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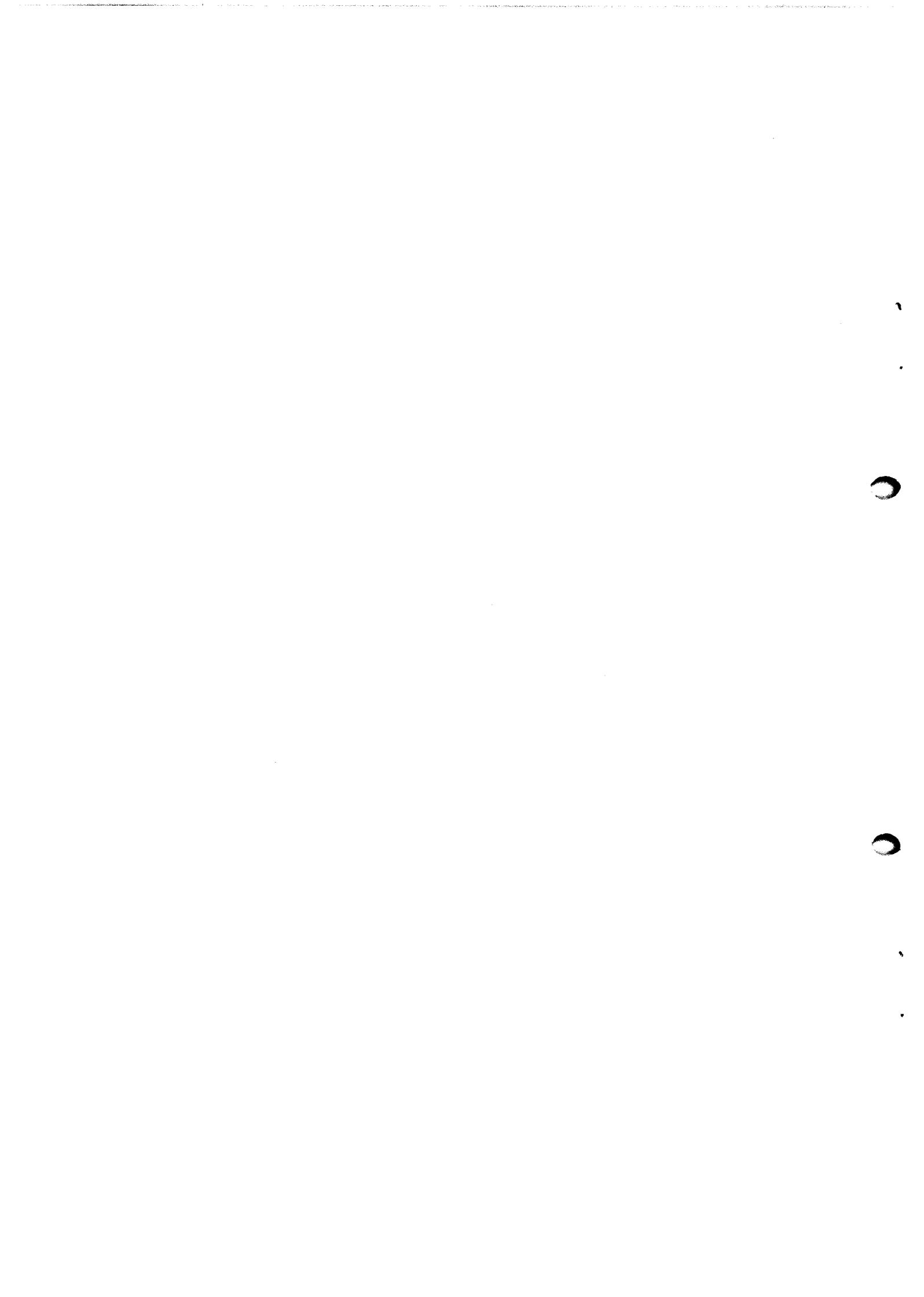
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INTERNATIONAL URANIUM RESOURCES EVALUATION PROJECT

I U R E P

NATIONAL FAVOURABILITY STUDIES

PHILIPPINES



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REFERENCES

FIGURE No. 1. Philippine Islands. Surveys for Nuclear Raw Materials.

