Joint ICTP-IAEA International School on Nuclear Waste
Actinide Immobilization. 10-14 September 2018

The CERUS Project

and the Argentina's back-end strategy for the research reactor spent fuel

Ceramization of radioactive elements in sintered uranium (CERUS)

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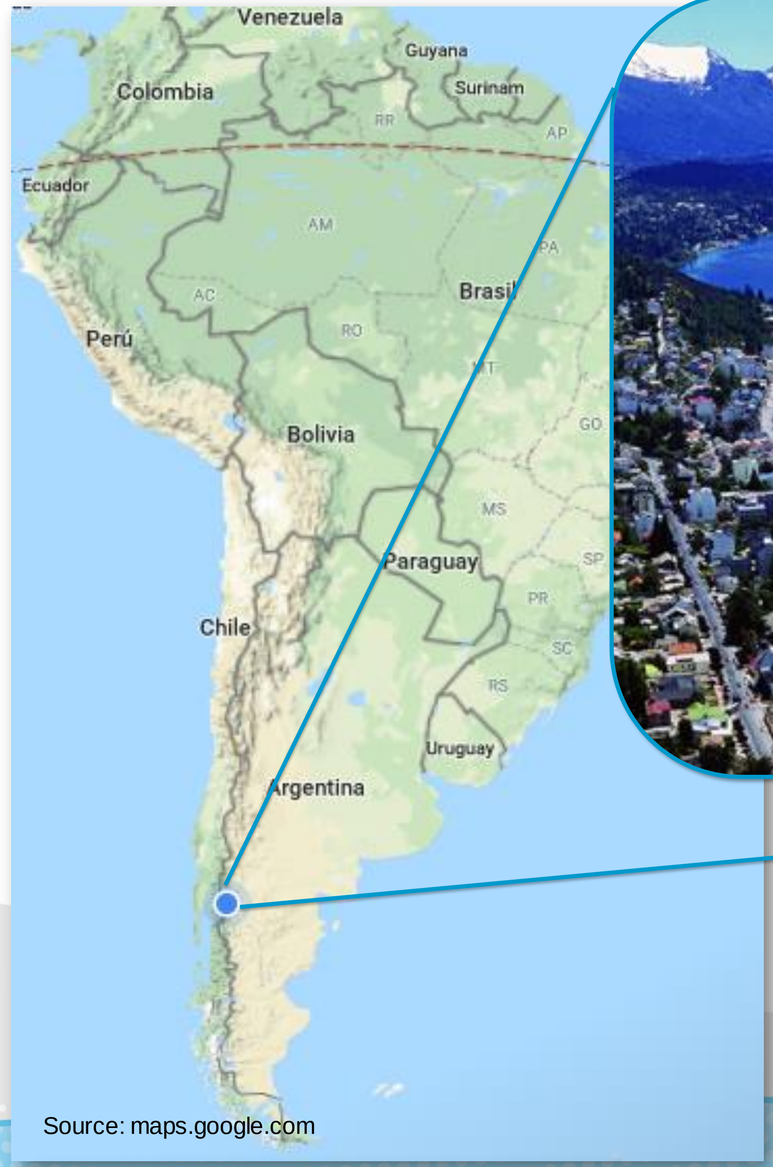
Organization

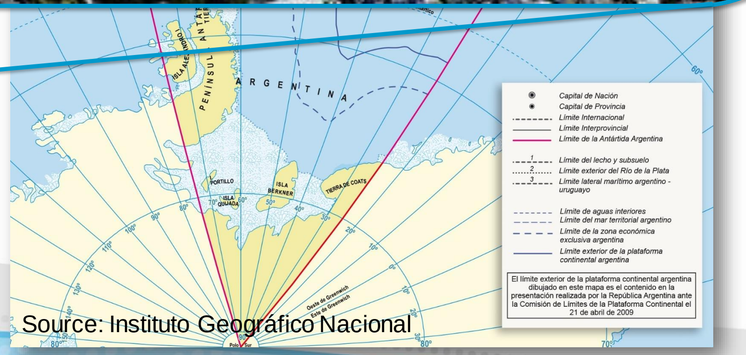
- Argentina and the nuclear industry
- Source of Spent Fuel and Radioactive Waste
- Repositories of SF
- Cerus Project
- Conclusions and Outlook

