STATUS OF THE NATURAL ANALOGUE STUDIES IN SOUTH AFRICA

WCMH Meyer, NV Jarvis, D Read, T Williams, M Knoper, MA Andreoli, MPG Pirow

necsa
We're in your world

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Background: South African interest in N.A.

- **1978**

  A site selection program to locate a suitable site for the storage/disposal of radioactive waste in South Africa was initiated by Necsa
- **1980**

  The selection criteria (Corner and Scott, 1980) that guided the choice of Vaalputs in 1986 therefore had the additional purpose of not only LILW disposal, but also the potential for HLW disposal
- **1987**

  A working group on the disposal of HLW in South Africa, consisting of members of various government departments, Escom and the Atomic Energy Corporation (AEC, now Necsa) was established.
- **Early 1990's**

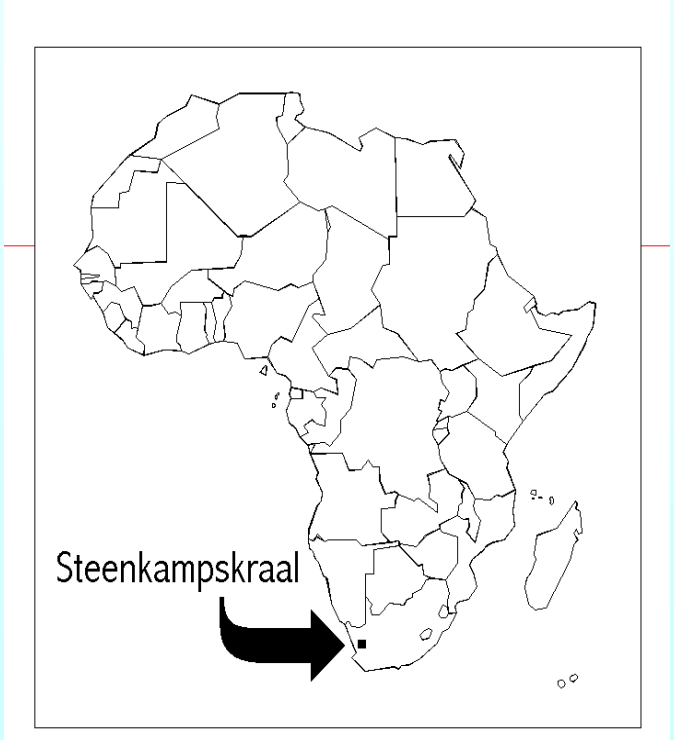
  NECSA decided to commence with "low-key" investigations on Vaalputs to establish its potential for HLW geological disposal. Steenkampskraal as NA was part of these studies
- **1990**

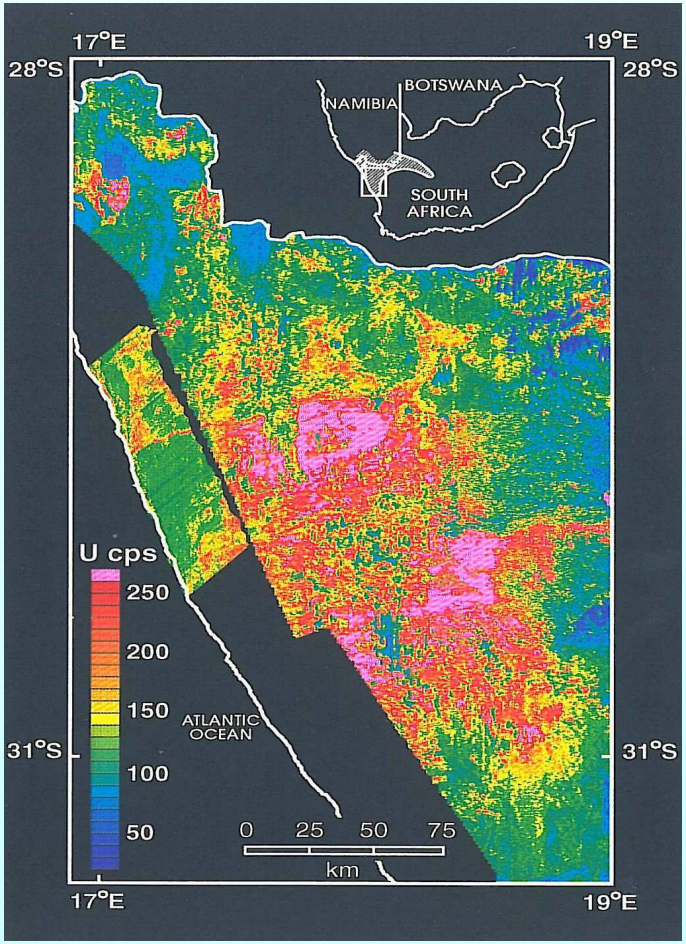
  Vaalputs was establish as a LLW geological disposal site and only Dr. Neil Jarvis was studying Steenkampskraal as a NA
- **1993**