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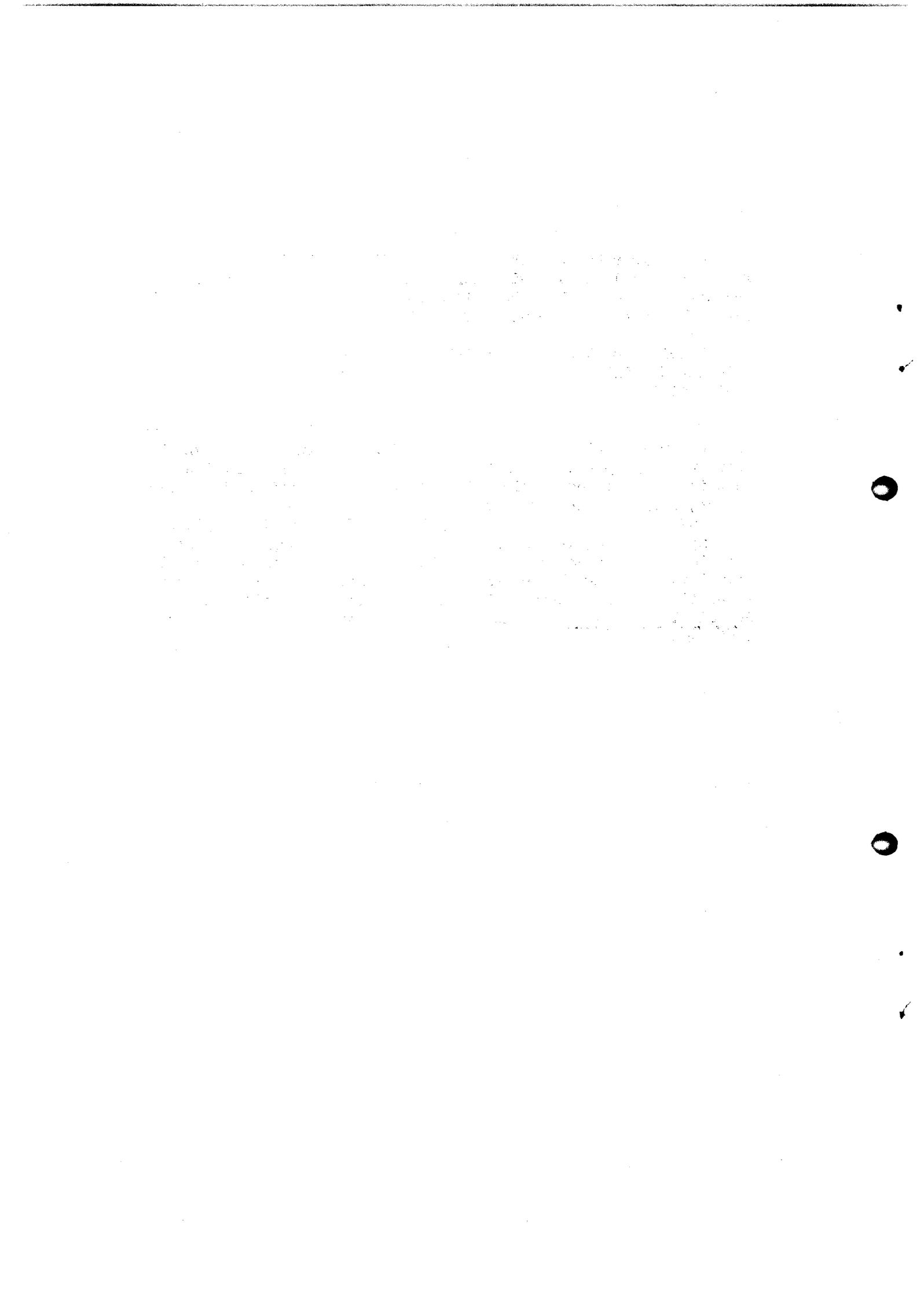
S U M M A R Y

Comparison between the geology of the Philippines and favourable geological environments for uranium in other parts of the world suggests that the Philippine geology is not likely to be favourable for the discovery of uranium.

Previous work has been mainly of a reconnaissance type and orientated mainly to checking the existing mining areas for radioactivity.

The only occurrence known at the present time is at Larap Mine in the Paracale District of Camarines Norte in Luzon. A magnetite iron ore body operated by Philippines Iron Mines Inc contained certain distinct beds, which, in addition to magnetite also contain copper, molybdenum and iron sulphides and uraninite. It is estimated that 200 short tons U_3O_8 is contained in 500,000 tons ore grading 0.04% U_3O_8 at Larap. A number of other largely untested but similar occurrences have also been identified in the Paracale District. A few small occurrences of uranium have recently been identified on the island of Samar. It is suggested that the Speculative Potential of the Philippines may be of the order of 1000 tonnes U_3O_8 .

