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INTERNATIONAL ATOMIC ENERGY AGENCY

REPORT ON THE

REVIEW OF THE ASSESSMENT OF SURFACE FAULTING AT THE RRR SITE

LUCAS HEIGHTS, AUSTRALIA

SYDNEY (AUSTRALIA)

12 - 16 August 2002

ROME (ITALY)

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REPORT TO ARPANSA

ORGANIZED BY THE

DIVISION OF NUCLEAR INSTALLATION SAFETY

DEPARTMENT OF NUCLEAR SAFETY

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PREFACE

Following an invitation from ARPANSA, an IAEA Design Safety Review Mission was organised to assist in the review of the Preliminary Safety Analysis Report submitted by the Australian Science and Nuclear Technology Organisation (ANSTO) in support of its application for a licence to construct the Replacement Research Reactor (RRR) at Lucas Heights in June 2001. The review areas included the seismic safety of the RRR.

Several expert missions were organized by the IAEA after the mission in June 2001, to provide further assistance to ARPANSA on specific subjects.

This report was prepared by Mr. Leonello Serva (Italy) in order to assist ARPANSA in the review of the capability question of a fault, which was discovered in the foundation excavation of the RRR.

In the Mission Report of June 2001, Issue No. 2 was related with seismic hazard (PSAR Section 3.2.6.2). Comment C3 under this issue refers to lack of sufficient site investigations (in comparison with the IAEA Safety Guide 50-SG-S1, Rev. 1).

The report of Mr. Serva addresses the issues of site investigations and fault capability which are related subjects. He also refers(or does he apply it) to the IAEA Safety Guide 50-SG-S1 (Rev. 1) as the applicable standard.

The report is considered to be in line with IAEA's safety review practice.

Aybars Gürpinar
SH-ESS
October 2002

1. INTRODUCTION

Following a request from the CEO of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) through the International Atomic Energy Agency, Prof. Leonello Serva has performed a series of activities (in the periods 12-16 August 2002, in Sydney, and August-September, 2002, in Rome). The purpose was to assess the potential capability (surface faulting hazard) of a fault located in the foundation rocks of the Replacement Research Reactor (RRR) at Lucas Heights.

In particular this activity consisted of i) the review of various documents; ii) site and site surroundings field visit; iii) meetings in Australia with ARPANSA, GeoScience Australia , ANSTO and ANSTO's consultants.

2. CONDUCT OF THE ACTIVITIES

The first part of these activities has been performed in Australia (Annex 1) where it was possible to see the fault at the foundation area and in several trenches made for this purpose. This was accompanied by:

1. a careful analysis of the documentation furnished by ARPANSA (see References 1-3);
2. a field reconnaissance of the area of 5 km radius from the site;
3. a presentation given by ANSTO the licence holder and its Consultants (see Annex 2) on the results they had reached at this stage;
4. several meetings (see list of the encountered persons, Annex 3).

Preliminary comments and suggestions (contents of section 3) were e-mailed to ARPANSA from Rome immediately after:

1) the visit to Australia; and
2) a telephone conference with ARPANSA, ANSTO and Dr. Kelvin Berryman (Principal ANSTO Consultant).

Afterwards, References 4, 5 and 6 were mailed to the writer in Rome (Italy) and the main conclusions and recommendations of this Report (presented in section 4) derive from the analysis of these documents.

3. PRELIMINARY FINDINGS (made prior to review of the ANSTO submission –Ref. 4, 5 and 6)

In this section the preliminary results are based on the contents of Ref. 1, 2 and 3, discussions with ARPANSA, ANSTO and ANSTO's consultants. These results were integrated with personal observations deriving from field investigations at the site and surrounding areas.

3.1. Available data and field investigations

<u>*Region and near region*</u>

In Ref. 1 it is stated that:

1. sediments related to Quaternary stage 5 (age 125000 years) are at the present sea level. In the stable areas of the world these sediments are at an elevation of 7-8 meters above sea level. This indicates that the Sydney basin has a low rate of tectonism;
2. it is assumed, conservatively, that earthquakes can be originated at a depth of 5 km;
3. focal mechanisms are mainly compressive but strike slip source mechanisms are also present. In situ stresses show also compressive tectonism, typical of cratonic areas.

