

(CNEA - REPO-29)

CNEA-NT 25/87

GEOLOGICAL AND GEOPHYSICAL
INVESTIGATIONS AT SIERRA
DEL MEDIO MASSIF-ARGENTINA

Perucca*, J.C.; Llambias**, E;
Puigdomenech, H.H.; Cebrelli, E. Castro,
C.E.; Grassi, I. and Salinas, L.I.

REPUBLICA ARGENTINA
COMISION NACIONAL DE ENERGIA ATOMICA
Dependiente de la Presidencia de la Nación
GERENCIA DE PROTECCION RADIOLOGICA Y SEGURIDAD

CNEA - REPO-29

CNEA-NT 25/87

GEOLOGICAL AND GEOPHYSICAL
INVESTIGATIONS AT SIERRA
DEL MEDIO MASSIF-ARGENTINA

Perucca*, J.C.; Llambias**, I.;
Puigdomenech, H.H.; Cebreli, E. Castro,
C.E.; Grassi, I. and Salinas, L.L.

Este trabajo fue presentado en el V Congreso Internacional sobre "Geología Aplicada a la Ingeniería", realizado en Buenos Aires, Argentina, del 20 al 25 de octubre de 1986.

* Institute of Mining Research, National University of San Juan, Argentina.

** Member of the CONICET, Argentina.

BUENOS AIRES
1987

INDEX CLASSIFICATION AND KEYWORDS

B52.00

GEOLOGY

GEOPHYSICS

ROCKS

UNDERGROUND DISPOSAL

GEOLOGICAL AND GEOPHYSICAL INVESTIGATIONS AT SIERRA DEL MEDIO MASSIF-ARGENTINA.

Perucca*, J.C.; Lambias**, E.; Puigdomenech, H.H.;
Cebrelli, E.; Castro, C.F.; Grassi, I. and Salinas, L.I.

ABSTRACT

Geological investigations were performed at Sierra del Medio (Cushamen County, Chubut Province in Central Patagonia), a mountainous massif of about 25 km by 8 km of migmatitic origin, which emerges from a depressed tectonic trench or graben called Pampa de Gastre. The most ancient rocks belong to biotitic and amphibolitic schist that passed almost entirely to tonalitic migmatites with a second process producing granitic rocks. Boreholes were drilled on the basis of conclusions from Landsat satellites imagery and aerial photographic sets, followed by field work on geological, petrographic, geophysical and hydrogeological features at surface, structural interpretation supported by geostatistical computations.

Two sets of boreholes were drilled to investigate subsurface rock behaviour at 300 m depth and 800 m depth respectively, beginning at peripheral places and ending at the central part or selected site. Basic purposes of boreholes were to define structural and petrographic features of the rock massif by a good comprehension of master joints and faulting distribution with its belts of alteration mylonitization or brecciation, mechanical properties of samples, chemical composition and variations, petrographic facies and mineralogy.

Boreholes provided data to investigate joints, faults and dikes as general discontinuities for hydraulic research like permeability or effective hydraulic conductivity, and their geostatistical modelling.

Boreholes are also being prepared for geophysical logging from which logthermal ones have already been completed.

RESUME

Les recherches ont été faites à Sierra del Medio (Dep. Cushamen, province du Chubut) ce petit massif montagneux migmatitique émerge comme un horst sur le nivel d'une depression tectonique connue comme Pampa de Gastre.

Des schist biotitiques et amphibolitiques sont les roches plus anciennes lesquelles ont été transformées presque complètement en migmatites tonalitoïdes et après granitisées jusqu'à granitiques migmatitiques. Les sous-sol a été investigué avec des sondages a carottage dont leur positions furent choisies en employant des études préalables sur images Landsat, photographies aériennes; et enfin sur le terrain en faisant des travaux

g eologiques, p etrographiques, g eophysiques et hidrog eologiques. Une interpretation structurelle a  t e obtenue par g eostatistique a l'aide d'un ordinateur.

Deux groupes de sondages ont  t e faites: L'un jusqu'  300 metre de profondeur, dans la p eripheries et l'autre jusqu'  800 metres dans le centre de l'air choiss e.

