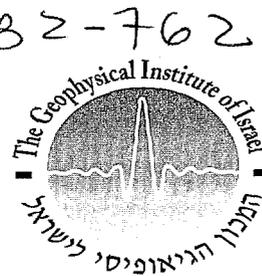


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ANNUAL REPORT

November 1995 - November 1996

Submitted to:

The US Agency for International Cooperation

SEISMIC MICROZONING

IN CAPITAL CITIES IN

THE SOUTH PACIFIC

PI: Avi Shapira

The Geophysical Institute of Israel, GII

(formerly The Institute for Petroleum Research and Geophysics)

CI: Alfred Simpson and Graham Shorten

South Pacific Applied Geosciences Commission, SOPAC.

Grant No. : TA-MOU-95-C13-024

US-AID Grant Project Officer

David Moulinex

Science Attache, US Embassy in Israel

Project Duration: August, 1995 - September 1998

EXECUTIVE SUMMARY

The main objectives of the projects are to evaluate the applicability of the SvE method for earthquake hazard assessment and to implement this method in microzoning capital cities in the South Pacific islands.

In accordance with the work program, the first 12 months were dedicated to: compilation of existing data relevant to the project, upgrading the capabilities of the DC to monitor the seismicity and provide essential data for the project and to provide training for local investigators and technical teams in executing seismological survey and studies.

The basis for a GIS to include the infrastructure, geological, geotechnical and seismological information was established by SOPAC, who also provided in the field training of GIS and Geology. GII evaluated the technical requirements, purchased and assembled the monitoring systems, installed the equipment and trained local collaborators to use the systems and maintain basic seismological analysis.

Meetings with government officers and engineers from the private sector were held in order to describe the project, its expected output and its application. The meetings were also followed by public lectures on the topic of Earthquake Hazard and Risk Assessment and Mitigation of Earthquake Loss.

SECTION I

A. RESEARCH OBJECTIVES

The overall aim of the project is to develop, test and improve a semi-empirical method, the SvE, to estimate the uniform-hazard site-specific acceleration response spectrum.

The testing ground for this study is the main capital cities of the South Pacific islands; Honiara in the Solomon Islands, Port Vila in Vanuatu, Suva in Fiji and Nuku'alofa in Tonga. The overall aim of the project incorporates the following objectives:

1. Implementation of the SvE method to establish a microzoning map for each of the cities; Suva, Nuku'alofa, Honiara and Port Vila through:
 - a) Evaluation and mapping of the response of various sites in the city to earthquake motions.
 - b) Evaluation of seismological scaling laws relevant to the region.
 - c) Establishment of a geological-seismological data base for the city using GIS.
2. To introduce into the nations of the South Pacific islands a modern approach to assessing earthquake hazards and implementing this in the form of regulations and building codes.
3. To promote seismological knowledge and understanding of local researchers, students and trainees, including earthquake monitoring and site investigations.

B. RESEARCH ACCOMPLISHMENTS

1. Development of the SvE

When the project proposal was formulated and newly approved, the SvE was merely a suggested concept to approach the problem of assessing earthquake hazard in applied engineering terms. In parallel to the activities related to the South Pacific region, a number of sites have been studied in Israel, mainly in order to gain practice in using the Nakamura (1987) method and test it against the technique of using a reference site and by analyzing strong motion data from the Gulf of Aqaba earthquake ($M_w = 7.2$) of November 22, 1995. Although these studies are not funded by this US-AID grant, they have a direct application to the project and are important to its success. In most cases we found that the Nakamura method is applicable and especially useful in defining a subsurface model to be integrated in the SvE computations.

An immediate result of these activities is the development of a PC-based program (temporary name - PC-FDA for frequency domain analysis) to analyze records of microseisms and seismic events and determine the empirical site response function. The

PC-FDA was written by A. Malitzky under the supervision of Dr. A. Shapira and Dr. Y. Zaslavsky (all of GII). In its present form, the program performs spectral analysis which helps in evaluating the quality of the accumulated data during field operations. It was used during joint field operations in Honiara and Suva during September/October, 1996.

