REPORT ON THE THIRD IAEA PANEL ON "PEACEFUL NUCLEAR EXPLOSIONS" - VIENNA, 27-30 NOVEMBER 1972

PURPOSE AND OUTCOME

1. The Panel was the third in a series of three which the Agency was recommended to arrange by the Working Group on Peaceful Nuclear Explosions (PNE) convened by the Secretariat in December 1969. Previous Panels were the subjects of reports KP/370/1 and KP/271/83.

2. The Agenda suggested that most of Thursday would be devoted to a general session on the Agency's role in PNE, followed by a session "Conclusions and Recommendations" on Friday morning. In the event the Chairman allowed ample time for presentation and discussion of papers which continued until mid-Thursday afternoon. The full meeting was then asked to endorse a single sheet of recommendations drafted by the Panel on Wednesday afternoon. This done, the Chairman closed the Panel one day early.

3. The recommentations of the Panel concerned the organisation, composition and timing (in one to two years time) of a further Panel on PNE and the need to examine how the Agency should respond to requests from Member States for assistance in obtaining PNE services. The recommendations are given in full in Appendix A.

PERSONALIA

4. [redacted] (Australia) again took the chair but apparently with some reluctance as compared with previous Panels; certainly he steered clear of controversy and, as indicated above, kept discussion on the future role of the IAEA to a minimum. Some 80 names are recorded in the official list of attendees (see Appendix B). The Americans and French had large teams but the Russians fielded a second eleven, apparently because of a disagreement with the Americans over the agenda; the latter had originally gone along with the Russian proposal of concentrating on cratering (uncontained) applications - possibly with the Pechora-Kama Canal in mind - but had later changed their minds. [redacted] withdrew from the original British team in order to attend a meeting in the United States. [redacted] (Canada) and [redacted] (United States) acted as Scientific secretaries; [redacted] opened and closed the meeting.

GENERAL IMPRESSIONS

5. Although the number of states represented at this third Panel meeting was larger than at the second the general tenor was at a somewhat lower level. There were two reasons for this: not surprisingly the amount of new information was small and the nuclear weapon States were not describing new projects in any detai

the Americans because they had little to add to what has already been published, the Russians because they had pretty obviously deliberately decided against releasing information on new projects at this stage.

6. Some dissatisfaction was expressed on the amount of help which the nuclear weapon States were prepared to offer the others; a number of States still appear to hope they will get "something for nothing" out of PNE. Clearly the issue of who pays will loom large in any consideration of the final trio of recommendations from the Panel.

7. There is increasing recognition that in any NPT Article V projects it is the non-nuclear-weapon States resources and people which will be involved. Some responsibility would have to be accepted by the nuclear weapon State providing the explosive and possibly also by the Agency.

8. Neither the Russians nor the UK make any statement on national policy as the agenda allowed. [redacted] the senior American, had apparently modified his statement immediately before presentation to remove some politically contentious material; he made it clear that all the American papers were to be regarded as expressing the views of their authors and did not necessarily indicate United States policy. The emphasis was on contained explosions for the recovery of natural resources, particularly gas stimulation but mentioning also oil from shale, copper from low grade ores and in situ coal gasification; geothermal energy only came up in discussion although it is being studied. In discussion it emerged that Rio Blanco, the next American gas stimulation project, is likely to take place in March or April. The latest delay was blamed on the November elections. Public relations have been handled in a much more positive way than at Rulison. The French [redacted] made a statement but the text was never issued and I was later told that it should be regarded as unofficial. It appeared that Paris was unhappy with what was said. [redacted] said that the CEA had intensified their efforts since the beginning of 1972. Work was orientated towards storage of liquid or gaseous hydrocarbons beneath the earth or the sea but other applications were not being neglected. They concluded that nuclear storage was economic for liquid hydrocarbons and that there was a possibility for such storage to be installed in W. Europe by the end of the 1970s. They had been able to corroborate American work. Present studies were less theoretical than in the past and were "applied to actual cases" (English interpretation). The programme developed during 1971 envisaged a pilot experiment for testing the technical feasibility of nuclear storage for liquid hydrocarbons by the end of 1974. There was co-operation with industry (this apparently means the French Institure of Petroleum and EIRP, the

French national petroleum company). [redacted] said they were open to international co-operation in this field and that the role of the Agency was decisive. [Note: In the absence of a written text and the apparently "unofficial" nature of the statement heard in translation it would be unwise to read too much into the above report on the French programme without seeking corroborative evidence]. In answer to a question [redacted] said that PNE was included in the Sixth Plan and referred to documents "Energy for the Sixth Plan" and the "Report of the Commission for the Finance Law 1973". He said that any pilot test would not be in continental Europe but left it unclear whether it would be on the European Continental Shelf; speaking of the general possibilities from an economic viewpoint he saw off-shore storage as the first possibility.