Ces sondages ont permis de conna tre les caracteristiques structurelles et p etrographiques du massif, principalement si elles que concernent les "Master joints", la distribution des failles avec les zones d'alteration, milonitization ou formation de br eche; les propriet es mecaniques des carottes, et leur composition chimique, p etrographique et min ralogique. De m eme, ceux-l a, ont  t e utilis es pour l'investigation des joints, failles, et filons rocheux comme des discontinuit es pour la recherche hydraulique (permeabilit e, et conductivite hydraulique effective) et leur modellation g eophysiques de lesquels on a fini d ej a les sondages th ermiques.

1. INTRODUCTION

Sierra del Medio, a gentle small range located in the Province of Chubut was, as first step, studied using vertical aerial photographs at a scale of about 1:40.000 with the control of field surveys. Taking this approach as decision base, a central sector having structural and petrographic characteristics with an adequate homogeneity and appropriate conditions to work as geological barriers was selected.

Consequently, with the geometric support of good topographic and cartographic surveys, petrographical, structural, hydrological, geomorphological, geophysical and geochemical studies were carried on.

This paper presents some of these subjects emphasizing not only the geological and geophysical studies but also the data geostatistical processing obtained on surface and at depth carrying out drill diamond boreholes.

2. GEOLOGICAL ASPECTS.

In order to achieve the geological outcrop cartography and sections, common geology stages were followed beginning with stereographic photointerpretation at a scale of 1:40.000 with field surveys, detected unit sampling, planimetric plotting of the overall region, microscopical investigations of each petrographical facie and physico-chemical and chemical analysis.

Figure N o1 shows a summary with the most important Sierra del Medio geological features.

The ancient rocks are biotitic schists with sillimanite and amphibolic schists yielded by a regional metamorphism. They are supposed as being of the pre-Cambrian or Lower Paleozoic age. As an intense migmatization changed almost every former rock into tonalitoid migmatites, only small and space relicts are present nowadays in Sierra del Medio. The age of this migmatic process is still unknown, but it could be assumed as pre-Cambrian or Lower Paleozoic.

The neosom and paleosom relationship gives rise to a certain arrangement that constitute the rock structure. These structures have been described according to Mehnert's nomenclature (1969).

Tonalitoid migmatites were partially granitized and profusely intruded by aplite-pegmatites hydrothermal fluids yielding granodioritoid migmatites and migmatitic granites. They are considered as being also of pre-Cambrian to Lower Paleozoic age. Every migmatite and migmatitic granite underwent cataclasis. Subsequently, dacite dikes unaffected by cataclasis were intruded so they are either of the Upper Paleozoic or Lower Triassic period (K/Ar dating).

Once the above mentioned dacite dike intrusion took place, left-strike-slip displacement faults with a north-western/south-eastern trend were formed. They constitute a couple originating a tension-fracture system with a predominant north-eastern/south-western trend, partially filled with basic dikes probably of Triassic age.

For a long time Sierra del Medio underwent a strong erosion period giving rise to its present configuration. During the Upper Tertiary fracturing processes have raised it as a "horst" in the central part of the Gastre great ditch graben.

The internal portions of this migmatitic massif were directly known by means of diamond drillholes cores. Two different groups of DDH were performed according to their objectives and length (Figure N°2). The former group was called "Intermediate Drillholes". They were disposed in a pattern so as to define the whole Sierra del Medio rocky massif structural and petrographic features. Different sets of main fractures and either their probable alteration or milonitization or breccia stripes were located and investigated. Rock mechanical features, their chemical composition, their petrographical facies and mineralogy were studied, as well.

According to the initial conclusion from surface geological research, structural photointerpretation and geophysical surveys (refraction seismic and resistivity), the various DDH were located taking into account some sites with the following behaviour:

- a. Those where surface features showed significant geologic anomalies.
- b. Those having petrographic and tectonic phenomena that originated bad-quality outcrops.
- c. Those where surface rocks outcrops were of an excellent mechanical quality.

There were nine intermediate drillholes covering in all 2,002 vertical metres with a mean core recovery of 90%.

The latter was called "Deep Drillholes" group. Four drillholes were performed in a selected area of Sierra del Medio and basic data for Engineering Preliminary Planning were obtained.

Geological criteria plus geostatistical estimation results defining the minor bi-dimensional fracturation area were considered so as to locate each drillhole.