Argentina and the nuclear industry



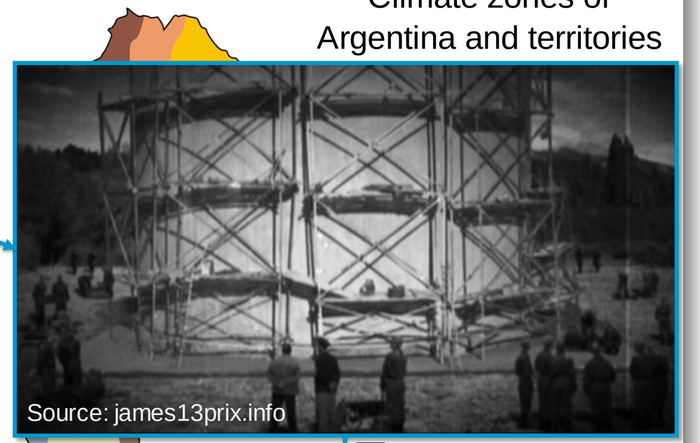
Source: maps.google.com


Source: Patagonia.com.ar



Source: Instituto Geográfico Nacional

Climate zones of Argentina and territories


Source: james13prix.info


Source: laangosturadigital.com.ar

Argentine Antarctica

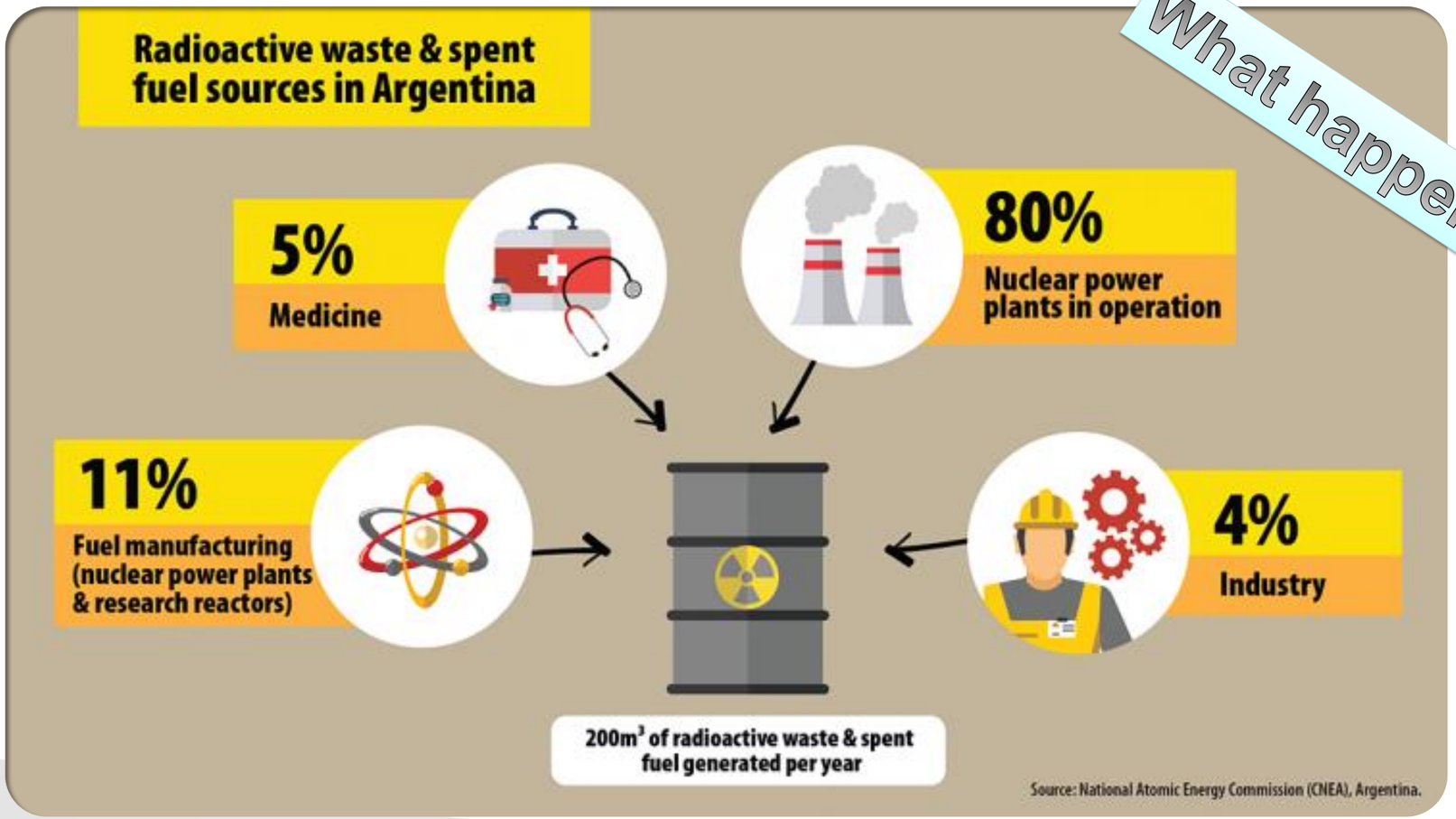
Source: mod of wikimedia.org

Argentina and the nuclear industry

- 3 Atomic Centers
- 6 MTR's
- 3 NPP
- 1 SMR in construction
- 813 Operational Nuclear Medicine Centers
- 5 Nuclear Medicine Facilities
- 1 Technological Area
- 9 Mining Activities Locations
- 5 Particle Accelerators for Radioisotope Production
- 339 Facilities with industrial applications
- 4 Irradiation Facility
- 1 Uranium Enrichment Plant
- 1 Uranium Purification Plant
- 1 Industrial Mining Complex
- 1 Heavy Water Industrial Plant
- 7 Nuclear Medicinie Centers Under Construction
- 5 Particle Acceletarors for Research
- 4 Regionals: Centro, Noroeste, Cuyo, Patagonia
- 1 Nuclear fuel facility
- 3 Academic Institutes

Source: CNEA

Source of Spent Fuel and Radioactive Waste



What happen with spent fuel?