9. The session "Statements on National Policy" also included papers from Venezuela and Egypt on possible PNE schemes in their countries. There was a description of the project for linking the Orinoco and Rio Negro rivers which had been examined in conjunction with Stanford University (report available). Questioned on the PTBT implications of this cratering project the speaker suggested that agreements would have to be reached with nearby states. The Egyptian paper was very similar to that presented at the 1971 Geneva Conference on Peaceful Uses of Atomic Energy. Neither the Egyptians nor the Venezuelans have approached the IAEA for assistance - the only application that is anywhere near formal remains that from the Malagaysain Republic (whose billed representative failed to turn up at the meeting). However the Venezuelans are to seek help from the US Army Corps of Engineers on their canal project <u>but</u> the letter will not specifically mention nuclear explosives as a possible construction tool.

The technical papers were divided into two groups - applications and phenomenology (radioactivity and seismic effects). The oral presentations and an inspection of the text suggest that the Russian papers contain useful information and will be well worth translation. Likewise a detailed reading of two of the French papers may throw more light on the extent of their interest in storage applications. One Russian paper (PL-388/19) contains apparently new photographs of slide dam construction using large charges (several thousand tons) of conventional explosives. The most significant American paper was that from Oak Ridge National Laboratory (PL-388/9) reporting further studies on the tritium hazard in stimulated natural gas. They appear to be really coming to grips with the problem and the table comparing the risks from a product containing a low level of activity with those experienced in other commercial and domestic activities gives a particularly encouraging picture.

10. The two UK presentations were well received but naturally cannot make the same impact as papers reporting new experimental work.

11. It was useful to be given details of the Russian approach to seismic damage and to note that the Americans seemed unable to give any convincing explanation as to why the Marvel nuclear shock tube experiment resulted in a subsidence crater asymnetric in the direction of the tube. An American presentation on measuring neutron cross sections using neutron flux from an underground nuclear explosion was hardly new; not surprisingly since the last experiment was in 1969 and the author, privately, could see little prospect of further American work in this area.

12. The last paper produced a minor sensation. [redacted], the French geophysicist, stated that the United States shot [redacted] had produced an earthquake. It turned out that he was referring to Love waves generated by the destressing of regions fairly near to the explosion point, a not uncommon phenomena at the Nevada Test Site. In the absence of the written paper it is perhaps charitable to suggest that interpretation difficulties may be the cause of the trouble but the American delegation was visibly nonplussed. After the discussion the Panel should be in no doubt that there is no evidence that underground nuclear explosions cause earthquakes of comparable or greater magnitude. Any aftershocks, as with natural earthquakes, are one or two orders less in magnitude.

PAPERS

13. A summary of the Panel papers is given in Appendix C. Appendix D gives details of five other papers received during the meeting.

[redacted]
14 December 1972

[redacted]
AWRE
Aldermaston

APPENDIX A

RECOMMENDATIONS OF THE THIRD IAEA PANEL ON PNE

The following is based on the draft considered at the final session; the official version from the Secretariat may differ slightly.

The consensus of the Panel was that the Agency should continue to facilitate the exchange and dissemination of information on PNE. The panel meetings held to date had been successful in providing an opportunity for the Non-nuclear Weapon States to watch the development of the technology. However it was recognised that, partly due to the success of the information exchanges of the two previous Panels and the somewhat slower rate at which new material on PNE is now emerging, there is no urgent need for a further Panel meeting in the near future.

With regard to future PNE Panels the Panel made the following recommendations:

1. The past composition of the Panels, with representation from Nuclear Weapon States and Non-nuclear Weapon States should be continued.

