

## World Heritage Sites

### Protected Areas and World Heritage



## VREDEFORT DOME SOUTH AFRICA

*This is the world's largest and oldest meteorite impact crater. It is accessible, and identifiable, in gentle, biodiverse and beautiful country rich in archaeological and anthropological remains.*

### COUNTRY

South Africa

### NAME

Vredefort Dome

### NATURAL WORLD HERITAGE SERIAL SITE

2005: Inscribed on the World Heritage list under Natural Criterion viii.

### IUCN MANAGEMENT CATEGORY

VI Managed Resource Protected Area

### BIOGEOGRAPHICAL PROVINCE

South African Woodland / Savanna (3.8.4)

### GEOGRAPHICAL LOCATION

The site straddles the Vaal river which forms the administrative boundary of the Northwest Province and the Free State Province in the nomination area. It is about 120 km southwest of Johannesburg, between the towns of Potchefstroom. and Parys. Located between 26° 52' to 26° 56' S and 27° 11' to 27° 26' E.

### DATE AND HISTORY OF ESTABLISHMENT

2002: The area was declared a National Heritage site in principle by the South African Natural Heritage Resources Agency, under the Natural Heritage Resources Act 25 of 1999, subject to the completion of a Cultural Heritage survey and Management Plan. It was not legally proclaimed.

### LAND TENURE

The World Heritage Site is mainly in private ownership. There are 149 farms in private ownership: 91 are located in Northwest Province (18,857ha) and 58 are in Free State Province (11,251ha). 600 hectares are owned by the State. The present management of the site is nominally the Natural World Heritage Site Management Authority but it was not yet operational in 2008 (IUCN, 2008).

### AREA

Core zone: 30,111 ha. This includes three nearby 1-ha outcrop satellite sites: the Stromatolite Basal Fault, Pseudotachylite (Quarry) and Chocolate Tablet, sites. It has a planned buffer zone of 14,422 ha.

### ALTITUDE

1,300m to 1,692.7m.

## PHYSICAL FEATURES

Vredefort Dome, some 120 km southwest of Johannesburg and covering 30,111 ha, is a representative part of a larger meteorite impact structure (or astrobleme) which has a radius of impact of 190 km. The eastern boundary of the distorted north easterly trending oval shaped nominated area is found 5 km from the town of Parys, with its western boundary located some 19 km from the town. The southern boundary of the nominated area lies about 6 km to the north of the town of Vredefort, and the northern boundary is about 26 km to the north of the town.

The Vredefort Dome is one of about 200 meteorite impact structures currently known. Its structure is the oldest (2,023 million years) and largest (radius 190 km) so far found on earth. It is one of only three meteorite impact structures known with a diameter greater than 150 km. It is also the most deeply eroded impact structure known, with current levels of exhumation of about 38 km. The nominated area includes part of the ring structure and a cross-section of the geological formations and structures that provide evidence for the impact. On the ground, the magnitude of the diameter of the multi-ring structure and of the forces which contributed to forming the overturned, steeply dipping and highly faulted hills of the Vredefort Dome can best be appreciated at a landscape scale from vantage points within the nominated area. The steepest gradient of the Vaal River is found where it courses through the Vredefort Dome hills giving rise to rapids, irregular stream patterns and islands and a range of riverine habitats. Short, sharp streams have formed steep gullies and valleys that have cut into these hills

The nominated area, delimited by secondary roads, contains the most visible part of the dome's structure. This comprises part of the central granite core in the rolling relatively flat cropland to the south, dotted with kopjes, and the first concentric rings to the northwest in the Vredefort Hills, which are bisected by the Vaal river. This landscape is partly grazed hillsides with scattered farms, but the quartzite hills, upturned by the impact, have steep northern slopes and both U- and V-shaped valleys which make for handsome scenery. The gradient of the river cutting through the hills has created many rapids, braids and islands, resulting in a variety of habitats.

## CLIMATE

The area has a climate of high seasonal and diurnal temperature variation. The summers are hot, wet and average between 15°C and 30°C. Winters are cold and dry with frosts, averaging between -10°C and 18°C. The average rainfall is 625mm of which 500mm falls in summer, often in thunderstorms. The prevailing winds are northerly.