Category 2. 1000-10,000



1. INTRODUCTION AND GENERAL GEOGRAPHY

The Philippine Islands lie in the western Pacific Ocean and form the largest island group of the Malay Archipelago. They extend between 4°23' and 21°25' north latitude and between 116° and 126° east longitude. The total land area of the Philippines is 114,830 square miles or 297,410 square kilometres. (See Figure No. 1)

There are over 7,100 islands in the group but only about 470 of these are more than one square mile in area, and only eleven of these reach an extent of 1,000 square miles. These eleven islands and their areas in square miles are: - Luzon (40,815), Mindanao (36,905), Samar (5,050), Negros (4,905), Palawan (4,550), Panay (4,445), Mindoro (3,760), Leyte (2,785), Cebu (1,710), Bohol (1,490) and Masbate (1,260). The islands form a roughly triangular pattern with Luzon at the northern apex and Palawan and Mindanao forming the south-western and the south-eastern corners, respectively.

The islands are bounded on the north and west by the South China Sea, on the east by the Philippine Sea (Pacific Ocean) and on the south by the Celebes Sea.

Three north-south trending mountain ranges, reaching elevations of 6,000 to 7,000 feet and with two intermediate lowland belts exist in northern Luzon. Southern Luzon, like many of the Visayan Islands, consists of a chain of mainly dormant, more or less recent volcanoes. Mindanao is an interrupted volcanic chain containing the dormant Mount Apo, 9,690 feet, the highest peak in the Philippines. The islands are noticeably lacking in extensive coastal plains and river lowlands. Except for reasonably good road connections between main centres in Luzon and Mindanao, other roads are mainly dirt tracks which may become difficult in wet weather. Much transport is effected by sea routes. Air connections are extensive and good.

2. GEOLOGY OF THE PHILIPPINES IN RELATION TO POTENTIALLY FAVOURABLE URANIUM BEARING AREAS

The Philippine archipelago is the youngest part of the Alpine-Himalayan island system and consists of rocks, as young as Tertiary-Quaternary which have been compressed and folded by mountain building movements. These movements are still in operation as is evidenced by present day earthquakes and active volcanoes.

Individual islands appear to be the tops of partly submerged, folded, faulted or volcanic mountains. Dissection of these mountains shows that the cores frequently consist of Pre-Tertiary basement rocks.

Philippine geology is predominantly Lower and Middle Tertiary in age and consists of igneous sedimentary and metamorphic rocks. The Tertiary rocks overly a Pre-Tertiary basement and are in turn overlain by volcanics, marine deposits and alluvium of Quaternary age.

A wide variety of plutonic and hypabyssal igneous intrusions exist and igneous rocks generally form a major part of the Philippine Islands, with the sedimentary formations merely forming a thin outer skin.

Comparison between the descriptions of the geology of the Philippines and favourable geological environments for uranium in other parts of the world, suggests that the Philippine geology is not likely to be generally favourable for the discovery of uranium minerals.

The very extensive areas of volcanic extrusive rocks which cover large parts of most of the islands, particularly Mindanao and Southern Luzon can be ruled out as likely host areas. The areas of basic and ultrabasics can likewise be dismissed and the extensive areas of Tertiary and Quarternary and Recent sediments are generally unfavourable, especially where distant from acidic or intermediate igneous intrusives.

The more probable areas are therefore in and surrounding acidic intrusives especially if intruded into basement rocks. Although not normally very favourable, all the grano-diorite and diorite intrusive areas and the rocks immediately surrounding them should be considered.

Of the mining areas, the metasomatic iron ore deposits where sulphides such as those of iron, copper and molybdenum also occur and where there is an acidic or intermediate intrusive nearby should be regarded as favourable. In the other metalliferous areas, the copper, lead, zinc deposits are most likely to be the next most favourable and finally the gold mining areas. The chromite manganese, mercury and the laterite nickel mining areas can probably be ignored.

The suggested favourable areas of the Philippines, in approximate descending degree of favourability and the reasons for them are now given in Table I.

Table I summarises the results of the work pertaining to item I in the stated terms of reference, i.e., the selection of geologically favourable areas for prospecting for nuclear raw materials.