During the meeting held on 14 August 2002 it was mentioned that an earthquake of M > 5 had occurred in the near region of the site (M=5.5, Picton earthquake of 1973, at 20 km depth, about 37 km South-East of Lucas Heights).

<u>*Site vicinity and site*</u>

In Ref. 1 it is stated that:

- in the 5 km radius from the site there are no lower Quaternary sediments in the valley floors (that is 100-120 meters below the plateau where the site is located), therefore it is not possible to trench in this area across the trace of the fault to date its possible Quaternary movements;

- in the near region there are escarpments, but these are not described in detail. On the other hand the Illawarra escarpment does not have a tectonic origin;
- the fault at the foundation rocks was already inferred during the site qualification stage; the supporting data were of hydrogeologial and geotechnical type.

During the one day field trip in the site area and its surroundings it was possible to see that the Triassic sandstones, intensely cross bedded, and sub horizontal (around 5-10 degrees) present vertical or sub-vertical joints in all exposures along the road and rail road cuts. Only one possible fault (of the three mentioned in Ref 3) was observed with a questionable offset. The weathered rocks have a thickness of around 2 metres.

According to Ref. 3, a lineament was mapped by Shervin & Holmes (1986) in the site and site vicinity area. This reference however, although it furnishes a detailed mapping of the joints and fractures in the 5 km radius, does not provide data to confirm (or deny) the existence of this lineament. It is important to point out, however that only a part, around one half, of the 5 km radius area was investigated by field survey because many parts are in the Heathcote Firing Range used by the Australian Army, and thus restricted areas are present).

Two major steeply-dipping joint sets are present; one striking 05-10 degrees and the second 100-130 degrees. It is reported that, this set of joints is related to stress release after folding or derives from extensional strains related to the opening of the Tasmanian Sea about 83 to 53 millions years ago.

There are three dominant sets of faults striking 005, 110 and 155. Ref. 3 which was Task 1 of the IGNS fault assessment study stated that the maximum offset of 005 family is 15 meters while the others are much bigger, but no numbers, or reasons are given. It is also stated that the faults are visible in coal mines, but the location of these coal mines is not reported in the Task 1 study. Three dykes are also reported in

Ref 3 in the near vicinity of the plant, the closest one is striking 013 degrees and extends 1.2 km, the second one strikes 020-028 degrees for a length of 2.8 km. The third one strikes 020 degrees and is 1 km long.

The field investigation did not reveal the presence of faults where superficial material was preserved; however a number of minor faults were found in the weathered rocks, with maximum vertical offset of 0.3 meters. It is stated that other faults of this type cannot be excluded in the area and a discussion of their origin has still to be made. The presence of the closest presumed dyke has been investigated and its existence was questioned in Ref 3

In conclusion, the Task 1 report (ref 3) states that no faults displace near surface material; this suggests that the faults are not young.

Meeting of 14 August

During the meeting of 14 August 2002 the following were established:

1) data from tunnels in the Sydney area (about 25 km from the RRR site) were used to understand density and type of faults in the near region. Most of them are of normal type and a few of reverse type. Offsets are compatible to the one found at the site. Strike slip component, however, cannot be excluded. This data and the data from the coal mines (see below) have been used together with the Task 1 data (Ref. 3) to define the regional and near regional tectonics;
2) according to Dr. I. Mumme (ARPANSA Consultant), a coal mine exists in this region, around 10 km away from the site;
3) in the coal mines analysed by Dr. Kelvin Berryman and his staff, there are two types of fault with directions NW-SE and N-S. However not all the faults have been mapped;
4) age dating: luminescence method performed in the material of the weathered/alluvium/diluvium layer gave, from the top to the bottom, 14ky, 22ky, 40ky 82ky and 150ky. This indicates that if the dating is correct, this material is not the weathering of the bottom rocks. At the time of the

meeting there was no dating data coming from the analysis of the fault gouge. However, according to ANSTO, the age dating information will be available in the near future. (see Refs 4, 5 and 6 discussed in section 4)

3.2. Preliminary conclusions from IGNS Task 1 and the Site Visit

From the information given by the reviewed documents (Ref.1, Ref.2 and Ref.3) and confirmed by the visit to the site surroundings and site area(including the reactor area and the several trenches) it is possible to conclude that:

1) it is very reasonable to infer that the site area geology and tectonics well represent the geology and tectonics of the 5 km radius area. However an ad hoc database of this area should be compiled. It should contain all the geological/tectonics elements inferred by literature data and by the results of *ad hoc* investigations (see IAEA 50-SG-S1, Rev.1);
2) in the reactor area excavation, it is clear that the fault, divided into two branches, is a normal fault with a maximum displacement in the Triassic sandstones of 1 metre. One branch of the fault shows also a possible reverse movement that according to the ANSTO Consultants is indicative of the reactivation of this fault in the current tectonic regime of this part of Australia, that has existed for the past 20 million years.
3) By a preliminary set of paleomagnetic data it is possible to state that the last movement of this fault is not younger than, at least 800000 years. However this age can be much older and new datings are expected for a definitive assessment of the last movement of the fault. (see review of Refs. 4, 5, and 6 in section 4)
4) In two trenches it is possible to see that this fault does not disturb a probable alluvial/eluvial or weathered rock ("soil"), stratum.

Taking into account the content of the IAEA 50-SG-S1, Rev.1 regarding the criteria for assessing fault capability in intraplate areas, although 800000 years represent a long interval, it would not be considered adequately conservative in comparison with the 20 million years that represent the age of the present tectonic regime of this part of Australia.

As discussed in section 4 it was, therefore, necessary to obtain more precise dating of the last movement which occurred along this fault. The author considers that adequate geomorphological considerations should be used in assessing the nature of the alluvium/eluvium/"soil" material, cited above, which was not affected by faulting. This could represent a significant reference datum for the definition of the last movement of the fault. In this regard, it is necessary to define the nature of this material and later to perform a model for its formation and potential complete erosion.

The fault gouge materials could be also used for this purpose. Suggestions on this item were given during the meetings and discussions with ANSTO and ARPANSA by both the author and the Geoscience Australia consultants.

During the discussions the author also suggested that further consideration should be given to the style and amount of faulting at the site, site vicinity and near region of the site (including the Lapstone Structural Complex). This is because during the 14 of August meeting, the ANSTO Consultants pointed out the possible capability of the Lapstone Structural Complex. If this is the case, reconsideration should be given to the conclusions given above. In this line it will be important to assess the type of capability of this feature in the context of the current tectonic regime of Australia given by the focal mechanisms and in situ stresses (see section 4 and the discussion on the Lapstone Structural Complex). A geological cross section showing its style and amount of faulting could be beneficial for its complete understanding.

It is recommended to update the PSAR Report in order to include these new data and also to eliminate misleading statements given in its different Sections; e.g. geotechnical chapter, seismological chapter (conclusive statements on the shallow earthquakes, such as the Picton earthquake, are expected).

The seismicity maps are very difficult to read therefore an additional one, including only the events equal and/or greater than Magnitude 4, could be very beneficial in any revision of the PSAR.

The inclusion of other data discussed during the meeting dealing with the absence of capable faults in the near regional and regional areas of the site should also be included.

4. DISCUSSION OF THE FINAL RESULTS

ARPANSA provided the author with a copy of the submission from ANSTO on the site geological investigations for the replacement reactor at Lucas Heights. This consisted of three reports (Ref 4, Ref 5 and Ref 6) that included the details of:

- The site excavation fault assessment
- Investigations from additional trenches dug as part of the near site studies
- The fault ageing studies undertaken for the faults
- Consultant Reports
- Peer review reports

The author has summarised the main findings of these reports and made some comments on the findings in the report sections below.

4.1 Studies in the Near Region and Vicinity of the Site

Near regional study

The Sydney basin extends northwards from Bateman's Bay to approximately 200 km north-northwest of Botany Bay. The main faulting activity in the Sydney Basin occurred as a result of the Tasmanian Sea opening 83-53 million years ago.

Typical fault displacements are less than 15 m but occasional displacements of up to 100 m and bed dips of $< 5°$ have been reported.

The Lapstone Structural Complex is a prominent tectonic and physiographic feature of the Sydney Basin. It consists of a number of related folds and faults, trending generally north-south, coincident with the eastern margin of the Blue Mountains. It is located about 60km west of Sydney and 35 km west of Lucas Heights. The complex is more than 100 km long and generally about 2 to 5 km wide.