Repositories

Spent Fuel Management Facilities

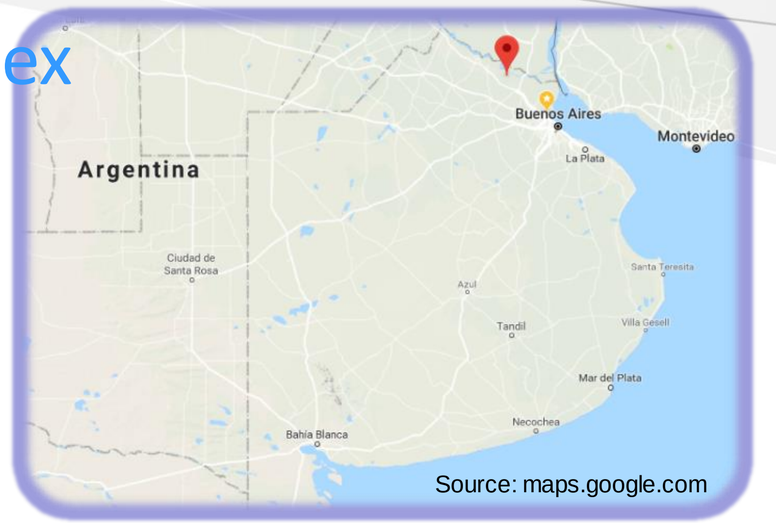
Site	Facility
CNA I	I & II Pool Building
CNA II	Pool Building
CNE	Storage Pool
	Storage Silos (ASECQ)
Ezeiza Radioactive Waste Management Area (AGE)	Central Storage Facilities for Research Reactors SF (DCMFEI)
Ezeiza Atomic Centre (CNEA)	Research Reactor Irradiated Fuel Storage Facility (FACIRI)

Waste Management Facilities

- NPP= systems of treatment and conditioning for solid, liquid and gaseous.
- CAE= Radio Isotope Production plant
- AGE= Storage of Rad. Sources, Long term Deposit, Cementing and compacting Pilot Plant
- Pilcaniyeu=LLW deposit
- UO_2Plant= Raw material deposit
- Mining and processing U minerals (Mendoza, Córdoba, Chubut, Salta, La Rioja)

Repositories – Atucha NPP Complex


Source: Lavanguardiadigital.com



Source: maps.google.com


Source: Espectadores.com.ar

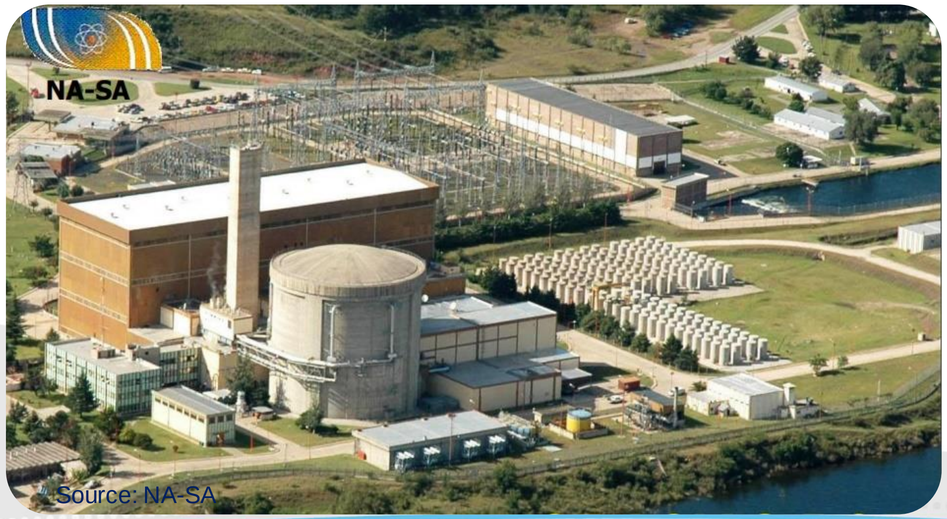

Source: CNEA

Site	System	Quantity	U_tot (kg)	Pu (est) (kg)
Atucha I	Pools I & II	11201	1705127.373	6405.647
Atucha II	Pools	1058	185789.718	679.015
Inventory at 31 December 2016				

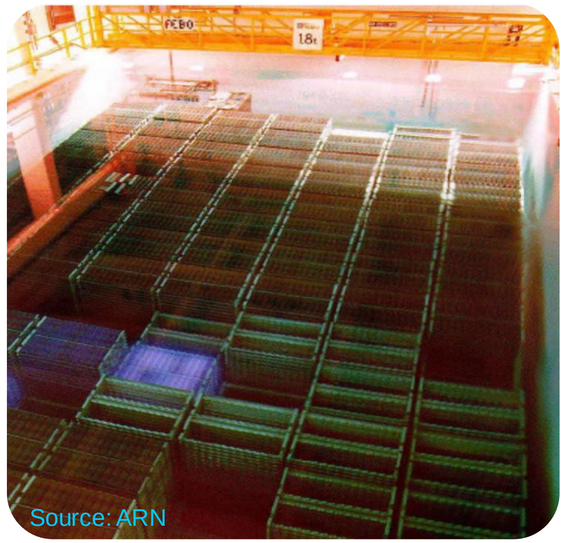
Repositories – Embalse NPP

Source: maps.google.com

Site	System	Quantity	U_tot (kg)	Pu (est) (kg)
Embalse	Pools	32101	600475.400	2056.496
	Silos	113160	2111529.164	7753.933
Inventory at 31 December 2016				