TABLE I

GEOLOGICALLY FAVOURABLE AREAS FOR PROSPECTING FOR NUCLEAR
RAW MATERIALS (URANIUM) IN THE PHILIPPINE ISLANDS

Location	Reasons for Favourability
1. Larap-Paracale District, Camarines Norte Luzon	Presence of granodiorite stock. Extensive metallic mineralisation, Au, Fe, and also Cu, Mo, Pb, Zn, etc. Known occurrence of radioactive minerals at Larap Mine. Radioactive aerial anomalies indicated by Huntings Survey.
2. Lobo Mine Areas Batangas, Southern Luzon	Presence of granodiorite stock. Radioactive anomaly of six times background found in 1953 in old mine tunnel. Cu, Fe, Au mineralisation.
3. Labugaon River Area Ilocos Norte, Northern Luzon.	Quartz-diorite host rock with eugranitic intrusions. A conspicuous radioactive aerial anomaly reaching seven times background.
4. Baguio District Mountain Province, Luzon	Extensive mineralised area, Au, Ag, Cu, Pb, Zn, and Fe. Quartz diorites and andesites with some granodiorite bodies intruded into slates, schists and charts.
5. Mati Area, Mindanao	One Huntings aerial anomaly near a magnetite sulphide ore deposit and associated with quartz diorite intrusives.
6. Marinduque Island	Various Huntings aerial anomalies, and Cu, Pb, Zn, Fe mineralization.
7. Sibuguey Area, Zamboanga del Sur, Mindanao	Magnetite iron ore area with sulphides. Diorite intrusives. Inconclusive evidence from Huntings aerial survey.
8. Atlas Consolidated Mine, Cebu	Extensive Cu mineralisation with subsidiary Mo, and magnetite. Diorite host rock.
9. Sipalay Mine, Negros Occidental.	Extensive Cu mineralisation with subsidiary Mo and magnetite. Diorite host rock.

TABLE I (continued)

10. Phosphate Rock Areas of Cebu, Negros, Bohol, and Luzon.	Reputed slight radioactivity associated with the phosphate deposits.
11. Masbate Gold District, Masbate Island.	Au-Ag Mineralisation in fractures in diorite. High general radioactive background reported in 1953 survey.
12. Jetafe District, Bohol Island.	Granitic intrusive, Au, Cu, Zn and Pb mineralisation.
13. Lubang Island Puerta Calera, Mindoro. Palawan Island. Panay, Samar, Islands.	Various reputed acidic intrusive rock and basement areas. Also Cu, Pb, Zn mineralised areas.
14. All the metalliferous areas near diorite intrusives and surrounding rocks.	General association with metalliferous deposits and intrusive non-ultrabasic rocks.
15. All coal, lignite and bituminous shale areas.	General association between uranium and carbonaceous matter.

3. PAST EXPLORATION

Previous nuclear raw materials prospecting and research work in the Philippines consisted of:-

- (a) A bibliographic study by the U.S. Atomic Energy Commission described in a report entitled "Possibilities for Uranium in the Philippine Islands" by E.K. Judd, H.E. De Sanctis and J.C. Brown issued in June 1953.
- (b) A combined Philippines Bureau of Mines and U.S.A.E.C. field reconnaissance described in a report entitled "Reconnaissance for Uranium in the Philippines" by N.C. Gamatero, J.C. Quema, S.L. Samaniego and C.F. Teodoro of the Bureau of Mines and H.E. Puttuck and H.S. Stafford of the U.S. Atomic Energy Commission issued in September 1953.
- (c) An airborne radiometric survey carried out by Huntings Geophysics Ltd. in 1954 as a subsidiary contract to an airborne magnetometer survey of six areas in the Philippines covering three areas of Luzon, two in Mindanao and the island of Marinduque. This survey was done on behalf of the Bureau of Mines and the U.S.A.E.C. through the Philippine Council for United States Aid. The total area covered amounted about 5,000 square kilometers. The work is briefly described in a report entitled "Report on an Airborne Radiometric Survey of Six Areas in the Republic of the Philippines in 1954" and issued in August 1955.
- (d) Prospecting work was done by private individuals and private companies during the years of maximum world search for uranium. The most successful work, arising from a fortuitous initial discovery was done by the staff of Philippine Iron Mines, Inc., Larap Mine, Camarines Norte. An announcement of this discovery was made at the Geneva Conference of 1956 in a paper entitled "Uranium Deposits in the Philippines" by A. Clemente and E. Reyes, published in the "Peaceful Uses of Atomic Energy" U.N., Vol. 6; Geol. of U. and T., U.N., N.Y., 1956. Further evidence on occurrences in the Larap area of Camarines Norte were given in "Notes on the Genesis of the Ore-Bearing Structures of the Paracale District, Camarines Norte, Philippines" by John E. Frost, Chief Geologist of the Philippine Iron Mines, Inc., Larap Mine, published in the Philippine Geologist, Vol. XIII, No. 2, June 1959.