Detailed analysis of faults from the Southern Coalfield (south of the RRR site) and from tunnels excavated within Hawkesbury Sandstone (north of the RRR site) indicate predominantly net normal fault displacements on two main sets which strike approximately northwest and north to north-northeast. Analysis of these data confirm that:

- faulting has been observed throughout the region and mapped extensively in the coal mines and as part of tunnel data for new roads and water/sewage transport channels;
- the two main fault directions in the region are northwest and north-northeast. In displacement terms, the northwest striking faults are the dominant set. The fault strands on the RRR site belong to the north-northeast set;
- normal faults have been seen, on average, every 150 metres in the tunnel data and apparently reverse faults every 1-3 km. These sets of faults have generally small displacements (less than 15 metres) considering their age;
- the geology and fault characteristics of the RRR site are consistent with the general pattern of extensive faulting that persists in the local region, a region of low tectonic activity.

Site vicinity and site areas

Fault and lineament data, compiled from rock exposures (i.e. road cuttings, natural exposures along tributaries of the Woronora River, and quarry walls) were examined in an area up to 5 km from the RRR site. Existing data were compiled from published reports. Fieldwork was carried out following completion of the desk study that included an aerial photographic interpretation of available colour aerial photographs. The study concluded that field reconnaissance of accessible soil and rock exposures within 5 km of the RRR site, revealed only a few small-scale normal faults with displacements less than 0.3m. None of these faults displaces soils and near-surface material.

As already indicated during meetings in Australia, taking into account also the near regional data, it is reasonable to infer that the site and site vicinity areas geology and tectonics well represent the geology and tectonics of the near regional area. However a more complete database of these two areas, as recommended in the IAEA 50-SG-S1, Revision 1, is still lacking.

4.2 Fault capability assessment

The two faults found at the foundation rocks of the RRR site strike to the north-northeast (000-020°), dip steeply (mostly 65-80' east and west) and have dip separations of c. 1-1.3 m (the eastern strand) and c. 0.20-0.32 m (the western strand), which are seen in the reactor excavations. Some smaller faults are clustered around these dominant structures.

In net displacement terms, the eastern fault strand is an apparent normal fault and is the dominant fault trace observed at the RRR site. The fault extends for at least 140 m across the site in a north-northeast direction (mean strike 013') and dips steeply to the east (mean dip 67°). Within the area comprising the footprint for the Reactor Building, the fault has a constant dip separation of c. 1-1.3 meters up through the rock sequence and across the excavation.

The western fault strand is the second largest faulting trace observed at the RRR site and has apparent displacement in an opposite direction to the normal fault. This fault trace extends for at least 120 m across the site in a north-northeast direction (mean strike 009°) and dips steeply to the east.

The two main fault strands converge in the northern part of the site to form a single fault zone.

Several of ANSTO's (see Ref 5) Consultants examined the information and two alternative interpretations have been proposed.

1) In the first interpretation both the eastern and western strands were formed during the opening of the Tasmanian Sea, i.e. 53-83 million years ago, and inhomogeneity in the strata or the stress field influenced the nature of the movement on the western strand. This hypothesis is supported by two main arguments. First, the fault plane dips at a somewhat steeper angle than would be expected for a true reverse fault. Second, and more important, the exposure of the same fault on the north face of the main excavation is normal in character and downthrown to the west. Further a series of small dykes up to approximately 0.5 m wide occurs to the west of the main excavation, which predates any potential fault movement. The dykes occupy a set of fractures that have a similar orientation to the normal faults and do not appear to have seen any significant disruption.

2) In the second interpretation, the eastern and western strands are part of a system that initiated as a normal fault system, formed during the Tasmanian Sea opening, 53-83 million years ago, with reverse reactivation occurring on one of the strands, and possibly both. This is the most conservative explanation because the reactivation is inferred to have occurred more recently than the Tasmanian Sea opening.

Three approaches were used to constrain the age of the last faulting in the foundation excavation for the RRR**.** One was to find and date material from the region of the fault itself. The second was to analyse borehole material to date a pervasive deep weathering episode that followed fault movement. The third was to trace the fault to an area where there was overlying material that could be studied, both in terms of geomorphology and for dating purposes. An assessment of the age of nearby related dykes was also made. A number of trenches were dug to trace the fault across the site and a trench was dug to the north of the site, where the fault was evident in the bedrock and where the younger overlying material was clearly not affected by the fault.