2. Seismic Data Acquisition

During February 1996, Dr. Shapira visited the collaborating institutions in the South Pacific islands (see IPRG Report. No. 564/54/96(1) , April 1996). Following this visit, the capabilities and needs of the collaborating institutions (all are government departments) in Fiji, Tonga, Vanuatu and the Solomon Islands were assessed and equipment was specified. The equipment was ordered and assembled at GII (Israel) during March-August 1996. The systems provided to each country and their application in the project are as follows:

- The Seismology Section of the Mineral Resources Dept., Fiji, is equipped with a PC-SDA system to perform site investigations in Suva and to collect data from the national seismic network which was further upgraded by acquiring new radio telemetry, automatic time synchronization and horizontal seismometers. The data of the national network will be used for evaluating regional seismicity parameters and earthquake scaling laws for the SvE.
- The Geology Dept. of the Secretary of Lands, Survey and Natural Resources, Tonga and the Geology Department of the Ministry for Mines and Water Resources, Vanuatu, are equipped with a 3C seismometer station, a PC-SDA system and a strong-motion accelerometer. The seismometric system will be used for both site investigations and earthquake monitoring. Data of the seismic network of Vanuatu, operated by ORSTOM, France, will also be incorporated in the project. (An agreement between ORSTOM, SOPAC and GII was drafted during Dr. Shapira's visit to Port Vila in October 1996).
- The Geology Department of the Ministry of Energy, Solomon Islands, has also been equipped with a PC-SDA and a strong motion accelerometer. New seismometers and communication systems were added to the existing systems to facilitate data acquisition of regional earthquakes at different distances.
- Technical teams from GII and the collaborating institutions installed the system during Sept.-Oct. 1996.

3. Compilation of Geological and Geotechnical Data

Dr. G. Shorten at SOPAC has undertaken the huge task of administrating the compilation of existing geological and geotechnical data for the studied cities to be installed on a Geographic Information System. The currently available data are:

- Suva: The basic information including coastal lines and overlying infrastructure has been collected for digitization. Geotechnical data (drill-holes, in-situ tests, laboratory tests, bore-holes and engineering soil classifications) have been compiled.

Geological structural map and topographical maps are ready. A lithological map is in a draft form.

- Honiara: Topographical maps have been digitized. Most of the large buildings are mapped. Some data from boreholes and lithology data have been collected.
- Nuku'alofa: The city map has been digitized. Geotechnical information has been gathered from six boreholes (more to be collected). A geological map of the city center is in draft form.
- Port Vila: The city map has been digitized. There is limited geotechnical data from boreholes. The main geological features in the town area have been mapped.

4. Compilation of Seismicity Data

Earthquake information for the period 1986-1995 was scanned through the bulletins of the National Earthquake Information Center of the US Geological Survey. Additional data from the Fiji and Vanuatu national networks provide a basic data set for identifying the main seismogenic areas within 200 km. of the cities and their seismicity parameters (currently being studied by G. Prasad, Fiji, Dr. M. Regnier, ORSTOM, Vanuatu and Dr. A. Hofstetter, Israel).

5. Preliminary Site Response Measurements

In Suva, Fiji, and in Honiara, Solomon Islands, the new system (PC-SDA) was used to measure microseisms at 2-4 sites in the cities. These operations were done primarily for training purposes, however, the data collected will be use for a first evaluation of the potential for site amplification effects and to complete the development of the software for site response analysis.

C. SCIENTIFIC IMPACT OF COLLABORATION.

One of the objectives of the project is to promote the scientific level of our collaborators. The emphasis is on two major aspects: (a) Monitoring of the seismicity and (b) Earthquake hazard assessments. During the reported period we focused on training local technical teams and researchers to operate and maintain the seismic monitoring systems. Tutoring and training was done almost on an individual level including, but not limited, to the topics: theoretical aspects of seismometry; types of seismic waves; instrument response and its determination; principal location methods; magnitude determinations and computerized detection algorithms.

The level of knowledge in seismology differs from one national organization to the other. In view of this fact, we changed the original plan, i.e., organizing a joint workshop and, instead, Israeli experts visited each center and worked individually with each of the persons enrolled in the project.