Several other private companies, geologists, mining engineers and amateur prospectors possessed Geiger counters, and scintillometers during this period but no other significant occurrences of uranium except those in the Paracale-Larap district of Camarines Norte have been recorded. Slight evidence of radioactivity in the phosphate areas of Cebu and Negros was noted and used in further prospecting for phosphate.

Following a request from the Philippines Government the I.A.E.A. supplied an expert for a 12 month mission in 1964. The expert was attached to the Philippine Bureau of Mines with liaison to the Philippine Atomic Energy Commission and visited most of the principal mining areas in the country, took part in field surveys of the Larap area and devised a future programme. Work was principally concentrated on the one known area of uranium occurrences, Larap Mine, Paracale, Camarines Norte, Luzon. The occurrence at Larap still exists but the iron ore mine has closed down. Recent activities by the Philippine Atomic Energy Commission at Larap has included exploratory drilling and sampling of drill cores. In 1975 preliminary investigation of reported radioactive anomalies was extended to mining areas in the island of Samar and a number of anomalous areas were confirmed.

4. URANIUM OCCURRENCES AND RESOURCES

(a) Larap Mine, Philippine Iron Mines Inc., Camarines Norte, Luzon

The only indigenous source of recoverable uranium in the Philippines at the present time is contained in the Bessemer pit area of Larap Mine, Camarines Norte. The orebody was operated by Philippine Iron Mines, Inc., a subsidiary of Atlantic Gulf and Pacific Company. The company was engaged in magnetite iron ore production on a substantial scale.

It has been estimated that there may be a content of 200 tons U_3O_8 contained in 500,000 tons of ore with a grade of 0.04% U_3O_8 . This material is contained in certain distinct beds which lie within the Bessemer low grade magnetite orebody and also contain copper, molybdenite and iron sulphide minerals.

If the ore could be selectively mined then, ore dressing tests done at the Bureau of Mines show that it would be technically possible to make a 50% recovery of the uranium.

The dominant geological feature of the Larap district is a granodiorite stock measuring approximately 12 kilometers in an east-west direction and reaching a maximum width of four kilometers. The rock is composed of albite, quartz and biotite with a little hornblende or pyroxene and was previously referred to as a granite.

The stock has been intruded into a series of metamorphosed basic and ultrabasic rocks of unknown age, consisting of serpentines, talc schists, chlorite schists and amphibole rocks.

Unconformably overlying the ultrabasics are a series of argillaceous sediments with limestones, arkoses and conglomerates which are known as the Universal formation and reputed to be of Miocene age. Unconformably overlying this Universal formation are a series of volcanics and agglomerates known as the Larap volcanics.

Three mineral zones in addition to the barren core of the granodiorite have been defined. The first is the gold zone, at the edge of the granodiorite. The second is the iron zone which is reputed to stretch from about two to five kilometers south of the southern boundary of the granodiorite and the third is an ill defined base metal zone lying to the south of the iron zone but overlapping it and parallel to it.

The magnetite orebodies at Larap appear to have been deposited along a thrust contact between underlying hornfels and overlying meta-volcanics and meta-sediments. In places, wedges of syenite porphyry may be found between the ore and the meta-volcanic hanging wall. Mineralisation is apparently controlled along the sole of this thrust fault and appears to be related to limestone members of the meta sediments.

Pyrometamorphic and contact silicates are found as irregular zones in the vicinity of the intrusive syenite. The rocks are coarse grained with dark green pyroxene, actinolite, muscovite, chlorite, epidote, quartz, calcite and apatite. The primary iron ore within the mineralized zone may form the matrix of the brecciated metamorphic rocks or occur as disseminations in the meta-sediments or as small bodies of pure magnetite. The low grade ores are commonly accompanied by pyrite mineralization.

Along the strike, the ore is cut by vertical tear faults and separated into pod like masses.

Accessory metallic minerals are pyrite, pyrrhotite, chalcopyrite, molybdenite, gold, scheelite and uraninite. The copper-molybdenum mineralization with associated uranium characteristically occurs within metamorphosed sediments similar to those which are hosts to the iron mineralization. These Cu-Mo-U "beds" are probably the highest temperature expression of the base metal mineralization. The gangue mineral assemblage associated with them is characterized by relatively high temperature minerals.