  Because of the lack of cohesion between the major role players and the lack of a national strategy for radioactive waste management at the time, the AEC halted any further investigations at the end of 1996 for a HLW disposal site as well as NA.

1. Steenkampskraal studies before 1995

Introduction





INTRODUCTION

The Steenkampskraal monazite mine is being studied as a natural analogue for the Vaalputs National Nuclear Waste Facility which lies about 100km to the north in a similar geology. Steenkampskraal is among the richest monazite ores in the world comprising up to 45% REE, 8.8% Th and 600ppm U. Mining has not occurred since the early sixties.

A view over the slimes dam towards spoil heaps at Steenkampskraal. Significant acidification of the soil has taken place here resulting in actinide and REE migration in the soil.

A view from the inselberg of the abandoned workings at Steenkampskraal.

Interest in Steenkampkraal

- Only 120 km from a possible HLW disposal site
- Steenkampskraal, located in southwestern Namaqualand, South Africa, is well known for a distinctive monazite ore vein situated within crystalline Mesoproterozoic granitic gneisses. Good exposures of the monazite vein on the surface and in underground mine tunnels has led to considerable interest in the monazite vein as a natural analogue of a high-level radioactive waste repository, thereby presenting an unique opportunity to study monazite degradation and chemical dispersal of actinides by surface and groundwater movement.
- The monazite vein is exposed for about 200 m on the surface as an E-W striking, 0.2-4 m wide band associated with an intrusive suite comprising dykes of granodiorite, granite, and quartz syenite
- The form/distribution/migration mechanism by U and Th in these colloid-rich palaeosoils could help with site models
- By studying the preservation of monazite during the the warm, humid conditions of the late Cretaceous period(about 65 million years ago) could help with matrix developement
- Comparison between natural and moddeled behaviour of actinides in a monazite matrix: the need to include (paleo)colloids ?
- .Migration of Th and REE can be used as analogue for Pu(IV) and Am(III) as evidence exists for rapid Th-silicate migration in colloidal form
- Dating of the altered monazite can be used to model the migration of U, Th and REE mobilised from the matrix.

Steenkampskraal studies before 1993

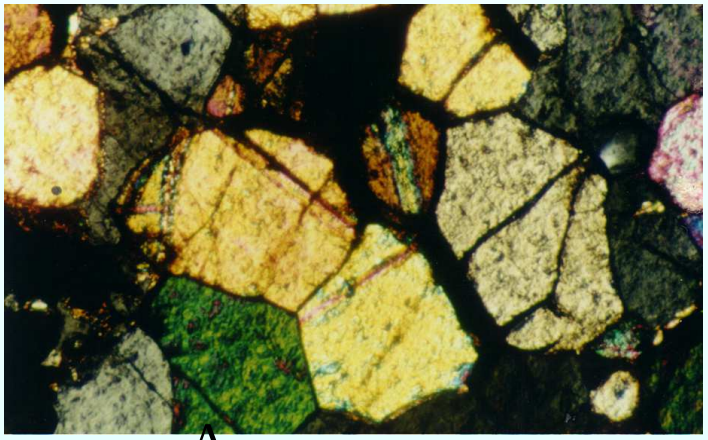
3. Monazite bearing rocks: Petrography

Type 1: phosphates ore. The typical ore of the mine, with up to 80% of phosphate minerals (monazite>apatite); the remainder 20% consists of sufides>oxides>zircon. Monazite grains are generally fresh and stable but incipient alteration may be locally present. Alteration is strongest in samples that are sheared or collected in the open pit. The monazite grains frequently present brownish rims caused by iron oxide staining, whereas altered, cloudy patches are less common.