D. PROJECT IMPACT

During Dr. Shapira's two visits to the region, discussions were held with local administration and decision makers to assure government support on one hand, but just as important, to increase awareness of the problem of earthquake hazard and how it may be mitigated. The response in Fiji, Tonga and the Solomon Islands was much greater than expected, i.e., decisions were made at a government level to integrate the expected results of the project (i.e., microzoning map of the capital city), in planning the future development of the cities and in building regulations.

An interesting development is the action taken by SOPAC to widen the scope of activities initiated by the US-AID Seismic microzoning project and launched the "Pacific Geo City Plan". The idea is to overlay seismological assessments with other hazard assessments (see Attachment A).

E. STRENGTHENING OF DC INSTITUTIONS

Paragraphs A to D above elaborate this issue. Evidently the DC have been strengthened in terms of upgraded technology and wider knowledge of seismology.

F. FUTURE WORK.

We plan to proceed in accordance with the original work plan. In the next months we hope to acquire earthquake information to facilitate evaluation of scaling laws and attenuation function(s) through continuous operation of the new or upgraded seismic monitoring systems. These activities will be carried out in and by the collaborating institutions in each country under the coordination of SOPAC. Incoming data (copies of seismograms will be sent to Israel) will be reviewed by GII researchers to assure quality of the data. E-mail and fax communication will be used to provide guidance.

SECTION II

A. MANAGERIAL ISSUES

SOPAC, together with the collaborating institutions, is trying recruit more young investigators to the project. The main difficulty is the absence of an academic curriculum in the field of seismology in any of the educational institutions of the South Pacific. Our major concern is the scarcity of qualified people in Vanuatu.

The contribution from Vanuatu, especially data of the regional network, is vital to the project. The Seismic Network of Vanuatu is run by the French organization ORSTOM under the supervision of Dr. M. Regnier. A Memorandum of Understanding between SOPAC, GII and ORSTOM has been drafted to facilitate collaboration.

B. BUDGET

We do not anticipate budgetary difficulties, however, following the decision to give higher priority to the establishment of the seismic monitoring system, we had to change the expenditure scheme, i.e., allocating more money for instrumentation and training during the first year of the project. At the same time, less money was spent on traveling of CD researchers within the South Pacific.

C. SPECIAL CONCERNS

Nothing to report.

D. COLLABORATION, TRAVEL, TRAINING AND PUBLICATIONS

1. The activities associated with collaboration and training are specified above.
2. During September 16 to November 2, 1996, teams from the GII Seismology Division traveled to the South Pacific islands (see Attachment A). Operations in the region were extended by one week due to the fact that one of the parcels, containing equipment for the region, was lost on the way between Tel Aviv and Suva and arrived late in Fiji.
3. Two manuals were published and distributed to the participating organizations:
Shapira, A. and V. Avirav, 1996. PC-SDA Operation Manual, Version 2.2, IPRG Report Z1/110(c)
Malitzky, A. and A. Shapira, 1996. PC-SDP - PC based seismic data processing software package, Version 2.0, IPRG Report Z1/111.

During the operations in the South Pacific islands we learned that the PC-SDP needs modifications in order to meet local monitoring conditions. Most of the modifications have been completed and an updated version will be published.

Both publications acknowledge the US-AID.

AID Grant No. TA-MOU-95-C13-024

ACTUAL DISBURSEMENTS REPORT

Grantee: The Geophysical Institute of Israel
Grant Number: AID Grant No. TA-MOU-95-C13-024
Period covered by this report: from August 1996 to October 1996

BUDGET LINE ITEM	BUDGET		DISBURSEMENTS THIS PERIOD		CUMMULATIVE DISBURSEMENT	BALANCE
	PRIME	SUB	PRIME	SUB		
Salaries		21,500				21,500
Materials and Supplies	3,000	3,750	995		2,063	937
Travel and Transport	64,100	45,400	36,015	505	41,473	22,627
Equipment		61,500		8,813	9,963	35,437
Indirect costs		750		125	60,497	1,003
TOTAL EXPENSES	67,100	132,900	37,010	9,443	114,412	85,588

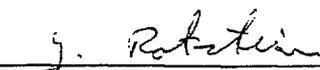
Comments:

1. Please attach a separate Request For Payment Form for each grantee!

Note: All amounts in U.S. Dollars (\$)

The undersigned hereby certifies: (A) that payment of the sum claimed is proper and due and that appropriate refund to AID will be made promptly upon request in the event of disallowance of costs not reimbursable under the terms of the agreement; (B) that information on the fiscal report is correct and such detailed supporting information as AID may reasonably require will be furnished promptly to AID on request; (C) that all requirements called for under the agreement to date of this certification have been met.