From these numerous investigations a zone of 24 km² was taken into account because it looked as if it was, at first, the best one all over the Sierra due to its petrographical, structural and mechanical features.

A total of 2,272 m were drilled in three vertical and one inclined wells (Figure N°3).

3. SITE GEOSTATISTICS

Based on the methods employed by traditional geology, the study of the minor fracturation rocky volume in the central sector of Sierra del Medio was carried out.

A data geostatistica¹ processing was also fulfilled. Applying geostatistics to the structure study it was possible to estimate not only the fracturation density variability characteristics but also the mistake made in the different estimations.

The N/L parameter behaviour was modelled on surface during the first stage of this work.

The universal krigage applications allowed to obtain the N/L mean values and their corresponding krigage typical deviations.

In this way a good correspondence between the estimated N/L model and the detailed geology survey was obtained.

Finally, a three-dimensional fracturation model arised complementing the geostatistical results with the geological studies.

4. GEOPHYSICAL INVESTIGATIONS

Geophysical investigation was aimed at knowing the behaviour of the massif limbs in order to define its extension beneath the modern overburden surrounding it since there were two possibilities: either gradual descent following the slope of the outcropping flank or sharp descent in fault blocks of subvertical walls. Results showed the behaviour of the hill as that of a fault block structure. This problem was treated using refraction seismic and resistivity

Geophysical methods were also used to define the thickness of the weathered layer at the center of the rock massif. For this purpose, an at-tempt was made to correlate seismic wave velocities with rock quality or RQD (rock quality designation) and frequency occurrence per unit length or N/L.

This correlation was good as later shown by cores from the wells.

Results obtained mathematically and from geophysical sounding and logging were good as later show by support drilling.

The accuracy and detail of non available information could be substantially improved by pilot scale (tunnels and shafts) mining work, which is out of the reach of the research agreement for the time being.

In orden to obtain geothermal gradient information and correlate thermal anomalies with possible graoundwater flow, temperature log measurements were performed.

Seismic refraction surveys were done using an ABEM TRIO seismograph with 12 transistorized channels and a sensitive paper recorder. The west-east trending lines with a length of a 1.300 m and line spacing of about 400 m were shot at the central body of the massif. Explosive sources were located every 110 m.

Electrical vertical sounding on modern accumulations (outwash and down-going fans) was carried out using Schlumberger symmetris 4-electrode arrays with a maximum AB spacing of about 1.000 m when working on the valleys around the Sierra.

Temperature logging was performed using a TI 51 S.E.A. probe, manufactured in Argentina, for measuring within 0.5°C equipped with and 800 m coaxial wire and temperature/depth digital reading. From data obtained in the course of the above mentioned surveys, it was concluded that Sierra flanks deepen almost vertically to the sedimentary cover surrounding it with no other blocks occurring down to 500 m depth. Thus, it can be concluded that the Sierra flanks are defined by dip throw fault planes.

When applying the above mentioned seismic refraction surveys on the granitic massif to the determination of the mechanical quality of the rock, it was noted that the low wave velocity (1.000 to 1.500 m/s) weathered layer was up to 150 m thick in surrounding areas or downgoing flanks the Sierra, whereas at the central part, the thickness of the weathered horizon appeared very shallow with apparent velocities higher than 6.000 m/s for sound rock from 20 m depth on.

The results obtained during the surveys satisfied the original requirements: seismic data match those from drilling holes where rock quality (RQD) and number of fractures per meter (N/L) were measured on cores.

Because of this good correlation, shown by, the series of support diamond drilling holes performed on parameter sites, rock quality was extrapolated into areas with no drilling based uniquely on geophysical data.

From thermal loggings performed along the drillholes, a geothermal gradient of a 1°C per 40 m was found, the value being typical of tectonically stable areas. Comparing thermal logs with core geological structure logs, thermal anomalies resulting from groundwater flow could be interpreted. Such anomalies occur in fracture rich areas. First, wells were allowed to settle for about 1 year and then temperature measurements were taken every 5 or 10 m, the sensor being left approximately for an hour at each measuring site.

Further research will involve regular logging aimed at comparing possible thermal anomaly fluctuations or variations as well as controlled electric and radioactive logging. In situ hydraulic conductivity surveys will also be executed.