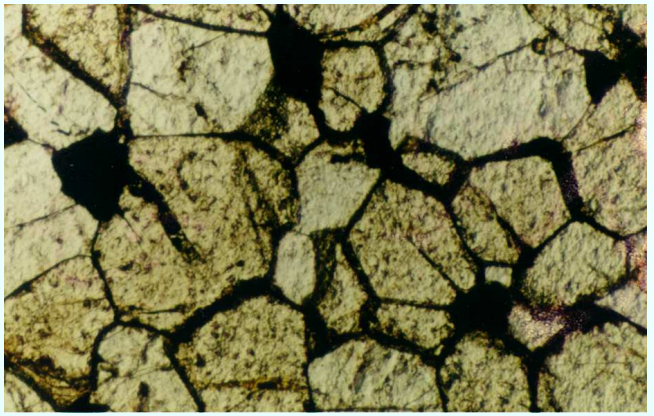
Type 2: oxide-rich ore. Magnetite-hercynite-ilmenite ironstone with disseminated grains of monazite and zircon. This type of ore occurs as rare bands within the phosphatic rock. Monazite grains are generally stable.

Type 3: quartzo-feldspathic ore. A monazite-rich tonalite. Chlorite, zoisite and allanite extensively replace plagioclase, biotite and monazite. The monazite grains are frequently found in various stages of alteration (photomicrographs C and D) that are most developed at the contact between the ore and its leucotonalite host.

Type 4: siliceous ore. Glassy, smoky quartz rock with disseminated small crystals of monazite, apatite, sulphides and zircon. Monazite tends to be stable.

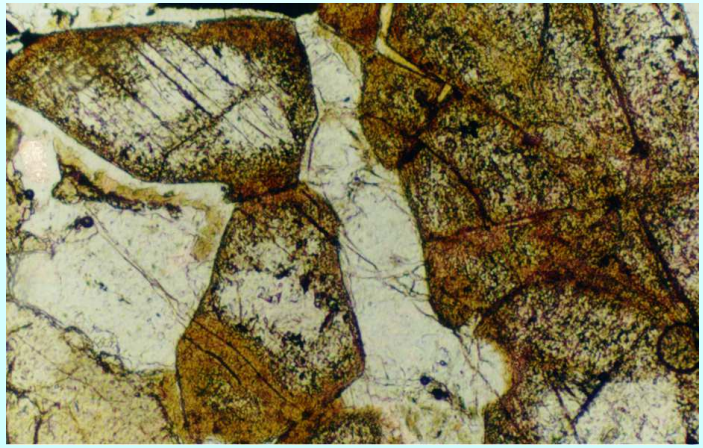


A

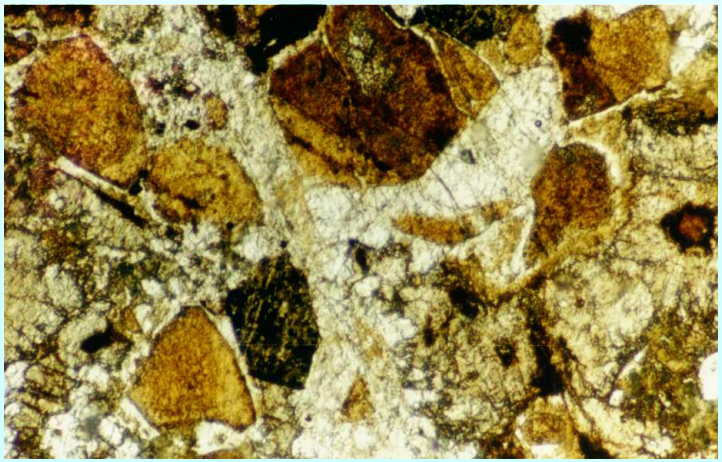


B

A and B: photomicrographs of fresh monazite and apatite grains in type 1, phosphatic monazite ore (plain and polarised light respectively)