Also within the Paracale area are a number of other similar occurrences which have only been partially assessed. A number of these are:- First Feda Iron Mine (magnetite, pyrrhotite and a uranium mineral) Star Claim, Submakin Prospect (magnetite, Au, Ag and Pb, Cu, Zn, Fe sulphides and a uranium mineral). Nakafe Claim (magnetite, sulphides and radioactivity). Capacuan (magnetite, sulphides and radioactivity). A number of other occurrences of radioactivity are known in the area.

Work in recent years by the P.A.E.C. has confirmed uranium mineralisation in the Cu - Zn mining areas in Bagacay on the island of Samar. Radiometric readings of 50 times background were recorded and grab samples gave values of between 0.02 and 0.08% U_3O_8 .

5. PRESENT STATUS OF EXPLORATION

In recent years, following the passage of Presidential Decree No. 647 declaring radioactive minerals as the property of the State not subject to mining location or disposition, it is expected that there will be intensified exploration for nuclear raw materials by Government authorized agencies.

The I.A.E.A. has been requested by the P.A.E.C. to provide three experts for brief periods over the next two years (a) an ore processing expert to help with devising a recovery system for the Larap ore (b) an aerial survey expert to assist with the P.A.E.C.'s aerial survey programme and (c) a geochemist to assist with a geochemical survey programme in Paracale and Samar.

6. POTENTIAL FOR NEW DISCOVERIES

As already noted, the Philippine geology is not likely to be generally favourable for the occurrence of uranium. The Larap occurrences are unusual and so far have given no indication of substantial uranium tonnages. It is likely that additional occurrences similar to Larap could be found in the Paracale district but it is probable that they would be of the same order of magnitude.

The possibilities in Samar appear to be only moderate and unless any new discovery is made in a different environment this would appear to define the Philippine potential. In summary it is believed that the Speculative Potential in the Philippines may be a few hundred tonnes U_3O_8 - possibly as much as 1000 tonnes U_3O_8 .

J. Cameron
Vienna 1976

Category 2 1000 - 10,000

REFERENCES

1. Judd E.K. et al "Possibilities for Uranium in the Philippine Islands". U.S.A.E.C. Report 1953.
2. Gamatero N.C., Puttuck H.E., Stafford H.S. et al "Reconnaissance for Uranium in the Philippines" U.S.A.E.C. Report, 1953
3. Huntings Ltd. "Report on an Airborne Radiometric Survey of Six Areas in the Republic of the Philippines in 1954". Huntings, London, August 1955.
4. Clemente A. & Reyes E. "Uranium Deposits in the Philippines". Peaceful Uses of Atomic Energy, U.N. Vol. 6, N.Y. 1956.
5. Cameron J. "Prospection and Evaluation of Nuclear Raw Materials : Report to the Government of the Philippines" I.A.E.A. T.A. Report No. 175, 1965.
6. Fernandez J.C. & Santos G.T. "Exploration for Radioactive Raw Materials in the Philippines". Phil. Bur. of Mines, 1976.

- 5 -

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J. Cameron
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REFERENCES

RME-4014, 3/p., 1953.

1. Judd E.K. et al, "Possibilities for Uranium in the Philippine Islands". U.S.A.E.C. Report 1953.

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2. Gamatero N.C., Puttuck H.E., Stafford H.S. et al
"Reconnaissance for Uranium in the Philippines"
U.S.A.E.C. Report, 1953

3. ^{Geophysics} Huntings Ltd. "Report on an Airborne Radiometric Survey of Six Areas in the Republic of the Philippines in 1954".
Huntings, London, August 1955. ^{for the IEC}

4. Clemente A. ^{and} Reyes E. "Uranium Deposits in the Philippines".
Peaceful Uses of Atomic Energy,
U.N. Vol. 6, N.Y. 1956.

5. Cameron J. "Prospection and Evaluation of Nuclear Raw Materials :
Report to the Government of the Philippines"
I.A.E.A. T.A. Report No. 175, 1965.

6. Fernandez J.C. ^{and} Santos G.T. "Exploration for Radioactive Raw
Materials in the Philippines".
Phil. Bur. of Mines, 1976.

2. Puttuck, H. E. and Stafford, H.S. "Search for Uranium
in the Philippines," U.S. Atomic Energy Comm.
AECU-3188, 20 p., 1955.