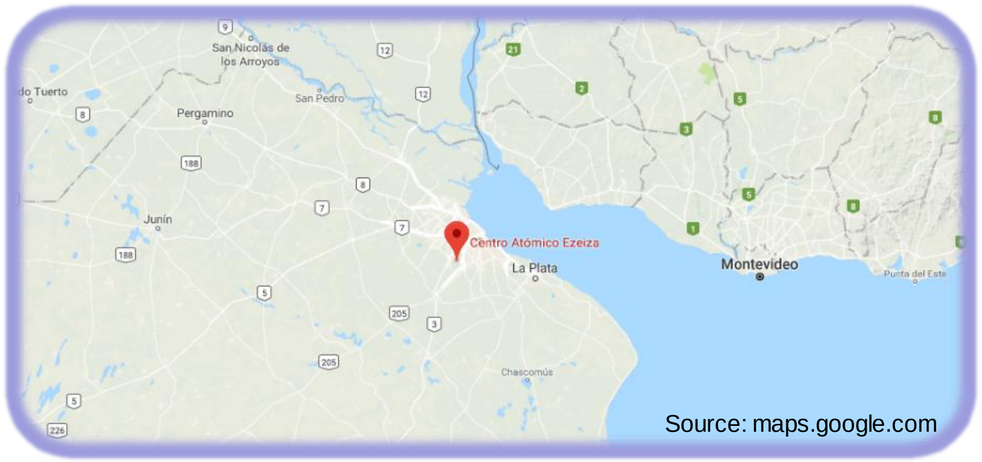
Source: NA-SA


Source: ARN


Source: Noqueremosinundarnos.blogspot

- Pool → 8 years at 80% power
- SF→Basket (x60)→ 9 bskt x silo
- 6 years of wet storage

Repositories - AGE



Source: maps.google.com

Site	Type	Quantity	Kg
AGE	MTR	146	173327
	PINS	232	14188
Inventory at 13 August 2013 (IAEA PIV)			

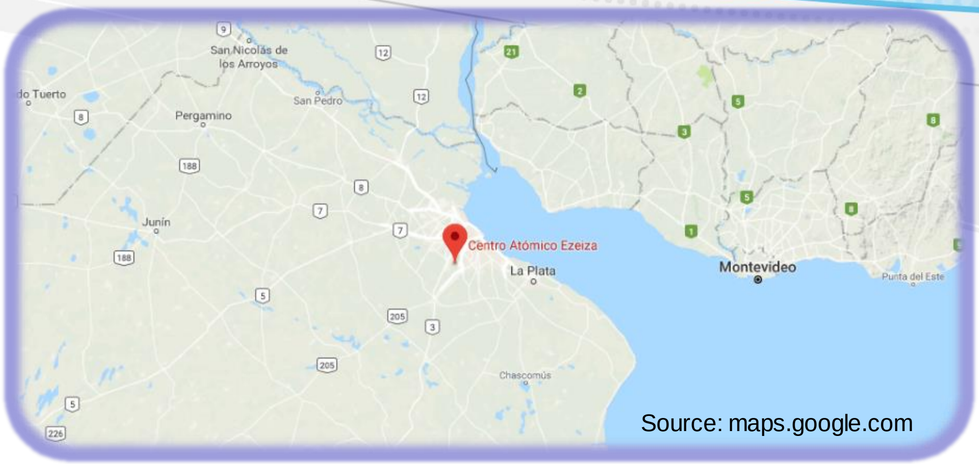

Source: “Google maps”