REFERENCES

- (1) Llambias, E. et al. "Petrografía de la formación M. Choique de la Sierra del Medio, Depto. Cushamen, Pcia de Chubut". IX Congreso Geológico Argentino. Bariloche, oct. 1984.
- (2) Proserpio, C. "Descripción geológica de la hoja 42d Gastre, Provincia de Chubut". Buenos Aires, Servicio Geológico Nacional, 1978.
- (3) Ravazzoli, J. y Sesana F. "Descripción geológica de la hoja 41c., Rfo Chico, Provincia de Rfo Negro". Buenos Aires, Servicio Geológico Nacional, 1977.
- (4) Grassi, J.I.; Perucca, J.C. y Salinas, L. "Control y ensayos perforaciones intermedias". San Juan, Argentina, Univ. Nac. de San Juan-Instituto de Investigaciones Mineras, 1984.
- (5) Grassi, J.I. y Salinas, L. "Control y ensayos perforaciones profundas". San Juan, Argentina, Univ. Nac. de San Juan-Instituto de Investigaciones Mineras, 1985.

LIST OF FIGURE CAPTIONS

- Fig. 1 Sierra del Medio: Geological features.
- Fig. 2 Intermediate and deep drillholes.
- Fig. 3 Intermediate drillholes

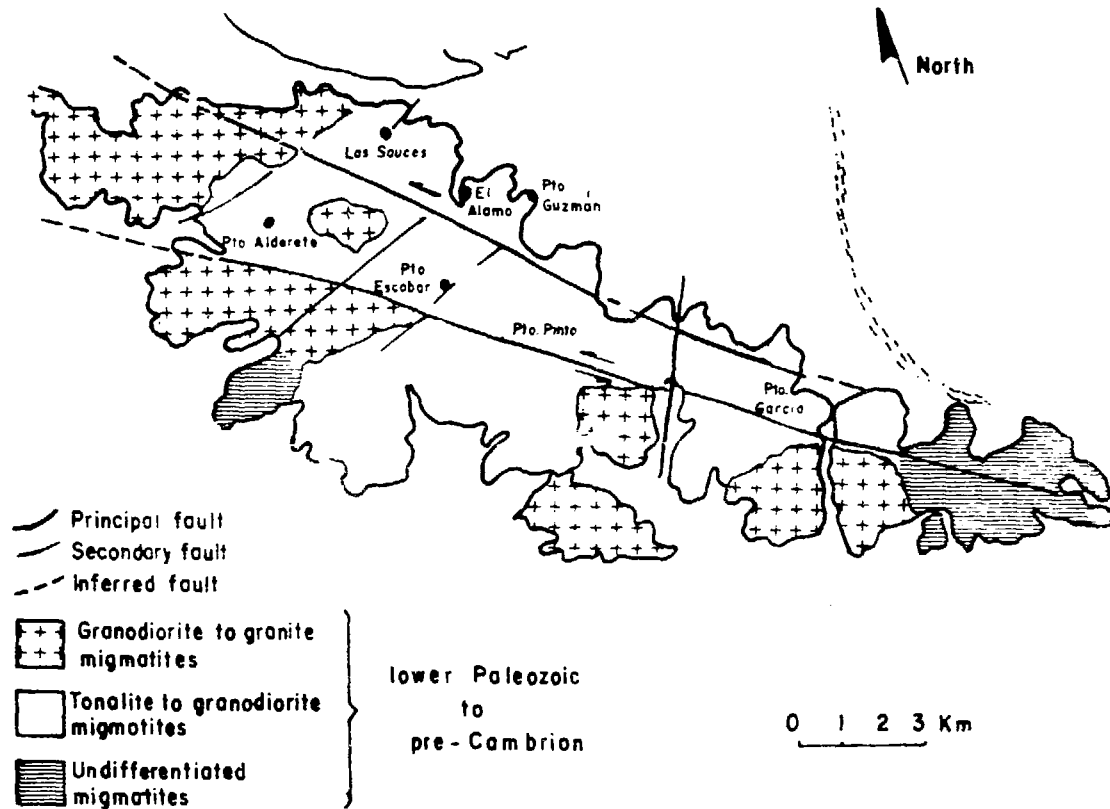


FIGURE N°1

SIERRA DEL MEDIO: GEOLOGICAL FEATURES

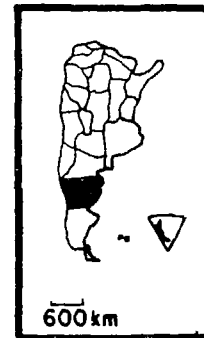
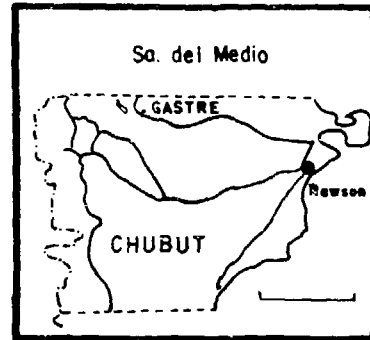
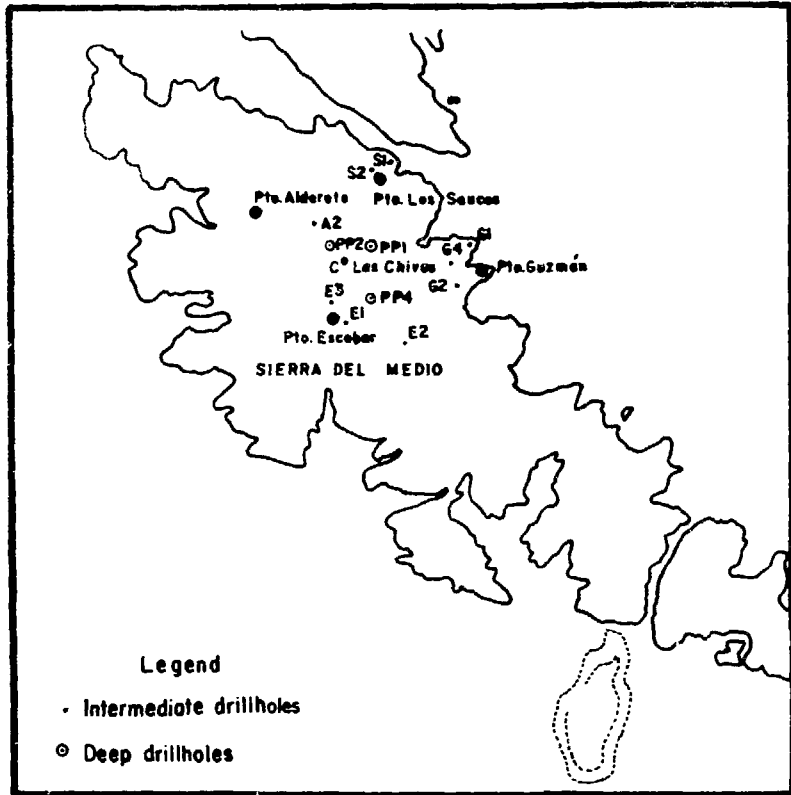
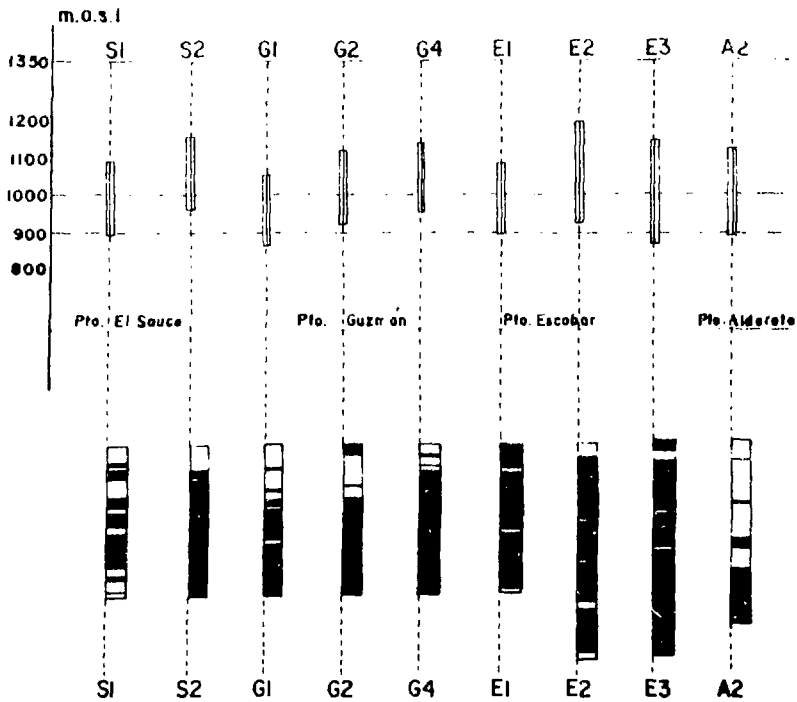