## VEGETATION

In spite of the extensive grazing and cultivation of lower areas of the site, the vegetation is well conserved in some areas and is varied owing to the topographic and geological diversity of the land. Floral mapping of the nominated area recognises 5 broad communities including the dolomite grasslands, andesite mountain bushveld, witwatersrand mountain bushveld, VD granite grassland and the riverine bushland. The dominant vegetation types are, in the north, rocky high veld grassland and *banken* veld (open grassland of wiry grasses) with hookthorn *Acacia caffra*. The south is basically grassland. This includes typical bush veld species such as grass veld sugarbush *Protea caffra* and false hookthorn *Acacia hereroensis*; also bush willow *Combretum* spp and red ivory *Berchemia zeyheri*, which are commoner hundreds of kilometers away. Kopjes hold thick stands of wild sweet olive trees *Olea europaea* ssp. *africana*. In between there is riverine bush and various types of hillside vegetation with the hardy deciduous Drege's tree fern *Cyathea dregei* in ravines. Lower down are unspoilt well watered wooded valleys containing a variety of microhabitats and trees such as white stinkwood *Celtis africana*, wild peach *Kiggelaria africana*, tree fuchsia *Halleria lucida*, sagewood *Buddleja salvifolia* and orange thorn *Cassinopsis ilicifolia*. At least 99 plant species have been recorded for a part of the area. The following distinct tree and shrub communities have been described; *Protea caffra*; *Acacia hereroensis*; *Olea europaea* ssp. *africana* - *Pavetta zeyheri*; *Combretum molle*; *Buddleja saligna* - *Rhoicissus tridentata*; *Salix capensis*; *Diospyros lycioidis* - *Rhus pyroides* and *Acacia karoo* - *Protasparagus suaveolens*.

## **FAUNA**

Farming extirpated many large animals native to the area though some are being re-introduced on game farms. The area however is very rich for some native species, especially butterflies, and includes many native birds, mammal species and other fauna. Some medium sized animals remain, such as the Cape baboon *Papio ursinus*, brown hyaena *Hyaena brunnea*, black-backed jackal *Canis mesomelas*, serval *Leptailurus serval* and steenbuck *Raphicerus campestris*. 50 species of small mammals are still found, among them the spotted-necked otter *Lutra maculicollis* and the white-tailed rat *Mystromys albicaudatus* (EN). The variety of habitats is reflected in the 200 bird species observed which include Cape vulture *Gyps coprotheres* (VU) and lesser kestrel *Falco naumanni* (VU), and in the area's listing as an Important Bird Area. Over 70 butterfly species have also been recorded.

## **CULTURAL HERITAGE**

Stone Age caves with skulls and tools have been found; and at *askoppies* (ash middens) in Tygerfontein and Buffelshoek there are late Iron Age settlements with extensive walls which contain deep deposits of cultural material. There is some rock art of the Khoi-San bushmen who once lived there and the ruined kraals of later Sotho and Tswana cultures. There are also remnants of battlefields and 19th century settlements such as the old mining village of Venterskroon, and of gold-mining which continued for 30 years round the turn of the 20th century.

## **LOCAL HUMAN POPULATION**

The site is shared between 149 farms growing predominantly maize in the flatter land over the core of the dome in the south, and in the hills, pastureland with scattered cultivation in valleys. The average property size is about 175 hectares but only about half the farms are permanently occupied for lack of water to irrigate. Much of the land, except along the river, is marginal for agriculture, and in Northwest province on the north side of the river, grazing is fast declining in favor of game farms and tourism, based on the beauty and variety of the scenery and its proximity to the Gauteng metropolitan area. The idea of nature conservancy has been less developed by the Free State landowners.