BY:



Dr. Yair Rotstein

TITLE: General Manager

DATE: December 5, 1996

Pacific Geo CitiPlan

22 August 1996 Volume 1, Issue 1

"...each study complemented the other to form a complete geoscientific basis for urban planning in Pacific capital cities."



Liquefaction in Niigata, Japan

Introduction to CitiPlan

A newsletter is born!

During the past year, several proposals from widely separate sources received substantial funding. The proposed studies were in the fields of seismic microzoning and shoreline vulnerability in Pacific capital cities.

The monies for these studies were subsequently channelled through SOPAC for project implementation.

Happily, many of the aims and means of the different studies coincided.

Both examined hazards to urban development, and both required production of a MapInfo database in geoscientific information for major cities in the Pacific.

It soon became obvious that it was not productive to compartmentalise these studies.

Rather, each study complemented the other to form a complete geoscientific basis for urban planning in Pacific capital cities.

In the process of implementation, it also became clear that the overlap in the studies, and the need-to-know in the various countries involved, gave rise to the need

for a *lingua franca*. Thus the newsletter was born!

The purpose of the newsletter is to provide a vehicle to keep all participating countries, organisations, researchers and donors up-to-date on events in the field.

It is hoped that this will provide a stimulus for greater interaction amongst participants.

The end result of this sharing of ideas and methods will be a far more efficient implementation of the projects in member countries.

At present, the horizon for these projects lies some 2-3 years down the track.

During this time, we hope to be able to publish news on a quarterly basis.



Lilia Waradi, Program Assistant, SOPAC helping with the organisation of CitiPlan.

A SOPAC newsletter incorporating news and events on seismic microzoning, shoreline vulnerability studies and planning for geohazards in cities of the Pacific

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The views expressed herein are those of the Editor and do not necessarily represent the official position of SOPAC

The main impetus for the start-up of Geo CitiPlan project came from a move by Israeli researcher, Dr Avi Shapiro, Director of the Institute of Petroleum and Geophysical Research (IPRG) in Israel, to initiate a seismic microzoning study in four Pacific capital cities.

Avi was keen to prove the *SvE* method (named after Shapiro and his collaborator, van Eck), and needed to find a region with high seismicity in order to do so.

With a USAID Grant of US\$200,000 in his pocket, Avi chose Nuku'alofa, Port Vila, Honiara and Suva as the sites for his studies.

He approached SOPAC to act as the co-ordinating body for the project in the Pacific region.

Graham Shorten, SOPAC's Coastal Engineering Geologist, took on the role of technical co-ordination of the geotechnical mapping effort.

The IPRG move followed hot on the heels of (but was unconnected with) a decision by the Fiji Department of Environment to contract SOPAC to carry out Fiji's commit-

(Continued on page 3)

In This Issue

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Submarine Slumps 2

Tasks for Microzoning Studies 3

Progress in-countries

Tonga

Fuka Kitekei'aho, SOPAC Assistant Training Co-ordinator and Tongan national, was recently in Nuku'alofa on leave for a tennis tournament.

He took time out to spend a few days searching out existing data held by Government departments and authorities in Tonga.

This has given Nuku'alofa a head-start in data collection.

Fuka made contact there with Kelepi Mafi of the Department of Lands and Surveys to brief him on the project and bring him up to speed on events.

Solomon Islands

Digitising is almost complete on one of the two 1:10,000 physical map sheets covering Honiara.

Losana Waqaliva, working with SOPAC's Bou Toloi during her USP holidays, carried out the arduous task as part of a training attachment to SOPAC.

Vanuatu

Morris Stephen has been nominated to assist Marc Regnier in field studies in Vanuatu.

Fiji

The Suva Vulnerability study is reaching its final stages.

The study was initiated with the efforts of Sefa Nawadra, Principal Environmental Officer, Fiji Department of Environment and Don Forbes, SOPAC's Coastal Geologist.

Don has since returned to Canada at the end of his contract and has been replaced with Steve Solomon who has taken over the guidance of the project.