A wide range of possible dating methods was considered. For this study, both direct numerical dating and relative dating methods were used. These included:

- study of the geomorphology and geochronology of the material in a trench where cover existed above the fault;
- optically Stimulated Luminescence (OSL) to date the unfaulted strata that overlie the fault in the trench;
- paleomagnetic dating using the magnetic signature of the rocks and relating that to the information known on magnetic reversals and on movements of the earth's magnetic pole. This was done both for material crossing the fault and with samples taken at various locations in trenches;
- fission track and (U-Th)/He dating of borehole material. The results constrain the total depth and timing of deep erosion which has occurred over the area and provide another minimum age estimate for the time of faulting.

The results obtained provide a consistent picture of the age of the material in the fault and overlying the fault.

The Optically Stimulated Luminescence data give consistent ages of the overlying Quaternary material that range from 14,000 years in the upper aeolian layers to greater than 104,000 years in the sand layers above the fault itself. There was no evidence that these layers have been displaced by the fault. Given the fact that this material appears to have been transported to the site and may have been subject to various removal and replacement cycles, these ages are much younger than the fault itself.

On the basis of the thermo chronology, a consistent picture emerges of the major episodes of movement and deposition. The age of the deep weathering episode, which post-dated the fault movement, provides an unambiguous constraint on the last possible time of fault movement and gives an interval of 35-10 million years since the last movement.

Paleomagnetic results of ferruginous material precipitated along bedding in bedrock across the fault and post dating any movement along the fault provide a direct assessment of the limiting age of the most recent movement of the fault. Analysis of the iron oxides in this material yields a mean age of 9 million years and not younger than 5 million years. That is, using the most conservative interpretation, there has been no fault movement for at least 5 million years.

The two main sets of criteria for assessing capability are those from the US Nuclear Regulatory Commission (NRC) and the International Atomic Energy Agency (lAEA). The findings of the investigations are here compared with the more conservative criteria from the IAEA.

The IAEA Safety Guide (50-SG-S1, 1991) sets out criteria for determining capability. The basis for answering such a question should be the database of geological and seismological investigations. Using the IAEA definition, a fault shall be considered capable if:

1) It shows evidence of past movement or movements of a recurring nature within such a period that it is reasonable to infer that further movement at or near the surface can occur. (In highly active areas, where both earthquake and geological data consistently reveal short earthquake recurrence intervals, periods of the order of tens of thousands of years may be appropriate for the assessment of capable faults. In less active areas, it is likely that much longer periods may be required.)

As discussed in Ref. 4, the most recent fault movement is at least 5 million years old and it is reasonable to infer that it could be also much older. The author agrees that 5 millions years, compared with the duration of the present tectonic regime, is, in any case, considered long enough, to prove the non capability of the fault.

2) A structural relationship has been demonstrated to a known capable

fault such that movement of the one may cause movement of the other at or near the surface.

The nearest known possible Capable Fault to the site fault is the Lapstone Structural Complex located approximately 35 km west of the site. Because of this substantial distance no secondary movement is expected to occur on the site fault. In addition, a considerable amount of geological and geophysical investigation has taken place between the Lapstone Structural Complex and the coast, related to coal and gas exploration. These investigations have proved conclusively that similar zones to the Lapstone Structural Complex do not extend further east towards Lucas Heights. Structural geology considerations also place the Lapstone Structural Complex in a separate tectonic zone, west of the coastal zone in which the site occurs.

3)The maximum potential earthquake associated with a seismogenic structure, as determined in section 4 (of the IAEA guide), is sufficiently large and at such a depth that is reasonable to infer that movement at or near the surface can occur.

This criterion, is not necessary, since the discovered fault is not capable and the present database does not indicate the presence of significant seismogenic structures in the site and site vicinity areas

4.3 Conclusions

Main conclusions and recommendations, here reported, derive from data reported in Chapter 3 and from the review of ANSTO Reports (Ref. 4, 5 and 6).

References 4, 5 and 6, answers all the important questions pointed out in Australia (see section 3). The answers to the others, can be easily incorporated in the suggested updating of the PSAR. This is necessary, in order to include the new data and to eliminate confusing or misleading statements given in its different PSAR Chapters.