C



D

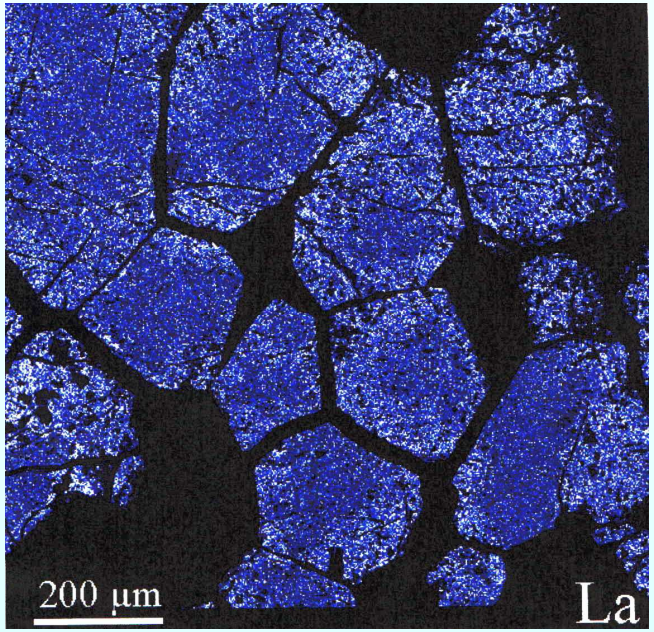
C and D: photomicrographs of type 3, quartzo-feldspathic ore showing partly altered, and completely altered monazite grains. Field of view: 1mm