Jens Kruger, recently graduated from the USP with a BSc, has been plugging away for months on the task of assembling the data, and the end is finally in sight.

Jens has been employed under funds provided through the Department of Environment.

Kiribati

Money may become available soon under GEF funds to conduct a pilot vulnerability study of a selected area of South Tarawa.

Submarine slumps project augments the Suva study

A research project offshore from Suva, in the mouth of the main passage into Suva Harbour, is seeking evidence for submarine slumping that caused a tsunami in Suva Harbour during the Richter magnitude 6.7 earthquake in 1953.

The tsunami resulted in a number of deaths and caused extensive damage to the main wharf.

Honours degree candidate, Luna Wong, is using seismic reflection profiling and other geophysical methods to map the seafloor in waters from the reef edge down to depths around 600 m. His aim is to delineate seafloor morphologies that will indicate submarine slope failure, as well as structures in the bedrock that might indicate movement on active faults.

From this he hopes to be able to predict the likelihood of future, tsunamigenic slope failures that might affect Suva.

Luna, currently on study leave from the Mineral resources Department of Fiji (MRD), is being helped in his work by the SOPAC team of Robert Smith, Marine Geologist, Simon Young, Senior Electronics Technician, and Graeme Frost, Purchasing Officer.

The team is utilising the 8 m aluminium catamaran, *Yautalei*, provided under an agreement with MRD, fitted with both SOPAC's and MRD's electronic and geophysical equipment.

The difficulty in interpreting the data from current methods points up the urgent need for SOPAC to obtain

funding for a multi-beam echosounder/swath mapping device which would simplify this, and similar tasks, enormously.

Luna's work will form an important adjunct to a pilot study being undertaken by UNDHA/SPOCC on the effect a future earthquake might have on a selected 4 square kilometre area of Suva inner city and harbour.

Luna should complete his Honours thesis at QUT in Brisbane later this year.

The logical extension of Luna's study - an examination of the proposed deepwater outfall sites for disposal of mine tailings from the mooted Namosi copper mine - is being carried out a little further down the coast from Suva.

The study at the outfall sites will attempt to assess the stability of submarine slopes under the effects of both the added weight of tailings and dynamic earthquake forces.

The epicentre of the 1953 earthquake was located in the near vicinity of the proposed outfalls.

MRD is largely funding the combined projects through in-kind provisions of boat, equipment, supplies and personnel.

Who is SOPAC?

The South Pacific Applied Geoscience Commission, SOPAC, started life over 25 years ago as COGP/SOPAC - the United Nations Committee for the Co-ordination of Prospecting in Off-shore Areas / South Pacific Region. Initially, the Committee's efforts were expended primarily in offshore, "blue-water" research areas.

However, as the organisation was weaned off UN funding to emerge as an inter-governmental organisation, its emphasis shifted towards nearshore and even onshore matters.

The membership of SOPAC has grown over the years to 15 Pacific countries with two French Pacific territories as associate members.

SOPAC takes its direction from a Board of Governors convened at its annual sessions.

With around 50 employees, SOPAC is located in Suva and serves its member countries in a very wide variety of geo-scientific fields.

Secondments

Part of the overall plan of this endeavour is that in-country counterparts will be brought to SOPAC to undertake training in MapInfo and, at the same time carry out some work on the microzoning project for their own country. Kenneth Bulehite - Water and Mineral Resources Division, Solomon Islands, and Kelepi Mafi - Department of Lands and Sur-

Travel

Israeli researcher Avi Shapira and his team from the IPRG will be travelling throughout the region during August and September. Avi and team members Lisa etc will be travelling to Honiara, Port Vila, Nuku'alofa and Suva to install new seismic equipment and train local counterparts in its use and application. See the back page for details.

(Continued from page 1)

ment under the Global Environment Fund (GEF) protocol.

Environment provided FS40,000 of GEF funds to SOPAC to determine the vulnerability of Suva to the

threat of sea-level rise under the influence of global warming and ocean expansion.

Workers at SOPAC recognised the potential of combining these types of studies to produce a comprehensive, and easily-accessible geological database based on the MapInfo software which SOPAC had already distributed to member countries.