Ref. 4, in particular, using suitable data, gives assurance that the last faulting occurred at the fault found at the foundation of the RRR, is extremely old. As a minimum and in the most conservative case, the fault is older than 5 million years; therefore, according to the IAEA criteria, it is not considered a *capable fault*. In the writer's opinion, this is also confirmed by the presence of the unfaulted *saprolite* layer in trench N.4 (Attachment 9 of Ref 5). Therefore these faults are clearly not potential seismic sources and they do not pose a surface-fault rupture hazard.

It is also clear and convincing that the Lapstone Structural Complex belongs to another seismotectonic province, therefore its potential *capability* does not affect the fault at the site.

Regarding the value of the vibratory ground motion at the site, because of the non-capability of the fault found at the foundation rocks of the RRR site, the conclusions derived in the PSAR remain valid.

4.4 Recommendations

In order to have a final and homogeneous set of data for the RRR site and to confirm the above conclusions, it is recommended:

i) to update the PSAR, including the new data described above and also to eliminate confusing or misleading statements given in its different Sections; e.g. geotechnical and seismological chapters;

ii) to complete the database of the site vicinity and site area, giving appropriate weight to what is requested in paragraphs: 311, 312, 313, 314, 315, 316, 329, 330, 331 of the IAEA, 50-SG-S1, Revision 1. This database, requested since the first IAEA mission, is, in fact, still lacking of data, such as the geological/geomorphological mapping at scale 1:5000 of the site vicinity area.

5. REFERENCES

1. RRR PSAR INVAP-ANSTO: Site characteristics, Chapter 3.2: Site characteristics. June 2001.

2. REPORT of COFFEY, 8 October 1999, S20251/1-AQ: ANSTO, Replacement Research Reactor, Lucas Heights, Report on near site investigations.

3. DRAFT document: Lucas Heights Replacement Research Reactor Project, active faulting assessment; written by P.Volk and K. Berryman, January 2002, Geological & Nuclear Sciences (It contains also conclusions of Ref. 2).

4. ANSTO Replacement Research Reactor Project. Submission to ARPANSA on the site geological investigations for the replacement research reactor at Lucas Heights. Prepared by the Australian Nuclear Science and technology Organisation, 12 September 2002. Document Number: RRRP-7500-3BEAN-002-A, Revision: A.

5. ANSTO Replacement Research Reactor Project. Additional geological investigations undertaken in support of the replacement research reactor at Lucas Heights. Prepared by the Australian Nuclear Science and technology Organisation, 12 September 2002. Document Number: RRRP-7500-3BEAN-003-A, Revision: A.

6. ANSTO- Replacement Research Project, Tasks 1 & 2- Site fault assessment. By A. Nicol, K. Berryman, R. Langridge, S. Cox, K. Simpson, P. Wolk & N. Hill. Institute of Geological & Nuclear Sciences Limited- COFFEY; Client Report 2002/103, September 2002.

7. IAEA (1991). Earthquake and associated topics in relation to NPP siting - Revision 1, Code of Practice, Safety Series 50-SG-S1, IAEA, 70 pp.

ANNEX 1 - Conduct of the works in Australia

Monday 12 August 2002: Meeting at ARPANSA, reading the documents (refs 1, 2 and 3) listed at the end of the report and site surroundings field visit with analysis of the tectonic evidences along railroad and road cuts.

Tuesday 13 August 2002:.Visit at the reactor excavation and trenches at the ANSTO site (Lucas Heights).

Wednesday 14 August 2002: Meeting with ARPANSA, ANSTO and Consultants at the ANSTO site.

Thursday 15 August 2002: Meeting at ARPANSA with John Loy (Chief executive officer) and Don Macnab (Director of the regulatory branch) Vince Diamond (Manager of nuclear installation section). Meeting at ANSTO site with Don Macnab, Vince Diamond and Ron Cameron and his staff.