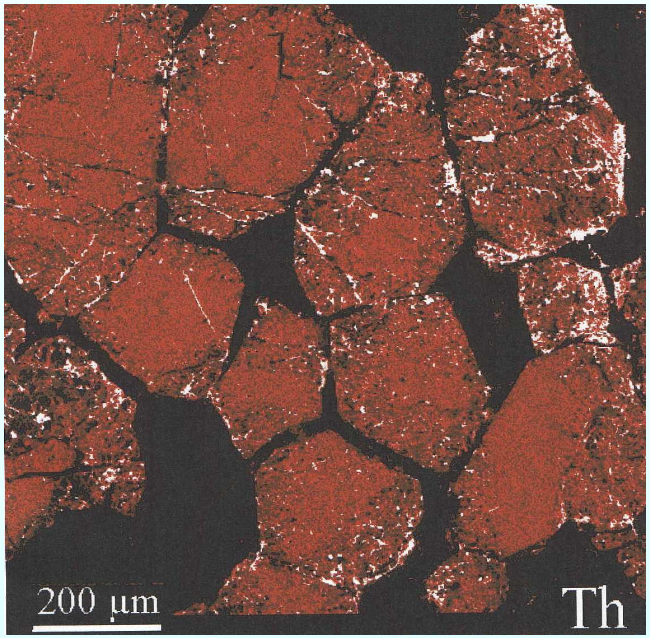
Steenkampskraal studies before 1995

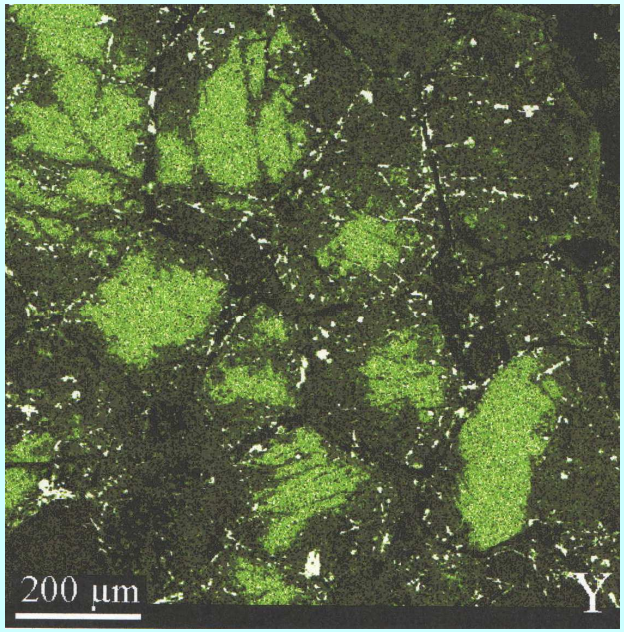
4. Monazite alteration: Geochemistry and mineralogy

- **Cryptic alteration:** No visible alteration: monazite grains remain optically pristine in thin section. Electron-microprobe analyses reveal large variations in U, Th content, and heavy REE depletion.
- **Partial alteration:** Monazite grains appear cloudy (photomicrograph C) and in all cases very depleted in Th and U, but less depleted in Gd and heavier REE.
- **Complete alteration:** Micro-crystalline phases, often inter-grown with each other, consisting of Th-silicates-oxides, and Y/Th-phosphates, rich in the heavy REE. These include an almost pure Y-phosphate (xenotime or churchite), with low Th and U contents, but an extreme HREE enrichment.

Phosphate matrixes for spent fuel disposal ?







Elemental maps for La, Th and Y Showing zonation of the REE in monazite. Note the concentration of Y and Th in secondary phases within cracks and around grain edges.

IMPLICATIONS FOR RADIOACTIVE WASTE DISPOSAL

- Synthetic phosphate matrices proposed for waste immobilisation due to refractory nature of monazite and successful lab leaching experiments- Optimum matrix ?
- Results from this study indicate that monazite can be altered and U, Th and REE can be mobilised from the matrix.
- REE can be mobilised and fractionated even at temperatures around 200-350°C
- Th, though regarded as less mobile, is released on alteration of monazite, tending to concentrate in secondary micro-crystalline phases. (This may have implications for Pu(IV) as evidence exists for rapid Th-silicate migration in colloidal form.
- U appears to be readily removed from Steenkampskraal monazite. Although re-concentrated in some alteration products, notably Y-Th phosphates, its is likely that substantial U has been lost from the system as is evidenced in the high levels of U in the groundwaters