FIGURE N°2

INTERMEDIATE AND DEEP DRILLHOLES

INTERMEDIATE DRILLHOLES



DEEP DRILLHOLES

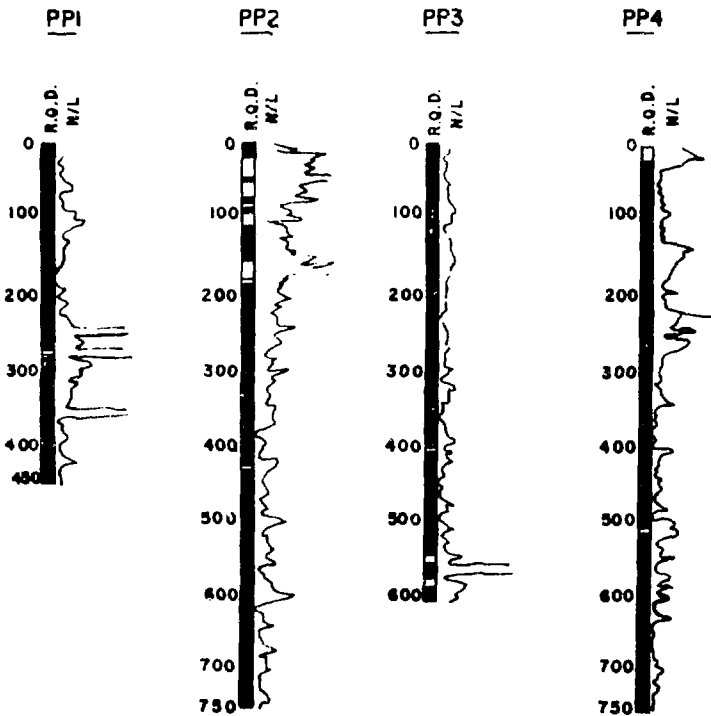


FIGURE N°3

- REPO-01 Beninson, D.; Migliori de Beninson, A.
"Radiological impact of radioactive waste management"
- REPO-02 Lucero Michaut, H.
"Aplicación de la geoestadística a la resolución de problemas estructurales en macizos rocosos homogéneos"
- REPO-03 Ventura, M.; Ferreri, J.C.
"Evolución temporal de un macizo granítico bajo cargas térmicas generadas por productos de fisión"
- REPO-04 Ventura, M.; Ferreri, J.C.
"Evolución temporal de un macizo granítico bajo cargas térmicas generadas por productos de fisión (estudio paramétrico)"
- REPO-05 Beninson, D.
"Radioactive emissions and radiation exposures resulting from nuclear power production"
- REPO-06 Beninson, D.; Lindell, B.
"Application of ICRP recommendations to radioactive waste isolation"
- REPO-07 Migliori de Beninson, A.; Cancio, D.
"Impacto radiológico de la gestión de residuos radiactivos del Programa Nuclear Argentino"
- REPO-08 Migliori de Beninson, A.; Palacios, E.
"Política en materia de gestión de desechos y su aplicación en Argentina"
- REPO-09 Palacios, E.; et al.
"Bases conceptuales para la construcción de un repositorio en la Argentina".
- REPO-10 Palacios, E.; et al.
"Estudios para la selección del emplazamiento de un repositorio en Argentina"
- REPO-11 Matar, J.A.; Girardi, J.P.; Matar de Sarquís, M.
"Aplicación de técnicas geoestadísticas al estudio de una formación granítica destinada a la construcción de un repositorio"
- REPO-12 Ferreri, J.C.; VENTURA, M.
"Numerical aspects of the study of the regional thermal impact of a radioactive waste repository"
- REPO-13 Ferreri, J.C.; Caballero, C.H.
"Difusión de calor a partir de una fuente plana rectangular finita"
- REPO-14 Beninson, D.; González, A.J.
"Radiological protection criteria for radioactive waste repositories"
- REPO-15 Palacios, E.; Ferreri, J.C.
"Marco conceptual para el desarrollo de los modelos de predicción de los efectos locales de un repositorio de residuos radiactivos de alta actividad"