2. The agenda for future Panels should be based on a number of specific PNE applications (eg gas stimulation, underground storage, mineral recovery, cratering) with working groups on specific technical topics such as rock mechanics, seismology, radioactivity.

3. The next PNE Panel should be held in one to two years time. The scheduling should be left to the Secretariat, after consultation with the Nuclear Weapon States, concerning the availability of new information.

The Panel observed that the Agency could conceivably receive requests for assistance in obtaining PNE services (ranging from paper studies to explosion services) in the reasonably near future. The facilitation of the availability of PNE-related services was recognised as a priority item by the Panel members. The Panel therefore made the following recommendations:

4. The Agency should develop detailed procedures for responding to requests from Member States for assistance in obtaining PNE services.

5. The Agency might convene a consultants meeting with representation from both potential supplier nations and Non-nuclear Weapon States to advise the Director General on procedures which would be acceptable to both groups of States.

6. The development of these procedures should preferably be undertaken before the end of 1973.

APPENDIX B

LIST OF PANEL MEMBERS AND OBSERVERS

* Denotes Panel Member

ountry		Name	Affiliation
rgentina		[redacted]	Comisión National de Energia Atomica Argentina, Buenos Aires
ustralia	*		Australian Atomic Energy Commission.
ustria			Österneichische Studiengesellschaft für Atomenergie GmbH
elgium			Ponderies Reunies de Belgique (partner in Geonuclear Nobel Paso)
razil			Instituto Engenharia Nuclear - DFN, Rio de Janerio
anada			Mines Branch, Department of Energy, Mines and Resources, Ottawa
hile			Permanent Mission to IAEA
enmark			Research Establishment, Risø
gypt			UAR Atomic Energy Establishment
rance			CEA
			SODETEG (Societé d'Etude technique d'enterprises géuérales)
			CEA
			CEA
			CEA (Montrouge)
			Centre d'Etudes Nucléaires de Grenoble
			CEA
			CEA-LDG
			CEA
			CEA
			CEA (ELF)

Country	Name	Affiliation
	[redacted]	Centre d'Etudes Nucléaires de Grenoble
		CEA
		Gaz de France
		CEA
		Institut Francais du Pétrole
Gabon		Gabon consulate
		Gabon consulate
Germany		Bundesanstalt für Bodenfurschung
		Bundesanstalt für Bodenfurschung
Holy Sea		Permanent Mission
India		Nuclear Physics Division Bhabha Atomic Research Centre Trombay
Indonesia		Permanent Mission
Israel		Israel Atomic Energy Commission
Italy		CNEN
		CNEN
Mexico		Instituto Nacional de Engergia Nuclear
Panama		Panamanian Embassy
Poland		Office of Government Commissione for Use of Nuclear Energy
Roumania		Permanent Mission
South Africa		Permanent Mission
Spain		Cabinete Tecnico de la Presidencia de la Junta de Energia Nuclear
Sweden		FOA
		Ministry for Foreign Affairs (formerly with FOA)
		National Institute of Radiation Protection

Country	Name	Affiliation
Switzerland	[redacted]	Institute für Reaktortechnik, Zurich
Turkey		Turkish Atomic Energy
UK		AWRE
		AWRE
		AWRE
USA		Lawrence Livemore Laboratory (LLL)
		US Army Corps of Engineers, Explosive Excavation Research Laboratory
		Los Alames Scientific Laboratory
		Division of Applied Technology, USAEC
		LLL
		US Arms Control and Disarmament Agency
		Division of Applied Technology, USAEC
		Dept of Civil Engineering, Stanford University
		Permanent Mission
		US Army Corps of Engineers, West Point
		US Army Corps of Engineers, Explosive Excavation Research Laboratory
		LLL
		USAEC, Nevada Operations Office
		El Paso Natural Gas
		Oak Ridge National Laboratory
		LLL
		LLL
		CER Geonuclear

Country	Name	Affiliation
	[redacted]	Division of Petroleum and Natural Gas, US Bureau of Mines
USSR		Institute of Physics of the Earth, Moscow
		" " " " "
		Hydro-Meterological Service Moscow
		Permanent Mission
Venezuela		Ministry of Mines and Hydrocarbons
		Instituto National de Canalizaciones
		" " "
EEC		EEC, Brusels
UN		Geology and Mining Section, Resources and Transport Divisio
WHO		

APPENDIX C

Technical Papers submitted to the Third IAEA Panel on Peaceful Nuclear Explosions, Vienna, 27-30 November 1972

PL-388/1 "Design of a waterway connecting the Orinoco and Rio Negro rivers in the Federal Territory of Amazonas, Venezuela" [redacted] Venezuela and [redacted] United States).