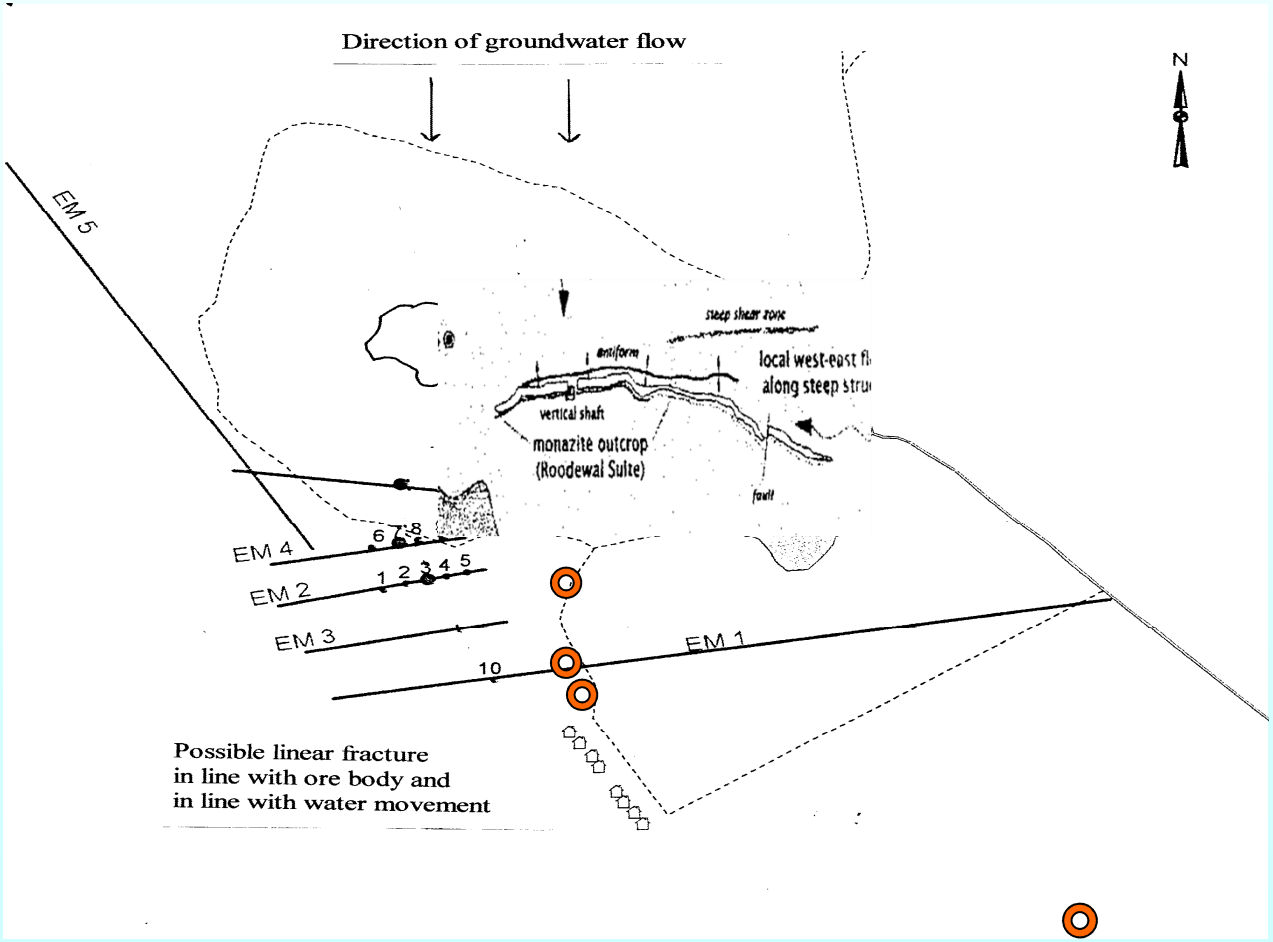
Colloidal migration mechanisms ?

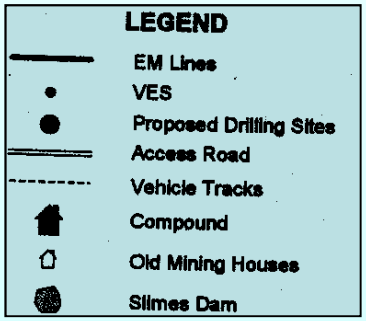
Colloid determination

During June 1997, the AEC of South Africa led a joint field trip to Steenkampskraal to sample existing boreholes. The sampling and analyses were performed by scientists from AEA Technology. Five boreholes were found to have enough water to allow purging followed by sampling to collect colloid concentrates. The procedure produced an ultra filtrate, a colloid concentrate and unfiltered water. pH, temperature and conductivity were measured *in situ*. Unfortunately, little is known about local hydrology at the mine site making it impossible to say with certainty that the boreholes sampled are connected with the ore body. Consequently interpretation of the results obtained is problematic at this stage, as the waters do not reflect what is expected from the study on monazite degradation. *One important result was that neither actinides nor REE were significantly associated with colloids*. A more definitive study whereby boreholes are sunk into fractures connected to the ore is planned.