## **VISITORS AND VISITOR FACILITIES**

The countryside of the Dome is beautiful and biodiverse, rich in archaeological remains and easily accessible from Johannesburg. As a focus, the nearby structure of the Dome to the north is very recognisable. Youth camps, hiking and bird-watching clubs already use the area. The potentials for summer tourism, recreation, education and research are all high: lodges and campsites are being developed by local landowners as an economic alternative to farming. Seventeen landowners in the hills have game-fenced their farms and begun to re-introduce some of the large game animals formerly existing in the area. There is an interim information centre and, near Vredefort town, a state-funded exhibition centre. Canoeing, rafting and fishing, camping, riding, hiking, mountain-biking and rock-climbing are all pursued on site. There is hotel, guesthouse and resort accommodation in the nearby towns of Parys and Potchefstroom and in game farms and corporate convention centres on site. In 2001 there was said to be well over 60,000 overnight visitors to the nominated area. However there are as yet no visitors' or information centres on site. A consultants' Strategic Management and Development Plan oriented towards tourism, was submitted with the nomination.

## **SCIENTIFIC RESEARCH AND FACILITIES**

The Vredefort Dome exposures of formations associated with the meteorite impact are of high quality and the area is of considerable scientific interest. Since it was first recognised in 1937, writing about the dome has been voluminous: at least 750 publications have been listed and researches continue into every aspect of the area. Intensive exploration by hundreds of bore holes of the gold-bearing strata in the northern folds have led to a deep understanding of the structure of the dome. Recently, international workshops held nearby in 1987 and 1999 on explosion structures and on the dome focussed attention on the area. A study of its cultural aspects in preparation for the development of management plans has also recently been completed.

## **CONSERVATION VALUE**

Vredefort Dome is the oldest, largest, and most deeply eroded meteorite impact structure in the world. It is the site of the world's greatest single, known energy release event. It contains high quality and

accessible geological (outcrop) sites which demonstrate a range of geological evidences of a complex meteorite impact structure. The rural and natural landscapes of the serial property help portray the magnitude of the ring structures resulting from the impact. The serial nomination is considered to be a representative sample of this meteorite impact structure. A comprehensive comparative analysis with other complex meteorite impact structures demonstrated that it is the oldest, the largest and the only example on earth providing a full geological profile of an astrobleme below the crater floor, thereby enabling research into the genesis and development of an astrobleme immediately post impact.

## **CONSERVATION MANAGEMENT**

The land within the nominated property is predominantly agricultural, has freehold status, and is subject to national, provincial and district statutory regulations. The following national legislation is applicable: the Physical Planning Act 88 of 1967, the World Heritage Convention Act 49 of 1999; the National Heritage Resources Act 25 of 1999; the National Environmental Management Acts 107 of 1998 and 57 of 2003 and its 2005 Regulations. At the Provincial level, the Northwest and Free State Provinces have applicable nature conservation ordinances regulating environmental aspects of the area. At the local level, the nominated property falls within the District Municipalities of Northern Free State and Southern District North West, and the Local Municipal areas of Potschefstroom (Northwest Province) and Parys (Free State Province), and their environmental regulations. A Vredefort Dome Steering Committee, involving district and local municipalities, provincial, and national government representatives, was set up to obtain World Heritage status and to appoint a Management Authority. A Vredefort Dome Stakeholder Forum was established for public participation and to raise awareness about World Heritage status and the proposed authority. In December 2002, the South African National Heritage Resources Agency decided in principle to declare the nominated property a National Heritage Site under the provisions of Act 25 of 1999, subject to the completion of the Cultural Heritage Survey and Management Plan.

In 2004, interim government management structures and actions were put in place in recognition of the property's World Heritage status. They included the Vredefort Dome Inter-provincial Task Team to provide interim technical and administrative management which was subsumed in the successor Natural World Heritage Site Management Authority. It was commissioned to develop an Integrated Management Plan for the property in accordance with the Act. Part of this process included preparation by Northwest Province of a Development Plan to include a Strategic Environmental Assessment of the area and a Management (zoning) Plan. This aimed to enhance the stature of the Dome as a National Heritage site. The area was considered for a National Park but the extent of private ownership made this plan too expensive. A Vredefort Dome Bergland Conservancy was established by private landowners in the Northwest Province as a Section 21 Company to convert the private properties of the area into a voluntary nature reserve and to conserve its unique aspects. The Conservancy prepared a management plan to realise these objectives. It will be represented in the Stakeholder Forum and it plays an important role in the promoting private landowner involvement in the property. A Vredefort Dome Conservancy was established in the Free State Province by private landowners. The Cultural Heritage Survey and Management Plan was completed by February 2005 and a Notice of Intent of Proclamation issued in 2007, but the Site had still not been legally proclaimed in May 2008 (IUCN,2008).