Such a waterway would greatly help the development of the territory by providing facilities for bulk transport. A canal 62 km long connecting tributaries of the two rivers is considered feasible using a combination of high energy chemical explosives (92 kt) for excavations less than 17 metres deep and 157 10-kt explosives for a 15.5 km excavation through the divide together with conventional earth moving operations. Total cost is estimated at $195 million. It is claimed that construction is possible without breaking existing treaties, (this apparently involves an agreement with neighbouring Brazil and Columbia on any fallout which might cross their boundaries). For further details see the paper 5 in Appendix D.

PL-388/2 "Possibilities of applying nuclear explosives for the development of natural energy resources in Egypt" [redacted] and [redacted] Egypt).

Based on the Egyptian paper to the 1971 UN Geneva Conference on Peaceful Uses of Atomic Energy but discusses two of the projects in greater detail. Proposals include storage of natural gas produced from the Gulf of Suez oil fields ([redacted]), stimulation of natural gas from the Abu Gharadiq Basin in the Western Desert and stimulation of oil reservoirs in the Gulf of Suez area. There is a brief mention of geothermal energy.

PL-388/3 "An analysis of [redacted] - a nuclear shock tube experiment" [redacted] and [redacted] United States - presented by [redacted].

This describes work, already fully reported, in which a [redacted] explosive was detonated 176m underground at one end of a 122m long, 1m diameter horizontal tunnel. Source energy was preferentially channeled down the tunnel and a cone-shaped cavity result. Later collapse led to the formation of an asymmetric crater whose configuration was not completely understood.

PL-388/4 "Radiologial accident prediction and techniques for practical operational control in a nuclear gas stimulation project" [redacted] United States).

Prompt venting of a deeply buried, gas stimulation, nuclear explosion is not considered credible. The paper describes a model for calculating leakage

rates for gaseous radionuclides at some time following detonation and describes how such leakage would be monitored and downwind dose-rates predicted in the improbable event of real leakage.

PL-388/5 "Measurements of neutron cross sections with nuclear explosives" ([redacted] United States).

A general review along the same lines as those which the author has given previously. In discussion it emerged that the Americans have no plans for continuing this work and hopes of some kind of international co-operation in the field appear to have dimmed.

PL-388/6 "Feasibility of in situ retorting of Green River oil shale utilizing nuclear explosives for fracturing" ([redacted] United States).

Touches only slightly on PNE and is mainly devoted to an account of two experimental above the ground oil shale retorts having capacities of 10 and 150 tons of shale respectively. Oil recovery rates are encouraging. The tests indicate that the creation of adequate permeability through carefully designed and controlled fracturising techniques is a critical factor in in-situ retorting.

PL-388/7 "Craters as engineering structures" ([redacted] United States)

A review paper by a member of the US Army Corps of Engineers summarising the results of studies and field investigations of the Zones and physical properties of explosively produced craters. Data from Danny Boy, Sedan, Sulky, Cabriolet, Buggy and Schooner and from many chemical explosions are used.

PL-388/8 "Explosive excavation for water environment and road cut applications" ([redacted] United States)

Describes a number of theoretical and experimental investigations carried out by the US Army Corps of Engineers since 1962. Emphasis has changed from chemical modelling of nuclear explosions to chemical explosive excavation for civil works.Cost effectiveness is expected to be greatest in a water environment.

PL-388/9 "Relative risks from radionuclides found in nuclearly stimulated natural gas" [redacted] United States).

One of the most interesting papers presented at the Panel.Shows a considerable advance in the American approach to this problem.Ranks radionuclides on the basis of their estimated radiation dose potentials and then calculates projected doses from gas usage and compares them with estimated doses from other radiation sources. Finally risk projections for the estimated doses are compared

with other risks encountered in the normal activities of life in technologically developed nations (eg 0.4 deaths per million population from radiation from consumer devices as compared with 0.1 deaths per million population from nuclearly stimulated natural gas).