Friday 16 August 2002: Meeting at ARPANSA with Don Macnab and Vince Diamond, for the report content and future activities

ANNEX 2 – Agenda for ANSTO-ARPANSA Meeting (14 August 2000)

8.30-9.00	Introduction and Background	Ron Cameron and Kelvin Berryman
9.00-9.30	Regional Geology of the Lucas Heights Region	Kelvin Berryman
9.30-10.00	Survey of faults and Fault densities	Kelvin Berryman
10.00-10.45	Questions	
10.45-11.00	Coffe	
11.00-11.45	Assessment and Evaluation of the fault on the RR site	Kelvin Berryman
11.45-12.15	Questions	
12.15-12.45	LUNCH	
12.45-1.45	Dating of the Fault	Barth Smith (University of Melbourne) Brad Pillans (ANU)
1.45-2.15	Questions	
2.15-2.30	Conclusions on the Assessment and Dating	Ron Cameron
2.30-2.45	Coffee	
3.00-3.45	Probabilistic Analysis of the Surface Rupture Recurrence	Terry Webb
3.45-4.00	Questions	
4.00-4.15	Summary	
4.15-5.00	Comments from ARPANSA	ARPANSA

ANNEX 3 - List of encountered persons in Australia

John LOY	ARPANSA
Don MACNAB	ARPANSA
Vince DIAMOND	ARPANSA
Ivan MUMME	ARPANSA consultant
John SCHNEIDER	ARPANSA Consultant GEO SCIENCE AUSTRALIA
Ron CAMERON	ANSTO
Greg WHITBOURN	ANSTO
Ross MILLER	ANSTO
Ken HORLOCK	ANSTO
Robin FAULKNER	IGNS (Manager ANSTO Cons.)
Kelvin BERRYMAN	IGNS (ANSTO Cons.)
Terry WEBB	IGNS (ANSTO Cons.)
Keith SIBSON	COFFEY (ANSTO Cons.)
Bart SMITH	Melbourne University (IGNS Cons.)
Bert SWAN	ANSTO Consultant
John CRIMSEY	ANSTO Consultant
Brad PILLANS	ANU-Canberra (IGNS Cons.)

Curriculum Vitae for
Dr Leonello Serva

BORN: October 22, 1951, at Cantalice (Rieti), Italy, Male.

EDUCATION: Doctor degree in Geology, University of Rome “La Sapienza”, (1974).

POSITIONS HELD:

Since 1977 has been working with the Italian Committee for Nuclear Energy (CNEN-DISP), later ENEA-DISP and, from January 1994, ANPA: National Agency for the Protection of the Environment; at present Director of the Unit “Natural Risks” dealing with environmental aspects of natural phenomena, such as earthquakes, floods and landslides.

Since 1982 Consultant of International Atomic Energy Agency (IAEA) as Expert in geoseismological matters about sites for NPP's and LLW. As such he has taken part in more than 80 missions in 25 countries in 4 continents

1988-1994, Member of the National Committee for Earth Sciences of the National Council of Research (CNR).

1989-1994, Member of the National Committee (at inter-Ministerial level) for the Defence against geological-hydraulic risks .

1993-2000, Member of the Steering Committee of the National Group for the Defence against Earthquakes (CNR-GNDT).

Since 1996, Expert of the European Commission, Directorate General XII “Science, Research and Development”, for the evaluation of european research projects dealing with Environmental Sciences (Natural and Technological Risks). **Since 1998** also Mid Term Reviewer of such research projects.

Since 2000, Contractor Professor at “Insubria” University of Como; course: geology and natural risks.

SCIENTIFIC CONTRIBUTIONS:

(1) Pioneering studies on the use of historical data for seismic hazard analysis, especially for NPPs and others critical facilities.

(2) Pioneering studies on the use of paleoseismological techniques in Italy and Europe.

(3) Pioneering studies on the use of paleoseismological data for seismic hazard analysis of NPPs and others critical facilities.

(4) Pioneering studies on the use of Holocene data for geologic-hydraulic hazard assessment.

SELECTED PUBLICATIONS:

A. Gurpinar, B. Mohammadioun, L. Serva and C. Stepp. (in press). Seismic hazard evaluation for nuclear power plants. Revision 2. Code of Practice, Safety Series 50-SG-S1, IAEA.

L. Ferreli, E.M. Guarneri, A. Hormes, A.M. Michetti,P. Perini, W. Rovinelli and L. Serva (in press). Evoluzione recente del paesaggio in Alta Valtellina: implicazioni sulla valutazione della pericolosità legata a deformazioni gravitative dei versanti e grandi frane. CNR-Fondazione CARIPLO, Special Issue: tettonica recente ed instabilità di versante nelle Alpi Centrali.

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