## **MANAGEMENT CONSTRAINTS**

The salient fact about the management of the site is that 99% of its land is private property. The lack of both legal protection and adoption of the integrated management Plan means that there is no management unit, boundary marking, monitoring or enforcement of regulations. The amount of land in private ownership is a source of difficulty as some landowners object to the protection of their land as a World Heritage site. The Department of Environment and Tourism and the local municipalities also lack accurate up to date on land ownership in the site. Some 46 illegal and unregulated developments are listed, degrading the integrity of the site and the setting of its geological localities. These include the development of tourist lodges and camps, helicopter overflights, potentially water polluting agriculture, poaching and vandalism (UNESCO,2009; IUCN, 2008). Tourist numbers and facilities are increasing and will need regulation. There is already some pollution of the Vaal river by effluents from the farmland, industry and metropolis upstream which have led to infestation by algae and water hyacinth *Eichhornia crassipes*. The Vaal valley has also been invaded by the alien water-demanding blue gum *Eucalyptus*

*globulus*. Prickly pear *Opuntia* spp, has also spread over the drier land. There has been some erosion on slopes. Gold exists in small quantities but its mining is not seen as a threat by geological experts, and stone quarrying is closely regulated. In the past a shatter cone has been drilled for samples. With increasing use of the site there is an increased likelihood of wildfires which the neighboring municipality may not have the means to control. Future monitoring will concentrate on these potential threats.

## **COMPARISON WITH SIMILAR SITES**

The multi-ring complex meteorite impact structure centred on the Vredefort Dome is the oldest meteorite impact structure known on earth. The catastrophic short duration impact that created it was the single greatest energy release event ever known to have affected Earth. Of the three largest meteorite impact structures, Vredefort Dome is not only the largest at 380 km in diameter, and oldest, but it has better exposures of the evidences of impact than either Sudbury in Canada, 250 km in diameter and 1,800 million years old, or Chicxulub in Yucatan, Mexico, 170 km in diameter, 60 million years old, and famous for its links to the dinosaur extinction at the end of Cretaceous. Field inspections at Vredefort Dome clearly demonstrated the outstanding quality of the geological evidence of the impact.

The property's structure provides the only structurally intact exposure of the basement, below the crater floor of a very large astrobleme. This is unique for the planet. It shows a geological section that reaches from the rocks which once covered the crater floor, through the floor, and down into the basement of the structure. The central cone of the crater rebounded by approximately 38 km to provide a surface outcrop equivalent of mantle rocks. These rocks also show a type of metamorphism found only in conditions of very high energy release. This characteristic may be unique to the nominated property. It is not found at Sudbury and Chicxulub. The energy released created chocolate tablet boudinage in cherts, and their association with distally situated ring thrusts is also thought to be unique. The impact forces overturned 17 km of strata to dip towards the centre of the structure. No other similar terrestrial phenomenon of this nature and comparable magnitude has been observed. Like other complex impact structures, Vredefort Dome includes examples of shatter cones, planar deformation features in minerals and high pressure mineral polymorphs but no evidence of impact melts. In sum, the property, has high quality exposures of a complex meteorite impact event which are readily accessible. It has special significance as evidence of the world's greatest single event release of energy. It is the world's only structurally intact exposure of the basement below the crater floor, of a very large astrobleme. It provides the only mappable and restorable profile that illustrates the genesis and development of an astrobleme during the very short time after impact.