Source: Ariel Alejandro Chavez

- Started 1972
- In 2003 studies of condition
  - Replace the facility

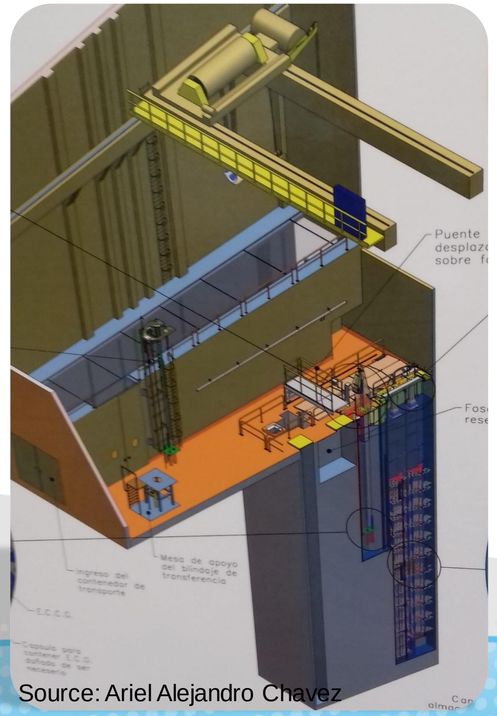
Repositories - FACIRI

Source: CNEA Magazine



Source: maps.google.com

Site	Type	Quantity	Kg
FACIRI	MTR	60	73065
Inventory at 31 December 2016			



Source: Ariel Alejandro Chavez

- Safety improvements
  - Conservation of SF
  - Water quality monitoring

➢ 2 collumns along16 m

➢ 19 grids/ collumn

➢ 32 SF assemblies

➢ Total capacity of 608 SF

Repositories

Projects

- The decision on the possible reprocessing or final disposal of the SF will be made before 2030.
- Atucha I- Burned Fuel Assemblies Dry Storage
  - Vertical subterrain Silos
    - 2 baskets, 9 SF per basket
- CAREM-25 NPP
  - Spent Fuel Storage Pool
    - Store SF originated during 10 years of full power operation
    - Cooling and clean up systems
    - Quality of the water, compensate water loos by evaporation, monitoring radiological, physical and chemical parameters
- RA-10 Reactor
  - Storage Pool, to cover 10 years of operation

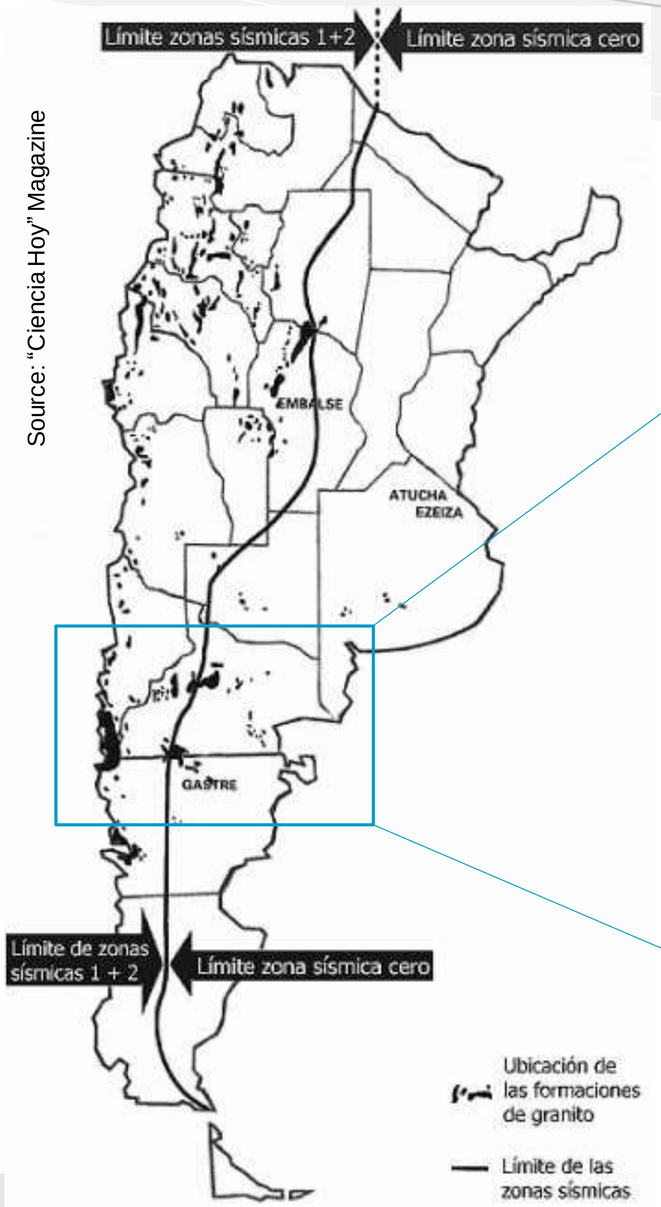
Repositories

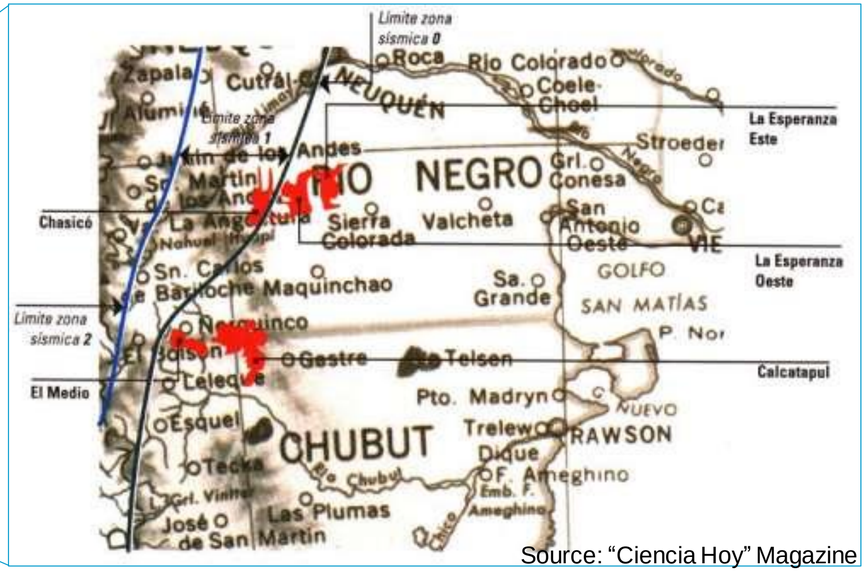
Projects

- The decision on the possible reprocessing or final disposal of the SF will be made before 2030.

