochemical structure of the Insizwa lobe of the Mount Ayliff complex with implications for the emplacement and evolution of the complex and its Ni-sulphide potential. *S. Afr. J. Geol.*, **106**, 409-428.

Marsh J.S. (2004). Rare Earth Element geochemistry of the Insizwa Lobe of the Mount Ayliff Complex, Eastern Cape, South Africa. *S. Afr. J. Sci.*, **100**, 556-560.

Miller J.A. and Harris C. (2006)in press. Petrogenesis of the Swaziland and northern Natal rhyolites of the Lebombo rifted volcanic margin, south east Africa. *J. Petrol.*, **48**, 185-218.

Riley, T.R., Millar, L., Watkeys, M.K., Curtis, M.L., Leat, P.T., Klausen, M.B. and Fanning, C.M. (2004). U-Pb zircon (SHRIMP) ages for the Lebombo rhyolites, South Africa: refining the duration of Karoo volcanism. *J. Geol. Soc.*, **161**, 547-550.

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KIMBERLITE AND MANTLE MATERIALS

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Barnett W. (2004). Subsidence breccias in kimberlite pipes - an application of fractal analysis. *Lithos*, **76**, 299-316.

Barton J.M. and Gerya T.V. (2003). Mylonization and decomposition of garnet: Evidence for

rapid deformation and entrainment of mantle-garnet-harzburgite by kimberlite magma, K1 Pipe, Venetai nine, South Africa, *S. Afr. J. Geol.*, **106**, 231-246.

Basson I.J. and Viola G. (2003). Structural overview of selected Group II kimberlite dyke arrays in South Africa: implications for kimberlite emplacement mechanisms. *S. Afr. J. Geol.*, **106**, 375-394.

Basson I.J. and Viola G. (2004). Passive kimberlite intrusion into actively dilating dyke-fracture arrays: evidence from fibrous calcite veins and extensional fracture cleavage. *Lithos*, **76**, 283-297.

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Burgess R., Kiviets G.B. and Harris J.W. (2004). Ar-Ar age determinations of eclogitic clinopyroxene and garnet inclusions in diamonds from the Venetia and Orapa kimberlites. *Lithos*, **77**, 113-124.

De Bruin D. (2005). Multiple compositional megacryst groups from the Uintjiesberg and Witberg kimberlites, South Africa. *S. Afr. J. Geol.*, **108**, 233-246.

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Hetman C.M., Scott Smith B.H., Paul J.L. and Winter F. (2004). Geology of the Gahcho Kué kimberlite pipes, NWT, Canada: root to diatreme magmatic transition zones. *Lithos*, **76**, 51-74.

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Le Roex A.P., Bell D.R. and Davis P. (2003) Petrogenesis of Group I kimberlites from Kimberley, South Africa: evidence from bulk-rock geochemistry. *J. Petrol.*, **44**, 2261-2286.

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