## STAFF

The Natural World Heritage Site Management Authority had installed three information officers of a projected staff of seven in 2009, who were expected to be skilled in light of the challenging relations with stakeholders on the site (UNESCO,2009). Expertise is to be drawn from national, provincial and local government sources, from Northwest University at Potchefstroom and the Universities of Witwatersrand and the Free State.

## BUDGET

No separate budget exists at present, but the Northwest Provincial Department for Environmental Affairs has granted \$90,000 towards a management plan. When a World Heritage Authority is established, the national government will help provincial and local authorities and private donors to support the site.

## LOCAL ADDRESSES

Vredefort Dome Forum and Dome Bergland Conservancy, POB 1344, Potchefstroom 2520, Northwest Province, South Africa

Department of Environmental Affairs Free State Province, POB 264, Bloemfontein 9300, South Africa.

## REFERENCES

The principal source for the above information was the original nomination for World Heritage status.

Bisschoff, A. (1999). *The Geology of the Vredefort Dome (and Geological Sheets)*. Council for Geoscience, Geological Survey of South Africa. Explanation of Sheets 2627CA, CB, CC, CD, DA, DC. 2727AA, AB, BA. Scale 1:50,000.

Brink, M., Waanders, F., Bisschoff, A. & Gay, N. (2000). The Foch Thrust-Potchefstroom Fault structural system, Vredefort, South Africa: a model for impact-related tectonic movement over a pre-existing barrier. *Journal of African Earth Sciences*, Vol 30, No 1, pp. 99-117. Elsevier Science Ltd.,U.K..

Brink, M., Waanders, F.& Bisschoff, A. (2004). *IUCN Technical Evaluation: Vredefort Dome, 30<sup>th</sup> August 2004, Geological Aspects*. Paper prepared for the IUCN Mission, Vredefort Dome, South Africa, 2004.

Brink, M, Bisschoff, A .& Waanders, F. 2004. *The Vredefort Impact Structure*. Potchefstroom, South Africa.

Brink, M., Bischoff, A., Wanders, F. & Schoch, A. (2005). *An Addendum to the Supplementary Information Document on the Vredefort Dome*. Department of Tourism, Environment and Economic Affairs, Free State, South Africa.

Contour (2002). *Vredefort Dome Conservancy Situation Analysis Report*.

Department of Tourism, Environment and Economic Affairs (2004). *Proposal: Vredefort Dome World Heritage Site, Free State Province, Republic of South Africa*. [Contains a bibliography of 47 references]

French, B. (1998). *Traces of Catastrophe. A Handbook of Shock-Metamorphic Effects in Terrestrial Meteorite Impact Structures* Lunar and Planetary Institute, Houston USA.

Glikson, A. (1996). Mega-impacts and mantle-melting episodes: tests of possible correlations. *AGSO Journal of Australian Geology and Geophysics*, 16 (4) pp. 587-607.

Gibson, R., Reimold, W. (1999). *Field Excursion through the Vredefort Impact Structure*. Department of Geology, University of Witwatersrand, South Africa.

Grieve, R, & Pilkington, M. 1996. The signature of terrestrial impacts. *AGSO Journal of Australian Geology and Geophysics*, 16 (4) pp. 399-420.

IUCN (2008). *State of Conservation Report Vredefort Dome (South Africa)*. Gland, Switzerland.

Planetary and Space Science Centre (2004), *Earth Impact Database, Impact Cratering on Earth (including World Impact Structures sorted by location)*. University of New Brunswick. .

Sutherland, F. (1996). The Cretaceous/Tertiary-boundary impact and its global effects with reference to Australia. *AGSO Journal of Australian Geology and Geophysics*, 16 (4) pp. 567-585.

Shoemaker, E., Shoemaker, C. (1996).The Proterozoic impact record of Australia. *AGSO Journal of Australian Geology and Geophysics*, 16 (4) pp.379-398.

UNESCO World Heritage Committee (2009). *Report of the 33rd Session of the Committee*. Paris.

Worboys, G. (2005). *World Heritage Nomination Technical Evaluation, Vredefort Dome (South Africa)*. IUCN, Gland, Switzerland.

**DATE:** July 2005. Updated 12-2006, August 2009, May 2011.