- Final Disposal of Spent Fuel
  - Deep geological repository in Argentina by 2060
  - R&D activities have been conducted in relation to the geology of sites to locate the repository location.
  - Sierra del Medio Project
    - Granite
    - Closed in 1996

Source: "Ciencia Hoy" Magazine





Source: "Ciencia Hoy" Magazine

PROJECT CERUS

CERUS/VITROCERUS is a method developed by National Atomic Energy Comission (CNEA) to conditioning Materials Test Reactors Spent Fuel Elements (MTRSFE). The key of the process is the use of natural or depleted uranium oxide to isotopically dilute the spent fuel, to reach a final enrichment of 1 to 2% U^{235}, as the immobilization matrix, obtaining a monolithic ceramic waste form.

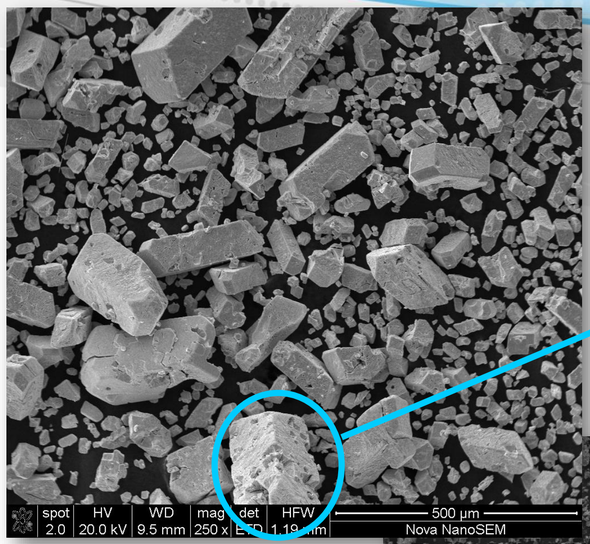
- SF enrichment ≈ 11%
- Addition of U_3O_8 (natural 0.711% or depleted 0.3% U^{235})

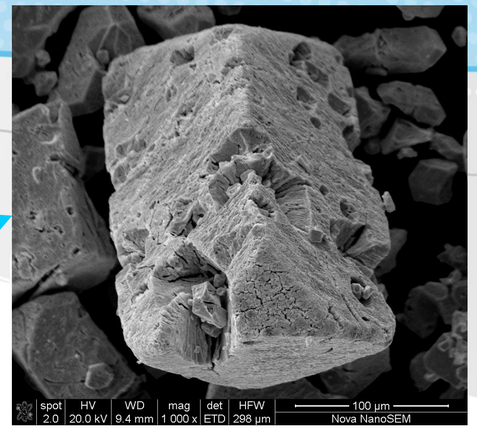
PROJECT CERUS

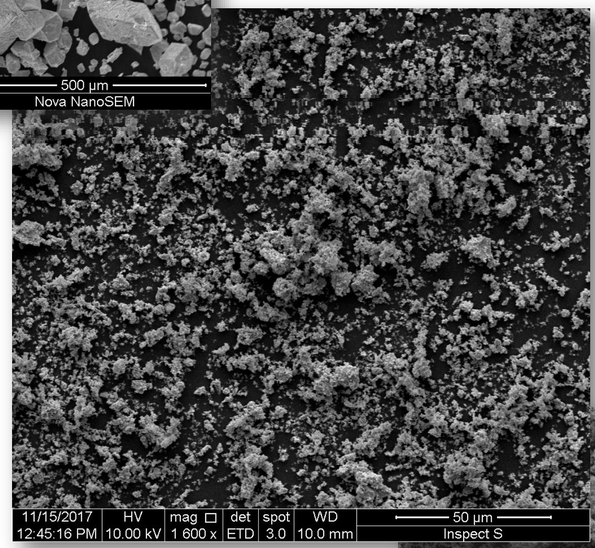
Precursor Powder

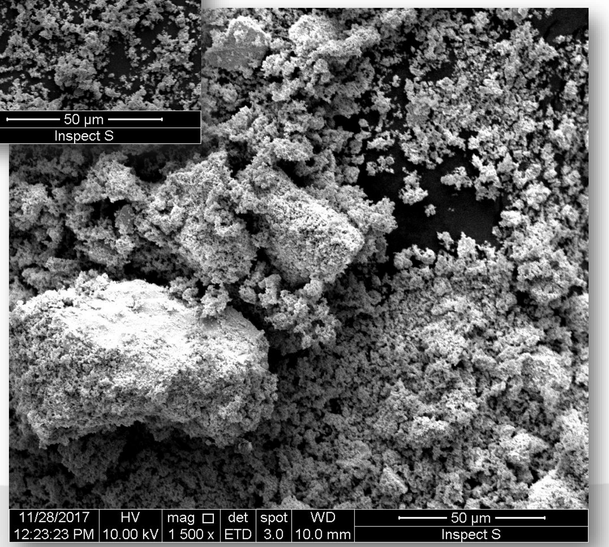
U_3O_8 Powder sinthesis

- Route 1: Thermal calcination UO_2 at 700°C
- Route 2: Dissolution UO_2 in nitric acid, Precipitation of ADU, and calcination at 700°C
- Route 3 (posible): Calcination of Uranium nitrate (solid) at 650°C