PL-388/10 "Calculation of rock fracturing from multiple nuclear explosive source" ([redacted] and [redacted] United States)

Gives SOC (1-D) calculations for Gasbuggy and Rulison and Tensor (2-D) calculations for simultaneously and sequentially detonated multiple nuclear explosions. A significant feature is the introduction of a criterion which relates the number of times a zone in the calculation is fractured to the regions round the explosion point where extensive fracturing is observed experimentally and to the increase in permeability in these zones.

PL-388/11 "Gas quality and geochemical studies in gas-stimulation experiments" ([redacted] United States)

Considers the cavity/chimney geochemistry in gas stimulation projects and the mechanisms by which CO_2 is produced. Includes experimental work involving the heating of gas-bearing shales under a variety of conditions. In multiple explosions there is expected to be more steam but less CO_2 released per unit yield than for a single explosion.

PL-388/12 "Nuclear chemical mining of primary copper sulphides" ([redacted] and [redacted] United States)

This is apparently the PNE application regarded with most favour in the United States at present apart from gas stimulation. The copper is recovered from a water-flooded nuclear chimney formed below the water table by the introduction of oxygen near the bottom of the mass of broken rock. High pressures and temperatures aid solution as is shown by laboratory and pilot plant studies described in the paper. Environmental problems are minimised by this approach.

PL-388/13* "Forecasting of radioactivity levels following a contained explosion" ([redacted] France)

Shows forecasts can be made and that once the quality and amount of radioactivity have been determined, the nature and level of contamination of products stored in a cavity can be assessed by a thermochemical study of the spatial and temporal distribution of the radionuclides. Applied to storage of hydrocarbons, particularly natural gas with emphasis on tritium.

PL-388/14* "Study of storage cavities produced by nuclear explosions" [redacted]

Analyses the general conditions that make the underground storage of gas

in France feasible. Considera a 20 kt explosion at 1500 metres depth leading to a cavity with radius 28 $\pm$ 0.5 m and a storage cost of 1.10 F/m^3 of gas. Discusses how cavity might be used, paying special attention to radioactivity hazards.

PL-388/15* "Experimental and theoretical studies of the dimensions of craters produced by chemical explosives" ([redacted]

Combines theory and results of experiments with medium-sized charges (1 to 250 kg) in silt and clay and small charges (5 to 15 g) in sand to derive nomographs giving crater dimensions as a function of explosive yield, geology and depth of burial. (A more extensive report on the theoretical aspects of this work has already appeared - CENG/ASP Note 69-18; also UCRL-TRANS 10459).

PL-388/16* "Geophysical importance of nuclear explosions" ([redacted], France) (only abstract available)

Discusses advances in seismology and knowledge of earth's crust which have resulted from seismic observations on underground nuclear explosions.

PL-388/17 "A computer method for predicting fallout levels resulting from peaceful nuclear cratering explosions" ([redacted], UK).

This paper has already been issued in the UK. It describes a cloud model which is included in the computer program DIFFAL which can be used to predict fallout levels in the first few tens to hundreds of kilometres downwind from nuclear explosions. Comparisons of predictions and observations are made for four nuclear cratering explosions and it is concluded that the method is suitable for predicting the fallout levels arising from a nuclear cratering explosion in a relatively moist soil environment.

PL-388/18 "Production of radioactivity in peaceful nuclear explosions" ([redacted], UK).

This paper has already been issued in the UK. Freely available information is gathered together to show the progress made in designing explosives for cratering and contained PNE projects which lead to minimum release of radioactive species particularly of fission products for the former and of [redacted] for the latter.

PL-388/19* "Development of the scientific and technological bases for creating reservoirs in salt formations by means of nuclear explosions". ([redacted], USSR).

Discusses main parameters of cavities created by underground nuclear explosions in rock salt formations. The integrity of the storage, the stability of the cavity and the role of the fractured zone around the main cavity are discussed.

PL-388/20* "The effect on buildings of seismic waves generated by underground nuclear explosions" ([redacted] USSR).

Classifies damage to different types of buildings from seismic motion. Gives peak particle velocities for onset of various types of damage in the close-in and far-out zones. Follows logically after PL-388/21.

PL-388/21* "Seismic waves generated by underground nuclear explosions" ([redacted], USSR).