Colloid sampling in the field at Steenkampskraal

Proposed drill sites into aquifer connected with the ore body (1993)





Part 2: Steenkampskraal studies between 1993 -1998

- Because of the lack of cohesion between the major role players and the lack of a national strategy for radioactive waste management at the time, the AEC halted any further investigations
- New elected government in 1994
- New government “quiet “regarding nuclear energy
- “QUIET” ? 8743 Nuclear researchers reduced to 827
- Budget was cut from MR825 to Mr100
- All research on spent fuel reprocessing stopped.
- All enrichment plants closed
- All fuel manufacturing plants closed
- HLW site research stopped
- ESCOM starts constructing “wind generator farm” in Cape Town
- Due to budget constrains and resignation of Dr. Neil Jarvis the NA studies was stopped

Quiet diplomacy = No Nuclear Industry ?

Part 3: Government nuclear policy after 1998

Huge change in Nuclear Policy after 12 years of “Quiet diplomacy” !!!!

White Paper on Energy Policy (1998)

Nuclear energy policy is guided by the White Paper on Energy Policy as approved by Government at the end of 1998, where it was retained as one of the policy options for power generation

In terms of the White Paper Government will investigate the long-term contribution nuclear power can make to the country's energy economy and, secondly, how the existing nuclear industrial infrastructure can be optimised.

Some of the main policy objectives relate to decisions regarding possible new nuclear power stations, the management of radioactive waste, safety monitoring of the nuclear industry, effectiveness and adequacy of regulatory oversight, and a review of bodies associated with the nuclear industry.

Nuclear Energy Act, 1999 (Act No.46 of 1999)

The Nuclear Energy Act provides for the following:

Establishment of the South African Nuclear Energy Corporation wholly owned by the State with its main function being to undertake and promote research and development in the field of nuclear energy and radiation science and technology

Ministerial responsibility for the implementation and application of the Safeguards Agreement and any additional protocols entered into by the Republic and the International Atomic Energy Agency (IAEA) in support of the Nuclear Non-Proliferation Treaty

Ministerial authority to regulate the acquisition and possession of nuclear material and related equipment in order to comply with the international obligations of the Republic.

Ministerial authority to prescribe measures regarding the discarding of radioactive waste and the storage of irradiated nuclear fuel.

National Nuclear Regulator Act, 1999 (Act No. 47 of 1999)

This Act establishes the National Nuclear Regulator. The main object of the Regulator is to provide for the protection of persons, property and environment against nuclear damage through the establishment of safety standards and regulatory practices.

Radioactive Waste Management Policy and Strategy for the Republic of South Africa (2005)

This document establishes a national radioactive waste policy framework setting out the principles for management. It further provides for the necessary management structures for radioactive waste management.

Possible scenario for South Africa
HTR Conference 2006: Minister of Finance

Additional: **10 GW nuclear power in SA by 2020**

20 GW nuclear power in SA by 2030

Scenario informed by the view that externalising the costs of carbon penalties will no longer be possible in 10-15 years time.

- 4 new PWRs acquired by Eskom by 2020
- 24 PBMRs acquired by Eskom by 2020
- A further 6 PWRs (or 60 PBMRs!!) by 2030
- Uranium beneficiation for the world market

June 2007

Eskom plans 10 new stations in 20 years

Nuclear power the way of the future, decides board

SAPA

South Africa could have at least 10 more nuclear power stations within two decades if Eskom has its way, according to the utility's chief executive, Jacob Maroga.

He told journalists at a briefing in Cape Town yesterday that in the face of global warming, nuclear power was the "next big viable alternative" to coal.

Eskom's board had made a strategic decision that a significant component of South Africa's power should come from nuclear generation.

It had decided that by 2025, up to 20 000 megawatt (MW) should be generated by conventional Koeberg-style nuclear plants.

Koeberg's two generating units put out a total of 1 800MW.

Maroga said the output of the proposed plants could vary from 900MW to 1 600MW. He agreed this would mean at least 10 new plants.

Eskom hoped to have a decision by the first half of next year on what could be a series of plants, representing a critical mass of business that would enable a supplier to commit resources to the project.

The utility has already approved plans for a second nuclear power station, and the environmental impact assessment for it has started.