They also saw the opportunity to build onto these focused studies to produce a more general geohazard planning base for Pacific capitals, in parallel with the primary studies.

On the whole, these cities are developing rapidly without the benefit of overarching city plans, and certainly without any co-ordinated geoscientific or geohazard database on which to base critical development decisions.

The money from IPRG and Environment provided the boost for which the region has

been waiting.

While not nearly enough to cover all of the needs, it has proved to be the fillip and the nucleation site for further funding - providing a basis upon which SOPAC is now building additional integrated studies in the region.

Funding news
 UNDP/HA/SPOCC has applied for \$40,000 from their UN parent in New York to fund SOPAC and IPRG to work on the geological aspects of the Suva Earthquake Preparedness Project. The Fiji Government has also applied to the French Government for a similar amount to help complete the Project.

Availability of data
 The data gathered from these various sources remain the property of the Governments of the countries involved and the various operational and funding agencies. However, SOPAC is ready to negotiate with these bodies on behalf of external organisations wishing to obtain data from the studies.



Yautalei ready to go on the submarine slumps project, Suva Harbour (see story page 2).

Tasks for micro-zoning studies

Below is a list (not exhaustive) of the types of existing information that should be considered first when carrying out a microzoning or vulnerability study.

Requirements for Microzoning/Vulnerability Studies

- Borehole, locations and full logs
 - Geotechnical
 - Groundwater
- Geotechnical Test Results
 - In-situ
 - Laboratory
- Maps, large and small scale
 - Geologic
 - Topographic
- Survey
 - fixed benchmarks
 - Datum
 - Projections
 - Origins
 - System (WGS84)
 - Conversions
- Publications and Reports
 - geological
 - geotechnical
 - groundwater
- Tide Gauge
 - Details
 - Data
- Wind
 - Digital records
 - Cyclone details
- Seismic Reflection
- Bathymetry
- Waves
- Currents
- Development Plans/Town Plans
- MapInfo data, existing
- Coastal Zone Classification or Mapping
- Sea-walls
 - Heights
 - Construction details
- Aerial Photos
 - Years
 - Flight lines



If not claimed, return to:

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Director
Seismology Division
P. O. Box 2286
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Pacific Geo CitiPlan

TENTATIVE ITINERARY FOR IPRG Team

- Dr. Avi Shapira : Director IPRG Seismology and Team Leader
- Mrs Veronic Avirav : System Engineer (Real-Time Programmer)
- Miss Alona Malitzky Ph.D. Student : Seismic Data Processing Developer
- Miss Lea Feldman M.A. in Geography : Chief Analyst of Seismic Data
- Mr Uri Peled BA in Geology : Operator and Analyst of Strong Motion Recorders
- Mr Yossi (Joseph) Swartz : Field Technician
- Mr David Levy : Field Technician

DATE	DEPART	TIME	ARRIVE	TIME	IPRG MEMBER
19/9/96	BRISBANE		NADI		AVI, YOSHI, DAVID, VERONIC
26/9/96	BRISBANE		NADI		ALONA ? might come on 19/9/
26/9/96	NADI		SUVA		ALONA ?
29/9/96	NADI		HONIARA		AVI, YOSHI, DAVID, VERONIC
4/10/96	HONIARA		BRISBANE		YOSHI, DAVID, VERONIC
5/10/96	HONIARA		PORT VILA		AVI, ALONA
8/10/96	PORT VILA		NADI		AVI, ALONA
8/10/96	NADI		NUKU'ALOFA		AVI, ALONA
10/10/96	BRISBANE		HONIARA		URI, LEA
12/10/96	NUKU'ALOFA		NADI		AVI, ALONA
12/10/96	HONIARA		PORT VILA		URI
13/10/96	NADI		SYDNEY		ALONA
13/10/96	NADI		HONIARA		AVI
17/10/96	PORT VILA		NADI		URI
17/10/96	NADI		SUVA		URI
19/10/96	HONIARA		NADI		AVI, LEA
22/10/96	SUVA		NADI		URI
22/10/96	NADI		NUKU'ALOFA		URI
23/10/96	NADI		SYDNEY		AVI, LEA
26/10/96	NUKU'ALOFA		NADI		URI
27/10/96	NADI		SYDNEY		URI

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