- REPO-16 Ferreri, J.C.; Ventura, M.
"Aspectos numéricos del modelado de los efectos locales de un repositorio de residuos radiactivos de alta actividad"
- REPO-17 Beninson, D.
"Criterios de radioprotección en el caso de eventos disruptivos probabilísticos"
- REPO-18 Ferreri, J.C.; Grandi, G.
"Models for the study of the local effects produced by a high-level radioactive waste repository"
- REPO-19 Beninson, D.J.; et al.
"The argentine radioactive waste repository: basic criteria, preliminary siting and design conceptual basis"
- REPO-20 De Micheli, S.M. de; et al.
"Uso del plomo en contenedores de residuos radiactivos de alta actividad: estudio de resistencia a la corrosión"
- REPO-21 Peruca, J.C.; et al.
"Investigaciones geológicas e hidrológicas con procesamiento geostatístico en la preselección del emplazamiento de un repositorio subterráneo para los residuos radiactivos de alta actividad del Programa Nuclear Argentino"
- REPO-22 Varani, J.L.; et al.
"Analysis of different vitreous matrices of the borosilicatype"
- REPO-23 Varani, J.L.; Petraitis, E.J.; Vazquez, A.
"Vitrificación de residuos radiactivos líquidos de alta actividad"
- REPO-24 Varani, J.L.; Petraitis, E.J.; Pasquali, R.C.
"Evaluación de matrices vítreas para inclusión de residuos radiactivos"
- REPO-25 Russo, D.; Messi de Bernasconi, N.; Audero, M.
"Fijación de residuos de alta actividad en matriz vítrea sinterizada"
- REPO-26 Wetten, C.; Grassi, J.I.
"Hydrogeological features of a rocky massif to be used as a nuclear repository"
- REPO-27 Girardi, J.P.; Matar de Sarquís, M.
"Selection of a minimum fracturation area by means of geostatistic for emplacement of subsurface civil works of a nuclear repository in crystalline rock"
- REPO-28 Matar, J.A.; et al.
"Geostatistical investigations of rock masses. The Sierra del Medio case (Argentina)"
- REPO-29 Perucca, J.C.; et al.
"Geological and geophysical investigations at Sierra del Medio Massif - Argentina"

- REPO-30 Russo, D.O.; Messi de Bernasconi, N.; Audero, M.A.
"Inmovilización de residuos de alta actividad en vidrios sinterizados: 1) Proceso de prensado en caliente"
- REPO-31 Bevilacqua, A.M.; et al.
"Inmovilización de residuos de alta actividad en vidrios sinterizados: II) Proceso de prensado a temperatura ambiente"
- REPO-32 Ventura, M.
"Predicción de la migración de radionucleidos en un medio rocoso. Parte I"
- REPO-33 Ventura, M.
"Predicción en la migración de radionucleidos en un medio rocoso. Parte II-Caso bidimensional"
- REPO-34 Palacios, E.
"Política argentina para la eliminación de residuos radiactivos"
- REPO-35 Pahisa, M.; et al.
"Primeros ensayos vinculados a la vitrificación de residuos líquidos de alta actividad".

COMISION NACIONAL DE ENERGIA ATOMICA
Gerencia Protección Radiológica y Seguridad

	Domicilio Postal Postal Address	Télex	Facsimil	Teléfono
Sede Central (Main Headquarters)	Av. Libertador 8250 1429 - Buenos Aires Argentina	21388 PREAT AR	701 - 2431 (int. 248) (ext. 248)	701 - 2431
Centro Atómico Ezeiza Ezeiza Atomic Center	Casilla de Correo 40 1802 - Aeropuerto Ezeiza Argentina	23462 CAE PRS AR	620 - 0480	620 - 0160