Five potential sites, one in the Eastern Cape, and the others along the western and northern Cape coast, have been identified.

Maroga said nuclear plants had to be close to large quantities of water, which in South Africa meant on the coast, and sea temperature also played a role in deciding where they would go.

Nuclear power was "the most viable technology" to curb carbon dioxide emissions.

Storage of highly radioactive spent fuel was an issue, and South Africa would follow developments around the world for the latest thinking.

He said South Africa's electricity consumption, which stood at 20 000MW in 1994, reached 36 000MW last week.

Eskom had already approved a R150 billion capital expansion programme over the next five years.

He said tariffs would have to reflect this increase in spending, and Eksom was engaging the national electricity regulator on a tariff "path" that would allow South Africa to remain internationally competitive.

South Africa was currently 30% cheaper than its next global competitor, Australia, and Eskom believed that while this gap would close, South Africa would still keep its position as the cheapest in the world.

Pretoria News
1 June 2007

NO MORE POWER GENERATION BY COAL OR WIND?

DEPARTMENT OF MINERALS AND ENERGY

JULY 2007

NUCLEAR ENERGY POLICY AND STRATEGY FOR THE REPUBLIC OF SOUTH AFRICA

DRAFT FOR PUBLIC COMMENT

Selected section of proposed act

*P1. Nuclear Energy shall be used as part of South Africa's **diversification** of primary energy sources to ensure security of energy supply.*
P2. *Nuclear Energy programme shall contribute to **economic growth** and **technology development** in South Africa through investment in infrastructure, creation of jobs and development of skilled workers.*
*P3. Nuclear Energy shall form part of South Africa's strategy to **mitigate climate change** and global warming.*

*P12. Government shall **support research, development and innovation** in the use of nuclear technology. Government shall also support participation in global nuclear energy technology innovation programmes..*

Nuclear industry proposed by SA government

- **Phase 1 2007 – 2010**
- Maintain and enhance current national nuclear infrastructure
- Conduct preparatory work for expansion of the nuclear infrastructure across the nuclear fuel cycle including preparations for the construction of nuclear power plants
- Continue research into advanced nuclear energy systems
- Accelerate skills development initiatives in line with expected expansion including increased capacity at institutions of higher learning.
- Promote uranium exploration and mining
- **Phase 2 2011 – 2015**
- Construction of new nuclear infrastructure including nuclear power plants
- Continued maintenance of existing nuclear infrastructure
- Demonstration of advanced nuclear energy systems
- Initiate localisation of nuclear equipment and component manufacturing – construction of heavy machinery infrastructure
- Build capacity for nuclear technology transfer
- **Phase 3 2016- 2025**
- Operation of new power plants
- Maintenance of existing nuclear infrastructure
- Local manufacturing of nuclear equipment and components
- Commercialisation of advanced nuclear energy systems
- Accelerate research into further advanced nuclear energy systems

Nuclear is back in SA !!!

Research projects planned that involves Steenkampskraal as NA

-DST (government body) survey Uranium in ground water around Steenkampkraal -2007

- Presence of bacteria at Steenkampskraal -2007

-Influence of bacteria on the reduction of Uranium –using uranium as food source-2007

-Influence of radiation on the mutation of bats-2007

-Co-operation between Khlopin Institute and Necsa to study monazite type waste forms for encapsulating long-lived LLW-started 2007

-Discussions between Necsa, CEA, Ansto, Khlopin Institute and Sheffield University to study the use of monazite type matrixes for transmutation of radioactive waste-planning phase

- New Waste Management curriculum has started at NW University that includes Steenkampskraal.- 2007

- In the process of acquire funding from DST to have conference in SA in March 2008 on curriculum development and for Sheffield lecturers to visit SA to help with “polishing "contents of curriculum. -2008

- Post for lecturer at NWU on Waste Management –Possible candidate from Sheffield ? Advert next week in international media -2007

- Research post for scientist at NECSA on HLW that includes Steenkampskraal. Was advertised last week in international media -2007

NA studies back on track –more results at next meeting ?

Thank you