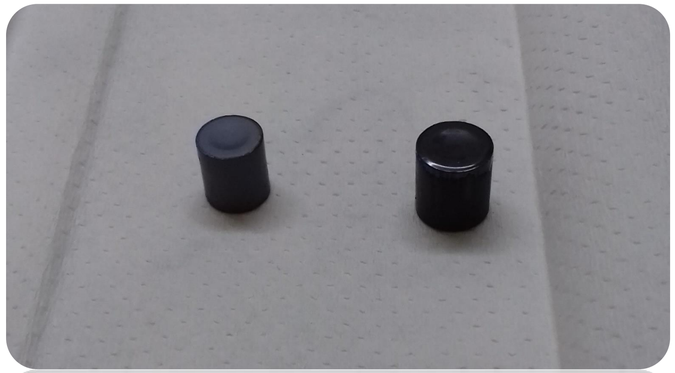


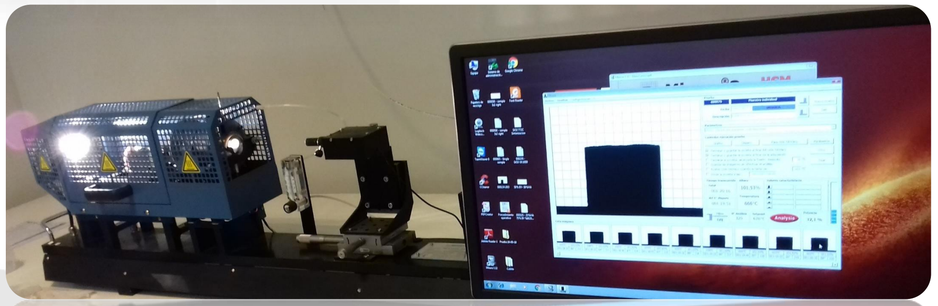


PROJECT CERUS

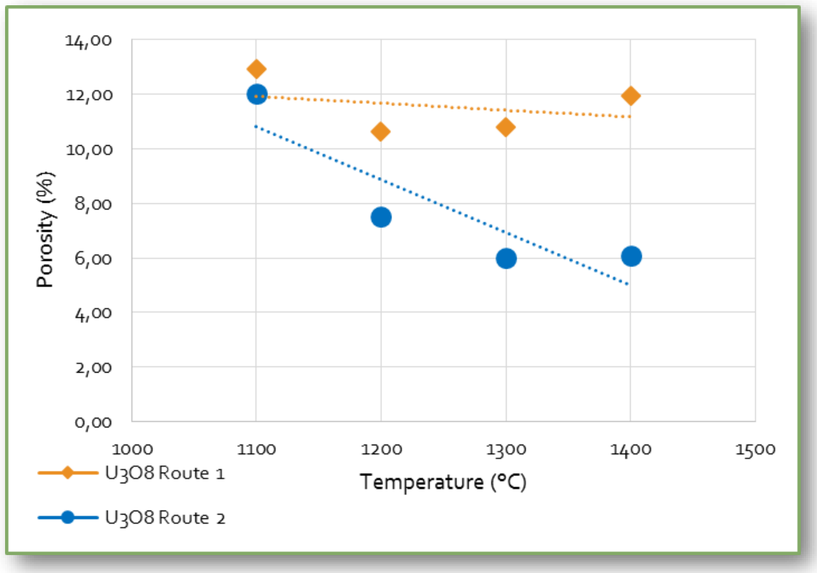
Pellets

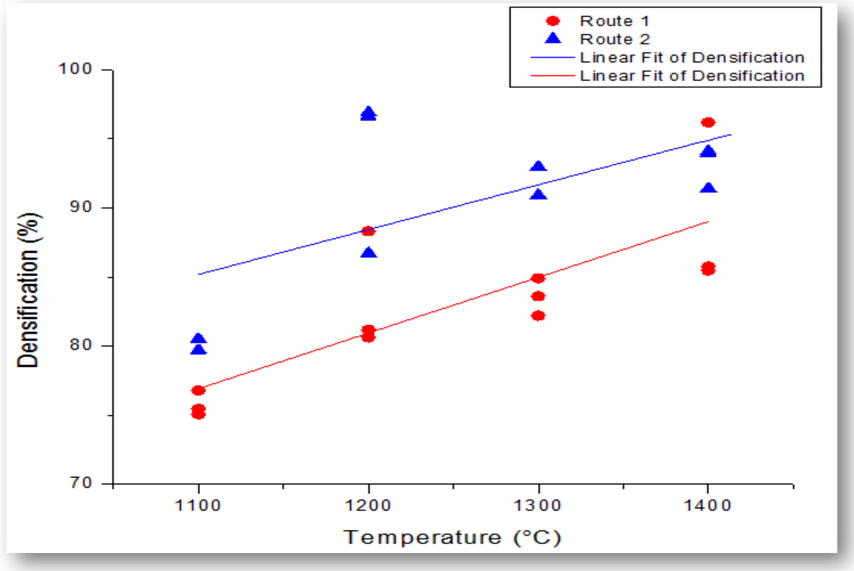
- Pressed at 432, 504, 576 y 752 Mpa, SS matrix Ø=9.2 mm
- Sintered at 1100, 1200, 1300 and 1400°C
  - Geometric density
  - Water and Hg immersion to obtain density and porosity
- HSM pellet 490 Mpa, 1300°C. Ø=4 mm