Gives Russian empirical formula for peak ground displacements and velocities resulting from underground explosions. Considers relation between explosion energy, geology and characteristics of resulting seismic waves and possibility of predicting these characteristics in a region which has not been subjected to thorough geophysical study.

PL-388/22* "The use of large explosions in dam construction" ([redacted]

Describes the Medeo and Varkhsh River explosions (photographs included). Discusses possible use of underground nuclear explosions in dam construction.

PL-388/23* "The phenomenology of earth and atmospheric contamination by the products of underground nuclear explosions". ([redacted] - presented by [redacted].

Uses results from American and Russian (1003, 1004, T-1, T-2) cratering explosions to describe and classify atmospheric and local contamination resulting from cratering explosions in terms of dose rate and dose, concentration of radioactive products, aerosol properties and isotopic composition in main contamination zones as functions of conditions under which explosions were conducted.

PL-388/24* "Activation of rock and the formation of radioisotopes from underground nuclear explosions". ([redacted] and [redacted].

Develops a model of the distribution of radioactivity in the early stages of a nuclear explosion, considering particularly the melt. This enables the fractionation of the main radioisotopes in the different contamination zones to be interpreted.

PL-388/25 "Population doses from underground nuclear explosions" ([redacted], Sweden).

Presents a model applicable to cratering explosions on the basis that population dose is mainly determined by the mean deposition and population density within a given area under certain general conditions. Numerical results are given

for a hypothetical 170 kt cratering explosion between latitudes 30° and 60° N and at longitudes 0°, 90°E, 180° and 90°W.

PL-388/26 "The national program for the use of peaceful nuclear explosives in the national economy of the Republic of Venezuela". ([redacted] Venezuela).

Covers possible applications in Venezuela of which the Orinoco-Rio Negro waterway (Paper PL-388/1 and Appendix D, Paper 5) and oil from bituminous sands (Appendix D, Paper 6) have been discussed in some detail. Other applications suggested are offshore oil storage beneath the seabed, fracturing of iron ore deposits in Guayana, water resources development and waste disposal. The paper closes with a statement on the Venezuelan attitude towards Article V of the Non-Proliferation Treaty (NPT).

PL-388/27 "Status of the US Plowshare Program". ([redacted] United States).

A fairly inocuous statement listing gas stimulation, oil from shale, copper solution mining and in-situ coal gasification as the main areas of interest and referring to Rio Blanco ("as early as March 1973") and Wagon Wheel ($13 to 15 million, "the major portion of which is expected to be borne by El Paso Natural Gas"). Other topics emphasised are the development of the [redacted] series of explosives and health physics (principally [redacted] in stimulated natural gas).

* Translation in preparation (to be published in AWRE Translation No.65)

APPENDIX D

OTHER REPORTS RECEIVED

1. "The role of the IAEA in international PNE projects". Presented by [redacted] at the Atomic Industrial Forum, Washington, USA November 1972.

Discusses the Agency's PNE programme, its responsibility to provide services relating to PNE, its responsibility in relation to "international observation" and possible procedures for arranging PNE services - the latter section contains some interesting speculation and may indicate Agency thinking on the subject.

2. "Nuclear Explosion engineering" - Contribution by [redacted] to [redacted] Yearbook of Science and Technology 1972.

3. "The use of nuclear explosives for water resources development in arid regions". Stanford University Department of Civil Engineering Technical Report No 150 (June 1971) by [redacted].

Discusses crater reservoirs - design, use, hazards and economics.

4. "Recovery of high-viscosity petroleum by steam from geothermal heat" Nuclear Technology 11 345 (July 1971) by [redacted].

Gives technical discussion of one project described in P-388/26.

5. "Design of a waterway connecting the Orinoco and Rio Negro rivers in the Federal Territory of Amazonas, Venezuela". Stanford University Department of Civil Engineering Technical Report No 153 (June 1972) by [redacted]

Detailed discussion of the scheme referred to in P-388/26.

Distribution

[redacted]

AWRE, Aldermaston
" "
" "
" "
" "

Foreign Office
DTI
Cabinet Office
UKAEA London Office
Ministry of Defence
United Kingdom Embassy, Vienna

6 spare copies

Appendices C and D are being given a wider circulation under separate cover.