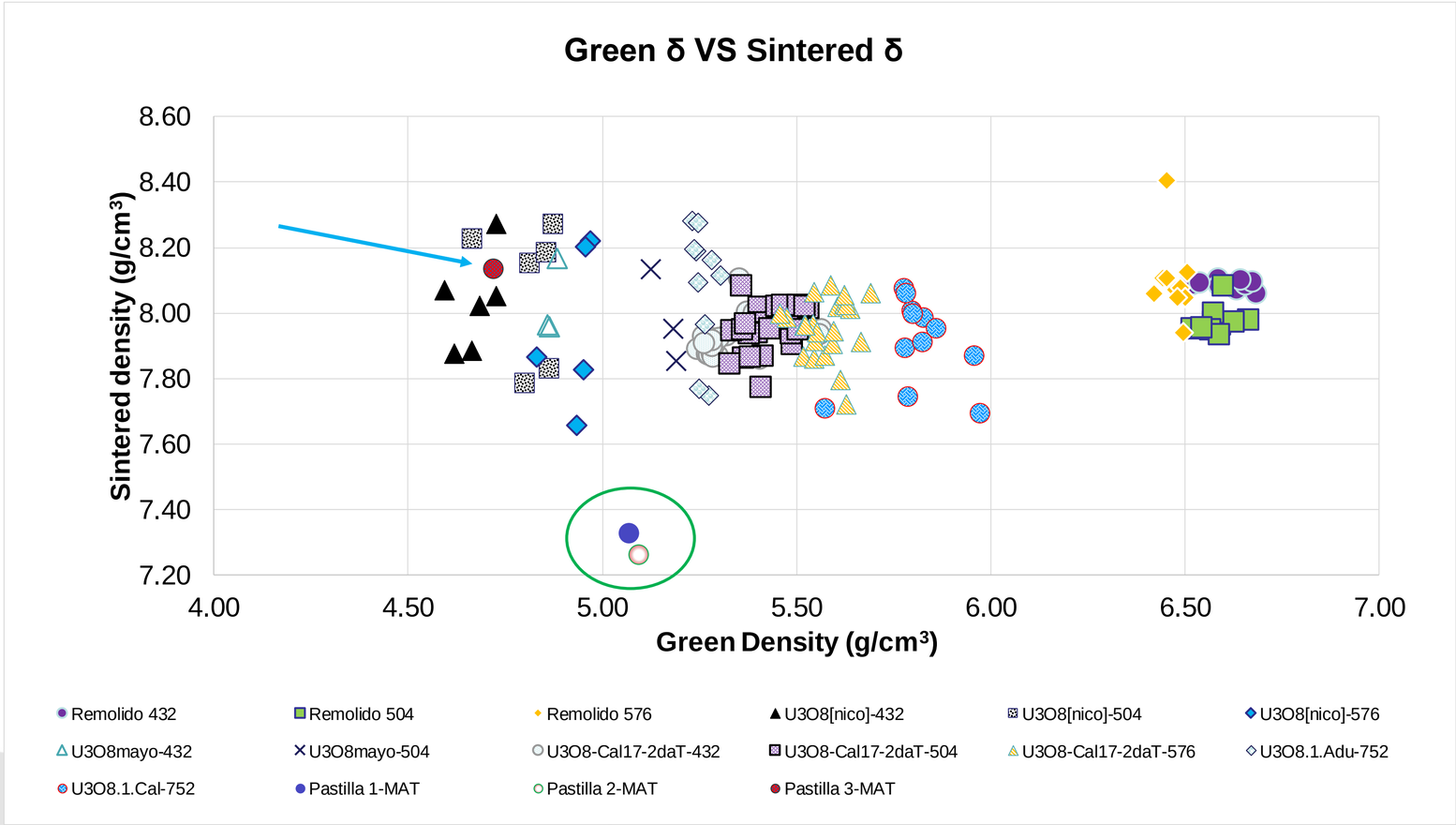
PROJECT CERUS





PROJECT CERUS

Pellets



PROJECT CERUS

U_3Si_2 - Al plates

Conclusions and Outlook

Conclusion

- The U_3O_8 powder was successfully obtained by three routes
- Best ceramic matrix is obtained by ADU route (densification, porosity)
- Succesfully oxidized and milled the Al-plate

Outlook

- Mix of oxidized Al-plate + U_3O_8 (ADU), press and sintered
- Characterize pellets
  - Mechanical behavior
  - Chemical behavior
  - Porosity
- Scaling in size the pellets

Thank you very much
for your attention!

Comisión Nacional de Energía atómica

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